

Alligator Energy

Program for Environment Protection & Rehabilitation

Samphire Uranium Project

Blackbush Deposit Field Recovery Trial

Version 3.0

TENEMENT HOLDER AND FIELD RECOVERY TRIAL OPERATOR:

Alligator Energy Limited:	ACN: 140 575 604 ABN: 79 140 575 604
Website:	https://alligatorenergy.com.au
Contact Person:	Dr Andrea Marsland-Smith
Email:	ams@alligatorenergy.com.au
Phone:	+61 (0) 7 3839 3904
Address:	PO Box 338 Spring Hill QLD 4004

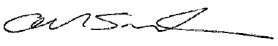
Declaration of Accuracy

I, Dr Andrea Marsland-Smith, the applicant, have taken the following steps to review the information in this application to ensure its accuracy.

This document has been prepared by suitably qualified Alligator Energy employees and consultants in accordance with the requirements set out in the Terms of Reference for Uranium In Situ Recovery PEPR's.

An internal process for review, endorsed or sign off by a suitable qualified and experienced company employee.

The information contained in this Program for Environment Protection & Rehabilitation is, to the best of my knowledge, an accurate representation of all field recovery trial activities that are proposed for the Samphire uranium project by Alligator Energy Ltd.

Name	Position	Signature	Date
Dr Andrea Marsland-Smith	Chief Executive Officer		12/8/2025

DOCUMENT HISTORY

Document Number:	CE_SAM_MP_FRT_PEPR
Revision:	Version 3.0
Status:	Approved for Submission
Date:	12 August 2025
Author:	M Daniel, E Thomas, K Levingstone, Dr Marsland-Smith
Checked:	Dr Marsland-Smith

VERSION CONTROL

Version	Date	Author(s)	Reviewers	Description of Changes
1.0	7/03/2025	M Daniel, E Thomas, K Levingstone, Dr Marsland-Smith	Dr Marsland-Smith	Initial Draft PEPR Submission for Regulatory Review.
2.0	22/06/2025	M Daniel, E Thomas, K Levingstone, Dr Marsland-Smith	Dr Marsland-Smith	Updated PEPR – Following Regulatory Review.
3.0	12/08/2025	M Daniel, E Thomas, K Levingstone, Dr Marsland-Smith	Dr Marsland-Smith	Final PEPR – Updated Following Additional Regulatory Comments.

Table of Contents

1 INTRODUCTION 1

1.1 Project Background 1
1.2 Project Objectives 4
1.3 Regulatory Framework 4
1.4 Project Resources & Market Considerations 7

2 DESCRIPTION OF THE ENVIRONMENT 9

2.1 Topography and Landscape 9
2.2 Climate 9
2.3 Topsoil and Subsoil 11
2.4 Geological Environment 13
2.5 Geohazards 17
2.6 Groundwater 19
2.7 Surface Water 36
2.8 Vegetation, Weeds & Plant Pathogens 39
2.9 Fauna 44
2.10 Local Community 45
2.11 Landowners and Land Use 46
2.12 Heritage 51
2.13 Proximity to Conservation Areas 52
2.14 Proximity to Infrastructure and Housing 54
2.15 Exempt Land 55
2.16 Amenity 55
2.17 Air Quality 55
2.18 Noise 56
2.19 Traffic 56
2.20 Pre-existing Site Contamination and Disturbance 57
2.21 Natural Radioactivity 57

3 EXPLORATION ACTIVITIES 59

3.1 Exploration Methods 59
3.2 Exploration Equipment 60
3.3 Exploration Management & Progressive Rehabilitation Practices 60

4 CONSTRUCTION & OPERATIONAL ACTIVITIES 63

4.1 Introduction 63
4.2 Field Recovery Trial - Overview 63
4.3 In Situ Recovery 69
4.4 Uranium Processing 77
4.5 Supporting Infrastructure 84
4.6 Wastes & Residues 88
4.7 Resource Inputs 94
4.8 Transport & Storage of Radioactive and Hazardous Materials 99
4.9 Land Use 100
4.10 Site Security 100

5 CARE & MAINTENANCE AND CLOSURE 102
5.1 Introduction 102
5.2 Closure Outcome Statement 102
5.3 Strategic Considerations 103
5.4 Groundwater Rehabilitation 105
5.5 Key Care & Maintenance and Closure Activities 116
5.6 Timing 125
5.7 Final Completion Sign Off 125
5.8 Rehabilitation Liability Estimate 126
6 STAKEHOLDER CONSULTATION 128
6.1 Purpose 128
6.2 Approach 128
6.3 Engagement Activities Undertaken to Date 129
6.4 Key Stakeholder Concerns and Responses 132
6.5 Stakeholder Engagement Plan 133
7 ENVIRONMENTAL OUTCOMES, MANAGEMENT & MONITORING 136
7.1 Overview 136
7.2 Soils 138
7.3 Groundwater 148
7.4 Surface Water 193
7.5 Vegetation, Weeds and Plant Pathogens 198
7.6 Native Fauna & Pests 216
7.7 Land Use & Third-Party Property 225
7.8 Heritage 231
7.9 Amenity & Conservation Values 235
7.10 Air Quality 244
7.11 Roads, Traffic & Transport 256
7.12 Noise 261
7.13 Public Health & Safety 268
7.14 Waste 276
8 REFERENCES 283
8.1 Reports & Publications 283
8.2 Legislation 286
9 TERMS, ACRONYMS & ABBREVIATIONS 289
9.1 Terms and Definitions 289
9.2 Acronyms & Abbreviations 291

Appendices

Appendix A: Retention Lease 137
Appendix B: Soil – Baseline Assessments
Appendix C: Soil – Baseline Data
Appendix D: Hydrogeological & Geological Assessments
Appendix E: Hydrogeological – Baseline Groundwater Quality

Appendix F: Natural Attenuation Modelling Report & Data Outputs
Appendix G: Revegetation Assessments – Samphire
Appendix H: Hydrology – Baseline Assessments
Appendix I: Hydrology – Baseline Water Quality Data
Appendix J: Flora & Fauna – Baseline Assessments
Appendix K: Flora & Fauna – Baseline Data
Appendix L: Native Vegetation Management Plan
Appendix M: Radiation – Baseline Assessments
Appendix N: Radiation – Baseline Data
Appendix O: Air Quality – Baseline Records
Appendix P: Visual Amenity – Baseline Records
Appendix Q: Noise – Baseline Assessment
Appendix R: Noise – Baseline Data
Appendix S: Stakeholder Engagement Records
Appendix T: Internal Management Plans

List of Tables

Table 1.1: Project & Project Proponent Details....1
Table 1.2: Blackbush Deposit Mineral Resource Estimate....8
Table 2.1: Summary of Groundwater Quality....31
Table 2.2: Summary of Catchment Areas....37
Table 2.3: Vegetation Associations Identified in the RL Area....40
Table 2.4: Key Demographic and Socioeconomic Statistics for Whyalla Area....46
Table 2.5: Proximity to Nearby Infrastructure....54
Table 2.6: Proximity to Homesteads and Major Localities....54
Table 4.1: Key Reagents, Volumes & Storage....80
Table 4.2: Predicted Process & Disposal Fluid Chemical & Radiological Compositions....84
Table 4.3: Key Waste Types & Estimated Volumes....88
Table 4.4: Summary of Key Liquid Disposal Residue Parameters....92
Table 4.5: Project Water Balance....96
Table 4.6: Hazardous Materials - Transport and Storage Details....99
Table 5.1: Initial concentrations of reactive minerals for the Model input calculated from wt%....107
Table 5.2: Model inputs for groundwater and lixiviant....108
Table 5.3: Summary of Natural Attenuation influencers for key parameters....109
Table 5.4 Summary of Rehabilitation and Closure Timing....125
Table 5.5: Summary of Rehabilitation Bond Cost Components....127
Table 6.1: Summarised Table of Concerns and Responses....132
Table 6.2: Engagement Strategies – FRT Phases....135
Table 7.1: Outcomes, Measurement & Leading Indicator Criteria – Soils....146
Table 7.2: Excursion Control Limits....153
Table 7.3: Target (Tertiary) Aquifer - Operational Monitoring Program....155
Table 7.4: Isolation Verification Limits....160
Table 7.5: Underlying Aquifer - Operational Monitoring Program....161
Table 7.6: Model Inputs & Sensitivity Trigger....165
Table 7.7: Target (Tertiary) Aquifer – Natural Attenuation Field Monitoring Program....169
Table 7.8: Key Modelled Chemistry Outputs (1.0 m/a scenario)....171
Table 7.9: Key Modelled Chemistry Outputs (1.3 m/a scenario)....172
Table 7.10: Key Modelled Chemistry Outputs (6.0 m/a scenario)....173
Table 7.11: Underlying Aquifer - Closure Monitoring Program....175
Table 7.12: Perimeter Monitor Wells – Leading Indicator Values....180

Table 7.13: Underlying Monitor Wells – Leading Indicator Values....183
Table 7.14: TARP – Action Timing....190
Table 7.15: Outcomes, Outcome Criteria, & Leading Indicators – Groundwater....191
Table 7.16: Outcomes, Measurement & Leading Indicator Criteria – Surface Water....197
Table 7.17: Native Vegetation - Maximum Clearance Area....199
Table 7.18: Outcomes, Measurement & Leading Indicator Criteria – Vegetation....212
Table 7.19: Vegetation, Weed & Plant Pathogen Monitoring Locations....214
Table 7.20: Pest Monitoring Sites....221
Table 7.21: Outcomes, Measurement & Leading Indicator Criteria – Native Fauna & Pests....224
Table 7.22: Outcomes, Measurement & Leading Indicator Criteria – Land Use & Third-Party....230
Table 7.23: Outcomes, Measurement & Leading Indicator Criteria – Heritage....234
Table 7.24: Visual Amenity - Photo Point Monitoring Locations....237
Table 7.25: Outcomes, Measurement & Leading Indicator Criteria – Amenity....243
Table 7.26: Air Quality (inc. Radiation) Monitoring Locations....249
Table 7.27: Outcomes, Measurement & Leading Indicator Criteria – Air Quality....253
Table 7.28: Outcomes, Measurement & Leading Indicator Criteria – Roads, Traffic....260
Table 7.29: Noise Monitoring Location....264
Table 7.30: Outcomes, Measurement & Leading Indicator Criteria – Noise....267
Table 7.31: Outcomes, Control & Management Strategies – Health, Safety & Property....273
Table 7.32: Outcomes, Control & Management Strategies – Waste....282

List of Figures

Figure 1.1: Location of the Alligator Energy's Retention Lease & Exploration Licences....3
Figure 2.1: Topography & Landscape Features, Including Pastoral Property Boundaries....10
Figure 2.2: Local Soils Classification....12
Figure 2.3: Simplified stratigraphic section showing regional geology EL5926....14
Figure 2.4: Cross section A-A' from the Blackbush Deposit to South of Port Pirie....15
Figure 2.5: Surface Projection of the uranium mineralisation.....16
Figure 2.6: Locations of faults and magnitude of earthquake occurrences....18
Figure 2.7: Groundwater investigation locations....22
Figure 2.8: Quaternary aquifer relative standing water level (rSWL)....23
Figure 2.9: Melton Sands groundwater contours (Freshwater equivalent)....24
Figure 2.10: Lower Kanaka Beds groundwater contours (Freshwater equivalent)....25
Figure 2.11: Fractured Rock Aquifer (FRA) relative standing water level....26
Figure 2.12: Regional potentiometric surface (modified from Taylor et al., 2015)....27
Figure 2.13: Hydrogeological Setting....28
Figure 2.14: Review of registered water wells within 10 km of the Samphire RL....34
Figure 2.15: Review of Potential Groundwater Dependant Ecosystems....35
Figure 2.16: Surface hydrology catchment area (Source: URS, 2010)....38
Figure 2.17: Baseline Flora and Fauna Survey Sites (EBS Ecology, 2010-2012)....41
Figure 2.18: Vegetation associations within and near the RL area....42
Figure 2.19: Vegetation associations within the RL area....43
Figure 2.20: Overlapping tenement applications....49
Figure 2.21: Overlapping geothermal licence applications....50
Figure 2.22: Heritage Areas....53
Figure 3.1: Fencing around rehabilitated drill pad....62
Figure 3.2: Drill pad rolled with the wheels of a loader.....62
Figure 4.1: General layout of the RL....68
Figure 4.2: FRT Wellfield, Water Supply, Plant and Disposal Well Locations....71
Figure 4.3: Example Wellfield Arrangement – Beverley Uranium Mine (CSIRO, 2004)....72

Figure 4.4: Well construction Schematics....74
Figure 4.5: Fluid Distribution Pipework within the Wellhouse....75
Figure 4.6: Example Portable Filter Skid....76
Figure 4.7: Simplified FRT Process Flow....78
Figure 4.8: Containerised IX Process Plant....79
Figure 4.9: Layout of the FRT Processing Plant & Support Infrastructure....82
Figure 4.10: Reagent Storage – Within Process Plant Area....83
Figure 4.11: Access Route....86
Figure 4.12: Internal Site Access Track....87
Figure 4.13: Project Water Balance....98
Figure 4.14: Site security layout, CCTV locations and land use....101
Figure 5.1: Flow path for FRT as used for reactive transport....107
Figure 5.2: Natural Attenuation Zone....110
Figure 5.3: Natural attenuation of key parameters, groundwater velocity of 1.3 m/a....111
Figure 5.4: Pyrite decreased by 50%: U as a function of distance....112
Figure 5.5: Comparison with and without uranophane: as a function of distance....112
Figure 5.6: Liquid Waste Plume Monitoring Wells Conceptual Section....114
Figure 5.7: Predicted Liquid Waste Plume Extent and Monitoring Location....115
Figure 5.8: Infrastructure to be retained as part of Care and Maintenance....118
Figure 5.9: Plan of FRT plant showing items to be removed during C&M....119
Figure 5.10:Progressive Revegetation Works to be completed during C&M....123
Figure 7.1: Photo of sheep-induced soil impacts near Coronation dam within the RL....141
Figure 7.2: Typical sheep tracks within the RL....141
Figure 7.3: Baseline soil sample locations for chemical and hydrocarbon assessments....145
Figure 7.4: Perimeter Groundwater Monitoring Network....157
Figure 7.5: Liquid Disposal Groundwater Monitoring Network....158
Figure 7.6: Underlying Groundwater Monitoring Network....162
Figure 7.7: Proposed Natural Attenuation Field Monitoring Well Locations....170
Figure 7.8: FRT Clearance Areas and 10 m Contingency Zones....201
Figure 7.9: Resource Infill Drilling Clearance Areas – 2.0 ha maximum....202
Figure 7.10: Historical Exploration Vegetation Clearance 2021-2025....203
Figure 7.11: Examples of Bluebush (*Maireana sedifolia*) regeneration post exploration....207
Figure 7.12: Native Vegetation and Weed Monitoring Sites....215
Figure 7.13: Pest Monitoring Sites....222
Figure 7.14: Visual Impact Monitoring Points....239
Figure 7.15: Air Quality Monitoring Locations....251
Figure 7.16: Noise Monitoring Locations (NM1 & NM2)....265

1 INTRODUCTION

1.1 Project Background

The Samphire Uranium Project is located within Retention Lease (RL) 137, covering an area of 2.37 km² (237 hectares) (Figure 1.1). The project is wholly owned by S Uranium Pty Ltd, a subsidiary of Alligator Energy Ltd (the project proponent), which is publicly listed on the Australian Securities Exchange (ASX).

Exploration activities within the project area began in 2006 under Exploration Licence (EL) 5926 (previously EL 3652) by Gingertom Resources Pty Ltd, a subsidiary of UraniumSA Ltd (UraniumSA). In August 2010, the northern portion of the EL was relinquished, and in August 2011, ownership was transferred from Gingertom Resources Pty Ltd to S Uranium Pty Ltd.

UraniumSA was responsible for the discovery and initial delineation of the Blackbush uranium deposit and the Plumbush uranium prospect (Figure 1.1). Between 2010 and 2011, UraniumSA conducted extensive baseline and technical studies on the Blackbush deposit in preparation for a proposed Field Recovery Trial (FRT) and associated RL application. However, the RL proposal was never submitted, largely due to the significant decline in uranium prices following the Fukushima Daiichi nuclear incident in 2011.

In Q4 2020, Alligator Energy Ltd (Alligator Energy) acquired S Uranium Pty Ltd and its associated assets. Following the acquisition, Alligator Energy resumed exploration, technical studies, and resource evaluations to support initial project feasibility assessments. On 22 July 2023, a revised RL proposal document was submitted to the Department of Energy and Mining (DEM) to facilitate a uranium in-situ recovery (ISR) field trial, which was subsequently granted in January 2025.

Alligator Energy plans to conduct a small-scale, three-month ISR field recovery trial at the Blackbush Deposit, located approximately 20 km southwest of Whyalla on the Eyre Peninsula. The FRT is intended to support the evaluation of ISR as a potential mining method and provide the basis for future feasibility and regulatory decision-making. Detailed project objectives are outlined in Section 1.2.

Table 1.1: Project & Project Proponent Details

Retention Lease Number:	RL137
Project Name:	Samphire Uranium Project, Field Recovery Trial.
Mineral Type:	Uranium
Name(s) of the Proponent:	Alligator Energy Ltd as the parent company of S Uranium Pty Ltd.
Location:	The RL is located on the Eyre Peninsula approximately 20 km southwest of Whyalla, South Australia. The topographical map sheet references are: • 1:250,000 Map Sheet: SI 53-8 Whyalla. • 1:100,000: Whyalla (6431), 1:100,000 Cultana (6432) Refer to Figure 1.1 for a location map of the RL.

Land Tenure:	The RL is located on Moonabie Pastoral property which is a privately held perpetual crown lease primarily used for sheep grazing of natural vegetation (Figure 2.1). The land parcel details are: • Title reference: Crown Lease Volume 6171, Folio 767 • Hundred: POYNTON S Uranium Pty Ltd has a caveat on the titles relating to a Land Access Deed inherited at the time of sale by UraniumSA Limited.
Native Title Land:	Native Title is extinguished over the Moonabie and surrounding Pastoral Leases however a Native Title Agreement for Exploration exists between S Uranium Pty Ltd and the Barngarla Determination Aboriginal Corporation (BDAC). Alligator Energy Ltd. operates in accordance with this agreement.
Exempt Land:	An area of 150 m around Coronation Dam is currently exempt under Section 9 of the *Mining Act 1971* from exploration and/or mining activities.
District Council/Corporation:	The Corporation of the City of Whyalla. • Remote Areas Zone

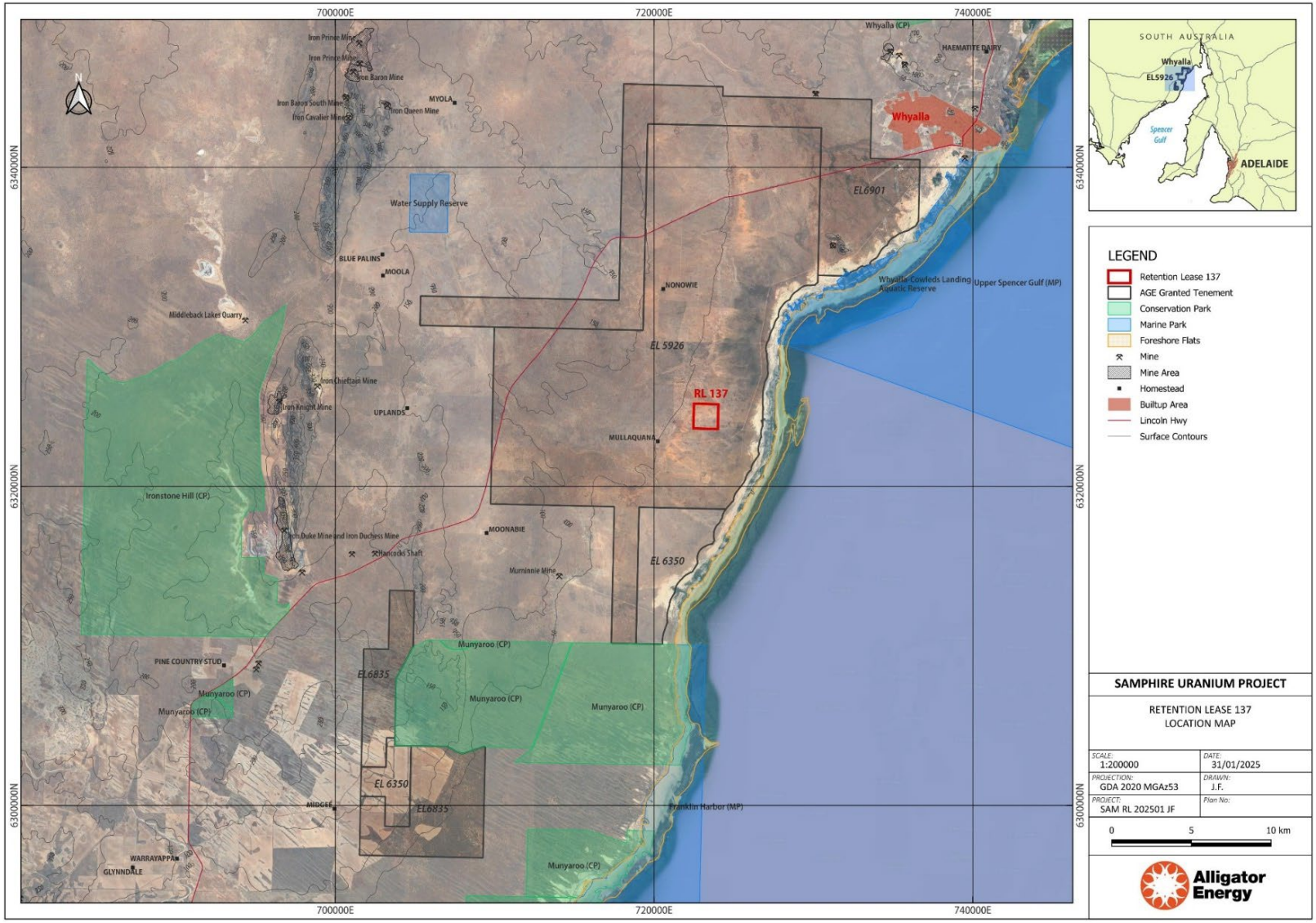


Figure 1.1: Location of the Alligator Energy's Retention Lease & Exploration Licences

1.2 Project Objectives

The objective of the Samphire FRT is to generate critical site-specific hydrogeological, geochemical and operational data necessary to evaluate the technical and environmental feasibility of ISR mining at the Blackbush uranium deposit.

Specifically, the key objectives of the FRT are to:

- Demonstrate the hydrogeological viability of ISR at the Blackbush Deposit through controlled injection and recovery of process fluids, including assessment of hydraulic connectivity, wellfield performance, and aquifer containment.
- Validate metallurgical recovery parameters under field-scale conditions to support process design, resin performance evaluation, and reagent optimisation for uranium extraction.
- Quantify environmental risks and attenuation behaviour, particularly with respect to groundwater quality, aquifer stability, and potential mobilisation of radionuclides or trace elements beyond the wellfield boundary.
- Support regulatory assessment of future mining proposals by collecting defensible environmental monitoring data, including radiological performance, groundwater response, waste stream characterisation, and surface infrastructure impacts.
- Inform the development of closure and rehabilitation strategies, including evaluation of aquifer restoration potential and residual impact management, aligned with expected requirements under the Mining Act 1971 (SA) and Environment Protection Authority (EPA) licensing.
- Demonstrate compliance capability under South Australia's ISR-specific regulatory framework, including compliance with conditions of Retention Lease RL 137, the Environment Protection Act 1993, and the Radiation Protection and Control Act 2021.

Outcomes of the trial will determine the viability of progressing to full-scale ISR operations and enable informed decision-making regarding mine planning, investment, and stakeholder engagement.

1.3 Regulatory Framework

1.3.1 Mining Act 1971

The Mining Act 1971 provides the primary legislative framework for the regulation of mining activities within South Australia. The development of the Samphire Uranium Project, including the FRT, has been undertaken in accordance with this Act following the granting of Retention Lease 137 (RL 137) (Appendix A). The RL was granted under Section 46 of the Act for a period of five years, to facilitate the exploration and evaluation of the identified uranium resource using ISR technology.

A RL is granted where a mineral resource (i.e., Blackbush Deposit) has been identified, but further evaluation is required to inform decisions regarding the potential progression to a Mineral Lease (ML). The lease permits exploration and trial operations that extend beyond the scope of activities permitted under an EL and supports the collection of technical, operational, and environmental data to assess the feasibility of future commercial extraction.

Following the granting of RL 137, this Program for Environment Protection and Rehabilitation (PEPR) has been prepared to meet the requirements set out in Part 10A of the Mining Act 1971 (SA) and the associated provisions of the Mining Regulations 2020 (SA). The preparation of this

PEPR has also been guided by the requirements outlined in DEM Terms of Reference 024 (DEM, 2020a), which, while primarily developed for full-scale mining operations, provides the necessary regulatory framework for the ISR-specific activities associated with the FRT.

This PEPR has been developed to demonstrate how the project will achieve the environmental outcomes, operational performance requirements, and rehabilitation objectives specified in the lease conditions. It outlines the strategies and controls to be implemented to ensure compliance with statutory obligations, minimise environmental impacts, and support the responsible development of the Samphire Uranium Project.

1.3.2 Associated Approvals

Environment Protection Act 1993

The Environment Protection Act 1993 provides the legislative framework for the protection, restoration, and sustainable management of the environment in South Australia. The Act is administered by the South Australian Environment Protection Authority (EPA SA) and applies to activities of environmental significance, including those associated with uranium ISR operations. The EPA regulates these activities through a licensing, approval, and compliance framework designed to prevent environmental harm and promote ecologically sustainable development.

The assessment of environmental impacts associated with the FRT occurs through a collaborative process involving the DEM and the EPA. As part of the PEPR submission process, the PEPR document undergoes a joint assessment to ensure that the proposed ISR activities align with both mining regulations and environmental protection requirements. This joint process provides an integrated understanding of the project's potential impacts on environmental receptors, including groundwater, surface water, air quality, and radiation exposure pathways.

Following this joint assessment, Alligator Energy is required to obtain the following statutory approvals under the Environment Protection Act 1993 for activities associated with the FRT:

1. Works Approval: Approval is required for the construction, installation, and commissioning of facilities associated with uranium ISR operations under Section 35 of the Act. This includes infrastructure related to uranium extraction and processing under Activity 2.9 – Mineral Works, and Activity 8.7 – Discharges to Marine and Inland Waters (includes discharges to groundwaters), as prescribed by Schedule 1 of the Act.
2. Environmental Licence: An Environmental Licence is required under Section 36 of the Act to authorise the operation of facilities involved in uranium extraction and the discharge of treated process water to surface water or groundwater systems. The licence conditions will specify:
    - Monitoring requirements to track potential water quality impacts.
    - Discharge limits to prevent contamination of receiving waters.
    - Reporting obligations to demonstrate compliance with EPA standards

Radiation Protection and Control Act 2021

The Radiation Protection and Control Act 2021 governs the safe use, handling, storage, and disposal of radioactive materials within South Australia. The Act is administered by the EPA and applies to activities involving radioactive materials, such as those associated with uranium ISR operations.

The assessment of radiation risks, particularly in relation to third parties and the environment, is conducted during the RL application and PEPR submission process. These assessments address the potential radiation impacts beyond the site boundary, including pathways of exposure to the public and environmental receptors. However, there is some regulatory crossover with the EPA licensing process, which forms the key assessment tool on matters of radiation safety.

In accordance with Section 18 of the Radiation Protection and Control Act 2021 (SA), Alligator Energy is required to obtain a Radiation Management Licence (Test for Developmental Purposes) for the FRT. The RMP, submitted alongside the PEPR, will provide the detailed protocols for radiation monitoring, exposure controls, waste management, and worker training. The EPA's assessment of the RMP will ensure alignment with the broader PEPR commitments and compliance with regulatory standards for radiation protection.

Native Vegetation Act 1991

The Native Vegetation Act 1991 and the Native Vegetation Regulations 2017 establish the regulatory framework for the clearance, management, and protection of native vegetation in South Australia. In accordance with this Act, Alligator Energy is required to obtain approval for native vegetation clearance associated with the FRT within RL 137.

Clearance associated with the FRT will be approved by DEM under delegation of the NVC through this PEPR process; the NVMP (Appendix L) documents how avoidance, minimisation, offsets and compliance will be implemented.

Landscape South Australia Act 2019

The Landscape South Australia Act 2019 provides the regulatory framework for the management and protection of water resources across the State. In accordance with this Act, Alligator Energy must apply for Well Construction Permits, and Water Affecting Activity Permits where relevant (e.g., draining or discharging water into a well).

Work Health and Safety Act 2012 and Dangerous Substances Act 1979

The Work Health and Safety Act 2012 and the Dangerous Substances Act 1979 and associated regulations, regulate the management of hazardous substances and workplace safety. Alligator Energy is required to obtain the following licences or registrations are required from SafeWork SA:

- Dangerous Substances Licence: Required for the storage, handling, and use of hazardous materials associated with ISR operations, including process chemicals and uranium-bearing solutions.
- Pressure Vessel Registration: Required for the operation of pressure vessels used during ISR processes.

To ensure workplace safety, Alligator Energy has developed project-specific safety management plans that incorporate risk assessments, emergency response protocols, worker training programs, and routine inspections of facilities used to store and handle hazardous materials.

Environment Protection and Biodiversity Conservation (EPBC) Act 1999 (Commonwealth)

The EPBC Act 1999 provides the statutory framework for the protection of matters of national environmental significance and ensures the environmentally responsible development of projects with potential environmental impacts.

In November 2010, UraniumSA Ltd submitted a Referral of Proposed Action for the Mullaquana Project Field Trial. On 11 February 2011, the Department of Sustainability, Environment, Water, Population and Communities (DSEWPC) determined the proposed trial to be 'Not a Controlled Action (particular manner)', allowing it to proceed without further environmental assessment, provided specified operational and environmental conditions were adhered to (DSEWPC, 2011).

Following the acquisition of S Uranium Pty Ltd by Alligator Energy in 2020, and the subsequent decision to proceed with the FRT in 2022, an independent third-party review confirmed that the proposed trial remained consistent with the original referral and its associated conditions. On 20 December 2022, the Department of Climate Change, Energy, the Environment and Water (DCCEEW) confirmed that a new referral was not required, allowing the FRT to proceed in accordance with the approved referral conditions (DCCEEW, 2022a).

Nuclear Non-Proliferation (Safeguards) Act 1987 (Commonwealth)

The Nuclear Non-Proliferation (Safeguards) Act 1987 establishes the national regulatory framework for the safeguarding and control of nuclear materials in accordance with Australia's international treaty obligations under the Treaty on the Non-Proliferation of Nuclear Weapons (NPT). The Australian Safeguards and Non-Proliferation Office (ASNO) administers this Act to ensure that nuclear material (including uranium) is used exclusively for peaceful purposes and to maintain compliance with international safeguards agreements.

During the FRT, no physical production of uranium product will occur; only a uranium-bearing eluate liquid will be generated, with uranium concentrations as described in Alligator Energy's submission to ASNO dated 7 March 2025.

On 12 March 2025, ASNO advised that, based on the process description, composition data, and intended management of the eluate provided in that submission, the planned FRT activities do not meet the definition of 'nuclear material' under the Safeguards Act and therefore do not require a licence. This advice applies on the basis that the activities are conducted in accordance with the parameters set out in the 7 March 2025 correspondence.

1.4 Project Resources & Market Considerations

1.4.1 Ore Reserves and Mineral Resources

The Blackbush Mineral Resource has been classified in accordance with the Joint Ore Reserves Committee (JORC) Code (2012). The deposit contains a combined Indicated and Inferred Mineral Resource of 18 Mlbs U_3O_8 at an average grade of 676 ppm U_3O_8, based on a 250 ppm U_3O_8 cut-off grade (Table 1.2).

Table 1.2: Blackbush Deposit Mineral Resource Estimate

JORC Category	Mt	Grade (U_3O_8 ppm)	U_3O_8 Metal (Mlb)
Indicated	8.2	786	14.2
Inferred	3.9	443	3.8
Total	12.1	676	18.0

The model is reported unconstrained and above a 250 ppm U3O8 lower cut-off grade for all zones in consideration of potential for recovery by in situ leach processes.

There is no historical depletion by production within the model area.

Estimation of the disequilibrium factored and topcut gamma data (feU3O8c) is by ordinary kriging using dynamic anisotropy for the mineralised zone.

Density is estimated by nearest neighbour estimation within the Kanaka Beds on the basis of logged geology as either 1.79 t/m3 for lignitic material or 1.92 t/m3 for other sediments; other paleochannel stratigraphies had a default of 1.90 t/m3 assigned; saprolite capping the basement granite was assigned a bulk density of 2.16 t/m3 and the primary basement granite was assigned a nominal bulk density of 2.70 t/m3.

The model assumes agglomeration of 12.5mE x 12.5mN x 1mRL parent blocks for definition of well fields for production.

The model does not account for dilution, ore loss, hydrogeology, or recovery issues. These parameters should be considered during the mining study as being dependent on the ISL treatment process.

Classification is according to JORC Code Mineral Resource categories.

Totals may vary due to rounded figures.

The Mineral Resource Estimate assuming a 70% recovery currently has an estimated life of mine of 12 years (Alligator Energy, 2023a). At the current long term uranium price of US$80/lb (which is forecast to increase) the project is currently economic as a standalone ISR operation. The FRT is critical for economic and technical optimisation prior to a potential Mining Lease application.

1.4.2 Production Rates and Products

The FRT is expected to transfer approximately 5,000 kilograms of uranium into eluate (the solution left from removal of uranium from ion exchange resin) during the ISR test period. The FRT will not produce uranium oxide precipitate, and no uranium product will be sold or exported during the trial phase. No metalliferous or extractive minerals other than uranium will be recovered or leave the RL area.

Any proposed land use changes by other developers/proponents in the vicinity of the deposit will be identified. Engagement with relevant stakeholders will be undertaken to ensure that no portion of the orebody or areas of high prospectivity elsewhere on the surrounding EL (EL5927) are sterilised by such future proposed developments. Alligator Energy will work with all parties to ensure its environmental outcomes can be met working under the South Australian Multiple Land Use Framework (Government of South Australia, 2016.).

2 DESCRIPTION OF THE ENVIRONMENT

2.1 Topography and Landscape

The Samphire RL is situated approximately 3.5 km west of the Spencer Gulf coastline, within the coastal plains of the Eyre Peninsula, near the western boundary of the Pirie Basin, and 13.7 km north of the Munyaroo Conservation Park (Figure 1.1). The site is essentially flat with a relief of approximately 0.8 m vertical change to every 100 m horizontal from west to east. The coastal plain is characterised by minor (<30 mm) drainage channels cut into the topsoil.

The key topographical features in the region are shown in Figure 2.1 and are described as follows:

- An approximate northeast to southwest trending escarpment running parallel to, and approximately 6 km inland from the coast. The top of the escarpment sits at an elevation of approximately 50 m and is approximately 700 m west of the RL area.
- A flat coastal plain starting at an elevation of approximately 20 m at the foot of the escarpment and gently shelving to sea level. The coastal fringe, approximately 800 m wide, comprises salt flats with some low mangrove development on a sandy beach.
- Deep Creek which is a major drainage catchment area for the Middleback Ranges is located approximately 4.4 km south of the RL area.

2.2 Climate

The climate of the Whyalla region has hot summers and cool winters, and moderate rainfall spread throughout the year. In summer, a sub-tropical high-pressure system, existing as a series of cells, progresses from west to east at about the latitude consistent with the Great Australian Bight. In winter, this system moves northward, and centres at about the latitude of Marree (~29°S). This seasonal movement of the sub-tropical high causes dry continental air to blow over the area for most of the year. These systems are responsible for the heaviest rainfall events in the region. In winter, frontal depressions from the Southern Ocean bring showers.

According to the Bureau of Meteorology (BOM, 2025), the region is dry, with an annual average rainfall at Whyalla Aerodrome of 268.8 mm. Whyalla averages 42 rainy days per year, while the remaining days are, on average, clear and sunny, contributing to high evaporation rates. Wind speed and direction data show a predominance of southerly winds for up to 38% of the time annually. In winter, northerly and north westerly winds prevail for up to 38% of the time, with calm conditions recorded 1% of the time. In summer, southerly winds prevail up to 60% of the time, with calm conditions rarely observed. The average wind speed is 21.6 km/h at 3pm and 14.5 km/h at 9am (BOM, 2025).

The mean maximum temperature in January is 30.2^{o}C and in July it is 17.1^{o}C. The mean minimum temperature is 17.1^{o}C in January and 5.3^{o}C in July (BOM, 2025).

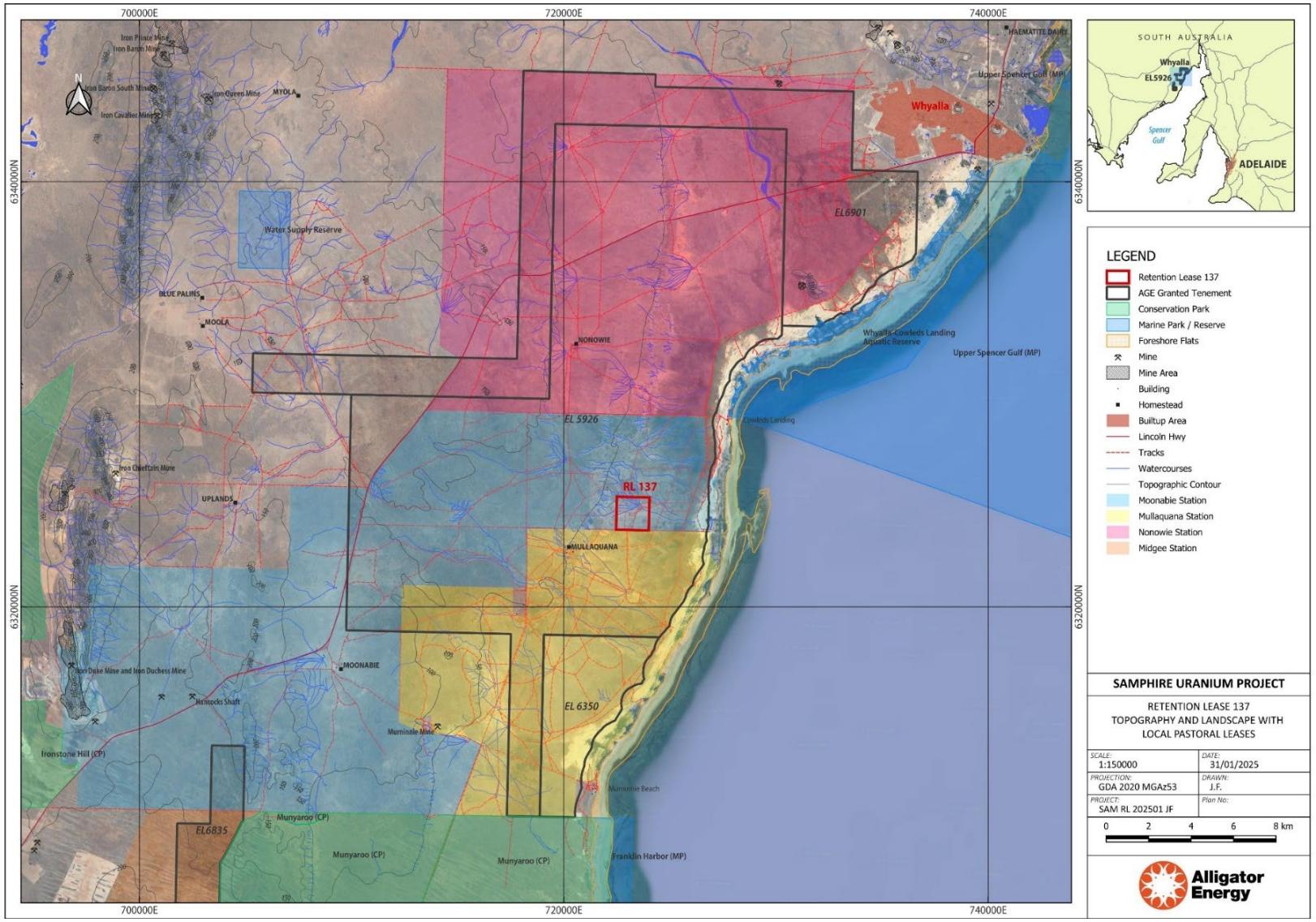


Figure 2.1: Topography & Landscape Features, Including Pastoral Property Boundaries

2.3 Topsoil and Subsoil

The RL area lies within the coastal plains of the Eyre Peninsula on the western boundary of the Pirie Basin. Topsoil is thin and consists of unconsolidated Holocene soils and alluvial and lacustrine sediments. Rare and poorly developed soil profiles are restricted to creek sections or the escarpment to the west.

Vegetation associations including soil surface condition, are in moderate condition, with obvious signs of disturbance (tracks and bare ground), depletion of one or more vegetation strata, considerable weed invasion and a patchy soil surface crust (see Section 2.8).

The soils of the plains, slopes and swales are typically calcareous throughout, whilst the dunes and sand sheets comprise of siliceous sands, with finer-grained red pedal clays on the plains and slopes (Figure 2.2).

Broad scale soil erosion, both sheet and gully, can be observed in the district, the impacts of long-term pastoral and feral animal overgrazing with hard hooved animal presence being the main cause. There is no gully erosion within the RL area (excluding the man-made drainages for a dam).

Soil depth of the region (Whyalla Environmental Association) is moderate and within the 30 to 100 cm range, with the A horizon generally less than 25 cm. The sub-soil has not been mapped (ASRIS, 2010).

Both clay and silt contents of the topsoil and subsoil are less than 20%. Sand content of the topsoil is 80 to 100%, and as a result the saturated hydraulic conductivity (a measure of how quickly water can move through saturated soil) is high (30 to 300 mm/hour). Stored organic carbon (which provides guide to nutrient levels and indicates soil physical fertility) is low (<2%) in the areas that have been mapped (ASRIS, 2010).

The probability of acid sulphate soils occurring in this area has been classified as extremely low (ASRIS, 2022) as the entire RL area is characterised by *Maireana sedifolia* chenopod shrubland, this species grows on calcareous soils, frequently on rises (Kutsche & Lay, 2003; Black, 1948; Mitchell, 1998). No acidic pH soils have been detected within the RL area or within *Maireana sedifolia* habitat on the Moonabie Pastoral Lease.

A study of soil salinity and pH was undertaken by UraniumSA Ltd on Moonabie and Mullaquana stations between 2010-2013 (Appendix B). In total there were 1210 sampling events of soil pH assessed during the study, which were found to be between 6.28 and 10.2, with an average of 8.5 (Appendix B). Additionally, a total of 231 drilling sumps have been excavated to a depth of 2 metres by Alligator Energy between 2020 - 2023 within the RL area. None were found to have saturated water; hence the likelihood of acid sulphate soils is extremely unlikely within the RL and other areas where the vegetation is predominately *Maireana sedifolia* habitat.

With respect to baseline radionuclide concentrations in the soils of the local area, no statistically significant differences were observed between any of the soil sample locations or sample types. However, ^{210}Pb was elevated in the surface samples compared to the 5–15 cm soil samples, a phenomenon that is well-documented (Appendix M).

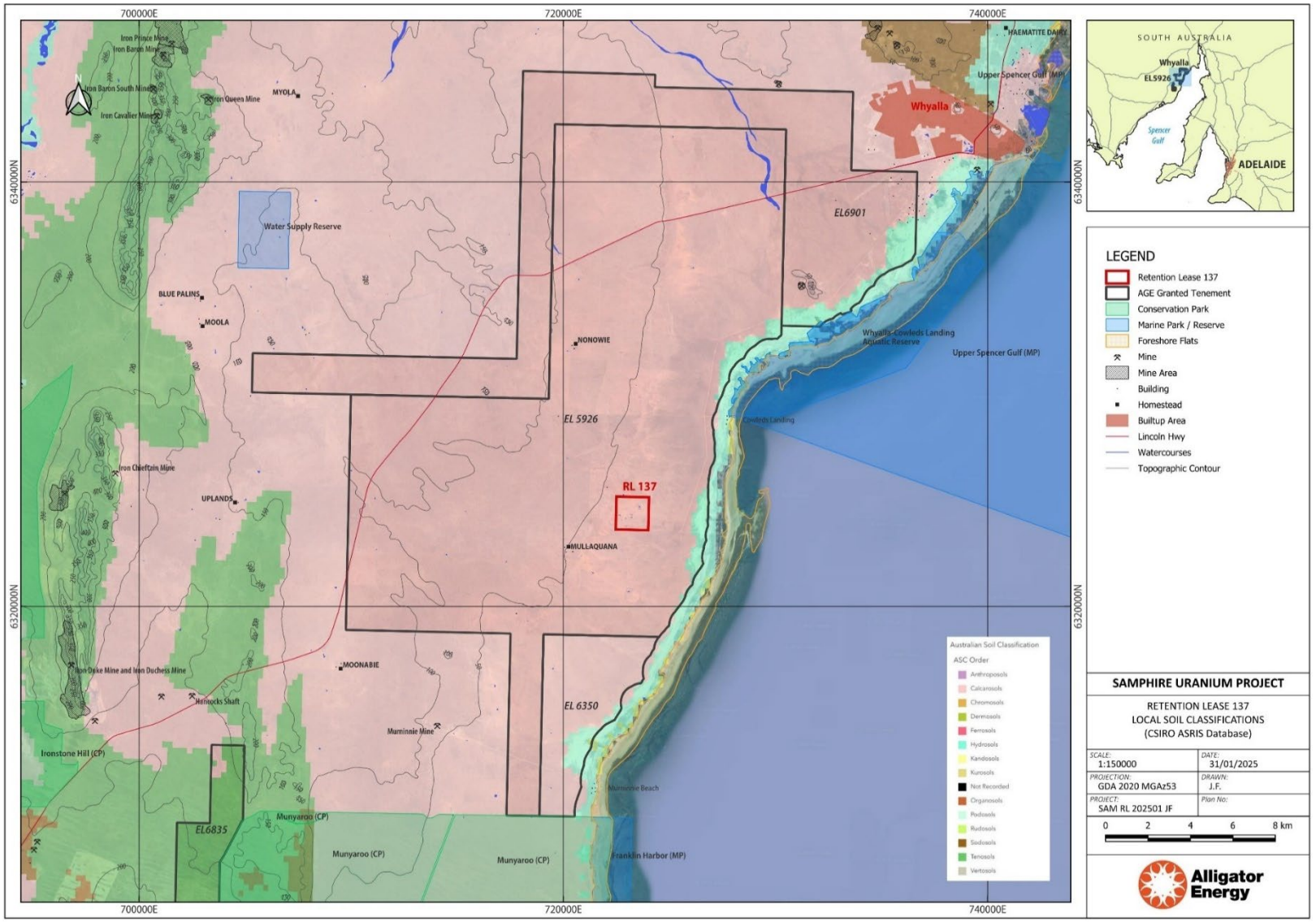


Figure 2.2: Local Soils Classification

2.4 Geological Environment

2.4.1 Regional Geology

Topographically, the area comprises a coastal plain in the east and a tableland in the west, the two geomorphic domains being separated by a 20 to 60 m high north-northeast trending fault escarpment. The eastern coastal plain has a thick flat-lying sedimentary cover sequence comprising Quaternary cover, Pliocene Gibbon Beds, Miocene Melton Limestone and Miocene Melton Sands, underlain by Eocene Kanaka Beds of the Pirie Basin. This sequence is locally underlain by a Proterozoic-aged Hiltaba suite granite intrusive and crystalline basement rocks. A lithological summary is presented in a simplified stratigraphic section shown in Figure 2.3.

The Kanaka Beds (host to sedimentary uranium mineralisation in the area) are fluvial in origin and comprise the basal Pirie Basin sediments. The unit extends over 80 km underneath the Spencer Gulf, to the south of Port Pirie (Figure 2.4) and is overlain by 40-100 m thick sequences of Melton Limestone (marl), Gibbon Beds (clay) and Quaternary (cover) sediments.

Historical drillhole data, and seismic data acquired in 1994 by the Department of Mines & Energy SA[1] (Jensen-Schmidt, 2011) further confirms the Kanaka beds do not outcrop at surface, are regionally extensive and overlain by thick cover sequences as described above. Other data sources that inform the regional geology comprise:

- Airborne electromagnetic and magnetic surveys,
- Ground based gravity surveys,
- Regional Aircore drilling,
- Regional rotary mud open hole and geophysical logging, and
- Sonic core drilling.

2.4.2 Local Geology

The geological setting of the Blackbush deposit has been interpreted by Alligator Energy using a total of 528 vertical rotary-mud drillholes (totalling 42.3 km of drilling) completed by UraniumSA from 2007 to 2012 and Alligator Energy in 2022. An additional 14 sonic coreholes (totalling 1,219 m) drilled by Alligator Energy in 2021-2022, are also included in the drillhole database.

The uranium mineralisation at Blackbush occurs in horizontal tabular lenses (50-90 m depth) in sand-dominated sediments of the Eocene Kanaka Beds within a Tertiary palaeochannel system. Uranium mineralisation can occur at all levels within the Kanaka Beds, although the FRT will be operating in the more permeable lower sand units which are generally coarse-grained to gravel in nature.

The palaeochannel is incised into the Proterozoic Hiltaba granite (Samphire Granite) which has a variably weathered saprolite surface at its contact with the Kanaka Beds. The Kanaka Beds comprise cyclic fluvial quartz dominated sands and gravels intercalated with silts and clays with fine grained carbonaceous material towards the top of the sequence. The Kanaka Beds are overlain by the laterally continuous Miocene Melton Limestone (marl and limestone), the clay-dominated Pliocene Gibbon Beds and a cover of Quaternary sediments (Figure 2.3).

[1] Now the Department for Energy and Mining (DEM).

The mineralisation at Blackbush is consistent with sandstone-hosted roll-front style uranium mineralisation occurring in approximately three sub-horizontal zones[2] which are constrained within the upper, middle, and lower lithologies of the Kanaka Beds. The common uranium minerals at Blackbush are uraninite and coffinite, common for this class of uranium deposit. The cumulative strike length of the deposit is approximately 2.7 km. Width of mineralisation across strike averages approximately 300 m, with widths of up to 450 m in some areas.

Figure 2.5 shows the extent of the Blackbush deposit uranium mineralisation. The most recent Mineral Resource Estimate published (Alligator Energy Limited 2023a) estimates a combined Inferred and Indicated resource of 17.5 Mlbs U_3O_8 at 250 ppm cut-off grade from 12.4 Mt @ 640 ppm U_3O_8.

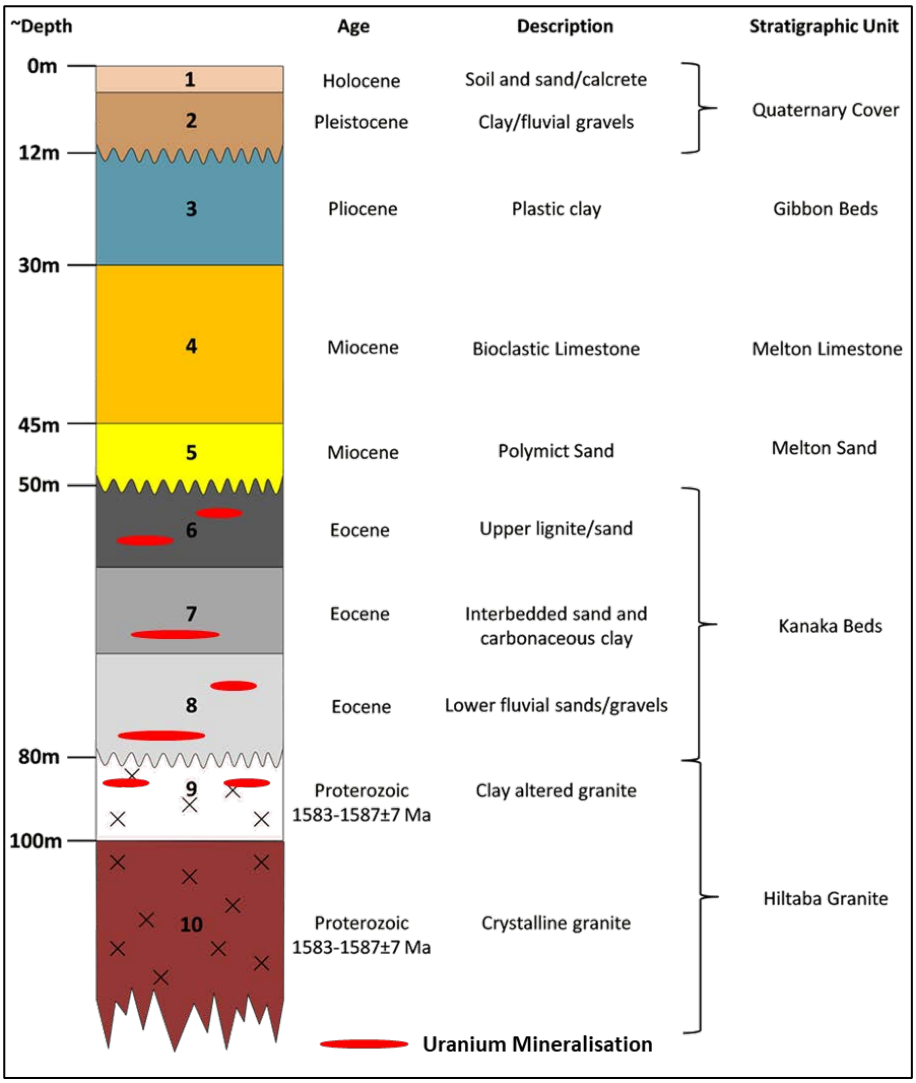


Figure 2.3: Simplified stratigraphic section showing regional geology EL5926 (modified after Internal Report (UraniumSA Limited, 2017).

[2] *Note: An additional zone below the Kanaka Beds in the basement and the upper lignite/sand is present but not considered to have "reasonable prospects for eventual economic extraction".*

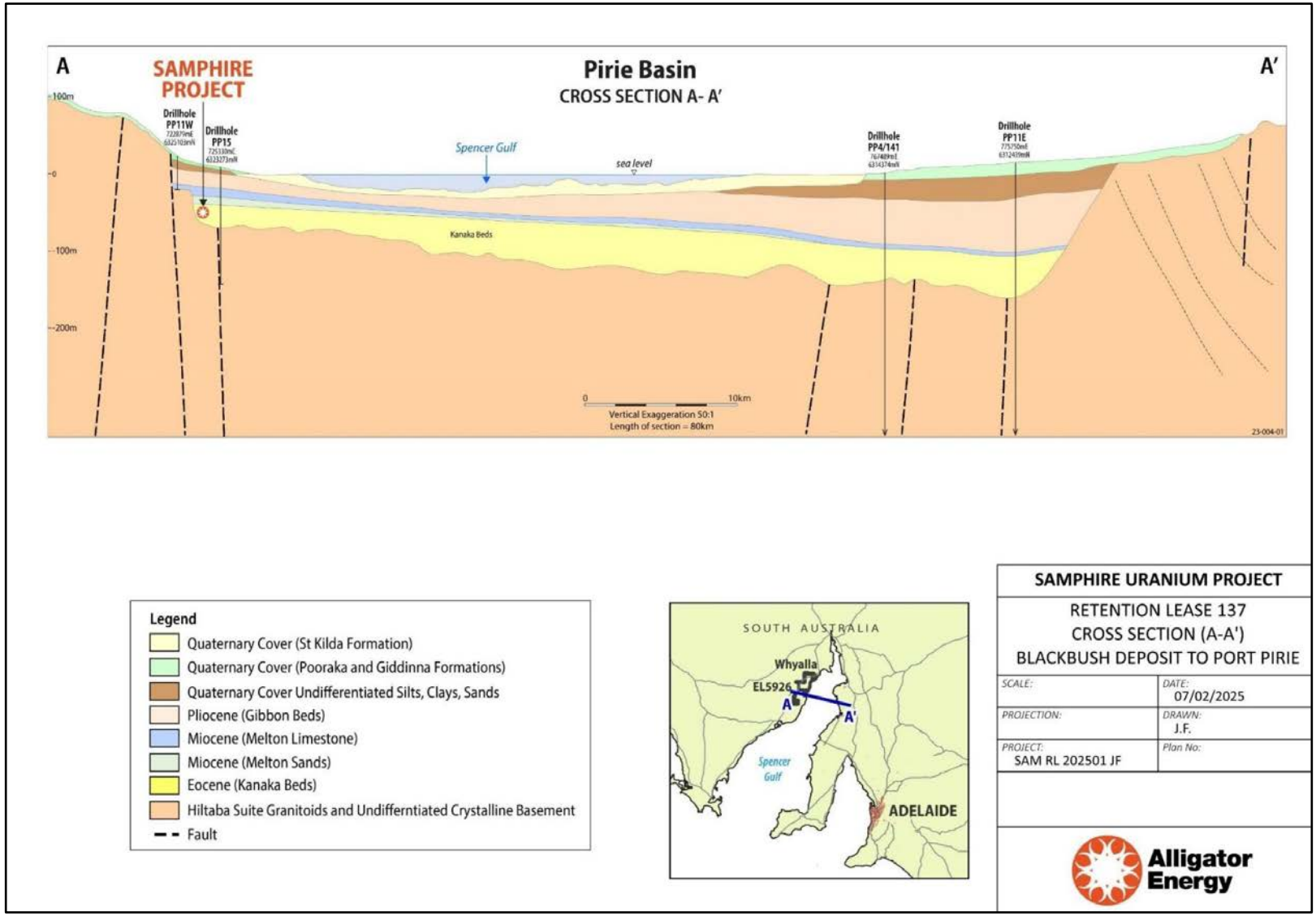


Figure 2.4: Cross section A-A' from the Blackbush Deposit to South of Port Pirie

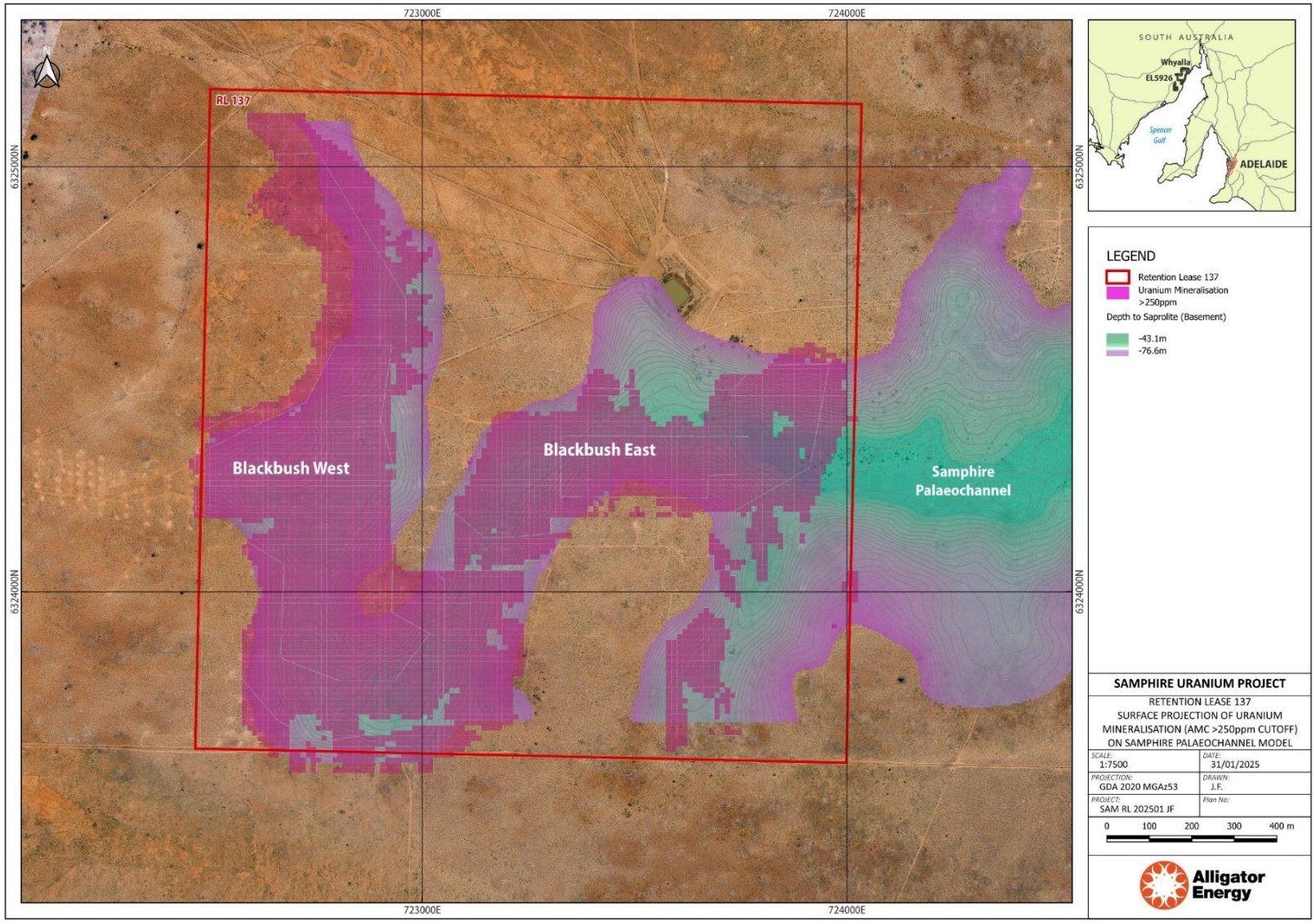


Figure 2.5: Surface Projection of the uranium mineralisation within the Samphire paleochannel.

2.5 Geohazards

Based on a recent search of the South Australian Government Data Directory Earthquake Hazard Zones, the RL area is in a low earthquake hazard zone and defined as having a hazard factor (Z) of less than 0.11.

No faults have been identified within the RL, based on regional geological mapping and site-specific investigations. Figure 2.6 shows the locations of faults and earthquake occurrences in the region (SARIG, 2022). There is no risk of landslips in the area, as the natural slope within the RL area is very shallow, with approximately 0.8 m vertical change to every 100 m with distance.

During the FRT, fluids will be injected and extracted from the Tertiary aquifer (Kanaka Bed Sands), however the aquifer is large and has a high hydraulic conductivity, meaning the change in water level/pressure is small, in the order of 20 m at an extraction well, and occurs over a small-time frame. Once FRT operations cease, water levels will return to their pre-FRT levels within days. For ISR operations, the net change in groundwater volumes aims to be zero (i.e. volume injected equals volume extracted) to ensure fluids are contained within the well array footprint. In ISR, groundwater is circulated in a closed loop so over-pressurising the aquifer or radical changes in pressures causing increased seismic activity is extremely unlikely if not impossible. There has never been reported from other ISR operations in South Australia or worldwide that this phenomenon occurs.

The Melton Limestone formation in the vicinity of the RL is described by Australian Groundwater Technologies Pty Ltd (AGT, 2011b, in Appendix D) as “variably calcareous plastic clay which grades downwards through marl and calcareous clay into a basal section of intercalated marl and bioclastic limestone.” Due to the high clay content of the Melton Limestone, there is no likelihood of caves or karst topography in the area that will cause instability from the FRT operation.

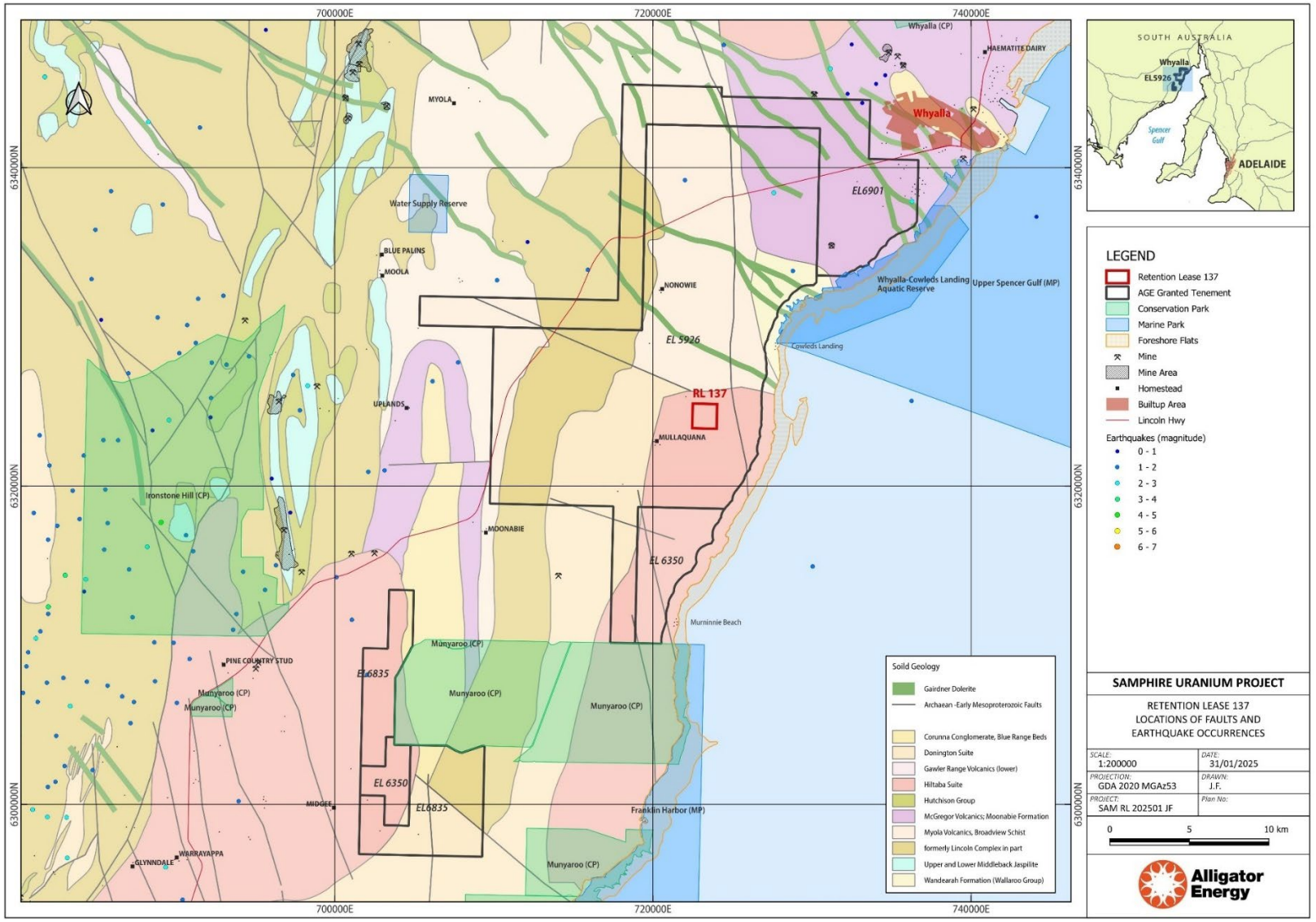


Figure 2.6: Locations of faults and magnitude of earthquake occurrences

2.6 Groundwater

2.6.1 Background

A significant body of work has been undertaken to develop a detailed understanding of the hydrogeological setting at the project site. This work has included:

- Stratigraphic interpretation of data from over 500 exploration holes.
- Measurement of chemical and water level data of 28 monitoring wells previously installed by UraniumSA Ltd (Figure 2.7; AGT 2011b in Appendix D).
- Extensive aquifer testing by Australian Groundwater Technologies (AGT) in 2011, including pump tests of up to five days' duration at four locations. Two test sites were located within the RL area, with another two sites further east, between the field trial site and the Gulf St Vincent (Figure 2.7; AGT 2011a, in Appendix D).
- Regional hydrogeological structure assessment undertaken by AGT in 2011, supplemented by a review conducted by Alligator Energy Limited. This work examined the continuity of aquifers and confining strata beneath the Gulf St Vincent (AGT, 2011b in Appendix D).
- Baseline groundwater monitoring conducted by Alligator Energy Limited between 2022 and 2025, with results presented in Appendix E.
- Preliminary groundwater quality determination and aquifer measurements performed by Alligator Energy to evaluate any hydraulic connection between the Tertiary and underlying Fractured Rock Aquifers (FRA) at the Blackbush site (Figure 2.7).
- Installation and baseline monitoring of a further 16 investigation wells have been undertaken since the submission of the RL application, targeting both the Tertiary aquifer and underlying FRA.

A detailed description of the hydrogeological setting, including results from aquifer testing conducted by UraniumSA Limited, is presented in Appendix D1 (AGT, 2011b) and diagrammatically summarised in Figure 2.13. A summary of baseline groundwater quality analysis is included in Appendix E1.

2.6.2 Aquifers & Confining Layers

The Samphire RL is located within the Tertiary Pirie Basin, outside of all prescribed water resource areas defined by the Landscape South Australia Act 2019.

Within the RL area, three primary aquifers have been identified in order of shallow to deepest:

- Quaternary Aquifer
- Tertiary Aquifer
- Fractured Rock Aquifer (FRA)

A summary of the hydrogeological setting is provided below and is diagrammatically illustrated in Figure 2.13.

Quaternary Aquifer

The Quaternary aquifer occurs at approximately 12 m depth within the RL area and consists of thin, marginally permeable fluvial sediments interbedded with predominantly clay-rich Quaternary deposits. The formation remains unsaturated at the FRT site due to the local elevation above the regional water table. However, further to the east, the sediments become saturated and host

saline to hypersaline groundwater. Yields from monitoring wells consistently measure below 0.1 L/s, indicating low permeability across tested sites.

In areas where the Quaternary sediments are saturated, aquifer pressure ranges from 2.9 to 3.7 mAHD (freshwater head). At these locations, a 0.02 upward gradient exists between the Tertiary and Quaternary aquifers, with higher pressure recorded in the Tertiary aquifer (Figure 2.8).

Tertiary Confining Beds

The Tertiary aquifer is separated from the overlying Quaternary sediments by a regionally extensive confining layer consisting of 18–22 m of plastic clay within the Gibbon Beds and 16–20 m of clay and marl within the Melton Limestone (Taylor et al. 2015).

The aquifer testing program conducted by AGT in 2011 involved constant discharge tests at four sites (AGT 2011a, in Appendix D): two sites were within the RL area, one was 1,200 m east, and another 2,200 m east. The purpose of these tests was to assess aquifer properties and to evaluate the continuity of the confining layer beneath the RL area and toward the Gulf St Vincent.

The results showed that pumping the Tertiary aquifer produced drawdown patterns consistent with confined aquifer behaviour, with no evidence of leakage from the confining strata above or below. Additionally, no pressure response was observed in the Quaternary aquifer during Tertiary aquifer pumping, confirming the absence of hydraulic connectivity between the two units.

Long-term tests indicated drawdown effects up to 1 km from the pumped well, with no corresponding drawdown in the Quaternary aquifer. This confirmed that the Quaternary and Tertiary aquifers are hydraulically disconnected across the tested sites. Further review of seismic and stratigraphic data from historical drilling indicates that the Gibbon beds and Kanaka beds, present beneath the Samphire site extend continuously beneath the Gulf St Vincent and deepen toward the east (Figure 2.4).

Tertiary Aquifer

The Tertiary aquifer, located between 45 m and 90 m depth, hosts the Blackbush orebody and is the target of the FRT trial and associated liquid waste disposal. The aquifer consists of interbedded sand, silt, clay, and lignite, with increased sediment thickness within the paleochannel system and thinning outside of it.

The aquifer comprises three stratigraphic units:

- Melton Sands: 4–6 m thick, containing fine to coarse-grained, iron-rich sands.
- Upper Kanaka Beds: 5–20 m thick consisting of medium to coarse-grained sands interbedded with clay and lignite; and
- Lower Kanaka Beds: 5–20 m thick, primarily composed of clean sands with minimal interbedding.

Hydraulic properties of the aquifer were determined through aquifer testing and subsequent modelling. The transmissivity of the Tertiary aquifer was measured at 110 m²/day with a storativity of 0.0002, indicating confined conditions. The horizontal hydraulic conductivity was calculated at 7 m/day (Appendix D3), while vertical conductivity was found to be significantly lower, ranging between 0.7 and 0.00003 m/day. This significant contrast between horizontal and vertical conductivity reflects the horizontally layered structure of the aquifer, with interbedded clay and lignite layers serving to constrain vertical flow.

Groundwater flow within the Tertiary aquifer is predominantly directed west to east, with recharge occurring through lateral inflow from the west and discharge to the east. Groundwater velocity calculations indicate velocities of 1–6 m/year, derived from hydraulic gradients of 0.0003, 0.00006, and 0.00009 for the Melton Sands, Upper Kanaka Beds, and Lower Kanaka Beds, respectively. Calculations were conducted using point-to-point data to account for variations in salinity, gradients, and permeability, rather than relying solely on groundwater contour maps.

The aquifer exhibits high salinity, with Total Dissolved Solids (TDS) ranging from 32,300 to 65,480 mg/L, demonstrating significant spatial variability. Groundwater elevation data is presented as freshwater equivalent (FWE) head, adjusted using Post (2021, Equation 11) to account for salinity-induced density variations.

Potentiometric pressure ranges from 2.1 to 4.35 m AHD (freshwater equivalent head), with standing water levels observed 10 to 15 m below ground surface. The Tertiary aquifer is capped by approximately 40 m of low-permeability material, consisting of the Gibbon Beds and Melton Limestone. Testing confirmed the absence of hydraulic connection between the Tertiary and Quaternary aquifers across the RL area.

The Tertiary aquifer is not confined entirely within the paleochannel system; in some areas, the Melton Sands and Kanaka Beds are not contained within the paleochannel boundary being a braided channel system. Due to this, groundwater velocity calculations were performed independently for each of the three primary aquifer units (Melton Sands, Upper Kanaka Beds, Lower Kanaka Beds) on a point-to-point basis.

Fractured Rock Aquifer (FRA)

The FRA underlies the Tertiary aquifer, residing within the Hiltaba Granite Formation approximately 120 m below ground surface. The interface between the Tertiary and FRAs is marked by a 50–70 m layer of saprolitic weathered basement sediments, which forms a low-permeability confining layer.

The hydraulic conductivity of the FRA was measured at 0.008 m/day, based on slug tests conducted in November 2023 (Appendix D4). Groundwater flow direction is southeast, with an estimated velocity of 0.07 m/year, derived from a hydraulic gradient of 0.001, an assumed effective porosity of 5% (within the typical range of 0–10% for crystalline basement, as noted by Freeze and Cherry (1979)), and the measured hydraulic conductivity.

Potentiometric pressure within the FRA ranges from 0.3 to 1.2 m AHD, with standing water levels measured between 15 and 20 m below ground surface. The salinity of the groundwater is significantly higher than in the Tertiary aquifer, with TDS concentrations ranging from 83,350 to 97,100 mg/L.

Hydraulic testing in 2011 (AGT 2011a in Appendix D3) showed "*no discernible leakage from overlying or underlying confining beds*" and additional monitoring during water supply operations in 2023 confirmed the hydraulic isolation of the FRA from the Tertiary aquifer. This, along with the vertical pressure differential, ranging from 6.2 to 8.7 m (FWE) and the presence of the low permeability saprolitic weathered basement, provides strong evidence of the aquifers' hydraulic disconnection within the RL.

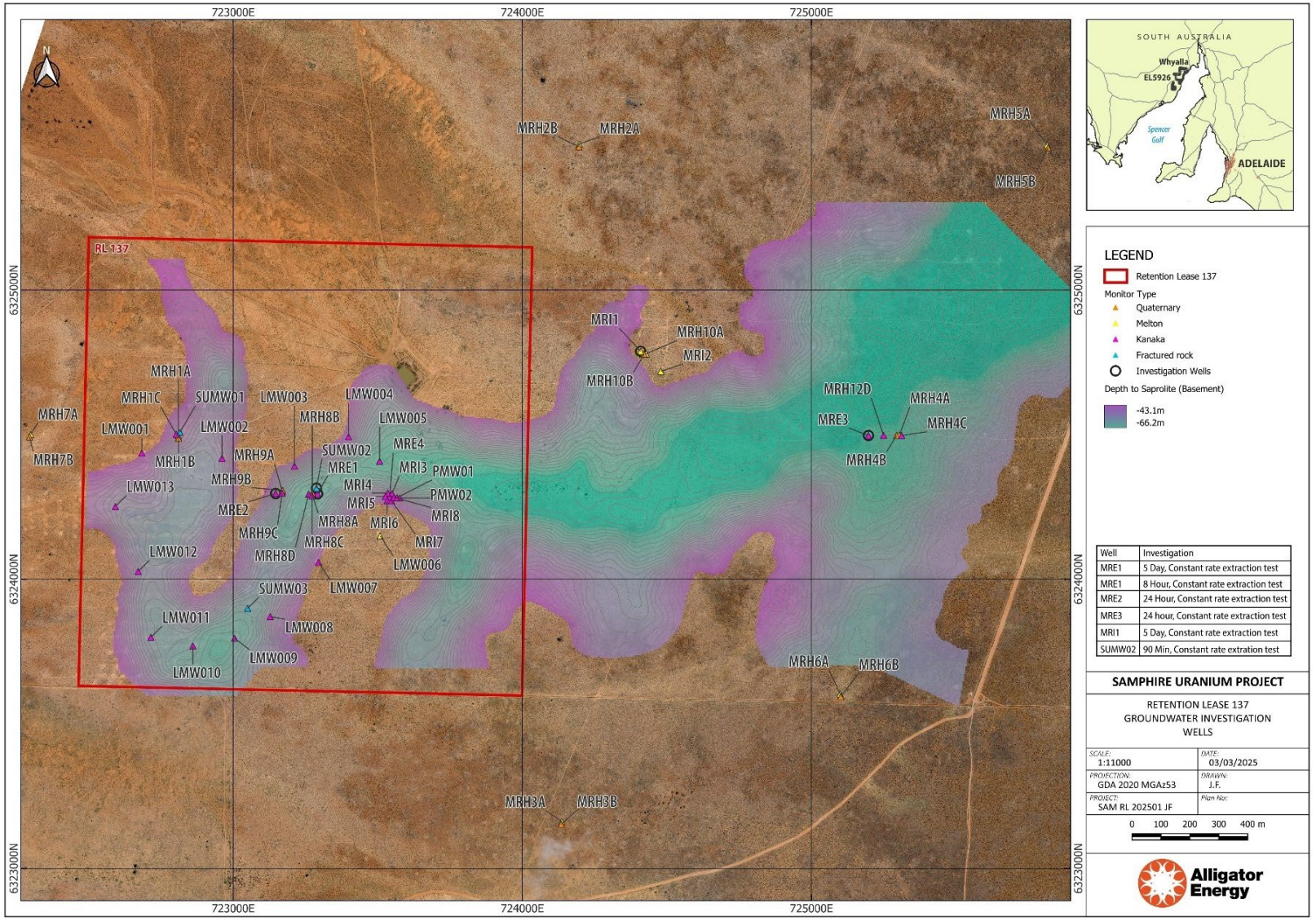


Figure 2.7: Groundwater investigation locations

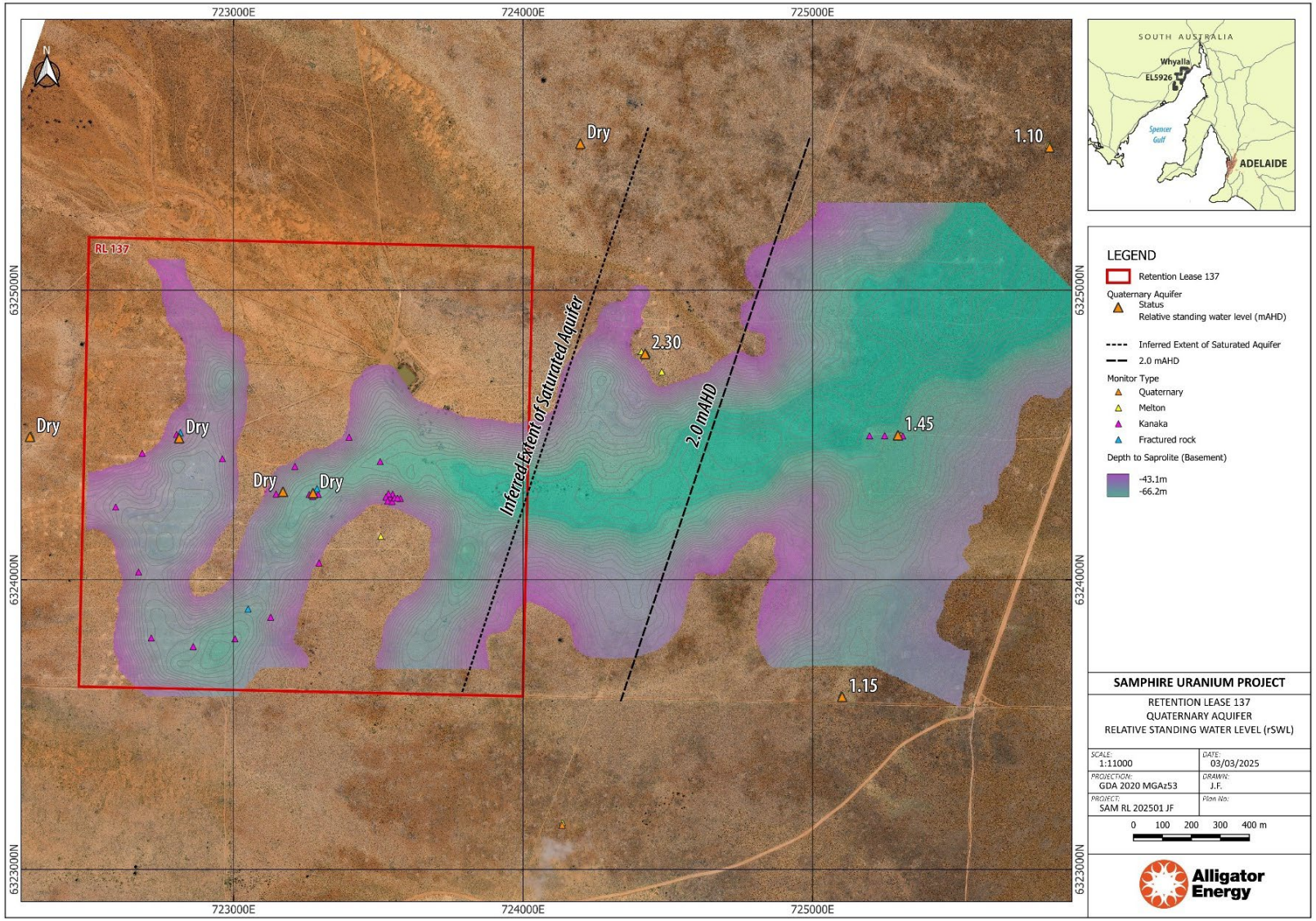


Figure 2.8: Quaternary aquifer relative standing water level (rSWL)

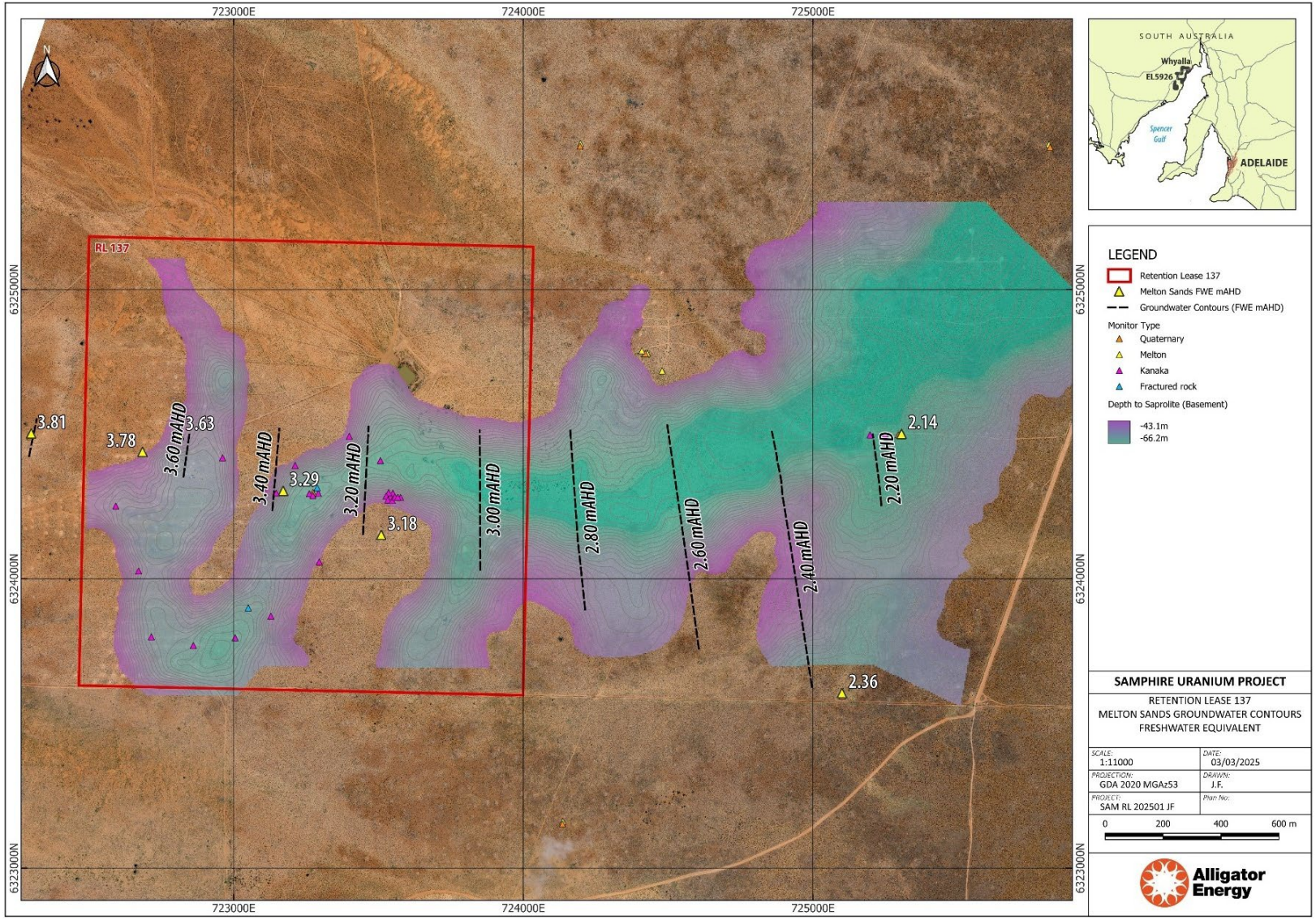


Figure 2.9: Melton Sands groundwater contours (Freshwater equivalent)

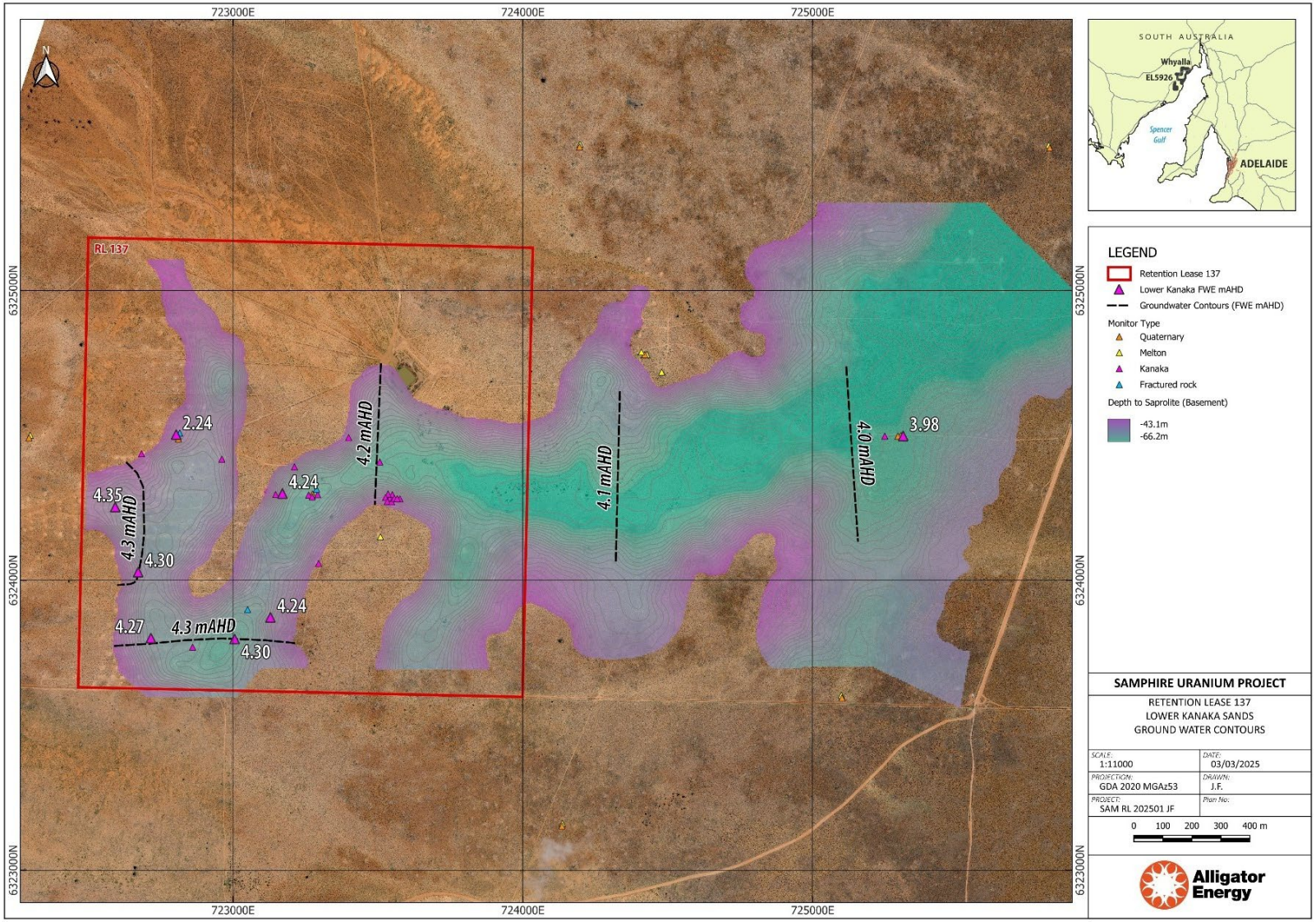


Figure 2.10: Lower Kanaka Beds groundwater contours (Freshwater equivalent)

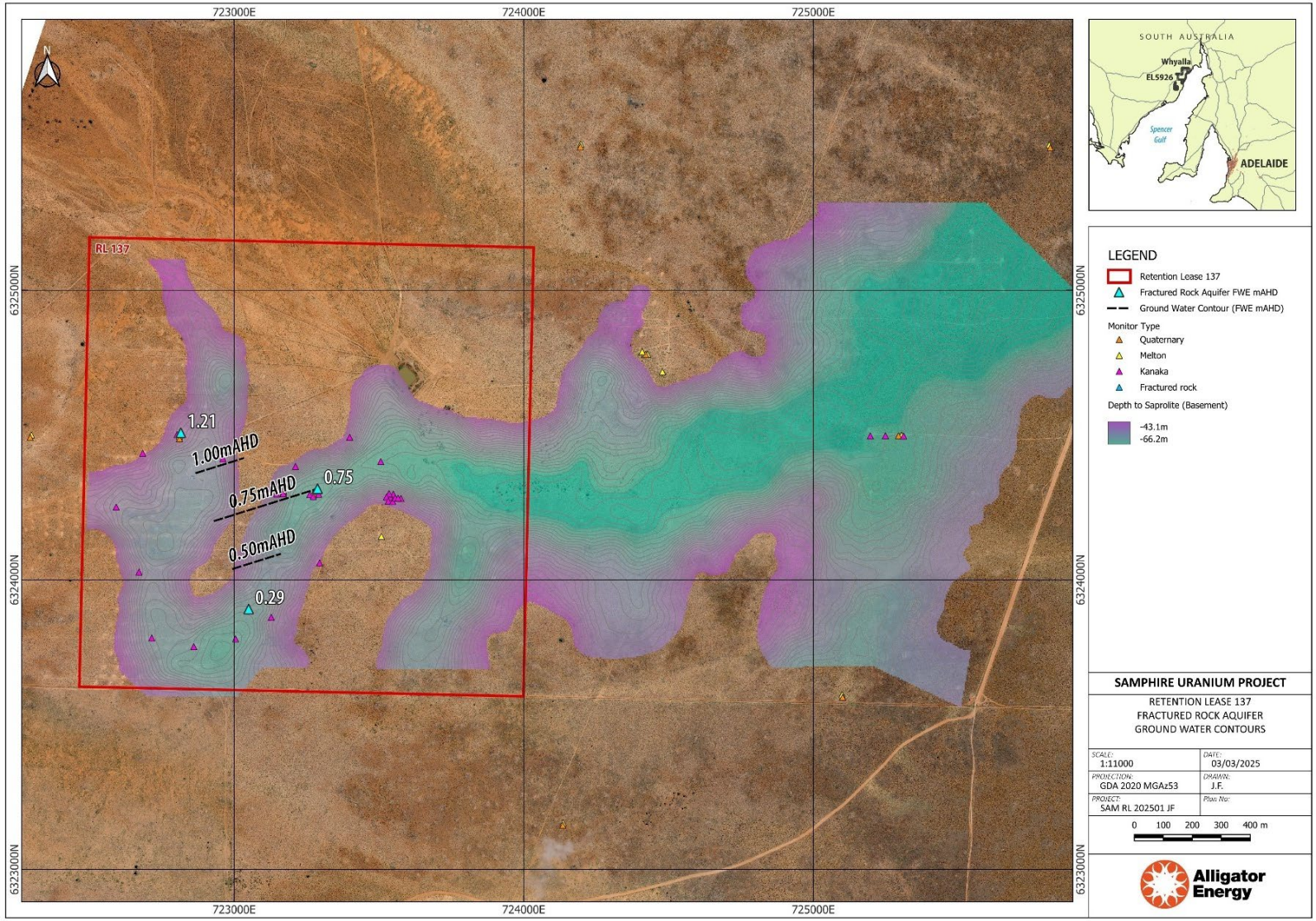


Figure 2.11: Fractured Rock Aquifer (FRA) relative standing water level rSWL) data

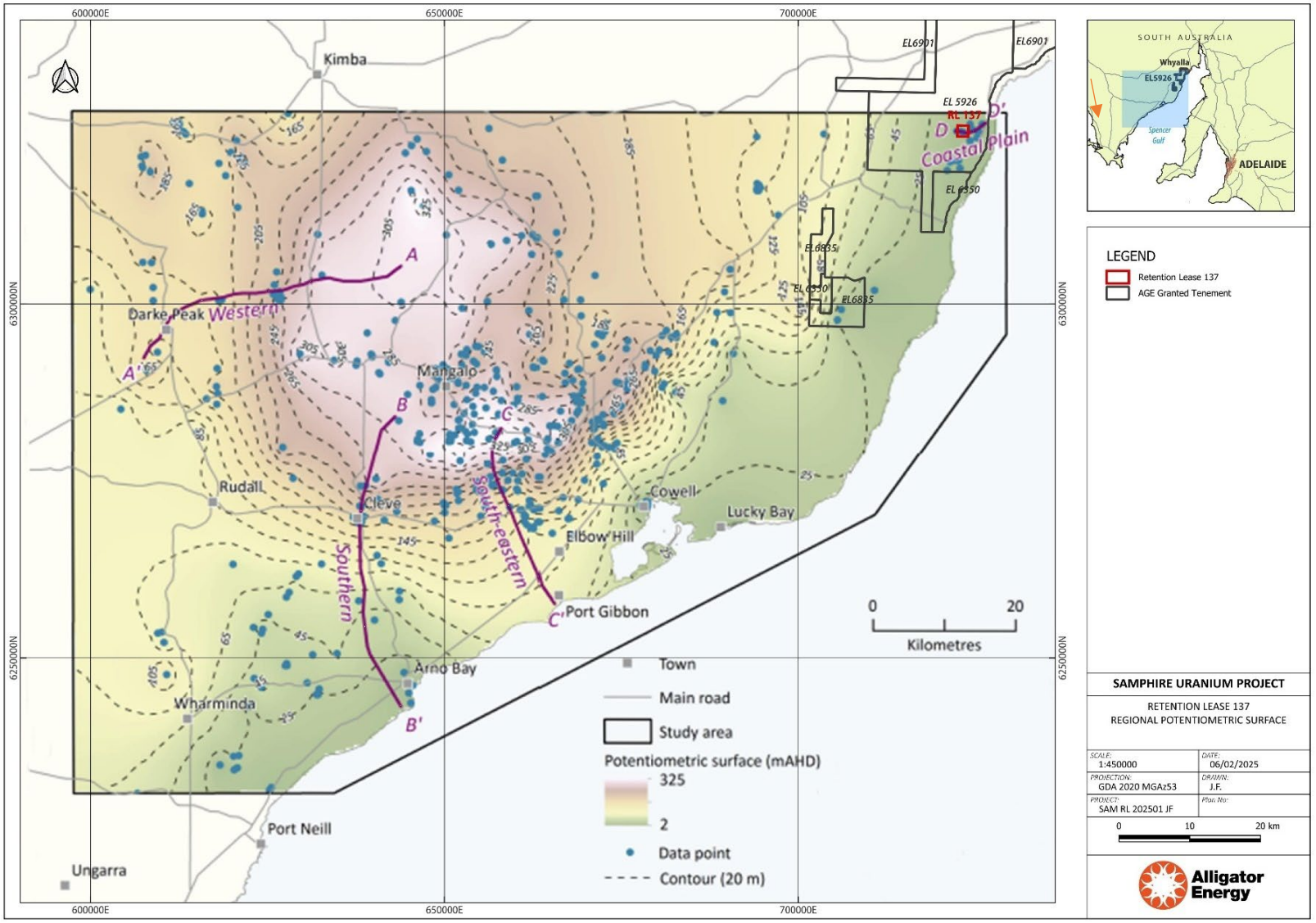


Figure 2.12: Regional potentiometric surface (modified from Taylor et al., 2015)

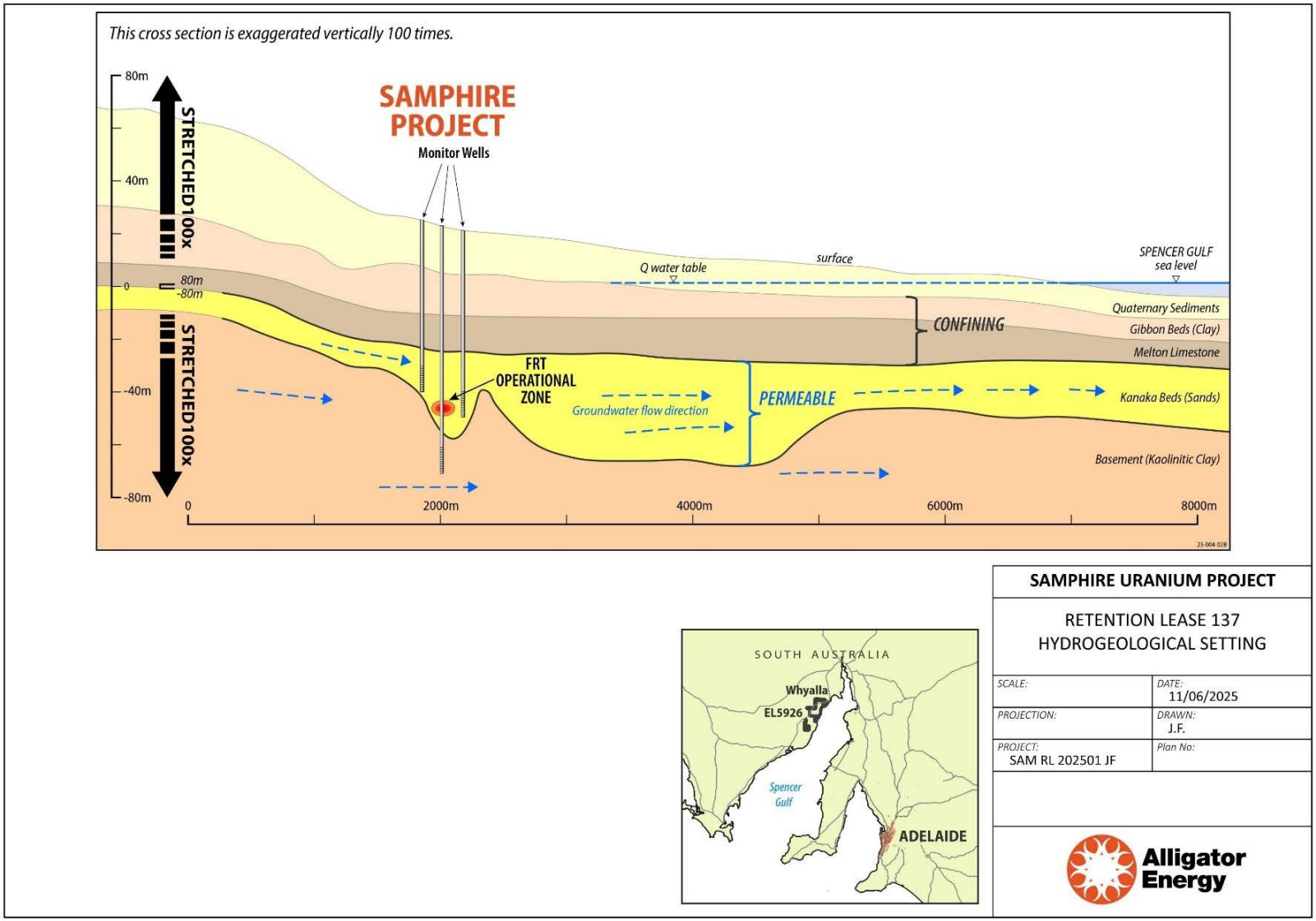


Figure 2.13: Hydrogeological Setting

2.6.3 Water Quality and Environmental Values

Baseline Groundwater Quality

Groundwater samples were taken from a total of 37 wells, including 4 Quaternary wells, and 30 Tertiary aquifer wells, in June 2010 and from 2022- 2024 (Figure 2.7). Sampling of 3 Fractured Rock wells occurred between April 2023 and December 2024 (Figure 2.7).

Sampling was undertaken using either low volume sampling pumps or high-volume sampling whereby wells were purged for at least 3 well volumes and samples taken only once physical parameters of electrical conductivity (EC) and pH had stabilised. For some low yielding wells in the Quaternary aquifer, purging was undertaken over a period of some days with wells allowed to recover between purging events. Samples taken from wells during aquifer testing (MRE1, MRE2 and MRE3) were taken toward the end of the discharge test after a large volume of water had been pumped. The 2022 samples were taken using low flow micropurge submersible pumps placed within the screen and purged until water quality parameters stabilised. Sample results obtained in both 2010 and 2022-2024 have been consistent regardless of sampling method.

Quaternary Aquifer

Four wells were sampled in 2010, Three wells have been sampled regularly since 2022, for a total of 12 sampling events, 6 of which are full analytic suite including, metals, cations and anions and Ra226, the remaining are targeted sampling for pH, TDS, Uranium, Sulphate and Chloride to gain baseline for the critical parameters. MRH3B to the southeast of the RL, sampled in 2010 was rehabilitated before Alligator Energy purchased the project.

The consistently sampled well are all to the east of the RL, where salinity levels range from 49,700 – 85,510 mg/L TDS.

Tertiary Aquifer

Thirty wells screened in the tertiary aquifer have been analysed between 2010 and December 2024. Of these, 17 were installed in 2010, sampling of a portion of these wells was recommenced in 2022 whereby 4 monthly samples were collected to begin the baseline study, sampling of these wells has continued to December 2024 on approximately a quarterly basis.

13 are investigation wells which have been installed by Alligator Energy in 2023, these wells were sampled monthly to obtain a set of 6 baseline samples, then sampled quarterly providing approximately 11 samples per well. The sample set consists of 2 full analytic suites, and the remainder targeted suites. All of these wells are located within the RL surrounding the operational area and will become, along with 2 other existing wells, the perimeter monitoring wells.

Salinity in the tertiary aquifer is high and varies from 32,300- 65,480 mg/L with elevation within the aquifer.

In addition to salinity, boron and Ra226 are elevated and exceed the ANZECC/ARMCANZ guidelines (2000) for livestock drinking water. ANZECC guidelines for livestock drinking water suggest maximum values for boron and Ra226 of 5 mg/L and 0.2 Bq/L respectively, Ra226 exceeds this value in 73 of 79 samples, with an average concentration of 54.4 Bq/L across all samples. The concentration of boron in the Tertiary aquifer ranges from 6.3 - 12.0 mg/L.

Uranium concentration also exceeds ANZECC guidelines of 0.2 mg/L in 47 samples across 9 wells.

Fractured Rock Aquifer

Three wells were installed in the project area in 2022/23, an average of 10 samples per well, 2 full analytic suites per well with the remaining targeted suites. Salinity is high, ranging from 83,350 - 97,100 mg/L.

Samples were submitted under standard chain of custody protocols to a NATA Certified Laboratory. A summary of groundwater quality data is presented in Table 2.1, with the complete dataset provided in Appendix E.

Environmental Values Assessment

Environmental values (EVs) are the beneficial uses of a water resource that require protection for ecosystem health, public benefit, welfare, safety and human health (SA Environment Protection (Water Quality) Policy 2015). EVs form the basis for water-quality management under South Australian legislation. ANZG (2018) provides the national framework, default guideline values and methods to derive site-specific guideline values to protect those EVs; it supersedes ANZECC & ARMCANZ (2000) and does not itself assign EVs.

Environmental/community values are defined as:

- Aquatic Ecosystems
- Recreation & Aesthetic Values
- Drinking Water
- Primary Industries (including irrigation, livestock watering, and aquaculture)
- Cultural and Spiritual Values

The Quaternary, Tertiary, and Fractured Rock aquifers within the RL area and surrounding region exhibit high salinity levels:

- Quaternary Aquifer: 49,700–85,510 mg/L TDS
- Tertiary Aquifer: 32,300–65,480 mg/L TDS
- Fractured Rock Aquifer: 83,350–97,100 mg/L TDS

Given the naturally high salinity (>13,000 mg/L TDS), potable, irrigation and stock-watering uses are not realistic for these aquifers without treatment. Under the SA Water Quality Policy, default EVs apply unless the EPA specifies otherwise. For this PEPR, routine compliance is assessed against site baseline water quality.

Under ANZG (2018), the water quality of these aquifers exceeds guideline trigger values for most community values, such as drinking water, primary industries, aquatic ecosystems and recreational use, due to elevated TDS, sulphate, boron, uranium and radiological indicators (e.g. Ra-226).

Table 2.1: Summary of Groundwater Quality

Analyte	Units	Quaternary Aquifer						Tertiary Aquifer						Fractured Rock Aquifer					
		No. Samples			Min	Ave	Max	No. Samples			Min	Ave	Max	No. Samples			Min	Ave	Max
		Total	ND	Anom.				Total	ND	Anom.				Total	ND	Anom.			
Physico-chemical Parameters																			
pH Value	pH Unit	37	0	1	5.6	6.4	7.9	257	0	0	5.7	6.8	7.6	30	0	0	6.5	6.9	7.7
Total Dissolved Solids	mg/L	37	0	4	49,700	68,520	85,510	271	0	13	32,300	43,407	65,480	29	0	3	83,350	89,146	97,100
Dissolved Metals																			
Boron	mg/L	19	0	0	14	18	21	89	0	0	6.3	8.9	12	6	0	0	5.3	6.6	7.9
Copper	mg/L	19	6	0	ND	0.019	0.056	89	50	0	ND	0.02	0.12	6	5	0	ND	0.001	0.002
Iron (ferrous)	mg/L	19	3	0	ND	0.27	0.87	87	42	1	ND	0.51	4.70	6	0	0	0.92	2.15	3.21
Mercury	mg/L	19	19	0	ND	0.0001	ND	89	82	0	ND	0.00007	0.0005	6	6	0	ND	0.00004	ND
Lead	mg/L	19	5	0	ND	0.01	0.055	89	47	0	ND	0.003	0.01	6	4	0	ND	0.001	0.006
Vanadium	mg/L	19	14	0	ND	0.012	0.006	89	56	0	ND	0.007	0.01	6	5	0	ND	0.001	0.002
Zinc	mg/L	19	3	0	ND	0.15	0.55	89	18	0	ND	0.10	1.98	6	4	0	ND	0.013	0.39
Aluminium	mg/L	18	18	1	ND	0.02	ND	89	61	0	ND	0.047	0.77	6	2	0	ND	0.011	0.022
Thorium	mg/L	19	15	0	ND	0.0042	0.0011	89	44	0	ND	0.004	0.011	6	3	0	ND	0.0007	0.0017
Uranium	mg/L	37	8	0	ND	0.004	0.011	269	0	1	0.003	0.105	0.474	29	0	0	0.009	0.044	0.087
Radium^{226}**	Bq/L	14	2	0	ND	0.16	0.9	79	1	0	ND	54	434	6	0	0	11	52	120
Major and Minor Anions																			
Total Alkalinity as $CaCO^3$	mg/L	19	0	1	39	95	175	88	0	0	50	166	460	6	0	0	68	94	117
Sulphate (SO_4^{2-})	mg/L	37	0	0	2,830	5,026	7,300	268	0	4	2,100	3,605	5,940	29	0	0	1,600	2,205	2,830
Chloride	mg/L	37	0	0	29,200	38,188	52,300	269	0	0	13,000	22,932	34,760	29	0	0	42,900	48,363	53,700
Fluoride	mg/L	19	0	0	0.1	0.3	0.5	88	1	0	ND	1.7	4.5	6	0	0	1.3	1.4	1.6
Major and Minor Cations																			
Calcium	mg/L	19	0	0	1,200	1,798	2,610	90	0	0	1,200	1,849	3,300	6	0	0	5,100	5,377	5,800
Magnesium	mg/L	19	0	0	1,700	2,294	3,450	90	0	0	1,200	1,543	2,390	6	0	0	1,730	1,968	2,100
Sodium	mg/L	19	0	0	13,000	17,921	29,200	88	0	0	6,800	10,485	20,700	6	0	0	21,000	24,650	32,000
Potassium	mg/L	19	0	0	77	109	184	88	0	0	76	114	213	6	0	0	263	311	390
Strontium	mg/L	19	0	0	25	40	54	87	0	0	21	30	47	6	0	0	51	56	66

** Precludes 2010 data as Ra^{226} was not analysed ; ND – Not Detected ; Anom – Anomalous ; ND assumed half of the LOR for the purposes of Average value. Total samples refers to all samples analysed for a given parameter including anomalous data removed from the dataset, Average value exceeds max value where higher LORs influence the average.

2.6.4 Third Party Users

A review of potential groundwater users within 10 km of the RL was completed by Alligator Energy as part of the RL proposal (Alligator Energy, 2023b). Wells recorded on government databases (WaterConnect SA, 2022) were reviewed and are shown in Figure 2.14. Of the 548 recorded wells, 525 were immediately discounted as they are:

- Recorded as abandoned or rehabilitated within the database,
- Mineral exploration holes, or
- Existing Alligator Energy (previously UraniumSA Ltd) monitor wells.

The Moonabie landholder, on whose property the RL is located, and two surrounding landowners confirmed they do not use groundwater (from wells or springs) for any purpose, as it is too saline for stock, domestic, or irrigation use. Landowners were aware of only one existing well, which had been capped and remains unused.

One water point (a spring) was recorded in the WaterConnect database; however, landowners were unaware of its existence. A ground-truthing survey conducted in November 2024 confirmed that no spring was present at the recorded location; instead, a Western Desert Myall tree was identified.

Despite the high salinity of groundwater in the region, some landowners have expressed potential interest in using reverse osmosis (RO) technology in the future to treat groundwater for agricultural or stock water supply. To date, there are no feasibility or scientific studies that have been undertaken to assess if applying RO would also remove the elevated levels of boron and Ra226 to render this groundwater suitable for livestock consumption and other agricultural applications.

As noted in Section 2.6.2, aquifers in the area are not within a ‘prescribed area’ under the Landscape South Australia Act 2019.

2.6.5 Groundwater Dependent Ecosystems

Groundwater Dependent Ecosystems (GDEs) are natural ecosystems that rely on groundwater seasonally or permanently to sustain their ecological functions, processes, and biodiversity. These ecosystems can include terrestrial vegetation, wetlands, rivers, springs, and subterranean habitats that support groundwater-dependent flora and fauna. The availability and quality of groundwater play a critical role in maintaining these ecosystems, particularly in arid and semi-arid regions like the Samphire RL area (BOM, 2025).

The Australian GDE Atlas has identified three categories of GDEs as potentially occurring within the region; however, all are located outside the RL boundary. The identified GDEs located outside the RL are described as follows:

1. Terrestrial GDEs:
    - Terrestrial GDEs depend on groundwater for their water requirements, particularly during dry periods when surface water is unavailable. In the wider region, terrestrial GDEs have been identified with:
        - A low potential of occurrence within the coastal intertidal areas approximately 4 km east of the RL area, where samphire and mangrove vegetation dominate.
        - A high potential of occurrence in an area approximately 8 km north, on Nonowie Station. This vegetation may access shallow groundwater lenses in areas with

perched water tables; however, both locations are situated outside of the RL boundary and the Coronation Paddock, where the proposed activities will occur.

2. Aquatic GDEs:

- Aquatic GDEs encompass surface water features, such as rivers, wetlands, and streams, that rely on groundwater for baseflow, water quality regulation, or the maintenance of habitat.
- In the project area there is a low potential for aquatic `GDEs in Deep Creek, located 4.5 km south of the RL area on Mullaquana Station. Another low-potential site has been identified near the coastline, approximately 3–4 km east of the RL area.
- These sites are beyond the expected area of influence of the proposed activities.

3. Subterranean GDEs:

- Subterranean GDEs include aquifers, caves, and other underground habitats that support groundwater-dependent fauna, such as stygofauna.
- In the project region, no subterranean GDEs have been identified within the Coronation Paddock or within a 2 km radius of the RL boundary.

Figure 2.15 illustrates the location of these potential GDEs in relation to the RL area.

Suitability of Groundwater for GDEs

The salinity levels in all aquifer systems within the RL are considered too high for stygofauna. South Australian Stygofauna typically require salinity to be less than 1500 µS/cm EC (or 960 mg/L), have a pH range of 4.3 to 7.37 and the geology to have the presence of cavities, fractures, or interstices (Hancock & Boulton, 2009). Note that the salinity within the RL area is 1-2 orders of magnitude above the 1500 µS/cm EC threshold.

Potential Groundwater-Dependent Flora

Acacia species, such as the Western Desert Myall, are typically associated with groundwater dependence when shallow, low-salinity groundwater is available. However, the groundwater beneath the RL area is too saline to support these species. While the GDE Atlas indicates the potential presence of Acacia-dominated terrestrial GDEs at Nonowie Station, these areas lie well beyond the RL boundary.

Absence of Groundwater-Dependent Wetlands and Springs

According to the Bureau of Meteorology (BOM) GDE Atlas (BOM, 2025), there are:

- No springs within the RL area or the larger ELs 5926 and 6350, and
- No wetlands within a 2 km radius of the RL.

Given the absence of GDEs within or near the RL area and the unfavourable groundwater conditions for stygofauna and groundwater-dependent vegetation, it is highly unlikely that the proposed FRT activities will impact any GDEs.

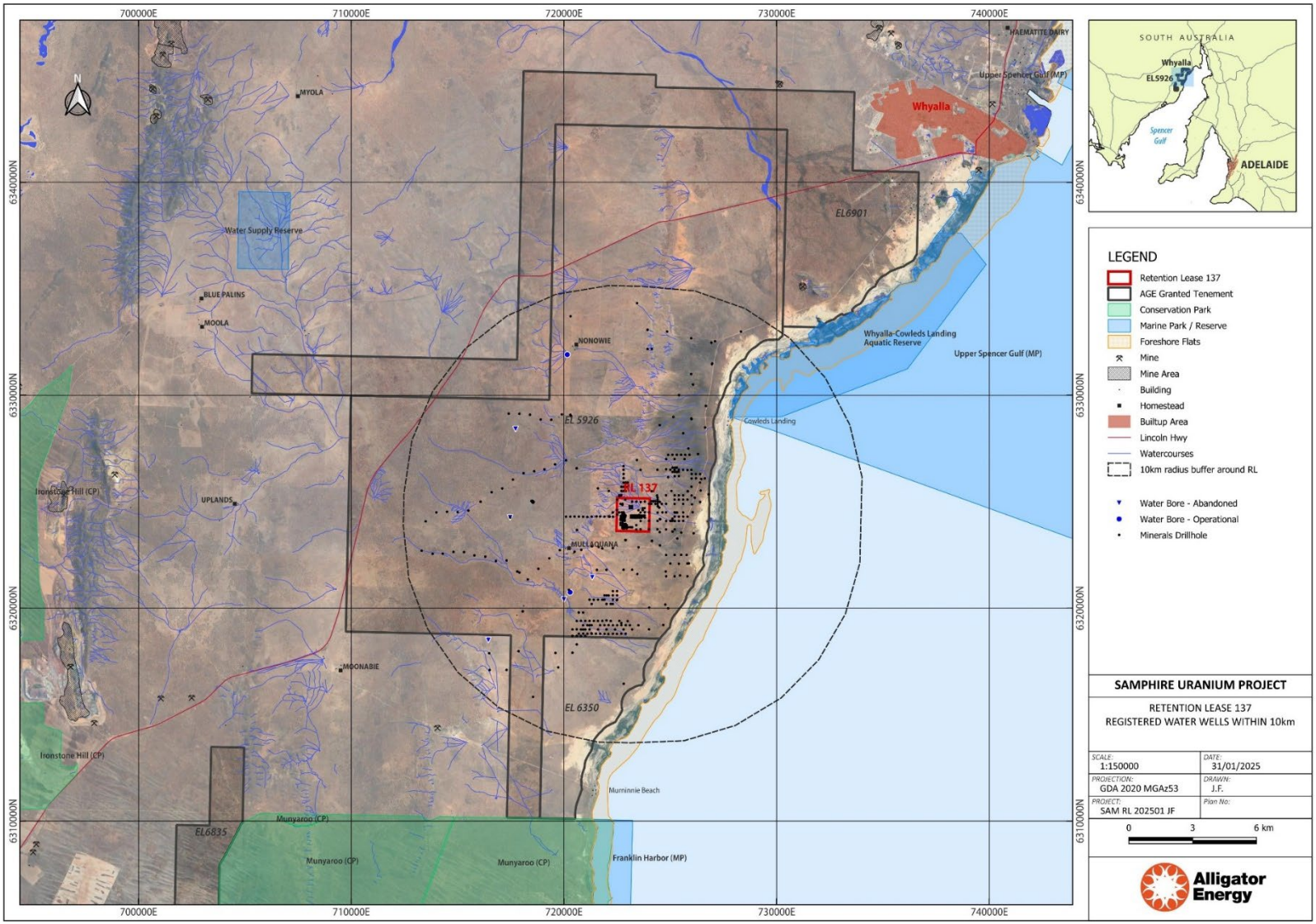


Figure 2.14: Review of registered water wells within 10 km of the Samphire RL (Source: WaterConnect, 2022)

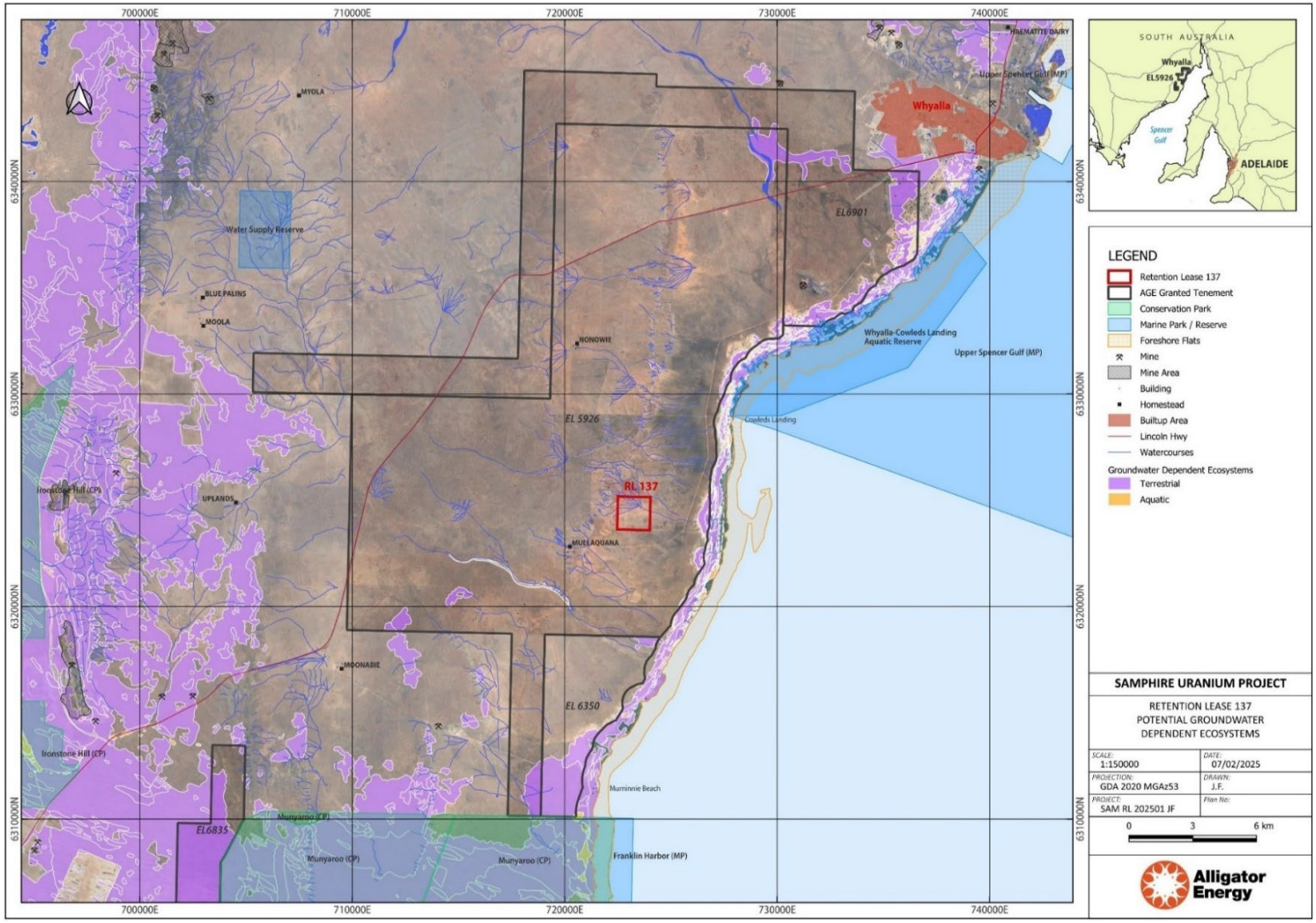


Figure 2.15: Review of Potential Groundwater Dependant Ecosystems within the vicinity of the Samphire RL (Source: BOM, 2021)

2.7 Surface Water

2.7.1 Background

The RL area is not within a prescribed water resources area under the Landscape South Australia Act 2019, nor within a water protection area under the River Murray Act 2003. Additionally, the application area does not fall within the Murray River Basin or any identified groundwater-surface water interaction zones.

The RL area has gently undulating terrain, with elevation changes of only a few hundred millimetres over several hundred metres. No significant drainage systems are present, and surface water flows are typically shallow and slow-moving due to the area's low relief.

Several hydrological and water quality assessments have been conducted in the RL area and surrounding region, including:

- Surface Hydrology Assessment (URS, 2010): This assessment included a catchment analysis, drainage mapping, and hydrological modelling to evaluate flood risk and surface water flow patterns.
- Surface Water Quality Monitoring (OST, 2011, Appendix H & Appendix I): Water quality samples were collected from multiple pastoral dams, including Coronation Dam, to assess radionuclide concentrations.
- Surface Water Reassessment (Appendix I): A follow-up water sampling program reassessed surface water quality to determine any temporal changes in radionuclide levels and other water quality indicators.

These studies confirm that the RL area lacks significant surface water features, and the flood risk is low due to the flat terrain and low-intensity, intermittent rainfall patterns.

2.7.2 Catchment Areas

A baseline surface hydrology assessment of the RL and broader region was conducted by URS in 2010 (see Appendix H). The regional catchment boundaries are shown in Figure 2.16, with key characteristics summarised in Table 2.2.

The assessment confirmed that no significant drainage systems traverse the RL area. The nearest major drainage system is Deep Creek, located 4.4 km south of the RL area. Deep Creek is an ephemeral drainage system with a catchment extending westward to the Middleback Ranges. Since it lies outside the RL catchment boundary and has no hydrological connection to the site, it does not influence site hydrology.

The RL area lies within two minor drainage catchments, designated A4 and A5 (Figure 2.16). Hydrological modelling (URS, 2010 in Appendix H) indicates that these catchments are unlikely to generate stream flows under foreseeable rainfall events.

Catchments A1, A2, A4, A5, and A6 are generally flat and lack well-defined channels. However, channels form along the western escarpment, where elevation drops from approximately 50 m above sea level to the coastal plain. Surface water movement within these catchments typically occurs as shallow (50–80 mm depth) sheet flows with low velocities (approximately 0.3 m/sec). Within the RL area, flow velocities are even lower due to reduced slope and increased infiltration over the flat terrain.

2.7.3 Hydrogeological Modelling

Streamflow modelling for 10-year and 100-year Average Recurrence Interval (ARI) events was conducted by URS (2010) for sub-catchments A4 and A5 within the RL area. For a 10-year ARI event, predicted flood depths were 25 to 34 mm, with a flow velocity of 0.1 m/s. For a 100-year ARI event, predicted flood depths were 42 to 56 mm, with a flow velocity of 0.2 m/s.

The flat topography (approximately 0.5% slope) and low rainfall result in slow-moving, shallow floodplain flows, posing a low flood risk.

2.7.4 Runoff Impact Assessment

Predicted runoff from the RL area under extreme rainfall events is unlikely to affect catchment areas, as the RL is located at the eastern boundary of all identified catchments. Catchment A5 runoff may have a minor impact on the RL area during extreme events.

Table 2.2: Summary of Catchment Areas

Catchment ID	Catchment Areas (km^2)
A1	48.5
A2	16.1
A3 (Deep Creek)	252.5
A4	16.8
A5	76.5
A6	38.0

2.7.5 Surface Water Features

One functional station dam, Coronation Dam, is located within the RL area (Figure 2.16).

Several landholder-constructed drainage channels cross the north-western corner of the RL area. These channels collect surface runoff and direct it toward Coronation Dam.

Beyond the RL area, the following observations were noted:

- Drainage lines to the north do not connect to the RL area.
- Drainage systems on adjacent pastoral properties (north and south) are also unconnected to the RL.
- Deep Creek, an ephemeral system on Mullaquana Station (5 km south of the RL area), is the only significant watercourse in the broader region.

2.7.6 Surface Water Quality Data

Baseline surface water quality monitoring for radionuclides was conducted by On Site Technology Pty Ltd in 2010 (OST, 2011, Appendix M), with samples collected from multiple pastoral surface dams, including Coronation Dam within the RL area.

In 2022, Alligator Energy resampled Coronation Dam and surrounding pastoral dams. In 2010, low levels of ^{226}Ra (0.04 to 0.15 Bq/L) and ^{210}Pb (maximum of 0.03 Bq/L) were detected and the samples analysed more recently returned ^{226}Ra at 0.04 Bq/L and ^{210}Pb at 0.04 Bq/L respectively. Baseline data is provided in Appendix I.

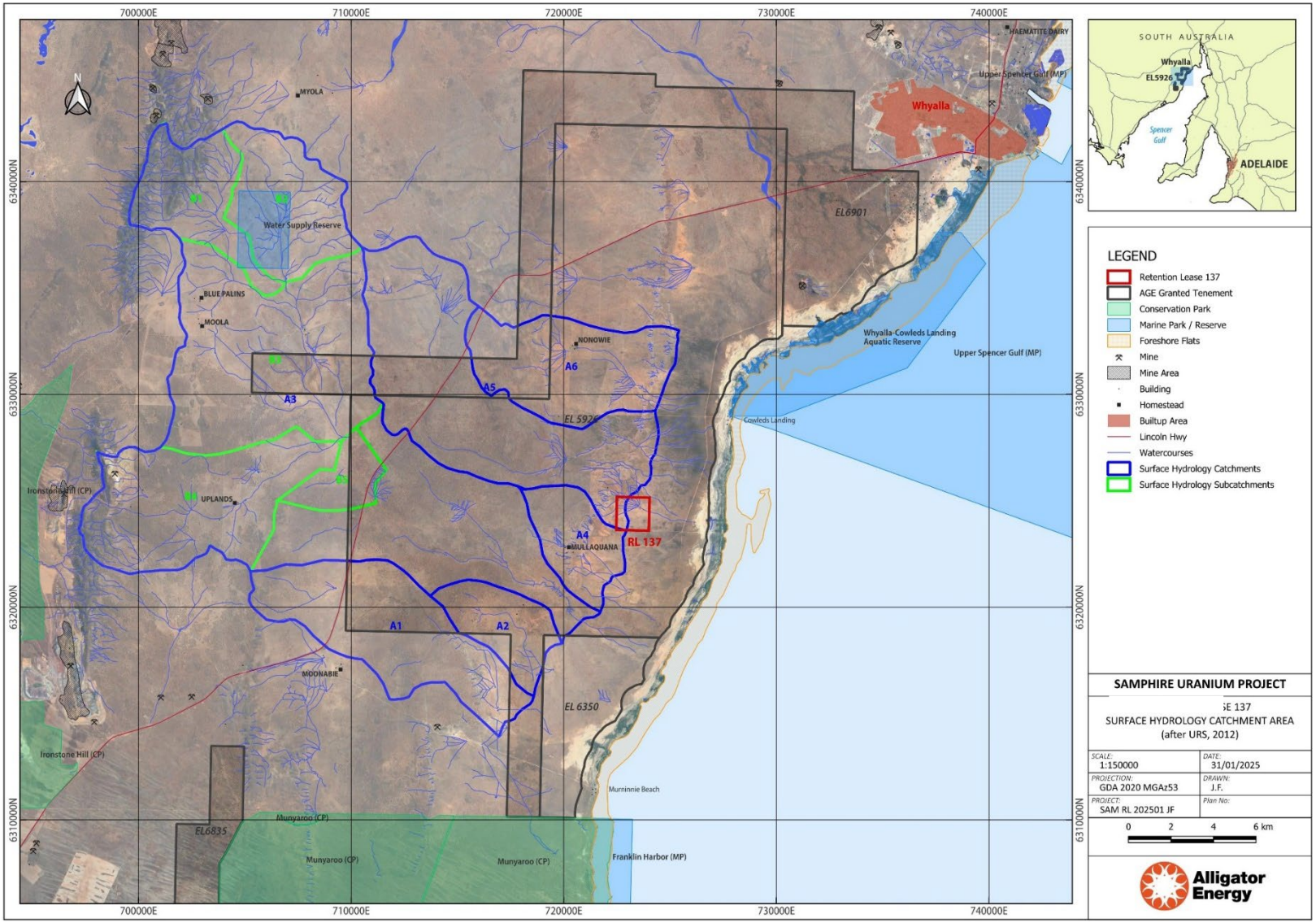


Figure 2.16: Surface hydrology catchment area (Source: URS, 2010)

2.8 Vegetation, Weeds & Plant Pathogens

2.8.1 Project Area Description

The RL area has been used for pastoral activities for more than 100 years, with evidence of historic overgrazing, and with obvious sheep 'grazing lines' on most remaining trees demonstrating the degradation of vegetation structure over time. The dominance of Pearl Bluebush and the lower density of bushes per hectare than that recorded by Dr. Peter Waite (Lange et al. 1984) in the 1890s, indicates preferential grazing over time by stock. It is expected that rabbit impacts on vegetation structure prior to Myxomatosis and Calicivirus virus have also contributed to the degradation of the vegetation structure.

Since 2020, the Coronation Dam paddock, on which where the RL is located, is now part of Moonabie Station. Previously, it was a stand-alone land parcel owned by S Uranium Pty Ltd until 2018 and before that, it was part of Nonowie Station prior to 2012.

2.8.2 Baseline Flora Surveys

Between 2009 and 2012, five flora and fauna surveys were conducted across an 11,647-hectare area, including the 237-hectare RL area (Figure 2.17). These surveys covered the former EL numbers 3542, 4242, and 3652 on Mullaquana and Nonowie Stations.

A further flora and fauna assessment was conducted in November 2023 to update species presence/absence data. The results showed no significant differences between 2010–2012 and 2023 surveys, considering natural species variability, differing survey methodologies, seasonal conditions, and varying grazing pressures. As noted by Dr. Travis How (EBS Ecology Director, pers. comm., 19 January 2024), minor species fluctuations between surveys are expected due to faunal mobility, survey scale variations, and seasonal climatic factors.

The six flora and fauna surveys referenced in this assessment are as follows:

- Mullaquana Flora and Fauna Baseline Survey (EBS Ecology, 2010a).
- Mullaquana Buffel Grass Survey (EBS Ecology, 2010b).
- Mullaquana Follow-up Flora and Fauna Survey (EBS Ecology, 2011a).
- Samphire Project Flora and Fauna Survey - 2011 (EBS Ecology, 2012a).
- Samphire Flora and Fauna Survey - 2012 (EBS Ecology, 2012b).
- Moonabie Flora and Fauna Survey 2023 (EBS Ecology, 2024).

A total of 111 flora species have been recorded within the entire study area (EL's & RL) (Figure 2.17), of which 97 are native and 14 are exotic. 10 principal vegetation associations were identified during baseline surveys within this wider study area (Figure 2.18). Within the RL area, at least 44 native flora species have been identified, and the area is characterised by two predominant vegetation associations (Table 2.3 & Figure 2.19):

- *Maireana sedifolia* / *Atriplex vesicaria* shrubland, predominantly featuring M. sedifolia (Pearl Bluebush), M. pyramidata (Black Bluebush), and A. vesicaria (Bladder Saltbush).
- *Acacia papyrocarpa* (Western Desert Myall) / *Myoporum platycarpum* / *Alectryon oleifolius* ssp. canescens open woodland.

Table 2.3: Vegetation Associations Identified in the RL Area

No.	Association description	Condition	Area (ha) within RL
1	*Acacia papyrocarpa* (Western Myall) +/- *Myoporum platycarpum* (False Sandalwood) +/- *Alectryon oleifolius ssp. canescens* (Bullock Bush) Open Woodland over Chenopod Shrubland or Tall Shrubland	Medium, with minimal observed disturbance	22.2
2	*Maireana sedifolia* (Peal Bluebush) / *Maireana pyramidata* (Black Bluebush) / *Atriplex vesicaria* (Bladder Saltbush) Open Low Shrubland over *Austrostipa nodosa* (Tall spear-grass) +/ *Sclerolaena obliquicuspis* (Oblique-spined Bindyi)	Medium - moderately degraded due to historical overgrazing.	212.8

Condition of the above vegetation associations are:

- Acacia papyrocarpa open woodland – Medium condition, dominated by *M. pyramidata* in the understorey. Patchy overstorey of Myall and Myoporum. Weeds are sparse, consisting only of *Medicago minima*, with substantial alteration to the vegetation structure, extensive clearing with evidence of heavy grazing
- *Maireana Sedifolia* low shrubland – medium condition, generally heavy grazing in between shrubs, evidence of vehicle and livestock tracks, scats and other disturbance under shrubs. Weeds are sparse, consisting of *Carrichtera annua* and *Medicago minima*.

The majority of the RL area is considered medium condition based on the vegetation survey point (Site 1) within the RL area (Figure 2.17). There are obvious signs of disturbance (tracks and bare ground), depletion of one or more vegetation strata (overstory of *A.papyrocarpa*), considerable weed invasion and a patchy soil surface crust (EBS Ecology, 2010b). The vegetation is also grazed by stock.

No threatened flora species were identified in the RL (EBS Ecology, 2010b). In the northeast corner and eastern part of the RL there *Myoporum platycarpum* (False Sandalwood), *Alectryonoleifolius ssp canescens* (Bullock Bush) and *Acacia papyrocarpa (*Western Desert Myall*)*, are present however they are outside the areas of activity and will not be disturbed.

Common weed species within the RL area include *Carrichtera annua* (Ward's weed), *Medicago polymorpha var. polymorpha* (Burr-medic), *Carthamus lanatus* (Saffron thistle), *Asphodelus fistulosus* (Onion Weed), *Marrimbium vulgare* (Horehound) and *Xanthium spinosum* (Bathurst Burr). A number of other weeds occur within the vicinity of the RL area, including *Oxalis pes-caprae* (Soursob) and *Lycium ferocissimum* (African boxthorn) which are declared weed species under the *Natural Resources Management Act, 2004* (SA), hence, are required to be controlled and managed.

Environmental weed species recorded beyond the RL area during the baseline survey, including those identified on neighbouring pastoral leases (Mullaquana and Nonowie), include *Vinca major* (blue periwinkle), *Mesembryanthemum nodiflorum* (slender iceplant), *Solanum linnaeanum* (apple of Sodom), *Salvia verbenaca* (wild sage), *Hordeum vulgare* (barley grass), *Nicotiana glauca* (tree tobacco), *Opuntia* sp. (prickly pear), and *Agave americana* (century plant). These species are of environmental concern due to their potential to degrade habitats by outcompeting native vegetation (EBS Ecology, 2010b).

No plant pathogens have been recorded or observed within the RL area.

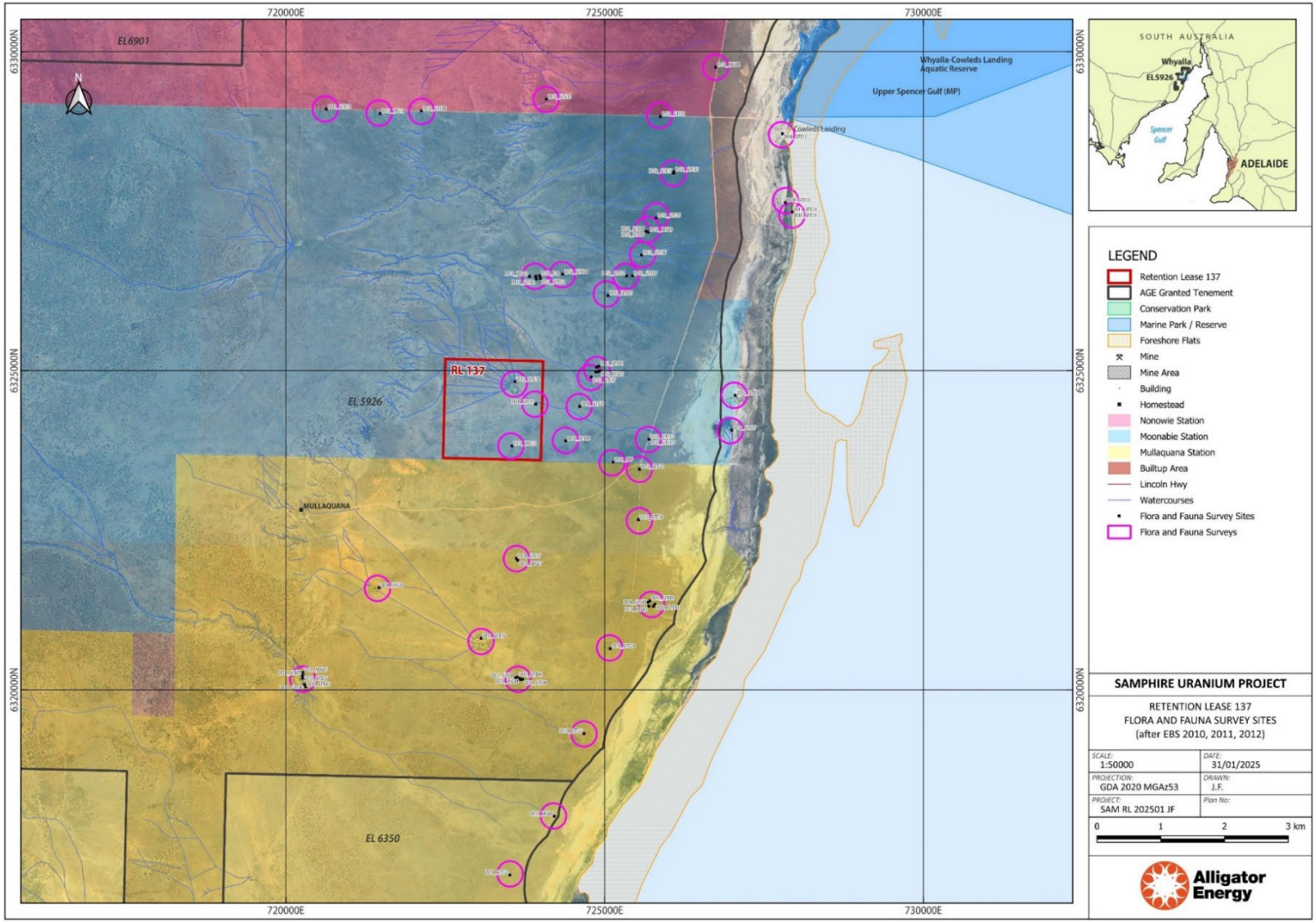


Figure 2.17: Baseline Flora and Fauna Survey Sites (EBS Ecology, 2010-2012)

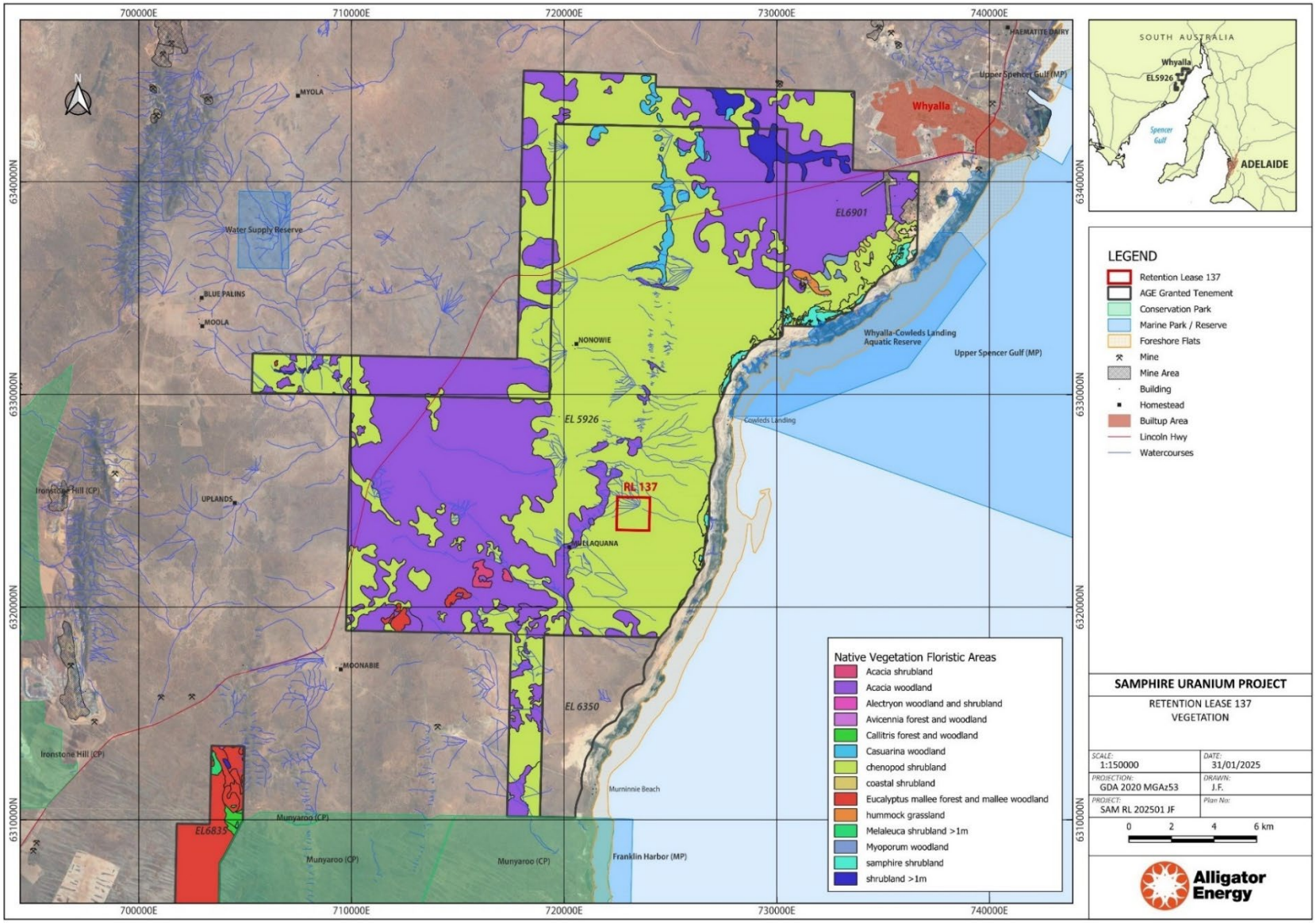


Figure 2.18: Vegetation associations within and near the RL area

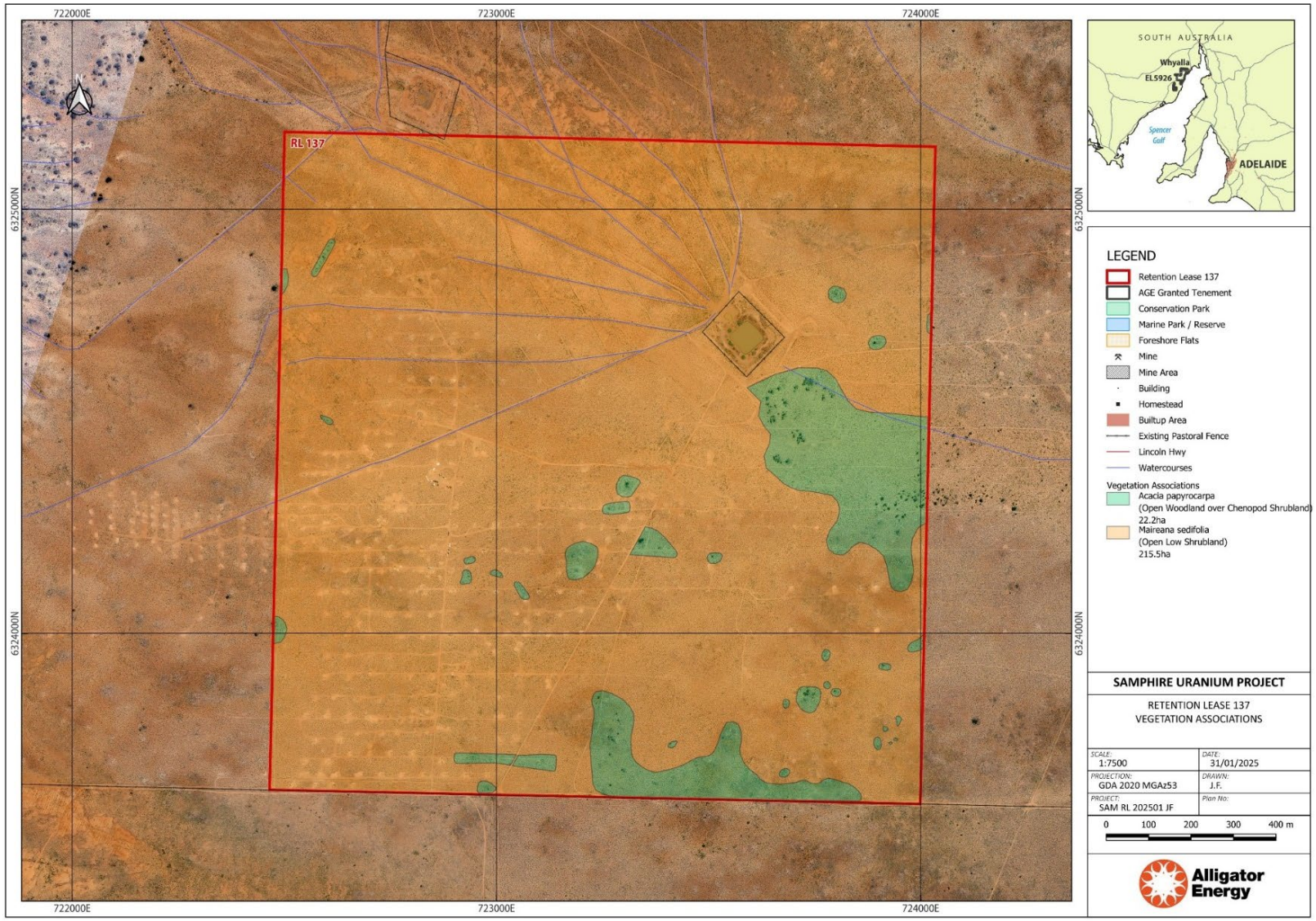


Figure 2.19: Vegetation associations within the RL area

2.8.3 Database Searches

The Protected Matters Database (DCCEEW 2022b), NatureMaps SA database (DEW, 2022) and the Directory of Important Wetlands in Australia (DCCEEW 2022b) were searched in August 2022 for flora species information.

The Protected Matters Database search tool of Matters of National Environmental Significance (MNES) identified four Commonwealth listed threatened flora species, although there have been no confirmed records of these species during any of the site flora surveys.

The four listed species are:

- Greencomb Spider-orchid (*Caladenia tensa*) - Endangered
- *Pterostylis xerophila*. Eyre Peninsula, Desert Greenhood - Vulnerable
- Yellow Swainson-pea (*Swainsona pyrophila*) - Vulnerable
- *Frankenia plicata* – Endangered

Since June 2013, Subtropical and Temperate Coastal Saltmarsh was listed as a Commonwealth threatened ecological community. This ecological community has not been identified within the RL however has been identified in the wider region, occurring in the coastal areas under regular or intermittent tidal influence.

The NatureMaps SA database (DEW, 2022) identified 32 potential state listed flora species in the region, however none were identified as close to the RL.

No other flora species of national or state conservation significance were identified within or in the vicinity of the RL area during surveys.

2.9 Fauna

2.9.1 Project Area - Baseline Survey Results

Six fauna surveys have been conducted within the RL and wider EL area by EBS Ecology from 2009 to 2012 with a further survey completed in 2023. These surveys are as follows:

- Mullaquana Flora and Fauna Baseline Survey (EBS Ecology, 2010a).
- Mullaquana Follow-up Flora and Fauna Survey (EBS Ecology, 2011a)
- Mullaquana Additional Bird Survey (EBS Ecology, 2011b)
- Samphire Project Flora and Fauna Survey - 2011 (EBS Ecology, 2012a)
- Samphire Flora and Fauna Survey - 2012 (EBS Ecology 2012b)
- Moonabie Flora and Fauna Survey 2023 (EBS Ecology 2024)

The number of species recorded in the broader study area during the various surveys included:

- Twenty mammal species, including ten bats
- Twenty-three reptile species
- Two amphibian (frog) species, and
- Fifty bird species

The number of native species recorded in or near the RL area, during the various surveys included:

- Eight mammal species including four bats
- Seventeen reptile species
- One amphibian species
- Minimum of twenty-one bird species

Non-native species identified in the study area during the surveys included:

- Sheep (*Ovis aries*),
- Rabbit (*Oryctolagus cuniculus*),
- House mouse (*Mus musculus*),
- Fox (*Vulpes vulpes*),
- Bird species such as Common Starling (*Sturnus vulgaris*) and Eurasian Skylark (*Alauda arvensis*).

No mammal, reptile, amphibian or invertebrate species of conservation significance were observed during the surveys nor are they likely to occur within the RL area.

2.9.2 Database Searches

Background database searches were conducted as part of the UraniumSA EPBC Referral (UraniumSA 2010) and again throughout 2022 (DCCEEW 2022b). The EPBC online Protected Matters Search Tool was used for a search radius of 5km around the RL. Biological Database of South Australia searches were also undertaken (DEW, 2023). Combined, the searches identified 45 bird species of conservation significance. A further 17 bird species have been recorded in the wider region.

2.10 Local Community

2.10.1 Whyalla

The RL area is located within the Whyalla Local Government Area (LGA), on a perpetual Crown pastoral lease, specifically Moonabie Station. Whyalla, the nearest township and service centre, is situated approximately 20 km northeast of the RL area. With a population of 21,960 in the 2021 Australian Bureau of Statistics (ABS) Census, Whyalla is South Australia's second-largest regional city and a key industrial hub, primarily focused on mining and steel production (ABS, 2021). Approximately 30% of Whyalla's workforce is employed in mining or manufacturing, including iron and steel production.

Other pastoral leases surrounding the RL area include Nonowie Station to the north and Mullaquana Station to the southeast, both contributing to the regional economy. These stations are engaged in sheep grazing and are home to a mix of permanent and seasonal residents. People residing on these stations maintain strong social and economic ties to Whyalla, which is a central hub for goods, services, and employment in the region.

Table 2.4 provides key demographic and socioeconomic statistics for the Whyalla population, compared to national figures for Australia.

Table 2.4: Key Demographic and Socioeconomic Statistics for Whyalla (Local Government Area) Compared to Australia (ABS, 2021)

Description	Year	Region	Australia
Estimated resident population number.	2021	21,960	25,697,298
Working age population (aged 15-64 years).	2021	55%	61.1%
Estimated number of resident Aboriginal and Torres Strait Islander population.	2021	1,160	812,728
Number of persons born overseas.	2021	2,513	7,500,000
Number of children enrolled in a preschool or preschool program.	2021	339	484,185
Median weekly income (excl. Government pensions and allowances).	2021	$641.00	$805.00
People working full time	2021	56.3%	55.9%
People working part time	2021	29.8%	31.2%
Number of jobs.	2019	13,770	20,138,132
Number of taxpayers who report having private health insurance.	2020	5,344	8,320,073
Number of passenger vehicles.	2020	12,384	14,679,246
Land area.	2020	107,134 ha	768,812,632 ha
Protected land area.	2020	3,478 ha	151,622,583 ha

2.10.2 Cowleds Landing

Cowleds Landing is the nearest locality outside the RL area (Figure 2.1), situated approximately 19 km south of Whyalla by road and 6.6 km from the RL area. It consists of around twelve fishing shacks, some of which are occupied seasonally, while others are used year-round. The area features a mangrove-lined beach ridge fronted by 500 m wide sand flats. To the south, the mangrove habitat extends approximately 8 km, interrupted only by small tidal creeks, making it inaccessible by vehicles. Cowleds Landing is also the southernmost point of the Whyalla-Cowleds Landing Aquatic Reserve.

2.11 Landowners and Land Use

2.11.1 Land Ownership

The RL area is located on Moonabie Perpetual Crown Lease (Figure 2.1) and is used for sheep grazing as part of a larger farming enterprise. The property is owned and operated by its current owners as part of the broader Moonabie Station.

To the north of the RL area, approximately 5 km away, lies the Nonowie Station, a separate pastoral enterprise with different ownership. The Nonowie Homestead is located on this property (Figure 2.1), where the current owners reside.

To the south of the RL area, the Mullaquana Lease abuts the southern boundary of the RL area. The Mullaquana Homestead, located approximately 2.4 km southwest of the RL, is occupied by the current owners (Figure 2.1).

2.11.2 Land Use

Land Use Within the RL

The RL area and surrounding region, approximately 40 km west and south of Whyalla, are predominantly used for sheep grazing on native saltbush vegetation. The RL covers 237 hectares within Moonabie Station's "Coronation Dam" paddock, which, like the adjacent Mullaquana Station, has a long history of sheep grazing.

Land Use Outside the RL

Between 0-3 km from the RL area:

- Land within 3 km of the RL is primarily used for pastoral purposes, predominantly sheep grazing.
- A Coastal Conservation Zone, approximately 2.4 km east of the RL area, extends north towards Whyalla and south along the Spencer Gulf, beyond the Munyaroo Conservation Reserve.

Between 3-5 km from the RL area:

- Murninnie Sand Pit, located approximately 3.4 km southeast of the RL area, is a sand quarry for construction materials (EML4101 & EML4102), though it operates infrequently.
- Deep Creek Sand Quarry, located approximately 4.4 km from the RL area, is an active sand quarry for construction materials.

Between 5 and 10 km from the RL area:

- The Whyalla-Cowleds Landing Aquatic Reserve lies approximately 5.4 km northeast of the RL area, at the northern end of the Coastal Conservation Zone.
- Cowleds Landing, a small coastal settlement with approximately 12 shacks, is located around 6.6 km northeast of the RL area, accessible via a designated access route.

Between 10-20 km from the RL area:

- Fishing shacks at Murninnie Beach are approximately 12.2 km south of the RL area.
- The Mount Young Quarry (EML4104), approximately 12.2 km northeast of the RL area, is an open-cut mine for dolomite extraction used in construction, operating seasonally.
- The Murninnie Private Mine (PM156), about 12.5 km southwest of the RL area, is intermittently prospected for copper extraction.
- Munyaroo Conservation Park is approximately 13.5 km south of the RL area.
- The Munyaroo Conservation Reserve, situated approximately 25.5 km south of the RL area, is around 4 km south of the Munyaroo Conservation Park.
- Whyalla Airport is located approximately 18.1 km northeast of the RL area.
- Water Supply Reserve is approximately 18.8 km northwest of the RL area.
- The 14 Mile Creek Sand Pit, approximately 20.7 km north of the RL area, is an open-cut sand mine for construction materials.
- The City of Whyalla is approximately 20 km northeast of the RL area.
- The Upper Spencer Gulf Nationally Important Wetland (SA020) is located about 35 km away. This area includes the upper reaches of Spencer Gulf, incorporating key coastal habitats such as mangroves and samphire areas at Whyalla, Blanche Harbour, Port Augusta, and Port Broughton, among other locations.

2.11.3 Local Zoning and Policies

The RL area is situated on a Perpetual Crown Lease, (plan parcel number H560400SE5) within the Whyalla Local Government Area, zoned as “Remote Areas”. Under the development policies, Desired Outcome 1 specifies that "resource extraction activities are developed in a manner that minimises human and environmental impacts" (PlanSA, 2022).

2.11.4 Future Development Plans or Land Use Changes

An Environmental Impact Statement (EIS) assessment process (Northern Water) for a proposed pipeline and desalination plant (Office of Northern Water Delivery, 2022) is noted with its siting potentially being placed east of the RL area (~2 km outside its boundary) and will pass through the eastern portion of Moonabie upon receipt of all approvals.

Several renewable energy projects, including wind and solar infrastructure, are being developed in the broader region, with some proposals extending into the RL area.

2.11.5 Overlapping/Adjacent Tenements

A Petroleum Exploration Licence (PEL) application No. 792 (PELA792) overlies the RL area (Figure 2.20).

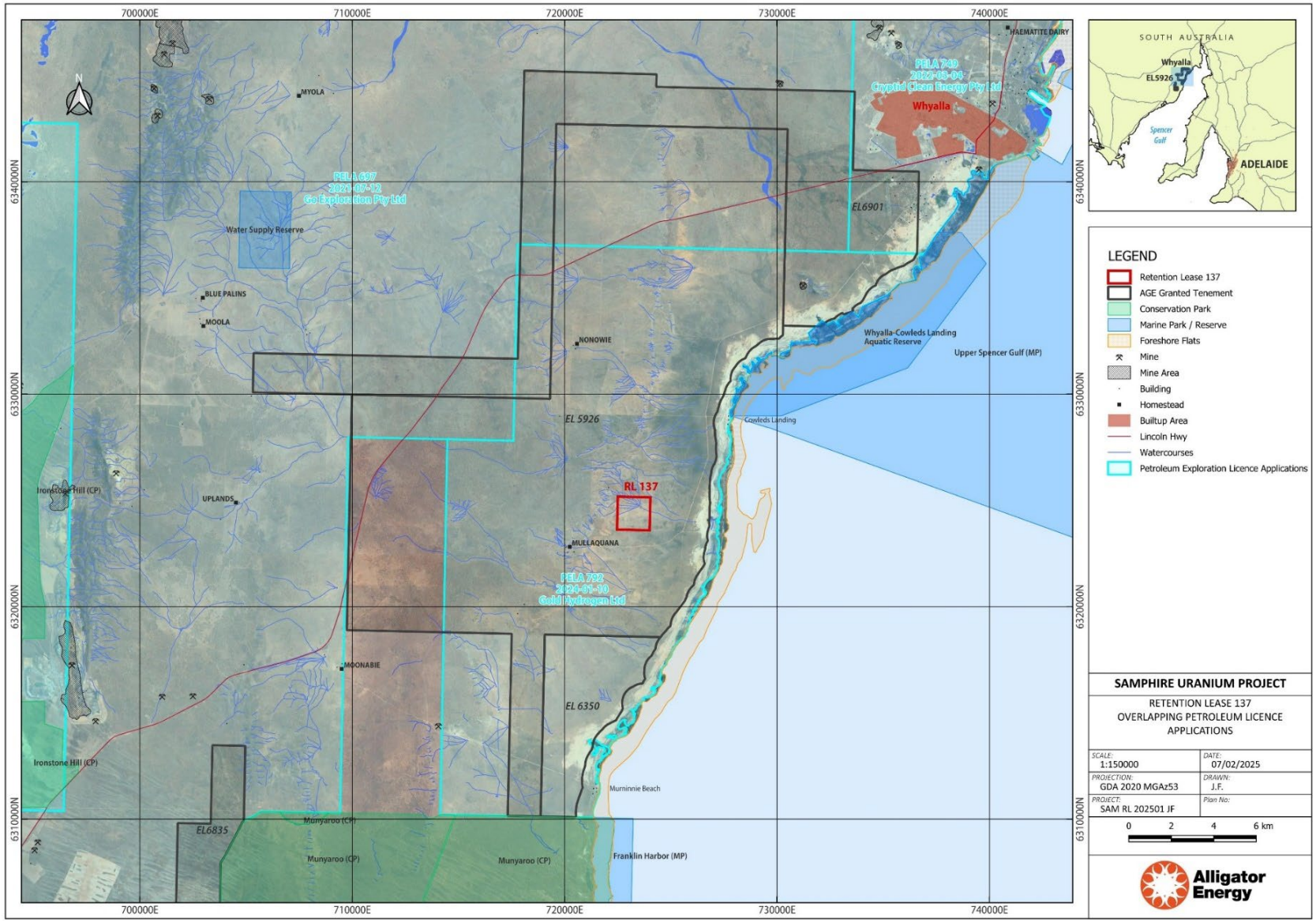


Figure 2.20: Overlapping tenement applications

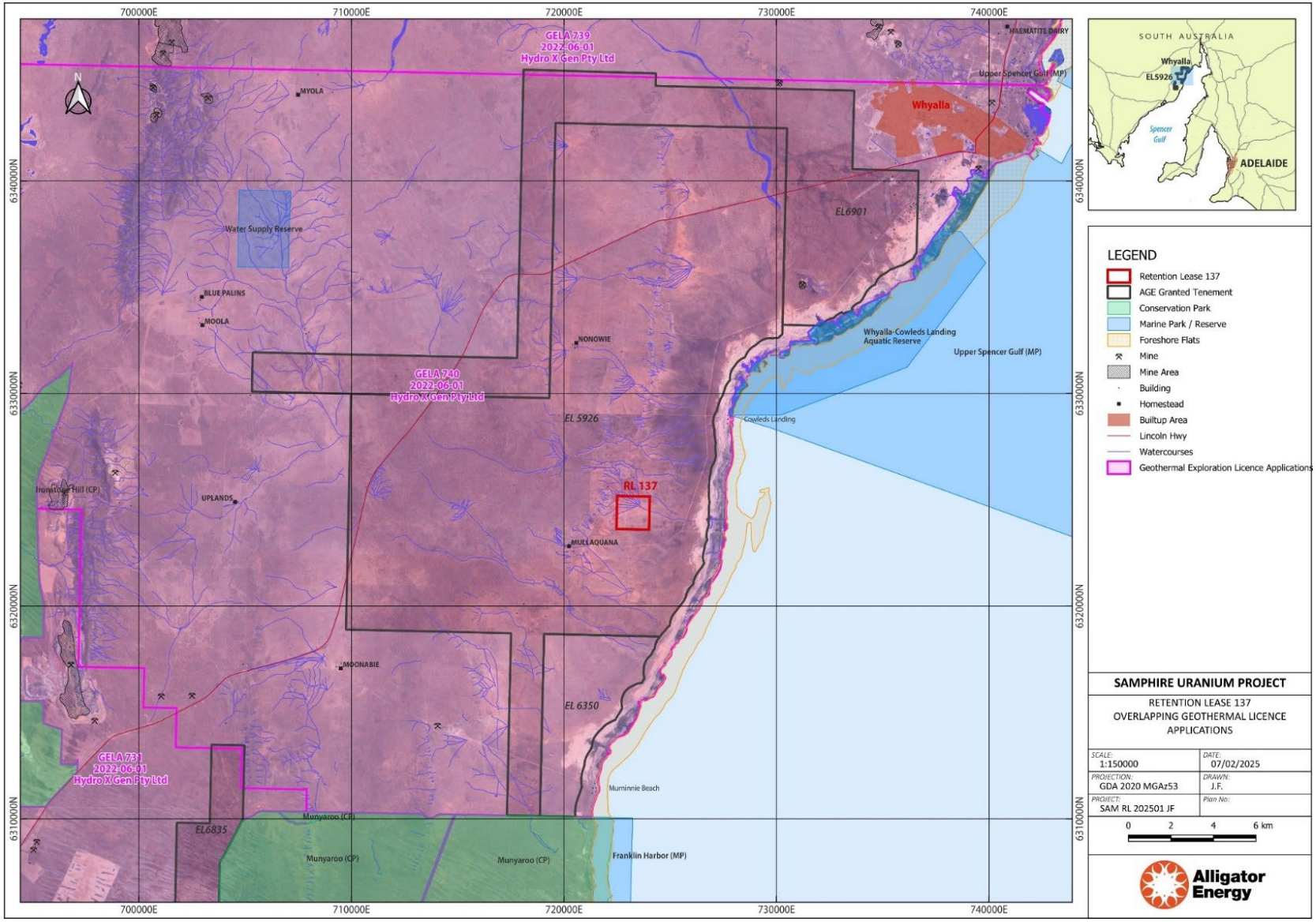


Figure 2.21: Overlapping geothermal licence applications

2.12 Heritage

2.12.1 Aboriginal Heritage

The primary act providing guidance on heritage matters is the South Australian Heritage Act 1988. However Aboriginal cultural heritage values are provided protection by three Acts in South Australia, these are the Aboriginal Heritage Act 1988 (SA), the Commonwealth Aboriginal and Torres Strait Islander Heritage Protection Act 1984 and the Commonwealth Environmental Protection and Biodiversity Conservation Act 1999. To meet requirements of these laws a number of cultural heritage surveys have been undertaken to identify any cultural heritage objects, places or values and to understand strategies to manage appropriately. The Barngarla Determination Aboriginal Corporation (BDAC), representing local Indigenous peoples were requested by Alligator Energy to assist with this program and BDAC engaged consultant anthropologist Dr Dee Gorring to undertake this work with BDAC representatives. Three reports have been completed to date.

The RL area lies within the broader boundaries of the Barngarla Native Title Determination Area (SCD2016/00A; Gorring, 2021). This Determination found Native Title has been extinguished over the Moonabie area, where the FRT activities are planned, as well as over the Mullaquana and Nonowie station areas (Figure 2.22) as can be seen in Croft on behalf of the Barngarla Native Title Claim Group v State of South Australia (No 2) [2016] FCA 724.

No formally registered Aboriginal heritage sites within the RL area or the surrounding Moonabie paddocks (letter DPC08/0356, from Dept Premier and Cabinet, 2009). However, the broader region holds significant cultural and ethnographic importance to the Barngarla people, particularly due to the presence of a Dreaming storyline and ancient travel routes in the landscape (Gorring, 2021; Gorring, 2022; Gorring, 2023).

Alligator Energy has conducted three heritage surveys in the RL area to date (September 2021, September 2022, and August 2023), with no heritage sites identified in the RL area or immediately adjacent within the Coronation Dam paddock (Gorring, 2021; Gorring, 2022; Gorring, 2023). Additional heritage surveys will be undertaken, when and as required, for future RL activities to ensure that heritage values continue to be protected and preserved.

2.12.2 Non-Indigenous Heritage

To the west of the RL, the ruins of an abandoned brick and plaster cottage ruin stand atop the escarpment. This structure, likely a remnant of early pastoral settlement, is not formally recognised on any state or national heritage registers.

A search of the South Australian Heritage Places database was conducted in January 2025 to identify any non-Indigenous heritage sites near the RL area (South Australian Heritage Places Database, 2025). There are no national heritage-listed locations within a 20 km radius of the RL area. The closest recorded location is the Gaol Wooden Lockup, located approximately 21 km north of the RL area in Whyalla. Additionally, the Gay Street Cottage, situated on Ekblom Street in Whyalla Norrie, is a state-listed heritage site in the South Australian Heritage Places Database (2025).

Since these sites are located at a considerable distance from the RL area and its associated access roads, non-Indigenous heritage is not considered to have significant implications for the project area (Figure 2.22).

2.12.3 Geological Heritage

Deep Creek geological monument is located 7.9 km to the west southwest of the RL area with the next closest site is Moonabie Range located approximately 38 km to the southwest (Figure 2.22). These locations were sourced from the South Australian Government Geological Monuments Database (2022).

Given their considerable distance from the RL area, geological heritage is not expected to have any impact and is not considered further in this assessment.

2.13 Proximity to Conservation Areas

No conservation areas occur within or are immediately adjacent to the RL area. However, several conservation areas are present in the wider region, which are shown in Figure 2.22.

The RL area does not encroach on the coastal fringe, and the most easterly part of the deposit is located approximately 3.2 km from the high tide mark.

The proximity of conservation areas to the RL area includes:

- The Coastal Intertidal Zone, approximately 2.4 km east of the RL area.
- The Whyalla-Cowleds Landing Aquatic Sanctuary Zone, located approximately 5.4 km northeast of the RL area.
- The Upper Spencer Gulf Marine Park, located approximately 5.5 km to the north-east of the RL boundary.
- A Native Vegetation Heritage Agreement area, located 9 km to the west of the RL area.
- The Munyaroo Conservation Park, approximately 13.5 km south of the RL area.
- The Cuttlefish Breeding Exclusion Zone, approximately 24.4 km northeast of the RL area.
- The Cuttlefish Coast Sanctuary Zone, nationally Heritage listed, approximately 37km northeast of the RL area.
- The Nationally Important Wetlands of the Upper Spencer Gulf, located approximately 24.4 km northeast of the RL area.
- The Munyaroo Conservation Reserve, approximately 25.5 km south of the RL area.

The RL area does not fall within the Adelaide Dolphin Sanctuary, Adelaide International Bird Sanctuary, or any Marine Park.

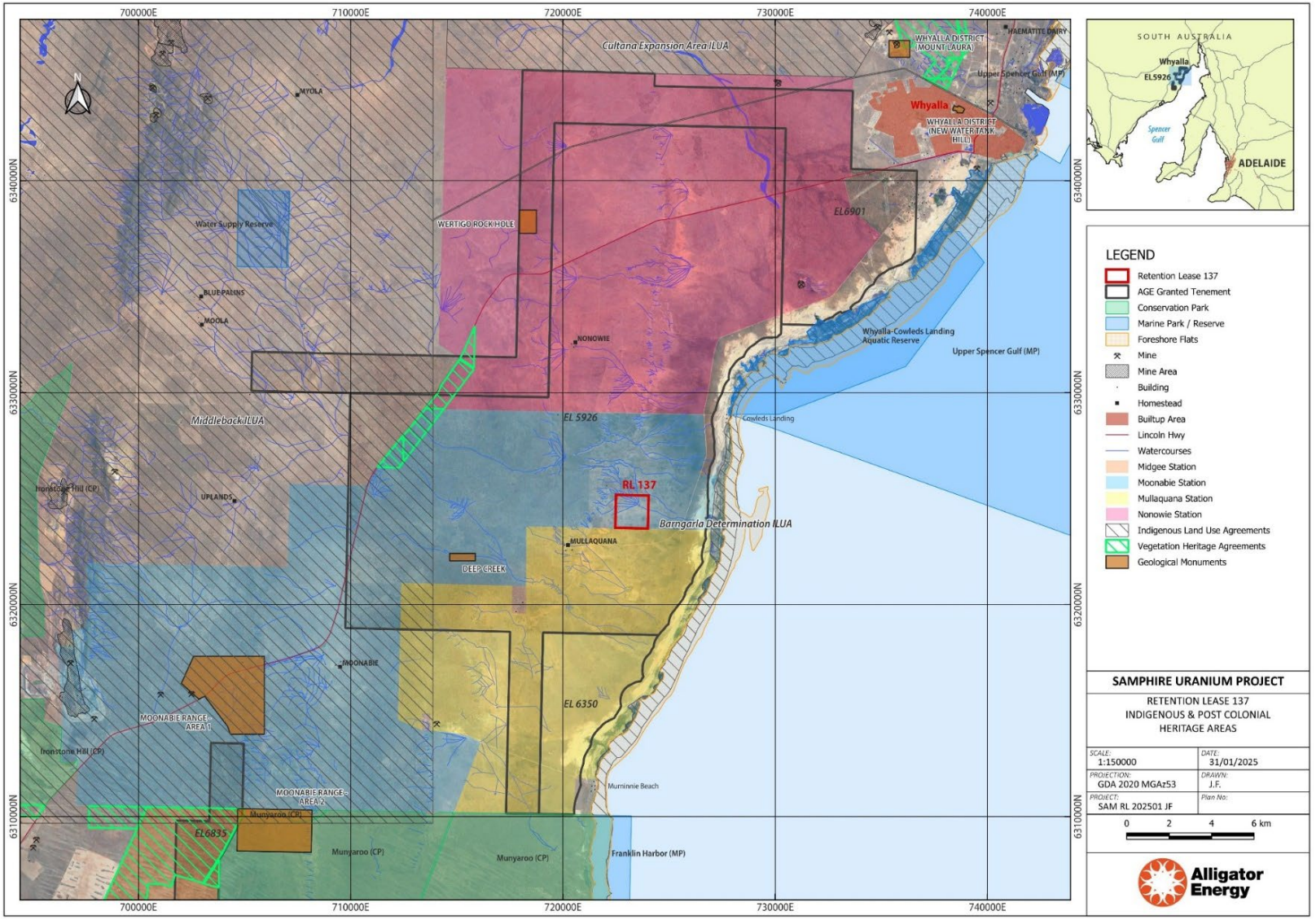


Figure 2.22: Heritage Areas

2.14 Proximity to Infrastructure and Housing

The immediate area in which the RL area lies is sparsely populated. Table 2.5 describes the proximity to infrastructure, Table 2.6 describes proximity to major homesteads and localities surrounding the RL area.

Table 2.5: Proximity to Nearby Infrastructure

Location	Approximate Distance to RL Area	Distance Measured by	Direction from RL Area	Description
Coronation Dam	Inside RL area	N/A	N/A	Used for stock watering.
Pipeline to Mullaquana Station	200 m	Direct line	East	Used to provide stock water to much of Mullaquana stations water points.
Eight Mile Creek Road	~2.1 km	Direct line	East	Minor road.
House Dam, Mullaquana Station	~2.4 km	Direct line	Southwest	N/A
Boundies Dam, Nonowie Station	~2.9 km	Direct line	Northwest	Used for stock watering.
Sheep Yards, Nonowie Station	~4.7 km	Direct line	Northwest	Operational.
Beach Dam, Mullaquana Station	~3.1 km	Direct line	South	Used for stock watering.
House Dam, Nonowie Station	~7.3 km	Direct line	North	N/A
Yarriga Dam, Nonowie Station	~11.6 km	Direct line	North	Storage and stock watering.
Lincoln Highway	~11.8 km	Direct line	West	Principal road.

Table 2.6: Proximity to Homesteads and Major Localities

Location	Approximate Distance to RL Area	Distance Measured by	Direction from RL Area	Population (ABS, 2021)
Mullaquana Homestead	~2.4 km	Direct line	Southwest	Landholders.
Cowleds Landing	~5.1 km	The access route from the RL area	Northeast	No census data available. Part of Whyalla LGA. Some permanent residents reside in this location.
Nonowie Homestead	~7.5 km	Direct line	North	Homestead residents.
Murninnie Beach	~12.2 km	Direct line	South	No census data available. Part of Whyalla LGA. Some permanent residents reside in this location.
Whyalla (LGA)	~23 km	By road	Northeast	~21,960 persons.
Cowell (Franklin Harbour LGA)	~129 km	By road	Southwest	~1323 persons.
Port Augusta (LGA)	~106 km	By road	Northeast	~14,453 persons
Port Pirie (LGA)	~197 km	By road	East	~17,754 persons

Location	Approximate Distance to RL Area	Distance Measured by	Direction from RL Area	Population (ABS, 2021)
Port Lincoln (LGA)	~290 km	By road	Southwest	~14,880 persons
Adelaide	~414 km	By road	Southeast	~1,402,393 persons

2.15 Exempt Land

Coronation Dam and 150 m buffer surrounding it are currently exempt from exploration and mining activities under Section 9 of the Mining Act 1971 (Figure 2.16). Under the Act, no waiver of exemption is required for the stock dam, as the FRT operation is located more than 150 metres of the dam, and furthermore the FRT operating area is fenced off out of the 150-metre area to ensure the multiple land uses are separate in this exempt zone.

2.16 Amenity

The RL area is fully confined to the coastal plain and is essentially flat, with a relief of approximately 0.8 m per 100 m from west to east.

Public access to the coast south of Whyalla is via the unsealed Eight Mile Creek Road to the Cowleds Landing beach shacks, or via the Lincoln Highway for access to Murninnie Beach which is approximately 12.2 km (by direct line) south of the RL area. Other than the immediate coastal fringe, the area is secured from public access due to the locations of the Nonowie and Mullaquana Stations.

Public vantage points with views of the FRT operation are very limited, i.e., restricted to some sections of Eight Mile Creek Road. The Nonowie Homestead and the beach shacks at Cowleds Landing do not have a direct line of sight to the project while the Mullaquana Homestead has partial views over the site.

2.17 Air Quality

Airborne particulates in the RL area primarily result from dust generated by stock movement, pastoral activities, and wind erosion of exposed surfaces. Due to its distance from major industrial pollution sources such as Whyalla, localised emissions are the primary air quality concern. Regional sources of airborne particulates also include mining, extractive operations, and potential future developments such as wind farms and land use changes

Freight transport and vehicle traffic along Lincoln Highway, approximately 11.8 km west of the RL area, contribute to airborne emissions through dust generation and vehicle exhaust, including particulate matter and nitrogen oxides

Potential sensitive receptors in the vicinity of the RL area that may be impacted by changes in air quality include:

- Mullaquana Homestead (approximately 2.4 km southwest).
- Nonowie Homestead (approximately 7.5 km north).
- Cowleds Landing (approximately 5.1 km northeast).

A baseline air quality investigation, focused on dust and radiation, was conducted by On Site Technology (OST) between September and December 2010 (OST, 2011; Appendix M).

Monitoring of total suspended particulates (TSP) at Mullaquana Homestead reported an average ambient dust concentration of 0.016 mg/m³, based on sampling over 11–12 day intervals using a high-volume sampler.

PM_{10} concentrations were measured at Nonowie and Mullaquana homesteads using DustTrak II instruments logging 1-minute interval data. Results showed 24-hour average PM_{10} levels ranging from 0.001 to 0.003 mg/m³, with short-duration peaks of up to 0.2 mg/m³ associated with localised vehicle activity. These peaks typically lasted 1 to 5 minutes and were associated with localised vehicular activity.

These results indicate relatively low dust levels, which may have been influenced by unusually high rainfall during the monitoring period, potentially suppressing dust emissions. Given ongoing and future regional developments, additional air quality assessments may be required to evaluate cumulative impacts from extractive industries, increased vehicle activity, and infrastructure projects such as wind farms.

2.18 Noise

The existing noise environment within the RL area is characteristic of a remote rural setting, with minimal sources of anthropogenic noise. Beyond pastoral activities, there are no current or permanent industrial operations or secondary industries contributing to background noise levels.

To establish baseline conditions, Sonus Pty Ltd conducted noise monitoring at Mullaquana Station from 15 to 29 September 2023 (Sonus Pty Ltd, 2023 in Appendix Q). The monitoring site was strategically selected to represent conditions at the nearest homestead to the RL area. The results confirmed that the acoustic environment is predominantly influenced by natural sources such as wind, fauna, and occasional pastoral activities.

During the monitoring period, the median daytime noise level (LAeq,15min) ranged between 42 and 50 dB(A), while the median nighttime levels ranged between 20 and 31 dB(A) (Appendix Q & R). These findings align with Alligator Energy's preliminary estimates, which suggested that background noise levels would be less than 30 dB(A) during the night and non-windy daytime periods.

Overall, the study confirms that the RL area experiences low baseline noise levels, with minimal anthropogenic contributions. However, future land developments, including potential mining activities, infrastructure projects, wind farms, and expanded pastoral operations, may introduce additional noise sources. Any future changes in land use will need to consider baseline noise conditions and comply with relevant environmental noise regulations to minimise potential impacts on nearby receptors.

2.19 Traffic

The RL area is accessible via Eight Mile Creek Road from the east or a track from Nonowie Homestead, which leads to Lincoln Highway to the northwest (Figure 1.1). Intersection turn-offs which must currently be negotiated to enter/exit the RL area include:

- Junction of Eight Mile Creek Road and the east-west access track to the RL area.
- Junction of the tracks within the RL area.
- Junction of the track to Nonowie Homestead and to Boundies Dam.
- Junction of track from Nonowie Homestead and Lincoln Highway.

- Junction of track between Nonowie Homestead and Boundies Dam and Lincoln Highway.

There has been a total of five road crashes on the Mullaquana road/Eight Mile Creek road between 2016 and December 2020 (PlanSA, 2022).

The annual average daily traffic estimate for a 24-hour period (two-way flow) along the Lincoln Highway was identified to be approximately 1,200 vehicles, consisting of approximately 240 commercial vehicles (22%) (PlanSA, 2022). The Road Safety in the Eyre Peninsula Region fact sheet (DPTI, 2015) identified 30 serious accidents for the Whyalla council area from 2010 to 2014.

2.20 Pre-existing Site Contamination and Disturbance

As outlined in Section 2.11, the RL area is located within Moonabie Station, which has a long history of sheep grazing. There are no known prior industrial activities, pre-existing contamination, or significant disturbances within the RL area or its immediate vicinity, except those associated with pastoral activities and exploration-related activities.

Pastoral activities have historically caused surface disturbance, primarily through grazing, while exploration activities have led to minor disturbances, such as the construction of drill holes, drill sumps, and the installation of water monitoring wells. These exploration-related disturbances have been addressed through ongoing surface remediation and revegetation efforts.

These disturbances, particularly those from pastoral activities, have contributed to surface degradation, including soil erosion, loss of vegetation strata, and the invasion of weeds, as detailed in Section 2.3. The RL area exhibits moderate levels of disturbance, with visible impacts including vegetation depletion, bare ground, tracks, and patchy soil crusting.

In addition, soil sampling carried out on Moonabie and Mullaquana stations between 2010-2013 (as detailed in Section 2.3) found that soil pH levels ranged from 6.28 to 10.2, with an average of 8.5, indicating generally alkaline conditions. The sampling did not indicate any significant contamination or acid sulphate soils, supporting the conclusion that pre-existing contamination is unlikely within the RL area.

2.21 Natural Radioactivity

A baseline radiation and air quality assessment was conducted by On Site Technology (OST) between September and December 2010 to establish ambient background conditions (OST, 2011; Appendix M). The investigation included total suspended particulate (TSP) sampling, long-lived alpha activity measurement, and continuous radon monitoring at selected locations near the RL.

At Mullaquana Homestead, TSP was sampled using a high-volume air sampler operating over 11–12 day intervals, with an average dust concentration of 0.016 mg/ m^3 recorded. Concurrent analysis of filters reported an average long-lived alpha activity of 0.029 mBq/ m^3. The contribution of naturally radioactive particles in local dust to alpha activity was estimated to range between 5% and 50%, with the balance attributable to atmospheric Po-210, a decay product of natural radon.

PM_{10} levels were recorded at both Nonowie and Mullaquana Homesteads using DustTrak II instruments logging at 1-minute intervals. 24-hour average PM_{10} concentrations ranged from 0.001 to 0.003 mg/ m^3, with short-duration spikes up to 0.2 mg/ m^3 associated with localised vehicular activity. These short peaks typically lasted 1–5 minutes and had minimal influence on

daily averages. All dust concentrations were considered low and may have been further reduced by above-average rainfall during the monitoring period.

Radon and Radon Progeny

Radon levels at Nonowie Homestead exhibited typical diurnal variation, ranging from 10 to 30 Bq/m^3, with occasional peaks up to 45 Bq/m^3. Measurements at other monitoring locations were broadly consistent, with an overall average of 16 Bq/m^3, except at Cowleds Landing, where levels were lower (8 Bq/m^3), consistent with its coastal location and reduced inland radon flux.

Radon progeny concentrations followed a similar trend. The average at Cowleds Landing was 10 nJ/m^3, compared to an average of 17 nJ/m^3 at inland locations. These values are consistent with background levels reported for other arid inland regions of South Australia, including Olympic Dam, Woomera, and Honeymoon.

Vegetation Radionuclide Assessment

As part of the baseline assessment, vegetation samples were collected to evaluate radionuclide content. Pearl bluebush (*Maireana sedifolia*) was sampled from three reference sites within the RL area in September 2010. These sites were chosen to reflect similar geological, meteorological, and land use conditions across the region.

Samples were analysed for radionuclide concentrations, with ^{232}Th and ^{210}Pb consistently detected above analytical detection limits. Other nuclides were generally at or below the detection threshold, except for one woody sample that exhibited significantly elevated ^{232}Th levels. Full results are available in Appendix M.

Baseline Gamma Radiation Survey

A baseline gamma radiation survey was conducted within the RL area in December 2022. The recorded average gamma dose rate at 1 metre from the ground surface was 0.04 µSv/h, with a maximum recorded value of 0.22 µSv/h. Survey results are provided in Appendix N.

Hydrological Radioactivity

The concentrations of naturally occurring radionuclides in local groundwater and surface water are addressed in Section 2.6 and Section 2.7, respectively.

3 EXPLORATION ACTIVITIES

Exploration activities within the RL area will primarily aim to further define the boundaries and characteristics of the identified resource, examine hydrogeological and geological conditions, and assess the potential for resource extension. These activities will be conducted by a multidisciplinary team of highly qualified geologists, hydrogeologists, geophysicists, and licensed drillers, ensuring that industry standards are met and exceeded throughout the process. The exploration methods employed will incorporate a range of remote sensing, surface sampling, and drilling techniques to gather data necessary for advancing the project.

3.1 Exploration Methods

The following exploration methods may be employed within the RL:

Drilling:

Rotary mud or core drilling will be used to obtain geological and mineralogical samples from different depths and locations within the RL area. These methods will provide vital information regarding the mineralisation and the structure of the deposit. Drillhole spacing will be strategically designed to allow accurate resource modelling and well placement. Additionally, investigation wells may be drilled specifically for baseline groundwater quality assessment and further hydrogeological analysis.

Geophysical Surveys:

Geophysical surveys will play a key role in identifying potential mineralised zones and refining geological models. These surveys may include magnetic, gravity, and seismic methods. Non-invasive techniques will be employed where possible to avoid surface disruption, particularly when mapping the subsurface geology. Airborne surveys using fixed-wing or rotary-wing aircraft may also be used to cover larger areas and collect high-resolution data, which will help in delineating key areas of interest for drilling.

Geophysical Logging:

Geophysical logging of drilled holes will be performed to obtain detailed subsurface data. This will help in the interpretation of rock types, mineralisation, and other geological characteristics, guiding further exploration and resource definition.

Metallurgical Testing:

Collected samples may undergo metallurgical testing to determine the mineral content, amenability to recovery methods, and the optimal processing techniques.

Hydrogeological Testing:

A series of hydrogeological tests will be conducted, including pump tests, to assess the movement of groundwater, aquifer characteristics, and the potential for water supply for operations.

Environmental Baseline Data Collection:

As part of the exploration activities, baseline environmental data may also be gathered, including soil, vegetation, and fauna surveys.

3.2 Exploration Equipment

The following equipment is routinely utilised during exploration activities:

- Drilling Rigs: Various types of drilling rigs will be used depending on the method, including rotary-mud rigs, auger rigs, and aircore rigs, to drill holes for resource delineation and hydrogeological testing.
- Water Tankers: Used to provide water for drilling operations and to support cooling and dust suppression during drilling activities.
- Support Trucks: These trucks are essential for handling drill rods and transporting drill pipes to and from drill sites, ensuring efficient operation and quick turnaround times.
- 4WD Vehicles: All-terrain vehicles for transportation to remote drill sites, ensuring access through difficult or rugged terrain typical of exploration areas.
- Geophysical Logging Trucks: Equipped with specialised equipment to perform downhole geophysical surveys and collect data on mineralisation, formation properties, and other geological features.

3.3 Exploration Management & Progressive Rehabilitation Practices

Alligator Energy has implemented enhanced environmental management practices that exceed standard industry protocols. These practices, developed in consultation with Natural Resources Management (NRM) experts (most of which work in the local area), aim to minimise land disturbance and enhance site rehabilitation.

A review of the success these practices can be found in Appendix G.

Key environmental management measures include:

<u>Vegetation Management</u>

- Revegetation efforts, including the application of fresh endemic seed to aid in ecosystem restoration (Figure 3.1).
- Use of Chenopod rolling (instead of grader clearing) for vehicle and drill rig access, preserving root structures for natural regrowth (Figure 3.2).
- Ongoing monitoring and protection of listed flora species, to the west of the RL.

<u>Weed and Pest Control</u>

- Strict hygiene protocols to prevent the introduction of new weed species (e.g., Buffel Grass).
- Regular weed control programs, including targeted spraying (e.g., Bathurst Burr).
- Rabbit control measures, including exclusion fencing of rehabilitated drill pads.

<u>Erosion and Soil Protection</u>

- Installation of run-off control structures to prevent soil loss along historical tracks.
- Implementation of hydroseeding programs using diverse native seed mixes, collected annually from Moonabie Station.
- Ongoing assessment of rehabilitated drill pads, demonstrating strong vegetation recovery compared to unfenced control areas (see Appendix G).

Wildlife and Habitat Protection

- Monitoring of listed bird species, including fencing of critical habitat areas.
- Increased native vegetation cover and plant diversity, leading to higher biodiversity and improved habitat quality.
- Recording of sightings of rare species, such as the Striated Fieldwren, in successfully rehabilitated areas.
- Control of feral predators and competitors, installation of habitat (nestboxes).

Collaboration with Landholders

- Engagement with pastoralists to address land management challenges.
- Knowledge-sharing and manpower support, including paddock scale Bathurst Burr removal and native seed collection assistance for neighbouring landholders.

Progressive Rehabilitation and Decommissioning

The rehabilitation and decommissioning of exploration sites is carried out progressively to ensure that disturbed areas are restored to a stable, environmentally sustainable condition. Key rehabilitation and decommissioning methods include:

- Drillholes: Drillholes will be decommissioned in accordance with the South Australian *Mineral Exploration Drillholes - General specifications for construction and backfilling (M21)* (DSD, 2012). Where drillholes intersect aquifers, sulphate-resistant cement grout will be installed to seal any water-bearing zones. The grout will extend through the aquifer and into adjacent confining beds to prevent cross-aquifer groundwater flow, in line with M21 specifications. For drillholes not intersecting aquifers, backfilling will be completed using drill cuttings, clean fill containing clay, or cement grout. Surface casing, where installed, will be removed or cut off at a minimum depth of 300 mm below ground surface (or 0.5 m where specified), and the remaining void will be backfilled with in-situ spoil. The surface will then be compacted to reduce the risk of subsidence.
- Drill/Mud Pits: Drilling muds and cuttings will be backfilled into the base of the pits and the area will be backfilled once dry. Soil layers will be reinstated in their natural sequence to support effective restoration and promote native revegetation.
- Drill Sites: Drill pads, pits, and holes will be graded and scarified to reinstate natural topography. Native species will be seeded using local seed sources to encourage biodiversity and prevent erosion.
- Temporary Access Tracks: Temporary tracks will be evaluated for disturbance, and where necessary, will be ripped or scarified and seeded to promote revegetation and prevent soil erosion.
- Equipment and Infrastructure Decommissioning & Waste Disposal: All exploration equipment and temporary infrastructure will be removed, and waste materials will be disposed of appropriately.

These management practices aim to minimise environmental impacts and ensure effective land rehabilitation.



Figure 3.1: Fencing around rehabilitated drill pad to remove rabbit and sheep grazing pressure on freshly sown endemic species.



Figure 3.2: Drill pad rolled with the wheels of a loader, rather than cleared with a blade, Pearl Bluebush (*Maireana sedifolia*) observed resprouting.

4 CONSTRUCTION & OPERATIONAL ACTIVITIES

4.1 Introduction

This section outlines the physical construction and operational execution of the FRT, detailing the methods, infrastructure, and sequencing of works required to safely and effectively conduct in-situ recovery (ISR) uranium extraction at the Samphire Project.

The content in this section is focused on describing what will occur during the construction and operational phases, including:

- Field layout and infrastructure installation.
- Sequenced ISR process steps and reagent use.
- Waste handling, containment and disposal.
- Supporting utilities and safety systems.

It provides a full technical description of how the FRT will be implemented, from groundwater preconditioning and ISR wellfield design through to the handling of eluate, liquid residues, and decontamination procedures.

Regulatory approvals, environmental criteria, and compliance monitoring frameworks are not the focus of this section and are instead detailed in Section 7 – Regulatory Frameworks & Environmental Management. That section should be referred to for all information related to licence conditions, monitoring requirements, performance criteria and reporting obligations.

4.2 Field Recovery Trial - Overview

Alligator Energy's FRT is designed to assess the technical feasibility and associated economic viability of a full-scale ISR uranium mine at the Samphire uranium deposit. The trial will employ a small-scale ISR process to generate essential data for assessing key aspects of the ISR method, including:

- Assessment of field uranium recovery rates and process recovery efficiency.
- Evaluation of lixiviant performance and wellfield chemistry.
- Analysis of wellfield flow rates and well array configuration performance.
- Testing of ion exchange resin loading, washing and elution.
- Assessment of uranium recovery from hyper-saline solutions using chelating ion exchange resins.
- Determination of water balance and design criteria.
- Evaluation of water disposal options.
- In field verification of natural attenuation modelled predictions.
- Estimation of preliminary operating costs for financial analysis.

4.2.1 In-Situ Recovery & Processing Techniques

In-Situ Recovery

In-situ recovery (ISR) is a method of extracting uranium directly from underground deposits without the need for traditional mining techniques like open-pit or underground mining. This process involves injecting a specially prepared chemical solution, known as lixiviant, into the uranium-bearing formation. The lixiviant dissolves the uranium from the rock, and the uranium-

laden solution is then pumped back to the surface, where it is processed to separate the uranium from the liquid. The technique is highly targeted, allowing the extraction of uranium from specific areas of the deposit while leaving the surrounding rock largely undisturbed.

The advantages of ISR are numerous, particularly in terms of its environmental and economic benefits. ISR minimises surface disturbance since it does not require excavation or large-scale earth-moving, which significantly reduces land disturbance. This method also uses significantly less water and energy compared to traditional mining methods, improving resource efficiency and lowering the overall environmental footprint. Additionally, ISR generates much less waste, as no overburden is removed, and limited waste is created. Overall, ISR offers a cleaner, safer, and more cost-effective alternative to traditional uranium mining techniques.

The ISR process to be utilised at Samphire during the FRT involves several key steps:

- Groundwater Treatment: The first step in the ISR process is the treatment of groundwater extracted from the target aquifer. The water is treated to remove excess salts and/or impurities, ensuring it has the proper chemical composition required for uranium extraction.
- Groundwater Conditioning: The treated water is then conditioned with specific reagents and oxidants to form a lixiviant solution (i.e., sulphuric acid, ferric sulphate, hydrogen peroxide). This lixiviant is designed to dissolve uranium from the surrounding rock formations and create a uranium-rich solution.
- ISR Mining: The lixiviant is injected into the uranium-bearing formation via a series of wells, where it is drawn through the rock to dissolve the uranium, and extracted via a centrally located extraction well. The extraction well transfers uranium-bearing solution back to the surface, where it undergoes further processing. The lixiviant, after being stripped of its uranium content during processing, is reconditioned and recycled back into the wellfield for reuse.

Uranium Processing

Upon reaching the surface, the uranium-laden solution, known as Pregnant Leach Solution (PLS) undergoes a partial processing sequence during the FRT to evaluate key parameters of the ISR process. The FRT focuses on the initial stages of uranium recovery, with no final product produced, as the uranium remains in solution.

The first step in surface processing is Ion Exchange (IX), where uranium is selectively adsorbed onto resin beads, concentrating it from the pregnant solution. Following this, the resin undergoes Elution, where 0.2 wt % sulphuric acid and salt solution is used to desorb the uranium from the resin, resulting in a concentrated uranium eluate. This eluate is stored in bunded tanks for further analysis and assessment.

In a full-scale ISR operation, the eluate would continue through additional steps, including precipitation, thickening and drying yielding a concentrated uranium product commonly U_3O_8 (yellowcake), which is ready for further refinement and shipping.

To re-iterate, the FRT will conclude at the elution stage, generating critical data on uranium extraction efficiency, lixiviant regeneration, and ion exchange performance, without progressing to uranium precipitation or final product formation.

4.2.2 FRT Infrastructure

The FRT will involve the following operational infrastructure (see Figure 4.2, Figure 4.8 and Figure 4.9):

Wellfield Area:

- Three wellfield arrays, each consisting of 5 wells.
- Connecting pipework and power cables.
- A water storage pond, to contain groundwater generated during hydrogeological test work.
- Groundwater monitoring wells.
- Water supply and liquid disposal wells.

Process Plant Area:

- Portable, prefabricated, containerised IX pilot plant, which contains three small ion exchange columns, and seven eluate tanks.
- Eluate storage tanks.
- Treated and liquid waste storage tanks.
- Reagent and fuel storage vessels and mixing skid.
- Wellhouse and filter skid.
- Portable, temporary diesel power generators.
- One small RO plant.
- Bunded plant area and sump provisions.
- Waste collection and temporary storage areas.
- Portable office/crib room, ablutions and laboratory.

4.2.3 Sequence of Activities

Construction Phase

The construction phase of the FRT is anticipated to take approximately two to three months. During this phase, all necessary infrastructure, systems, and equipment will be established to support the operational stages of the FRT. Additionally, all infrastructure will undergo testing to demonstrate full functionality and system integration before transitioning into the operational phase.

Key activities and milestones during this phase include:

1. Site Preparation and Infrastructure Setup:

- Clearing and grading of designated areas for equipment installation and facility setups.
- Installation or upgrade of temporary access tracks for smooth transportation of materials and equipment.
- Setup of water supply systems, including the installation of groundwater extraction wells and associated storage facilities.
- Well integrity testing and hydrogeological pump testing to demonstrate connectivity between monitoring wells and production wells.
- Construction of plant bunded earthworks and installation of HDPE lining to contain potential leaks or spills.
- Construction of the temporary water holding pond to store groundwater for treatment.

2. Plant and Equipment Installation:

- Installation of a small modular RO plant for groundwater treatment, ensuring all systems are properly integrated.
- Installation of storage facilities for fuel and reagents, along with associated chemical dosing systems to prepare the lixiviant.

- Installation of production and monitoring wells, as well as reticulation pipework, to facilitate lixiviant circulation and uranium extraction.
- Setup of the prebuilt, containerised, three-column Ion Exchange (IX) circuit for processing uranium and concentrating it onto resin.

3. Final Environmental and Safety Protocols:

- Implementation of spill containment bunds and earthen berms to prevent any inadvertent discharge of chemicals or fluids.
- Establishment of fluid control systems to manage all aspects of liquid flow, including leakage detection and emergency containment.
- Installation of temporary office and ablution facilities for operational staff.

4. Commissioning of Systems:

- Sequential testing and commissioning of key infrastructure, including the RO plant, lixiviant conditioning systems, and ISR processing equipment.
- Calibration of monitoring and control systems to ensure proper functionality and safe operation during the operational phase.
- Full integration of all systems, including verification of hydraulic and chemical flows, ensuring smooth transitions between different phases of the process.
- Final safety checks, including system and emergency response protocols, to ensure the safety and reliability of the site before transitioning to full-scale operations.

Upon completion of the construction phase, the site will be fully equipped and ready to transition into the operational phase, which will commence immediately after the construction period.

Operational Phase

The operational phase of the FRT is scheduled to take approximately three months, with the ISR process being implemented sequentially across various wellfield arrays. The trial is expected to begin promptly after receiving operational approvals and will run continuously, 24 hours a day, 7 days a week across two, 12-hour shifts. The primary objective during this phase is to assess the technical feasibility and performance of the ISR process, and key activities are summarised below.

Step 1: Groundwater Treatment

- The operational phase begins with groundwater treatment, where groundwater is extracted from a water supply well within the target aquifer.
- The extracted groundwater undergoes RO to remove excess chlorides.
- Treated RO groundwater is then injected into the formation, with the target wellfield receiving approximately three pore volumes of treated groundwater prior to reagent addition.
- This step is estimated to take 1-2 weeks per wellfield area.

Step 2: Groundwater Conditioning

- Once groundwater treatment is complete, native groundwater is extracted, further treated by RO, and then dosed with typical ISR reagents i.e., sulphuric acid, hydrogen peroxide, and ferric sulphate.
- These reagents form the low pH "mining lixiviant," which is circulated throughout the operational zone, optimising the chemical conditions for uranium extraction.
- The conditioning phase is expected to take less than 1 week.

Step 3: In-Situ Recovery

- The lixiviant is injected into the uranium-bearing formation through a series of wells. The lixiviant dissolves uranium from the surrounding rock as it percolates through the formation.
- The uranium-rich lixiviant is then pumped to the surface for further processing.
- This extraction process is expected to take 2-4 weeks per wellfield, depending on the specific operational parameters.
- Uranium is concentrated onto resin beads in the IX plant.
- The spent lixiviant is reconditioned and recirculated back into the wellfield for additional extraction cycles.
- The uranium-loaded resin is stripped (eluted) to form a concentrated uranium eluate fluid, which is then stored in bunded tanks for further processing.

Throughout the operational phase, various operational adjustments will be made to optimize the performance of the lixiviant, resin, and wellfields, ensuring that the ISR process remains efficient and effective in extracting uranium from the target aquifer.

Care & Maintenance, Decommissioning and Closure

At the conclusion of the FRT and following an evaluation of its technical and financial feasibility, Alligator Energy will determine the next steps regarding the project's progression. If the decision is made to proceed with full mine permitting, Alligator Energy plans to transition key infrastructure into a care and maintenance phase while decommissioning and remediating redundant equipment and infrastructure in preparation for future mining activities. This phase will ensure that any infrastructure not required for the next stage of operations is appropriately managed and secured.

Infrastructure needed for closure (e.g. relating to active groundwater remediation will be retained until closure outcomes have been met.

In the event that full mine permitting does not proceed, Alligator Energy will undertake full rehabilitation of the site, including the removal of all surface infrastructure and materials once closure outcomes have been met. The site will be returned to its original condition to support the continuation of pastoral activities.

Given the short duration of the FRT, no progressive rehabilitation will be undertaken during the trial. Full details on the care and maintenance, decommissioning, and closure process can be found in Section 5.

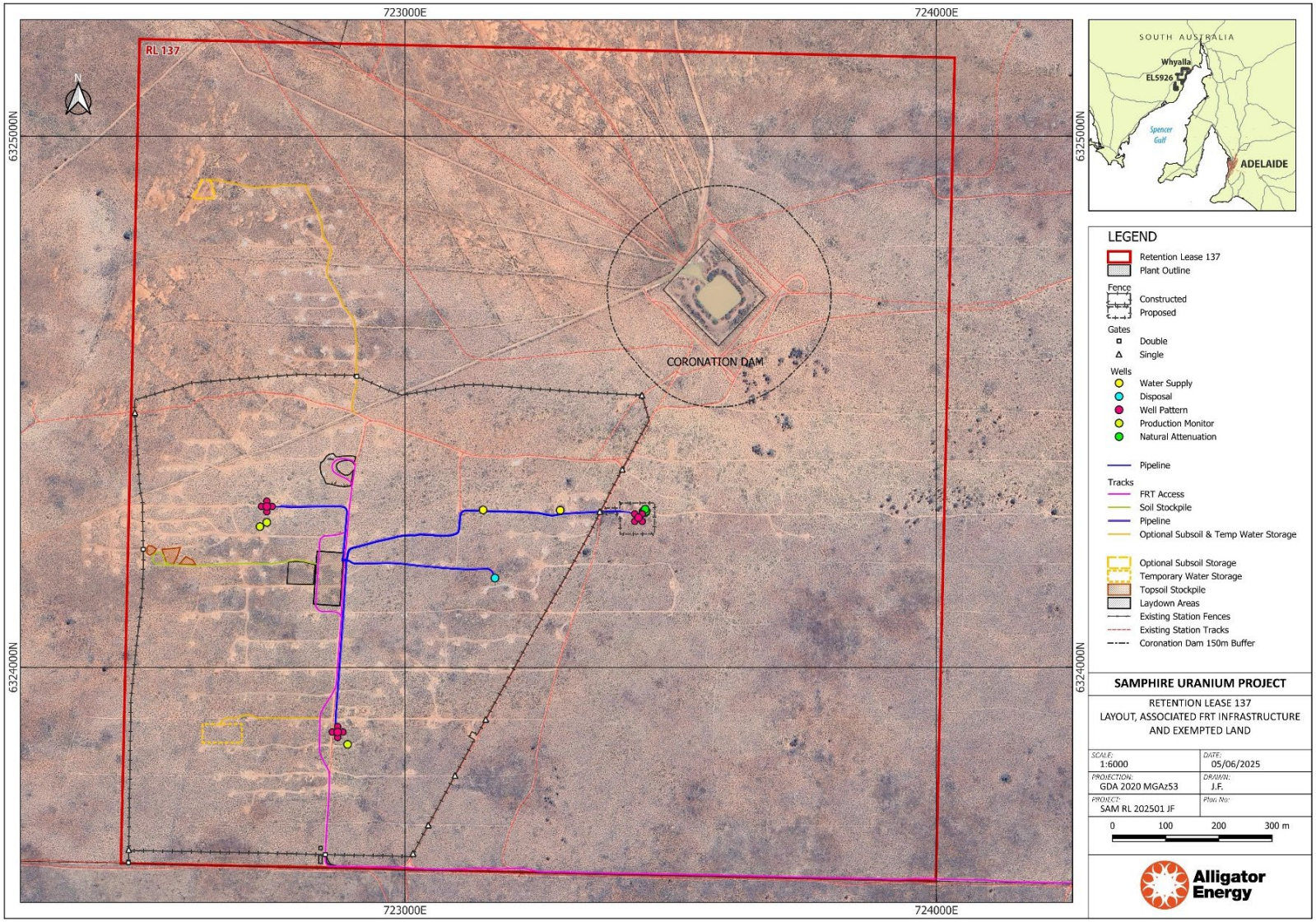


Figure 4.1: General layout of the RL, associated FRT infrastructure and Exempted Land (Coronation dam)

4.3 In Situ Recovery

4.3.1 Operational Description

Stage 1: Groundwater Treatment (Preconditioning)

Alligator Energy's laboratory test work identified that elevated chloride levels in the native groundwater may limit ion exchange resin performance during uranium recovery. To address this, groundwater preconditioning via reverse osmosis (RO) will be implemented as part of an initial groundwater treatment phase to reduce chloride concentrations before the addition of uranium leaching reagents. The use of RO during the FRT will also serve as a test of its effectiveness in managing high chloride levels and improving ion exchange performance under site-specific conditions.

Groundwater from the Tertiary aquifer will be extracted and stored in a Low-Density Polyethylene (LDPE) tank. It will then be filtered to remove sediment, passed through a back-washable media filter for suspended solids removal, dosed with an antiscalant to prevent scaling, and processed through the RO plant to achieve the necessary chloride reduction. The treated, low-chloride groundwater will be reinjected into the Tertiary aquifer at the site of the well array, creating a low-salinity plume, as detailed in Table 2.1 and Table 4.2. This preconditioning phase, anticipated to take 1–2 weeks per well array, will provide essential data on the feasibility of using RO for chloride management in a full-scale ISR operation.

Stage 2: Groundwater Conditioning

The uranium extraction process begins with wellfield pre-conditioning, where sulphuric acid is added to groundwater to create a lixiviant (a recovery solution) that is then circulated between the injection and extraction wells in a closed loop. Once the target pH is achieved, oxidants are added to the injected lixiviant to facilitate uranium leaching from the ore body. Uranium will be recovered from the mining lixiviant via an ion exchange (IX) process.

The following reagents are involved in the conditioning and leaching process, as shown in Figure 4.6:

- Sulphuric Acid (H_2SO_4, 98%) – Lowers pH enhancing uranium solubility.
- Ferric Sulphate ($Fe_2(SO_4)_3$, 42%) – Acts as an oxidant to convert uranium to a soluble state.
- Hydrogen Peroxide (H_2O_2, 50%) – Provides additional oxidation to maintain uranium in solution.

Stage 3: ISR Mining

The ISR mining method utilised for the FRT will incorporate 3 well arrays. The injection and extraction wells will be screened to target a specific mineralised horizon at corresponding depths 2-3 m thick. Wells will be placed 10m apart. Extraction of the uranium from the mineralised zone will use a fortified solution consisting of diluted sulphuric acid (0.2-0.3 wt%) and ferric sulphate which is flushed through the ore zone to dissolve the uranium which is then recovered from the formation via an extraction well. Laboratory testing has shown an optimum recovery will be achieved using a pH of approximately 1-2.

When the circulating leach solution reaches the target uranium content it will be directed to the processing plant for uranium recovery. The barren lixiviant returning from the ion exchange process is regenerated by the addition of sulphuric acid to restore the necessary acidity, hydrogen

peroxide to maintain oxidising conditions, and ferric sulphate to facilitate the dissolution of additional uranium. Once regenerated, the lixiviant is re-injected into the wellfield, ensuring a continuous circulation loop that optimises uranium extraction while minimising reagent loss and promoting efficient resource use.

Up to 0.5% of the of the volume of groundwater circulated (called the bleed stream) will be extracted from the mining fluids at the process plant and directed to the wastewater tank, creating a net negative gradient to ensure mining fluids remain contained within the designated mining zone.

This fluid is then re-injected into the formation at the designated disposal wells along with RO brine generated.

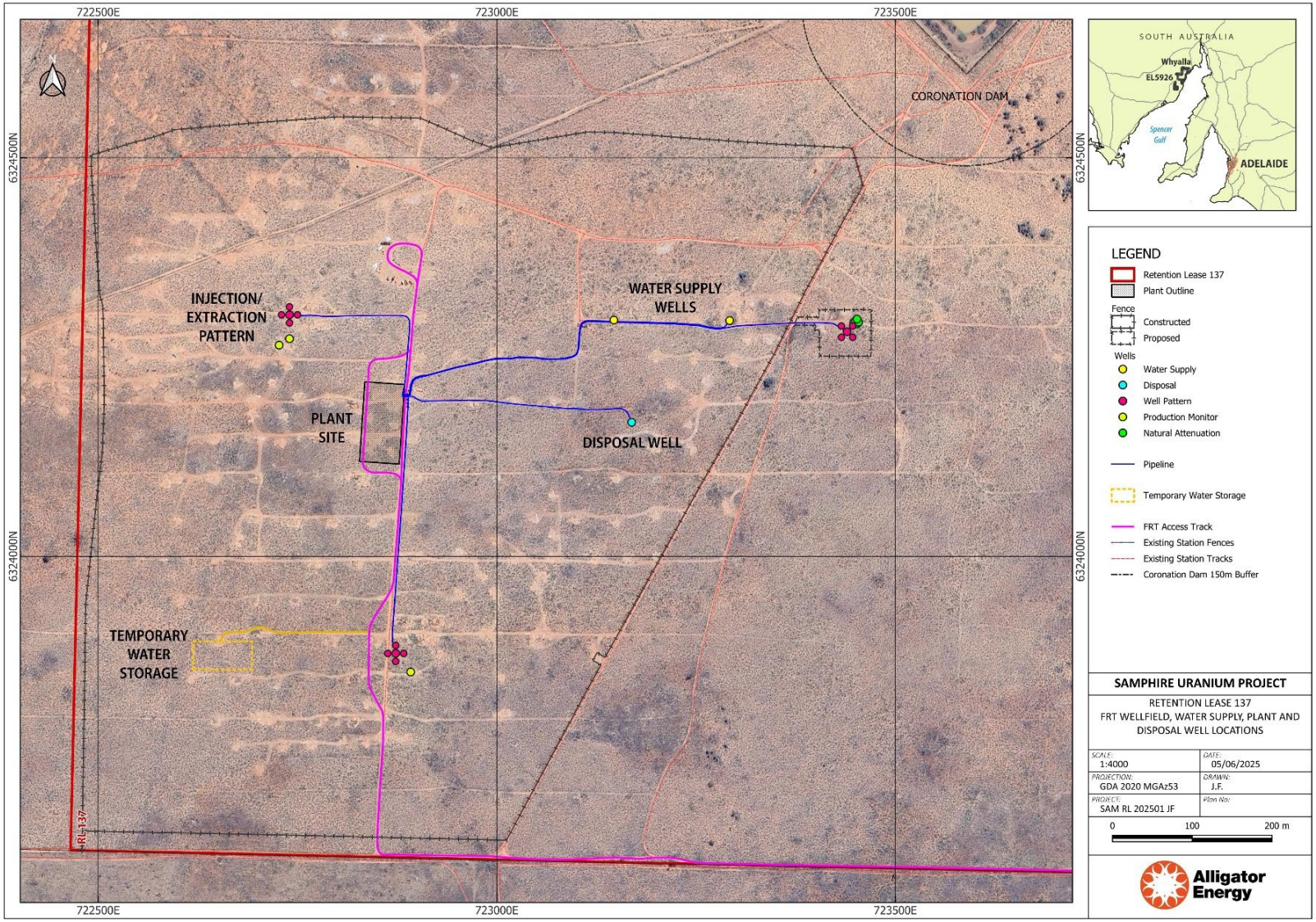


Figure 4.2: FRT Wellfield, Water Supply, Plant and Disposal Well Locations

4.3.2 ISR Infrastructure

Well Arrays

The FRT wellfield will consist of three well arrays, each arranged in a five-spot pattern with one central production (extraction) well surrounded by four injection wells. Wells will be spaced approximately 10 metres apart, with the general layout shown in Figure 4.2.

Each well array will be enclosed by an earthen perimeter berm, 0.3–0.5 metres in height, designed to contain surface water during significant rainfall events and prevent runoff into downstream pastoral areas. The berm will also serve as a containment measure for any potential spill events.

Drip trays will be installed at each wellhead to capture any minor leaks or drips from wellhead equipment, preventing contamination of the surrounding soil and groundwater. Additionally, each wellhead will be fitted with leak detection probes enabling real-time monitoring of potential leaks or equipment failures. These probes will be integrated with an alarm system, ensuring a prompt response to any detected issues.

An example of wells and associated infrastructure within a wellfield are shown in Figure 4.3.



Figure 4.3: Example Wellfield Arrangement – Beverley Uranium Mine (CSIRO, 2004)

Water Supply & Liquid Waste Disposal Wells

Two water supply wells will provide groundwater primarily for the RO plant, with redundancy to ensure uninterrupted supply during maintenance or unforeseen outages. Extracted groundwater will be stored in a low-density polyethylene (LDPE) tank before treatment, producing low chloride permeates for injection during wellfield preconditioning and lixiviant preparation.

Two disposal wells will be installed to inject brine from the RO plant and process waste streams back into the Tertiary aquifer. One disposal well will be drilled as a disposal well, the second disposal well will be a re-purposed liquid waste disposal monitor well, located 20m to the northeast of the primary disposal well. The secondary well will be utilised as a disposal well in the event the primary disposal well is unable to meet disposal needs due to clogging.

These wells will be equipped with drip trays, pressure gauges, and leak detection probes, and will be continuously monitored via the central control system.

Both the water supply and disposal wells will be strategically located within the wellfield and enclosed by perimeter berms to contain any accidental surface spills (Figure 4.2).

Well Construction Specifications

All wells will be drilled and constructed in accordance with national water well construction standards (National Uniform Drillers Licensing Committee, 2020). The process involves:

Drilling

- A pilot hole (100–250 mm) is drilled to just above or below the target depth, depending on well completion requirements.
- Drill cuttings and fluids are contained in sumps constructed adjacent to the well under construction. Sump size will vary based on formation permeability to ensure proper saline water management and prevent spillage.

Geophysical Logging & Sample Collection – Production & Injection Wells

- Geophysical logging tools are used to assess the lithology, hydrogeological conditions, and uranium mineralisation.
- Sample materials are collected and, once well construction is complete, excess samples are returned to the sumps.

Well Casing & Sealing

Wells will be constructed using one of the following three methods, depending on site-specific conditions:

- Two-Stage Under Ream
    - PVC casing (100–150 mm) installed through the target horizon.
    - Cementing of the annulus using sulphate-resistant cement.
    - Under-reaming of the screen zone, followed by the installation of slotted PVC casing and gravel packing.
- Two-Stage Gravel Pack
    - PVC casing (100–150 mm) installed to just above the target horizon.
    - Annular space cemented with sulphate-resistant cement.
    - Target interval drilled out, followed by installation of slotted PVC casing and gravel packing.
- Single-Stage Completion
    - Full casing assembly, including slotted PVC screen, installed as one piece.
    - Cementing of the annular space, with gravel pack added if required.

Schematics of each of these methods are presented in Figure 4.4.

Well Development & Testing

- Wells are airlifted to remove residual drilling fluids and fine sediments.
- Integrity testing is performed at a minimum pressure of 700 kPa to confirm casing and annulus seals.
- Wells will be re-tested after any maintenance or refurbishment involving a drilling rig.

Final Wellhead Installation

- Injection and disposal wells fitted with wellheads and pressure gauges to prevent over-pressurisation.
- Production wells equipped with submersible pumps and wellheads.
- All wells, except monitoring wells, will be equipped with drip trays and level probes for rapid leak detection. These probes will be integrated into a central control system for immediate response to any detected leaks.
- Extraction wells will be fitted with an airline and pressure gauge to allow water level monitoring during operation.
- No provisions are made to monitor quality of injection and extraction solutions at the wellhead, this will occur using inline sensors and routine sampling at the wellhouse.

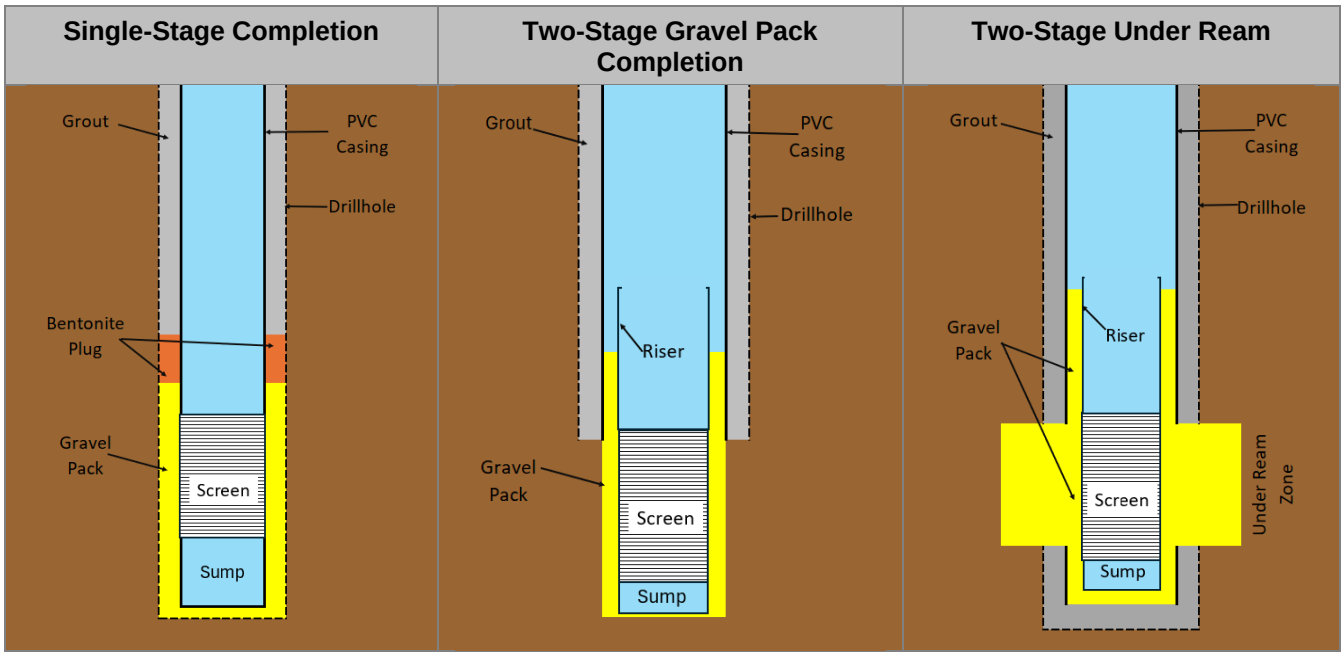


Figure 4.4: Well construction Schematics

Reticulation Systems

The wellfield reticulation system transfers barren lixiviant from the wellhouse and filter skid in the process plant to injection wells and returns loaded lixiviant to the IX pilot plant. Pipework is also used to transfer raw water from the water supply wells to the RO plant and waste solutions to the liquid disposal wells.

Reticulation lines are installed on the surface to ensure minimal soil and vegetation disturbance, and to aid removal. Some lines may be partly buried to enable a vehicle cross over point and/or to manage interaction with other infrastructure.

All reticulation pipework will be bound by perimeter earthen berms to ensure fluid containment in the event of a fluid release. Leak detection will be managed by monitoring pressure and flow differentials in the wellhouse, with anomalies automatically reported to the control room. Differentials are reported to the control room and shutdown of reticulation system is automated.

All reticulation pipework is rated to an operating pressure of 1000 kPa and will be constructed from HDPE pipe poly welded together to form continuous sections. All welds will be subject to formal QA/QC measures and then pressure tested to 1000 kPa with groundwater prior to use.

Pressure testing will conform with relevant industry standards and will be designed to test over the maximum operating pressure of 950 kPa, expected pressures around 400-600 kPa.

Reticulation pipework will typically be constructed using 60 mm lines, although up to 90 mm lines may be used where required.

Wellhouses

During the operation of each wellfield, a fluid control centre, known as a wellhouse, will regulate the distribution of mining fluids between the wellfield and the IX pilot plant. A wellhouse manages flow rates of mining lixiviant injected and extracted from the host aquifer, ensuring mining fluids are balanced and preventing any excursions of fluid outside the operational zone (see Figure 4.4).

During the FRT, each of the wellfields will be connected to a the self-bunded containerised wellhouse located within the bunded plant area. The wellhouse comprises the HDPE pipework, multiple sets of valves, flow meters, and associated leak detection and pressure sensors. Within the wellhouse a level transmitter is installed in the fluid sumps bund which will be used to monitor for potential fluid loss or leaks within the wellhouse itself will be connected to the central control system to enable a rapid response. All pipework within the wellhouse will be pressure tested to a minimum of 1,000 kPa to ensure structural integrity and compliance with industry standards.

Fluid management controls installed in wellhouses will also detect fluid loss within the reticulation pipework, including both trunklines and feeder lines. This will be achieved by:

- Monitoring pressure changes in incoming and outgoing trunkline fluids.
- Detecting flow variations in feeder lines.
- Comparing flow differentials between injection and extraction lines.



Figure 4.5: Fluid Distribution Pipework within the Wellhouse

Filter Skids

A small bank of filters consisting of four filter canisters (two for extraction and two for the injection) will be installed near the wellhouse within the FRT plant to filter mining lixiviant prior to injection and following extraction (see Figure 4.5). A bypass system is set up within the filter bank to enable individual filter cartridges to be bypassed for filter bag changes or maintenance.

Pressure gauges located on the top of each canister, are used to determine when filter bag changes are required. Filtration ensures particulates are removed from the lixiviant prior to entering the IX plant and provide a capture point for any potential resin carried over from the IX process. These filter skids will be installed within the plant bunds.



Figure 4.6: Example Portable Filter Skid

Reverse Osmosis (RO) Plant

A containerised RO plant with a treatment capacity of 125 kL/day will be installed within an earthen bund adjacent to the process plant (see Figure 4.8). The RO process will remove dissolved salts, particularly chlorides, from the extracted groundwater, producing approximately 50 kL/day of low-chloride permeate (40% yield) suitable for injection into the wellfield. The remaining 75 kL/day of brine (60% yield), containing concentrated chlorides, will be transferred to a dedicated storage tank and reinjected into the formation via the liquid waste disposal system.

The RO plant will include a high-pressure pump for membrane filtration, thin-film composite membranes designed to remove high chloride concentrations, and an automated control system managing pressure, flow, conductivity, and alarms. Supporting infrastructure will include piping, valves, and pre- and post-treatment storage tanks.

Water Storage Pond

A water storage pond will be constructed as part of the wellfield development to support pumping tests required during the construction phase. These pumping tests are essential for demonstrating hydraulic connectivity between the wellfield arrays and the perimeter monitoring wells, ensuring that the aquifer system responds as expected to groundwater extraction and injection activities.

Up to 3 megalitres (ML) of groundwater will be extracted from the mineralised portion of the target aquifer during these tests. This water will be temporarily stored in the lined pond and subsequently utilised for FRT operations or exploration drilling activities. Any remaining water at the conclusion

of the FRT operational phase will be re-injected into the aquifer through the disposal well, minimising long-term impacts on groundwater resources.

The water storage pond will measure 35 metres by 35 metres with a depth of 3 metres and will be lined with a 1 mm high-density polyethylene (HDPE) liner, prefabricated and installed as a single continuous piece to prevent potential leaks. A 0.5-metre freeboard will be maintained at all times to prevent overtopping and accommodate stormwater inflows during high rainfall events. Fencing will be installed around the pond for safety and site security, and a surface water diversion berm will be constructed to prevent external runoff from entering the pond, ensuring water quality is maintained.

Topsoil and subsoil excavated during pond construction will be stockpiled separately adjacent to the pond and hydroseeded to reduce erosion and dust generation throughout the operational period. If required, in order to maintain the water storage pond area, excess subsoil may be stored in the optional subsoil storage area. The location of the water storage pond, adjacent soil stockpiles (single area) and the optional subsoil storage area is provided in Figure 4.1.

4.4 Uranium Processing

4.4.1 Operational Description

The uranium recovery process during the FRT will utilise an ion exchange (IX) system to extract uranium from the U-loaded (pregnant) lixiviant. The process begins when the pregnant lixiviant, containing dissolved uranium from the ISR wellfield, is pumped to the IX plant. Within the IX columns, uranium ions are selectively adsorbed onto specially designed resin beads. This adsorption stage ensures that uranium is separated from the bulk of the lixiviant. The barren lixiviant is regenerated and recirculated back to the wellfield.

The loaded resin is periodically subjected to an elution process, where a sodium chloride (NaCl) solution strips the uranium from the resin, producing a concentrated uranium-rich eluate. Following elution, the resin is regenerated using diluted sulphuric acid, which removes impurities, primarily chlorides, preparing it for reuse in the IX system. The uranium-rich eluate is then transferred to dedicated storage tanks within the bunded area of the processing plant for product testing and verification. No uranium precipitation, drying, or final product packaging will occur during the FRT, with all uranium remaining in solution form. The simplified FRT process flow is illustrated in Figure 4.6.

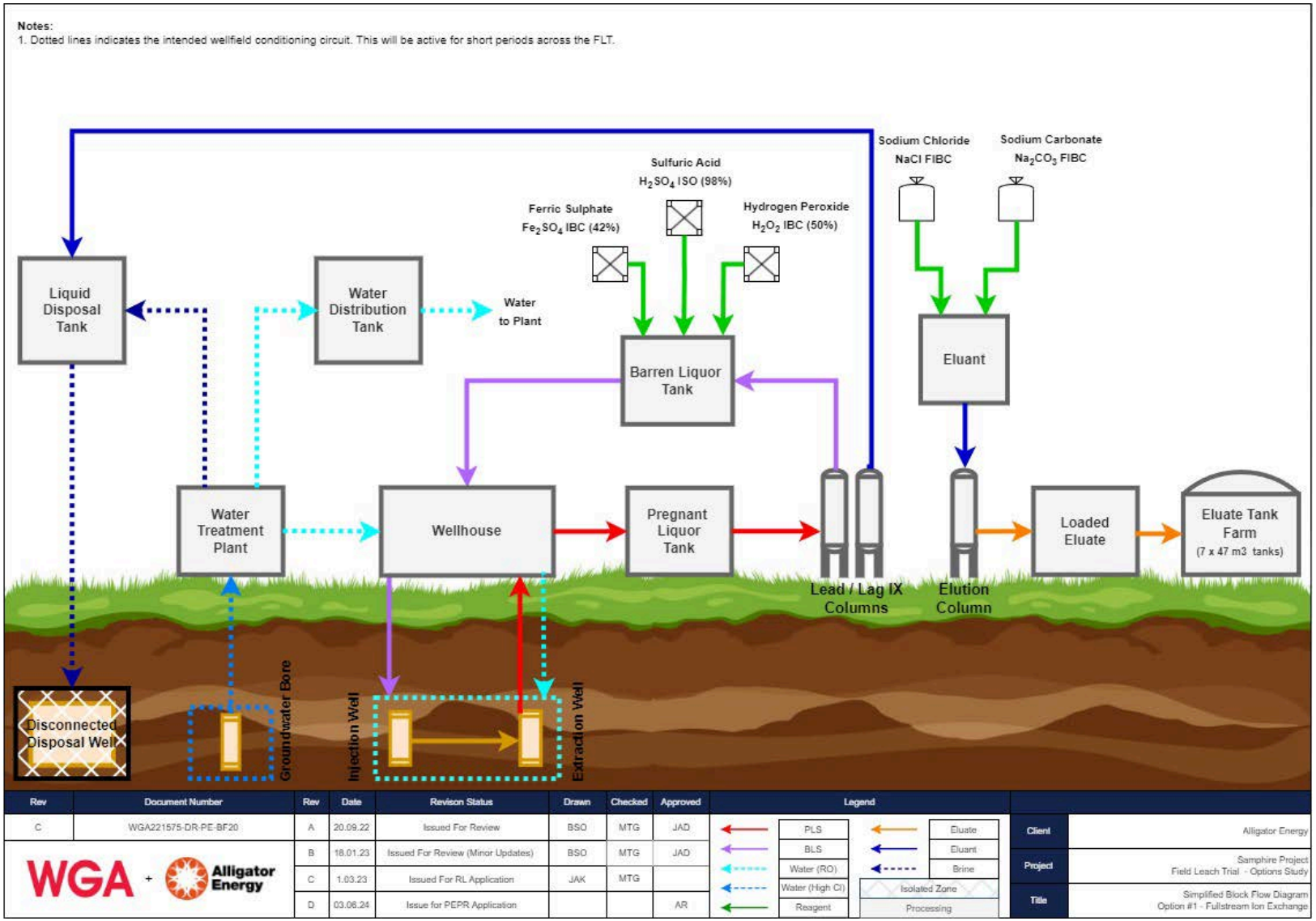


Figure 4.7: Simplified FRT Process Flow

4.4.2 Processing Infrastructure

Ion Exchange Plant

The IX plant is a modular, containerised system housed within a 40-foot container, manufactured offsite and will be delivered to the project area for rapid deployment (Figure 4.7). The plant will consist of three IX columns arranged in a lead-lag-elute configuration to allow continuous processing of pregnant lixiviant. Each IX column has a total volume of 2.4 m^3, with a resin bed volume of 1.536 m^3, optimised for the expected flow rates and uranium concentrations during the FRT.

The columns are constructed from Polyamide PA6, a material selected for its chemical compatibility with acidic and saline process liquors and its structural integrity under process conditions. Automated control valves will manage the flow of lixiviant into and out of each column, with instrumentation installed to monitor flow rates, pressures, and resin loading status. The plant's control system will allow operators to switch between lead, lag, and elute modes through a semi-automated central control board, ensuring operational flexibility and continuous processing.

The IX plant will incorporate several key safety and operational features, including:

- Spill detection systems with sensors positioned within the container bund to detect any leaks from piping, columns, or tanks.
- Level alarms on all process vessels to prevent overflow or dry operation.
- Pressure monitoring systems to ensure all piping and vessels operate within safe pressure ranges.
- Differential pressure sensors across each IX column to detect resin blockages or flow restrictions.

Onsite technicians will monitor the IX plant 24 hours a day during the FRT, conducting routine inspections, responding to alarms, and performing maintenance as required.



Figure 4.8: Containerised IX Process Plant

Eluate Storage Area

Uranium rich solutions produced from elution (IX stripping) will be stored in sealed bunded tanks (eluate farm) for future product testing and verification. Eluate will be stored in up to eight, 46,400 L, ultraviolet stabilised polyethylene tanks (LLDPE), installed within the HDPE double lined process plant bund (Figure 4.8). Each of the tanks will have high level alarm instrumentation installed (ultrasonic or similar).

Liquid Waste Storage

Process bleed streams, washdown water, and RO brine will be directed into a dedicated disposal tank within the process plant's bunded area. A 46,400 L ultraviolet stabilised polyethylene (LLPDE) tank will be used to collect and sample waste waters prior to disposal (see Figure 4.8).

Reagent Types & Storage

Chemicals used during the ISR and IX process will be stored in the central process plant zone. Each reagent will be stored in self-bunded storage vessels, located adjacent to the bulk chemical storage area. Diesel will be stored in a self-bunded portable tank located at the main administration area. Final locations of chemical and fuel and storage areas are shown in Figure 4.8. Chemical storage has been positioned at adequate distances from protected works and public places, including administration areas in compliance with the Dangerous Substances Act 1979 and Dangerous Substances Regulations 2002. Bunding and separation measures align with regulatory and safety guidelines. The quantities of hazardous chemicals intended for use in the FRT have been reviewed against Schedule 15 of the Work Health and Safety Regulations *2012* and are below the threshold limits for classification as a Major Hazard Facility (MHF).

Table 4.1 provides a full list of chemicals, fuels, and storage quantities for the FRT.

Table 4.1: Key Reagents, Volumes & Storage

No.	Chemical/Fuel	Application	On-Site Storage Capacity	Amount Required	Storage Vessel	Bunding Details
1	Sulphuric Acid (H_2SO_4) 98% w/v	Used to acidify leaching solution to enhance the dissolution of uranium.	17,000 L	10,000 L	Self-bunded stainless steel Class-8 Iso tank.	Stored within the central process bund in compliance with the Liquid storage, bunding and spill containment guidelines (EPA, 2016).
2	Sodium Carbonate (Na_2CO_3)	Used in the IX conversion process to optimize uranium extraction.	4 Tonnes	10 Tonnes	Bulk bag in 20' container (1T)	Storage within the central process bund within shipping containers, ensuring appropriate separation distances are maintained from acids.
3	Sodium chloride (NaCl)	Used as a reference to calculate the concentration of other ions in the lixiviant solution.	7 Tonnes	37 Tonnes	Bulk bag in 20' container (1T)	Storage within the central process bund within shipping containers, ensuring appropriate separation distances are maintained from acids.

No.	Chemical/Fuel	Application	On-Site Storage Capacity	Amount Required	Storage Vessel	Bunding Details
4	Ferric Sulphate $Fe_2(SO_4)_3$ 42% w/v	Used as an oxidant to enhance the dissolution of uranium.	4, 000 L	13,000 L	Plastic, rigid, IBC (1,000 L).	Stored on bunded pallets and within the central process bund in compliance with the Liquid storage, bunding and spill containment guidelines (EPA, 2016).
5	Hydrogen peroxide (H_2O_2) - 50%	Used as an oxidant to enhance the dissolution of uranium	2,000 L	5,000 L	Plastic, rigid, IBC (1,000 L).	Stored on bunded pallets and within the central process bund in compliance with the Liquid storage, bunding and spill containment guidelines (EPA, 2016).
6	Diesel	Used to power onsite generators, machinery and vehicles.	10,000 L	200,000 L	Mobile diesel tanker (10,000L)	Double bunded, mobile diesel tanker.

Plant Bund

An earthen bund lined with high density polyethylene (HDPE) will be constructed to house all of the processing infrastructure and associated reagent and eluate storage. The earthen bund will cover approximately 1,300 m^2 in total size and double lined with HDPE. Matting will be placed along specific access areas to enable personnel with an anti-slip walking surface. The bunded area will incorporate a central sump capable of containing at least 120% of the total capacity of the largest tank in accordance with EPA (2016) bunding requirements, as well as any accumulated stormwater. A dedicated sump pump will transfer the contents of the sump contents to the liquid disposal tank for later disposal (see Figure 4.8).

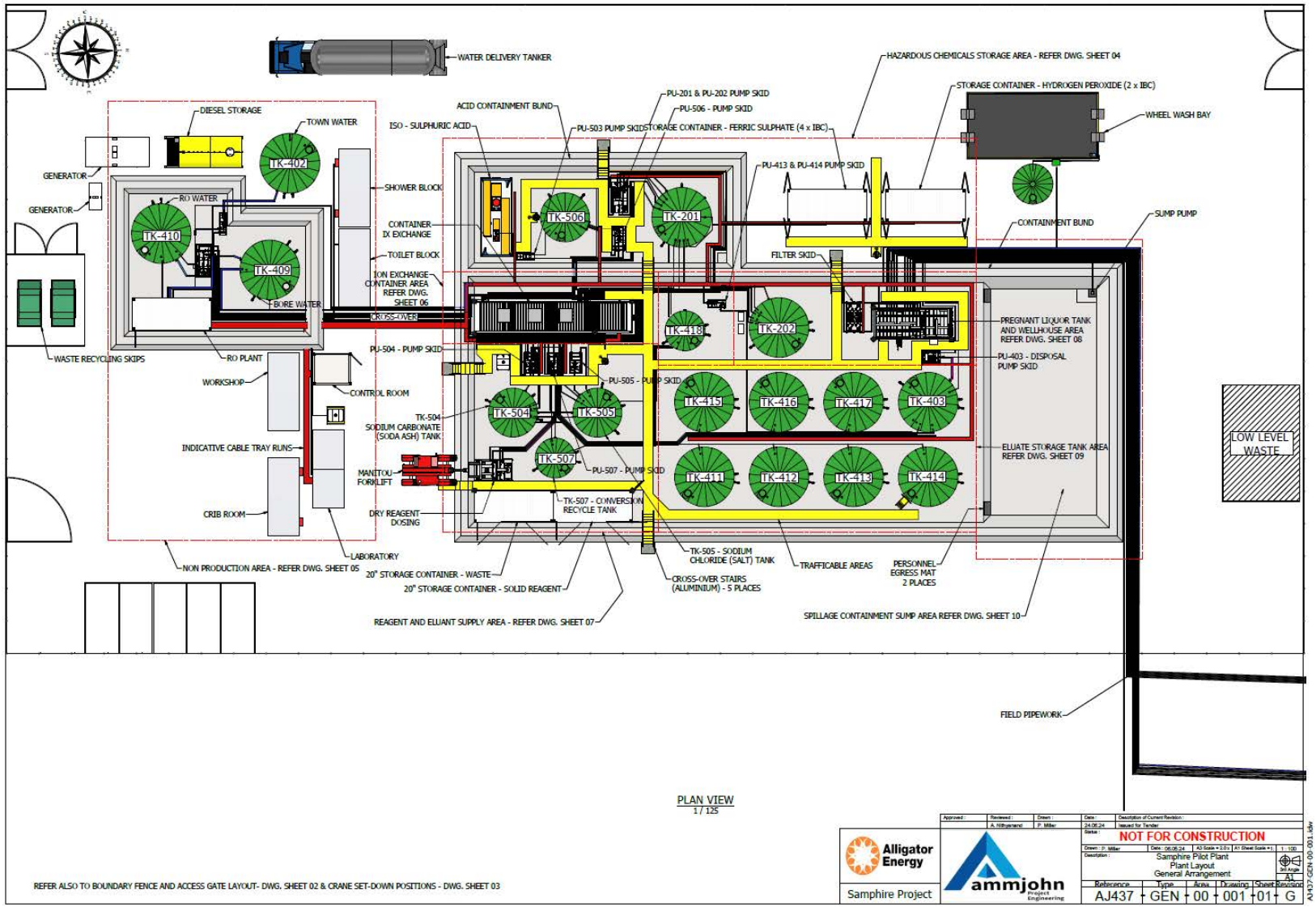


Figure 4.9: Layout of the FRT Processing Plant, Water Treatment Area & Support Infrastructure

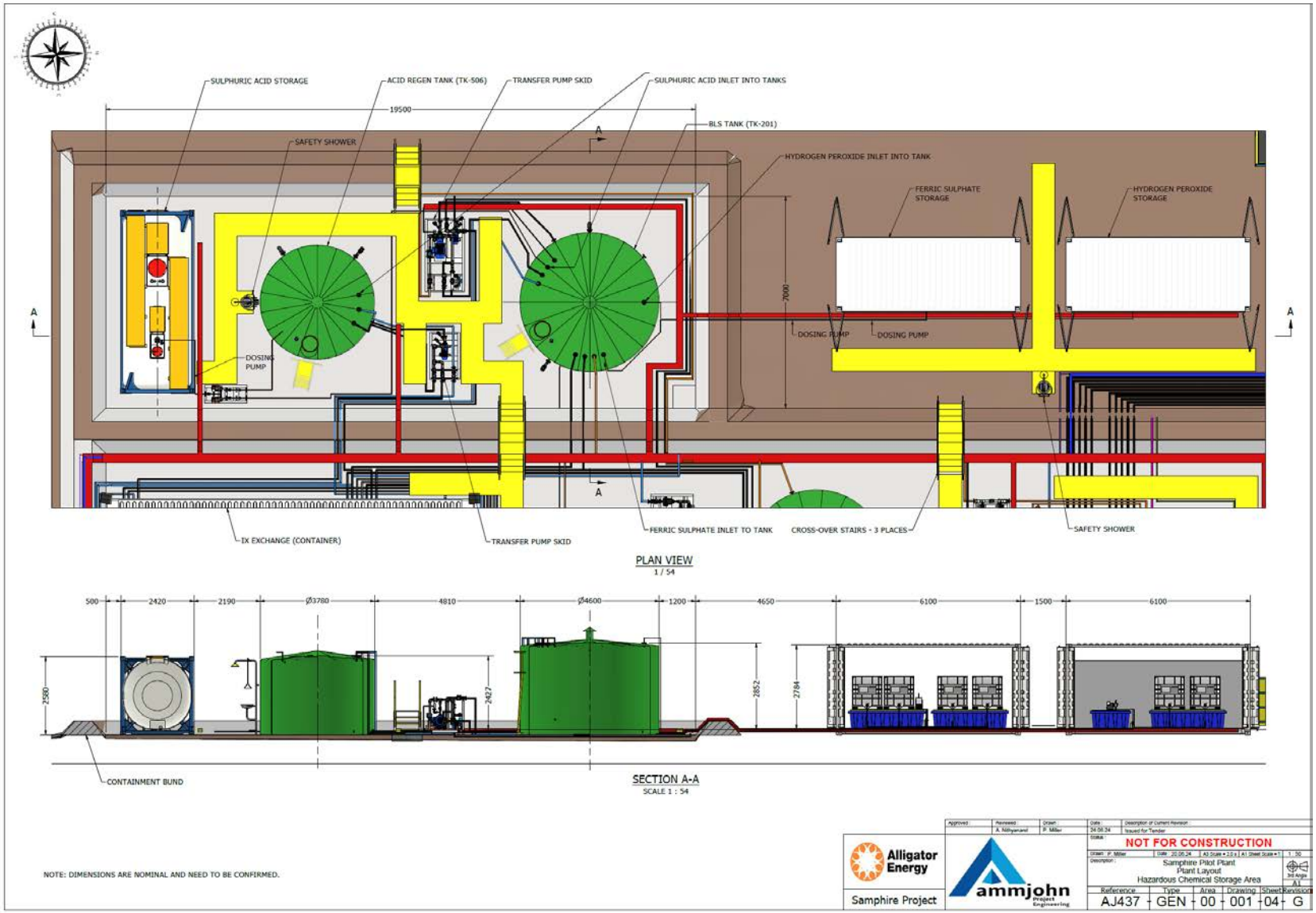


Figure 4.10: Reagent Storage – Within Process Plant Area

4.4.3 Mining & Waste Fluid Compositions

The anticipated chemical and radiological compositions of key mining and waste disposal fluids as determined by laboratory test work is detailed in Table 4.2.

Table 4.2: Predicted Process & Disposal Fluid Chemical & Radiological Compositions

Analyte	Unit	Barren Lixiviant	Pregnant Lixiviant	Eluate	Reverse Osmosis Brine	Liquid Disposal Fluids
U^3O^8 (average)	ppm	2	100	30,000	0	0-0.8
U^3O^8 (min-max)	ppm	0.04-19.76	20-750	10,000 – 50,000	0	0
Chloride	g/L	24	24	100	35-55	35-55
Iron	mg/L	903	903	50	#	#
Sulphate	mg/L	2,438	2,438	10,000	4,998	4,943
Calcium	mg/L	1,113	1,113	500	2,498	2,272
Boron	mg/L	8	8	#	#	#
Silicon	mg/L	25	25	#	#	#
Strontium	mg/L	22	22	#	#	#
Titanium	mg/L	12	12	#	#	#
Phosphorus	mg/L	<1	<1	#	#	#
Molybdenum	mg/L	1	1	#	#	#
Potassium	mg/L	107	107	#	#	#
Aluminium	mg/L	3	3	#	#	#
Magnesium	mg/L	1,423	1,423	#	2,165	1,969
Sodium	mg/L	11,920	11,920	150,000	#	#
Total Dissolved Solids	mg/L	N/A	N/A	N/A	50,000-70,0000	50,000-70,000
Redox	mV	450-550	450-550	400	#	#
pH	units	1.5-1.8	1.5-1.8	5	8	7.5-8

Concentration or value will not be available until the FRT operations commence.

4.5 Supporting Infrastructure

4.5.1 Access Roads & Tracks

No new access roads will be constructed for the FRT. Existing tracks within the RL will be utilised, with maintenance or minimal upgrades undertaken as necessary in consultation with the landholder. Vehicle movements to and from the site will rely on existing public roads, both sealed and unsealed, including Eight Mile Creek Road, which will serve as the primary route for work-related activities throughout the field trial. Access routes to the FRT are illustrated in Figure 4.10. No airstrip will be constructed as part of this project.

4.5.2 Accommodation

Accommodation for personnel during the construction, operation, and decommissioning phases of the FRT will be located off-site in Whyalla area. All personnel working at the FRT will commute to and from the site.

4.5.3 Administration & Support Buildings

A series of temporary, portable ATCO-style buildings will be brought to the RL for the FRT to support site personnel and visitors. These buildings include:

- Crib room and kitchenette.
- Change rooms, toilets and laundry facilities.
- Control room.
- Laboratory.
- Workshop.

The layout of these buildings is shown in Figure 4.8.

4.5.4 Public & Private Services and Utilities Used

Alligator Energy will be providing temporary potable water, with temporary holding tanks used for grey water and sewage management. Power will be supplied by temporary generators. Telecommunications will be provided by the existing Telstra mobile network.

4.5.5 Stormwater, Silt Control & Drainage

The field trial site is essentially flat, with a very slight gradient towards the east. Modified drainage channels have been installed along the surface to direct surface water runoff to the northeast, where Coronation Dam is situated. Within the site, there is a possibility of very shallow sheet flooding up to 80 mm in depth.

Stormwater diversion bunding (whoa-boys) will be installed or repaired on station tracks to redirect stormwater into the existing station dam drains. The intent is to reduce surface water flows reaching the FRT area during storm events.

To manage drainage and potential spill events, an earthen berm up to 0.5 m in height will be constructed around the perimeter of each wellfield pattern and along all reticulation pipelines connecting the wells to the plant. These berms will:

- Protect wellfield infrastructure in the event of a sheet flow flood,
- Manage silt and control runoff in disturbed areas, and
- Ensure non-operational areas are protected in the event of a localised ISR fluid release.

The large size of the earthen berms will allow any stormwater collected to dissipate naturally.

Within the FRT plant structure, a large HDPE-lined sump will be constructed to manage all fluids within the process area, contain stormwater, and prevent environmental releases in the event of a process fluid spill. Any stormwater collected in this area will be treated as liquid waste and pumped to the liquid waste storage tank for underground disposal see (Figure 4.8).

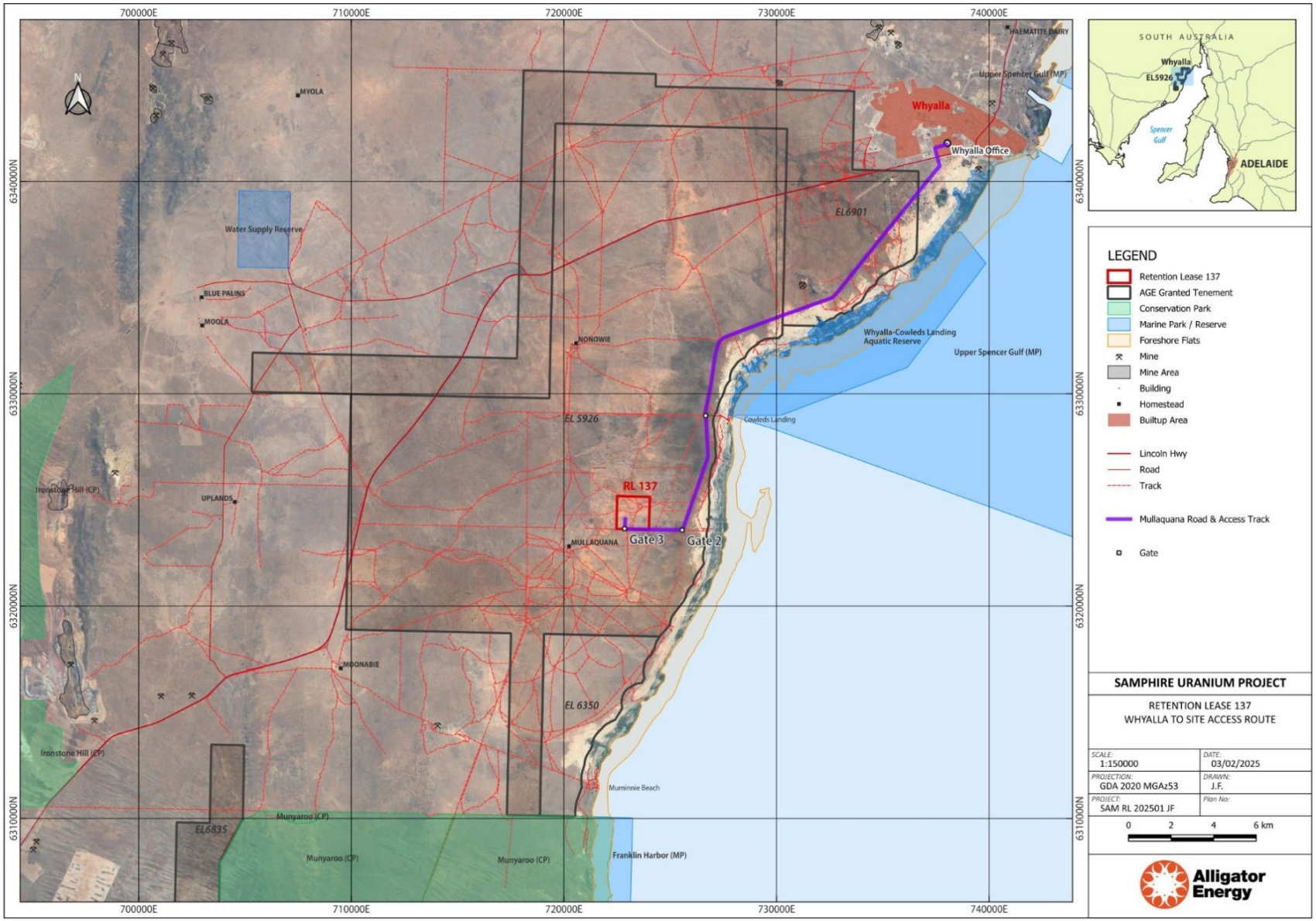


Figure 4.11: Access Route

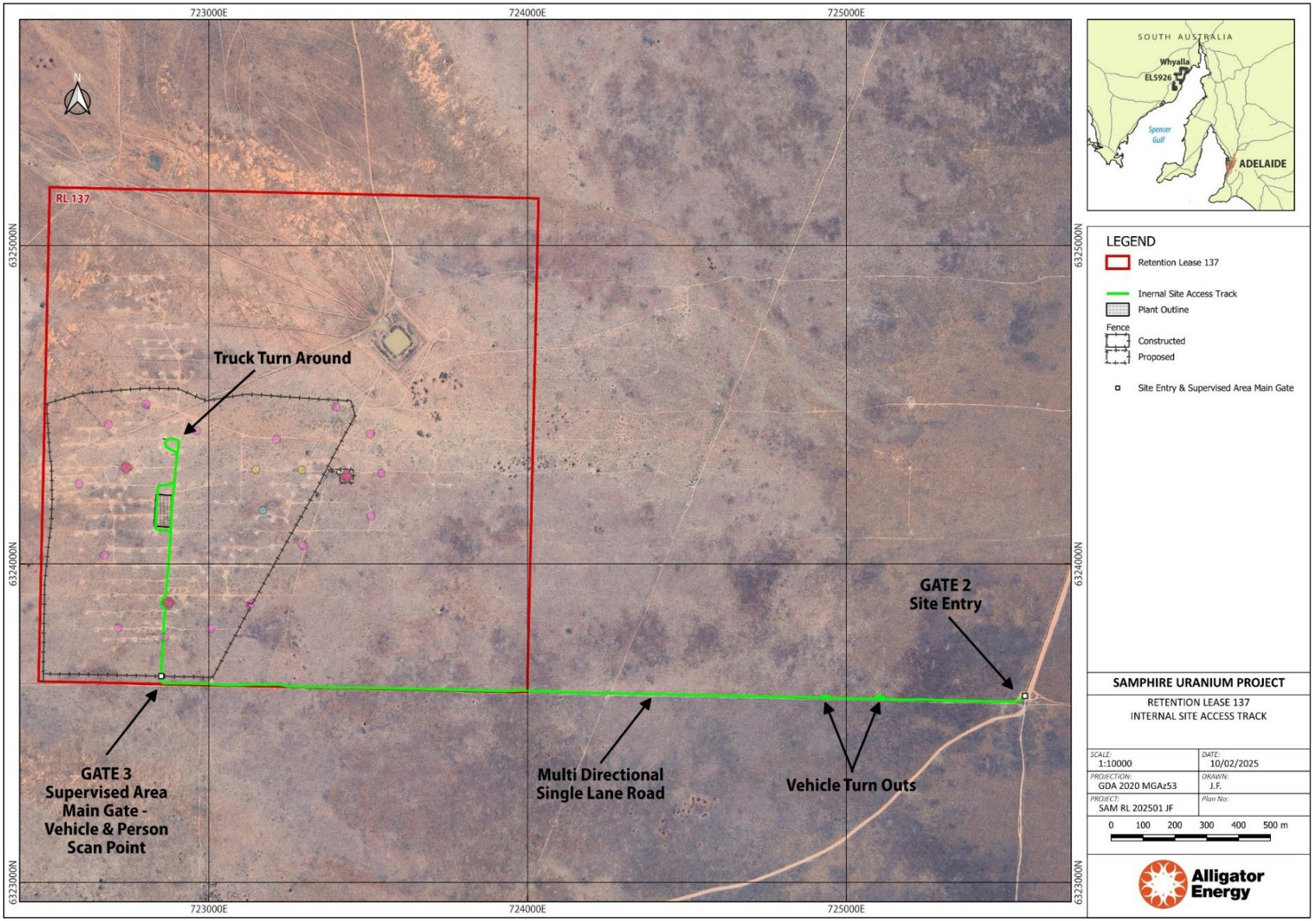


Figure 4.12: Internal Site Access Track

4.6 Wastes & Residues

Wastes generated during the construction, operation, and decommissioning of the FRT will be classified into two broad categories:

1. Low-Level Radioactive Waste (LLRW): Any material or equipment used within the FRT area will by default be classified as low-level radioactive waste, unless assessed and cleared by the Radiation Safety Officer (RSO) against radiological clearance limits.
2. Non-Radioactive Waste: Materials and waste streams that do not contain radioactive residues and have been assessed as below clearance limits will be treated as standard industrial waste.

The classification and management of waste will be conducted in accordance with the Environment Protection Act 1993 and the Radiation Protection and Control Act 2021.

4.6.1 Waste Generation & Management

Key waste types, estimated volumes, classification and disposal method are detailed in Table 4.3.

Table 4.3: Key Waste Types & Estimated Volumes

Classification	Type	Associated Area/ Material	Estimated Volumes	Disposal Method
Non-Radioactive (Industrial) Liquid Residues or Waste	Grey water	• Administration areas. • Ablutions	90 m^3	Grey water and sewage will be trucked to Whyalla by licenced contractors for authorised disposal within Council facilities.
	Sewage	• Toilets		
	Stormwater	• Infrastructure, wellfield & • reticulation areas.	50 m^3	Fluids will be allowed to evaporate or naturally dissipate into subsoils.
	Reverse osmosis (RO) brine.	• Groundwater treatment. • Plant water production.	5,670 m^3	All liquids will be transferred to the liquid storage vessel and then directed to the liquid disposal zone.
	Unused reagents	• Process plant.	1-15 m^3	Fuels or chemicals not utilised during the ISR FRT will be transported off-site by licensed contractors for re-use or disposal.
Non-Radioactive (Industrial) Solid Waste	Packaging and containers (carboard/ glass/ wood/ plastic)	• Construction activities • General consumable use.	20 m^3	Cardboards, plastics and wooden pallets will be recycled at designated sites within Whyalla. Non-recyclable waste will be treated as industrial waste.
	Putrescible wastes	• Crib facilities	5 m^3	Industrial waste will be removed from the site by licenced contractors and disposed of within the Whyalla council landfill facilities.
	Cans, bottles	• Crib facilities	<1 m^3	Cans and bottles will be recycled at designated sites within Whyalla.

Classification	Type	Associated Area/ Material	Estimated Volumes	Disposal Method
	Unused chemicals and fuels	• Process plant. • General administrative area.	2 m^3	Chemicals and fuels not required on conclusion of the FRT will be removed by licenced specialist contractors and returned to the supplier or manufacturer.
	Soil contamination	• Spills of chemicals and or fuels to soil.	<1 m^3	All non-radioactive spills to soil will be excavated and transferred to a licenced disposal or treatment facility.
Low-Level Radioactive Liquid Residue	Washdown water	• Process plant area • Washdown bay. • Laboratory,	5-10 m^3	All waste liquids will be transferred to the liquid storage vessel. During operational phases these fluids will be diluted with RO brine. All fluids will be directed to the liquid disposal zone from the liquid disposal storage vessel.
	Spills	• Spills within bunded areas.	<1 m^3	
	Stormwater	• Stormwater collecting in bunded process areas.	<5 m^3	
	Barren lixiviant bleed	• Bleed stream extracted from the process stream to manage wellfield fluid containment.	100 m^3	
	Residual process solutions	• IX columns • Process & disposal tanks & vessels. • Reticulation pipework.	<85 m^3	
	Resin washing	• Water/mild acid used to rinse and regenerate stripped resin.	530 m^3	
	Eluate	• IX process final product.	370 m^3	Eluate will be temporarily stored within a designated bunded area and will either be processed in future if the project develops into a mine or will be disposed of in accordance with instructions issued by the Minister or a person authorised by the Minister, as per RL 137, 2nd schedule Lease condition 11.
Low-Level Radioactive Solid Waste	Filter bags	• Filter skid operations in the wellfield and/or plant.	5 m^3	All solid low-level radioactive waste streams will be transferred to a designated secure storage area prior to offsite disposal at a licenced low level radioactive waste disposal facility.
	Process sediments and solids.	• Sediments and solids formed in process vessels and pipework.	2 m^3	

Classification	Type	Associated Area/ Material	Estimated Volumes	Disposal Method
	ISR & process components	• HDPE pipework, vessels, infrastructure, bunding and ancillary instrumentation that cannot be decontaminated.	<500 m^3	
	Miscellaneous	• PPE, rags, used tools and materials that cannot be decontaminated.	5 m^3	
	Resins	• Process resins	10 m^3	Resins will be temporarily stored within a designated bunded area and will be either reused in the event the project develops into a mine or will be disposed in a licenced low level radioactive waste facility.
	Drilling by-products	• Sample chips • Drill muds	TBA	Sample material and drill muds generated during the drilling process will be disposed of within the drill sump, with a minimum 2 meters of clean fill over the sump.

4.6.2 Waste Storage & Disposal

Low-Level Radioactive Waste

Secure onsite storage will be maintained for all low-level radioactive waste generated during the FRT, ensuring compliance with the Radiation Protection and Control Act 2021 and associated regulations. Storage requirements and handling procedures will align with the Radiation Management Plan (RMP).

Final disposal will be conducted offsite at an authorised radioactive waste facility, transported by licensed contractors in accordance with regulatory approvals.

Non-Radioactive Waste

All non-radioactive waste will be securely contained in designated waste receptacles before being transported offsite by licensed contractors to authorised facilities for recycling, treatment, or disposal.

Putrescible and general solid waste will be managed in sealed, pest-resistant containers to prevent environmental contamination. Hazardous waste, including chemical and hydrocarbon-contaminated materials, will be stored in bunded areas to prevent spills or leaks.

EPA-licensed operators will be engaged for the collection, transport, and disposal of hazardous materials, ensuring full compliance with environmental protection regulations.

Further details on the management of wastes and associated monitoring and verification programs are provided in Section 7.14.

4.6.3 Liquid Waste Disposal Management

Low-level radioactive liquid residues, consisting predominantly of non-radioactive RO reject water, will be disposed of through re-injection into the target aquifer during FRT operations.

This approach is consistent with the technical context outlined in the Commonwealth Government ISR Uranium Mining Best Practice Guide (DEWHA, 2010), which provides ISR-specific regulatory guidance on liquid waste/residue management options.

However, reference to DEWHA (2010) is not intended to imply compliance with South Australian legislation.

All liquid waste disposal activities will be conducted in full compliance with South Australian regulatory requirements, including the Environment Protection Act 1993 (SA) and applicable licensing conditions set by the South Australian EPA.

Liquid Disposal Site

The re-injection site, shown in Figure 4.2, has been strategically selected to ensure that disposed residues are not injected into the economic ore zone. This ensures resources remain accessible for potential future mining operations. The site is located approximately 500 m from the RL boundary, minimising the potential for liquid residues to migrate beyond the RL area. The Natural Attenuation Assessment shows attenuation of lixiviant to occur within 400m of the mining zone, as average disposal solution is already close to baseline it is expected any localised change to groundwater chemistry will occur in significantly less distance. This positioning ensures the water quality of the Tertiary aquifer is not impacted outside the RL area.

Disposal Rates and Injection Volumes

The estimated average rate of liquid residues injection during the field trial (assuming negligible evaporation) is estimated at 1.2 L/s, with a total disposal volume 6,300 m^3. The full project water balance is provided in Figure 4.12.

Water Quality

The anticipated chemical compositions of the liquid residue stream are presented in Table 4.4. The RO brine is expected to account for >90% of the total liquid residue stream with a small amount of barren lixiviant (acidified groundwater) that has already had the uranium removed and water used for cleaning parts of the FRT infrastructure. As the plant residues will be entering the disposal stream in batches daily or every second day rather than in a continuous stream, the chemistry of the liquid waste has been averaged based on the proportion of each residue entering the liquid waste disposal stream during the operational phase. As all residues will be held in a common liquid residue disposal tank prior to disposal this is a reasonable approach.

The average disposal chemistry is predicted to contain less than 1 mg/L uranium which is only slightly elevated from baseline levels. Sulphates and pH of the liquid residue stream are also predicted to be within the ranges of concentrations in native groundwater of the target aquifer.

Total Dissolved Solids (TDS) is predicted to be within the range of native groundwater.

Table 4.4: Summary of Key Liquid Disposal Residue Parameters

Parameter	FRT Liquid Residues	Baseline Water Quality – Tertiary Aquifer
pH	7.1	5.7 – 7.6
Sulphate (mg/L)	4,900	2,100 – 5,900
Uranium (mg/L)	0.8	0.4
TDS (mg/L)	52,000	32,300 – 65,480

Hydraulic Capacity

The hydraulic capacity of the aquifer to accept the planned fluid injection has been assessed. Pressure impacts were assessed using the Theis equation (Theis, 1935). Aquifer properties determined through aquifer testing (AGT, 2011a) were employed in this assessment:

- Transmissivity = 110 m^2/day
- Storativity = 0.0002

Maximum pressure increase at the well screen is approximately 8 m head, based on a short-term maximum flow rate of 5.5 L/s for 1 day, this value is considered a worst case scenario designed to take into account the impact of clogging in the well and disposal well downtime resulting in the need to increase disposal for a short period of time to reduce accumulated volumes. Average liquid waste disposal rate is expected to be 1.22 L/s which would result in 2.5 m increase in head after 90 days.

The fracture pressure of this aquifer has been calculated using a simplification of the Bernoulli equation which considers a single point in a system at rest. The formula below is adapted from Cimbala and Cengel (2014):

$P=\rho gh$

Where:

P = hydrostatic pressure (Pa)

ρ= density of material (1800 $kg.m^{-3}$)

g = acceleration due to gravity (9.81 $m.s^{-2}$)

h = thickness of the overburden (55 m)

When converted back to mH20, gives 99 mH20 or approximately 44 m above ground surface. The standing water level is approximately 15 m below ground level. A pressure increase of 59 m would be required to risk fracturing of this aquifer.

The predicted maximum pressure increases of 8 m resulting from injection of liquid residues is well within the fracture pressure limit for this aquifer and poses no risk to the integrity of the overlying confining layers.

Re-injection pressure will be limited to 400 Kpa at the well head to completely eliminate any risk to the integrity of the overlying confining layers.

Mining & Process Chemical Fate

Chemicals utilised in the ISR and IX process dissolved within the mining lixiviant and waste fluids from the FRT plant will be retained in solution and disposed as liquid waste during the FRT.

The main liquid wastes from the wellfield and processing plant will be:

- RO reject water (brine).
- Re-circulated leaching solution (bleed).
- Residual liquids from plant operation and washdown of FRT infrastructure.

The waste fluids will be held in the “Liquid Residue Disposal Tank” along with the RO brine prior to disposal into the target aquifer (Tertiary aquifer).

A comprehensive monitoring network will be established at the liquid disposal site to track and verify the behaviour of disposal fluids during active injection activities. The network includes a series of dedicated monitoring wells at the liquid disposal site, which will monitor the movement and distribution of injected fluids in real-time.

The disposal area is also enclosed within a perimeter lateral monitoring network, which verifies containment within the designated operational area. Furthermore, the disposal area is situated within 250 m of an underlying monitor well, specifically designed to confirm the isolation of the underlying FRA aquifer, ensuring that fluids do not penetrate or impact deeper aquifers, thereby maintaining aquifer integrity (Figure 7.4). Full details of the operational groundwater monitoring network are provided in Section 7.3.

Although mining and process chemicals make up a small proportion of the overall disposal volume, they will be actively attenuated by the dominant RO brine. The maximum extent of disposal fluids prior to being fully attenuated is provided in Figure 5.7, and this is discussed in greater detail in Section 5.4. Closure monitoring will focus on demonstrating the continued isolation of the underlying FRA (Section 7.3).

4.6.4 Ignition Sources

A detailed review of ignition sources associated with the FRT has identified several potential risks due to the presence of fuels, chemicals, and diesel-powered equipment. Key materials stored on-site include sulphuric acid, hydrogen peroxide, sodium chloride, sodium bicarbonate, ferric sulphate, and diesel. Additionally, operational equipment such as generators, vehicles, and power tools present ignition risks if not properly managed.

Identified Risks and Controls

The following potential risks and key controls have been identified:

- Fuel Storage and Handling: Diesel, while less volatile, is combustible. Grounding and bonding during fuel transfers, proper tank maintenance, and adherence to AS1940 standards mitigate this risk.
- Power Tools and Generators: Sparks or heat from diesel-powered equipment will be managed through regular maintenance, proper ventilation, and the use of spark arrestors.
- Hot Work Activities: Sparks from welding or grinding will be controlled through a Hot Work Permit System and fire watch protocols.

- Static Electricity: Proper earthing and bonding in accordance with the Australian Standard AS/NZS 1020:2023 will prevent static discharge during the transfer of fuels and chemicals.

By implementing these controls, the FRT site ensures compliance with Australian standards and reduces the likelihood of ignition-related incidents.

4.6.5 Other Airborne Emissions

The FRT will also generate emissions from the use of diesel generators and vehicles. These sources contribute to airborne pollutants such as carbon dioxide (CO_2), nitrogen oxides (NO_x), particulate matter (PM), carbon monoxide (CO), and volatile organic compounds (VOCs). While these emissions are not anticipated to significantly impact air quality beyond the site boundary.

Generators used for FRT operations will emit pollutants during construction, operational and decommissioning phases. These emissions will be managed by maintaining all equipment to minimise exhaust emissions, using low-sulphur diesel fuel where possible, and ensuring generators are positioned to reduce exposure to workers and sensitive receptors.

Vehicles used for transporting personnel, equipment, and materials to and from the FRT site will also contribute to airborne emissions. Diesel-powered vehicles, in particular, emit NO_x, PM, and CO. Emissions will be managed by adhering to strict maintenance schedules, implementing the project Traffic Management Plan with speed limits to minimise idling and dust generation, and using modern, fuel-efficient vehicles where possible.

A monitoring and reporting framework will be implemented to track fuel usage and evaluate emissions.

4.7 Resource Inputs

4.7.1 Workforce, Procurement & Operator Capabilities

Alligator Energy has assembled a highly experienced team to execute the FRT for the Samphire Uranium Project, leveraging South Australia's extensive history of ISR uranium mining. The company's capability is underpinned by a specialist workforce, robust site management structures, and a strong commitment to local procurement and workforce development.

Workforce and Expertise

Alligator Energy has selectively recruited employees, contractors, and consultants with extensive prior expertise in ISR operations. The project team includes professionals across key disciplines such as:

- Geology
- Hydrogeology
- Environmental Management
- Radiation Protection
- Mine and Project Management

This expertise ensures that the field trial is conducted safely, efficiently, and in compliance with all regulatory requirements.

Site Management and Operational Oversight

The Samphire FRT site will be managed by Alligator Energy's Site Manager/Supervisor, who will have full responsibility for the safe and secure operation of the site. The Site Manager/Supervisor will be supported by:

- General Manager - Operations – overseeing project execution and supervision.
- General Manager - Approvals and Sustainability & Environmental Manager – ensuring environmental management and compliance with PEPR commitments.Hydrogeologist – monitoring groundwater conditions and ISR performance.
- Process Technical Staff – managing field trial operations and ISR process control.

The Site Manager/Supervisor will report directly to the General Manager - Operations, along with other senior management and administrative staff.

Workforce Composition and Staging

During the construction, commissioning, and decommissioning of infrastructure, a larger number of contractors will be engaged to undertake site works, which is anticipated to take between two and four months. Workforce numbers are expected to be small, with fewer than 20 personnel on-site at any given time.

The operational phase of the field trial is expected to require approximately six personnel, though not all will be on-site simultaneously. This excludes Alligator Energy's exploration drilling team, which will also be working in the EL area. The drilling team consists of:

- One to two drill rigs
- Up to six drillers
- One geologist
- One field technician

Induction & Worker Training

Induction and training programs will be provided for all site workers to ensure they receive appropriate health, safety, environmental, and radiation protection instructions relevant to their roles. Additional training programs will be provided for specific job functions, focusing on work instructions and site-based procedures, particularly those with medium to high residual risk rankings.

Recruitment & Procurement Processes

Where possible, personnel will be recruited from Whyalla and the wider region, including the Barngarla Native Title group.

Given the project's proximity to Whyalla, goods and services will be predominantly sourced from Whyalla, supplemented by other regional centres and Adelaide where required. Alligator Energy is committed to engaging local labour and sourcing supplies from the region wherever practicable.

4.7.2 Energy Sources

The energy requirements for the FRT will be entirely met by diesel-powered equipment, reflecting the project's temporary nature and the need for reliable energy in a remote location. Over the duration of the FRT, diesel consumption is projected to total approximately 200,000

litres. Of this, 95% will be used for non-transport fuel needs, primarily to power generators running continuously (24/7) to ensure a consistent energy supply. The remaining 5% will be allocated to transport fuel usage, including light vehicles, forklifts, and drilling equipment.

The primary energy source for the FRT will be an on-site diesel-powered generator, capable of meeting peak power requirements of 200 kW and average demands of 91 kW. Total annual energy consumption from all sources is estimated at 197 MWh, equivalent to approximately 7,300 gigajoules (GJ). This energy mix is designed to meet the demands of continuous power generation, commuting, and on-site transport.

Due to the short-term nature of the trial, diesel represents the most practical and reliable energy source given the current project constraints. However, this reliance on diesel is expected to result in approximately 500 tonnes of CO_2-equivalent (CO_2-e) emissions. Opportunities for efficiency improvements or the adoption of alternative, zero-emission energy sources are minimal at this stage, and no carbon offsets are proposed for the project.

4.7.3 Water Sources & Balance

Water Sources

Alligator Energy will source all raw water from water supply wells within the Tertiary (target) aquifer. This water will be processed through the onsite RO plant, where low-chloride water will be used to supply the process plant and support wellfield conditioning activities (see Figure 4.12).

Total raw water consumption for the life of the FRT is estimated at 10 ML.

The ISR mining process is predominantly a closed loop system, with only a small bleed volume removed from the process. This bleed volume, which represents reagent use, is estimated at a maximum of 0.4 ML for the life of the project.

Potable water will be transported to the project site from Whyalla via truck and stored in dedicated water tanks for use in administration areas. Up to 0.25 ML of offsite-sourced potable water is expected to be required for the duration of the FRT.

The net water balance for the project is effectively zero, with only 0.27 ML under injection due to the storage of eluate at the surface. The only net addition not accounted for in this water balance is the volume of rainwater that falls in the lined plant area which will be disposed of through the liquid waste disposal stream.

The full project water balance is provided in Figure 4.12 and Table 4.5.

Table 4.5: Project Water Balance

Activity	Outputs (Extraction from aquifer)		Remains at surface		Input (injection into aquifer)	
	Volume (ML)	Total (ML)	Volume (ML)	Total (ML)	Volume (ML)	Total (ML)
Groundwater to RO		9.50				
Wellfield Circulation		16.33				16.29
Groundwater conditioning						2.50
Initial lixiviant make up						0.45

Activity	Outputs (Extraction from aquifer)		Remains at surface		Input (injection into aquifer)	
	Volume (ML)	Total (ML)	Volume (ML)	Total (ML)	Volume (ML)	Total (ML)
Reagent Addition						0.02
Sulphuric Acid					0.010	
Peroxide					0.006	
Ferric Sulphate					0.008	
Disposal						6.30
RO Reject					5.70	
Rinse					0.22	
Conversion (IX)					0.22	
BLS bleed					0.01	
Backwash					0.11	
Bleed (net extraction-injection					0.04	
Eluate storage				0.32		
Rainfall on lined plant area						Unknown
Total	**25.83**				**25.56**	
Net (input – output)					**0.27 less injection**	

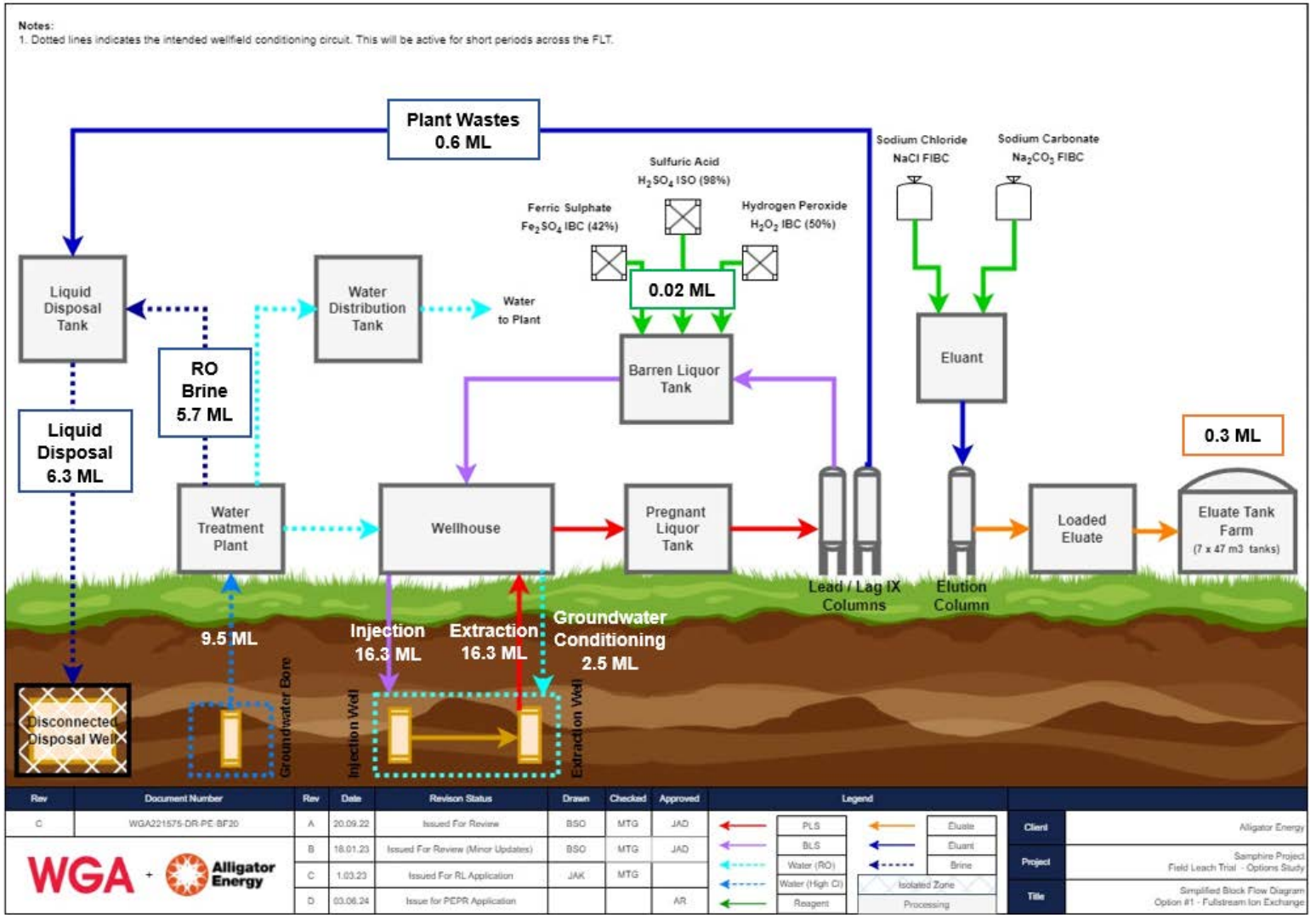
Note: potable water has not been accounted for in this water balance as it will be used in the administration areas and removed by as grey waste to be disposed at a licensed facility

Water Disposal & Discharge

Wastewater generated during the ISR process will be collected in the wastewater tank within the plant area and re-injected in the Tertiary (target) aquifer. Total liquid wastes generated during the project is estimated at 6,300 m^3 and consisting of:

- 5,700 m^3 of brine from the RO process
- 605 m^3 from the process bleed stream and washdown waters.

Grey water generated in the administration area will be collected in tanks for offsite disposal in Whyalla.



*Raw water will be pumped to temporary water storage tank prior to processing by the Water Treatment Plant (RO)

Figure 4.13: Project Water Balance

4.8 Transport & Storage of Radioactive and Hazardous Materials

4.8.1 Radioactive Materials – Transport & Storage

The project may require the transport of the following radioactive materials:

- Prompt Fission Neutron (PFN) tools.
- Geophysical tool calibration sources.
- Radioactive sample material (solids/liquids).
- Low-level radioactive wastes.

All radioactive materials will be transported in compliance with the Radiation Protection and Control Act 2021 and associated Regulations. All transport activities will be undertaken in accordance with the project RMP approved by the South Australian EPA, and by fully trained and authorised personnel.

4.8.2 Hazardous Materials - Transport & Storage

During the operational phase of the project, various hazardous materials will be transported to the site to support processing and operational requirements. These materials will be stored in appropriate containment systems to ensure safety, regulatory compliance, and environmental protection. At the conclusion of the FRT, any residual quantities of these materials will be either reused, securely stored, treated, or transported off-site in accordance with approved disposal procedures.

The hazardous materials anticipated for transport and on-site storage are detailed in Table 4.6.

Table 4.6: Hazardous Materials - Transport and Storage Details

No.	Chemical/Fuel	Storage Vessel	Frequency of Delivery	Form of Delivery
1	Sulphuric Acid (H_2SO_4) 98% w/v	Self-bunded stainless steel Class-8 ISO tank.	Once	ISO tanker (10,000 L)
2	Sodium Carbonate (Na_2CO_3)	Bulk bag in 20’ container (1T)	Fortnightly	Palletised bulk bags (1T each) by truck
3	Sodium Chloride (NaCl)	Bulk bag in 20’ container (1T)	Fortnightly	Palletised bulk bags (1T each) by truck
4	Ferric Sulphate $Fe_2(SO_4)_3$ 42% w/v	Plastic, rigid, IBC (1,000 L).	Monthly	Truck with IBCs (1,000 L each)
5	Hydrogen peroxide (H_2O_2) - 50%	Plastic, rigid, IBC (1,000 L).	Monthly	Truck with IBCs (1,000 L each)
6	Diesel	Mobile self-bunded diesel tank (10,000L)	Weekly	Road Tanker / Fuel Tanker Truck

All chemicals and fuels classified as Dangerous Goods will be transported in accordance with the South Australian Dangerous Substances Act 1979 and its associated regulations. To ensure compliance with safety and environmental standards, all transport operations will be undertaken by fully licensed contractors with expertise in handling hazardous materials.

4.9 Land Use

Operational portions of the RL, encompassing the wellfields, process plant and administration area, will be fenced to clearly defining a FRT management area under the sole control of Alligator Energy (Figure 4.1). Within this area, no entry is permitted to any person or activity unless agreed and approved by Alligator Energy. The remainder of the RL will be subject to exploration and other RL management activities (e.g., environmental and radiation monitoring), however, will also be accessed and utilised by the landowner for pastoral activities. No activities outside those specified in this document, and environmental monitoring and land management activities will be undertaken by Alligator Energy. Within the unfenced portions of the RL the landowner will continue to undertake pastoral activities (Figure 4.1).

4.10 Site Security

The Samphire RL is located approximately 5 km west of the Mullaquana public road. Access to the private pastoral track, which branches off from the public road, is controlled by the landowners of the Mullaquana, Moonabie, and Nonowie Stations. This track is kept locked via a main gate (Gate 2) to prevent public access. No alternative public access to the track is available from any other public road, including the Lincoln Highway to the west.

During the FRT, Alligator Energy will ensure that entry to the Moonabie pastoral property will occur via Gate 1 which will remain shut and locked at all times (Figure 4.11).

Within the Moonabie pastoral paddock, an additional stock fence has been constructed around the operational area to restrict access exclusively to authorised personnel. CCTV systems will monitor all access points to this operational area. The process plant will also be secured by a perimeter security fence, with CCTV installed to provide surveillance over entry points and key infrastructure to monitor and deter unauthorised access.

To ensure security, the site will be staffed 24/7 throughout the duration of the FRT. After the conclusion of FRT operations, operational areas will continue to be locked at all times, monitored via CCTV by an external security company engaged to provide 24/7 remote surveillance and immediate response capabilities in the event of unauthorised access.

Signage will be placed at all gated entrances to the RL to prevent inadvertent unauthorised access; however, no signage will be installed at any public access points.

4.10.1 Eluate Storage & Security

The Australian Safeguards and Non-Proliferation Office (ASNO) has provided advice (pers comm Michal Botha, 15 February 2023 & 6 March 2025) that the proposed security arrangement is sufficient to meet ASNO requirements for the tank storage of the resultant eluate.

.

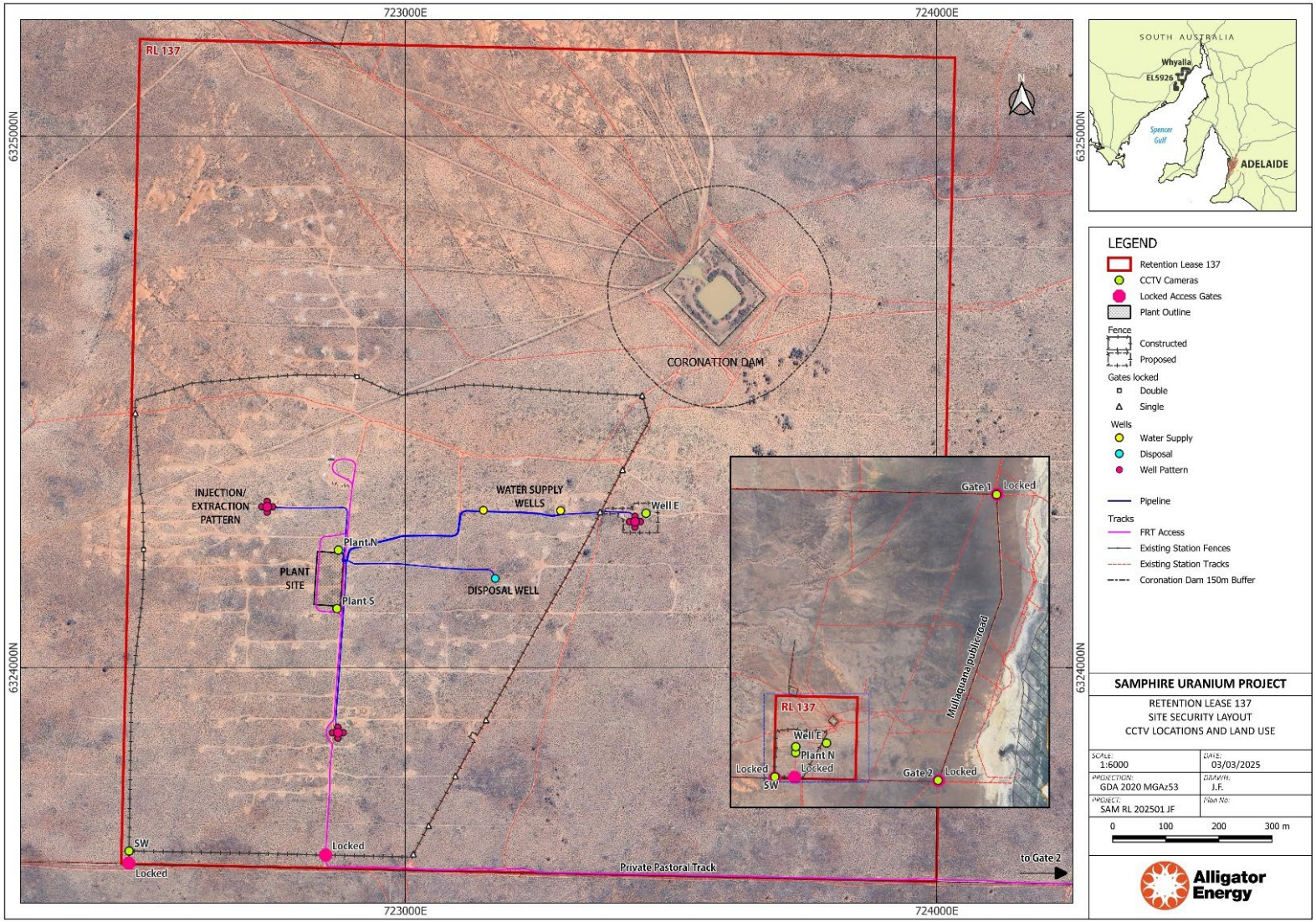


Figure 4.14: Site security layout, CCTV locations and land use.

5 CARE & MAINTENANCE AND CLOSURE

5.1 Introduction

This section outlines the closure and care & maintenance strategy for the Samphire FRT focusing on the specific activities that will be implemented to achieve safe, stable and sustainable post-trial conditions. It describes what will be done and how closure actions will be carried out, including infrastructure removal, groundwater rehabilitation, landform stabilisation, and the re-establishment of pastoral land use.

This section is structured around practical implementation: it provides the detailed physical, technical and environmental measures required to achieve site rehabilitation. However, this section does not attempt to define regulatory outcomes or assessment criteria.

The regulatory framework for closure, including the specific outcome-based conditions, compliance indicators, and verification measures, is provided in Section 7, consistent with the structure of the PEPR.

The FRT is a critical decision point for the future of ISR mining at the Blackbush deposit. Depending on the outcome of the trial:

- If ISR is viable, the site will enter a care and maintenance phase to allow for continued monitoring, infrastructure retention and progressive rehabilitation while further approvals are pursued.
- If ISR is determined to be unviable, the site will proceed directly to full closure, involving complete decommissioning, rehabilitation and relinquishment.

In both cases, closure activities will be executed in alignment with best-practice mine closure guidance and South Australian regulatory requirements to support long-term environmental stability, landholder access and productive post-mining land use.

5.1.1 Regulatory and Industry Frameworks

The Samphire FRT closure and care and maintenance strategy aligns with key national and international regulatory frameworks, including:

- Australian Guidelines for Mine Closure (Department of Industry, Science, Energy and Resources (DISER). (2016) – Outlines best practices for progressive rehabilitation and closure planning.
- Commonwealth ISR Uranium Mining Best Practice Guide (DEWHA, 2010) – Provides specific guidance for ISR project decommissioning.
- South Australian Department for Energy and Mining (DEM) – RL 137– Defines project specific regulatory conditions for site closure.
- International Council on Mining & Metals (ICMM) Integrated Mine Closure Good Practice Guide (ICMM, 2025) – Emphasises a risk-based, adaptive approach to mine closure.

By aligning the FRT closure approach with these national and international frameworks, Alligator Energy ensures a scientifically rigorous and regulatory-compliant rehabilitation process.

5.2 Closure Outcome Statement

The closure measures described in this section have been developed specifically to support the agreed post-mining land use of pastoral grazing. These measures, including infrastructure

removal, revegetation with endemic species, erosion control, and groundwater monitoring, will restore land capability, stabilise surface conditions, and ensure that no residual environmental risks prevent continued land use by the pastoral landholder.

Verification of closure success, including the re-establishment of vegetation cover and land access, will be undertaken in accordance with the environmental outcomes and performance criteria defined in Section 7. Final relinquishment will only occur once compliance with these outcomes is confirmed and regulatory sign-off is granted.

This integrated closure approach ensures that the FRT site will be returned to a safe, stable and productive condition, suitable for long-term pastoral use, consistent with historical land use and regulatory expectations.

5.3 Strategic Considerations

The approved post-mining land use for the RL area is pastoral (sheep grazing), consistent with current and historical land use.

Effective closure and care and maintenance planning requires a structured approach to ensure environmental stability, stakeholder alignment, and regulatory compliance. The following key considerations have guided the development of the site's closure framework, ensuring that both pathways (i.e. care and maintenance or full closure) achieve sustainable post-mining land use.

5.3.1 Stakeholder Concerns and Expectations

Stakeholder engagement has been central to planning the transition to either care and maintenance or closure. During consultations, the following concerns were raised:

- Post-FRT land use and site restoration requirements, particularly ensuring that the land is returned to a productive pastoral state.
- Groundwater impacts, including concerns about potential contamination and the long-term fate of the target aquifer.
- Vegetation and ecosystem recovery, ensuring that native vegetation is restored in line with an ecological rehabilitation standard that is fit for purpose for the Western Myall ecological community.
- Retention of infrastructure, with the expectation that no permanent infrastructure will remain unless agreed upon by the landholder and regulators.

These concerns have been incorporated into the planning framework to ensure transparency, regulatory compliance, and alignment with community and landholder expectations.

5.3.2 Land Use Considerations

Since the land is currently used for pastoral purposes, the closure strategy has been designed to return the land to its original use with no long-term impairment to grazing. Key principles guiding land use restoration include:

- Full removal of infrastructure, except where it is required for exploration, environmental or pastoral activities, and has been approved with the landowner and the Department for Energy and Mining.
- Rehabilitation of all disturbed areas, ensuring that erosion control measures and revegetation strategies support long-term land stability.

- Targeted rehabilitation will ensure minimal long-term restrictions on grazing, maintaining land suitability for sustainable pastoral activities.

Land use closure strategies are detailed in full in Section 7.7.

5.3.3 Future Aquifer Use and Protection

The Tertiary aquifer within the RL area has naturally elevated salinity, with high sulphate concentrations and naturally occurring radionuclides (see Table 2.1). While it has no current designated environmental value under the EPA Water Quality Policy (EPA, 2015), its potential for future use remains a key consideration in site closure planning.

Closure conditions under Schedule 4 of RL 137 (Attachment A) require that the quality of groundwater in the Tertiary aquifer outside the RL boundary is not adversely affected by the field recovery trial, beyond natural background variation. In addition, Schedule 4 requires no adverse change, outside of natural background variation, to the water quality of the underlying aquifer.

This outcome will be achieved through a combination of:

- Aquifer isolation: Maintaining hydraulic separation between the Tertiary aquifer and adjacent non-target formations to prevent cross-contamination.
- Well decommissioning: Sealing all FRT wells in accordance with regulatory standards to eliminate vertical connectivity and ensure long-term aquifer integrity.
- Monitored natural attenuation: Allowing groundwater affected by the FRT to revert towards baseline conditions through natural geochemical processes, consistent with modelled predictions.
- Validation of attenuation processes: Confirming the effectiveness of natural attenuation through field monitoring and comparison with reactive transport model outputs.
- Residual condition documentation: Characterising post-trial groundwater quality to inform future land and resource planning and support regulatory transparency.

The attenuation-based rehabilitation strategy for the Tertiary aquifer is supported by site-specific reactive transport modelling, which demonstrates that key parameters (e.g. uranium, sulphate, iron) will stabilise within a defined zone downgradient of the FRT area, and well within the RL boundaries. Full details on natural attenuation mechanisms, modelled predictions and the compliance validation framework is provided in Section 5.4 and Section 7.3.

5.3.4 Closure Scenarios and Transition Pathways

Following the completion of the FRT the site will transition into one of two defined pathways, depending on the feasibility of ISR mining. The primary objective of either scenario is to ensure environmental stability, protect groundwater resources, and rehabilitate the landscape in compliance with regulatory obligations and best practice mine closure standards.

The closure scenarios include:

- Scenario 1 - Care & Maintenance with Partial Rehabilitation: If ISR mining remains a viable option, the site will transition into care and maintenance while regulatory approvals for a ML are pursued. This phase includes continued groundwater monitoring, infrastructure retention, and progressive rehabilitation.

- Scenario 2 - Full Rehabilitation & Closure: If ISR is determined to be unfeasible, the site will proceed with full decommissioning and rehabilitation to return the land to a stable, non-polluting condition suitable for long-term pastoral use.

While these pathways represent distinct approaches, the same environmental protection principles apply, with ongoing monitoring, progressive rehabilitation, and compliance verification ensuring a responsible transition to post-mining land use.

5.4 Groundwater Rehabilitation

5.4.1 Groundwater

As defined in Section 5.3.3 and Appendix A, closure will demonstrate no adverse change, beyond natural background variation, to the water quality of the target aquifer outside the Land.

ISR activities necessarily altered groundwater chemistry within the mineralised aquifer inside the wellfield during operations. Closure will demonstrate that these changes are contained, controlled and trending back towards baseline and demonstrate that no adverse change has occurred outside the Land.

Groundwater within the Tertiary aquifer exceeds 13,000 mg/L TDS, which means it is naturally unsuitable for common uses (e.g. drinking, irrigation or livestock) without treatment. Regardless of suitability for use, the aquifer will be managed under the general environmental duty (Environment Protection Act 1993 s25) and consistent with the Environment Protection (Water Quality) Policy 2015 to prevent further degradation of groundwater quality (i.e. no significant deviation from baseline).

Following cessation of the FRT, Alligator Energy will implement monitored natural attenuation (MNA) to return groundwater affected by the trial towards baseline, verified by monitoring of key indicators (e.g., pH, sulphate and uranium). Natural attenuation (NA) is the “process where groundwater, which has been altered through the addition of leach solution, reverts through reaction to its surrounding aquifer matrix and pre-existing groundwater over a period of time to or towards its pre-contaminated state, without additional attenuating treatment” (CSIRO, 2004). The method minimises energy and resource consumption while avoiding the generation of surface solid waste.

5.4.2 Natural Attenuation Assessment

An assessment of the ability of natural attenuation to remediate residual field trial fluids that remain in well patterns at the completion of the FRT has modelled by world-leading independent consultants at Umwelt- und Ingenieurtechnik GmbH Dresden (UIT). The modelling has been conducted using TRN a geochemical modelling program developed by UIT which uses PHREEQC code developed by USGS. PHREEQC has been reviewed as fit for purpose specific to uranium in-situ recovery activities (Davis and Curtis, 2007). UIT have completed this type if 1D reactive transport modelling for other uranium in-situ recovery operations in South Australia (UIT, 2008; UIT, 2017) to support Mine Lease applications and operational restarts. The full UIT NA report is presented in Appendix F (UIT, 2024).

Given the very low groundwater velocity and low vertical conductivity of the aquifer along with the small size and short duration of the FRT, Alligator consider the stand alone 1D model sufficient as the plume moves such a small distance during the 5-year validation period. One of the

objectives of the FRT is to obtain further hydrogeological information to construct a robust groundwater model which would be used to support future works as the project progresses.

The NA model presented is designed to be conservative so as to provide a worst-case scenario allowing the assessment of impact to the groundwater system. This is done by choosing the worst-case scenario values where there is uncertainty, e.g. selecting low dispersivity values meaning minimal transverse mixing as mixing/dilution with native groundwater is key driver in the achievement of NA. The assessment found that the residual FRT solution will be fully attenuated, pH, uranium and sulphate concentrations return back close to baseline levels/ within ECLs, within 400m of the operational area.

Model Set Up

UIT developed a one-dimensional model that integrates transport processes and geochemical interactions (thermodynamics and kinetics). It consists of three main components:

- Transport module (advection and dispersion, single and dual porosity).
- Geochemical module (utilising PHREEQC routines, thermodynamic databases, and kinetic models including enzyme kinetics).
- Graphical User Interface – GUI (data input, visualisation, scenario comparisons).

The initial conditions for the model were informed by:

- Post mining plume chemistry is based on the barren lixiviant chemistry informed by ANSTO column leach tests (ANSTO, 2022).
- Mineralogy of the target formation (ANSTO, 2022; Young, 2022).
- Average groundwater chemistry from baseline sampling in 2010 and 2022 (6 samples from 6 wells screened in the Kanaka Sands). Groundwater samples provided as part of the Baseline Groundwater Data in Appendix E.
- Groundwater velocities calculated using the formula

  $$\text{Linear} = k \times i / \phi\text{eff}$$

  Where:

  k = Hydraulic conductivity (7 m/day), this is the average hydraulic conductivity (7 m/day) from aquifer tests completed in 2010 (AGT, 2011a)

  i = Hydraulic gradients from 2022 data (0.0003, 0.00006, and 0.00009), and

  ϕeff = Effective porosity (15%) from a calibrated groundwater model of tracer tests completed by USA in 2011.

  The values of 1.0, 1.3 and 6 m/a were designed to give a range of velocities representative of those expected in different portions of the aquifer. The base case is considered to be 1.3 m/a.

- The wellfield pattern geometry, 20m leach zone due to the 20m diameter of each pattern. The length of the downgradient zone is determined by the distance travelled by the plume for a given scenario time.

Key Model Assumptions:

- Post FRT plume is diluted both in the direction of groundwater flow (longitudinal dispersion) and vertically (transversal dispersion). The ratio between the two is determined from the ratio of longitudinal and transversal velocities using the method described in Appendix F.

- Once the plume leaves the leach zone it moves through the mineralised downgradient zone where coffinite is a major reductant rather than barren ground where pyrite would be the main reductant (absence of coffinite). This is an important distinction as pyrite is a much more effective reductant than coffinite. The minimal dilution, low flow velocity and reductant type presents a worst-case scenario for natural attenuation.
- It is assumed the pre leaching concentrations of all reactive minerals is constant across the entire model domain. However, the majority of reactive minerals in the leach zone are consumed during the FRT operations. Concentrations of the reactive minerals in both the leached and downgradient zones at the beginning of the simulation defined in Appendix F.
- Homogeneous flow properties across the model domain.
- Uranium precipitates as amorphous UO_2(am) rather than uraninite or coffinite. This means the uranium precipitate will not be re-mobilised.
- Total porosity of 30% and effective porosity of 15% has been used based on a calibrated model of a tracer test completed by USA (Groundwater Science, 2012).

The reactive transport model setup is presented in Appendix F. Initial concentrations for reactive minerals are also presented in Table 5.1, full mineralogy report (Young, 2022) presented in Appendix F.

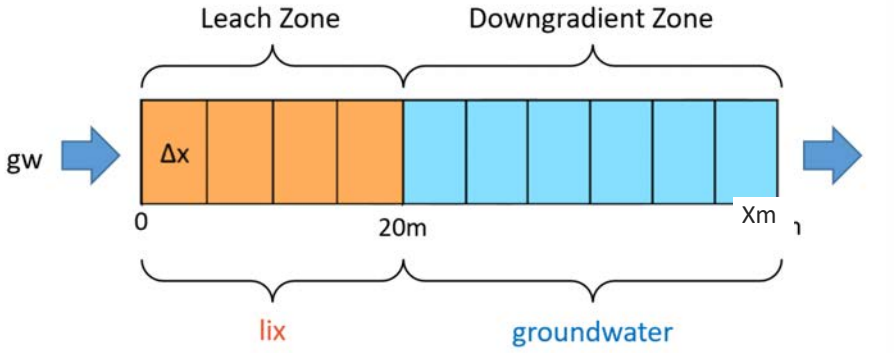


Figure 5.1: Flow path for FRT as used for reactive transport

Table 5.1:Initial concentrations of reactive minerals for the Model input calculated from wt%

Mineral		Mi	leach zone		downgradient zone	
		g/mol	wt%	C_i(mM)	wt%	C_i(mM)
Dolomite	$CaMg(CO_3)_2$	184.4	0	0	0.01	6.7
Coffinite	$USiO_4$	330.1	0	0	0.97	363.4
Kaolinite	$Al_2Si_2O_5(OH)_4$	258.2	0.3	150	0.61	292.2
Pyrite	FeS_2	120.0	0	0	1.05	1082.3
Uranophane	$Ca(UO_2)_2(SiO_3OH)_2{\cdot}5H_2O$	586.4	0	0	0.03	6.3

Table 5.2: Model inputs for groundwater and lixiviant

parameter		gw	lix
T	°C	18.8	25
pH	-	6.50	1.5
pe	-	0.34	5.00
Ca	mg/L	2110	1136
Mg	mg/L	1630	1457
Na	mg/L	11894	8725
K	mg/L	133	95
SO4	mg/L	3478	7740
DIC	mg/L	19.3	-
Cl	mg/L	24367	20249
Fe	mg/L	1.5	3000
Al	mg/L	0.017	4
U	mg/L	0.1	164
Si	mg/L	<0.02	22
Sr	mg/L	33.2	21

Scenarios

Three scenarios were tested:

- Groundwater Velocity 1.0 m/a
- Groundwater Velocity 1.3 m/a
- Groundwater Velocity 6.0 m/a

All other parameters were kept as described in the Model Setup section with the only change being the groundwater velocity.

Model Results

The modelling results presented in full in Appendix F, show the plume, once it moves outside of the leached zone, is being attenuated by the formation.

pH increases by three pH units within 30 m of the leach zone, returning to baseline levels at approximately 200m. pH increases above background at the upstream end of the plume after 100m model distance due to the precipitation of siderite.

As the solution moves through mineralised zones containing uranophane, uranium concentrations initially rise. However, as pH increases, uranophane dissolution decreases, leading to uranium precipitation.

Sulphate attenuates through dilution and the precipitation of gypsum. The precipitation decreases sulphate concentrations back below baseline levels on the upstream side/tail of the plume.

Iron initially attenuates through dilution, therefore very little change in concentration is noted until pH levels increase enough to allow the precipitation of siderite. Once siderite precipitation begins, concentrations decrease from approximately 2800 mg/L to approximately 200 mg/L in 150m.

The geographic extent of groundwater attenuation prior to the return of groundwaters to baseline ranges is shown in Figure 5.2.

A summary of the key drivers for natural attenuation for the key parameters is presented in Table 5.2. Model outputs are provided in Table 7.8, Table 7.9 and Table 7.10.

Table 5.3: Summary of Natural Attenuation influencers for key parameters

Parameter	Natural Attenuation Influencers
pH	• Dilution • Dolomite, Kaolinite dissolution • Ion exchange/ reduction by coffinite
Uranium	• Dilution • Mineralisation type
Sulphate	• Dilution • Gypsum precipitation
Iron	• Dilution • Siderite precipitation

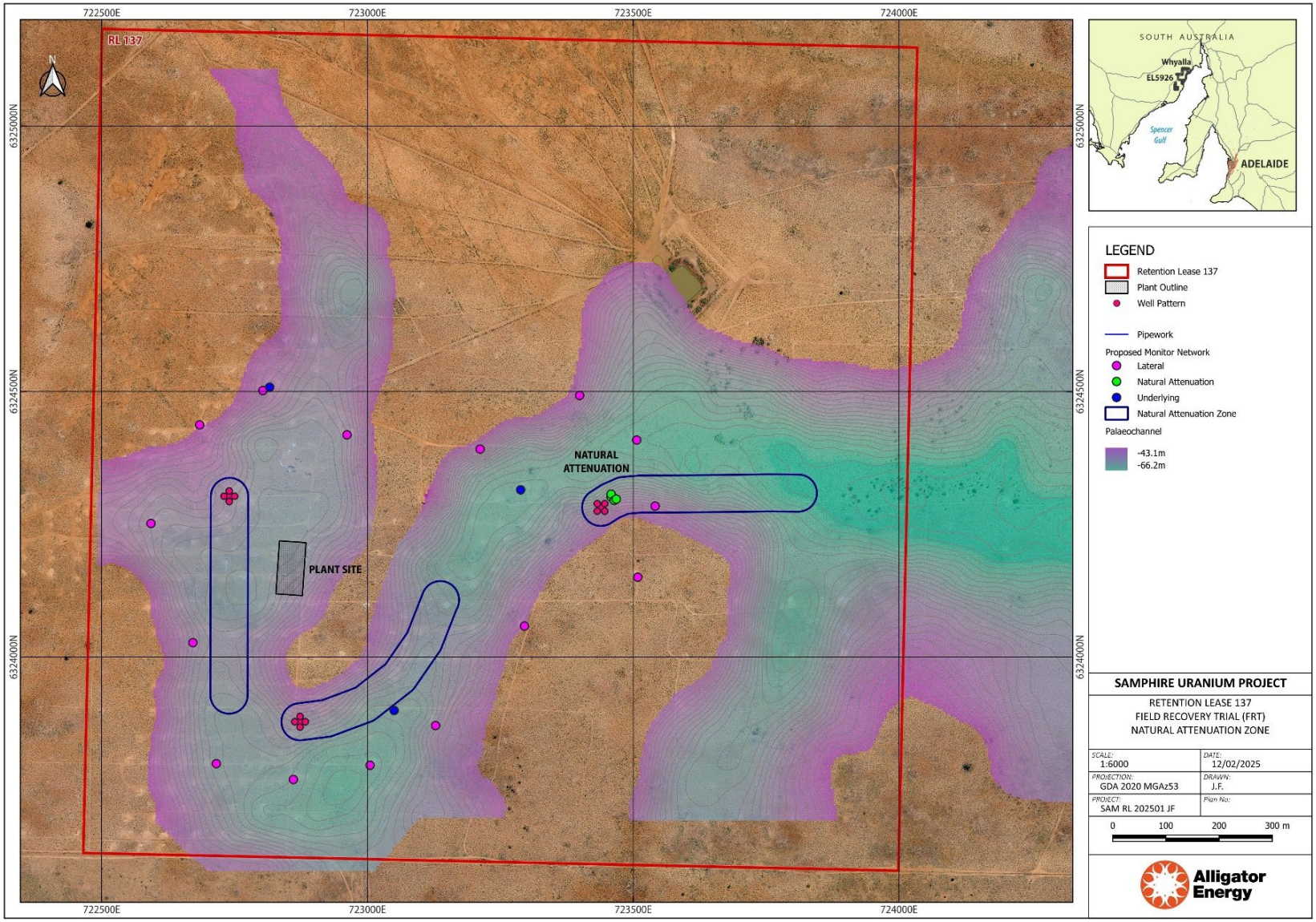


Figure 5.2: Natural Attenuation Zone

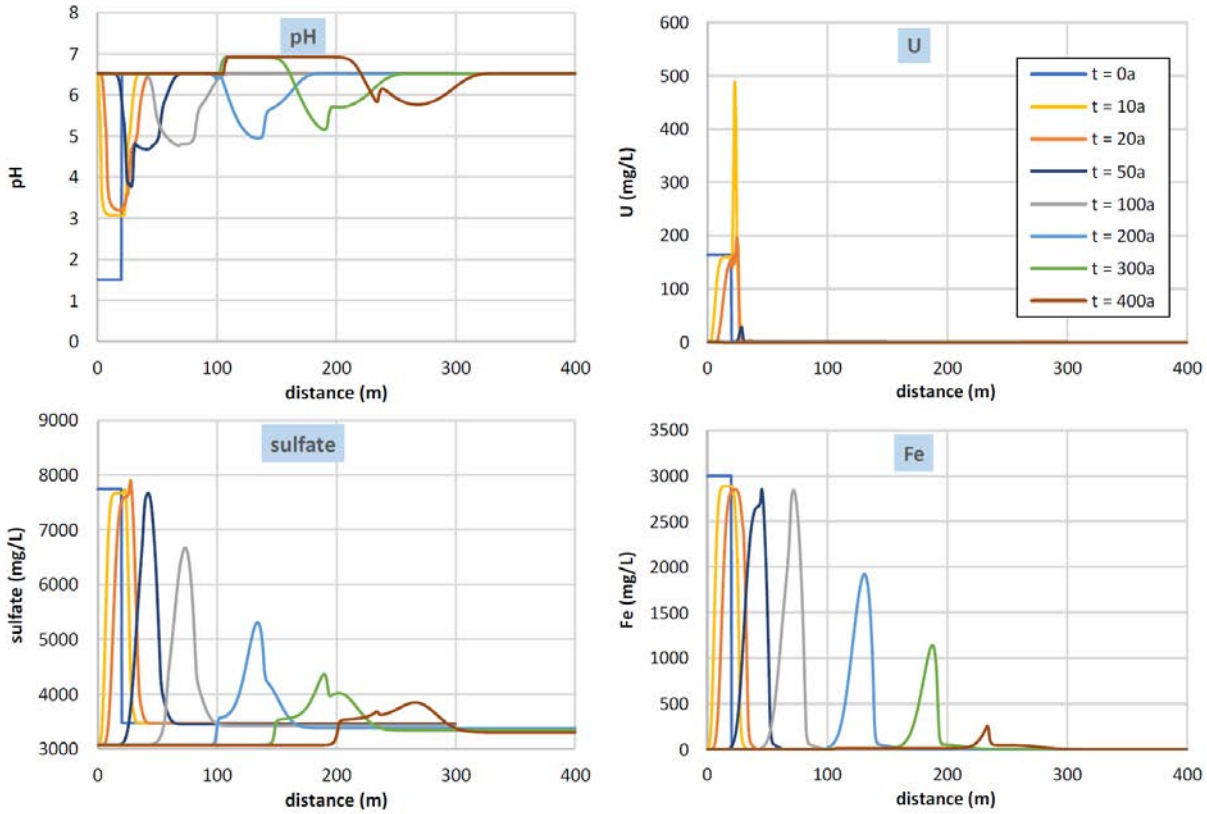


Figure 5.3: Natural attenuation of key parameters, groundwater velocity of 1.3 m/a. Reproduced from UIT (2023).

Sensitivity Analysis

Uranophane and pyrite have been chosen for the sensitivity analysis as they are the key parameters in the attenuation of uranium and have the highest degree of uncertainty.

Pyrite:

The dissolution of pyrite reduces the Oxidation Reduction Potential (ORP) of the lixiviant, creating a reducing environment causing the uranium in solution to precipitate out/attenuate the leach solution. Variation in the quantity of pyrite in the formation has a large impact on the uranium concentration in solution.

The pyrite concentration in the downstream zone was decreased by 50%. The resultant change in uranium concentration at 10 years post FRT is presented in Figure 5.4 where groundwater velocity is 6 m/year. The concentration of uranium is predicted to be higher than the base case prediction of 150 mg/L due to the higher ORP (less reductant). However, due to the continued presence of coffinite (also a reductant), the impact of the decreased pyrite concentrations is lessened.

Uranophane:

Uranophane is easily dissolved in low pH lixiviant, it does not require the oxidant to leach like other uranium bearing minerals (such as coffinite). In addition, the modelled parameters for uranophane have the lowest confidence, therefore it is important to know its impact.

A comparison of the main parameters for base case scenario and one with uranophane removed (amount assigned to coffinite) is presented in Figure 5.5. The comparison shows no difference in the sulphate and iron concentrations and only a slight increase in pH attenuation for a small portion of the plume for the v = 6 m/year scenario due to the increased concentrations of coffinite. Uranium concentrations in the downstream zone are significantly reduced in all no uranophane scenarios due coffinite being more difficult to leach.

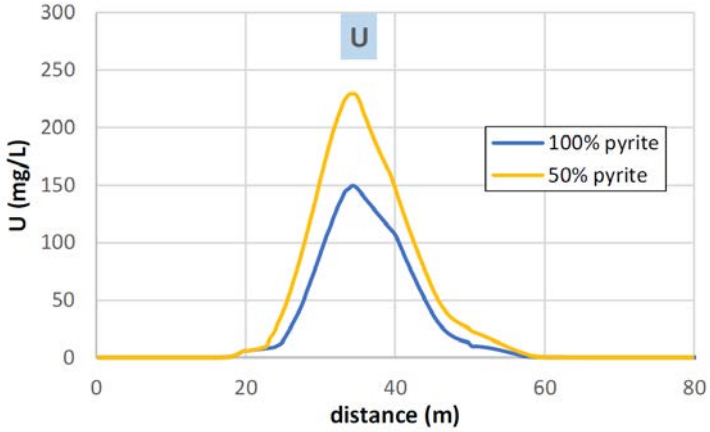


Figure 5.4: Pyrite decreased by 50%: U as a function of distance at t = 10 years with v = 6 m/yr. Reproduced from UIT (2023).

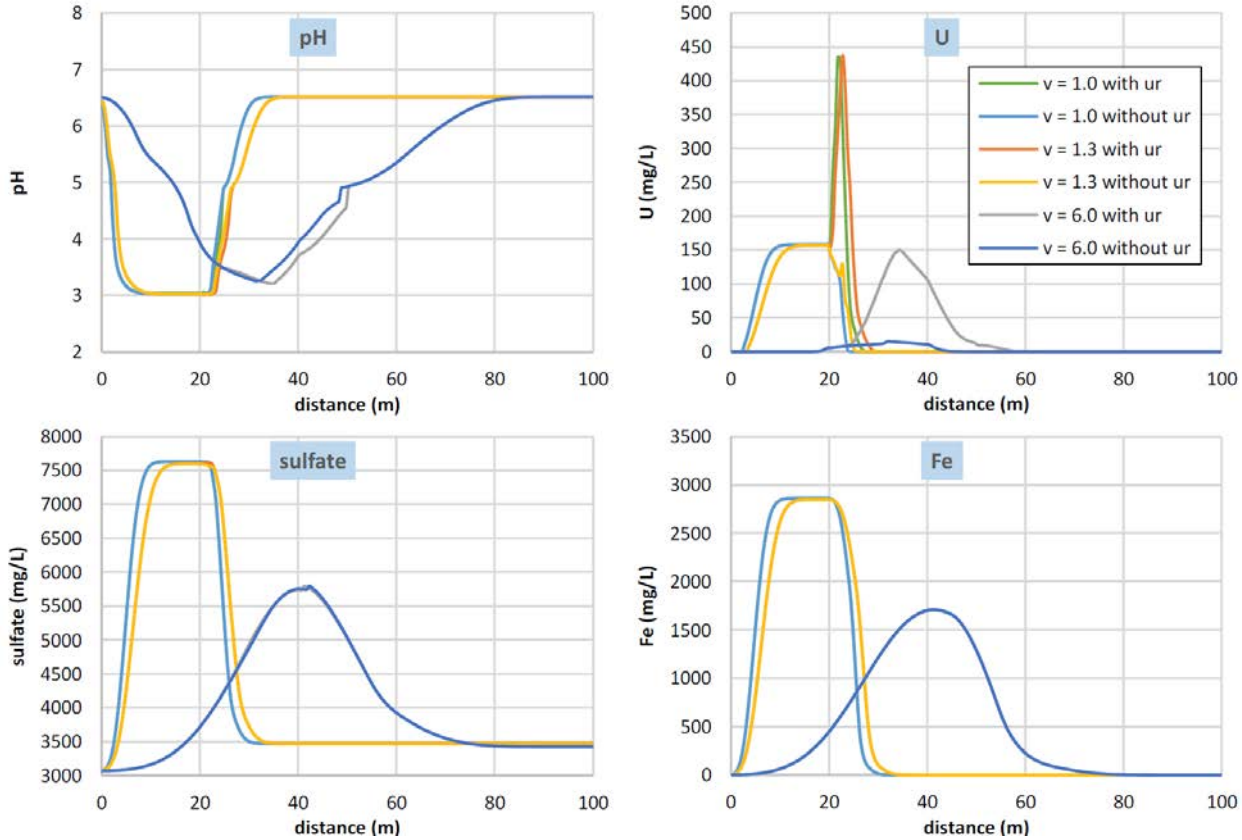


Figure 5.5: Comparison with and without uranophane: pH, U, sulphate and iron as a function of distance at t = 10 years. Reproduced from UIT (2023).

5.4.3 Liquid Disposal Solutions

The composition of liquid waste to be disposed is presented in Table 4.2 (Section 4.4.3). Waste from the plant will consist of less than 10% of the total disposal with RO reject water making up >90% of the volume, the 2 streams of liquid waste will be stored in a single tank prior to disposal. In this sense the liquid waste is being actively attenuated through dilution with the RO reject water prior to injection. The liquid waste disposal plume will be monitored to confirm location for internal purposes but will not be considered as part of natural attenuation assessments.

Plume Extent

The extent of the plume of liquid waste can be calculated geometrically (as a cylinder) since, in this hydrogeological setting where natural groundwater movement is very slow, movement of the liquid waste plume will be approximately radial and primarily driven by injection of the fluid and constrained by the confined thickness of the aquifer unit. The plume extent is calculated using:

- A plume thickness (height) of 6 m – Screen length, this maximises well capacity without compromising well development efficiency.
- An effective porosity of 30% - highly conductive screen zone at the base of the aquifer, expected to have a higher porosity than the majority of the aquifer, in particular the zone where NA is being monitored.
- Estimated total injection volume and rate as presented in Section 4.6.3.
- The formula:

$$\text{Volume} = \pi * r^2 * \text{height} * \text{porosity}$$

This gives a radial extent of 35 m is predicted. The predicted extent of the liquid waste plume for the re-injection location is presented in Figure 5.7.

This prediction is the position of a “sharp front” of liquid waste. In practice, dilution at the margin of the plume is expected through dispersion. This will result in a dilute halo which extends some distance beyond the predicted 35 m extent. Further the shape of the plume may be influenced by spatial variations in hydraulic conductivity of the aquifer sediments.

Monitoring

To monitor movement of disposal liquids injected into the aquifer, ‘disposal plume monitoring wells’ will be installed into the target aquifer. Specifically, monitoring wells will be installed distances of approximately 20, 40 and 60 m radial distance from the disposal well, as the 20m monitor well is expected to contacted well before the conclusion of the trial it will also act as a backup disposal well in the event of well failure or clogging (Figure 5.6). The timing of contact and reaction to injection of each of these wells will add to the hydrogeological model for the site as well as tracking the extent of the disposal plume. Planned location of the disposal well and disposal plume monitors are shown in Figure 7.4 and Table 7.3 in Section 7.3.4.

Monitoring of the disposal plume monitoring wells will be completed monthly during operations and continue quarterly for up to 1 year after for wells that have not been contacted by the plume at the conclusion of the operational phase.

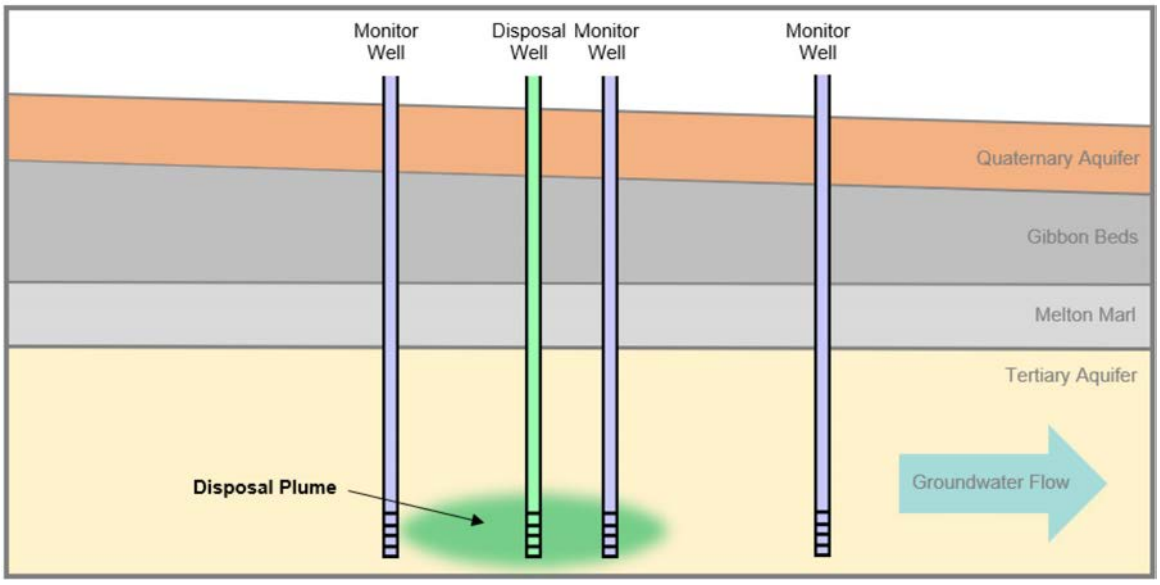


Figure 5.6: Liquid Waste Plume Monitoring Wells Conceptual Section.

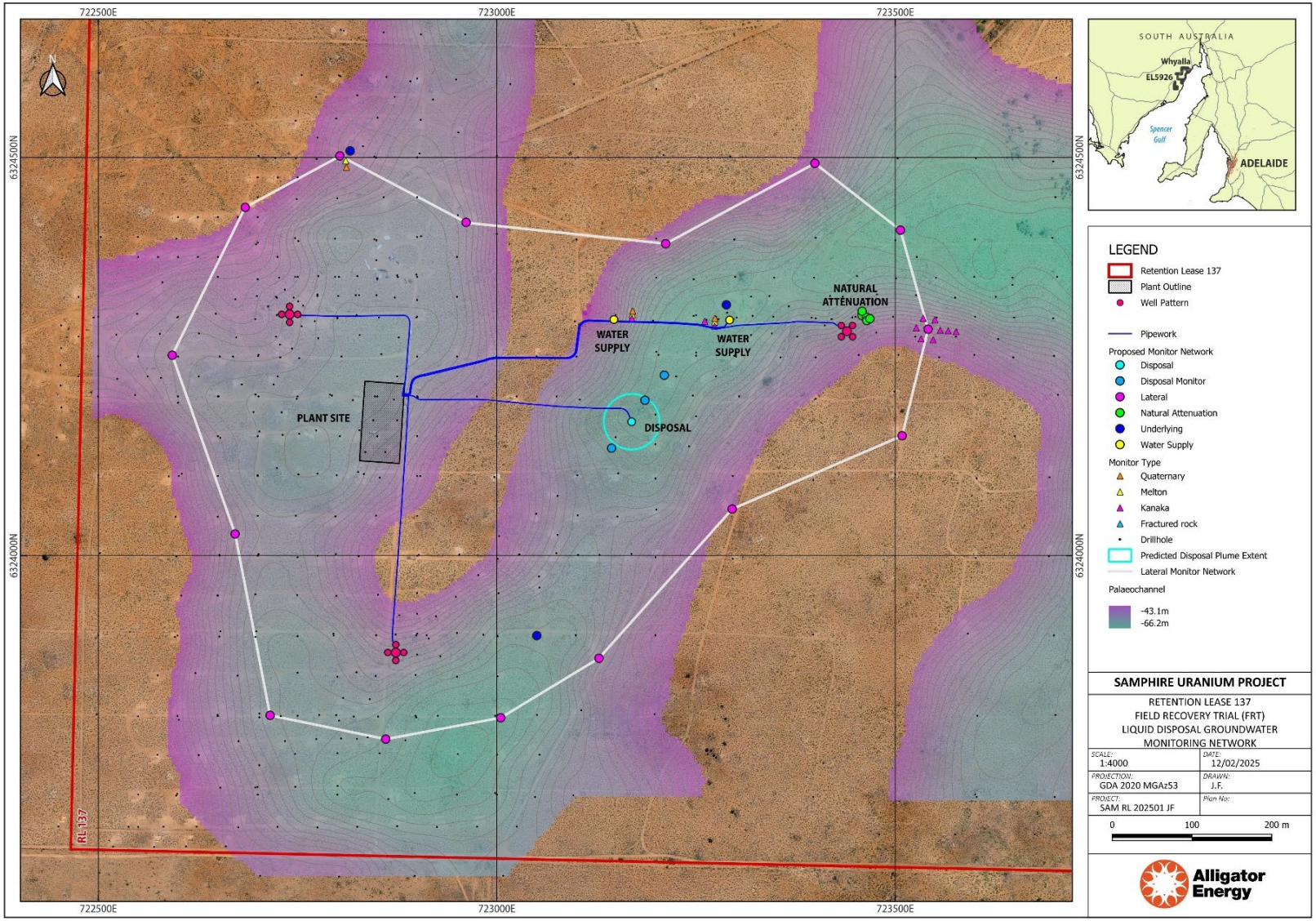


Figure 5.7: Predicted Liquid Waste Plume Extent and Monitoring Location.

5.5 Key Care & Maintenance and Closure Activities

The care and maintenance and closure strategies are built around four key activities, which are fundamental to both phases but adapted to meet the specific requirements of each:

1. Infrastructure Retention and Decommissioning – Managing the removal or retention of site infrastructure to ensure environmental stability while maintaining flexibility for future operations.
2. Groundwater Remediation and Monitoring – Validating non-target aquifer stability and demonstrating the effectiveness of groundwater rehabilitation.
3. Landscape Rehabilitation and Environmental Stabilisation – Restoring disturbed land, preventing erosion, and supporting the return of native vegetation.
4. Security and Access Control – Managing site security prior to RL relinquishment, to protect infrastructure, prevent unauthorised access, and ensure compliance with regulatory safety standards.

Each of these activities will be carried out with strict adherence to regulatory requirements, ensuring that closure outcomes specified by DEM can be demonstrated.

5.5.1 Infrastructure Decommissioning

Care & Maintenance

During the care and maintenance phase, a combination of infrastructure retention and decommissioning will be undertaken to ensure continued environmental protection, risk mitigation, and the reduction of final decommissioning liabilities. If the site transitions to full closure immediately following the FRT, the decommissioning activities described below will be expanded to include full infrastructure removal.

Key activities to be undertaken during care and maintenance include:

- Residual Fluids Removal:
  - All remaining mining fluids will be pumped out of wellfield infrastructure.
  - Pipe networks and vessels will be flushed with raw water to prevent long-term contamination risks.
- Well Decommissioning:
  - Internal well infrastructure (e.g., pumps) will be removed where the well is not required for any active remedial phase.
  - Wells will be retained for long-term groundwater monitoring, remediation or future use.
- Dismantling of pipelines:
  - Pipelines not required for remedial or future works will be disconnected, flushed, and cut into manageable lengths. Pipelines potentially required for accelerated natural attenuation of groundwater, and use of disposal wells will be retained.
  - Reusable sections will be stored, while non-reusable pipework will be transferred to a licensed waste facility.
- Wellhouse and filter skid:
  - Cleaned and kept for potential use if active groundwater remediation is required.
- Processing equipment/vessels works:

  - Eluate tanks will be sealed for long term storage.
  - Pumps, instrumentation, and electrical cables will be assessed for use during care and maintenance.
  - Items not required will be transferred to a licenced disposal facility.

- Residual processing fluids removal:
  - Residual processing fluids i.e., BLS in IX columns and in internal pipework will be transferred to the liquid disposal holding tank/vessel, where it will be directed to the liquid disposal zone for re-injection (see Figure 5.7).
- Residual chemicals management:
  - Neutralised or treated as part of the site decommissioning process, or
  - Transported off-site by licensed hazardous waste contractors for disposal or further processing in compliance with environmental regulations.
- Water storage pond decommissioning:
  - Residual water will be drained and tested for contamination.
  - Contaminated sediments above exemption levels will be removed and treated as low-level radioactive waste.
  - If no medium term use for pond is identified the HDPE liner will be cut up and assessed for radiological contamination before disposal.
  - As above, if no medium term use identified, the excavation backfilled and natural ground surface re-established (see Figure 5.8).
- Buildings and site facilities management:
  - Hired transportable offices, control room, change rooms/toilets, and storage units will be cleaned and removed (see Figure 5.9).
  - The diesel storage tank and generator will be cleaned and removed from site.
  - Non-essential structures will be dismantled and disposed of in line with waste management regulations.
- Roads and access tracks management:
  - All internal roads and tracks will be retained during care and maintenance for ongoing pastoral use, future use during care and maintenance or closure works, groundwater monitoring and potential future groundwater remediation.

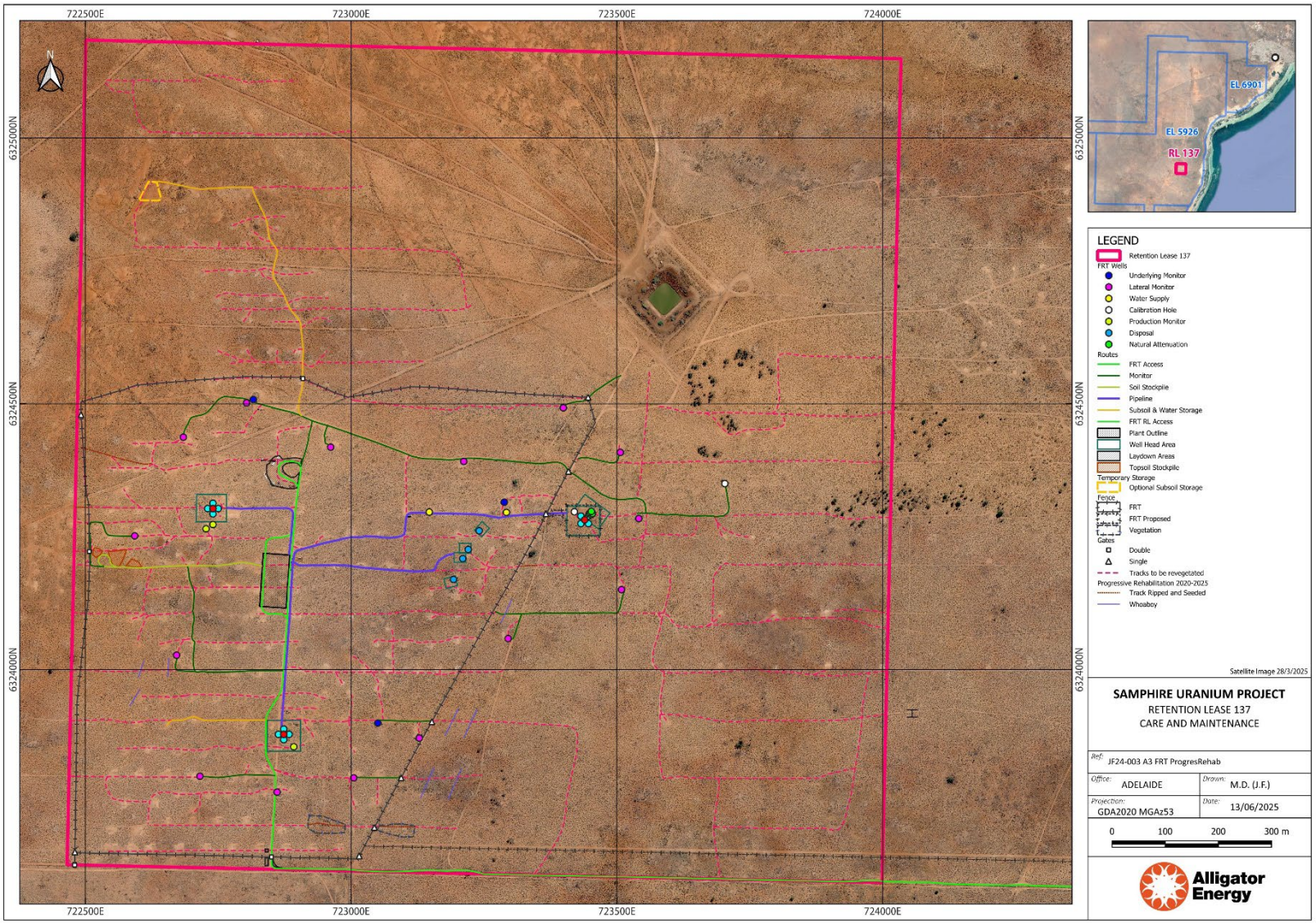


Figure 5.8: Infrastructure to be retained as part of Care and Maintenance

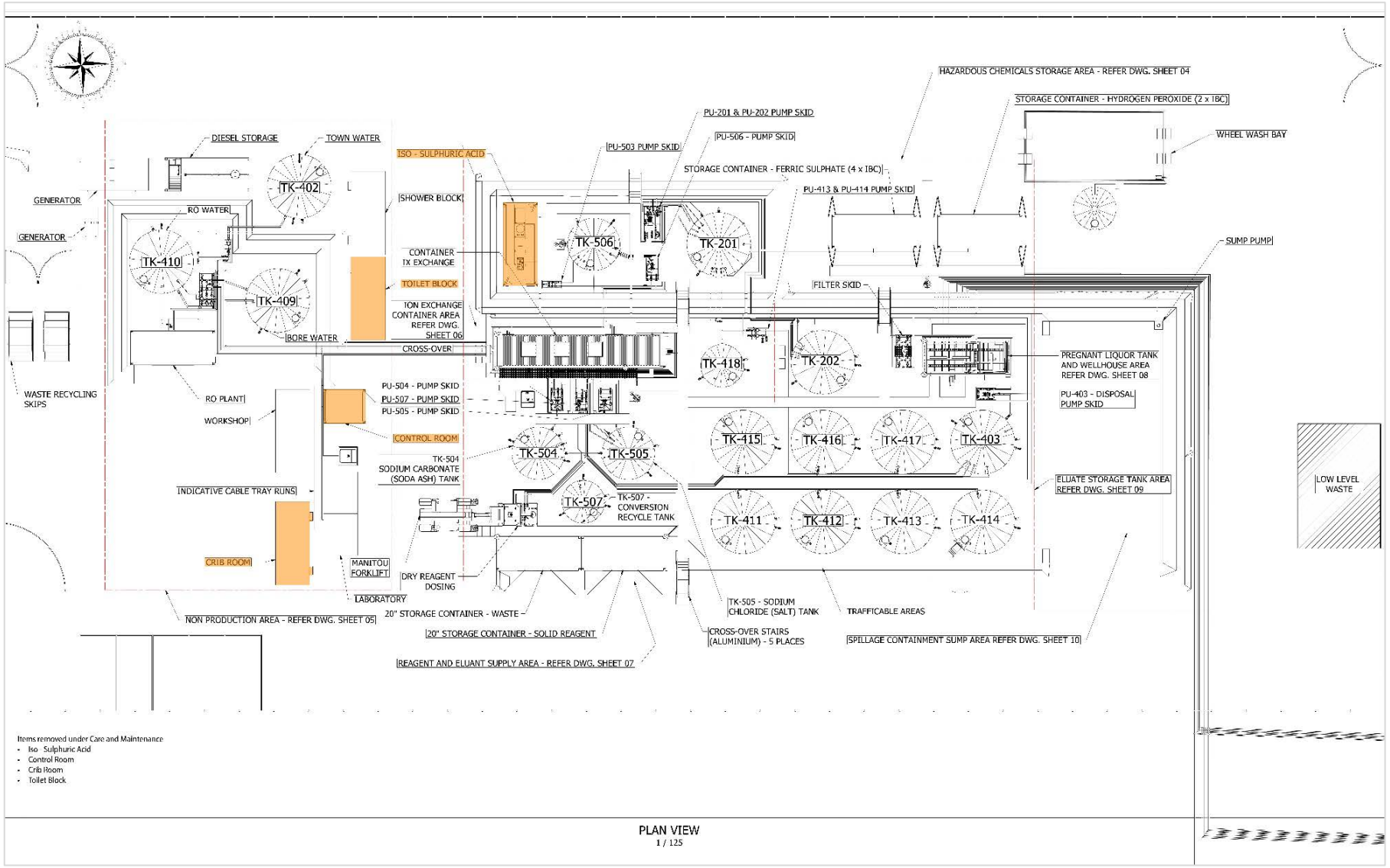


Figure 5.9: Plan of FRT plant showing items to be removed during Care and Maintenance, ISO acid tank, toilet, control and crib rooms

Closure

If ISR mining is deemed unfeasible following the completion of the FRT, the site will transition directly into full closure, bypassing any care and maintenance phase. In this case, the decommissioning activities described above will be expanded to achieve full infrastructure removal and site rehabilitation.

Key activities to be undertaken during Closure include:

- Wellfield and Infrastructure Removal:
  - All internal well infrastructure, including pumps, feeder liners, and pipe networks, will be removed for off-site disposal.
  - All wells will be decommissioned in accordance with the South Australian *Mineral Exploration Drillholes - General specifications for construction and backfilling (M21)* (DSD, 2012).
    - Any drillholes intersecting aquifers will be sealed with sulphate resistant cement grout extending through the water-bearing zone or the full length of the drillhole to prevent cross-aquifer groundwater flow.
    - Drillholes that do not penetrate aquifers will be either cement grouted or backfilled with drill cuttings or clean fill.
    - Surface casing, where present, is removed or cut at least 300 mm below ground level (or 0.5 m where required), and the void is backfilled with in-situ spoil and the surface is compacted to reduce subsidence risk.
- Wellhouse and filter skid:
  - The wellhouse and filter skid will be cleaned, disconnected, and disposed of.
  - Contaminated components will be tested and either decontaminated or disposed of as low level radioactive waste.
- Surface Infrastructure Dismantling:
  - Process plant facilities and equipment will be dismantled, cleaned, and removed from the site, ensuring no residual contamination remains.
  - All remaining temporary buildings will be removed, with any contaminated structures undergoing radiological assessment before off-site disposal.
- Final Contamination and Radiological Survey:
  - A comprehensive gamma radiation survey will be conducted across the site to confirm all radiological exposure levels meet regulatory safety thresholds.
  - Soil contamination surveys will ensure that no residual chemicals or hazardous substances remain in rehabilitated areas.
- Roads & Access Tracks
  - Pre-existing roads and access tracks will be retained for ongoing pastoral use.
  - All project tracks will be rehabilitated using erosion control techniques, including:
    - Scarification to break compacted surfaces.
    - Seeding with native vegetation ground cover to stabilise soil.
    - Construction of contour banks and sediment traps to prevent erosion.
- Final Works:
  - Once all closure obligations are met, final inspections will be conducted by independent auditors to verify compliance.

- Security fencing and access restrictions will be progressively removed as the site meets post-closure rehabilitation objectives.

5.5.2 Groundwater Remediation and Monitoring

Care & Maintenance and Closure

During a care and maintenance or closure phase, groundwater remediation will focus on validating modelled natural attenuation predictions and verifying the continued protection of non-target aquifers. This phase is essential for ensuring compliance with closure requirements while allowing for continued groundwater monitoring to support future ISR approvals.

Key activities include:

- Groundwater Stability Monitoring:
  - Monitoring results will be compared to baseline data to confirm non-target aquifers remain unaffected by residual trial solutions.
- Groundwater Remediation Activities:
  - Monitoring of groundwater pH, uranium, sulphate, and iron concentrations will be conducted to assess alignment with NA modelled expectations.
  - Groundwater natural attenuation models will be updated based on observed data, ensuring accurate predictions of long-term aquifer conditions.
  - Any deviations from expected attenuation behaviour will trigger a contingency review, with additional remediation measures implemented if required (Ref. Trigger Action Response Plan – TARP in Section 7.3.7).

Full details of the natural attenuation modelling predictions are provided in Section 5.3.2 and monitoring programs for care and maintenance or closure are provided in Section 7.3.

5.5.3 Landscape Rehabilitation

Care & Maintenance

During care and maintenance, progressive rehabilitation will be undertaken only in non-essential areas that are no longer required for operational access, groundwater monitoring, or potential remedial activities. Rehabilitation works will focus on stabilising landforms, managing erosion, and encouraging native vegetation recovery in disturbed exploration areas. This phase also provides an opportunity to trial and refine remediation techniques, reducing uncertainty and improving confidence in final closure outcomes.

Key activities include:

- Soil Surveys and Contamination Management:
  - Targeted soil surveys will be undertaken to assess potential contamination from operational activities in areas where infrastructure has been decommissioned.
  - Areas exceeding regulatory contamination thresholds will undergo targeted removal or remediation.
- Soil Stabilisation & Erosion Control:
  - Areas compacted during operations will be lightly scarified to improve water infiltration.

- Contour banks and sediment traps will be installed to prevent soil erosion.

- Topsoil Management & Landform Restoration:
  - Stockpiled topsoil and subsoil will be redistributed to encourage natural regeneration.
  - Berms or artificial landscape modifications will be removed to reinstate natural topography.

- Revegetation works:
  - Revegetation will be limited to non-operational areas that are no longer required during care and maintenance and are primarily restricted to areas disturbed during prior exploration phases Figure 5.10.
  - These areas will be rehabilitated using locally sourced native seed mixes and techniques consistent with the surrounding vegetation communities.
  - Passive revegetation will be prioritised, leveraging local seed stock for regeneration.
  - In larger disturbed areas, targeted seeding of endemic species primarily *Maireana sedifolia* (Pearl Bluebush), *Maireana pyramidata* (Black Bluebush), and *Atriplex vesicaria* (Bladder Saltbush), will be conducted.

- Monitoring & Adaptive Management:
  - Monitoring of revegetation success will be undertaken to:
    - Assess rehabilitation effectiveness.
    - Demonstrate achievement of closure outcomes (e.g., ground cover, weed management) as outlined in Table 7.18, and or
    - Identify remedial measures if necessary.

Closure

If the site moves directly into full closure, activities described for care and maintenance above will be adopted across all decommissioned areas.

Further details on soil and vegetation management and monitoring are provided in full in Section 7.2 and 7.5 respectively.

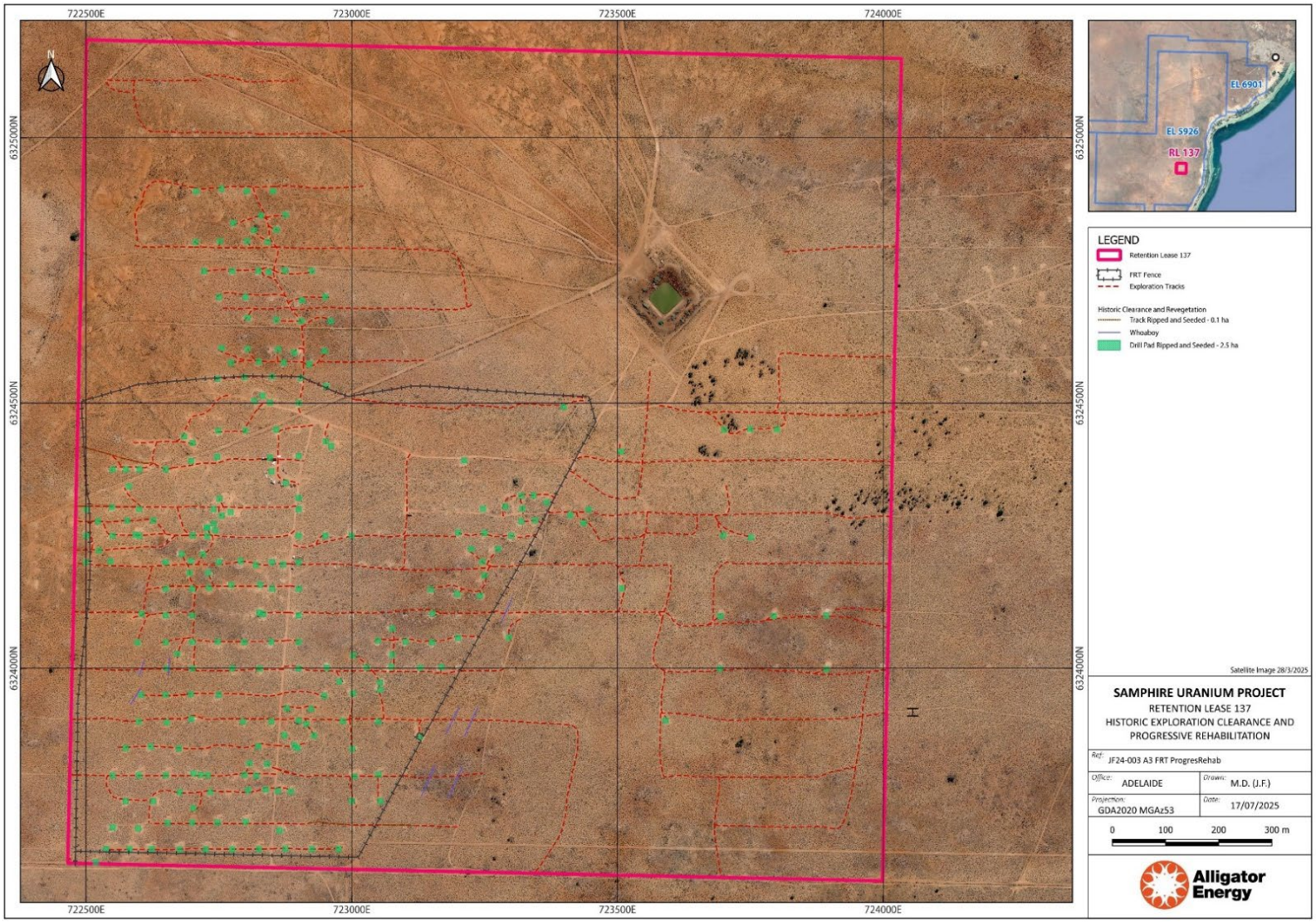


Figure 5.10: Progressive Revegetation Works to be completed during Care and Maintenance

5.5.4 Security and Access Control

Care & Maintenance

Security measures will be implemented to protect retained infrastructure, prevent unauthorised access, and ensure compliance with regulatory requirements.

Key security controls include:

- Perimeter Security:
  - The fence around the FRT operational area will be retained with existing security fencing and locked access gates.
  - CCTV surveillance systems will be maintained at key access points and operational areas to monitor unauthorised entry.
  - The site will continue to be monitored 24/7 by an external security contractor.
- Access Controls:
  - Site access will be strictly controlled through a formal authorisation process, requiring personnel, contractors, and visitors to complete an induction covering site-specific hazards and security protocols before entry.
  - All entries and exits will be logged to maintain oversight of personnel movement.
- Infrastructure Protection:
  - Monitor wells will be capped and any remaining infrastructure will be secured to prevent interference.
  - Non-essential infrastructure will be removed.
- Incident Response and Monitoring:
  - Any unauthorised access attempts, security breaches, or environmental disturbances will be recorded in an internal incident management system. Security patrols will be conducted periodically to ensure fencing integrity, and access control measures remain effective.
- Regulatory Compliance:
  - The security measures implemented during care and maintenance will align with the safety and public access control strategies outlined in Section 7.13 to mitigate any risks to public health and safety.

Closure

During closure, security provisions will be progressively reduced as infrastructure is removed from the site, ensuring that risks are managed appropriately during final site handover.

Key security actions include:

- Progressive Security Reduction:
  - As infrastructure is removed and environmental monitoring obligations are fulfilled, security measures will be scaled down in coordination with regulatory sign-off and landowner agreements.
- Access Controls & Security:
  - All security fencing will be retained until all closure activities are completed.

- All CCTV and external monitoring will be retained until all residual contaminated materials are removed from the RL.

These security measures will ensure that site risks are managed effectively during both the care and maintenance phase and the final closure stage, maintaining compliance with safety, environmental, and regulatory obligations.

5.6 Timing

Estimated timeframes for the rehabilitation and closure of the FRT are provided below in Table 5.3.

Table 5.4 Summary of Rehabilitation and Closure Timing

Item / Area	Details	Timing (Year)				
		1	2	3	4	5
Wellfield Infrastructure Removal	Care & Maintenance[3]					
	Full Closure[4]					
Process Plant Infrastructure	Care & Maintenance					
	Full Closure					
Support Infrastructure	Care & Maintenance					
	Full Closure					
Contamination Assessments	Care & Maintenance					
	Full Closure					
Environmental Rehabilitation / Revegetation	Care & Maintenance					
	Full Closure					
Environmental Remediation & Monitoring	Care & Maintenance					
	Full Closure					
Lease Relinquishment	Care & Maintenance					
	Full Closure					

5.7 Final Completion Sign Off

Table 5.3 outlines the FRT closure schedule for decommissioning activities based on the specific closure activity or component. The relinquishment of any area will require the agreed completion (closure) criteria to be met to the satisfaction of DEM. All closure outcomes and measurement criteria are detailed in Section 8.

As part of the RL relinquishment, the following long-term provisions will be implemented to ensure that future landowners and land users are informed of the prior FRT activities:

Comprehensive Site Records and Data Management

- GPS coordinates for operational areas, site disturbance maps, and all closure specifications will be compiled and submitted to DEM and the EPA SA Radiation Protection Branch.

[3] In line with the care and maintenance specifications detailed in Section 5.4.
[4] In line with the closure specifications detailed in Section 5.4.

- These records will be digitally archived with DEM and other relevant agencies to ensure long-term accessibility for future land users, government agencies, and researchers.
- A publicly accessible record (subject to regulatory approval) will be maintained, outlining the general location, nature, and environmental status of the site post-closure.

Land Use Restrictions and Ongoing Notifications

- A Land Access Agreement has been established with the landholder to ensure clear communication regarding project-related activities. While this agreement does not impose a statutory restriction, it includes provisions requiring that the landholder be kept informed of groundwater conditions and any associated limitations arising from exploration or mining activities.
- This mechanism ensures the landholder is formally made aware of these considerations, including the restricted use of groundwater in areas where no known beneficial use currently exists, and where natural attenuation processes will be ongoing.
- Subject to regulatory requirements, a legal instrument may be applied to the projected extent of affected groundwater within the Tertiary aquifer.

Future Landowner and Stakeholder Engagement

- Before final lease relinquishment, Alligator Energy will consult with DEM, EPA SA, and the pastoral leaseholder to ensure that adequate information is transferred to potential future landowners or users.
- If any residual infrastructure is to be retained at the request of the landowner, these arrangements will be formalised in the Mine Completion Report, with a record of any infrastructure agreements held by DEM.
- If necessary, a public fact sheet or landholder information package will be developed to provide clear guidance on the historical use of the site and any ongoing environmental considerations.

Long-Term Monitoring and Compliance Oversight

- Any ongoing surveillance or remedial works post-lease relinquishment will be established in consultation with DEM.
- If post-closure groundwater or environmental monitoring is required, the responsibility, frequency, and reporting obligations will be agreed upon with government agencies prior to relinquishment.
- A final Mine Completion Report will be submitted to DEM and EPA SA, ensuring that all relevant information is documented and accessible for future reference.

Regulatory Compliance and Final Relinquishment Process

- The formal RL relinquishment will be conducted in full compliance with DEM specifications and relevant environmental legislation.

Prior to relinquishment, Alligator Energy will confirm with regulatory agencies that all conditions have been met and that all necessary land use notifications and records are in place for future stakeholders.

5.8 Rehabilitation Liability Estimate

The FRT bond calculations were developed using the South Australian Rehabilitation Liability Estimate Calculator (Version 1.3) for In-Situ Recovery Operations. The cost estimate assumes

that all decommissioning and rehabilitation works are undertaken by a third party and provides provisions for contingency groundwater remediation works.

All waste will be transported to a licenced disposal facility off-site.

Closure cost estimates will be updated annually through the RL period to reflect infrastructure changes.

Table 5.5: Summary of Rehabilitation Bond Cost Components

No.	Component Description	Relevance	Component Cost
1	Accommodation	Not Applicable	$ 0
2	Administration Area	Not Applicable	$ 0
3	Processing Facility	Pilot Processing Facility	$ 830,134
4	Trunklines	Not Applicable	$ 0
5	Laydown Areas	Not Applicable	$ 0
6	Waste Facilities	Not Applicable	$ 0
7	Ancillary Areas	Not Applicable	$ 0
8	Services Infrastructure	Not Applicable	$ 0
9	Wellfield	FRT Wellfield Area	$ 684,962
10	Equipment Mobilisation & Demobilisation	All Areas	$ 3,614
		Subtotal - Direct Costs (A)	**$ 1,518,710**
		Monitoring & In-Direct Costs (B)	**$ 1,172,671**
		Total Rehabilitation Liability – Rounded (A+B)	**$ 2,690,000**

6 STAKEHOLDER CONSULTATION

6.1 Purpose

Alligator Energy has implemented a stakeholder engagement framework grounded in the principles of open information sharing. This framework aligns with the Better Together SA Multiple Land Use Framework (Government of SA, 2016) and the International Association for Public Participation (IAP2) Spectrum of Public Participation (IAP2, 2014). These guiding principles ensure that stakeholder interactions are meaningful, transparent, and inclusive.

The Community Engagement Plan (CEP) (Appendix T) defines how Alligator Energy identifies and engages stakeholders within Whyalla and surrounding communities. It also incorporates mechanisms for managing stakeholder complaints, maintaining transparency, and ensuring accountability as part of the project's Complaints Register. The CEP outlines strategies employed during the development, operation, and closure phases of the FRT and RL lifecycle, fostering long-term collaboration and trust.

Key objectives include:

- Enhancing positive relations between stakeholders.
- Sharing clear, accurate, and timely information about the project.
- Establishing mechanisms for addressing stakeholder concerns.
- Promoting environmental and community sustainability.

6.2 Approach

Alligator Energy's approach to stakeholder engagement involves:

- Understanding the Community: Stakeholder mapping through a detailed analysis of landholders, community groups, and other entities likely to be impacted by or interested in the project.
- Adaptive Consultation: Engagement activities are tailored to the evolving needs of stakeholders throughout the project lifecycle.
- Open Dialogue: Information is shared proactively through public meetings, one-on-one discussions, and online platforms.
- Complaints Handling and Monitoring: A 24/7 free-call complaints line is in place and currently active to ensure accessibility for public feedback.

Key documents guiding engagement include:

- Community Engagement Plan (CEP).
- Stakeholder Map: Identifying engagement levels aligned with the IAP2 Spectrum of Public Participation (2014).
- Community Engagement Implementation Plan (CEIP): Detailing practical actions for engagement.
- Community Engagement Register: Recording all engagement activities and outcomes to ensure transparency in the internal consultation database.
- Complaints Register: Tracking complaints, responses, and resolutions in the internal consultation database to ensure accountability for addressing complaints in a timely manner.

6.3 Engagement Activities Undertaken to Date

6.3.1 Stakeholder Identification

Alligator Energy has undertaken a systematic process to identify stakeholders relevant to the Samphire Project, ensuring all affected and interested parties are accounted for and effectively engaged. This process included a comprehensive review of past consultation activities and stakeholder mapping exercises to build a detailed understanding of the community. Alligator Energy has employed a full-time Stakeholder Engagement Manager to implement the plan and oversee ongoing engagement.

Process Overview

Desktop Review

A detailed review of UraniumSA's 2010–2011 community engagement activities were conducted. This included examining records of public meetings and reviewing feedback provided by community members during the project's earlier phases. These insights informed the understanding of historical stakeholder concerns and priorities.

Stakeholder Mapping

A thorough mapping exercise was conducted, incorporating expertise from Alligator Energy's experienced project team. This process was further enhanced by input from an external consultant with over 20 years of experience in community engagement, economic development, and Aboriginal affairs within the Whyalla region. The mapping exercise aimed to ensure comprehensive coverage of all potentially impacted or interested parties.

Identified Stakeholders

The key stakeholder groups identified through this process include:

- Whyalla Community Members, Pastoralists, and Businesses:
  Individuals and enterprises located near the project area, with a direct interest in its potential social, economic, and environmental impacts.
- Adjacent Landholders / Residents:
  Property owners in the immediate vicinity of the RL who may experience direct effects from the operations.
- Local, State, and Federal Government Representatives:
  Government officials and agencies responsible for regulatory oversight, approvals, and policymaking related to uranium mining and environmental management.
- Indigenous Communities:
  The Barngarla Determination Aboriginal Corporation (BDAC) and other Indigenous groups with cultural and historical ties to the project area.
- Local Environmental and Conservation Organisations:
  Groups focused on protecting the region's ecological and biodiversity values.

6.3.2 Engagement Activities

Since acquiring the Samphire Project in 2020, Alligator Energy has implemented a phased and comprehensive stakeholder engagement program. Initial engagement efforts were focused on key stakeholders, including immediate and adjacent landholders, the Whyalla City Council, State

and Federal Members of Parliament, and the Barngarla Determination Aboriginal Corporation (BDAC). Broader community engagement was initiated in late 2022 to ensure inclusivity and transparency.

Engagement Highlights

Initial Engagement:

Engagement with key stakeholders commenced immediately after the project acquisition in 2020, establishing the groundwork for meaningful, long-term relationships with critical community groups. These early conversations were instrumental in ensuring that local perspectives were integrated into the project planning process from the very beginning, fostering trust and collaboration.

Community-Wide Engagement:

Expanding on these initial efforts, Alligator Energy broadened its outreach to the entire Whyalla community in late 2022. A series of public meetings and drop-in sessions were held at Mount Laura Homestead on December 12-13, 2022; January 31-February 1, 2023; February 21-22, 2024; and February 5-6, 2025. In addition to these meetings, Alligator Energy appointed a dedicated Stakeholder Engagement Manager to strengthen communication and relationship-building.

Collaborative efforts with key local organisations, including Landscape South Australia and Simec, were also undertaken to address the issue of invasive species such as the Hudson Pear. At the Whyalla Community Picnic, Alligator Energy engaged in over 40 conversations with local residents, further deepening connections within the community. Presentations and briefings were held with local emergency services, including SAPOL, SAAS, MFS, SA Health, and other agencies, ensuring a comprehensive understanding of the project's potential impact.

To further enhance accessibility, project materials were displayed at the Whyalla Public Library for two weeks, allowing the broader public to engage with the project at their convenience. Additionally, a free 1800 number was introduced, staffed 24/7, to facilitate ongoing community inquiries and ensure direct communication with the project team.

Looking ahead, while the FRT remains operational, Alligator Energy is planning a series of pop-up information sessions and other community engagement activities to provide further opportunities for interaction and feedback. These initiatives continue to demonstrate our commitment to ongoing, transparent communication with the Whyalla and surrounding communities.

All of these engagement efforts were promoted widely across local media, including the Whyalla News, radio, community noticeboards, and the Whyalla City Council's Facebook page, maximizing visibility and participation.

Summary of Engagement Activities

Since 2020, Alligator Energy has facilitated 97 meetings and corresponding interactions with local and neighbouring landholders. Over 20 individual meetings have been conducted with Barngarla Native Title Holders, elected officials, the Whyalla City Council, and various industry representatives. Public meetings and information sessions have attracted approximately 60 participants, representing a diverse cross-section of stakeholders. This ongoing engagement underscores Alligator Energy's dedication to build strong community relationships and ensuring that all voices are heard throughout the project's lifecycle.

Communication and Accessibility

To ensure transparency and accessibility, presentations from the 2022-2025 community information sessions were made available on Alligator Energy's website (www.alligatorenergy.com.au). These resources included an email address for stakeholder feedback (feedback@alligatorenergy.com.au) and a dedicated contact number.

Complaints Management

Alligator Energy maintain a detailed complaints register to ensure all complaints and actions to resolve complaints are formally recorded. The following information is captured in the register:

- The time and date a complaint is received.
- Details of the complainant (if provided or anonymous).
- The nature of the complaint.
- Actions taken to resolve the complaint, including follow-up communications with the complainant.
- Reasons for no action (if applicable).

Alligator Energy operates a 24/7 free-call complaints line as a mechanism to receive feedback, concerns, and suggestions from the public during active FRT phases. The complaints line contact information shall be advertised through:

- Local media outlets.
- Alligator Energy's website.
- Community engagement events.

Historical Context and Incorporation of Feedback

Alligator Energy has also integrated insights from UraniumSA's prior engagement activities during 2010–2011, which included public consultation and feedback gathering. This historical consultation data informed the development of Alligator Energy's Retention Lease Proposal, particularly the assessment of environmental impacts. Draft outcome criteria, initially presented at the December 2022 public meetings, were updated based on feedback received and revisited during subsequent community engagement sessions Alligator have held.

6.3.3 Record of Stakeholder and Community Consultation Activities

Alligator Energy's consultation has primarily been in the form of one-on-one discussions with local landowners, broader community meetings, drop -in sessions, collaborative efforts with key local organisations, including Landscape South Australia and Simec and meetings with various regulatory agencies. Meetings have also been held on a regular basis providing updates on the progress of the project with local (State and Federal) MP's, Local Government representatives (Whyalla City Council), government agencies, local environment committees, service organisations, local businesses and landowners.

The Community Engagement Register (Appendix S) provides a breakdown of community and stakeholder engagement activities undertaken by Alligator Energy from 2020 in addition to a summary of activities undertaken by UraniumSA (2010- 2011) in relation to their proposed field trial at that time.

6.4 Key Stakeholder Concerns and Responses

Key stakeholder concerns raised during project consultation phases were tabled in Section 7.7 of the Samphire RL Proposal document, available on Department for Energy and Mining (DEM) website. Statutory consultation for the RL Proposal assessment (as per Section 56H of the Mining Act 1971) occurred from 23 August to 20 September 2023. Issues raised during this period were reviewed and addressed as part of a formal response document which is publicly available on the DEM website.

A table summarising key stakeholder concerns and Alligator Energy's responses is provided in Table 6.1 below:

Table 6.1: Summarised Table of Concerns and Responses

No	Concern Raised	Summarised Alligator Energy's Response
1	Radioactive release during mining	The in-situ recovery (ISR) process dissolves uranium directly within a controlled and contained solution underground, minimising risks. Operations are strictly regulated under multiple legislative frameworks, ensuring safety and environmental protection.
2	LLRW disposal and transport	Low-level radioactive waste (LLRW) is managed with care and precision—either safely reinjected into the aquifer or transported under stringent national and international protocols, ensuring safety for communities and the environment.
3	Concentration of radioactive materials	Radioactive fluids are securely stored in specially designed vessels during the trial. Afterward, the site will be fully rehabilitated to its original state, leaving no operational residue.
4	Use of sulphuric acid and contamination	Australia's strict regulations ensure natural groundwater restoration post-trial. Historic contamination in other countries stemmed from weaker frameworks, which are avoided through our robust safeguards.
5	End use of uranium	The Field Recovery Trial will not produce uranium oxide concentrate (UOC). Any uranium from Australian projects is exported under stringent international agreements, ensuring exclusive use for peaceful purposes.
6	Cumulative radiation risks	We comply with ARPANSA's rigorous standards, which account for cumulative exposure risks, protecting workers, communities, and the environment.
7	Groundwater restoration post-trial	Groundwater naturally recovers post-trial, verified through monitoring programs. We are committed to ensuring baseline conditions are restored.
8	Radioactive mine tailings	ISR mining does not produce mine tailings or waste rock, making it a cleaner, more sustainable method compared to traditional mining.
9	Rehabilitation commitments	Rehabilitation is central to our operations. We exceed regulatory requirements by restoring areas progressively and securing financial guarantees to ensure thorough and responsible rehabilitation.
10	Impact of Beverley ISR incidents	Lessons from past ISR projects have been integrated into our planning. This trial is small, controlled, and designed to meet today's stringent safety standards.
11	Proximity to communities	ISR has a strong safety record near communities. The small scale of this trial, combined with strict safeguards, ensures minimal impact while adhering to the highest safety standards.
12	Community trust and engagement	Transparency is a priority. Multiple engagement sessions have been held to share information, address concerns, and gather feedback. We remain committed to open dialogue throughout the project.
13	Livestock and farming risks	The trial area will be securely fenced to prevent livestock interaction. Safety measures ensure no risks to animals or the integrity of farming operations.
14	Spill and flood risks	Robust spill prevention and flood mitigation measures are in place, including advanced containment systems and detailed response plans, to protect the surrounding environment.

No	Concern Raised	Summarised Alligator Energy's Response
15	Road degradation from traffic	The trial's small scale limits traffic increases. We are committed to maintaining road conditions and collaborating with stakeholders to minimise impact.
16	Impact on aesthetics and property values	We have implemented measures like tree planting and operational adjustments to mitigate visual and noise impacts. We continue to work with residents to reduce any disruption.
17	Aquifer contamination	Groundwater impacts are localised and temporary, with natural processes restoring conditions over time. Comprehensive monitoring ensures safety and transparency.
18	Radiation exposure risks	Radioactive materials will be securely contained, and regular monitoring will confirm radiation levels remain well below regulatory limits, ensuring the safety of workers and communities.
19	Whyalla's green transition	This trial aligns with Whyalla's development goals, coexisting with renewable energy initiatives like solar and wind farms, and demonstrating our commitment to sustainability.
20	Socioeconomic impacts	Although temporary, the trial supports regional development and aligns with Whyalla's broader initiatives, contributing to the local economy and community growth.

6.5 Stakeholder Engagement Plan

Alligator Energy is committed to conducting its business activities with transparency and accountability. Our CEP for the FRT at the Samphire Project near Whyalla will outline our approach to engaging with stakeholders, ensuring they are informed, respected, and empowered throughout the trial. This plan is underpinned by our company's Vision and Values, ensuring our operations align with the expectations of all stakeholders, especially those in the local communities where we operate.

6.5.1 Strategic Objectives

The stakeholder engagement approach for the Samphire Project is guided by the following objectives, ensuring all interactions are meaningful, transparent, and aligned with community and environmental values:

Inform Stakeholders:

Alligator Energy is committed to providing stakeholders with accurate, timely, and easily accessible information about the FRT. This includes clearly outlining the trial's purpose, processes, and anticipated benefits to both the local community and the environment.

Establish clear channels for feedback and complaints, including a 24/7 complaints line, ensuring stakeholders have accessible mechanisms to raise concerns.

Engage the Local Community:

Building strong relationships with the local community is a priority. This involves actively listening to their concerns, answering questions, and incorporating feedback into project planning and execution. The aim is to ensure local voices are heard and considered during the phases of the FRT.

Build Trust:

Through proactive communication and a transparent approach, Alligator Energy strives to establish itself as a responsible and reliable company. Consistent and honest interactions will reinforce the company's commitment to stakeholder engagement and long-term accountability.

Ensure Safety:

The safety of workers, community members, and the environment remains paramount. Alligator Energy will clearly communicate the safety measures in place, ensuring that all stakeholders understand the rigorous protocols being implemented to protect them.

Manage Expectations:

Effective engagement requires clear communication about project timelines, potential impacts, and overall objectives. By keeping stakeholders informed and managing expectations, Alligator Energy aims to maintain trust and alignment throughout the trial.

6.5.2 Target Stakeholders

To ensure meaningful engagement throughout the RL project lifecycle, stakeholders have been categorised into primary and secondary groups. This classification allows for tailored communication and engagement strategies that address the specific needs, interests, and concerns of each group.

Primary Stakeholders

These stakeholders are directly impacted by or closely involved in the RL activities and require frequent, detailed communication and active engagement:

- Local Pastoralists, Residents, and Businesses: Individuals and entities situated near the project area who may experience its direct social, economic, or environmental impacts.
- Native Title Holders and Indigenous Communities: Groups with cultural and historical ties to the land, requiring respect for their heritage and active collaboration on land-use matters.
- Community Organisations: Includes environmental and conservation groups whose focus on ecological protection aligns with the project's commitment to sustainability.
- Workers and Contractors: Individuals involved in the project's operations, including construction, field recovery trials, and rehabilitation activities.

Secondary Stakeholders

These stakeholders are indirectly affected by the RL activities or hold a broader interest in its implications. They require periodic updates and engagement to address overarching concerns:

- Government Regulators and Policymakers: Representatives at Federal, State, and Local levels responsible for overseeing compliance, issuing approvals, and shaping policies related to uranium mining and environmental management.
- Media Outlets and Journalists: Channels for disseminating information to the broader public, ensuring transparency and fostering public understanding of the project.
- Broader Public: Individuals and groups with an interest in the environmental, economic, or social implications of uranium mining and its potential impacts on regional and global sustainability.

6.5.3 Engagement Strategies

Table 6.2 provides an overview of the key engagement strategies proposed by Alligator Energy during all FRT phases. These strategies are designed to ensure that essential project information is communicated to interested parties and that opportunities for regular feedback and consultation are provided.

Table 6.2: Engagement Strategies – FRT Phases

Phase	Key Activities
Phase 1: Pre-Construction	• Host a community session in Whyalla to introduce the project and gather feedback. • Meet with local leaders, Indigenous groups, and stakeholders to discuss impacts. • Release project updates via media, FAQs, and newsletters.
Phase 2: Construction	• Provide bi-weekly updates through community pop-ups with visuals (e.g., maps, charts, photos). • Offer site tours for Indigenous groups and landowners. • Share progress regularly on the website and social media.
Phase 3: Operation	• Host a session to explain the transition to operations and monitoring processes. • Facilitate site visits for transparent reporting and updates.
Phase 4: Post-Operation	• Conduct a forum to share project outcomes and next steps, like rehabilitation. • Collect feedback to improve future engagement. • Provide final project summary to interested parties.

6.5.4 Monitoring and Engagement

To ensure effective engagement, Alligator Energy will implement a comprehensive monitoring and evaluation process. Key performance indicators, such as event attendance, website traffic, and social media interactions, will be tracked to assess the impact of our communications. Regular reviews of stakeholder feedback, including questions, concerns, and suggestions, will help identify recurring themes and emerging issues, guiding adjustments to our engagement strategies to better meet stakeholder expectations throughout the RL lifecycle. A 24-hour complaints hotline ensures accessibility, with all complaints documented, investigated, and addressed in a timely manner. Patterns identified in the complaints register will inform preventative measures and operational improvements.

We are committed to transparency by providing regular updates on engagement activities and environmental performance through reports and forums. Stakeholder feedback on environmental matters, such as groundwater, air quality, and vegetation, will inform monitoring programs to meet the RL's environmental outcomes. We will also engage with third-party land users, including pastoral leaseholders, to minimise disruption to their activities. Respect for Aboriginal and non-Aboriginal heritage will remain a priority, with concerns addressed in consultation with stakeholders and in compliance with legislation

7 ENVIRONMENTAL OUTCOMES, MANAGEMENT & MONITORING

7.1 Overview

This section summarises the potential impacts associated with the outlines the environmental outcomes associated with the Samphire RL, along with the associated control and management strategies, monitoring programs, measurement criteria, and leading indicator criteria. These elements are provided in accordance with Section 70B of the Mining Act 1971, Regulation 63 of the Mining Regulations 2020, and Terms of Reference 024 for Uranium In-Situ Recovery PEPRs (DEM 2020a).

The FRT, encompassing construction, operation, and closure phases, has the potential to impact a range of environmental elements and associated factors identified in the Samphire RL Proposal (Alligator Energy, 2023b). These include:

Environmental Elements:

- Soils
- Groundwater
- Surface Water
- Vegetation, Weeds and Plant Pathogens
- Native Fauna and Invasive Species
- Air Quality

Land Use and Community Considerations:

- Land Use
- Heritage
- Amenity
- Roads, Traffic and Transport
- Noise
- Public Health, Safety and Property
- Waste

Each of these elements is addressed in Sections 7.2 through to Section 7.14, with consideration given to the following components:

Context

This section provides an overview of the environmental element, including relevant background information, existing conditions, and updates from recent environmental monitoring activities. It also summarises FRT-specific activities that establish the context for the subsequent discussion on potential impacts.

Potential Impacts

The potential impacts section details potential impacts associated with the FRT, as identified through environmental assessments undertaken during the RL proposal stage (Alligator Energy, 2023b). Note, only impacts with a credible source-pathway-receptor linkage are considered. Additional potential impacts may be included where further clarification or supplementary

assessment has been conducted following the RL proposal review or in response to stakeholder feedback.

Regulatory Outcomes

The defined regulatory outcomes for each environmental, land use or community element as detailed in RL 137 (Appendix A) are presented in this section. An outcome is defined as a measurable environmental, social, or economic condition that must be achieved to ensure compliance with the Mining Act 1971 and associated regulations. These outcomes focus on specific environmental and social condition needs to be achieved, rather than prescribing how activities must be conducted.

Key Control and Management Strategies

This section outlines the control and management strategies designed to prevent, mitigate, or manage potential impacts. These strategies include site-specific measures, engineering controls, and procedural requirements necessary to achieve environmental outcomes.

Monitoring and verification programs are incorporated within this section where applicable, ensuring that management strategies are continuously assessed for effectiveness and remain aligned with regulatory expectations.

This section also assesses any uncertainties or assumptions that may affect the effectiveness of control strategies in achieving the regulatory outcomes. Uncertainties are evaluated based on knowledge gaps, data limitations, and sensitivity to environmental conditions. In addition, if additional work is required, it will focus on further monitoring and assessments, targeted trials, or adaptive management to refine strategies and ensure compliance.

Outcome Measurement Criteria and Leading Indicator Criteria

To ensure compliance with environmental outcomes, outcome measurement criteria are defined for each element. These criteria outline the parameters used to evaluate environmental performance, including:

- Measurement parameters and methods.
- Sampling locations and monitoring frequency.
- Implementation responsibilities and record-keeping requirements.
- Achievement indicators for each outcome.
- Assessment frequency across project phases.

In cases where control strategies are critical to achieving an outcome, leading indicator criteria are also established. These indicators serve as early warning signals, allowing for proactive management if there is a risk that a control measure may fail or become ineffective.

7.2 Soils

7.2.1 Context

The RL area lies within the coastal plains of the Eyre Peninsula, where the topsoil consisting of thin Holocene soils and unconsolidated alluvial and lacustrine sediments. Soil composition is 80–100% sand, with low nutrient levels and high permeability (30–300 mm/hour saturated hydraulic conductivity). Soil depth ranges from 300 mm to 1000 mm, with an A horizon generally less than 25 mm thick. The risk of water erosion or scalding is classified as low, consistent with much of the Eyre Peninsula (DEW, 2022). A full description of local topsoil and subsoil is provided in Section 2.3.

Baseline assessments indicate that natural radionuclide concentrations in local soils are within expected background levels, with no significant variation between sampling locations or depths. However, ^{210}Pb concentrations are slightly elevated in surface soils compared to deeper layers (5–15 cm), a phenomenon consistent with natural radioactive decay and atmospheric deposition (Appendix M). These baseline conditions will serve as a reference for post-closure monitoring and compliance assessment to ensure no residual radiological contamination from FRT activities.

As part of FRT operations, soil and vegetation disturbance will be limited to a maximum additional area of 5.58 hectares. Approximately half of this area will require topsoil and subsoil stripping, while the remainder may be affected by vehicles, machinery movements and project infrastructure, such as surface-laid reticulation pipelines. The total impacted area is shown in Figure 4.2.

7.2.2 Potential Impacts

The potential impacts to soil from the FRT operations have been assessed in the Samphire RL Proposal document (Alligator Energy, 2023b) and the associated Samphire Response Document (Alligator Energy, 2024).

The potential impacts to soil associated with the development and implementation of the FRT, with identified source-pathway-receptor linkages include:

- Loss of soil quantity through erosion reducing the ability to support revegetation and pastoral use.
- Degradation of soil quality due to compaction or contamination, preventing successful revegetation and pastoral use.
- Change in soil chemical and radiological composition from localised spills, potentially restricting revegetation and pastoral use.

7.2.3 Regulatory Outcomes and Conditions

The Fourth Schedule – Environmental Outcomes and Conditions of the RL (Appendix A) establishes the soil-related regulatory requirements that Alligator Energy must achieve and sustain during operations and closure. These requirements include environmental outcomes, management conditions, and compliance criteria to ensure soil protection.

The conditions set out in this schedule define the necessary environmental performance standards and management strategies that must be implemented to prevent soil contamination, erosion, and degradation both on and off the RL throughout the project lifecycle.

Soil Outcome

- The Tenement Holder must ensure there is no contamination of land and soils either on or off the Land post completion as a result of field recovery trial activities.

Soil Strategy

The Tenement Holder is required to address the following matters for the purposes of Regulation 63(1)(b) of the Mining Regulations 2020 in relation to the Fourth Schedule:

- Develop and implement a Spill Management Procedure in accordance with the EPA Bunding and Spill Management Guideline (EPA, 2016).

7.2.4 Control, Management and Monitoring Activities

Effective soil management within the RL is essential to preserving topsoil quality, minimising erosion, and supporting future rehabilitation efforts. Soil management strategies will be implemented to maintain soil structure, reduce erosion and dust generation, and promote long-term land stability within the RL operational area.

The RL is situated on a pastoral property, where unfenced areas will remain available for grazing under agreements with the landowner. For instance, sheep will continue to access Coronation Dam, which lies outside the active FRT area but within the RL boundary. While soil conservation measures will be applied in fenced and operational areas, pre-existing soil impacts from pastoral activities, such as compaction, stock tracks, and localised erosion, may persist in unfenced sections as these areas remain in use by the pastoralist.

Alligator Energy will implement targeted soil management strategies to align with regulatory requirements, industry accepted NRM practices, minimise environmental impacts and complement existing pastoral land use practices. These measures will align with regulatory requirements and support long-term broad scale land rehabilitation objectives, typically expressed in the Eyre peninsula landscapes board regional plan. Where feasible, soil management activities will also complement existing pastoral land use practices to maintain broader soils and erosion stability.

The following sections outline the specific management measures that will be applied throughout the FRT, including topsoil and subsoil preservation, erosion prevention, dust suppression, contamination response, and rehabilitation efforts.

Topsoil & Subsoil Management & Preservation

For areas requiring excavation for FRT construction, topsoil will be carefully stripped and stored to retain its biological and structural integrity for future rehabilitation. Key management measures include:

- Topsoil Stripping and Stockpiling: A recommended 200 mm depth of topsoil (or as determined by on-site assessment) will be stripped and stockpiled for later use.
- Stockpile Design: Topsoil stockpiles will:
  - Not exceed 1 metre in height to minimise compaction and maintain soil aeration.
  - Have a batter slope of less than 1V:2H for stability.
  - Be bunded with subsoil, with a sediment fence installed between the bund and topsoil to prevent mixing.
  - Remain uncompacted to preserve microbial activity and seed banks.

- Hydroseeding of Stockpiles: Direct seeding with native grasses and small shrubs will be undertaken as soon as practicable using a hydroseeder to stabilise the soil and reduce erosion risks.
- Documentation & Monitoring: Soil stockpile locations and approximate volumes will be documented and regularly monitored to assess their stability and condition.

Soil Erosion Prevention and Management

To maintain soil health and structure, a range of erosion control techniques will be applied to reduce the impact of lateral surface water flow, particularly during high-intensity rainfall events on compacted or disturbed areas. Key erosion prevention and management measures include:

- Sheet and Gully Erosion Control: Soil conservation management techniques will be implemented to stabilise areas affected by historic soil erosion, including:
  - Contour lines in paddocks with significant sheet and gully erosion.
  - Installing sediment traps, such as whoa-boys, rock barriers, vegetation debris, contour banks, and silt fencing (if required), will be placed upslope of gully erosion lines to reduce further spread.
- Rainfall Impact Mitigation: To reduce the erosive effects of rainfall on exposed soils, efforts will focus on preserving natural vegetation cover, where possible, in areas not directly impacted by mining or grazing operations and where possible rapid revegetation of impacted areas.
- Revegetation and Ecosystem Restoration: Where revegetation occurs, only native Australian species endemic to the Whyalla region will be used to ensure long-term sustainability and ecosystem restoration.

Dust Suppression and Soil Compaction Management

Soil compaction and dust generation can result in topsoil loss, reduced infiltration, and degradation of soil quality. To mitigate these impacts, the following management activities will be implemented during active project phases:

- Track and Traffic Management: Key controls include:
  - Enforcing a traffic management plan (Appendix T) to restrict vehicle movement to approved tracks, minimising off-track soil compaction.
  - Maintaining stabilised roads in high-traffic zones to reduce soil compaction and disturbance.
- Dust Suppression Measures: Dust control will be achieved through:
  - Water (potable) spraying on access tracks.
  - Applying organic dust suppressants where required.
  - Limiting vehicle speeds to 20 km/h to minimise dust lift-off.
  - Maintaining vegetation cover in off-track areas (where possible) to stabilise soil and reduce airborne dust.
- Use of Native Mulch: Vegetation debris from other RL development activities (e.g., fence or pipeline construction) may be placed on recently rehabilitated sites to:
  - Improve wind protection.
  - Enhance soil moisture retention.
  - Support successful revegetation.

Vegetation Clearance or Impact Minimisation

To minimise soil disturbance, topsoil and subsoil stripping will be restricted to essential infrastructure pads, such as those required for tank, pipework and reagent bunds or sumps. Other infrastructure areas will remain vegetated, with surfaces rolled rather than cleared to ensure stability and reduce erosion risk. The FRT operational area will also be fenced until RL relinquishment to minimise ongoing pastoral impacts (Figure 7.1 and Figure 7.2).



Figure 7.1: Photo of sheep-induced soil impacts near Coronation dam within the RL



Figure 7.2: Typical sheep tracks within the RL

Spill Prevention, Detection & Response

To comply with Regulation 63(1)(b) of the Mining Regulations 2020 and the Fourth Schedule requirements (RL137, in Appendix A), Alligator Energy has developed a Spill Management Plan (Appendix T) in accordance with the EPA Bunding and Spill Management Guideline (EPA, 2016). This procedure ensures that spill prevention, detection, and response measures are in place to protect soil quality and prevent contamination.

Infrastructure Design & Containment Measures

All pipework, vessels, and reagent storage areas will be constructed in accordance with industry best practices and pressure-tested before commissioning. Bunding around vessels will comply with EPA SA liquid storage guidelines, ensuring effective containment. Leak detection equipment, including drip trays, probes, flow meters, and level alarms, will be installed at key infrastructure points, and spill containment measures- such as drip trays, bunds, earthen berms, and spill kits- will be strategically located around wells, filter skids, tanks, and vessels.

Process Monitoring and Leak Detection

Continuous monitoring of process fluids will be undertaken to ensure system integrity. Automated leak detection systems will be installed to detect and respond to any breaches promptly. Details on these systems are provided in Section 4.2 and Section 4.3.

Preventative Inspections & Spill Monitoring

Routine physical inspections of instrumentation, pipelines, tanks, bunded areas, and chemical storage facilities will be undertaken to identify potential failures or structural issues before they result in spills. These inspections will focus on:

- Assessing structural integrity of containment and bunding systems.

- Detecting signs of material degradation that could lead to leaks.
- Ensuring compliance with spill containment and management protocols.

Any spills to soil will be immediately logged in the incident management system in accordance with the Alligator Energy Spill Management Plan. Logged data will include:

- GPS coordinates of the spill location and its extent.
- Depth of soil penetration.
- Chemical or radiological composition of the spill.
- Remediation actions undertaken.

Spill Response & Remediation

All spills will be remediated within 72 hours of identification, unless physical access constraints (e.g. beneath fixed infrastructure or pipework) prevent safe or practicable access. In such cases, remediation will occur immediately following the completion of the FRT operational phase.

Post-remediation inspections and soil sampling will be conducted to confirm that the affected area has been effectively managed, ensuring that:

- Residual contamination risks are eliminated.
- Soil conditions remain within background variability.
- Regulatory compliance is maintained.

Baseline & Post Remediation Soil Assessments

Chemical & Hydrocarbon Assessments

Baseline soil sampling has been conducted at 10-metre grid spacings at a depth of 0–30 mm, specifically beneath chemical storage areas (Appendix C). Samples have been analysed at a NATA-accredited laboratory for metals, including iron (Fe), aluminium (Al), and lead (Pb); cations, including calcium (Ca), magnesium (Mg), sodium (Na), and potassium (K); and other key parameters such as sulphate (SO_4^{2-}), pH, electrical conductivity (EC), acid neutralising capacity (ANC), and chloride-soluble exchangeable cations (Ca, Mg, Na, K, Al). Baseline data is provided in Appendix C.

Post-remediation soil sampling will be undertaken at the same locations, see Figure 7.3, using the original 10-metre grid spacing and depth (0–30 mm) to verify that soils have not been affected by project activities. Results will be compared against baseline data to confirm that soil conditions remain consistent with natural background levels.

For diesel storage areas, additional testing will be conducted for total petroleum hydrocarbons (TPH C10–C40) and oil & grease (O&G) to assess potential hydrocarbon contamination in areas where diesel is stored, handled, or decanted.

To validate post-closure conditions, hypothesis testing will be applied using a significance threshold of $p \geq 0.05$. This ensures that any minor variations observed do not indicate a meaningful increase in contamination, preventing false positives while maintaining a scientifically robust approach.

Radiological Surveys & Monitoring

Baseline soil sampling for radionuclides has also been conducted at 30-meter grid spacing below the processing components in the process plant area at depths of 0-30 mm (Appendix C). Samples have been analysed using ICP-MS and gamma spectrometry to quantify radionuclide

concentrations in the soil. These radionuclides serve as key indicators for the presence of uranium-bearing material and are critical to establishing site-specific background levels and are provided in Appendix C.

Post-closure soil sampling will be conducted at the same locations and depths to assess whether radionuclide concentrations remain within the range of natural background variability. Samples will again be analysed via ICP-MS and gamma spectrometry. Results will be compared with baseline data, and statistical hypothesis testing ($p \geq 0.05$) will be applied to determine whether any observed differences are statistically significant. This ensures any minor natural variation is appropriately accounted for, while confirming that no radiological impacts from project activities persist post-closure.

Decommissioning & Rehabilitation

Following the completion of FRT activities, defined care and maintenance and/or closure activities will commence within three months to minimise the duration of soil stockpiling where relevant.

Post-closure rehabilitation activities will focus on remediating disturbed land, restoring natural ecosystems before follow-up chemical and/or radiological sampling.

This includes:

- Recontouring the landscape to remove any man-made modifications (e.g., earthen berms) and replacing removed soils,
- Scarifying compacted areas to promote soil aeration and revegetation,
- Revegetating disturbed zones with site-appropriate plant species.

Data Management

All monitoring activities across all FRT lifecycle will be recorded in the Alligator Energy Environment and Radiation Database. This centralised database system, tracks, and analyses baseline and post-closure data, ensuring it remains accessible for regulatory compliance demonstration.

Uncertainties, Assumptions & Future Works

The effectiveness of the control strategies outlined above has been assessed to identify any significant uncertainties, assumptions, or potential future work required to ensure the achievement of regulatory outcomes. This evaluation considers the sensitivity of these uncertainties and whether additional data collection or adaptive management measures may be necessary.

No major uncertainties or assumptions have been identified that would compromise the effectiveness of soil management strategies.

Many of the soil management strategies outlined above have been successfully implemented during previous exploration phases, demonstrating their effectiveness under site-specific conditions. These strategies are informed by an established understanding of local environmental characteristics, including:

- Soil composition and stability,
- Benefits of excluding stock and ferals on soil erosion and compaction,
- Feasibility of bushland regrowth and transplantation,
- Weed and grazing pressure management,

- Effective soil erosion control.

Alligator Energy's holistic natural resource management approach described in Section 7.2.4, developed in collaboration with station owners, ensures that soil and vegetation values are maintained or improved over time. Given the critical role of topsoil in sustaining the local ecosystem, active adaptive management strategies remain central to ensuring long-term soil stability and rehabilitation success. The nominated control measures are considered robust and validated, with no additional studies or trials required at this stage.

7.2.5 Outcome Measurement Criteria & Leading Indicator Criteria

This section defines the Outcome Measurement Criteria, which establish the performance benchmarks used to demonstrate compliance with the soil outcomes outlined in Section 7.2.3. These criteria specify how soil protection measures will be assessed to ensure they remain effective throughout operations and post-closure. Additionally, the monitoring and verification requirements necessary to demonstrate compliance, as detailed in Section 7.2.4, are summarised here. These requirements outline the monitoring locations, frequencies, analytical parameters, and verification methodologies that will be applied to track soil quality and stability. A comprehensive summary of these criteria, monitoring programs, and verification measures is provided in Table 7.1.

In some cases, where control strategies are critical to achieving an outcome, leading indicator criteria are also established. These indicators serve as early warning signals, allowing for proactive management if there is a risk that a control measure may fail or become ineffective.

However, for soil management and protection, leading indicators are not considered necessary due to the nature of soil-related processes and the robustness of the applied outcome criteria. Unlike environmental aspects such as air or water quality, where real-time monitoring can provide early warnings (e.g., sensors detecting chemical spills or airborne dust levels), soil-related changes occur gradually over extended timeframes. Consequently, soil stability and quality are best assessed through periodic sampling, analysis, and verification rather than real-time leading indicators.

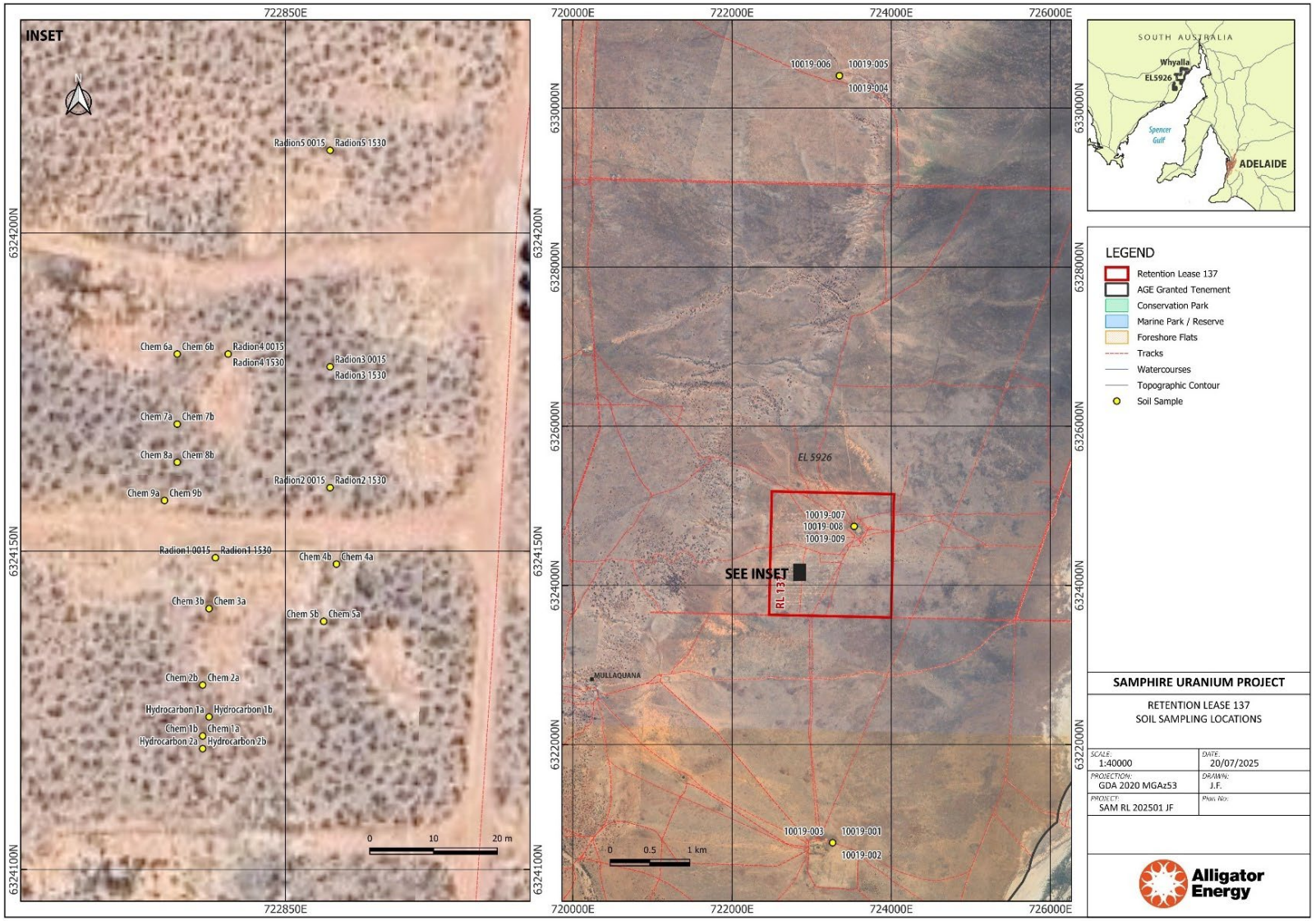


Figure 7.3: Baseline soil sample locations for chemical and hydrocarbon assessments.

Table 7.1: Outcomes, Measurement & Leading Indicator Criteria – Soils

Outcome(s)	What will be Measured & Form	Locations	Frequency & Duration	Records & Responsibility	Control or Baseline Data	Outcome Achievement	Leading Indicator
No contamination of land and soils either on or off the Land post completion as a result of field recovery trial activities. During construction, operation and post completion, ensure there are no adverse impacts to third–party land use or property on or off the land as a result of field recovery trial activities other than those agreed between the tenement holder and affected users	<u>Spill Records & Response:</u> • GPS coordinates of the spill location and extent. • Depth of spill penetration. • Nature of the spill (chemical/radiological composition). • Remediation actions undertaken.	RL	Event-based spill reporting. Annual audits of spill records and remediation activities.	Environmental Manager. All incident records will be stored in the Alligator Energy Safety Management Database.	Appendix C	All spills to soil are recorded and remediated in line with the Alligator Energy Spill Management Plan; and Gamma surveys and soil sampling undertaken during closure confirm that: • Chemical and radiological parameters remain within natural background ranges, as established by baseline sampling (Appendix C & N); and/or • No statistically significant increases ($p \geq 0.05$) in analyte concentrations are observed relative to baseline conditions. • Where exceedances are identified, confirmatory sampling and targeted remediation are undertaken to return concentrations to baseline levels prior to final closure.	N/A
	<u>Gamma Surveys</u> • 3 m grid spacings.	All FRT infrastructure areas (Figure 4.2).	On completion of final remediation and prior to RL relinquishment.	Environmental Manager Records are stored in the Alligator Energy Environment & Radiation Database.	Appendix N.		
	<u>Soil Sampling – Chemical Storage Areas</u> • 10 m grid spacing, 0–30 mm depth Analytes: Fe, Al, Pb, Ca, Mg, Na, K, SO_4^{2-}, pH, EC, exchangeable cations.	Chemical and storage areas (Appendix C Figure 4.10 & Figure 7.3).			Appendix C		
	<u>Soil Sampling – Fuel Storage Areas</u> • 10 m grid spacing, 0–30 mm depth. • Analytes: TPH C10-C40, Oil & Grease.	FRT pilot plant footprint (Appendix C Figure 4.10 & Figure 7.3).					
	<u>Soil Sampling – Pilot Plant Footprint</u> • 50 m grid spacing, 0–30 mm depth • Analytes:						

Outcome(s)	What will be Measured & Form	Locations	Frequency & Duration	Records & Responsibility	Control or Baseline Data	Outcome Achievement	Leading Indicator
	• Uranium (mg/kg) & Thorium (mg/kg) via ICP-MS. • Th-234 (Bq/g), Th-230 (Bq/g), Ra-226 (Bq/g) & Pb-210 (Bq/g), Ra-228 (Bq/g), Th-228, Pb-212 (Bq/g) via gamma spectroscopy.						

7.3 Groundwater

7.3.1 Context

The Tertiary aquifer, which hosts uranium mineralisation, is the target aquifer for mining activities within the RL area. It is a confined system with low vertical hydraulic conductivity, minimising vertical water movement between aquifers. The aquifer is laterally continuous across the RL area and exhibits favourable hydraulic characteristics for in-situ recovery (ISR) operations. However, groundwater within the Tertiary aquifer is highly saline, with Total Dissolved Solids (TDS) ranging from 32,000 to 65,000 mg/L, making it unsuitable for potable or agricultural use (see Section 2.6).

Overlying the Tertiary aquifer is the Quaternary aquifer, a thin, marginally permeable layer consisting of fluvial sediments within predominantly clayey Quaternary deposits. Within the FRT area, this aquifer is unsaturated, lacks hydraulic pressure, and has no connection to the Tertiary aquifer. To the east of the RL area, where the Quaternary aquifer is saturated, it hosts saline to hypersaline groundwater but remains hydraulically isolated from the underlying Tertiary aquifer in the vicinity of the RL.

Beneath the Tertiary aquifer lies the FRA, hosted within the crystalline Hiltaba Granite Formation. It is separated from the Tertiary aquifer by a 50–70 m thick saprolitic weathered basement, which acts as an effective confining layer. Aquifer testing has confirmed no vertical leakage between these units. The FRA has even higher salinity, with TDS levels ranging from 83,350 to 97,100 mg/L.

During ISR mining, native groundwater from the Tertiary aquifer is mixed with sulphuric acid, ferric sulphate, and hydrogen peroxide to create a mining lixiviant. This solution is circulated within the aquifer to selectively dissolve uranium mineralisation within the designated Field Recovery Trial (FRT) areas.

ISR operations generate a liquid waste stream comprising RO brine, plant water, and a minor proportion of lixiviant bleed. This waste is reinjected into the Tertiary aquifer under carefully controlled conditions (see Section 4.5).

At the conclusion of the FRT, any groundwater affected by residual mining solutions will be rehabilitated through monitored natural attenuation (NA). This process will restore water quality to its pre-mining state or to defined environmental performance criteria (see Section 5.3).

As a precaution, groundwater from with the RL 137 boundary from the tertiary aquifer cannot be used for future pastoral or agricultural purposes. No groundwater is currently used for pastoral or agricultural purposes as the salinity levels make this prohibitive.

7.3.2 Potential Impacts

The potential impacts on groundwater quality from the FRT operations have been assessed in the Samphire RL Proposal document (Alligator Energy, 2023b) and the associated Samphire Response Document (Alligator Energy, 2024).

The key FRT activities that could impact groundwater quality include the introduction of a mining lixiviant into the target (Tertiary) aquifer during trial ISR operations, which will change baseline pH, redox potential, and metal concentrations within an operational zone and the disposal of a liquid waste stream.

As a result of these activities, the following potential groundwater impacts may occur:

- Reduction in the environmental value of the Tertiary (target) aquifer, affecting its natural water quality, leading to the degradation of groundwater suitability for potential future uses.
- Reduction in the environmental value of the FRA (underlying) aquifer, affecting its natural water quality.

7.3.3 Regulatory Outcomes & Conditions

The Fourth Schedule – Environmental Outcomes and Conditions of RL 137 (Appendix A) establishes the groundwater related regulatory requirements that Alligator Energy must achieve and sustain during operations and closure. These requirements include environmental outcomes, management conditions, and compliance criteria to ensure groundwater protection.

The conditions set out in this schedule define the necessary environmental performance standards and management strategies that must be implemented to prevent adverse impacts on groundwater quality within both the target aquifer and underlying aquifer throughout the project lifecycle.

Groundwater Outcomes (Operational Phase):

- The Tenement Holder must, in carrying out authorised operations, ensure that there is no adverse change, outside of natural background variation, to the water quality of the target aquifer outside of the Land.
- The Tenement Holder must, in carrying out authorised operations, ensure that there is no adverse change, outside of natural background variation, to the water quality of the underlying aquifer.

Groundwater Closure Outcomes:

The Tenement Holder must demonstrate, to the satisfaction of the Minister, that the following mine completion outcomes will be achieved and sustained after mine closure:

- Target Aquifer Closure Outcome – No adverse change, outside of natural background variation, to the pre-mining water quality of the target aquifer beyond the coordinates specified in the Third Schedule of the Tenement Document.
- Underlying Aquifer Closure Outcome – No adverse change, outside of natural background variation, to the pre-mining water quality of the underlying aquifer.

Groundwater Strategy

The Tenement Holder is required to address the following matters for the purposes of Regulation 63(1)(b) of the Regulations in relation to the Fourth Schedule Clause 3.1:

- Develop a Trigger, Action and Response Plan (TARP) to determine the process for groundwater active remediation of the target aquifer in the event that natural attenuation cannot be validated during the term of the RL.

Groundwater Criteria

The Tenement Holder is required to address the following matters for the purposes of Regulation 63(1)(c) of the Regulations in relation to Fourth Schedule Clauses 1 and 2 for groundwater quality:

- Establish compliance groundwater monitoring bores that are at appropriate locations and of sufficient density and depth to measure or infer the groundwater quality on the land.
- Design of the monitoring and measurement criteria framework must consider a mechanism to determine changes in groundwater quality that is caused by the field recovery trial as distinct from other sources of impact.

- The measurement parameters and values that are taken to demonstrate achievement of the outcome must appropriately measure change to baseline groundwater quality.
- The frequency of measurement must be appropriate to ensure demonstration of achievement of the outcome.
- Measurement criteria is to be determined through consultation with DEM, DEW, EPA and any other relevant government department.
    - The measurement criteria must consider the potential oxidation of pyrite on metal(loid)s mobilisation in the downgradient zone.
    - The measurement criteria must be informed by leach testing to access the mobilisation potential of uranophane, which was identified to have the highest uncertainty with the modelled chemistry.

Groundwater Leading Indicator Criteria

The Tenement Holder is required to address the following matters for the purposes of Regulation 63(1)(d) of the Regulations in relation to Fourth Schedule Clauses 1 and 2 for groundwater quality:

- Leading indicator criteria based on baseline groundwater quality; and
- The frequency of leading indicator measurements must be appropriate to ensure there is an early warning of failure of any strategy; and
- Leading indicator criteria must be integrated with the Trigger, Action and Response Plan.

7.3.4 Control, Management & Monitoring Activities – Operations

The operational phase of the FRT requires stringent fluid control, monitoring, and management strategies to ensure that mining solutions remain contained within the defined operational area of the target aquifer and that surrounding groundwater systems are protected in accordance with regulatory requirements. This section details the control and management measures, and monitoring programs implemented to maintain fluid containment, verify groundwater quality, and ensure compliance with the Fourth Schedule of RL137.

FRT Fluid Controls

To prevent unintended migration of mining solutions, fluid control measures will be implemented to maintain containment within the designated mining zone. A net negative hydraulic gradient will be established by extracting up to 0.5% from the mining fluids (bleed stream) at the process plant, directing this portion to the wastewater tank. This controlled extraction induces an inward hydraulic flow within the operational area, effectively containing process fluids within this area and minimising the risk of excursions.

Flow rates at the wellhouse will be continuously monitored and adjusted to maintain hydraulic balance within the Tertiary aquifer. Automated system controls will regulate injection and extraction rates, preventing over-pressurisation and unwanted lateral migration. Any deviation from the expected flow balance will trigger an immediate investigation by the site operator and hydrogeologist, with corrective actions (well flow rebalancing or other) undertaken as required. Additional details on fluid control measures are provided in Section 4.

Well Construction Standards

All wells will be constructed and tested in accordance with national water well construction standards (National Uniform Drillers Licensing Committee, 2020) to ensure aquifer integrity and prevent vertical or horizontal excursions of mining fluids (see Section 4.2.2).

Each well will be cased and sealed using industry-standard methods, including:

- Pressure cementing with sulphate-resistant cement to enhance durability.
- Bentonite sealing, where required, to create a secure hydraulic barrier and precise screen placement.

To confirm well integrity, airlifting and pressure testing will be conducted at a minimum pressure of 700 kPa. Retesting will occur after any maintenance activities which put well integrity at risk (i.e. maintenance requiring a drill rig) to ensure continued performance. These construction and monitoring protocols are designed to keep process fluids contained within the target aquifer, preventing unintended migration and protecting surrounding groundwater resources.

Baseline Groundwater Quality Characterisation

A comprehensive groundwater quality dataset has been established for the Tertiary and Fractured Rock aquifers using historical data from 2010, along with an ongoing monitoring program from 2022 to 2024. Groundwater sampling has been conducted across a network of regulatory monitoring wells to characterise natural variability and establish a robust pre-FRT reference point.

The full baseline assessment is presented in Section 2.6.3, with a summary of groundwater quality data in Table 2.1 and the complete dataset available in Appendix E. Baseline data will be used to differentiate natural groundwater variability from any changes associated with FRT activities, ensuring effective monitoring and management throughout the project.

Operational - Target Aquifer Monitoring

Monitoring of the Tertiary aquifer during the FRT is critical to verifying the effectiveness of fluid control measures and ensuring that mining lixiviant and disposal fluids remain contained within the operational area. A perimeter monitoring network has been established to track the movement of process fluids and provide early detection of potential excursions before they reach the tenement boundary.

In addition to perimeter monitoring, a liquid disposal monitoring network will be implemented to track the controlled migration of disposal fluids within the operational area. Monitoring well placement has been designed based on international best practice guidelines, including NUREG-1569, which provides technical and regulatory requirements for ISR uranium operations (U.S. Nuclear Regulatory Commission, 2003). Well spacing has been determined based on hydraulic gradient, transmissivity, and flow direction, ensuring optimal monitoring coverage and early detection of any potential fluid movement.

To confirm hydraulic connectivity between monitoring and production wells, a large-scale pumping test will be conducted before operations commence. The test will involve simultaneous pumping of at least two extraction wells for up to five days at a total rate of 7 L/s, with drawdown responses measured at perimeter monitoring wells. A minimum drawdown of 20 cm at each monitoring well will confirm connectivity. If connectivity is not confirmed, well placement and screen depths will be reviewed, and corrective actions, such as re-screening or installing additional monitoring wells, will be undertaken.

<u>Excursion Control Parameters & Excursion Control Limits</u>

Excursion Control Parameters (ECPs) have been selected to detect potential fluid excursions and distinguish FRT related changes from natural groundwater variability. The selection of these parameters follows international best practice and was informed by regulatory consultation.

South Australian regulatory frameworks currently lack specific requirements for excursion control parameters in ISR uranium operations. To address this, Alligator Energy has adopted the regulatory framework developed by the United States Nuclear Regulatory Commission (NRC), as detailed in NUREG-1569, "Standard Review Plan for In-Situ Leach Uranium Extraction License Applications" (U.S. Nuclear Regulatory Commission, 2003). This framework has been successfully applied in the four existing ISR operations in South Australia, and provides clear specifications for monitoring, selection, and management of excursion control parameters.

According to NUREG-1569, a minimum of three parameters should be used for excursion monitoring and to provide further confidence and to reduce the risk of false positive NUREG-1569 also recommends an exceedance be defined as 2 or more excursion control parameters exceeding their upper limits. Based on this, the three key ECPs selected for the FRT are:

- pH: A reliable indicator of geochemical changes in the aquifer. The ISR lixiviant is more acidic than natural groundwater, making pH a key early warning parameter for fluid excursions.
- Sulphate: A highly mobile ion commonly associated with ISR lixiviant given the addition of H_2SO_4 as a reagent to enhance recovery of the uranium from the target extraction zone. It serves as a sensitive tracer for detecting lixiviant migration.
- Uranium: The primary mineral of interest in ISR operations. Changes in uranium concentrations provide direct evidence of lixiviant movement.

These parameters have been successfully implemented at existing ISR operations in South Australia and are recognised as effective indicators of potential excursions.

While iron is an important parameter for operational monitoring, it has not been included as an ECP due to its limited mobility in groundwater. Iron rapidly precipitates as siderite or hydroxides, making it ineffective for tracking long-range lixiviant migration. However, iron will still be monitored for internal process control and geochemical stability within the wellfield.

Excursion Control Limits (ECLs) establish threshold values that define when groundwater quality changes are statistically significant and require corrective action. These limits were developed to distinguish natural groundwater variability from potential lixiviant migration. To ensure a scientifically valid approach, ECLs have been calculated based on baseline groundwater data for the Tertiary Aquifer collected during the RL application process (2010 data) and the 2022–2024 baseline monitoring program (Appendix E).

NUREG-1569 prescribes that each upper control limit must be “greater than the baseline concentration for its respective excursion indicator” such that false positives are not a frequent problem but not so high that significant groundwater degradation could occur. To achieve this the ECL values have been derived using three standard deviations (3σ) from the mean of baseline groundwater quality data for sulphate and pH as is commonplace among ISR operations in South Australia. Whereas five standard deviations (5σ) above the mean has been used to calculate the ECL for uranium to ensure the value is greater than the baseline range (0.003 - 0.474 mg/L, Table 2.1). This method ensures that only statistically significant changes trigger an excursion response.

- pH: The ECL is set at three standard deviations below the mean, as the lixiviant is more acidic than native groundwater.
- Sulphate: The ECL are set at three standard deviations above the mean, providing a conservative threshold for detecting lixiviant migration.
- Uranium: The ECL are set at five standard deviations above the mean, providing a conservative threshold for detecting lixiviant migration and demonstrating no adverse

change in groundwater quality while providing confidence that concentrations within the range of the baseline dataset (Table 2.1) do not provide an avenue for falsely indicating plume migration.

Sulphate and pH follow a normal distribution in native groundwater chemistry and the direct impact of operations on pH, U and Sulphate make these acceptable ECL parameters.

These values have been recalculated using the full set of Tertiary Aquifer groundwater chemistries up to December 2024, confirming that the initial values calculated for pH and sulphate remain appropriate.

The final ECL values are presented Table 7.2 with the full calculation methodology and data provided in Appendix E.

Table 7.2: Excursion Control Limits

Analyte	Excursion Control Limit
pH	≤ 5.8
Sulphate	≥ 5,845 mg/L
Uranium	≥ 0.56 mg/L

ECLs are used to determine whether a potential excursion has occurred. An excursion event is triggered when any parameters ECL is exceeded.

These exceedance criteria are based on established ISR groundwater management practices in South Australia, ensuring early detection of potential excursions while minimising false positives due to natural groundwater variability.

Monitor Well Types & Purpose

Two monitoring well types will be installed within the Target Aquifer during the operational phase:

1. Perimeter Monitor Wells:
   Installed around the FRT pattern area to verify fluid control and balance. These wells provide early detection of potential excursions, ensuring mining solutions remain within the RL boundaries.
2. Liquid Disposal Monitor Wells:
   Positioned down-gradient of the disposal zone, these wells track the movement and extent of disposed fluids, ensuring that migration remains within the designated area and under operational control.

Leading Indicator Triggers – Early Warning for Potential Perimeter Excursions

While ECLs define compliance thresholds, Leading Indicator Triggers provide an early warning mechanism to detect unexpected groundwater quality changes at perimeter wells before an ECL exceedance occurs.

A leading indicator is triggered if any of the following conditions are met at a perimeter monitoring well:

- ≥2 consecutive U or SO_4 results exceed 2 standard deviations above the mean for that well's dataset.
- ≥2 consecutive pH results fall 2 SD below the mean for that well's dataset.

These triggers do not confirm an excursion but indicate a potential trend requiring verification sampling, increased monitoring, and hydrogeological assessment. Confirmed triggers will be reported to DEM within 24 hours, and the affected well will be placed on weekly monitoring for a minimum of four weeks. Corrective measures such as hydraulic adjustments and flow balancing

will be implemented if monitoring suggests early signs of lixiviant migration, with escalation to an ECL response (TARP 2) if necessary.

These values are determined using well-specific baseline data presented in Table 7.12 as part of a defined TARP (TARP 1).

Perimeter Monitoring Network Design

The perimeter monitoring network is a key safeguard to ensure lixiviant remains contained within the designated mining zone and does not migrate beyond the operational area or RL boundary. It is designed to provide early detection of any lateral fluid movement, allowing for timely corrective actions before any potential excursion occurs.

The network has been designed based on international best-practice principles, specifically NUREG-1569 (U.S. Nuclear Regulatory Commission, 2003). This document establishes the technical and regulatory framework for ISR uranium operations, specifying requirements for monitoring well placement, spacing, and hydrogeological considerations to detect potential lixiviant excursions.

According to NUREG-1569, perimeter monitoring networks must be designed to effectively detect lateral fluid migration in time to implement corrective actions before excursions occur. They should be placed down-gradient of the mining zone, where fluid movement is most likely to occur. The network must also monitor both overlying and underlying aquifers to identify any potential vertical migration. Well spacing and placement should be determined by hydraulic gradient, transmissivity, and flow direction, rather than arbitrary fixed distances.

While NUREG-1569 provides the foundation for perimeter monitoring well placement, ISR operations in South Australia have refined these specifications to align with local hydrogeological conditions and regulatory consultation. These refinements, based on four existing and approved ISR operations in the State, focus on risk-based perimeter well spacing, using hydraulic gradient and flow direction rather than fixed distances. Monitoring placement is targeted within high-permeability zones to enhance excursion detection sensitivity. Additionally, historical ISR operational data has been used to optimise network design for local aquifer conditions (DEWHA, 2010).

For the FRT operational zone, perimeter monitoring wells will be installed to provide comprehensive coverage of potential fluid movement. The specifications include:

- Placement up to 250 m from the edge of the operational zone and at least 100 m from the RL boundary to allow sufficient time for detection before an excursion reaches the tenement boundary.
- Spacing at a maximum of 150 m apart in the down-gradient direction, where the highest risk of fluid migration exists.
- Spacing at a maximum of 250 m apart in lateral and up-gradient directions, where migration risk is lower.

All wells will be screened within the highest permeability sediments at depths equivalent to the production wells, ensuring they effectively track lixiviant movement. The perimeter monitoring network for the operational phase of the FRT is illustrated in Figure 7.4 and detailed in Table 7.3.

Liquid Disposal Monitoring Network

A monitoring network will be installed near the disposal zone to track the movement and extent of disposed fluids during FRT operations. This network is designed to monitor the controlled migration of disposal fluids within designated areas.

The liquid disposal monitoring network is illustrated in Figure 7.5 and detailed in Table 7.3.

Connectivity Testing

To confirm that perimeter monitoring wells are hydraulically connected to the FRT operational area, a large-scale pumping test will be conducted before operations commence. The test will involve:

- Pumping at least two extraction wells simultaneously for up to five days at a total rate of 7 L/s.
- Monitoring drawdown responses at each perimeter well to confirm connectivity.

Stored groundwater will be contained in a lined pit (described in Section 4.2.2) until utilised during operations or reinjected into the aquifer.

Hydraulic connection will be confirmed if a minimum drawdown of 20 cm is observed at each perimeter monitoring well. If connection is not confirmed at any well, an investigation will be conducted to determine the cause. This may involve:

- Reviewing well placement, screen depths, installation methods, and geology.
- Reworking the unconnected well (e.g., adjusting screen depth or additional development).
- Drilling a replacement monitoring well if reworking is unsuccessful.
- Conducting a smaller-scale pumping test on an individual well to verify connectivity.

If an unconnected well is determined to be outside the main aquifer channel and presents a low risk of fluid excursion, no additional work may be required.

These measures ensure that the monitoring network is fully functional before operations begin, providing confidence that lixiviant containment can be effectively tracked and managed throughout the FRT.

Monitoring Program

A comprehensive groundwater monitoring program for the Tertiary aquifer will be implemented to demonstrate ongoing compliance with the groundwater outcomes detailed in Section 7.3.3. The location of the Perimeter monitoring network is presented in Figure 7.4, the Liquid disposal monitoring network in Figure 7.5 and the program provided in Table 7.3.

Monthly sampling of the perimeter monitoring wells allows for timely detection of changes in groundwater chemistry outside of natural variation.

Table 7.3: Target (Tertiary) Aquifer - Operational Monitoring Program

Well No.	Type	Monitoring Frequency	Monitoring Parameters	Coordinates (GDA2020 / MGA53)	
				Easting	Northing
LMW001	Perimeter	Monthly	SWL, EC, pH, SO_4, U.	722684.3	6324437.3
LMW002	Perimeter	Monthly	SWL, EC, pH, SO_4, U.	722961.4	6324418.5
LMW003	Perimeter	Monthly	SWL, EC, pH, SO_4, U.	723211.8	6324391.7
LMW004	Perimeter	Monthly	SWL, EC, pH, SO_4, U.	723399.1	6324492.6
LMW005	Perimeter	Monthly	SWL, EC, pH, SO_4, U.	723506.4	6324408.7
LMW006	Perimeter	Monthly	SWL, EC, pH, SO_4, U.	723508.6	6324150.6
LMW007	Perimeter	Monthly	SWL, EC, pH, SO_4, U.	723295.3	6324058.5
LMW008	Perimeter	Monthly	SWL, EC, pH, SO_4, U.	723128.2	6323871.2
LMW009	Perimeter	Monthly	SWL, EC, pH, SO_4, U.	723004.9	6323796.5

Well No.	Type	Monitoring Frequency	Monitoring Parameters	Coordinates (GDA2020 / MGA53)	
				Easting	Northing
LMW010	Perimeter	Monthly	SWL, EC, pH, SO_4, U.	722860.6	6323769.6
LMW011	Perimeter	Monthly	SWL, EC, pH, SO_4, U.	722715.5	6323799.5
LMW012	Perimeter	Monthly	SWL, EC, pH, SO_4, U.	722671.6	6324027.2
LMW013	Perimeter	Monthly	SWL, EC, pH, SO_4, U.	722592.7	6324251.6
MRH1C	Perimeter	Monthly	SWL, EC, pH, SO_4, U.	722803.1	6324501.8
MRE4	Perimeter	Monthly	SWL, EC, pH, SO_4, U.	723541.1	6324284.3
DMW01	Liquid Disposal	Monthly	SWL, EC, pH, SO_4, U.	Planned	
DMW02	Liquid Disposal	Monthly	SWL, EC, pH, SO_4, U.	Planned	
DMW03	Liquid Disposal	Monthly	SWL, EC, pH, SO_4, U.	Planned	

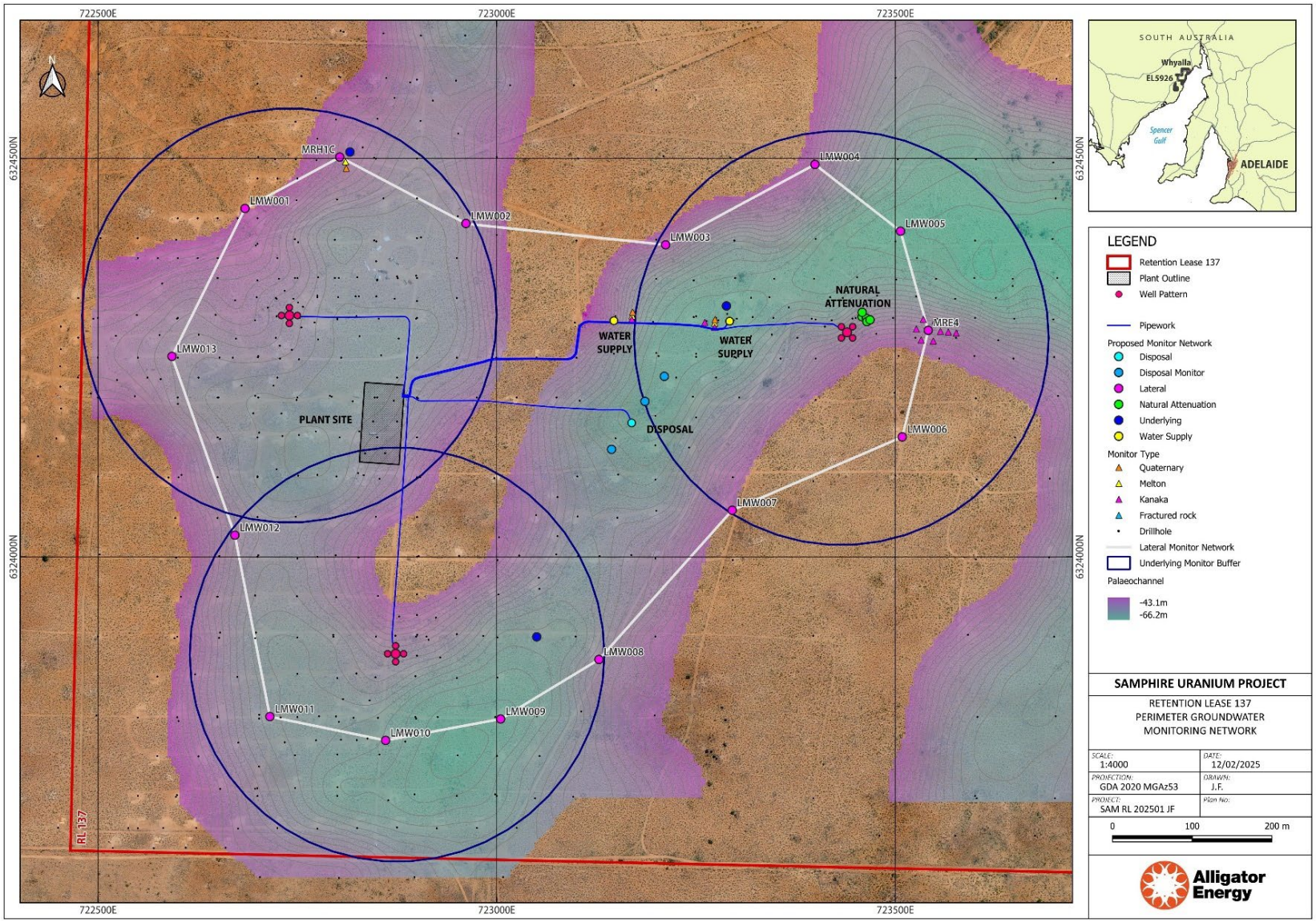


Figure 7.4: Perimeter Groundwater Monitoring Network

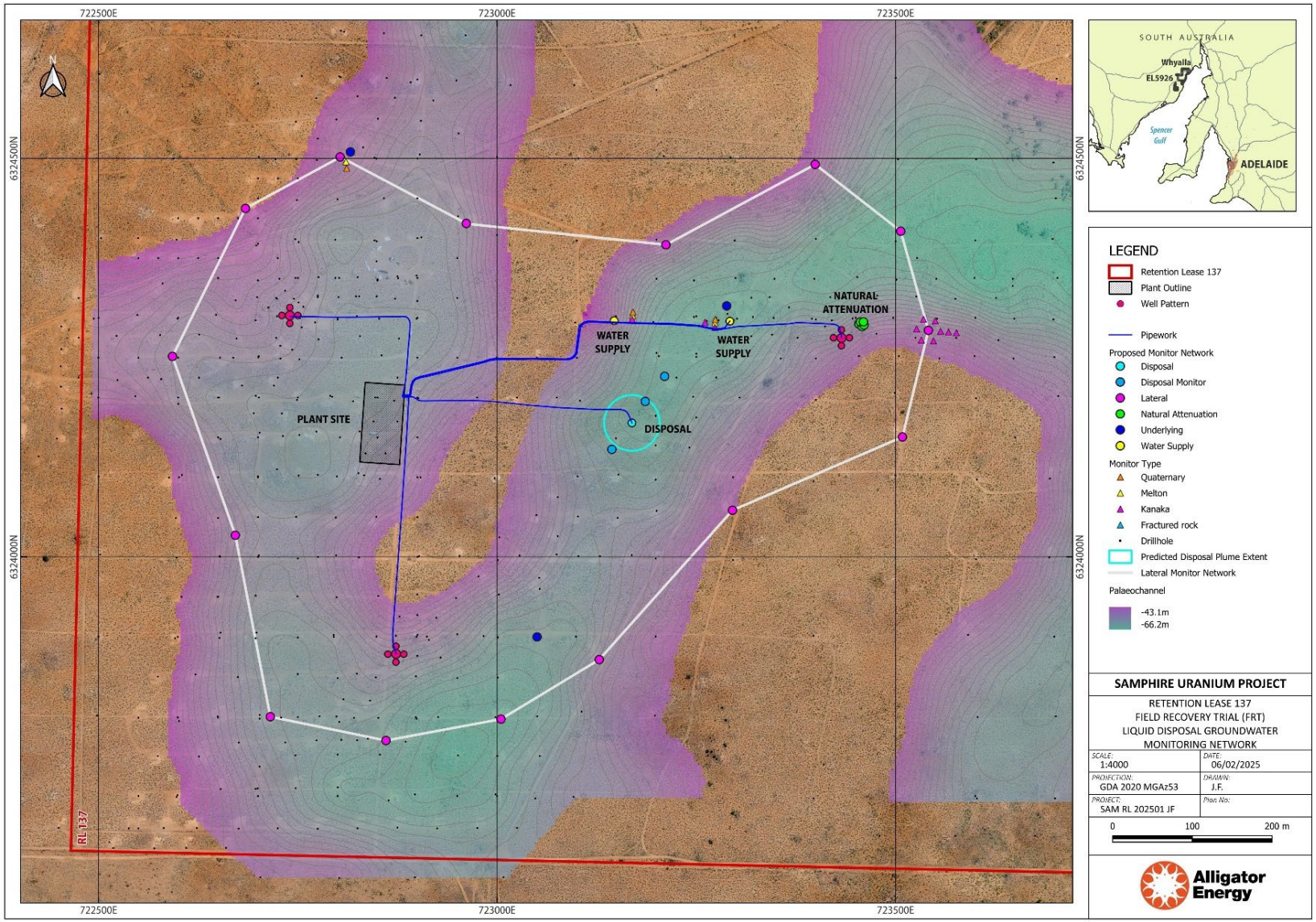


Figure 7.5: Liquid Disposal Groundwater Monitoring Network

Operational – Underlying Aquifer Monitoring

Monitoring of the FRA during the operational phase of the FRT is critical to ensuring that mining fluids remain contained within the Tertiary (target) aquifer and do not migrate vertically into the underlying FRA. This is achieved through a dedicated underlying aquifer monitoring network, which continuously monitors groundwater quality in the FRA within areas where FRT activities are being conducted.

This section outlines the monitoring network design, verification criteria, and contingency measures implemented to:

- Confirm that the FRA remains hydraulically isolated from FRT operations.
- Provide early detection of vertical fluid migration through groundwater quality and pressure monitoring.
- Establish Isolation Verification Limits (IVLs) to define statistically significant deviations from baseline groundwater conditions.
- Implement contingency actions if monitoring indicates a potential excursion or loss of aquifer isolation.

Monitor Well Type & Purpose

One category of monitoring well is installed within the underlying FRA to assess containment effectiveness:

1. Underlying Aquifer Monitor Wells:
   Positioned within the granitic fractured rock basement to confirm that mining fluids do not migrate downward from the Tertiary aquifer.

Underlying Aquifer Monitor Network

The underlying aquifer monitoring network acts as an early detection system to ensure the FRA remains hydraulically isolated from FRT activities.

This network is designed to:

- Verify no vertical migration of fluids from the target (Tertiary) aquifer into deeper groundwater systems.
- Monitor hydraulic connectivity between the two aquifers to confirm that natural conditions are maintained.
- Detect any changes in water levels and groundwater chemistry that may indicate an unexpected impact from operations.

Key well placement and design considerations include:

- Monitoring well spacing ensures no production, injection, or disposal well is further than 250m from an underlying monitoring well.
- All wells are installed into the FRA at depths sufficient to monitor groundwater conditions.
- The open bore section is drilled to ensure the well is screened within the FRA, with casing seated in consolidated granite basement to prevent cross-aquifer flow.

Isolation Verification Limits (IVLs) – Underlying Aquifer

To confirm that the underlying FRA remains hydraulically isolated from FRT activities, Isolation Verification Limits (IVLs) have been established for key groundwater quality parameters. These IVLs define statistically significant deviations from baseline conditions and provide a framework to:

- Verify that no vertical migration has occurred by comparing current groundwater quality to long-term baseline conditions.
- Provide a threshold (2 SD from the mean) that accounts for natural groundwater variability.
- Act as a benchmark for regulatory compliance and ongoing aquifer monitoring.

The FRA is considered to remain isolated when:

- pH, sulphate, and uranium concentrations remain within two standard deviations (2 SD) of the mean baseline concentrations across all previous FRA baseline monitoring results (Table 7.4 and Appendix E).

These IVLs serve as the primary threshold for assessing any statistically significant groundwater quality variations due to FRT activities.

Table 7.4: Isolation Verification Limits

Analyte	Isolation Verification Limits	
	Lower Limit	Upper Limit
pH (pH Unit)	6.4	7.5
Sulphate (mg/L)	1,500	2909
Uranium (mg/L)	NA	0.2

An excursion event is triggered if any single parameter exceeds its IVL.

Leading Indicator Triggers – Early Warning for Potential Vertical Migration

While IVLs define acceptable baseline variability, Leading Indicator Triggers provide an early warning mechanism to detect unexpected groundwater quality changes at an individual well level before an IVL exceedance occurs.

A Leading Indicator Trigger occurs if:

- Three or more consecutive uranium or sulphate results exceed 2 SD above the mean for that specific well.
- Three or more consecutive pH results fall 2 SD below the mean for that specific well.

These leading indicators do not confirm an excursion but indicate a potential trend requiring increased monitoring and hydrogeological assessment.

These values will be calculated with well specific baseline water quality data provided in Appendix E, and any additional monitoring results collected up until the operational phase of the FRT trial commences.

Monitoring Program

A comprehensive groundwater monitoring program for the underlying aquifer will be implemented to demonstrate ongoing compliance with the groundwater outcomes detailed in Section 7.3.3. The location of the underlying monitoring network is presented in Figure 7.6, while the monitoring program is detailed in Table 7.5.

Table 7.5: Underlying Aquifer - Operational Monitoring Program

Well No.	Monitoring Frequency	Monitoring Parameters	Coordinates (GDA2020 / GDA53)	
			Easting	Northing
SUMW01	Monthly	SWL, EC, pH, SO_4, U.	722815.9	6324508.2
SUMW02	Monthly	SWL, EC, pH, SO_4, U.	723288.1	6324315.0
SUMW03	Monthly	SWL, EC, pH, SO_4, U.	723050.2	6323899.6

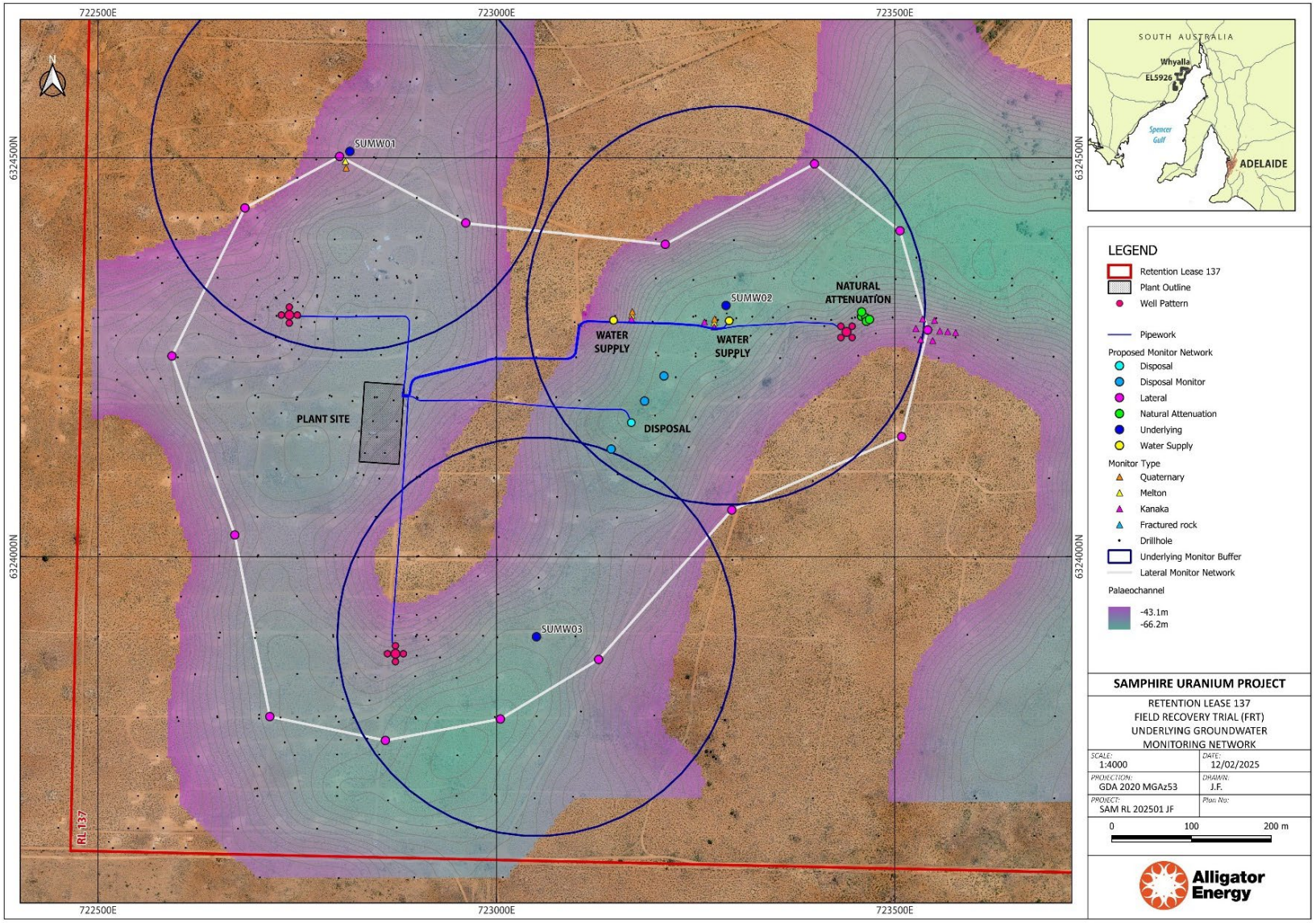


Figure 7.6: Underlying Groundwater Monitoring Network

7.3.5 Control, Management & Monitoring Activities - Closure

Natural Attenuation Model Assessment Phase I: Preliminary Model Inputs Assessment/Calibration

FRT Data Collection

Prior to and during the operational FRT phase, additional hydrogeological, geological, and production data will be collected to validate the NA model inputs. This data will be used to assess uncertainties in model assumptions, and where relevant improve the accuracy of predictions for the NA Field Assessment Phase (Phase III).

The following data collection and field investigations will be conducted to validate groundwater flow dynamics, characterise subsurface conditions, and the model presented is fit for purpose:

- Well Installation & Monitoring:
  - Installation of the full FRT monitoring well network and FRT wellfield patterns.
  - Collection of additional water quality data & hydrogeological parameters.
- Hydrogeological Assessments:
  - Connectivity pumping tests to confirm hydrogeological parameters including hydraulic conductivity.
  - Borehole Magnetic Resonance (BMR) logging to evaluate porosity and permeability on a well-by-well basis.
- Geological Characterisation:
  - Assaying FRT well drill cuttings for improved geochemical characterisation and subsurface understanding.
- Operational Monitoring:
  - Regular sampling of lixiviant composition during FRT operations.
  - Recording measured injection and extraction volumes.
  - Tracking observed plume migration patterns.
  - Acid consumption rates.

Sensitivity Assessment

The sensitivity assessment is designed to evaluate the impact of variations in key NA model inputs on model predictions. It serves as an early warning mechanism for potential failure of NA to effectively mitigate FRT-impacted groundwater within the maximum attenuation distances (Figure 5.2) and the predicted maximum concentrations over time and distance provided in Tables 7.8-7.10 (UIT 2024 & Appendix F).

By establishing thresholds and limits for critical model parameters, the sensitivity assessment ensures that deviations beyond these limits are identified before they affect regulatory compliance.

Collected field data will be assessed against the thresholds and limits defined in Table 7.6. If any parameters exceed these limits, the following actions will be undertaken:

- Review of Model Assumptions: The validity of current model assumptions will be reassessed.
- Model Rerun: If required, the NA model will be adjusted and rerun using updated input values to ensure deviations in input data do not result in a credible risk of exceeding outcome criteria.

This iterative process confirms that the model presented in Section 5.4.2 remains appropriate and fit for purpose.

The sensitivity limits in Table 7.6 are derived from model simulations in which individual parameters were systematically varied to assess their influence on attenuation rate and distance. These limits define the acceptable range for key model inputs, ensuring that any deviations beyond these thresholds are flagged for review and potential rerun of the model with updated inputs to assess any changes in impact.

Key observations noted as a result of the model runs:

- Very few scenarios resulted in a potential to exceed attenuation distance.
- Increase in groundwater velocity increases dilution and results in overall faster attenuation, in terms of both distance and time, but uranium and pH travels further before significant attenuation occurs resulting in potential exceedance in early time attenuation concentrations. A maximum trigger value for groundwater velocity is set at 10 m/year compared to the modelled 1-6 m/year.
- Decreased groundwater velocity decreases the rate of dilution in iron and sulphate resulting is a potential exceedance in concentrations (rate) of these parameters. The sensitivity trigger for minimum groundwater velocity has been set at 0.7 m/year.
- Porosity impacts dilution and distance travelled by the plume, higher effective porosity travels further and could potentially exceed concentrations close the leach zone before dilution has a significant impact. Lower porosity may not attenuate as quickly as the plume does not travel as far. Sensitivity trigger values for effective porosity are set at 11% (lower limit) and 25% (upper limit) where current input is 15%.
- As iron and sulphate attenuation relies heavily on dilution, concentrations above those specified in the model will likely result in exceedances of the attenuation rates in within the initial NA monitoring wells. Trigger values for iron and sulphate in the lix are set just above input lix values applied to the model.
- A decrease in pH would be a result in increased addition of sulphuric acid, increasing sulphate which will result in exceeding attenuation rates. Trigger value for pH in the lix is 1.4, just below the input value of 1.5.
- An increase in uranium (coffinite) mineralisation in the downgradient zone does not significantly impact natural attenuation as leaching of uranium in this instance in limited by the lixiviant chemistry. However, an increase in the uranophane species of uranium mineralisation has the potential to impact uranium concentrations in solution. It is uncertain at this time if analysis of the drill cuttings will be able to identify uranium species due to the drilling method. Uranium concentrations in formation will be measured/analysed using geophysical tools and XRF analysis of the drill cuttings. It is therefore reasonable to assess an increase in uranium mineralisation to allow for timely assessment of input data. The sensitivity trigger is set at 1.5x or 1.5wt%, where the model input is currently 1wt% uranium mineralisation (0.97 wt% Coffinite, 0.03 wt% Uranophane).
- Redox potential (pe) directly impacts the leaching of uranium in the downgradient zone, any higher than the modelled will have the potential to exceed both uranium concentration and redox potential in the downgradient zone. The sensitivity trigger for redox potential has been set at 5.1, where the model input is 5.0.

By comparing real-world observations with these sensitivity limits, the assessment identifies uncertainties that could impact model reliability and, if necessary, triggers corrective actions to maintain regulatory compliance.

Table 7.6: Model Inputs & Sensitivity Trigger

Model Input	Assumed Value	Potential Deviations	Implications on Model Accuracy	Sensitivity Trigger	Sensitivity Limit
Groundwater Velocity (v)	1.0 m/a, 1.3 m/a, 6.0 m/a	Higher or lower velocities beyond assumed range.	Faster velocities could reduce time for attenuation due to increased dilution; slower velocities could delay plume contact at monitoring wells.	Yes	Lower limit: <0.7m/a Upper limit: >10m/a
Porosity (ε)	εT: 0.3 (total). εF: 0.15 (mobile); εP: 0.15 (immobile)	Variations due to aquifer heterogeneity.	Changes affect mass transfer and retardation, leading to over- or under-prediction of contaminant migration.	Yes	Upper limit: εT: 0.45 (total). εF: 0.25. εP: 0.20 Lower limit: εT: 0.25 (total). εF: 0.12. εP: 0.14
Dispersivity (aL, mixT)	aL: 0.16 m (longitudinal); mixT: 0.001 (transverse)	Lower dispersivity may limit mixing and dilution.	Reduced dilution leads to higher concentrations further downgradient than predicted.	No	Not measurable by the conclusion of FRT.
Lixiviant Chemistry	Derived from lab tests (SO_4, U, Fe concentrations and pH levels).	Field variations from lab chemistry.	Deviations impact geochemical reactions, attenuation rates, and contaminant concentrations.	Yes	pH <1.4 Fe >3050 mg/L U >165 mg/L SO_4 >7850 mg/L
pH	6.5	Lower baseline pH may inhibit reduction processes.	Suboptimal pH reduces uranium immobilisation, sulphate reduction, and mineral precipitation.	No	Sufficient baseline data collected to confirm this value is reasonable.
Uranium (U)	Modelled based on assumed reactivity and precipitation rates.	Higher concentrations than predicted.	Elevated uranium indicates inaccurate mineralogical characterisation, insufficient adsorption, precipitation, or dilution effects.	Yes	2.0 wt%
Redox Potential (pe)	Assumed based on reducing conditions in the aquifer.	Higher pe values indicate less reducing conditions.	Suboptimal redox conditions can limit attenuation reactions, especially for uranium and sulphate.	Yes	5.1

If the sensitivity assessment identifies an exceedance in maximum distance, this activates the Trigger Action Response Plan (TARP 5), detailed below. The TARP process ensures that any deviations from modelled predictions are promptly addressed through model reassessment, regulatory reporting, and, if necessary, additional contingency actions to maintain compliance with groundwater quality objectives.

Natural Attenuation Model Re-Run

At the completion of FRT operations, the NA model will be reviewed using the comprehensive dataset collected throughout the operational phase. The need for a model rerun will be determined based on the results of the sensitivity assessment and the extent to which observed field data aligns with model predictions.

If deviations beyond established sensitivity thresholds are identified, the model will be rerun to confirm deviations in input data do not result in a credible risk in exceeding outcome criteria. However, if field data remains within acceptable limits, no rerun may be necessary.

The updated model outputs, if adjusted, will be integrated into Phase II: Field Monitoring Program and the final NA model assessment phase (Phase III). These outputs will be used to demonstrate the effectiveness of NA in achieving the groundwater quality outcomes required for closure.

Natural Attenuation Model Assessment Phase II: Field Monitoring Program

The NA field monitoring program will track groundwater quality post-FRT to assess the effectiveness of NA processes in restoring water quality by comparing observed field data against modelled attenuation predictions provided in Table 7.8, Table 7.9 and Table 7.10.

Monitoring Well Locations – Key Considerations & Siting Specifications

To validate the NA, five dedicated monitoring wells will be installed within the target aquifer to assess the actual attenuation of FRT fluids against model predictions (Appendix F). These wells will be positioned down-hydraulic gradient of the wellfield to track the migration of residual mining fluids (Figure 7.7).

A key challenge in post-mining groundwater monitoring is accurately determining the final position of the lixiviant plume at closure. This is critical for:

- Predicting plume migration pathways.
- Ensuring timely detection of the disposal plume.
- Verifying compliance with closure requirements.

To mitigate uncertainty, a multi-faceted approach will be used, integrating:

- Ongoing hydrogeological data collection to track plume behaviour.
- Numerical modelling to refine plume migration predictions.
- In-situ conductivity probes to confirm plume extent in real-time.

This methodology ensures optimal well placement and accurate plume tracking, minimising the risk of undetected migration.

The first three NA monitoring wells will be installed based on modelled predictions of lixiviant extent at the conclusion of FRT operations. The first well will be positioned to intercept the lixiviant plume, marking the transition zone between the fully contacted wellfield and native aquifer water. The initial wells will validate well placement accuracy and guide the positioning of subsequent NA monitoring wells.

The placement of the initial 3 NA wells will be determined through the utilisation of a simple groundwater model constructed in Groundwater Vistas. The model has been designed to simulate the impacts of various operational scenarios, in particular the chloride reduction phase. It is a simple 5-layer model, each layer is 2m thick to simulate screen length with 1m discretisation in the x and y directions, it incorporates hydraulic parameters calculated from the pumping test presented in Appendix D and uses both pathlines and chloride concentrations to track the location

of the plume and lixiviant halo for each operational scenario tested. Due to the short duration of this test work the influence of hydraulic gradients is not considered in this model whose main aim in relation to NA is to determine the location of the plume at the conclusion of test work.

At the conclusion of FRT operations, the effectiveness of the initial well placements will be reviewed, and the model used to place the initial monitors will be updated incorporating updated hydrogeological, operational and field monitoring data including:

- Hydraulic parameters calculated from the connection pumping test
- Well construction data
- Injection and extraction volumes for both chloride reduction and lixiviant circulation
- Timing of contact of production wells during chloride reduction and circulation
- Timing of contact of NA wells

Based on this assessment final distances to the plume will be determined for installed NA wells, along with the groundwater velocity which will determine which model output tables will apply to the installed NA monitors. This determination will be presented in the first Annual Compliance Report post operations. Additional NA monitoring wells will be installed if necessary to improve spatial coverage and model assessment. Final well locations will be adjusted to ensure optimal tracking of residual mining fluid migration.

Placement decisions will be informed by:

- Pre-operational hydrogeological data, including downhole geophysics and pumping tests.
- Operational data, such as observed flow rates, injection/extraction volumes, and FRT runtime.

To ensure comprehensive monitoring, a staggered, zigzag well placement strategy will be employed to:

- Maintain uniform spacing relative to plume location at the conclusion of FRT operations.
- Minimise well to well interference and preserve structural integrity.
- Ensure optimal spatial coverage for tracking plume migration.

Subsequent monitoring wells will be placed at 1.5 m increments from the first well, with exact locations refined using real-time monitoring data collected during FRT operations.

Preventative Measures for Effective Monitoring

To improve monitoring effectiveness and prevent unintended plume movement, the following measures will be implemented:

- Pre-Installation of Select Monitoring Wells:
  - Select monitoring wells will be installed before FRT operations commence to prevent unintentional plume migration caused by airlifting or well development.
  - Water extraction during well development could inadvertently draw the lixiviant plume toward the well, necessitating proactive placement to mitigate this risk.
- Optimised Well Spacing:
  - A 1.5-meter interval will be maintained between monitoring wells to enable high-resolution tracking of plume movement, even at slow groundwater velocity.
  - This spacing ensures that plume contact can be monitored effectively within the available operational timeframe.
- Plume Contact Design:

  - At least one monitoring well will be positioned within the lixiviant plume halo at the conclusion of FRT operations.
  - This strategic placement ensures immediate detection and facilitates rapid collection of field observations to confirm predicted vs. actual plume movement.
- Monitoring Well Construction & Instrumentation:
  - Due to the short screen lengths of FRT wells and close well spacing, screen depths will be precisely constrained within the target zone.
  - In-situ conductivity and chemical parameter probes will be deployed in wells not yet contacted by the plume, complementing conventional low-flow sampling techniques.
  - This approach will reduce the risk of undetected lixiviant migration and enhance data accuracy.

All NA monitoring wells will be screened within the same horizon as the extraction and injection wells to ensure accurate tracking of lixiviant movement.

Pre-FRT Baseline Monitoring

To establish a robust baseline for groundwater chemistry, each NA monitoring well installed prior to FRT operations commence will be sampled a minimum of twice prior to the start of FRT. This will confirm consistency with groundwater conditions with baseline water quality data (Appendix E) as well as between the NA monitors, ensuring that any observed changes post-FRT can be attributed to operational impacts rather than natural variation.

The baseline groundwater monitoring will also confirm groundwater velocity at this location in the aquifer and therefore confirm whether the 1.0 m/yr 1.3 m/yr or 6 m/yr model is used.

NA Field Monitoring

The monitoring program is summarised in Table 7.7 and is shown in Figure 7.7.

Groundwater samples will be collected at quarterly intervals using low-flow or discrete interval sampling techniques. NA monitoring wells will be equipped with salinity data loggers to monitor changes in salinity indicating contact by the residual lixiviant plume.

Samples analysis will concentrate on pH, sulphate and uranium, as these parameters are the most reliable indicators of plume behaviour and natural attenuation performance, and therefore are used for direct comparison against modelled predictions and demonstration of compliance with closure outcomes.

In addition, redox potential, calcium, magnesium, sodium, potassium, iron, aluminium, chloride, dissolved inorganic carbon, silicon and strontium will also be analysed during routine sampling. These parameters will support geochemical interpretation, comparison with modelled predictions, and any post-FRT model updates; however, they will not form part of the regulatory compliance assessment.

Once the residual lixiviant plume reaches a monitoring well, quarterly sampling and analysis will continue to evaluate geochemical trends over time and distance. Data will be compared against modelled predictions to confirm that attenuation rates and contaminant concentrations remain within expected thresholds (see Table 7.8, 7.9 and 7.10).

NA field monitoring will continue until regulatory relinquishment of the RL or until field verification of attenuation is achieved. The final NA model assessment phase (III) will commence 20–24 months post-FRT, ensuring that sufficient time is available to:

- Assess long-term groundwater quality trends.

- Implement contingency actions if required.
- Complete all groundwater remediation works within five years of the RL grant date.

If full-scale ISR mining proceeds, monitoring at FRT locations will continue until sufficient field observations are obtained to confirm NA modelled impacts are maintained or the area is incorporated into ongoing operations.

Table 7.7: Target (Tertiary) Aquifer – Natural Attenuation Field Monitoring Program

Well No.	Type	Monitoring Frequency	Monitoring Parameters
NA01	Natural Attenuation	Quarterly	pH, SO_4, U
NA02	Natural Attenuation	Quarterly	pH, SO_4, U
NA03	Natural Attenuation	Quarterly	pH, SO_4, U
NA04	Natural Attenuation	Quarterly	pH, SO_4, U
NA05	Natural Attenuation	Quarterly	pH, SO_4, U

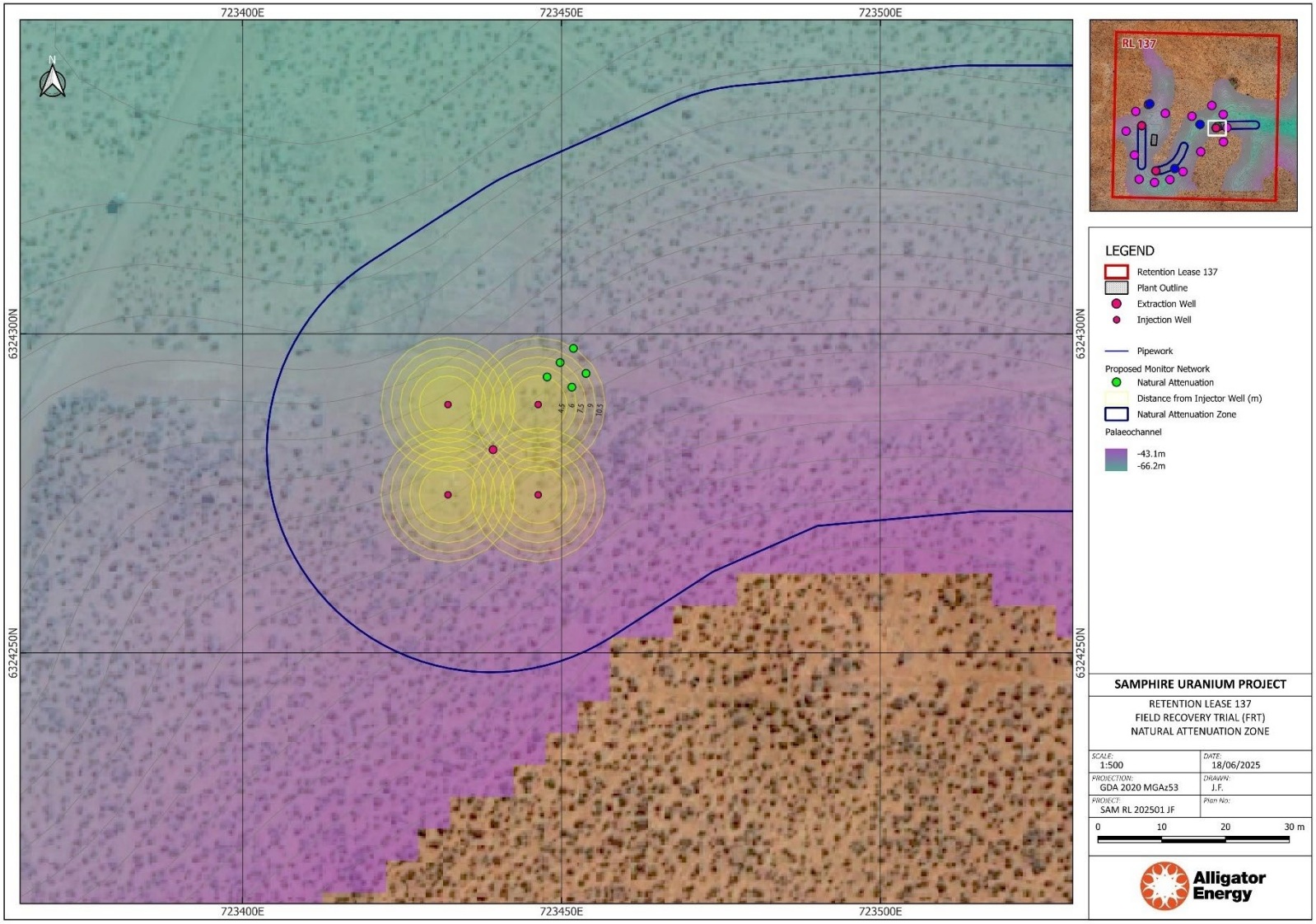


Figure 7.7: Proposed Natural Attenuation Field Monitoring Well Locations

Table 7.8: Key Modelled Chemistry Outputs for proposed natural attenuation monitor wells (1.0 m/a scenario) for the first 5 years post FRT.

Distance from the Plume (m)[5]	Analyte	Unit	Time Elapsed Since FRT Conclusion (Years)																			
			0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75	3.00	3.25	3.50	3.75	4.00	4.25	4.50	4.75	5.00
0.75 m	pH	(pH Units)	6.52	4.00	2.37	2.15	2.18	2.19	2.12	2.13	2.14	2.15	2.17	2.19	2.22	2.25	2.29	2.32	2.36	2.39	2.43	2.47
	U	(mg/L)	0.1	17.5	35.4	50.0	60.0	65.6	68.8	70.0	72.0	108.0	179.0	250.0	304.8	360.0	414.2	470.0	524.5	555.0	579.2	600.0
	Sulphate	(mg/L)	3478	3890	4304	4660	5004	5310	5582	5860	6095	6210	6347	6500	6636	6780	6891	7000	7100	7180	7272	7350
1.0 m	pH	(pH Units)	6.52	5.40	5.00	3.30	2.40	2.20	2.20	2.28	2.24	2.24	2.25	2.28	2.30	2.30	2.35	2.40	2.40	2.44	2.45	2.48
	U	(mg/L)	0.1	3.0	12.0	26.0	38.0	46.0	50.0	54.0	56.0	70.0	115.0	150.0	195.0	250.0	270.0	340.0	380.0	430.0	500.0	570.0
	Sulphate	(mg/L)	3478	3510	3750	4000	4400	4700	4900	5250	5400	5600	5800	6000	6250	6400	6600	6700	6800	7000	7000	7100
1.5 m	pH	(pH Units)	6.52	6.52	6.52	5.35	3.70	3.00	3.00	2.75	2.60	2.50	2.50	2.48	2.50	2.52	2.50	2.49	2.55	2.54	2.55	2.60
	U	(mg/L)	0.1	0.1	0.1	5.0	16.0	21.0	28.0	33.0	36.0	38.0	52.0	70.0	90.0	100.0	140.0	166.0	205.0	250.0	333.0	400.0
	Sulphate	(mg/L)	3478	3478	3478	3570	3800	3910	4180	4280	4550	4700	5000	5200	5400	5650	5800	6000	6100	6210	6350	6500
2.0 m	pH	(pH Units)	6.52	6.52	6.52	6.30	5.80	4.70	4.00	3.40	3.05	2.90	2.80	2.76	2.80	2.82	2.70	2.70	2.70	2.70	2.70	2.76
	U	(mg/L)	0.1	0.1	0.1	0.5	4.0	6.0	12.0	17.0	21.0	23.0	29.0	36.0	43.0	52.0	73.0	90.0	110.0	136.0	180.0	220.0
	Sulphate	(mg/L)	3478	3478	3478	3500	3550	3590	3770	3880	4050	4150	4330	4500	4600	4850	4950	5200	5300	5480	5630	5850
2.5 m	pH	(pH Units)	6.52	6.52	6.52	6.52	6.52	6.10	5.10	4.40	4.00	3.70	3.70	3.60	3.50	3.25	3.35	3.20	3.30	3.20	3.30	3.20
	U	(mg/L)	0.1	0.1	0.1	0.0	0.1	0.3	2.0	7.0	10.0	13.0	12.0	12.0	15.0	22.0	27.0	36.0	45.0	56.0	65.0	68.0
	Sulphate	(mg/L)	3478	3478	3478	3477	3478	3510	3550	3640	3720	3800	3900	3950	4070	4120	4300	4400	4650	4800	4950	5160
3.0 m	pH	(pH Units)	6.52	6.52	6.52	6.52	6.52	6.45	6.20	6.00	5.60	5.20	5.10	4.70	4.60	4.10	4.40	4.10	4.30	4.10	4.30	4.00
	U	(mg/L)	0.1	0.1	0.1	0.1	0.1	0.1	0.5	1.0	2.0	4.0	3.0	1.0	3.0	6.0	6.0	4.0	10.0	9.0	15.0	9.0
	Sulphate	(mg/L)	3478	3478	3478	3477	3478	3480	3500	3520	3570	3600	3680	3700	3800	3840	3980	4000	4150	4300	4350	4540
3.5 m	pH	(pH Units)	6.52	6.52	6.52	6.52	6.52	6.52	6.52	6.52	6.30	6.14	5.80	5.60	5.30	5.40	5.05	5.17	4.95	5.02	4.85	4.88
	U	(mg/L)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.4	0.1	0.3	0.1	0.7
	Sulphate	(mg/L)	3478	3478	3478	3477	3478	3477	3477	3492	3500	3520	3580	3590	3680	3750	3780	3900	3870	3910	4020	4080
4.0 m	pH	(pH Units)	6.52	6.52	6.52	6.52	6.52	6.52	6.52	6.52	6.45	6.46	6.10	6.10	5.75	6.00	5.50	5.78	5.35	5.48	5.20	5.30
	U	(mg/L)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1
	Sulphate	(mg/L)	3478	3478	3478	3477	3478	3477	3477	3484	3478	3490	3500	3530	3600	3700	3660	3860	3750	3700	3850	3860
4.5 m	pH	(pH Units)	6.52	6.52	6.52	6.52	6.52	6.52	6.52	6.52	6.50	6.51	6.35	6.38	6.15	6.21	5.90	5.98	5.70	5.70	5.50	5.50
	U	(mg/L)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Sulphate	(mg/L)	3478	3478	3478	3477	3478	3477	3477	3476	3478	3480	3478	3490	3530	3600	3560	3710	3600	3600	3700	3700
5.0 m	pH	(pH Units)	6.52	6.52	6.52	6.52	6.52	6.52	6.52	6.52	6.52	6.52	6.52	6.45	6.52	6.26	6.30	6.00	6.00	5.78	5.75	5.65
	U	(mg/L)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Sulphate	(mg/L)	3478	3478	3478	3478	3478	3478	3478	3478	3478	3478	3478	3478	3478	3478	3478	3478	3500	3588	3600	3650

[5] Table is translated directly from model output tables provided in Appendix F, where values did not correlate directly with the timing or distances required, values were determined visually from graphed results. Where specific NA well distances from the confirmed lixiviant plume deviate from those presented in Table 7.8, predicted concentrations for the nearest bracketing distances will be averaged to estimate site-specific values.

Table 7.9: Key Modelled Chemistry Outputs for proposed natural attenuation monitor wells (1.3 m/a scenario) for the first 5 years post FRT.

Distance from the Plume (m)[6]	Analyte	Unit	Time Elapsed Since FRT Conclusion (Years)																			
			0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75	3.00	3.25	3.50	3.75	4.00	4.25	4.50	4.75	5.00
0.75 m	pH	(pH Units)	5.75	3.00	2.17	2.08	2.03	2.02	2.01	2.02	2.04	2.06	2.10	2.13	2.17	2.21	2.25	2.29	2.33	2.36	2.40	2.44
	U	(mg/L)	6.0	30.0	55.0	75.0	80.0	85.0	86.4	90.0	125.0	180.6	235.0	280.0	325.9	370.0	410.0	444.8	475.0	500.0	505.0	520.0
	Sulphate	(mg/L)	3630	4250	4850	5350	5730	6000	6220	6360	6490	6638	6780	6900	7020	7110	7200	7289	7350	7400	7460	7500
1.0 m	pH	(pH Units)	6.30	5.40	3.80	2.18	2.15	2.13	2.10	2.10	2.10	2.10	2.14	2.17	2.19	2.22	2.26	2.30	2.34	2.38	2.40	2.45
	U	(mg/L)	2.7	13.0	32.0	54.0	63.0	69.0	70.0	75.0	98.0	133.0	175.0	212.0	254.0	310.0	370.0	435.0	470.0	505.0	530.0	550.0
	Sulphate	(mg/L)	3530	3790	4230	4750	5120	5410	5700	5910	6120	6330	6480	6620	6730	6820	6940	7080	7150	7220	7300	7370
1.5 m	pH	(pH Units)	6.62	6.81	5.45	3.45	2.88	2.52	2.38	2.33	2.28	2.30	2.29	2.28	2.30	2.31	2.32	2.37	2.40	2.42	2.45	2.49
	U	(mg/L)	0.1	0.1	6.0	21.0	33.0	44.0	48.0	56.0	61.0	68.0	89.0	112.0	142.0	187.0	240.0	307.0	345.0	395.0	458.0	500.0
	Sulphate	(mg/L)	3465	3450	3600	3950	4280	4580	4830	5100	5340	5600	5820	6000	6190	6340	6500	6610	6700	6820	6920	7050
2.0 m	pH	(pH Units)	6.55	6.62	6.27	5.57	3.94	3.02	2.72	2.60	2.53	2.50	2.46	2.44	2.43	2.44	2.44	2.46	2.48	2.50	2.54	2.56
	U	(mg/L)	0.1	0.1	2.0	5.0	14.0	24.0	30.0	35.0	39.0	43.0	55.0	68.0	88.0	104.0	124.0	160.0	190.0	235.0	285.0	337.0
	Sulphate	(mg/L)	3478	3478	3510	3590	3820	4050	4270	4460	4650	4860	5080	5300	5540	5720	5910	6080	6210	6380	6530	6660
2.5 m	pH	(pH Units)	6.52	6.52	6.64	6.55	5.07	4.18	3.73	3.38	3.10	2.90	2.78	2.71	2.67	2.64	2.62	2.62	2.62	2.62	2.63	2.64
	U	(mg/L)	0.1	0.1	0.1	0.1	2.5	8.0	16.0	22.0	25.0	28.0	33.0	39.0	49.0	60.0	75.0	100.0	120.0	145.0	170.0	200.0
	Sulphate	(mg/L)	3478	3478	3477	3477	3550	3700	3870	4040	4190	4330	4500	4670	4850	5030	5230	5480	5630	5830	6010	6170
3.0 m	pH	(pH Units)	6.52	6.52	6.55	6.54	6.22	5.88	5.38	4.60	4.05	3.50	3.25	3.10	3.00	2.95	2.92	2.85	2.81	2.77	2.77	2.77
	U	(mg/L)	0.1	0.1	0.1	0.1	0.1	2.0	5.0	8.0	14.0	22.0	23.0	25.0	29.0	35.0	44.0	55.0	68.0	83.0	103.0	125.0
	Sulphate	(mg/L)	3478	3478	3477	3477	3480	3540	3620	3740	3880	4000	4130	4250	4390	4510	4680	4850	5020	5200	5400	5580
3.5 m	pH	(pH Units)	6.52	6.52	6.52	6.52	6.52	6.58	6.15	5.43	4.78	4.60	3.93	3.74	3.62	3.55	3.47	3.40	3.34	3.26	3.24	3.25
	U	(mg/L)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	3.0	10.0	11.0	14.0	20.0	25.0	30.0	35.0	40.0	50.0	63.0	78.0
	Sulphate	(mg/L)	3478	3478	3477	3477	3477	3480	3510	3580	3660	3770	3860	3980	4090	4180	4280	4400	4520	4670	4830	5000
4.0 m	pH	(pH Units)	6.52	6.52	6.52	6.52	6.52	6.61	6.34	5.89	5.45	5.65	4.77	4.57	4.42	4.30	4.22	4.15	4.06	3.98	3.95	3.92
	U	(mg/L)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	5.0	9.0	13.0	14.0	14.0	15.0	20.0	23.0	28.0
	Sulphate	(mg/L)	3478	3478	3477	3477	3477	3477	3480	3500	3550	3600	3680	3760	3850	3940	4020	4120	4200	4300	4400	4530
4.5 m	pH	(pH Units)	6.52	6.52	6.52	6.52	6.52	6.53	6.45	6.30	6.10	6.15	5.63	5.42	5.22	5.10	5.00	4.92	4.84	4.75	4.70	4.67
	U	(mg/L)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	1.0	1.0	1.0
	Sulphate	(mg/L)	3478	3478	3477	3477	3477	3477	3477	3480	3500	3520	3570	3610	3700	3750	3830	3910	3990	4060	4130	4210
5.0 m	pH	(pH Units)	6.52	6.52	6.52	6.52	6.52	6.52	6.52	6.52	6.52	6.40	6.40	6.20	6.00	5.85	5.70	5.70	5.60	5.45	5.40	5.35
	U	(mg/L)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Sulphate	(mg/L)	3478	3478	3477	3477	3477	3477	3476	3476	3480	3490	3510	3540	3570	3620	3690	3750	3800	3880	3940	4000

[6] Table is translated directly from model output tables provided in Appendix F, where values did not correlate directly with the timing or distances required, values were determined visually from graphed results. Where specific NA well distances from the confirmed lixiviant plume deviate from those presented in Table 7.9, predicted concentrations for the nearest bracketing distances will be averaged to estimate site-specific values.

Table 7.10: Key Modelled Chemistry Outputs for proposed natural attenuation monitor wells (6.0 m/a scenario) for the first 5 years post FRT.

Distance from the Plume (m)[7]	Analyte	Unit	Time Elapsed Since FRT Conclusion (Years)																			
			0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75	3.00	3.25	3.50	3.75	4.00	4.25	4.50	4.75	5.00
0.75 m	pH	(pH Units)	1.70	1.68	1.67	1.70	1.75	1.81	1.85	1.90	1.95	2.00	2.05	2.09	2.14	2.18	2.21	2.26	2.31	2.36	2.42	2.48
	U	(mg/L)	136.2	137.5	141.4	146.3	154.5	173.9	190.0	205.0	220.0	232.0	242.0	250.0	252.0	249.0	243.8	236.0	222.0	208.0	182.0	152.0
	Sulphate	(mg/L)	7105	7150	7257	7291	7316	7354	7380	7410	7420	7427	7415	7350	7232	7100	6952	6750	6570	6400	6240	6050
1.0 m	pH	(pH Units)	1.76	1.74	1.68	1.70	1.75	1.81	1.85	1.90	1.95	2.00	2.05	2.09	2.14	2.18	2.21	2.26	2.31	2.36	2.42	2.48
	U	(mg/L)	124.0	127.0	138.0	141.0	146.0	172.0	195.0	214.0	230.0	246.0	260.0	270.0	275.0	274.0	270.0	260.0	249.0	234.0	210.0	180.0
	Sulphate	(mg/L)	6800	6900	7160	7200	7250	7280	7320	7350	7380	7400	7400	7360	7240	7130	6975	6780	6610	6440	6280	6100
1.5 m	pH	(pH Units)	2.00	1.94	1.70	1.71	1.76	1.80	1.85	1.90	1.95	2.00	2.05	2.09	2.14	2.18	2.21	2.26	2.31	2.36	2.41	2.47
	U	(mg/L)	100.0	104.0	128.0	130.0	132.0	160.0	192.0	218.0	240.0	266.0	282.0	297.0	310.0	312.0	312.0	304.0	295.0	280.0	258.0	230.0
	Sulphate	(mg/L)	6000	6300	6980	7050	7050	7130	7175	7230	7280	7320	7330	7310	7242	7140	7020	6840	6680	6520	6360	6200
2.0 m	pH	(pH Units)	2.34	2.18	1.76	1.75	1.77	1.81	1.86	1.90	1.95	2.00	2.05	2.09	2.14	2.18	2.21	2.26	2.31	2.35	2.41	2.45
	U	(mg/L)	68.0	82.0	119.0	122.0	123.0	142.0	175.0	216.0	245.0	274.0	296.0	318.0	336.0	342.0	348.0	344.0	333.0	320.0	297.0	270.0
	Sulphate	(mg/L)	5000	5600	6850	6900	6850	6980	7050	7120	7175	7230	7260	7270	7230	7150	7050	6890	6740	6580	6440	6290
2.5 m	pH	(pH Units)	2.90	2.70	1.88	1.80	1.78	1.81	1.86	1.90	1.95	2.00	2.05	2.09	2.14	2.18	2.21	2.26	2.31	2.35	2.41	2.44
	U	(mg/L)	36.0	60.0	110.0	114.0	114.5	128.0	156.0	200.0	240.0	273.0	302.0	332.0	356.0	368.0	376.0	374.0	365.0	356.0	340.0	310.0
	Sulphate	(mg/L)	4150	5000	6600	6700	6780	6830	6920	7000	7075	7130	7180	7210	7200	7140	7065	6920	6790	6650	6500	6360
3.0 m	pH	(pH Units)	4.00	3.70	2.00	1.88	1.81	1.83	1.86	1.91	1.95	2.00	2.05	2.09	2.14	2.18	2.21	2.26	2.31	2.34	2.41	2.44
	U	(mg/L)	10.0	40.0	99.0	106.0	106.5	117.0	140.0	176.0	225.0	269.0	300.0	338.0	366.0	384.0	396.0	400.0	395.0	390.0	370.0	346.0
	Sulphate	(mg/L)	3750	4500	6100	6500	6720	6710	6760	6860	6950	7025	7090	7140	7155	7120	7065	6950	6820	6690	6560	6435
3.5 m	pH	(pH Units)	5.60	4.50	2.24	2.00	1.88	1.87	1.86	1.92	1.95	2.00	2.05	2.09	2.14	2.17	2.21	2.26	2.31	2.34	2.41	2.44
	U	(mg/L)	0.1	24.0	86.0	96.0	100.0	105.0	125.0	154.0	200.0	256.0	296.0	335.0	370.0	394.0	410.0	422.0	422.0	416.0	400.0	376.0
	Sulphate	(mg/L)	3550	4100	5500	6150	6600	6570	6630	6750	6830	6920	6990	7050	7095	7080	7045	6950	6850	6730	6610	6500
4.0 m	pH	(pH Units)	6.10	5.00	2.64	2.18	1.98	1.91	1.90	1.93	1.96	2.00	2.05	2.09	2.14	2.17	2.21	2.26	2.30	2.34	2.39	2.43
	U	(mg/L)	0.1	16.0	70.0	86.0	91.0	95.0	110.0	134.0	175.0	230.0	275.0	320.0	366.0	400.0	417.0	438.0	440.0	440.0	425.0	408.0
	Sulphate	(mg/L)	3500	3800	5000	5700	6300	6400	6530	6670	6730	6790	6880	6960	7020	7025	7005	6950	6860	6760	6650	6550
4.5 m	pH	(pH Units)	6.40	5.30	2.95	2.38	2.10	1.95	1.93	1.94	1.96	2.00	2.05	2.09	2.14	2.17	2.21	2.26	2.30	2.34	2.39	2.43
	U	(mg/L)	0.1	14.0	54.0	74.0	86.0	90.0	100.0	118.0	150.0	200.0	248.0	305.0	360.0	396.0	422.0	450.0	455.0	460.0	450.0	438.0
	Sulphate	(mg/L)	3480	3700	4500	5200	5850	6250	6440	6600	6630	6665	6770	6860	6940	6970	6970	6930	6860	6770	6680	6580
5.0 m	pH	(pH Units)	6.62	5.45	3.08	2.58	2.22	2.02	1.96	1.96	1.98	2.01	2.05	2.09	2.14	2.18	2.21	2.26	2.30	2.34	2.39	2.43
	U	(mg/L)	0.1	12.0	36.0	62.0	82.0	86.0	95.0	104.0	135.0	170.0	215.0	286.0	350.0	382.0	423.0	460.0	470.0	480.0	480.0	466.0
	Sulphate	(mg/L)	3460	3660	4100	4800	5600	6120	6400	6590	6550	6510	6630	6750	6860	6920	6940	6910	6850	6760	6670	6585

[7] Table is translated directly from model output tables provided in Appendix F, where values did not correlate directly with the timing or distances required, values were determined visually from graphed results. Where specific NA well distances from the confirmed lixiviant plume deviate from those presented in Table 7.10, predicted concentrations for the nearest bracketing distances will be averaged to estimate site-specific values.

Natural Attenuation Model Assessment Phase III: Final Model Assessment

The Final NA Model Assessment Phase (Phase III) is designed to confirm the long-term effectiveness of natural attenuation in mitigating FRT-impacted groundwater and ensuring compliance with closure requirements. This phase will validate that attenuation rates and concentrations remain within predicted limits, and the extent of the attenuation zone does not exceed predicted boundaries.

NA Model Refinement

If Phase II field data is within expected limits but indicates opportunities for improved accuracy in natural attenuation predictions, the NA model may be rerun using the updated site-specific dataset. This refinement will:

- Enhance understanding of NA processes and long-term plume behaviour.
- Improve confidence in closure predictions by incorporating field-validated attenuation trends.

This model refinement is not intended to reassess compliance but rather to improve predictive accuracy and strengthen the scientific basis for closure verification.

Final Model Assessment Process

To formally verify the NA model's effectiveness the Natural Attenuation Model Assessment Report will be produced. This review will assess field data collected during Phase II monitoring against the model's predictions and confirm:

- No reduction in NA rates as defined in Table 7.8, Table 7.9 & Table 7.10.
- No increase in the extent of the NA zone beyond the boundaries shown in Figure 5.2.
- Observed groundwater chemistry trends verify NA is progressing within maximum limits predicted.
- Plume migration patterns to ensure containment within the expected attenuation zone.

If the Natural Attenuation Model Assessment Report confirms compliance, this final assessment phase will support regulatory sign-off and RL relinquishment. If the review cannot confirm compliance, the related TARP will be initiated.

This final validation step ensures that the NA model reasonably represents long-term groundwater behaviour, providing a scientifically defensible basis for closure certification.

Underlying Aquifer – Closure Monitoring

Ensuring the long-term isolation of the FRA post-FRT is critical to demonstrating compliance with groundwater outcomes. The closure phase will include a stability monitoring program to verify that the FRA remains isolated from FRT activities, and that groundwater quality remains within baseline ranges.

Groundwater Quality Closure Criteria

The FRA is considered to have remained isolated if:

- Groundwater quality at all underlying monitoring wells remains within two standard deviations (2 SD) of the mean baseline concentrations for pH, sulphate, and uranium, based on the full FRA baseline dataset (Appendix E).
- No sustained upward trends are observed in excursion control parameters over the post-FRT monitoring period.

Post-FRT Stability Monitoring Program

A structured monitoring program will be implemented to track groundwater conditions following the cessation of FRT activities. This program will focus on confirming that groundwater quality within the underlying FRA remains stable and within expected baseline variability, thereby verifying that there has been no vertical migration of fluids from the Tertiary (target) aquifer into the FRA.

All underlying aquifer monitoring wells established for the operational phase will be retained for stability monitoring. Wells will be sampled using low flow sampling or discrete interval samplers.

Sampling Frequency: Monthly sampling for at least six months post-FRT, transitioning to quarterly sampling based on observed stability trends.

Table 7.11: Underlying Aquifer - Closure Monitoring Program

Well No.	Monitoring Frequency	Monitoring Parameters
SUMW01	Quarterly for two years post FRT operations.	pH, SO4, U.
SUMW02		
SUMW03		

7.3.6 Uncertainties, Assumptions & Future Works

Fractured Rock Aquifer Hydraulic Gradients

Preliminary local water level data collected as part of the RL application process, showed a discrepancy between local head maps and regional head maps for the underlying aquifer however stabilisation of the salinity and heads post well development shows local head maps correlate to the regional head maps (Figure 2.12). Due to the high salinity of the FRA groundwater data for this aquifer outside of the immediate vicinity is sparce. This introduces uncertainty into hydraulic gradient calculations.

To address these uncertainties, additional sampling will be undertaken during the FRT to refine salinity values within the FRA. Improved salinity data will enable a more accurate determination of hydraulic gradients, enhancing the reliability of models and ensuring robust management of the aquifer system.

Natural Attenuation Assessment

Natural attenuation has been identified as a key strategy to mitigate groundwater impacts associated with lixiviant plume migration during and after the FRT. The effectiveness of this approach depends on validating model predictions against actual field conditions and demonstrating compliance with closure requirements. To ensure the robustness of the NA model and its applicability to real-world conditions, several uncertainties and assumptions must be addressed.

Key uncertainties include variability in subsurface conditions and lixiviant chemistry, the timing and extent of downgradient monitoring well contact, the correlation of modelled predictions with field monitoring results, and the inherent limitations of the 1D reactive transport model used in the assessment. These challenges are further compounded by the limited timeframe associated with the RL, which restricts opportunities to fully validate NA processes before closure criteria must be demonstrated.

This section outlines the primary uncertainties and assumptions associated with the use of natural attenuation, as well as the future works planned to address them. Together, these measures ensure a systematic and adaptive approach to groundwater management, supporting effective and compliant remediation.

Natural Attenuation Model Inputs

The natural attenuation model relies on key inputs such as redox states, sorption capacities, groundwater flow rates, and lixiviant chemistry, derived from a combination of field data collected during the exploration phase (e.g., geological data, baseline groundwater sampling, and hydrogeological testing) and laboratory testwork (e.g., simulated lixiviant chemistry). While these inputs provide a solid foundation, the absence of widescale drilling (e.g., for pattern installation), full monitoring well networks, and comprehensive data from actual FRT activities (e.g., actual mining lixiviant chemistry and broadscale hydrogeological testing) introduces some uncertainties regarding the model's accuracy.

To mitigate these uncertainties, the model incorporates a conservative approach to parameter selection and scenario design, aimed at overestimating potential risks and ensuring robust predictions under a range of conditions. Examples of this conservative approach include:

- Groundwater Velocity Assumptions: The model simulates multiple groundwater velocity scenarios (1.0 m/a, 1.3 m/a, and 6.0 m/a) to account for variability in flow rates. This ensures that predictions are valid for both slower and faster flow conditions, reducing the likelihood of underestimating contaminant transport.
- Mineral Reactivity Adjustments: Conservative assumptions and sensitivity analysis on a 50% reduction in pyrite availability. Adjustment of log K values for Uranophane dissolution to simulate a realistic but worst-case scenario in terms of NA where uranophane is dissolved at pH higher than "optimal mining" pH, reflect cautious estimates for geochemical attenuation processes.
- Exclusion of Microbial Sulphate Reduction: Due to uncertainty in its contribution at the field scale, microbial sulphate reduction was excluded from initial modelling efforts. This ensures predictions are not overly optimistic about attenuation performance.
- Dispersivity Parameters: Conservative dispersivity values (longitudinal dispersivity of 0.16 m and minimal transverse mixing) minimise reliance on dilution and dispersion to meet attenuation targets.

These conservative assumptions provide a safety buffer against potential inaccuracies in the initial model and reduce the likelihood of non-compliance with modelled maximum concentration and distances established in the model that must be demonstrated for closure.

Beyond the redundancies incorporated into the model, future works to address these assumptions and uncertainties will include the collection of FRT operational data to verify specific NA model input parameters, as presented in the Phase I: NA Model Assessment Works detailed in 7.3.5. Related contingency actions are detailed in TARP No. 5, No. 6 and No. 9.

Limitations of the 1D Reactive Transport Model

The 1D reactive transport model provides a simplified yet conservative framework for predicting lixiviant plume migration, focusing on flow and geochemical reactions along a single streamline. While effective for its purpose, the model's ability to account for multidimensional processes such as horizontal and vertical mixing is limited, which may influence long-term plume behaviour in heterogeneous aquifers. As such, it may underestimate dilution and dispersive effects, introducing some limitations to its predictive accuracy but again depicts the worst-case scenario.

In the context of the FRT, the confined nature of the Tertiary aquifer, well-defined flow path and low groundwater velocity align well with the assumptions of the 1D model, making it a suitable tool for the preliminary investigative stage project is currently at and is adequate in demonstrating the effective application of NA for groundwater rehabilitation. Conservative design elements, such as simulating a range of groundwater velocities, reducing pyrite availability, and excluding microbial sulphate reduction, ensure predictions err on the side of caution while minimising the risk of overestimating attenuation performance.

The FRT will provide site-specific data on key parameters such as groundwater flow rates, porosity, and lixiviant chemistry. This data will be used to validate assumptions and re-run the model as needed, guided by sensitivity thresholds established in the sensitivity assessment (see NA Model Assessment Phase: I in Section 7.3.5). Should the project progress to a full ML application, modelling approaches with increased complexity, such as 2D or 3D simulations, will be employed incorporating the data collected to validate the 1D model to provide a more detailed analysis of plume behaviour and attenuation processes.

Downgradient NA Monitoring Well Contact

While groundwater flow rates and directions have been estimated with reasonable confidence based on available data, some residual uncertainties remain due to site-specific heterogeneity and the limited extent of field-scale validation. These uncertainties may result in designated downgradient monitoring wells not being contacted by the lixiviant plume within the expected timeframe, potentially delaying the timely validation of modelled attenuation processes. Such delays could complicate the confirmation of aquifer conditions against model predictions and hinder the ability to assess plume behaviour effectively.

A particular challenge arises in accurately determining the position of the lixiviant plume at the conclusion of mining, as this has direct implications for the timing and detection of the disposal plume. To mitigate this issue, ongoing hydrogeological data collection, modelling and assessment incorporating in-situ conductivity probes will provide confidence in the plume's location at closure. This allows for accurate predictions of plume migration and ensures the distance (in meters) between the plume edge and the next closest monitoring well.

Additional preventative measures detailed in Section 7.3.5 include:

- Pre-Installation of Monitoring Wells: Monitoring wells will be installed prior to FRT operations to avoid unintended plume movement toward the well during airlifting or well development. This is critical because water extraction during these activities could unintentionally pull groundwater and the lixiviant plume toward the well.
- Optimised Well Spacing: Wells will be spaced at 1-meter intervals, ensuring that even under the slowest hydrogeological flow rates, plume contact at successive monitoring wells can be tracked within the limited monitoring duration available.
- Plume Contact Design: Wells will be strategically positioned to ensure that at least one monitoring well is in direct contact with, or within the halo of, the lixiviant plume at the conclusion of FRT operations. This design provides immediate data for plume tracking and shortens the timeframe for validating model predictions.
- Monitor Well Construction: due to the short screen lengths of the FRT wells and close spaced nature of the NA monitoring wells, screen locations will be tightly constrained. In addition, in-situ physical and chemical parameter probes will be employed in wells not yet contacted by the plume. This approach minimises the risk of undetected lixiviant when solely utilising conventional low flow sampling methods, ensuring accurate and comprehensive monitoring.

In cases where significant delays or issues with downgradient lixiviant detection are encountered, specific TARPs have been developed (TARP No. 7 and No. 8) to ensure appropriate contingencies are initiated in a timely manner.

Correlation of Modelled Predictions with Field Monitoring

The NA model relies on assumptions and input parameters, such as lixiviant chemistry, groundwater flow rates, and mineral availability, which were informed by exploration data, laboratory tests, and conservative assumptions. While this provides a strong foundation, actual field geochemical data (e.g., pH, uranium, and metal/metalloid concentrations) collected post-FRT may not always align with model predictions.

Discrepancies could arise due to overly conservative assumptions, such as simplified or conservative estimates for mineral reactivity (e.g., uranium mineralisation as amorphous (UO_2) or the exclusion of microbial processes like sulphate reduction, which were omitted due to high uncertainties in their field-scale contributions. Additionally, variability in field conditions, such as differences in aquifer characteristics like hydraulic conductivity, porosity, or redox potential, could contribute to deviations. Furthermore, the absence of widescale field monitoring and real-time adjustments to the model prior to the FRT introduces inherent limitations.

Field data consistently falling outside the predicted range, such as elevated concentrations of contaminants or lower than predicted pH levels, could signal insufficient attenuation or inaccuracies in model assumptions. Model reruns may be required if deviations in parameters like lixiviant concentrations, porosity, or chemical trends (e.g., sulphate, iron, or uranium) are observed. Successive exceedances of predicted values for key parameters, sulphate, uranium, and/or minimum thresholds for pH, will trigger an immediate investigation into attenuation performance and potential model adjustments in line with TARP No. 5 (see Section 7.3.6).

Achievement of Closure Requirements & Contingency Active Remediation Provisions

The ability of NA to restore groundwater quality and meet final closure criteria remains contingent upon the validation of attenuation efficacy through field data. As discussed in the preceding sections, uncertainties in subsurface variability, monitoring well contact timing, and field monitoring correlations all influence the reliability of model predictions. Additionally, the limited timeframe associated with the RL may hinder full verification of attenuation processes and introduce residual uncertainties.

If preliminary verification of attenuation is not achieved within 24–28 months post-FRT, or if insufficient data are available to confirm attenuation efficacy, further actions will include increased data collection, rerun of the model with updated inputs, and, if necessary, the implementation of contingency measures. These contingency actions are detailed in full in Section 7.3.6 as TARP No. 9. This plan details the active remedial actions that will be undertaken to ensure closure outcomes can be demonstrated.

7.3.7 Trigger Action Response Plan (TARP)

The groundwater Trigger, Action, and Response Plan (TARP) establishes a structured approach to identifying, responding to, and mitigating deviations from expected groundwater behaviour. This plan ensures compliance with regulatory groundwater quality criteria and NA assessment requirements. It integrates leading indicator criteria to facilitate early intervention where necessary.

The key objectives of the TARP:

- Establish thresholds for early warning indicators to proactively manage groundwater quality risks.
- Define clear actions when exceedances occur, ensuring timely remedial measures.
- Maintain compliance with the groundwater closure outcomes and monitoring strategies outlined in the RL conditions.

TARP triggers are categorised based on deviations from modelled NA predictions and field monitoring results.

TARP 1: Perimeter Monitor Well - Leading Indicator Triggered (Operations)

A leading indicator trigger serves as an early warning system, identifying trends in groundwater quality that could indicate a potential excursion before an ECL is exceeded. This allows for proactive management and ensures that containment strategies remain effective.

Leading indicator values for each perimeter monitor well is presented in Table 7.12. These values represent the calculated 2 SD thresholds for each well, derived from baseline datasets, and are the operational thresholds referenced in the trigger criteria below.

Trigger Event:

A leading indicator is triggered if:

- ≥2 consecutive uranium (U) or sulphate (SO_4) results exceed 2 standard deviations (SD) above the mean for that well's dataset.
- ≥2 consecutive pH results fall 2 SD below the mean for that well's dataset.

Response Actions:

Step 1: Verification Sampling & Initial Assessment

- A verification sample will be collected from the affected monitoring well within 24 hours of a leading indicator exceedance being identified.
- Field parameters (pH, conductivity) will be measured in real-time to assess trends before laboratory analysis.
- Laboratory analysis will be conducted to confirm uranium and sulphate concentrations.
- Results will be compared against historical trends to provide a preliminary indication as to whether the exceedance is due to natural variability or if it indicates a potential excursion.

Step 2: Initial Regulatory Notification & Reporting

- If the verification sampling confirms a leading indicator is triggered, regulatory notification will be provided to DEM within 24 hours.

Step 3: Hydrogeological Assessment & Continued Monitoring

- A technical review of aquifer conditions will be conducted, including:
    - Assessment of hydraulic gradients and pressure variations.

  - Consideration of impacts associated with recent well construction, residual drilling muds etc.
  - Analysis of data to determine if the trend is localised or widespread.
- The affected well will also be placed on weekly sampling schedule for a minimum of four weeks to track groundwater quality trends.
- Results will be continuously assessed to determine whether conditions return to baseline, remain stable, or show further deviation.

Step 4: Regulatory Reporting

- Following the hydrogeological assessment and within 1 month after the leading indicator is triggered, a detailed assessment report summarising findings, monitoring trends, and any recommended containment or corrective actions will be submitted to DEM.

Step 5: Implementation of Corrective Actions (If required)

- If continued monitoring and assessment confirm the likely presence of initial traces of mining lixiviant, corrective actions will be implemented, which may include:
  - Hydraulic Adjustments: Increasing extraction rates at nearby production wells to strengthen the inward hydraulic gradient, preventing further movement of lixiviant.
  - Flow Rate Balancing: Adjusting injection and extraction rates at the wellfield to improve containment and reduce risk of lateral migration.
- Corrective actions will be done in consultation with regulatory agencies.
- If monitoring results continue to trend beyond expected limits, a formal Excursion Control Limit (ECL) exceedance response will be enacted.

Table 7.12: Perimeter Monitor Wells – Leading Indicator Values

ECL	pH (pH units)	Uranium (mg/L)	Sulphate (mg/L)
	5.80	**0.56**	**5,845**
LMW001	5.92	0.33	4,872
LMW002	6.04	0.16	5,363
LMW003	6.37	0.17	5,399
LMW004	6.40	0.15	5,408
LMW005	6.28	0.08	4,386
LMW006	6.31	0.09	4,711
LMW007	6.96	0.04	4,851
LMW008	6.31	0.09	4,172
LMW009	6.32	0.02	3,872
LMW010	6.36	0.04	4,853
LMW011	6.22	0.24	4,467
LMW012	6.38	0.29	4,487
LMW013	5.94	0.28	4,994
MRE4	6.50	0.04	3,915
MRH1C	5.85	0.34	4,087
Note: The values presented in this table represent the calculated 2 standard deviation thresholds derived from the baseline dataset for each well. These thresholds are the operational leading indicator value.			

TARP 2: Perimeter Monitor Well - ECL Trigger Response (Operations)

In the event an ECL is exceeded at a perimeter monitoring well during the FRT operational phase, the following response protocol will be implemented to contain the excursion. These steps ensure prompt corrective action, regulatory compliance, and protection of surrounding groundwater resources.

Trigger Event:

An ECL exceedance is defined as any of the following conditions being met in a groundwater sample from a perimeter well:

- pH ≤ 5.8
- ≥ Sulphate (SO_4) ≥ 5,845 mg/L
- ≥ Uranium (U) ≥0.56 mg/L

Response Actions:

Step 1: Verification Sampling & Initial Assessment

- Immediate Re-sampling:
  - A verification sample will be collected from the affected perimeter monitoring well within 24 hours of detecting the exceedance.
  - Field parameters (pH, conductivity) will be measured in real-time to confirm anomalies before laboratory analysis.
  - Laboratory analysis will also be undertaken to assess sulphate and uranium concentrations.
- Comparison Against Baseline & Historical Data:
  - Results will be compared with historical trends to determine if the exceedance is due to a natural fluctuation or an actual excursion.
- If the re-sampling confirms an exceedance, the incident is formally classified as a reportable incident.

Step 2: Initial Regulatory Notification & Reporting

- If the verification sampling confirms the ECL has been triggered, regulatory notification will be provided to DEM within 24 hours.

Step 3: Immediate Corrective Actions

- Hydraulic Control Adjustments:
  - Increase Extraction Rates: Pumping at nearby extraction wells will be increased immediately to establish a stronger inward hydraulic gradient and draw lixiviant back into the operational zone.
  - Modify Wellfield Flow Balance: The lixiviant balance across the wellfield will be adjusted based on real-time monitoring data to enhance containment. This could include reducing injection rate or turning off injection completely if deemed appropriate.
- The affected well will also be placed on weekly sampling schedule to track groundwater quality trends.

Step 4: Incident Investigation & Regulatory Reporting

- A technical review of aquifer conditions will be conducted, including:
  - Assessment of hydraulic gradients and pressure variations.
  - Analysis of operational data (e.g., balance details).

- Following the hydrogeological assessment and within 1 month after the ECL is triggered, a detailed assessment report summarising findings, monitoring trends, and any recommended containment or corrective actions will be submitted to DEM.

Step 5: Implementation of Additional Corrective Actions (If required)

- Installation of Additional Monitor Wells:
  - Monitor wells may be installed to track and assess the effectiveness of the corrective actions.
  - Long term weekly sampling and assessment of the effectiveness of the corrective action will be undertaken.
- Additional corrective actions may be developed in consultation with regulatory agencies.

TARP 3: Underlying Monitor Well - Leading Indicator Triggered (Operations)

A leading indicator trigger serves as an early warning of potential changes in groundwater quality within the underlying aquifer that warrant further investigation. Upon detection, the following immediate actions will be implemented to assess the potential risk and determine if escalation to an IVL exceedance is required.

Leading indicator values for each underlying monitor well is presented in Table 7.13. These values represent the calculated 2 SD thresholds for each underlying monitor well, derived from baseline datasets, and are the thresholds referenced in the trigger criteria below.

Trigger Criteria

A leading indicator is triggered if:

- ≥2 consecutive uranium (U) or sulphate (SO_4) results exceed 2 standard deviations (SD) above the mean for that well's dataset.
- ≥2 consecutive pH results fall 2 SD below the mean for that well's dataset.

Response Actions:

Step 1: Verification Sampling

- A verification sample will be collected from the affected monitoring well within 24 hours of a leading indicator exceedance being identified.
- Field parameters (pH, conductivity) will be measured in real-time to assess trends before laboratory analysis.
- Laboratory analysis will be conducted to confirm uranium and sulphate concentrations.
- Results will be compared against historical trends to provide a preliminary indication as to whether the exceedance is due to natural variability or if it indicates a potential excursion.

Step 2: Initial Regulatory Notification

- If the verification sampling confirms a leading indicator is triggered, regulatory notification will be provided to DEM within 24 hours.

Step 3: Hydrogeological Assessment & Preliminary Actions

- A technical review of aquifer conditions will be conducted, including:
  - Assessment of hydraulic gradients and pressure variations.
  - Review of borehole integrity and well construction logs.
  - Analysis of groundwater flow patterns to determine if the trend is localised or widespread.

- Sampling frequency for the affected well and any surrounding monitoring wells will be increased to weekly to track trends.

Step 4: Regulatory Reporting

- Following the hydrogeological assessment and within 1 month after the leading indicator is triggered, a detailed assessment report summarising findings, monitoring trends, and any recommended containment or corrective actions will be submitted to DEM.

Step 5: Long Term Correction Actions

- If results continue to trend towards an IVL exceedance, additional control measures, such as increased hydraulic control or targeted wellfield adjustments, will be considered.
- If subsequent sampling results fall back within expected ranges, monitoring frequency will be gradually reduced, and regulatory reporting requirements will be fulfilled.

Table 7.13: Underlying Monitor Wells – Leading Indicator Values

IVL	pH (pH units)	Uranium (mg/L)	Sulphate (mg/L)
	6.40	**0.2**	**2,909**
SUMW01	6.44	0.06	2,876
SUMW02	6.51	0.08	3,034
SUMW03	6.55	0.02	2,814
Note: The values presented in this table represent the calculated 2 standard deviation thresholds derived from the baseline dataset for each well. These thresholds are the operational leading indicator value.			

TARP 4: Underlying Monitor Well – Isolation Verification Limit Exceedance (Operations)

An IVL exceedance signifies a statistically significant deviation from baseline groundwater quality conditions, requiring immediate investigation and regulatory response. This trigger indicates a potential loss of isolation in the FRA and must be addressed as a high-priority event.

Isolation verification limits for the underlying monitor wells are presented in Table 7.4.

Trigger Criteria

A IVL exceedance is triggered if:

- ≥2 consecutive uranium (U) or sulphate (SO_4) results exceed 2 standard deviations (SD) from the mean of baseline ranges for the FRA.
- ≥2 consecutive pH results fall 2 SD from the mean of baseline ranges for the FRA.

Response Actions

Step 1: Immediate Verification & Containment

- A verification sample will be collected within 24 hours to confirm the exceedance and assess trends in groundwater chemistry.
- Field parameters (pH, conductivity) will be measured in real-time to assess trends before laboratory analysis.
- Laboratory analysis will be conducted to confirm uranium and sulphate concentrations.

Step 2: Initial Regulatory Notification & Reporting

- If the verification sampling confirms a IVL has been exceeded, regulatory notification will be provided to DEM within 24 hours.

Step 3: Immediate Corrective Actions

- All FRT injection and extraction activities will be suspended immediately to prevent further movement of fluids until the situation is fully assessed.
- The affected well and surrounding FRA monitoring wells will be sampled weekly until stability is re-established.

Step 4: Incident Investigation & Regulatory Reporting

- A detailed risk assessment will be conducted to determine the extent of potential vertical migration, including:
    - Hydraulic connectivity assessment to confirm the source of variation.
    - Well integrity review to assess casing, annular seals, and well construction logs.
    - Geochemical analysis to identify any shifts in aquifer conditions.
- Following the incident investigation and within 1 month after the ECL is initially triggered, a detailed assessment report summarising findings, monitoring trends, and any recommended containment or corrective actions will be submitted to DEM.

Step 5: Corrective & Mitigation Actions

- Based on the findings of Step 4, a structured Corrective Action Plan (CAP) will be developed to address the exceedance and, if required, implement measures to remediate impacted groundwater.
- Installation of Additional Monitoring Wells: If the exceedance persists, new monitoring wells may be installed to enhance tracking of vertical movement trends and refine the response strategy.

TARP 5: Exceedance of the Natural Attenuation Models Sensitivity Limits

This TARP addresses the potential failure of key assumptions underlying the NA model used to predict the extent of groundwater impact. The sensitivity limits in Table 7.6 define acceptable ranges for critical input parameters (e.g. hydraulic gradient, redox conditions, final lixiviant concentrations). Exceedance of these limits indicates that the model's predictive reliability may be compromised, triggering early re-evaluation of compliance risk. This TARP provides a leading indicator framework to support timely model reassessment and regulatory engagement before groundwater outcomes are at risk.

Trigger Criteria:

An exceedance of key NA model input parameters, as defined by the sensitivity limits in Table 7.6. The assessment of field data against the sensitivity limits will occur at the conclusion of the operational phase.

Response Actions:

Step 1: Verification of Sensitivity Limit Exceedance & Regulatory Notification

- The parameters or monitoring results exceedance will be immediately verified following the assessment of field data against the sensitivity limits. This assessment will be conducted at the conclusion of the operational phase once all lab results have been received and operational data can be collated.
- Within 24 hours of a confirmed sensitivity limit exceedance, an initial notification will be submitted to DEM.

Step 2: Model Reassessment & Risk Analysis

- Model Rerun: The NA model will be re-run using the latest field data for all sensitivity parameters to determine risk of compliance breach in relation to groundwater outcome measurement criteria.
- Hydrogeological Review: A detailed review of aquifer conditions will be performed, including:
    - Geochemical analysis to assess attenuation effectiveness.
    - Hydraulic connectivity evaluation to verify whether model assumptions remain valid.
- Mitigation Strategy Development: A structured mitigation plan will be developed based on updated modelling results, incorporating additional monitoring or intervention strategies as required.

Step 3: Regulatory Reporting

- Following the model reassessment and mitigation strategy development a detailed assessment report will be submitted to DEM within 1 month of the leading indicator being triggered.

Step 4: Intervention Measures

- Regulatory Contingency Activation: If the updated model predicts a credible risk of exceeding groundwater outcome limits, TARP No. 9 (Active Remediation) will be triggered.

TARP 6: Field Exceedance of Modelled Predictive Concentrations

This TARP addresses situations where field monitoring results diverge from NA model predictions, indicating potential model underperformance or emerging compliance risk. This TARP enables early detection and structured investigation to determine whether model assumptions remain valid or if escalation to active intervention is warranted.

Trigger Criteria:

NA field monitoring results exceed modelled predictive concentrations for 2 consecutive sampling events for SO_4, U or minimum concentration for pH (Table 7.8, Table 7.9 & Table 7.10). As the aim of NA is for concentrations of key parameters to return back to baseline, any value that falls within natural variation (ECLs defined in Table 7.2) will not be considered an exceedance even if the value exceeds that presented in Table 7.8, Table 7.9 & Table 7.10.

Response Actions:

Step 1: Immediate Confirmation & Initial Regulatory Reporting

- Confirmatory Sampling: A verification sample will be collected and analysed to confirm the exceedance.
- Regulatory Notification & Reporting:
    - Initial notification to government authorities within 24 hours of identification.

Step 2: Sensitivity Analysis & Model Rerun

- Sensitivity Analysis: The NA model will be rerun using the latest field monitoring results to determine the cause of deviation.
- Geochemical & Hydrogeological Review: Additional aquifer stability assessments will be conducted to assess:
    - Potential geochemical feedback mechanisms affecting attenuation rates.
    - Changes in groundwater flow patterns that could impact contaminant transport.

Step 3: Intervention Decision Point & Regulatory Reporting

- Risk Assessment & Mitigation Strategy: If the model rerun suggests a significant risk of non-compliance, TARP No. 9 (Active Remediation) will be activated.
- Regulatory Reporting: Following the analysis and strategy development, a detailed report summarising findings, any recommended actions will be submitted to DEM within 1 month of the leading indicator being triggered.
- Implementation of Additional Monitoring Measures: If the exceedance is marginal or within manageable limits, enhanced field monitoring will be implemented before escalating remediation actions.

TARP 7: No Field Verification Results or Significantly Outside Modelled Predictive Concentrations – 12 Months Post FRT

This TARP addresses the limited NA verification window and triggers a preliminary investigation where monitoring has not intercepted the residual lixiviant plume within 12 months post FRT, so siting/construction issues can be corrected immediately. (TARP 7 is not a regulatory non-compliance indicator; it is a monitoring sufficiency check.)

Trigger Criteria:

Downgradient NA monitoring wells:

- No contact: No credible indication of lixiviant contact within 12 months from conclusion of the FRT; or
- 70% confirmation (lab-based): Results indicate a material shortfall relative to the model, defined as:
    - Uranium or sulphate: either two consecutive laboratory results are <70% of the modelled value for that well at the sampling dates or the median of the last three laboratory results is <70% of the modelled value; and
    - pH: uses the same two-consecutive/median-of-three test to the size of the pH change from the well baseline relative to the modelled change. Where the modelled pH shift is very small (not practically detectable), a practical check will be used instead: pH is within 0.5 units of the modelled pH.

Response Actions:

Step 1: Post FRT Groundwater Review

- Post FRT Review: 12 months post conclusion of the FRT operational phase, a review of the NA groundwater monitoring results against the modelled predictive concentrations will be undertaken.
- Regulatory Notification: Following the post FRT review, any TARP 7 triggers will be formally notified to DEM via the quarterly Environment and Radiation Compliance Report.

Step 2: Investigations Required for any Triggered Events

- Hydrogeological Review: A reassessment of plume migration behaviour using updated groundwater monitoring and modelling data will be undertaken within 30 days.
- Monitor Well Review: Downhole induction (conductivity) logging will be undertaken across the target aquifer (above and below the screen) within 30 days to confirm no lixiviant signature outside the screened interval.
    - If mining lixiviant is identified, well rescreening and a full monitor well review will be undertaken within 30 days.

  Note: A NA model review/rerun may be completed outside the TARP to inform interpretation and network placement; it is not a TARP closure requirement.

Step 3: Contingency Actions

- Installation of Additional Monitoring Wells:
    - Where the plume has not been detected at the first uncontacted monitor well, post FRT conclusion, new NA well(s) will be installed between the uncontacted monitoring well and FRT pattern to improve tracking resolution within 30 days (subject to drill rig availability).
    - A secondary NA monitoring transect may also be deployed further downgradient from a separate FRT pattern for cross-validation pending results of the hydrogeological review. This requirement will be determined within 90 days of the TARP being triggered.
- Increased Monitoring Frequency: Monitoring frequency will be increased to monthly intervals for wells that have triggered TARP 7, to improve early detection of plume migration and ensure timely response
- Plume Acceleration Measures: Controlled groundwater extraction may be initiated to create an artificial gradient and accelerate plume migration, allowing for earlier detection.
- Governance & Reporting: A TARP 7 trigger register (per well) will be maintained with dates, criteria met, actions and close-out; and summarised in the Environment and Radiation quarterly reports.

TARP 8: No Field Verification Results – 18 Months Post FRT

This TARP addresses the continued absence of lixiviant or plume indicators in downgradient NA monitoring wells 18 months after ISR operations have ceased. This includes results showing elevated concentrations of Uranium and Sulphate (or decreased pH) compared to native groundwater but not enough to indicate monitoring of the main plume, as determined in TARP 7. This TARP initiates formal regulatory notification and site-specific reassessment, including trialling accelerated attenuation measures. It serves as a final staging point before escalation to active remediation under TARP 9 if plume verification remains unresolved.

Trigger Criteria:

Continued absence of lixiviant detection or insufficient concentrations as determined by TARP 7 in down-gradient NA monitoring wells 18 months post-FRT.

Response Actions:

Step 1: Immediate Regulatory Notification & Risk Assessment

- Government Notification: Initial leading indicator reporting to DEM within 24 hours of identification to regulatory authorities indicating extended verification delays.
- Plume Migration Analysis: A comprehensive review of:
    - Groundwater velocity and hydrogeological transport mechanisms.
    - Potential geochemical interactions affecting lixiviant mobility.
    - Revised NA modelling predictions using updated site data.

Step 2: Risk Assessment

- Plume Migration Analysis: A comprehensive review of:
    - Groundwater velocity and hydrogeological transport mechanisms.
    - Potential geochemical interactions affecting lixiviant mobility.
    - Revised NA modelling predictions using updated site data.

Step 3: Regulatory Reporting

- Following the risk assessment and within 1 month after the leading indicator is triggered, a detailed assessment report summarising findings, and proposed accelerated natural attenuation actions will be submitted to DEM.

Step 4: Trialling Accelerated Natural Attenuation

- Controlled Groundwater Extraction: A targeted pumping strategy will be trialled to create an artificial groundwater gradient, pulling the residual mining plume further than it would naturally in the same timeframe.
- Plume Movement Verification: Groundwater sampling data will be continuously assessed to determine if extraction successfully enhances lixiviant transport.

Step 5: Final Decision Point – Active Remediation Trigger

- If field monitoring continues to show no plume contact within six additional months, active remediation measures will be enacted under TARP No. 9 (Active Remediation).
- Final Corrective Action Plan (CAP) – If required, a formal CAP will be developed detailing remediation strategies, long-term monitoring adjustments, and additional site interventions.

TARP 9: Credible Risk of Exceeding Modelled FRT Impacts – Active Groundwater Remediation

In the event earlier contingency actions fail, and/or that the NA rates and maximum distances associated with the NA model cannot be met, the Active Groundwater Remediation Plan will be prepared and activated to ensure the 'measurement criteria' can be achieved.

Trigger Criteria:

Active remediation measures will be initiated if any of the following conditions are met:

- The re-run of the NA model performed during Phase I or II of the assessment program predicts a credible risk of exceeding NA extents (Figure 5.2) or maximum/minimum values (Table 7.8, Table 7.9 & Table 7.10).
- Field monitoring data shows no plume contact within six months after implementing corrective actions under TARP 8 (i.e., 24 months post conclusion of the FRT).
- The NA Model Assessment Report (conducted 24–28 months post-FRT) identifies either of the following:
    - Lack of, or insufficient field data to verify NA.

Response Actions:

Step 1: Regulatory Notification & Reporting:

- Initial notification within 24 hours of the leading indicator trigger.
- Formal reporting submitted within one month of trigger confirmation.

Step 2: Causal Analysis & Root Cause Assessment:

- Conduct a detailed hydrogeochemical and or field monitoring review to identify underlying reasons for model failure.
- Define physical and chemical parameters contributing to deviations.

Step 3: Model Adjustment & Rerun:

- Adjust model parameters (e.g. pH, Fe, SO_4^{2-}) to align with groundwater outcome measurement criteria.
- Conduct conservative scenario modelling to evaluate remediation effectiveness.

- Set the required changes to groundwater chemistry to conservatively align with outcome criteria's NA rates and maximum distances and measures to monitor and verify compliance.

Step 4: Development of an Active Groundwater Remediation Plan:

- If the model rerun confirms a credible risk of exceeding groundwater outcome limits, a formal Active Groundwater Remediation Plan will be developed.
- This plan will define the required adjustments of groundwater chemistry required to conservatively align with outcome criteria's NA rates and maximum distances (defined in Step 3).
- This plan will then detail how this will be achieved, with dilution being identified as the preferred remediation approach, due to its:
  - Effectiveness in reducing uranium, sulphate, and acidity concentrations.
  - Proven success in South Australian mine closure programs (e.g., Angas Zinc Mine (Terramin, 2017 & Terramin, 2018).
  - Minimal environmental impact, ensuring a net-zero water balance without secondary waste generation.
- This plan will be provided to regulatory agencies for formal review.

Step 5: Implementation of Active Remediation Measures:

- This will involve circulation of residual mining plume through existing FRT infrastructure and diluting with native groundwater or RO water until target concentrations defined in Step 3 are met.
- The residual plume would be pumped from the wellfield pattern to tanks in the plant where dilution will occur either in batches or as a continuous stream, then re-injected into the wellfield patten.
- Raw groundwater would be sourced from the same water supply wells utilised during the FRT operations.
- Monitoring of key parameters will occur at least daily to ensure dilution is working and the decrease in concentration (or increase in pH) can be shown over time.
- Circulation will continue until concentrations of the target parameters are demonstrated to be at or below the target value for 3 pore volume exchanges without additional dilution.
- Each FRT pattern will be completed in turn, with the first being the NA monitored pattern so validation monitoring can be initiated while the other 2 patterns are being remediated.

Step 6: Monitoring & Validation:

- Conduct monthly verification sampling during active remediation and comparison to the target concentrations and distanced defined in Step 3.
- Implement an accelerated NA monitoring transect for six months post-remediation.
- Update NA model assessment report based on treated groundwater data.

Step 7: Final Compliance Review:

- Complete an updated NA model assessment report.
- Confirmation that attenuation rates and plume extent align with closure criteria.

Timing of Actions

The timing of TARP responses is summarised in Table 7.14 ensuring alignment with the groundwater closure strategy.

Table 7.14: TARP – Action Timing

No.	Action	Timing
1	Regulatory notification (leading indicator trigger)	Within 24 hours of event
2	Root cause assessment	Within 1 month of trigger event
3	Model adjustments and rerun	Within 2 months of trigger event
4	Final remediation plan development	Within 2 months of active remediation being triggered
5	Active groundwater remediation initiation	Within 3 months of active remediation being triggered
6	Verification monitoring (remediation phase)	Weekly sampling during remediation.
7	Post-remediation monitoring & model assessment	Monthly monitoring for six months
8	Final validation	3 months post-remediation monitoring

7.3.8 Outcome Measurement Criteria & Leading Indicator Criteria

This section defines the outcome measurement criteria, which serve as the performance benchmarks used to demonstrate compliance with the groundwater outcomes outlined in Section 7.3.3.

Additionally, this section summarises the monitoring and verification requirements necessary to assess compliance, as detailed in Section 7.3.4 (Operations) and c Section 7.3.5 (Closure). These requirements establish the monitoring locations, frequencies, analytical parameters, and verification methodologies that ensure groundwater protection measures remain effective throughout operations and post-closure. This program is provided in Table 7.15.

Where applicable, Leading Indicator Criteria have been incorporated to provide early warning signals, allowing proactive responses before regulatory exceedances occur.

Table 7.15: Outcomes, Outcome Criteria, & Leading Indicators – Groundwater

Outcome	What will be Measured & Form	Locations	Frequency & Duration	Responsibility & Records	Control or Baseline Data	Outcome Achievement	Leading Indicator(s)
Target Aquifer - Operations: No adverse change, outside of natural background variation, to the water quality of the target aquifer outside of the Land.	Water quality in perimeter monitor wells is sampled using low flow or discrete interval sampling techniques and analysed for pH, SO_4 and U. Water quality of liquid disposal monitor wells will be sampled using low flow or discrete interval sampling techniques and analysed for pH, SO_4 and U.	Table 7.3, Figure 7.4 & Figure 7.5.	Monthly during operations. Monthly during disposal activities.	Senior Hydrogeologist Water quality records are stored in the Alligator Energy Environmental Database.	Appendix E.	FRT-impacted groundwater remains within the RL, verified by no ECL exceedance at perimeter monitoring wells. ECL limits are: • pH: ≤ 5.8 • Sulphate: ≥ 5,845 mg/L • Uranium ≥ 0.56 mg/L	• ≥2 results for U or SO_4 exceed 2 SD above the mean of that well's dataset, and/or • ≥2 pH results falling 2 SD below the mean of that well's dataset
Target Aquifer - Closure: No adverse change, outside of natural background variation, to the pre-mining water quality of the target aquifer outside of the area specifically defined in the map and coordinates specified in the RL Third Schedule.	Water quality within the FRT zone and downgradient of the FRT Zone (natural attenuation monitoring wells) is sampled using low flow or discrete interval sampling techniques and analysed for pH, SO_4, U.	Table 7.7 & Figure 7.7.	Quarterly post FRT operations, until sufficient data is collected for NA verification.	Senior Hydrogeologist Water quality records are stored in the Alligator Energy Environmental Database.	Appendix F, Table 7.8, Table 7.9 & Table 7.10.	A 'Natural Attenuation Model Assessment report' assessing field data against the NA model predictions confirms: • No reduction in natural attenuation rates as defined in Table 7.8, Table 7.9 & Table 7.10, or • No increase in extent of the natural attenuation zone (Figure 5.2). Thereby demonstrating that there will be no change to the water quality of the target aquifer outside the RL.	Key natural attenuation model inputs exceed the sensitivity trigger limits (Table 7.6) Natural attenuation field monitoring results exceed modelled predictive concentrations for 2 consecutive sampling events (Table 7.8, Table 7.9 & Table 7.10) for SO_4, U or minimum concentration for pH. Down gradient natural attenuation monitoring wells make no contact with the lixiviant within 18 months from conclusion of the FRT.

Outcome	What will be Measured & Form	Locations	Frequency & Duration	Responsibility & Records	Control or Baseline Data	Outcome Achievement	Leading Indicator(s)
							Preliminary model assessment failure 24-28 months post FRT operation, or insufficient data available to validate NA
Underlying Aquifer - Operations: No adverse change, outside of natural background variation, to the water quality of the underlying aquifer.	Water quality within the underlying Fractured Rock Aquifer is sampled using low flow or grab sampling techniques. Laboratory analysis: pH, SO_4 and U.	Table 7.5 & Figure 7.6.	Monthly during active FRT activities.	Senior Hydrogeologist Water quality records are stored in the Alligator Energy Environmental Database.	Appendix E.	Groundwater quality for pH, SO_4 and U is maintained within 2 SDs of the mean of baseline ranges for the Fractured Rock Aquifer.	≥2 results for U or SO_4 exceed 2 SD above the mean, and/or ≥2 pH results fall 2 SD below the mean for that well.
Underlying Aquifer - Closure: No adverse change, outside of natural background variation, to the pre-mining water quality of the underlying aquifer.	Water quality within the underlying Fractured Rock Aquifer is sampled using low flow or grab sampling techniques. Quarterly analysis: pH, SO_4 and U.	Table 7.11 & Figure 7.6.	Quarterly for two years post FRT operations.	Senior Hydrogeologist Water quality records are stored in the Alligator Energy Environmental Database.	Appendix E.	Groundwater quality for pH, SO_4 and U is maintained within 2 SDs of the mean of baseline ranges for the Fractured Rock Aquifer.	N/A

7.4 Surface Water

7.4.1 Context

Within the RL area, Coronation Dam is the sole permanent surface water feature (see Figure 4.1). It is used for stock watering within the Moonabie Perpetual Crown Lease and is supported by landholder-constructed drainage channels that divert surface water to the dam. No other permanent surface water bodies exist in the RL vicinity, although there are remnants of one historic abandoned older dam that no longer retains water (URS, 2010).

To ensure continued stock access, and multiple land use approach, for the landholder, Coronation Dam has been excised from the Field Recovery Trial (FRT) operational area using sheep-proof fencing. Additionally, earthen berms will be repaired or constructed around FRT project infrastructure to ameliorate surface water drainage reporting to the FRT process plant and ensure surface water continues to drain into the dam.

Several artificial watering points, including Yarringa Dam and House Dam at Nonowie Station; Boundies Dam, House Dam and Beach Dam at Mullaquana Station, are all located well outside the RL area and beyond its potential drainage catchment (see Table 2.5).

A baseline hydrological assessment (URS, 2010) identified no significant drainage systems within the RL area. The RL lies within two minor, unnamed drainage catchments (A4 and A5), where hydrological modelling indicates no stream flows under typical rainfall conditions. Deep Creek, the only significant drainage system in the broader area, is located 4.4 km south of the RL area and is outside its catchment boundary.

The RL area features a flat slope of approximately 0.5%, resulting in slow and shallow sheet flows during extreme rainfall events. Runoff from these events is unlikely to significantly affect downstream catchments, as the RL area lies at the easternmost boundary of all relevant catchments. Minor impacts from catchment A5 are anticipated under extreme conditions.

Baseline assessments indicate that Coronation Dam and surrounding pastoral dams exhibit consistent water quality, suitable for current pastoral use. Further details on water quality monitoring and results are provided in Section 2.7 and Appendix I.

7.4.2 Potential Impacts

The potential impacts to surface water quality from the FRT operations have been assessed in the Samphire RL Proposal document (Alligator Energy, 2023b).

The primary potential impact associated with the FRT, with identified source-pathway-receptor linkages, is:

- Contamination of surface water bodies and or pastoral dams, which may affect natural water quality and potential uses. This contamination could result from:
    - Runoff carrying sediments, chemicals, or waste materials due to land disturbance and operational activities.
    - Accidental spills or leaks of process fluids, reagents, or hydrocarbons, leading to direct pollution of nearby water bodies.
    - Improper management of wastewater from the site, potentially introducing contaminants into natural drainage systems.

- Erosion and sediment transport from cleared or disturbed areas, increasing turbidity and altering surface water chemistry.

7.4.3 Regulatory Outcomes & Compliance Conditions

The Fourth Schedule – Environmental Outcomes and Conditions of the RL (Appendix A) establishes the surface water-related regulatory requirements that Alligator Energy must achieve and sustain during operations and closure. These requirements include environmental outcomes, management conditions, and compliance criteria to ensure surface water protection.

The conditions set out in this schedule define the necessary environmental performance standards and management strategies that must be implemented to prevent adverse impacts on surface water quality both on and off the RL throughout the project lifecycle.

Surface Water Outcomes

- The Tenement Holder must, during construction, operation and post completion, ensure that there is no adverse impact to the quality of surface water caused by field recovery trial activities.

7.4.4 Control, Management & Monitoring Activities

Effective surface water management throughout the FRT lifecycle will be achieved through spill prevention, containment, monitoring, and verification measures. These strategies ensure compliance with regulatory requirements and the protection of Coronation Dam.

Construction Phase Controls

Spill Prevention & Containment

- All pipework and vessels will be constructed to industry best practices, pressure-tested before use (Section 4.2.3), and bunded in compliance with EPA SA liquid storage guidelines (EPA 2016). Pipework related to water bore drilling &, construction and water truck dust suppression does not need to be pressure tested but inspected as part of daily pre-starts.
- Diversion structures (e.g., earthen berms, bunds, and low-flow channels) or raised pads (≥50 cm high) will prevent sheet-flow flooding around infrastructure.
- Existing pastoral water diversion drains and banks upslope of the FRT area will be maintained and upgraded where necessary to prevent unintended runoff into operational areas.
- Drip trays, leak detection probes, flow meters, and level alarms will be installed at ISR infrastructure to provide early detection of leaks.
- Spill containment features, such as bunds, drip trays, and spill kits, will be installed around wells, wellhouses, filter skids, and tanks to prevent uncontrolled discharges.
- Earthen berms enclosing wellfield areas will confine any potential spills and prevent off-site migration of contaminants.

FRT Operations Controls

Process Control & Monitoring

- Automated fluid monitoring systems will be in place to promptly detect leaks or anomalies in fluid levels and pressures.
- Continuous tracking of process fluids will ensure early identification of potential breaches.

Preventative Inspections & Immediate Response

- Regular on-ground inspections and maintenance checks will monitor the condition of instrumentation, infrastructure, and containment systems.
- Small leaks or issues will trigger immediate repair protocols to prevent escalation.

Spill Management Protocol

- A site-specific Spill Management Plan will be implemented, detailing reporting, investigation, and remediation procedures.
- Contamination assessments will be conducted as required, with all follow-up actions documented and tracked.

Closure & Rehabilitation

Infrastructure Removal & Site Remediation

- All FRT infrastructure will be dismantled, and site surfaces will be regraded to their original contours.
- Any residual contamination will be excavated and disposed of off-site.

Independent Contamination Assessment

- A third-party assessment will confirm that no residual contamination remains, ensuring the safe return of land to pastoral use.

Monitoring & Verification Programs

Baseline Water Quality Monitoring

Baseline water quality sampling at Coronation Dam has been conducted under previous hydrological and radiological assessments (Appendix I & M), including physical, chemical, and radionuclide analyses. Baseline sampling has been used to define existing water quality data and background radionuclide concentrations.

Post-Decommissioning Water Quality Monitoring

The broader drainage network extends beyond the project area, meaning pastoral activities and future land uses could influence water quality. Post-decommissioning monitoring will focus exclusively on radionuclides, as these are the primary indicators of potential project-related contamination.

Post-decommissioning samples will then be compared against existing baseline data (Appendix I) to demonstrate Coronation Dam remains unaffected by project activities.

Routine Site Inspections

Regular inspections of drainage infrastructure (berms, bunds, and stormwater channels) will ensure they remain effective in managing runoff and preventing drainage into Coronation Dam.

- Post-rainfall inspections will assess system performance, with repairs or enhancements conducted as required.
- Hydrological observations will be used to validate runoff models and guide adaptive management.
- Routine inspections of pipelines, chemical storage areas, and bunded zones will ensure structural integrity and identify potential spill risks.
- All spill incidents will be logged in the incident management system, detailing:
    - Location and extent

- Remediation actions taken
- Verification that cleanup was effective

Uncertainties, Assumptions & Future Works

The control strategies presented above have been assessed to determine whether any significant uncertainties exist regarding their effectiveness, including the sensitivity of these uncertainties and whether additional future works would be required to address them.

While the nominated control strategies are considered robust and adequately validated based on site conditions and available data, one key uncertainty relates to potential external influences on surface water quality at Coronation Dam. The broader drainage catchment extends beyond the project area and includes pastoral activities and potential future land uses, which may contribute to natural variations in water quality independent of project activities.

To address this, post-decommissioning monitoring will focus on radionuclide levels, as these serve as key indicators of potential project-related impacts.

7.4.5 Outcome Measurement Criteria & Leading Indicator Criteria

This section defines the Outcome Measurement Criteria for surface water quality, ensuring compliance with the Surface Water Outcomes in Section 7.4.3. These criteria establish how surface water protection measures will be assessed throughout operations and post-closure.

Monitoring and verification requirements, detailed in Section 7.4.4, include sampling locations, frequencies, analytical parameters, and verification methods to track surface water quality and hydrological stability. A detailed breakdown of outcome criteria, measurement methods, and compliance verification is provided in Table 7.16.

While some environmental aspects rely on leading indicators for early warning, surface water contamination risks are best assessed through periodic sampling and laboratory analysis. Radionuclide concentrations serve as the primary indicator of potential contamination, with post-closure monitoring comparing results against baseline conditions to confirm water quality remains within natural background variability.

Hydrological controls such as drainage diversions, earthen berms, and bunding are designed to prevent surface water impacts. Their effectiveness is verified through regular inspections and water quality monitoring rather than real-time indicators. This risk-based approach aligns with regulatory requirements and ensures long-term surface water protection.

Table 7.16: Outcomes, Measurement & Leading Indicator Criteria – Surface Water

Outcome	What will be Measured & Form	Locations	Frequency & Duration	Responsibly & Records	Control or Baseline Data	Outcome Achievement	Leading Indicator
Surface Water: No adverse impact to the quality of surface water caused by field recovery trial activities, during construction, operation or post remediation phases.	Grab water samples from Coronation Dam, analysed for radionuclides. Analytical Methods: • Gamma-ray spectroscopy: U-238/Th-234, Th-230, Ra-226, Pb-210, Po-210, Th-232, Ra-228.	Coronation Dam (Appendix I).	1 x on completion of FRT construction. 1 x completion of operation. 1 x post completion of remediation.	Environmental Manager Water quality records are stored in the Alligator Energy Environmental Database.	Baseline samples - Appendix I.	Surface water sampling at Coronation Dam demonstrates that radionuclide concentrations remain within baseline ranges.	N/A
Note: For additional considerations and potential interactions affecting surface water quality, refer to Section 7.2: Soils and Section 7.10: Air Quality							

7.5 Vegetation, Weeds and Plant Pathogens

7.5.1 Context

Vegetation within the RL and surrounding area is primarily dominated by *Maireana sedifolia* (Pearl Bluebush), *Maireana pyramidata* (Black Bluebush), and *Atriplex vesicaria* (Bladder Saltbush), forming a low open shrubland vegetation association. A smaller area of *Acacia papyrocarpa* (Western Myall), *Myoporum platycarpum*, and *Alectryon oleifolius* (Bullock Bush) open woodland is also present, comprising approximately 9% of the RL area. Vegetation across the RL has been significantly modified by over a century of pastoral activities, including grazing, wood harvesting, and historic impacts from invasive species such as rabbits. As a result, the vegetation structure and density are altered, with a baseline assessment classifying the vegetation condition as "moderate" (Section 2.8).

Six surveys conducted between 2009 and 2023 identified a total of 111 flora species within the broader survey area, of which 97 are native and 14 are exotic. Within the RL, 44 native flora species have been recorded, consistent with the two primary vegetation associations (Table 2.3). Surveys found no evidence of threatened flora species or sensitive vegetation communities in the RL area, and vegetation clearance associated with the project is classified as low risk under the Native Vegetation Act 1991.

Project Activities

Activities within the RL will require small-scale vegetation clearance. The maximum clearance area has been divided into three distinct clearance categories:

1. FRT Project Clearance - 5.125 ha

   This clearance is for the core infrastructure required to support the FRT, including:
   - FRT plant area
   - Wells
   - Pipelines
   - Track upgrades and road widening to facilitate truck access
   - Water storage pond.

   This area is shown in Figure 7.8 and includes a 10 m Contingency Zone to allow micrositing of infrastructure. Any use of the Contingency Zone will be reconciled within the 7.125 ha new-clearance cap; no net increase will occur without prior approval.

2. Resource Infill Drilling Clearance Areas - 2.0 ha

   This clearance is for exploration activities conducted within the RL, including drill pads and tracks planned for a total of 125 exploration holes to further delineate the orebody.

   The total area that may be subject to resource infill drilling is shown in Figure 7.9, however is just a maximum of 2 ha.

3. Historic Exploration Lease Clearance - 7.633 ha

   This historical clearance has been undertaken for exploration drill pads, tracks, laydown areas and fencing installations. This clearance has been undertaken during previous exploration activities from 2021-2025, and is subsumed into the RL137 SEB area, as per Mining Act 1971, sect 10A, clause 2.3. This area is shown in Figure 7.10.

The maximum cumulative clearance accounted for SEB is 14.758 ha, comprising 7.125 ha of new clearance sought under this PEPR and 7.633 ha of historical exploration clearance (pre-2025) included for SEB accounting only. A breakdown between new clearance and historic clearance is provided in Table 7.17.

Table 7.17: Native Vegetation - Maximum Clearance Area

Clearance Type	Area	Figure Reference	Clearance Size (Ha)
New (this PEPR)	FRT Clearance Areas	Figure 7.8	5.125
	Resource Infill Drilling Areas	Figure 7.9	2.000
Historic (SEB accounting only)	Historical Exploration Lease Clearance (prior to 2025)	Figure 7.10	7.633
Totals	**New clearance sought**		**7.125**
	Cumulative area considered for SEB		**14.758**

The area has been assessed as low risk under the *Native Vegetation Act*, and only one vegetation association will be cleared within this area: *Maireana sedifolia* (Bluebush) / *Maireana pyramidata* (Black Bluebush) / *Atriplex vesicaria* (Bladder Saltbush).

7.5.2 Potential Impacts

The potential impacts to native vegetation from the FRT operations have been assessed in the Samphire RL Proposal document (Alligator Energy, 2023b).

The key potential impacts associated with the development and implementation of the FRT, with identified source-pathway-receptor linkages, are:

- Reduction in native flora species abundance within the RL due to land disturbance, vegetation clearance, dust deposition, and changes to soil and hydrological conditions.
- Introduction of new weed species or plant pathogens within the RL, facilitated by vehicle and equipment movement, soil disturbance, and water flow.
- Increased density and distribution of declared weed species (under the Landscape South Australia Act 2019) within the RL.
- Long-term reduction in conditions favourable for revegetation, caused by soil degradation, loss of seed banks, hydrological alterations, or contamination, potentially hindering rehabilitation success.

7.5.3 Regulatory Outcomes & Compliance Conditions

The Fourth Schedule – Environmental Outcomes and Conditions of RL137 (Appendix A) establishes the regulatory requirements for native vegetation and weed management that Alligator Energy must achieve and maintain throughout construction, operation, and closure. These requirements ensure the protection of native vegetation, the minimisation of disturbance impacts, and the prevention of weed and pest proliferation within and beyond the RL area.

The conditions outlined in this schedule define the environmental performance standards and management strategies necessary to prevent the loss of native vegetation abundance and diversity due to project activities, minimise indirect impacts such as dust deposition, soil degradation, and fire risk, and ensure rehabilitation success in alignment with long-term land use objectives. Additionally, they set clear obligations to prevent the introduction or spread of weeds, plant pathogens, and pest species within the RL area

Native Vegetation Outcome

- The Tenement Holder must during construction and operation ensure there is no loss of abundance and/or diversity of native vegetation on or off the Land through:
  - Clearance.
  - Dust/contaminant deposition.
  - Soil erosion/soil compaction.
  - Fire.
  - Other damage.

  Unless a significant environmental benefit (SEB) has been approved in accordance with the relevant legislation.

Weed Outcome

- The Tenement Holder must, during construction and operation, ensure no introduction of new species of environmental weed, plant pathogens or pests (including feral animals), nor sustained increase in abundance of existing weed or pest species on the RL.

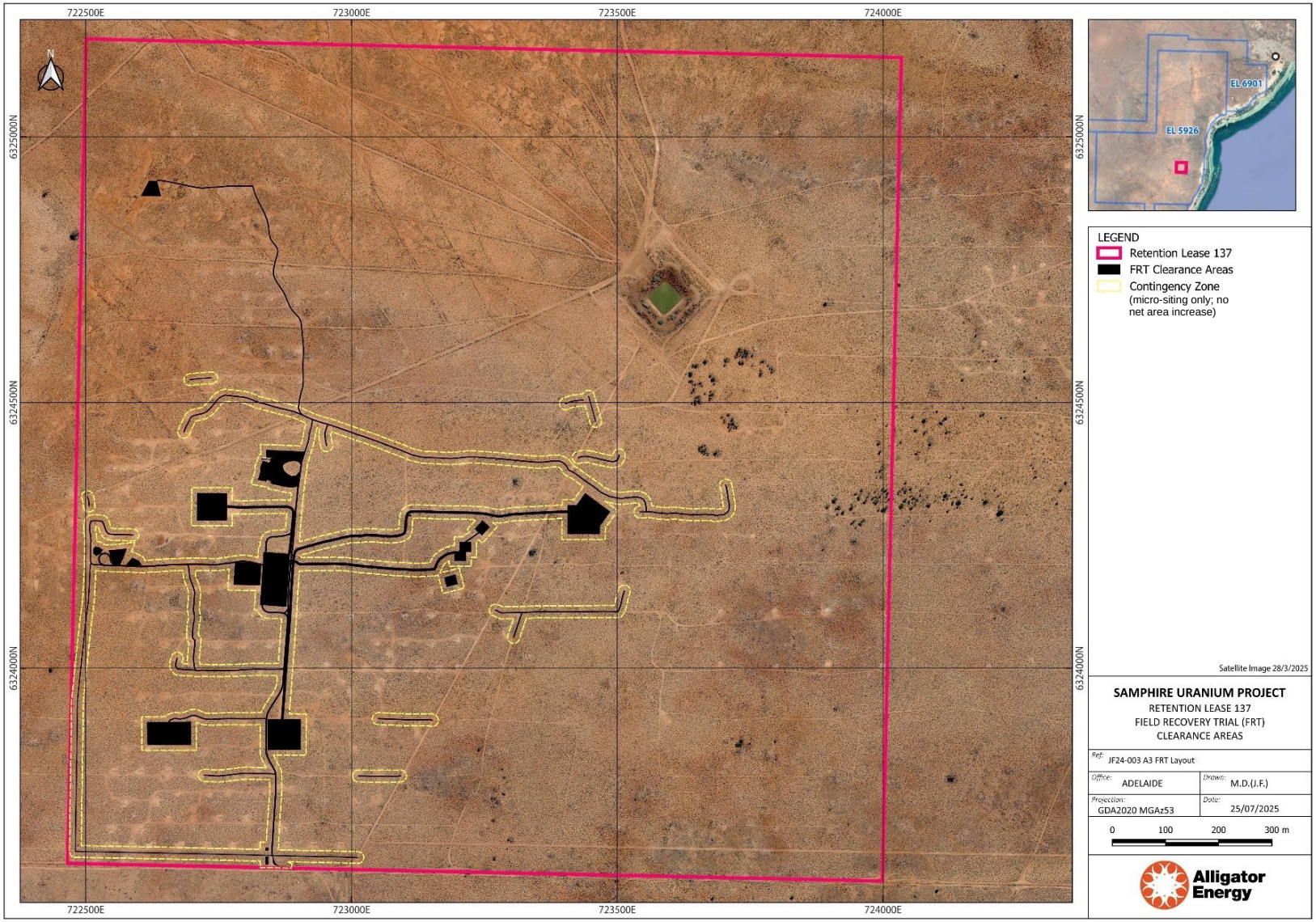


Figure 7.8: FRT Clearance Areas and 10 m Contingency Zones

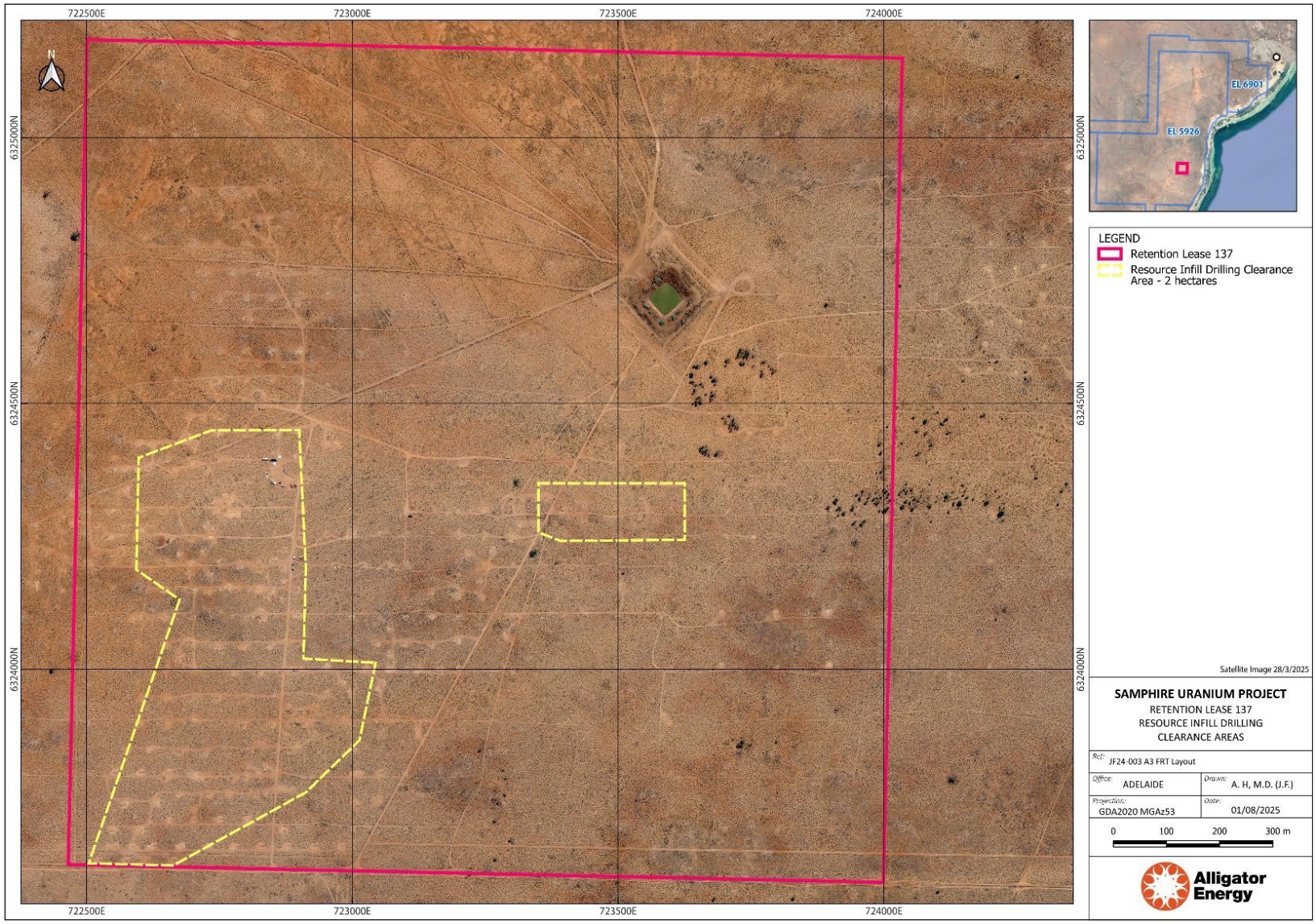


Figure 7.9: Resource Infill Drilling Clearance Areas – 2.0 ha maximum

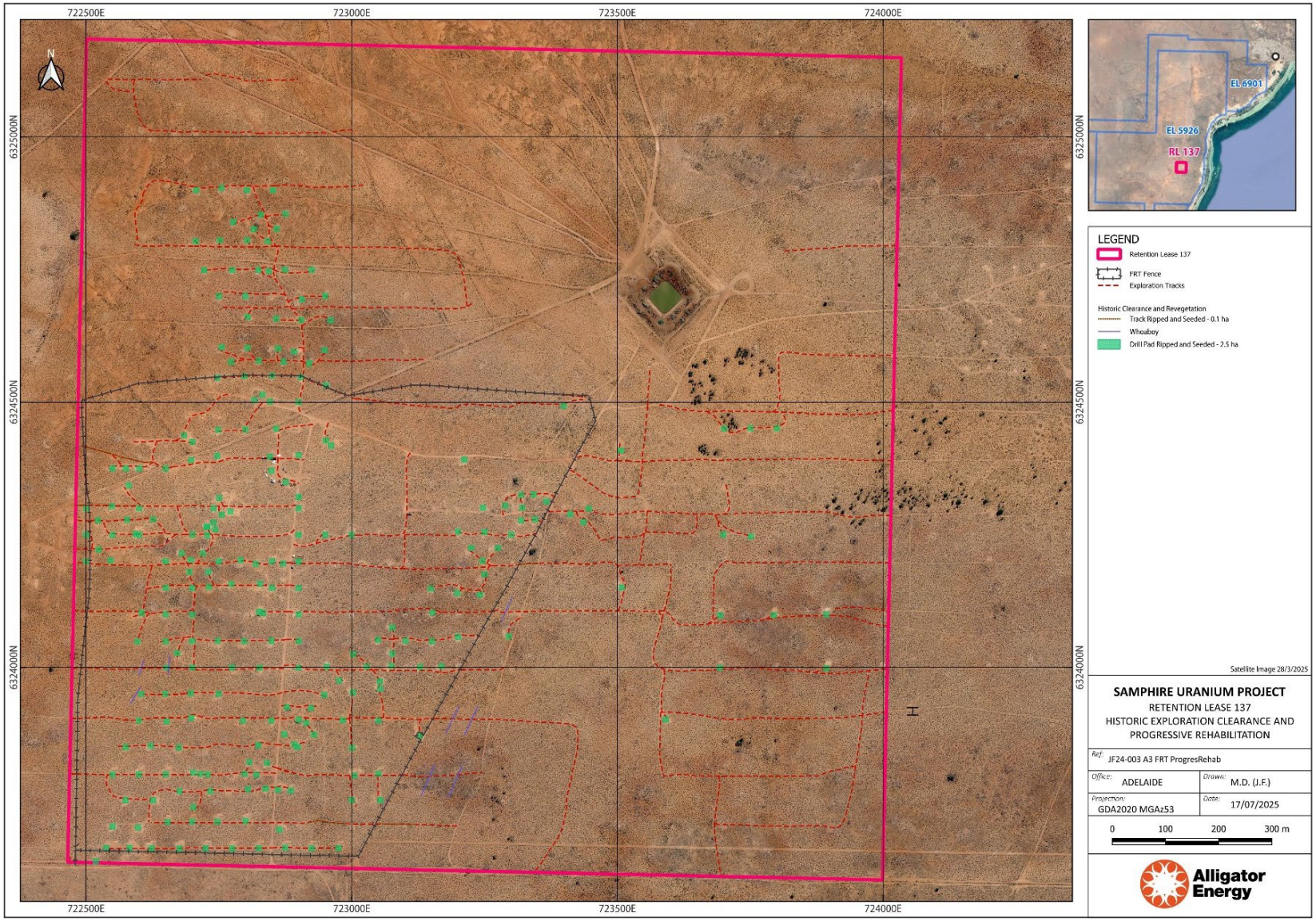


Figure 7.10: Historical Exploration Vegetation Clearance 2021-2025

7.5.4 Control, Management & Monitoring Activities

To ensure compliance with the Native Vegetation Act 1991, Mining Act 1971, and associated guidelines, Alligator Energy has developed a comprehensive vegetation management strategy to mitigate the potential impacts identified in Section 7.5.2.

The Samphire Native Vegetation Management Plan (NVMP) (Appendix L) provides the framework for managing vegetation clearance within the RL, ensuring that native vegetation is protected, disturbance is minimised, and rehabilitation aligns with regulatory and environmental best practices.

This section outlines the key measures within the NVMP, including pre-disturbance assessments, impact mitigation strategies, rehabilitation measures, offset requirements, offset requirements for previous exploration clearing in the RL area and long-term monitoring programs. The full NVMP is provided in Appendix L.

Native Vegetation Protection & Compliance Framework

The NVMP ensures that vegetation clearance activities comply with regulatory obligations and support Alligator Energy's environmental commitments. It outlines avoidance, mitigation, rehabilitation, and offset measures to ensure regulatory compliance.

Key features of the NVMP include:

- Baseline Vegetation Assessments: Comprehensive surveys conducted to classify vegetation associations and their ecological condition against a standard methodology.
- Mitigation Hierarchy Implementation: Avoidance, minimisation, rehabilitation, and offsetting strategies to address vegetation clearance impacts.
- Significant Environmental Benefit (SEB) Management: Meeting SEB obligations through revegetation efforts or contributions to the Native Vegetation Fund.
- Monitoring and Reporting: Structured mechanisms to demonstrate compliance, track rehabilitation progress, and inform adaptive management.

Native Vegetation Assessments

In 2023, EBS Ecology conducted a vegetation assessment, for the proposed native vegetation clearance in accordance with the Native Vegetation Council (NVC) guidelines (EBS Ecology, 2023, in Appendix L). The assessment is a structured ecological survey method developed by the Native Vegetation Council (NVC) to evaluate vegetation condition, biodiversity value, and landscape function in arid and semi-arid regions (DEW, 2020). This assessment provides a scientific basis for determining SEB offset requirements.

A total of nine survey sites were established within the Moonabie Pastoral property (Coronation Dam Paddock) during the survey to represent the range of vegetation communities affected by the proposed clearance. Surveys were conducted following NVC protocols to ensure scientifically valid data collection. The assessment evaluated vegetation condition, biodiversity significance, and disturbance levels. The full assessment report and associated scoresheets are provided in Appendix L.

NVMP Mitigation Measures

The mitigation hierarchy is the primary framework applied to manage vegetation clearance impacts in RL137 and is detailed in full in the NVMP (Appendix L). This approach systematically addresses impacts by prioritising avoidance, minimising unavoidable

impacts, rehabilitating disturbed areas, and offsetting residual impacts. This strategy ensures compliance with the Native Vegetation Act 1991 and aligns with the project's objective to achieve measurable environmental benefits.

Avoidance Measures

Key methods employed to avoid the clearance of native vegetation during operational actives within the Samphire RL include:

- Use of existing pastoral infrastructure where possible, e.g., pastoral roads (site access road) and pastoral tracks.
- Careful site selection and infrastructure placement and design. (ensuring ecologically and culturally significant vegetation are avoided).
- Ensuring all proposed clearance areas are reviewed through a formal process and assessed by the Environment Manager to determine if they are necessary.

In addition, a cultural heritage clearance, conducted in 2021 by Elders from the Barngarla Determination Aboriginal Corporation (BDAC), emphasised the importance of minimising impacts on mature vegetation within the project area. Specific species identified for protection include:

- Black Oak (*Casuarina pauper*),
- Mallee (various Eucalyptus species),
- Mulga (*Acacia aneura*),
- Sandalwood (*Santalum spicatum*),
- Wild Peach (Quandong) (*Santalum acuminatum*),
- Myall (*Acacia papyrocarpa*), and
- Bush Medicine, Emu bush (*Eremophila alternifolia*).

Minimisation Measures

Minimisation strategies focus on reducing the extent and intensity of unavoidable disturbances, and include:

- Infrastructure Design and Operational Refinement:
  - Trial works infrastructure is designed to be modular and minimal impact, resulting in a modest construction footprint.
- Clearance Controls:
  - Blanket surface clearance of vegetation (surface grading) is avoided except in specific circumstances. Clearance is limited to precise locations for necessary infrastructure (e.g., wellheads and well pattern piping).
  - Where possible surface infrastructure will be lain directly on the ground surface without vegetation clearance (e.g., some reticulation pipework).
  - Vegetation will only be removed and stockpiled where excavation is necessary, otherwise it will be rolled, preserving root structures, minimising soil disruption and preserving organic matter. Experience from on-site exploration rehabilitation activities has demonstrated the effectiveness of these methods, with significant regeneration of local species even in areas of substantial disturbance.
  - Internal policy restricts the clearance of trees or shrubs taller than 1 metre unless specifically authorised by Management.
  - A Landscape and Vegetation Permit is required for any new ground-disturbing activities. Permits ensure that:

- All new vegetation clearance areas are as defined in the NVMP (Appendix L and Figure 7.8 and Figure 7.9)
- Native vegetation clearance amounts are within the limits defined in the NVMP (Appendix G and Table 7.17).
- Internal vegetation clearance permits must be signed off by the Environmental Manager (or delegate) before any ground disturbance occurs.
- Disturbance areas are not excessive for the proposed task/activity.
- Disturbance does not occur in areas with threatened or listed species.

- Designated Tracks & Off-Track Protocols:
  - Strict off-track movement prohibitions will be enforced, with any violations treated as environmental incidents requiring immediate rehabilitation.
  - Additionally, stabilised roads will be provided in high-traffic zones to minimise environmental degradation.
- Stockpile Management & Soil Conservation:
  - Stockpile management is addressed in Section 7.2, focusing on topsoil and subsoil stockpile height limits (1m and 3m, respectively).
  - This section also details the use of hydroseeding for long-term stockpiles and the implementation of routine monitoring to identify weed infestations and erosion risks.
- Dust Suppression Measures:
  - Access tracks within the RL will be watered with potable water and/or dustbinder.
  - Vehicle speeds will be restricted to 20 km/h to minimise dust lift-off.
  - Vegetation cover will be maintained in areas not subject to direct operations to help stabilise soils and prevent airborne dust.
- Fire Management:
  - Fire risk management will be covered separately, ensuring fire protection measures are in place for all project infrastructure.
  - Emergency response protocols will be outlined to mitigate potential bushfire risks within the RL area.
- Traffic Management & Vehicle Hygiene
  - A traffic management plan (Appendix T) is in place to enforce existing track use to minimise soil disturbance and prevent weed spread.
  - Vehicle and equipment hygiene protocols will require cleaning before site entry and exit to prevent contamination from external sources.
- Weed and Pest Management:
  - Ongoing weed and feral animal management, including summer/winter weeds `and rabbit warren surveillance.
  - Vehicle and equipment hygiene will be inspected at entry points to prevent the introduction or spread of invasive species. Declared weeds (under the Landscape South Australia Act 2019) will be promptly managed following the control measures outlined in the NVMP, with records maintained to demonstrate compliance.
  - Integrated pest and weed management principles to prevent introduction of new weed species.

- Collaborative management efforts with local landowners to prevent pest proliferation.
- Environmental staff are all competent in weed identification and control and are qualified to utilise herbicides and the spray rigs owned by Alligator Energy.

- Fencing & Grazing Control
  - Fencing has been erected around the FRT operational area, protecting regenerating vegetation from grazing pressure and ensuring successful post-closure rehabilitation efforts.



Figure 7.11: Examples of Bluebush (*Maireana sedifolia*) regeneration post exploration disturbance.

Rehabilitation and Restoration Measures

Rehabilitation efforts target the restoration of vegetation to pre-disturbance conditions will be undertaken through the following measures:

- Progressive Rehabilitation:
  - Surface rehabilitation and revegetation works will be carried out in areas no longer required for FRT activities on conclusion of the operational phase of the FRT and the exploration revegetation management will continue.
  - However, in the event the project proceeds to full mine approvals and the site is placed in care and maintenance, most of the surface infrastructure (e.g., access tracks, processing areas, and wells) will be retained until full closure occurs. As such broadscale revegetation across the project area is not currently planned and will be restricted to former exploration disturbance areas (see Figure 5.10 and Section 5.5.3).
  - Progressive rehabilitation is therefore focused on areas impacted by exploration activities and other temporary disturbances that are not required for ongoing site access or monitoring.
  - This system has been trialled under approved Exploration PEPR's to date within the immediate and surrounding area and proven successful (Appendix G).

  - When the FRT pipework is not needed, but prior to full closure activities, the pipework will be rehabilitated and revegetation of those pipeline runs undertaken.
- Vegetation and Soil Management:
  - Rolling chenopod bushes where possible for heavy vehicle access preserves topsoil, enabling rapid regrowth from root stock.
  - Reseeding disturbed areas (e.g., drill sumps) using native species like *Maireana sedifolia*, *Maireana pyramidata*, *Lycium australe*, and *Acacia papyrocarpa*.
  - Collect, treat, and store native seeds annually to ensure fresh, viable seeds for revegetation.
  - Installation of erosion management structures, called whoa-boys and ripping and seeding of compacted tracks no longer required.
- Trialled Innovations:
  - Trialled transplanting chenopod bushes from construction areas to rehabilitation sites, rapidly increasing vegetation coverage.
- Collaboration and Risk Mitigation:
  - Assistance will be provided to neighbouring properties with weed control to prevent windborne seed dispersal across boundaries.
- Rehabilitation Priorities:
  - Fencing of woodland vegetation under threat from overgrazing by rabbits, kangaroos, sheep, or goats. Juvenile Acacia's are susceptible and will be a focus, targeting any threatened species outside the RL, but within the same paddock (in partnership with landowners) such as *Allocasuarina verticillata*, *Santalum spicatum*, and *Cratystylis conocephala*.
  - Eradicate weeds in the project area and along the access road corridor, focusing on controlling known infestations and preventing new introductions.
  - Direct seeding will be undertaken as per proven methods for the RL137 site, i.e. directed seeded at a rate of 20kg/ha of local endemic native seed, hydroseeded where possible, use of nitrogen based fertiliser and dustbinder, exclusion of feral grazing pressure, preventative management of soil erosion, and vehicle exclusion from rehabilitated areas. These practices are outlined in the NVMP (Appendix L) and in an Alligator internal Natural Resources Management Plan for the Samphire project.
- Timing of removal of rabbit proof fencing;
  - The removal of fencing can only occur once the outcome criteria for revegetation is met. Landowners will be consulted on the removal, vegetation condition and re-use of any materials. Reporting on the vegetation coverage of the fenceline after removal will be undertaken.
  - Lightweight vehicles will be used to remove the fence, resulting in minimal impact to vegetation, side by side ATV and attached trailer will be used. Fencing wire can be removed by hand, with rolling onto a wire spinner in the 100m manufactured lengths for re-use. Star pickets will be removed using a hand operated picket lifter. Steel strainer posts and gate posts can be removed by a hydraulic lifter.

<u>Offsets:</u>

Based on the 2023 rangeland assessment (EBS Ecology; Appendix L) and the NVC Rangelands SEB Calculator (July 2025), the Significant Environmental Benefit (SEB) requirement for the cumulative area of clearance considered (14.758 ha; comprising 7.125

ha new clearance and 7.633 ha historical exploration disturbance for SEB accounting only) is 623.98 SEB points. SEB will be secured prior to commencement of any new clearing.

SEB will be delivered by one (or a combination) of the following, in order of preference:

- Purchase of SEB credits totalling 623.98 points from an approved provider.
- On-ground offset generating 623.98 points by securing and managing an appropriate offset site, with like-for-like actions documented in an SEB Management Plan approved by the NVC.
- Payment to the Native Vegetation Fund of $67,023.71 (indexed at July 2025[5]); final amount subject to indexation at the date of payment).

Given Alligator Energy do not own or manage land in the area, Alligator Energy will prioritise the purchase of SEB credits as the preferred offset method, if available for the vegetation communities impacted. However, if no appropriate credits can be secured, a direct contribution to the Native Vegetation Fund will be undertaken as an alternative. Further details are provided in Appendix L.

Monitoring Activities

Stockpile Monitoring and Management

As part of the soil monitoring (see Section 7.2), annual inspections of topsoil and subsoil stockpiles will verify compliance with height limits (1 meter for topsoil and 3 meters for subsoil) and assess the condition of stockpiles for erosion, pests, and weeds. Stockpiles will also be monitored to ensure erosion is limited (i.e., are hydro-seeded or vegetated) and maintain soil nutrient health. Issues such as weed infestation or erosion will be addressed promptly through herbicide application, reseeding or contouring as necessary.

Dust Monitoring

As part of air quality monitoring (see Section 7.10), monthly monitoring of deposited dust levels will be conducted during active operational phases (i.e., construction, operations and decommissioning and remediation) using passive dust collectors placed at designated operational and control sites. Data from operational sites will be compared to control sites and baseline data to demonstrate that dust suppression measures, such as increased watering or limiting vehicle movements, are effective.

Fire Management Monitoring

Any fires within the RL will be treated as incidents and will subsequently be documented in detail, including location, cause, and mitigation actions. Precautionary, control and monitoring measures will be put in place to ensure that project activities do not result in unplanned fires and that appropriate prevention measures are in place. Fires associated with pastoral activities within the RL, but outside the FRT area (i.e. camp or comfort fires used during lamb tailing or stock unloading) will not be treated as an incident.

Weed and Pest Surveys

Three control 50 by 50 metre monitoring quadrats and six impact quadrats have been established to provide an ongoing assessment of the effectiveness of the controls defined above. Step point monitoring (100 steps) at each quadrat will be undertaken for weed species recorded occurring prior to 2025 within the paddock to gain knowledge of population changes. Impact and control site data will be compared to determine there is no proportional

[5] Amounts subject to indexation at payment date as per NVC requirements

difference. Additionally, 20-minute active search surveying within each of the nine quadrats for new weed species in this paddock (Coronation Dam paddock) will be undertaken by an experienced environmental professional. Surveying will be undertaken annually.

Alligator Energy's environmental staff are all competent in weed identification and will log any opportunistic observations of declared weeds.

Weed and pest survey data will be reported to the appropriate database for Government access (i.e. the Feralscan web data base, or BDBSA).

Post-Closure Rehabilitation Monitoring

Vegetation will be monitored annually over a three-year period, with drone photography used to assess ground cover and species establishment in cleared areas. Vegetation recovery will be compared to baseline vegetation levels via aerial imagery, percentage cover and species identification.

A report reviewing the vegetation mitigation approach and the success of techniques applied on the Samphire site exploration areas provides confidence in achieving a high standard of revegetation coverage and diversity (Appendix G). Full details on vegetation monitoring and verification program to support closure outcomes is provided in Section 7.5.5.

Data Management and Reporting

Data Management

All monitoring data, including vegetation clearance, weed and pest surveys, dust levels, and fire incidents, will be stored in the Alligator Energy Environmental Database.

Auditing and Reporting

An annual audit will be undertaken to review compliance with vegetation-specific environmental outcomes, as outlined in the NVMP. This process ensures transparency and adherence to commitments under the Native Vegetation Act 1991.

Key components of the audit include:

- Permit Reconciliation: Verifying that issued permits align with actual clearances.
- Field Verification: Conducting physical inspections or aerial imagery reviews to confirm clearance extents.
    - Compliance Checks: Ensuring all vegetation clearance adheres to the following:
    - Granted permits in place prior to disturbance occurring (location and extent).
    - Total cumulative new clearance remains within 7.125 ha; cumulative SEB-accounted area remains at 14.758 ha (Appendix L, Figure 7.8, Figure 7.9 and Table 7.17).

An annual compliance report will be prepared to summarise monitoring data, document corrective actions, and provide evidence compliance with vegetation outcomes. As part of this process, an audit be submitted to DEM and DEW detailing:

- Total vegetation clearance area (ha) during the reporting period.
- Cumulative vegetation clearance from the commencement of the project.
- Updated maps comparing actual clearance areas with approved extents.
- Evidence of sufficient payments to the NVC.
- Rehabilitation progress in areas where vegetation has been cleared.

Uncertainties, Assumptions & Future Works

The control strategies presented above have been assessed to determine whether any significant uncertainties exist regarding their effectiveness, including the sensitivity of any such uncertainties and whether additional future works would be required to address them.

An assessment of the vegetation strategies undertaken during exploration has been undertaken and the results demonstrate the effectiveness of the strategies (Appendix G).

It should be noted that many of the endemic species of chenopods that have been used on site for rehabilitation during exploration activities (2021-2025), have grown, matured and produced seed within two years, so while they are less than 50 cm in height, they are mature and provide good inputs to the native seed bank. This provides confidence in the ability of the revegetation to reach a number of plants per area that is comparable with the monitored vegetation control sites. The species that have shown this ability include *Atriplex holocarpa, nummularia* and *vesicaria; Dissocarpus biflorus var, Enchylaena tomentosa, Maireana georgei* and *Sclereoleana* species. If a rehabilitated site attains the same range of plant number per area as the control sites, then the pastoralism land use values are achieved. A range of chenopod species in one particular area is superior in resilience, biodiversity values and as a sheep grazing system, than for example having a single species stand of Pearl bluebush. The dominance, i.e. greater than 90% of Pearl bluebush is an indication of long-term selective sheep grazing pressure and as a result is not indicative of an optimal grazing system, sheep prefer a mix of bush types, especially Atriplex. Hence having a criteria based on numbers of mature chenopods per area rather than a particular species provides greater grazing system criteria value.

No significant uncertainties, assumptions, or future works have been identified or planned by the proponents undertaking the work on the RL. However, due to the potential future multiple land use, it is possible some vegetation values, particularly by dust entrainment or weed spread, could be impacted by other parties. Additionally, stock may introduce new weed species and other land users and neighbouring parties could introduce weeds inadvertently in immediate adjacent areas to the RL, or within the RL but outside of the FRT fence. All endeavours will be made to work co-operatively to ensure vegetation values are not impacted outside what is approved in the native vegetation management plan.

7.5.5 Outcome Measurement Criteria & Leading Indicator Criteria

This section defines the outcome measurement criteria for vegetation, weeds, and plant pathogen management, ensuring compliance with the native vegetation outcomes and weed and pest outcomes outlined in Section 7.5.3. A detailed breakdown of the outcome criteria, measurement methods, and compliance verification is provided in Table 7.18.

While some environmental aspects, such as air and water quality, rely on leading indicators to provide early warning signals, vegetation management is best assessed through long-term monitoring of vegetation cover, species diversity, and weed presence. However, some leading indicators relating to dust, off track vehicle use, fires or soil stockpile placement are included for completeness.

Table 7.18: Outcomes, Measurement & Leading Indicator Criteria – Vegetation, Weeds & Plant Pathogens

Outcome	What will be Measured & Form	Locations	Frequency & Duration	Responsibility & Records	Control or Baseline Data	Outcome Achievement	Leading Indicator
Native Vegetation: During construction, operation and post completion, ensure that there is no loss of abundance and/or diversity of native vegetation on or off the Land through: • Clearance; • Dust/contaminant deposition; • Soil erosion/soil compaction • Fire; and/or • Other damage; unless a significant environmental benefit (SEB) has been approved in accordance with the relevant legislation.	Location and extent of vegetation clearance from: • Internal clearance permits • Ground-truthing and aerial imagery. Additional monitoring measures: • Passive dust deposition • Stockpile inspections • Fire incident reports • Traffic incidents.	RL area shown in Figure 7.8 & Figure 7.9. Dust monitoring sites (Table 7.24 & Figure 7.15).	Annual clearance reconciliation. Monthly dust monitoring during active phases Annual stockpile inspections Event-based incidents (fire, traffic).	Environmental Manager. Records in Alligator Energy Environmental, Radiation and Safety Databases.	Appendix L (NVMP) & Table 7.17, Figure 7.8 & Figure 7.9. Appendix O – Baseline Dust Deposition Data.	Native vegetation clearance is: • Within the pre-approved buffer area and maximum area (ha) detailed in the NVMP, and • Sufficient SEB is in place prior to clearance occurring.	• Monthly passive dust deposition at any operational site exceeds that site's maximum baseline results for two consecutive periods. • Audits find soil stockpiles are not constructed within size specifications or hydroseeded where they are retained >3 months. • 2 or more reported incidents relating to off-track use during reporting period. • No uncontrolled fires reported during the reporting period caused by project activities.
	Aerial revegetation monitoring. • 10 operational area quadrats - 10m x10m. Assessed by a suitably qualified environmental specialist via aerial imagery.	10 x control sites and 10 x remediated post operational sites (Table 7.19 & Figure 7.12).	Annual assessments until measurement criteria can be demonstrated.	Environmental Manager. Records in Alligator Energy Environmental Database.	10 control sites (Table 7.19 & Figure 7.12).	Survey of 10 revegetation operational area quadrats of native chenopod plant numbers each have 95% or greater numbers when compared to control site quadrats.	Survey of operational sites have evidence of greater individual plant die off when compared to numbers of plant die off at control sites.

Outcome	What will be Measured & Form	Locations	Frequency & Duration	Responsibility & Records	Control or Baseline Data	Outcome Achievement	Leading Indicator
Weed & Pests: During construction and operation, ensure no introduction of new species of environmental weed, plant pathogens or pests (including feral animals), nor sustained increase in abundance of existing weed or pest species on the Land.	Declared weed surveys completed by a suitably qualified environmental professional, assessing a 50 x 50 m quadrant for new weed species at each defined impact and control site. Step point surveying for 100m will assess declared weed species abundance, and distribution and demonstrate reduced weed presence compared to control sites.	6 x FRT operational sites & 3 x control sites (Table 7.19 and Figure 7.12).	Annual until RL relinquishment.	Environmental Manager Vegetation clearance, weed management, survey and revegetation records are stored in the Alligator Energy Environmental Database.	3 x control sites (Table 7.19 & Figure 7.12). Baseline declared weed species – Appendix K.	Survey records confirm: • No newly identified declared[6] weed species at operational sites compared to baseline survey data. • No increase in declared[7] weed species at operational sites compared to control sites for more than two consecutive monitoring periods.	<1 record per year of herbicide applied are kept within the environmental database, indicating weed control is being undertaken.

[6] Under the Landscape South Australia Act 2019.

Table 7.19: Vegetation, Weed & Plant Pathogen Monitoring Locations

ID	Monitoring Type	Control or Impact Site	Location	Coordinates (GDA 2020 MGA 53)	
				Easting	Northing
WM1	Weeds & Revegetation	Control	Outside of FRT fenced area	723492	6324761
WM2	Weeds & Revegetation	Control	Outside of FRT fenced area	722921	6325296
WM3	Weeds & Revegetation	Control	Outside of FRT fenced area	724497	6324878
VegMFRT1	Weeds & Revegetation	Impact	Within FRT fenced area	723243	6324037
VegMFRT2	Weeds & Revegetation	Impact	Within FRT fenced area	723256	6324054
VegMFRT3	Weeds & Revegetation	Impact	Within FRT fenced area	722516	6324473
VegMFRT4	Weeds & Revegetation	Impact	Within FRT fenced area	722519	6323736
VegMFRT5	Weeds & Revegetation	Impact	Within FRT fenced area	722921	6323736
VegMFRT6	Weeds & Revegetation	Impact	Within FRT fenced area	722748	6323679
cBBRM22-039	Revegetation	Impact	Within FRT fenced area	722520	6324290
cBBRM22-050	Revegetation	Impact	Within FRT fenced area	722630	6324300
cBBRM22-066	Revegetation	Impact	Within FRT fenced area	722580	6324350
cBBRM22-068	Revegetation	Impact	Within FRT fenced area	722570	6324350
Veg01	Revegetation	Control	Outside of FRT fenced area	724921	6324997
Veg02	Revegetation	Control	Outside of FRT fenced area	723818	6326477
Veg09	Revegetation	Control	Outside of FRT fenced area	725685	6327170
Veg10	Revegetation	Control	Outside of FRT fenced area	723547	6323821
Veg10A	Revegetation	Control	Outside of FRT fenced area	723543	6323825
Veg 11	Revegetation	Control	Outside of FRT fenced area	721480	6329029
Veg 12	Revegetation	Control	Outside of FRT fenced area	723358	6326524

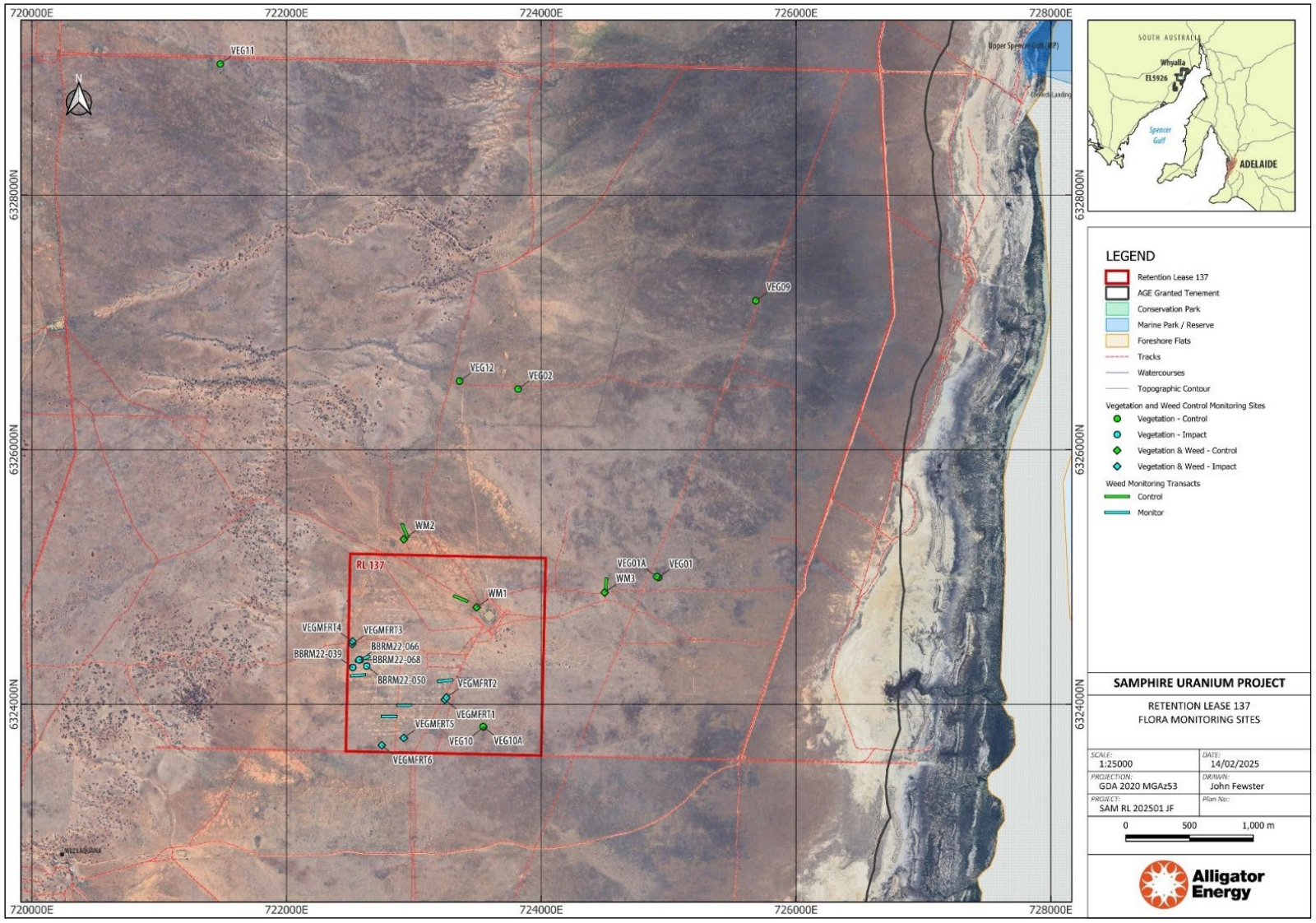


Figure 7.12: Native Vegetation and Weed Monitoring Sites

7.6 Native Fauna & Pests

7.6.1 Context

Several native fauna species have been identified within and near the RL area. The full results of the fauna surveys conducted to date are summarised in Section 2.9 and provided in full in Appendix J.

No mammal, reptile, frog or invertebrate species of conservation significance were observed in the RL during the surveys or are likely to occur in the RL area.

Although not all were identified within RL area, several bird species of conservation significance have been recorded in the local area, including the Slender-billed thornbill (*Acanthiza iredalei iredalei*), Western Grasswren (*Amytornis textilis myall*) and Great Egret (*Ardea alba*), Little Egret (*Egretta garzetta*), Sooty Oystercatcher (*Haematopus fuliginosus*), and the Australian Bustard (*Ardeotis australis*).

Fauna surveys conducted to date have also identified several pest species within the area, namely, the European rabbit (*Oryctolagus cuniculus*), House Mouse (*Mus musculus*), and Red Fox (*Vulpes vulpes*) (see Appendix J). Additionally, Feral Goats (*Capra hircus*) and Feral Cats (*Felis catus*) have been opportunistically observed within the RL area.

The RL is situated within an active pastoral property that is used for livestock grazing. As part of RL works, a fenced operational area will be established to define management boundaries, restrict pastoral grazing and aid operational management. FRT activities will also require vegetation clearance to accommodate essential project infrastructure, including the FRT plant area, well arrays, access tracks, and pipelines. The total clearance area of 14.758 ha is described in detail in Section 7.5.

7.6.2 Potential Impacts

The potential impacts on native fauna from the FRT operations have been assessed in the Samphire RL Proposal document (Alligator Energy, 2023b).

The key potential impacts associated with the development and implementation of the FRT, with identified source-pathway-receptor linkages, are:

- Reduction in native fauna species diversity and abundance, due to habitat disturbance, vegetation clearance, noise, light pollution, increased human activity, and potential contamination of water or soil.
- Increased abundance of introduced pest species, resulting from habitat modification, increased food and water availability, or reduced competition with native species.

7.6.3 Regulatory Outcomes & Compliance Conditions

The Fourth Schedule – Environmental Outcomes and Conditions of RL137 (Appendix A) establishes the regulatory requirements for native fauna protection and pest management that Alligator Energy must meet throughout construction, operation, and closure. These requirements ensure the protection of native wildlife, the minimisation of disturbance impacts on fauna populations, and the prevention of feral animal and pest species proliferation within and beyond the RL area.

Native Fauna Outcome

- The Tenement Holder must ensure there are no native fauna injuries or deaths due to field trial activities that could have been reasonably prevented.

Pest Outcome

- The Tenement Holder must, during construction and operation, ensure no introduction of new species of environmental weed, plant pathogens or pests (including feral animals), nor sustained increase in abundance of existing weed or pest species on the RL.

7.6.4 Control, Management & Monitoring Activities

Alligator Energy has developed a fauna and pest management strategy to mitigate potential project impacts on native wildlife, enhance habitat conditions, and control feral species within the RL operational area. These measures will be implemented across construction, operation, and closure phases to ensure regulatory compliance, minimise environmental disturbance, and contribute to broader biodiversity conservation efforts.

Feral Species Control & Grazing Management

To reduce total grazing pressure and improve habitat conditions, the RL fenced operational area will exclude livestock grazing and undergo targeted feral species management:

- Rabbit (*Oryctolagus cuniculus*) control: Active burrow removal to prevent overgrazing and soil degradation, annual introduction of Calici virus if recommended by Eyre Peninsula Landscapes SA staff.
- Goat (*Capra hircus*) and fox (*Vulpes vulpes*) control: Trapping and baiting programs to reduce predation pressure and habitat degradation.
- Sheep grazing exclusion: The fenced RL operational area will restrict livestock access, allowing native vegetation to regenerate and preventing soil compaction from excessive trampling.
- Feral predator control: Foxes and feral cats (*Felis catus*) will be targeted to reduce predation risks for native fauna, Felixer, a Sodium Fluroacetate (1080) applicator will be deployed, as well as 1080 fox baiting.
- Weed and pest species monitoring: Ongoing surveys will track population trends and inform adaptive management responses.

These actions will increase habitat value for native wildlife, promoting long-term ecological resilience within the RL.

Vegetation Enhancement & Habitat Restoration

Habitat restoration within the RL fenced operational area will focus on native vegetation recovery through:

- Direct seeding at ~20 kg/ha: A diverse mix of native bush and grass species is being seeded to restore pre-European vegetation structure and support biodiversity.
- Targeted revegetation efforts: Tubestock plantings of species including *Acacia oswaldii, Acacia papyrocarpa*, *Santalum spicatum* (Sandalwood), and *Santalum acuminatum* (Quandong) will enhance habitat structure and food resources.
- Tree and shrub protection – Individual high-value trees (A. papyrocarpa, *Alectryon oleifolius*) will be fenced to prevent grazing damage.

- Alligator Energy's Environmental, Social and Governance (ESG) Initiative – A dedicated 4-hectare revegetation and visual amenity project (1000 m x 40 m) will enhance biodiversity values within the RL area.

This revegetation strategy will enhance foraging and nesting opportunities for native species, contributing to regional conservation objectives.

Minimisation of Habitat Disturbance

To reduce direct impacts on fauna from construction and operations, habitat clearance will be minimised:

- No clearance of mature trees: Hollow-bearing and structurally significant vegetation, such as large upright dead trees with habitat hollows and perches and old growth bluebush greater than a metre in height will be preserved wherever possible.
- Nest box trials: Artificial nesting structures will be trialled to supplement habitat for tree-dwelling fauna.
- Progressive rehabilitation: Cleared areas will be restored with native species to maintain habitat continuity post-disturbance.

Clearing will be restricted to essential areas, ensuring habitat disturbance is kept to a minimum.

Entrapment & Fauna Protection Measures

To prevent wildlife entrapment, Alligator Energy will implement protective measures:

- Fauna escape ramps or netting: Installed in any excavations, sumps, or tanks deeper than 0.5 m.
- Infrastructure fencing and capping: Wells, pipelines, tanks, and open structures will be securely fenced or covered to prevent fauna access.
- Routine inspections: Environmental personnel will regularly monitor site infrastructure for potential entrapment risks and undertake corrective actions as required.

These measures will ensure that fauna is protected from potential hazards throughout the project lifecycle.

Minimising Risks from Chemical Exposure

To prevent wildlife exposure to hazardous substances, Alligator Energy will:

- Enclose tanks and bunded areas to prevent fauna access.
- Conduct routine inspections to detect fluid accumulation in containment areas.
- Immediately remediate spills to prevent chemical exposure to wildlife.

These measures will ensure that fauna is not adversely affected by project-related contaminants.

Traffic & Equipment Interaction Controls

To reduce vehicle-wildlife interactions, Alligator Energy will enforce:

- A Traffic Management Plan (Appendix T) that set outs strict speed limits, caution wildlife signage and designated traffic routes to minimise collision risks.
- Fauna awareness training for all personnel to improve wildlife response protocols.
- Incident reporting for any fauna-related vehicle strikes, with corrective actions implemented where necessary.

- By limiting disturbance from site vehicles and machinery, these measures will help protect mobile fauna within the RL area.

Food & Waste Management to Reduce Pest Attraction

To prevent pest attraction and reduce human-wildlife interactions, the following controls will be implemented:

- Prohibition of domestic animals: No pets or non-native species will be allowed within the RL.
- Food waste containment: Sealed bins will be used to prevent pest attraction.
- On-site food consumption controls: Restricted to designated areas to minimise food availability for scavengers.
- Proper waste management will prevent population increases in pest species such as rabbits, foxes, and mice.

Alignment with Conservation Priorities

Within the RL 137 area, conservation measures will align with EPBC-listed fauna priorities, particularly for the Western Grasswren (*Amytornis textilis myall*), which is susceptible to habitat degradation.

To maintain and improve habitat quality, Alligator Energy will:

- Reduce grazing pressure by excluding livestock from key areas.
- Actively manage weeds and feral species to maintain habitat integrity.
- Retain trees, for hollow and perch habitat and wherever possible avoid damage to bluebush greater than 1 metre.
- Revegetate with native species that provide critical shelter and food resources.
- Restore habitat corridors along the RL access road within the Moonabie pastoral property to support fauna movement.
- Monitor soil erosion and implement stabilisation measures to maintain ground cover for foraging species.

These actions will enhance biodiversity values within the RL 137, support native fauna resilience, and align with regional conservation objectives.

Native Fauna Incident Monitoring & Verification

Alligator Energy is committed to ensuring no preventable injuries or fatalities to native fauna occur as a result of field trial activities. To achieve this, a structured incident logging, investigation, and response framework has been established, ensuring compliance with the Animal Welfare Act 1985 and broader regulatory requirements.

<u>Fauna Incident Reporting & Investigation</u>

All fauna-related incidents within the RL area will be logged, investigated, and reviewed to determine whether they could have been reasonably prevented. Each incident report will include:

- Date, time, and precise location of the event.
- Species involved, if identifiable.
- Nature of the incident (e.g., injury, fatality, near-miss).
- Root cause assessment, identifying contributing factors.

- Evaluation of preventability.
- Actions taken to manage or prevent recurrence.

Incident data will be stored within Alligator Energy's Safety Management Database and will be audited annually to ensure compliance.

Corrective Action & Preventability Assessment

- Incidents classified as preventable will be investigated, with corrective actions implemented within 30 days of the event.
- Any recurring issues will trigger adjustments to fauna protection measures, such as changes to traffic management, exclusion fencing, or waste storage practices.
- Any personnel involved in a preventable fauna incident will be retrained immediately, with records maintained in training logs.
- Repeated non-compliance by any individual will result in appropriate intervention, including disciplinary action where necessary.

Vehicle Interaction Monitoring

- Incident reporting for fauna collisions will be maintained and reviewed to identify high-risk zones.
- Adaptive management will adjust speed limits or traffic routes as needed.

Pest Monitoring & Verification Program

Pest Monitoring Program

Annual pest monitoring will be conducted to evaluate population trends of rabbits, foxes, and invasive rodents within the RL area. Monitoring data will guide targeted control programs, which will be adapted based on monitoring results.

The presence and activity of feral species (e.g., rabbits, foxes, cats, and rodents) will be monitored using a combination of direct and remote detection methods:

- Infrared Camera Surveys:
    - Cameras will be deployed at all operational and control monitoring sites for a minimum of 10 days per year.
    - Images will be analysed annually, with species counts recorded and reported to:
        - DEM (Department for Energy and Mining) annually.
        - FeralScan website (https://www.feralscan.org.au/) quarterly, in collaboration with the Eyre Peninsula Landscapes Board.
- Annual on foot spotlighting survey.
- Permanently Deployed Felixer Unit:
    - A targeted feral control system used to detect and manage feral cat and fox populations, this records images of all feral species identified and applies targeted control measures.
    - South Australian government and landowner authorisation for Felixer use is in place.
- Opportunistic Observations:
    - All feral species sightings will be recorded by field personnel during routine inspections.
    - Monitoring locations and methodologies are detailed in Table 7.20 and shown in Figure 7.13.

Food & Waste Management Audits

- Routine inspections will also be undertaken verify compliance with waste storage and disposal protocols to prevent pest attraction.

Table 7.20: Pest Monitoring Sites

ID	Location	Monitoring Type	Control or Impact Site	Coordinates (GDA2020 / MGA Zone 53)	
				Easting	Northing
SPOT1	East of FRT fence, transect to east	Annual spotlighting on foot for feral species	Control	723133	6323869
SPOT2	Inside FRT fence, follow track west of Myall	Annual spotlighting on foot for feral species	Impact	723314	6324192
SPOT3	Inside FRT fence, parallel to Coronation Dam track – LMW008	Annual spotlighting on foot for feral species	Impact	723133	6323867
SPOT4	Inside FRT fence, on track near LMW003	Annual spotlighting on foot for feral species	Impact	723130	6323870
SPOT5	Pipeline Control, no. 2	Annual spotlighting on foot for feral species	Control	723222	6324401
CAM6	Pipeline Control No. 2	Annual spotlighting on foot for feral species	Control	724785	6324894
CAM1 CAM2 CAM3	Within the FRT fence	Camera monitoring for feral species presence/absence (Felixer located at one of these sites)	Impact	723185 723109 723065	6324182 6324141 6324418
CAM4 CAM5 CAM6	Outside the FRT fence	Camera monitoring for feral species presence/absence	Control	722839 725124 724546	6324590 6323617 6324335

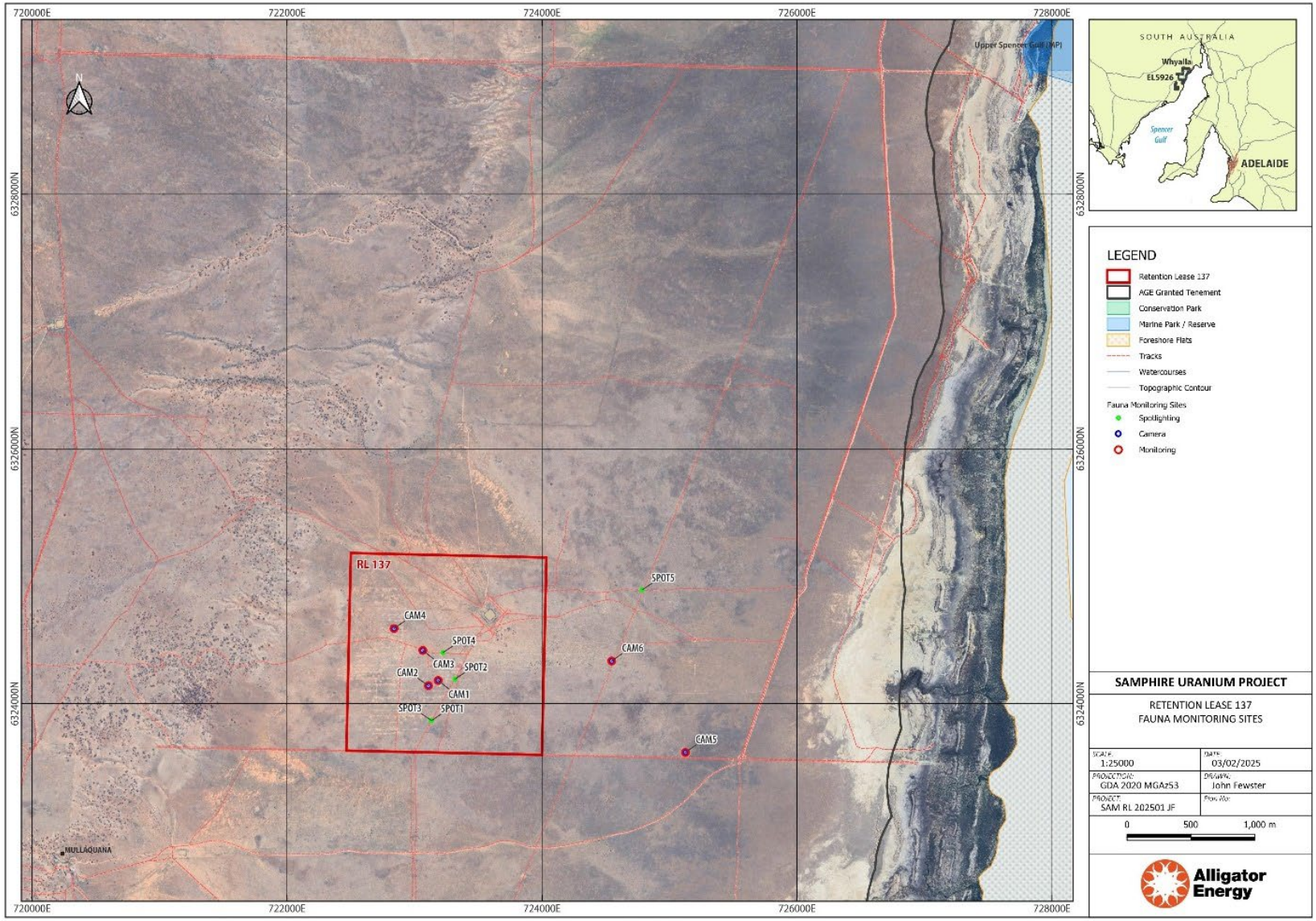


Figure 7.13: Pest Monitoring Sites

Uncertainties, Assumptions & Future Works

The control strategies presented above have been assessed to determine whether any significant uncertainties exist regarding their effectiveness, including the sensitivity of any such uncertainties and whether additional future works would be required to address them.

No significant uncertainties, assumptions, or future works related to RL activities have been identified or planned. Uncertainties acknowledged are regarding the cumulative and potentially combined impacts of other proposed local developments that are projected for the next 10-year period (i.e. large footprint water supply pipeline, wind and solar farms), livestock grazing and effects of climate change (i.e. drought intensity and frequency). The combination of these cumulative changes in land uses and projected more extreme climatic events on native fauna and pests may be negative.

Alligator Energy will endeavour to maintain open communication and collaborate at a landscape scale wherever possible to address or mitigate potential negative changes.

Alligator Energy will update pest and native species survey data to the appropriate government accessible data base on a quarterly basis (i.e Feralscan, or BDBSA), of the surveying taking place.

The fencing of the FRT site to exclude livestock and the active control of rabbits will result in increased vegetation growth within the FRT. This increase in native vegetation cover is anticipated to improve native fauna habitat and boost native seed production per unit area when compared to neighbouring areas. As a result, this may contribute to increased seed dispersal in the wider area, supporting rangeland resilience.

7.6.5 Outcome Measurement Criteria & Leading Indicator Criteria

The specific measurement criteria, measurement methods, and compliance criteria for demonstrating adherence to the approved environmental outcome for native fauna and pest management are provided in Table 7.21.

Where control strategies play a critical role in achieving an environmental outcome, leading indicator criteria have been established to provide an early warning to the failures in control and management strategies.

Table 7.21: Outcomes, Measurement & Leading Indicator Criteria – Native Fauna & Pests

Outcome	What will be Measured & Form	Locations	Frequency & Duration	Responsibility & Records	Control or Baseline Data	Outcome Achievement	Leading Indicator
Native Fauna: No native fauna injuries or deaths due to field trial activities that could have been reasonably prevented.	All identified fauna injuries or deaths are logged as incidents with the following data recorded: • Date, time, and location. • Species involved (where possible). • Nature of incident is (e.g., injury, fatality) • Root cause and assessment of preventability[7]. • Corrective actions taken. • Compliance or non-compliance with the *Animal Welfare Act 1985*.	RL.	Event based incident reporting and investigation. Annual compliance audit on the preventability of fauna related incident records.	Environmental Manager Alligator Energy Environmental Database & Safety Management Database.	N/A	All fauna-related incidents are assessed and confirmed as not reasonably preventable, with corrective actions implemented where relevant.	N/A
Weed & Pests: During construction and operation, ensure no introduction of new species of environmental weed, plant pathogens or pests (including feral animals), nor sustained increase in abundance of existing weed or pest species on the Land.	Pest monitoring methods include: • Permanently deployed Felixer. • Annual spotlighting survey • Infrared camera surveys: o Conducted at all defined operational and control monitoring sites. o Minimum duration: 10 days per monitoring period. • Opportunistic observations: o Documented during routine site inspections. Survey records must include: • GPS coordinates of each sighting. • Species identified (if known). • Assessment of pest species presence and abundance compared to control sites. • Actions taken (if required).	Table 7.20 & Figure 7.13.	Annual pest monitoring and surveillance, including 10-day infrared camera deployments per period, continued until RL relinquishment.	Environmental Manager Alligator Energy Environment Database.	3 x control sites (Table 7.20 & Figure 7.13). Baseline records of previously identified pest species Appendix K.	Survey data demonstrates: • No newly identified declared pest species compared to baseline survey data. • No increase in pest species detected by infrared cameras at operational sites compared to control sites for more than two consecutive monitoring periods.	N/A

[7] See Section 9.1 for the definition of a preventable incident to native fauna.

7.7 Land Use & Third-Party Property

7.7.1 Context

The RL encompasses a total area of 2.37 km² (237 ha) and is entirely located within the Moonabie pastoral property, which is currently used exclusively for sheep grazing (refer to Figure 1.1). Within this area, the RL includes one existing active station dam, Coronation Dam (refer to Figure 4.1), which is currently used for stock watering.

Operational portions of the RL, including the well arrays, process plant, and administration area, will be enclosed with sheep-proof fencing, defining a clear management area under the sole control of Alligator Energy (refer to Figure 4.1). While access to the Moonabie property is restricted to the landowner and authorised pastoral representatives, access to fenced operational areas within the RL will be strictly controlled, with no entry permitted unless explicitly approved by Alligator Energy. This fencing will temporarily excise parts of the RL required for FRT activities, where pastoral activities will not be permitted.

The remaining unfenced portions of the RL will continue to support multiple land uses, including, pastoral activities by the landowner, such as stock watering at Coronation Dam, as specified in the land access agreement. These areas will also be subject to exploration and RL management activities by Alligator Energy, including environmental and radiation monitoring. No other land uses or activities will be permitted within the RL for the duration of the RL grant period.

Importantly, it is the intention that all areas within the RL, including those temporarily fenced off for operational use, will be rehabilitated and reinstated to support the original pastoral land use following the cessation of FRT activities. This aligns with the agreed end land use as specified in the access arrangements and closure planning framework.

Outside of the RL area but within the Coronation dam paddock, it is anticipated that additional land uses may occur in the future, including the Northen Pipeline construction and operation and possible wind and solar energy projects.

A small number of pastoral homesteads are located within the broader local area, with the nearest being Mullaquana Homestead, approximately 2.4 km from the RL, and Nonowie Homestead, approximately 7.5 km away. Additionally, a small cluster of beach shacks are located at Cowleds Landing, approximately 6.6 km east of the RL.

Further details on the landowners and land use within the project area and surrounding region are provided in Section 2.11 and shown in Figure 2.1

7.7.2 Potential Impacts

The potential land use impacts from the FRT operations have been assessed in the Samphire RL Proposal document (Alligator Energy, 2023b).

The key potential impacts associated with the development and implementation of the FRT, based on identified source-pathway-receptor linkages, are:

- Loss of grazing area for pastoral use due to disturbance from FRT activities, including land clearing, infrastructure development, and restricted access to grazing areas. This may reduce the available land for livestock grazing and impact pastoral productivity.

- Contamination of local land and water resources, resulting from chemical spills, process fluids, or waste materials associated with FRT operations. This could affect soil quality, vegetation health, and water availability, potentially leading to restrictions on pastoral activities and long-term land use constraints.
- Unauthorised damage to third-party property, including livestock, fences, gates, vehicles, and private road infrastructure, as a result of vehicle, truck, and machinery use during project activities. Movement of personnel, vehicles, and equipment to and from the RL increases the potential for accidental damage to pastoral assets.

7.7.3 Regulatory Outcomes & Compliance Conditions

The Fourth Schedule – Environmental Outcomes and Conditions of RL137 (Appendix A) establishes the regulatory requirements for land use compatibility and third-party property protection that Alligator Energy must meet throughout construction, operation, and post-completion. These requirements ensure that project activities do not interfere with or negatively impact third-party land use or property within or beyond the RL area.

Land Use and Third-Party Property Outcome:

- The Tenement holder must, during construction, operation and post completion, ensure there are no adverse impacts to third–party land use or property on or off the land as a result of field recovery trial activities other than those agreed between the tenement holder and affected users.

7.7.4 Control, Management & Monitoring Activities

To maintain compatibility with existing land uses and ensure third-party property protection, a structured management and monitoring framework has been developed. This framework focuses on minimising disruptions to pastoral activities, securing project areas, and ensuring environmental and infrastructure integrity throughout the FRT.

Management Strategies

Landowner Compensation

- Annual compensation payments are made to Moonabie PL landowners to offset temporary grazing land losses resulting from the fenced project area.
- Formal Land Access Agreements are maintained between Alligator Energy and the landowner, including:
  - Agreed land use impacts and compensation provisions.
  - Documented changes or variations to ensure continued pastoral compatibility.
  - Grievance resolution procedures to manage any disputes or concerns regarding land use.

Access Control

- Sheep-proof fencing encloses operational areas (well arrays, process plant, administration area) to prevent unauthorised access and limit grazing land excision.
- Access to fenced operational areas is restricted and strictly controlled, with no entry permitted unless explicitly agreed upon and approved by Alligator Energy.

- The remaining unfenced portions of the RL remain available to the landowner solely for pastoral activities, including access to Coronation Dam for stock watering, as outlined in the Land Access Agreement.

Vegetation Disturbance Minimisation

- Vegetation disturbance and clearance limits are defined and approved under the Native Vegetation Management Plan (NVMP).
- All project-related clearance is conducted under strict internal permits reviewed by the Environmental Manager.

Dust Management

- Routine track watering using potable water and where required, dust suppressant 'dustbinder', mitigates anthropogenic dust generation.
- Dust monitoring gauges are deployed at FRT boundaries to track dust levels.

Revegetation Measures

- Native vegetation disturbed by FRT infrastructure is restored upon project conclusion, ensuring conditions suitable for future pastoral activities.
- Post-closure monitoring verifies the successful re-establishment of native species in all impacted areas.
- Multiple land use comparisons will be conducted using aerial photogrammetry to assess native species coverage in uncleared areas, both outside of and within the FRT fenced area, to demonstrate equal or improved vegetation coverage within the FRT.

Refer to Section 7.5.4 for additional vegetation management measures.

Monitoring & Verification

A monitoring and verification framework has been implemented to ensure compliance with land use and third-party property protection requirements. This program aligns with regulatory outcomes, ensuring that project activities do not adversely impact pastoral operations, private property, or the surrounding environment.

Land Use Compliance Monitoring

Annual review of land access agreements, ensuring:

- Continued compliance with agreed land use terms.
- Documentation of any amendments or variations to agreements.
- Verification that pastoral access to unfenced RL areas and Coronation Dam remains unaffected.
- Internal audits of compensation payments and landowner commitments to confirm:
    - Payments are processed annually, in accordance with agreements.
    - Any changes in land use or additional requirements are documented.

Access Control & Property Protection

Quarterly inspections of fences, gates, and access roads, including:

- Verification of fence integrity and required maintenance.
- Assessment of private road conditions to ensure project-related traffic does not cause damage.

- Access records maintained, ensuring:
  - Only authorised personnel enter fenced areas.
  - Restricted access to third-party properties is enforced.

Management & Stakeholder Engagement

- All land use-related grievances logged and investigated within 7 days.
- Corrective actions implemented and documented within 14 days.
- Stakeholder engagement reports compiled annually, summarising:
  - Landowner feedback and concerns.
  - Resolutions for any property or access disputes.

Internal Audits & Compliance Checks

Annual internal audits to verify compliance with:

- Land access agreements and compensation terms.
- Vegetation disturbance minimisation and revegetation strategies.
- Property protection measures, including fencing and road maintenance.
- Independent post-closure audits to confirm:
  - Successful rehabilitation of disturbed areas.
  - Land use compatibility post-FRT.
  - Restoration of grazing land productivity.

Regulatory Reporting & External Verification

Annual Compliance Reports submitted to regulators, detailing:

- Findings from monitoring programs.
- Vegetation and land use verification results.
- Grievance and complaint resolution records.

Uncertainties, Assumptions & Future Works

The control strategies outlined above have been assessed to determine whether any significant uncertainties exist regarding their effectiveness, including the sensitivity of these uncertainties and whether additional future works would be required to address them.

No significant uncertainties, assumptions, or future works have been identified or planned specifically for the RL activities.

However, uncertainties exist regarding the cumulative impacts of other proposed local developments projected over the next 10 years (e.g., large-footprint water supply pipelines, wind and solar farms) and the effects of climate change. The combination of these land use changes and projected extreme climatic events may negatively impact existing land uses, including pastoralism.

Additionally, feral animal management, particularly goat populations, will require a coordinated approach among development proponents in collaboration with neighbouring properties, land users and Landscapes SA. Goat populations travel over multiple properties, and a consistent regional approach is required to be effective.

Alligator Energy commits to maintaining open communication and working collaboratively with other stakeholders at a landscape scale to address or mitigate potential negative changes wherever possible.

7.7.5 Outcome Measurement Criteria & Leading Indicator Criteria

The specific measurement criteria, measurement methods and the criteria for demonstrating compliance with the approved environmental outcome for land use is provided in Table 7.22

Where there is a high level of reliance on control strategies to achieve an environmental outcome, leading indicator criteria have also been provided to provide an early warning to the failure of control and management strategies.

Table 7.22: Outcomes, Measurement & Leading Indicator Criteria – Land Use & Third-Party Property

Outcome	What will be Measured & Form	Locations	Frequency & Duration	Responsibility & Records	Control or Baseline Data	Outcome Achievement	Leading Indicator
Land Use: During construction, operation and post completion, ensure there are no adverse impacts to third–party land use or property on or off the land as a result of field recovery trial activities other than those agreed between the tenement holder and affected users.	Records of any grievances or complaints related to land use impacts, including resolution outcomes.	N/A	Annual until RL relinquishment	Alligator Community Engagement Manager All documents and records will be retained within the Alligator Stakeholder Engagement Database.	N/A	Internal audit demonstrates: • All grievances or complaints relating to land use impacts within or outside the RL are: o Recorded and investigated within 7 days. o Closed out with corrective actions documented within 14 days.	N/A

7.8 Heritage

7.8.1 Context

The RL area is located within the Barngarla Native Title Claim (SAD6011/98); however, Native Title has been extinguished over the Moonabie Perpetual Crown Lease, where FRT activities are planned.

Although no formally registered Aboriginal heritage sites were identified during surveys conducted in 2021, 2022, and 2023, the wider region holds significant anthropogenic values for the Barngarla people. These include mythological and ethnographic importance, such as a Dreaming storyline and ancient travel routes that traverse the landscape. Recognising these cultural values, Alligator Energy is committed to implementing measures that respect and protect the cultural heritage of the Barngarla people.

No non-Aboriginal heritage sites to date have been identified within a 10 km radius of the RL area. Additionally, the Deep Creek Geological Heritage Site is located approximately 6 km to the west of the RL, on Moonabie Station, well outside the project area.

Further details on Aboriginal, Non-Aboriginal, and geological heritage are provided in Sections 2.12.1, 2.12.2, and 2.12.3, respectively.

7.8.2 Potential Impacts

The potential impacts to heritage from FRT operations have been assessed in the Samphire RL Proposal document (Alligator Energy, 2023b).

The key potential impact associated with the development and implementation of FRT, based on an identified source-pathway-receptor linkages, is:

- Disturbance or damage to an Aboriginal site, object, or remain not yet identified, due to ground disturbance, excavation, or infrastructure development. This could result in unintentional harm to culturally significant sites and a loss of heritage value.

This impact may arise from the use of machinery for ground excavations, vegetation clearing, and off-track vehicle movements, all of which have the potential to disturb subsurface materials.

7.8.3 Regulatory Outcomes & Compliance Conditions

The Fourth Schedule – Environmental Outcomes and Conditions of RL137 (Appendix A) establishes the regulatory requirements for heritage protection that Alligator Energy must meet throughout construction, operation, and post-completion. These requirements ensure that project activities do not cause damage, disturbance, or interference to Aboriginal or Non-Aboriginal heritage sites, objects, or remains, unless explicitly authorised under relevant legislation.

The protection of Aboriginal cultural heritage is governed by the Aboriginal Heritage Act 1988, which mandates that any discoveries of heritage sites, objects, or remains must be reported, and appropriate management measures undertaken in consultation with Barngarla representatives and relevant authorities. Similarly, the protection of non-Aboriginal heritage falls under the Heritage Places Act 1993, ensuring that historical and culturally significant sites remain preserved.

Heritage Outcome:

- The Tenement Holder must, during construction and operation, ensure there is no damage, disturbance or interference to Aboriginal or Non-Aboriginal heritage sites, objects or remains unless it is authorised under the relevant legislation.

7.8.4 Control, Management & Monitoring Activities

Alligator Energy recognises the cultural significance of the broader region to the Barngarla people, including its mythological and ethnographic values, such as Dreaming storylines and ancient travel routes. Although no formally registered Aboriginal heritage sites were identified within the RL boundary during heritage surveys conducted in September 2021, September 2022, and August 2023 (see Section 2.12), Alligator Energy remains committed to protecting any Aboriginal or Non-Aboriginal heritage values should they be encountered during FRT activities. This commitment aligns with obligations under the Aboriginal Heritage Act 1988 and broader land use principles.

To ensure compliance with legislative requirements and respect cultural values, Alligator Energy has developed a Heritage Management Framework, which includes preventative controls, response protocols, and ongoing engagement measures to protect Aboriginal heritage sites, objects, and remains.

Heritage Protection Measures

The following measures will be implemented to prevent disturbance to heritage values and ensure compliance with the Aboriginal Heritage Act 1988:

Ongoing Heritage Surveys & Consultation

- Pre-disturbance heritage surveys will be conducted as required for areas not previously surveyed within the RL boundary.
- Ongoing engagement with the Barngarla Determination Aboriginal Corporation (BDAC) will ensure that any concerns regarding heritage protection are addressed.
- Any newly identified areas of cultural significance will be reported to BDAC and regulatory authorities, and appropriate management measures will be determined.

Cultural Awareness & Training

- Mandatory heritage awareness training will be provided to all personnel and contractors working within the RL area.
- Training will cover:
    - Legal obligations under the Aboriginal Heritage Act 1988.
    - Protocols for managing cultural discoveries and the importance of protecting heritage values.
    - Recognition of culturally significant landscapes, sites, and objects.

Procedures for Heritage Discovery

If Aboriginal sites, objects, or remains are discovered during field activities, the following response procedures will be strictly followed:

- Immediate cessation of work within a 50-meter buffer zone of the find.
- Site protection measures, such as temporary fencing or signage, will be implemented to prevent further disturbance.
- Notification of the discovery to the Environmental Manager and BDAC.

- Reporting to the Minister for Aboriginal Affairs and Reconciliation in accordance with the Aboriginal Heritage Act 1988.
- Further consultation with BDAC and relevant authorities to determine the appropriate course of action before resuming activities.

Land Disturbance & Vegetation Preservation

- Existing access roads and tracks will be prioritised for operational use to minimise unnecessary disturbance.
- No development within 10 meters of watercourses, stone outcrops, sandhills, sandridges, or salt/clay pans unless approved in consultation with BDAC. (Note: None of these features are currently identified within the RL boundary).
- Culturally significant vegetation species, including Black Oak (*Casuarina pauper*), Mallee, Mulga, Sandalwood (*Santalum spicatum*), Quandong (*Santalum acuminatum*), Myall (*Acacia pendula*), and Bush Medicine plants, will be protected. Minimal clearing will occur, limited to areas essential for operations, Only Myall and Emu bush are within the RL (M.Daniel pers obs) and these will not be cleared.

Exclusion Zones

- Heritage exclusion zones will be established for any newly identified cultural or archaeological sites.
- Areas of significance identified during BDAC consultation or future surveys will be designated as no-go areas.
- No exclusion zones have been identified within the RL boundary to date.

Ongoing Monitoring & Reporting

- Regular heritage monitoring and reporting will ensure ongoing compliance with regulatory requirements and protection of Aboriginal cultural values.
- Any newly discovered heritage features will be recorded, reported, and managed in consultation with BDAC.
- Annual compliance reporting to verify that heritage management measures have been implemented correctly.

Uncertainties, Assumptions & Future Works

The control strategies outlined above have been assessed to determine whether any significant uncertainties exist regarding their effectiveness. No significant uncertainties or future works have been identified beyond routine heritage surveys and ongoing consultation with BDAC.

7.8.5 Outcome Measurement Criteria & Leading Indicator Criteria

The specific measurement criteria, measurement methods and the criteria for demonstrating compliance with the approved environmental outcome for heritage is provided in Table 7.23.

Where there is a high level of reliance on control strategies to achieve an environmental outcome, leading indicator criteria have also been provided to provide an early warning to the failure of control and management strategies.

Table 7.23: Outcomes, Measurement & Leading Indicator Criteria – Heritage

Outcome	What will be Measured & Form	Locations	Frequency & Duration	Responsibility & Records	Control or Baseline Data	Outcome Achievement	Leading Indicator
Heritage: During construction and operation, ensure there is no damage, disturbance or interference to Aboriginal or Non-Aboriginal heritage sites, objects or remains unless it is authorised under the relevant legislation.	Internal incident reports documenting any discovery of a heritage site, objects or remains. Records will include: • Date and location of discovery (if applicable). • Actions taken, including cessation of work and notification to relevant authorities. • Evidence of authorisation received under the Aboriginal Heritage Act 1988 before resuming work.	N/A	Annual until RL relinquishment.	Environmental Manager Heritage survey records are stored in the Alligator Energy's internal server.	Prior heritage survey results across the RL area are held by Alligator Energy and will be provided to regulatory agencies on request.	Internal audit confirms: • Any incidents involving the discovery of a potential heritage site, object, or remains were managed as follows: o Work immediately ceased upon discovery. o Notifications were made to relevant authorities. o Authorisation was obtained before resuming work, in compliance with the Aboriginal Heritage Act 1988.	N/A

7.9 Amenity & Conservation Values

7.9.1 Context

The RL area is situated within a relatively flat, sparsely populated pastoral grazing property on the Eyre Peninsula, approximately 24 km south of Whyalla and 3.6 km west of Spencer Gulf. The site is confined to the shrubland plains, adjacent to coastal samphire flats. Public vantage points with views of the FRT infrastructure are limited to portions of Nonowie Station, Mullaquana Homestead, and sections of Eight Mile Creek Road.

While several conservation areas exist in the broader region, none are located within or immediately adjacent to the RL boundary. The RL does not extend to the coastal fringe, with the nearest part of the deposit situated more than 2.5 km from the high tide mark.

Detailed discussions on the existing visual amenity, topography, and conservation areas are provided in Sections 2.1 and 2.13.

7.9.2 Potential Impacts

The potential impacts on amenity and conservation values from FRT operations have been assessed in the Samphire RL Proposal document (Alligator Energy, 2023b).

Visual Amenity Impacts

The key potential impact associated with the development and implementation of FRT, with identified source-pathway-receptor linkages, is:

- Reduction in local visual amenity, primarily affecting residents of Mullaquana Homestead, due to:
  - Removal or disturbance of native vegetation during construction and operation.
  - Installation of project infrastructure, which may contrast with the surrounding landscape.
  - Use of lighting for night operations, increasing visibility of the site.
  - Vehicle movements for 24-hour project operations, contributing to changes in the natural visual setting.

Conservation Area Impacts

A comprehensive risk assessment, undertaken as part of the RL Proposal submission (Alligator Energy, 2023b), determined that FRT activities will not impact regional conservation areas, including the Upper Spencer Gulf Marine Park (5.5 km northeast) and the Coastal Reserve (2.8 km east).

No viable pathway exists for environmental harm due to:

- Significant spatial separation (minimum 2.8 km from coastal ecosystems, and 5.5 km from the Marine Park).
- Land Use Characteristics: The site is pastoral land with no ecological linkage to conservation zones.
- Hydrological Isolation: No credible groundwater or surface water connectivity exists between project activities and marine/coastal ecosystems.

7.9.3 Regulatory Outcomes & Compliance Conditions

The Fourth Schedule – Environmental Outcomes and Conditions of RL137 (Appendix A) establishes the regulatory requirements for visual amenity management that Alligator Energy must adhere to throughout construction, operation, and post-completion. These requirements ensure that project activities are designed and managed to minimise visual contrast and blend with the surrounding landscape as much as reasonably practicable.

Visual Amenity Outcome

- The Tenement Holder must, during construction, operation, and post-completion, ensure that the form, contrast, and reflective aspects of field recovery trial activities are visually softened to blend with the surrounding landscape as much as reasonably practicable.

Upper Spencer Gulf Marine Park Condition

- The Tenement Holder must ensure that there is no impact on the Upper Spencer Gulf Marine Park as a result of field recovery trial activities or other authorised operations.

7.9.4 Control, Management & Monitoring Activities

Visual Amenity Measures

Operational activities within the RL will be visible from limited vantage points, including pastoral areas, shearing sheds, and internal property tracks. To minimise the visual impact of operations, Alligator Energy has implemented mitigation measures, incorporating:

Infrastructure and Landscape Integration

Screening measures to protect the existing visual amenity of the site (Section 2.16) have been designed to account for the site's topography, the low height of existing vegetation, the location of sensitive receptors, and the temporary nature of the FRT. These measures include:

- Blending Infrastructure with the Landscape: Infrastructure components such as pipework, process plant containers, and other major site equipment will be painted in non-reflective, earth/vegetation-toned colours to reduce contrast with the environment.
- Stockpile Management: Topsoil and overburden stockpiles will be stabilised and hydro-mulched to blend with the surrounding landscape.

In addition, all temporary FRT infrastructure will be dismantled and removed as soon as it is no longer required, minimising long-term visual impact.

Lighting & Night-Time Visual Impact Reduction

- Use of Directional and Shielded Lighting: Lighting will be designed to minimise skyglow and light spill while maintaining operational safety.
- Minimised Lighting Usage: Lights will be turned off when not required for safety or operations to reduce unnecessary visibility.

Vegetation Management & Visual Screening

- Minimising Vegetation Disturbance: Native vegetation removal will be limited to essential areas to preserve the natural landscape and reduce visual impact.
- Progressive Rehabilitation: Disturbed areas will be revegetated as soon as practicable, reducing the duration of exposed ground surfaces.

Community Engagement & Complaints Handling

- Stakeholder Consultation: Adjacent landowners and residents will be consulted about site layout, activities, and potential visual changes.
- Community Feedback Register: A community complaints system will be maintained, ensuring concerns related to visual impact are recorded, investigated, and addressed through corrective actions.

Monitoring & Verification Programs

To ensure compliance with the approved environmental outcome for amenity, a combined monitoring and verification program will be implemented. This program is designed to:

- Assess the effectiveness of visual amenity management strategies.
- Provide early indicators of potential visual impact issues.
- Verify that all commitments are being met during construction, operation, and decommissioning phases.

Photographic Monitoring and Verification

Quarterly photographs will be taken during the construction, operations, and active decommissioning phases at designated photo points (Table 7.24 and Figure 7.14). These photographs will be used to:

- Assess how well infrastructure blends with the natural environment under daylight and nighttime conditions and
- Confirm vegetation management measures in accordance with the NVMP.
- Evaluate the effectiveness of glare minimisation measures such as shielding and directional lighting (nighttime photographs).

Baseline photographs (Appendix P) will be used for comparison to verify changes over time. These assessments will ensure visual impacts remain within acceptable limits and align with commitments outlined in 7.9.3.

Table 7.24: Visual Amenity - Photo Point Monitoring Locations

ID	Location	Photograph Direction	Coordinates	
			Latitude	Longitude
Photo point 1	Gate 2 on Moonabie property.	Northwest	-33.20331	137.41983
Photo point 2	Gate 3 on Mullaquana property	North	-33.20333	137.39078
Photo point 3	Gate 8 on Mullaquana property boundary	Northeast	-33.20334	137.3868

Audits of Visual Amenity Management Measures

Internal audits will be conducted quarterly during construction and operational phases to verify the implementation and effectiveness of control measures.

Audits will include:

- Ensuring screening measures are in place and maintained
- Verifying that non-reflective or low-contrast materials are used for infrastructure to minimise visual contrast.
- Conducting nighttime audits to assess lighting arrangement and effectiveness, including:
    - Shielding and directional measures to reduce light spill.

    - Minimising skyglow and glare
- Checking for the timely removal of temporary infrastructure and adherence to progressive rehabilitation commitments.

Stakeholder Feedback and Complaints

Stakeholder feedback and complaints related to visual impacts will be actively monitored throughout construction, operation, and decommissioning phases. All complaints will be logged in the Stakeholder Register, investigated within 7 days, and resolved with corrective actions implemented and documented within 14 days.

Regular engagement with stakeholders will help identify and address potential concerns early to prevent escalation.

Compliance Reporting

Monitoring and verification results will be reviewed and reported as part of the RL's Annual Compliance Reports, which will be submitted to regulatory authorities.

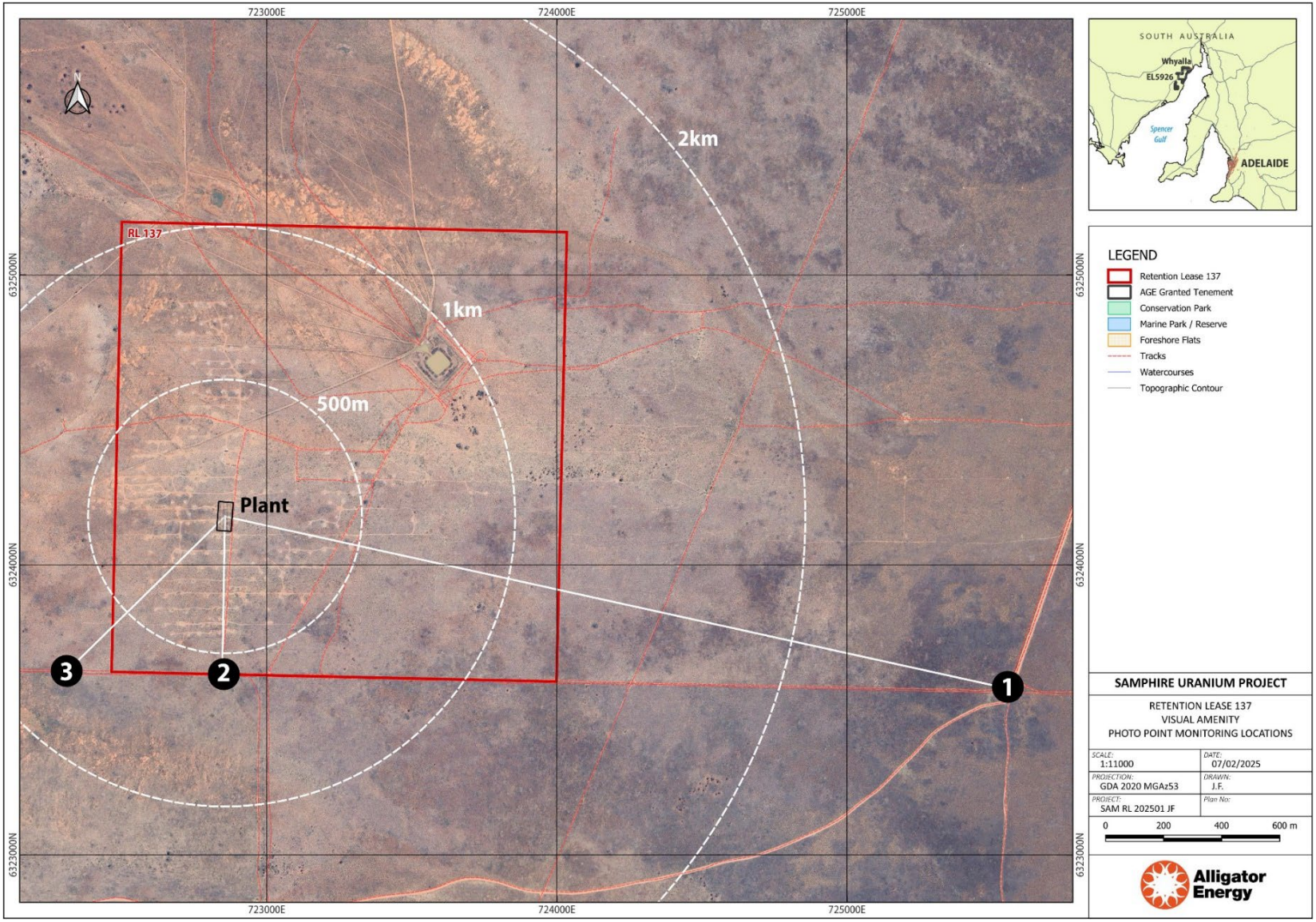


Figure 7.14: Visual Impact Monitoring Points

Conservation Areas & Marine Protection Measures

As required under RL137 (Second Schedule, Condition 9), Alligator Energy must ensure that FRT activities have no impact on the Upper Spencer Gulf Marine Park. While the Marine Park is located beyond the RL boundary (~5.5 km northeast), careful management is necessary to prevent potential indirect impacts.

The following strategies have been implemented to ensure compliance and safeguard coastal and marine ecosystems:

Surface and Groundwater Management:

Engineering measures (described in Section 7.4), including containment systems and controlled drainage, prevent hydrological pathways from transporting potential contaminants toward the marine environment. Groundwater extraction and reinjection processes (described in Section 7.3) are carefully managed to maintain the integrity of hydrogeological regimes and prevent unintended groundwater flow changes.

Erosion and Sediment Control:

Best-practice erosion and sediment control measures, such as stabilised surfaces, windbreaks, and sediment traps, are employed to prevent sediment transport via wind or runoff to coastal and marine areas.

Waste and Hazardous Material Containment:

Strict waste management protocols, including bunded storage, spill prevention systems, and waste disposal procedures, ensure that hazardous materials are contained and do not pose contamination risks. All fuel, chemicals, and processing by-products are securely stored and handled under regulatory requirements.

Air Quality and Dust Control:

Dust emissions are actively managed through regular road watering, vehicle speed limits, and dust suppression treatments, preventing airborne particles from affecting sensitive coastal ecosystems.

Ongoing Environmental Monitoring & Compliance Verification:

Extensive monitoring programs assess potential environmental risks across multiple pathways, including groundwater, surface water, soil, and air quality. Baseline data has been established, and ongoing monitoring ensures that any changes are detected early, allowing for corrective action before impacts occur.

Other Conservation Areas – Coastal Reserve & Native Vegetation Heritage Area

In addition to the Upper Spencer Gulf Marine Park, the adjacent Coastal Reserve and a Native Vegetation Heritage Area (~9 km west of the RL boundary) are recognised as sensitive environmental areas requiring protection from project-related impacts.

- Coastal Reserve (~2.8 km east of RL boundary):
  The coastal reserve extends along the western shore of Spencer Gulf, serving as a transitional zone between the terrestrial shrubland and marine habitats. The reserve's primary conservation values include intact samphire and mangrove ecosystems, which provide habitat for migratory shorebirds and marine-associated fauna, including fish nursery areas.
- Native Vegetation Heritage Area (~9 km west of RL boundary):

The Native Vegetation Heritage Area protects a semi-arid chenopod shrubland ecosystem that has undergone historical degradation due to grazing pressures. The RL site does not overlap with this conservation area, and given the distance, existing paddock fencing and lack of ecological connectivity, there is no credible pathway for project-related impacts.

Key protection measures for coastal and conservation areas includes:

Spatial Separation and Buffering:

The considerable distance between RL activities and these conservation areas prevents direct or indirect impact pathways, such as dust transport, water runoff, or habitat fragmentation. Existing vegetation acts as a natural buffer, limiting potential disturbances.

Land Title and Use Distinctions:

A review of land title records confirms that the RL area is on a separate land parcel (Title Ref: CL6171/768; Plan Parcel: H560400 S7) from the adjacent coastal reserve (Title Ref: CR5904/208; Plan Parcel: D56246 Q108). The distinction in land ownership and land use such as road infrastructure with windrows controlling water flows versus coastal conservation efforts further reduces risk.

No Identified Ecological Pathways:

Comprehensive environmental risk assessments have found no plausible pathway for RL activities to impact the coastal reserve or Native Vegetation Heritage Area. Potential air, water, and ground-based transport mechanisms have been assessed and deemed non-significant.

Commitment to Conservation Area Protection

Alligator Energy is committed to ensuring that FRT activities do not negatively impact conservation areas, including the Upper Spencer Gulf Marine Park, the Coastal Reserve, and the Native Vegetation Heritage Area. This commitment is upheld through:

- Ongoing monitoring and verification programs to assess environmental conditions.
- Implementation of preventative and adaptive management strategies to address potential risks.
- Compliance with relevant legislation and regulatory frameworks, ensuring that project activities align with environmental best practices.
- Engagement with local stakeholders and conservation bodies to ensure transparency and responsible land management.

Through these measures, Alligator Energy ensures that conservation areas remain unaffected, maintaining environmental integrity and biodiversity within the broader region.

Uncertainties, Assumptions & Future Works

The control strategies presented above have been assessed to determine whether any significant uncertainties exist regarding their effectiveness, including the sensitivity of any such uncertainties and whether additional future works would be required to address them.

However, uncertainties are acknowledged regarding the cumulative impacts of other proposed local developments projected over the next 10 years (e.g., large-footprint water supply pipelines, wind and solar farms) and the effects of climate change. The combination of these cumulative changes in land use and projected extreme climatic events may negatively impact amenity values.

7.9.5 Outcome, Measurement Criteria & Leading Indicator Criteria

The specific measurement criteria, measurement methods and the criteria for demonstrating compliance with the approved environmental outcome for amenity is provided in Table 7.25.

Where there is a high level of reliance on control strategies to achieve an environmental outcome, leading indicator criteria have also been provided to provide an early warning to the failure of control and management strategies.

Table 7.25: Outcomes, Measurement & Leading Indicator Criteria – Amenity

Outcome	What will be Measured & Form	Locations	Frequency & Duration	Responsibility & Records	Control or Baseline Data	Outcome Achievement	Leading Indicator
Amenity: Ensure the form, contrasting aspects and reflective aspects of field recovery trial activities are visually softened to blend in with the surrounding landscape as much as reasonably practical.	Photographs taken at designated photo points during the day and night to: • Assess the visual blending of infrastructure with the natural environment. • Evaluate lighting glare minimisation.	Table 7.24 & Figure 7.14	Quarterly during operational phases.	Environment Manager All records will be retained in Alligator Energy's internal server.	Appendix P.	Photographs confirm Alligator owned infrastructure blends with the natural environment and glare is minimised.	N/A
	Audit of RL area to ensure all visual amenity management measures are in place as committed to in Section 7.9.4, such as: • Hydroseeding of long-term soils stockpiles. • Non-reflective or low-contrast materials used where possible in infrastructure. • Shielding or directional lighting is used where possible to minimise glare.	RL	Quarterly during construction and operational phases.	Environment Manager All records will be retained in Alligator Energy's internal server.	N/A	Audits confirm implementation of visual amenity management measures during construction and operational phases.	N/A

7.10 Air Quality

7.10.1 Context

The RL area is situated away from major industrial air pollution sources (such as Whyalla's industrial areas), with the local air emissions being derived from pastoral activities, local road and track use and traffic on the Lincoln Highway, located approximately 11.8 km west of the RL area.

The nearest residential dwelling is located approximately 2.4 km southwest of the RL. Cowleds Landing beach shacks are located 5.1 km northeast, while Nonowie Homestead is situated approximately 7.5 km from the RL. A full description on baseline air quality is detailed in Section 2.17.

The construction, operation, and decommissioning of the FRT will result in localised changes to air quality, primarily due to vehicle movements on unsealed tracks, minor excavation activities, and the operation of diesel generators over the three-month trial period. While ISR mining is a wet process that does not generate fugitive dust from ore handling or crushing, minor increases in airborne radionuclides may occur due to radon emanation, fine particle suspension, and operational emissions.

Radiation has been included in the air quality assessment because airborne pathways are key transport mechanism for radionuclides. While radiation risks are also assessed in the sections on soil, groundwater, and surface water, airborne dispersion is the primary mechanism for potential off-site transport.

Dust Sources

Baseline dust levels in the region are primarily influenced by the arid climate, seasonal winds, and the expansive pastoral landscape, as detailed in Section 2.17.

During the FRT, the main sources of dust will arise from surface disturbances, including soil and vegetation disturbance, as well as vehicle and truck movements along access tracks, drilling operations for well installation, and initial construction activities.

To effectively manage and minimise airborne dust, particularly during high-wind events, a comprehensive set of dust control measures will be implemented.

Radon Sources

Radon release is primarily associated with the decay of radium present in the native groundwater of the target aquifer. The average radium concentration in the groundwater is 58 Bq/L (see Table 2.1), and its decay product, radon, is expected to be released during groundwater extraction. However, due to the low-grade mineralisation, radium concentrations, and the design of the process infrastructure, airborne radon concentrations within the RL are anticipated to remain low.

Radon will be managed through the use of degassing points, such as those located in the temporary water storage area and venting points installed on process infrastructure. These systems are designed to promote controlled radon release away from regularly occupied work areas, ensuring worker safety. During the ISR process, increased radium and radon concentrations are expected in the initial extraction of native groundwater from the ore zone, as well as during the surface storage and circulation of pregnant lixiviant.

Given the low anticipated radon release concentrations, short half-life, large RL area and rapid dilution of radon in air, no significant increase in radon concentrations is expected outside the operational FRT boundaries. This assumption will be verified through monitoring programs to ensure that radon concentrations both within the FRT area and at the RL boundary remain within regulatory radiation limits.

Radium concentrations will be monitored in process fluids throughout the FRT, and radon and its decay product concentrations will be assessed within project areas. These measurements will guide radiological evaluations for potential future mining operations and ensure the project adheres to all regulatory radiation safety requirements.

7.10.2 Potential Impacts

The potential impacts to air quality from FRT operations have been assessed in the Samphire RL Proposal document (Alligator Energy, 2023b).

The key potential impacts associated with the development and implementation of FRT, with identified source-pathway-receptor linkages, are:

- Decrease in air quality due to non-radioactive dust generation, primarily from vehicle and machinery movements on dirt tracks, wellfield operations, and vegetation clearance.
- Decrease in air quality due to radioactive dust or radon generation, resulting from radiological particulates released during drilling, routine ISR processes, or un-remediated radiological fluid spills.
- Decrease in air quality due to combustion emissions, including carbon monoxide (CO), sulphur dioxide (SO_2), nitrogen dioxide (NO_2), and particulate matter, released from fuel combustion during equipment, vehicle, and generator use.

7.10.3 Regulatory Outcomes and Compliance Conditions

The Fourth Schedule – Environmental Outcomes and Conditions of RL137 (Appendix A) establishes the regulatory requirements for air quality that Alligator Energy must meet throughout construction, operation, and post-completion. These requirements ensure that project activities do not result in air quality degradation or radiation exposure risks beyond regulatory thresholds.

Air Quality Outcome:

- The Tenement Holder must, during construction and operation, ensure there are no public health impacts and/or nuisance impacts as a result of airborne emissions and/or dust generated by field recovery trial activities.

Air Quality Criteria:

- The Tenement Holder is required to address the following matters for the purposes of Regulation 63(1)(c) of the Regulations in relation to Fourth Schedule Clause 15 for air quantity:
    - Establish measurement locations that are appropriate and of sufficient density and height to measure or infer the air quality.
    - Design of the monitoring and measurement criteria framework must consider a mechanism to determine changes in air quality that is caused by the field recovery trial as distinct from other sources of impact.

- The measurement parameters and values that are taken to demonstrate achievement of the outcome must appropriately measure change to baseline air quality or air quality at the control sites.
- The frequency of measurement must be appropriate to ensure demonstration of achievement of the outcome.
- Measurement criteria is to be determined through consultation with DEM, DEW, EPA and any other relevant government department.

Radiation Outcome:

- The Tenement Holder must ensure there are no public health or environmental impacts from radionuclides (including radon) as a result of field recovery trial activities or other authorised operations.

Radiation Criteria:

- The Tenement Holder is required to address the following matters for the purposes of Regulation 63(1)(c) of the Regulations in relation to Fourth Schedule Clause 17 for radiation;
  - Establish measurement locations that are appropriate and of sufficient density and height to measure or infer the radionuclide exposure;
  - Design of the monitoring and measurement criteria framework must consider a mechanism to determine changes in radionuclides that is caused by the field recovery trial as distinct from other sources of impact.
  - The measurement parameters and values that are taken to demonstrate achievement of the outcome must appropriately measure change to baseline radionuclide ranges or radionuclide levels at the control sites.
  - The frequency of measurement must be appropriate to ensure demonstration of achievement of the outcome.
  - Measurement criteria is to be determined through consultation with DEM, DEW, EPA and any other relevant government department.

7.10.4 Control, Management and Monitoring Activities

A comprehensive air quality and radiation management framework has been established to prevent public health impacts, environmental contamination, and nuisance dust emissions associated with FRT activities. This framework aligns with regulatory requirements and includes proactive controls, time-integrated monitoring and verification mechanisms to ensure compliance with air quality and radiation outcomes.

Dust Suppression Measures

Track and Access Route Management

Regular watering of roads and tracks using potable water mixed with dustbinder:

- Dustbinder prevents dust entrainment and when correctly applied eliminates dust from dirt roads.
- Dustbinder will be applied in the first weeks of construction and will be reapplied whenever dust is observed being generated higher than the axle height of any vehicle driving on the track at 20km/h
- Water and dustbinder will also be used on all construction and drilling sites.

Dust Control on Construction and Drilling Sites

- Water and dustbinder application at excavation, drilling, and high-dust activity areas.
- Time-integrated monitoring to ensure dust remains within acceptable levels.

Exclusion of Hard-Hooved Animals

- Hard-hooved animals, such as sheep and cattle, will be excluded from the fenced FRT area to prevent soil and vegetation disturbance and revegetation works.

Wind and Weather Considerations

- High wind conditions will be monitored, with winds frequently exceeding 18 km/h (5 m/s).
- Construction activities adjusted or postponed during high wind periods to reduce dust emissions.

Minimisation of Vegetation Clearance & Ground Disturbance

- Project footprint limited to 10.995 ha to prevent excessive ground disturbance.
- No large-scale vegetation clearance, stockpiling, or unnecessary land clearing.
- Use of pre-existing tracks for vehicle access, minimising soil exposure.

Combustion Emission Management

- Diesel generators will be maintained and operated in line with manufacturer specifications.
- Engine emissions from project vehicles and equipment comply with relevant Australian Standards for exhaust emissions.

Radiation Emission & Exposure Controls

- ISR processes are fully wet based, significantly limiting airborne radionuclide generation.
- No uranium precipitation will occur, and process residues remain contained within the lixiviant pipeline and tank system.
- Radiological spills, if they occur, are immediately remediated to prevent airborne dust contamination.
- Passive and active dust deposition monitoring is conducted at operational and control sites to track particulate movement and assess radiological content.
- Pregnant lixiviant spills are contained within bunded areas and remediated within 24 hours to prevent radionuclide dispersion.

Closure & Rehabilitation Controls

- All temporary infrastructure and equipment will be dismantled and removed upon project completion.
- Areas disturbed by FRT activities will be progressively rehabilitated to restore soil stability and vegetation cover.
- Radiological clearance surveys will be conducted to verify that residual activity levels meet pre-operational baseline conditions.
- Dust and airborne radionuclide monitoring will continue post-closure to confirm that long-term air quality standards are met.

Monitoring and Verification Programs

The monitoring and verification program for air quality is designed to assess compliance with the approved environmental outcomes for air quality and radiation. The program incorporates continuous and systematic monitoring, data analysis, and verification of control measures to ensure public health, environmental quality, and nuisance impacts are effectively managed.

The objectives of the monitoring and verification program are to:

- Verify that dust, particulate, and airborne radionuclide emissions from FRT activities remain within acceptable limits.
- Ensure compliance with the *Radiation Protection and Control Act 2021* and Regulations.
- Provide early detection of changes in air quality attributable to FRT activities, enabling timely corrective actions.
- Differentiate between air quality impacts caused by FRT activities and those from external sources (e.g., local traffic or pastoral activities).

Dust Deposition Monitoring

Passive dust deposition monitoring at the Samphire Project is designed to detect project-attributable changes in ambient dust levels within or immediately surrounding the RL, while accounting for natural background variability. Monitoring is conducted monthly across a network of operational (impact) and control sites, as detailed in Table 7.26 and Figure 7.15. Dust deposition is analysed and reported as total insoluble matter, expressed in grams per square metre per month (g/m²/month).

The compliance criterion of 4 g/m²/month, referenced in Table 7.27, is derived from Table 7.1 of the Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales (DEC, 2005). This benchmark is widely used across Australia and provides a scientifically and regulatorily recognised standard for assessing amenity-related dust impacts.

While this criterion is typically applied as a 12-month rolling average for ongoing operations, the Samphire Project is expected to operate for less than 12 months. Accordingly, dust deposition performance will be assessed using a 3-month rolling average, consistent with the project's limited operational timeframe. This modified approach ensures the criterion is applied proportionately while still enabling meaningful assessment of cumulative dust impacts.

The adoption of this criterion is justified based on both regulatory precedent and site-specific context. The surrounding land uses, primarily pastoral activity and potential future development, require effective dust management to maintain local air quality and avoid nuisance-level impacts. Applying this standard allows for early detection of emerging dust issues while accounting for contributions from natural background sources.

Results are reviewed monthly against the verification criteria in Table 7.27, with data from control sites used to provide context regarding meteorological conditions and background variability.

Radiation Monitoring

Given the importance of radiation protection, a comprehensive radiation monitoring program will ensure compliance with regulatory standards, focusing on airborne radionuclides and radon. Radiation monitoring has been included within the air quality monitoring framework because airborne pathways are a key transport mechanism for radionuclides.

Monitoring includes:

- Airborne Particulates: Long-lived alpha particles, and gamma emitting radionuclides using low and high-volume air sampling and gamma spectroscopy.
- Radon and Radon Decay Product Monitoring: Passive radon monitors (Rn) and radon decay product (RnDP) monitoring using Environmental Radon Daughter Product Monitors (ERDM).

The outcome measurement criteria for airborne gamma emitting radionuclides has been set at within ± 20% of baseline/control site levels during operational phases, as specified in Table 7.27. This is to account for:

- The known natural variability of background radiation, influenced by geochemical conditions, seasonal radon flux, and regional atmospheric conditions.
- The limited control data (i.e., one site) and the relatively short baseline dataset (≤6 months), which may not fully capture long-term trends.

Air quality monitoring locations are detailed in Table 7.26 and Figure 7.15, with the full monitoring program provided in Table 7.27.

Table 7.26: Air Quality (inc. Radiation) Monitoring Locations

ID	Monitoring Types	Impact or Control Site	Coordinates	
			Easting	Northing
RM1	DD, LLA, HVAS, Gamma, Rn, RnDP	Impact	723325	6323625
RM2	DD, LLA, Gamma, Rn, RnDP	Impact	723325	6324380
RM3	DD, LLA, Gamma, Rn, RnDP	Impact	723275	6325130
RM4	DD, LLA, Gamma, Rn, RnDP	Impact	722485	6324265
RM5	DD, LLA, Gamma, Rn, RnDP	Control	720360	6322670
RM6	DD, LLA, Gamma, Rn, RnDP	Impact	724000	6324390
RM7	DD, LLA, Gamma, Rn, RnDP	Control	720240	6326935
RM8	DD, LLA, Gamma, Rn, RnDP	Control	726615	6328940
RM9	HVAS	Impact	722423	6323689
RM10	HVAS	Control	709545	6317184

DD = Deposited dust, monitored via static dust deposition gauges
LLA = Airborne long lived alpha activity monitoring via low and medium volume sampling.
HVAS = High volume air sampling and radionuclide gamma spectroscopy.
Rn = Radon monitoring via passive radon monitors.
RnDP = Radon decay product monitoring via Electronic Radon Daughter Monitors (ERDMs)
Gamma = Environmental gamma dose monitoring locations.

Stakeholder Feedback and Complaints

Stakeholder feedback and complaints related to air quality and radiation impacts will be actively monitored throughout all project phases. Complaints will be logged in the stakeholder register, investigated within 7 days, and resolved with corrective actions implemented and documented within 14 days. Regular engagement with stakeholders will address concerns proactively and prevent escalation.

Compliance Reporting

Monitoring and verification results will be reviewed and included in the RL's Annual Compliance Reports submitted to regulatory authorities. These reports will provide:

- Dust deposition and radiation monitoring data, compared against baseline and control site values.
- Audit results verifying the implementation of air quality control measures.
- A summary of stakeholder feedback, complaints, and corrective actions.

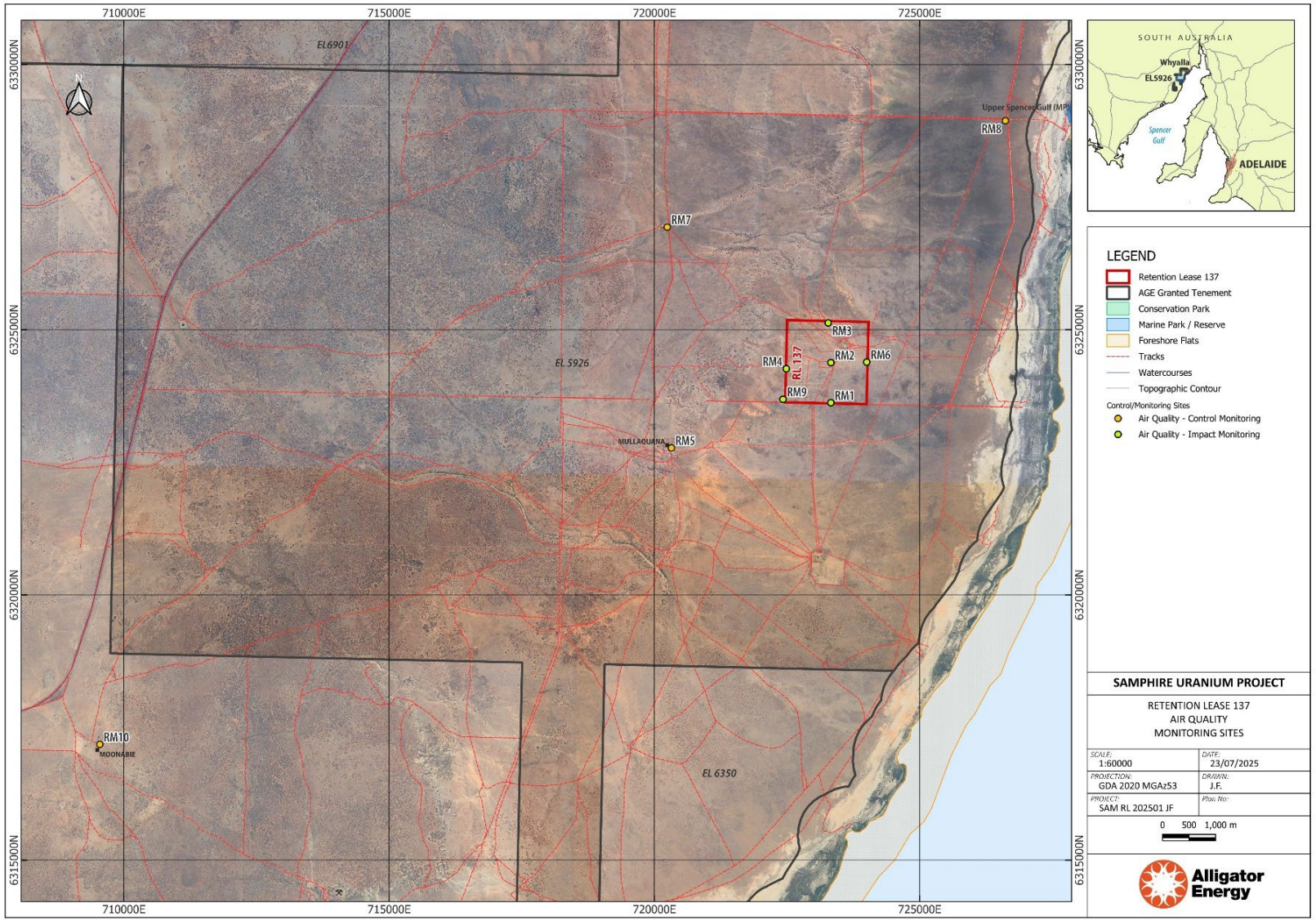


Figure 7.15: Air Quality Monitoring Locations

Uncertainties, Assumptions & Future Works

There are no significant uncertainties regarding the effectiveness of air quality and radiation management controls. However, regional infrastructure projects (such as future wind farms or pipeline construction) could contribute to dust levels detected during monitoring. If external developments are identified as potential dust sources, coordination with relevant stakeholders will be undertaken to distinguish project-related air quality impacts from broader regional influences.

Adaptive management strategies will be implemented if exceedances are observed, including increased monitoring frequency or additional dust suppression measures.

7.10.5 Outcome Measurement Criteria & Leading Indicator Criteria

The specific measurement criteria, measurement methods and the criteria for demonstrating compliance with the approved environmental outcome for air quality is provided in Table 7.27.

Where there is a high level of reliance on control strategies to achieve an environmental outcome, leading indicator criteria have also been provided to provide an early warning to the failure of control and management strategies.

Table 7.27: Outcomes, Measurement & Leading Indicator Criteria – Air Quality

Outcome	What will be Measured & Form	Locations	Frequency & Duration	Responsibility & Records	Control or Baseline Data	Outcome Achievement	Leading Indicator
Air Quality: No public health impacts and/or nuisance impacts as a result of airborne emissions and/or dust generated by field recovery trial activities.	Passive dust deposition deployed across the operational areas and representative control sites. Deposited dust is analysed for total insoluble matter (g/m^3/month).	Table 7.26 & Figure 7.15	Monthly during construction, operational, and physical decommissioning phases. One month per quarter for all non-active phases.	Environment Manager All records will be retained in Alligator Energy's Environment & Radiation Database.	Appendix O.	Deposited dust (total insoluble matter) at any operational (impact) monitoring site has not exceeded 4 g/m^2/month, averaged over a 3-month period.	Monthly passive dust deposition at any operational site exceeds that site's maximum baseline results for two consecutive periods.
Radiation: No public health or environmental impacts from radionuclides (including radon) as a result of field recovery trial activities or other authorised operations.	Airborne particulates via high-volume air sampler. Samples will be analysed for natural radionuclides using HR gamma-spectrometry: Th-234, Ra-226, Pb-210.	Table 7.26 & Figure 7.15	Monthly from the commencement of commissioning and during all active phases. Biannual during non-active phases.	Environment Manager All records will be retained in Alligator Energy's Environment & Radiation Database.	Appendix N.	Radionuclide concentrations will be monitored and maintained within ± 20% of the established baseline data ranges (Appendix N). If any exceedances occur, statistical testing will confirm whether the increase is statistically significant compared to the baseline and/or control site levels.	N/A.
			Biannual until all decommissioning and remedial works are complete, and closure criteria have been demonstrated.			Radionuclide concentrations will remain within the established baseline data ranges (Appendix N) for two or more consecutive sampling periods.	N/A

Outcome	What will be Measured & Form	Locations	Frequency & Duration	Responsibility & Records	Control or Baseline Data	Outcome Achievement	Leading Indicator
	Airborne particulates measured via low or medium flow sampling pumps and long-lived alpha activity analysed via alpha counters.	Table 7.26 & Figure 7.15	Monthly during active operational and decommissioning phases. Biannual during non-active phases.	Environment Manager All records will be retained in Alligator Energy's Environment & Radiation Database.	Appendix N.	Radiation dose rates from all exposure pathways for members of the public remain below 1 mSv per year above background levels.	Dose rates from all exposure pathways for members of the public exceeds 0.25 mSv in a monitoring quarter.
			Biannual until outcome achievement for closure can be demonstrated.			On closure, long-lived alpha activity must remain within the established baseline and control site ranges. If any exceedances occur, statistical testing confirms no significant increase ($p \geq 0.05$) compared to baseline and/or control site levels.	N/A
	Radon will be monitored using area Passive Radon Monitors, and Environmental Radon Daughter Product Monitors (ERDM) during active phases.	Table 7.26 & Figure 7.15	Monthly RnDP monitoring during active operational and decommissioning phases. Annual during non-active phases. Radon monitoring will commence from commissioning until closure outcomes can be demonstrated.	Environment Manager All records will be retained in Alligator Energy's Environment & Radiation Database.	Appendix N.	Radiation dose rates from all exposure pathways for members of the public remain below 1 mSv per year above background levels.	Dose rates from all exposure pathways for members of the public exceeds 0.25 mSv in a monitoring quarter.
						On closure, environmental radon and radon decay product concentrations at the designated monitoring locations are within the established baseline and control site ranges.	N/A

Outcome	What will be Measured & Form	Locations	Frequency & Duration	Responsibility & Records	Control or Baseline Data	Outcome Achievement	Leading Indicator
						If any exceedances occur, statistical testing confirms no significant increase ($p \geq 0.05$) compared to baseline and/or control site levels.	

7.11 Roads, Traffic & Transport

7.11.1 Context

During the construction, operation, and decommissioning phases of the FRT, Alligator Energy will utilise the existing Eight Mile Creek Road and an unnamed private road to access the RL, no new access roads will be constructed. Existing tracks within the RL will be utilised, with maintenance or minimal upgrades undertaken as necessary in consultation with the landholder. Access routes to the FRT are illustrated in Figure 4.11.

During the FRT, vehicle movements are estimated to include two–five light vehicle trips per day and an average of one heavy vehicle trips per week. During the mobilisation phase, up to two heavy vehicle movement per day may be required. A land access agreement is in place with the owner of the Moonabie property, where the RL is situated, ensuring all activities are conducted in accordance with the agreed terms and conditions.

Alternative all-weather access routes to the site are available, providing contingency options for vehicle movements during prolonged adverse weather conditions. The existing roads and tracks are in good condition and are deemed suitable for the types and weights of vehicles anticipated throughout the FRT.

Within the site, the internal track layout has been carefully designed to support safe and efficient vehicle movements while minimising vegetation clearance and disturbance. Access to the site is through Gate 2, located along the southeastern boundary, which connects to a multi-directional single-lane road serving as the primary internal track. To accommodate two-way traffic, strategically positioned turnout zones have been incorporated to ensure vehicles can pass safely and congestion is minimised. The track layout provides direct access to the FRT Plant, which serves as the central operational hub. Adjacent to the plant, a designated truck turnaround area enables the safe and efficient manoeuvring of heavy vehicles, including loading and unloading operations, without the need for reversing.

Gate 3, located near the southwestern boundary of the RL, functions as a supervised access point for vehicles and personnel. It includes a scan point to ensure security and operational oversight.

7.11.2 Potential Impacts

The potential impacts to traffic and transport from FRT operations have been assessed in the Samphire RL Proposal document (Alligator Energy, 2023b).

The key potential impacts associated with the development and implementation of FRT, with identified source-pathway-receptor linkages, are:

- Increased road and track use leading to deterioration of unsealed roads and tracks, particularly along Eight Mile Creek Road and unnamed private pastoral tracks, affecting landowners, councils, and road users. While vehicle movements will be limited, increased usage may require track maintenance.
- Increased risk of traffic accidents due to project-related light and heavy vehicle movements. Any increase in traffic along transport routes may elevate accident risks for local residents, workers, and tourists, though the overall traffic volume is expected to remain low.
- Potential spills of hazardous materials or waste during road transport of reagents, geophysical tools, or waste materials to and from the RL area. These spills could pose risks

to road users and local councils, necessitating spill response and transport safety measures.

An increase in congestion leading to transport delays was also assessed but not confirmed as a significant impact, as the estimated maximum daily project traffic (2–5 light vehicles and 1 heavy vehicle) is unlikely to cause noticeable delays.

7.11.3 Regulatory Outcomes & Compliance Conditions

The Fourth Schedule – Environmental Outcomes and Conditions of RL137 (Appendix A) outlines the regulatory requirements for traffic management that Alligator Energy must adhere to throughout the construction, operation, and post-completion phases of the project. These requirements are in place to ensure that project activities do not result in traffic-related accidents or safety issues beyond acceptable thresholds for both the public and FRT related traffic.

Traffic Safety Outcome:

- The Tenement Holder must, during construction and operation, ensure no traffic accidents involving members of the public and mine related traffic that could have been reasonably prevented by the Tenement Holder.

Traffic Strategies:

- Tenement Holder is required to address the following matters for the purposes of Regulation 63(1)(b) of the Regulations in relation to the Fourth Schedule Clause 19:
  - Develop a track maintenance program.
  - Develop a traffic management plan.

7.11.4 Control, Management & Monitoring Activities

Alligator Energy has developed a comprehensive traffic management strategy to ensure safe and efficient vehicle movements throughout the construction, operational, and closure phases of the FRT. These measures are designed to:

- Minimise traffic-related risks to personnel, contractors, and the public.
- Ensure road conditions remain suitable for project traffic.
- Maintain compliance with regulatory requirements outlined in the Fourth Schedule – environmental outcomes and conditions of RL137.

Traffic Management & Safety Measures

Traffic Management Plan

All vehicle movements adhere to a project specific Traffic Management Plan (Appendix T) which includes:

- Mandatory speed limits on both public and private access roads to ensure safe operations.
- Designated vehicle access routes that minimise environmental disturbance.
- Turnout zones along internal roads to accommodate two-way traffic and prevent congestion.
- Strict drug and alcohol policies apply to all personnel operating vehicles within the RL.

Operator Training & Inductions

- All vehicle operators are licensed and trained for their specific vehicle class.

- Contractors, employees, and visitors must complete an online induction covering:
  - Site-specific road use requirements.
  - Emergency response procedures for vehicle incidents.
  - Traffic safety protocols for shared road use with pastoral operations.

Road & Track Maintenance

Track Maintenance Program

A track maintenance program has been developed as part of the Traffic Management Plan (Appendix T) in collaboration with relevant landowners to:

- Monitor and maintain private access roads leading to and within the RL.
- Repair unsealed roads and tracks subject to increased traffic loads.
- Ensure road conditions remain suitable for both light and heavy vehicles throughout the FRT.

Maintenance activities will include:

- Grading and resurfacing where necessary to prevent track degradation.
- Drainage maintenance to prevent surface water pooling and minimise erosion where necessary.

Hazardous Material Transport & Compliance

Hazardous Transport Protocols

All chemical reagent transfers are conducted by licensed specialist operators, ensuring:

- Safe handling, loading, and unloading procedures.
- Compliance with transport regulations for hazardous materials.
- Waste transfers are managed by EPA-licensed operators using EPA transport certificates to ensure proper documentation and disposal.

Radiation Safety & Compliance

The transport of radioactive materials complies with:

- The Radiation Protection and Control Act 2021.
- Requirements for a valid Radiation Management Licence.
- Radioactive waste and material transport follows strict protocols, including:
  - Sealed and labelled containers.
  - Approved transport routes to licensed disposal facilities.

Incident Prevention & Response Measures

Traffic Incident Reporting & Management

A hazard and incident reporting system is in place to:

- Log and investigate traffic-related incidents.
- Implement corrective actions to prevent future occurrences.
- Ensure timely response to stakeholder concerns or complaints.
- Stakeholder complaints regarding traffic impacts will be logged and reviewed to identify improvement areas.

Emergency Response for Traffic Incidents

Emergency response plans include:

- Defined response protocols for vehicle accidents or road hazards.
- Communication systems for notifying emergency responders in case of an incident.
- Coordination with local authorities for emergency support if required.

Monitoring & Compliance Verification

Compliance Monitoring

Traffic and road use monitoring will be conducted to ensure:

- Adherence to traffic management protocols.
- Proper maintenance of access roads.
- Safe transport of hazardous materials.

Record-Keeping & Audits

All records related to traffic, incidents and hazards, community complaints, road maintenance, and hazardous transport will be:

- Retained in Alligator Energy's internal safety and stakeholder management databases.
- Reviewed annually as part of compliance audits.
- Audited to confirm timely resolution of traffic hazards and complaints.

Community Engagement & Feedback

Regular engagement with adjacent landowners and road users to:

- Assess potential traffic concerns.
- Ensure transparency in project-related road use.
- Address feedback through adaptive traffic management measures.

Uncertainties, Assumptions & Future Works

The control strategies presented above have been assessed to determine whether any significant uncertainties exist regarding their effectiveness, including the sensitivity of any such uncertainties and whether additional future works would be required to address them.

No significant uncertainties, assumptions, or future works have been identified or planned.

7.11.5 Outcome Measurement Criteria & Leading Indicator Criteria

The specific measurement criteria, measurement methods and the criteria for demonstrating compliance with the approved environmental outcome for road use, traffic and the transport of goods is provided in Table 7.28.

Where there is a high level of reliance on control strategies to achieve an environmental outcome, leading indicator criteria have also been provided to provide an early warning to the failure of control and management strategies.

Table 7.28: Outcomes, Measurement & Leading Indicator Criteria – Roads, Traffic & Transport

Outcome	What will be Measured & Form	Locations	Frequency & Duration	Responsibility & Records	Control or Baseline Data	Outcome Achievement	Leading Indicator
Traffic: During construction and operation, ensure no traffic accidents involving members of the public and mine related traffic that could have been reasonably prevented by the Tenement Holder.	Reported traffic hazards, incidents, and complaints Investigation records and corrective actions Site visitor and worker induction and training completion records related to site access and traffic management.	N/A	Event based reporting and investigations. Annual audit of records relating to traffic incidents and complaints until RL relinquishment.	Environment Manager All records will be retained in Alligator Energy's internal safety and stakeholder management databases.	N/A	An audit of internal records demonstrates: • All traffic incidents and complaints are logged and investigated in accordance with internal procedures. • Investigations determine that incidents could not have been reasonably prevented, with root causes identified and corrective actions applied where relevant.	N/A

7.12 Noise

7.12.1 Context

As detailed in Section 2.18, a baseline noise study was conducted by Sonus Pty Ltd (2023) at Mullaquanna Station between 15 and 29 September 2023 (Appendix Q). The study confirmed that the RL area is characterised by a remote rural noise environment, with minimal anthropogenic noise. The monitoring revealed that natural sources, such as wind, fauna, and occasional pastoral activities, dominate the acoustic environment.

During the monitoring period, median daytime noise levels ranged between 42 and 50 dB(A), while nighttime levels ranged from 20 to 31 dB(A). These results align with Alligator Energy's preliminary estimates, suggesting background noise levels of less than 30 dB(A) during calm, non-windy nights. Notably, noise from a drill rig could not be detected above the ambient background noise at the Mullaquanna Homestead, reinforcing that the noise environment is predominantly low.

The nearest residential dwelling is located approximately 2.4 km southwest of the RL, with the Cowleds Landing beach shacks situated 5.1 km northeast, and Nonowie Homestead located 7.5 km away.

A further modelling review was undertaken in June 2025 by Resonate and monitoring recommendations provided (report A250511LT1). A subsequent report further reviewed the EPA policy and limits in July 2025 (report A250511LT1A). The report provided compliance limits for a location point (NM1) to ensure the EPA noise policy night time limit of 49 dB(A) and daytime noise limit of 57 dB(A) at the Mullaquanna homestead location is maintained.

Noise Sources

Noise during the construction and decommissioning phases will primarily result from the use of heavy equipment such as cranes, trucks, generators, and excavation machinery. Peak noise levels for these activities are estimated to be around 100 dB at the source. Generators will contribute approximately 70 dB, and vehicle movements (e.g., trucks and utility vehicles) will generate similar levels. These activities will be carried out in compliance with the Environment Protection (Commercial and Industrial Noise) Policy 2023, ensuring adherence to noise regulations.

During the operational phase, which will run 24/7 for an estimated period of three months, noise will primarily originate from equipment such as a 15 kW centrifugal pump (producing 70–75 dB at 1 meter), diaphragm and dosing pumps (producing 50–60 dB), and a boom forklift (90–100 dB at 1 meter). Additionally, construction vehicles will contribute to the site noise. At night, noise will mainly come from an 11 kW centrifugal pump, surrounded by noise deadening tanks and a high-pressure pump, housed within a shipping container, producing up to 70 dB. Submersible pumps placed below the water surface will generate minimal surface noise, with their associated 4 kW variable speed drives (housed within a switchboard container) rated at 60–65 dB.

For context, a Toyota Hilux utility vehicle generates noise levels of around 70–75 dB at 1 meter under typical operating conditions. Noise attenuation follows the inverse square law, where sound levels decrease by 6 dB with each doubling of distance from the source. For example, a 70 dB noise source at 1 meter would attenuate to 64 dB at 2 meters, 58 dB at 4 meters, and 52 dB at 8 meters. Additional attenuation is anticipated from ground absorption, with soft soil and low vegetation providing an estimated 1–2 dB reduction per doubling of distance.

7.12.2 Potential Impacts

The potential impacts of noise from FRT operations have been assessed in the Samphire RL Proposal document (Alligator Energy, 2023b).

The key potential impact associated with the development and implementation of FRT, with identified source-pathway-receptor linkages, is:

- Nuisance noise levels at nearby residential properties, resulting from project-related vehicle movements, construction, operational, and decommissioning activities.

7.12.3 Regulatory Outcomes & Compliance Conditions

The Fourth Schedule – Environmental Outcomes and Conditions of RL137 (Appendix A) outlines the regulatory requirements for noise management that Alligator Energy must comply with during construction, operation, and post-completion phases of the project. These requirements are designed to prevent adverse noise impacts that could affect the public or result in nuisance complaints due to field recovery trial activities or other authorised operations.

Noise Outcome:

- The Tenement Holder must, during construction and operation, ensure no public nuisance impacts from noise as a result of field recovery trial activities or other authorised operations.

7.12.4 Control, Management & Monitoring Activities

Alligator Energy is committed to minimising noise impacts associated with the FRT by implementing a range of proactive noise management strategies. These measures are designed to reduce noise disturbance to nearby receptors, particularly the Mullaquana Homestead, which has been identified as the most sensitive noise receptor.

Noise Source Management

Equipment & Machinery Selection

- All equipment and machinery will be selected and maintained to minimise noise emissions and comply with occupational and environmental noise standards.
- Where feasible, low-noise equipment will be prioritised for use in site operations.

Operational Controls & Scheduling

- Daytime Scheduling of Noisy Activities:
  - Where possible, noisy construction, decommissioning, and operational activities will be conducted during daytime hours to minimise nighttime disturbances.
- Limiting Non-Essential Equipment Use at Night:
  - Non-essential equipment and machinery will not be operated at night unless required for critical activities.

Vehicle Movements & Traffic Noise Reduction

- The small project workforce results in minimal vehicle movements, reducing traffic-related noise impacts.
- One-way traffic flow will be implemented where possible to:

    - Reduce noise from reversing alarms.
    - Optimise vehicle movement efficiency to limit unnecessary acceleration or braking noise.
- Noise from reversing alarms will be further reduced by:
    - Using low-noise or broadband reversing alarms where feasible.
    - Designing one-way vehicle movement routes to minimise reversing requirements.

Natural & Baseline Noise Attenuation

Regional Wind Conditions & Natural Noise Barriers

- Frequent wind speeds exceeding 18 km/h (5 m/s) are typical for the region and will contribute to natural noise attenuation for construction and operational activities.
- The presence of a large dam near the homestead, aligned with the FRT area, provides additional natural noise attenuation, further reducing noise propagation.

Low Baseline Noise Contribution

- Baseline noise studies indicate that noise from operational vehicles and equipment is already inaudible at the Mullaquana Homestead.
- Given this low baseline noise contribution, FRT site activities are expected to contribute minimally to overall ambient noise levels and are not anticipated to result in sustained exceedances of policy thresholds at the Mullaquana Homestead.

Community Engagement & Complaints Management

Community Consultation & Notification

Ongoing communication with adjacent landholders and residents to:

- Inform them about the project's construction schedule and operational activities.
- Address concerns proactively and implement adaptive management measures where required.

Community Feedback & Complaints Register

A community feedback and complaints register will be maintained to:

- Record and track any noise-related concerns from local residents.
- Trigger investigations into any reported noise issues.
- Ensure corrective or adaptive management measures are implemented where necessary.

Project Duration & Noise Exposure

The total duration of construction, operation, and decommissioning is estimated to be less than 12-18 months, ensuring that:

- Noise-generating activities are short-term and temporary.
- Potential disturbances are minimised through controlled scheduling and management practices.

Monitoring & Verification

To ensure ongoing compliance with environmental noise regulations, a noise monitoring system will be installed adjacent the Mullaquana property boundary, between the FRT operational area and within a direct line to the most sensitive nearby receptor to the RL.

The continuous noise monitoring program will:

- Collect additional data on baseline noise conditions prior to operational activities.
- Measure and record real-time noise levels, allowing for immediate detection of exceedances.
- Enable prompt investigation and corrective actions if noise levels approach or exceed regulatory thresholds.
- Ensure compliance with the Environment Protection (Commercial and Industrial Noise) Policy 2023 and other applicable environmental noise regulations.

The monitoring system will be calibrated and maintained regularly to ensure accurate and reliable data collection. Where noise levels approach or exceed regulatory thresholds, and are determined to be attributable to project activities, mitigation strategies. such as operational adjustments, will be implemented to prevent sustained exceedances and minimise impacts on nearby receptors. Noise monitoring data will be evaluated against the outcome measurement criteria in Table 7.30, which references the applicable maximum noise levels under the *Environment Protection (Commercial and Industrial Noise) Policy 2023* for the nearest sensitive receptor.

The monitoring locations are detailed in Table 7.29 and Figure 7.16.

Table 7.29: Noise Monitoring Location

ID	Site Details	Monitoring Types	Site Type	Coordinate GDA2020 / MGA 54	
				Easting	Northing
NM1	Near the South west corner of RL, close to Mullaquanna boundary	Permanent monitoring site	Control/Diagnostic Location.	722466	6323650
NM2	Near Mullaquanna homestead, at the same site as RM5	Permanent monitoring site	Compliance Assessment Point (Sensitive Receiver)	720441	6322815

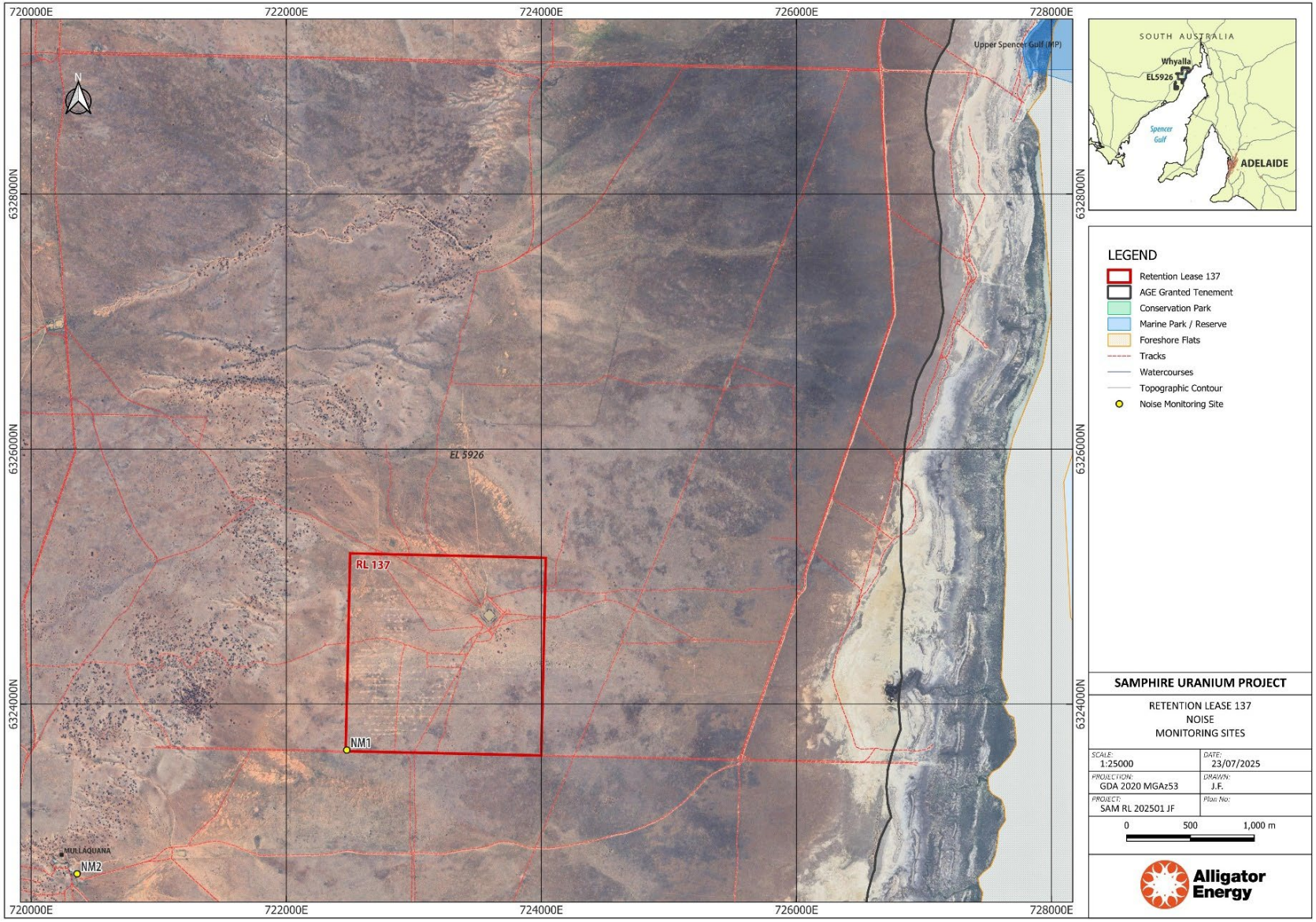


Figure 7.16: Noise Monitoring Locations (NM1 & NM2)

Uncertainties, Assumptions & Future Works

The control strategies presented above have been assessed to determine whether any significant uncertainties exist regarding their effectiveness, including the sensitivity of any such uncertainties and whether additional future works would be required to address them.

An independent baseline noise monitoring program was conducted at Mullaquanna homestead by Sonus Pty Ltd in September 2023 (Appendix Q & R) with the collected data providing an indication of baseline noise levels. Additionally, noise data was recorded during exploration drilling within the FRT site, and these results were compared against the requirements of the Environmental Protection (Commercial and Industrial Noise) Policy 2023. A further model review was undertaken by Resonate Consultants to provide noise limits for the Mullaquanna boundary monitoring location. This assessment confirmed the FRT noise impacts at the premises will be negligible, providing confidence in the control strategies (Appendix Q).

Uncertainties remain regarding the potential cumulative or singular noise impacts of other proposed local developments projected over the next 10 years (e.g., large-footprint water supply pipelines, wind and solar farms). These changes in land use may negatively impact noise in the area. It is acknowledged that future cumulative noise impacts may emerge from third-party developments beyond Alligator Energy's control. These will be reviewed if relevant during ongoing monitoring and stakeholder engagement.

7.12.5 Outcome Measurement Criteria & Leading Indicator Criteria

The specific measurement criteria, measurement methods and the criteria for demonstrating compliance with the approved environmental outcome for noise is provided in Table 7.30.

Where there is a high level of reliance on control strategies to achieve an environmental outcome, leading indicator criteria have also been provided to provide an early warning to the failure of control and management strategies.

Table 7.30: Outcomes, Measurement & Leading Indicator Criteria – Noise

Outcome	What will be Measured & Form	Locations	Frequency & Duration	Responsibility & Records	Control or Baseline Data	Outcome Achievement	Leading Indicator
Noise: No public nuisance impacts from noise as a result of field recovery trial activities or other authorised operations.	Noise level measurements undertaken using a calibrated sound level meter in line with Australian and New Zealand Standard AS/NZS IEC 61672.1:2019.	Table 7.29 & Figure 7.16.	Permanent noise monitoring during active operational phases.	Environment Manager All records will be retained in Alligator Energy's Environment Database.	Appendix R.	Measured noise levels at the Mullaquanna Boundary (impact site NM1) do not result in sustained or attributable exceedances of the prescribed EPA prescribed noise policy limits from confirmed project related activities when compared to Mullaquanna monitoring site NM2. Noise generated by FRT or other authorised operations, at NM1, will not exceed: • 79 dB(A) during daytime (7 am – 10 pm) • 71 dB(A) during night-time (10 pm – 7 am)	N/A
	All reported stakeholder comments or complaints related to noise. Timing for close out of complaints or incidents.	Event-based monitoring if specific complaints or incidents are reported.	Annual until RL relinquishment.	Environment Manager All records will be retained in Alligator Energy's Environment Database.	N/A	Audit of all logged stakeholder complaints demonstrates all reported stakeholder complaints were followed up within 24 hours and investigated in full within 7 days.	N/A

7.13 Public Health & Safety

7.13.1 Context

The RL area is situated entirely within the privately managed Moonabie Pastoral Lease, with no direct public access to the operational area. The nearest public access point is via the unsealed Eight Mile Creek Road, which provides entry to Cowleds Landing Beach Shacks as well as access roads servicing the Moonabie, Nonowie, and Mullaquana Stations. The majority of the surrounding area, excluding the immediate coastal fringe, is secured by locked gates to restrict public entry. These gates are managed by the respective landowners of the Nonowie and Mullaquana Stations, providing additional layers of access control.

The portion of the RL designated for the FRT will be fully fenced and locked at all times to prevent unauthorised access. To enhance security, CCTV systems will be installed at key access points and operational areas, with 24/7 external monitoring during any unmanned project phases where residual FRT infrastructure remains in place.

In the event that the FRT results in a decision to proceed to a ML application, the site will be partially decommissioned and rehabilitated to maintain environmental and public safety (see Section 5). All residual chemicals, fuels and reagent storage vessels will be removed from site. Wells not required for environmental monitoring or ongoing use will be sealed and capped. Areas where infrastructure has been decommissioned will be monitored and assessed to demonstrate no residual contaminants remain (See Section 7.2). Specific infrastructure, such as the process plant or transportable buildings, may be retained securely on-site for future reuse. Eluate generated by the FRT will be securely stored within the fenced, locked and 24/7 monitored bunded trial plant area.

In the event that the FRT does not progress to a full ML application a comprehensive closure strategy will be implemented to ensure the long-term safety and health of the public (see Section 5). All FRT surface infrastructure will be dismantled and removed in accordance with closure specifications detailed in Section 5 to eliminate potential physical hazards, prevent unauthorised access, and reduce the risk of residual contamination. Post-remediation radiological and chemical monitoring will be conducted to verify that contaminants are within safe regulatory limits.

These measures, combined with independent verification of closure activities, will ensure that the site does not pose residual risks to public health, safety, or the environment, guaranteeing a safe return to natural land use conditions.

Note that additional considerations for land use during closure are addressed in Section 7.7.

7.13.2 Potential Impacts

The potential impacts to public safety and third-party property from FRT operations have been assessed in the Samphire RL Proposal document (Alligator Energy, 2023b).

The key potential impacts associated with the development and implementation of FRT, with identified source-pathway-receptor linkages, are:

- Public injuries and/or fatalities due to unauthorised access to the RL, where members of the public may enter the site and come into contact with equipment, machinery, or ISR infrastructure, posing a risk of injury.

- Increased radiation dose to the public exceeding statutory limits, resulting from ISR field trial activities, including drilling, ISR operations, and IX processing. Potential exposure pathways include airborne long- and short-lived alpha particulates and gamma radiation.

7.13.3 Regulatory Outcomes & Compliance Conditions

The Fourth Schedule – Environmental Outcomes and Conditions of RL137 (Appendix A) sets forth the regulatory requirements for public health, safety, and protection of property that Alligator Energy must adhere to during construction, operation, and post-completion phases. These conditions are aimed at ensuring that the project is carried out in a way that protects public health and safety, prevents accidents, and avoids adverse impacts on third-party land use or property.

In addition to public safety and land use protections, the Fourth Schedule of RL137 also provides radiation-related outcomes, particularly in relation to potential impacts on third parties, both during the operational phase and after project closure. These impacts are assessed across multiple exposure pathways, excluding air quality, which is addressed separately.

Public Safety Outcomes:

- The Tenement Holder must during construction and operation ensure that unauthorised entry to the site does not result in public injuries and/or deaths that could have been reasonably prevented.
- The Tenement Holder must demonstrate that post completion, the risks to the health and safety of the public so far as it may be affected by FRT activities or other authorised activities are as low as reasonably practicable.

Radiation Outcome:

- The Tenement Holder must ensure there are no public health or environmental impacts from radionuclides (including radon) as a result of FRT activities or other authorised operations.

Radiation Criteria:

- The Tenement Holder is required to address the following matters for the purposes of Regulation 63(1)(c) of the Regulations in relation to Fourth Schedule Clause 17 for radiation:
    - Establish measurement locations that are appropriate and of sufficient density and height to measure or infer the radionuclide exposure.
    - Design of the monitoring and measurement criteria framework must consider a mechanism to determine changes in radionuclides that is caused by the FRT as distinct from other sources of impact.
    - The measurement parameters and values that are taken to demonstrate achievement of the outcome must appropriately measure change to baseline radionuclide ranges or radionuclide levels at the control sites.
    - The frequency of measurement must be appropriate to ensure demonstration of achievement of the outcome.
    - Measurement criteria is to be determined through consultation with DEM, DEW, EPA and any other relevant government department.

7.13.4 Control, Management & Monitoring Activities

To ensure public health and safety during all construction, operational, and post-closure phases, a range of preventative, management, and verification strategies will be implemented. These measures focus on preventing unauthorised access, mitigating potential radiation exposure risks, and verifying compliance with safety and environmental standards.

Site Security & Access Control

Fencing & Access Restrictions

- Full perimeter fencing around operational areas (e.g., wellfields, FRT plant) to prevent unauthorised entry.
- Locked gates and secure access points to restrict entry, with access logs maintained.
- Warning signage installed at all perimeter locations, clearly indicating restricted access and potential hazards.

24/7 Security Measures

CCTV surveillance installed at all critical access points, including:

- Main RL entrance (Gate 2).
- Entry points to fenced FRT operational and plant areas.
- Internal monitoring of processing plant and reagent storage zones.
- CCTV feeds monitored remotely when the site is unmanned.

Incident Reporting & Investigation

- Any unauthorised access incidents logged immediately in the internal incident reporting system.
- Full investigation conducted within 30 days by an independent third party for any injury or security breach.
- A stakeholder complaints register will track and resolve all safety-related concerns within 14 days.

Public Engagement & Awareness

- Regular landholder communication to ensure pastoralists remain informed of site activities and security procedures.
- Supervised site visits for community members, providing a controlled environment to observe operations safely.

Radiation Protection & Exposure Control

Radiation Exposure Management

- ISR operations are fully wet based, preventing airborne radionuclide generation.
- All uranium-bearing materials remain within a closed-loop piping and tank system, eliminating exposure pathways to the public.

Gamma & Radon Monitoring

- Environmental gamma dose rates will be monitored using permanently installed Optically Stimulated Luminescence (OSL) monitors at designated locations (Table 7.26).
- Radon and radon decay product concentrations will be continuously monitored in operational areas and control sites.

Post-Closure Radiation Surveys

- Gamma radiation surveys will be conducted at a minimum of 3-meter grid spacings across all operational areas, ensuring that post-closure radiation levels remain within baseline conditions.
- Statistical analysis ($p \geq 0.05$) will determine whether post-closure radiation levels are significantly different from baseline conditions.
- Baseline and post-closure soil samples will be analysed via gamma spectrometry for key radionuclides (U-234, Th-230, Ra-226, Pb-210).

Regulatory Compliance Verification

- Quarterly monitoring of gamma and radon exposure levels during active phases, ensuring compliance with the 1 mSv per year public dose limit.
- Early warning trigger (0.25 mSv per monitoring quarter) implemented to identify potential exceedances before regulatory limits are approached.

Closure & Rehabilitation Measures

Infrastructure Decommissioning & Site Reinstatement

- Complete removal of FRT surface infrastructure, including:
  - Process plant, transportable buildings, and ISR pipework.
  - All residual chemical and reagent storage facilities.
  - Decontamination of any equipment before removal.
- Verification inspections to confirm all infrastructure has been decommissioned per closure specifications (Section 5).

Well Decommissioning & Groundwater Protection

- Extraction and Injection wells not required for ongoing groundwater monitoring programs, or future use will be sealed using best-practice decommissioning methods (cement grout from bottom of hole to top) to prevent vertical contamination.
- Groundwater monitoring data compared against modelled natural attenuation predictions to ensure compliance with target water quality objectives.

Contaminant Verification & Remediation

- Post-remediation chemical and radiological monitoring conducted to verify no residual contamination remains.
- Independent third-party verification surveys to confirm compliance with soil and water closure standards.

Landform & Vegetation Restoration

- Regrading of disturbed land to match surrounding topography to prevent erosion and ensure stability.
- Revegetation with native species to restore ecological function and prevent dust generation.
- Aerial photogrammetry surveys to confirm vegetation regrowth and land use compatibility post-closure.

Final Public Safety Compliance Check

- Independent site inspection conducted before relinquishment of RL, verifying:
  - All decommissioning and remediation activities meet closure specifications.

- The site poses no residual risks to public health and safety.
- Radiation and contaminant levels remain within acceptable limits.

Uncertainties, Assumptions & Future Works

The control strategies presented above have been assessed to determine whether any significant uncertainties exist regarding their effectiveness, including the sensitivity of any such uncertainties and whether additional future works would be required to address them.

No significant uncertainties, assumptions, or future works have been identified or planned. The existing control strategies are considered robust and adequately validated based on current site conditions and available data.

Again, uncertainties are acknowledged regarding the cumulative or singular impacts of other proposed local developments projected over the next 10 years (e.g., large-footprint water supply pipelines, wind and solar farms). It is planned to make best endeavours to communicate with all future land users.

7.13.5 Outcome Measurement Criteria & Leading Indicator Criteria

The specific measurement criteria, measurement methods and the criteria for demonstrating compliance with the environmental outcomes for public health, safety and property detailed in Section 7.13.3, are provided in Table 7.31.

Where there is a high level of reliance on control strategies to achieve an environmental outcome, leading indicator criteria have also been provided to provide an early warning to the failure of control and management strategies.

Table 7.31: Outcomes, Control & Management Strategies – Public Health, Safety & Property

Outcome	What will be Measured & Form	Locations	Frequency & Duration	Responsibility & Records	Control or Baseline Data	Outcome Achievement	Leading Indicator
Public Safety: During construction and operation ensure that unauthorised entry to the site does not result in public injuries and/or deaths that could have been reasonably prevented.	Site inspections (including photographic records) to assess all FRT gates remain closed and locked when not in use (actively attended), fences are intact, and security systems are in place and functioning.	FRT operational area fence line, FRT plant area, gates and main RL paddock gates (Figure 4.13).	Monthly inspection during construction, operational and active decommissioning phases. Quarterly during care & maintenance phases.	Environment Manager. All records will be retained in Alligator Energy's Safety Management Database.	N/A	Audit of security inspection records demonstrates: • Perimeter fencing around the operational portions of the RL has been completed prior to construction commencing and is retained during all construction and operational phases. • Perimeter fencing around the trial processing plant area has been constructed prior to commissioning commencing and is retained throughout the operational and care & maintenance phases. • All gates leading into the RL paddock area and gates into the FRT operational area, and FRT plant area remain closed and locked when not actively attended. • CCTV has been installed in the following locations prior to commissioning commencing and are retained during all construction, operational and decommissioning phases: o Gate 2 o Gates into the FRT operational area o Gates into the FRT plant area o Operational components within the FRT plant area • 24/7 security surveillance is in place and functional prior to the cessation of 24/7 site manning.	N/A

Outcome	What will be Measured & Form	Locations	Frequency & Duration	Responsibility & Records	Control or Baseline Data	Outcome Achievement	Leading Indicator
	All reported hazards & incidents involving any third-party. All reported stakeholder comments or complaints. Timing for close out of complaints or incidents.	Event Based	Annual to RL relinquishment.	Environment Manager All records will be retained in Alligator Energy's Safety Management and/or Stakeholder Database.	N/A	Annual audit of internal records finds: • All public injuries and/or deaths resulting from unauthorised access to the tenement are recorded in the incident register within 24 hours and are formally investigated by a suitably qualified independent third-party within one calendar month (or other time as agreed with Regulatory agencies). • The results of the documented investigations demonstrate the tenement holder could not have reasonably prevented the incident from occurring.	N/A
Public Safety - Closure: Demonstrate that post completion, the risks to the health and safety of the public so far as it may be affected by field recovery trial activities or other authorised activities are as low as reasonably practicable.	Physical site inspection and review conducted by a suitably qualified expert to review all decommissioning and remediation records to confirm all infrastructure has been removed, wells decommissioned and contaminants removed in accordance with the closure specifications detailed in Section 5.	Entire RL area.	Immediately prior to an application to relinquish the RL[8].	Environment Manager All records will be retained in Alligator Energy's Safety Management Database.	N/A	Independent site inspection and documentation review confirms that all closure activities (e.g., infrastructure removal, well decommissioning, land recontouring, contaminant remediation) meet the approved closure plan (Section 5) and closure requirements for soil (Table 7.1), surface water (Table 7.16), land use (Table 7.22) amenity (Table 7.25) ensuring no residual risks to public health and safety.	N/A

[8] Where the RL is not subsumed by a larger ML application.

Outcome	What will be Measured & Form	Locations	Frequency & Duration	Responsibility & Records	Control or Baseline Data	Outcome Achievement	Leading Indicator
Radiation: No public health or environmental impacts from radionuclides (including radon) as a result of field recovery trial activities or other authorised operations	Environmental gamma dose rates will be measured utilising permanently sited Optically Stimulated Luminance (OSL) monitors.	Table 7.26 & Figure 7.15.	Quarterly during all active project phases.	Environment Manager All records will be retained in Alligator Energy's Environment & Radiation Database.	Appendix N	Radiation dose rates from all exposure pathways for members of the public remain below 1 mSv per year above background levels.	Dose rates from all exposure pathways for members of the public exceeds 0.25 mSv in a monitoring quarter.
	Gamma dose rates survey completed at a minimum of 3 m grid spacings within the footprint of all operational infrastructure (e.g., well arrays, FRT plant areas, pipeline routes), where sources of potential radiological contaminants exist.	Operational areas of the RL (Figure 4.2).	1 x on conclusion of decommissioning and remediation works.	Environmental Manager Radiation records are stored in the Alligator Energy Radiation Database.	Appendix N	Radiological surveys conducted at closure confirm that: • All post-closure radiation measurements are ≤ maximum baseline levels. • If exceedances occur, statistical testing confirms no significant increase in mean dose rates ($p \geq 0.05$).	N/A
See Table 7.26 (Air Quality) for the consideration of other radiation exposure pathways.							

7.14 Waste

7.14.1 Context

The Samphire FRT will generate a variety of waste streams, including sewage, greywater, packaging materials, putrescible waste, unused chemicals, decommissioned infrastructure, and contaminated soil. These waste streams will be managed in compliance with the requirements outlined in the Environment Protection Act 1991, the Radiation Protection Act 2021, and their associated regulations and guidelines.

Alligator Energy's waste management approach is as follows:

- Non-radioactive waste: All non-radioactive waste will be transported offsite by licensed contractors to authorised facilities in Whyalla for appropriate disposal, recycling, or treatment.
- Low-level radioactive solid waste: Disposal of low-level radioactive solid waste will be conducted strictly in accordance with the project's RMP, ensuring compliance with all relevant regulatory requirements. Licensed contractors will transport this waste to authorised disposal facilities.

Further details on waste types, estimated generation amounts and disposal pathways are provided in Section 4.5.

7.14.2 Potential Impacts

The potential impacts of waste generation and disposal from FRT operations have been assessed in the Samphire RL Proposal document (Alligator Energy, 2023b).

The key potential impact associated with the development, implementation and closure of the FRT, with identified source-pathway-receptor linkages, is:

- Environmental contamination and health risks due to improper disposal of commercial or industrial waste, including hazardous materials, process residues, and general operational waste.

7.14.3 Regulatory Outcomes & Compliance Conditions

The Fourth Schedule – Environmental Outcomes and Conditions of RL137 (Appendix A) outlines the regulatory requirements for waste management that Alligator Energy must adhere to during the construction, operation, and post-completion phases. These conditions ensure that all waste generated by project activities is managed and disposed of in a way that complies with applicable legislation, prevents environmental harm, and minimises risks to human health.

Waste Outcome:

- The Tenement Holder must in constructing and operating the Lease ensure that all commercial or industrial waste is disposed of in accordance with relevant legislation.

7.14.4 Control, Management & Monitoring Activities

Waste Management Strategy

Alligator Energy is committed to implementing best-practice waste management strategies throughout all phases of the FRT within the RL. The company's approach aligns with the waste management hierarchy established under the Environment Protection Act 1993, as well as the requirements of the Radiation Protection and Control Act 2021, ensuring the safe handling, storage, and disposal of radioactive and non-radioactive waste.

The waste management hierarchy prioritises the following approaches:

1. Avoidance & Minimisation: Preventing waste generation at the source through operational efficiencies and process optimisation.
2. Reuse & Recycling: Maximising resource recovery to reduce landfill dependency and minimise environmental impact.
3. Treatment & Disposal (as a last resort): Ensuring safe and responsible disposal of residual waste, particularly radioactive materials, in compliance with legislative and regulatory requirements.

By systematically applying this hierarchy, Alligator Energy aims to; reduce environmental impacts associated with waste generation and disposal, optimise resource efficiency through material reuse and recycling and ensure full compliance with the Environment Protection Act 1993 and the Radiation Protection and Control Act 2021.

1. Avoidance & Reduction

Process Optimisation to Minimise Waste Generation

Advanced process optimisation techniques have been implemented to minimise waste generation during ISR operations, ensuring that waste production is prevented at the source. This includes:

- Precise Control of Lixiviant Injection and Extraction Volumes
  - Optimising the injection and extraction process to maximise uranium recovery while minimising unnecessary fluid waste generation.
  - Advanced real-time monitoring of lixiviant flow rates to prevent overuse and inefficiencies.
  - Adaptive recovery techniques to ensure the process is responsive to changing conditions.
- Reduction of Residual Fluid Volumes
  - Limiting the volume of water and chemical reagents needed per extraction cycle.
  - Engineering process refinements to reduce residual process fluid accumulation, minimising excess liquid waste.
  - Implementing hydrogeological modelling to ensure optimal lixiviant circulation with minimal waste generation.

Waste Minimisation Strategies

Alligator Energy actively designs and operates its waste management systems to eliminate unnecessary waste production through:

- Use of Reusable Materials and Reduction of Single-Use Plastics
  - Preference for multi-use equipment and containers to reduce single-use disposables.
  - Procurement policies that prioritise bulk materials with minimal packaging waste.

    - Restriction of non-essential disposable plastics from site operations.
- Provisions for Offsite Recycling and Reuse
    - Sorting and repurposing materials where feasible to extend their lifecycle.
    - Decontamination of items with surface contamination to facilitate reuse.
    - Partnerships with certified recycling facilities to process scrap metals, plastics, and other recyclable materials.
- Efficient Equipment Utilisation
    - Hiring specialised equipment for short-term use rather than purchasing items that contribute to long-term waste accumulation.
    - Maintaining equipment to extend operational life, reducing premature disposal.
- Use of Returnable or Reusable Containers
    - Bulk liquid storage solutions designed for multiple uses before requiring disposal.
    - Reusable intermediate bulk containers (IBCs) for storage and transport of chemicals.

2. Reuse & Recycling

Closed-Loop ISR Process

It is inherent in the “closed-loop” ISR process that process fluids are reconditioned and reused, reducing the need for freshwater intake and minimising wastewater generation. Key benefits include:

- Reduced Water Consumption
    - Process water is continuously recycled, significantly reducing groundwater extraction requirements.
    - Treatment of ISR fluids for recirculation within the system, rather than discharging as waste.
- Minimisation of Wastewater Generation
    - Implementation of filtration and chemical precipitation systems to remove impurities from process fluids, allowing for reuse.
    - Water balance management to prevent excess water accumulation and associated waste disposal issues.

Reuse and Recycling Strategies

As described under ‘*Avoidance & Reduction’*, key reuse and recycling strategies include:

- Use of Reusable Materials and Reduction of Single-Use Plastics
- Provisions for Offsite Recycling and Reuse

3. Treatment & Disposal (as a Last Resort)

Reinjection of Treated Fluids

Alligator Energy has identified reinjection of waste fluids as the most sustainable disposal method, leveraging natural attenuation processes to:

- Reduce contaminant load before reintroducing fluids into the aquifer.
- Promote groundwater restoration through dilution and natural chemical interactions.
- Minimise surface waste storage and avoid unnecessary land disturbance.
- Reduce carbon consumption associated with the process.

Other Disposal Options Considered

- Evaporation Ponds – Rejected due to:
  - Significant land disturbance and land use impacts from the size of pond construction required.
  - Generation of solid low level radioactive waste residues, requiring further disposal.
- Offsite Transport of Liquid Waste – Rejected due to:
  - High carbon footprint from transportation logistics.
  - Safety risks associated with the bulk transport of large quantities of low-level radioactive fluids.
  - Regulatory complexities regarding long-distance waste disposal.

Offsite Disposal of Solid Wastes

All non-radioactive solid waste generated during construction, operation, and decommissioning will be:

- Transported offsite by licensed contractors to authorised waste management facilities in Whyalla.
- Disposed of, recycled, or treated in accordance with EPA guidelines and waste classification standards.

Disposal of low-level radioactive solid waste will be strictly managed in compliance with:

- The project's RMP.
- The Radiation Protection and Control Act 2021 and relevant EPA regulations governing safe handling, transport, and disposal.
- Licensed transport contractors and authorised disposal facilities that meet the required safety and radiation control standards.

Volume Minimisation Strategies

To reduce the total volume of low-level radioactive solid waste requiring offsite disposal, the following compaction and processing techniques will be implemented where feasible:

- Compaction:
  - Mechanical compression of waste materials to reduce overall storage volume before transport.
  - Use of compaction where required equipment to increase waste density, optimising transport efficiency.
- Chipping & Size Reduction:
  - Non-hazardous solid waste components (e.g., contaminated wood, plastics, or non-metallic debris) will be chipped or shredded where practicable to minimise bulk waste volume.
  - Processed waste will be stored in sealed containers to prevent cross-contamination and facilitate safe transport.
- Material Sorting & Segregation:
  - Sorting of contaminated and non-contaminated materials to ensure only radioactive waste is classified for regulated disposal, minimising the quantity requiring special handling.
  - Decontamination of surface-contaminated items, where possible, to allow for recycling or non-hazardous disposal.

These measures will reduce transportation and disposal costs, optimise storage capacity, and enhance environmental sustainability while maintaining strict compliance with radiation safety and waste disposal regulations.

Comprehensive tracking, reporting, and compliance verification will be conducted throughout the waste handling and disposal process, ensuring full adherence to regulatory requirements and environmental protection commitments.

General Waste Management Measures

Waste Segregation & Storage Points

Clearly labelled segregation and storage points for:

- Recyclables, non-recyclables, and hazardous non-radioactive waste.
- Low-level radioactive waste, ensuring compliance with radiation safety standards.

Waste Management Plans

Development of a Non-Radioactive Waste Management Plan and a Low-Level Management Plan to:

- Provide clear, structured guidelines on waste handling.
- Ensure safe collection, temporary storage, and offsite disposal.

Training & Awareness

Personnel training programs on:

- Proper waste segregation and disposal methods.
- Handling procedures for hazardous and radioactive waste.
- Best practices for waste minimisation in daily operations.

Hazardous Waste Management

- Chemical and fuel storage in designated bunded areas to prevent spills.
- Safety Data Sheets (SDS) readily available for all hazardous substances.
- Engagement of licensed contractors for safe transport and disposal of listed materials.

Liquid & Putrescible Waste Disposal

- Greywater & Sewage
    - Sealed tank storage with disposal at EPA-licensed wastewater facilities.
- Putrescible Waste
    - Stored in pest-proof containers and regularly removed to prevent odour and wildlife attraction.

Regular Inspections & Compliance Monitoring

- Routine inspections of waste storage and handling areas to verify compliance.
- Internal audits to track waste generation trends and evaluate efficiency of minimisation strategies.

The compliance assessment methodology is provided in Table 7.32 below.

Uncertainties, Assumptions & Future Works

The control strategies presented above have been assessed to determine whether any significant uncertainties exist regarding their effectiveness, including the sensitivity of any such uncertainties and whether additional future works would be required to address them.

No significant uncertainties, assumptions, or future works have been identified or planned

7.14.5 Outcome Measurement Criteria & Leading Indicator Criteria

The specific measurement criteria, measurement methods and the criteria for demonstrating compliance with the approved environmental outcome for waste is provided in Table 7.32.

Where there is a high level of reliance on control strategies to achieve an environmental outcome, leading indicator criteria have also been provided to provide an early warning to the failure of control and management strategies.

Table 7.32: Outcomes, Control & Management Strategies – Waste (Industrial and Commercial)

No	Outcome	What will be Measured & Form	Locations	Frequency & Duration	Responsibility & Records	Control or Baseline Data	Outcome Achievement	Leading Indicator
19	Waste: all commercial or industrial waste is disposed of in accordance with relevant legislation.	All waste types, and volumes are logged within the internal database prior to removal from site. EPA Licence details for all listed waste transporter. Waste transport certificates for all listed waste removed from site.	N/A	Annual audit during active construction, operational and decommissioning phases.	Environment Manager. Waste Records are maintained in the Environment & Radiation Database.	N/A	Internal audit confirms that: • Listed waste movements are tracked and documented in compliance with EPA requirements. • Any non-radioactive waste removed from site has been transferred to offsite EPA-licensed disposal or recycling facilities in line with regulations. • Any low-level radioactive waste removed from site has been transferred only to facilities licensed for radioactive waste.	N/A
				Once on conclusion of all site decommissioning and remedial activities.			Independent site inspection and documentation review confirms: • No residual wastes remain on site, apart from materials agreed and approved with the landowner and regulatory agencies.	N/A

8 REFERENCES

8.1 Reports & Publications

ABS. (2021). *2021 Census Data*. Australian Bureau of Statistics, Commonwealth of Australia. Retrieved November 2022, from https://www.abs.gov.au/census.

AGT. (2011a). *Samphire aquifer testing.* Report prepared by Australian Groundwater Technologies Pty Ltd for UraniumSA Limited, January 27, 2011.

AGT. (2011b). *Samphire Project hydrogeological setting*. Report prepared by Australian Groundwater Technologies Pty Ltd for UraniumSA Limited, March 17, 2011.

Alligator Energy. (2023a). ASX release, December 7, 2023. Retrieved from https://wcsecure.weblink.com.au/pdf/AGE/02751141.pdf.

Alligator Energy. (2023b). *Retention Lease Proposal, Samphire Uranium Project.* Version 2.0, July 21, 2023).

Alligator Energy. (2024). *Samphire Uranium Project – Retention Lease Proposal Response Document* (Version 1.0, March 15, 2024).

Alligator Energy. (2025a). *Samphire Uranium Project – Spill Management Plan* [Internal document].

Alligator Energy. (2025b). *Samphire Uranium Project – Traffic & Track Management Plan* [Internal document].

ANSTO. (2022). *Samphire saline leaching and ion exchange test work.* Report prepared for Alligator Energy, November 11, 2022.

ANZECC & ARMCANZ. (2000). *Australian and New Zealand guidelines for fresh and marine water quality*. Australian Government, Canberra.

ANZG. (2018). *Australian and New Zealand guidelines for fresh and marine water quality*. Australian and New Zealand Governments, Canberra, ACT.

ASRIS. (2010). *Australian Soil Resource Information System: National soil database*. Australian Government.

ASRIS. (2022). *Soil salinity and acid sulfate soil risk mapping for South Australia*. Australian Government.

Black, J. S. (1948). *Flora of South Australia*. Government Printer, Adelaide.

BOM. (2021). *Groundwater dependent ecosystems atlas*. Retrieved from https://www.bom.gov.au.

BOM. (2025). *Climate statistics for Australian locations*. Retrieved from http://www.bom.gov.au.

Cimbala, J.M., and Cengel, Y.A. (2014). Fluid Mechanics: Fundamentals and Applications, Third Edition, *Bernoulli and Energy Equations*.

CSIRO. (2004). *Review of environmental impacts of the acid in-situ leach uranium mining process.* Report prepared for the South Australian Environment Protection Authority. Retrieved from http://www.epa.sa.gov.au/pdfs/isl_review.pdf.

Davis, J.A. and Curtis, G.P., 2007, Consideration of geochemical issues in groundwater restoration at uranium in-situ leach mining facilities: U.S. Nuclear Regulatory Commission, NUREG/CR-6870, 86 p.

DCCEEW. (2022a). *Referral determination for Field Recovery Trial (FRT).* Australian Government.

DCCEEW. (2022b). *Protected matters search tool. Australian Government*. Retrieved August 2022, from https://www.dcceew.gov.au/environment/epbc/protected-matters-search-tool.

DEW. (2020). Rangelands assessment manual. Native Vegetation Council, Government of South Australia. https://cdn.environment.sa.gov.au/environment/docs/rangelands_assessment_manual_1_july_2020.pdf

DEW. (2022). *NatureMaps. Government of South Australia*. Retrieved August 2022, from https://data.environment.sa.gov.au/NatureMaps/Pages/default.aspx.

DEW. (2023). *Biological Database of South Australia (BDBSA*). Government of South Australia.

DEWHA. (2010). Australia's in situ recovery uranium mining best practice guide: Groundwaters, residues, and radiation protection. Commonwealth of Australia, Canberra.

DEM. (2020a). *DEM Determination 24: Terms of reference (TOR) for uranium in-situ recovery applications – PEPRs*. Government of South Australia. Retrieved from https://www.energymining.sa.gov.au.

DISER. (2016). *Mine closure: Leading practice sustainable development program for the mining industry*. Commonwealth of Australia, Canberra.

DPTI. (2015). *Road safety in the Eyre Peninsula region fact sheet*. Government of South Australia.

DSD. (2012). *Mineral exploration drillholes — General specifications for construction and backfilling (Information Sheet M21).* Department of State Development, Government of South Australia. Retrieved from https://sarigbasis.pir.sa.gov.au/WebtopEw/ws/samref/sarig1/image/DDD/ISM21.pdf

DSEWPC. (2011). *EPBC referral decision: Mullaquana project field trial*. Australian Government.

EBS Ecology. (2010a). *Mullaquana Flora and Fauna Baseline Survey*. Report prepared for UraniumSA, February 12, 2010.

EBS Ecology. (2010b). *Mullaquana Buffel Grass Survey.* Report prepared for UraniumSA, December 14, 2010.

EBS Ecology. (2011a). *Mullaquana Follow-up Flora and Fauna Survey – November 2010*. Report prepared for UraniumSA, February 2, 2011.

EBS Ecology. (2011b). *Mullaquana Additional Bird Survey*. Report prepared for UraniumSA, March 24, 2011.

EBS Ecology. (2012a). *Samphire Project Flora and Fauna Survey – September 2011*. Report prepared for UraniumSA, February 14, 2012.

EBS Ecology. (2012b). *Samphire Project Flora and Fauna Survey – Spring 2012*. Report prepared for UraniumSA, December 5, 2012.

EBS Ecology. (2023). *Rangeland Assessment*. Report prepared for Alligator Energy.

EBS Ecology. (2024). *Moonabie Samphire Uranium Project Flora and Fauna Assessment*. Report to Alligator Energy Limited.

EPA (2016). *Liquid Storage, Bunding and Spill Containment Guidelines*. Government of South Australia, Adelaide.

Freeze, RA & Cherry, JA (1979). Groundwater, Prentice Hall, New Jersey.

Government of South Australia. (2022). Geological Monuments Database. Retrieved from https://catalog.sarig.sa.gov.au/geonetwork/srv/eng/catalog.search#/metadata/fc8236ff-be38-4369-a461-e3046e618989.

Government of South Australia. (2016). South Australian Multiple Land Use Framework. Retrieved March 6, 2025, from https://www.energymining.sa.gov.au/industry/minerals-and-mining/communities-and-land-access/multiple-land-use-policy-framework.

Gorring, D. (2021). *Cultural heritage survey report DG-090* [Unpublished report].

Gorring, D. (2022). *Cultural heritage survey report DG-170* [Unpublished report].

Gorring, D. (2023). *Cultural heritage survey report DG-179* [Unpublished report].

Groundwater Science. (2012). *Mullaquana Project Groundwater Circulation Trial.* Report prepared for UraniumSA, May 15, 2012.

Hancock, P., & Boulton, A. (2009). Stygofauna ecology in Australian groundwater systems. *Freshwater Biology, 54(5),* 902-916.

Hvorslev, M. J. (1951). *Time lag and soil permeability in ground-water observations* (Bulletin No. 36). Waterways Experiment Station, US Army Corps of Engineers, Vicksburg, Mississippi.

IAP2 (International Association for Public Participation). (2014). *Public Participation Spectrum.* Retrieved January 2023, from https://iap2.org.au/wp-content/uploads/2019/07/IAP2_Public_Participation_Spectrum.pdf.

ICMM. (2025). *Integrated Mine Closure Good Practice Guide* (3rd ed.). International Council on Mining & Metals.

Jensen-Schmidt, B. (2011). *Spencer Gulf Seismic Survey Report.* Included as Appendix B in: Alligator Energy Limited (2023), *Samphire Project Field Recovery Trial Report.* Alligator Energy Limited, Adelaide.

JORC. (2012). *Australasian code for reporting of exploration results, mineral resources and ore reserves.* JORC.

Kutsche, F., & Lay, B. (2003). *A guide to the native vegetation of South Australia.* Adelaide: Department of Environment and Heritage.

Lange, RT, Nicolson, AD & Nicolson, DA (1984). *'Vegetation Management of Chenopod Rangelands in South Australia*', The Rangeland Journal, vol. 6, no. 1, pp. 46–54.

Mitchell, P. (1998). *Soil landscapes of South Australia.* South Australian Department for Environment and Natural Resources.

National Uniform Drillers Licensing Committee. (2020). *Minimum construction requirements for water bores in Australia* (4th ed.).

Office of Northern Water Delivery. (2022). *Northern Water Supply Project.* Government of South Australia. Retrieved from https://www.northernwatersupply.sa.gov.au/.

OST. (2011). *Baseline Radiation Survey Samphire Project.* Report prepared for UraniumSA, February 8, 2011.

PlanSA. (2022). *The SA Planning and Property Atlas.* Government of South Australia. Retrieved November 2022, from http://www.sappa.plan.sa.gov.au.

PlanSA. (2025). *Property details and planning information.* Government of South Australia. Retrieved January 24, 2025, from https://code.plan.sa.gov.au.

Post, V. E. A., & Simmons, C. T. (2021). *Variable-density groundwater flow.* The Groundwater Project, Guelph, Ontario, Canada. Retrieved from https://doi.org/10.21083/978-1-77470-046-4.

SARIG (South Australian Resource Information Gateway). (2022). *South Australian Resource Information Gateway.* Retrieved January 14, 2022, from https://map.sarig.sa.gov.au/.

SARIG. (2022). *Faults and earthquake zones database.* Government of South Australia. Retrieved from https://map.sarig.sa.gov.au.

Sonus Pty Ltd. (2023). *Samphire Uranium Project – Mullaquana Station noise monitoring* (Report No. S7888C2). Report prepared for Alligator Energy, Adelaide, South Australia.

South Australian Heritage Places Database. (2025). *Heritage Register Search Results: Whyalla Region.* Government of South Australia.

Taylor AR, Pichler MM, Olifent V, Thompson J, Bestland E, Davies PJ, Lamontagne S, Suckow A, Robinson N, Love A and Munday T. 2015. *Groundwater Flow Systems of North-eastern Eyre*

Peninsula (G-FLOWS Stage-2): Hydrogeology, geophysics and environmental tracers. Goyder Institute for Water Research Technical Report Series No. 15/37, Adelaide, South Australia

Terramin. (2017). *Mine Closure Plan – Angus Zinc Mine, Strathalbyn SA.* Retrieved April 2018, from https://sarigbasis.pir.sa.gov.au/WebtopEw/ws/samref/sarig1/image/DDD/PEPR1272476.pdf.

Terramin. (2018). *Angas Zinc Mine Compliance Report 2017.* Report prepared for the Department of the Premier and Cabinet: Minerals. Retrieved April 2018, from https://sarigbasis.pir.sa.gov.au/WebtopEw/ws/samref/sarig1/image/DDD/MCR486251.pdf.

Theis, C. V. (1935). *The relation between the lowering of the piezometric surface and the rate and duration of discharge of a well using groundwater storage. American Geophysical Union Transactions, 16, 519–524*.

UIT. (2008) Natural Attenuation Project: From Lab Tests to FME Aquifer. Report prepared for Heathgate Resources Pty. Ltd., November 2008.

UIT. (2017) NA Study Honeymoon: 1D Reactive Transport Modelling. Report prepared for Groundwater Science Pty. Ltd., June 2017.

UIT. (2023). *Natural Attenuation NA Study for FLT at the Samphire Tenement in South Australia.* Report prepared for Alligator Energy Ltd, January 2023.

UraniumSA. (2010). *EPBC referral submission for the Mullaquana Project.* Australian Government, Department of Sustainability, Environment, Water, Population and Communities.

UraniumSA Limited. (2017). *Stratigraphy and Mineralogy of the Blackbush Palaeochannel.* Internal Report.

URS Australia Pty Ltd. (2010). *Hydrology Baseline Investigation – Samphire Uranium Project.* Report prepared for UraniumSA, June 29, 2010.

U.S. Nuclear Regulatory Commission (NRC). (2003). *Standard review plan for in situ leach uranium extraction license applications (NUREG-1569).* Office of Nuclear Material Safety and Safeguards, Washington, DC. Retrieved from https://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1569/.

WaterConnect SA. (2022). *Groundwater database search: Samphire Uranium Project region.* Government of South Australia.

WCC. (2020). *Whyalla City Council Strategic Development Plan 2021–2030*. Retrieved from https://www.whyalla.sa.gov.au/__data/assets/pdf_file/0022/652801/Strategic-Management-Plan-2021-2030-Endorsed-16.03.2020.pdf

WSP. (2024). *Samphire Project Field Recovery Trial – Groundwater Pathways to the Spencer Gulf*: Technical Note, report prepared for Alligator Energy Ltd, 2024

Young, Brian (2022): Mineralogy of Alligator Energy Composite. Technical Memorandum AM/TM. ANSTO. NSW Australia.

8.2 Legislation

8.2.1 South Australia (SA)

Aboriginal Heritage Act 1988 (SA)

- Aboriginal Heritage Regulations 2017 (SA)

Animal Welfare Act 1985 (SA)

- Animal Welfare Regulations 2012 (SA)

Dangerous Substances Act 1979 (SA)

- Dangerous Substances (Dangerous Goods Transport) Regulations 2008 (SA)

Environment Protection Act 1993 (SA)

- Environment Protection Regulations 2009 (SA)
    - Environment Protection (Noise) Policy 2007 (SA)
    - Environment Protection (Water Quality) Policy 2015 (SA)

Heritage Places Act 1993 (SA)

- Heritage Places Regulations 2020 (SA)

Landscape South Australia Act 2019 (SA)

- Landscape South Australia (General) Regulations 2020 (SA)
- Landscape South Australia (Water Management) Regulations 2020 (SA)

Local Government Act 1999 (SA)

- Local Government (General) Regulations 2013 (SA

Marine Parks Act 2007 (SA)

- Marine Parks (Zoning) Regulations 2012 (SA)

Mining Act 1971 (SA)

- Mining Regulations 2020 (SA)

National Parks and Wildlife Act 1972 (SA)

- National Parks and Wildlife (National Parks) Regulations 2016 (SA)

Native Vegetation Act 1991 (SA)

- Native Vegetation Regulations 2017 (SA)

Radiation Protection and Control Act 2021 (SA)

- Radiation Protection and Control Regulations 2022 (SA)

River Murray Act 2003 (SA)

- River Murray Regulations 2003 (SA)

Road Traffic Act 1961 (SA)

- Road Traffic (Road Rules—Ancillary and Miscellaneous Provisions) Regulations 2014 (SA)

Work Health and Safety Act 2012 (SA)

- Work Health and Safety Regulations 2012 (SA)

8.2.2 Commonwealth (Cth)

Australian Radiation Protection and Nuclear Safety Act 1998 (Cth)

- Australian Radiation Protection and Nuclear Safety Regulations 2018 (Cth)
    - RPS F-1 – Fundamentals for Protection Against Ionising Radiation
    - RPS C-2 – Code for the Safe Transport of Radioactive Material (Rev. 1)
    - RPS C-3 – Code for Disposal Facilities for Solid Radioactive Waste
    - RPS C-6 – Code for Disposal of Radioactive Waste by the User
    - RPS G-1 – Guide for Radiation Protection of the Environment
    - RPS G-2 – Guide for Radiation Protection in Existing Exposure Situations

- RPS G-4 – Guide for Classification of Radioactive Waste
- RPS 9 – Code of Practice and Safety Guide for Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing

Environment Protection and Biodiversity Conservation Act 1999 (Cth)

- Environment Protection and Biodiversity Conservation Regulations 2000 (Cth)

Native Title Act 1993 (Cth)

Nuclear Non-Proliferation (Safeguards) Act 1987 (Cth)

- Nuclear Non-Proliferation (Safeguards) Regulations 1987 (Cth)

9 TERMS, ACRONYMS & ABBREVIATIONS

9.1 Terms and Definitions

Term/Phrase	Definition/Context
Access to Pastoral Lessee	Legal access granted to pastoralists for domestic use and livestock watering, ensuring minimal disruption to existing land uses.
Active Operational Phase	Periods of time within the RL grant period where active construction, operational or decommissioning activities are being undertaken.
Alligator Energy	Alligator Energy Ltd, parent company of the tenement holder S Uranium Pty Ltd.
Approved Program	An operational plan approved under Part 10A of the Act, outlining authorised activities and compliance measures.
Authorised Operations	Activities allowed under the retention lease, including uranium in-situ recovery trials, environmental monitoring, and exploration for minerals.
Baseline Data	Baseline data refers to environmental and radiological information collected from both proposed impact sites (prior to project disturbance) and control sites. It represents the pre-operational condition of the environment and provides the foundation for assessing changes over time, including natural variability and project-related impacts.
Community Engagement Plan (CEP)	A structured plan outlining engagement with local communities, addressing concerns, and providing information about operations.
Complaints Register	A log of complaints from the public about operations, detailing the issue, response, and corrective actions.
Control Site	Control site refers to a location outside the zone of influence of the proposed activity, used to represent background or unimpacted environmental conditions. Control sites are selected to be comparable to impact sites and are included in baseline data to support differentiation between natural variation and project-related changes.
Eluate	A concentrated uranium solution extracted during uranium processing through ion exchange recovery methods.
Eluate Storage and Disposal	Proper storage and disposal of uranium eluate in compliance with legislation to ensure environmental and public safety.
Environmental Outcomes	Performance standards ensuring no adverse impacts on natural resources such as groundwater, soil, air quality, and biodiversity.
Field Recovery Trial (FRT)	A controlled trial using uranium in-situ recovery techniques to evaluate the feasibility of full-scale mining operations.
Measurement Criteria	Parameters and standards for monitoring environmental factors like groundwater, air, and radiation, ensuring operations meet regulatory outcomes.
Micrositing of Infrastructure	Fine-scale relocation of the vegetation disturbance footprint by up to 10 m in any direction within the mapped disturbance envelope to avoid mature vegetation or other site constraints (e.g. heritage, geotechnical conditions, well re-drills), with no increase in total clearing.
Mine Completion	The process of restoring the Land to a state where it can be surrendered, ensuring it meets regulatory requirements for environmental stability and safety.
Mineral Tenement	A retention lease granting the exclusive right to explore for minerals and conduct trials to gather data for future mining lease applications.
Minerals	The resource(s) specified under the Mineral Tenement, in this case, uranium, targeted for exploration or recovery.

Term/Phrase	Definition/Context
Native Vegetation and Fauna	Conservation measures to protect and avoid harm to local plants and wildlife during exploration and operations.
Noise and Air Quality	Standards to minimise noise and air pollution, ensuring no public nuisance or health impacts.
Native vegetation clearance pre-approved area	Native vegetation clearance pre-approved area includes a 10 metre buffer zone from the edge of the planned SEB approved areas as a contingency measure for flexibility during operations. The total vegetation cleared must still remain within the maximum area (ha) approved under the SEB permit.
Pest	Any invasive animal species declared under the Landscape South Australia Act 2019, requiring management to prevent ecological harm.
Preventable Incident	An incident involving native fauna is considered reasonably preventable if it meets the following criteria: • Failure of Mitigation Measures or Procedures: o The incident resulted from non-compliance with established fauna management procedures (e.g., exceeding speed limits, failure to maintain exclusion zones, improper use of fauna-safe equipment). o Repetition of Non-Compliance by the Same Individual: o The incident involved the same individual failing to comply with site rules or procedures more than once. o The first instance is not deemed preventable by Alligator Energy if: o The individual is retrained, disciplined, or otherwise appropriately managed after the initial non-compliance. o Additional measures are implemented to prevent recurrence (e.g., supervision, system adjustments). o If the individual repeats the same non-compliance and appropriate interventions were not implemented by Alligator, the incident is deemed reasonably preventable. • Proactive Actions: Alligator Energy can demonstrate that: o All personnel were trained in fauna management procedures before the incident. o Mitigation measures were in place and maintained as per the company's natural Resource management plan for Samphire project on Moonabie. o Audits of compliance with procedures were conducted regularly, and gaps were addressed promptly.
Proactive Actions	Alligator Energy can demonstrate personnel training, mitigation measures, and compliance audits to prevent fauna-related incidents.
Public Safety	Measures implemented to prevent injuries or fatalities from unauthorised site access or operational hazards.
Reasonably Prevented	An incident is considered to be reasonably preventable if it could have been avoided through the application of controls, procedures, or behaviours that are commonly expected of a competent operator in the same circumstances. This includes risks that are foreseeable and can be mitigated using standard industry practices, site-specific procedures, or regulatory requirements. It excludes incidents arising from unforeseeable events or those outside the control of the Tenement Holder.
Rehabilitation	The process of restoring the Land post-operations, addressing environmental, ecological, and safety concerns for long-term sustainability.
Retention Lease (RL)	A Mineral Tenement issued under the Mining Act 1971 (SA) limited to exploration and trials, designed to gather information for potential mining lease applications.
Significant Environmental Benefit (SEB)	Offsets or compensatory measures required to mitigate the impact of clearing native vegetation during operations.

Term/Phrase	Definition/Context
Site	The operational area within the Land, including all locations used for exploration, recovery trials, and related activities.
Tenement Document	The legal document defining rights, obligations, and conditions of the retention lease, including all associated schedules and requirements.
Tenement Holder / Operator	The entity (S Uranium Pty Ltd) holding the Mineral Tenement and responsible for complying with all terms and conditions. For the purposes of the PEPR the parent company Alligator Energy Ltd is referred to as the tenement holder and tenement operator.
The Land	The area of 237.77 hectares in the Mullaquana Area (approximately 80 km SW of Port Augusta), granted under the Mineral Tenement.
Third-Party Land Use	Ensuring minimal or no disruption to neighbouring land uses and compensating for any agreed-upon impacts.
Third-Party Land User	Any landowner or stakeholder whose property or activities may be affected by operations under the Mineral Tenement.
Third Party Property	Infrastructure, assets, or land not owned by the Tenement Holder but potentially impacted by authorised activities.
Time-Integrated Monitoring	A monitoring method in which airborne particulate matter is collected continuously over a defined period (e.g. 24 hours, one week, or one month), producing a single average value for that period. Analysis is typically conducted offline (e.g. by gravimetric or chemical means), with results expressed as time-weighted average concentrations or deposition rates.
Traffic Management	Strategies to prevent accidents involving mining vehicles and public road users through proper route planning and safety measures.
Trigger, Action, and Response Plan (TARP)	A plan outlining actions to address groundwater impacts, including monitoring and remediation strategies if natural attenuation fails.
Upper Spencer Gulf Marine Park	A protected marine area near the project, requiring strict measures to prevent adverse environmental impacts from operations.
Visual Amenity	Measures to reduce the visual impact of operations, such as blending facilities with the surrounding landscape.
Waste Management	Proper disposal of industrial waste in compliance with environmental and safety regulations.
Weeds	Invasive plant species threatening native vegetation and biodiversity, requiring monitoring and management during operations.

9.2 Acronyms & Abbreviations

Acronym/Abbreviation	Full Form
ABS	Australian Bureau of Statistics
ANZECC/ARMCANZ	Australian and New Zealand Guidelines for Fresh and Marine Water Quality
ARI	Average Recurrence Interval
ARPANSA	Australian Radiation Protection and Nuclear Safety Agency
AS	Australian Standard
ASNO	Australian Safeguards and Non-Proliferation Office
ATCO	(Trade name) Portable Building System
BDAC	Barngarla Determination Aboriginal Corporation
BOM	Bureau of Meteorology
Bq/L	Becquerel per litre

Acronym/Abbreviation	Full Form
CCTV	Closed-Circuit Television
Company	Alligator Energy Ltd
DEW	Department for Environment and Water
DEM	Department for Energy and Mining
DPTI	Department of Planning, Transport and Infrastructure
DD	Deposited Dust
EC	Electrical Conductivity
ECL	Excursion Control Limit
EL	Exploration License
EPA	Environment Protection Authority
EPBC Act	Environment Protection and Biodiversity Conservation Act
ePEPR	Exploration Program for Environment Protection and Rehabilitation
FRA	Fractured Rock Aquifer
FRT	Field Recovery Trial
FWE	Fresh Water Equivalent
FIFO	Fly-In Fly-Out
$Fe_2(SO_4)_3$	Ferric Sulphate
FRA	Fractured Rock Aquifer
GDE	Groundwater Dependent Ecosystems
GPS	Global Positioning System
HDPE	High-Density Polyethylene
H_2O_2	Hydrogen Peroxide
H_2SO_4	Sulphuric Acid
HVAS	High-Volume Air Sampler
IAEA	International Atomic Energy Agency
IBC	Intermediate Bulk Container
ISO	International Organisation for Standardisation (ISO) standards
ISR	In-Situ Recovery
IX	Ion Exchange
JORC	Joint Ore Reserves Committee
KL	Kilolitres
kPa	Kilopascal
LGA	Local Government Area
LLA	Long-Lived Alpha Activity
LLDPE	Linear Low-Density Polyethylene
LLRW	Low-Level Radioactive Waste
MHF	Major Hazard Facility
Mlbs	Million pounds
ML	Mineral Lease
m^3	Cubic meters
SDS	Safety Data Sheets
mSv	Millisievert
mV	Millivolts
µSv/h	Microsieverts per hour
NaCl	Sodium Chloride
$NaCO_3$	Sodium Carbonate

Acronym/Abbreviation	Full Form
NAMW	Natural Attenuation Monitoring Well
NA	Natural Attenuation
N/A	Not Applicable
NGER	National Greenhouse and Energy Reporting
NEPM	National Environment Protection Measure
NPT	Non-Proliferation of Nuclear Weapons Treaty
NVMP	Native Vegetation Management Plan
NVC	Native Vegetation Council
OSL	Optically Stimulated Luminescence
ORP	Oxidation Reduction Potential
PEPR	Program for Environment Protection and Rehabilitation
PFN	Prompt Fission Neutron
PPE	Personal Protective Equipment
ppm	Parts per million
RL	Retention Lease
RLP	Retention Lease Proposal
RMP	Radiation Management Plan
RO	Reverse Osmosis
Rn	Radon
RnDP	Radon Decay Products
rSWL	Relative Static Water Level
SA	South Australia
SD	Standard Deviation
SEB	Significant Environmental Benefit
SEO	Statement of Environmental Outcomes
SO_4^{2-}	Sulphate Ion
S-P-R	Source, Pathway, Receptor
TARP	Trigger, Action, and Response Plan
TDS	Total Dissolved Solids
ToR	Terms of Reference
TSP	Total Suspended Particulates
U	Uranium
U_3O_8	Triuranium Octoxide (Uranium Oxide)
UIT	Umwelt-und Ingenieurtechnik GmbH Dresden
UO_2	Uranium Dioxide
UOC	Uranium Oxide Concentrate
USD	United States Dollar
US	United States
WHS	Work Health and Safety

APPENDICES

Appendix A: Retention Lease 137

Government of South Australia

Mining Act 1971

TENEMENT DOCUMENT

RETENTION LEASE

TENEMENT HOLDER	S Uranium Pty Ltd ACN 116 348 915
CLASS OF LEASE	Retention Lease (RL): The Retention Lease is limited to exploration operations and authorises the Tenement Holder to carry out authorised operations to obtain information required to support an application for a mining lease where those authorised operations are not suited to being conducted under an exploration licence.
RL NUMBER	137
TERM OF LEASE	Five (5) years under section 46 of the Act
COMMENCEMENT DATE	10 January 2025
EXPIRY DATE	9 January 2030
MINERAL(S)	Minerals: Uranium
AREA OF LEASE	237.77 hectares located in the Middleback Range Area approximately 25 km South-West of Whyalla

TABLE OF CONTENTS **Page No.**

Details of Grant of the Mineral Tenement 3

Terms and conditions required by the Act to be specified in the Tenement Document 3

Description of the Land 3

Term, Commencement and Expiration 3

Rental 3

Definitions 5

Interpretation 7

FIRST SCHEDULE 9

TERMS 9

SECOND SCHEDULE 10

CONDITIONS 10

THIRD SCHEDULE 14

MAP 14

DESCRIPTION OF AREAS 15

FOURTH SCHEDULE 16

ENVIRONMENTAL OUTCOMES 16

Details of Grant of the Mineral Tenement

1 On 11 December 2024, pursuant to Part 7 of the Act, the Minister made a decision to grant a retention lease (the Mineral Tenement) described in this document (Tenement Document).

2 The Mineral Tenement is granted:

2.1 to S Uranium Pty Ltd, ACN 116 348 915

2.2 for the purpose of subsection 43(1)(a) where the applicant seeks an authorisation to carry out authorised operations to obtain information required to support an application for a mining lease where those authorised operations are not suited to being conducted under an exploration licence.

3 The Mineral Tenement is numbered RL 137.

Terms and conditions required by the Act to be specified in the Tenement Document

EXPLANATORY NOTE: The Mineral Tenement is subject to any terms and conditions prescribed under section 43(3)(a) of the Act and the terms and conditions specified in this Tenement Document, including in the Schedules of this Tenement Document.

Description of the Land

4 The Mineral Tenement is granted over an area of 237.77 hectares located in the Middleback Range Area approximately 25 km South-West of Whyalla.

5 The location of the Mineral Tenement is more specifically defined in the map and coordinates specified in the Third Schedule of this Tenement Document.

Term, Commencement and Expiration

6 The Mineral Tenement is granted for the term of five (5) years. The term of the Mineral Tenement commenced on 10 January 2025, and, subject to the Act and the Regulations, the Mineral Tenement will cease on 9 January 2030.

EXPLANATORY NOTE: The Act contains provisions for earlier expiry or termination (for example, surrender) and provisions for the renewal of the Mineral Tenement.

Rental

7 The Tenement Holder shall pay, by way of rental, such sums as may be prescribed by the Regulations in accordance with section 56M of the Act.

EXPLANATORY NOTE: Regulation 50 and Schedule 2 of the Regulations provide for rental.

Environmental Outcomes

8 The Fourth Schedule of this Tenement Document specifies the outcomes, criteria, strategies, and other information that the Tenement Holder is required to address (in

addition to any requirements of the Regulations) in any program submitted in accordance with Part 10A of the Act.

Further Terms and Conditions

9 The First and Second Schedules of this Tenement Document specify further terms and conditions of the Mineral Tenement.

Definitions

10 In this Tenement Document, the following words have the following meanings:

10.1 "**Act**" means the *Mining Act 1971* of South Australia;

10.2 "**Applicant**" means the person or persons who applied for the Mineral Tenement;

10.3 "**Approved Program**" means the program approved under Part 10A of the Act;

10.4 "**DEM**" means the Department for Energy and Mining and includes any substituted Department;

10.5 **"DEW"** means the Department for Environment and Water and includes any substituted Department:

10.6 **"Eluate"** means the concentrated uranium fluid recovered through the Ion Exchange process;

10.7 **"EPA"** means the Environment Protection Authority under the *Environment Protection Act 1993* of South Australia;

10.8 "**Insolvency Administration**" means:

10.8.1 If the Tenement Holder is a body corporate:

10.8.1.1 an administrator is appointed to the Tenement Holder or action is taken to make such an appointment;

10.8.1.2 The Tenement Holder resolves to be wound up;

10.8.1.3 an application is made to a court for an order or an order is made that the Tenement Holder be wound up (whether on grounds of insolvency or otherwise

10.8.1.4 The Tenement Holder ceases to carry on business;

10.8.1.5 a receiver or a receiver and manager of property of the Tenement Holder is appointed whether by a court or otherwise;

10.8.1.6 an application is made to a court for an order appointing a liquidator or provisional liquidator in respect of the Tenement Holder or one of them is appointed, whether or not under an order;

10.8.1.7 The Tenement Holder enters into a compromise or arrangement with its creditors or a class of them; or

10.8.1.8 The Tenement Holder is or states that it is unable to pay its debts when they fall due.

10.8.2 If the Tenement Holder is a natural person:

10.8.2.1 The Tenement Holder has committed an act of bankruptcy as contemplated by the *Bankruptcy Act 1966* (Cth);

10.8.2.2 The Tenement Holder is unable to pay his or her debts as and when they become due and payable;

10.8.2.3 the court has made a sequestration order against Party B's estate;

10.8.2.4 a creditors' petition has been presented against the Tenement Holder;

10.8.2.5 The Tenement Holder has presented to the Official Receiver a declaration of intention to present a debtor's petition;

10.8.2.6 The Tenement Holder becomes a bankrupt;

10.8.2.7 a meeting of creditors of the Tenement Holder is convened; or

10.8.2.8 The Tenement Holder lodges with his or her trustee a proposal to his or her creditors for a composition in satisfaction of his or her debts or a scheme of arrangement of his or her affairs.

10.9 "**the Land**" means the land over which the Mineral Tenement is granted and which is described in the Third Schedule of this Tenement Document and includes any part thereof;

10.10 "**Mine completion**" or **"completion"** means the Land has been rehabilitated to an extent that the Minister could approve an application for surrender of the Mineral Tenement under section 56X of the Act;

10.11 "**Mineral(s)**" means the minerals referred to in the First Schedule of this Tenement Document;

10.12 "**Mineral Tenement**" means the retention lease granted to the Tenement Holder, as referred to in paragraphs 1 and 2 of this Tenement Document and all of the rights and obligations encompassed in the grant;

10.13 "**the Minister**" means the Minister for Energy and Mining (or any other Minister to whom the Act has been committed under the *Administrative Arrangements Act 1994*);

10.14 **"Pest"** means any pest animals declared under the *Landscape South Australia Act 2019*;

10.15 "**Proposed Program**" means the document required to be submitted for approval under Part 10A of the Act by the date specified in this Tenement Document;

10.16 "**Regulations**" means the *Mining Regulations 2020* of South Australia;

10.17 **"Retention Lease"** means the Mineral Tenement as defined above;

10.18 "**site**" means the Land;

10.19 "**Tenement Document**" means this document including all Schedules;

10.20 **"Third party land user"** means any owner of land as defined by the Act and **"third party land use"** has a corresponding meaning;

10.21 **"'"Third Party Property and Infrastructure"** means property and infrastructure that is not owned by the Tenement Holder;

10.22 **"Weeds"** means any invasive plant that threatens native vegetation in the local area or any species recognised as invasive in South Australia

Interpretation

11 For the purposes of interpreting this Tenement Document the following will apply:

11.1 Unless otherwise stated, any term which is used in this Tenement Document which has a specific meaning in the Act or the Regulations, has that same meaning in this Tenement Document.

11.2 A word importing:

11.2.1 the singular includes the plural;

11.2.2 the plural includes the singular; and

11.2.3 a gender includes every other gender.

11.3 Unless inconsistent with or repugnant to the context the following words shall have the meanings set opposite to them respectively –

11.3.1 “amendment” includes an addition, excision or substitution;

11.3.2 “the term” includes any renewal or extension thereof.

11.4 A reference to any legislation or to any provision of any legislation includes:

11.4.1 all legislation, regulations, proclamations, ordinances, by-laws and instruments issued under that legislation or provision; and

11.4.2 any modification, consolidation, amendment, re-enactment or substitution of that legislation or provision.

11.5 If the Mineral Tenement is granted to more than one person, all of the persons to whom it is granted are all jointly and severally liable for compliance with the Act, the Regulations and this Tenement Document;

11.6 If, by virtue of a dealing under section 15AB of the Act, the Mineral Tenement comes to be held by more than one person, they will all be jointly and severally liable for compliance with the Act, the Regulations and this Tenement Document;

11.7 If any act pursuant to this Tenement Document would otherwise be required to be done on a day which is not a Business Day then that act may be done on the next Business Day;

11.8 To the extent that there is any inconsistency, on the one hand, between a term or condition of this Tenement Document and, on the other hand, the Act or Regulations, the Act or Regulations shall prevail;

11.9 Subject to the transitional provisions in any amendment to the Act or the Regulations, all provisions referred to in this Tenement Document shall be taken to include any such amendment;

11.10 Subject to the transitional provisions in any amendment to the Act or the Regulations, to the extent that there is any inconsistency, on the one hand, between a term or condition of this Tenement Document, and, on the other hand, any amendments to the Act or Regulations, the amended Act or Regulations shall prevail;

11.11 Footnotes and Explanatory notes do not form part of this Tenement Document;

11.12 The contents page does not form part of this Tenement Document;

11.13 The front page and all of the Schedules form part of this Tenement Document.

Entered in the Mining Register on 10 January 2025

In accordance with section 15AA of the Act.

Signed by … Caroline Andrews ……..

Caroline Andrews
Mining Registrar

Date: 10 January 2025

The Tenement Document will be entered into the Mining Register and will be available through the Mining Register Search Tool on the South Australian Resources Information Gateway (SARIG) at https://tenementregister.sarig.sa.gov.au/

FIRST SCHEDULE

TERMS

EXPLANATORY NOTE: A term confers a right in relation to a Mineral Tenement.

Authorised Operations

1. The term of the Mineral Tenement is 5 years.

2. The grant of the Mineral Tenement authorises uranium in-situ recovery (ISR) field recovery trial (FRT) operations that are consistent with the operations described in the Retention Lease Application Proposal document dated 21 July 2023 and Response Document dated 31 July 2024. *[Explanatory Note: This authorisation is in addition to the right to prospect for minerals on the Land and the exclusive right to apply for a mining lease in respect of the Land pursuant to section 43(2) of the Act.]*

SECOND SCHEDULE

CONDITIONS

Explanatory note: A condition is a clause that imposes a restriction on a Mineral Tenement.

Type of Retention Lease

1. The Retention Lease is limited to exploration operations and is granted for the purpose of subsection 43(1)(a) where the applicant seeks an authorisation to carry out authorised operations to obtain information required to support an application for a mining lease where those authorised operations are not suited to being conducted under an exploration licence.

Transparency

2. The Tenement Holder consents to any reportable incident reports submitted under the Regulations being made available for public inspection.

Submission of Proposed Program

3. The Tenement Holder must submit a Proposed Program for the purpose of Part 10A of the Act within 12 months after the grant of the Mineral Tenement or within such longer period of time as the Minister or a person authorised by the Minister may allow.

Complaints Register

4. The Tenement Holder must operate a 24 hour per day, 7 day per week, free-call telephone complaints line for the purpose of receiving complaints from members of the public in relation to authorised operations.
5. The Tenement Holder must take reasonable measures to notify the public of the complaints line telephone number and the fact that it is a complaints line.
6. The Tenement Holder must establish and maintain a public complaints register. The public complaints register must, as a minimum, record the following detail in relation to each complaint received in which it is alleged that environmental harm (including an environmental nuisance) has been caused by the authorised operations:
    6.1 the time at which the complaint was received;
    6.2 all personal details of the complainant which were provided by the complainant or, if no such details were provided, a note to that effect;
    6.3 the subject-matter of the complaint;

6.4 the action taken by the tenement holder in relation to the complaint, including any follow-up contact with the complainant; and

6.5 if no action was taken by the tenement holder, the reasons why no action was taken.

7. All records in respect of the public complaints must be maintained for a period of at least 7 years.

Community Engagement Plan

8. The Tenement Holder must prepare, implement and maintain (to the satisfaction of the Minister or a person authorised by the Minister) a Community Engagement Plan ("CEP") that:

8.1 Sets out the purpose, objectives and parameters of engagement with the community;

8.2 Identifies all community stakeholders likely to be affected by authorised operations;

8.3 Sets out the tools and techniques that the Tenement Holder intends to use for:

8.3.1 Identifying community attitudes and expectations;

8.3.2 Providing information to the community;

8.3.3 Receiving feedback from the community;

8.3.4 Analysing community feedback and considering community concerns or expectations; and

8.3.5 Registering, documenting and responding to communications from members of the community;

8.3.6 Outlines an action plan to commence the proposed engagement activities; and

8.3.7 Addresses any further matter that the Minister, or a person authorised by the Minister, advises in writing.

Upper Spencer Gulf Marine Park

9. The Tenement Holder must ensure that there is no impact on the Upper Spencer Gulf Marine Park as a result of field recovery trial activities or other authorised operations.

Eluate Storage and Disposal

10. The Tenement Holder must ensure that all concentrated uranium eluate produced during the field recovery trial is stored in accordance with relevant legislation for the term of the Mineral Tenement.
11. The Tenement Holder must dispose of all concentrated uranium eluate produced during the field recovery trial in accordance with any instructions issued by the Minister or a person authorised by the Minister.

Change in Details

12. The Tenement Holder must furnish to the Mining Registrar information about any of the following:

    12.1 a change in the name of the Tenement Holder;

    12.2 a change in the registered or business address of the Tenement Holder, or a change in any other address provided for correspondence or service including an email address;

    12.3 the Tenement Holder entering into any form of Insolvency Administration.

13. The information required by clause 12 must be provided within 14 days after the requirement to furnish the information arises.

Access to Pastoral Lessee

14. If the Land is subject to a pastoral lease under the *Pastoral Land Management and Conservation Act 1989*, the Tenement Holder must give the pastoral lessee access to the land for domestic purposes and for watering stock (although the Tenement Holder is not required to give the pastoral lessee access to water provided or stored by the lessee by artificial means).

Other Legislation

15. The Tenement Holder must comply with all State and Commonwealth legislation and regulations applicable to the activities undertaken pursuant the grant of the Mineral Tenement including (but not limited to) the**:**

    15.1 Environment Protection and Biodiversity Conservation Act (Cth) 1999;

    15.2 Dangerous Substances Act (SA) 1979;

    15.3 National Parks and Wildlife Act (SA) 1972;

    15.4 Marine Parks Act (SA) 2007;

    15.5 Landscape SA Act 2019;

    15.6 Planning, Development and Infrastructure Act (SA) 2016;

    15.7 South Australian Public Health Act 2011;

15.8 *Aboriginal Heritage Act (SA) 1988;*

15.9 *Heritage Places Act (SA) 1993;*

15.10 *Work Health and Safety Act (SA) 2012;*

15.11 *Environment Protection Act (SA) 1993;*

15.12 *Native Vegetation Act (SA) 1991;*

15.13 *Mines and Works Inspection Act (SA) 1920;*

15.14 *Harbors and Navigation Act 1993;*

15.15 *Nuclear Non-Proliferation (Safeguards) Act (Cth) 1987;*

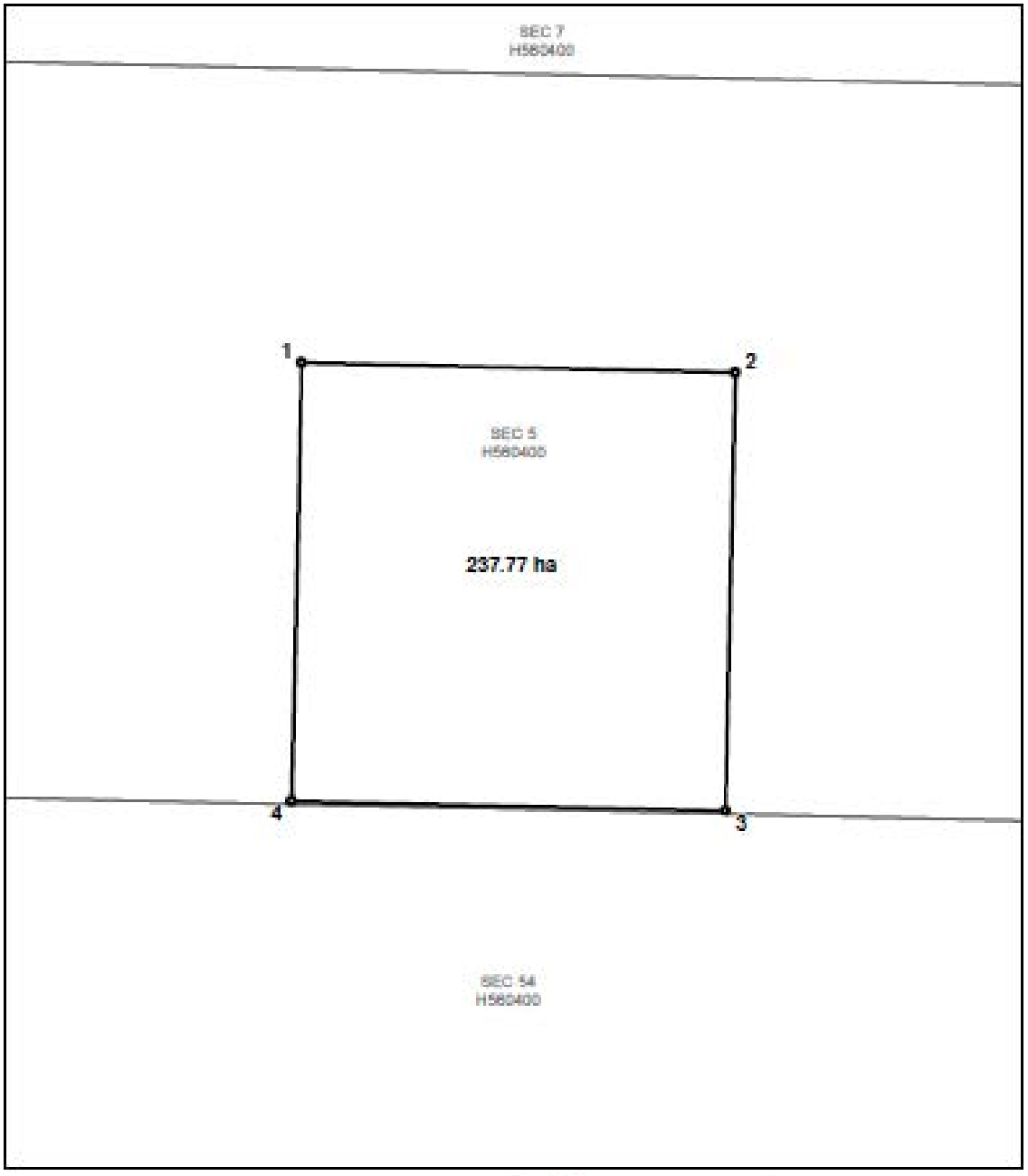
15.16 *Radiation Protection and Control Act (SA) 2021;*

15.17 *Road Traffic Act (SA) 1961; and*

15.18 *Native Title Act (Cth) 1993.*

THIRD SCHEDULE

MAP



NOTE: The boundary of this lease is depicted so as to best represent the relationship to the surrounding cadastral parcels. The legal boundary is to be ascertained by the coordinates specified.

DATE PRODUCED: 18/12/2024

THIRD SCHEDULE

DESCRIPTION OF AREAS

All that part of the State of South Australia, bounded by a line joining the points of coordinates set out in the following table:

Map Grid of Australia 2020 Zone 53		
Point	Easting	Northing
1	722501.49mE	6325184.28mN
2	724035.15mE	6325149.17mN
3	723999.55mE	6323599.62mN
4	722466.18mE	6323633.08mN

Area: 237.77 ha

Based on information provided by the applicant

FOURTH SCHEDULE

ENVIRONMENTAL OUTCOMES

ENVIRONMENTAL **OUTCOMES** AND ASSOCIATED CRITERIA **PURSUANT TO SECTION 70B(2)(b)** OF THE MINING ACT 1971 AND STRATEGIES PURSUANT TO REGULATION 63(1)(b) OF THE MINING REGULATIONS 2020

Explanatory note: The Fourth Schedule of this Tenement Document sets out Outcomes contemplated pursuant to section 70B(2)(b) of the Act that the Tenement Holder is required to address in any program submitted in accordance with Part 10A of the Act. The Fourth Schedule may also specify requirements for strategies and criteria relevant to the Outcomes.

Groundwater Outcomes

1. The Tenement Holder must, in carrying out authorised operations, ensure that there is no adverse change, outside of natural background variation, to the water quality of the target aquifer outside of the Land.

2. The Tenement Holder must, in carrying out authorised operations, ensure that there is no adverse change, outside of natural background variation, to the water quality of the underlying aquifer.

Groundwater Closure Outcomes

3. The Tenement Holder must demonstrate to the satisfaction of the Minister that the following mine completion outcomes (in so far as they may be affected by authorised operations) are expected to be achieved and sustained after mine closure:
   3.1. No adverse change, outside of natural background variation, to the pre-mining water quality of the target aquifer outside of the area specifically defined in the map and coordinates specified in the Third Schedule of this Tenement Document.
   3.2. No adverse change, outside of natural background variation, to the pre-mining water quality of the underlying aquifer.

Groundwater Strategy

4. The Tenement Holder is required to address the following matters for the purposes of Regulation 63(1)(b) of the Regulations in relation to the Fourth Schedule Clause 3.1:

   4.1. Develop a Trigger, Action and Response Plan (TARP) to determine the process for groundwater active remediation of the target aquifer in the event that natural attenuation cannot be validated during the term of the Retention Lease.

Groundwater Criteria

5. The Tenement Holder is required to address the following matters for the purposes of Regulation 63(1)(c) of the Regulations in relation to Fourth Schedule Clauses 1 and 2 for groundwater quality:

   5.1. Establish compliance groundwater monitoring bores that are at appropriate locations and of sufficient density and depth to measure or infer the groundwater quality on the land;

5.2. Design of the monitoring and measurement criteria framework must consider a mechanism to determine changes in groundwater quality that is caused by the field recovery trial as distinct from other sources of impact.
5.3. The measurement parameters and values that are taken to demonstrate achievement of the outcome must appropriately measure change to baseline groundwater quality.
5.4. The frequency of measurement must be appropriate to ensure demonstration of achievement of the outcome.
5.5. Measurement criteria is to be determined through consultation with DEM, DEW, EPA and any other relevant government department.
5.5.1. The measurement criteria must consider the potential oxidation of pyrite on metal(loid)s mobilisation in the downgradient zone.
5.5.2. The measurement criteria must be informed by leach testing to assess the mobilisation potential of uranophane, which was identified to have the highest uncertainty with the modelled chemistry.

Groundwater Leading Indicator Criteria

6. The Tenement Holder is required to address the following matters for the purposes of Regulation 63(1)(d) of the Regulations in relation to Fourth Schedule Clauses 1 and 2 for groundwater quality:

6.1. leading indicator criteria based on baseline groundwater quality; and
6.2. The frequency of leading indicator measurements must be appropriate to ensure there is an early warning of failure of any strategy; and
6.3. leading indicator criteria must be integrated with the Trigger, Action and Response Plan.

Soil Outcome

7. The Tenement Holder must ensure there is no contamination of land and soils either on or off the Land post completion as a result of field recovery trial activities.

Soil Strategy

8. The Tenement Holder is required to address the following matters for the purposes of Regulation 63(1)(b) of the Regulations in relation to the Fourth Schedule Clause 7:
8.1. Develop a spill management procedure in accordance with EPA Bunding and spill management guideline, May 2016.

Surface Water Outcome

9. The Tenement Holder must, during construction, operation and post completion, ensure that there is no adverse impact to the quality of surface water caused by field recovery trial activities.

Native Vegetation Outcome

10. The Tenement Holder must during construction and operation ensure there is no loss of abundance and/or diversity of native vegetation on or off the Land through:

10.1. Clearance;
10.2. dust/contaminant deposition;

10.3. soil erosion/soil compaction
10.4. fire; and/or
10.5. other damage;

unless a significant environmental benefit (SEB) has been approved in accordance with the relevant legislation.

Native Fauna Outcome

11. The Tenement Holder must ensure there are no native fauna injuries or deaths due to field trial activities that could have been reasonably prevented.

Weeds and Pest Outcome

12. The Tenement Holder must, during construction and operation, ensure no introduction of new species of environmental weed, plant pathogens or pests (including feral animals), nor sustained increase in abundance of existing weed or pest species on the Land.

Land use and third–party property Outcome

13. The Tenement holder must, during construction, operation and post completion, ensure there are no adverse impacts to third–party land use or property on or off the land as a result of field recovery trial activities other than those agreed between the tenement holder and affected users.

Heritage Outcome

14. The Tenement Holder must, during construction and operation, ensure there is no damage, disturbance or interference to Aboriginal or Non-Aboriginal heritage sites, objects or remains unless it is authorised under the relevant legislation.

Visual Amenity Outcome

15. The Tenement Holder must, in construction, operation and post completion ensure that the form, contrasting aspects and reflective aspects of field recovery trial activities are visually softened to blend in with the surrounding landscape as much as reasonably practical.

Air Quality Outcome

16. The Tenement Holder must, during construction and operation, ensure there are no public health impacts and/or nuisance impacts as a result of airborne emissions and/or dust generated by field recovery trial activities.

Air Quality Criteria

17. The Tenement Holder is required to address the following matters for the purposes of Regulation 63(1)(c) of the Regulations in relation to Fourth Schedule Clause 16 for air quantity:
    17.1. Establish measurement locations that are appropriate and of sufficient density and height to measure or infer the air quality;
    17.2. Design of the monitoring and measurement criteria framework must consider a mechanism to determine changes in air quality that is caused by the field recovery trial as distinct from other sources of impact.

17.3. The measurement parameters and values that are taken to demonstrate achievement of the outcome must appropriately measure change to baseline air quality or air quality at the control sites.
17.4. The frequency of measurement must be appropriate to ensure demonstration of achievement of the outcome.
17.5. Measurement criteria is to be determined through consultation with DEM, DEW, EPA and any other relevant government department.

Radiation Outcome

18. The Tenement Holder must ensure there are no public health or environmental impacts from radionuclides (including radon) as a result of field recovery trial activities or other authorised operations.

Radiation Criteria

19. The Tenement Holder is required to address the following matters for the purposes of Regulation 63(1)(c) of the Regulations in relation to Fourth Schedule Clause 18 for radiation;
    19.1. Establish measurement locations that are appropriate and of sufficient density and height to measure or infer the radionuclide exposure;
    19.2. Design of the monitoring and measurement criteria framework must consider a mechanism to determine changes in radionuclides that is caused by the field recovery trial as distinct from other sources of impact.
    19.3. The measurement parameters and values that are taken to demonstrate achievement of the outcome must appropriately measure change to baseline radionuclide ranges or radionuclide levels at the control sites.
    19.4. The frequency of measurement must be appropriate to ensure demonstration of achievement of the outcome.
    19.5. Measurement criteria is to be determined through consultation with DEM, DEW, EPA and any other relevant government department.

Traffic Outcome

20. The Tenement Holder must, during construction and operation, ensure no traffic accidents involving members of the public and mine related traffic that could have been reasonably prevented by the Tenement Holder.

Traffic Strategies

21. Tenement Holder is required to address the following matters for the purposes of Regulation 63(1)(b) of the Regulations in relation to the Fourth Schedule Clause 20:
    21.1. Develop a track maintenance program.
    21.2. Develop a traffic management plan.

Noise Outcome

22. The Tenement Holder must, during construction and operation, ensure no public nuisance impacts from noise as a result of field recovery trial activities or other authorised operations.

Public Safety Outcomes

23. The Tenement Holder must during construction and operation ensure that unauthorised entry to the site does not result in public injuries and/or deaths that could have been reasonably prevented.

24. The Tenement Holder must demonstrate that post completion, the risks to the health and safety of the public so far as it may be affected by field recovery trial activities or other authorised activities are as low as reasonably practicable.

Waste Outcome

25. The Tenement Holder must in constructing and operating the Lease ensure that all commercial or industrial waste is disposed of in accordance with relevant legislation.

Appendix B: Soil – Baseline Assessments

B1: Review of UraniumSA Ltd.'s 2013 Soil pH Testwork - Samphire Retention Lease Application Area. Prepared by Alligator Energy, February 2024.

Alligator Energy

Review of UraniumSA Ltd.'s 2013 Soil pH Testwork - Samphire Retention Lease Application Area

Samphire Uranium Project



Prepared by: Ashleigh Hisee

Introduction

Acid sulphate soils as defined by Department of Climate Change, Energy, the Environment and Water (DCCEEW, 2024) is soil which contains chemical compounds known as metal sulphides. Sulphides such as pyrite (FeS_2), pentlandite ($(Fe,Ni)_9S_8$), sphalerite ((Zn,Fe)S) for example can react when exposed to oxygen, forming sulphuric acid (EPA South Australia 2007; Vaughan 2018). Soils are considered acidified if the soil pH reaches 4 or below (EPA South Australia 2007; University of Adelaide).

Sulphide compounds have been shown to be present in high salinity environments including estuaries, mangrove swamps, coastal lakes and salt marshes (Bush et al. 2004). Sulphuric acid compounds can accumulate in the soil and be readily dissolved to sulphuric acid solutions when exposed to rain, drainage pathways and other water sources. The oxidation reaction reduces the available oxygen in water and can reduce the pH to 4 or less (EPA South Australia 2007). If these sulphide soils were present within the Samphire Project area, this could have the potential to de-oxygenate and acidify surface water supplies.

At the Samphire Project vegetation predominantly contains a mix of *Atriplex vesicaria, Maireana pyramidata, Maireana radiata and Maireana sedifolia* (Figure 1). The soil profile is unsaturated with observations of limestones in the soil profiles which matches the types of vegetation noted above (Seeds of SA website).

On site there are a series of artificial drainage pathways and very dry soil conditions. Acid sulphate soils normally occur when soils are waterlogged and/or oxygen-free reducing oxidation of sulphide compounds and then become exposed to air (Bush et al., 2004). To explore any possible chance of acid sulphate soils being a potential risk at the Samphire Project, Alligator has undertaken a review of soil pH data collected by previous project operator UraniumSA Ltd (USA) in 2013.

The USA soil pH have been compared for pH gradient. A subset of soil of samples were selected from the area of the proposed Retention Lease to observe if there were any acidic soils specifically in this area. The premise being, if the pH of these samples are equal to or lower than 4, this would indicate acidic soils were present and further investigation would be required.

Method

1. A series of soil samples were taken from 11 drill sites, by USA (Figure 2), at a series of 5 metre intervals starting from 0m to 50m. At each 5m interval, soil depths samples were taken from 0cm to 100cm in 10cm intervals.

2. A pH probe was used to test the samples pH and results were recorded.

3. Excel graphs were compared to EPA South Australia and DCCEEW guidelines for indication of acid sulphide soils. If any indication was detected, then further investing plans would commence.

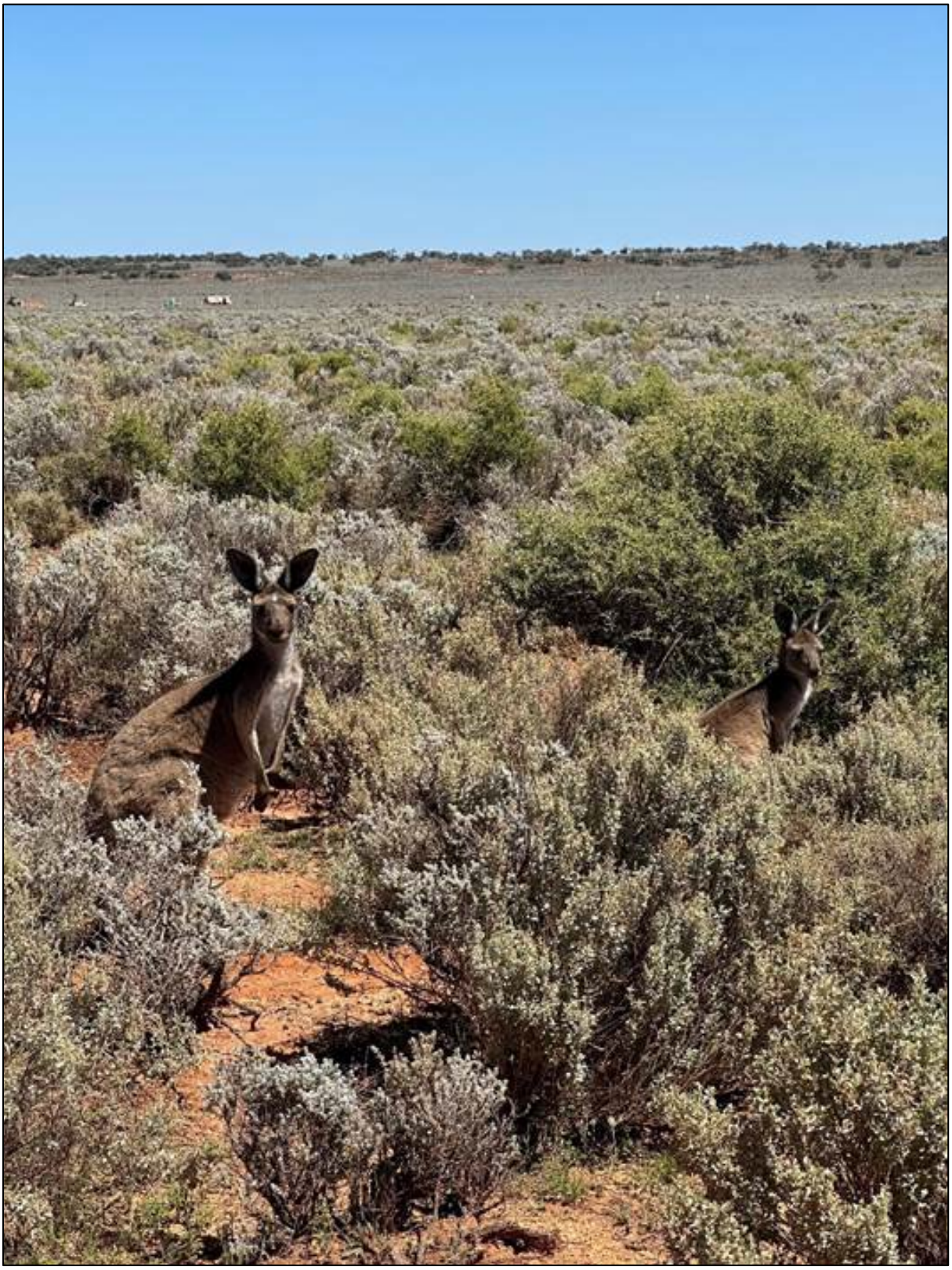


Figure 1: Photo from site of the vegetation and environment onsite. The site mostly contains a mix of A. vesicaria, M. pyramidata, M. radiata and M. sedifolia.

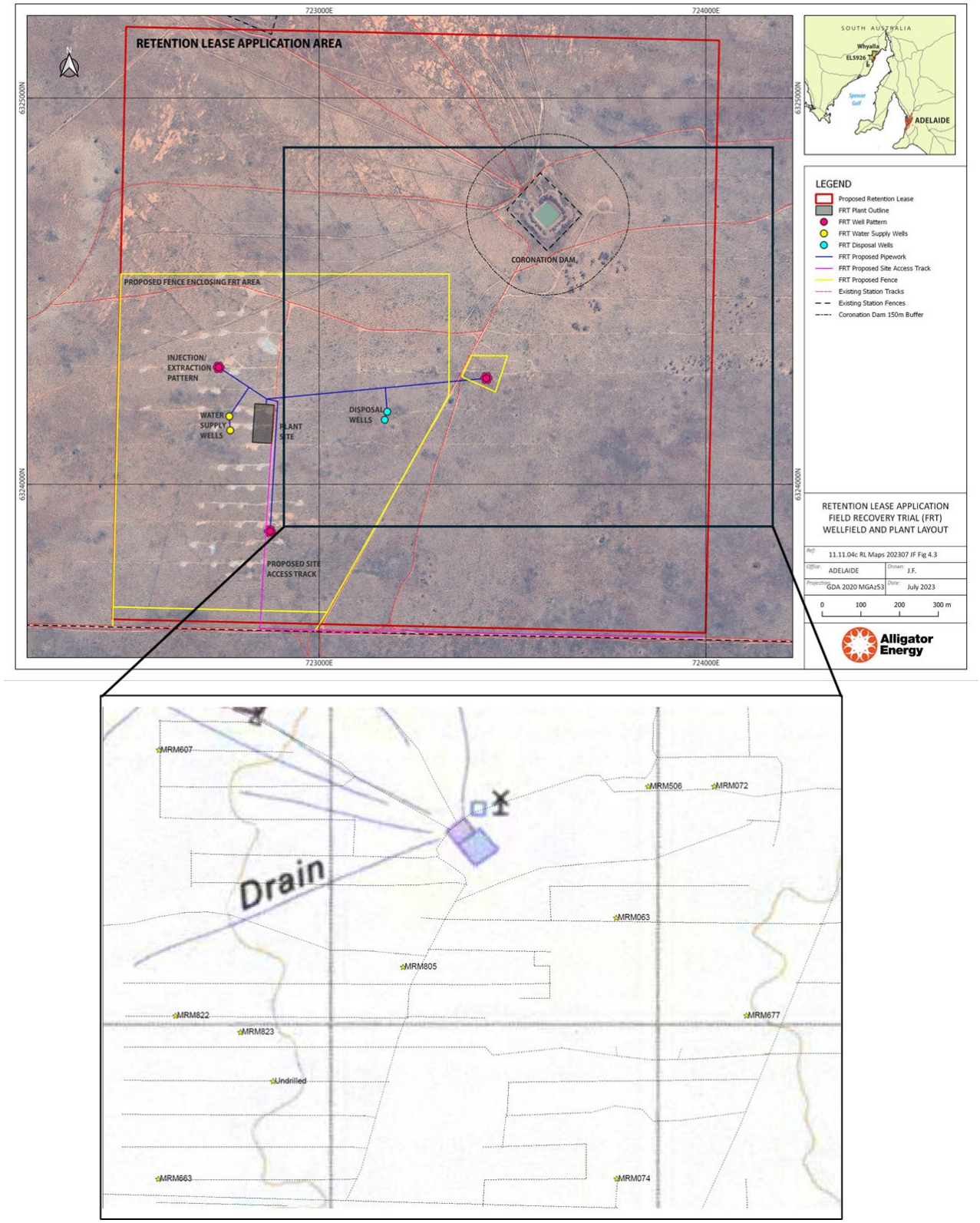


Figure 2: Map MRM drill site tested by Uranium SA. Data was not provided for drill holes 667 and the undrilled holes. Drill holes MRM072 and MRM677 were outside the current exploration lease.

Results and Discussion

The USA data indicates that no presence of acid sulphate soils within the samphire Retention Lease application area. All of the soils sampled, tested above a pH of 4 which is considered nonacidic soils (EPA South Australia 2007; University of Adelaide). The alkaline soils tested returned an average pH of 8.5 (Figure 3). This was expected as this aligns with the observed vegetation and landscape/environment of the site. Figure 3 below shows soils are mostly alkaline with the pH ranging from approximately 6.28 to 10.2 with the majority of data points ranging from 7.5 to 9.5. Raw data is included in Appendix 1.

There appears to be no significant change in pH (i.e. from alkaline to acidic) with distance from the drill site where samples were taken (Figures 4 & 5) and between drillholes suggesting a consistent alkaline category across the retention ease area for soils. pH appeared to be affected by depth of hole as results from the same hole had similar fluctuations in pH from same distance site.

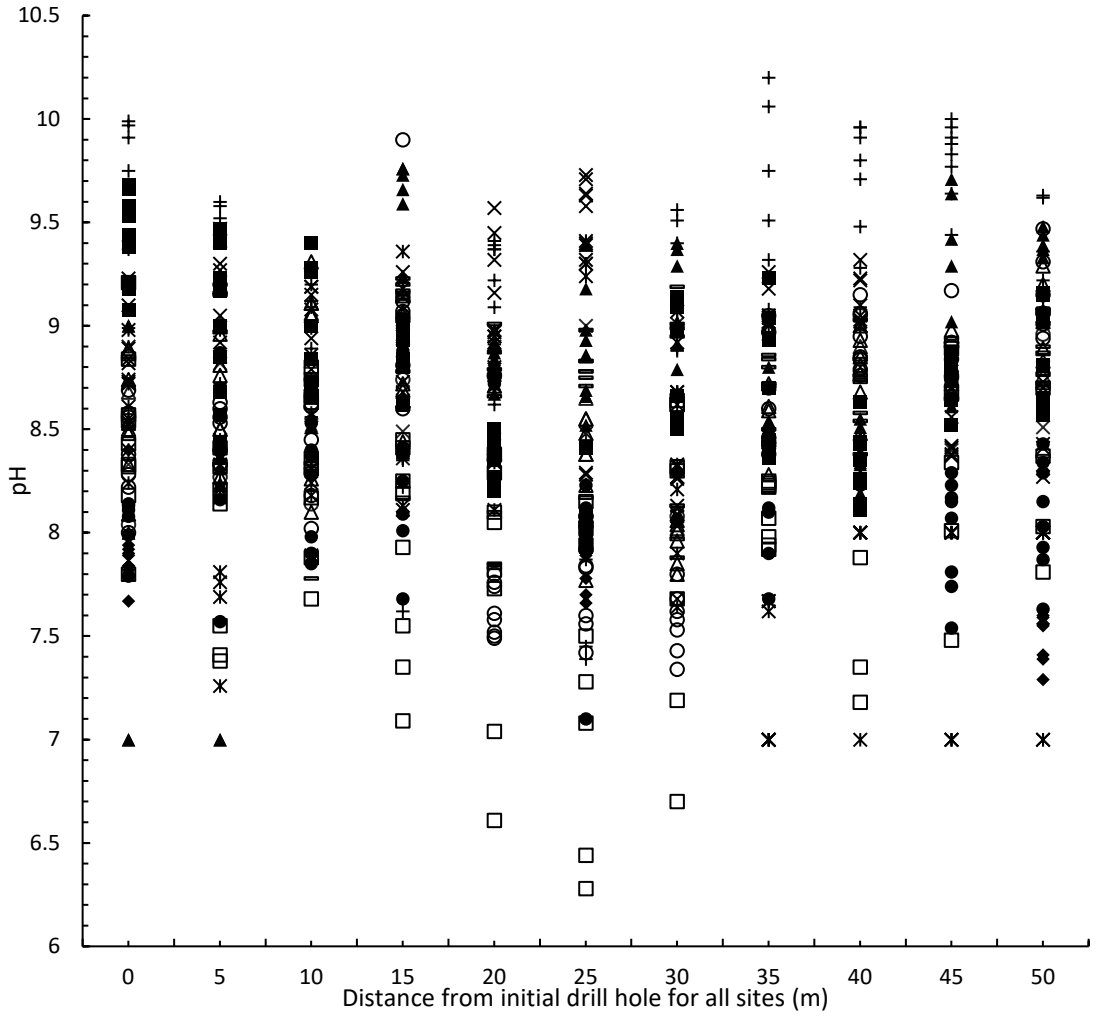


Figure 3: Distance from initial drill hole (m) effects on pH for all sites.

Drill site MRM 063 (+), drill site MRM 072, not in retention lease, drill site MRM 074 (-), drill site MRM 506, drill site MRM 607 (*), drill site MRM 663 (X), drill site MRM 805, drill site MRM 822, drill site MRM 823, drill site MRM 867 (◇) and drill site MRM 1044.

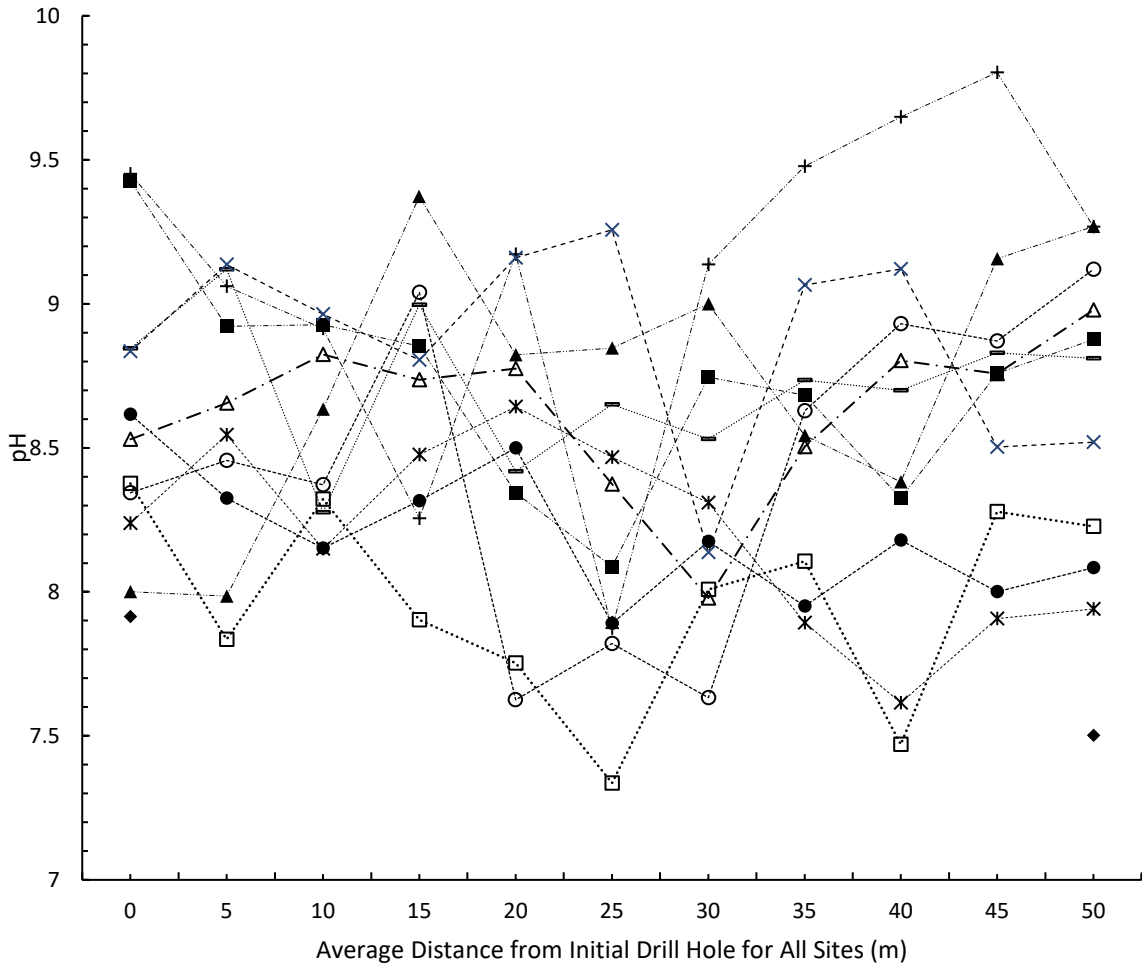
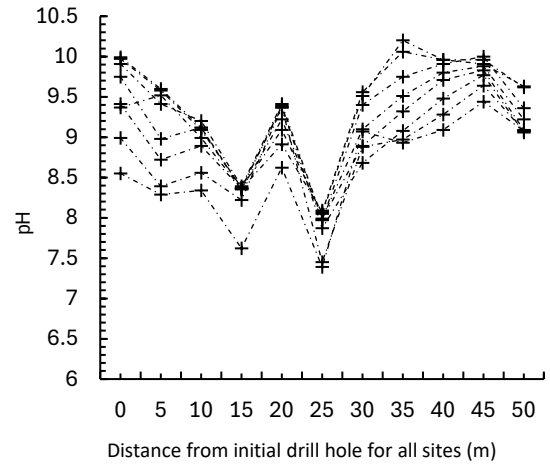
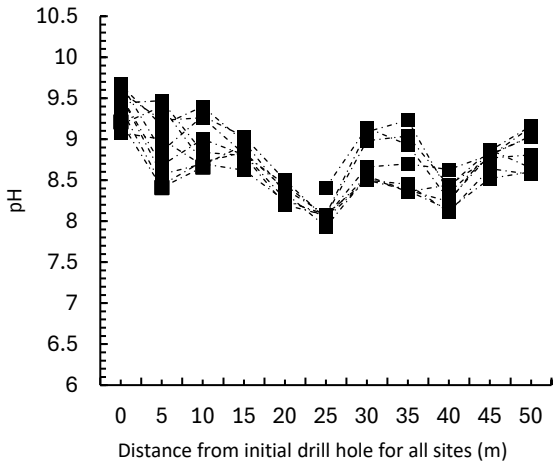


Figure 4: Variation of soil pH with distance from drillhole (m) for all sites.

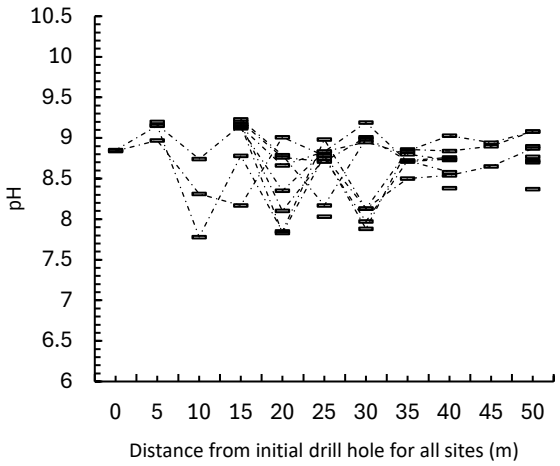
Drill site MRM063 (+), drill site MRM072, not in retention lease, drill site MRM074 (-), drill site MRM506, drill site MRM607 (*), drill site MRM663 (X), drill site MRM805, drill site MRM 822, drill site MRM823, drill site MRM867 (◇) and drill site MRM1044. Dotted line shows the trend between different depths at the same distance ranging from 0cm to 100cm deep with 10cm intervals.



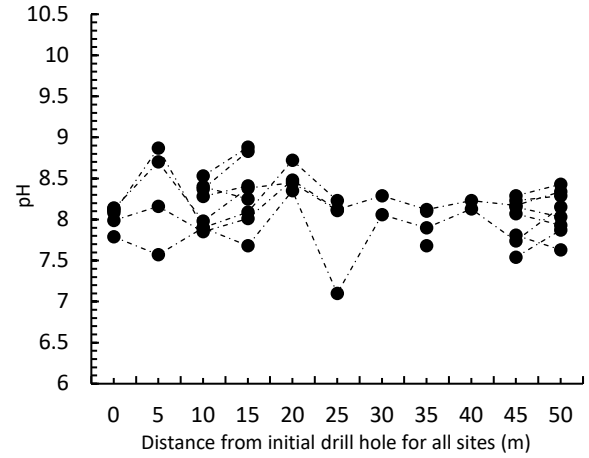
A MRM063



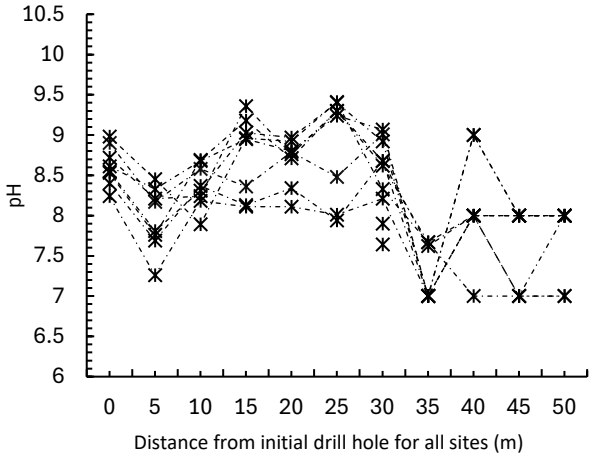
B MRM072 Not in retention lease



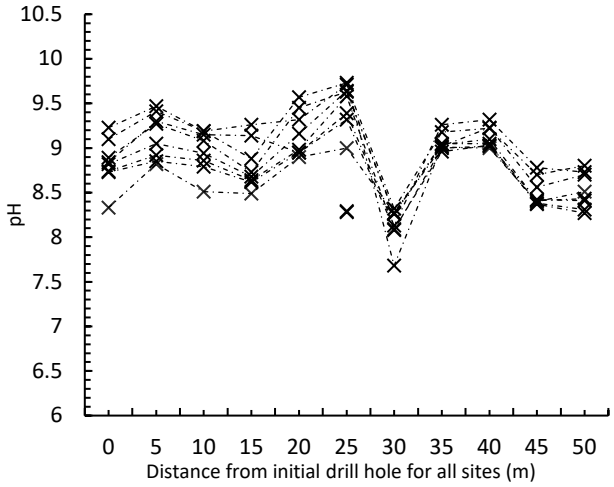
C MRM074



D MRM506



E MRM607



F MRM663

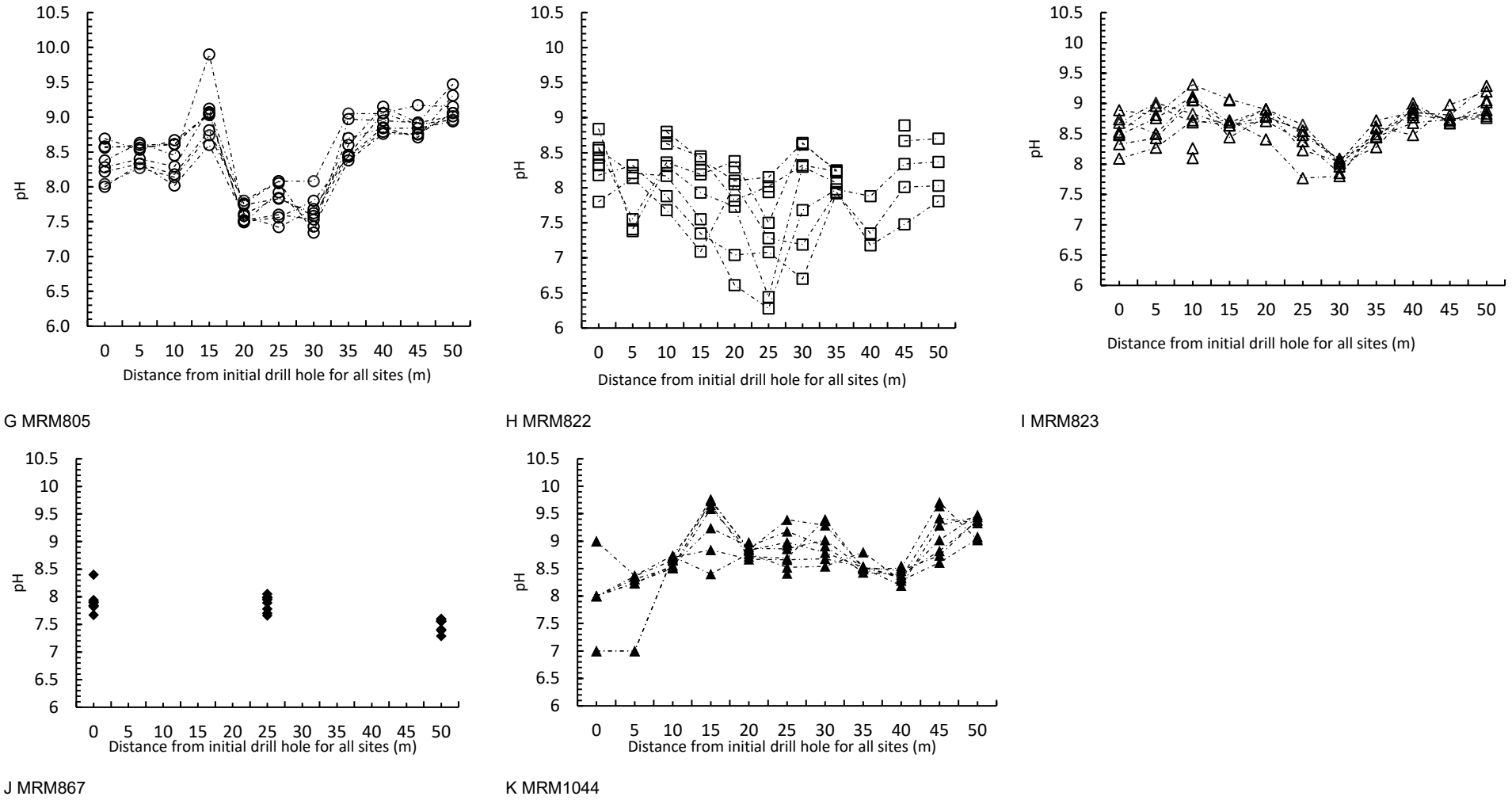


Figure 5: Variation of pH with distance from individual drill holes where initial sample was taken.

Drill site MRM063 (+), drill site MRM072, Not in retention lease (■) drill site MRM074 (-), drill site MRM506 (●), drill site MRM607 (*), drill site MRM663 (X), drill site MRM805 (○), drill site MRM822 (□), drill site MRM823 (△), drill site MRM867 (◇) and drill site MRM1044 (▲). Dotted line shows the trend between different depths at the same distance ranging from 0cm to 100cm deep with 10cm intervals.

Prevention Strategies (Accidental Exposure Treatment Plans)

As part of Alligator Energy's environmental management, many of the DCCEEW (2024) recommended water quality prevention strategies to acid sulphate soils are already in place as part of our sustainability program. The procedures in place are increasing vegetation coverage which has shown to reduce soil quality risk level. All extracted saline water used in Alligator's current drilling operations is stored in tanks to eliminate any risk to soil quality.

Conclusions

The data suggest the presence of acid sulphate soils are unlikely within the proposed Retention Lease area. due to the widespread alkalinity recorded, the observation of limestones in the soil profiles and the unsaturated soil profile and the vegetation is recorded as being found in calcareous soils (Seeds of SA website).

Appendix 1: Raw Data

Site	depth (cm)	Distance from the initial drill hole (m)										
		0	5	10	15	20	25	30	35	40	45	50
MRM 063	10	8.55	8.29	8.34	7.62	8.62	7.39	9.07	8.93	9.09	9.44	9.08
	20	8.99	8.39	8.56	8.22	9.37	7.45	8.88	8.97	9.28	9.64	9.08
	30	9.41	8.72	8.89	8.36	9.39	7.87	8.68	9.08	9.48	9.77	9.06
	40	9.75	8.98	9.12	8.37	9.37	7.98	8.89	9.32	9.71	9.83	9.09
	50	9.91	9.41	9.2	8.39	9.41	7.99	9.1	9.51	9.8	9.88	9.22
	60	9.99	9.6	9.12	8.35	9.22	7.97	9.4	9.75	9.91	10	9.36
	70	9.97	9.58	9.09	8.37	9.09	8.05	9.51	10.2	9.96	9.96	9.62
	80	9.37	9.52	8.99	8.36	8.91	8.07	9.56	10.06	9.96	9.91	9.63
	90											
	100						8.09					
MRM 072	10	9.08	9	8.68	8.93		8.41	9.14	8.93	8.26	8.81	9.03
	20	9.18	9.4	8.72	8.84	8.39	8.08	9.09	9.23	8.35	8.79	9.15
	30	9.44	9.47	8.84	8.8	8.2	8.07	8.98	9.04	8.43	8.86	9.16
	40	9.58	9.23	9.26	8.82	8.27	8.05	8.66	8.7	8.63	8.81	9.04
	50	9.66	9.17	9.4	8.97	8.35	7.93	8.54	8.36	8.44	8.77	8.81
	60	9.68	8.85	9.28	9.03	8.5	8.03	8.5	8.38	8.24	8.87	8.65
	70	9.53	8.68	9	8.81	8.45	8.05	8.55	8.37	8.14	8.52	8.6
	80	9.53	8.57	8.7	8.62	8.25	8.08	8.5	8.45	8.11	8.64	8.57
	90	9.38	8.44	8.73								
	100	9.21	8.41	8.66								
MRM 074	10	8.84	8.97	8.31	8.17	9.01	8.78	8.13	8.5	8.54	8.65	8.87
	20	8.85	9.15	7.78	8.78	7.85	8.98	8.13	8.84	9.03	8.94	9.08
	30		9.16	8.74	9.16	7.83	8.78	7.88	8.86	8.84	8.9	9.08
	40		9.2		9.17	8.1	8.75	7.97	8.72	8.76		8.9
	50				9.12	8.35	8.83	8.95	8.8	8.73		8.72
	60				9.14	8.66	8.83	9.19	8.71	8.74		8.7
	70				9.2	8.76	8.71	9.01	8.72	8.58		8.77
	80				9.23	8.79	8.17	8.99		8.38		8.37
	90											
	100						8.03					
MRM 1044	10	7	7	8.72	8.4	8.77	8.52	8.54	8.8	8.28	8.61	9.04
	20	7	7	8.7	8.84	8.67	8.66	8.68	8.52	8.46	8.74	9.39
	30	8	8.23	8.56	9.24	8.9	9.18	8.91	8.43	8.39	8.82	9.37
	40	8	8.24	8.51	9.59	8.83	8.98	8.79	8.52	8.33	9.02	9.48
	50	8	8.31	8.52	9.73	8.87	8.86	9.02	8.51	8.19	9.29	9.44
	60	8	8.36	8.65	9.76	8.84	9.39	9.29	8.53	8.34	9.42	9.33
	70	9	8.37	8.67	9.76	8.98	8.93	9.37	8.54	8.55	9.64	9.08
	80	9	8.37	8.74	9.66	8.72	8.69	9.4	8.49	8.51	9.71	9.02
	90											
	100						8.41					
MRM 506	10	7.79	7.57	7.9	7.68	8.35	7.1	8.06	7.9	8.13	7.74	8.15
	20	7.99	8.16	7.85	8.01	8.48	8.12	8.29	8.12	8.23	8.17	8.34
	30	8.08	8.87	7.9	8.09	8.72	8.23		7.68		8.29	8.43
	40	8.13	8.7	7.98	8.38	8.45	8.11		8.1		8.23	8.29
	50	8.11		8.53	8.88						8.15	8.03
	60	8.14		8.37	8.83						8.07	7.93
	70			8.28	8.41						7.54	7.87
	80			8.4	8.25						7.81	7.63

Site	depth (cm)	Distance from the initial drill hole (m)										
		0	5	10	15	20	25	30	35	40	45	50
	90											
	100											
MRM 607	10	8.98	8.45	7.89	8.96	8.92	9.41	8.33	7.67	7	7	7
	20	8.72	8.21	8.24	9.36	8.76	9.3	8.62	7.67	8	7	7
	30	8.53	7.76	8.69	9.18	8.71	9.3	8.68	7.62	8	7	8
	40	8.55	7.81	8.31	9.03	8.97	9.4	8.92	7	8	8	8
	50	8.61	8.33	8.68	8.95	8.8	9.24	9.07	7	8	8	8
	60	8.9	8.17	8.58	8.36	8.79	8.48	9.01	7	8	8	8
	70	8.4	7.69	8.37	8.13	8.34	7.94	8.68	7	9	8	8
	80	8.24	7.26	8.18	8.11	8.11	8.01	8.21	7	9	8	8
	90							7.64				
	100							7.9				
MRM 663	10	8.84	9.3	9.15	9.14	8.95	9.39	8.13	9.26	9.32	8.78	8.73
	20	9.23	9.47	9.19	9.26	9.32	9.71	8.32	9.18	9.22	8.7	8.8
	30	9.1	9.41	9.19	8.88	9.57	9.73	7.68	9.02	9.23	8.56	8.7
	40	8.89	9.27	9.08	8.73	9.45	9.63	8.26	9.04	9.1	8.41	8.43
	50	8.82	9.05	8.94	8.68	9.16	9.64	8.27	9.05	9.05	8.37	8.27
	60	8.74	8.92	8.86	8.64	8.98	9.58	8.08	9	9.02	8.38	8.31
	70	8.73	8.85	8.79	8.62	8.95	9.32	8.09	8.96	9.03	8.42	8.41
	80	8.33	8.82	8.51	8.49	8.9	9	8.27	9.01	9	8.4	8.51
	90						8.29					
	100						8.28					
MRM 805	10	8.00	8.33	8.02	8.60	7.58	7.42	7.68	8.46	9.06	9.17	9.15
	20	8.58	8.56	8.61	9.05	7.52	7.60	7.53	8.60	9.15	8.92	9.47
	30	8.69	8.53	8.67	9.03	7.50	7.56	7.80	8.44	8.85	8.71	9.31
	40	8.56	8.60	8.61	9.07	7.49	7.92	7.43	8.38	8.76	8.76	9.06
	50	8.38	8.63	8.45	9.90	7.61	7.84	7.58	8.43	8.79	8.75	9.06
	60	8.28	8.40	8.29	9.12	7.74	7.83	7.62	8.70	8.84	8.84	8.94
	70	8.22	8.33	8.18	8.81	7.76	8.08	7.34	8.97	8.95	8.92	9.01
	80	8.04	8.27	8.14	8.74	7.80	8.08	8.08	9.05	9.05	8.90	8.96
	90											
	100						8.05					
MRM 822	10	7.8	8.14	7.68	7.09	8.05	7.28	7.19	7.94	7.18	7.48	7.81
	20	8.18	8.32	7.88	7.35	7.04	7.08	6.7	7.92	7.35	8.01	8.03
	30	8.54	8.21	8.17	7.55	6.61	6.28	7.68	7.98	7.88	8.34	8.37
	40	8.84	7.41	8.31	7.93	7.73	6.44	8.3	8.07		8.67	8.7
	50	8.57	7.55	8.36	8.19	8.38	7.5	8.62	8.25		8.89	
	60	8.43	7.38	8.74	8.25	8.29	7.94	8.62	8.22			
	70	8.32		8.8	8.41	8.1	8.15	8.64	8.23			
	80	8.33		8.63	8.45	7.82	8.02	8.32	8.24			
	90											
	100											
MRM 823	10	8.53	8.96	8.69	8.72	8.41	7.77	7.8	8.61	8.48	8.98	9.2
	20	8.89	8.81	9.31	9.07	8.9	8.23	8.04	8.72	8.85	8.81	9.29
	30	8.5	8.5	9.06	9.05	8.8	8.38	7.96	8.59	8.77	8.67	9.05
	40	8.33	8.43	9.05	8.64	8.79	8.55	8.06	8.44	9	8.68	9.02
	50	8.48	8.76	9.11	8.44	8.78	8.55	8.01	8.28	8.93	8.72	8.89
	60	8.68	9.01	8.83	8.64	8.9	8.65	8.02	8.45	8.9	8.72	8.76
	70	8.74	8.5	9.11	8.69	8.91	8.48	8.09	8.49	8.81	8.74	8.83
	80	8.09	8.27	8.72	8.64	8.71	8.38	7.85	8.45	8.68	8.74	8.79

Site	depth (cm)	Distance from the initial drill hole (m)										
		0	5	10	15	20	25	30	35	40	45	50
	90			8.26								
	100			8.1								
MRM 867	10	7.67					7.78					7.41
	20	7.89					7.66					7.29
	30	7.82					7.7					7.39
	40	8.4					7.98					7.55
	50	7.84					7.95					7.56
	60	7.9					7.89					7.56
	70	7.92					7.95					7.56
	80	7.84					7.99					7.6
	90	7.94					8.05					7.59
	100						7.99					

References

Bush, R. T., Fyfe, D., & Sullivan, L. A. (2004). Occurrence and abundance of monosulfidic black ooze in coastal acid sulfate soil landscapes. *Soil Research*, *42*(6), 609-616.

DCCEEW (2024). Department of Climate Change, Energy, the Environment and Water - Acid Sulfate Soils. https://www.waterquality.gov.au/issues/acid-sulfate-soils.

Seeds of SA. Department of Environment and Water, Seeds of South Australia. https://spapps.environment.sa.gov.au/SeedsOfSA/speciesinformation.html?rid=2814

EPA South Australia (2007). Acid sulfate soil materials. https://www.epa.sa.gov.au/files/8371_guide_sc_acid.pdf

Appendix C: Soil – Baseline Data

Appendix C: Samphire RL 137 - Baseline Soil Data

Baseline Soil Radionuclides - Activity Data

Sample ID	Sampling Location	Sample Depth	U-238 (Bq/g)	Th-234 (Bq/g)	Pa-234 (Bq/g)	Th-230 (Bq/g)	Ra-226 RDP (Bq/g)	Ra-226 186 (Bq/g)	Pb-210 (Bq/g)	Ra-228 (Bq/g)	Th-228 (Bq/g)	Pb-212 (Bq/g)
Radion4_0015	FRT Process Plant Footprint	0-15 cm	0.0365 ± 0.0101	0.0365 ± 0.0101	< 0.178	< 0.0994	0.0363 ± 0.00161	0.0659 ± 0.00676	0.0707 ± 0.0109	0.0468 ± 0.00195	< 0.00543	0.0493 ± 0.00424
Radion4_1530	FRT Process Plant Footprint	15-30 cm	0.0388 ± 0.0106	0.0388 ± 0.0106	< 0.172	< 0.0935	0.0217 ± 0.000944	0.0643 ± 0.00674	0.0766 ± 0.0117	0.0424 ± 0.00177	< 0.00576	0.0463 ± 0.00398
Radion5_0015	FRT Process Plant Footprint	0-15 cm	0.0326 ± 0.0103	0.0326 ± 0.0103	< 0.293	< 0.165	0.0318 ± 0.00159	0.0608 ± 0.00752	0.0678 ± 0.0123	0.0415 ± 0.00238	< 0.00919	0.0453 ± 0.00395
Radion5_1530	FRT Process Plant Footprint	15-30 cm	0.031 ± 0.0101	0.031 ± 0.0101	< 0.337	< 0.173	0.0289 ± 0.00143	0.0637 ± 0.00827	0.0627 ± 0.0117	0.0418 ± 0.00259	< 0.0104	0.0448 ± 0.00391
Radion1_0015	FRT Process Plant Footprint	0-15 cm	0.0355 ± 0.0113	0.0355 ± 0.0113	< 0.338	< 0.18	0.0368 ± 0.00174	0.0613 ± 0.00879	0.0846 ± 0.0148	0.0397 ± 0.00229	0.0443 ± 0.00388	0.0443 ± 0.00388
Radion3_0015	FRT Process Plant Footprint	0-15 cm	0.0352 ± 0.0106	0.0352 ± 0.0106	< 0.293	< 0.162	0.0237 ± 0.00128	0.0553 ± 0.00787	0.0729 ± 0.0125	0.0458 ± 0.0025	0.0449 ± 0.00392	0.0449 ± 0.00392
Radion1_1530	FRT Process Plant Footprint	15-30 cm	0.0252 ± 0.00828	0.0252 ± 0.00828	< 0.345	< 0.146	0.0391 ± 0.00197	0.0726 ± 0.00941	0.0466 ± 0.00798	0.042 ± 0.00274	0.0461 ± 0.00404	0.0461 ± 0.00404
Radion2_1530	FRT Process Plant Footprint	15-30 cm	0.0546 ± 0.0156	0.0546 ± 0.0156	< 0.336	< 0.187	0.0362 ± 0.00173	0.0561 ± 0.00838	0.0704 ± 0.0128	0.0441 ± 0.00248	0.0484 ± 0.00423	0.0484 ± 0.00423
Radion3_1530	FRT Process Plant Footprint	15-30 cm	0.0407 ± 0.0123	0.0407 ± 0.0123	< 0.343	< 0.182	0.0369 ± 0.00177	0.0603 ± 0.00798	0.0561 ± 0.0112	0.047 ± 0.00253	0.0485 ± 0.00424	0.0485 ± 0.00424
Radion2_0015	FRT Process Plant Footprint	0-15 cm	0.0443 ± 0.013	0.0443 ± 0.013	< 0.33	< 0.176	0.0253 ± 0.00141	0.0694 ± 0.00899	0.0872 ± 0.0144	0.0435 ± 0.00253	0.0511 ± 0.00445	0.0511 ± 0.00445

Note: Soil samples were analysed by high-resolution gamma spectrometry (HPGe) to determine radionuclide activities. Results are reported in Bq/g with counting uncertainties, detection limits, and QC checks documented.

Baseline Soil Radionuclides – Elemental Data

Sample ID	Sampling Location	Sample Depth	U (mg/kg)	Th (mg/kg	Al (mg/kg)	Ca (mg/kg)	Cl (mg/L)	Cr (mg/L)	Cu (mg/L)	Fe (mg/kg)	K (mg/kg)	Mg (mg/kg)	Na (mg/kg)	Ni (mg/L)	P (mg/L)	Pb (mg/kg)	S (mg/kg)	Si (mg/L)	Sr (mg/L)	Ti (mg/L)	V (mg/L)
10019-001	South Dam	0-15 cm	1.20	8.00																	
10019-002	South Dam	0-15 cm	1.40	9.90																	
10019-003	South Dam	0-15 cm	1.20	7.30																	
10019-004	Central Dam	0-15 cm	2.30	9.50																	
10019-005	Central Dam	0-15 cm	1.60	10.00																	
10019-006	Central Dam	0-15 cm	2.10	11.00																	
10019-007	Operation	0-15 cm	2.00	14.00																	
10019-008	Operation	0-15 cm	2.30	15.00																	
10019-009	Operation	0-15 cm	1.90	12.00																	
10019-010	Coronation (North) Dam	0-15 cm	1.90	13.00																	
10019-011	Coronation (North) Dam	0-15 cm	1.40	13.00																	
10019-012	Coronation (North) Dam	0-15 cm	2.80	16.00																	
Radion1_1530	FRT Process Plant Footprint	15-30 cm	1.60	10.30	48,700	58,800	500	52	25	28,700	16,400	930	4,100	16	300	12	100	280,600	163.10	3200	74
Radion1_0015	FRT Process Plant Footprint	0-15 cm	1.70	10.60	49,500	34,100	300	40	21	29,600	17,800	8,500	3,900	16	300	13		296,600	113.80	3190	71
Radion2_1530	FRT Process Plant Footprint	15-30 cm	1.50	9.80	47,500	63,500	700	45	24	28,000	15,700	9,000	3,500	16	300	13		270,800	156.80	3100	67
Radion3_1530	FRT Process Plant Footprint	15-30 cm	1.40	9.40	44,200	55,700	300	45	21	26,800	15,900	8,100	3,600	14	300	13		290,900	138.70	3030	64
Radion2_0015	FRT Process Plant Footprint	0-15 cm	1.50	9.70	52,100	41,300	300	42	28	30,600	17,300	9,300	3,400	17	300	14		288,800	122.70	3520	73
Radion3_0015	FRT Process Plant Footprint	0-15 cm	1.40	9.50	52,000	36,300	300	40	21	29,000	17,200	7,900	3,700	15	300	14		312,600	107.80	3250	67
Radion4_1530	FRT Process Plant Footprint	15-30 cm	1.60	11.40	53,600	34,200	300	49	24	31,600	18,000	9,200	3,900	18	300	14	200	300,600	119.70	3510	73
Radion5_0015	FRT Process Plant Footprint	0-15 cm	1.40	9.70	49,300	22,200	300	40	19	30,400	18,600	7,900	3,700	15	300	14	200	322,100	90.10	3310	67
Radion5_1530	FRT Process Plant Footprint	15-30 cm	1.30	11.70	48,600	25,800	300	50	18	30,300	18,300	7,900	3,700	15	300	14	300	317,500	95.10	3240	69
Radion4_0015	FRT Process Plant Footprint	0-15 cm	1.60	10.90	56,000	19,300	300	45	21	33,000	19,300	9,100	3,800	19	300	15	300	309,200	94.90	3590	73

Note: Soil samples were analysed by ICP-MS for elemental concentrations following laboratory acid digestion. Data are reported in mg/kg (dry weight) with method detection limits and QC checks documented. Blank cells indicate samples not analysed or results below the detection limit (BDL).

Appendix C: Samphire RL 137 - Baseline Soil Data (cont.)

Baseline Soil Quality - Summary of Physical & Chemical Parameters

Sample Depth	pH (pH Units) - Min	pH (pH Unit) - Ave	pH (pH Unit) - Max	Cond. (µS/cm) - Min	Cond. (µS/cm) - Ave	Cond. (µS/cm) - Max	Ca (mg/kg) - Min	Ca (mg/kg) - Ave	Ca (mg/kg) - Max	Mg (mg/kg) - Min	Mg (mg/kg) - Ave	Mg (mg/kg) - Max	K (mg/kg) - Min	K (mg/kg) - Ave	K (mg/kg) - Max	Na (mg/kg) - Min	Na (mg/kg) - Ave	Na (mg/kg) - Max
0-15 cm	7.70	8.20	8.70	280	1270	5500	3500	25121	41300	7,200	8,207.14	9,300	7,900.0	11,764.3	19,300.0	230	2,024.29	3,900
15-30 cm	7.90	8.43	8.90	220	1389	3800	8800	38557	63500	930	7,545.00	9,200	5,800.0	10,735.7	18,300.0	270	2,302.86	4,100
Total	**7.70**	**8.32**	**8.90**	**220**	**1329**	**5500**	**3500**	**31839**	**63500**	**930**	**7,876.07**	**9,300**	**5,800.0**	**11,250.0**	**19,300.0**	**230**	**2,163.57**	**4,100**

Baseline Soil Quality - All Physical & Chemical Parameter Data

Sample ID	Sample Depth	pH (pH Unit)	Conductivity (µS/cm)	SO_4 (mg/kg)	Al (mg/kg)	Fe (mg/kg)	Pb (mg/kg)	Ca (mg/kg)	Mg (mg/kg)	K (mg/kg)	Na (mg/kg)	S (mg/kg)
Chem 1a	0-15 cm	7.80	2300	560	36,000	32,000	12	3,500	7,700	8,600.0	1,700	170
Chem 2a	0-15 cm	8.40	310	47	31,000	28,000	10	29,000	8,100	8,300.0	290	370
Chem 3a	0-15 cm	8.10	1200	87	30,000	27,000	11	25,000	8,100	8,100.0	1,900	480
Chem 4a	0-15 cm	7.70	5500	790	35,000	29,000	11	31,000	8,900	8,400.0	3,900	880
Chem 5a	0-15 cm	8.40	290	46	34,000	30,000	11	25,000	8,500	8,100.0	370	340
Chem 6a	0-15 cm	8.70	310	32	33,000	28,000	10	14,000	7,300	8,200.0	350	450
Chem 7a	0-15 cm	8.40	280	34	30,000	29,000	10	20,000	7,200	7,900.0	230	150
Chem 8a	0-15 cm	8.30	320	42	29,000	28,000	11	26,000	8,200	8,300.0	290	450
Chem 9a	0-15 cm	8.00	920	68	35,000	30,000	11	25,000	8,200	8,600.0	810	270
Chem 1b	15-30 cm	8.40	2800	340	35,000	32,000	11	8,800	8,600	8,600.0	2,000	220
Chem 2b	15-30 cm	8.90	840	52	23,000	23,000	8	41,000	7,200	6,300.0	1,500	770
Chem 3b	15-30 cm	8.60	1800	240	29,000	26,000	9	55,000	8,100	6,600.0	2,700	760
Chem 4b	15-30 cm	8.10	3800	880	30,000	27,000	10	51,000	8,800	7,200.0	3,900	660
Chem 5b	15-30 cm	8.50	1000	48	32,000	27,000	10	42,000	8,400	7,300.0	1,400	270
Chem 6b	15-30 cm	8.60	330	34	31,000	29,000	11	16,000	7,200	7,900.0	380	130
Chem 7b	15-30 cm	8.30	310	28	31,000	28,000	11	25,000	7,800	8,500.0	270	380
Chem 8b	15-30 cm	8.60	220	29	19,000	22,000	9	38,000	6,900	5,800.0	290	440
Chem 9b	15-30 cm	7.90	1400	99	38,000	28,000	12	25,000	7,500	7,800.0	1,000	470

Note: Soil samples were analysed for pH, electrical conductivity (EC), and major cations (Ca, Mg, K, Na) and anions (S as sulphate) at a NATA accredited laboratory, in accordance with standard soil chemistry procedures.

Appendix C: Samphire RL 137 - Baseline Soil Data (cont.)

Baseline Soil Quality - Hydrocarbon Data

Sample ID	Sample Depth	TRH - >C10-C16 (mg/kg)	TRH - >C10-C40 (mg/kg)	TRH - >C16-C34 (mg/kg)	TRH - >C34-C40 (mg/kg)	TRH - C10-C14 (mg/kg)	TRH - C15-C28 (mg/kg)	TRH - C29-C36 (mg/kg)	TRH - C6-C10 (mg/kg)	TRH - C6-C9 (mg/kg)	TRH - Total C10-C36 (mg/kg)	TRH - Total C6-C36 (mg/kg)	TRH - Total C6-C40 (mg/kg)	VOCs - Benzene (mg/kg)	VOCs - Ethylbenzene (mg/kg)	VOCs - m&p-Xylenes (mg/kg)	VOCs - Naphthalene (mg/kg)	VOCs - o-Xylenes (mg/kg)	VOCs - Toluene (mg/kg)	VOCs - Total Xylenes (mg/kg)	Oil and Grease (mg/kg)
Hydrocarbon 1a	0-15 cm	<10	<20	<10	<10	<10	<10	<10	<10	<10	<10	<20	<20	<0.1	<0.1	<0.05	<0.1	<0.1	<0.1	<0.2	<100
Hydrocarbon 1b	15-30 cm	<10	<20	<10	<10	<10	<10	<10	<10	<10	<10	<20	<20	<0.1	<0.1	<0.05	<0.1	<0.1	<0.1	<0.2	<100
Hydrocarbon 2a	0-15 cm	<10	<20	<10	<10	<10	<10	<10	<10	<10	<10	<20	<20	<0.1	<0.1	<0.05	<0.1	<0.1	<0.1	<0.2	<100
Hydrocarbon 2b	15-30 cm	<10	<20	<10	<10	<10	<10	<10	<10	<10	<10	<20	<20	<0.1	<0.1	<0.05	<0.1	<0.1	<0.1	<0.2	<100

Note:

- Soil samples were analysed for total recoverable hydrocarbons (TRH), volatile organic compounds (VOCs), and oil and grease by a NATA-accredited laboratory using standard methods:
- All reported results are in mg/kg (dry weight). Results below the laboratory reporting limits are denoted by "<" values.

Appendix C: Samphire RL 137 - Baseline Soil Data (cont.)

Baseline Soil & Sediment - Sampling Locations

Sample ID	Sampling Location	Northing (53H)	Easting (53H)
10019-001	South Dam	6320767	723264
10019-002	South Dam	6320767	723264
10019-003	South Dam	6320767	723264
10019-004	Central Dam	6330407	723349
10019-005	Central Dam	6330407	723349
10019-006	Central Dam	6330407	723349
10019-007	Operation	6324743	723534
10019-008	Operation	6324743	723534
10019-009	Operation	6324743	723534
10019-010	Coronation (North) Dam	6335896	726066
10019-011	Coronation (North) Dam	6335896	726066
10019-012	Coronation (North) Dam	6335896	726066
Chem 1a	FRT Process Plant Footprint	6324121	722837
Chem 1b	FRT Process Plant Footprint	6324121	722837
Chem 2a	FRT Process Plant Footprint	6324129	722837
Chem 2b	FRT Process Plant Footprint	6324129	722837
Chem 3a	FRT Process Plant Footprint	6324141	722838
Chem 3b	FRT Process Plant Footprint	6324141	722838
Chem 4a	FRT Process Plant Footprint	6324148	722858
Chem 4b	FRT Process Plant Footprint	6324148	722858
Chem 5a	FRT Process Plant Footprint	6324139	722856
Chem 5b	FRT Process Plant Footprint	6324139	722856
Chem 6a	FRT Process Plant Footprint	6324181	722833
Chem 6b	FRT Process Plant Footprint	6324181	722833
Chem 7a	FRT Process Plant Footprint	6324170	722833
Chem 7b	FRT Process Plant Footprint	6324170	722833
Chem 8a	FRT Process Plant Footprint	6324164	722833
Chem 8b	FRT Process Plant Footprint	6324164	722833
Chem 9a	FRT Process Plant Footprint	6324158	722831
Chem 9b	FRT Process Plant Footprint	6324158	722831
Hydrocarbon 1a	Fuel & Hydrocarbon Storage Footprint	6324124	722838
Hydrocarbon 1b	Fuel & Hydrocarbon Storage Footprint	6324119	722837
Hydrocarbon 2a	Fuel & Hydrocarbon Storage Footprint	6324119	722837
Hydrocarbon 2b	Fuel & Hydrocarbon Storage Footprint	6324119	722837
Radion1_0015	FRT Process Plant Footprint	6324149	722839
Radion1_1530	FRT Process Plant Footprint	6324149	722839
Radion2_0015	FRT Process Plant Footprint	6324160	722857
Radion2_1530	FRT Process Plant Footprint	6324160	722857
Radion3_0015	FRT Process Plant Footprint	6324179	722857
Radion3_1530	FRT Process Plant Footprint	6324179	722857
Radion4_0015	FRT Process Plant Footprint	6324181	722841
Radion4_1530	FRT Process Plant Footprint	6324181	722841
Radion5_0015	FRT Process Plant Footprint	6324213	722857
Radion5_1530	FRT Process Plant Footprint	6324213	722857

Appendix D: Hydrogeological & Geological Assessments

D1: Mullaquana Project Hydrogeological Setting. Report prepared for UraniumSA Ltd by Australian Groundwater Technologies Pty Ltd, March 2011.

Note:

1. The document presented here in Appendix D1 is a revision of a previously finalised report. Section 3 of the report has been updated to include data/calculations from field testing which occurred after the initial report along with minor grammatical corrections. Whilst this version is marked “DRAFT” Alligator Energy consider this the final version.
2. Footnote on page 16 in relation to porosity data states “From metallurgical test work of core samples within the field site (URS 2010)”; the report referenced makes no reference to this test work nor is Alligator Energy aware of any porosity test work completed. Please disregard this statement.
3. Section 4 of this report can be considered obsolete, this work relating to Natural Attenuation has been superseded by the work completed by UIT (Appendix F).

Australian
Groundwater
Technologies Pty Ltd
Mecrus Group



AGT Report no: UAC-1043-R003
March 2011

Mullaquana Project
Hydrogeological Setting

Prepared for UraniumSA

Document Control

Mullaquana Project Hydrogeological Setting

Report no
UAC-1043-R003

Prepared for
Uranium SA

Author	Date
Ben Jeuken	13/3/2011

Reviewed by	Date
Zac Sibenaler	17/3/2011

Approved by	Date
Ben Jeuken	17/3/2011

Revision history

Revision No.	Date Issued	Reason/Comments
V1	17/3/2011	Draft for Client Comment

Distribution

Copy No.	Location

Note: This is a controlled document within the document control system.
If revised, it must be marked SUPERSEDED and returned to the AGT QA Representative

Statement of Limitations

The services performed by AGT have been conducted in a manner consistent with the level of quality and skills generally exercised by members of its profession and consulting practice. This report is solely for the use of UraniumSA and may not contain sufficient information for purposes of other parties or for other uses. Any reliance on this report by third parties shall be at such parties' sole risk.

The information in this report is considered to be accurate with respect to information provided or conditions encountered at the site during the investigation. AGT has used the methodology and sources of information outlined within this report and have made no independent verification of this information beyond the agreed scope of works. AGT assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that the information provided to AGT was false.

AUSTRALIAN GROUNDWATER TECHNOLOGIES PTY LTD
ABN 97 110 928 928
Unit 5, 1 London Road, MILE END SOUTH SA 5031
PH: (08) 8352 4262
Fax: (08) 8354 3076
www.agwt.com.au

Contents

Document Control II
Contents III
1 Introduction 4
1.1 Background 4
2 Geological Setting 5
2.1 Regional Setting 5
2.2 Site Specific Stratigraphy 6
2.2.1 Overview 6
2.2.2 Quaternary 6
2.2.3 Gibbon Beds Clay (Pc) 6
2.2.4 Melton Clay / Marl (Mm) 7
2.2.5 Melton Sands (Ms) 7
2.2.6 Kanaka Beds (Es) 7
2.2.7 Basement Geology 8
3 Hydrogeology 9
3.1 Hydrostratigraphy and structure 9
3.1.1 Quaternary 9
3.1.2 Tertiary 9
3.2 Groundwater Investigations 10
3.2.1 Investigation wells 10
3.2.2 Level data and density correction 11
3.2.3 Chemical sampling and analysis 12
3.2.4 Aquifer testing to determine aquifer properties 13
3.3 Hydrogeological model 15
3.3.1 Quaternary 16
3.3.2 Tertiary 16
3.4 Third Party Groundwater Use 17
4 Natural Attenuation of Mining Fluids 18
4.1 Overview 18
4.2 Measured acid consumption 18
4.2.1 Kanaka Beds Unit 18
4.2.2 Melton Sands Unit 18
4.2.3 Melton Clay /Marl 18
4.3 Estimated plume extent 18
4.4 Summary 19
5 References 20
6 Figures 21
7 Appendix A – Geological Logs 31
8 Appendix B – Density correction of water level data 32
9 Appendix C – Chemical Analysis of Groundwater Samples 33

1 Introduction

1.1 Background

Australian Groundwater Technologies (AGT) has been engaged by UraniumSA (USA) to collate and analyse the available geological and hydrogeological data to develop a hydrogeological model of USA's Mullaquana uranium prospect, and specifically the Blackbush mineralised zone, which is the planned target for an In-situ Recovery Field Trial (ISR-FT).

The aim of this work is to develop a robust understanding of the hydrogeological setting, aquifer properties, confining bed properties, aquifer pressures and natural groundwater flow regimes to support a Retention Licence application to undertake an ISR-FT at this site.

This report provides an update of the Hydrogeological Assessment reported in AGT, (2010). The current report includes a summary of the results of extensive aquifer testing undertaken at the site in late 2010. A detailed aquifer testing report was provided in AGT (2011).

2 Geological Setting

2.1 Regional Setting

The Study area is situated within the Pirie Basin (Figure 1). The Pirie Basin is a north trending structural depression coincident with the Torrens Hinge Zone. Tertiary sediments of the Pirie Basin contain fluvial and marine facies, with deposition commencing in the Late Eocene. The south eastern boundary encompasses northern Yorke Peninsula, extending from Port Broughton south to Melton, then west to Wallaroo, in order to include the distribution of Melton Limestone (Alley and Lindsay, 1995).

The Tertiary basin fill comprises three major stratigraphic units: the early Tertiary Kanaka Beds, unconformably overlain by Late Oligocene to Early Miocene Melton Sand (informal name) and Limestone and then Pliocene-Pleistocene Gibbon Beds (Alley and Lindsay, 1995).

The Eocene aged Kanaka Beds are a succession of carbonaceous siltstone, shale and sand, with minor lignite, underlying the Melton Limestone and Sands. The Kanaka Beds extend discontinuously from Port Augusta to northern Yorke Peninsula along the eastern basin margin and from the north of Whyalla to the south of Cowell in the west. The Kanaka Beds uncomfortably overlie fresh and highly weathered Adelaidean strata, or Gawler Craton basement. Limited palynological data are available for this area and the age of the Kanaka Beds is late Eocene. It is indicated that the unit was deposited in a marginal marine to fluvial environment (Alley and Lindsay, 1995).

The informally named Melton Sand lies between the Kanaka Beds and the Melton Limestone. The unit comprises well rounded, poorly to well sorted quartztose sandstone, sparsely fossiliferous glauconitic gravelly sand and ferruginous sandstone. The Melton Limestone overlies and includes the informally named Melton Sand and is an intercalated clay, marl and bioclastic limestone succession representing five Late Oligocene and early Middle Miocene transgressive intervals (Alley and Lindsay, 1995).

The Gibbon Beds overlie the Melton Limestone and regionally comprise mottled clayey sand, sandy clay and conglomerate. In the project area the unit is eight to ten metres thick and thickens east across Spencer Gulf. Although unfossiliferous, the beds are probably non-marine and of Pliocene-Pleistocene age correlated with the Uley Formation on southern Eyre Peninsula (Alley and Lindsay, 1995).

Quaternary sediments overlay the Tertiary sediments, they consist of clays, gravels and sands, with some areas of surface limestone and aeolian sands. In the Pirie Basin, Pleistocene alluvial sands comprise Hindmarsh Clay, Telford Gravel and Pooraka Formation. Regionally, this sequence overlies irregular bedrock topography and total thickness is highly variable, from 40m to 150m. The Hindmarsh clay is consolidated mottled red, grey and yellow clay and sandy clay with discrete sand and gravel lenses. The Telford Gravel is typically coarse grained with large boulders

throughout. The Pooraka formation consists of unconsolidated silty clay, sand and carbonate earth with occasional gravel (Martin et al., 1998).

Natural boundaries of the Pirie Basin on either side of Spencer Gulf are formed by Cambrian and Precambrian basement rocks of the Mount Lofty - Flinders Ranges in the east and by the Gawler Craton to the west.

To better understand the structure of the sediments extending from the Mullaquana beneath the Spencer Gulf, a west-east geological cross-section through the area was constructed using all available data (Figure 2). Geological control for this section was provided as follows:

- The structure within the Mullaquana project area was interpreted from exploration and resource definition drilling undertaken by UraniumSA. Geological drillhole logs are provided as Appendix A.
- The bounding structure to the west of Mullaquana was taken from the sections presented in Forbes et al, (1983).
- Two drillholes on the eastern side of the Spencer Gulf provided structural control at this extent of the section. A SADME stratigraphic hole, PP4, provided depth to basement, whilst a coal exploration hole, P141, informed the thickness of Tertiary stratigraphic units (Figure 3).
- Control on the depth to basement some 10km offshore form Mullaquana was provided by Seismic Line 94DME-44 (Figure 3). This seismic Line indicates a continuity of the Tertiary sequence and a depth to basement rock of approximately -105 to -115mAHD. This depth is reasonably consistent (some 10m lower) than the depth to basement shown on the inferred section.

The data indicate that the Tertiary sediments are likely to continue to deepen for at least 7 to 10km to the east and offshore from Mullaquana.

2.2 Site Specific Stratigraphy

2.2.1 Overview

The stratigraphy encountered at the Blackbush Prospect at Mullaquana is consistent with the regional stratigraphic model of the Pirie Basin (Table 1). Site specific detail for each of the stratigraphic units is provided below.

2.2.2 Quaternary

The extensive young cover comprises of gypcrete and calcrete imposed on silt, sand and clay. In the Mullaquana Project area fluvial zones meander across the coastal plain and occur at the base of this section.

2.2.3 Gibbon Beds Clay (Pc)

In the Mullaquana Project area the Gibbon Beds clay has a thickness of 16 to18 metres. It is comprised of thick bedded massive plastic clay, with little compositional variation in the Blackbush prospect area.

2.2.4 Melton Clay / Marl (Mm)

Across the Mullaquana Project area the Miocene Melton Limestone comprises an upper section of variably calcareous plastic clay which grades downwards through marl and calcareous clay into a basal section of intercalated marl and bioclastic limestone. The bioclastic limestone is typically composed of millimetric sized fragments in a micritic calcite or silica matrix, silica commonly predominates. Intercalated clay, marl and limestone bands vary from a few centimetres to tens of centimetres to a meter thick. Typically the entire unit is 16 to 20 metres thick.

2.2.5 Melton Sands (Ms)

The informally named Melton Sand unit is present throughout the Mullaquana Project area occurring below the Miocene Melton Limestone and overlying either Eocene Kanaka Beds or weathered basement rocks. The unit is characterised by well rounded, fine to coarse grained to pebble fragments from varying quartztose, lithic and iron rich lithologies. Through the section and across the area, beds alternate from very well sorted with little to no matrix, through to intercalated sand/silt and silt/clay units with matrix dominated by jarosite in the north and west and by glauconite in the east and south. Typically the unit is four to six metres thick thinning to a meter or less over basement highs.

2.2.6 Kanaka Beds (Es)

Across the Mullaquana Project area the Eocene Kanaka Beds comprise cycles of sand/clay/lignite and sand deposited in marginal marine/lacustrine and fluvial settings. Locally at the Blackbush Prospect a fluvial dominated sequence runs from the north and west extending east into the more generally prevailing marginal marine setting.

The Kanaka Beds in the Mullaquana area are defined by the presence of sand units comprised of angular to sub-angular, fragment supported, clear quartz grains. Individual sand beds have a restricted range of grain size, angularity and very low matrix. Intercalated clay units are carbonaceous grading into lignitic clays and lignite – vitrinite fragments are relatively common with localised concentrations of liptinite.

Across the Mullaquana Project and particularly within the Blackbush Prospect the top of the Kanaka Beds is characterised by a white pipeclay intercalated with grey to black clays and lignite succeeded by typical clay/lignite/sand units (description below). At close drill hole spacing (>10m and <100m) there is erosional variability in the +/- 2m range at the upper surface. The inference is that this horizon represents a period of sub-aerial exposure and probable erosion post Eocene and pre-Melton Sand.

Within the Kanaka Beds a typical sedimentary cycle comprises two units. An upper unit [Es(U)] of clay, lignite clay and lignite in beds a few centimetres to a meter or so thick, intercalated with fine to coarse grained quartz sand beds of similar thicknesses. This upper unit overlies a lower unit [Es(L)] of thick bedded to massive fine to coarse grained sand. Where the lower sand rests on basement it is frequently terminated by a granular sand or pebble band a few centimetres to a meter thick at the unconformity.

In the east of the Mullaquana Project area, particularly where mixed marginal marine/lacustrine/fluvial conditions dominate, the Eocene section comprises up to

three cycles of clay/lignite/sand and sand. This section typically thins and condenses westwards as the depositional setting laps onto an emergent basement.

In the local area of the Blackbush Prospect single cycle fluvial sequence is confined within a channel incised into granite basement. Drill hole data indicates a prevalent channel width of 300 – 400m and side slopes of between 20 and 30. Outside the channel margins thin clay dominated Eocene sits directly on clay weathered to saprolite granite, and within the channel the Eocene basal pebble bands sits on weathered but clearly recognisable granite.

.

2.2.7 Basement Geology

Basement to the Tertiary sediments is a granite stock of presumed Hiltaba age. The upper surface of the granite is pervasively and intensely weathered with the widespread development of a saprolite profile comprising clay as matirx to disseminated angular fine to coarse grained clear quartz. Comparison of remnant fabrics within the saprolite with core of fresh granite indicates that the saprolite formed in-situ without disaggregation and transport.

The saprolite profile is preserved intact across the majority of the area but with localised erosional windows. Routine exploration drill holes stop after intersecting less than 10m of saprolite, with occasional holes being pushed on a few tens of meters. Recent drilling to obtain core of fresh granite intersected some 90m of saprolite. Parts of the western portion of the incised Eocene channel in the Blackbush area lie directly on weathered but clearly recognisable granite.

Interpretation of available aeromagnetic data (PIRSA database) and of airborne electromagnetic data (AEM, acquired by UraniumSA Limited) indicates fault structures extend into the body of the granite stock from the surrounding terrains However, the structures do not express as major features in the AEM resistivity sections.

3 Hydrogeology

3.1 Hydrostratigraphy and structure

The Hydrogeological units within the Pirie Basin are separated on a basis of similar lithological and hydraulic characteristics and outlined in Table 1. Cross sections have been constructed to show the relationship between the various hydrostratigraphic units and structural setting across the trial site (Figure 5 and Figure 6).Geological logs are provided in Appendix A).

Table 1: Hydrostratigraphic Units

Hydrostratigraphic Unit	Geological unit	Symbol	Description	Thickness (m)
Quaternary aquifer	Quaternary Sediments	Q	Gypcrete and Calcrete on sand silt and clay. Fluvial zones at base of section.	16-20
Tertiary Confining Bed	Gibbon Beds Clay	Pc	Thick bedded plastic clay, regionally extensive.	18 -22
	Melton Clay / Marl	Mm	Intercalcated, clay and marl, regionally extensive	16-20
Tertiary Aquifer	Metlon Sand	Ms	Upper Miocene Unit - Fine to coarse grained iron rich sands.	4-6
	Upper Kanaka Beds	Es(u)	Medium to coarse grained sands, inter-bedded with clay and lignite.	5-20
	Lower Kanaka Beds	Es(l)	Clean sand, minimal inter-beds	5-20
Basement Confining Bed	Weathered Basement	B	Saprolite, Kaolinitic Clays – weathered Hiltaba Granite	90+

3.1.1 Quaternary

The Quaternary Sediments at Mullaquana are unsaturated to the west where they are elevated above the regional water table. To the east where sediments dip down, the formation is saturated at the base and hosts saline to hyper-saline groundwater.

3.1.2 Tertiary

The Tertiary aquifer comprises the informal Melton Sands and the underlying Kanaka Beds Sands. These units host saline to very saline groundwater. The Tertiary aquifer is confined by the overlying Melton Limestone Marls and the Gibbon Beds clays.

3.2 Groundwater Investigations

3.2.1 Investigation wells

UraniumSA installed nests of groundwater investigation wells at seven locations on the Mullaquana Lease shown in Figure 7. At each site wells were installed into:

- the Quaternary sediments (at the base of the Quaternary) and
- the Tertiary aquifer where an upper and lower well were installed.
    - The upper well was installed into the Melton Sands unit, whilst
    - the lower well was installed into the Es(L) unit, (where present)
- Well completion details are presented in Table 2. Geological Logs are presented in Appendix A.

Two test production wells were installed at the proposed field trial site These wells are screened across mineralised sands within the Es(U). Pumping Tests were undertaken at these wells to provide information regarding likely production well yields, and aquifer hydraulic conductivity estimates.

Table 2: Hydrogeological investigation well completion details and survey data.

WellID	Permit Number	Easting	Northing	Stratigraphic Interval	Collar RL (mAHD)	Screen top	Screen Base
MRH1A	185439	722810.5	6324496.0	Ms	20.71	55	58
MRH1B	185440	722811.4	6324487.7	Q	20.71	11	14
MRH1C	185441	722803.1	6324501.8	Es(L)	20.78	71	74
MRH2A	185442	724195.9	6325495.3	Ms	17.22	37	40
MRH2B	185443	724197.1	6325505.0	Q	17.19	12.5	15.5
MRH3A	185453	724136.5	6323161.8	Ms	12.31	44	47
MRH3B	185454	724134.9	6323152.1	Q	12.39	14	17
MRH4A	185446	725304.8	6324499.4	Ms	7.22	36	39
MRH4B	185448	725294.3	6324497.7	Q	7.43	11	12.5
MRH4C	185447	725311.7	6324496.9	Es(L)	7.19	76	79
MRH5A	185449	725814.8	6325501.7	Ms	8.10	45	48
MRH5B	185450	725818.4	6325491.9	Q	8.23	16	17.5
MRH6A	185451	725099.2	6323603.8	Ms	7.91	43	46
MRH6B	185452	725101.2	6323594.5	Q	7.88	13.5	15
MRH7A	185444	722300.0	6324500.8	Ms	27.42	50	53
MRH7B	185445	722296.0	6324492.1	Q	27.56	10.5	12

One test well was installed at a site 1500m to the east where the Tertiary aquifer lithology changes to a marginal marine setting. This test site served to provide information regarding aquifer properties on a regional scale. Importantly, this site provided the opportunity to test the integrity of the confining layer between the Tertiary and Quaternary aquifers. Aquifer test pumping well details are presented in Table 2.

Table 3: Aquifer test pumping well completion details.

WellID	Permit Number	Easting	Northing	Stratigraphic Interval	Collar RL (mAHD)	Screen top (mBGL)	Screen Base (mBGL)
MRE1	193899	723297	6324297	Es(U)	16.3	56	63
MRE2	193895	723144	6324297	Es(U)	16.3	58	63
MRE3	-	725197	6324499	Es(U)	7.1	50	71

A further nest of 2 observation well and two injection wells were installed at an injection site. Well details are presented in Table 2.

Table 4: injection site investigation well completion details.

WellID	Permit Number	Easting	Northing	Stratigraphic Interval	Collar RL (mAHD)	Screen top (mBGL)	Screen Base (mBGL)
MRI1	193896	724410	6324786	Ms	11.6	41	49
MRI2	193894	724480	6324722	Ms	10.9	40	49
10A	193893	724427	6324781	Ms	11.5	45	48
10B	193892	724419	6324780	Q	11.6	13	16

3.2.2 Level data and density correction

Groundwater levels in surveyed wells were measured approximately every two weeks by USA over a period of some 4 months from February to June, 2010. Water levels were stable over this period.

Water level reference point elevation at the well collars was surveyed by Michael Grear Surveys on the 22/7/2010. Reported relative vertical survey accuracy was 0.02 m. Well survey data are presented in Table 2.

The aquifer pressure at each well was calculated by taking an average depth to water level measured over the period of record (excluding anomalous data), correcting to elevation using the collar survey data, and corrected for groundwater density (due to salinity) in the monitoring well, to yield freshwater equivalent aquifer pressures for each well point expressed in mAHD. Salinity data is described in the following section. Equivalent freshwater head calculations are presented in Appendix B. Data is presented in Table 3 and Figure 7.

Wells completed at the base of the Quaternary sediments to the west were dry, demonstrating that the formation is unsaturated at these locations. This is consistent with the observed water table, and the elevation of the sediments. Dry wells were: MRH1B, MRH2B, MRH4B, and MRH7B (Figure 7).

Table 5: Density corrected freshwater equivalent aquifer pressure data.

WellID	Average SWL	Screened interval	Formation	Salinity (mg/L TDS)	Density	Equivalent Freshwater head (mAHD)
MRH1A	18.90	55-58	Melton Sands	33800	1.024	2.71
MRH1C	18.63	71-74	Base of Kanaka Beds	44600	1.032	3.88
MRH2A	15.94	37-40	Melton Sands	47200	1.034	2.05
MRH3A	11.09	44-47	Melton Sands	44000	1.032	2.32
MRH3B	11.28	14-17	Quaternary Sediments	49700	1.036	1.27
MRH4A	6.33	36-39	Melton Sands	46700	1.034	1.95
MRH4C	6.16	76-79	Base of Kanaka Beds	51500	1.032	3.31
MRH5A	7.51	45-48	Melton Sands	60800	1.045	2.34
MRH5B	7.72	16-17.5	Quaternary Sediments	80200	1.060	1.05
MRH6A	6.96	43-46	Melton Sands	42800	1.031	2.11
MRH6B	7.23	13.5-15	Quaternary Sediments	60200	1.044	0.96
MRH7A	24.40	50-53	Melton Sands	33000	1.023	3.65

Where saturated, the aquifer pressure in the Quaternary sediments ranges from approximately 0.9 to 1.3 mAHD. Gradient is inferred towards the east to reach a common datum of sea level.

Aquifer pressure in the Tertiary aquifer ranges from 3.88 mAHD to 1.95mAHD. Aquifer pressure decreases toward the east. An upward vertical pressure gradient is observed from the Lower Kanaka Beds up to the overlying Melton Sands unit. The pressure in the Tertiary aquifer is also greater than the pressure in the overlying Quaternary aquifers.

3.2.3 Chemical sampling and analysis

Groundwater samples were taken from each of the wells following appropriate purging and sample preservation protocols. Chemical analyses are presented as Appendix C. Salinity at each well is marked in Figure 7.

Salinity in the Quaternary aquifer ranges from 50,000 to 80,000 and increases to the North and towards the coast.

Salinity in the Tertiary aquifer ranges from 33,000 to 51,500. The salinity in the upper Melton Sands unit increases with distance to the east. The salinity in the deeper Kanaka Beds unit is generally higher than the Melton sands and also shows an increasing trend to the east.

Groundwater samples were taken from Test production well during pumping tests and analysed for Ra226 concentration in addition to the standard full suite of analyses..

The salinity of all groundwater sampled in this area far exceeds the ANZEC limits (ANZEC 2000) for any agricultural or potable use. In addition uranium concentrations and Ra226 concentrations in the Tertiary aquifer exceed limits for potable and irrigation use.

3.2.4 Aquifer testing to determine aquifer properties

An extensive program of aquifer testing was undertaken at the site in order to develop a robust understanding of the hydrogeological regime. Aquifer testing is reported in Detail in AGT (2011). A brief overview is presented here.

Aquifer tests were undertaken at 3 sites within the study area shown in Figure 7 and summarised in Table 3:

Table 6: Overview of aquifer testing sites.

Site	Well	Tests
Production site	MRE001	3 x 100 minute Step Test 5 day Constant Rate Test
	MRE002	3 x 100 minute Step Test 24 hr Constant Rate Test
Injection Site	MRI001	3 x 30 minute Step Test 5 day Constant Rate Test
Regional Site	Regional Test Well	3 x 100 minute Step Test 24 hr Constant Rate Test

The general conclusions which can be drawn from the testing are summarised in Table 3.

Table 7: General conclusions from aquifer testing.

Site	Aquifer	Conclusions from aquifer tests
Production Test site	Quaternary	Unsaturated at this site
	Tertiary	• Confined aquifer which under pumping stress exhibits no discernable leakage from overlying or underlying confining beds. • Extensive aquifer exhibits no marked boundary conditions during extended pumping for 2.2 days. (Beyond this time re-injection of pumped water obscured possible boundary conditions). • All Tertiary aquifer units [Ms, Es(U) and Es(L)] are hydraulically connected. • Vertical hydraulic conductivity is less than the horizontal hydraulic conductivity by up to several orders of magnitude. This is likely due to inter-bedding observed within the aquifer sediments. The result is that, under pumping stress fluids within the aquifer will move far more readily in the horizontal plane that the vertical plane. • Average hydraulic conductivity of sand units is 7 m/day.
Injection Site	Quaternary	• Saturated • Hydraulically isolated from Tertiary aquifer.
	Tertiary	• Only Ms unit is present at this site • Confined aquifer • Average hydraulic conductivity of 31 m/day • No-flow boundary at approx 300m from the pumped well
Regional site	Quaternary	• Saturated • Hydraulically isolated from Tertiary aquifer.
	Tertiary	• Confined aquifer • Average hydraulic conductivity of 5 m/day • Tertiary aquifer Ms unit is hydraulically isolated from Es(U) and Es(L) units.

A summary of the aquifer properties derived from aquifer testing is presented in Table 3 below.

Table 8: Summary of aquifer testing results

Site	Hydrostratigraphy		Tertiary aquifer properties							
	Quaternary	Tertiary	Type	Total Tertiary aquifer Thickness (m)	Cumulative thickness of Tertiary aquifer sand units (m)	T (m^2/day)	K (m/day)	S	Ss	Boundary Conditions
Production Site	Unsaturated	Eocene and Miocene sand units	Confined	35	15	110	7	0.0002	0.000006	None
Injection Site	Saturated	Miocene sand units	Confined	7	7	215	31	0.0005	0.000071	no-flow boundary at approx 310m
Regional Site	Saturated	Eocene and Miocene sand units	Confined	35	18	85	5	0.00021[1]	0.000006[1]	none

Notes

1) Storativity and specific storage for regional site is inferred from specific storage at production site.

T = Transmissivity

K = hydraulic conductivity (Calculated from cumulative thickness of Tertiary aquifer units)

S = Storativity

Ss= specific storage (Calculated from total Tertiary Aquifer thickness)

A key aim of the aquifer testing was to determine boundary conditions at the Mullaquana site since understanding the hydrogeological structure at the site is important in understanding groundwater flow regimes. Boundary conditions inferred from analsyis of the pumped test data are summarised in Table 3 below.

Table 9: Summary of boundary conditions.

Site	Vertical Boundaries	Lateral Boundaries
Production	Confined with no discernable leakage	None within 1200m. Aquifer is laterally open
Injection	Confined with no discernable leakage	Single no-flow boundary at approx 310m distance. Likely to be a pinching out or facies change of the Ms unit.
Regional	Confined with no discernable leakage	None within approx 980m. Aquifer is laterally open

3.3 Hydrogeological model

Figure 8 presents the geological structure at the Blackbush project site overlaid by aquifer pressure data and groundwater salinity data. Inferred groundwater flow regimes are presented on the figure and discussed below.

3.3.1 Quaternary

The Quaternary sediments are unsaturated at the trial site and saturated and hyper-saline towards the coast. The increasing salinity toward the east is likely to be due to evaporative discharge where the water table approaches the surface close to the coast. These sediments are separated from the mining zone by around 40m of low permeability sediments of the Gibbon beds and Melton Limestone. The aquifer pressure in the Quaternary sediments is less than the pressure in the underlying confined Tertiary aquifer.

3.3.2 Tertiary

The Tertiary aquifers are confined by the approximately 40 m thickness of low permeability Melton Limestone marls and the Gibbon Bed clays. The Upper Melton Sand units laps onto basement to the west and extends across the site at least as far as drilling extends to the east. The Kanaka Beds infill incised channel structures to the west, before forming extensive sheet sands to the east.

The upper Melton Sands unit exhibits a pressure gradient from the west to the east. Likewise the Kanaka Beds unit exhibit a pressure gradient from west to east of approximately 0.0002, indicating that the potential for natural flow is from the west to the east.

The flow velocity in the Kanaka beds is calculated to be approximately 1.3 m/year, based on the estimated hydraulic conductivity of 7 m/day, measured porosity of 0.45[1], and measured aquifer pressure gradient of 0.0002.

At the Mullaquana production test site the entire thickness of Tertiary sands i.e., Melton sands and Upper and and Lower Kanaka Beds is in good hydraulic connection. This is evidenced by the drawdown that occurs in all layers when water is pumped from the Upper Kanaka Beds.

The drawdown response to pumping at all tested sites is consistent with a confined aquifer. This indicates that the Tertiary aquifer is vertically confined above by the Melton Marl and below by weathered basement and does not exhibit significant vertical leakage.

The paleochannel incised into basement at the Mullaquana site responds to pumping as an open system. This indicates that the paleochannel does not form a bounded strip aquifer, and that permeable aquifer sediments are draped over the paleochannel boundaries to form continuous sheet sands. This is consistent with the observed continuity of the Tertiary sands, particularly the Melton sand unit.

Inflow to the Tertiary system is inferred to be via lateral inflow from the west.

Discharge from the system is likely to be via lateral flow to the east and very slow, diffuse upward leakage through the confining beds to discharge to the Spencer Gulf.

[1] From metallurgical test work of cores samples within the field trial site (URS, 2010).

3.4 Third Party Groundwater Use

There are 11 water wells recorded within approximately 10km of the site and a further 14 recorded water bores at distances between 10 and 20km[2]. None of these bores have been located during site survey undertaken by UraniumSA (pers. comm., Russel Bluck[3] 2010), and it is likely that all were abandoned due to the high salinity of the regional groundwater being unsuitable for agricultural use.

[2] Data Sourced from Drillhole Enquiry System (https://des.pir.sa.gov.au/deshome.html)
[3] Managing Director UraniumSA

4 Natural Attenuation of Mining Fluids

4.1 Overview

The process where groundwater, which has been altered through the addition of leach solution, reverts through reaction to its surrounding aquifer matrix and pre-existing groundwater over a period of time to or towards its pre-contaminated state, without additional attenuating treatment is termed natural attenuation (CSIRO,2004).

The Tertiary aquifer at the Mullaquana Project exhibits a very slow migration of groundwater towards the east. At the completion of the ISR-FT, residual mining fluid left in the pore spaces of the rock can be expected to begin to move with the natural groundwater migration. Along this flow-path, natural attenuation of mining fluid is expected to occur as the mining fluid contacts and reacts with 'fresh" un-altered aquifer material.

The distance that mining solution will move before complete natural attenuation of acidic mining fluids is achieved has been estimated from acid consumption data measured through laboratory testing of aquifer material.

4.2 Measured acid consumption

4.2.1 Kanaka Beds Unit

Drill core of the Kanaka Beds sand aquifer, which is the target for mining, was recovered and standard bottle roll laboratory tests were undertaken to determine the amount of sulphuric acid consumed by reactive materials within the rock matrix. Measured acid consumption was 13kg acid consumed per tonne of aquifer material (SGS, 2010).

4.2.2 Melton Sands Unit

Mineralogical analysis of the upper Melton sands unit, which overly the ISR-FT target zone, shows a 2 to 5% calcite concentration. This equates to acid consumption of 19 to 47 kg/tonne.

4.2.3 Melton Clay /Marl

Similarly, the overlying Melton Marls can be expected to provide an even greater buffering capacity, though this has not yet been measured. Typical calcite concentration in Marls range around 30%.

4.3 Estimated plume extent

The distance that residual mining fluid will travel before all acid is consumed can be calculated quite simply as the distance in which the plume of mining fluid will encounter a volume of rock large enough to consume all the residual acid left behind in the pore spaces of the ISR-FT. This is shown conceptually in Figure 8.

For a 25 m radius field trial pattern, the residual volume of mining solution is estimated to be 10,800m^3 (allowing for standard flare away from the pattern). The acid content

of residual fluid with pH 1.7 is 1.5 Kg/m^3. This equates to a total mass of residual acid of 16,200 kg. The rock volume needed to consume all this acid is 700m^3. If the mining solution begins to migrate east, with a plume width of 50m and a plume thickness of 2m, then 700 m^3 of rock will have been encountered within 7m. Calculations are shown in Table 4.

This means that all acid is expected to be consumed within a lateral flow path of approximately 7m.

Table 10: Acid consumption calculations.

Acid Consumption	13	Kg / Tonne Dry Rock (Ore)
Residual Acid Concentration	1.5	Kg / m3 mining solution
Pore Volume of Patterns	1800	m3
Assumed "Flare factor"	6	flare of soln away from pattern
Residual pore volume	10800	m3 mining solution
Residual reagent	16200	Kilograms
Rock Mass To buffer reagent	1246	Tonnes
Rock Volume to buffer	692	m3 (rock density 1.8)
Assumed plume width	50	m
Assumed plume thickness	2	m
Distance to buffer	7	m

4.4 Summary

The data indicate that the Kanaka beds have the chemical capacity to attenuate residual mining fluid within a very short distance.

The very high acid consumption of the overlying Melton Sand and Melton Limestone provides a chemical “cap” or seal to the ISR-FT zone.

The acid consumption is expected to be acceptable for mining, where acid is continually added to the mining solution and circulated through the orebody. However, once mining ceases and no more acid is added to the system, the residual acid will be consumed within a very short distance as it moves laterally and contacts fresh unaltered rock.

5 References

AGT, 2010 *Mullaquana Project Hydrogeological Setting.* Consultants Report to UraniumSA. Australian Groundwater Technologies Report UAC-1043-R001_V5

AGT, 2010 *Mullaquana Project Aquifer Testing.* Consultants Report to UraniumSA. Australian Groundwater Technologies Report UAC-1043-R002_V2

Alley and Lindsay, 1995 *Pirie Basin* in *The Geology of South Australia Volume 2, the Phanerozoic.* Bulletin 54, South Australian Department of Mines and Energ.

ANZECC/ARMCANZ 2000. Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand.

CSIRO Land and Water. 2004. Review of Environmental Impacts of the Acid In-situ Leach Uranium Mining Process. Report for the South Australian Environment Protection Authority.
http://www.epa.sa.gov.au/pdfs/isl_review.pdf

Forbes, Parker and Flint 1983 Whyalla 1:250,000 Geological Map. South Australian Department of Mines and Energy.

GSI, 1998 Analysing Pumping Test data by the Logan Method. Geological Survey of Ireland Newsletter 34 December 1998.

Logan, J. 1964. Estimating transmissivity from routine production tests of water wells. Ground Water, 2, No. 1, 35-37.

Martin R., Sereda A. and Clarke D. (1998) Spencer regions strategic water management strategy. PIRSA DME 37/95

SGS, (2010) Uranium Leach Testwork Job No: 10594, by SGS Lakefield Oretest Pty Ltd, Unpublished Report.

URS (2010) Mullaquana Project – Preliminary Hydrogeological Assessment Conceptual Model. Technical Memo to UraniumSA

Weight and Sonderegger, 2000. Manual of Applied Field Hydrogeology. McGraw Hill New York

6 Figures

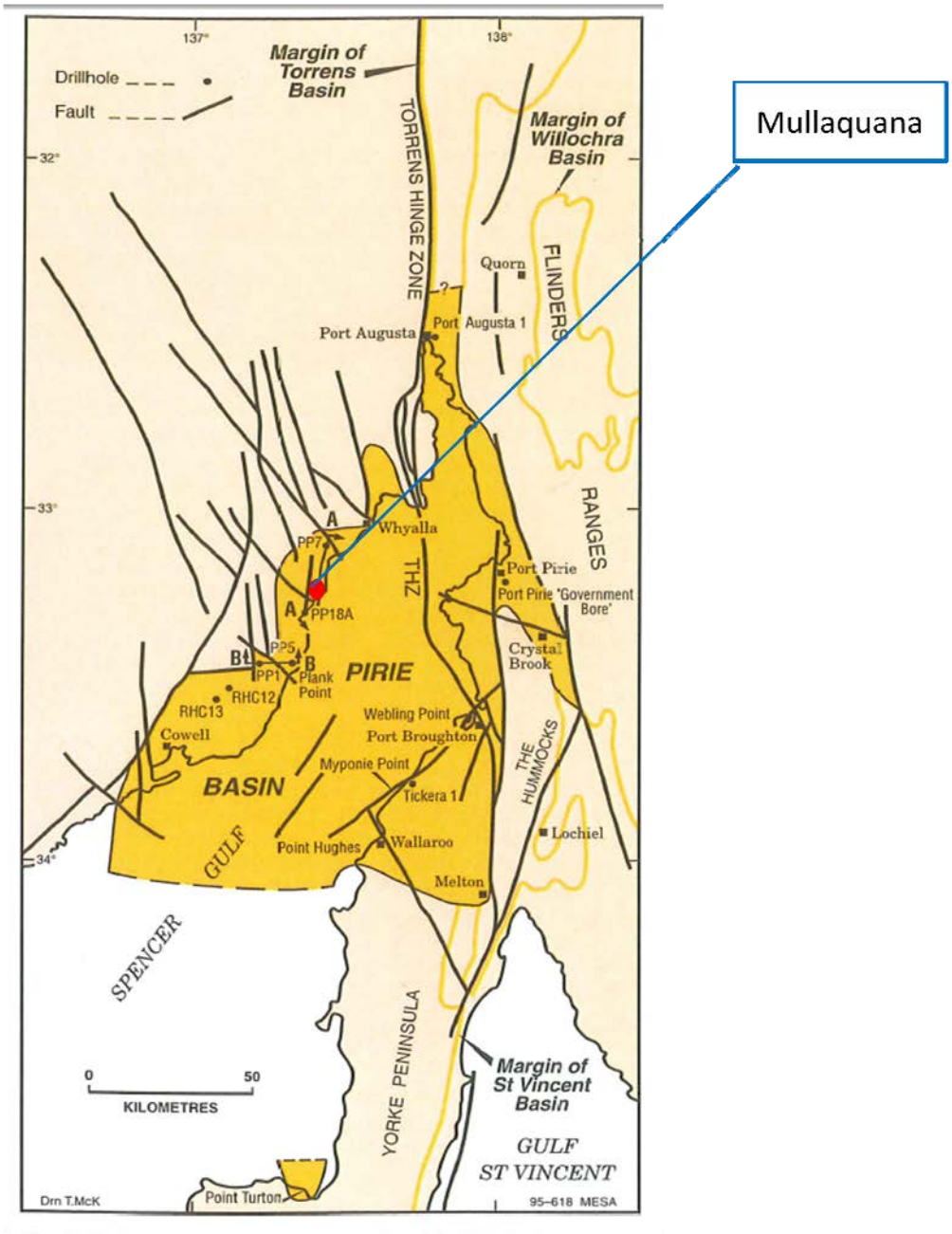


Figure 1: Locality Map and Pirie Basin setting

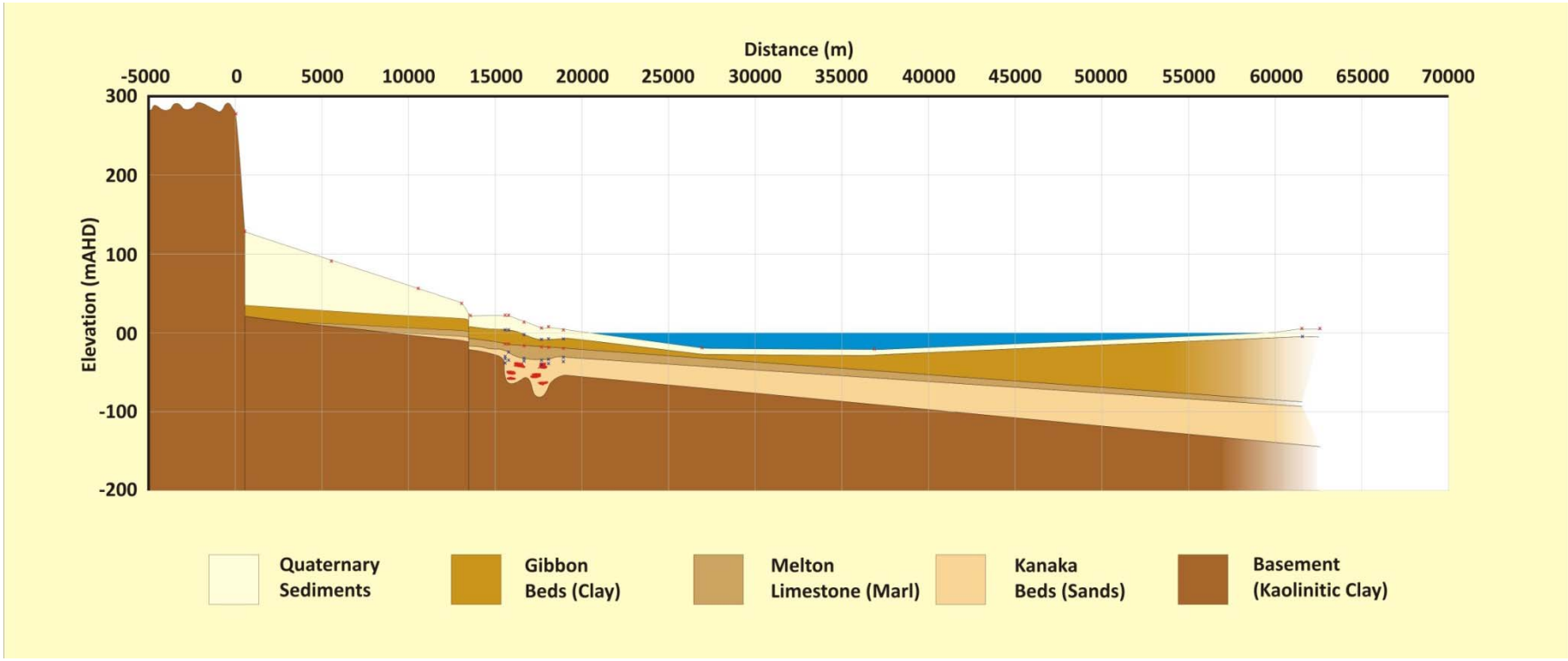


Figure 2: Regional West – East Cross Section

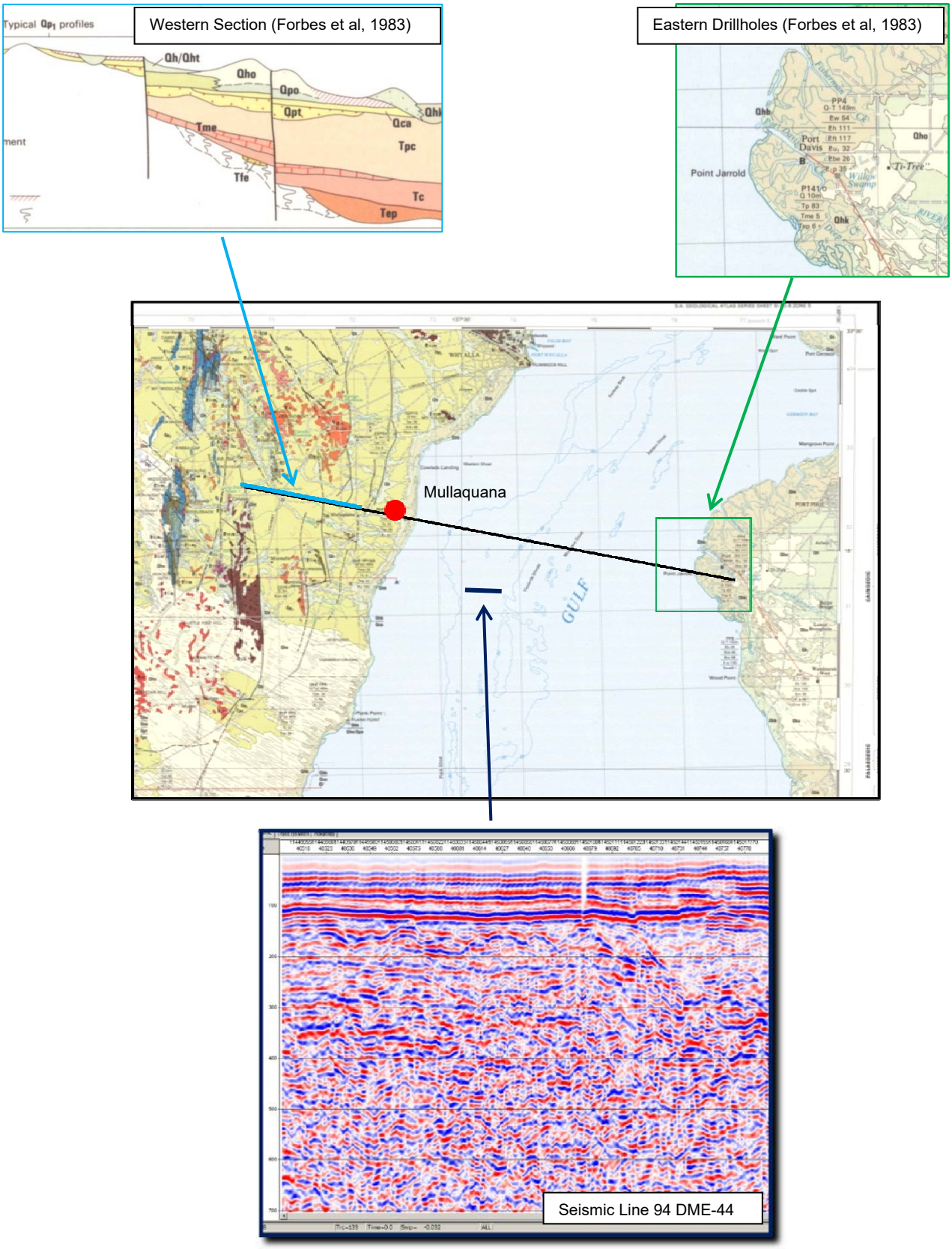


Figure 3: Regional West – East Cross Section Source Data

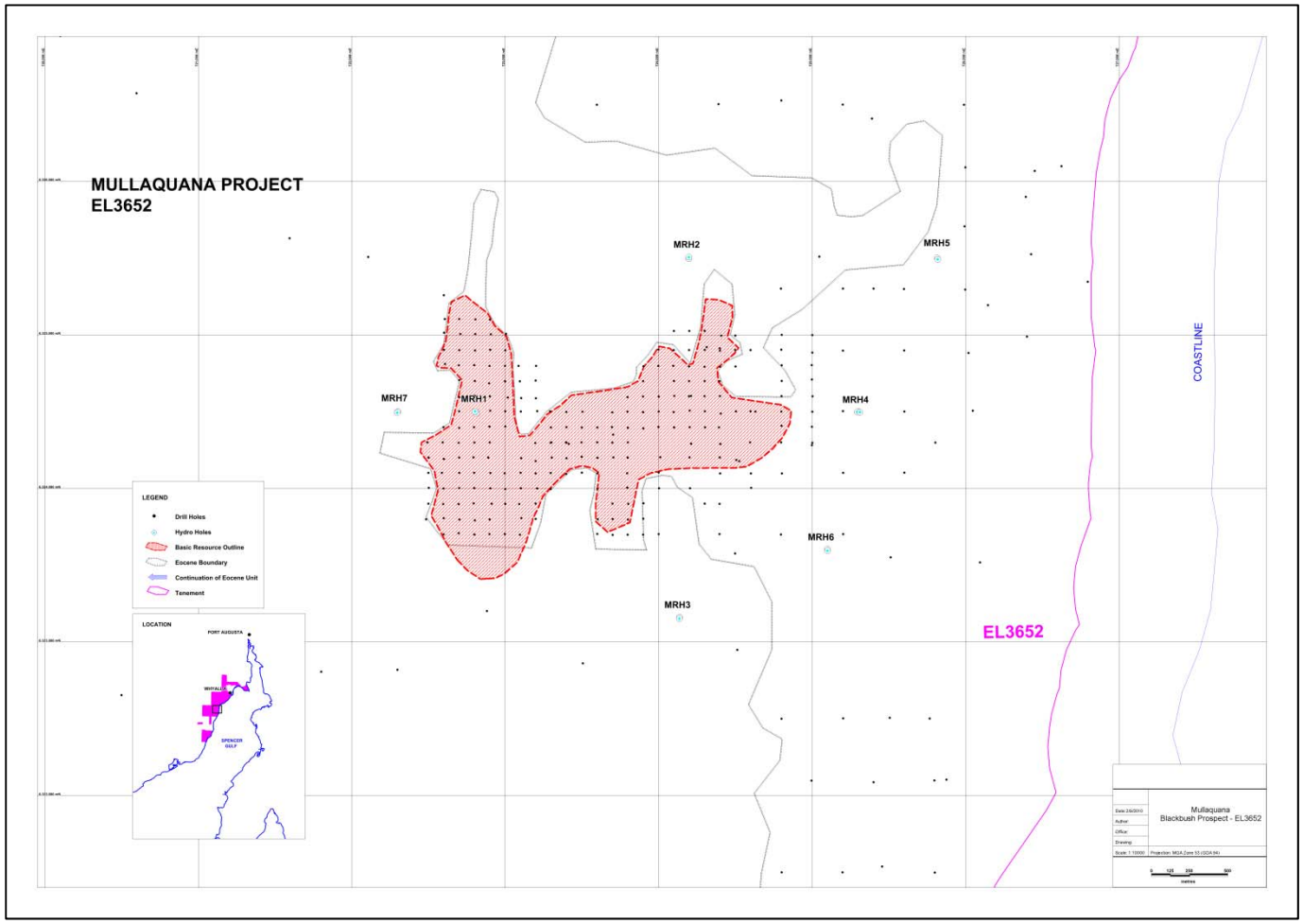


Figure 4: Mullaquana site, channel structure, extent of Kanaka Beds, and ore outline.

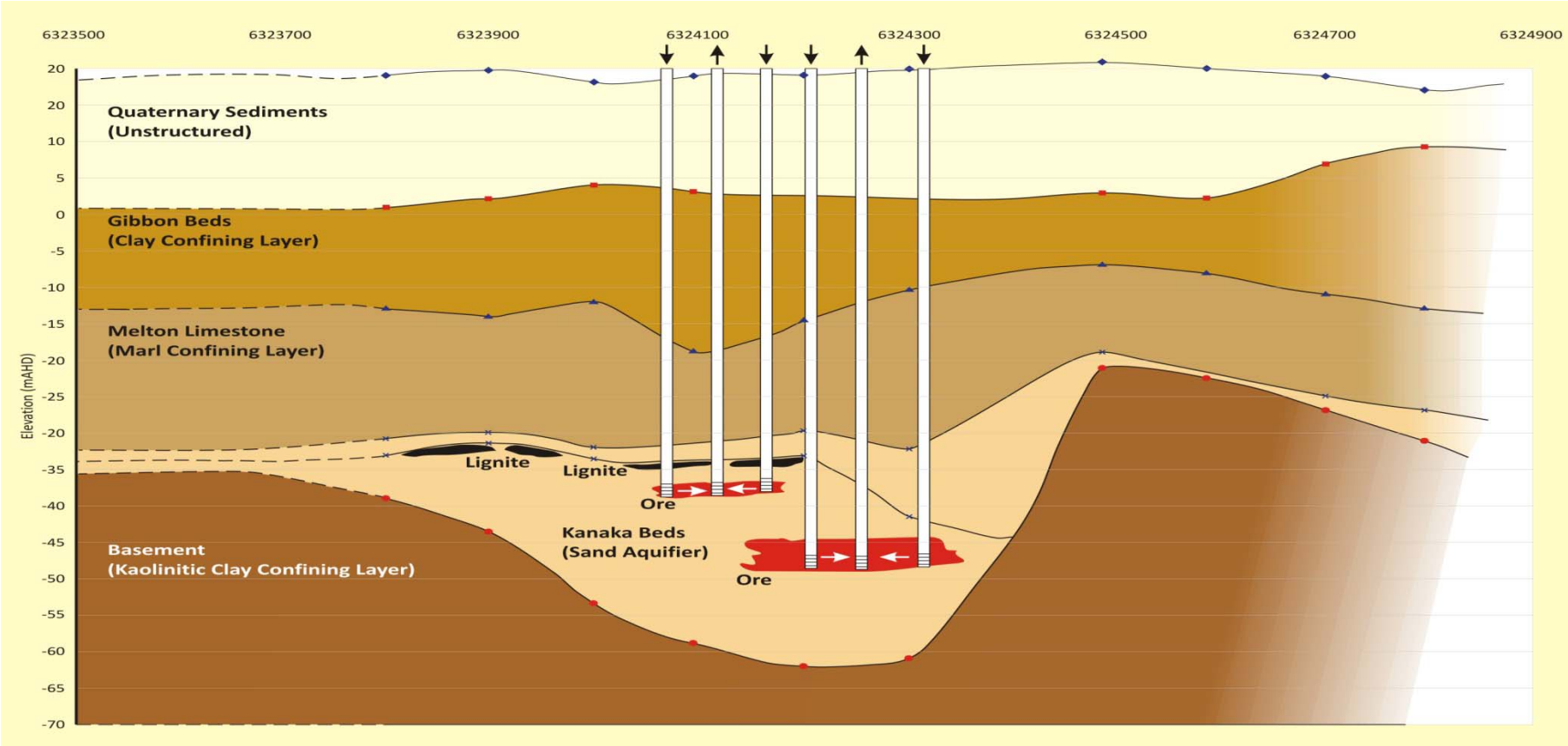


Figure 5: Field Trial Site South – North Cross Section

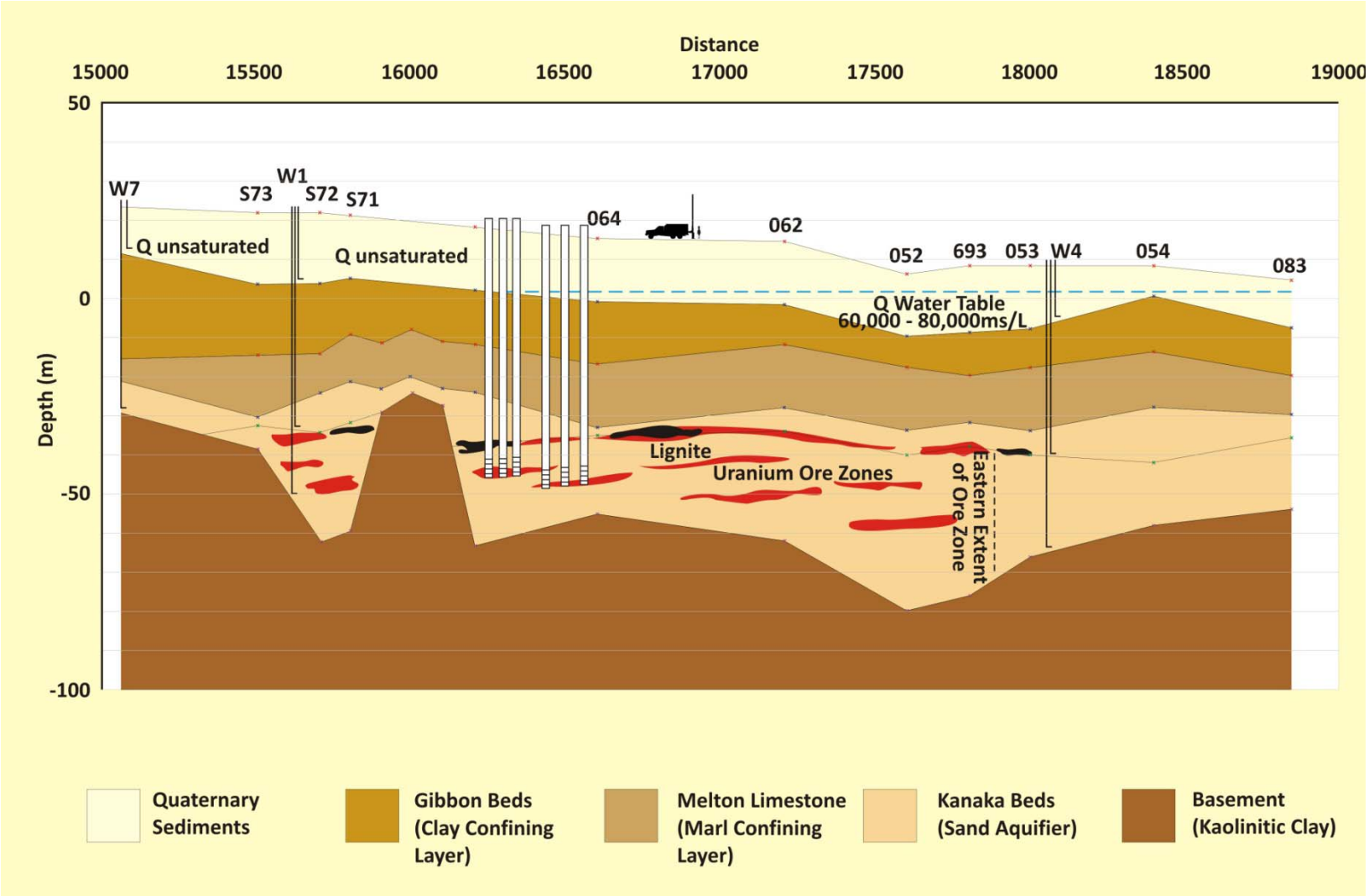


Figure 6: Field Trial Site West – East Cross Section

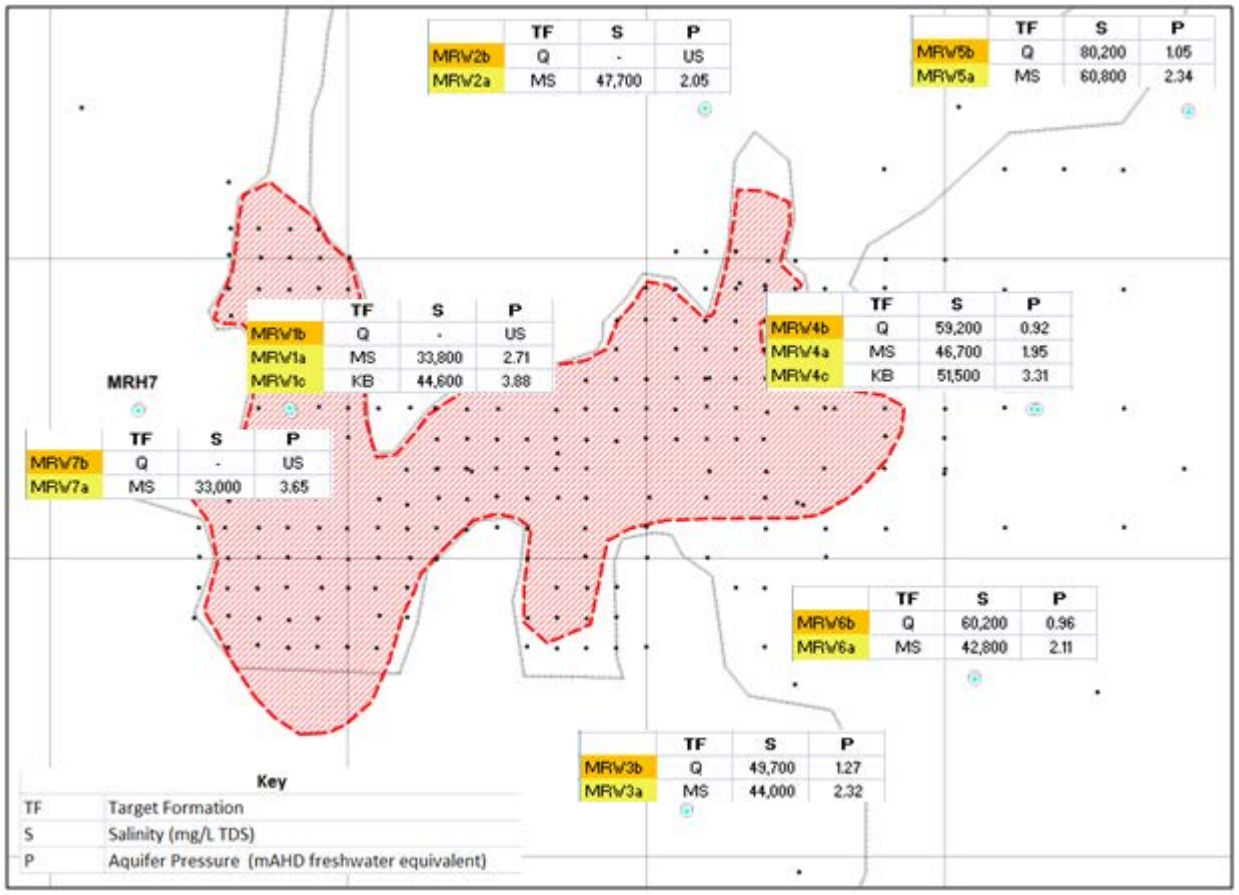


Figure 7: Hydrogeological Investigation well locations and measured data

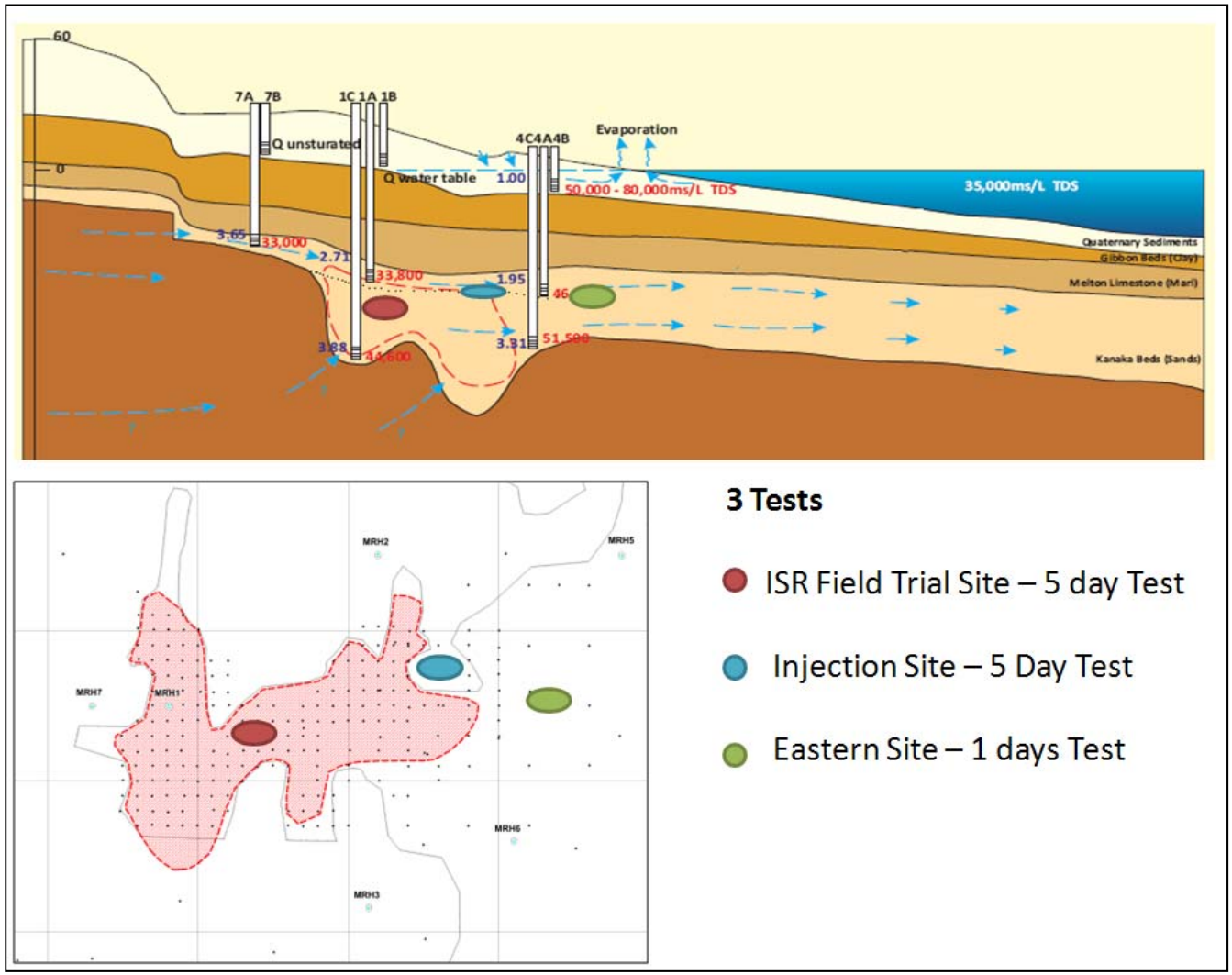


Figure 8: Aquifer (pumping) test sites

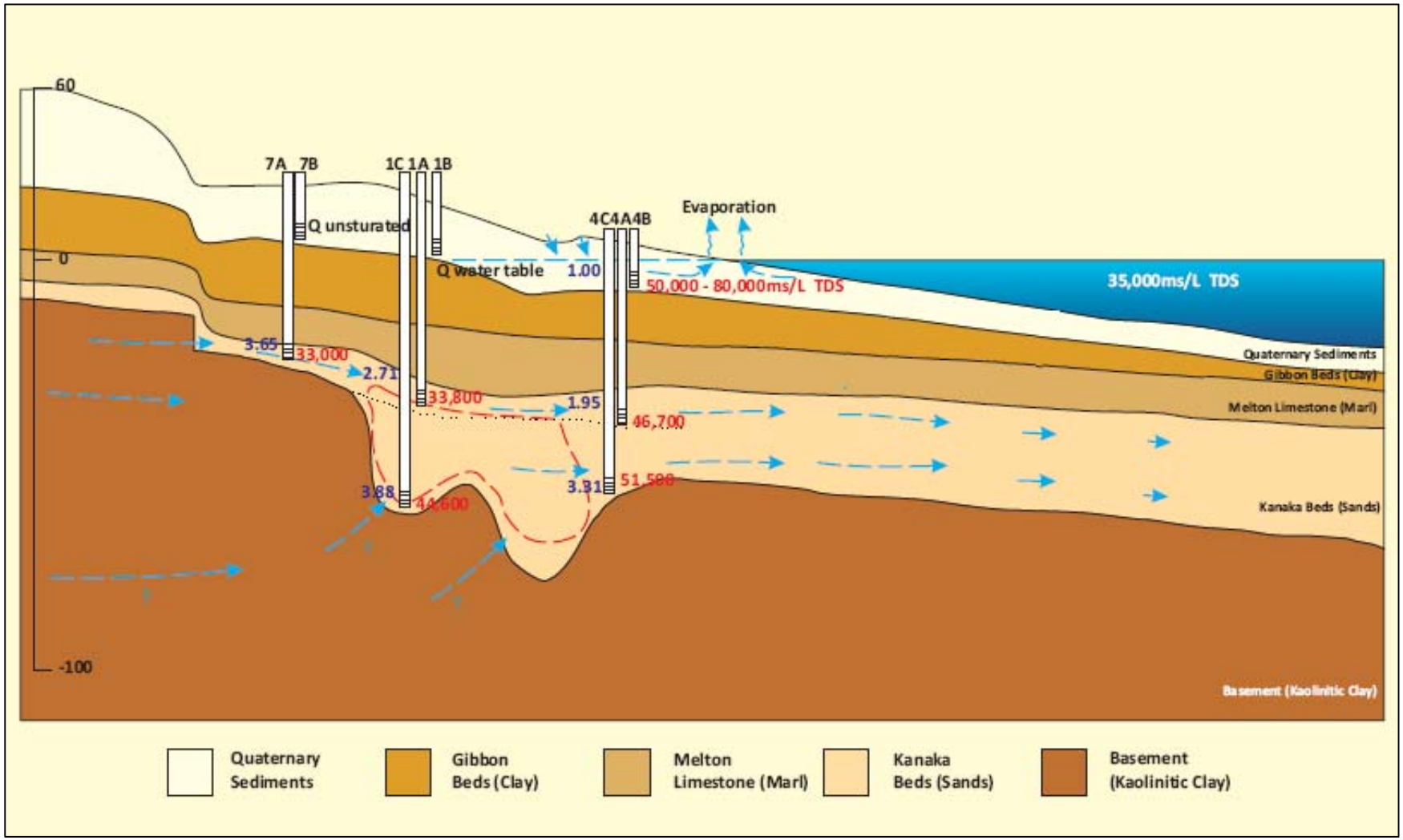


Figure 9: Hydrogeological Model. Red labels – groundwater salinity (mg/L). Blue labels - aquifer Pressure (mAHD freshwater equivalent). Dashed red line extent of mineralisation.

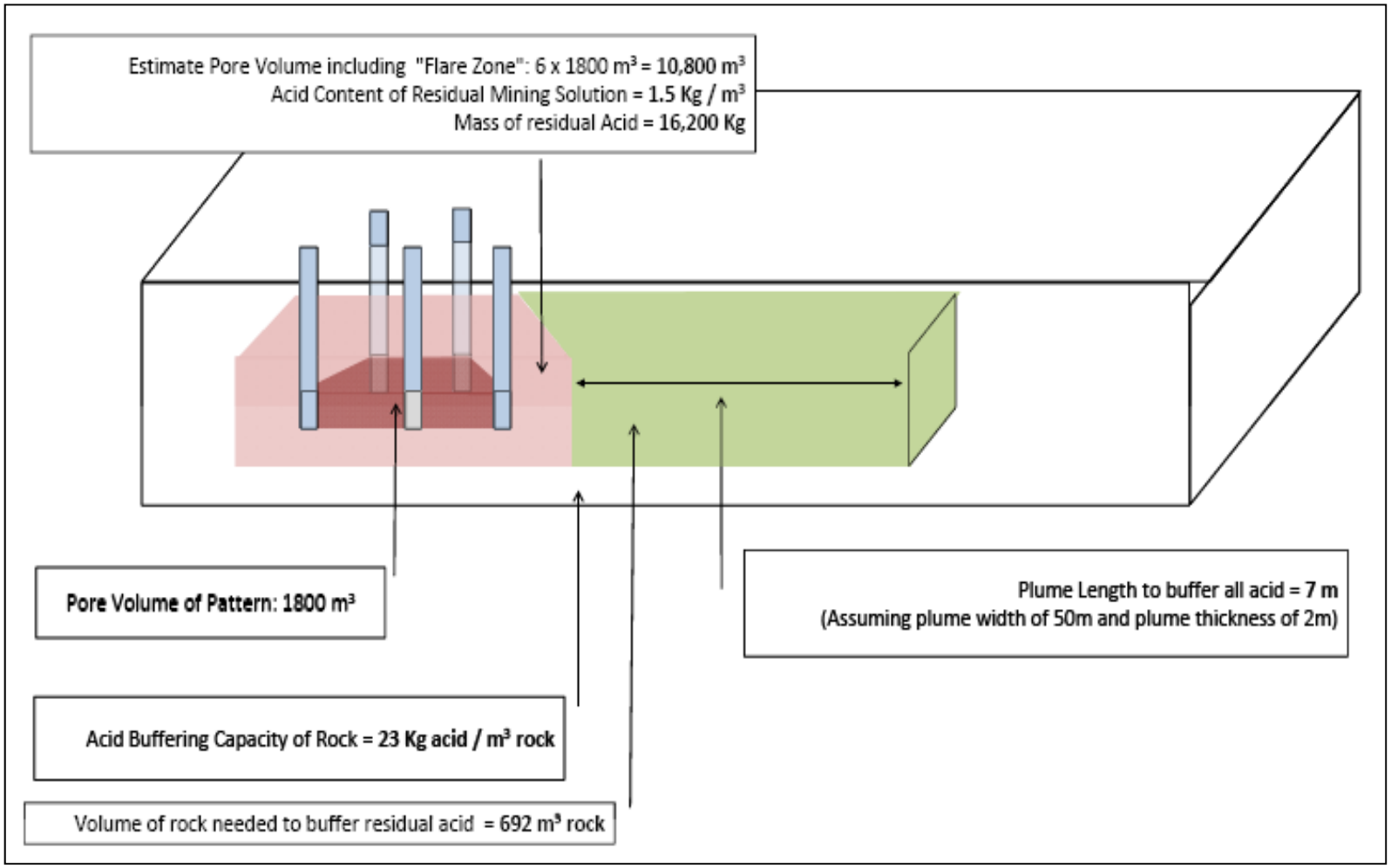


Figure 10: Natural attenuation of acidic mining fluids – conceptual diagram.

7 Appendix A – Geological Logs

Appendix A will be provided on request.

8 Appendix B – Density correction of water level data

WellID	Collar RL (mAHD)	Average SWL (m)	Screen Top (m)	Screen Base (m)	Screen Midpoint (m)	Salinity (mg/L TDS)	Density	Equivalent Freshwater head (mAHD)
MRH1A	20.71	18.90	55	58	56.5	33800	1.024	2.71
MRH1C	20.78	18.63	71	74	72.5	44600	1.032	3.88
MRH2A	17.22	15.94	37	40	38.5	47200	1.034	2.05
MRH3A	12.31	11.09	44	47	45.5	44000	1.032	2.32
MRH3B	12.39	11.28	14	17	15.5	49700	1.036	1.27
MRH4A	7.22	6.33	36	39	37.5	46700	1.034	1.95
MRH4B	7.43	6.72	11	12.5	11.75	59200	1.043	0.92
MRH4C	7.19	6.16	76	79	77.5	51500	1.032	3.31
MRH5A	8.10	7.51	45	48	46.5	60800	1.045	2.34
MRH5B	8.23	7.72	16	17.5	16.75	80200	1.060	1.05
MRH6A	7.91	6.96	43	46	44.5	42800	1.031	2.11
MRH6B	7.88	7.23	13.5	15	14.25	60200	1.044	0.96
MRH7A	27.42	24.40	50	53	51.5	33000	1.023	3.65

9 Appendix C – Chemical Analysis of Groundwater Samples

Analyte	Units	'A' wells							'B' wells				'C' wells		'D' wells		
		MRH1A	MRH2A	MRH3A	MRH4A	MRH5A	MRH6A	MRH7A	MRH3B	MRH4B	MRH5B	MRH6B	MRH1C	MRH4C	MRE001	MRE002	MRE003
		24/05/2010	23/05/2010	21/05/2010	22/05/2010	23/05/2010	22/05/2010	24/05/2010	21/05/2010	22/05/2010	23/05/2010	21/05/2010	24/05/2010	22/05/2010	11/11/2010	20/11/2010	24/11/2010
Physico-chemical parameters																	
pH Value	pH Unit	7.01	7.47	7.03	6.98	6.86	7.08	7.08	4.75	6.67	6.67	6.19	6.85	6.77	7.1	7.2	7.2
Total Dissolved Solids @180°C	mg/L	33800	47200	44000	46700	60800	42800	33000	49700	59200	80200	60200	44600	51500	33000	36000	48000
Suspended Solids (SS)	mg/L	15	16	5	43	3	3	112	6	47	424	8	9	18	< 1	8	8
Chemical Oxygen Demand	mg/L	66	174	899	623	213	827	262	722	312	656	1210	318	1250	75	76	61
Dissolved Metals																	
Arsenic	mg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.014	0.015	0.017	0.021
Barium	mg/L	0.04	0.034	0.025	0.04	0.043	0.032	0.08	0.042	0.049	0.071	0.038	0.056	0.058	0.04	0.04	0.07
Beryllium	mg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.014	<0.010	<0.010	<0.010	<0.010	<0.010	0.002	0.002	0.002
Boron	mg/L	8.4	9.9	9	8.8	9.4	9.5	8.6	19.1	17.8	16.9	19	8.3	7.1	7.8	7.8	6.5
Cadmium	mg/L	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	0.0002	< 0.0002	< 0.0002
Cobalt	mg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.209	0.191	0.174	0.081	<0.010	<0.010	0.003	0.003	0.006
Chromium	mg/L	<0.010	0.053	<0.010	<0.010	<0.010	<0.010	0.01	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.003	0.005	0.004
Copper	mg/L	<0.020	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.036	<0.010	0.012	0.012	<0.010	<0.010	0.05	0.28	0.074
Iron (ferrous)	mg/L	<0.05	<0.05	<0.05	0.08	<0.05	<0.05	<0.05	0.19	0.14	<0.05	0.51	1.05	2.68	< 0.05	< 0.05	0.08
Manganese	mg/L	0.052	0.01	0.128	0.042	0.031	0.017	0.504	1.24	3.86	3.42	4.88	0.135	1.02	0.021	< 0.005	0.65
Mercury	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel	mg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.089	0.033	0.047	0.058	<0.010	<0.010	0.021	0.024	0.038
Lead	mg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.055	<0.010	<0.010	<0.010	<0.010	<0.010	< 0.001	0.003	< 0.001
Vanadium	mg/L	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	< 0.005	< 0.005	< 0.005
Zinc	mg/L	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	0.051	<0.050	<0.050	<0.050	<0.050	<0.050	0.06	0.28	0.11
Aluminium	mg/L	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	0.03	7.65	<0.01	<0.01	<0.01	<0.01	<0.01	< 0.05	< 0.05	< 0.05
Bismuth	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	< 0.005	< 0.005	< 0.005
Lithium	mg/L	0.323	0.141	0.394	0.464	0.37	0.374	0.269	0.204	0.13	0.205	0.076	0.411	0.692	0.2	0.2	0.41
Silver	mg/L	0.0004	0.0008	0.0005	0.0006	0.0005	0.0006	0.0003	0.0006	0.0007	0.0023	<0.0001	0.0009	0.0002	< 0.005	< 0.005	< 0.005
Thorium	mg/L	0.0005	0.0003	0.0002	0.0001	<0.0001	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0003	<0.0001	-	-	-
Tin	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	< 0.005	< 0.005	< 0.005
Uranium	mg/L	0.229	0.0373	0.0593	0.0542	0.024	0.0554	0.174	0.0052	0.0021	0.0018	0.0043	0.0842	0.0066	0.1	0.2	< 0.1
Major and minor anions																	
Hydroxide Alkalinity as CaCO3	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	< 10	< 10	< 10
Carbonate Alkalinity as CaCO3	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	< 10	< 10	< 10
Bicarbonate Alkalinity as CaCO3	mg/L	167	69	138	148	141	148	157	2	85	80	96	152	145	180	190	160
Total Alkalinity as CaCO3	mg/L	167	69	138	148	141	148	157	2	85	80	96	152	145	180	190	160
Sulfate as SO4 2-	mg/L	4480	4950	4630	4420	5810	4670	5060	5440	5130	6930	7300	4090	4080	3800	3900	3900
Sulfide as S2-	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	< 0.05	< 0.05	< 0.05
Chloride	mg/L	20400	27300	28200	30400	34600	26600	23800	29200	38100	49000	35100	26500	33000	20000	20000	29000
Fluoride	mg/L	1.4	1.5	1.5	1.2	1	1.7	1.4	0.1	0.2	0.1	0.2	1.3	1.2	1.3	1.4	1.4
Nitrate as N	mg/L	1.18	12.7	0.44	0.09	0.18	0.22	2.16	2.7	0.02	0.46	0.02	0.06	<0.01	0.22	0.36	< 0.02
Nitrite as N	mg/L	<0.01	0.03	0.02	0.01	<0.01	<0.01	0.03	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	< 0.02	< 0.02	< 0.02
Total Kjeldahl Nitrogen as N	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.4	0.7	<0.1	<0.1	< 0.1	< 0.1	< 0.1
Reactive Phosphorus as P	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.14	< 0.01	< 0.01
Major and minor cations																	
Calcium	mg/L	1690	2120	2310	2520	2220	2220	1780	2130	2610	2350	1790	2360	3300	1800	1900	2700
Magnesium	mg/L	1570	1640	1640	1860	2390	1740	1570	1800	2430	3450	2430	1880	2000	1700	1800	2000
Sodium	mg/L	10400	16300	14400	15000	20700	14900	11900	17500	21700	29200	20500	12700	17900	9400	8200	13000
Potassium	mg/L	113	119	159	150	185	158	109	184	103	135	133	150	213	100	110	190
Strontium	mg/L	22.4	29.2	29	33.6	39.5	29.1	24.2	36.5	49.1	50.1	30.1	32	41	24	23	33

D2: Geological Logs for the Mullaquana Project

Geological Logs for the wells used in the Mullaquana Project Hydrogeological Setting (Appendix D1) are presented below. Note, only 1 log for the deepest well in each nest of wells is available and presented. Screen zones and distance to each well in the nest is provided in each log.

Lithology			
LOES	Loess	DOLM	Dolomite
SAND	Sand	DUNI	Dunite
SDQT	Sand - Qtz, mostly monomict	EVAP	Evaporite
SDFD	Sand - Feldspar	GABB	Gabbro
SDLI	Sand - Lithic, mostly polymict	GLAU	Glauconite
LAG	Lag	GNES	Gneiss
SILT	Silt	GPE	Gypcrete
CLAY	Clay	GRAN	Granite
SOIL	Soil	GRYF	Feldspath-graywacke
CALC	Calcrete	GRYL	Lithic Graywacke
SILC	Silcrete	GRYW	Greywacke (15 - 75% matrix)
FERC	Ferricrete	HORF	Hornfels
GRAV	Gravel	HORN	Hornblendite
SHAL	Shale	IRNS	Ironstone
SLST	Siltstone	KOMA	Komatiite
SDST	Sandstone	LIGN	Lignite
ANDA	Andesite	LIST	Limestone
ANOR	Anorthosite	LOST	No sample
AREA	Arkosic Arenite (0-15% matrix)	MARB	Marble
AREL	Lithic Arenite	MARL	Marl
AREQ	Quartz Arenite	MIGM	Migmatite
BASA	Basalt	MSED	Metasediments
BIF	BIF	MUD	Mudstone (75% matrix)
BREC	Breccia	MYLO	Mylonite
CAVT	Cavity	PERI	Peridotite
CHER	Chert	PYRO	Pyroclastic / Tuff
COAL	Coal	QZIT	Quartzite
CONG	Conglomerate	RHYO	Rhyolite
CYST	Claystone	SCHT	Schist
DACI	Dacite	SKAR	Skarn
DIOR	Diorite	SLAT	Slate
DOLE	Dolerite	VOLC	Volcaniclastic (undiff.)

Grain Size		Roundness	
MD	no gritty feel between fingers	VA	Very angular
ST	trace of grit between fingers	AN	Angular
VF	visible grains	SA	Sub-angular
VG	clearly visible grains	SR	Subrounded
MG	medium sand	RD	Rounded
CG	coarse sand	WR	Well Rounded
VC	very coarse sand		
GR	granule		
PE	pebble		

Alteration/Mineralogy	
BY	Botryoidal/framboidal pyrite
CB	Carbonaceous
CC	Calcareous
CE	Carbonate
FD	Feldspar
FE	Ferruginous
GY	Gypsum
HA	Halite
HM	Haematite
LI	Limenite
LT	Lithic
MA	Marcasite
MG	Magnetite
MI	Micaceous
OP	Opalised
PY	Pyrite
QT	Quartz
SI	silicification
SM	Smectite

Style	
BL	Blebby
BR	Brecciated
DS	Disseminated
GC	Grain Coated
LE	Leached
MT	Mottled
MX	Matrix Mineralized
PT	Patchy
PV	Pervasive
RE	Replacement
VE	Vein

Sorting	
WS	well sorted
PS	poorly sorted
US	unsorted

Oxidation	
M	Mixed
O	Oxidized
R	Reduced
BOCO	Redox Front - Base of Complete Oxidation
TOFR	Top of fresh rock

Hole Type	
A	Air Core
AUG	Auger
C	Reverse Circulation
CH	Channel
COST	Costean
D	Diamond
M	Rotary Mud
NR	Not Recorded
R	Rotary Air Blast
ROLL	Roller Cone
VAC	Vacuum
H	Hydrogeological

Colour	
BL	Blue
BR	Brown
BU	Buff
BK	Black
CM	Cream
GR	Green
GY	Grey
KH	Khaki
MV	Mauve
OR	Orange
OW	Off White
PK	Pink
PU	Purple
RD	Red
TN	Tan
WH	White
YL	Yellow

Original Survey Method	
GPS	Garmin Handheld GPS
MAG	Magnetometer
EASTMAN	Eastman Camera - Single Shot
GYRO	Gyroscope
COLL	Collar - lined up drill mast with compass
NR	Not recorded

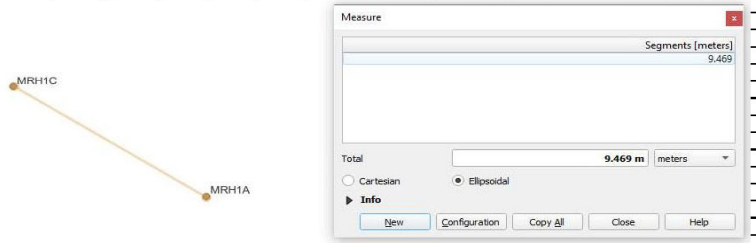
Age	
QU	Quaternary
CZ	Cainozoic
TE	Tertiary
ME	Mesozoic
PE	Pleistocene
PI	Pliocene
MI	Miocene
OL	Oligocene
EO	Eocene
CR	Cretaceous
JU	Jurassic
TR	Triassic
PR	Permian
CA	Carboniferous
DE	Devonian
SI	Silurian
OR	Ordovician
CM	Cambrian
PR	Proterozoic
AR	Archaean

Lithology Stratigraphy	
YC	Young cover
PS	Pollymict sand
PC	Plastic clay
MS	Monomict sand
L	Lignite
CY	Clay
BL	Bioclastic limestone
BS	Basement metasediments
BG	Basement granite
BN	Basement gneiss

Colour Tone	
D	Dark
L	Light
M	Mottled

MRH1C, MRH1A (9m away)

Hole ID	mFrom	mTo	Colour Tone	Colour 1	Colour 2	Lithology 1	Lith 1 %	Lith 1 GS	Lith 1 R	Lith 1 S	Lithology 2	Lith 2 %	Lith 2 GS	Lith 2 R	Lith 2 S	Lithology 3	Oxidation	Mineralogy	Alteration	Alteration Style	Strat Age	Lithology Stratigraphy	Comments
MRH1C	0	2	D	RD	BR	SILT	60				SAND	20	CG	SR	WS	CALC		MG			QU	YC	MOTTLED AND SOIL PROPHILE
MRH1C	2	4	D	RD	BR	SILT	90				SAND	10	MG	SR	WS	CALC		MG			QU	YC	
MRH1C	4	6	D	RD	BR	SILT	90				SAND	10	CG	SR	WS	CALC		MG			QU	YC	COMMON IRONSTONES
MRH1C	6	8	D	RD	BR	SILT	80				SAND	20	GR	RD	PS	CALC	M	MG			QU	YC	
MRH1C	8	10	D	RD	BR	SILT	70				SAND	31	CG	RD	PS						QU	YC	
MRH1C	10	12	D	RD	BR	SILT	90				SAND	10	GR	SR	PS		M				QU	YC	
MRH1C	12	14	D	RD	BR	CLAY	100	MD													QU	YC	
MRH1C	14	16	D	RD	BR	CLAY	100	MD													QU	PC	
MRH1C	16	18	D	RD	BR	CLAY	100	MD													QU	PC	BROWN GREY CLAY/SILT WITH MINOROCCASIONAL GRAVEL
MRH1C	18	20	D	RD	BR	CLAY	100	MD													QU	PC	
MRH1C	20	22	D	GY	BR	CLAY	90	MD			SAND	10	VG	RD	WS						QU	PC	
MRH1C	22	24	D	GY	BR	CLAY	90	MD			SAND	10	VG	RD	WS						QU	PC	
MRH1C	24	26	D	GY	BR	CLAY	100	MD													QU	PC	
MRH1C	26	28	D	GY	BR	CLAY	100	MD													QU	PC	
MRH1C	28	30	L	GY	BR	CLAY	100	MD													QU	PC	
MRH1C	30	32	L	GY	BR	CLAY	90	MD			SAND	10	VG	RD	WS	SILT					QU	PC	
MRH1C	32	34	L	GY	BU	SILT	90				CALC	10				SAND					QU	PC	
MRH1C	34	36	L	BU	GY	MARL	50				SILT	40				SAND					MI	BL	CALC CLAY GRADING TO ARG MARL
MRH1C	36	38	L	BU	OW	LIST	80				SILT	20				SAND					MI	BL	
MRH1C	38	40	L	BU	OW	LIST	80				SILT	20				SAND					MI	BL	
MRH1C	40	42	L	OW	OW	LIST	80				SILT	30				SAND					MI	BL	LIMESTONE, NODULAR WITH ABUNDANT SILICEOUS HARD BANDS
MRH1C	42	44	L	BU	BR	LIST	90				SILT	10									MI	BL	
MRH1C	44	46	L	BU	KH	LIST	60				SILT	30				SAND					MI	BL	
MRH1C	46	48	L	BU	OW	LIST	70				SDLI	20	VG	SR	WS	SILT	O	HM			MI	BL	
MRH1C	48	50	L	BR	BU	LIST	50				SDLI	40	VG	SR	WS	SILT	O	HM			MI	PS	OXIDIZED,HAM, JAROSITE,
MRH1C	50	52	L	BR	KH	SDLI	60	CG	SA	PS	SILT	30				LIST	O	HM			MI	PS	
MRH1C	52	54	D	OW	BU	LIST	50				SDLI	40	MG	RD	WS	SILT	O				MI	PS	
MRH1C	54	56	D	BU	OW	SDLI	80	CG	SA	PS	SILT	20					O	LI			MI	PS	
MRH1C	56	58	D	GY	BR	SDQT	70	CG	SA	PS	SILT	30				CALC	R				EO	MS	MICRCONGLIMERATE, GLUCONITIC,
MRH1C	58	60	D	GY	BR	SDQT	70	CG	SR	PS	SILT	30						PY			EO	MS	
MRH1C	60	62	D	GY	BR	SDQT	80	VC	SR	PS	SILT	20									EO	MS	
MRH1C	62	64	D	GY	BR	SDQT	80	CG	SR	PS	SILT	20						HM	PY		EO	MS	
MRH1C	64	66	D	GY	BR	SILT	50	MG	SR	WS	SILT							PY			EO	MS	
MRH1C	66	68	D	GY	BK	CLAY	80				SDQT	20	VC	AN	PS						PR	BG	BASEMET
MRH1C Screen	71	74																					
MRH1A Screen	55	58																					

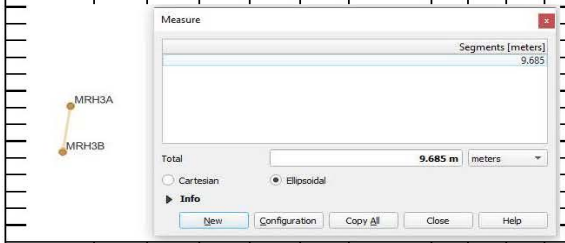


MRH2A

Hole ID	mFrom	mTo	Colour Tone	Colour 1	Colour 2	Lithology 1	Lith 1 %	Lith 1 GS	Lith 1 R	Lith 1 S	Lithology 2	Lith 2 %	Lith 2 GS	Lith 2 R	Lith 2 S	Lithology 3	Oxidation	Mineralogy	Alteration	Alteration Style	Strat Age	Lithology Stratigraphy	Comments
MRH2A	0	2	L	OW	BR	SOIL	60				SAND	30	CG	SR	WS	SILT		MG			QU	YC	SOIL, MOTTLED, CALCRETE
MRH2A	2	4	L	OW	BR	SOIL	50				SAND	40	VG	SR	WS	WS		MG			QU	YC	
MRH2A	4	6	L	BR	OW	SAND	50	GR	SR	WS	SILT	40	VG	SR	PS	SOIL		MG			QU	YC	
MRH2A	6	8	L	BR	RD	GRAV	40	GR	SR	WS	SOIL	40				SILT		MG			QU	YC	
MRH2A	8	10	D	BR	RD	SAND	50	CG	SR	PS	SILT	40				SOIL					QU	YC	OXIDIZED SAND AND SILT, COMMON IRONSTONE NODULES
MRH2A	10	12	D	BR	RD	GRAV	40	GR	SR	PS								MG			QU	YC	
MRH2A	12	14	D	BR	RD	GRAV	40	GR	SA	PS	SAND	40	VC	SR	PS	SOIL		MG			QU	YC	
MRH2A	14	16	D	BR	RD	SILT	60				SAND	40	VC	SR	PS						QU	YC	
MRH2A	16	18	D	BR	RD	SAND	50	CG	SA	PS	SILT	50						MG			QU	YC	
MRH2A	18	20	D	GY	BR	CLAY	90				SAND	10	VG	RD	WS			PY			QU	PC	
MRH2A	20	22	D	GY	BR	CLAY	100	MD													QU	PC	
MRH2A	22	24	D	GY		CLAY	100	MD													QU	PC	GREY TO BROWN CLAY, PARTLY OXIDIZED
MRH2A	24	26	D	GY		CLAY	100	MD													QU	PC	
MRH2A	26	28	D	GY	BU	CLAY	60	MD			MARL	40						PY			QU	PC	
MRH2A	28	30	L	BU	GY	MARL	60				SILT										MI	BL	
MRH2A	30	32	L	BU	OW	MARL	60				SILT	40									MI	BL	BUFF TO KHAKI AND GREY LIMESTONE, TOP SECTION GRADES TO ARG
MRH2A	32	34	L	BU	BR	LIST	70				SILT	30						PY			MI	BL	MARL AND CALC CLAY/ SILT, OCC PYR,
MRH2A	34	36	L	OW	BU	LIST	80				SILT	20									MI	BL	
MRH2A	36	38	L	OW	BR	LIST	90				SILT	10									MI	BL	
MRH2A	38	40	L	OW	WH	LIST	90				SAND	10	VG	SR	WS	SILT					MI	BL	BRPWN- BUFF ARRENACEOUS LIME STONE, WITH INTERCALATED SILT,
MRH2A	40	42	L	WH	OW	LIST	80				SAND	20	VG	SR	WS	SILT					MI	PS	BROWN TO YELLOW MUSTARD SAND, ABUDANT, PARTLY OXIDIZED HEM,
MRH2A	42	44		OW	BR	SAND	40	VG	SR	WS	LIST					SILT		PY			MI	PS	COM JARROSITE AND LIMONITE CLAYS, UPPER SECTION CALC, COMM
MRH2A	44	46		BR	BU	SAND	70	VG	SR	PS	SILT	20				LIST		HM					GRAVELL, SAND IS LITHIC QUATRZITE, WITH ABUD SILTY AND CALC
																							MATRIX
MRH2A Screen	37	40																					

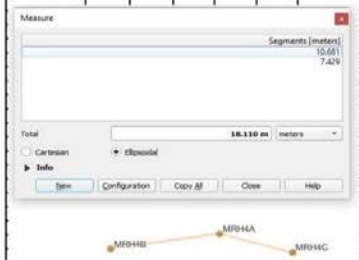
MRH3A, MRH3B (10m away)

Hole ID	mFrom	mTo	Colour Tone	Colour 1	Colour 2	Lithology 1	Lith 1 %	Lith 1 GS	Lith 1 R	Lith 1 S	Lithology 2	Lith 2 %	Lith 2 GS	Lith 2 R	Lith 2 S	Lithology 3	Oxidation	Mineralogy	Alteration	Alteration Style	Strat Age	Lithology Stratigraphy	Comments
MRH3A	0	2	L	BR	OW	SILT	60				SAND	40	VC	SA	PS	SOIL		CC			QU	YC	Predom. Soil, mottked silt and stainedc sand with cac and silty
MRH3A	2	4	D	RD	BR	SAND	50	GR	SA	PS	SILT	50				GRAV		MG			QU	YC	matrix.
MRH3A	4	6	D	RD	BR	silt	60				sand	40									QU	YC	
MRH3A	6	8	D	RD	BR	SILT	80				SAND	20	MG	SR	WS	GRAV		MG			QU	YC	COMMON IRON STONE NODULES
MRH3A	8	10	D	RD	BR	SILT	100														QU	YC	
MRH3A	10	12	D	RD	BR	SILT	100														QU	YC	
MRH3A	12	14	D	RD	BR	SILT	100														QU	YC	
MRH3A	14	16	D	RD	BR	SILT	90				SAND	10	VC	SR	WS	GRAV					QU	PC	
MRH3A	16	18	D	BR	GY	silt	90				SAND	11	VC	SR	WS	GRAV					QU	PC	STICKY GREY TO BROWN CLAY/ SILT. OCC PYR. PARTLY OXIDIZED
MRH3A	18	20	D	GY	BR	CLAY	100	MD													QU	PC	
MRH3A	20	22	D	GY	BR	CLAY	100	MD													QU	PC	
MRH3A	22	24	D	GY	BR	CLAY	100	MD													QU	PC	
MRH3A	24	26	D	GY	BR	CLAY	100	MD													QU	PC	
MRH3A	26	28	D	BR	GY	CLAY	80	MD			MARL	20									QU	PC	
MRH3A	28	30	L	BU	GY	LIST	70				SILT	40				MARL					MI	BL	BIOLCLAST LIME STONE, ABUD FOSSIL FRAG, UPPER SECTION IS
MRH3A	30	32	L	BU	GY	LIST	60				SILT	40									MI	BL	TRANSITIONAL,GRADES TO CALC MARL,LOWER SECTION IS ARRENACEOUS
MRH3A	32	34	L	BU	GY	LIST	60				SILT										MI	BL	AND GRADES TO MIOCENE POLYMICT SAND
MRH3A	34	36	L	BU	GY	LIST	80				SILT										MI	BL	
MRH3A	36	38	L	BU	GY	LIST	70				SILT										MI	BL	
MRH3A	38	40	L	BU	GY	LIST	80														MI	BL	
MRH3A	40	42	L	BU	KH	LIST	70				SAND	20	MG	SR	WS	SILT					MI	BL	
MRH3A	42	43	L	BU	BR	SAND	50				SILT	40	ST			LIST	O				MI	PS	MIOCENE SAND, PREDOM LITHIC QUARTZITE, HIGHLY OXIDIZED
MRH3A	43	44	D	BR	BU	SAND	60	VC	SR	PS	SILT	35	ST				O				MI	PS	UPPER SECTION IS IS HIGHLY CALC, COM TO ABUD JARROSITE
MRH3A	44	45	D	BR	BU	SAND	90	VC	SR	PS	GRAV	10	GR	SA	PS	SILT	O				MI	PS	LIMONITIC, TRACE GLAUCONITE, INTERBEDS OF GRAVEL SANDS
MRH3A	45	46	D	BR	YL	SAND	60	VC	SR	PS	SILT	40					O				MI	PS	
MRH3A	46	47	D	BR	YL	SILT	60	ST			SAND	40					O				MI	PS	
MRH3A	47	40	D	YL	BR	SILT	80	ST			SAND	20	MG	SR	WS								
MRH3A Screen	44	47																					
MRH3B Screen	14	17																					



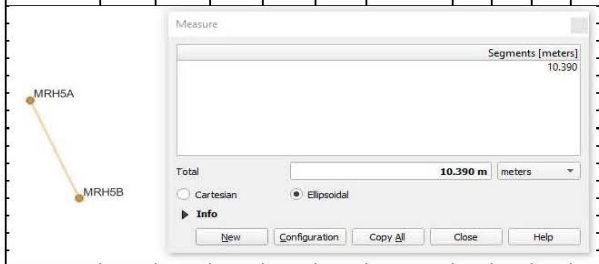
MRH4C, MRH4B (17m away), MRH4A (7m away)

Hole ID	mFrom	mTo	Colour Tone	Colour 1	Colour 2	Lithology 1	Lith 1 %	Lith 1 GS	Lith 1 R	Lith 1 S	Lithology 2	Lith 2 %	Lith 2 GS	Lith 2 R	Lith 2 S	Lithology 3	Oxidation	Mineralogy	Alteration	Alteration Style	Strat Age	Lithology Stratigraphy	Comments
MRH4C	0	2	D	RD	BR	SILT	60				SAND	20	CG	SR	WS	GALC		MG			QU	YC	
MRH4C	2	4	D	RD	BR	SILT	80				SAND	10	MG	SR	WS	GALC		MG			QU	YC	SOIL, OXIDIZED, MOTTLED AND CALCRETE SILLT AND SAND INTERBEDDED
MRH4C	4	6	D	RD	BR	SILT	70				SAND	30	CG	SR	WS	GALC		MG			QU	YC	
MRH4C	6	8	D	RD	BR	SILT	70				SAND	30	CG	RD	PS			MG			QU	YC	COM, ABUD IRONE STONE, TRACE GRAVELL
MRH4C	8	10	D	RD	BR	SILT	70				SAND	31	CG	RD	PS						QU	YC	
MRH4C	10	12	D	RD	BR	SAND	50	CG	RD	PS	SILT	50									QU	YC	
MRH4C	12	14	D	RD	BR	SILT	90				SAND	10	VG	SR	WS						QU	YC	
MRH4C	14	16	D	RD	BR	SILT	80				SAND	20	CG	SR	PS						QU	YC	OCC, CONG AND GRAVEL
MRH4C	16	18	D	RD	BR	SILT	80				SAND	20	GR	SR	PS						QU	YC	
MRH4C	18	20	D	RD	BR	SILT	90	ST			SAND	10	GR	SA	PS						QU	PC	
MRH4C	20	22	D	RD	BR	SILT	90	ST			SAND	10	GR	SA	PS						QU	PC	GREY TO BROWN CLAY/SILT, STICKY, FINE SAND LAMINAE
MRH4C	22	24	D	RD	BR	SILT	90	ST			SAND	10	MG	RD	WS						QU	PC	
MRH4C	24	26	D	BU	BR	SILT	90	ST			SAND	10	VG	RD	WS						QU	PC	
MRH4C	26	28	D	BU	KH	MARL	60				SAND	20	VG	RD	WS	SILT					CZ	BL	
MRH4C	28	30	L	BU	KH	MARL	60				SAND	20	MG	SR	WS	SILT					CZ	BL	
MRH4C	30	32	L	BU	BR	LIST	80				SAND	10	VG	RD	WS	SILT					CZ	BL	LIMESTONE, ABUD FOSSIL FRAG, TRACE LIMONITE SPECKS, PRED ARG
MRH4C	32	34	L	BU	GY	LIST	60				SILT	30				SAND					CZ	BL	
MRH4C	34	36	L	GY	BU	SILT	50				LIST	40				SAND					CZ	BL	
MRH4C	36	38	L	BR	BU	LIST	60				SAND	20	MG	SR	WS	SILT					CZ	BL	
MRH4C	38	40	L	BR	BU	LIST	60				SAND	20	MG	SR	WS	SILT	O	HM			CZ	BL	
MRH4C	40	42	L	BR	BU	SDLI	80	VC	SR	WS	SILT	30				LIST	O	HM			MI	PS	OXIDIZED, LIMNITE, MARROSITE CLAY, LIMONITE, GRAVEL
MRH4C	42	44	L	BR	KH	SDLI	90	VC	SR	WS	SILT	10					O	HM			MI	PS	
MRH4C	44	46	L	BR	BU	SDLI	100	VC	SR	WS	SILT						O	HM			MI	PS	
MRH4C	46	48	L	BR		SDLI	90	VC	SR	WS	SILT	10					O	HM			MI	PS	MARROSITE,LIMONITE, CLAYS, WELL OXIDIZED, GRAVEL & PEBBLES
MRH4C	48	50	L	BR	RD	SDLI	80	MG	RD	WS	SILT	20					O	HM			MI	PS	
MRH4C	50	52	L	GY	BR	SDQT	60	VG	SA	PS	SILT	40					R	PY			EO	MS	REDOX, GLUCONITIC,PYRITIC, MICROCONGLOMERATE
MRH4C	52	54	D	BK	GY	LIGN	80				SDQT	10	MG	RD	WS	LIST		PY			EO	MS	
MRH4C	54	56	D	BK	GY	LIGN	80				SDQT	20	VG	RD	WS						EO	MS	
MRH4C	56	58	D	GY	BR	SDQT	60	VC	SA	PS	SILT					LIGN					EO	MS	
MRH4C	58	60	D	GY	BR	SDQT	100	VC	SR	WS								PY			EO	MS	
MRH4C	60	62	D	GY		SDQT	90	VC	SR	WS	SILT	10									EO	MS	
MRH4C	62	64	D	GY	BK	SDQT	90	VC	SR	WS	SILT	20						HM	PY		EO	MS	CONG/GRAVEL, CHANNEL SANDS, LIGNITE SAND, ABUD CARB CLAST
MRH4C	64	66	D	GY	BR	SILT	60				SDQT	40	VG	RD	WS			PY			EO	MS	TRACE PYR, TRACE TO COM SIDERITE, IN PART SAND IS STAINED
MRH4C	66	68	D	GY	BK	SDQT	80	MG	SR	WS	SILT	20									EO	MS	
MRH4C	68	70	D	GY	BR	SDQT	90	MG	SR	WS	SILT	10									EO	MS	
MRH4C	70	72	D	BK	GY	LIGN						20	MG	RD	WS	SILT		PY	MI		EO	MS	
MRH4C	72	74	D	BK	GY	SDQT	60	CG	SR	PS	LIGN	20				SILT					EO	MS	
MRH4C	74	76	D	GY	BK	SDQT	50	MG	SR	PS	SILT	40				LIGN					EO	MS	
MRH4C	76	78	D	GY	BR	SDQT	80	CG	SR	PS	SILT	40									EO	MS	
MRH4C	78	80	L	OW	GY	CLAY	80				SDQT	20	VC	SA	PS						PR	BL	
MRH4C Screen	76	79																					
MRH4B Screen	11	12.5																					
MRH4A Screen	36	39																					



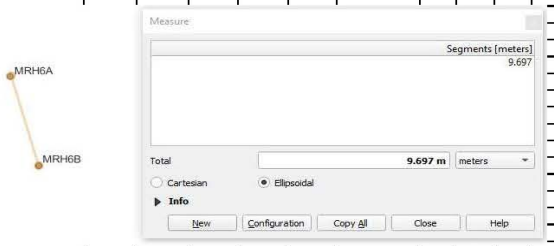
MRH5A, MRH5B (10m away)

Hole ID	mFrom	mTo	Colour Tone	Colour 1	Colour 2	Lithology 1	Lith 1 %	Lith 1 GS	Lith 1 R	Lith 1 S	Lithology 2	Lith 2 %	Lith 2 GS	Lith 2 R	Lith 2 S	Lithology 3	Oxidation	Mineralogy	Alteration	Alteration Style	Strat Age	Lithology Stratigraphy	Comments
MRH5A	0	2	L	BR	OW	SILT	65				SAND	30	MG	RD	WS	SOIL	M	MG			QU	YC	SOIL, MOTTLED, SILT
MRH5A	2	4	D	BR	RD	SILT	100				SOIL										QU	YC	
MRH5A	4	6	D	BR	RD	SAND	60	MG	SR	PS	SILT	40				GRAV	M	MG			QU	YC	
MRH5A	6	8	D	BR	RD	SAND	20	MG	SR	PS	SILT	20				GRAV		MG			QU	YC	
MRH5A	8	10	D	BR	RD	SILT	100											MG			QU	YC	
MRH5A	10	12	D	BR	RD	SILT	100														QU	YC	
MRH5A	12	14	D	BR	RD	SILT	100														QU	YC	
MRH5A	14	16	D	BR	RD	GRAV	40	GR	SA	PS	SAND	40	VC	SA	PS	SILT		MG			QU	YC	PREDOM GRAVEL AND VCOARSE SAND AND OXIDIZED SILT,
MRH5A	16	18	D	BR	RD	GRAV	41	GR	SA	PS	SAND	41	VC	SA	PS	SILT		MG			QU	YC	ABUDANT IRONSTONE OF GRAVEL SIZE
MRH5A	18	20	D	BR	GY	GRAV	42	GR	SA	PS	SAND	42	VC	SA	PS	SILT		MG			QU	PC	
MRH5A	20	22	D	BR	GY	CLAY	80	MD			SAND	20	CG	SA	PS	GRAV					QU	PC	
MRH5A	22	24	D	BR	GY	CLAY	90	MD			MARL					SAND					QU	PC	
MRH5A	24	26	L	BU	GY	LIST	90				SILT					SAND		MG			MI	BL	BUFF COLORED LIMESTONE WITH MINOR SILT, MINOR SANDY, LIMONITIC SPECKS
MRH5A	26	28	L	BU	BR	LIST	80				SILT										MI	BL	
MRH5A	28	30	L	BU	BR	LIST	90				SILT										MI	BL	NODULAR, HARD SILTY BANDS, FOSSIL SHELL FRAGMENTS
MRH5A	30	32	L	BU	RD	LIST	60				SILT										MI	BL	
MRH5A	32	34	L	BU	KH	LIST	90				SAND	10	VC	SA	PS	SILT		LI			MI	BL	HARD SILIC BAND, NODULAR, LIMONITIC
MRH5A	34	35	L	BU	KH	LIST	60				SAND	20	VC	SA	PS	SILT					MI	BL	
MRH5A	36	36	L	BU	GY	LIST	90				SILT	10	VC	SR	PS	SILT					MI	BL	
MRH5A	38	37	L	BU	BR	LIST	80				SAND	20	VC	SR	PS	SILT					MI	BL	
MRH5A	40	42	L	BR	OW	SAND	80	VC	SA	PS	SILT	10				LIST					MI	PS	
MRH5A	42	43	D	BR	OW	SAND	60	MG	SR	WS	MARL	30				SILT					MI	PS	OXIDISED SANDN ABUDANT HEMATITE ALTERING, CALC MATRIX
MRH5A	43	44	D	BR	GY	SAND	90	MG	SR	WS	SILT	10						HA			MI	PS	
MRH5A	44	45	D	BR	GY	SAND	100	CG	SR	WS								HA			MI	PS	
MRH5A	45	46	D	BR	GY	SAND	80	MG	SR	WS	SILT	20						HA			MI	PS	JAROSITE CLAY MATRIX, LIMONITIC AND TRACE GLAUCONITE
MRH5A	46	47	D	BR	GY	SAND	80	MG	SR	WS	SILT	20						HA			MI	PS	
MRH5A	47	48	D	BR	GY	SAND	70	MG	SR	PS	SILT	30						HA			MI	PS	
MRH5A	48	49	D	BK	GY	LIGN	80				SILT	20				SAND					EO	MS	LIGNITE: DUL, AMORPHOUS, MIC, ARG, GRADE TO CARB SILT, TRACE PYR
																							Sand: transparent, quratzosetype
MRH5A Screen	45	48																					
MRH5B Screen	16	17.5																					



MRH6A, MRH6B (9m away)

Hole ID	mFrom	mTo	Colour Tone	Colour 1	Colour 2	Lithology 1	Lith 1 %	Lith 1 GS	Lith 1 R	Lith 1 S	Lithology 2	Lith 2 %	Lith 2 GS	Lith 2 R	Lith 2 S	Lithology 3	Oxidation	Mineralogy	Alteration	Alteration Style	Strat Age	Lithology Stratigraphy	Comments
MRH6A																							
MRH6A	0	2	L	OW	BR	SAND	60	VC	SA	PS	SILT	40				SOIL	M	MG			QU	YC	
MRH6A	2	4	L	BR	BU	GRAV	60	GR	SA	PS	SAND	30	VC	SA	PS	SILT	M				QU	YC	OXIDISED SILT SAND, SOIL, MOTTLED, OCC IRONSTONE NODULE
MRH6A	4	6	L	BR	BU	SILT	80				SAND	20	MG	SR	WS	GRAV	M	CC			QU	YC	
MRH6A	6	8		BR	RD	SAND	60	CG	SA	PS	SILT	40				GRAV		MG			QU	YC	
MRH6A	8	10		BR	RD	SAND	60	CG	SA	PS	SILT	40				GRAV		MG			QU	YC	OXIDIZED SILT WITH OCC IRON STONE, MINOR VF-F SAND,
MRH6A	10	12		BR	RD	SILT	90	ST			SAND	10	VG	RD	WS						QU	YC	
MRH6A	12	14		BR	RD	CLAY	100	MD										MG			QU	YC	
MRH6A	14	16		BR	GY	CLAY	100	MD			SAND							MG			MI	PC	
MRH6A	16	18		BR	GY	CLAY	90	MD			SAND	10	VG	RD	WS						MI	PC	BROWN GREY, SILT/CLAY OCC IRON STONE
MRH6A	18	20		BR	GY	CLAY	100	MD													MI	PC	
MRH6A	20	22		BR	OW	SILT	90	MD			MARL	10									MI	PC	
MRH6A	22	24		BR	OW	SILT	70	ST			LIST	30									MI	PC	
MRH6A	24	26		BR	OW	SILT	50	ST			LIST	30				SAND					MI	PC	
MRH6A	26	28		OW	BR	LIST	80				SILT	20									MI	BL	
MRH6A	28	30		BU	BR	LIST	90				SILT	10									MI	BL	LIME STONE, IN PART GRADING TO MARL AND CALC SILT, PREDOM ARG
MRH6A	30	32		BU	BR	LIST	80				SILT	20				SAND					MI	BL	NODULATED, HARD SILICEOUS BANDS, OCC PYR
MRH6A	32	34		BU	BR	LIST	90				SAND	10	VG	SR	WS	SLST					MI	BL	
MRH6A	34	36		BU	BR	LIST	80				SAND	10	MG	SR	WS	SLST	O				MI	BL	
MRH6A	36	38		BU	BR	LIST	80				SAND	10	VG	SR	WS	SLST					MI	BL	BUFF BROWN OFF WHITE LIMESTONE AS ABOVE
MRH6A	38	40		BU	BR	LIST	90				SAND	10	VG	SR	WS	SLST	O				MI	BL	
MRH6A	40	42		BR	KH	SAND	60	CG	SR	PS	SILT	40	ST			LIST	O	HM			MI	PS	
MRH6A	42	43		BR	YL	SAND	50	CG	SR	PS	SILT	50	ST				O				MI	PS	
MRH6A	43	44		BR	YL	SAND	95	CG	SR	PS	SILT	5	ST				O	HM			MI	PS	BROWN, YELLOW TO MUSTARD SAND WITH ABUNDANT OXIDISED SILT
MRH6A	44	45		BR	YL	SAND	95	CG	SR	PS	SILT	5	ST				O				MI	PS	OCC- TR GLAUC OXIDISING TO JARROSITE CLAY, ABD LIMONITE CLAY
MRH6A	45	46		BR	YL	SAND	90	VC	SR	PS	SILT	10	ST				O	HM			MI	PS	VERY COARSE SAND, ABUD GRAVELL AND CONGLOMERATE
MRH6A	46	47		GY	BR	SAND	60	VC	SR	PS	SILT										EO	MS	MIOCENE -EOCENE UNCONFORMITY, REDOX ZONE 50% SEDIMENTS ARE
																							REDUCED, EOCENE SAND IS PREDOM MONOMICT TYPE WITH CLEAR
MRH6A Screen	43	46																					QUARTZ GRAIN, SLIGHTLY CALC, COM SILTY MATRIX
MRH6B Screen	13.5	15																					



MRH7A

Hole ID	mFrom	mTo		Colour Tone	Colour 1	Colour 2	Lithology 1	Lith 1 %	Lith 1 GS	Lith 1 R	Lith 1 S	Lithology 2	Lith 2 %	Lith 2 GS	Lith 2 R	Lith 2 S	Lithology 3	Oxidation	Mineralogy	Alteration	Alteration Style	Strat Age	Lithology Stratigraphy	Comments
MRH7A	0	2		D	RD	BR	SILT	80	ST			SAND	20	VF	SR	WS	SOIL	M	MG			QU	YC	
MRH7A	2	4		D	BR	BU	SILT	80	ST			SAND	20	VC	SA	PS	SOIL	M				QU	YC	OXIDISED SILT SAND, SOIL, MOTTLED, OCC IRONSTONE NODULE
MRH7A	4	6		D	BR	BU	SILT	90	ST			SAND	10	MG	SR	WS	GRAV	M	CC			QU	YC	
MRH7A	6	8		D	BR	RD	SILT	60				GRAV	40	GR	SA	PS	SAND		MG			QU	YC	GRAVELL WITH ABUD SILT
MRH7A	8	10		D	BR	RD	SILT	80	ST			SAND	10	ST			GRAV		MG			QU	YC	OXIDIZED SILT WITH OCC IRON STONE, MINOR VF-F SAND, GRAVELL
MRH7A	10	12		D	BR	RD	GRAV	50	GR	SA	PS	SAND	30	VC	SA	PS	SILT					QU	YC	
MRH7A	12	14		D	BR	GY	SILT	100	ST										MG			QU	PC	GREY TO BROWN PLASTIC STICKY SILT/ CLAY
MRH7A	14	16		D	GY	BR	SILT	100	MD										MG			MI	PC	
MRH7A	16	18		D	BR	GY	SILT	90	MD													MI	PC	BROWN GREY, SILT /CLAY OCC IRON STONE
MRH7A	18	20		D	GY	BR	CLAY	100	MD													MI	PC	
MRH7A	20	22		D	GY	BR	CLAY	100	MD													MI	PC	
MRH7A	22	24		D	GY	BR	CLAY	100	MD													MI	PC	
MRH7A	24	26		D	GY	BR	CLAY	100	MD													MI	PC	GREY TO BROWN CLAY/SILT, STICKY, OCC PYR
MRH7A	26	28		D	GY	BR	CLAY	100	MD													MI	PC	
MRH7A	28	30		D	GY	BR	CLAY	100	MD													MI	PC	
MRH7A	30	32		D	GY	BR	CLAY	100	MD													MI	PC	
MRH7A	32	34		D	GY	BR	CLAY	100	MD													MI	PC	
MRH7A	34	36		D	GY	BR	CLAY	100	MD													MI	PC	
MRH7A	36	38		D	GY	BR	CLAY	90	MD			MARL	10									MI	PC	
MRH7A	38	40		L	BU	GY	LIST	60	MD			SAND	20	VF	SR	WS	SILT					MI	BL	BUFF TO OFF WHITE TO PROWN LISTONE, TRACE LIMONITE SPECKS
MRH7A	40	42		L	BU	KH	LIST	40				SAND	40	VG	SR	WS	SILT	O	HM			MI	BL	TRACE PYR, AR TO ARG, IN PART GRADES TO MARL AND CALC SILT
MRH7A	42	44		L	BR	BU	SAND	50	MG	SR	WS	SILT	50	ST			LIST	O				MI	PS	
MRH7A	44	46		D	BR	YL	SAND	60	MG	SR	WS	SILT	40	ST			LIST	O	HM			MI	PS	BROWN, OW SAND WITH ABUNDANT OXIDISED SIL CALC MATRIX
MRH7A	46	48		D	BR	YL	SILT	60				SAND	40	CG	SR	PS		O				MI	PS	OCC- TR GLAUC, COMMON OXIDISED TO JARROSITE, ABD LIMONITE CLAY
MRH7A	48	50		D	BR	YL	SAND	60	VC	SR	PS	SILT	SILT					O	HM			MI	PS	VERY COARSE SAND, ABUD GRAVELL AND CONGLOMERATE
MRH7A	50	52		D	BR	YL	SAND	80	VC	SR	PS	GRAV	15	GR	SA	PS	SILT					MI	PS	OXIDISED SAND WITH GRAVELL, ABUD SILTY MATRIX, SILIGHTLY CALC
MRH7A	52	54		D	BR	YL	SAND	50	VC	SR	PS	SILT	40				GRAV							JARROSITE AND LIMONITE CLAYS, COM HEM PARTLY OXIDIZED
MRH7A Screen	53	50																						

D3: Mullaquana Aquifer Testing. Report prepared for UraniumSA Ltd by Australian Groundwater Technologies Pty Ltd, January 2011.

Australian Groundwater Technologies Pty Ltd

Mecrus Group



UAC-1043-R002
27/1/2011

Mullaquana Aquifer Testing

Prepared for UraniumSa

Document Control

Document Title

Mullaquana Aquifer Testing

Report no

UAC-1043-R002_V2

Prepared for

UraniumSa

Author	Date
Ben Jeuken	17/12/2010
Reviewed by	**Date**
Don Armstrong	19/12/2010
Approved by	**Date**
Ben Jeuken	27/1/2011

Revision history

Revision No.	Date Issued	Reason/Comments
1	12/12/2010	Draft for Client Comment
2	27/1/2011	Final Report

Distribution

Copy No.	Location
1	Electronic

Note: This is a controlled document within the document control system.
If revised, it must be marked SUPERSEDED and returned to the AGT QA Representative

Statement of Limitations

The services performed by AGT have been conducted in a manner consistent with the level of quality and skills generally exercised by members of its profession and consulting practice. This report is solely for the use of UraniumSA and may not contain sufficient information for purposes of other parties or for other uses. Any reliance on this report by third parties shall be at such parties' sole risk.

The information in this report is considered to be accurate with respect to information provided or conditions encountered at the site during the investigation. AGT has used the methodology and sources of information outlined within this report and have made no independent verification of this information beyond the agreed scope of works. AGT assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that the information provided to AGT was false.

AUSTRALIAN GROUNDWATER TECHNOLOGIES PTY LTD
ABN 97 110 928 928
Unit 5, 1 London Road, MILE END SOUTH SA 5031
PH: (08) 8352 4262
Fax: (08) 8354 3076
www.agwt.com.au

Executive Summary

1.1 Introduction

UraniumSA (USA) are working towards development of the Blackbush mineralised zone using In-Situ Recovery (ISR) methods. USA are currently engaged in the preparation of an application for a Retention Lease to undertake feasibility studies into development of the deposit. The feasibility study entails an ISR Field Trial (ISR-FT).

The report presents the results of aquifer (pumping) Tests that were undertaken at the Mullaquana Prospect Blackbush Mineralised zone.

The aim of the aquifer testing was to determine

- Aquifer Properties
  - Hydraulic Conductivity,
  - Storage,
  - Transmissivity)

- Boundary Conditions
  - confinement,
  - leakage between aquifer units,
  - lateral boundary conditions)

This information provides an understanding of the hydrogeological system, which will enable an informed risk assessment of the potential impacts of the ISR-FT which forms part of the regulatory approval process for the ISR-FT.

The testing also provides estimates of aquifer properties which inform the design and operational management of the ISR –FT.

1.2 Scope of Work

Aquifer Tests were undertaken at 3 sites within the study area summarised in Table E1:

1. **Production Site.** The planned In-Situ Recovery Field Trial (ISR-FT).

2. **Regional Investigation Site**. Located approximately 2500m east of the ISR-FT site, where the Tertiary sediments transition into a marginal marine depositional setting.

3. **Injection Site.** The site of planned disposal of liquids through injection into the aquifer.

Table E1: Overview of aquifer testing

Site	Well	Tests
Production site	MRE001	3 x 100 minute Step Test 5 day Constant Rate Test
	MRE002	3 x 100 minute Step Test 24 hr Constant Rate Test
Injection Site	MRI001	3 x 30 minute Step Test 5 day Constant Rate Test
Regional Site	Regional Test Well	3 x 100 minute Step Test 24 hr Constant Rate Test

1.3 Hydrogeological setting

Details of the geological and hydrogeological setting are presented in AGT, (2010). An updated summary is presented here.

The Hydrogeological units at the site are separated on a basis of similar litho logical and hydraulic characteristics and outlined in Table E2.

Table E2: Hydrostratigraphic units

Hydrostratigraphic Unit	Geological unit	Symbol	Description	Thickness (m)
Quaternary aquifer	Quaternary Sediments	Q	Gypcrete and Calcrete on sand silt and clay. Fluvial zones at base of section.	16-20
Tertiary Confining Bed	Pliocene Clay	Pc	Thick bedded plastic clay, regionally extensive.	18 -22
	Miocene Marl	Mm	Intercalcated, clay and marl, regionally extensive	16-20
Tertiary Aquifer	Miocene Sand	Ms	Upper Miocene Unit - Fine to coarse grained iron rich sands.	4-6
	Upper Eocene Sand	Es(U)	Lower Eocene Unit – medium to coarse grained sands, interbedded with clay and lignite.	5-20
	Lower Eocene Sand	Es(U)	Clean sand, minimal interbedds	5-20
Basement Confining Bed	Weathered Basement	B	Saprolite, Kaolinitic Clays – weathered Hiltaba Granite	90+

1.4 Results

1.4.1 General Conclusions

The general conclusions which can be drawn from the testing are summarised Table E3.

Table E3: general conclusions from aquifer testing.

Site	Aquifer	Conclusions from aquifer tests
Production Test site	Quaternary	Unsaturated at this site
	Tertiary	• Confined aquifer which under pumping stress exhibits no discernable leakage from overlying or underlying confining beds. • Extensive aquifer exhibits no marked boundary conditions during extended pumping for 2.2 days. (Beyond this time re-injection of pumped water obscured possible boundary conditions). • Ms, Es(U) and Es(L) units are hydraulically connected. • Vertical hydraulic conductivity is less than the horizontal hydraulic conductivity by up to several orders of magnitude. This is likely due to inter-bedding observed within the aquifer sediments. The result is that, under pumping stress fluids within the aquifer will move far more readily in the horizontal plane that the vertical plane. • Average hydraulic conductivity is 7 m/day. • Production well yield of 5 L/s can be expected for wells with 5m screened interval. Well yields will decrease with screen length.
Injection Site	Quaternary	• Saturated • Hydraulically isolated from Tertiary aquifer.
	Tertiary	• Only Ms unit is present at this site • Confined aquifer • Average hydraulic conductivity of 31 m/day • No-flow boundary at approx 300m from the pumped well
Regional site	Quaternary	• Saturated • Hydraulically isolated from Tertiary aquifer.
	Tertiary	• Confined aquifer • Average hydraulic conductivity of 5 m/day • Ms unit hydraulically isolated from Es(U) and Es(L) units.

1.4.2 Aquifer Properties

A summary of the data derived from aquifer testing is presented in Table E4 below.

Table E4: Summary of aquifer testing results

Site	Hydrostratigraphy		Tertiary aquifer properties							
	Quaternary	Tertiary	Type	Total Tertiary aquifer Thickness (m)	Cumulative thickness of Tertiary aquifer sand units (m)	T (m^2/day)	K (m/day)	S	Ss	Boundary Conditions
Production Site	Unsaturated	Eocene and Miocene sand units	Confined	35	15	110	7	0.0002	0.000006	None
Injection Site	Saturated	Miocene sand units	Confined	7	7	215	31	0.0005	0.000071	no-flow boundary at approx 310m
Regional Site	Saturated	Eocene and Miocene sand units	Confined	35	18	85	5	0.00021[1]	0.000006[1]	none

Notes

1) Storativity and specific storage for regional site is inferred from specific storage at production site.

T = Transmissivity
K = hydraulic conductivity
S = Storativity
Ss= specific storage

1.4.3 Boundary conditions

One aim of the aquifer testing was to determine boundary conditions at the Mullaquana site since understanding the hydrogeological structure at the site is important in understanding groundwater flow regime. Boundary conditions inferred from analsyis of the pumped test data are summarised in the Table below

Table E5: Summary of boundary conditions

Site	Vertical Boundaries	Lateral Boundaries
Production	Confined with no discernable leakage	None within 1200m. Aquifer is laterally open
Injection	Confined with no discernable leakage	Single no-flow boundary at approx 310m distance. Likely to be a pinching out or facies change of the Ms aquifer unit.
Regional	Confined with no discernable leakage	None within approx 980m. Aquifer is laterally open

Contents

Document Control II
Executive Summary III
1.1 Introduction III
1.2 Scope of Work III
1.3 Hydrogeological setting IV
1.4 Results V
1.4.1 General Conclusions V
1.4.2 Aquifer Properties V
1.4.3 Boundary conditions VI
Contents VII
Figures IX
2 Introduction 1
3 Scope of Work 2
4 Hydrogeological Setting 3
4.1.1 Quaternary 4
4.1.2 Tertiary 4
5 Production Site 5
5.1 Overview 5
5.2 MRE1 Testing 6
5.2.1 MRE1 - Step Test 6
5.2.2 MRE1 - 5 Day Constant Rate Test 6
5.2.2.1 Aquifer Properties 7
5.2.2.2 Boundary Conditions 7
5.2.2.3 Vertical Hydraulic conductivity 8
5.2.2.4 Site-wide response to pumping 9
5.3 MRE2 Testing 10
5.3.1 MRE2 - Step Test 10
5.3.2 MRE2 - 1 Day Constant Rate Test 10
5.3.2.1 Aquifer Properties 11
5.3.2.2 Boundary Conditions 11
5.3.2.3 Vertical Hydraulic conductivity 11
6 Injection Site 12
6.1 Overview 12
6.2 MRI001 Testing 12
6.2.1 MRI001 - Step Test 12
6.2.2 MRI001 - Constant Rate Test. 12
6.2.2.1 Hydraulic Connection to the Quaternary aquifer 13
7 Regional Site 14
7.1 Overview 14
7.2 MRE3 Testing 14
7.2.1 MRE3 - Step Test 14
7.2.2 MRE3 - Constant Rate Test 14
7.2.2.1 Hydraulic Connection to the Quaternary aquifer 15
8 Groundwater Chemical data. 16
9 References 17
10 Figures 18
11 Appendix 1 – MRE1 Step Test Data 43
12 Appendix 2 – MRE1 CRT Data 44
13 Appendix 3 – MRE2 Step Test Data 46
14 Appendix 4 – MRE2 CRT Data 47
15 Appendix 5 – MRI001 Step Test Data 49

16 Appendix 6 – MRI001 CRT Data 51
17 Appendix 7 – MRE3 Step Test Data 53
18 Appendix 8 – MRE3 CRT Data 54
19 Appendix 9 – Regional water level data 55
20 Appendix 10 – Chemical data 56

Figures

Figure 1: Conceptual Hydrogeological Model 19
Figure 1: Production site well infrastructure plan view 20
Figure 2: Production site well infrastructure section view 21
Figure 3: MRE1 Step Test Results 22
Figure 4: MRE1 Pumped Well Drawdown – Jacob analysis 22
Figure 5: MRE1 Pumped Well Recovery – Theis analysis 23
Figure 6: MRE1 Distance Drawdown analysis 23
Figure 7: MRE1, 8 D observation well - Jacob analysis 24
Figure 8: MRE1, MRE2 Observation well - Jacob analysis 24
Figure 9: MRE1, MRE2 observation well – Theis analysis 25
Figure 10: MRE1, 1A and 1C observation wells - Theis analysis 25
Figure 11: MRE1 – 1A, 1C & 7A Observation well – Jacob analysis 26
Figure 11: MRE1 – All observation wells – vertical connectivity analsyis 26
Figure 12: MRE1 – 9A, 9C Observation Well - Weeks Analysis 27
Figure 13: MRE2 Step Test Results 27
Figure 14: MRE2 – Pumped Well- Jacob Analysis 28
Figure 15: MRE2 – Pumped Well- Theis recovery analysis 28
Figure 16: MRE2 – MRE1 Observation well Jacob Analysis 29
Figure 17: MRE2 – MRE1 Observation well Theis Analysis 29
Figure 18: MRE2 – 1A, 1C Observation Well - Jacob Analysis 30
Figure 19: MRE2 – 8A, 8C Observation Well - Weeks Analysis 30
Figure 20: 5 day Constant rate extraction and injection – site-wide response to pumping and injection. 31
Figure 22: Injection Site Well Layout 32
Figure 23: Injection Site Cross Section 33
Figure 24: MRI001 Step Test Results 34
Figure 25: MRI001 Injection Well -Jacob analysis 34
Figure 26: MRI001 Injection Well –Theis recovery analysis 35
Figure 27: MRI001 Observation wells –Jacob analysis. 35
Figure 28: MRI001 Observation wells –Theis analysis. 36
Figure 29: Injection Test Quaternary aquifer response. 36
Figure 30: Regional Site Well Layout 38
Figure 31: Regional Site Cross Section 39
Figure 32: MRE3 Step Test Results 40
Figure 33: MRE3 Pumped Well -Jacob analysis 40
Figure 34: MRE3 Pumped Well –Theis recovery analysis 41
Figure 35: MRE3 All observation wells. 41
Figure 36: MRE3 12D and 4C Theis analsyis 42

2 Introduction

UraniumSA (USA) are working towards development of the Blackbush mineralised zone using In-Situ Recovery (ISR) methods. USA are currently engaged in the preparation of an application for a Retention Lease to undertake feasibility studies into development of the deposit. The feasibility study entails an ISR Field Trial (ISR-FT).

The report presents the results of aquifer (pumping) Tests that were undertaken at the Mullaquana Prospect Blackbush Mineralised zone.

The aim of the aquifer testing was to determine

- Aquifer Properties
  - Hydraulic Conductivity,
  - Storage,
  - Transmissivity

- Boundary Conditions
  - Confinement,
  - Leakage between aquifer units,
  - Lateral boundary conditions)

This information provides an understanding of the hydrogeological system, which will enable an informed risk assessment of the potential impacts of the ISR-FT which form part of the regulatory approval process for the ISR-FT.

The testing also provides estimates of aquifer properties which inform the design and operational management of the ISR –FT.

3 Scope of Work

Aquifer Tests were undertaken at 3 sites within the study area:

4. **Production Site.** The planned In-Situ Recovery Field Trial (ISR-FT)

5. **Regional Investigation Site**. Located approximately 2500m east of the ISR-FT site, where the Tertiary sediments transition into a marginal marine depositional setting.

6. **Injection Site.** The site of planned disposal of liquids through injection into the aquifer.

Tests at sites 1 and 2 were undertaken by pumping from production wells while disposing of water to an injection well at Site 3.

The test at Site 3 comprised constant rate injection using water from the first constant rate test at the Production Site.

Step tests were undertaken at each site with the aim of firstly determining a sustainable flow rate for the constant rate tests, and secondly assessing well performance.

Tests are summarised in Table 1 below and described in the sections that follow.

Table 1: Overview of aquifer testing

Site	Well	Tests
Production site	MRE001	3 x 100 minute Step Test 5 day Constant Rate Test
	MRE002	3 x 100 minute Step Test 24 hr Constant Rate Test
Injection Site	MRI001	3 x 30 minute Step Test 5 day Constant Rate Test
Regional Site	Regional Test Well	3 x 100 minute Step Test 24 hr Constant Rate Test

4 Hydrogeological Setting

Details of the geological and hydrogeological setting are presented in AGT, (2010). An updated summary is presented here.

The Study area is situated within the Pirie Basin. The Hydrogeological units at the study site are separated on a basis of similar litho logical and hydraulic characteristics as outlined in Table 2.

Table 2: Hydrostratigraphic Units

Hydrostratigraphic Unit	Geological unit	Symbol	Description	Thickness (m)
Quaternary aquifer	Quaternary Sediments	Q	Gypcrete and Calcrete on sand silt and clay. Fluvial zones at base of section.	16-20
Tertiary Confining Bed	Pliocene Clay	Pc	Thick bedded plastic clay, regionally extensive.	18 -22
	Miocene Marl	Mm	Intercalcated, clay and marl, regionally extensive	16-20
Tertiary Aquifer	Miocene Sand	Ms	Upper Miocene Unit - Fine to coarse grained iron rich sands.	4-6
	Upper Eocene Sand	Es(u)	Lower Eocene Unit – medium to coarse grained sands, inter-bedded with clay and lignite.	5-20
	Lower Eocene Sand	Es(l)	Clean sand, minimal inter-beds	5-20
Basement Confining Bed	Weathered Basement	B	Saprolite, Kaolinitic Clays – weathered Hiltaba Granite	90+

Figure 1 presents the geological structure at the Blackbush project site overlaid by aquifer pressure data and groundwater salinity data. Inferred groundwater flow regimes are presented on the figure and discussed below.

4.1.1 Quaternary

The Quaternary sediments are unsaturated at the trial site and saturated and hyper-saline towards the coast. The increasing salinity toward the east is likely to be due to evaporative discharge where the water table approaches the surface close to the coast. These sediments are separated from the mining zone by around 40m of low permeability sediments of the Pliocene Clay and Melton Marl. The aquifer pressure in the Quaternary sediments is less that the pressure in the underlying confined Tertiary aquifer.

4.1.2 Tertiary

The Tertiary aquifer is confined by the approximately 40 m thickness of low permeability Miocene marls and the Pliocene clays. The Tertiary aquifer Miocene Sand unit (Ms) laps onto basement to the west and extends across the site at least as far as drilling extends to the east. The Tertiary aquifer Eocene sand units (Es(U) and Es(L) infill incised channel structures to the west, before forming extensive sheet sands to the east.

The Tertiary aquifer exhibits a pressure gradient from west to east of approximately 0.0003, indicating that the potential for natural flow is from the west to the east.

Inflow to the Tertiary system is inferred to be via lateral inflow from the west. Downward leakage is considered unlikely due to a) the overlying quaternary aquifer is unsaturated, and b) the low permeability sediments overlying the tertiary aquifers provide a significant barrier to leakage.

Discharge from the system is likely to be via lateral flow to the east and very slow, upward leakage through the confining beds to diffuse leakage to the Spencer Gulf.

Mineralisation is hosted mainly in the Es(U) and Es(L) units. Some trace mineralisation is observed in the Ms unit.

5 Production Site

5.1 Overview

Two wells were pumped at this site. A 5 day constant rate test was undertaken pumping from MRE1, whilst a 24 hr constant rate test was undertaken at MRE2.

The aim of the 5 day constant rate test was to provide information regarding aquifer hydraulic conductivity (permeability) and storage coefficient as well as vertical leakage between Eocene sand units at the test site. Further, the extended duration of the test provided robust data with which to assess boundary conditions and vertical leakage for a considerable distance from the test site.

The aim of the 24hr test from MRE2 was to provide additional data to assess aquifer properties, particularly vertical leakage between sand units at the test site.

At the test site pumped wells were installed into the Es(U) unit of the Tertiary Aquifer. Monitoring wells were installed into the Ms, Es(U) and Es(L). In addition three wells were installed into the base of the Quaternary sediments however these were found to be unsaturated:

Well Infrastructure is shown in Figure 1 and Figure 2 and summarised in Table 1.

Table 3: Production Site Well Details

Hole_ID	Permit Number	Easting	Northing	Stratigraphic Interval	Collar RL (mAHD)	Screen top (mBGL)	Screen Base (mBGL)
MRE1	193899	723297	6324297	Es(U)	16.3	56	63
MRE2	193895	723144	6324297	Es(U)	16.3	58	63
1C	185441	722808	6324497	Es (L)	20.1	71	74
8C	193897	723275	6324289	Es (L)	16.3	77	80
9C	193900	723171	6234300	Es (L)	17.2	77	80
8D	193901	723275	6324300	Es(U)	16.3	58	61
1A	185439	722801	6324502	Ms	20.2	55	58
8A	193888	723278	6324297	Ms	16.3	48	51
9A	193890	723168	6324300	Ms	17.2	47	50
1B	185440	722808	6324489	Q	20.1	11	14
8B	193889	723275	6324300	Q	16.3	11	14
9B	193891	723170	6324306	Q	17.2	11	14

5.2 MRE1 Testing

5.2.1 MRE1 - Step Test

Step Test results are shown as Figure 3. Data is presented as Appendix 1.

The well equation which describes drawdown over time for a given pumping rate is:

$$s_t = 42.8\ Q + 3.1\ Q \log(t) + 22\ Q^2$$

Where:

s_t = drawdown (m)
Q = pumping rate (m^3/minute)
t = time of pumping (minutes)

Transmissivity estimated from this test is 110m^2/day

This equation shows that most of the drawdown during pumping is due to well losses (friction as water passes through the disturbed near well zone, gravel pack and well screen). For a flow rate of 5 L/s (0.3m^3/min), 2m of drawdown is due to aquifer loss and 14.8m is due to well losses. This means that drawdown (and hence well yield will vary approximately linearly with well screen length.

It is possible that greater well yields can be obtained by more efficient well completion methods.

5.2.2 MRE1 - 5 Day Constant Rate Test

MRE1 was pumped at 6.5 L/s for 5 days. Pumping commenced at 9:30 am on 11/11/2010. The flow rate was successfully held constant for the duration of the test.

Drawdown in the pumped well was measured manually. Drawdown at observation wells was measured with data loggers and supplemented by manual readings. Logged data was compared to manual readings. Logged data for MRE2 was found to be faulty and only the manual data was used. For all other wells the logged data was used.

Drawdown data are presented as Appendix 2.

Drawdown at the pumped well was analysed used the Jacob method and Theis Recovery Method. Results are shown in Table 1. Drawdown Plots are shown as Figure 4 and Figure 5.

Table 4: MRE1 CRT analysis and results

Observation well	Radius (m)	Analysis Method	Transmissivity (m2/day)	Storativity	Boundary Effects	Comments
MRE1	(pumped well)	Jacob	102	-	recharge boundary at t = 2.2 days	
		Theis Recovery	78	-	-	
8D	20	Jacob	102	-	recharge boundary at t = 2.2 days	Early data affected by partial penetration
MRE2	150	Jacob	102	0.00013	recharge boundary at t = 3.0 days	
		Theis Curve Match	100	0.0002	recharge boundary at t = 2.0 days	
1A & 1C	525	Jacob	128	0.00025	recharge boundary at t = 3.0 days	
		Theis Curve Match	100	0.00037	recharge boundary at t = 3.0 days	
7A	1020	Jacob	128	0.00022	recharge boundary at t = 3.0 days	
		Theis Curve Match	130	0.00058	recharge boundary at t = 3.2 days	
All		Distance Drawdown	98	0.00028		

Drawdown data at observation wells 8D, MRE2, 1A, 1B and 7a were analysed using the Jacob straight line method, Theis curve matching method and distance-drawdown. Results are summarised in Table 1, plots are shown as Figure 7 through Figure 11. The data show that the aquifer exhibits a response to pumping which is consistent with a confined aquifer. Data exhibits a close match with the Theis curve at all wells which are sufficiently distant from the pumped well to remove partial penetration effects (MRE1, 1A and 1C and 7A). This indicates that leakage to the aquifer is negligible.

5.2.2.1 Aquifer Properties

Aquifer Transmissivity calculated from this data averages approximately 100 m^2 per day, and storativity averages around 0.00029. This site exhibits a 15 m thickness of permeable aquifer sediments within a total stratigraphic thickness of 35m including silt, clay and lignite intervals. The estimates above equate to an average hydraulic conductivity of 6.6 m/day for permeable sand units, and a storage coefficient of 9.6×10^{-6} for the entire stratigraphic thickness[1].

5.2.2.2 Boundary Conditions

No discharge boundaries are evident in the early time drawdown data, this indicates that the ~ 500m wide channel inferred from basement structure is not hydraulically sealed and the aquifer behaves as an open, unbounded system.

[1] Only permeable sand units are considered to contribute significantly to aquifer transmissivity, whilst the full stratigraphic interval including silt, clay and lignite units contribute to storage.

A recharge boundary effect observed in the data starting at between 2.2 to 3 days is consistent with the reinjection of pumped water at the injection site located 1200m distant. The arrival of the reinjection pressure effects in an aquifer can be calculated as:

$$t = S.r^2/(2.25.T)$$

where:

t = time to arrival of pressure effects
T = Transmissivity (m2/day)
S = storativity
r = radial distance from injection point

For r = 1200, T = 100 and S = 0.00029 the calculated time of arrival is 1.8 days. The minor discrepancy between calculated arrival time and measured arrival time of boundary effects is likely due to variations in aquifer thickness, and hydraulic conductivity between the injection and extraction site.

5.2.2.3 Vertical Hydraulic conductivity

When viewed on a log-linear plot (Figure 11), drawdown at all wells completed in the Tertiary aquifer approaches a common slope. This indicates that the entire Tertiary sequence, Ms, Es (U) and Es(L), behaves as one inter-connected aquifer. The muted drawdown at wells in the Ms and Es(L), indicates that there are low permeability beds between these units and the Es(U) which is accessed by the pumped well.

Drawdown data at observation wells completed in horizons above and below the pumped well were analysed using the Weeks Method (Kruseman and Deridder, 2000) to determine the average vertical hydraulic conductivity of the sediments separating the observation wells from the pumped well. Well 9A is completed in the overlying Miocene Sand interval, while well 9C is completed in the underlying Lower Eocene Sand interval. Drawdown data at these wells was compared to data from MRE2, which is completed in the same horizon as the pumped well. For this comparison, data from MRE2 (located 150m from the pumped well) was corrected to represent a 140m radius from the pumped well consistent with the position of wells 9A and 9C.

Results are shown in Table 2. This analysis shows:

- Sediments separating the Es(U) and the Ms exhibit very low hydraulic conductivity consistent with a clay.
- Sediments separating the Es(U) from the Es(L) exhibit a moderately low hydraulic conductivity consistent with inter-bedded silts and sands.

Table 5: MRE1 CRT Vertical hydraulic conductivity results

Obs well	Stratigraphic unit	Screened interval	Thickness of separation from pumped well[1]	Average vertical hydraulic conductivity (m/day)
9A	Ms	47 – 50	6	0.00003
9C	Es (L)	77-80	14	0.7

1) Pumped well screened 56 -63 in Upper Eocene

5.2.2.4 Site-wide response to pumping

All site-wide observation wells were monitored during the 5 day constant rate extraction and concomitant injection test. Results are presented graphically as Figure 20 and raw data is attached as Appendix 9.

Analysis of this data is summarised in Table 3 and shows that:

- At sites 1 and 7 the Tertiary aquifer exhibits pressure drawdown in response to extraction. At site 1, the Ms, and Es units behave as one connected aquifer system (drawdown is the same). The Quaternary aquifer is unsaturated at these sites.
- Site 3 shows no response to pumping or injection in either the Tertiary aquifer Ms unit or the Quaternary aquifer. The Tertiary aquifer Es unit is absent at this site.
- At site 4 the Tertiary aquifer Ms unit exhibits an increase in pressure in response to injection. The deeper Es units exhibit a very muted response to injection. The Quaternary aquifer shows no response
- Sites 2, 5 and 6 exhibit a pressure increase in the Tertiary aquifer Ms unit in response to injection. The magnitude of the pressure response decreases with distance from the injection site. No response is observed in the Quaternary aquifer.

Table 6: Site-wide pressure response (mH_2O) following 5 day extraction and injection

Site	Tertiary Aquifer		Quaternary Aquifer
	Miocene Sand Unit	Eocene Sand Unit	
1	-1	-1	Unsaturated
2	+0.3	absent	Unsaturated
3	No response	absent	No response
4	+0.3	+0.05	No response
5	+0.15	Not monitored	No response
6	+0.15	Not monitored	No response
7	-0.35	absent	Unsaturated

This data indicates that the:

- The Tertiary aquifer is extensive across the site
- The Miocene and Eocene units are hydraulically well connected to the west and hydraulically separate to the east.
- The Quaternary aquifer (where the sediments are saturated) is hydraulically isolated from the Tertiary aquifer across the entire site.

5.3 MRE2 Testing

5.3.1 MRE2 - Step Test

Step Test results are shown as Figure 13. Data is presented as Appendix 3.

The well equation which describes drawdown over time for a given pumping rate is:

$$s_t = 45.8\ Q + 3.2\ Q \log(t) + 26.8\ Q^2$$

Where:

s_t = drawdown (m)
Q = pumping rate (m^3/minute)
t = time of pumping (minutes)

Transmissivity estimated from this test is 98 m^2/day.

This equation shows that the majority of drawdown is due to well losses consistent with the results for MRE1.

5.3.2 MRE2 - 1 Day Constant Rate Test

MRE2 was pumped at 6.5 L/s for 1 day. Pumping commenced at 8:30 am on 20/11/2010. The flow rate was successfully held constant for the duration of the test.

Drawdown in the pumped well was measured manually. Drawdown at observation wells was measured with data loggers and supplemented by manual readings. Logged data was compared to manual readings. For all wells the logged data was used.

Drawdown data are presented as Appendix 4.

Data analysis was undertaken as per the MRE1 Test, drawdown plots are presented as Figure 14 through Figure 18 and summarised in Table 3.
The data and analytical results are consistent with the results from pumping at MRE1

Table 7: MRE2 CRT analysis and results

Observation well	Radius (m)	Analysis Method	Transmissivity (m2/day)	Storativity	Boundary Effects	Comments
MRE2	(pumped well)	Jacob	103	-		
		Theis Recovery	114	-		
8D	130	Jacob	128	-		Partial Penetration effects
MRE1	150	Jacob	131	0.00018		
		Theis Curve Match	130	0.00017		
1A & 1C	525	Jacob	147	0.00011		

5.3.2.1 Aquifer Properties

Calculated transmissivity is marginally higher than at MRE1 averaging 125 m^2/day, whilst storativity is marginally lower averaging 0.00015. This variation is likely to be due to variability in the lithology of aquifer sediments.

The data show a good match with a Theis curve (Figure 17), which indicates that the aquifer is confined and that leakage is negligible.

5.3.2.2 Boundary Conditions

No marked boundary effects are observed in the data.

5.3.2.3 Vertical Hydraulic conductivity

Results of analysis are shown in Figure 19 and Table 4. Compared to the MRE1 test, this analysis shows a marked reduction in the calculated vertical hydraulic conductivity between the pumped well and the observation well screening the Lower Eocene sands, consistent with a clay layer separation between the wells. This may be due to a clay inter-bed between the pumped well and well 8C, which does not extend across to well 9C which showed a much greater response to pumping from MRE1.

Table 8: MRE2 CRT Vertical hydraulic conductivity analysis results

Obs well	Stratigraphic unit	Screened interval	Thickness of separation from pumped well[1]	Average vertical hydraulic conductivity
8A	Miocene Sands	48 – 51	7	0.00007
8C	Lower Eocene	77- 80	14	0.00013

1) Pumped well screened 58 -63 in Upper Eocene

6 Injection Site

6.1 Overview

Testing at this site entailed a brief injection step test to assess well capacity followed by a constant rate test comprising injection of water at 6.5 L/s for 5 days.

The injection well was screened across the Miocene sands. At this site the Miocene sands directly overly basement. Two observation wells were screened across the Miocene sands, and one observation well was installed into the Quaternary sediments which are saturated at this site.

Well details are summarised in Table 5, well layout is show in Figure 22 and a geological cross section presented as Figure 23.

Table 9: Injection Site Well Details

Hole_ID	Permit Number	Easting	Northing	Stratigraphic Interval	Collar RL (mAHD)	Screen top (mBGL)	Screen Base (mBGL)
MRI1	193896	724410	6324786	Ms	11.6	41	49
MRI2	193894	724480	6324722	Ms	10.9	40	49
10A	193893	724427	6324781	Ms	11.5	45	48
10B	193892	724419	6324780	Q	11.6	13	16

6.2 MRI001 Testing

6.2.1 MRI001 - Step Test

Step Test results are shown as Figure 24. Data is presented as Appendix 5.

The duration of each of the injection steps was constrained to 30 min by the available storage in the balance tanks. These steps are too short to allow interpretation of the data to derive a well equation for this well.

Examination of the subsequent constant rate test data shows that this well was subject to considerable clogging (Figure 25) which would have quickly rendered the well equation invalid.

Future injection infrastructure should include filtration to prevent well clogging.

6.2.2 MRI001 - Constant Rate Test.

MRI001 was injected at 6.5 L/s for 5 days. Pumping commenced at 9:30 am on 11/11/2010. The flow rate was successfully held constant for the duration of the test.

Pressure rise in the pumped well was measured manually. Pressure at observation wells was measured with pressure transducers and data loggers.

Drawdown data are presented as Appendix 6.

Pressure plots are presented as Figure 25 through Figure 28 and the results of analysis are summarised in Table 6.

Table 10: MRI001 CRT analysis and results

Observation well	Radius (m)	Analysis Method	Transmissivity (m2/day)	Storativity	Boundary Effects	Comments
MRI1	Injection well	Jacob	102	-	Discharge boundary at t= 0.2 days	Clogging effects after t = 1 day
		Theis Recovery	193	-	-	
10a	11	Jacob	214	0.003	Discharge boundary at t= 0.2 days	Extraction well influence after t = 2 days
		Clark Curve Match	228	0.00062	Boundary at 340 m	Extraction well influence after t = 2 days
MRI2	95	Jacob	285	0.00028	Discharge boundary at t= 0.14 days	Extraction well influence after t = 2 days
		Clark Curve Match	270	0.00047	Boundary at 285m	Extraction well influence after t = 2 days

The average calculated transmissivity at this site is approximately 215 m^2/day. The aquifer thickness at this site is approximately 7m which equates to an average hydraulic conductivity of 31 m/day. This is consistent with well sorted coarse sand.

The Clark (1988) suite of software was used to analyse the drawdown at the two observation wells. The analytical model which best matches the observed drawdown is a confined aquifer with a boundary approximately 310m from the pumped well. This indicates that:

a) The aquifer is confined and leakage is negligible at this site, and
b) A no-flow boundary, likely a facies change or pinching out of aquifer sediments is present at a distance of some 300m from the pumped well.
c) A discharge boundary effect observed in the data starting at 2 days is consistent with the reinjection of pumped water at the MRE1 extraction site located 1200m distant.

6.2.2.1 Hydraulic Connection to the Quaternary aquifer

The quaternary sediments are saturated at this site. Pressure in the Quaternary sediments was monitored during the CRT. Pressure response is shown in Figure 29. No response to injection is observed in the Quaternary aquifer which indicates that the Quaternary aquifer is not hydraulically connected to the Tertiary aquifer.

The Quaternary aquifer data do show minor pressure fluctuations consistent with the variation in atmospheric pressure measured at Whyalla airport some 20 km to the north (BOM, 2010) which affects pressure transducer readings.

7 Regional Site

7.1 Overview

Testing at this site entailed a step test to assess well capacity followed by a constant rate test at 5 L/s for 1 day.

The extraction well was screened across the full thickness of the Upper Eocene sands. Observation wells were installed into the Quaternary, Miocene Sands, Upper Eocene sands and Lower Eocene Sands.

Well details are summarised in Table 7, well layout is show in Figure 30 and a geological cross section presented as Figure 31.

Table 11: Regional Site Well Details

Hole_ID	Permit Number	Easting	Northing	Stratigraphic Interval	Collar RL (mAHD)	Screen top (mBGL)	Screen Base (mBGL)
MRE3		725197	6324499	Es(U)	7.1	50	71
4A	185446	725307	6324497	Ms	6.5	36	39
12D		725247	6324499	ES(U)	7.0	55.5	58.5
4C	185447	725315	6324494	Es(L)	6.5	76	797
4B	185448	725297	6324495	Q	6.7	11	12.5

7.2 MRE3 Testing

7.2.1 MRE3 - Step Test

A step test comprising 3 x 100 minute steps at 2.5, 5 and 7.5 L/s was undertaken. Data is presented as Appendix 7. The well exhibited an improvement in efficiency due to development when pumped at 7.5 L/s this is evidenced by a reduction in drawdown, and silt produced during pumping. This well development makes the data invalid for calculation of a well equation.

7.2.2 MRE3 - Constant Rate Test

MRE3 was pumped at 5 L/s for 24hrs. Flow rate was constrained to 5 L/s due to reduced injection capacity at the injection site.

Pumping Commenced at 10:30 on the 24/11/2010. The flow rate was held constant for the duration of the test.

Drawdown in the pumped well was measured manually. Pressure at observation wells was measured manually and with pressure transducers and data loggers.

Drawdown data are presented as Appendix 8.

Drawdown plots are presented as Figure 33 through Figure 36 and the results of analysis are summarised in Table 8.

The results of analysis are variable. This is believed to be due to the inter-bedded nature of the aquifer. All of the observation wells are partially penetrating, whilst the pumped well is screened across all aquifer units. The following can be inferred from the data:

- The transmissivity calculated from the drawdown and recovery at the fully penetrating pumped well is likely to yield the most accurate estimate for the Eocene aquifer as a whole. This means the transmissivity of this unit is approximately 85 m^2/day.
- The Storativity of the aquifer cannot be calculated from the partially penetrating observation wells. However a reasonable estimate can be made, assuming a specific storage of 1 x 1^{-5} m^{-1}, consistent with the results for the Eocene aquifer at the Production Site, and Eocene aquifer thickness at this site of 22m to yield a Storativity value of 0.00022.
- The aquifer is confined and does not show discernable leakage effects.
- The boundary effect observed at observation well 4C may indicate that the aquifer unit accessed by this well is bounded, either by a facies change or pinch out of the unit.
- No drawdown was observed at the well completed in the Miocene sand unit. This indicates that the two units are hydraulically isolated at this site. Examination of the cross section presented as Figure 23, shows that the 4A well is reported to be screened across the Miocene Marl confining bed, however, this well shows a clear response to injection into the Miocene sand unit at the injection site during the 5 day test. This indicates that the well is functioning effectively as a Miocene sand observation point.

Table 12: MRE3 CRT analysis and results

Observation well	Radius (m)	Analysis Method	Transmissivity (m2/day)	Storativity	Boundary Effects	Comments
MRE3	Pumping well	Jacob	91	-		Fully Penetrating
		Theis Recovery	79	-		
12D	53	Jacob	52	0.0005		Partially penetrating
		Clark Curve Match	50	0.002		
4C	98	Jacob	208	0.001	Discharge boundary at t=0.6 days	Partially penetrating
		Clark Curve Match	175	0.0017		

7.2.2.1 Hydraulic Connection to the Quaternary aquifer

The Quaternary sediments are saturated at this site. Pressure in the Quaternary sediments was monitored during the CRT. Pressure response is shown in Figure 35. No response to extraction is observed in the Quaternary aquifer which indicates that the Quaternary aquifer is not hydraulically connected to the Tertiary aquifer.

The Quaternary aquifer data do show minor pressure fluctuations consistent with the variation in atmospheric pressure measured at Whyalla airport some 20 km to the north (BOM, 2010) which affects pressure transducer readings.

8 Groundwater Chemical data.

A sample of groundwater was taken at the completion of pumping during each Constant rate Test and submitted for analysis. Results are summarised in the Table below. Complete results are presented as Appendix 10.

Table 13: Groundwater Chemistry Summary

Analyte	Units	MRE001	MRE002	MRE003
pH Value	pH Unit	7.1	7.2	7.2
Total Dissolved Solids @180°C	mg/L	33000	36000	48000
Uranium	mg/L	0.1	0.2	< 0.1
Total Alkalinity as CaCO3	mg/L	180	190	160
Sulfate as SO4 2-	mg/L	3800	3900	3900
Chloride	mg/L	20000	20000	29000
Fluoride	mg/L	1.3	1.4	1.4
Calcium	mg/L	1800	1900	2700
Magnesium	mg/L	1700	1800	2000
Sodium	mg/L	9400	8200	13000
Potassium	mg/L	100	110	190
Strontium	mg/L	24	23	33

9 References

AGT (2010) Mullaquana *Project Hydrogeological Setting.* Report to UraniumSA. AGT report number UAC-1043-R001V5.

Kruseman and Deridder, 1994, Analysis and Evaluation of Pumping Test Data Publication 47 IILRI, Netherlands.

Clarke, D.K 1998 Groundwater Discharge Tests: Simulation and Analysis. ELSEVIER, Amsterdam

10 Figures

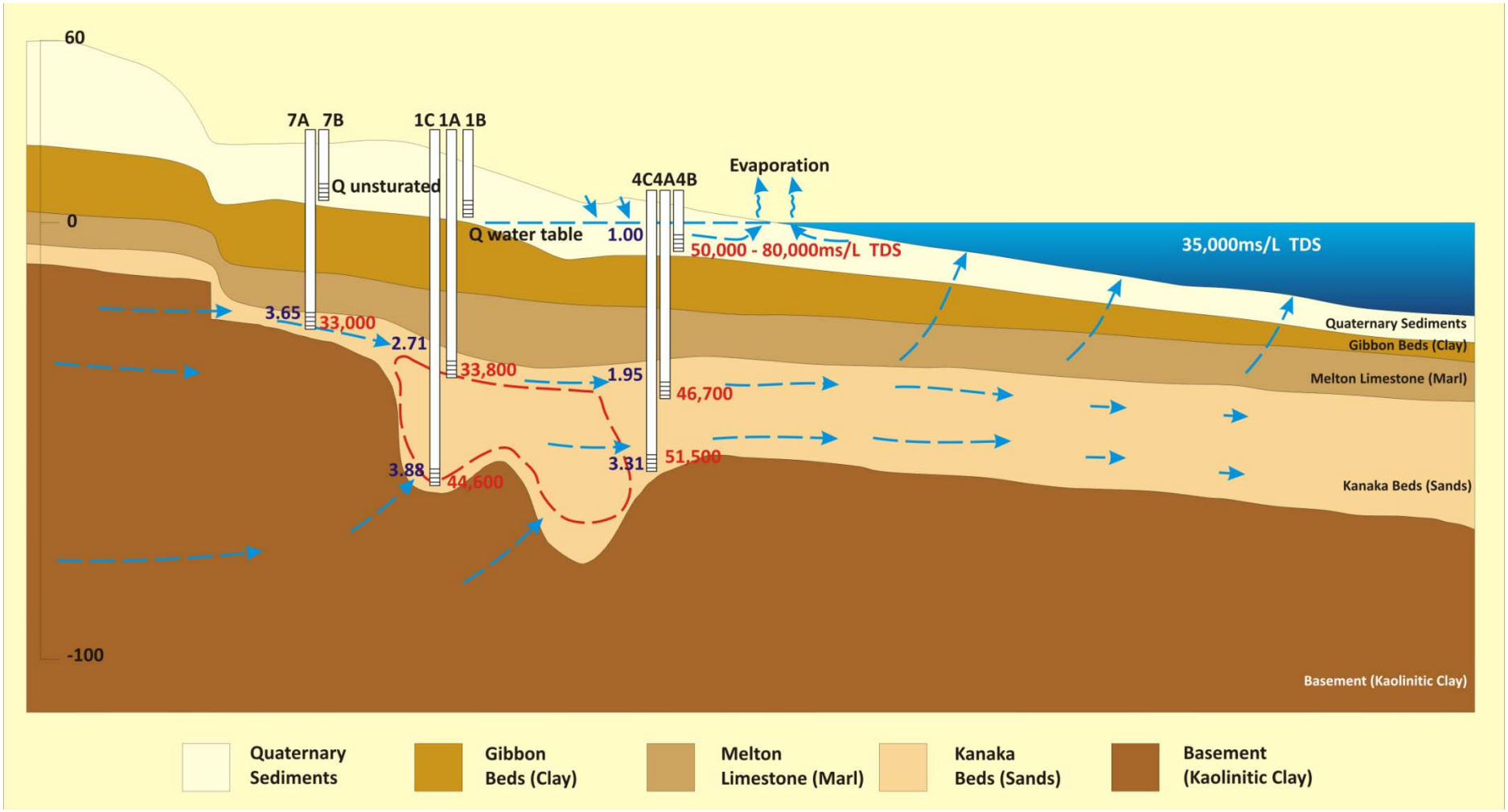


Figure 1: Conceptual Hydrogeological Model

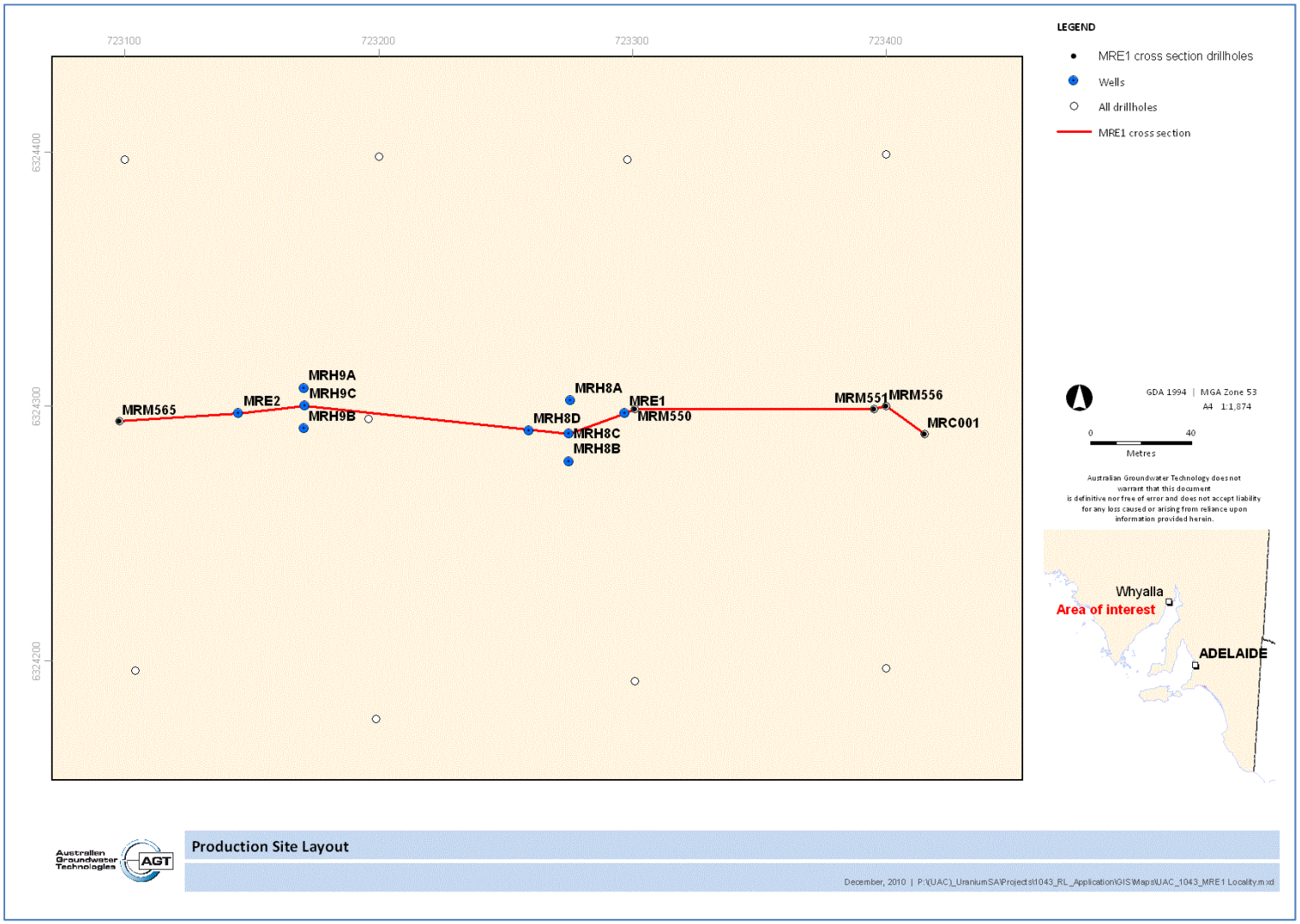


Figure 2: Production site well infrastructure plan view

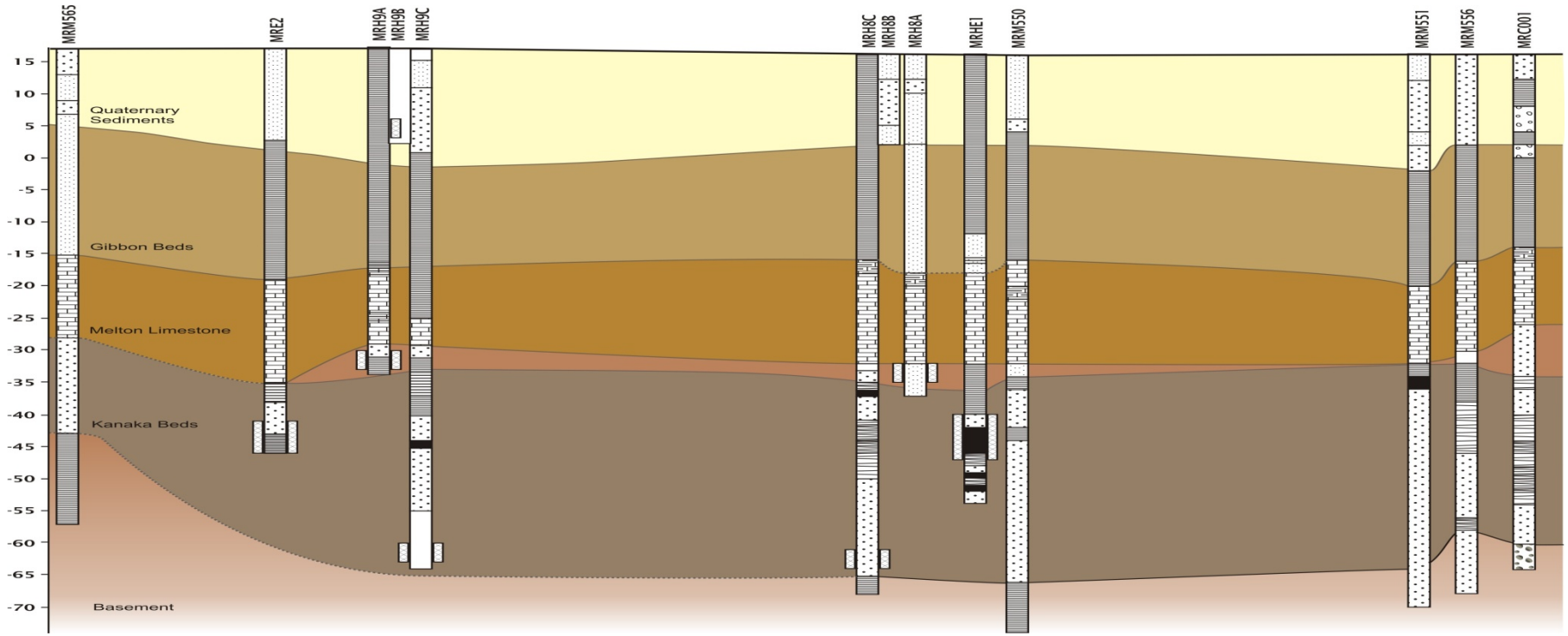


Figure 3: Production site well infrastructure section view

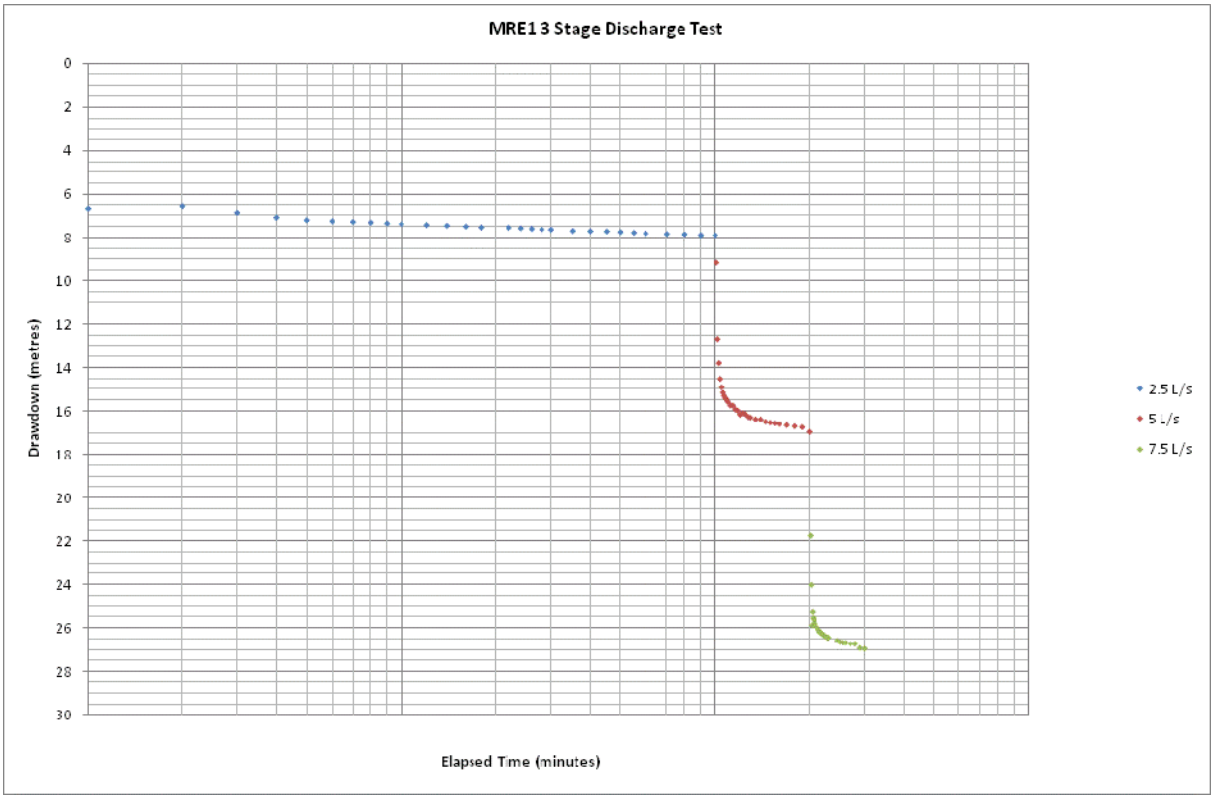


Figure 4: MRE1 Step Test Results

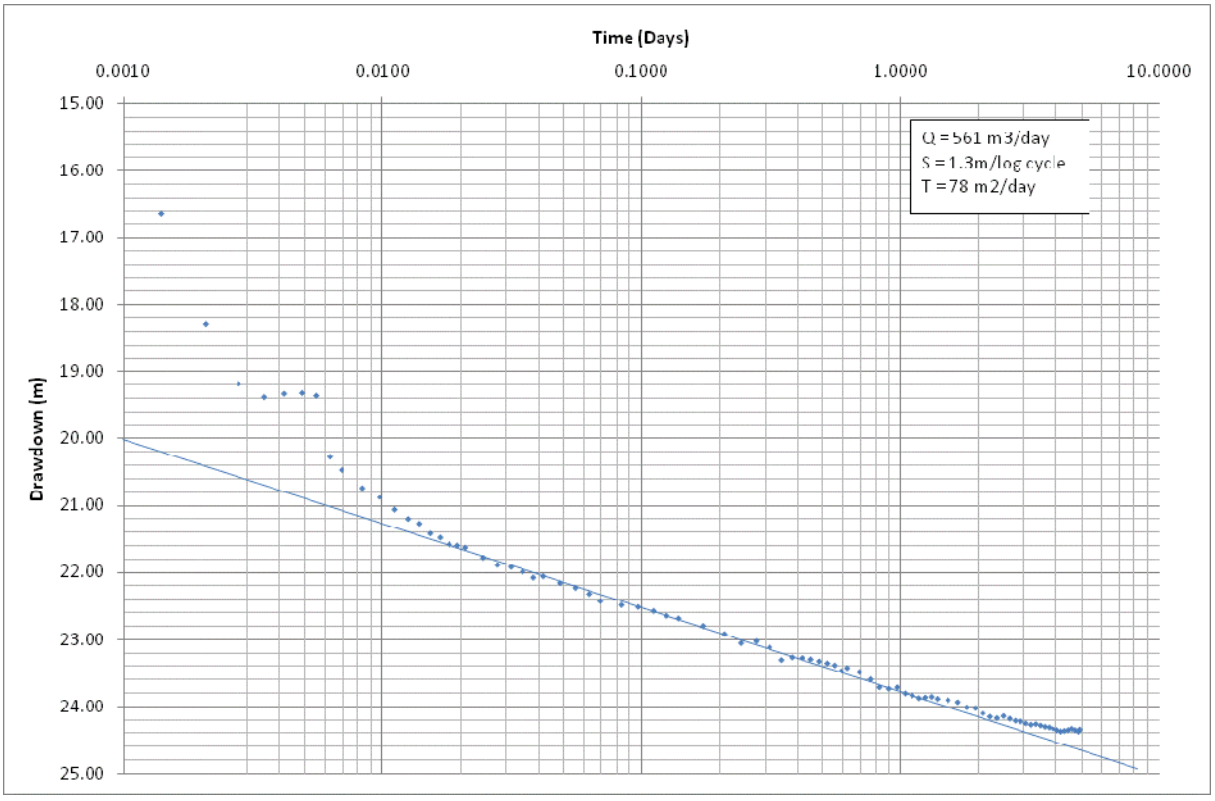


Figure 5: MRE1 Pumped Well Drawdown – Jacob analysis

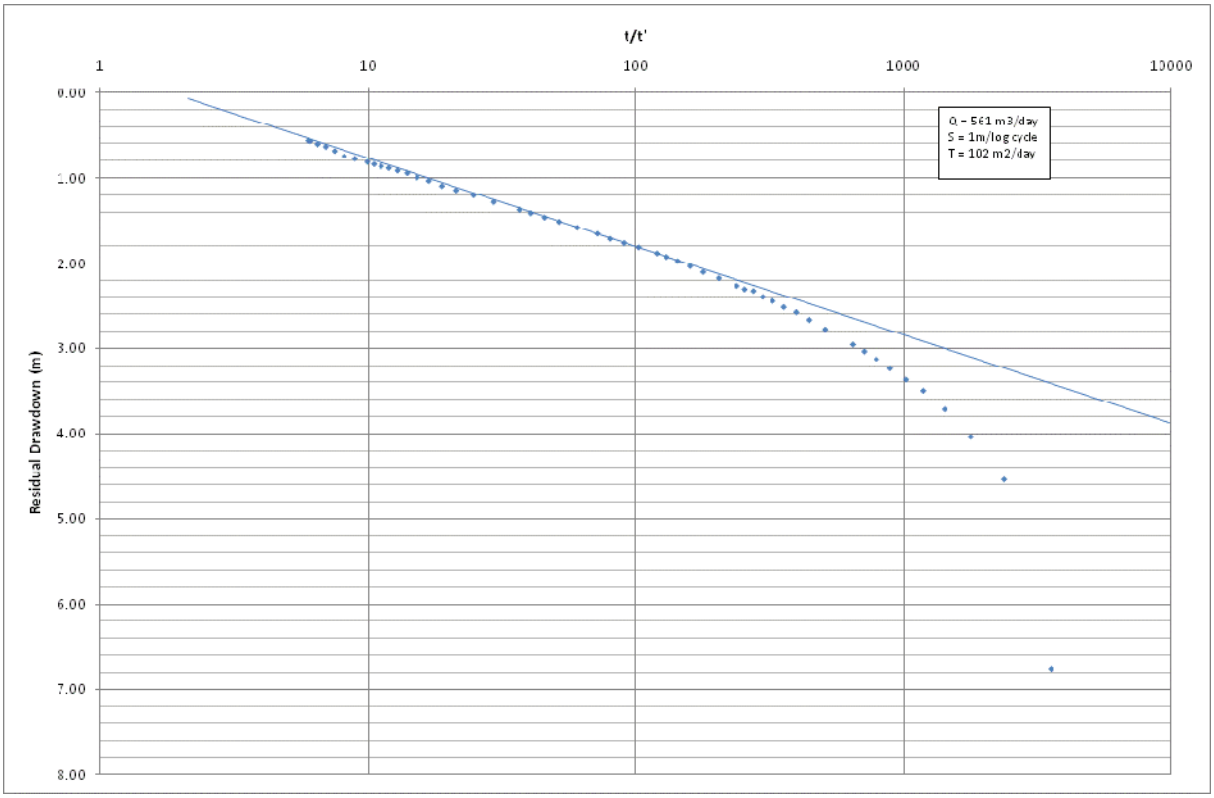


Figure 6: MRE1 Pumped Well Recovery – Theis analysis

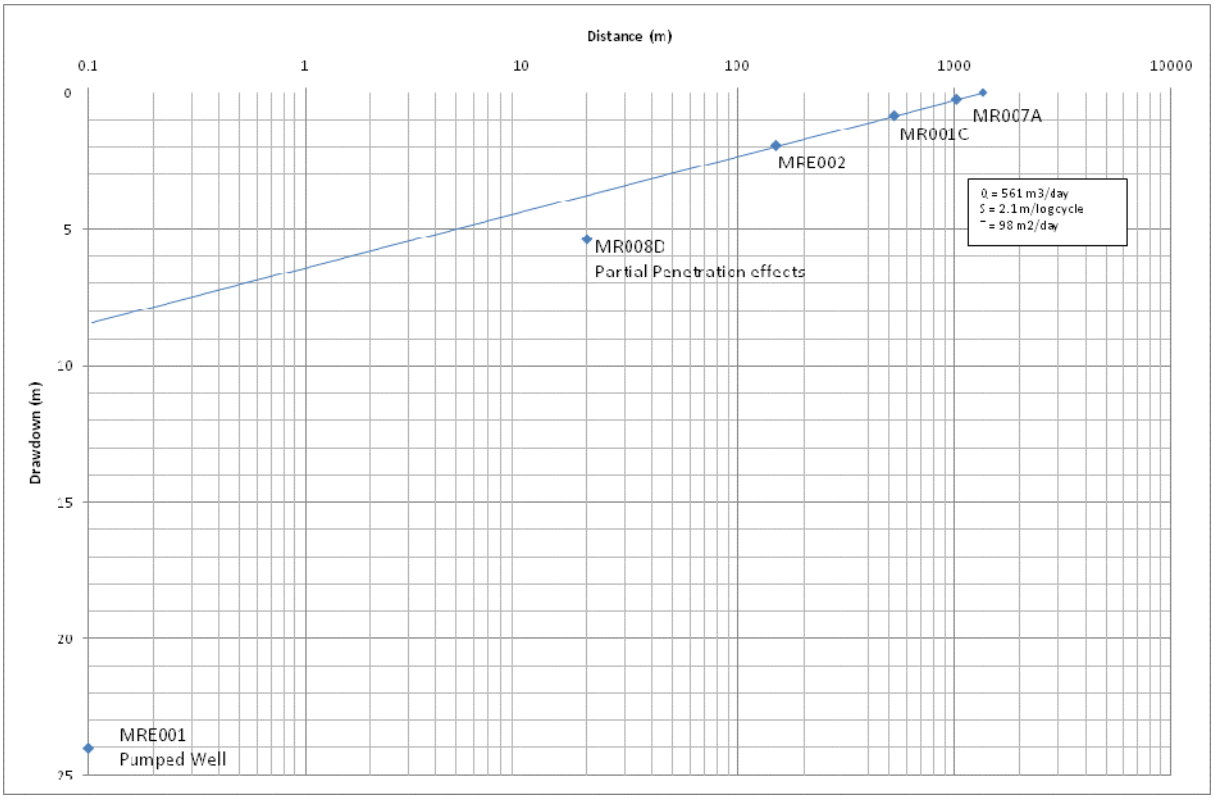


Figure 7: MRE1 Distance Drawdown analysis

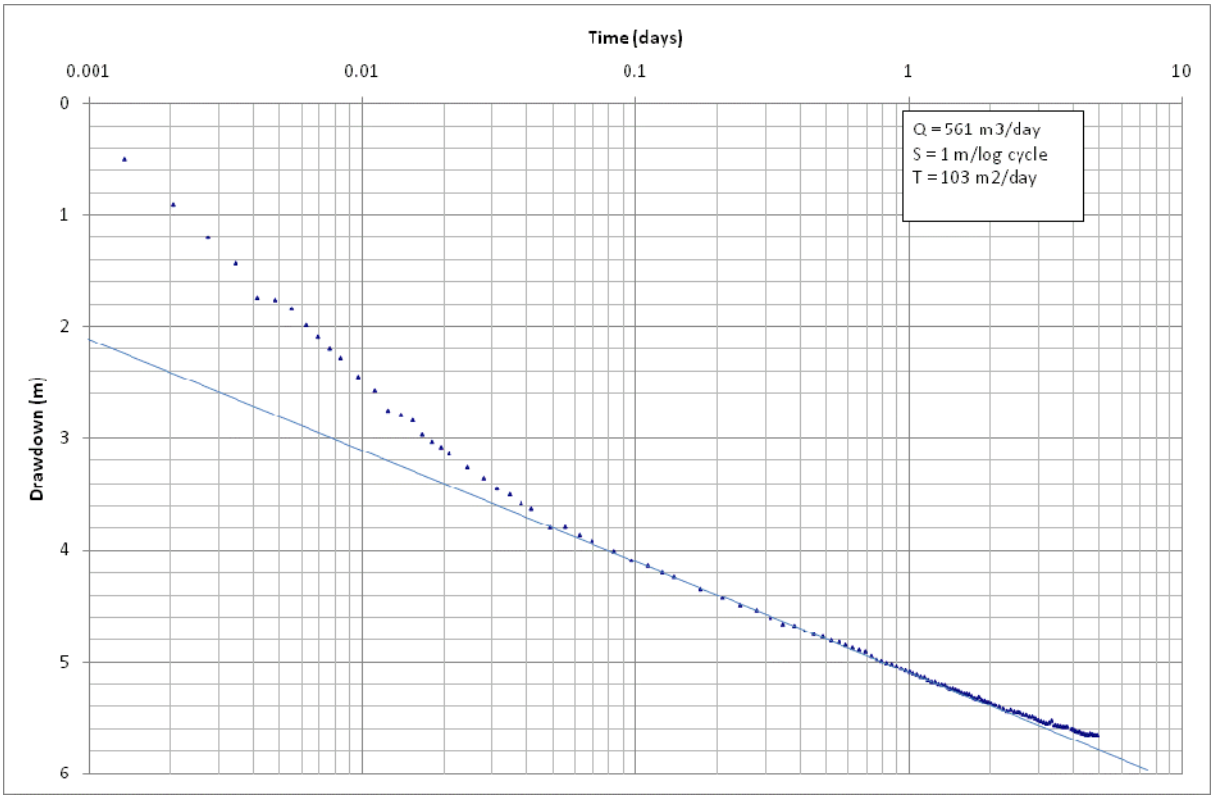


Figure 8: MRE1, 8 D observation well - Jacob analysis

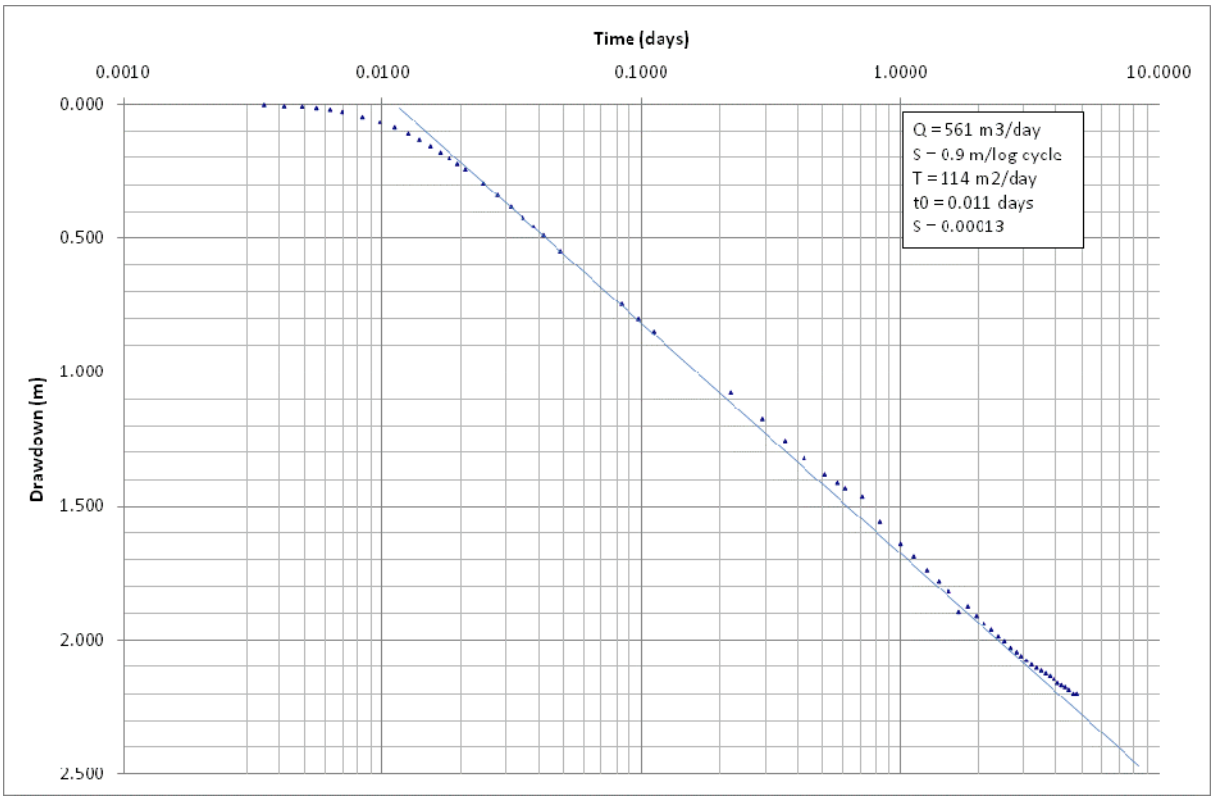


Figure 9: MRE1, MRE2 Observation well - Jacob analysis

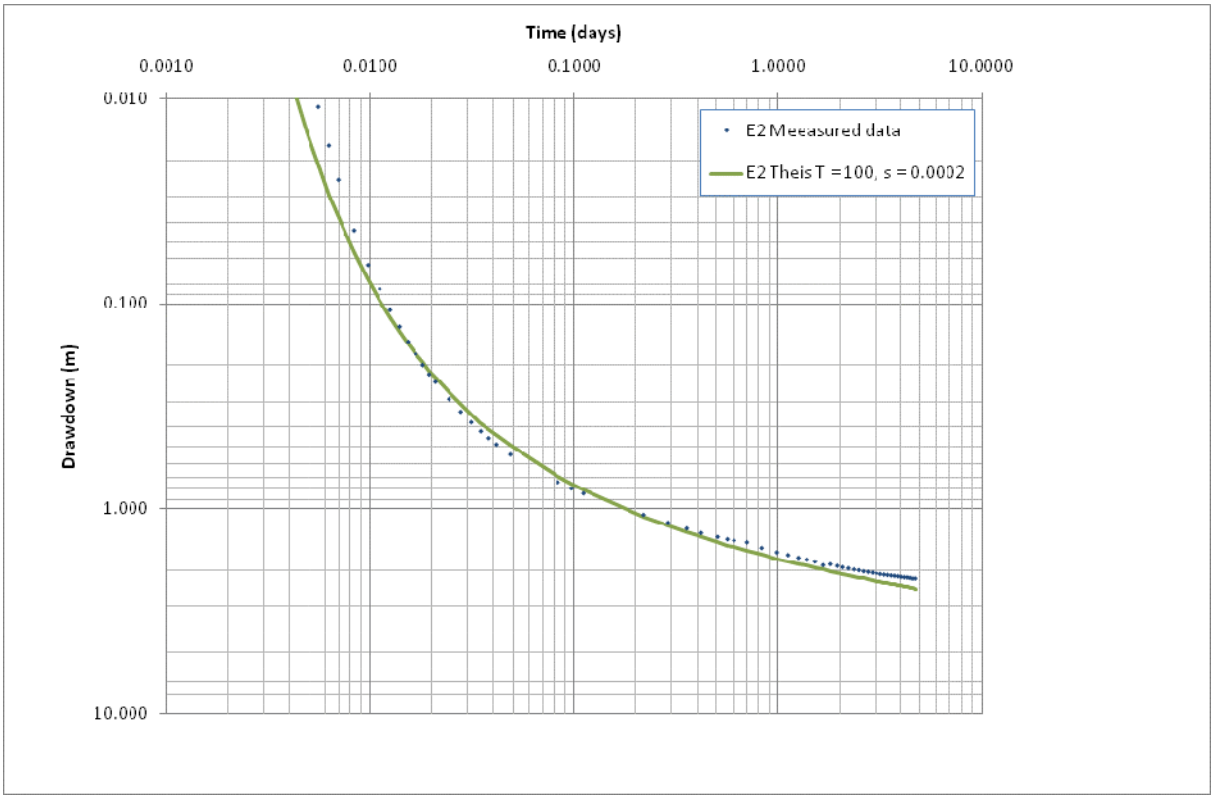


Figure 10: MRE1, MRE2 observation well – Theis analysis

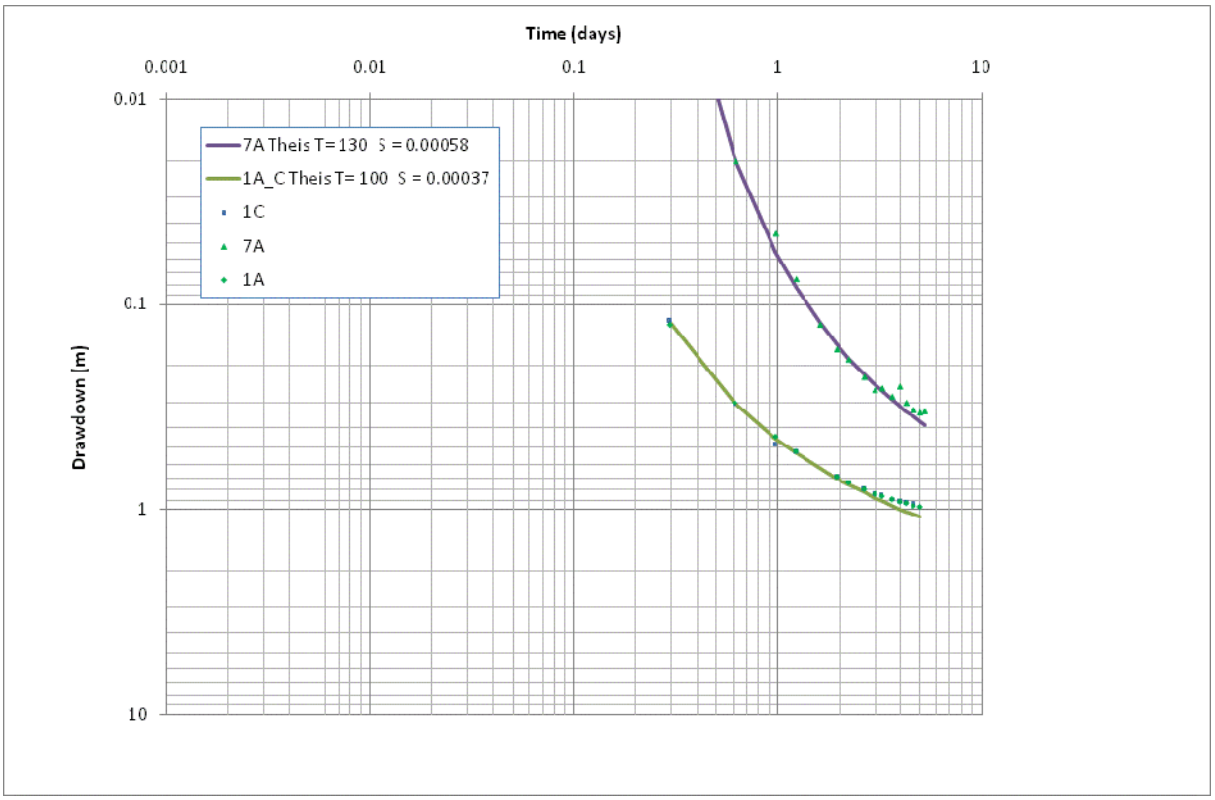


Figure 11: MRE1, 1A&C and 7A observation wells - Theis analysis

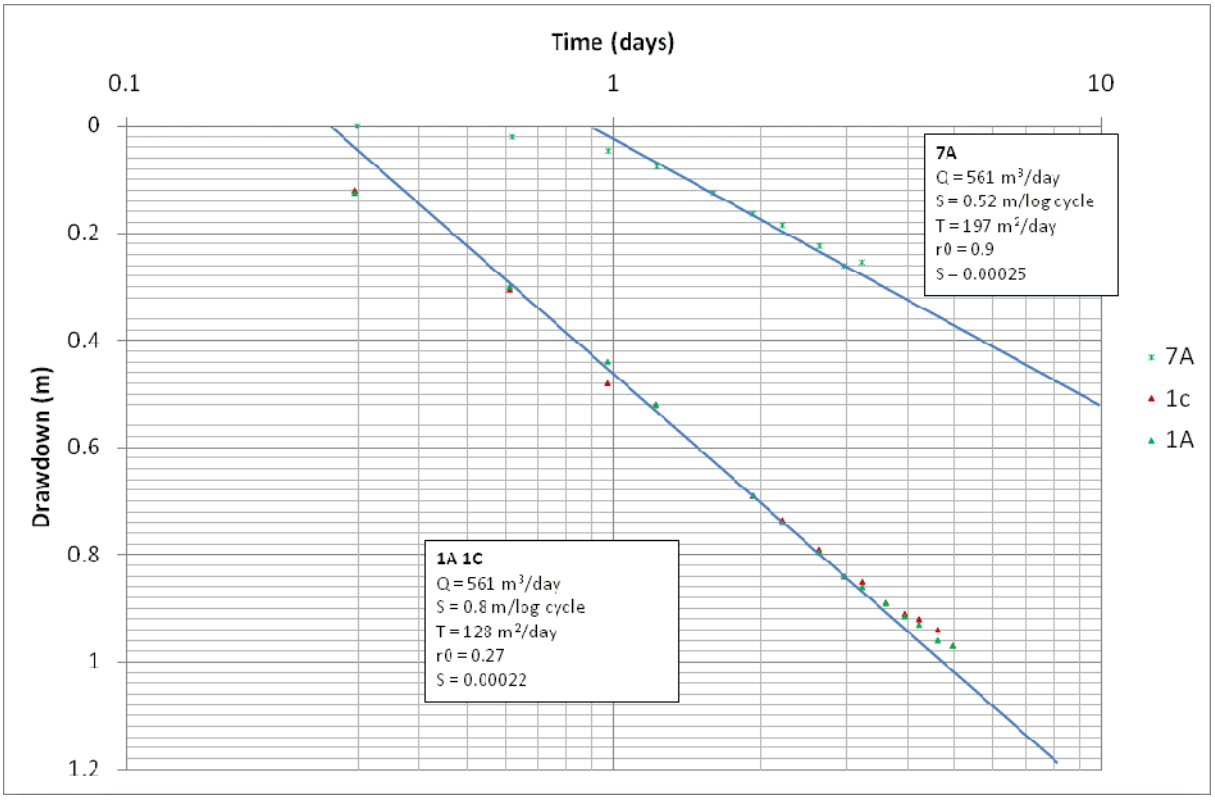


Figure 12: MRE1 – 1A, 1C & 7A Observation well – Jacob analysis

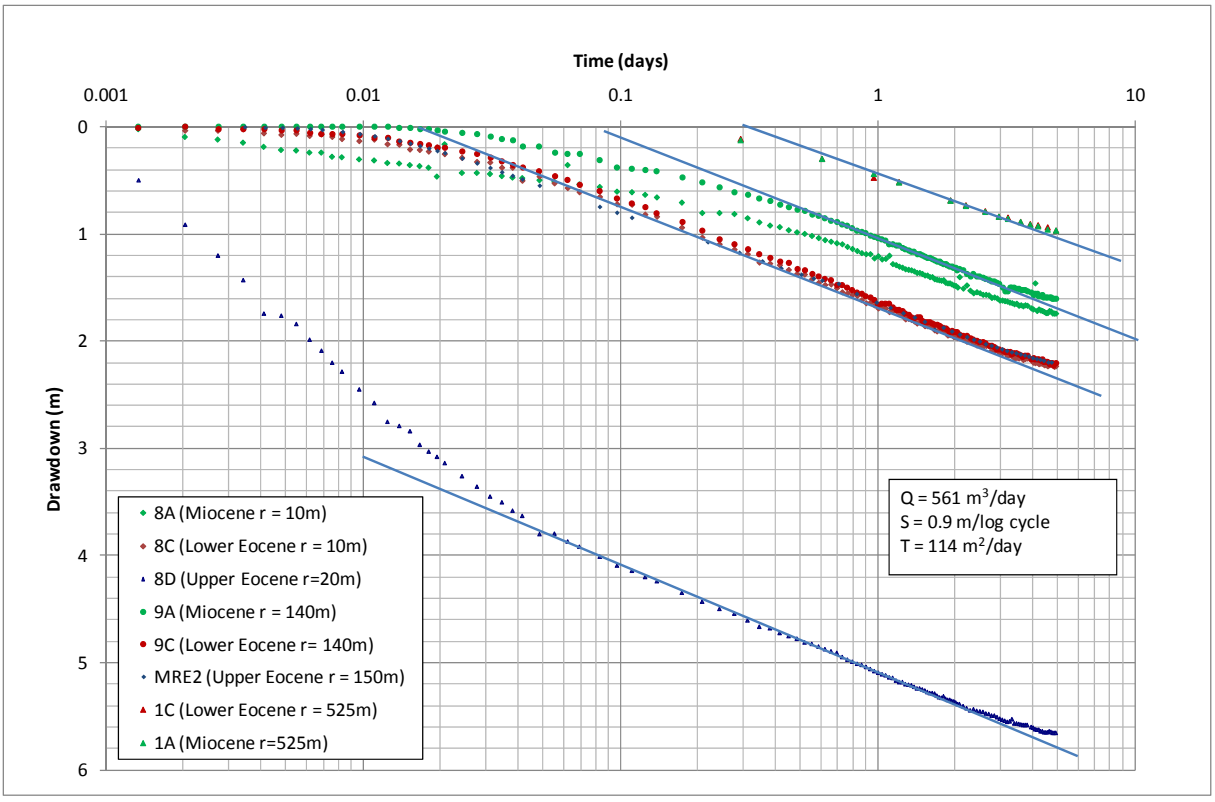


Figure 13: MRE1 – All observation wells – vertical connectivity analysis

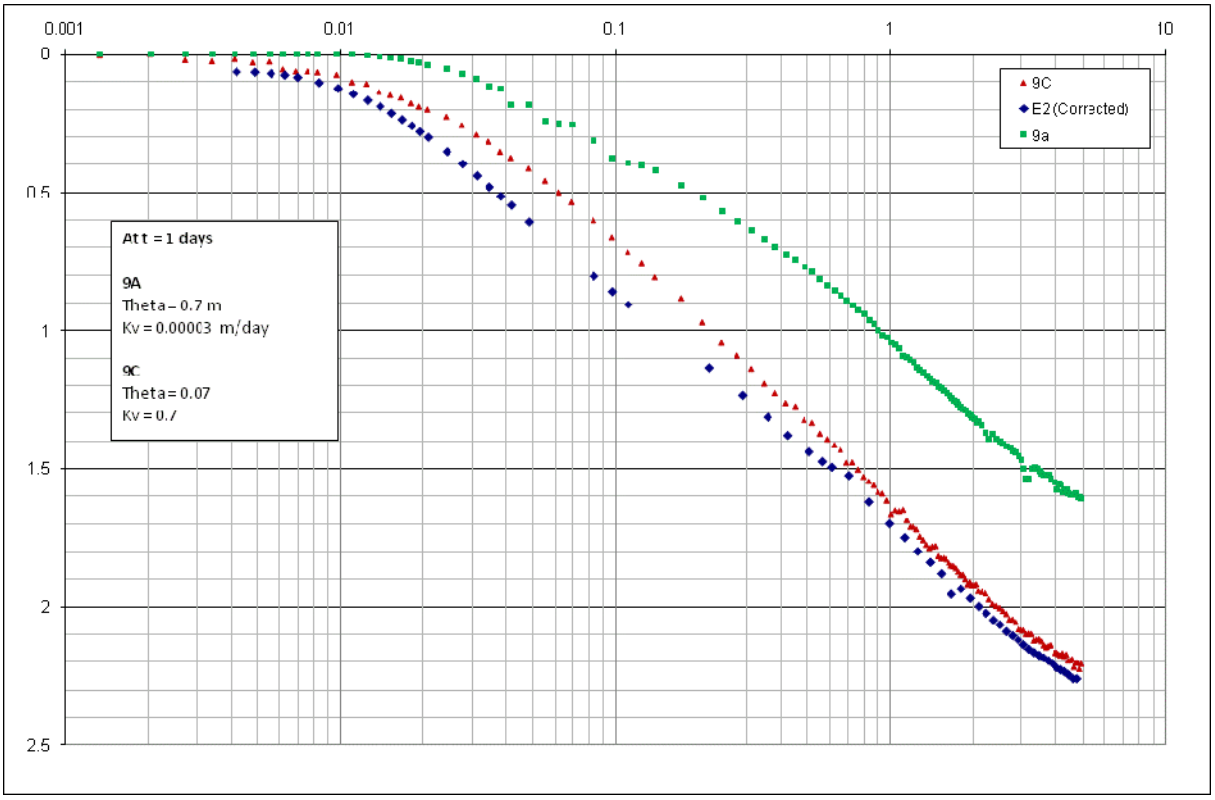


Figure 14: MRE1 – 9A, 9C Observation Well - Weeks Analysis

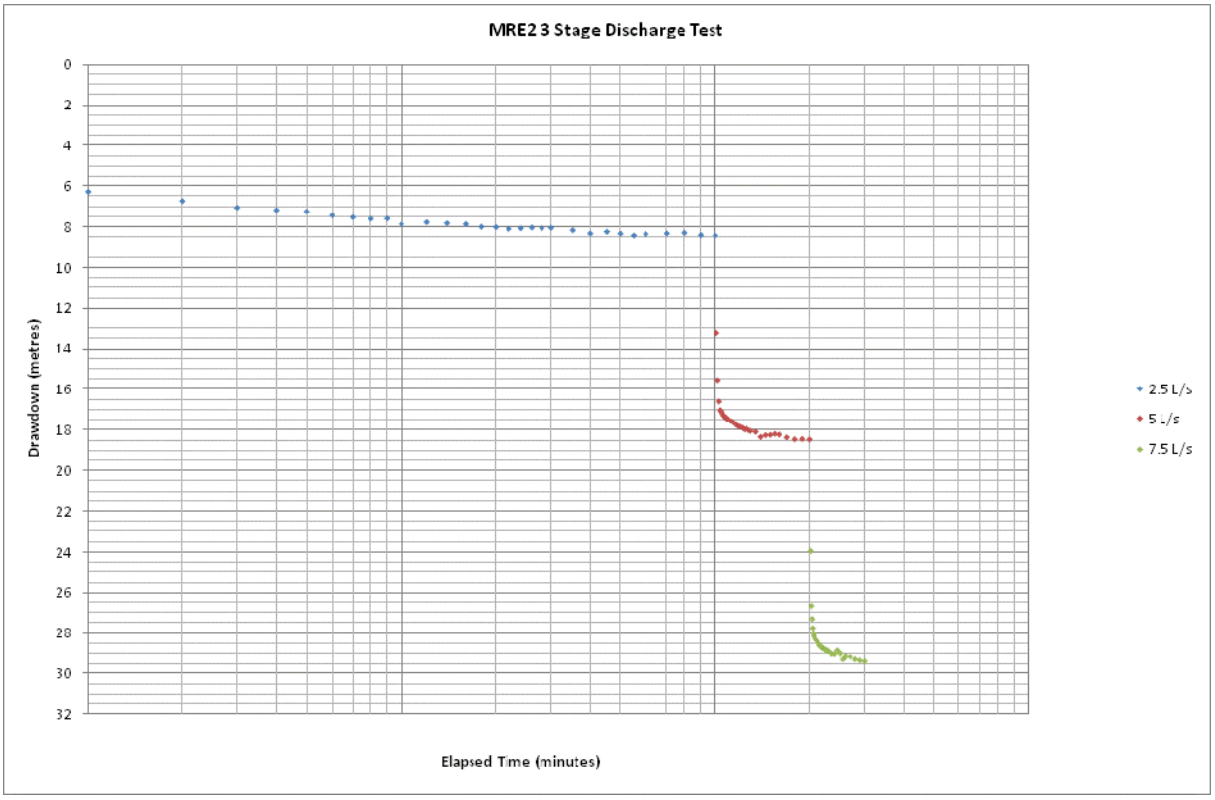


Figure 15: MRE2 Step Test Results

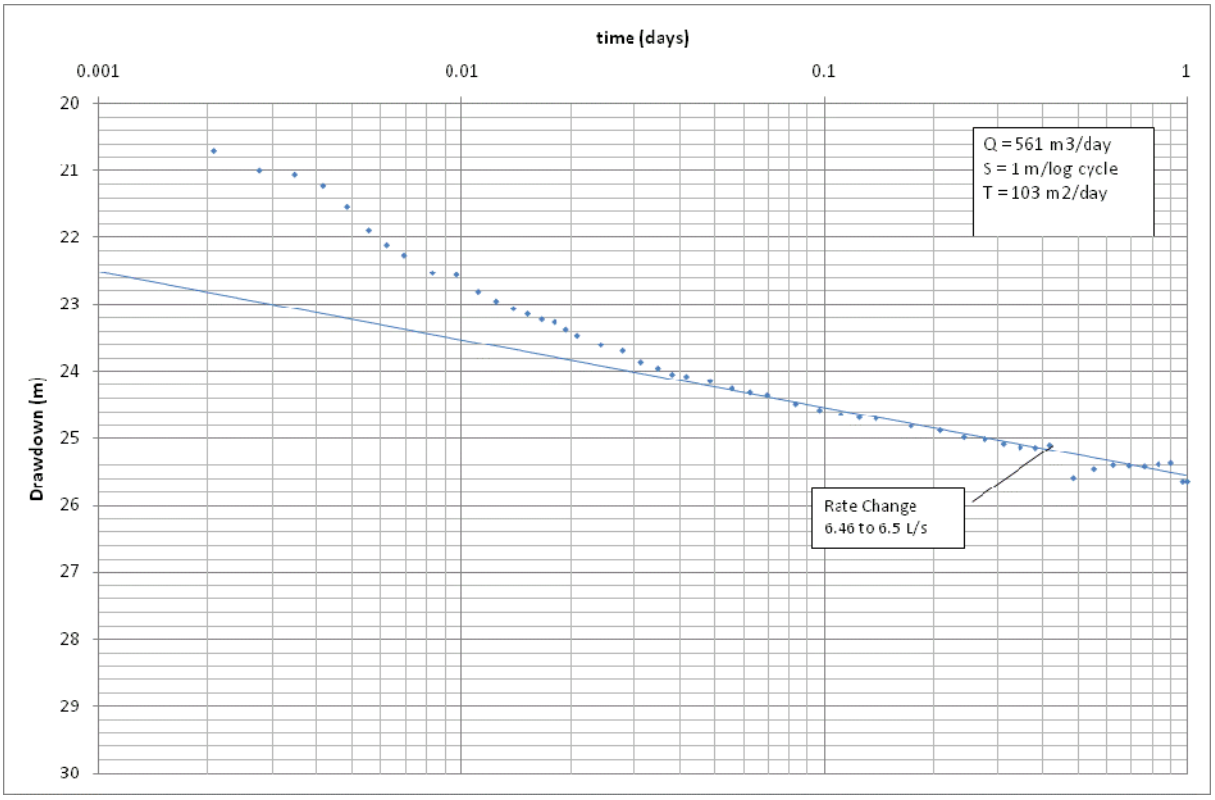


Figure 16: MRE2 – Pumped Well- Jacob Analysis

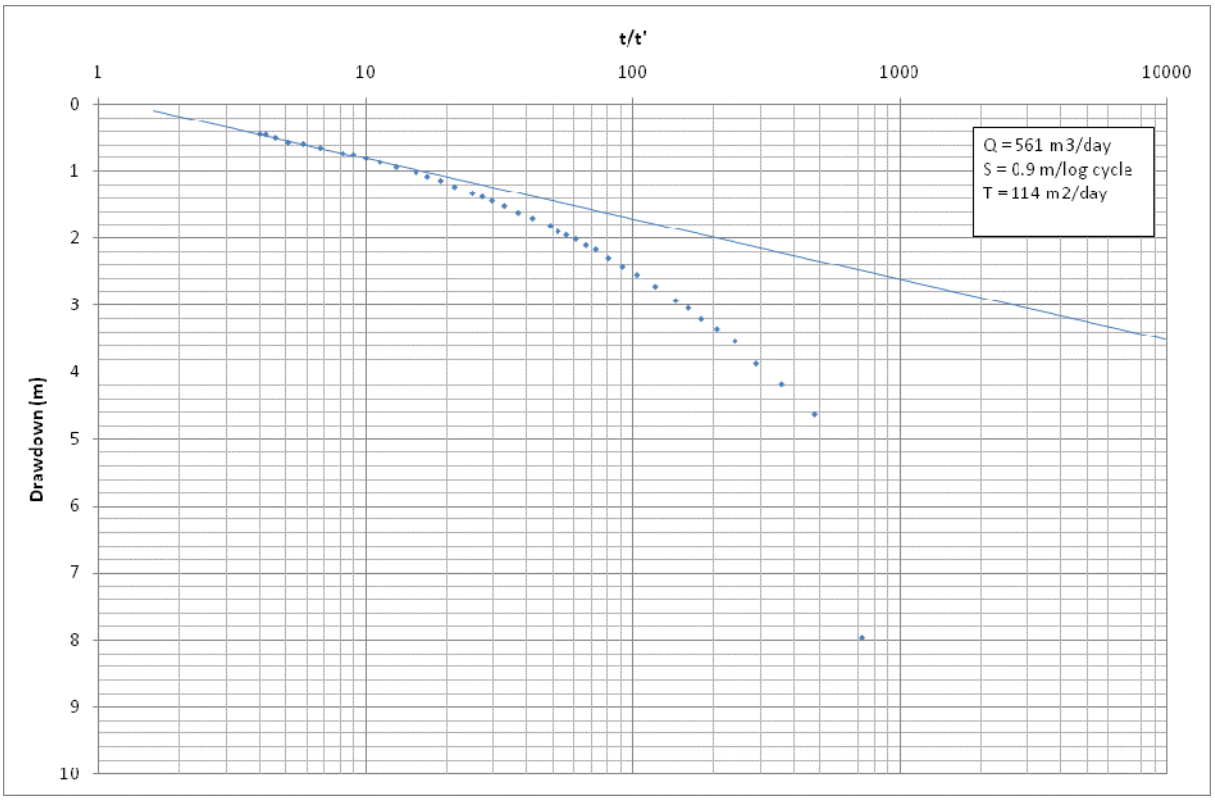


Figure 17: MRE2 – Pumped Well- Theis recovery analysis

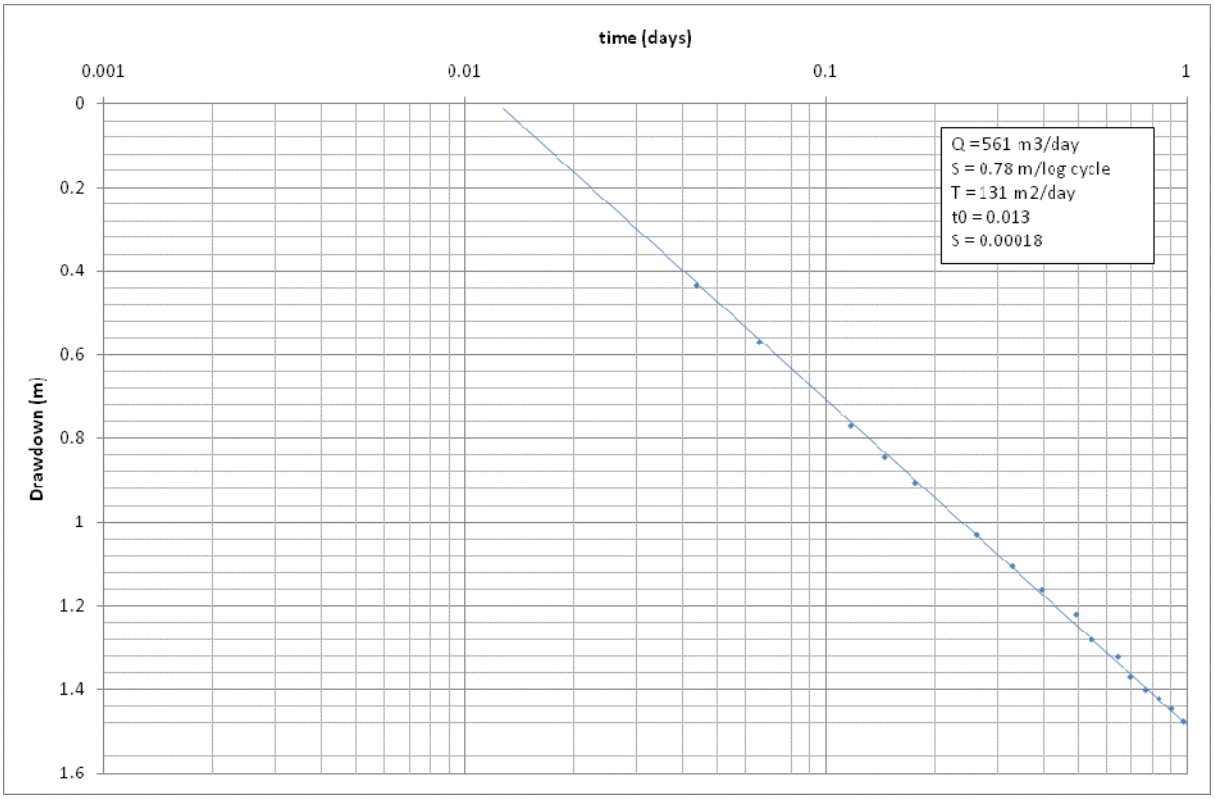


Figure 18: MRE2 – MRE1 Observation well Jacob Analysis

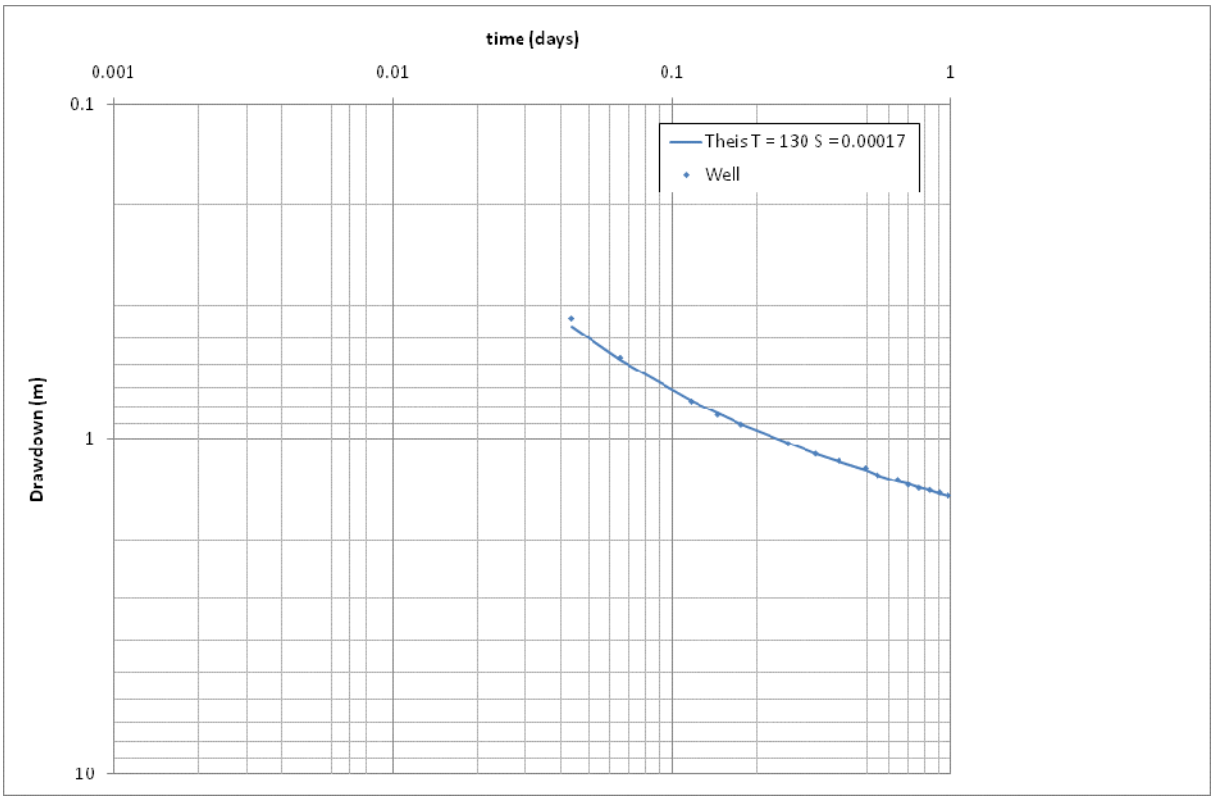


Figure 19: MRE2 – MRE1 Observation well Theis Analysis

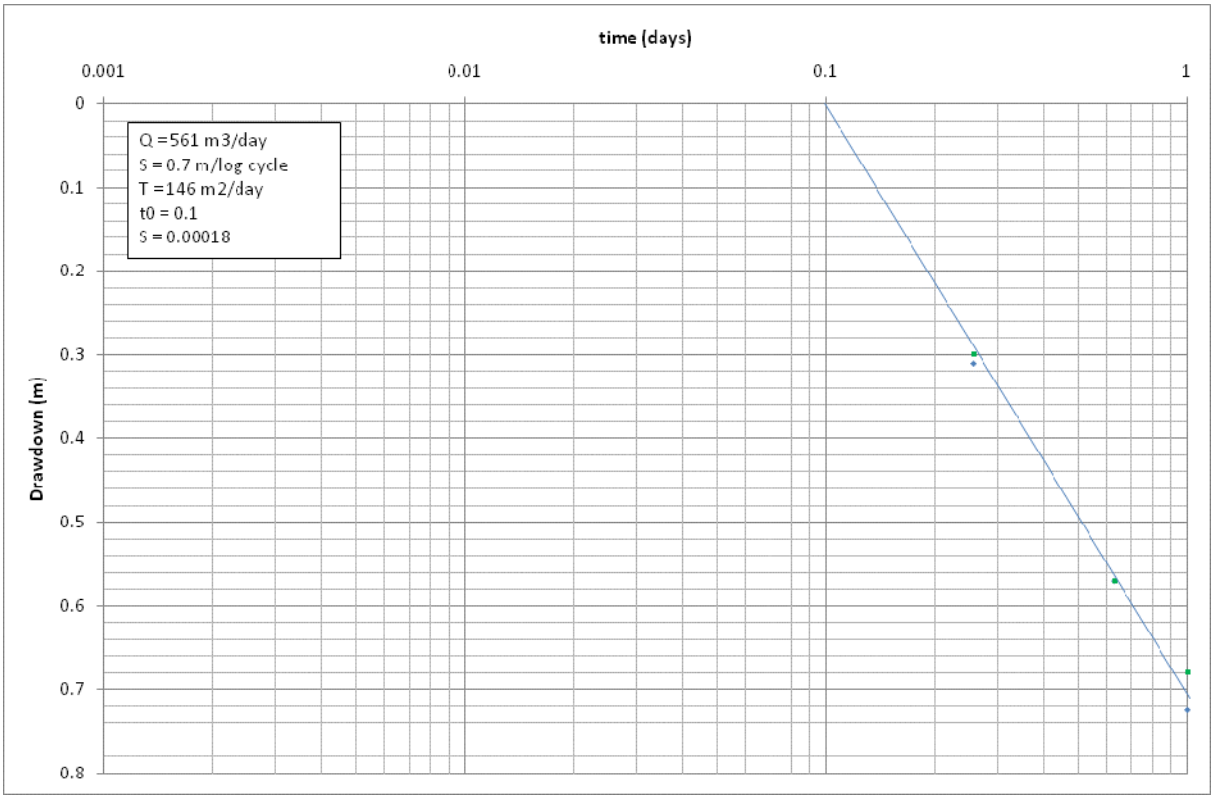


Figure 20: MRE2 – 1A, 1C Observation Well - Jacob Analysis

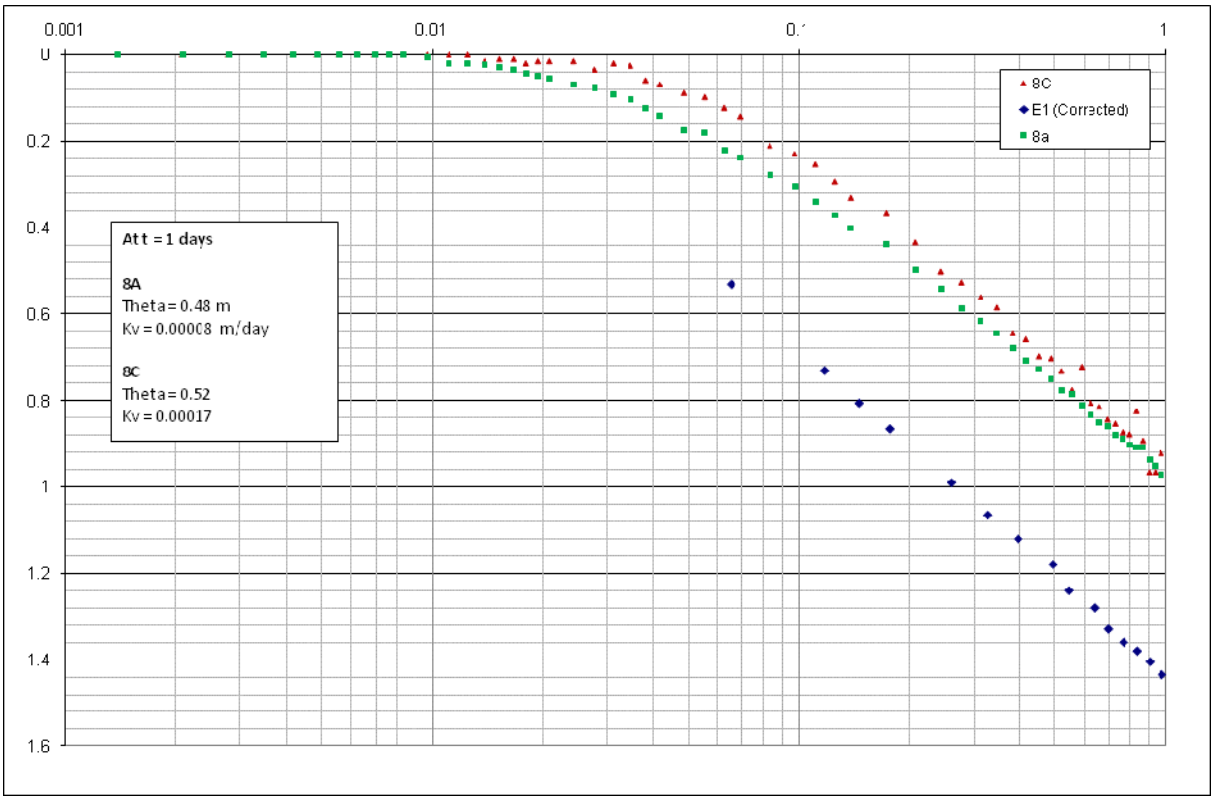


Figure 21: MRE2 – 8A, 8C Observation Well - Weeks Analysis

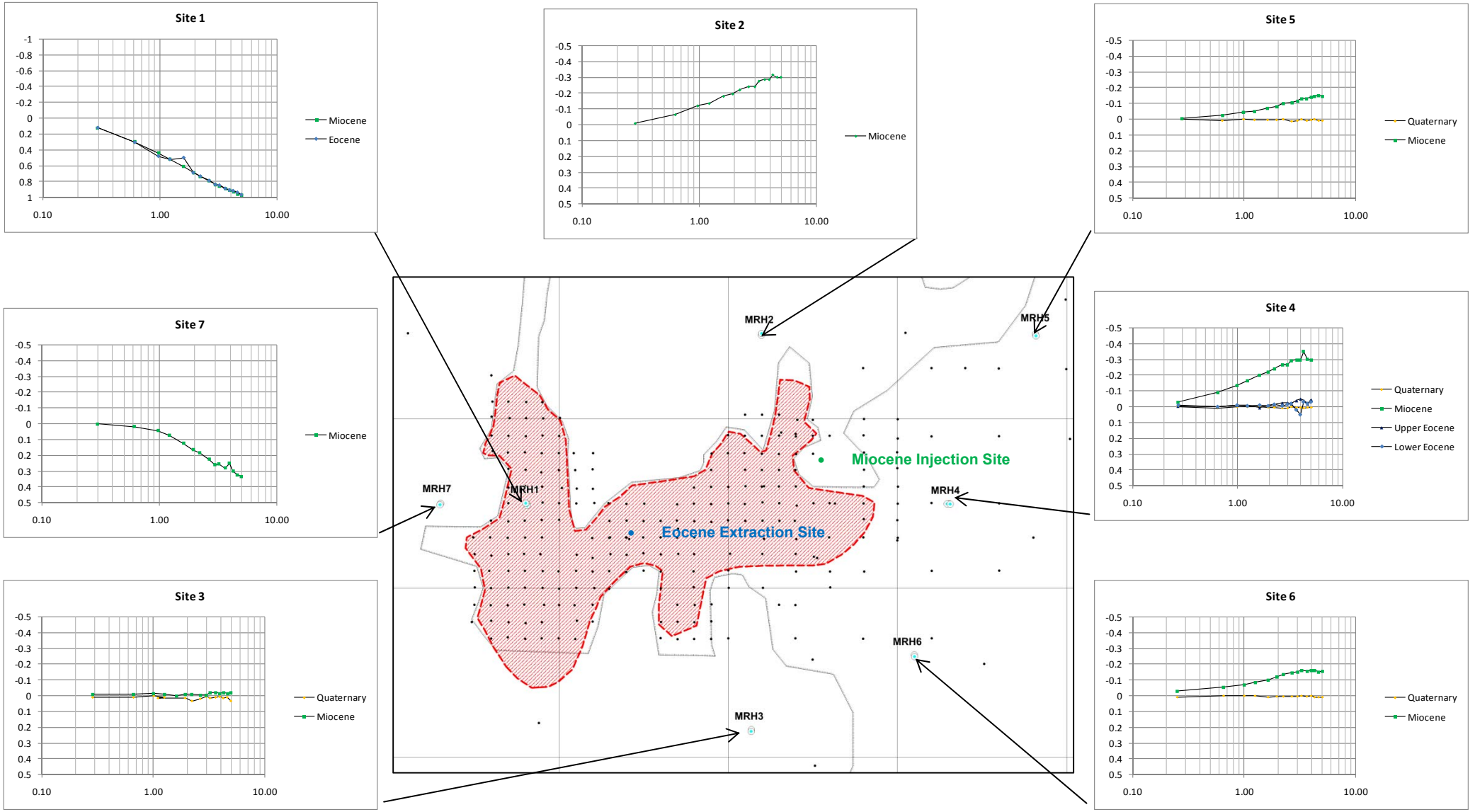


Figure 22: 5 day Constant rate extraction and injection – site-wide response to pumping and injection.

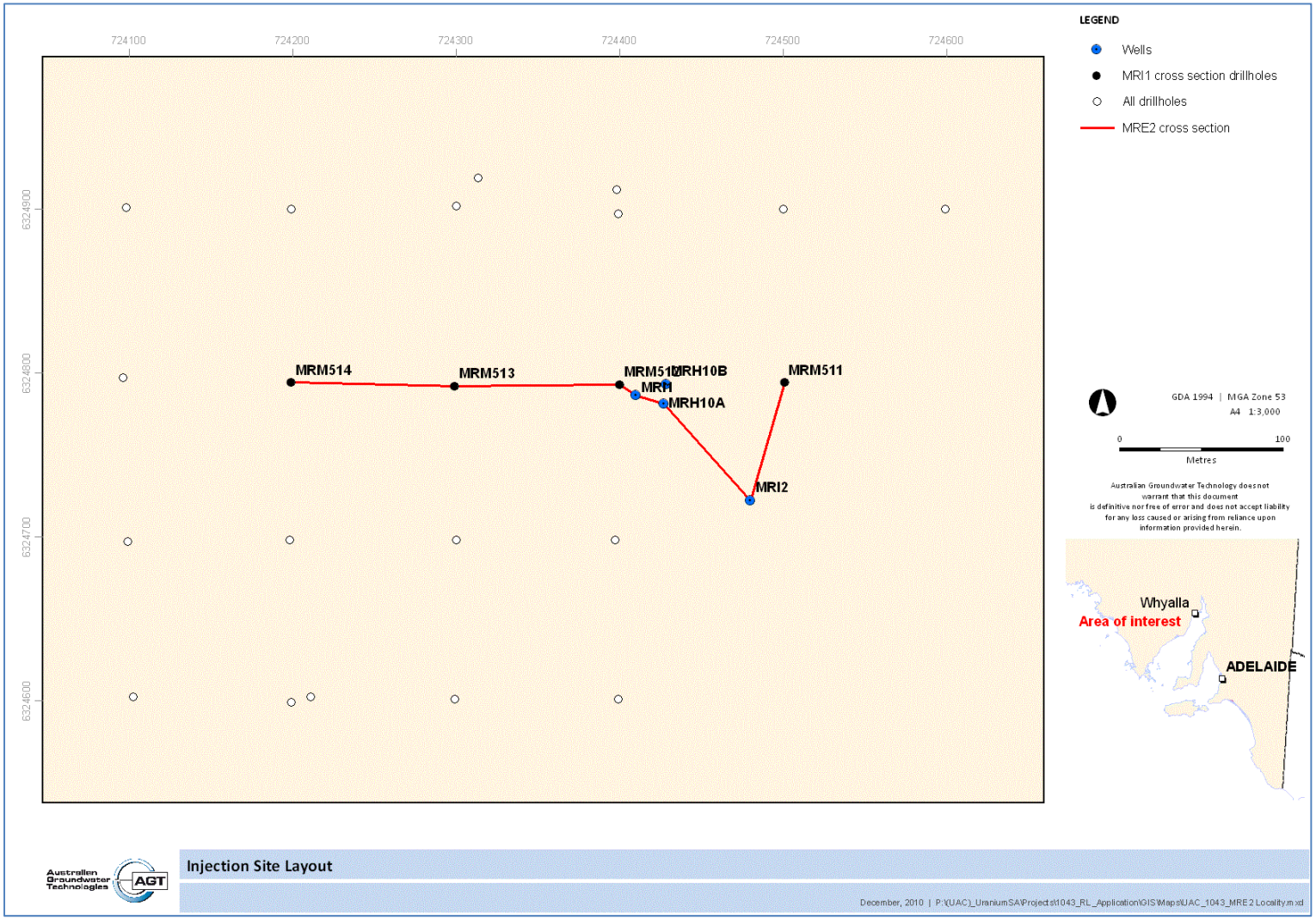


Figure 23: Injection Site Well Layout

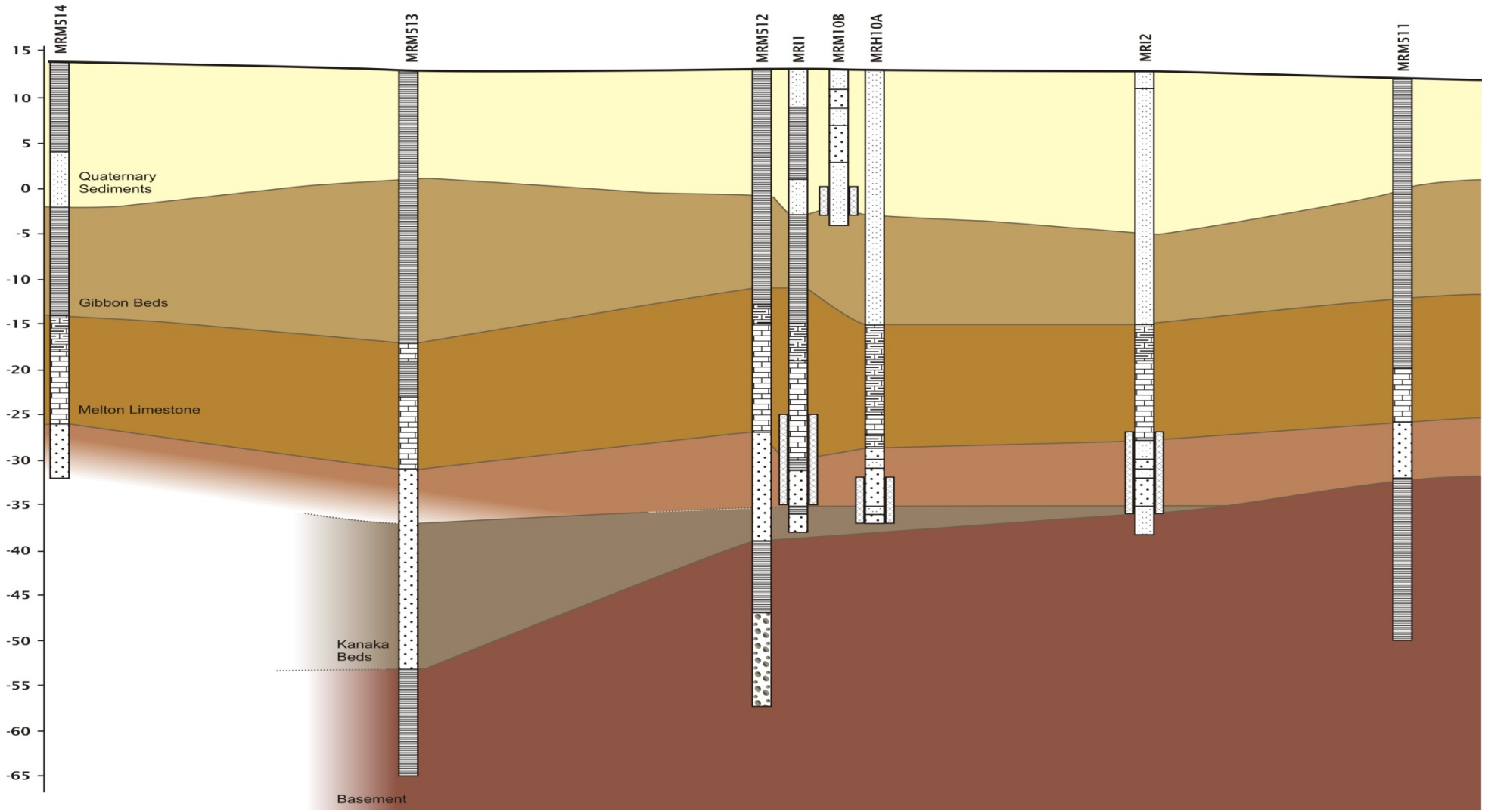


Figure 24: Injection Site Cross Section

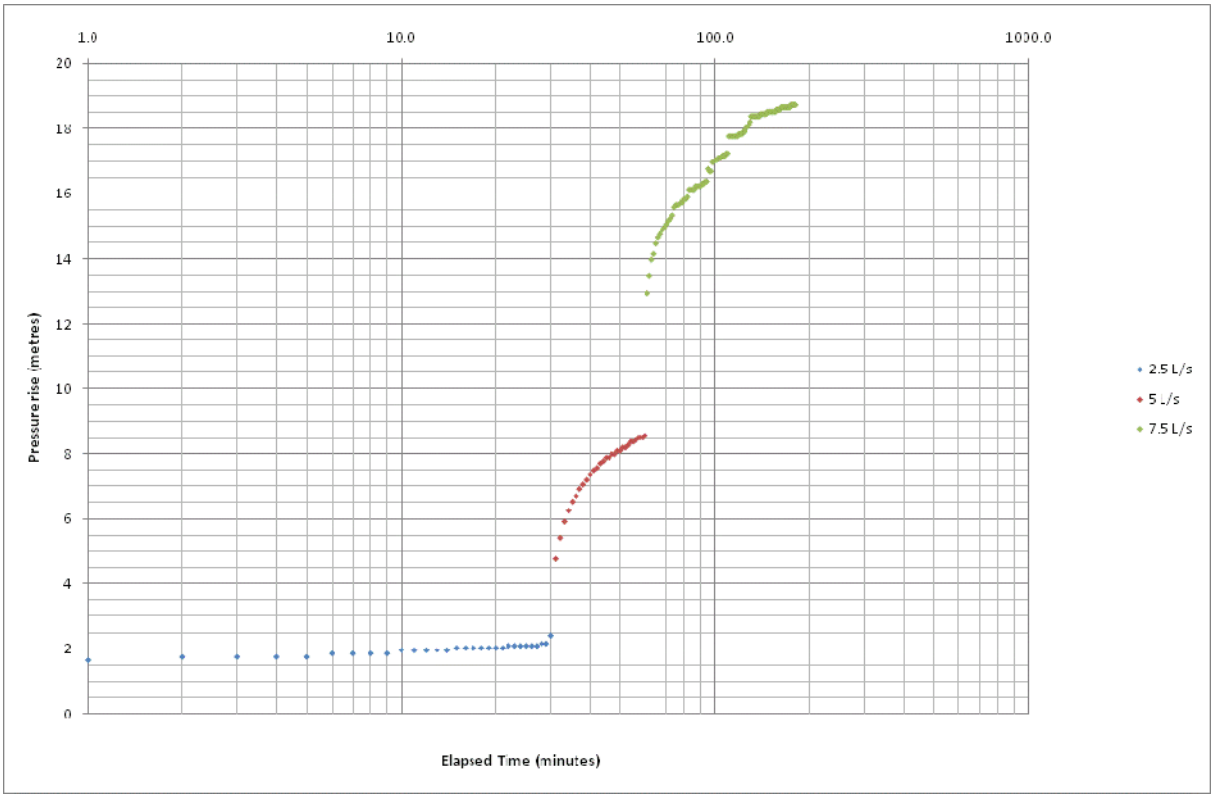


Figure 25: MRI001 Step Test Results

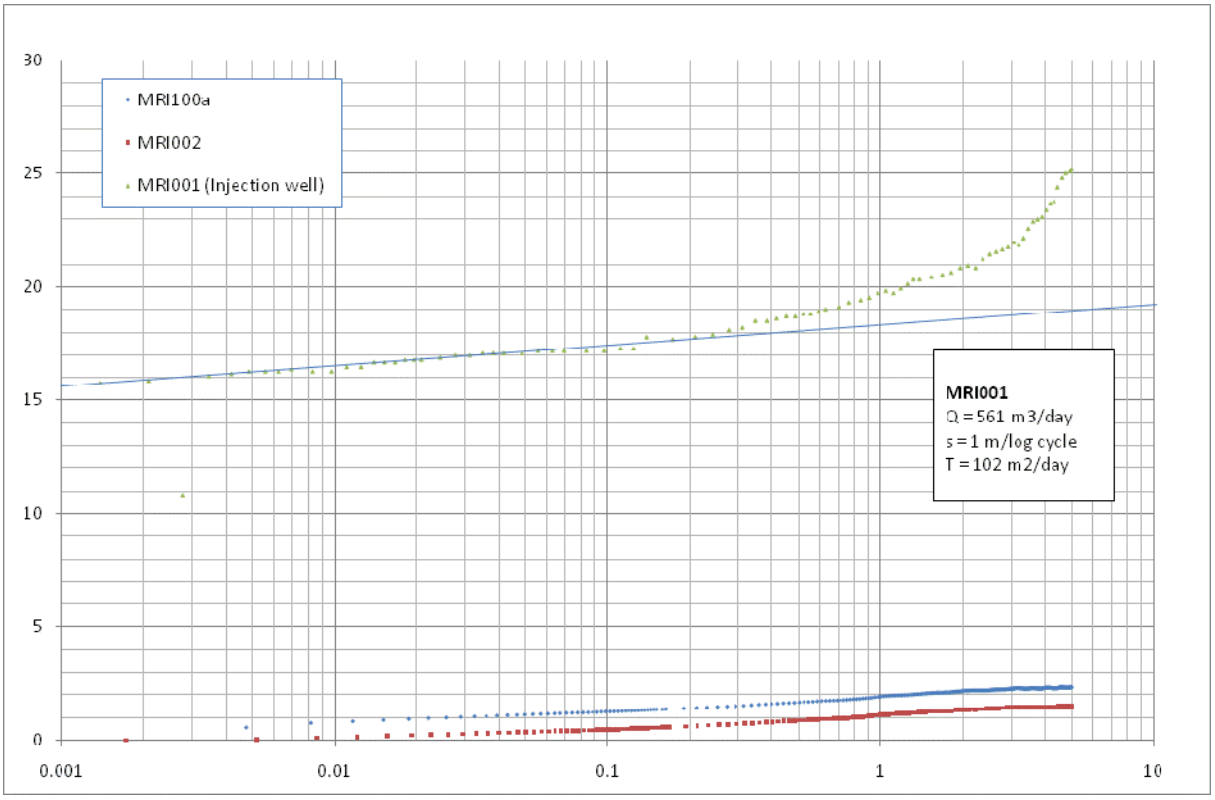


Figure 26: MRI001 Injection Well -Jacob analysis

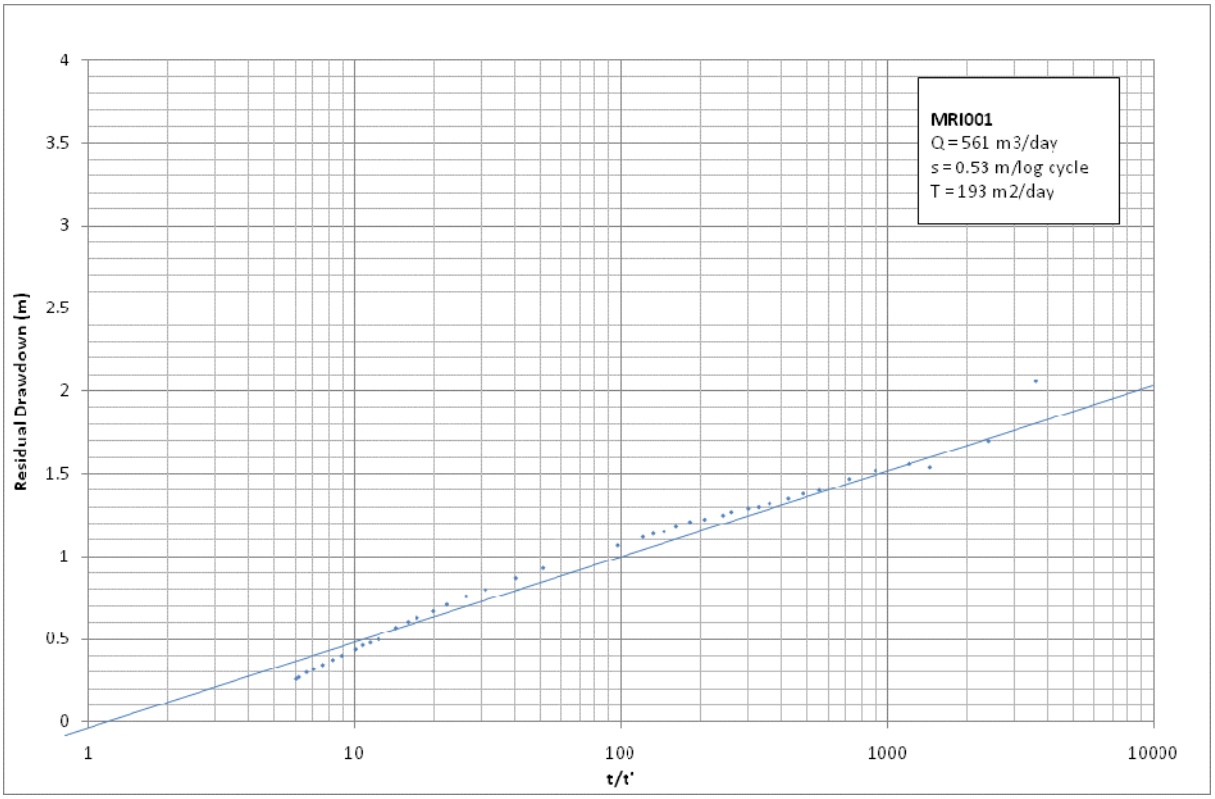


Figure 27: MRI001 Injection Well –Theis recovery analysis

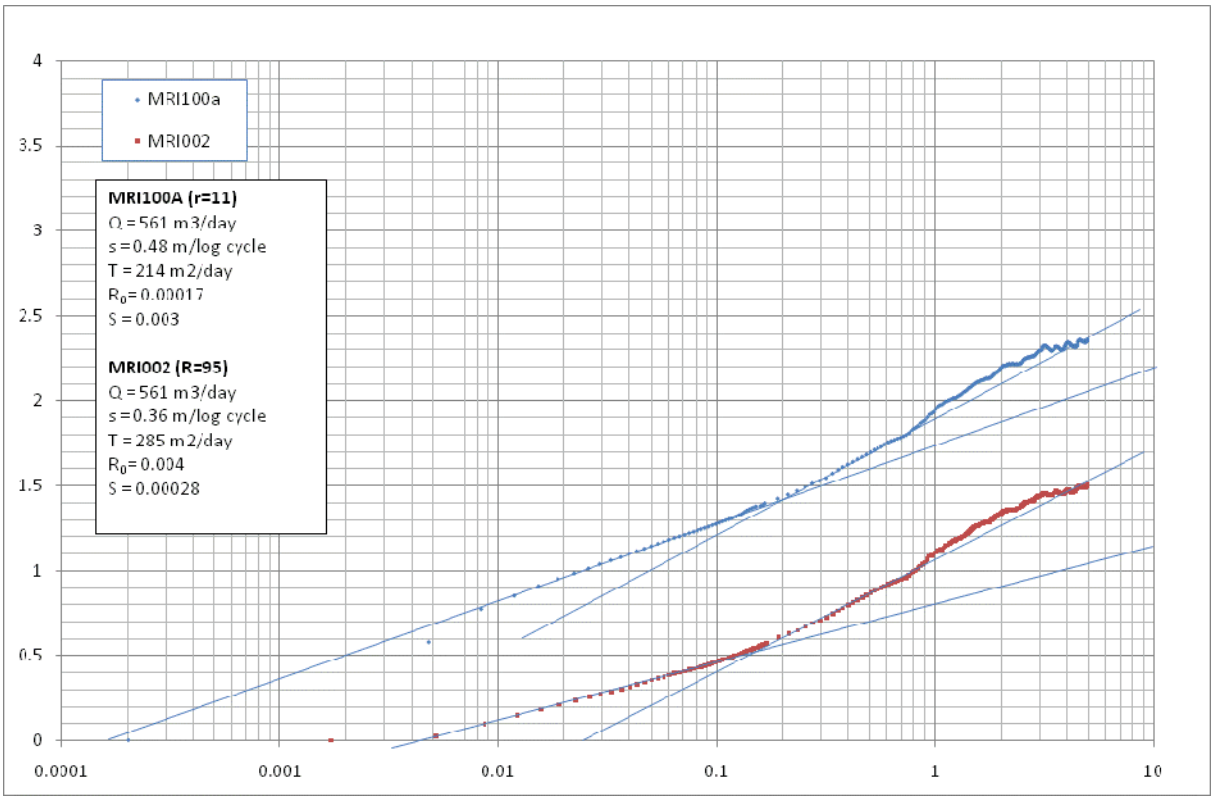


Figure 28: MRI001 Observation wells –Jacob analysis.

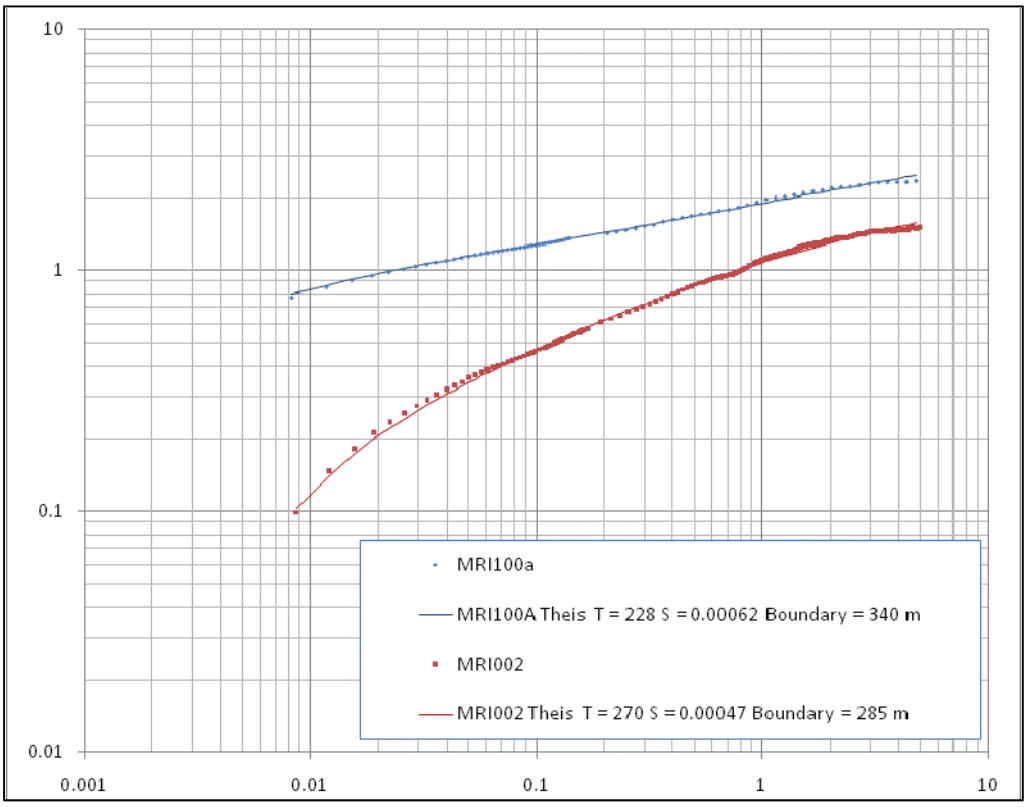


Figure 29: MRI001 Observation wells –Clarke analysis.

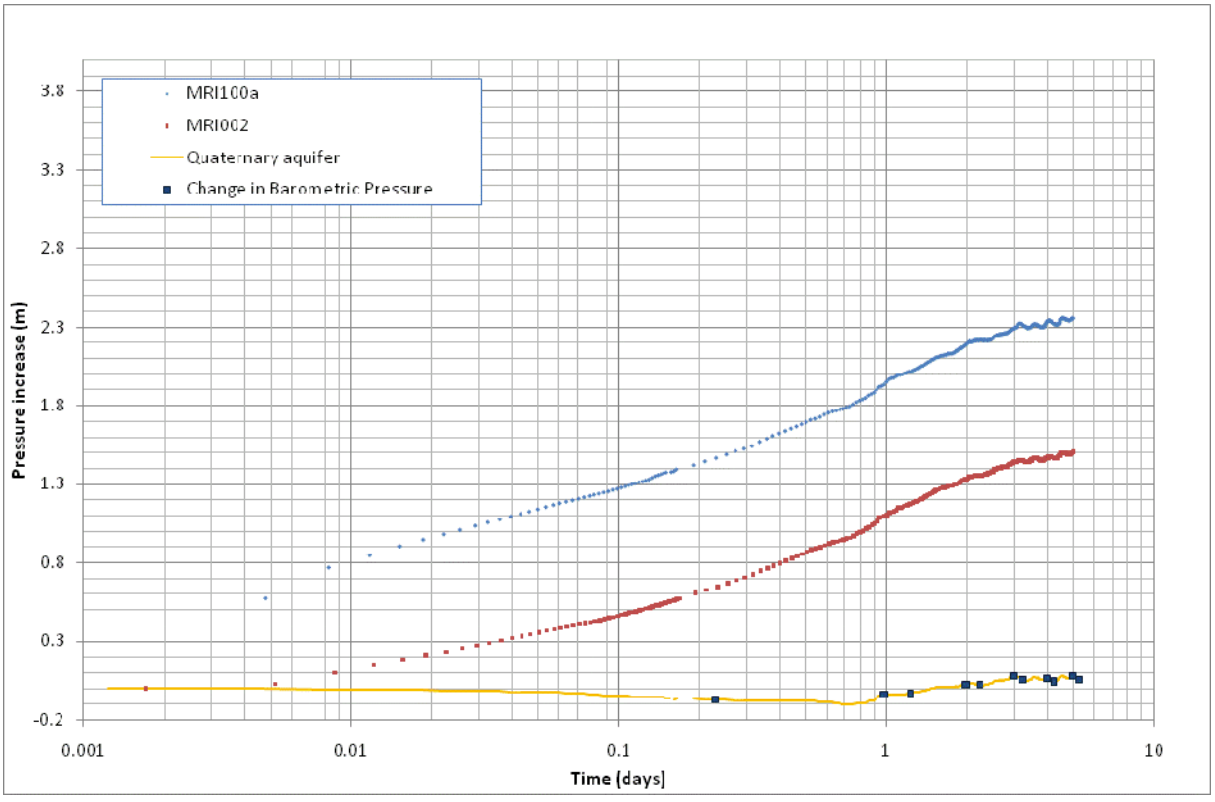


Figure 30: Injection Test Quaternary aquifer response.

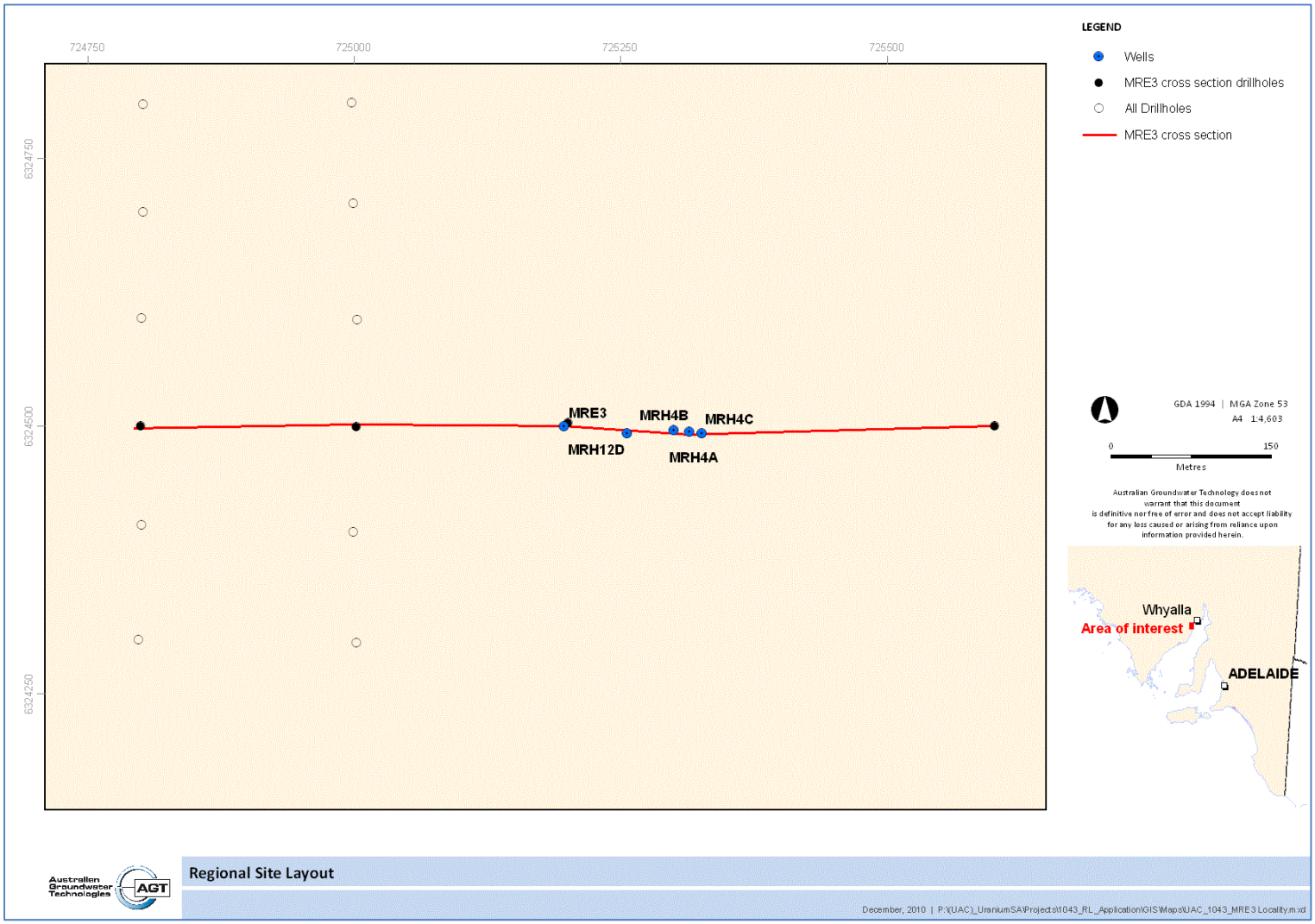


Figure 31: Regional Site Well Layout

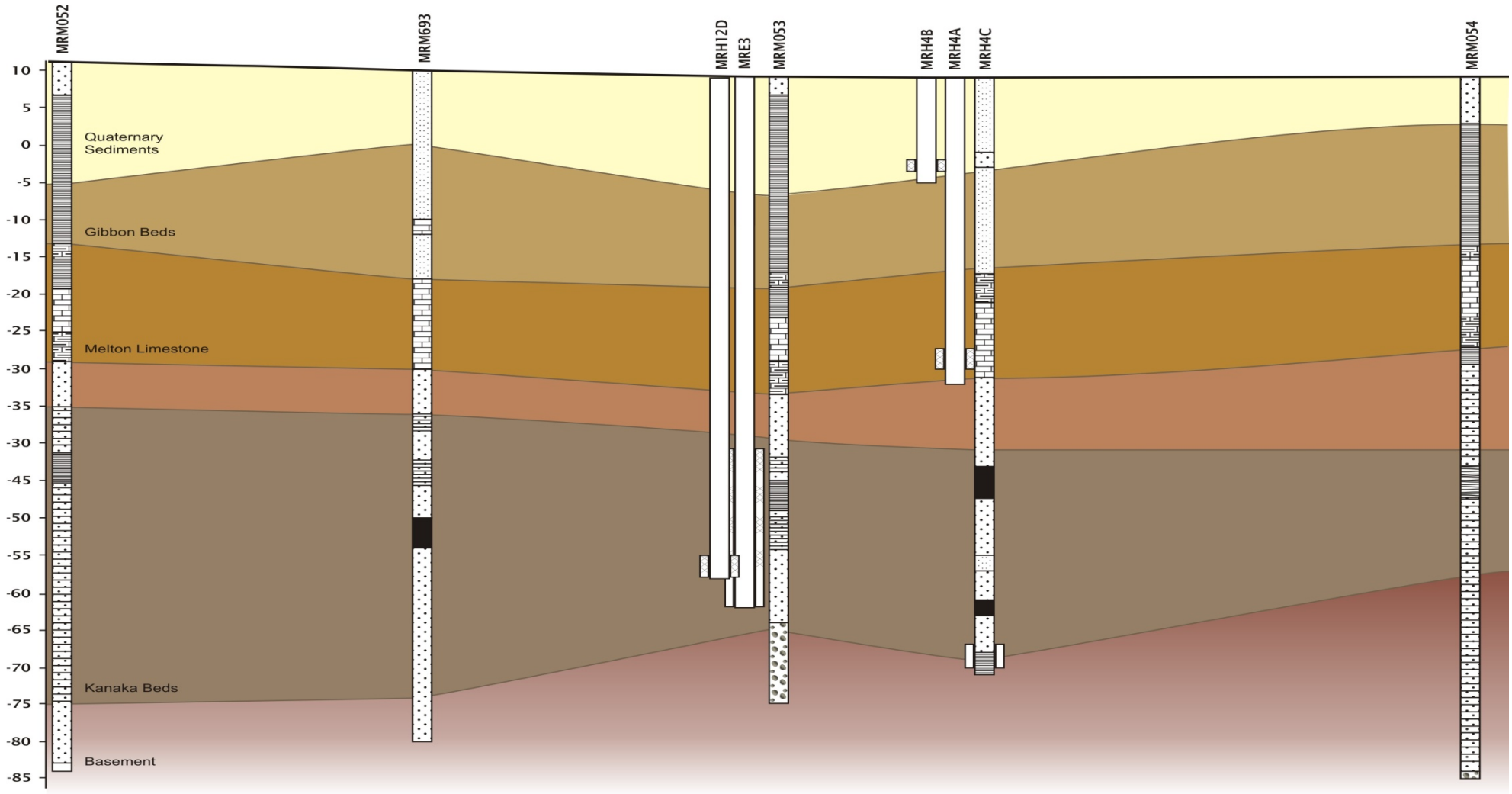


Figure 32: Regional Site Cross Section

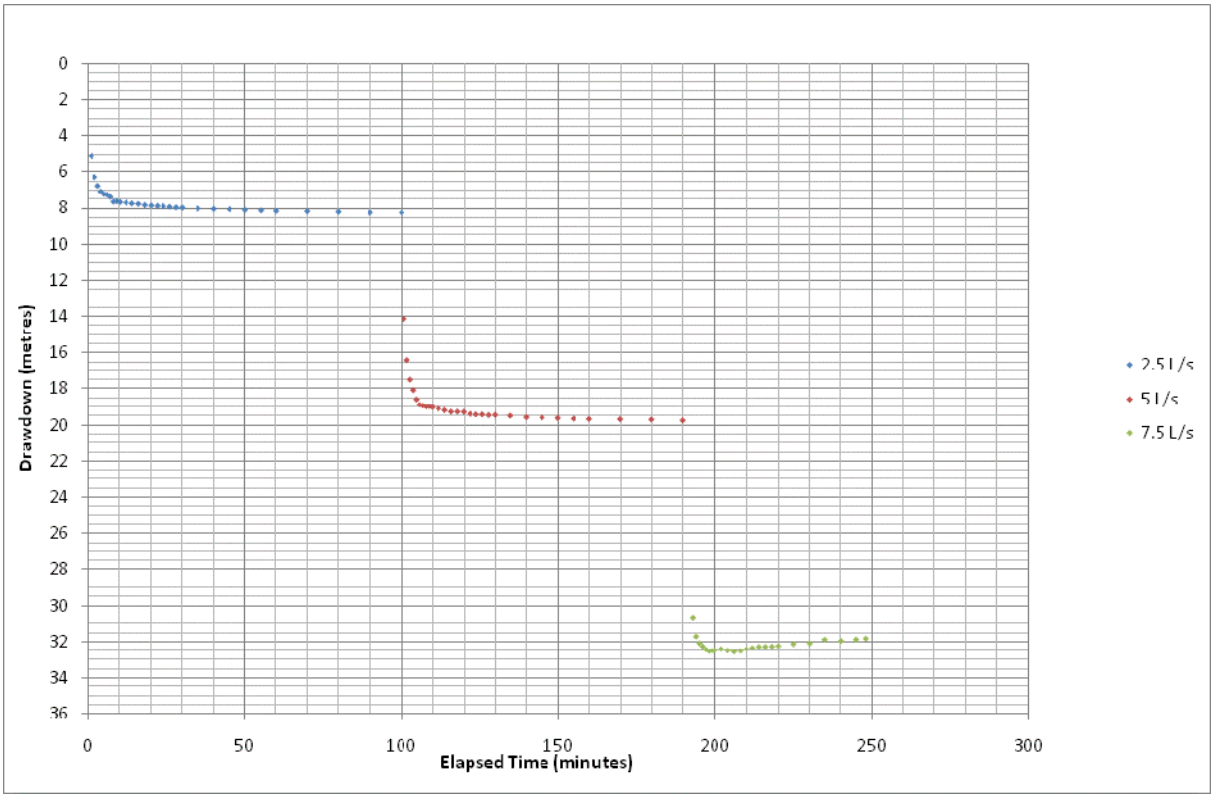


Figure 33: MRE3 Step Test Results

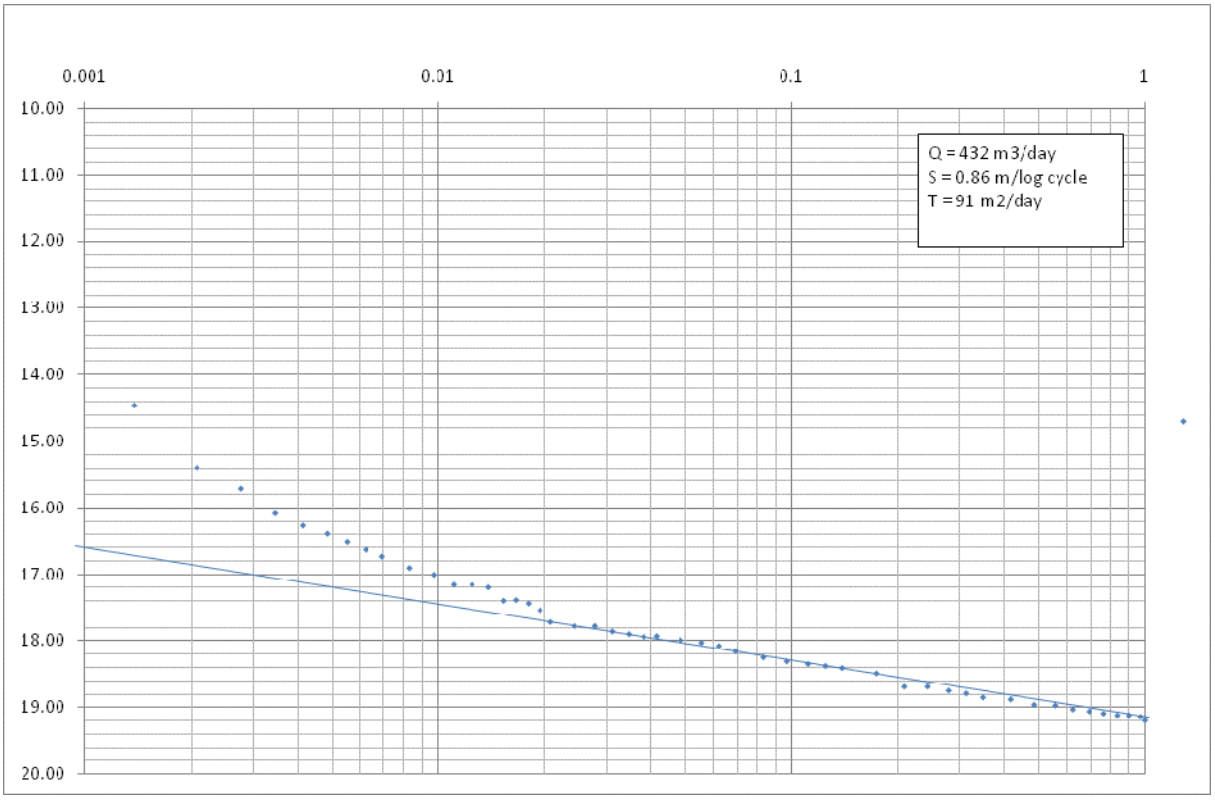


Figure 34: MRE3 Pumped Well -Jacob analysis

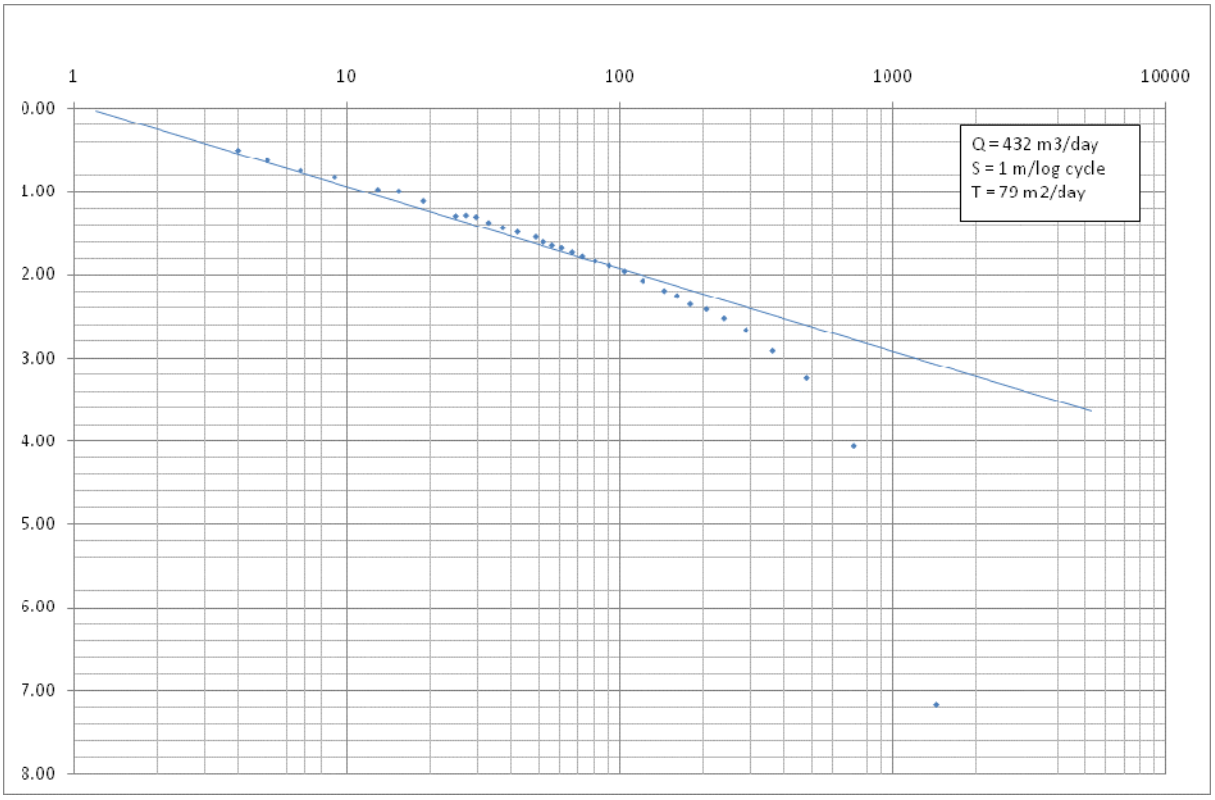


Figure 35: MRE3 Pumped Well –Theis recovery analysis

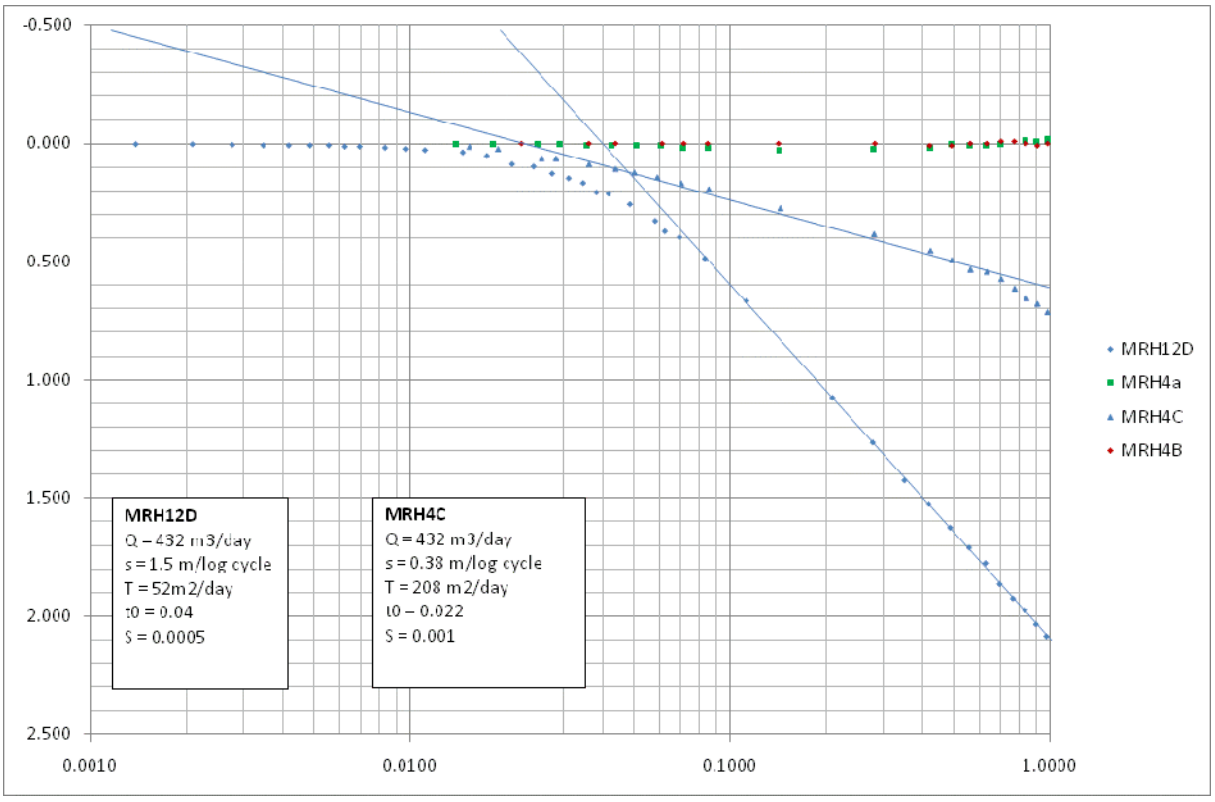


Figure 36: MRE3 All observation wells.

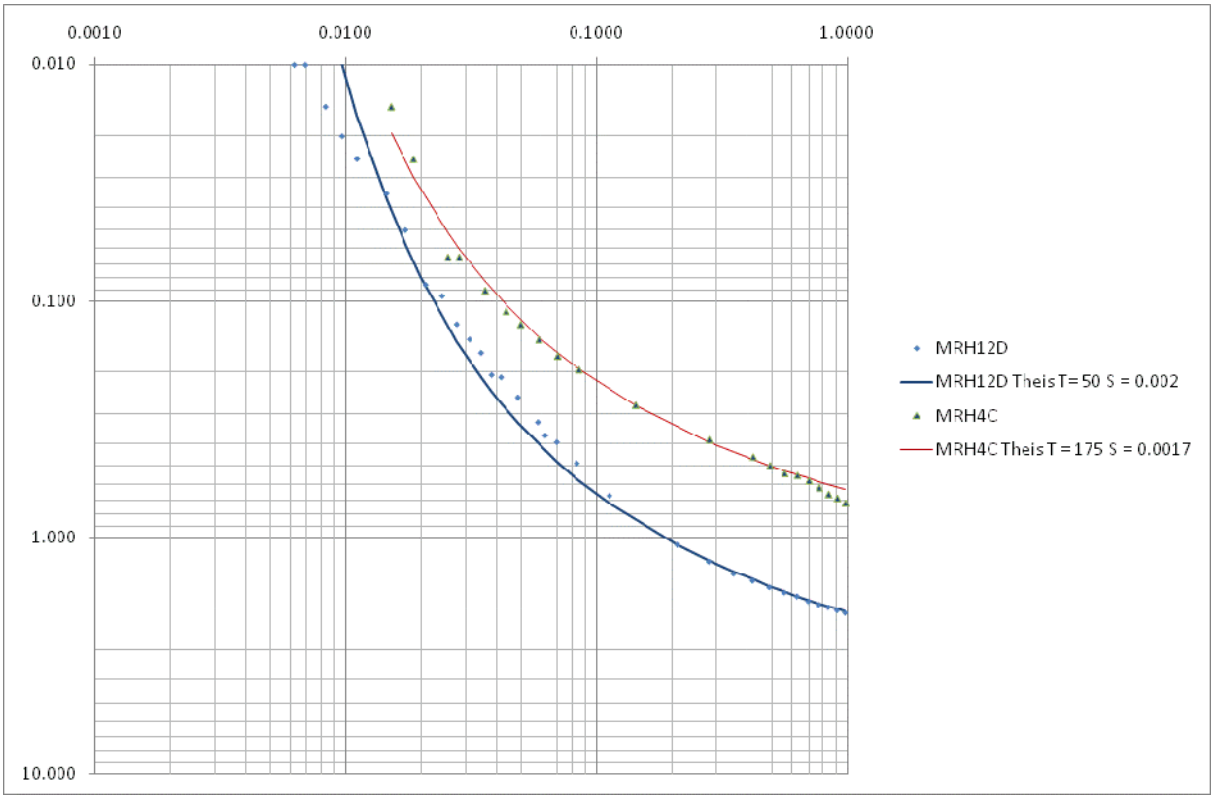


Figure 37: MRE3 12D and 4C Theis analsyis

11 Appendix 1 – MRE1 Step Test Data

t(min)	s (m)	q (L/s)	t(min)	s (m)	q (L/s)	t(min)	s (m)	q (L/s)
0	0	0	100	7.88	5	200	16.97	7.5
1	6.69	2.5	101	9.17	5	201	21.75	7.5
2	6.57	2.5	102	12.69	5	202	24	7.5
3	6.87	2.5	103	13.81	5	203	25.87	7.5
4	7.09	2.5	104	14.52	5	204	25.26	7.5
5	7.2	2.5	105	14.91	5	205	25.53	7.5
6	7.25	2.5	106	15.16	5	206	25.59	7.5
7	7.28	2.5	107	15.31	5	207	25.72	7.5
8	7.31	2.5	108	15.42	5	208	25.78	7.5
9	7.35	2.5	109	15.5	5	209	25.91	7.5
10	7.38	2.5	110	15.59	5	210	25.93	7.5
12	7.42	2.5	112	15.75	5	212	26.07	7.5
14	7.45	2.5	114	15.76	5	214	26.08	7.5
16	7.49	2.5	116	15.93	5	216	26.17	7.5
18	7.53	2.5	118	15.99	5	218	26.19	7.5
20		2.5	120	16.17	5	220	26.26	7.5
22	7.54	2.5	122	16.1	5	222	26.3	7.5
24	7.57	2.5	124	16.13	5	224	26.34	7.5
26	7.59	2.5	126	16.21	5	226		7.5
28	7.62	2.5	128	16.27	5	228	26.42	7.5
30	7.63	2.5	130	16.3	5	230	26.42	7.5
35	7.69	2.5	135	16.38	5	235		7.5
40	7.7	2.5	140	16.39	5	240		7.5
45	7.71	2.5	145	16.5	5	245	26.56	7.5
50	7.74	2.5	150	16.54	5	250	26.63	7.5
55	7.77	2.5	155	16.57	5	255	26.66	7.5
60	7.8	2.5	160	16.61	5	260	26.66	7.5
70	7.83	2.5	170	16.66	5	270	26.71	7.5
80	7.84	2.5	180	16.71	5	280	26.71	7.5
90	7.88	2.5	190	16.75	5	290	26.91	7.5
						300	26.94	7.5

12 Appendix 2 – MRE1 CRT Data

	Obs wells Logger data				
t (days)	8A s (m)	8C s (m)	8D s (m)	9A s (m)	9C s (m)
0.0006	0.01	0.01	0.06	0.00	0.00
0.0013	0.02	-0.01	0.49	0.00	0.01
0.0020	0.09	0.03	0.91	0.00	0.00
0.0027	0.12	0.03	1.20	0.00	0.02
0.0034	0.14	0.02	1.43	0.00	0.03
0.0041	0.18	0.06	1.74	0.00	0.02
0.0048	0.21	0.07	1.76	0.00	0.03
0.0055	0.22	0.06	1.84	0.00	0.03
0.0062	0.24	0.08	1.98	0.00	0.06
0.0069	0.24	0.07	2.09	0.00	0.06
0.0076	0.28	0.09	2.20	0.00	0.06
0.0083	0.28	0.11	2.28	0.00	0.07
0.0097	0.30	0.13	2.45	0.00	0.08
0.0111	0.31	0.12	2.58	0.00	0.10
0.0125	0.34	0.16	2.75	0.01	0.11
0.0138	0.34	0.16	2.79	0.01	0.14
0.0152	0.35	0.21	2.84	0.01	0.15
0.0166	0.36	0.21	2.97	0.02	0.16
0.0180	0.38	0.23	3.03	0.03	0.18
0.0194	0.46	0.19	3.08	0.03	0.19
0.0208	0.16	0.25	3.14	0.04	0.20
0.0243	0.43	0.29	3.26	0.05	0.23
0.0277	0.43	0.33	3.36	0.07	0.26
0.0312	0.44	0.33	3.45	0.09	0.29
0.0347	0.46	0.38	3.50	0.12	0.32
0.0381	0.47	0.38	3.58	0.13	0.35
0.0416	0.48	0.50	3.63	0.18	0.38
0.0486	0.50	0.46	3.80	0.19	0.41
0.0555	0.51	0.53	3.80	0.24	0.46
0.0625	0.35	0.57	3.87	0.25	0.50
0.0694	0.54	0.61	3.92	0.26	0.54
0.0833	0.56	0.65	4.01	0.31	0.60
0.0972	0.60	0.72	4.09	0.38	0.67
0.1111	0.61	0.73	4.14	0.40	0.72
0.1250	0.63	0.82	4.20	0.40	0.76
0.1388	0.66	0.84	4.24	0.42	0.81
0.1736	0.71	0.94	4.35	0.47	0.88
0.2083	0.80	1.03	4.43	0.52	0.97
0.2430	0.80	1.10	4.50	0.57	1.05
0.2777	0.81	1.15	4.54	0.61	1.09
0.3125	0.85	1.19	4.61	0.64	1.14
0.3472	0.89	1.27	4.67	0.67	1.19
0.3819	0.92	1.28	4.68	0.70	1.23
0.4166	0.94	1.29	4.72	0.73	1.26
0.4513	0.97	1.34	4.75	0.75	1.27
0.4861	0.98	1.38	4.78	0.77	1.32
0.5208	1.00	1.38	4.81	0.79	1.34
0.5555	1.02	1.42	4.83	0.82	1.37
0.5902	1.04	1.46	4.85	0.84	1.39
0.6250	1.06	1.48	4.88	0.86	1.41
0.6597	1.07	1.47	4.90	0.87	1.43
0.6944	1.09	1.51	4.91	0.89	1.48
0.7291	1.10	1.55	4.95	0.91	1.48
0.7638	1.12	1.56	4.97	0.93	1.50
0.7986	1.14	1.57	4.99	0.94	1.53
0.8333	1.16	1.58	5.01	0.96	1.55
0.8680	1.18	1.62	5.02	0.98	1.56
0.9027	1.19	1.65	5.04	1.00	1.58
0.9375	1.19	1.64	5.06	1.02	1.59
0.9722	1.23	1.67	5.08	1.02	1.61
1.0069	1.21	1.70	5.10	1.04	1.66
1.0416	1.24	1.68	5.11	1.05	1.65
1.0763	1.23	1.70	5.12	1.07	1.65
1.1111	1.20	1.73	5.14	1.09	1.65
1.1458	1.28	1.73	5.14	1.10	1.69
1.1805	1.29	1.72	5.17	1.11	1.71
1.2152	1.31	1.75	5.18	1.11	1.71
1.2500	1.32	1.77	5.18	1.13	1.72
1.2847	1.33	1.80	5.20	1.14	1.75

Manual MRE002 Data	
t (days)	MRE2 s (m)
0.0000	0.000
0.0035	0.000
0.0042	0.005
0.0049	0.006
0.0056	0.011
0.0063	0.017
0.0069	0.025
0.0083	0.044
0.0097	0.065
0.0111	0.085
0.0125	0.108
0.0139	0.130
0.0153	0.154
0.0167	0.177
0.0181	0.200
0.0194	0.222
0.0208	0.242
0.0243	0.293
0.0278	0.338
0.0313	0.381
0.0347	0.421
0.0382	0.455
0.0417	0.488
0.0486	0.547
0.0556	
0.0625	
0.0694	
0.0833	0.745
0.0972	0.800
0.1111	0.847
0.2194	1.075
0.2910	1.175
0.3576	1.255
0.4229	1.320
0.5069	1.380
0.5660	1.415
0.6111	1.435
0.7083	1.465
0.8333	1.560
0.9944	1.640
1.1257	1.690
1.2625	1.740
1.3993	1.780
1.5313	1.820
1.6715	1.895
1.8097	1.875
1.9528	1.910
2.0958	1.939
2.2361	1.963
2.3771	1.988
2.5056	2.005
2.6424	2.030
2.7819	2.045
2.9201	2.060
3.0597	2.077
3.1986	2.093
3.3375	2.105
3.4757	2.115
3.6146	2.125
3.7535	2.135
3.8924	2.145
4.0326	2.160
4.1736	2.168
4.3111	2.175
4.4479	2.185
4.6285	2.200
4.7667	2.200

Manual 1C data	
t (days)	1C s (m)
0.2951	0.125
0.6118	0.3
0.9722	0.44
1.2188	0.52
1.1000	
1.9319	0.69
2.2188	0.74
2.6375	0.795
2.9785	0.84
3.2312	0.86
3.6181	0.89
3.9437	0.915
4.2340	0.93
4.6097	0.96
4.9701	0.97

Manual 1A data	
t (days)	1A s (m)
0.2951	0.12
0.6118	0.305
0.9722	0.48
1.2188	0.52
1.1000	
1.9319	0.69
2.2188	0.735
2.6375	0.79
2.9785	0.84
3.2312	0.85
3.6181	0.89
3.9437	0.91
4.2340	0.92
4.6097	0.94
4.9701	0.97

Manual 7A data	
t (days)	7A s(m)
0.2986	0
0.6174	0.02
0.9750	0.045
1.2257	0.075
1.6056	0.125
1.9354	0.165
2.2229	0.185
2.6424	0.225
2.9806	0.26
3.2347	0.255
3.6181	0.28
3.9437	0.25
4.2340	0.3
4.6097	0.325
4.9701	0.335

1.3194	1.34	1.80	5.21	1.15	1.76
1.3541	1.34	1.81	5.21	1.16	1.77
1.3888	1.35	1.82	5.23	1.17	1.79
1.4236	1.37	1.84	5.24	1.19	1.78
1.4583	1.37	1.83	5.24	1.19	1.78
1.4930	1.38	1.83	5.25	1.20	1.82
1.5277	1.39	1.86	5.26	1.21	1.82
1.5625	1.39	1.86	5.28	1.22	1.82
1.5972	1.40	1.85	5.29	1.23	1.83
1.6319	1.40	1.87	5.29	1.24	1.84
1.6666	1.42	1.90	5.29	1.24	1.85
1.7013	1.43	1.91	5.31	1.25	1.85
1.7361	1.43	1.89	5.33	1.26	1.86
1.7708	1.44	1.90	5.33	1.27	1.87
1.8055	1.43	1.88	5.32	1.28	1.88
1.8402	1.46	1.92	5.34	1.28	1.88
1.8750	1.46	1.95	5.35	1.29	1.90
1.9097	1.46	1.95	5.35	1.30	1.92
1.9444	1.47	1.94	5.36	1.31	1.91
1.9791	1.48	1.97	5.36	1.31	1.92
2.0138	1.49	1.97	5.37	1.32	1.92
2.0486	1.50	1.98	5.39	1.33	1.92
2.0833	1.40	1.98	5.39	1.33	1.94
2.1527	1.51	1.99	5.41	1.34	1.95
2.2222	1.48	2.01	5.43	1.37	1.95
2.2916	1.53	2.00	5.45	1.39	1.97
2.3611	1.56	2.02	5.44	1.37	1.99
2.4305	1.55	2.05	5.45	1.39	2.00
2.5000	1.56	2.04	5.46	1.40	2.00
2.5694	1.57	2.06	5.46	1.41	2.01
2.6388	1.57	2.05	5.48	1.42	2.02
2.7083	1.58	2.05	5.48	1.43	2.04
2.7777	1.60	2.09	5.50	1.44	2.04
2.8472	1.60	2.09	5.50	1.44	2.06
2.9166	1.60	2.09	5.51	1.45	2.08
2.9861	1.62	2.12	5.53	1.47	2.08
3.0555	1.62	2.12	5.54	1.50	2.08
3.1250	1.63	2.11	5.54	1.53	2.10
3.1944	1.63	2.14	5.55	1.53	2.10
3.2638	1.64	2.14	5.55	1.50	2.10
3.3333	1.65	2.15	5.53	1.50	2.12
3.4027	1.66	2.17	5.57	1.50	2.12
3.4722	1.65	2.16	5.57	1.51	2.12
3.5416	1.67	2.17	5.57	1.52	2.12
3.6111	1.67	2.14	5.58	1.52	2.14
3.6805	1.68	2.18	5.58	1.52	2.15
3.7500	1.67	2.17	5.58	1.52	2.14
3.8194	1.67	2.17	5.58	1.54	2.14
3.9583	1.70	2.18	5.60	1.55	2.17
4.0277	1.71	2.21	5.61	1.57	2.16
4.0972	1.46	2.21	5.62	1.55	2.17
4.1666	1.72	2.21	5.63	1.56	2.17
4.2361	1.71	2.22	5.63	1.58	2.17
4.3055	1.72	2.22	5.64	1.58	2.18
4.3750	1.72	2.22	5.64	1.58	2.17
4.4444	1.73	2.23	5.65	1.59	2.19
4.5138	1.74	2.23	5.65	1.59	2.19
4.5833	1.74	2.24	5.65	1.59	2.19
4.6527	1.72	2.23	5.64	1.59	2.22
4.7222	1.73	2.21	5.65	1.59	2.20
4.7916	1.75	2.23	5.66	1.60	2.20
4.8611	1.75	2.25	5.66	1.60	2.22
4.9305	1.75	2.24	5.66	1.61	2.20

13 Appendix 3 – MRE2 Step Test Data

t(min)	s (m)	q (L/s)	t(min)	s (m)	q (L/s)	t(min)	s (m)	q (L/s)
0	0	0						
1	6.29	2.5	101	13.23	5	201	23.96	7.5
2	6.74	2.5	102	15.54	5	202	26.68	7.5
3	7.06	2.5	103	16.59	5	203	27.3	7.5
4	7.18	2.5	104	17.01	5	204	27.74	7.5
5	7.26	2.5	105	17.1	5	205	27.99	7.5
6	7.45	2.5	106	17.23	5	206	28.11	7.5
7	7.54	2.5	107	17.32	5	207	28.19	7.5
8	7.62	2.5	108	17.35	5	208	28.25	7.5
9	7.61	2.5	109	17.43	5	209	28.3	7.5
10	7.88	2.5	110	17.47	5	210	28.35	7.5
12	7.79	2.5	112	17.54	5	212	28.41	7.5
14	7.84	2.5	114	17.6	5	214	28.52	7.5
16	7.88	2.5	116	17.71	5	216	28.58	7.5
18	8.01	2.5	118	17.8	5	218	28.66	7.5
20	8.03	2.5	120	17.84	5	220	28.7	7.5
22	8.11	2.5	122	17.89	5	222	28.74	7.5
24	8.09	2.5	124	17.96	5	224	28.77	7.5
26	8.05	2.5	126	17.94	5	226	28.81	7.5
28	8.08	2.5	128	17.99	5	228	28.86	7.5
30	8.06	2.5	130	18.04	5	230	28.86	7.5
35	8.18	2.5	135	18.08	5	235	28.99	7.5
40	8.34	2.5	140	18.33	5	240	29	7.5
45	8.26	2.5	145	18.24	5	245	28.83	7.5
50	8.35	2.5	150	18.23	5	250	28.97	7.5
55	8.44	2.5	155	18.18	5	255	29.24	7.5
60	8.37	2.5	160	18.21	5	260	29.11	7.5
70	8.34	2.5	170	18.35	5	270	29.12	7.5
80	8.31	2.5	180	18.44	5	280	29.24	7.5
90	8.42	2.5	190	18.43	5	290	29.29	7.5
100	8.44	2.5	200	18.45	5	300	29.34	7.5

14 Appendix 4 – MRE2 CRT Data

MRE2		8D		MRE1		1A		1C		7A	
t	s	t	s	t	s	t	s	t	s	t	s
0.0000		0	0.00	0	0	0	0	0	0	0	0
0.0007		0.0007	0.00	0.0438	0.43	0.2562	0.31	0.2556	0.30	0.2576	0.00
0.0014	19.94	0.0014	0.00	0.0653	0.57	0.6285	0.57	0.6285	0.57	0.6285	0.03
0.0021	20.71	0.0021	0.01	0.1174	0.77	1.0000	0.73	1.0000	0.68	1.0000	0.07
0.0028	21.01	0.0028	0.02	0.1458	0.84						
0.0035	21.07	0.0035	0.03	0.1771	0.90						
0.0042	21.23	0.0042	0.05	0.2611	1.03						
0.0049	21.55	0.0049	0.09	0.3278	1.11						
0.0056	21.89	0.0056	0.11	0.3958	1.16						
0.0063	22.12	0.0063	0.12	0.4931	1.22						
0.0069	22.27	0.0069	0.15	0.5451	1.28						
0.0083	22.53	0.0076	0.19	0.6424	1.32						
0.0097	22.56	0.0083	0.21	0.6979	1.37						
0.0111	22.81	0.0097	0.26	0.7674	1.40						
0.0125	22.95	0.0111	0.33	0.8368	1.42						
0.0139	23.06	0.0125	0.38	0.9062	1.45						
0.0153	23.14	0.0139	0.42	0.9764	1.48						
0.0167	23.22	0.0153	0.46								
0.0181	23.26	0.0167	0.51								
0.0194	23.37	0.0181	0.56								
0.0208	23.46	0.0194	0.60								
0.0243	23.6	0.0208	0.63								
0.0278	23.69	0.0243	0.72								
0.0313	23.86	0.0278	0.79								
0.0347	23.95	0.0313	0.86								
0.0382	24.04	0.0347	0.92								
0.0417	24.07	0.0382	0.98								
0.0486	24.14	0.0417	1.03								
0.0556	24.25	0.0486	1.12								
0.0625	24.31	0.0556	1.19								
0.0694	24.35	0.0625	1.26								
0.0833	24.48	0.0694	1.31								
0.0972	24.57	0.0833	1.39								
0.1111	24.63	0.0972	1.45								
0.1250	24.68	0.1111	1.51								
0.1389	24.7	0.1250	1.55								
0.1736	24.81	0.1389	1.60								
0.2083	24.87	0.1736	1.68								
0.2431	24.97	0.2083	1.75								
0.2778	25	0.2431	1.81								
0.3125	25.07	0.2778	1.86								
0.3472	25.12	0.3125	1.90								
0.3819	25.13	0.3472	1.93								
0.4167	25.09	0.3819	1.96								
0.4861	25.58	0.4167	1.99								
0.5556	25.45	0.4514	2.02								
0.6250	25.39	0.4861	2.05								
0.6944	25.4	0.5208	2.08								
0.7639	25.41	0.5556	2.10								
0.8333	25.38	0.5903	2.12								
0.9028	25.36	0.6250	2.14								
0.9722	25.63	0.6597	2.16								
1.0000	25.63	0.6944	2.18								
1.0007	10.41	0.7292	2.21								
1.0014	7.96	0.7639	2.21								
1.0021	4.63	0.7986	2.23								
1.0028	4.18	0.8333	2.24								
1.0035	3.86	0.8681	2.25								
1.0042	3.54	0.9028	2.27								
1.0049	3.35	0.9375	2.29								
1.0056	3.2	0.9722	2.31								
1.0063	3.04	1.0000	2.32								
1.0069	2.93	1.0007	2.33								
1.0083	2.72	1.0014	2.32								
1.0097	2.55	1.0021	2.32								
1.0111	2.43	1.0028	2.31								
1.0125	2.29	1.0035	2.29								
1.0139	2.16	1.0042	2.28								
1.0153	2.1	1.0049	2.26								
1.0167	2.01	1.0056	2.23								
1.0181	1.95	1.0063	2.21								

Obs well Logger Data					
t	MRH8A	MRH8C	MRH8D	MRH9A	MRH9C
0.0007	0.00	0.00	0.00	0.00	0.00
0.0014	0.00	0.00	0.00	0.01	0.01
0.0021	0.00	0.00	0.01	0.03	0.00
0.0028	0.00	0.00	0.02	0.04	0.00
0.0035	0.00	0.00	0.03	0.04	0.00
0.0042	0.00	0.00	0.05	0.05	0.00
0.0049	0.00	0.00	0.09	0.07	0.00
0.0056	0.00	0.00	0.11	0.08	0.00
0.0063	0.00	0.00	0.12	0.09	0.00
0.0069	0.00	0.00	0.15	0.11	0.00
0.0076	0.00	0.00	0.19	0.12	0.02
0.0083	0.00	0.00	0.21	0.14	0.00
0.0097	0.00	0.00	0.26	0.17	0.00
0.0111	0.02	0.00	0.33	0.20	0.01
0.0125	0.02	0.00	0.38	0.23	0.00
0.0139	0.02	0.01	0.42	0.27	0.00
0.0153	0.03	0.01	0.46	0.30	0.03
0.0167	0.03	0.01	0.51	0.32	0.00
0.0181	0.04	0.02	0.56	0.35	0.03
0.0194	0.05	0.01	0.60	0.38	0.00
0.0208	0.05	0.01	0.63	0.40	0.00
0.0243	0.07	0.01	0.72	0.47	0.00
0.0278	0.08	0.03	0.79	0.52	0.00
0.0313	0.09	0.02	0.86	0.57	0.00
0.0347	0.10	0.02	0.92	0.62	0.04
0.0382	0.12	0.06	0.98	0.67	0.00
0.0417	0.14	0.07	1.03	0.70	0.06
0.0486	0.18	0.09	1.12	0.78	0.08
0.0556	0.18	0.10	1.19	0.83	0.16
0.0625	0.22	0.12	1.26	0.89	0.12
0.0694	0.24	0.14	1.31	0.94	0.13
0.0833	0.28	0.21	1.39	1.02	0.18
0.0972	0.30	0.23	1.45	1.08	0.18
0.1111	0.34	0.25	1.51	1.14	0.14
0.1250	0.37	0.29	1.55	1.18	0.33
0.1389	0.40	0.33	1.60	1.23	0.28
0.1736	0.44	0.37	1.68	1.31	0.32
0.2083	0.50	0.43	1.75	1.38	0.42
0.2431	0.54	0.50	1.81	1.43	0.51
0.2778	0.59	0.53	1.86	1.47	0.52
0.3125	0.62	0.56	1.90	1.51	0.59
0.3472	0.64	0.59	1.93	1.55	0.53
0.3819	0.68	0.64	1.96	1.58	0.66
0.4167	0.71	0.66	1.99	1.61	0.73
0.4514	0.73	0.70	2.02	1.65	0.59
0.4861	0.75	0.70	2.05	1.68	0.65
0.5208	0.78	0.73	2.08	1.70	0.71
0.5556	0.79	0.78	2.10	1.73	0.75
0.5903	0.81	0.72	2.12	1.74	0.75
0.6250	0.84	0.81	2.14	1.77	0.72
0.6597	0.85	0.82	2.16	1.79	0.77
0.6944	0.86	0.84	2.18	1.80	0.84
0.7292	0.88	0.85	2.21	1.82	0.81
0.7639	0.89	0.87	2.21	1.84	0.85
0.7986	0.90	0.88	2.23	1.85	0.88
0.8333	0.91	0.83	2.24	1.86	0.92
0.8681	0.91	0.89	2.25	1.88	0.91
0.9028	0.94	0.97	2.27	1.89	0.82
0.9375	0.95	0.97	2.29	1.91	0.90
0.9722	0.97	0.92	2.31	1.93	0.92
1.0000	0.98	0.96	2.32	1.94	0.93
1.0007	0.98	0.96	2.33	1.93	0.94
1.0014	0.98	0.96	2.32	1.92	0.94
1.0021	0.98	0.96	2.32	1.92	0.94
1.0028	0.98	0.97	2.31	1.91	0.94
1.0035	0.99	0.97	2.29	1.90	0.94
1.0042	0.99	0.97	2.28	1.89	0.94
1.0049	0.99	0.97	2.26	1.88	0.94
1.0056	0.99	0.96	2.23	1.87	0.94
1.0063	0.98	0.97	2.21	1.86	0.94
1.0069	0.98	0.97	2.17	1.85	0.94

1.0194	1.9
1.0208	1.81
1.0243	1.7
1.0278	1.62
1.0313	1.52
1.0347	1.44
1.0382	1.38
1.0417	1.33
1.0486	1.23
1.0556	1.14
1.0625	1.08
1.0694	1.02
1.0833	0.94
1.0972	0.87
1.1111	0.81
1.1250	0.75
1.1389	0.73
1.1736	0.65
1.2083	0.59
1.2431	0.57
1.2778	0.5
1.3125	0.45
1.3333	0.445

1.0069	2.17
1.0076	2.14
1.0083	2.11
1.0097	2.05
1.0111	2.01
1.0125	1.95
1.0139	1.90
1.0153	1.86
1.0167	1.82
1.0181	1.77
1.0194	1.73
1.0208	1.69
1.0243	1.60
1.0278	1.52
1.0313	1.46
1.0347	1.40
1.0382	1.34
1.0417	1.31
1.0486	1.22
1.0556	1.15
1.0625	1.09
1.0694	1.05
1.0833	0.96
1.0972	0.89
1.1111	0.84
1.1250	0.80
1.1389	0.76
1.1736	0.68
1.2083	0.62
1.2431	0.57
1.2778	0.52
1.3125	0.48

1.0076	0.98	0.97	2.14	1.83	0.94
1.0083	0.98	0.97	2.11	1.81	0.94
1.0097	0.98	0.97	2.05	1.79	0.94
1.0111	0.98	0.97	2.01	1.76	0.94
1.0125	0.97	0.96	1.95	1.72	0.94
1.0139	0.96	0.96	1.90	1.69	0.94
1.0153	0.96	0.96	1.86	1.66	0.94
1.0167	0.95	0.96	1.82	1.63	0.94
1.0181	0.95	0.96	1.77	1.61	0.94
1.0194	0.94	0.96	1.73	1.58	0.94
1.0208	0.93	0.95	1.69	1.55	0.93
1.0243	0.92	0.95	1.60	1.49	0.93
1.0278	0.91	0.94	1.52	1.43	0.92
1.0313	0.89	0.93	1.46	1.38	0.92
1.0347	0.88	0.92	1.40	1.33	0.91
1.0382	0.87	0.92	1.34	1.29	0.90
1.0417	0.86	0.92	1.31	1.25	0.89
1.0486	0.83	0.89	1.22	1.17	0.87
1.0556	0.81	0.87	1.15	1.11	0.85
1.0625	0.79	0.86	1.09	1.06	0.83
1.0694	0.78	0.84	1.05	1.01	0.81
1.0833	0.74	0.81	0.96	0.93	0.78
1.0972	0.69	0.77	0.89	0.87	0.75
1.1111	0.66	0.73	0.84	0.82	0.72
1.1250	0.63	0.71	0.80	0.77	0.69
1.1389	0.61	0.68	0.76	0.74	0.67
1.1736	0.56	0.62	0.68	0.66	0.61
1.2083	0.51	0.58	0.62	0.60	0.56
1.2431	0.46	0.53	0.57	0.55	0.51
1.2778	0.42	0.49	0.52	0.50	0.47
1.3125	0.39	0.45	0.48	0.46	0.44

15 Appendix 5 – MRI001 Step Test Data

t(min)	s (m)	q (L/s)
0.0	0	0
1.0	1.66	2.5
2.0	1.764	2.5
3.0	1.764	2.5
4.0	1.764	2.5
5.0	1.764	2.5
6.0	1.867	2.5
7.0	1.867	2.5
8.0	1.867	2.5
9.0	1.867	2.5
10.0	1.971	2.5
11.0	1.971	2.5
12.0	1.971	2.5
13.0	1.971	2.5
14.0	1.971	2.5
15.0	2.04	2.5
16.0	2.04	2.5
17.0	2.04	2.5
18.0	2.04	2.5
19.0	2.04	2.5
20.0	2.04	2.5
21.0	2.04	2.5
22.0	2.109	2.5
23.0	2.109	2.5
24.0	2.109	2.5
25.0	2.109	2.5
26.0	2.109	2.5
27.0	2.109	2.5
28.0	2.178	2.5
29.0	2.178	2.5
30.0	2.42	2.5
31.0	4.768	5
32.0	5.425	5
33.0	5.908	5
34.0	6.253	5
35.0	6.53	5
36.0	6.702	5
37.0	6.91	5
38.0	7.048	5
39.0	7.186	5
40.0	7.359	5
41.0	7.497	5
42.0	7.566	5
43.0	7.704	5
44.0	7.773	5
45.0	7.877	5
46.0	7.877	5
47.0	7.98	5
48.0	7.98	5
49.0	8.084	5
50.0	8.084	5
51.0	8.187	5
52.0	8.187	5
53.0	8.256	5
54.0	8.36	5
55.0	8.36	5
56.0	8.429	5
57.0	8.498	5
58.0	8.498	5
59.0	8.498	5
60.0	8.567	5
61.0	12.955	7.5
62.0	13.473	7.5
63.0	13.991	7.5
64.0	14.164	7.5
65.0	14.475	7.5
66.0	14.648	7.5
67.0	14.751	7.5
68.0	14.889	7.5
69.0	14.958	7.5
70.0	15.062	7.5
71.0	15.166	7.5
72.0	15.235	7.5
73.0	15.338	7.5
74.0	15.58	7.5
75.0	15.649	7.5
76.0	15.649	7.5
77.0	15.649	7.5
78.0	15.718	7.5
79.0	15.718	7.5
80.0	15.822	7.5
81.0	15.822	7.5
82.0	15.891	7.5
83.0	16.133	7.5
84.0	16.133	7.5
85.0	16.133	7.5
86.0	16.133	7.5
87.0	16.236	7.5
88.0	16.236	7.5
89.0	16.236	7.5
90.0	16.236	7.5
91.0	16.305	7.5
92.0	16.305	7.5
93.0	16.374	7.5
94.0	16.374	7.5
95.0	16.754	7.5
96.0	16.685	7.5
97.0	16.685	7.5
98.0	16.961	7.5
99.0	16.961	7.5
100.0	17.03	7.5
101.0	17.03	7.5
102.0	17.03	7.5
103.0	17.1	7.5
104.0	17.1	7.5
105.0	17.1	7.5
106.0	17.169	7.5
107.0	17.169	7.5
108.0	17.169	7.5
109.0	17.238	7.5
110.0	17.238	7.5
111.0	17.756	7.5
112.0	17.756	7.5
113.0	17.756	7.5
114.0	17.756	7.5
115.0	17.756	7.5
116.0	17.756	7.5
117.0	17.756	7.5
118.0	17.756	7.5
119.0	17.825	7.5
120.0	17.825	7.5
121.0	17.825	7.5
122.0	17.825	7.5
123.0	17.894	7.5
124.0	17.894	7.5
125.0	17.963	7.5
126.0	18.032	7.5
127.0	18.032	7.5
128.0	18.101	7.5
129.0	18.101	7.5
130.0	18.205	7.5
131.0	18.377	7.5

132.0	18.377	7.5
133.0	18.377	7.5
134.0	18.377	7.5
135.0	18.377	7.5
136.0	18.377	7.5
137.0	18.377	7.5
138.0	18.377	7.5
139.0	18.377	7.5
140.0	18.446	7.5
141.0	18.446	7.5
142.0	18.446	7.5
143.0	18.446	7.5
144.0	18.446	7.5
145.0	18.446	7.5
146.0	18.446	7.5
147.0	18.515	7.5
148.0	18.515	7.5
149.0	18.515	7.5
150.0	18.515	7.5
151.0	18.515	7.5
152.0	18.515	7.5
153.0	18.515	7.5
154.0	18.515	7.5
155.0	18.515	7.5
156.0	18.515	7.5
157.0	18.585	7.5
158.0	18.585	7.5
159.0	18.585	7.5
160.0	18.585	7.5
161.0	18.585	7.5
162.0	18.654	7.5
163.0	18.654	7.5
164.0	18.654	7.5
165.0	18.654	7.5
166.0	18.654	7.5
167.0	18.654	7.5
168.0	18.654	7.5
169.0	18.654	7.5
170.0	18.654	7.5
171.0	18.654	7.5
172.0	18.654	7.5
173.0	18.654	7.5
174.0	18.654	7.5
175.0	18.723	7.5
176.0	18.723	7.5
177.0	18.723	7.5
178.0	18.723	7.5
179.0	18.723	7.5
180.0	18.723	7.5
181.0	18.723	7.5

16 Appendix 6 – MRI001 CRT Data

MRI1		MRI100A		MRI2		MRI100B		Change in Barometric Pressure	
t	s	t	s	t	s	t	s	t	delta pressure
0.0000		0.0002	0.00	0.0017	0.00	0.0012	0.00	0.0000	0
0.0007	15.7	0.0048	0.58	0.0052	0.03	0.0047	0.00	0.2292	-0.07
0.0014	15.8	0.0083	0.77	0.0087	0.10	0.0082	-0.01	0.9792	-0.04
0.0021	15.9	0.0117	0.85	0.0121	0.15	0.0117	-0.01	1.2292	-0.03
0.0028	10.8	0.0152	0.91	0.0156	0.18	0.0151	-0.01	1.9792	0.03
0.0035	16.1	0.0187	0.95	0.0191	0.21	0.0186	-0.01	2.2292	0.03
0.0042	16.2	0.0221	0.98	0.0225	0.23	0.0221	-0.01	2.9792	0.08
0.0049	16.3	0.0256	1.01	0.0260	0.26	0.0255	-0.01	3.2292	0.06
0.0056	16.3	0.0291	1.04	0.0295	0.27	0.0290	-0.02	3.9792	0.06
0.0063	16.3	0.0326	1.06	0.0330	0.29	0.0325	-0.02	4.2292	0.04
0.0069	16.4	0.0360	1.08	0.0364	0.30	0.0360	-0.02	4.9792	0.08
0.0083	16.3	0.0395	1.10	0.0399	0.32	0.0394	-0.02	5.2292	0.06
0.0097	16.3	0.0430	1.11	0.0434	0.33	0.0429	-0.02		
0.0111	16.5	0.0464	1.13	0.0469	0.34	0.0498	-0.02		
0.0125	16.5	0.0499	1.14	0.0503	0.36	0.0533	-0.02		
0.0139	16.7	0.0534	1.16	0.0538	0.37	0.0568	-0.02		
0.0153	16.7	0.0569	1.17	0.0573	0.38	0.0603	-0.03		
0.0167	16.7	0.0603	1.18	0.0607	0.39	0.0637	-0.03		
0.0181	16.8	0.0638	1.19	0.0642	0.40	0.0672	-0.03		
0.0194	16.8	0.0673	1.20	0.0677	0.40	0.0707	-0.03		
0.0208	16.8	0.0708	1.21	0.0712	0.41	0.0742	-0.03		
0.0243	16.9	0.0742	1.22	0.0746	0.42	0.0776	-0.04		
0.0278	17.0	0.0777	1.23	0.0781	0.42	0.0811	-0.04		
0.0313	17.0	0.0812	1.23	0.0816	0.43	0.0846	-0.04		
0.0347	17.1	0.0846	1.24	0.0850	0.44	0.0880	-0.04		
0.0382	17.1	0.0881	1.25	0.0885	0.44	0.0915	-0.04		
0.0417	17.1	0.0916	1.26	0.0920	0.45	0.0950	-0.05		
0.0486	17.1	0.0951	1.27	0.0955	0.45	0.0985	-0.05		
0.0556	17.2	0.0985	1.27	0.0989	0.46	0.1019	-0.05		
0.0625	17.2	0.1020	1.28	0.1024	0.47	0.1054	-0.05		
0.0694	17.2	0.1055	1.29	0.1059	0.48	0.1089	-0.05		
0.0833	17.2	0.1089	1.29	0.1094	0.48	0.1123	-0.05		
0.0972	17.2	0.1124	1.30	0.1128	0.49	0.1158	-0.05		
0.1111	17.3	0.1159	1.31	0.1163	0.49	0.1193	-0.05		
0.1250	17.3	0.1194	1.31	0.1198	0.50	0.1228	-0.05		
0.1389	17.8	0.1228	1.32	0.1232	0.50	0.1262	-0.05		
0.1736	17.7	0.1263	1.33	0.1267	0.51	0.1297	-0.05		
0.2083	17.8	0.1298	1.33	0.1302	0.51	0.1332	-0.05		
0.2431	17.9	0.1333	1.34	0.1337	0.52	0.1367	-0.06		
0.2778	18.1	0.1367	1.35	0.1371	0.53	0.1401	-0.06		
0.3125	18.2	0.1402	1.36	0.1406	0.53	0.1505	-0.06		
0.3472	18.5	0.1542		0.1547	0.55	0.1610	-0.07		
0.3819	18.5	0.1696		0.1701	0.57	0.1886	-0.07		
0.4167	18.6	0.1866		0.1871	0.57	0.2303	-0.07		
0.4514	18.7	0.2053	1.42	0.2059	0.61	0.2720	-0.08		
0.4861	18.7	0.2258	1.45	0.2264	0.63	0.3136	-0.08		
0.5208	18.8	0.2484	1.47	0.2491	0.65	0.3761	-0.08		
0.5556	18.8	0.2732	1.49	0.2740	0.67	0.4386	-0.08		
0.5938	18.9	0.3005	1.53	0.3014	0.71	0.5011	-0.08		
0.6285	19.0	0.3306	1.54	0.3315	0.73	0.5636	-0.08		
0.7014	19.1	0.3636	1.59	0.3647	0.76	0.6261	-0.09		
0.7674	19.3	0.4000	1.62	0.4012	0.80	0.7095	-0.10		
0.8458	19.4	0.4400	1.66	0.4413	0.81	0.7928	-0.10		
0.9063	19.5	0.4840	1.68	0.4854	0.86	0.8761	-0.08		
0.9778	19.7	0.5324	1.71	0.5339	0.88	0.9595	-0.05		
1.0472	19.8	0.5856	1.73	0.5873	0.90	1.0428	-0.04		
1.1146	19.7	0.6442	1.76	0.6461	0.93	1.1470	-0.04		
1.1833	19.9	0.7086	1.78	0.7107	0.95	1.2511	-0.03		
1.2528	20.1	0.7795	1.82	0.7817	0.98	1.3553	-0.02		
1.3229	20.4	0.8574	1.87	0.8599	1.03	1.4595	0.00		
1.3931	20.4	0.9432	1.92	0.9459	1.09	1.5636	0.01		
1.5347	20.5	1.0375	1.97	1.0405	1.12	1.6678	0.01		
1.6806	20.6	1.1412	2.00	1.1445	1.15	1.7720	0.00		
1.8194	20.7	1.2554	2.02	1.2590	1.18	1.8761	0.02		
1.9611	20.9	1.3809	2.06	1.3849	1.21	1.9803	0.03		
2.0868	21.0	1.5190	2.10	1.5234	1.25	2.0845	0.03		
2.2250	20.9	1.6709	2.12	1.6757	1.28	2.1886	0.03		
2.3681	21.3	1.8380	2.15	1.8433	1.30	2.2928	0.02		
2.5174	21.5	2.0218	2.19	2.0276	1.35	2.3970	0.03		
2.6528	21.6	2.2240	2.21	2.2304	1.35	2.5011	0.04		
2.7917	21.7	2.4463	2.22	2.4534	1.37	2.6053	0.05		

2.9271	21.8	2.6910	2.25	2.6988	1.41	2.7095	0.05
3.0694	22.0	2.9601	2.28	2.9686	1.44	2.8136	0.05
3.2069	21.9	3.2561	2.31	3.2655	1.45	2.9178	0.07
3.3458	22.2	3.5817	2.32	3.5920	1.47	3.0220	0.07
3.4826	22.6	3.9399	2.32	3.9513	1.47	3.1261	0.07
3.6215	22.9	4.3339	2.32	4.3464	1.47	3.2303	0.06
3.7604	23.0	4.7672	2.34	4.7810	1.49	3.3345	0.05
3.9000	23.1					3.4386	0.06
4.0403	23.4					3.5428	0.07
4.1812	23.7					3.6470	0.07
4.3194	23.8					3.7511	0.05
4.4583	24.4					3.8553	0.05
4.6354	24.8					3.9595	0.06
4.7743	25.0					4.0636	0.06
4.9576	25.1					4.1678	0.05
5.0146	25.2					4.2720	0.04
						4.3761	0.05
						4.4803	0.07
						4.5845	0.08
						4.6886	0.07
						4.7928	0.07
						4.8970	0.07
						5.0011	0.08

17 Appendix 7 – MRE3 Step Test Data

t(min)	s (m)	q (L/s)
0	0	0
1	5.12	2.5
2	6.31	2.5
3	6.79	2.5
4	7.1	2.5
5	7.25	2.5
6	7.28	2.5
7	7.42	2.5
8	7.68	2.5
9	7.65	2.5
10	7.7	2.5
12	7.73	2.5
14	7.77	2.5
16	7.8	2.5
18	7.86	2.5
20	7.89	2.5
22	7.91	2.5
24	7.92	2.5
26	7.96	2.5
28	7.99	2.5
30	8	2.5
35	8.05	2.5
40	8.07	2.5
45	8.09	2.5
50	8.12	2.5
55	8.15	2.5
60	8.18	2.5
70	8.2	2.5
80	8.22	2.5
90	8.26	2.5
100	8.27	2.5

t(min)	s (m)	q (L/s)
101	14.13	5
102	16.4	5
103	17.51	5
104	18.08	5
105	18.59	5
106	18.89	5
107	18.94	5
108	18.99	5
109	18.98	5
110	19.03	5
112	19.11	5
114	19.2	5
116	19.28	5
118	19.28	5
120	19.29	5
122	19.4	5
124	19.43	5
126	19.43	5
128	19.47	5
130	19.46	5
135	19.5	5
140	19.58	5
145	19.6	5
150	19.63	5
155	19.66	5
160	19.68	5
170	19.69	5
180	19.71	5
190	19.76	5

t(min)	s (m)	q (L/s)
191	28.75	7.5
192		7.5
193	30.74	7.5
194	31.74	7.5
195	32.1	7.5
196	32.28	7.5
197	32.46	7.5
198	32.55	7.5
199	32.52	7.5
200	32.49	7.5
202	32.43	7.5
204	32.51	7.5
206	32.58	7.5
208	32.53	7.5
210	32.42	7.5
212	32.37	7.5
214	32.3	7.5
216	32.3	7.5
218	32.29	7.5
220	32.26	7.5
225	32.15	7.5
230	32.11	7.5
235	31.91	7.5
240	31.98	7.5
245	31.9	7.5
248	31.85	7.5

18 Appendix 8 – MRE3 CRT Data

MRE3		MRH12D		MRH4a		MRH4C		MRH4a	
t	s	t	s	t	s	t	s	t	s
0.0000	0.00	0.0000	0.000	0.0000	0	0.0000	0	0.0000	0
0.0007	11.48	0.0007	0.000	0.0139	0.000	0.0153	0.015	0.0222	0
0.0014	14.46	0.0014	0.000	0.0181	0.000	0.0188	0.025	0.0361	0
0.0021	15.39	0.0021	0.000	0.0250	0.000	0.0257	0.065	0.0438	0
0.0028	15.71	0.0028	0.002	0.0292	0.005	0.0285	0.065	0.0611	0
0.0035	16.08	0.0035	0.005	0.0354	0.010	0.0361	0.09	0.0715	0
0.0042	16.26	0.0042	0.005	0.0424	0.010	0.0438	0.11	0.0847	0
0.0049	16.38	0.0049	0.005	0.0507	0.010	0.0500	0.125	0.1410	0
0.0056	16.50	0.0056	0.005	0.0604	0.010	0.0590	0.145	0.2819	0
0.0063	16.63	0.0063	0.010	0.0708	0.020	0.0701	0.17	0.4187	0.01
0.0069	16.73	0.0069	0.010	0.0847	0.020	0.0854	0.195	0.4889	0.01
0.0083	16.90	0.0083	0.015	0.1424	0.030	0.1431	0.275	0.5597	0
0.0097	17.00	0.0097	0.020	0.2806	0.025	0.2806	0.385	0.6292	0
0.0111	17.15	0.0111	0.025	0.4222	0.020	0.4208	0.455	0.6986	-0.01
0.0125	17.15	0.0146	0.035	0.4896	0.000	0.4903	0.495	0.7681	-0.01
0.0139	17.19	0.0174	0.050	0.5604	0.010	0.5611	0.535	0.8354	0
0.0153	17.39	0.0208	0.085	0.6299	0.010	0.6306	0.545	0.9063	0.01
0.0167	17.38	0.0243	0.095	0.6972	0.000	0.7000	0.575	0.9757	0
0.0181	17.43	0.0278	0.125	0.9750	-0.020	0.7708	0.615		
0.0194	17.53	0.0313	0.145	0.8368	-0.015	0.8382	0.655		
0.0208	17.71	0.0347	0.165	0.9069	-0.010	0.9076	0.68		
0.0243	17.77	0.0382	0.205	0.9750	-0.010	0.9764	0.715		
0.0278	17.77	0.0417	0.210						
0.0313	17.85	0.0486	0.255						
0.0347	17.89	0.0583	0.325						
0.0382	17.93	0.0625	0.370						
0.0417	17.92	0.0694	0.395						
0.0486	17.98	0.0833	0.485						
0.0556	18.02	0.1125	0.665						
0.0625	18.07	0.2090	1.075						
0.0694	18.15	0.2792	1.265						
0.0833	18.24	0.3507	1.425						
0.0972	18.30	0.4181	1.525						
0.1111	18.34	0.4868	1.625						
0.1250	18.37	0.5583	1.710						
0.1389	18.40	0.6278	1.775						
0.1736	18.48	0.6958	1.865						
0.2083	18.68	0.7653	1.925						
0.2431	18.68	0.8340	1.975						
0.2778	18.74	0.9042	2.035						
0.3125	18.78	0.9736	2.085						
0.3472	18.84								
0.4167	18.87								
0.4861	18.95								
0.5556	18.96								
0.6250	19.02								
0.6944	19.05								
0.7639	19.08								
0.8333	19.11								
0.9028	19.11								
0.9722	19.13								
1.0000	19.19								

19 Appendix 9 – Regional water level data

Miocene 1A		Eocene 1C		Miocene 2A		Miocene 3A		Quaternary 3B		Miocene 4A		Quaternary 4B		Lower Eocene 4C		Upper Eocene 12D	
t	s	t	s	t	s	t	s	t	s	t	s	t	s	t	s	t	s
0.30	0.125	0.30	0.12	0.29	-0.01	0.29	-0.01	0.29	0.01	0.27	-0.03	0.27	0	0.27	-0.01	0.27	-0.005
0.61	0.3	0.61	0.305	0.63	-0.065	0.66	-0.01	0.66	0.01	0.65	-0.09	0.65	0.01	0.65	0	0.65	0
0.97	0.44	0.97	0.48	0.97	-0.12	1.01	-0.015	1.01	0	0.99	-0.135	0.99	0	0.99	-0.01	0.99	-0.01
1.22	0.52	1.22	0.52	1.22	-0.135	1.26	-0.01	1.26	0.01	1.24	-0.165	1.24	0	1.24	-0.005	1.24	-0.01
1.60	0.61	1.60	0.5	1.61	-0.18	1.61	0	1.10	0.015	1.63	-0.2	1.63	0	1.63	-0.01	1.63	0.005
1.93	0.69	1.93	0.69	1.93	-0.195	1.93	-0.01	1.93	0.015	1.96	-0.22	1.96	0.005	1.96	-0.005	1.96	-0.01
2.22	0.74	2.22	0.735	2.22	-0.22	2.22	-0.01	2.22	0.035	2.24	-0.24	2.24	0.005	2.24	-0.015	2.24	-0.015
2.64	0.795	2.64	0.79	2.64	-0.24	2.64	-0.005	2.64	0.02	2.67	-0.265	2.67	0.01	2.67	-0.005	2.67	-0.025
2.98	0.84	2.98	0.84	2.98	-0.24	2.98	-0.005	2.98	0.005	3.00	-0.265	3.00	0.01	3.00	-0.015	3.00	-0.025
3.23	0.86	3.23	0.85	3.23	-0.275	3.23	-0.02	3.23	0.015	3.25	-0.29	3.25	0	3.25	-0.02	3.25	-0.02
3.62	0.89	3.62	0.89	3.62	-0.285	3.62	-0.02	3.62	0.01	3.64	-0.295	3.64	0.005	3.64	0.02	3.64	-0.04
3.94	0.915	3.94	0.91	3.94	-0.285	3.94	-0.015	3.94	0.005	3.97	-0.295	3.97	0.005	3.97	0.05	3.97	-0.05
4.23	0.93	4.23	0.92	4.23	-0.315	4.23	-0.02	4.23	0.015	4.26	-0.35	4.26	0.01	4.26	-0.03	4.26	-0.04
4.61	0.96	4.61	0.94	4.61	-0.3	4.61	-0.015	4.61	0.01	4.64	-0.3	4.64	0.005	4.64	-0.02	4.64	-0.02
4.97	0.97	4.97	0.97	4.97	-0.3	4.97	-0.02	4.97	0.035	5.03	-0.295	5.03	0.005	5.03	-0.03	5.03	-0.045

Miocene 5A		Quaternary 5B		Miocene 6A		Quaternary 6B		Miocene 7A	
t	s	t	s	t	s	t	s	t	s
0.28	-0.005	0.28	0	0.25	-0.03	0.25	0.01	0.30	0
0.64	-0.025	0.64	0.01	0.66	-0.055	0.66	0	0.62	0.02
0.99	-0.045	0.99	0	1.00	-0.07	1.00	0	0.97	0.045
1.24	-0.05	1.24	0.005	1.25	-0.085	1.25	0	1.23	0.075
1.62	-0.07	1.62	0.005	1.64	-0.1	1.64	0.01	1.61	0.125
1.95	-0.08	1.95	0.005	1.96	-0.12	1.96	0.005	1.94	0.165
2.24	-0.1	2.24	0	2.25	-0.135	2.25	0.005	2.22	0.185
2.66	-0.105	2.66	0.015	2.68	-0.145	2.68	0.005	2.64	0.225
2.99	-0.115	2.99	0.01	3.01	-0.15	3.01	0.005	2.98	0.26
3.25	-0.13	3.25	0	3.26	-0.16	3.26	0	3.23	0.255
3.64	-0.13	3.64	0.01	3.65	-0.155	3.65	0.005	3.62	0.28
3.97	-0.14	3.97	0.005	3.98	-0.16	3.98	0	3.94	0.25
4.25	-0.145	4.25	0	4.27	-0.16	4.27	0.01	4.23	0.3
4.63	-0.15	4.63	0.01	4.65	-0.15	4.65	0.01	4.61	0.325
5.02	-0.145	5.02	0.01	5.04	-0.155	5.04	0.01	4.97	0.335

20 Appendix 10 – Chemical data

Analyte	CAS #	Units	LOR	MRE001 Dec 2010	MRE002 Dec 2010	MRE003 Dec 2010
Physico-chemical parameters						
pH Value		pH Unit	0.01	7.1	7.2	7.2
Total Dissolved Solids @180°C	GIS-210-010	mg/L	1	33000	36000	48000
Suspended Solids (SS)		mg/L	1	< 1	8	8
Chemical Oxygen Demand		mg/L	5	75	76	61
Dissolved Metals						
Arsenic	7440-38-2	mg/L	0.001	0.015	0.017	0.021
Barium	7440-39-3	mg/L	0.001	0.04	0.04	0.07
Beryllium	7440-41-7	mg/L	0.001	0.002	0.002	0.002
Boron	7440-42-8	mg/L	0.1	7.8	7.8	6.5
Cadmium	7440-43-9	mg/L	0.0001	0.0002	< 0.0002	< 0.0002
Cobalt	7440-48-4	mg/L	0.001	0.003	0.003	0.006
Chromium	7440-47-3	mg/L	0.001	0.003	0.005	0.004
Copper	7440-50-8	mg/L	0.001	0.05	0.28	0.074
Iron (ferrous)		mg/L	0.05	< 0.05	< 0.05	0.08
Manganese	7439-96-5	mg/L	0.001	0.021	< 0.005	0.65
Mercury	7439-97-6	mg/L	0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel	7440-02-0	mg/L	0.001	0.021	0.024	0.038
Lead	7439-92-1	mg/L	0.001	< 0.001	0.003	< 0.001
Vanadium	7440-62-2	mg/L	0.01	< 0.005	< 0.005	< 0.005
Zinc	7440-66-6	mg/L	0.005	0.06	0.28	0.11
Aluminium	7429-90-5	mg/L	0.01	< 0.05	< 0.05	< 0.05
Bismuth	7440-69-9	mg/L	0.0001	< 0.005	< 0.005	< 0.005
Lithium	7439-93-2	mg/L	0.001	0.2	0.2	0.41
Silver	7440-22-4	mg/L	0.0001	< 0.005	< 0.005	< 0.005
Tin	7440-31-5	mg/L	0.005	< 0.005	< 0.005	< 0.005
Uranium	7440-61-1	mg/L	0.0001	0.1	0.2	< 0.1
Ra 226	WRS	Bq/L		23.6	3.26	20.5
Major and minor anions						
Hydroxide Alkalinity as CaCO3	DMO-210-001	mg/L	1	< 10	< 10	< 10
Carbonate Alkalinity as CaCO3	3812-32-6	mg/L	1	< 10	< 10	< 10
Bicarbonate Alkalinity as CaCO3	71-52-3	mg/L	1	180	190	160
Total Alkalinity as CaCO3		mg/L	1	180	190	160
Sulfate as SO4 2-	14808-79-8	mg/L	1	3800	3900	3900
Sulfide as S2-	18496-25-8	mg/L	0.1	< 0.05	< 0.05	< 0.05
Chloride	16887-00-6	mg/L	1	20000	20000	29000
Fluoride	16984-48-8	mg/L	0.1	1.3	1.4	1.4
Nitrate as N	14797-55-8	mg/L	0.01	0.22	0.36	< 0.02
Nitrite as N		mg/L	0.01	< 0.02	< 0.02	< 0.02
Total Kjeldahl Nitrogen as N		mg/L	0.1	< 0.1	< 0.1	< 0.1
Reactive Phosphorus as P		mg/L	0.01	0.14	< 0.01	< 0.01
Major and minor cations						
Calcium	7440-70-2	mg/L	1	1800	1900	2700
Magnesium	7439-95-4	mg/L	1	1700	1800	2000
Sodium	7440-23-5	mg/L	1	9400	8200	13000
Potassium	7/09/7440	mg/L	1	100	110	190
Strontium	7440-24-6	mg/L	0.01	24	23	33

mgt LabMark ENVIRONMENTAL LABORATORIES

Certificate of Analysis

Australian Groundwater Technologies Pty Ltd
Unit 5 / 1 London Road
MILE END SOUTH
SOUTH AUSTRALIA 5031

Attention: -Nikki Fotheringham

NATA Accredited
Laboratory Number 1261

The tests covered by this document have been performed in accordance with NATA and ISO/IES 17025 and are traceable to national standards of measurement.
This document shall not be reproduced, except in full.

Report	284438-W
Client Reference	MULLAQUANNA
Received Date	Dec 03, 2010

Client Sample ID			**MRE001**
Sample Matrix			**Water**
mgt-LabMark Sample No.			**10-De01276**
Date Sampled			**Dec 01, 2010**
Test/Reference	PQL	Unit	
Alkali Metals			
Calcium	0.5	mg/L	1800
Magnesium	0.5	mg/L	1700
Potassium	0.5	mg/L	100
Sodium	0.5	mg/L	9400
Soluble Heavy Metals			
Bismuth (filtered)	0.005	mg/L	< 0.005
Lithium (filtered)	0.005	mg/L	0.20
Chemical Oxygen Demand (COD)	5	mg/L	75
Chloride	5	mg/L	20000
Ferrous Iron - Fe2+	0.05	mg/L	< 0.05
Fluoride	0.02	mg/L	1.3
Nitrate (as N)	0.02	mg/L	0.22
Nitrite (as N)	0.02	mg/L	< 0.02
pH	0.1	units	7.1
Phosphorous filterable reactive (P)	0.01	mg/L	0.14
Sulphate (as SO4)	5	mg/L	3800
Sulphide (S)	0.05	mg/L	< 0.05
Suspended Solids	1	mg/L	< 1
Total Dissolved Solids	10	mg/L	33000
Total Kjeldahl Nitrogen (N)	0.1	mg/L	< 0.1
Alkalinity			
Bicarbonate Alkalinity-mg CaCO3/L	10	mg/L	180
Carbonate Alkalinity-mg CaCO3/L	10	mg/L	< 10
Hydroxide Alkalinity-mg CaCO3/L	10	mg/L	< 10
Total Alkalinity as CaCO3	20	mg/L	180
Heavy Metals			
Aluminium (filtered)	0.05	mg/L	< 0.05
Arsenic (filtered)	0.001	mg/L	0.015
Barium (filtered)	0.02	mg/L	0.04
Beryllium (filtered)	0.001	mg/L	0.002
Boron (filtered)	0.05	mg/L	7.8
Cadmium (filtered)	0.0002	mg/L	0.0002
Chromium (filtered)	0.001	mg/L	0.003
Cobalt (filtered)	0.001	mg/L	0.003
Copper (filtered)	0.001	mg/L	0.050
Lead (filtered)	0.001	mg/L	< 0.001
Manganese (filtered)	0.005	mg/L	0.021

Client Sample ID			**MRE001**
Sample Matrix			**Water**
mgt-LabMark Sample No.			**10-De01276**
Date Sampled			**Dec 01, 2010**
Test/Reference	PQL	Unit	
Nickel (filtered)	0.001	mg/L	0.021
Silver (filtered)	0.005	mg/L	< 0.005
Strontium (filtered)	0.005	mg/L	24
Tin (filtered)	0.005	mg/L	< 0.005
Uranium*	0.1	mg/L	0.1
Vanadium (filtered)	0.005	mg/L	< 0.005
Zinc (filtered)	0.001	mg/L	0.060
Mercury (filtered)	0.0001	mg/L	< 0.0001

Sample History

Where samples are submitted/analysed over several days, the last date of extraction and analysis is reported.

Description	Testing Site	Extracted	Holding Time
Alkali Metals - Method: USEPA 6010B - Heavy Metals	Oakleigh	Dec 03, 2010	28 Day
Soluble Heavy Metals - Method: Soluble Heavy Metals	Oakleigh	Dec 03, 2010	1 Month
Chemical Oxygen Demand (COD) - Method: APHA 5220 COD Open Reflux Method	Oakleigh	Dec 03, 2010	7 Day
Chloride - Method: APHA 4500-Cl (Cl by Discrete Analyser)	Oakleigh	Dec 03, 2010	28 Day
Ferrous Iron - Fe2+ - Method: APHA 3500-Fe B. (Iron Speciation)	Oakleigh	Dec 03, 2010	24 Hour
Fluoride - Method: APHA 4500F (Fluoride by ISE)	Oakleigh	Dec 03, 2010	28 Day
Nitrate (as N) - Method: APHA 4500-NO3 Nitrate Nitrogen by FIA	Oakleigh	Dec 03, 2010	2 Day
Nitrite (as N) - Method: APHA 4500-NO2 Nitrite Nitrogen by FIA	Oakleigh	Dec 03, 2010	2 Day
pH - Method: APHA 4500 pH by Direct Measurement - **pH Holding time 30mins. Samples analysed outside holding time.	Oakleigh	Dec 03, 2010	6 Hour
Phosphorous filterable reactive (P) - Method: APHA 4500-P Phosphate (filterable reactive)	Oakleigh	Dec 03, 2010	5 Day
Sulphate (as SO4) - Method: APHA 4500-SO4 Sulfate by FIA	Oakleigh	Dec 08, 2010	28 Day
Sulphide (S) - Method: APHA 4500-S C & D - Sulphide	Oakleigh	Dec 03, 2010	7 Day
Suspended Solids - Method: APHA 2540D Total Suspended Solids	Oakleigh	Dec 03, 2010	7 Day
Total Dissolved Solids - Method: APHA 2540C Total Dissolved Solids	Oakleigh	Dec 03, 2010	7 Day
Total Kjeldahl Nitrogen (N) - Method: APHA 4500 TKN	Oakleigh	Dec 03, 2010	28 Day
Alkalinity - Method: APHA 2320 Alkalinity by Titration	Oakleigh	Dec 08, 2010	14 Day
Heavy Metals - Method: USEPA 6020 Heavy Metals & USEPA 7470/71 Mercury	Oakleigh	Dec 03, 2010	28 Day

Quality Control Results

Sample, Test, Result Reference	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Codes
Method Blank							
Soluble Heavy Metals Soluble Heavy Metals							
Bismuth (filtered)	mg/L	< 0.005			0.005	Pass	
Lithium (filtered)	mg/L	< 0.005			0.005	Pass	
Method Blank							
Phosphorous filterable reactive (P)	mg/L	< 0.01			0.01	Pass	
Method Blank							
Heavy Metals USEPA 6020 Heavy Metals & USEPA 7470/71 Mer							
Aluminium (filtered)	mg/L	< 0.005			0.005	Pass	
Arsenic (filtered)	mg/L	< 0.005			0.005	Pass	
Barium (filtered)	mg/L	< 0.005			0.005	Pass	
Beryllium (filtered)	mg/L	< 0.005			0.005	Pass	
Boron (filtered)	mg/L	< 0.005			0.005	Pass	
Cadmium (filtered)	mg/L	< 0.0002			0.0002	Pass	
Chromium (filtered)	mg/L	< 0.005			0.005	Pass	
Cobalt (filtered)	mg/L	< 0.005			0.005	Pass	
Copper (filtered)	mg/L	< 0.005			0.005	Pass	
Lead (filtered)	mg/L	< 0.005			0.005	Pass	
Manganese (filtered)	mg/L	< 0.005			0.005	Pass	
Nickel (filtered)	mg/L	< 0.005			0.005	Pass	
Silver (filtered)	mg/L	< 0.005			0.005	Pass	
Strontium (filtered)	mg/L	< 0.005			0.005	Pass	
Tin (filtered)	mg/L	< 0.005			0.005	Pass	
Vanadium (filtered)	mg/L	< 0.005			0.005	Pass	
Zinc (filtered)	mg/L	< 0.005			0.005	Pass	
LCS - % Recovery							
Soluble Heavy Metals Soluble Heavy Metals		Result 1					
Bismuth (filtered)	%	111			70-130	Pass	
Lithium (filtered)	%	110			70-130	Pass	
LCS - % Recovery							
Heavy Metals USEPA 6020 Heavy Metals & USEPA 7470/71 Mer		Result 1					
Arsenic (filtered)	%	103			70-130	Pass	
Barium (filtered)	%	99			80-120	Pass	
Boron (filtered)	%	110			80-120	Pass	
Cadmium (filtered)	%	103			70-130	Pass	
Chromium (filtered)	%	106			70-130	Pass	
Cobalt (filtered)	%	105			70-130	Pass	
Copper (filtered)	%	104			70-130	Pass	
Lead (filtered)	%	101			70-130	Pass	
Manganese (filtered)	%	107			80-120	Pass	
Nickel (filtered)	%	104			70-130	Pass	
Strontium (filtered)	%	99			70-130	Pass	
Zinc (filtered)	%	106			70-130	Pass	
[Duplicate of 10-De01276]							
Heavy Metals		Result 1	Result 2	RPD			
Mercury (filtered)	mg/L	< 0.0001	< 0.0001	<1	30%	Pass	

Comments

Sample Integrity

Custody Seals Intact (if used)	N/A
Attempt to Chill was evident	Yes
Sample correctly preserved	Yes
Organic samples had Teflon liners	Yes
Sample containers for volatile analysis received with minimal headspace	No
Samples received within HoldingTime	Yes
Some samples have been subcontracted	No

Authorised By



Michael Wright
NATA Signatory

Final report - this Report replaces any previously issued Report

- Indicates Not Requested

* Indicates NATA accreditation does not cover the performance of this service

Uncertainty data is available on request

mgt-LabMark shall not be liable for loss, cost, damages or expenses incurred by the client, or any other person or company, resulting from the use of any information or interpretation given in this report. In no case shall mgt-LabMark be liable for consequential damages including, but not limited to, lost profits, damages for failure to meet deadlines and lost production arising from this report. This document shall not be reproduced except in full and relates only to the items tested. Unless indicated otherwise, the tests were performed on the samples as received.

mgt LabMark
ENVIRONMENTAL LABORATORIES

Certificate of Analysis

Australian Groundwater Technologies Pty Ltd
Unit 5 / 1 London Road
MILE END SOUTH
SOUTH AUSTRALIA 5031

Attention: -Nikki Fotheringham

NATA Accredited
Laboratory Number 1261

The tests covered by this document have been performed in accordance with NATA and ISO/IES 17025 and are traceable to national standards of measurement.
This document shall not be reproduced, except in full.

Report	284440-W
Client Reference	MULLAQUANNA
Received Date	Dec 03, 2010

Client Sample ID			**MRE002**
Sample Matrix			**Water**
mgt-LabMark Sample No.			**10-De01277**
Date Sampled			**Dec 01, 2010**
Test/Reference	PQL	Unit	
Alkali Metals			
Calcium	0.5	mg/L	1900
Magnesium	0.5	mg/L	1800
Potassium	0.5	mg/L	110
Sodium	0.5	mg/L	8200
Soluble Heavy Metals			
Bismuth (filtered)	0.005	mg/L	< 0.005
Lithium (filtered)	0.005	mg/L	0.20
Chemical Oxygen Demand (COD)	5	mg/L	76
Chloride	5	mg/L	20000
Ferrous Iron - Fe2+	0.05	mg/L	< 0.05
Fluoride	0.02	mg/L	1.4
Nitrate (as N)	0.02	mg/L	0.36
Nitrite (as N)	0.02	mg/L	< 0.02
pH	0.1	units	7.2
Phosphorous filterable reactive (P)	0.01	mg/L	< 0.01
Sulphate (as SO4)	5	mg/L	3900
Sulphide (S)	0.05	mg/L	< 0.05
Suspended Solids	1	mg/L	8.0
Total Dissolved Solids	10	mg/L	36000
Total Kjeldahl Nitrogen (N)	0.1	mg/L	< 0.1
Alkalinity			
Bicarbonate Alkalinity-mg CaCO3/L	10	mg/L	190
Carbonate Alkalinity-mg CaCO3/L	10	mg/L	< 10
Hydroxide Alkalinity-mg CaCO3/L	10	mg/L	< 10
Total Alkalinity as CaCO3	20	mg/L	190
Heavy Metals			
Aluminium (filtered)	0.05	mg/L	< 0.05
Arsenic (filtered)	0.001	mg/L	0.017
Barium (filtered)	0.02	mg/L	0.04
Beryllium (filtered)	0.001	mg/L	0.002
Boron (filtered)	0.05	mg/L	7.8
Cadmium (filtered)	0.0002	mg/L	< 0.0002
Chromium (filtered)	0.001	mg/L	0.005
Cobalt (filtered)	0.001	mg/L	0.003
Copper (filtered)	0.001	mg/L	0.28
Lead (filtered)	0.001	mg/L	0.003
Manganese (filtered)	0.005	mg/L	< 0.005

Client Sample ID			**MRE002**
Sample Matrix			**Water**
mgt-LabMark Sample No.			**10-De01277**
Date Sampled			**Dec 01, 2010**
Test/Reference	PQL	Unit	
Nickel (filtered)	0.001	mg/L	0.024
Silver (filtered)	0.005	mg/L	< 0.005
Strontium (filtered)	0.005	mg/L	23
Tin (filtered)	0.005	mg/L	< 0.005
Uranium*	0.1	mg/L	0.2
Vanadium (filtered)	0.005	mg/L	< 0.005
Zinc (filtered)	0.001	mg/L	0.28
Mercury (filtered)	0.0001	mg/L	< 0.0001

Sample History

Where samples are submitted/analysed over several days, the last date of extraction and analysis is reported.

Description	Testing Site	Extracted	Holding Time
Alkali Metals - Method: USEPA 6010B - Heavy Metals	Oakleigh	Dec 03, 2010	28 Day
Soluble Heavy Metals - Method: Soluble Heavy Metals	Oakleigh	Dec 03, 2010	1 Month
Chemical Oxygen Demand (COD) - Method: APHA 5220 COD Open Reflux Method	Oakleigh	Dec 03, 2010	7 Day
Chloride - Method: APHA 4500-Cl (Cl by Discrete Analyser)	Oakleigh	Dec 03, 2010	28 Day
Ferrous Iron - Fe2+ - Method: APHA 3500-Fe B. (Iron Speciation)	Oakleigh	Dec 03, 2010	24 Hour
Fluoride - Method: APHA 4500F (Fluoride by ISE)	Oakleigh	Dec 03, 2010	28 Day
Nitrate (as N) - Method: APHA 4500-NO3 Nitrate Nitrogen by FIA	Oakleigh	Dec 03, 2010	2 Day
Nitrite (as N) - Method: APHA 4500-NO2 Nitrite Nitrogen by FIA	Oakleigh	Dec 03, 2010	2 Day
pH - Method: APHA 4500 pH by Direct Measurement - **pH Holding time 30mins. Samples analysed outside holding time.	Oakleigh	Dec 03, 2010	6 Hour
Phosphorous filterable reactive (P) - Method: APHA 4500-P Phosphate (filterable reactive)	Oakleigh	Dec 03, 2010	5 Day
Sulphate (as SO4) - Method: APHA 4500-SO4 Sulfate by FIA	Oakleigh	Dec 08, 2010	28 Day
Sulphide (S) - Method: APHA 4500-S C & D - Sulphide	Oakleigh	Dec 03, 2010	7 Day
Suspended Solids - Method: APHA 2540D Total Suspended Solids	Oakleigh	Dec 03, 2010	7 Day
Total Dissolved Solids - Method: APHA 2540C Total Dissolved Solids	Oakleigh	Dec 03, 2010	7 Day
Total Kjeldahl Nitrogen (N) - Method: APHA 4500 TKN	Oakleigh	Dec 03, 2010	28 Day
Alkalinity - Method: APHA 2320 Alkalinity by Titration	Oakleigh	Dec 08, 2010	14 Day
Heavy Metals - Method: USEPA 6020 Heavy Metals & USEPA 7470/71 Mercury	Oakleigh	Dec 03, 2010	28 Day

Quality Control Results

Sample, Test, Result Reference	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Codes
Method Blank							
Alkali Metals USEPA 6010B - Heavy Metals							
Calcium	mg/L	< 0.5			0.5	Pass	
Magnesium	mg/L	< 0.5			0.5	Pass	
Potassium	mg/L	< 0.5			0.5	Pass	
Sodium	mg/L	< 0.5			0.5	Pass	
Method Blank							
Soluble Heavy Metals Soluble Heavy Metals							
Bismuth (filtered)	mg/L	< 0.005			0.005	Pass	
Lithium (filtered)	mg/L	< 0.005			0.005	Pass	
Method Blank							
Chemical Oxygen Demand (COD)	mg/L	< 5			5	Pass	
Chloride	mg/L	< 5			5	Pass	
Ferrous Iron - Fe2+	mg/L	< 0.05			0.05	Pass	
Nitrate (as N)	mg/L	< 0.02			0.02	Pass	
Nitrite (as N)	mg/L	< 0.02			0.02	Pass	
Phosphorous filterable reactive (P)	mg/L	< 0.01			0.01	Pass	
Sulphate (as SO4)	mg/L	< 5			5	Pass	
Sulphide (S)	mg/L	< 0.05			0.05	Pass	
Suspended Solids	mg/L	< 1			1	Pass	
Total Dissolved Solids	mg/L	< 10			10	Pass	
Total Kjeldahl Nitrogen (N)	mg/L	< 0.1			0.1	Pass	
Method Blank							
Alkalinity APHA 2320 Alkalinity by Titration							
Bicarbonate Alkalinity-mg CaCO3/L	mg/L	< 10			10	Pass	
Carbonate Alkalinity-mg CaCO3/L	mg/L	< 10			10	Pass	
Hydroxide Alkalinity-mg CaCO3/L	mg/L	< 10			10	Pass	
Total Alkalinity as CaCO3	mg/L	< 20			20	Pass	
Method Blank							
Heavy Metals USEPA 6020 Heavy Metals & USEPA 7470/71 Mer							
Aluminium (filtered)	mg/L	< 0.005			0.005	Pass	
Arsenic (filtered)	mg/L	< 0.005			0.005	Pass	
Barium (filtered)	mg/L	< 0.005			0.005	Pass	
Beryllium (filtered)	mg/L	< 0.005			0.005	Pass	
Boron (filtered)	mg/L	< 0.005			0.005	Pass	
Cadmium (filtered)	mg/L	< 0.0002			0.0002	Pass	
Chromium (filtered)	mg/L	< 0.005			0.005	Pass	
Cobalt (filtered)	mg/L	< 0.005			0.005	Pass	
Copper (filtered)	mg/L	< 0.005			0.005	Pass	
Lead (filtered)	mg/L	< 0.005			0.005	Pass	
Manganese (filtered)	mg/L	< 0.005			0.005	Pass	
Nickel (filtered)	mg/L	< 0.005			0.005	Pass	
Silver (filtered)	mg/L	< 0.005			0.005	Pass	
Strontium (filtered)	mg/L	< 0.005			0.005	Pass	
Tin (filtered)	mg/L	< 0.005			0.005	Pass	
Vanadium (filtered)	mg/L	< 0.005			0.005	Pass	
Zinc (filtered)	mg/L	< 0.005			0.005	Pass	
Mercury (filtered)	mg/L	< 0.0001			0.0001	Pass	
LCS - % Recovery							
Alkali Metals USEPA 6010B - Heavy Metals		Result 1					
Calcium	%	117			70-130	Pass	
Magnesium	%	115			70-130	Pass	
Potassium	%	113			70-130	Pass	
Sodium	%	116			70-130	Pass	
LCS - % Recovery							
Soluble Heavy Metals Soluble Heavy Metals		Result 1					
Bismuth (filtered)	%	111			70-130	Pass	
Lithium (filtered)	%	110			70-130	Pass	
LCS - % Recovery							
		Result 1					
Chemical Oxygen Demand (COD)	%	75			70-130	Pass	
Chloride	%	101			70-130	Pass	
Ferrous Iron - Fe2+	%	106			70-130	Pass	

Sample, Test, Result Reference	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Codes
Fluoride	%	80			70-130	Pass	
Nitrate (as N)	%	88			70-130	Pass	
Nitrite (as N)	%	115			70-130	Pass	
Sulphate (as SO4)	%	107			70-130	Pass	
Sulphide (S)	%	96			70-130	Pass	
Suspended Solids	%	123			70-130	Pass	
Total Kjeldahl Nitrogen (N)	%	88			70-130	Pass	
LCS - % Recovery							
Heavy Metals USEPA 6020 Heavy Metals & USEPA 7470/71 Mer		Result 1					
Arsenic (filtered)	%	103			70-130	Pass	
Barium (filtered)	%	99			80-120	Pass	
Boron (filtered)	%	110			80-120	Pass	
Cadmium (filtered)	%	103			70-130	Pass	
Chromium (filtered)	%	106			70-130	Pass	
Cobalt (filtered)	%	105			70-130	Pass	
Copper (filtered)	%	104			70-130	Pass	
Lead (filtered)	%	101			70-130	Pass	
Manganese (filtered)	%	107			80-120	Pass	
Nickel (filtered)	%	104			70-130	Pass	
Strontium (filtered)	%	99			70-130	Pass	
Zinc (filtered)	%	106			70-130	Pass	
Mercury (filtered)	%	101			70-130	Pass	
[Duplicate of 10-De00900 - BATCH]							
Alkali Metals		Result 1	Result 2	RPD			
Calcium	mg/L	39	39	<1	30%	Pass	
Magnesium	mg/L	100	100	<1	30%	Pass	
Potassium	mg/L	14	14	<1	30%	Pass	
Sodium	mg/L	530	530	<1	30%	Pass	
[Duplicate of 10-De00748 - BATCH]							
Soluble Heavy Metals		Result 1	Result 2	RPD			
Bismuth (filtered)	mg/L	< 0.005	< 0.005	<1	30%	Pass	
Lithium (filtered)	mg/L	0.014	0.014	<1	30%	Pass	
[Duplicate of 10-De00376 - BATCH]							
		Result 1	Result 2	RPD			
Chemical Oxygen Demand (COD)	mg/L	1300	1300	<1	30%	Pass	
Chloride	mg/L	< 5	< 5	<1	30%	Pass	
Ferrous Iron - Fe2+	mg/L	0.16	0.17	3.3	30%	Pass	
Fluoride	mg/L	1.4	1.5	4.1	30%	Pass	
Nitrate (as N)	mg/L	0.36	0.39	7	30%	Pass	
Nitrite (as N)	mg/L	< 0.02	< 0.02	<1	30%	Pass	
pH	units	8.6	8.7	1	30%	Pass	
Phosphorous filterable reactive (P)	mg/L	0.1	0.099	2.9	30%	Pass	
Sulphate (as SO4)	mg/L	120	120	1.9	30%	Pass	
Sulphide (S)	mg/L	2.8	3	7	30%	Pass	
Suspended Solids	mg/L	250	260	<1	30%	Pass	
Total Dissolved Solids	mg/L	1600	1700	4	30%	Pass	
Total Kjeldahl Nitrogen (N)	mg/L	3.4	3.8	13	30%	Pass	
[Duplicate of 10-Oc23264 - BATCH]							
Alkalinity		Result 1	Result 2	RPD			
Bicarbonate Alkalinity-mg CaCO3/L	mg/L	340	340	<1	30%	Pass	
Carbonate Alkalinity-mg CaCO3/L	mg/L	< 20	< 20	<1	30%	Pass	
Hydroxide Alkalinity-mg CaCO3/L	mg/L	< 20	< 20	<1	30%	Pass	
Total Alkalinity as CaCO3	mg/L	340	340	<1	30%	Pass	
[Duplicate of 10-De01522 - BATCH]							
Heavy Metals		Result 1	Result 2	RPD			
Arsenic (filtered)	mg/L	< 0.005	rerun	<1	30%	Pass	
Barium (filtered)	mg/L	0.057	0.06	4.3	30%	Pass	
Beryllium (filtered)	mg/L	< 0.001	< 0.005	<1	30%	Pass	
Boron (filtered)	mg/L	0.049	0.046	5.9	30%	Pass	
Cadmium (filtered)	mg/L	< 0.0002	< 0.0002	<1	30%	Pass	
Chromium (filtered)	mg/L	< 0.005	0.0069	28	30%	Pass	
Cobalt (filtered)	mg/L	< 0.005	< 0.005	<1	30%	Pass	
Copper (filtered)	mg/L	< 0.005	< 0.005	<1	30%	Pass	
Lead (filtered)	mg/L	< 0.005	< 0.005	<1	30%	Pass	
Manganese (filtered)	mg/L	< 0.005	< 0.005	<1	30%	Pass	
Nickel (filtered)	mg/L	< 0.005	< 0.005	12	30%	Pass	

Sample, Test, Result Reference	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Codes
Silver (filtered)	mg/L	< 0.005	< 0.005	<1	30%	Pass	
Strontium (filtered)	mg/L	0.2	0.2	2	30%	Pass	
Tin (filtered)	mg/L	< 0.005	< 0.005	<1	30%	Pass	
Vanadium (filtered)	mg/L	< 0.005	0.005	20	30%	Pass	
Zinc (filtered)	mg/L	0.018	0.019	5.5	30%	Pass	
Mercury (filtered)	mg/L	< 0.0001	< 0.0001	<1	30%	Pass	
[Spike of 10-De00900 - BATCH] - % Recovery							
Alkali Metals		Result 1					
Calcium	%	121			70 - 130	Pass	
Magnesium	%	104			70 - 130	Pass	
Potassium	%	113			70 - 130	Pass	
Sodium	%	129			70 - 130	Pass	
[Spike of 10-De00376 - BATCH] - % Recovery							
		Result 1					
Chemical Oxygen Demand (COD)	%	94			70 - 130	Pass	
Chloride	%	107			70 - 130	Pass	
Ferrous Iron - Fe2+	%	111			70 - 130	Pass	
Fluoride	%	117			70 - 130	Pass	
Nitrate (as N)	%	94			70 - 130	Pass	
Nitrite (as N)	%	88			70 - 130	Pass	
Phosphorous filterable reactive (P)	%	94			70 - 130	Pass	
Sulphate (as SO4)	%	118			70 - 130	Pass	
Sulphide (S)	%	98			70 - 130	Pass	
Total Kjeldahl Nitrogen (N)	%	107			70 - 130	Pass	
[Spike of 10-De01277] - % Recovery							
Alkalinity		Result 1					
Total Alkalinity as CaCO3	%	92			70 - 130	Pass	
[Spike of 10-De01522 - BATCH] - % Recovery							
Heavy Metals		Result 1					
Arsenic (filtered)	%	83			70 - 130	Pass	
Barium (filtered)	%	87			70 - 130	Pass	
Beryllium (filtered)	%	91			70 - 130	Pass	
Boron (filtered)	%	90			70 - 130	Pass	
Cadmium (filtered)	%	93			70 - 130	Pass	
Chromium (filtered)	%	99			70 - 130	Pass	
Cobalt (filtered)	%	87			70 - 130	Pass	
Copper (filtered)	%	83			70 - 130	Pass	
Lead (filtered)	%	84			70 - 130	Pass	
Manganese (filtered)	%	91			70 - 130	Pass	
Nickel (filtered)	%	83			70 - 130	Pass	
Tin (filtered)	%	92			70 - 130	Pass	
Vanadium (filtered)	%	94			70 - 130	Pass	
Zinc (filtered)	%	84			70 - 130	Pass	
Mercury (filtered)	%	87			70 - 130	Pass	

Comments

Sample Integrity

Custody Seals Intact (if used)	N/A
Attempt to Chill was evident	Yes
Sample correctly preserved	Yes
Organic samples had Teflon liners	Yes
Sample containers for volatile analysis received with minimal headspace	No
Samples received within HoldingTime	Yes
Some samples have been subcontracted	No

Authorised By



Michael Wright
NATA Signatory

Final report - this Report replaces any previously issued Report

- Indicates Not Requested

* Indicates NATA accreditation does not cover the performance of this service

Uncertainty data is available on request

mgt-LabMark shall not be liable for loss, cost, damages or expenses incurred by the client, or any other person or company, resulting from the use of any information or interpretation given in this report. In no case shall mgt-LabMark be liable for consequential damages including, but not limited to, lost profits, damages for failure to meet deadlines and lost production arising from this report. This document shall not be reproduced except in full and relates only to the items tested. Unless indicated otherwise, the tests were performed on the samples as received.

mgt LabMark ENVIRONMENTAL LABORATORIES

Certificate of Analysis

Australian Groundwater Technologies Pty Ltd
Unit 5 / 1 London Road
MILE END SOUTH
SOUTH AUSTRALIA 5031

Attention: -Nikki Fotheringham

NATA Accredited
Laboratory Number 1261

The tests covered by this document have been performed in accordance with NATA and ISO/IES 17025 and are traceable to national standards of measurement.
This document shall not be reproduced, except in full.

Report	284444-W
Client Reference	MULLAQUANNA
Received Date	Dec 03, 2010

Client Sample ID			**MRE003**
Sample Matrix			**Water**
mgt-LabMark Sample No.			**10-De01287**
Date Sampled			**Dec 01, 2010**
Test/Reference	PQL	Unit	
Alkali Metals			
Calcium	0.5	mg/L	2700
Magnesium	0.5	mg/L	2000
Potassium	0.5	mg/L	190
Sodium	0.5	mg/L	13000
Soluble Heavy Metals			
Bismuth (filtered)	0.005	mg/L	< 0.005
Lithium (filtered)	0.005	mg/L	0.41
Chemical Oxygen Demand (COD)	5	mg/L	61
Chloride	5	mg/L	29000
Ferrous Iron - Fe2+	0.05	mg/L	0.08
Fluoride	0.02	mg/L	1.4
Nitrate (as N)	0.02	mg/L	< 0.02
Nitrite (as N)	0.02	mg/L	< 0.02
pH	0.1	units	7.2
Phosphorous filterable reactive (P)	0.01	mg/L	< 0.01
Sulphate (as SO4)	5	mg/L	3900
Sulphide (S)	0.05	mg/L	< 0.05
Suspended Solids	1	mg/L	8.0
Total Dissolved Solids	10	mg/L	48000
Total Kjeldahl Nitrogen (N)	0.1	mg/L	< 0.1
Alkalinity			
Bicarbonate Alkalinity-mg CaCO3/L	10	mg/L	160
Carbonate Alkalinity-mg CaCO3/L	10	mg/L	< 10
Hydroxide Alkalinity-mg CaCO3/L	10	mg/L	< 10
Total Alkalinity as CaCO3	20	mg/L	160
Heavy Metals			
Aluminium (filtered)	0.05	mg/L	< 0.05
Arsenic (filtered)	0.001	mg/L	0.021
Barium (filtered)	0.02	mg/L	0.07
Beryllium (filtered)	0.001	mg/L	0.002
Boron (filtered)	0.05	mg/L	6.5
Cadmium (filtered)	0.0002	mg/L	< 0.0002
Chromium (filtered)	0.001	mg/L	0.004
Cobalt (filtered)	0.001	mg/L	0.006
Copper (filtered)	0.001	mg/L	0.074
Lead (filtered)	0.001	mg/L	< 0.001
Manganese (filtered)	0.005	mg/L	0.65

Client Sample ID			**MRE003**
Sample Matrix			**Water**
mgt-LabMark Sample No.			**10-De01287**
Date Sampled			**Dec 01, 2010**
Test/Reference	PQL	Unit	
Nickel (filtered)	0.001	mg/L	0.038
Silver (filtered)	0.005	mg/L	< 0.005
Strontium (filtered)	0.005	mg/L	33
Tin (filtered)	0.005	mg/L	< 0.005
Uranium*	0.1	mg/L	< 0.1
Vanadium (filtered)	0.005	mg/L	< 0.005
Zinc (filtered)	0.001	mg/L	0.11
Mercury (filtered)	0.0001	mg/L	< 0.0001

Sample History

Where samples are submitted/analysed over several days, the last date of extraction and analysis is reported.

Description	Testing Site	Extracted	Holding Time
Alkali Metals - Method: USEPA 6010B - Heavy Metals	Oakleigh	Dec 03, 2010	28 Day
Soluble Heavy Metals - Method: Soluble Heavy Metals	Oakleigh	Dec 03, 2010	1 Month
Chemical Oxygen Demand (COD) - Method: APHA 5220 COD Open Reflux Method	Oakleigh	Dec 03, 2010	7 Day
Chloride - Method: APHA 4500-Cl (Cl by Discrete Analyser)	Oakleigh	Dec 03, 2010	28 Day
Ferrous Iron - Fe2+ - Method: APHA 3500-Fe B. (Iron Speciation)	Oakleigh	Dec 03, 2010	24 Hour
Fluoride - Method: APHA 4500F (Fluoride by ISE)	Oakleigh	Dec 03, 2010	28 Day
Nitrate (as N) - Method: APHA 4500-NO3 Nitrate Nitrogen by FIA	Oakleigh	Dec 03, 2010	2 Day
Nitrite (as N) - Method: APHA 4500-NO2 Nitrite Nitrogen by FIA	Oakleigh	Dec 03, 2010	2 Day
pH - Method: APHA 4500 pH by Direct Measurement - **pH Holding time 30mins. Samples analysed outside holding time.	Oakleigh	Dec 03, 2010	6 Hour
Phosphorous filterable reactive (P) - Method: APHA 4500-P Phosphate (filterable reactive)	Oakleigh	Dec 03, 2010	5 Day
Sulphate (as SO4) - Method: APHA 4500-SO4 Sulfate by FIA	Oakleigh	Dec 08, 2010	28 Day
Sulphide (S) - Method: APHA 4500-S C & D - Sulphide	Oakleigh	Dec 03, 2010	7 Day
Suspended Solids - Method: APHA 2540D Total Suspended Solids	Oakleigh	Dec 03, 2010	7 Day
Total Dissolved Solids - Method: APHA 2540C Total Dissolved Solids	Oakleigh	Dec 03, 2010	7 Day
Total Kjeldahl Nitrogen (N) - Method: APHA 4500 TKN	Oakleigh	Dec 03, 2010	28 Day
Alkalinity - Method: APHA 2320 Alkalinity by Titration	Oakleigh	Dec 08, 2010	14 Day
Heavy Metals - Method: USEPA 6020 Heavy Metals & USEPA 7470/71 Mercury	Oakleigh	Dec 03, 2010	28 Day

mgt-LabMark Internal Quality Control Review

General

1. Laboratory QC results for Method Blanks, Duplicates, Matrix Spikes, and Laboratory Control Samples are included in this QC report where applicable. Additional QC data may be available on request.
2. All soil results are reported on a dry basis, unless otherwise stated.
3. Actual PQLs are matrix dependant. Quoted PQLs may be raised where sample extracts are diluted due to interferences.
4. Results are uncorrected for matrix spikes or surrogate recoveries.
5. SVOC analysis on waters are performed on homogenised, unfiltered samples, unless noted otherwise.
6. Samples were analysed on an 'as received' basis.
7. This report replaces any interim results previously issued.

Holding Times

Please refer to 'Sampling and Preservation Chart for Soils & Waters' for holding times. (LM-FOR-ADM-020)
For samples received on the last day of holding time, notification of testing requirements should have been received at least 6 hours prior to sample receipt deadlines as stated on the Sample Receipt Acknowledgment.
If the Laboratory did not receive the information in the required timeframe, and regardless of any other integrity issues, suitably qualified results may still be reported.

Holding times apply from the date of sampling, therefore compliance to these may be outside the laboratory's control.

****NOTE:** pH duplicates are reported as a range NOT as an RPD

UNITS

mg/kg:milligrams per Kilogram
mg/L:milligrams per litre
µg/l: micrograms per litre
ppm: Parts per million
ppb: Parts per billion
%: Percentage
org/100ml: Organisms per 100 millilitres
NTU: Nephelometric Turbidity Units

TERMS

Dry: Where a moisture has been determined on a solid sample the result is expressed on a dry basis.
LOR: Limit Of Reporting.
SPIKE: Addition of the analyte to the sample and reported as percentage recovery.
RPD: Relative Percent Difference between two Duplicate pieces of analysis.
LCS: Laboratory Control Sample - reported as percent recovery.
CRM: Certified Reference Material - reported as percent recovery.
Method Blank: In the case of solid samples these are performed on laboratory certified clean sands. In the case of water samples these are performed on de-ionised water.
Surr - Surrogate: The addition of a like compound to the analyte target and reported as percentage recovery.
Duplicate: A second piece of analysis from the same sample and reported in the same units as the result to show comparison.
Batch Duplicate: A second piece of analysis from a sample outside of the client's batch of samples but run within the laboratory batch of analysis.
Batch SPIKE: Spike recovery reported on a sample from outside of the client's batch of samples but run within the laboratory batch of analysis.
USEPA: U.S Environmental Protection Agency
APHA: American Public Health Association
ASLP: Australian Standard Leaching Procedure (AS4439.3)
TCLP: Toxicity Characteristic Leaching Procedure
COC: Chain Of Custody
SRA: Sample Receipt Advice

QC - ACCEPTANCE CRITERIA

RPD Duplicates: Global RPD Duplicates Acceptance Criteria is 30% however the following acceptance guidelines are equally applicable:
Results <10 times the LOR : No Limit
Results between 10-20 times the LOR : RPD must lie between 0-50%
Results >20 times the LOR : RPD must lie between 0-20%
Surrogate Recoveries : Recoveries must lie between 50-150% - Phenols 20-130%.

QC DATA GENERAL COMMENTS

1. Where a result is reported as a less than (<), higher than the nominated LOR, this is due to either matrix interference, extract dilution required due to interferences or contaminant levels within the sample, high moisture content or insufficient sample provided.
2. Duplicate data shown within this report that states the word "BATCH" is a Batch Duplicate from outside of your sample batch, but within the laboratory sample batch at a 1:10 ratio. The Parent and Duplicate data shown is not data from your samples.
3. Organochlorine Pesticide analysis - where reporting LCS data, Toxophene & Chlordane are not added to the LCS.
4. Organochlorine Pesticide analysis - where reporting Spike data, Toxophene is not added to the Spike.
5. Total Recoverable Hydrocarbons - where reporting Spike & LCS data, a single spike of commercial Hydrocarbon products in the range of C12-C30 is added and it's Total Recovery is reported in the C10-C14 cell of the Report.
6. Recovery Data (Spikes & Surrogates) - where chromatographic interference does not allow the determination of Recovery the term "INT" appears against that analyte.
7. Polychlorinated Biphenyls are spiked only using Arochlor 1260 in Matrix Spikes and LCS's.
8. For Matrix Spikes and LCS results a dash " -" in the report means that the specific analyte was not added to the QC sample.
9. Duplicate RPD's are calculated from raw analytical data thus it is possible to have two sets of data below the LOR with a positive RPD - eg: LOR 0.1, Result A = <0.1 (raw data is 0.02) & Result B = <0.1 (raw data is 0.03) resulting in a RPD of 40% calculated from the raw data.

Quality Control Results

Sample, Test, Result Reference	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Codes
Method Blank							
Alkali Metals USEPA 6010B - Heavy Metals							
Calcium	mg/L	< 0.5			0.5	Pass	
Magnesium	mg/L	< 0.5			0.5	Pass	
Potassium	mg/L	< 0.5			0.5	Pass	
Sodium	mg/L	< 0.5			0.5	Pass	
Method Blank							
Soluble Heavy Metals Soluble Heavy Metals							
Bismuth (filtered)	mg/L	< 0.005			0.005	Pass	
Lithium (filtered)	mg/L	< 0.005			0.005	Pass	
Method Blank							
Chemical Oxygen Demand (COD)	mg/L	< 5			5	Pass	
Chloride	mg/L	< 5			5	Pass	
Ferrous Iron - Fe2+	mg/L	< 0.05			0.05	Pass	
Fluoride	mg/L	< 0.02			0.02	Pass	
Nitrate (as N)	mg/L	< 0.02			0.02	Pass	
Nitrite (as N)	mg/L	< 0.02			0.02	Pass	
Phosphorous filterable reactive (P)	mg/L	< 0.01			0.01	Pass	
Sulphate (as SO4)	mg/L	< 5			5	Pass	
Sulphide (S)	mg/L	< 0.05			0.05	Pass	
Suspended Solids	mg/L	< 1			1	Pass	
Total Dissolved Solids	mg/L	< 10			10	Pass	
Total Kjeldahl Nitrogen (N)	mg/L	< 0.1			0.1	Pass	
Method Blank							
Alkalinity APHA 2320 Alkalinity by Titration							
Bicarbonate Alkalinity-mg CaCO3/L	mg/L	< 10			10	Pass	
Carbonate Alkalinity-mg CaCO3/L	mg/L	< 10			10	Pass	
Hydroxide Alkalinity-mg CaCO3/L	mg/L	< 10			10	Pass	
Total Alkalinity as CaCO3	mg/L	< 20			20	Pass	
Method Blank							
Heavy Metals USEPA 6020 Heavy Metals & USEPA 7470/71 Mer							
Aluminium (filtered)	mg/L	< 0.005			0.005	Pass	
Arsenic (filtered)	mg/L	< 0.005			0.005	Pass	
Barium (filtered)	mg/L	< 0.005			0.005	Pass	
Beryllium (filtered)	mg/L	< 0.005			0.005	Pass	
Boron (filtered)	mg/L	< 0.005			0.005	Pass	
Cadmium (filtered)	mg/L	< 0.0002			0.0002	Pass	
Chromium (filtered)	mg/L	< 0.005			0.005	Pass	
Cobalt (filtered)	mg/L	< 0.005			0.005	Pass	
Copper (filtered)	mg/L	< 0.005			0.005	Pass	
Lead (filtered)	mg/L	< 0.005			0.005	Pass	
Manganese (filtered)	mg/L	< 0.005			0.005	Pass	
Nickel (filtered)	mg/L	< 0.005			0.005	Pass	
Silver (filtered)	mg/L	< 0.005			0.005	Pass	
Strontium (filtered)	mg/L	< 0.005			0.005	Pass	
Tin (filtered)	mg/L	< 0.005			0.005	Pass	
Vanadium (filtered)	mg/L	< 0.005			0.005	Pass	
Zinc (filtered)	mg/L	< 0.005			0.005	Pass	
Mercury (filtered)	mg/L	< 0.0001			0.0001	Pass	
LCS - % Recovery							
Alkali Metals USEPA 6010B - Heavy Metals		Result 1					
Calcium	%	85			70-130	Pass	
Magnesium	%	85			70-130	Pass	
Potassium	%	83			70-130	Pass	
LCS - % Recovery							
Soluble Heavy Metals Soluble Heavy Metals		Result 1					
Bismuth (filtered)	%	111			70-130	Pass	
Lithium (filtered)	%	110			70-130	Pass	
LCS - % Recovery							
		Result 1					
Chemical Oxygen Demand (COD)	%	91			70-130	Pass	
Chloride	%	126			70-130	Pass	
Ferrous Iron - Fe2+	%	95			70-130	Pass	

Sample, Test, Result Reference	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Codes
Fluoride	%	80			70-130	Pass	
Nitrate (as N)	%	88			70-130	Pass	
Nitrite (as N)	%	115			70-130	Pass	
Sulphate (as SO4)	%	107			70-130	Pass	
Sulphide (S)	%	96			70-130	Pass	
Suspended Solids	%	123			70-130	Pass	
Total Kjeldahl Nitrogen (N)	%	88			70-130	Pass	
LCS - % Recovery							
Heavy Metals USEPA 6020 Heavy Metals & USEPA 7470/71 Mer		Result 1					
Arsenic (filtered)	%	103			70-130	Pass	
Barium (filtered)	%	99			80-120	Pass	
Boron (filtered)	%	110			80-120	Pass	
Cadmium (filtered)	%	103			70-130	Pass	
Chromium (filtered)	%	106			70-130	Pass	
Cobalt (filtered)	%	105			70-130	Pass	
Copper (filtered)	%	104			70-130	Pass	
Lead (filtered)	%	101			70-130	Pass	
Manganese (filtered)	%	107			80-120	Pass	
Nickel (filtered)	%	104			70-130	Pass	
Strontium (filtered)	%	99			70-130	Pass	
Zinc (filtered)	%	106			70-130	Pass	
Mercury (filtered)	%	104			70-130	Pass	
[Duplicate of 10-De00900 - BATCH]							
Alkali Metals		Result 1	Result 2	RPD			
Calcium	mg/L	39	39	1	30%	Pass	
Magnesium	mg/L	100	100	1	30%	Pass	
Potassium	mg/L	14	14	4	30%	Pass	
Sodium	mg/L	530	530	1	30%	Pass	
[Duplicate of 10-De00748 - BATCH]							
Soluble Heavy Metals		Result 1	Result 2	RPD			
Bismuth (filtered)	mg/L	< 0.005	< 0.005	<1	30%	Pass	
Lithium (filtered)	mg/L	0.014	0.014	2.1	30%	Pass	
[Duplicate of 10-De02262 - BATCH]							
		Result 1	Result 2	RPD			
Chemical Oxygen Demand (COD)	mg/L	320	310	2.8	30%	Pass	
Chloride	mg/L	4100	4100	<1	30%	Pass	
Ferrous Iron - Fe2+	mg/L	0.17	0.17	4.1	30%	Pass	
Fluoride	mg/L	1.4	1.5	4.1	30%	Pass	
Nitrate (as N)	mg/L	0.36	0.39	7	30%	Pass	
Nitrite (as N)	mg/L	< 0.02	< 0.02	<1	30%	Pass	
pH	units	8.6	8.7	1	30%	Pass	
Phosphorous filterable reactive (P)	mg/L	0.58	0.57	1.3	30%	Pass	
Sulphate (as SO4)	mg/L	120	120	1.9	30%	Pass	
Sulphide (S)	mg/L	2.8	3	7	30%	Pass	
Suspended Solids	mg/L	260	**	4	30%	Pass	
Total Dissolved Solids	mg/L	2600	2400	4	30%	Pass	
Total Kjeldahl Nitrogen (N)	mg/L	3.4	3.8	13	30%	Pass	
[Duplicate of 10-Oc23264 - BATCH]							
Alkalinity		Result 1	Result 2	RPD			
Bicarbonate Alkalinity-mg CaCO3/L	mg/L	340	340	<1	30%	Pass	
Carbonate Alkalinity-mg CaCO3/L	mg/L	< 20	< 20	<1	30%	Pass	
Hydroxide Alkalinity-mg CaCO3/L	mg/L	< 20	< 20	<1	30%	Pass	
Total Alkalinity as CaCO3	mg/L	340	340	<1	30%	Pass	
[Duplicate of 10-De01522 - BATCH]							
Heavy Metals		Result 1	Result 2	RPD			
Arsenic (filtered)	mg/L	< 0.005	rerun	<1	30%	Pass	
Barium (filtered)	mg/L	0.057	0.06	4.3	30%	Pass	
Beryllium (filtered)	mg/L	< 0.001	< 0.005	<1	30%	Pass	
Boron (filtered)	mg/L	0.049	0.046	5.9	30%	Pass	
Cadmium (filtered)	mg/L	< 0.0002	< 0.0002	<1	30%	Pass	
Chromium (filtered)	mg/L	< 0.005	0.0069	28	30%	Pass	
Cobalt (filtered)	mg/L	< 0.005	< 0.005	<1	30%	Pass	
Copper (filtered)	mg/L	< 0.005	< 0.005	<1	30%	Pass	
Lead (filtered)	mg/L	< 0.005	< 0.005	<1	30%	Pass	
Manganese (filtered)	mg/L	< 0.005	< 0.005	<1	30%	Pass	
Nickel (filtered)	mg/L	< 0.005	< 0.005	12	30%	Pass	

Sample, Test, Result Reference	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Codes
Silver (filtered)	mg/L	< 0.005	< 0.005	<1	30%	Pass	
Strontium (filtered)	mg/L	0.2	0.2	2	30%	Pass	
Tin (filtered)	mg/L	< 0.005	< 0.005	<1	30%	Pass	
Vanadium (filtered)	mg/L	< 0.005	0.005	20	30%	Pass	
Zinc (filtered)	mg/L	0.018	0.019	5.5	30%	Pass	
Mercury (filtered)	mg/L	< 0.0001	< 0.0001	<1	30%	Pass	
[Spike of 10-De00900 - BATCH] - % Recovery							
Alkali Metals		Result 1					
Calcium	%	121			70 - 130	Pass	
Magnesium	%	104			70 - 130	Pass	
Potassium	%	113			70 - 130	Pass	
Sodium	%	129			70 - 130	Pass	
[Spike of 10-De02262 - BATCH] - % Recovery							
		Result 1					
Chemical Oxygen Demand (COD)	%	97			70 - 130	Pass	
Chloride	%	117			70 - 130	Pass	
Ferrous Iron - Fe2+	%	106			70 - 130	Pass	
Fluoride	%	117			70 - 130	Pass	
Nitrate (as N)	%	94			70 - 130	Pass	
Nitrite (as N)	%	88			70 - 130	Pass	
Phosphorous filterable reactive (P)	%	99			70 - 130	Pass	
Sulphate (as SO4)	%	118			70 - 130	Pass	
Sulphide (S)	%	98			70 - 130	Pass	
Total Kjeldahl Nitrogen (N)	%	107			70 - 130	Pass	
[Spike of 10-De01287] - % Recovery							
Alkalinity		Result 1					
Total Alkalinity as CaCO3	%	92			70 - 130	Pass	
[Spike of 10-De01522 - BATCH] - % Recovery							
Heavy Metals		Result 1					
Arsenic (filtered)	%	83			70 - 130	Pass	
Barium (filtered)	%	87			70 - 130	Pass	
Beryllium (filtered)	%	91			70 - 130	Pass	
Boron (filtered)	%	90			70 - 130	Pass	
Cadmium (filtered)	%	93			70 - 130	Pass	
Chromium (filtered)	%	99			70 - 130	Pass	
Cobalt (filtered)	%	87			70 - 130	Pass	
Copper (filtered)	%	83			70 - 130	Pass	
Lead (filtered)	%	84			70 - 130	Pass	
Manganese (filtered)	%	91			70 - 130	Pass	
Nickel (filtered)	%	83			70 - 130	Pass	
Tin (filtered)	%	92			70 - 130	Pass	
Vanadium (filtered)	%	94			70 - 130	Pass	
Zinc (filtered)	%	84			70 - 130	Pass	
Mercury (filtered)	%	90			70 - 130	Pass	

Comments

Sample Integrity

Custody Seals Intact (if used)	N/A
Attempt to Chill was evident	Yes
Sample correctly preserved	Yes
Organic samples had Teflon liners	Yes
Sample containers for volatile analysis received with minimal headspace	No
Samples received within HoldingTime	Yes
Some samples have been subcontracted	No

Authorised By



Michael Wright
NATA Signatory

Final report - this Report replaces any previously issued Report

- Indicates Not Requested

* Indicates NATA accreditation does not cover the performance of this service

Uncertainty data is available on request

mgt-LabMark shall not be liable for loss, cost, damages or expenses incurred by the client, or any other person or company, resulting from the use of any information or interpretation given in this report. In no case shall mgt-LabMark be liable for consequential damages including, but not limited to, lost profits, damages for failure to meet deadlines and lost production arising from this report. This document shall not be reproduced except in full and relates only to the items tested. Unless indicated otherwise, the tests were performed on the samples as received.

WESTERN RADIATION SERVICES

ABN 17 053 332 602

13 January 2011

Ref: WRS-J6250
Order No: 9263

Australian Groundwater Technologies Pty Ltd
Unit 5, 1 London Road
MILE END SOUTH SA 5031

Attn: Nikki Fotheringham

ANALYTICAL REPORT

The results (to 95%, 2σ confidence level) for Radium-226 analyses of three (3) liquid samples as received at our laboratory on 10 December 2010 are detailed below.

WRS No.	Client Sample ID	Ra-226 (Bq/l)
25857	MRE001	23.6 ± 1.7
25858	MRE002	3.26 ± 0.32
25859	MRE003	20.5 ± 1.5

MDL: Radium-226 0.003 Bq/l

Method: LTP No. 3 Radium 226 Analysis

Madassar A. Qureshi
Authorised Signatory

NATA

NATA Accreditation Number 14174

This document is issued in accordance with NATA's accreditation requirements. Accredited for compliance with ISO/IEC 17025. This document shall not be reproduced, except in full.

Unit 15, 88-90 Briggs St, Welshpool, PO Box 418, Cloverdale, W.A. 6985
Tel: (08) 9470 3000 Fax: (08) 9470 3001
E-Mail: admin@westernradiation.com.au
www.westernradiation.com.au

Annotated sections from the Mullaquana Aquifer Testing (AGT,2011) Report

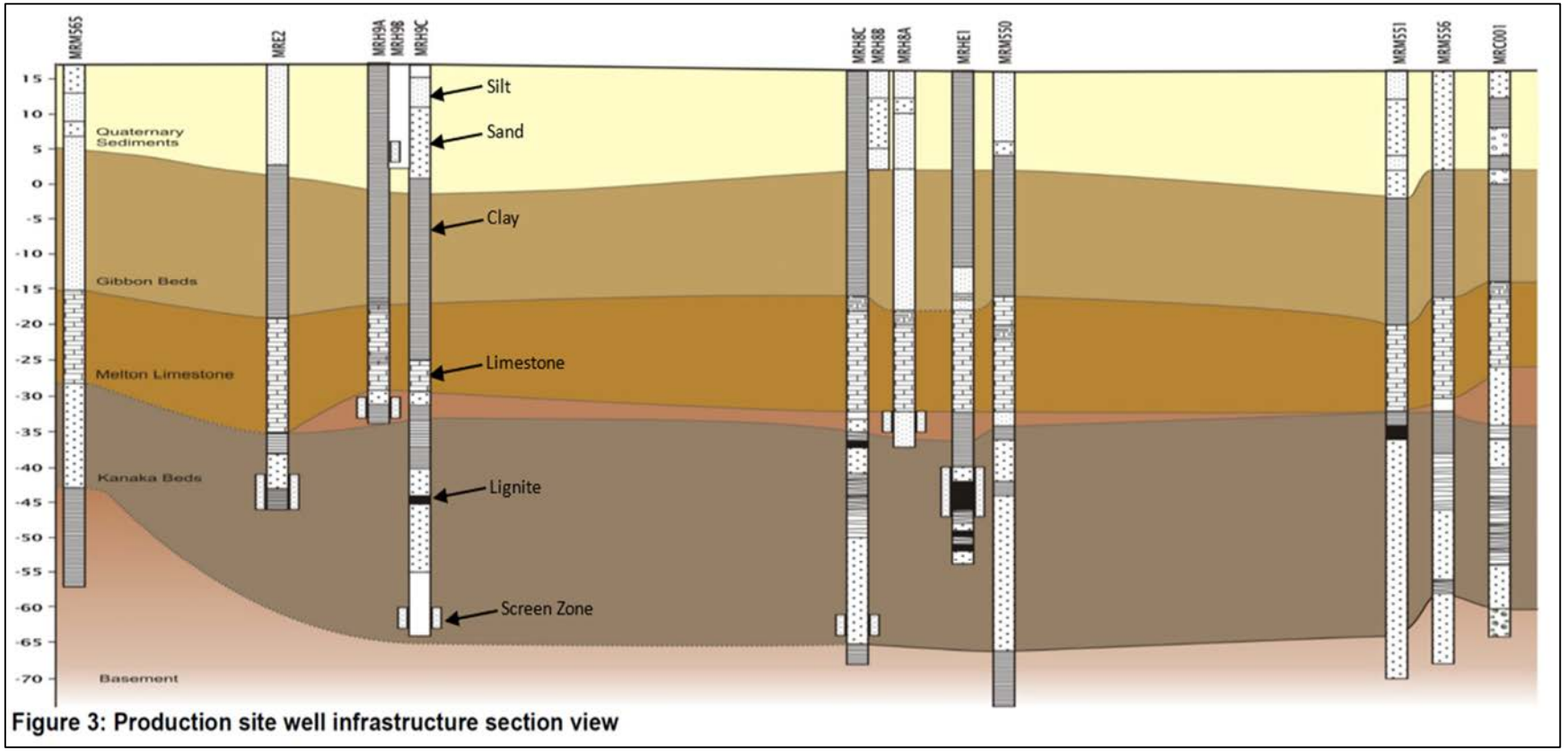


Figure 3: Production site well infrastructure section view

Note: MRM565 and MRH8A drill cuttings initially logged as silt but interpreted as gibbon clays by geologist as is reflected in this cross section. Subsequent confirmation of this interpretation was completed through visual inspection of the drill cuttings collected at the time of drilling.

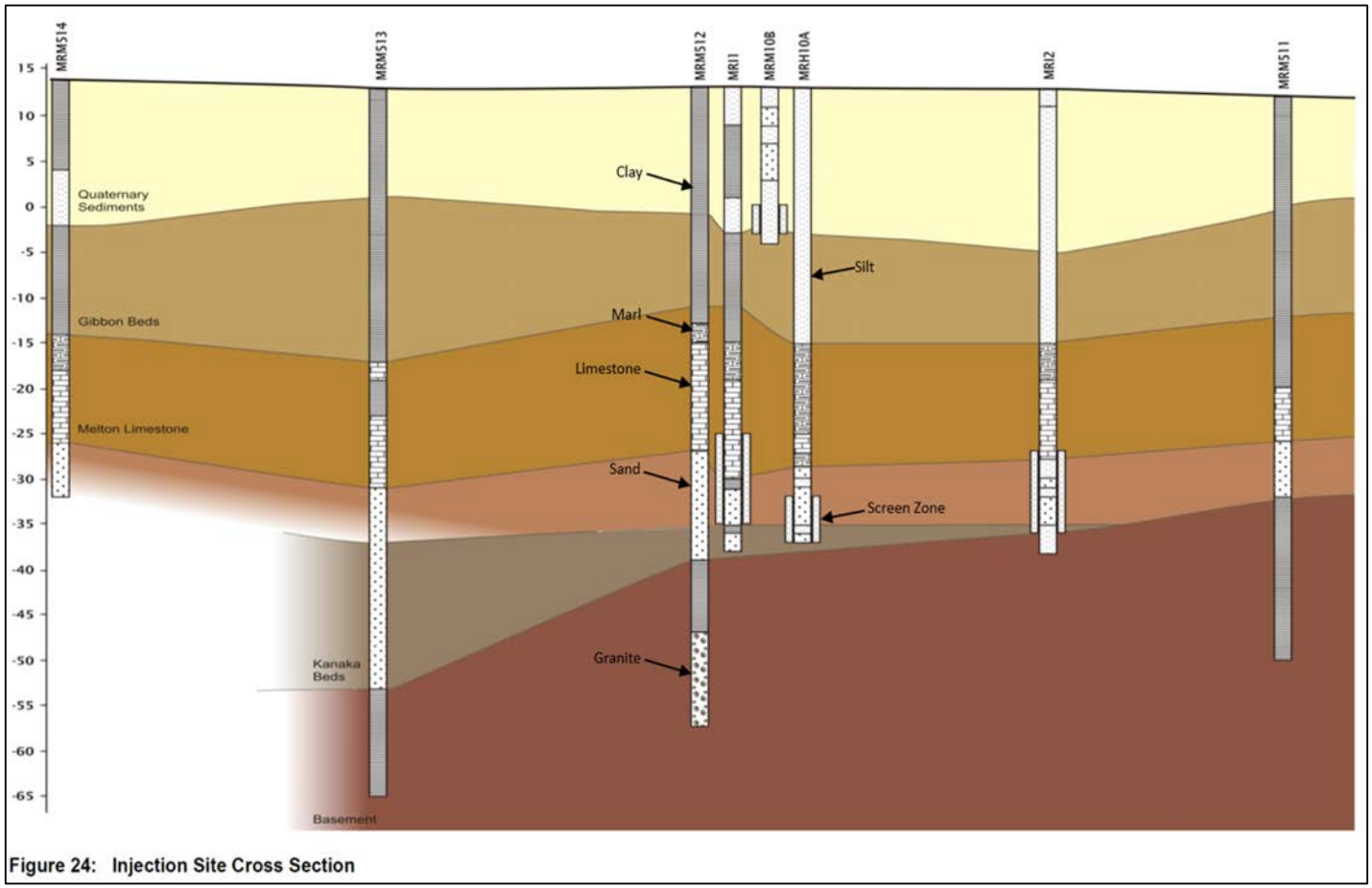


Figure 24: Injection Site Cross Section

Note: MRH10A and MRI2 drill cuttings initially logged as silt but interpreted as gibbon clays by geologist as is reflected in this cross section. Subsequent confirmation of this interpretation was completed through visual inspection of the drill cuttings collected at the time of drilling.

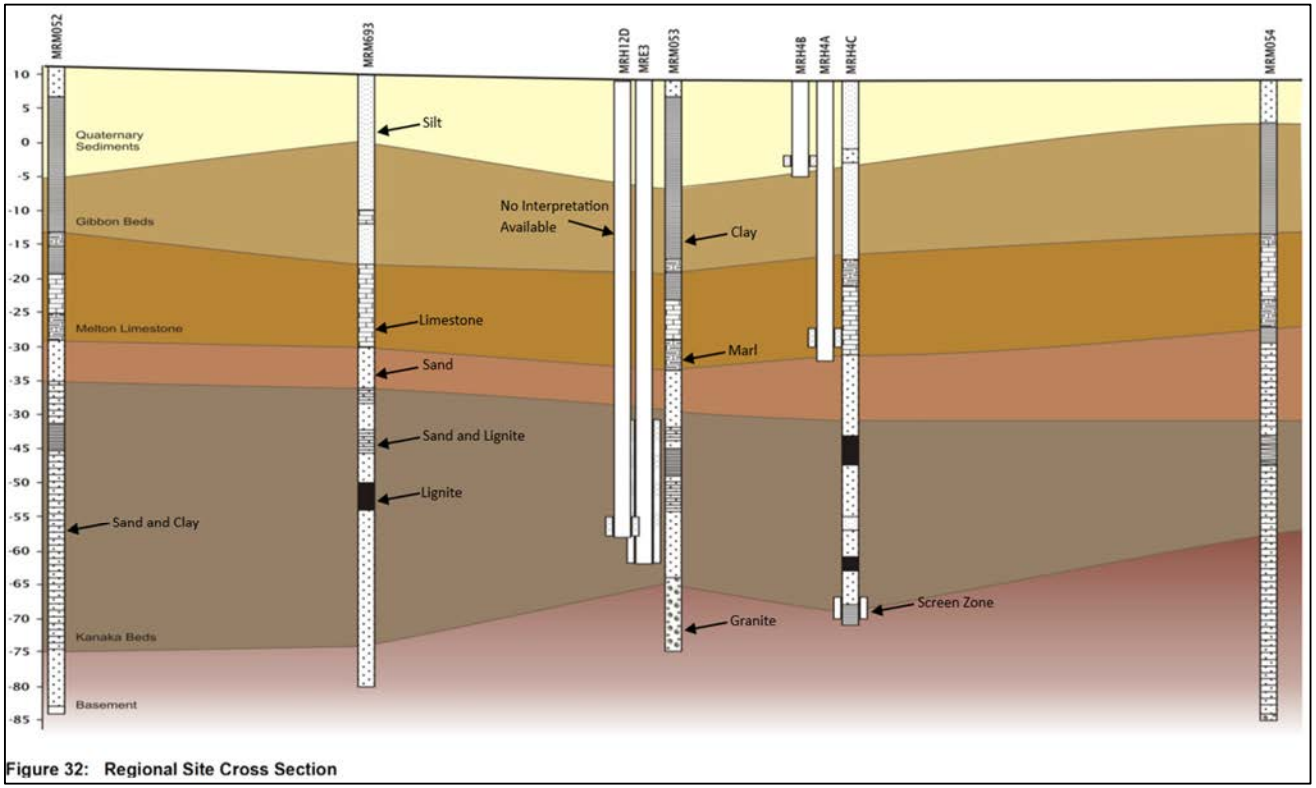


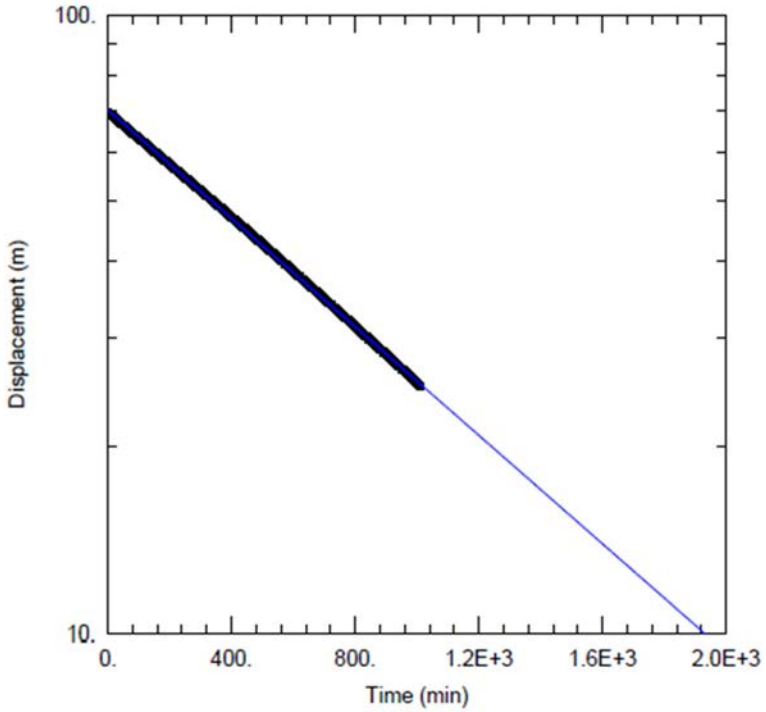
Figure 32: Regional Site Cross Section

Note: MRM693 and MRH4C drill cuttings initially logged as silt but interpreted as gibbon clays by geologist as is reflected in this cross section. Subsequent confirmation of this interpretation was completed through visual inspection of the drill cuttings collected at the time of drilling.

Drill cutting logs for MRH12D, MRE3, MRH4B and MRH4A were not available at the time of compiling this cross section and these wells were included to show relevant screen depths. MRM053 and MRH4C have been used as representative holes due to their close proximity (in the order of 7-50m)

D4: Fractured Rock Aquifer Drawdown Analysis – Alligator Energy, 2023.

Analysis of Recovery Data Post Development of Investigation Well SUMW02



SUMW02

Data Set: C:\...\SUMW02_slug.aqt
Date: 07/17/23 Time: 14:09:20

PROJECT INFORMATION

Test Well: SUMW02

AQUIFER DATA

Saturated Thickness: 150. m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (SUMW02)

Initial Displacement: 69.67 m
Total Well Penetration Depth: 49. m
Casing Radius: 0.062 m
Static Water Column Height: 128.2 m
Screen Length: 48. m
Well Radius: 0.062 m

SOLUTION

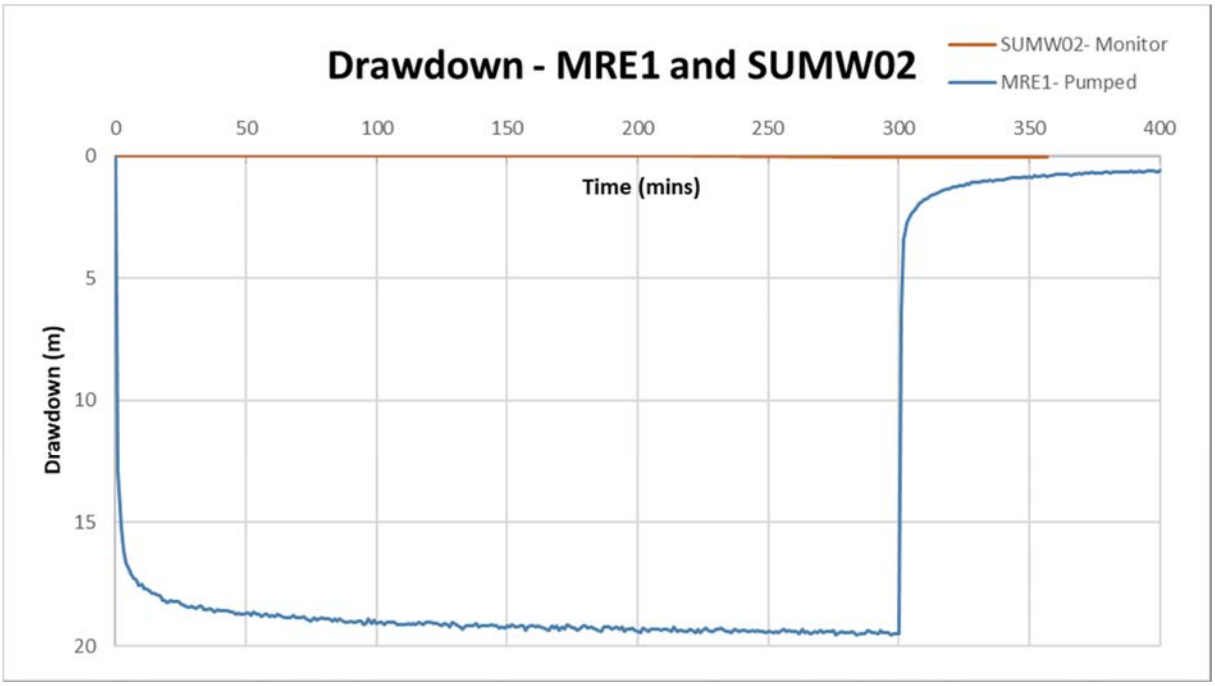
Aquifer Model: Confined Solution Method: Hvorslev
K = 0.0003873 m/day y0 = 70.21 m

Hydraulic Conductivity Analysis of Well SUMW02

In May 2023 water levels in MRE1 and SUMW02 were monitored while filling the exploration drilling water supply tanks (existing infrastructure approved under ePEPR 2022-033). Monitoring this event allowed us to further our understanding of the relationship between the Tertiary aquifer and the underlying Fractured Rock aquifer. A Tertiary well, MRE1, was pumped for 5 hours at a

rate of 6 L/s to fill our drilling supply tanks which have a capacity of 100,000 L; drilling water was concurrently removed from the tanks to supply the 2 drill rigs onsite. A Fractured Rock investigation well, SUMW02, located 20m from the pumped well was also being monitored during this time. Data collected from both wells was corrected for changes in barometric pressure and analysed using the Hvorslev (1951) equation and Aqtesolv software.

SUMW02 showed no drawdown as a result of pumping and therefore there is no connection between the Tertiary and Fractured Rock aquifers at this location.



Drawdown in MRE1 (Pumped Kanaka Well) and SUMW02

D5: Samphire Project Field Recovery Trial – Groundwater Pathways to the Spencer Gulf. Technical Note PS212148-WSP-ADL-MNG-LTR Rev2, prepared by WSP Australia Pty Ltd for Alligator Energy Ltd, March 2024.

Our ref: PS212148-WSP-ADL-MNG-LTR-00001 Rev2

6 March 2024

Emma Thomas
Senior Hydrogeologist
Alligator Energy
PO Box 338,
Spring Hill Qld 4004

Dear Emma

Samphire Project Field Recovery Trial - Groundwater Pathways to the Spencer Gulf

Please find the following memorandum which relates to the Samphire Uranium Project on the Eyre Peninsula, South Australia. WSP have been engaged to provide a hydrogeological opinion on groundwater pathways between the proposed field leach trial and the Spencer Gulf.

Findings from our evaluation are contained within.

Thank you for the opportunity to conduct this review. If you have any queries, please contact Paul Magarey on the details below.

Yours sincerely

Paul Magarey
Principal Hydrogeologist

Jason van den Akker
Principal Hydrogeologist

cc: Alligator Energy - Andrea Marsland-Smith

Level 17, 83 Pirie Street
Adelaide SA 5000
GPO Box 398
Adelaide SA 5001

Tel: +61 8 8405 4300
Fax: +61 8 8405 4301
www.wsp.com

WSP acknowledges that every project we work on takes place on First Peoples lands.
We recognise Aboriginal and Torres Strait Islander Peoples as the first scientists and engineers and pay our respects to Elders past and present.

1. Context and scope of work

WSP Australia (WSP) have been engaged by Alligator Energy to assist with groundwater reviews for their proposed field recovery trial (FRT) on the Eyre Peninsula. The FRT is proposed to evaluate the feasibility of mining at the Blackbush deposit via in-situ recovery (ISR) methods. The proposed trial is accompanied by a retention lease (RL) application recently submitted to the Department for Energy and Mining (DEM). As currently proposed, the FRT will comprise a number of injection and extraction wells targeting the Kanaka Beds, a Tertiary aged sand sequence at the base of the regional Tertiary succession (AGT, 2011). The site of the FRT is approximately 3.5 km west of the Spencer Gulf and is 20 km south of Whyalla.

Recently the RL and FRT application has been lodged with the DEM. As part of statutory consultation process DEM have received a number of submissions from members of the public expressing concern with the proposal. Key concerns relate to impacts the FRT may have on the Spencer Gulf and specifically, the potential for uranium rich fluids to discharge to the ocean.

Whilst not stated explicitly, it is assumed that a key concern of the community is the potential for direct discharge to the sea floor which could then impact ecosystems and humans via direct or indirect contact. This is on the basis that:

- Mining fluid would contain groundwater with elevated uranium and low pH.
- Mining fluids would migrate towards the coast from the FRT site.
- Discharge to the Gulf would occur as a point source to the sea floor, similar to a spring vent on the land surface.

This memorandum explores the concepts above and its likelihood by considering available geological, geophysical (seismic) and hydrogeological data. The WSP scope of work included:

- Review technical reports provided by Alligator Energy to understand the hydrogeological environment of the FRT site.
- Review the seismic data available for the Spencer Gulf off-shore of the FRT trial site.
- Provide an opinion with respect to the groundwater pathways between the target Kanaka Beds and the marine floor environment.
- Provide commentary with respect to risk associated with the proposed FRT.

2. Geological data and seismic interpretation

Alligator Energy (and its predecessor Uranium SA) completed a series of geology and groundwater investigations including work by AGT (2011). Additionally, seismic survey of the Spencer Gulf region offshore of the FRT site was completed in 1994 (PIRSA, 1994). This data was obtained from DEM and re-interpreted by a qualified geophysicist (Jensen-Smith, 2011). WSP has reviewed this information to correlate geology at the FRT site (onshore) with seismic data off-shore. This is important to evaluate the likely geological continuity of aquifers and confining beds and likely groundwater flow paths.

The following key comments are noted from reviews of technical reports:

AGT, 2011.

- The target aquifer for the FRT is the Tertiary Aquifer comprising the Miocene aged Melton Sands and Eocene aged Kanaka Beds. The Kanaka Beds are the main component of this aquifer and consist of fine to coarse sands at the base of the Tertiary sediments (Pirie Basin). The upper part of the sequence comprises of lignitic[1] sands and is capped with a white clay (termed pipeclay per AGT, 2011). It is underlain by highly weathered granite described as saprolite.
- The Kanaka Beds are overlain by Melton Limestone and Gibbon Beds. The Melton limestone is described as a marl (calcareous clay) while the Gibbon Beds are described as a plastic clay. The combined thickness of the units is in the order of 30 m to 40 m at the site. Together they are conceptualized as a low permeability unit or confining layer to the main Tertiary Aquifer (Melton Sands and Kanaka Beds).
- Groundwater elevation data measured at the FRT site reports between 2 to 4 m Australian height datum (mAHD) for the Kanaka Beds. Groundwater levels in the overlying Quaternary Sediments are in the order of 1 to 2 mAHD. This confirms potential for upward leakage from the Kanaka Beds into overlying units. Additionally, groundwater is inferred to flow in an easterly direction based on hydraulic data measured at the site. However, hydraulic gradients are low and groundwater movement is inferred to be slow in the order of 1 to 6 m per year.
- Aquifer pumping tests completed on test bores at the FRT site and 1.5 km downgradient report moderate to high aquifer transmissivities (85 m^2/day to 215 m^2/day), while test pumping analysis confirms that leakage was not detected during the 5-day pumping tests. This confirms that the overlying marl and clay is an effective barrier to flow, with limited connected pore space to transmit groundwater.
- Groundwater salinity at the FRT site is saline to hypersaline (33,000 to 51,000 mg/L) with environmental value for industrial use. The high salinity is indicative of low annual recharge.

Seismic Report – Jensen- Smith (2011).

The seismic report by Jensen Smith (2011) was evaluated to assess the continuity of stratigraphic horizons offshore to the FRT site. The report includes interpretations from 'seismic reflections' which when combined with available drill data can be used to infer geology sequences offshore. In reviewing the report the following is noted:

- The sea floor and sub-floor stratigraphic horizons are clearly discernible in the seismic reflection data (Attachment A).
- The basement rock (Proterozoic bedrock) is seen to be undulating, with peaks and troughs in the bedrock profile.
- Kanaka Beds (and Melton Sands) are seen to infill and on-lap the bedrock, indicating variable thickness depending on bedrock topography.
- The Gibbon Beds and Melton Limestone are clearly visible in the seismic data and report thicknesses in the order of 20 m each. This is consistent with thickness observed in the on-shore position at the FRT site.
- The contacts between the Kanaka Beds, Melton Limestone, Gibbon Beds are relatively flat with no obvious dip. No stratigraphic off-sets are seen in the Tertiary sequences to indicate displacement by faulting. This suggests that the units are competent and maintain their structural integrity below the ocean.

---

1 broken down plant matter

3. Discussion and Conclusions

Our review has been undertaken to assess the geology and hydrogeological setting of FRT site, offshore geology and the potential discharge mechanisms of groundwater from the Tertiary Kanaka Beds. Based on reviews the following is noted:

- The target aquifer units for the FRT are the Tertiary Kanaka Beds and Melton Sands. These units are continuous offshore as interpreted from seismic reflection data.
- Groundwater elevation in the Kanaka Beds report at ~3 mAHD at the FRT site and is interpreted to flow in an easterly direction.
- Based on geological and hydrogeological data, groundwater will continue to flow east within the Kanaka Beds and will remain confined, with potential for upward leakage restricted by the calcareous marls and clays of the Melton Limestone and Gibbon Beds. This evaluation is supported by aquifer testing at the site (AGT, 2011), with no discernible leakage evident from overlying and underlying units when pumping from the Kanaka Beds. This confirms that the overlying tertiary confining beds (Melton Limestone and Gibbon Beds) are competent with very low permeability. These overlying marls and clay are interpreted to extend offshore in the western side of the Spencer Gulf.
- When considering discharge of groundwater from a confined aquifer into an overlying water body (lake, ocean) the main discharge mechanisms are:
    - Point source discharge which may occur via a spring, vent or preferential zone generated by a fault;
    - diffuse discharge, which is the slow, upward movement of groundwater via the overlying aquitard (low permeability clay or marl). The rate of diffuse discharge is governed by the hydraulic properties of the aquitard and pressure difference between the aquifer and the water body, which in this case is very low.
- Based on reviews it is apparent that the Tertiary Kanaka Beds are hydraulically isolated from the overlying sediments and sea floor with no evidence for point source discharge of groundwater from the Tertiary Aquifer. Therefore point source discharge to the ocean is unlikely.
- Diffuse discharge is deemed to be the primary discharge mechanism of groundwater from the Tertiary Kanaka Beds. This is expected to occur very slowly and across a wide area, as the water is required to move through 30 to 40 m of low permeability clay / marl.
- Based on hydraulic gradient between the Kanaka Beds and Sea level (3 m upward gradient), travel time for groundwater movement from the Kanaka Beds through the overlying confining layers (clay / marl) is estimated at around 4700 years. This assumes:
    - clay thickness of 30 m (confining bed thickness)
    - An upward hydraulic gradient of 0.1 m
    - literature values for plastic clay and marl materials of 8.64×10^{-6} m/day, with effective porosity of 0.05 (Freeze and Cherry, 1979).

  Thus, discharge to the Gulf will be very slow and in the order of thousands of years.
- This assessment does not consider natural attenuation of mining fluids which has been modelled to occur within a distance of 400 m from the FRT wells (UIT, 2024).

4. Closing

Thank you for the opportunity to provide this review. If you have any queries please contact Paul Magarey at paul.magarey@wsp.com.

5. References

AGT (2011). *Mullaquana Project Hydrogeological Setting*. AGT Report no: UAC-1043-R003 March 2011

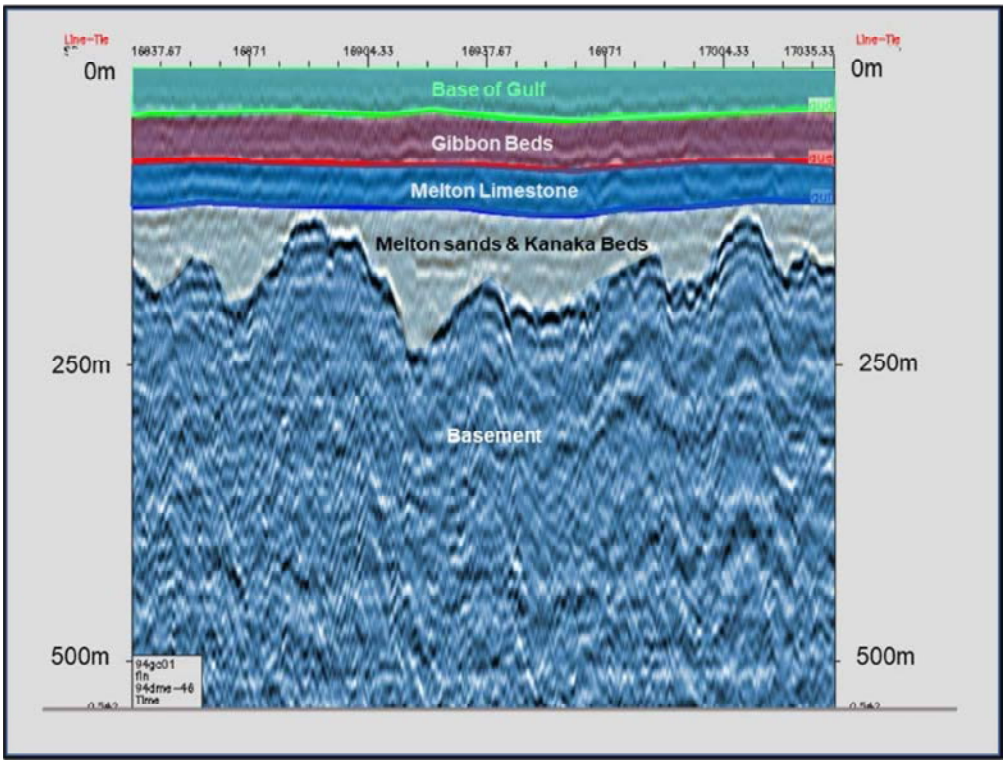
Freeze, R.A. and Cherry, J.A., (1979). *Groundwater*. Prentice Hall Australia, May 1979.

Jensen-Smith, B., (2011). *Spencer Gulf Seismic Survey Report*. Report for Uranium SA's In-situ Recovery Field Trial, Mullaquana Project. 28th July 2011, Revision 4.

UIT (2024). *Natural Attenuation Study for Field Recovery Trial at the Samphire Tenement in South Australia*. UIT GmbH Dresden Zum Windkanal 21, D-01109 Dresden, Germany. February 2024.

Attachment A
Seismic Reflection Data in the Spencer Gulf

A.1 Seismic Reflection Data in the Spencer Gulf (after Jensen Smith, 2011).



Appendix E: Hydrogeological – Baseline Groundwater Quality

E1: Baseline Groundwater Quality Data

| | | | Physico-chemical Parameters | | | | | | | | | | Dissolved Metals | | | | | | | | | |

| Physico-chemical Parameters | | | | | | | | | | | | | Dissolved Metals | | | | | | | | | | | | |

| Analyte | | | Physico-chemical Parameters | | | | | | | | | | Dissolved Metals | | | | | | | | | |

| Analyte | | | Physico-chemical Parameters | | | | | | | | | | Dissolved Metals | | | | | | | | | |

E2: Samphire Project – Excursion Control Parameter & Control Limit Calculations

Excursion Control Limit Determination - Tertiary Aquifer

	pH	TDS (mg/L)	Uranium (mg/L)	Sulphate (mg/L)
# Observations	257	258	268	264
# Detects	257	258	268	264
Minimum Detect	5.7	32,300	0.00	2,100
Maximum Detect	7.6	65,480	0.47	5,940
# Non-detects	-	-	-	-
Minimum Non-detect	-	-	-	-
Maximum Non-detect	-	-	-	-
% Non-detects	-	-	-	-
Mean	6.8	43,407	0.11	3,605
St. Dev	0.3	7,968	0.09	629
Interquartile Range				
10th Percentile	6.5	34,518	0.02	2,935
20th Percentile	6.6	35,580	0.03	3,100
25th Percentile	6.6	36,196	0.03	3,190
50th Percentile	6.7	43,850	0.06	3,505
75th Percentile	6.9	48,200	0.17	3,898
80th Percentile	6.9	49,820	0.19	4,010
90th Percentile	7.1	55,900	0.22	4,500
95th Percentile	7.3	59,715	0.26	4,950
99th Percentile	7.3	62,187	0.43	5,732
Median	6.7	43,850	0.06	3,505
MEAN	6.8	43,407	0.11	3,605
3x Stdev	0.8	23,904	-	1,886
5x Stdev	-	-	0.46	-
ECL - Calculated	6.0	-	0.56	5,491
Barren Lixiviant	1.5		30	7,500
ECL-RLA Calc	5.8		1	5,845
ECL-PEPR Calc	6.0		0.56	5,491
% Difference	2.5%		NA	6.1%

Excursion Control Limits (ECLs) were calculated for the Tertiary aquifer on a small dataset (42 samples) for the Retention Lease Application (RLA) and have been recalculated for the PEPR using a much more extensive dataset. The full data set used for the calculations in the above table are presented in Appendix E, the data set includes 271 sampling events.

The recalculation showed only a small change from the initial calculation for pH and SO4, confirming the initial values presented in the RLA are valid. While uraium calculations also showed little variation from initial values presented in the RLA, AGE has reviewed the methodology in consultation with government agencies and propose the uranium ECL value of 0.56 mg/L. the value is calculated using a 5x standard deviation which takes into account the high potential of false positives where the ECL value falls with the baseline values creating a non-compliance when the value is within natural variation. Futher justification and discussion on calculation of ECLs is provided in the PEPR document.

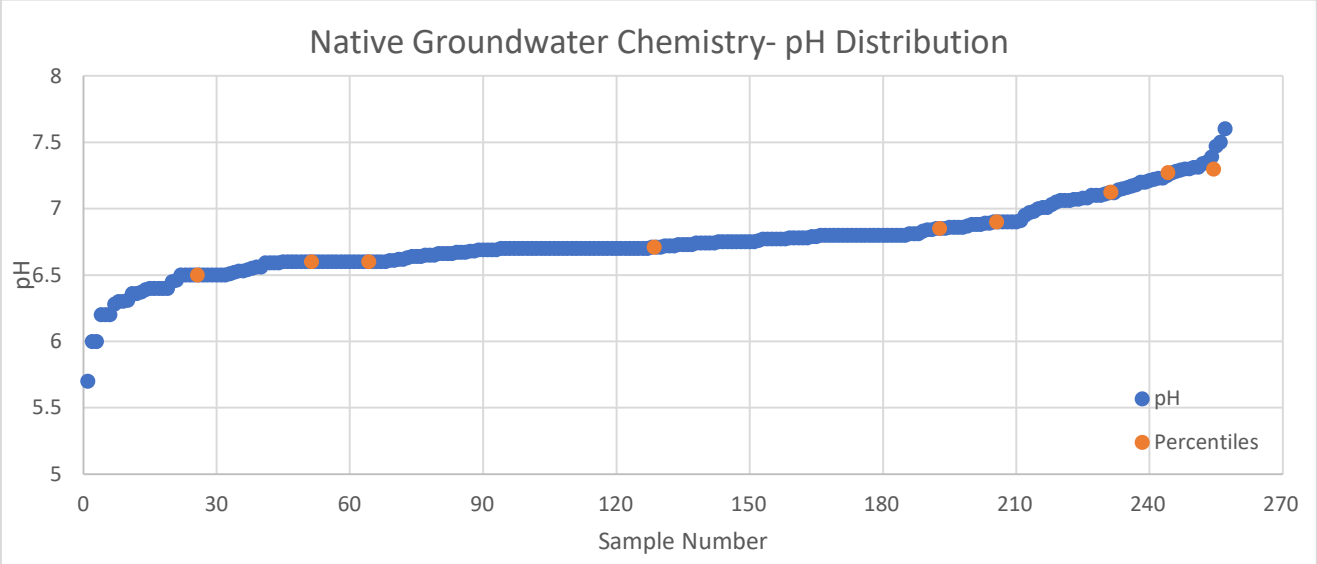
ECL Determination

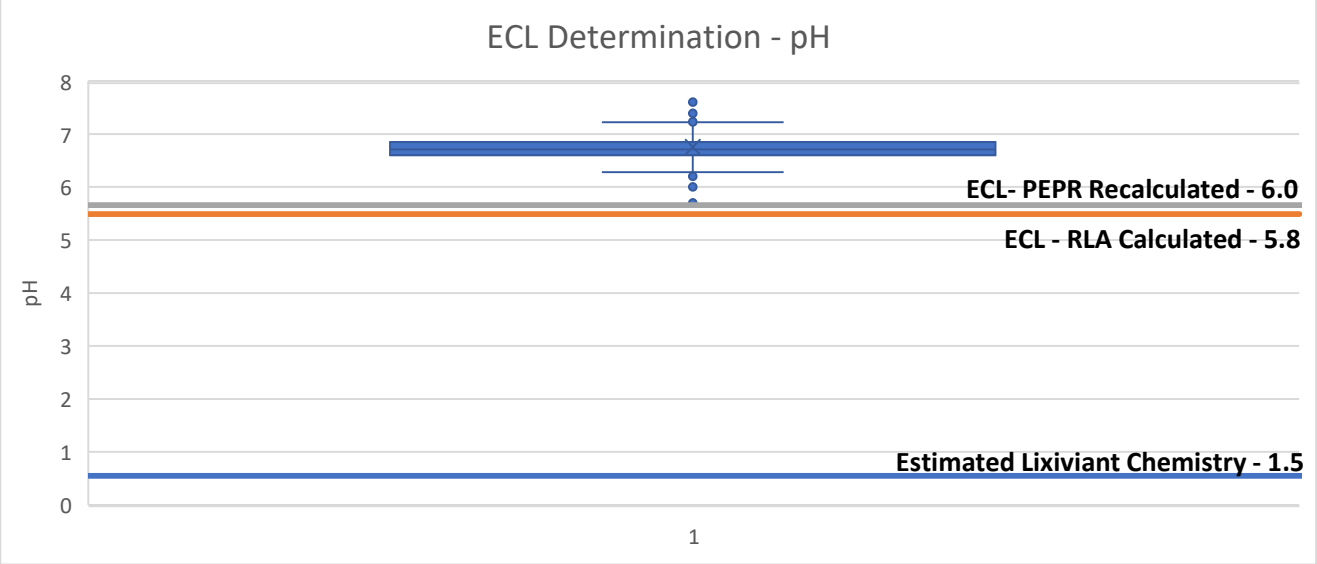
AGE propose the use of the following ECL values:
pH 5.8
Sulphate 5,845 mg/L
Uranium 0.56 mg/L

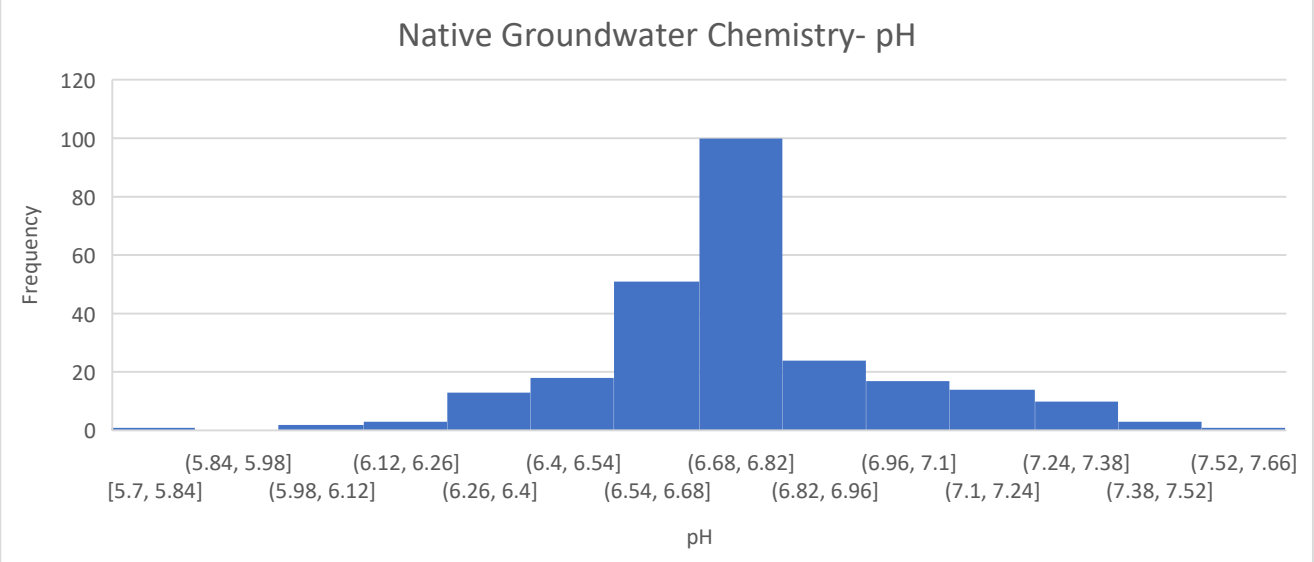
The following charts show:
1. Data distribution and the percentiles shown on the main page for each parameter. This chart was used to indicate and remove any anomalous data from the data set and shows the variability in the data along with any step changes in parameters that could indicate a sub population within the main dataset.
2. Box and whisker plot along with estimated lixiviant concentrations and calculated Excursion Control Limits. Once ECL has been calculated this plot will indicate if the value is appropriate through visually showing any outliers that fall outside of the ECL and also the difference between the dataset, ECL and estimated lixiviant chemistry.
3. Histogram to demonstrate data distribution pattern.

General Comments
- pH, sulphate and uranium ECL values are appropriate with calculated values showing unlikely to produce false positives and will demonstrate distinct change from native groundwater chemistry towards estimated lixiviant.
- Sulphate and pH demonstrate normal data distribution.

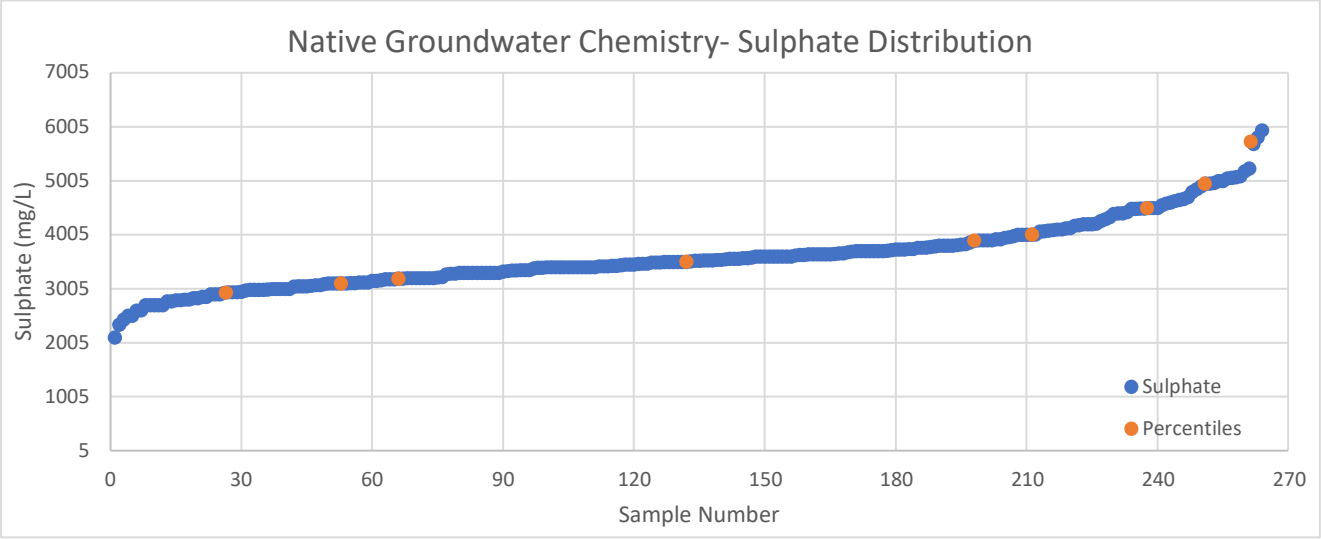
Excursion Control Limit Determination- pH

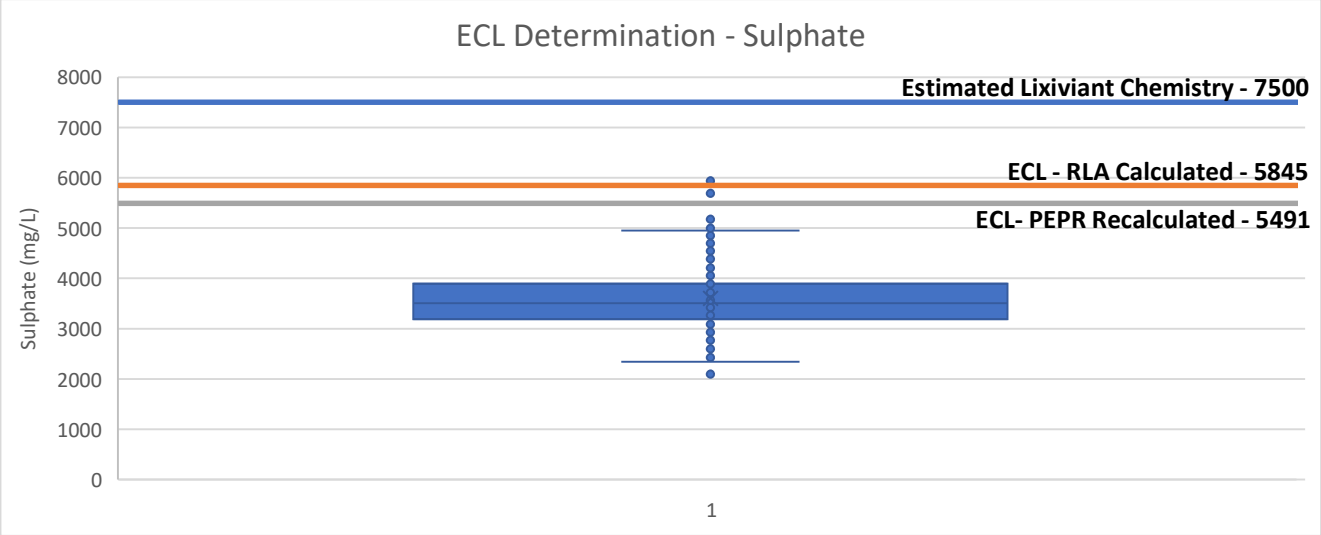


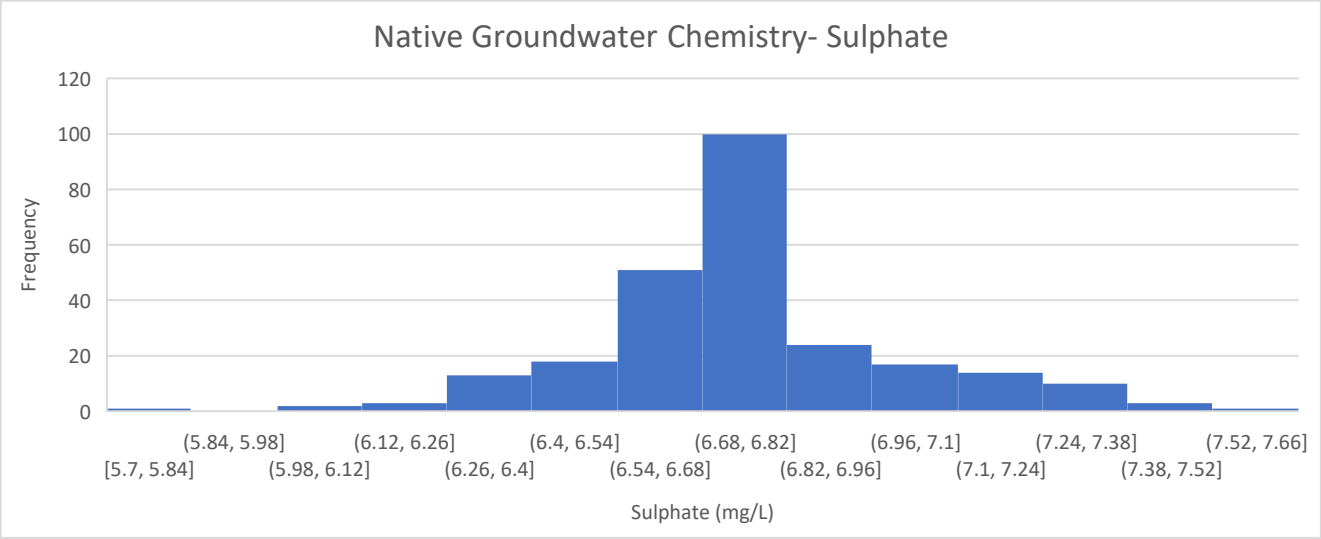




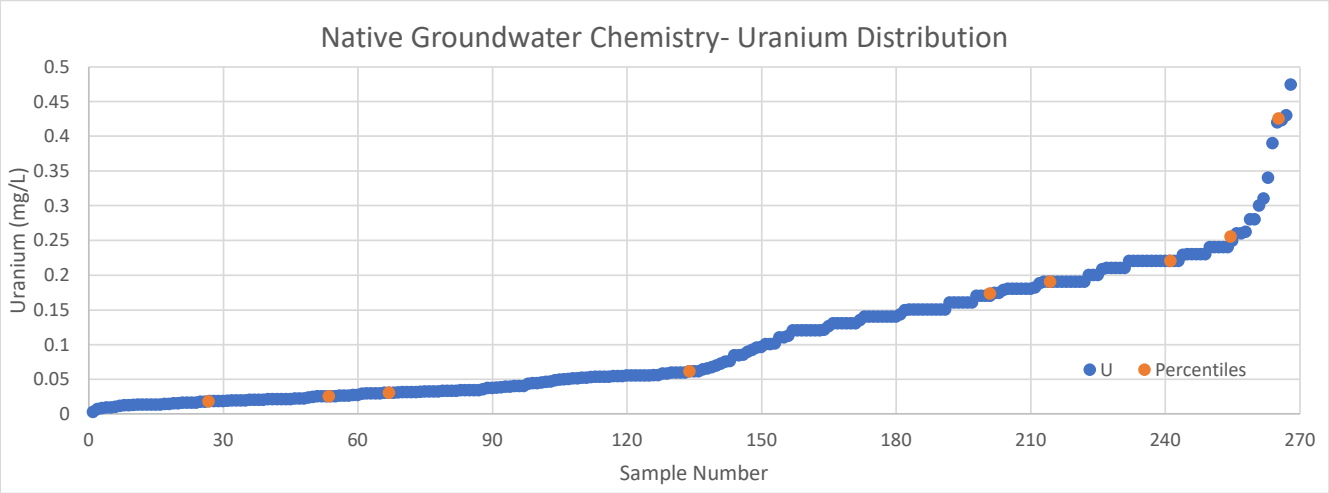
Excursion Control Limit Determination- Sulphate

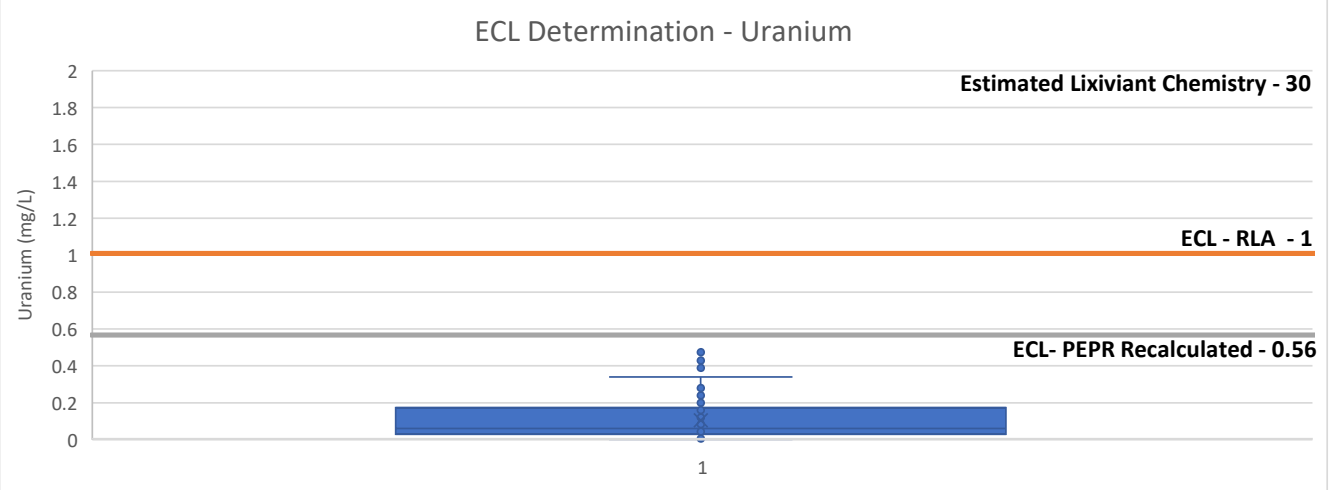


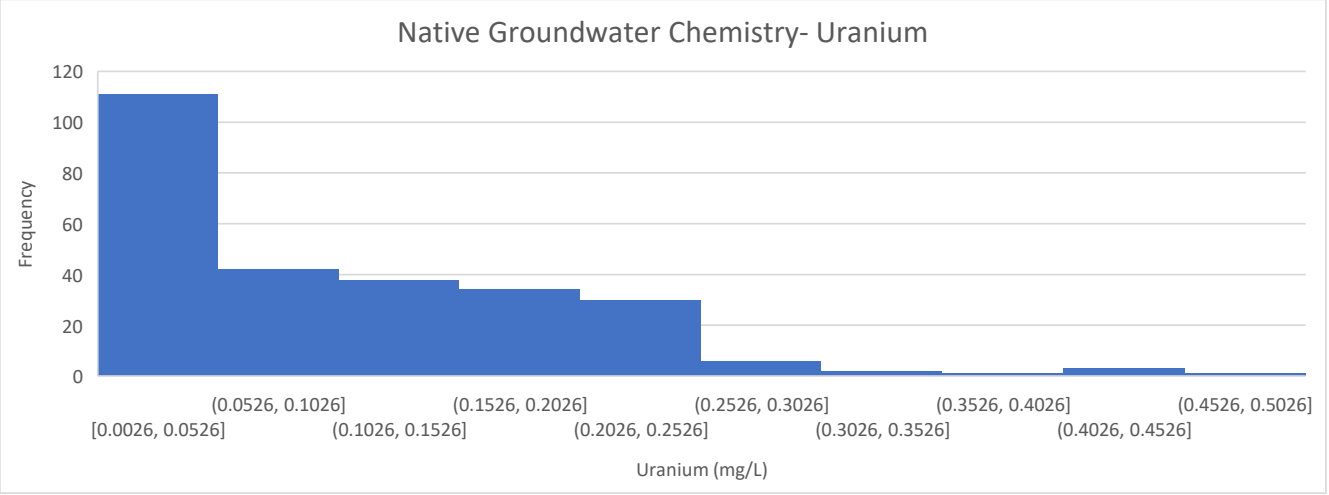




Excursion Control Limit Determination- Uranium







Appendix F: Natural Attenuation Modelling Report & Data Outputs

F1: Natural Attenuation Study for FRT at the Samphire tenement in South Australia. Report prepared by Umwelt- und Ingenieurtechnik GmbH Dresden (UIT GmbH Dresden) for Alligator Energy Limited, March 2024.

Note: This report states:

> *"Two primary aquifers have been identified beneath the Retention Lease area (Fig. 2.3): the Quaternary and Tertiary aquifers. The confined Tertiary aquifer system hosts the ore-body of interest and is the target for the mining."*

This statement is incorrect and should read:

> *"Two primary aquifers have been identified beneath the Retention Lease area (Fig. 2.3): the Tertiary and Fractured Rock aquifers. The confined Tertiary aquifer system hosts the ore-body of interest and is the target for the mining."*

A third aquifer, the quaternary aquifer, is present to the east of the RL but is unsaturated beneath the RL.

Natural Attenuation

NA Study for FRT at the Samphire tenement in South Australia

– FINAL REPORT –

REVISION 2

submitted to

Alligator Energy
Suite 2, 128 Bowen Street
Spring Hill, QLD 4000 Australia

by

UIT GmbH Dresden
Zum Windkanal 21, D-01109 Dresden, Germany

CONFIDENTIAL

– March 2024 –

FINAL REPORT

REVISION 2

NA Study Samphire

NA Study for FRT at the Samphire tenement in South Australia

AUTHORS: Silvio Kutter
Marcus Veltri
Dr. Jana Nicolai

CONTACT: Dr. Jana Nicolai
Phone: +49-351-8 86 46 12
Fax: +49-351-8 86 57 74
E-Mail: j.nicolai@uit-gmbh.de

CONTENTS

LIST OF TABLES 5
LIST OF FIGURES 7
ABBREVIATIONS AND ACRONYMS 9
1 INTRODUCTION AND OBJECTIVES 11
1.1 Background 11
1.2 Methodology and Reactive-Transport Model (TRN) 12
2 CONCEPTUAL MODEL AND MODEL SETUP 15
2.1 Site Description 15
2.2 Model Setup 18
2.2.1 Overview 18
2.2.2 Hydraulic Model Setup 19
2.2.3 Groundwater Flow Velocity 20
2.2.4 Single vs. Dual Porosity 21
2.2.5 Numerical Dispersion (and its Preclusion) 22
2.2.6 Model Discretization 23
2.2.7 Input Dataset: Hydraulic Parameters 24
2.3 Geochemistry 26
2.3.1 Basic Concept 26
2.3.2 Elements of Mineral Assembly 28
2.3.3 Initial Inventory of Reactive Minerals 29
2.3.4 Aqueous Solutions 31
2.3.5 Ion Exchange on Clay Minerals 32
2.3.6 Dissolution Kinetics with SI Control 33
3 NATURAL ATTENUATION 35
3.1 Definition of Scenarios 35
3.2 Results 37
3.2.1 NA post-FRT 37
3.2.2 Parameter Variation 43
4 SUMMARY 45
5 PUBLICATION BIBLIOGRAPHY 49
APPENDIX 50

LIST OF TABLES

Tab. 2.1 Hydrostratigraphic units (Jeuken 2011a) 16
Tab. 2.2 Averaged groundwater composition from an assumed post-FRT lix composition and mean unaffected groundwater composition over a 30 m aquifer depth. 19
Tab. 2.3 Discretization of the flow path 24
Tab. 2.4 Parameters of 1D TRN column 24
Tab. 2.5 Geochemical factors that influence the concentration of the solutes (TH – pure thermodynamics approach, K – kinetics) 29
Tab. 2.6 Initial inventory Ci(M) of reactive minerals for the model input calculated from wt% 30
Tab. 2.7 Model input for groundwater and lixiviant 31
Tab. 2.8 Kinetic parameters used in TRN 34
Tab. A.1 Concentrations as a function of time. Variant: v = 1.0 m/a. Position: 0.75 m in leach zone. 50
Tab. A.2 Concentrations as a function of time. Variant: v = 1.0 m/a. Position: 1.25 m in leach zone. 50
Tab. A.3 Concentrations as a function of time. Variant: v = 1.0 m/a. Position: 2.25 m in leach zone. 50
Tab. A.4 Concentrations as a function of time. Variant: v = 1.0 m/a. Position: 3.25 m in leach zone. 51
Tab. A.5 Concentrations as a function of time. Variant: v = 1.0 m/a. Position: 4.75 m in leach zone. 51
Tab. A.6 Concentrations as a function of time. Variant: v = 1.0 m/a. Position: 0.75 m in downgradient zone. 51
Tab. A.7 Concentrations as a function of time. Variant: v = 1.0 m/a. Position: 1.25 m in downgradient zone. 52
Tab. A.8 Concentrations as a function of time. Variant: v = 1.0 m/a. Position: 2.25 m in downgradient zone. 52
Tab. A.9 Concentrations as a function of time. Variant: v = 1.0 m/a. Position: 3.25 m in downgradient zone. 52
Tab. A.10 Concentrations as a function of time. Variant: v = 1.0 m/a. Position: 4.75 m in downgradient zone. 53
Tab. A.11 Concentrations as a function of time. Variant: v = 1.3 m/a. Position: 0.75 m in leach zone. 54
Tab. A.12 Concentrations as a function of time. Variant: v = 1.3 m/a. Position: 1.25 m in leach zone. 54
Tab. A.13 Concentrations as a function of time. Variant: v = 1.3 m/a. Position: 2.25 m in leach zone. 55
Tab. A.14 Concentrations as a function of time. Variant: v = 1.3 m/a. Position: 3.25 m in leach zone. 55
Tab. A.15 Concentrations as a function of time. Variant: v = 1.3 m/a. Position: 4.75 m in leach zone. 56

Tab. A.16 Concentrations as a function of time. Variant: v = 1.3 m/a. Position: 0.75 m in downgradient zone. 56
Tab. A.17 Concentrations as a function of time. Variant: v = 1.3 m/a. Position: 1.25 m in downgradient zone. 57
Tab. A.18 Concentrations as a function of time. Variant: v = 1.3 m/a. Position: 2.25 m in downgradient zone. 57
Tab. A.19 Concentrations as a function of time. Variant: v = 1.3 m/a. Position: 3.25 m in downgradient zone. 58
Tab. A.20 Concentrations as a function of time. Variant: v = 1.3 m/a. Position: 4.75 m in downgradient zone. 58
Tab. A.21 Concentrations as a function of time. Variant: v = 6.0 m/a. Position: 0.75 m in leach zone. 59
Tab. A.22 Concentrations as a function of time. Variant: v = 6.0 m/a. Position: 1.25 m in leach zone. 59
Tab. A.23 Concentrations as a function of time. Variant: v = 6.0 m/a. Position: 2.25 m in leach zone. 59
Tab. A.24 Concentrations as a function of time. Variant: v = 6.0 m/a. Position: 3.25 m in leach zone. 60
Tab. A.25 Concentrations as a function of time. Variant: v = 6.0 m/a. Position: 4.75 m in leach zone. 60
Tab. A.26 Concentrations as a function of time. Variant: v = 6.0 m/a. Position: 0.75 m in downgradient zone. 60
Tab. A.27 Concentrations as a function of time. Variant: v = 6.0 m/a. Position: 1.25 m in downgradient zone. 61
Tab. A.28 Concentrations as a function of time. Variant: v = 6.0 m/a. Position: 2.25 m in downgradient zone. 61
Tab. A.29 Concentrations as a function of time. Variant: v = 6.0 m/a. Position: 3.25 m in downgradient zone. 61
Tab. A.30 Concentrations as a function of time. Variant: v = 6.0 m/a. Position: 4.75 m in downgradient zone. 62

LIST OF FIGURES

Fig. 1.1 Modular structure of the Reactive Transport Model TRN 12
Fig. 1.2 Cell structure of 1D reactive transport column 13
Fig. 2.1 Locality Map and Pirie Basin setting (Jeuken 2011b) 15
Fig. 2.2 West – East Cross Section of the study area (Jeuken 2011b) 16
Fig. 2.3 Map of well locations within the retention lease 17
Fig. 2.4 Schematic of FRT area within the Tertiary aquifer (not to scale) 18
Fig. 2.5 Flow path for mine as used for reactive transport 20
Fig. 2.6 Single vs. dual porosity approach 21
Fig. 2.7 Conditions for zero numerical dispersion 23
Fig. 2.8 Longitudinal vs. transversal dispersion 25
Fig. 2.8 Main geochemical transformations within the dual porosity approach (double arrows symbolize reversible processes) 27
Fig. 2.9 Elements and mineral assembly of the “Minimum Model” 28
Fig. 2.10 Initial IX load on clay minerals for the leach zone (left) and downgradient zone (groundwater) (right) 33
Fig. 3.1 Variant v = 1.0 m/a: pH, U, sulfate, and Fe as a function of distance at t = 0, 10, 20, 50, 100, 150. 200 and 250 years 37
Fig. 3.2 Variant v = 1.3 m/a: pH, U, sulfate, and Fe as a function of distance at t = 0, 10, 20, 50, 100, 150, 200 and 250 years 38
Fig. 3.3 Variant v = 6 m/a: pH, U, sulfate, and Fe as a function of distance at t = 0, 5, 10, 25 and 50 years 39
Fig. 3.4 pH, U, sulfate, and Fe as a function of distance. pH value > 5.6 (v 1.0: 210a, v 1.3: 165 a, v 6.0: 42a) 40
Fig. 3.5 Variant v = 1 m/a: pH, U, sulfate, and Fe as a function of time 41
Fig. 3.6 Variant v = 1.3 m/a: pH, U, sulfate, and Fe as a function of time 42
Fig. 3.7 Variant v = 6 m/a: pH, U, sulfate, and Fe as a function of time 42
Fig. 3.8 Pyrite decreased by 50%: U as a function of distance at t = 10 years with v = 6 m/a 43
Fig. 3.9 Comparison with and without uranophane: pH, U, sulfate, and Fe as a function of distance at t = 10 years 44

ABBREVIATIONS AND ACRONYMS

1D	1 dimensional
3D	3-dimensional
DIC	Dissolved Inorganic Carbon
GUI	Graphical User Interface
gw	groundwater
IX	Ion Exchange
FRT	Field Recovery Trial
lix	Lixiviant
NA	Natural Attenuation
ORP	Oxidation-Reduction Potential (in short: redox potential)
SI	Saturation Index
TRN	Reactive Transport Model (developed by UIT)
UIT	Umwelt- und Ingenieurtechnik GmbH Dresden, Germany
USGS	U.S. Geological Survey
wt%	Weight Percent

List of Symbols

a_L	longitudinal dispersion	[L]
a_T	transversal dispersion	[L]
A	cross section (of flow tube)	[L^2]
AEC	anion exchange capacity	[mol/M]
CEC	cation exchange capacity	[mol/M]
c_i	mass concentration of species i ($c_i = m_i/V$)	[M/L^3]
C_i	molar concentration of species i ($C_i = n_i/V$)	[mol/L^3]
C_{TOT}	total ion-exchange capacity	[mol/L^3]
D	diffusion coefficient	[L^2/T]
D_L	longitudinal dispersion ($D_L = a_L\ v$)	[L^2/T]
E_h	measured redox potential (ORP)	[volts]
F	FARADAY constant F = 96 490 J/(mol V)	[J/(mol V)]
H	height of flow tube (or average aquifer thickness)	[L]
i	index of chemical element or mineral phase	unitless
I	ionic strength	[mol/L^3]
K	equilibrium constant	[$(mol/L^3)^x$]
L	length of flow path (or column)	[L]
m	mass	[M]
m_0	initial mass	[M]
m_{core}	core mass ($m_{core} = \rho_b V$)	[M]
m_i	mass of chemical element	[M]
mix_T	transversal dilution factor	[L^3/L^3]
M	molar mass	[M/mol]
n_i	molar amount of chemical element i ($n_i = m_i/M_r$)	[mol]
n_{sites}	number of ion-exchanger sites	[mol]
N	total cell number	unitless

q	flow rate	[1/T]
Q	total discharge (volumetric flow)	[L^3/T]
R	gas constant R = 8.314 J $K^{-1}mol^{-1}$	[J $K^{-1}mol^{-1}$]
r_0	kinetic rate constant	[mol/(L^3T)]
t	time variable	[T]
T	temperature	Kelvin
T	length of simulation time	[T]
T_{dual}	half-life period of dual-porosity mass transfer: $T_{dual} = \ln 2/\alpha_{dual}$	[T]
T_{leach}	length of leaching time	[T]
v	real flow velocity (motion of the molecules)	[L/T]
v_f	specific discharge (filter velocity, DARCY's velocity)	[L/T]
v_T	vertical velocity	[L/T]
V	(total) volume	[L^3]
V_F	'mobile water' pore volume	[L^3]
V_P	'stagnant water' pore volume	[L^3]
x	longitudinal coordinate (spatial variable)	[L]
x_i	fraction of chemical element i in core sample (= m_i/m_{core})	[M/M]
y	coordinate (vertical to x)	[L]
z	elevation coordinate (vertical to x)	[L]
α	dual-porosity mass transfer rate	[T^{-1}]
α_{dual}	normalized dual-porosity mass transfer rate: $\alpha_{dual} = (\varepsilon_T/\varepsilon_{res})\ \alpha$	[T^{-1}]
α_L	longitudinal dispersivity	[L]
α_{TH}	transverse dispersivity in horizontal direction	[L]
α_{TV}	transverse dispersivity in vertical direction	[L]
ΔG	free GIBBS energy	[J]
Δt	width of timestep	[T]
Δx	length of cell	[L]
Δy	width of cell	[L]
Δz	thickness of cell	[L]
ε	porosity	[L^3/L^3]
ε_F	effective porosity (mobile water domain)	[L^3/L^3]
ε_P	porosity of stagnant water domain	[L^3/L^3]
ε_T	total porosity ($\varepsilon_T = \varepsilon_F + \varepsilon_P$)	[L^3/L^3]
ρ_b	bulk density	[M/L^3]

1 INTRODUCTION AND OBJECTIVES

1.1 Background

The Samphire Project owned by Alligator Energy Ltd was previously owned by Uranium South Australia and has historically been referred to as the Mullaquana Project or Blackbush Uranium Deposit. The project was taken through a range of regulatory approvals for a field leach trial in 2010-2011; however, final approval was not received prior to the project being put on hold in 2011. The project was acquired by Alligator Energy in 2021, and approvals to undertake a 3-month field recovery trial (FRT) recommenced.

An existing baseline aquifer characterization, groundwater quality assessments and a basic hydrogeological model and natural attenuation assessment were completed in 2011 by Australian Groundwater Technologies Pty Ltd in the following reports:

- "Mullaquana Project Hydrogeological Setting" – Report by Australian Groundwater Technologies (AGT), 2011 (Jeuken 2011b)
- "Mullaquana Aquifer Testing" – Report by Australian Groundwater Technologies, 2011 (Jeuken 2011a)

At the time of the original FRT proposal, these hydrogeological assessments were deemed sufficient from a regulatory perspective, however new requirements under the South Australian Mining Act have been recently released that require more in-depth hydrogeological assessments particularly in relation to the natural attenuation of residual mining fluids.

The new requirements specify upgrades to the existing hydrogeological investigations and preliminary natural attenuation assessments.

The key regulatory requirements require Alligator Energy to be able to detail the following in approval documents:

- Predicted rate, distance and extent of residual mining post field leach trial.
- Predicted attenuated groundwater quality (based on aqueous geochemistry) based on the quantified aquifer characteristics, volumes, rates and chemical makeup of residual mining fluid.
- A description of any significant degree of uncertainty or limitations on modelling and quality of data, and any further verification required post FRT completion (e.g., field monitoring).

Scope of Work. According to the proposal, the study comprises the following tasks:

Task 1 – Literature and Data Review

- Review of provided data and completion by literature data if necessary
- Data compilation and preparation

Task 2 – NA Modeling

- A numerical 1D model of groundwater flow as basis of the TRN model for the proposed Retention Lease Area
- 1D reactive transport TRN model for residual mining fluid

Task 3 – Documentation and Reporting

- Brief written report summarizing methodology, assumptions, and results
- Handover of copies of the models for future modification and verification works

1.2 Methodology and Reactive-Transport Model (TRN)

1D Modeling Software. 1D groundwater scenarios were simulated with the Reactive Transport Model TRN. TRN belongs to a well-tested family of other environmental models developed by UIT in the past two decades. TRN is written in the object oriented language C++ using special chemistry classes which include the numerical routines of the USGS computer code PHREEQC (Parkhurst and Appelo 2013).

The model combines transport with geochemistry (thermodynamics and kinetics) and consists of three main parts as shown in Fig. 1.1:

- transport module (advection and dispersion, single and dual porosity)
- geochemical module (based on PHREEQC routines, thermodynamic databases, and kinetic models including enzyme kinetics)
- Graphical User Interface – GUI (data input, visualization, scenario comparisons)

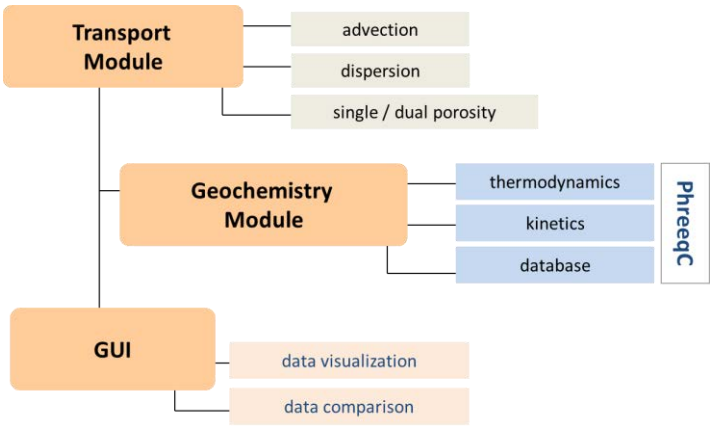


Fig. 1.1 Modular structure of the Reactive Transport Model TRN

TRN is equipped with several visualization tools so that the user is able to interact with the running system and check intermediate results. About 20% of the source code deals with plausibility tests. At every time step TRN checks the local and global mass balance (in each cell and in the whole column). Any inconsistency generates an error message. Adopting the ideas of (Appelo and Postma 2005) the transport model is free of *numerical*

dispersion. This is a great advantage: fronts move neatly and remain sharp; they are only influenced by hydrodynamic dispersion.

A typical setup for 1D reactive transport is sketched in Fig. 1.2. The column (or flow path in the subsurface) is split into N cells. Each cell can be configured separately composing a flow path through different layers/zones. In a dual-porosity approach each cell consists of two subdomains: mobile water and stagnant.

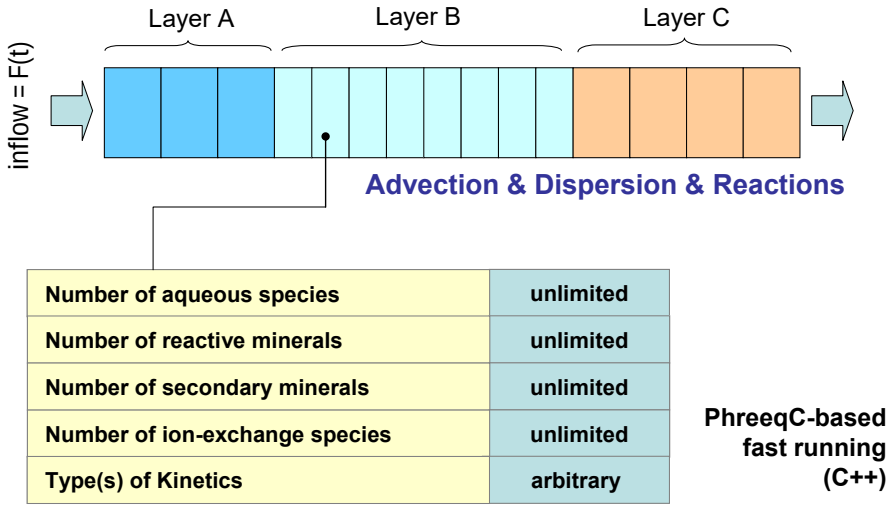


Fig. 1.2 Cell structure of 1D reactive transport column

2 CONCEPTUAL MODEL AND MODEL SETUP

2.1 Site Description

The study area is situated within the Pirie Basin (Fig. 2.1). The Pirie Basin is a north trending structural depression coincident with the Torrens Hinge Zone in South Australia.

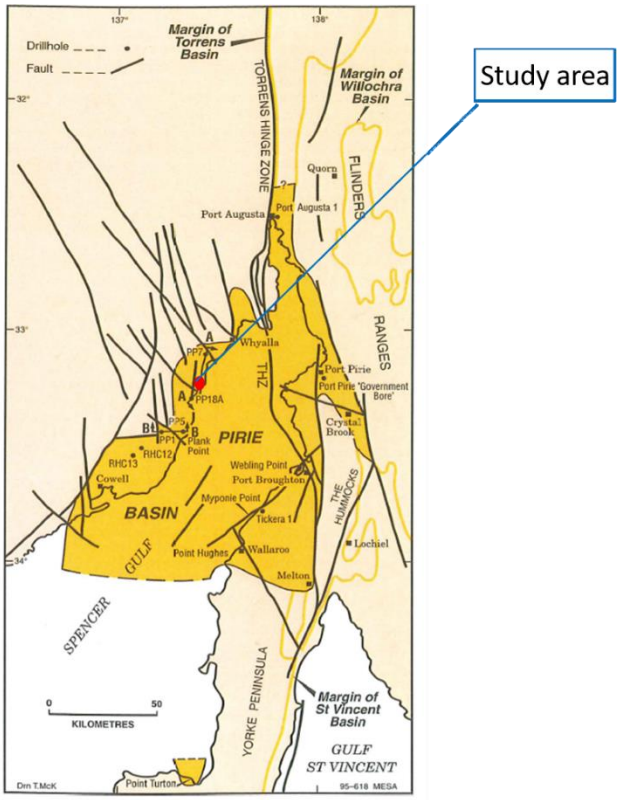


Fig. 2.1 Locality Map and Pirie Basin setting (Jeuken 2011b)

The hydrogeological units at the study site are separated on a basis of similar lithological and hydraulic characteristics as outlined in Tab. 2.1. A cross section has been constructed to show the relationship between the various hydrostratigraphic units and structural settings across the trial site (Fig. 2.2).

Two primary aquifers have been identified beneath the Retention Lease area (Fig. 2.3): the Quaternary and Tertiary aquifers. The confined Tertiary aquifer system hosts the orebody of interest and is the target for the mining. The Tertiary aquifer comprises the Melton Sands and the underlying Kanaka Beds Sands, hosting saline to very saline groundwater. Mineralisation is hosted mainly in the Es(U) and Es(L) units, with only some trace mineralisation observed in the Ms unit.

Tab. 2.1 Hydrostratigraphic units (Jeuken 2011a)

Hydrostratigraphic Unit	Geological unit	Symbol	Description	Thickness (m)
Quaternary aquifer	Quaternary Sediments	Q	Gypcrete and Calcrete on sand silt and clay. Fluvial zones at base of section.	16-20
Tertiary Confining Bed	Gibbon Beds Clay (Pliocene)	Pc	Thick bedded plastic clay, regionally extensive.	18 -22
	Melton Clay / Marl (Miocene)	Mm	Intercalcated, clay and marl, regionally extensive	16-20
Tertiary Aquifer	Metlon Sand (Miocene)	Ms	Upper Miocene Unit - Fine to coarse grained iron rich sands.	4-6
	Upper Kanaka Beds (Upper Eocene Sand)	Es(u)	Medium to coarse grained sands, inter-bedded with clay and lignite.	5-20
	Lower Kanaka Beds (Lower Eocene Sand)	Es(l)	Clean sand, minimal inter-beds	5-20
Basement Confining Bed	Weathered Basement	B	Saprolite, Kaolinitic Clays – weathered Hiltaba Granite	90+

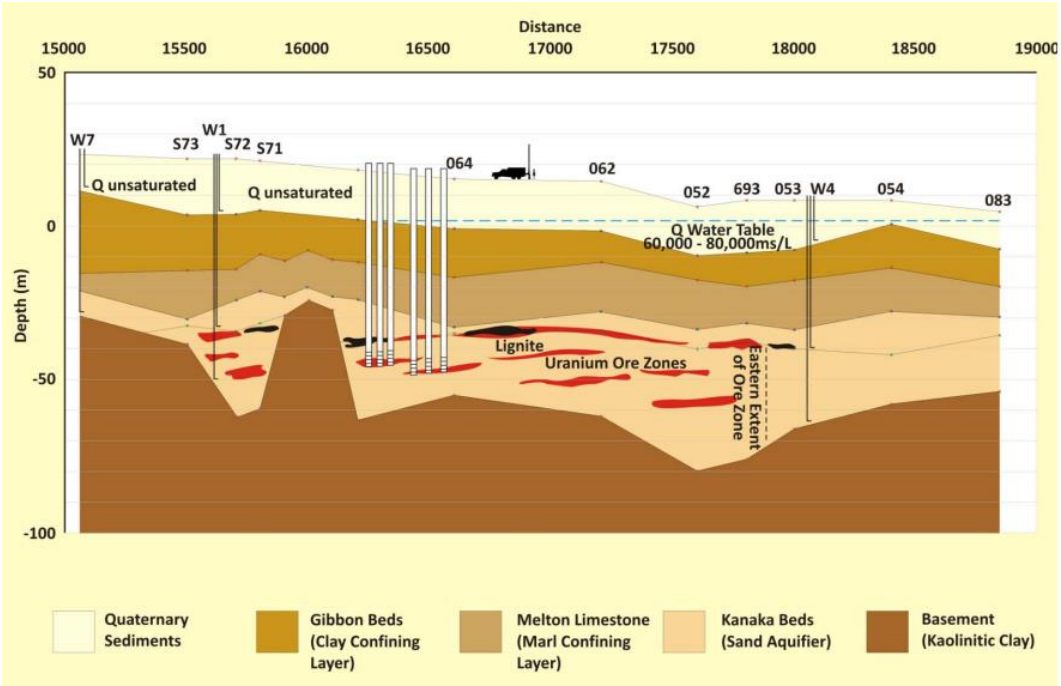


Fig. 2.2 West – East Cross Section of the study area (Jeuken 2011b)

The Tertiary aquifer is vertically confined and capped by the overlying laterally continuous Miocene marls and the Pliocene clays which in aggregate is some 40 m in thickness. Aquifer testing demonstrated that there is no significant hydraulic connection between the Tertiary and Quaternary aquifers at the sites tested. Weathered basement rock forms the hydraulic basement at this site (Jeuken 2011c).

The Tertiary aquifer exhibits a pressure gradient from west to east. Recharge into the Tertiary system is thus inferred to be via lateral inflow from the west with discharge via lateral flow to the east (Jeuken 2011a). For a more detailed description of the hydrogeological setting of the study area, refer to (Jeuken 2011b).

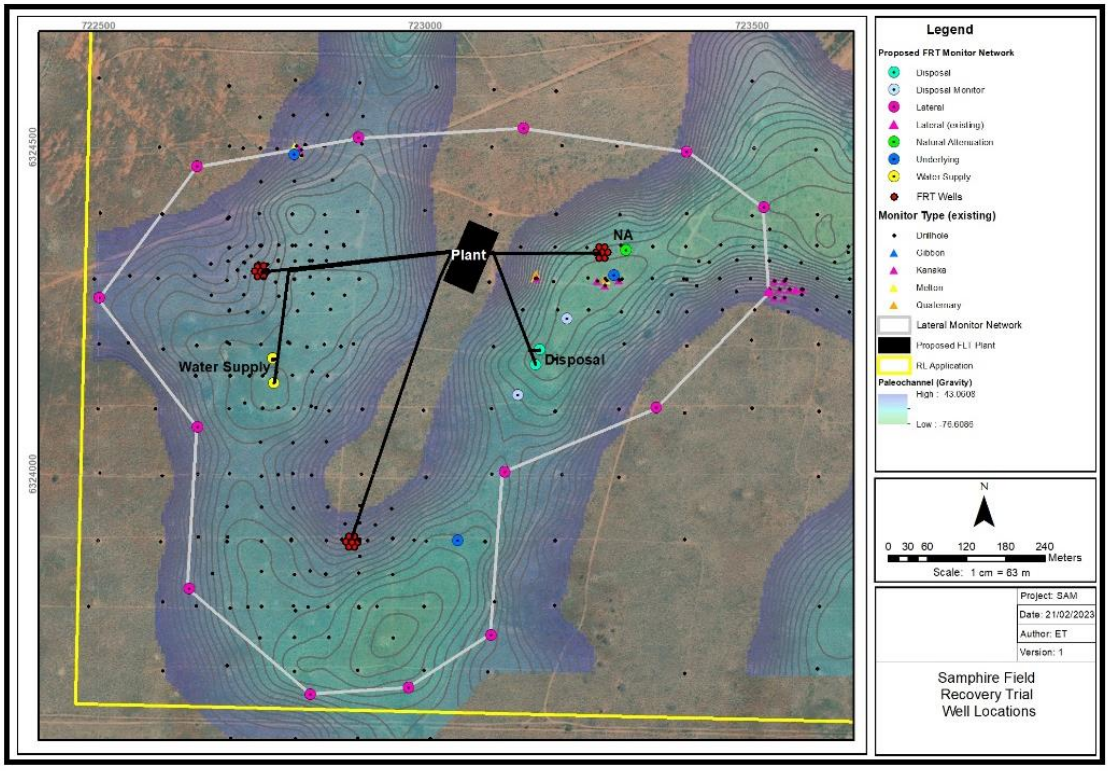


Fig. 2.3 Map of well locations within the retention lease

2.2 Model Setup

2.2.1 Overview

The post-FRT scenario begins after closure, whereby at t=0 the stagnant and mobile pore spaces of the leach zone contain the chemically reduced lixiviant and outside the recovery zone the aquifer contains natural groundwater. Natural groundwater flows into the recovery zone and pushes the dissolved minerals and contaminants from the recovery zone into the natural groundwater.

The FRTs are all planned to be realized in a similar design with small wellfield dimensions of about 20 m in diameter and 2 m in filter length, schematically depicted in Fig. 2.4. The model focuses on the simulation of a flow path through the recovery zone into the natural groundwater zone along a streamline of the groundwater flow (1-dimensional). The main interest is in the change of chemical conditions; the hydraulic conditions are considered to be constant along the flow path since no detailed discretized data is yet present for the specific local areas of the planned FRTs.

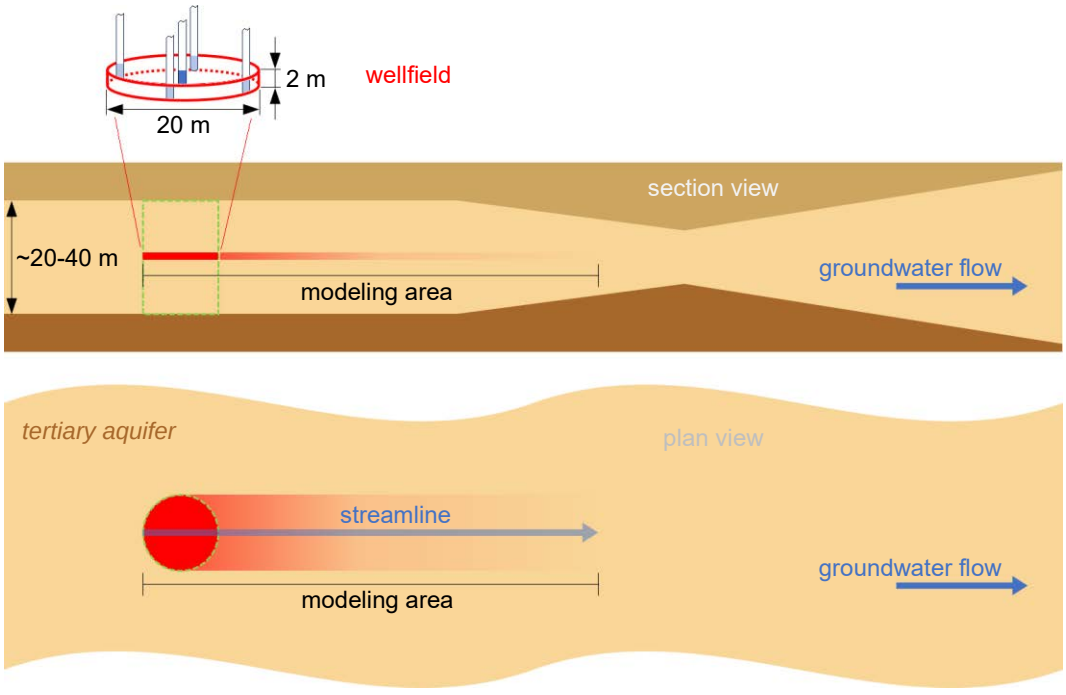


Fig. 2.4 Schematic of FRT area within the Tertiary aquifer (not to scale)

The simulated chemical conditions are representative of the volume along the streamline and does not represent the conditions of the complete aquifer. The volume affected by the FRT is small compared to the volume over the complete aquifer depth, depicted as green cylinder in Fig. 2.4. With an aquifer depth of about 20 to 40 m, the groundwater volume above and below the affected volume is about 9 to 19 times larger than the affected area.

If the groundwater composition is averaged over the depth of the aquifer at the time directly after the FTR, when the affected area is smallest, the averaged groundwater composition over depth would show significant differences only for the sum parameters pH and pe and the main elements of Fe, Al, Si. An increase in sulfate might be noticeable but the documented range in the groundwater is quite large. Critical minor elements are U and potentially heavy metals that might be mobilized during the FRT. Exemplarily, Tab. 2.2 presents the averaged groundwater composition assuming an aquifer depth of 30 m.

Tab. 2.2 Averaged groundwater composition from an assumed post-FRT lix composition and mean unaffected groundwater composition over a 30 m aquifer depth.

Parameter		Post-FRT Lixiviant	Groundwater	Averaged over depth
T	°C	25	18.8	19.2
pH	-	1.5	6.50	2.74
pe	-	5.00	0.34	2.87
Ca	mg/L	1136	2110	2045
Mg	mg/L	1457	1630	1618
Na	mg/L	8725	11894	11683
K	mg/L	95	133	130
SO4	mg/L	7740	3478	3762
DIC	mg/L	-	19.3	18.0
Cl	mg/L	20249	24367	24092
Fe	mg/L	3000	1.5	201
Al	mg/L	4	0.017	0.283
U	mg/L	164	0.1	11.0
Si	mg/L	22	<0.02	3.16
Sr	mg/L	21	33.2	32.4

The elements listed in Tab. 2.2 are all considered in the reactive transport simulation aiming to quantify the natural attenuation along the streamline although the presented results are for the main parameters only. The detailed setup and assumptions are presented in the following sections.

2.2.2 Hydraulic Model Setup

The 1D flow path of the reactive transport model TRN comprises two zones (Fig. 2.5):

- recovery zone — which was leached during field recovery trial
- downgradient zone — where mining fluid moves according to natural groundwater flow (after completion of field recovery trial)

Whereas the pores within the *leach zone* are filled with mining solution (*lix*), the downgradient zone (non-leaching zone) contains natural groundwater (*gw*).

According to Fig. 2.3 and Fig. 2.4 the length of the *leach zone* is defined by the wellfield dimension of 20 m in diameter. The *downgradient zone* depends on the simulation time and the groundwater velocity, e.g. for a 30-year forecast with a groundwater velocity of 1 m/a a length of 30 m would be sufficient. For a higher groundwater velocity or longer

simulation time, the downgradient zone will be extended. The resulting flow path for the Samphire field trial area is shown in Fig. 2.5.

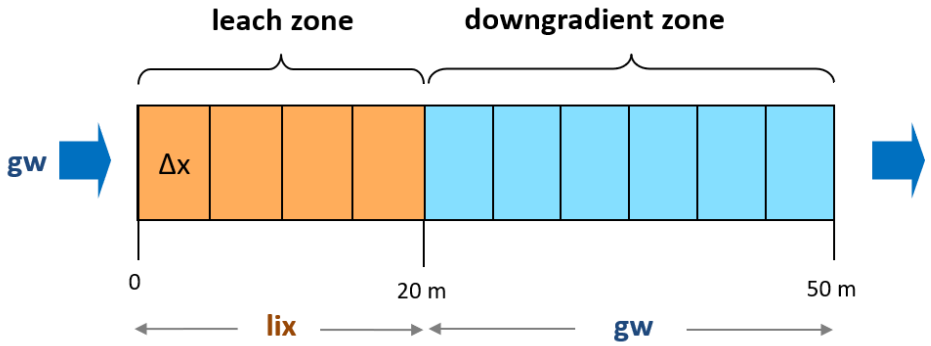


Fig. 2.5 Flow path for mine as used for reactive transport with a downgradient zone of 30 m

2.2.3 Groundwater Flow Velocity

Types of Flow. In reactive transport modelling the different quantities of hydraulic flow (with different physical units) include:

(2.1) volumetric flow (discharge) Q [L^3/T]

(2.2) DARCY or filter velocity (flux) $v_f = \frac{Q}{A}$ [L/T]

(2.3) groundwater flow velocity (entering reactive transport) $v = \frac{v_f}{\varepsilon_F}$ [L/T]

(2.4) flow rate (with respect to one cell of pore volume V_F) $q = \frac{Q}{\Delta V_F}$ [1/T]

For transport phenomena, flux Q is defined as discharge per unit area, where A represents the cross-section area perpendicular to the flow direction. Note that we abbreviate velocities by the small letter *v* and flow rates by *q*. Also, the small-letter subscript f in v_f refers to 'filter velocity' while the capital-letter subscript F in ε_F and V_F refers to the free or mobile water space (in a dual-porosity approach).

Numerics requires a spatial discretization of the entire flow path (or column) into N cells: $L = N\,\Delta x$, where L is the total length and Δx the cell length. $\Delta V_F = \varepsilon_F\, A\, \Delta x$ is the effective-pore volume of one cell.

DARCY's Law. The relation between filter velocity v_f and hydraulic conductivity k_f is described by DARCY's law:

(2.5) $$v_f = -K \frac{\partial h}{\partial x} = -K\ \mathrm{grad}\ h$$

where grad h denotes the hydraulic head gradient (for steady-state flow in *saturated* porous media in *x* direction).

Groundwater Velocities. A hydraulic conductivity of 7 m/d (obtained close to the FRT site) was used to calculate groundwater velocities of 1, 1.3 and 6 m/a for different elevations of the aquifer. These various groundwater velocities were individually simulated in the reactive-transport models. For the Samphire site, homogeneous flow properties are assumed, that is, the same groundwater velocities are used for the *leach zone* and *downgradient zone*.

Flow Rate. The amount of leaching solution that moves through the cells can be quantified also by the flow rate q, which is the ratio of the volumetric inflow Q to the effective pore volume of one cell:

$$q = \frac{Q}{\Delta V_F} = \frac{v_f}{\varepsilon_F \, \Delta x} \qquad \text{(‘pore volume exchange rate’)} \tag{2.6}$$

Please note, that the flow rate refers to a single REV (or column cell), and not to the whole flow path or column.

2.2.4 Single vs. Dual Porosity

In the so-called ‘single porosity approach’ one single water phase travels with groundwater velocity v (or flow rate q = v/Δx) along a chain of N model cells (of cell length Δx). In the ‘dual porosity approach’, however, there are *two* distinct water phases in each cell: mobile water (F – free water) and stagnant water (P – immobile pore water). Both water phases are coupled via the mass transfer rate α – as shown in Fig. 2.6.

The dual-porosity approach reflects the fact that in real environmental media pores are partly active (mobile) and partly inactive (immobile or stagnant). The inactive pores are filled with solution but the velocity inside those pores is negligible compared with the velocity in active pores.

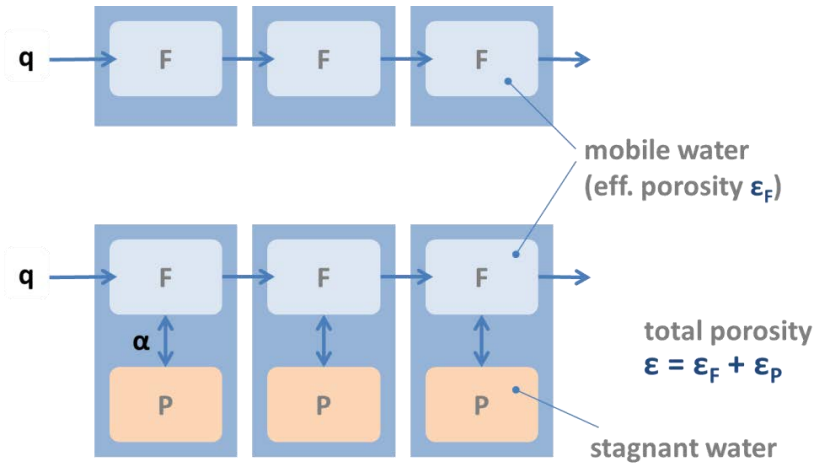


Fig. 2.6 Single vs. dual porosity approach

Several types of volumes are defined by the porosities ε_F and ε_P:

(2.7) total volume: $V_T = V_{solid} + V_{void}$

(2.8) free-water volume: $V_F = \varepsilon_F V_T$

(2.9) stagnant-water volume: $V_P = \varepsilon_P V_T$

$\Big\} \quad V_{void} = V_F + V_P$

(2.10) total porosity: $\varepsilon = \varepsilon_F + \varepsilon_P = \frac{V_{void}}{V_T}$

In the present report the reactive transport modeling is based on the dual-porosity approach. The *leach zone* and *downgradient zone* are characterized by

(2.11) $\varepsilon_F = 0.15$ and $\varepsilon_P = 0.15$

Transport Equation. In the dual porosity approach, the transport equation describes the concentrations $c_i^F(t,x)$ and $c_i^P(t,x)$ of dissolved species i in the free and stagnant water as a function of time t and distance:[1]

(2.12) $$\frac{\partial c_i^F}{\partial t} = -v\frac{\partial c_i^F}{\partial x} + D_L\frac{\partial^2 c_i^F}{\partial x^2} + \alpha\left(\frac{\varepsilon_P}{\varepsilon_F}\right)(c_i^P - c_i^F)$$

(2.13) $$\frac{dc_i^P}{dt} = -\alpha\,(c_i^P - c_i^F)$$

The first two terms in Eq. (2.12) describe advection (with groundwater velocity v) and dispersion (with the longitudinal dispersion coefficient D_L). The exchange between both water phases is controlled by the mass-transfer rate α (third term). Note: While Eq. (2.12) represents a partial differential equation, Eq. (2.13) represents just an ordinary differential equation.

Mass-Transfer Rate. The diffusion-like mass transfer between mobile and stagnant water pores is controlled by the rate α that enters Eqs. (2.12) and (2.13). Unfortunately, this quantity is not well known, and results typically from model fitting. In the underlying study α is estimated to a value of $7.6 \cdot 10^{-5}$ h^{-1}. This value is a good estimate, as it correlates with previous TRN simulations for natural attenuation in South Australia.

2.2.5 Numerical Dispersion (and its Preclusion)

While *hydrodynamic* dispersion is a real physical process, *numerical* dispersion is an artefact of computation. However, one can always take a particular time-spatial discretization which is free of any numerical dispersion (Appelo and Postma 2005). Given the groundwater velocity v (or discharge Q) and the cell length Δx, the value of the timestep Δt is then no longer arbitrary, but should be fixed to:

[1] In order to keep things simple any coupling to reaction kinetics and equilibrium thermodynamics (precipitation, dissolution, ion exchange) is omitted in the equation (but not in the model).

(2.14) $$\Delta t = \frac{\Delta x}{v} = \frac{\varepsilon_F A \cdot \Delta x}{Q} \quad \Leftrightarrow \quad \text{no numerical dispersion}$$

According to Eq. (2.6) this yields a simple relation between flow rate q and timestep Δt:

(2.15) $$q = \frac{1}{\Delta t}$$

Since Δt represents the breakthrough time for one cell (or REV), the flow rate q represents the inverse of the cell-breakthrough time. The relations are summarized in Fig. 2.7.

In the present report, Eq. (2.14) is applied in all reactive transport simulations (using UIT's PHREEQC-based software TRN). This is a great advantage: fronts move neatly and remain sharp; they are only influenced by *hydrodynamic* dispersion. The price paid for is that we no longer have the freedom of choosing Δx and Δt independently.

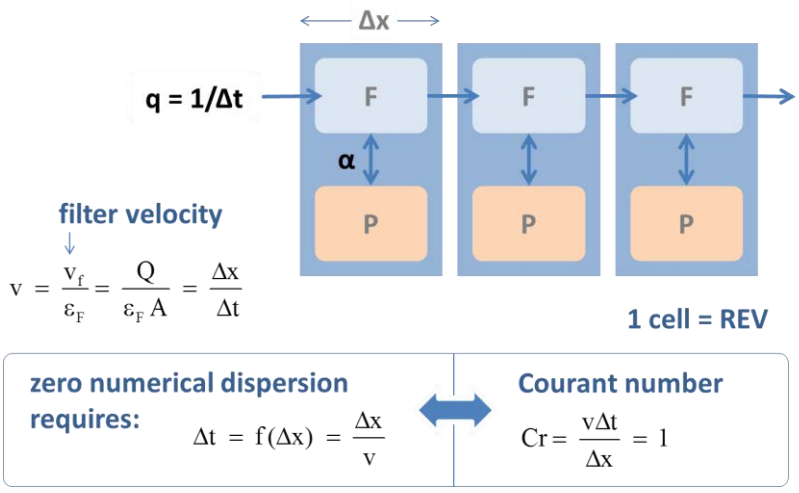


Fig. 2.7 Conditions for zero numerical dispersion

2.2.6 Model Discretization

Once we know the groundwater velocities v in both zones (leach zone and downgradient zone) the model discretization can be performed. This is done – according to Sec. 2.2.5 – for a model that is free of *numerical* dispersion.

Based on the simulation task we used 2 types of discretization, one for the long-period scenarios to baseline conditions, and a finer spatial discretization for the short-term results. The total flow path (depicted in Fig. 2.5) is decomposed as followed:

Samphire	long-period scenarios	→	flow length: 400 m	400 cells
	short-period scenarios	→	flow length: 100 m	200 cells

The input data used in TRN are summarized in Tab. 2.3 including the related time discretization. The simulation time was adapted to the needs of the scenario dependent on the considered groundwater velocity.

Tab. 2.3 Discretization of the flow path dependent on

v = Δx/Δt (m/a)	zone	x_{start} (m)	x_{end} (m)	Δx (m)	Δt (h)	N	N_{first}	N_{last}
1.0	leach zone	0	20	0.5 / 1.0	4383.00 / 8766.00	400	1	40 / 20
	downgradient zone	20	100 / 400				41 / 21	200 / 400
1.3	leach zone	0	20	0.5 / 1.0	6743.08 / 3371.54	400	1	40 / 20
	downgradient zone	20	100 / 400				41 / 21	200 / 400
6.0	leach zone	0	20	0.5 / 1.0	1461.00 / 730.50	400	1	40 / 20
	downgradient zone	20	100 / 400				41 / 21	200 / 400

2.2.7 Input Dataset: Hydraulic Parameters

Tab. 2.4 summarizes the hydraulic and geometric input parameters for reactive transport modelling at the Samphire site (based on the model setup as shown in Fig. 2.5).

Tab. 2.4 Parameters of 1D TRN column

Parameter	Description	Unit	Samphire		
v	**groundwater velocity**	**m/a**	**1.0**	**1.3**	**6.0**
ε_T	total porosity	–	0.3	0.3	0.3
ε_F	mobile porosity	–	0.15	0.15	0.15
ε_P	immobile porosity	–	0.15	0.15	0.15
α	mass transfer rate	h^{-1}	7.6e-5	7.6e-5	7.6e-5
a_L	longitudinal dispersivity	m	0.16	0.16	0.16
mix_T	transversal mix factor	–	0.001	0.001	0.001

The parameters are discussed in the following Sections:

- model discretization: Δt and Δx — in Sec. 2.2.5 and 2.2.6
- groundwater velocity v — in Sec. 2.2.3
- porosities ε_F and ε_P — in Sec. 2.2.4
- dual-porosity mass exchange rate — in Sec. 2.2.4

Hydrodynamic Dispersion. The hydrodynamic dispersion D_L, that enters the transport equation (2.12), is described by the so-called dispersivity a_L:

(2.16) $$D_L = a_L v$$

Dispersion flattens breakthrough curves. However, in a dual-porosity approach the dispersion effect is overshadowed by the 'mass-transfer effects'. In other words, dual porosity mimics both some kind of dispersion (flattening) and retardation (delayed breakthrough). As a conclusion, the exact value of the dispersivity (which is seldom known) has very slight effect on the forecast.

Due to the fact that the *narrow* 'flow path' (1D model space) is embedded within a huge groundwater basin there is an ongoing dilution caused by transversal dispersion.

While *longitudinal* dispersion is part of any 1D transport model, transversal dispersion is not. In reactive transport calculations with PHREEQC-coupling, longitudinal dispersion is

implemented by a mix factor mix_L [PA99, AP05]. The same idea is adopted for the transversal dispersion:

(2.17) longitudinal dispersion: $$mix_L = \frac{a_L}{\Delta x}$$ (standard description)

(2.18) transversal dispersion: $$mix_T = \frac{(v_T / v)\, a_L}{\Delta z}$$ (assumption)

where Δz is the typical height of the plume (cf. Fig. 2.8). The mix factor mix_T controls the ongoing mixing of the (polluted) solution inside a cell with (unpolluted) groundwater.

The idea behind longitudinal and transversal dispersion is sketched in Fig. 2.8.

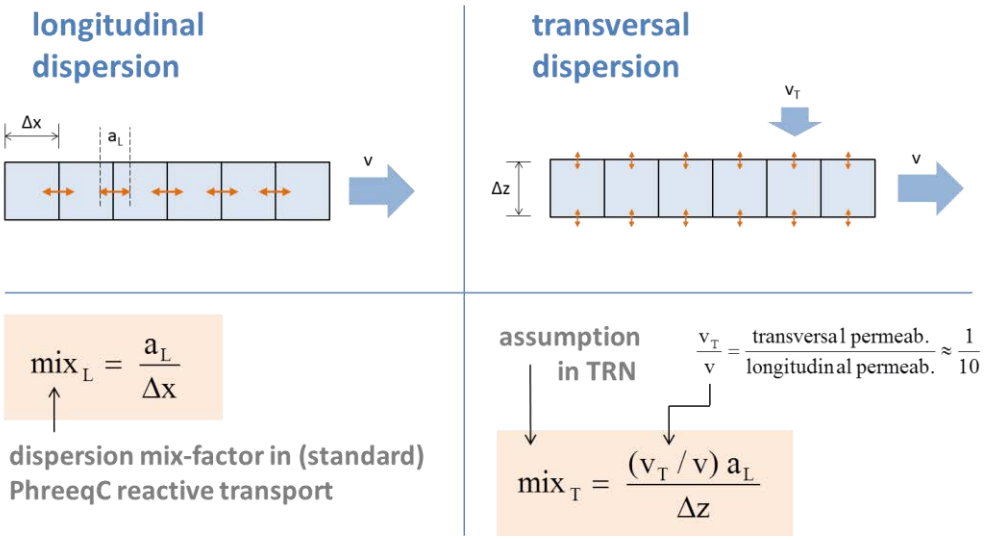


Fig. 2.8 Longitudinal vs. transversal dispersion

Due to the layered structure of the aquifer the transversal dispersion is low and could be neglected in short-term scenarios, however, with ongoing simulation time the dilution due to transversal dispersion becomes more significant and needs to be considered.

The FRT is planned to be operated in an average aquifer thickness of 20 to 40 m. The maximum extent of the plume in vertical direction is estimated to be close to the planned filter length of 2 m.

For the transversal dispersivity we assume that the ratio between longitudinal and transversal velocities is given by the ratio of longitudinal to transversal permeabilities given by the reciprocal of the anisotropy that is loosely described by several numbers of magnitude. Therefore, we assume an anisotropy factor of 50, 5 times higher than the typical value.

For $a_L = 0.16$ m and $\Delta z = 3$ m (worst case) a transversal mix factor of 0.001 is estimated, which should be compared with the longitudinal mix factor 0.16 (valid for average cell geometry of $\Delta x = 1$ m):

It shows that the dilution effect caused by transversal dispersion is almost 2 orders of magnitude smaller than that of the longitudinal dispersion.

Three additional assumptions are:

(i) The transversal dispersion comprises two parts:

transversal dispersivity in vertical direction a_{TV}

transversal dispersivity in horizontal direction a_{TH}

TRN considers only the *vertical* dispersion (in z-direction), but neglects the transversal dispersion in horizontal direction

(2.19) $a_{TH} = 0$ (conservative assumption)

This is a conservative assumption because it does not enhance the transversal mixing.

(ii) The flow path is surrounded by an 'infinite' groundwater reservoir (i.e. the water composition *outside* the column cells does not change during dispersion). Possible inaccuracies would be compensated by (i).

In conclusion, the transversal mix factor of 0.001 is a worst case assumption, because in practice, the dilution effect is assumed to be higher.

2.3 Geochemistry

2.3.1 Basic Concept

In reactive transport modelling the flow path is spatially discretized into a chain of N cells. Each cell itself obeys a substructure where pore solutions interact with the aquifer material.

Dual Porosity. The reactive transport model TRN allows the application of two principal concepts: single-porosity and dual-porosity. In the present report we apply the dual porosity approach introduced in Sec. 2.2.4. Transport of dissolved solids is considered by advection and dispersion in active (mobile) pores while the diffusion process dominates in the stagnant pores. The interchange of solutions between mobile and stagnant pores is described by the first-order mass transfer rate α.

There are several ways to design how a pore solution interacts with minerals as well as ion exchangers (clays). In the present report we adopt a site-specific arrangement shown in Fig. 2.9. Here, five *reactive* minerals (pyrite, dolomite, uranophane, kaolinite, and coffinite) dissolve inside the stagnant water domain. Precipitation of *secondary* minerals occurs mainly in the mobile water pores. However, the model considers the general case where precipitation is enabled in both domains.

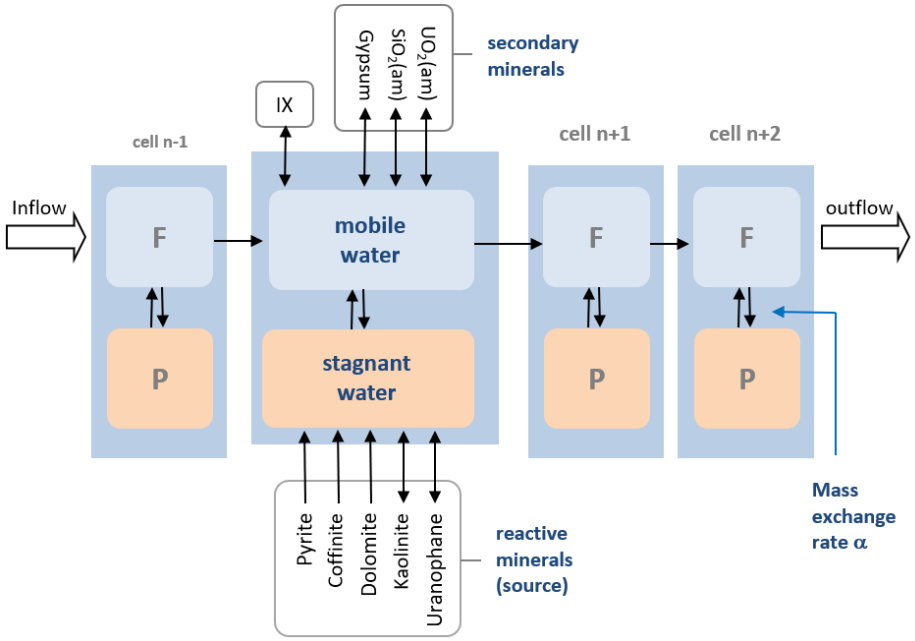


Fig. 2.9 Main geochemical transformations within the dual porosity approach (double arrows symbolize reversible processes)

In this way, the following main processes are considered:

- dissolution of reactive minerals in the stagnant phase (as source of elements)
- precipitation/re-dissolution of secondary minerals in both phases
- ion exchange (IX) in the mobile phase

[Note: Ion exchange is implemented in the mobile water phase; however, it's no problem for the model to handle it in the stagnant water domain or in both domains simultaneously.]

Thermodynamics vs Kinetics. The double arrows in Fig. 2.9 symbolize reversible processes controlled by thermodynamic equilibrium. In principle, there are two possibilities to simulate the dissolution of reactive minerals:

- by thermodynamics (based on log K values contained in the PHREEQC database)
- by kinetics (based on a kinetic formula and additional parameters)

The advantage of the equilibrium approach is that it relies on fundamental thermodynamic data rather than on empirical kinetic data (which are less known and, in most cases, not available). Thus, in the present approach all reactions – except of pyrite and coffinite dissolution – are treated as equilibrium reactions based on log k values (taken from the PHREEQC's standard database *wateq4f*). In this way, the number of *free* parameters reduces significantly.

Thermodynamic Data. PHREEQC, which is embedded in the reactive transport model TRN, uses the standard database *wateq4f*.

Kinetics. The TRN model allows the *kinetic* oxidation of coffinite, pyrite and/or organic matter. All reactions consume oxidation agents and lower the redox potential (ORP),

which promotes the transition U(6) ⇒ U(4) outside the leaching zone. Eventually, U(4) precipitates as amorphous UO_2.

2.3.2 Elements of Mineral Assembly

Primary Minerals. The source of the following elements is an outcome of the dissolution of *reactive* minerals:

- dolomite $CaMg(CO_3)_2$ source for Ca and Mg
- kaolinite $Al_2Si_2O_5(OH)_4$ source for Al and Si
- pyrite FeS_2 source for Fe and S
- uranophane $Ca(UO_2)_2(SiO_3OH)_2{\cdot}5H_2O$ source for U, Ca and Si
- coffinite $USiO_2$ source for U and Si

This set was identified as the smallest set of reactive minerals that is obligatory to describe the effects of NA. In the following, we adopt this mineral set and refer to it as the "minimal model" as summarized in Fig. 2.10.

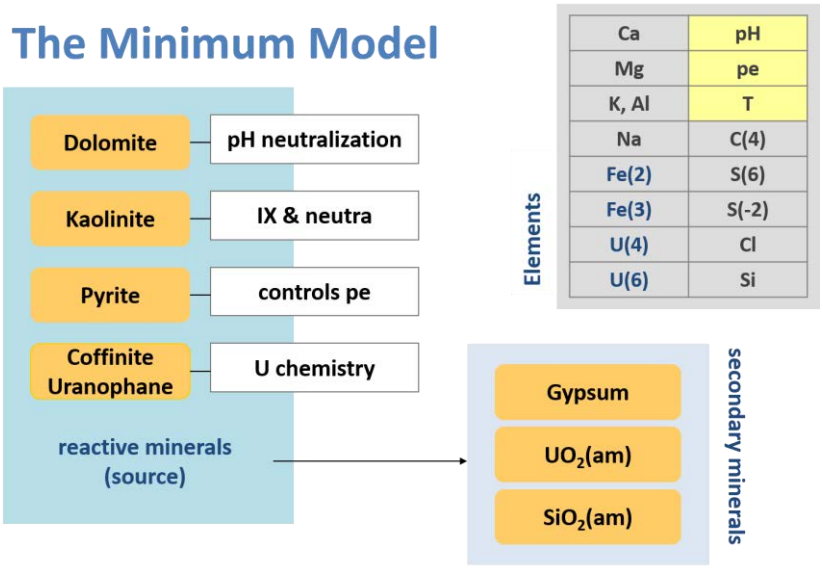


Fig. 2.10 **Elements and mineral assembly of the "Minimum Model"**

Secondary Minerals. *Secondary* minerals do not have an initial inventory. They precipitate and re-dissolve depending on the pH-pe conditions. This process is thermodynamically controlled (no kinetic approach is used). It is implemented in both domains: mobile and stagnant water pores. Five secondary minerals are assumed:

- Gypsum $CaSO_4{\cdot}2H_2O$
- Amorphous UO_2 UO_2 (am)
- Amorphous silica SiO_2 (am)
- Amorphous $Al(OH)_3$ $Al(OH)_3$ (am)
- Siderite $FeCO_3$

with the corresponding log K values:

(2.20) $CaSO_4 \cdot 2H_2O = Ca^{+2} + SO_4^{-2} + 2H_2O$ log K = -4.48

(2.21) $UO_2 + 4H^+ = U^{+4} + 2H_2O$ log K = 0.1

(2.22) $SiO_2 + 2H_2O = H_4SiO_4$ log K = -2.71

(2.23) $Al(OH)_3 + 3H^+ = Al^{+3} + 3H_2O$ log K = 10.8

(2.24) $FeCO_3 = Fe^{+2} + CO_3^{-2}$ log K = -10.89

Tab. 2.5 provides a list of all sources (minerals that dissolve and ion exchange) and sinks (minerals that precipitate and ion exchange) that affect the element concentrations in the solution. The abbreviations TH and K indicate whether the mineral is treated by equilibrium thermodynamics or kinetics.

Chloride (Cl) is included intentionally into the table in order to remind us that it is influenced neither by minerals nor by ion exchange; it behaves like a tracer.

Tab. 2.5 Geochemical factors that influence the concentration of the solutes (TH – pure thermodynamics approach, K – kinetics)

element	reactive minerals (dissolution only)			secondary minerals (precipitation & re-dissolution)			IX
Ca	dolomite	$CaMg(CO_3)_2$	TH	gypsum	$CaSO_4{:}2H_2O$	TH	CaX_2
Mg	dolomite	$CaMg(CO_3)_2$	TH				MgX_2
Na							NaX
K							KX
S(6)	pyrite	FeS_2	K	gypsum	$CaSO_4{:}2H_2O$	TH	
S(-2)	pyrite	FeS_2	K				
Fe	pyrite	FeS_2	K	siderite	$FeCO_3$	TH	FeX_2
Al	kaolinite	$Al_2Si_2O_5(OH)_4$	TH	$Al(OH)_3$(am)	$Al(OH)_3$	TH	AlX_3
Si	kaolinite	$Al_2Si_2O_5(OH)_4$	TH	SiO_2(am)	SiO_2	TH	
U	coffinite uranophane	$USiO_2$ $Ca(UO_2)_2(SiO_3OH)_2 \cdot 5H_2O$	K TH	UO_2(am)	UO_2	TH	
Cl							
DIC	dolomite	$CaMg(CO_3)_2$	TH	siderite	$FeCO_3$	TH	

2.3.3 Initial Inventory of Reactive Minerals

The initial inventory of reactive minerals (dolomite, kaolinite, uranophane, pyrite, and coffinite) at t = 0 is an important input of the geochemical model in TRN. For this purpose we had to convert the assumed mineral amount (given in wt%) to the molar amount:

(2.25) wt% of mineral i $\Rightarrow$ C_i (= molar amount per liter pore solution)

The following relations are well-known:

(2.26) mass fraction of mineral i $$x_i = \frac{m_i}{m_T} = \frac{m_i}{\rho_b V}$$

(2.27) molar content of mineral i per 1 L solution $$C_i = \frac{n_i}{V_P} = \frac{n_i}{\varepsilon_P V}$$

(2.28) molar amount of mineral i $$n_i = \frac{m_i}{M_i}$$

Here, ε_P denotes the porosity of the stagnant-water domain, ρ_b the assumed bulk density (of the Kanaka Beds), and M_i the molar mass of mineral i. From these relations one gets the formula for the molar mineral content per liter pore solution:

(2.29) $$C_i = \frac{\rho_b}{\varepsilon_P M_i} x_i = \frac{\rho_b}{\varepsilon_P M_i} \cdot \frac{wt\%}{100}$$

The values for the bulk density and stagnant-water porosity are:

bulk density	$\rho_b = 1.855$ g/cm^3	(aquifer sand)
porosity	$\varepsilon_P = 0.15$	(stagnant water pores)

The initial inventory of reactive minerals that enters the TRN model was calculated by Eq. (2.29) for given (or estimated) abundancies (values in wt%). Dolomite was used as the measured "carbonates" due to the observed correlation between Mg and Ca (Young 2022). For the leach zone, it is assumed that the calcareous and uranium-bearing minerals are completely consumed during the FRT. Kaolinite will be reduced during FRT but not completely. The estimate assumes that 50% of the kaolinite are consumed. The obtained values for C_i (together with the original wt% values) are listed in Tab. 2.6.

Tab. 2.6 Initial inventory Ci(M) of reactive minerals for the model input calculated from wt%

Mineral		Mi	leach zone		downgradient zone	
		g/mol	wt%	C_i(mM)	wt%	C_i(mM)
Dolomite	$CaMg(CO_3)_2$	184.4	0	0	0.01	6.7
Coffinite	$USiO_4$	330.1	0	0	0.97	363.4
Kaolinite	$Al_2Si_2O_5(OH)_4$	258.2	0.3	150	0.61	292.2
Pyrite	FeS_2	120.0	0	0	1.05	1082.3
Uranophane	$Ca(UO_2)_2(SiO_3OH)_2{\cdot}5H_2O$	586.4	0	0	0.03	6.3

The dissolution of dolomite, kaolinite, and uranophane is described by thermodynamics (rather than kinetics). The dissolution stops when saturation is reached (at SI = 0) – independent of the initial amount. Therefore, the estimated amount for kaolinite does not affect the results if it is not completely consumed. Dolomite, kaolinite, and uranophane have the corresponding log K values, respectively:

(2.30) $CaMg(CO_3)_2 = Ca^{+2} + Mg^{+2} + 2CO_3^{-2}$ log K = -18.09

(2.31) $Al_2Si_2O_5(OH)_4 + 6H^+ = 2Al^{+3} + 2H_4SiO_4 + H_2O$ log K = 7.435

(2.32) $Ca(UO_2)_2(SiO_3OH)_2 + 6H^+ = Ca^{+2} + 2UO_2^{+2} + 2H_4SiO_4$ log K = 5.489

The log K value for uranophane from the used standard database *wateq4f* did not result in plausible simulation results, since the mineral was already unstable and dissolved

completely in water. Therefore, the log K value was reduced accordingly that the uranophane is stable at pH neutral conditions and will be dissolved at acidic conditions, only. The corresponding pH value was choosen to be above the pH of the lixiviant to simulate a potential dissolution downgradient and hence to consider the worst case for the natural attenuation scenario (best case for U recovery).

2.3.4 Aqueous Solutions

The simulations for the Samphire Project are based on two types of aqueous solutions

- neutral groundwater (downgradient zone; inflow) **gw**
- lixiviant (inside leach zone) **lix**

Note that groundwater plays a double role. It acts as the initial solution in all cells outside the leach zone, and it is used as the composition of inflow water that enters the leach zone. The composition of the groundwater and lixiviant are presented in Tab. 2.7. The composition of the lixiviant assumes a maximum iron concentration of 3000 mg/L as an upper limit for the FRT. Furthermore, it is defined that the oxidation potential is consumed; hence, the ferric iron is almost completely reduced to ferrous iron. All solutions are in the state of chemical equilibrium and free of charge-balance errors, $\Delta IB = 0$ (adjusted by PHREEQC calculations).

Tab. 2.7 Model input for groundwater and lixiviant

parameter		gw	lix
T	°C	18.8	25
pH	-	6.50	1.5
pe	-	0.34	5.00
Ca	mg/L	2110	1136
Mg	mg/L	1630	1457
Na	mg/L	11894	8725
K	mg/L	133	95
SO4	mg/L	3478	7740
DIC	mg/L	19.3	-
Cl	mg/L	24367	20249
Fe	mg/L	1.5	3000
Al	mg/L	0.017	4
U	mg/L	0.1	164
Si	mg/L	<0.02	22
Sr	mg/L	33.2	21

2.3.5 Ion Exchange on Clay Minerals

Any natural sediment contains at least small amounts of clay or other minerals (rather than pure quartz SiO_2). The mineralogical analysis of site-specific sediment material affirms the presence of clay minerals (predominantly in form of Kaolinite) (Young 2022). Clay minerals act as ion exchangers. Therefore, in all calculations ion exchange of the cations H^+, K^+, Na^+, Ca^{2+}, Mg^{2+}, Fe^{2+}, and Al^{3+} is taken into account.

Thermodynamics. The ion exchange is defined by the following reactions (with log K values from the standard database *wateq4f*):

(2.33) $H^+ + X^- = HX$ $\log K = 1.0$

(2.34) $K^+ + X^- = KX$ $\log K = 0.7$

(2.35) $Na^+ + X^- = NaX$ $\log K = 0.0$

(2.36) $Ca^{+2} + 2X^- = CaX_2$ $\log K = 0.8$

(2.37) $Mg^{+2} + 2X^- = MgX_2$ $\log K = 0.6$

(2.38) $Fe^{+2} + 2X^- = FeX_2$ $\log K = 0.44$

(2.39) $Al^{+3} + 3X^- = AlX_3$ $\log K = 0.36$

CEC. Besides thermodynamic data (log K values from *wateq4f*) the ion exchange model requires the input parameter "total cation capacity per pore volume"

(2.40) $$C_{TOT} = \frac{n_{sites}}{V_{pore}} = \frac{CEC \cdot m_{clay}}{V_{pore}}$$

Here, the cation exchange capacity CEC of a typical clay mineral (Kaolinite) is

(2.41) $$CEC = \frac{n_{sites}}{m_{clay}} \approx 100 \frac{meq}{100\ g}$$

Assuming a clay content of 0.61 %, that is, $f = m_{clay}/m_m = 0.0061$, and a bulk density $\rho_b = 1.855\ g/cm^3$ we get

(2.42) $$C_{TOT} = \frac{f \cdot \rho_b}{\varepsilon} \quad CEC \approx \frac{1}{\varepsilon} \cdot 11.3 \frac{meq}{L}$$

where the porosity ε is either equal to ε_F (when the ion exchanger acts in the mobile water domain) or equal to ε_P (when it acts in the stagnant water domain). In the present simulations we use ε_F, i.e. IX in contact with mobile water.

Initial Load. Fig. 2.11 displays the initial IX load on clay minerals (at t = 0) for the leaching zone (left) and the downgradient groundwater zone (right). Inside the acidic leaching zone, the clays are heavily occupied by H^+ ions. The species distribution is almost independent of the C_{TOT} value.

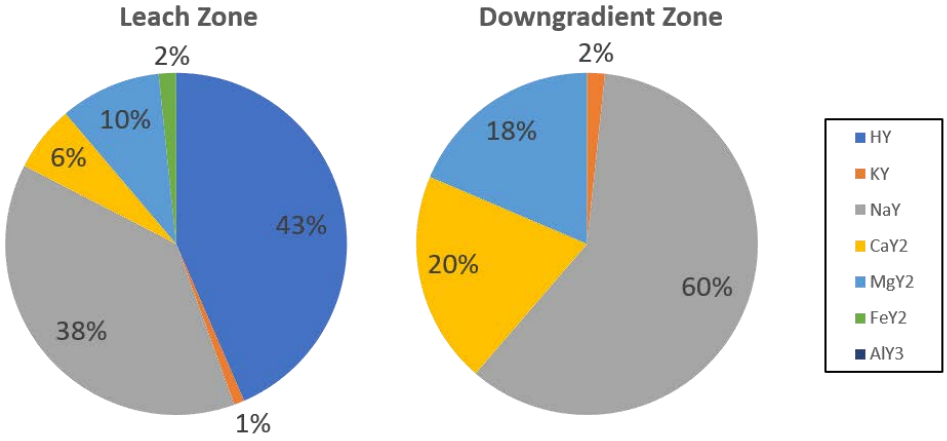


Fig. 2.11 Initial IX load on clay minerals for the leach zone (left) and downgradient zone (groundwater) (right)

2.3.6 Dissolution Kinetics with SI Control

Three reactive minerals (dolomite, kaolinite, uranophane) are treated by equilibrium thermodynamics while the other two reactive minerals (coffinite, pyrite) are treated by kinetics.

Kinetics. The dissolution of mineral i is described by

(2.43) $$\frac{dC_i}{dt} = -\,\text{rate}\; C_i(t) \qquad \text{with initial condition:} \quad C_i(t=0) = C_i^{(0)}$$

where C_i is the molar amount of mineral i per 1 L pore solution. The initial amount $C_i^{(0)}$ is presented in Tab. 2.6. The *rate* (with physical unit time^{-1}) is defined by:

(2.44) $$\text{rate} = r_i \left(\frac{H^+}{1\,M}\right)^{a_i} \left(\frac{A}{1\,M}\right)^{b_i} \qquad \text{with} \quad H^+ = 10^{-pH}$$

where

$H^+ = H^+(t)$	molar concentration of $H^+ = 10^{-pH}$ in the solution	
$A = A(t)$	molar concentration of oxidant (e^- acceptor)	
r_i	constant dissolution rate	(model parameter)
a_i	model parameter	
b_i	model parameter	

In Eq. (2.43), the rate automatically becomes zero when the mineral amount is exhausted: rate $\rightarrow$ 0 when $C_i \rightarrow 0$.

In addition to the kinetic formula in Eq. (2.44) we add some kind of 'SI control' (The saturation index SI of mineral i calculated by PHREEQC.):

(2.45) $$\text{rate} = \begin{cases} r_i \left(H^+/1M\right)^{a_i} \left(A/1M\right)^{b_i} & \text{for SI} < 0 \\ 0 & \text{else} \end{cases}$$

This formula precludes mineral dissolution when the solution becomes saturated or over-saturated (SI ≥ 0) and a mineral dissolution becomes thermodynamically implausible.

Parameters. The kinetic parameters in Tab. 2.8 are used in all TRN simulations. These kinetic parameter values correlate to previous TRN simulations for natural attenuation in South Australia.

Tab. 2.8 Kinetic parameters used in TRN

mineral	r_i (1/day)	r_i (1/s)	a_i	b_i
pyrite	$3.0 \cdot 10^{-4}$	$3.5 \cdot 10^{-9}$	-0.50	0.58
coffinite	$3.5 \cdot 10^{-3}$	$4.0 \cdot 10^{-8}$	0.37	0.31

3 NATURAL ATTENUATION

3.1 Definition of Scenarios

The underlying geochemistry for NA simulation is quite complex (cf. Sec. 2.3). In the following we focus on the fate of key parameters pH, U, Fe, and sulfate:

- as a function of distance from the leach zone (at fixed time)
- as a function of time (at fixed distance)

The four parameters are influenced by several factors:

- pH influenced by dolomite and kaolinite dissolution as well as IX
- uranium influenced by dilution, U(4) vs. U(6) mineralization
- sulfate influenced by dilution, gypsum precipitation
- Fe influenced by dilution, pyrite dissolution, siderite precipitation

The model assumes (besides dilution) the presence of reductants in the form of coffinite and pyrite (organic matter present would also act as a reductant but was not considered here). In comparison to a post-mining scenario U mineralization is still present downgradient the FRT zone. Thus, U mobilization and immobilization play an important role in the scenarios. Beside the conservative assumption for the uranophane (U(VI) mineral) also the conservative assumption for the U(IV) immobilization was chosen by the assumption that U(IV) precipitates as amorphous UO_2(am) rather than as crystalline uraninite or coffinite.

Fe is mainly attenuated by the microbial sulfate reduction that leads to the precipitation of ferrous sulfides. While the process is well-known and likely to occur, microbial sulfate reduction is kinetically driven and mainly depends on the presence of the kind and amount of organic matter as well as the microbial community. With increasing pH and decreasing redox potential the sulfate reduction rate increases and Fe is precipitated. Due to the high uncertainty of these parameters, we decided for the conservative approach without sulfate reduction, since the effects are:

- only relevant in long-term,
- driven by the redox potential that can be observed during monitoring,
- hardly distinguishable from the other effects in the earlier stage of attenuation.

Scenarios. We consider the NA post-FRT for the Samphire site by simulating different groundwater velocities within the site at 1.0, 1.3, and 6.0 m/a to cover different hydraulic conditions. All scenarios are considered post leaching starting after FRT closure. At t = 0 the recovery zone is influenced by the lixiviant. Outside the recovery zone (at x >20 m) the aquifer is filled with natural groundwater. It describes how the natural groundwater flows into the recovery zone and pushes the dissolved inventory from the recovery zone into the unaffected groundwater. Thereby, the downgradient zone is considered as ore zone.

The long-period forecast was simulated for different simulation times dependent on the groundwater velocity to ensure that the baseline conditions for the streamline are reached

for the critical parameters, pH and U. It presents the time and distance for groundwater restoration along the streamline. Please note, that the groundwater quality of the surrounding aquifer stays mostly unaffected.

The same forecast is done with a finer discretization to provide detailed data for the NA transect wells to compare monitoring data to the model results. The aim of the comparison is to prove the natural attenuation occurs in a predicted magnitude.

Additionally, we consider a couple parameter variations that are of critical importance in comparison to a post-mining scenario. Typically, in post-mining scenarios the amount of reducing minerals is varied to consider their effect on the attenuation process since establishing of reducing conditions is critical for the immobilization of U and heavy metals. Additionally, the amount of neutralizing minerals is of interest since metals like Al and Fe are immobilized at neutral conditions as hydroxides or carbonates.

As mentioned before, for FRTs the downgradient zone is within the ore zone, thus, U is considerably present and can still be mobilized compared to post-mining scenarios. Also, U is present as coffinite, the reducing U(IV) mineral, and uranophane, the pH dependent U(VI) mineral. Therefore, the focus of the parameter variation is on the effect of the different U mineralization. For comparability the scenarios are defined that the initial U amount stays identically in all scenarios. Thus, in these scenarios the amount of the pyrite instead of coffinite and uranophane (separately) is varied within the downgradient zone.

Variations 1) considers the effect of the reducing minerals, both coffinite and pyrite, with the pyrite amount decreased by 50% in the downgradient zone. Variation 2) compares the effect of the chosen U mineral for the U mobilization by considering the amount of uranium to be completely present as coffinite (compared to partly uranophane and partly coffinite). This scenario was also defined due to the high uncertainty in the thermodynamic data of uranophane. Despite the different dissolution chemistry of coffinite and uranophane, this scenario is closer to a more refractory dissolution behavior of the uranophanes. The forecast of the variation scenarios was simulated for 10 years.

3.2 Results

3.2.1 NA post-FRT to baseline conditions

Concentrations and pH vs. Distance. Fig. 3.1, Fig. 3.2, and Fig. 3.3 show the fate of the mining fluid as a function of distance from the leach zone with a groundwater velocity of 1.0 m/a, 1.3 m/a, and 6.0 m/a, respectively. These graphs are represented at different times to show the evolution: from t = 0 to 500, 400, 100 years, respectively. The recovery zone extends from 0 to 20 m; behind it starts the downgradient zone (x > 20 m). A total distance of 400 m was simulated for all three groundwater velocities.

Generally, increasing the simulation groundwater velocity results in an increase in the distance traveled by the mining fluid as well as an increased effect by dilution. The effects from the chemistry are more pronounced in the lower groundwater velocity scenarios.

Fig. 3.1 presents the results of the slowest groundwater velocity scenario. For the baseline criteria we focused on pH and U concentration as the most critical parameters. The pH curve shows two buffer zones; one about pH 3.5 due to the precipitation of uranophanes, and one about pH 4.5 due to the precipitation of $Al(OH)_3$. The Al originates from the dissolution of kaolinite and its precipitation mainly defines the pH attenuation rate. Furthermore, the pH exceeds the initial groundwater pH at about 100 m due to the precipitation and re-dissolution of siderite.

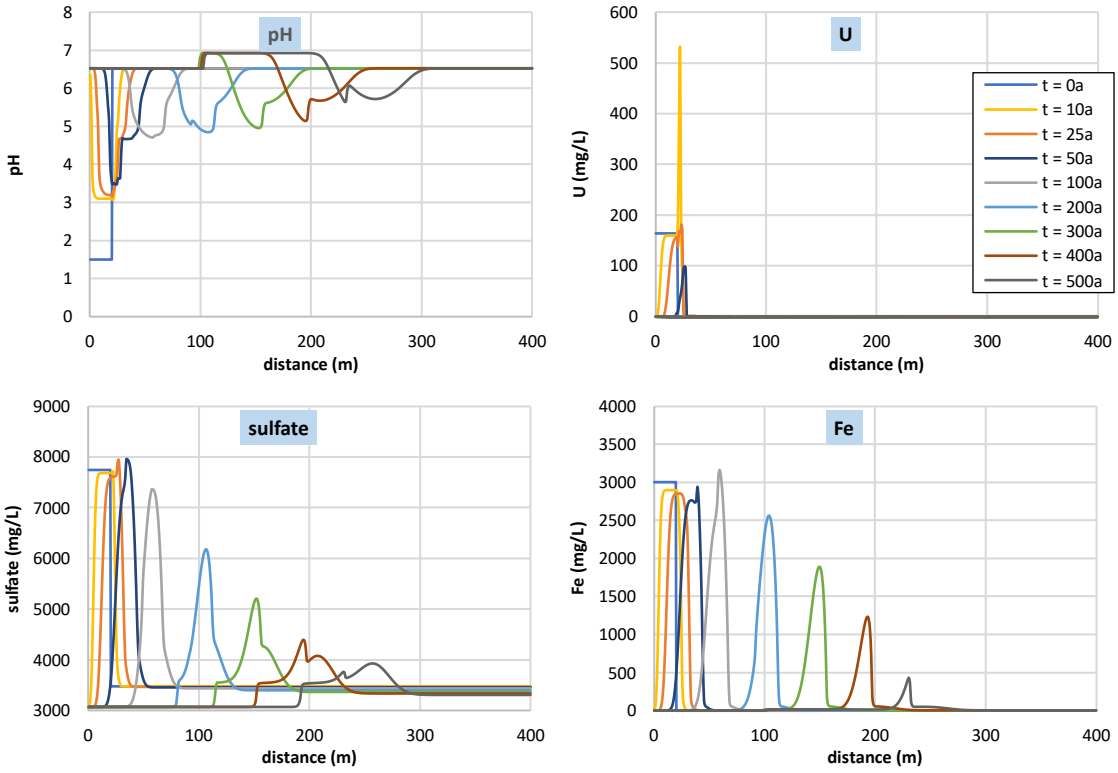


Fig. 3.1 Variant v = 1.0 m/a: pH, U, sulfate, and Fe as a function of distance at t = 0, 10, 25, 50, 100, 200, 30, 400 and 500 years

Uranium is strongly increasing due to the dissolution of uranophanes in the downgradient zone. But is also attenuated first due to the availability of coffinite and pyrite establishing reduced conditions. The attenuation of U represents the reduction of the redox potential relevant for the sulfate reduction process.

Sulfate is mainly attenuated by dilution but also by gypsum precipitation observable by the lower sulfate concentration than in the natural groundwater. The higher sulfate concentration in the lix leads by mixing with the naturally occurring groundwater to gypsum formation. The gypsum is slightly redissolved leading to gypsum saturated solutions.

Also, iron is mainly attenuated by dilution. Only at higher pH (above pH 5) siderite precipitation leads to a faster attenuation rate. Considering the pH and U curves, Al and U(IV) precipitation are completed and optimum conditions for sulfate reduction will be established after a period of earlier than 100 years. Thus, significant reduction in Fe can be expected additionally to the shown attenuation mainly by dilution.

Fig. 3.2 presents the simulation results of the groundwater velocity of 1.3 m/a. The chemical processes are identically to the previous described simulation. The attenuation rate is higher than for the smaller groundwater velocity since the neutralization potential of the downgradient zone is reached faster. While the minimum pH of natural groundwater of pH 5.6 is reached for the whole plume after about 490 years for a groundwater velocity of 1.0 m/a, and around 375 years at 1.3 m/a, the travel distance is almost identically.

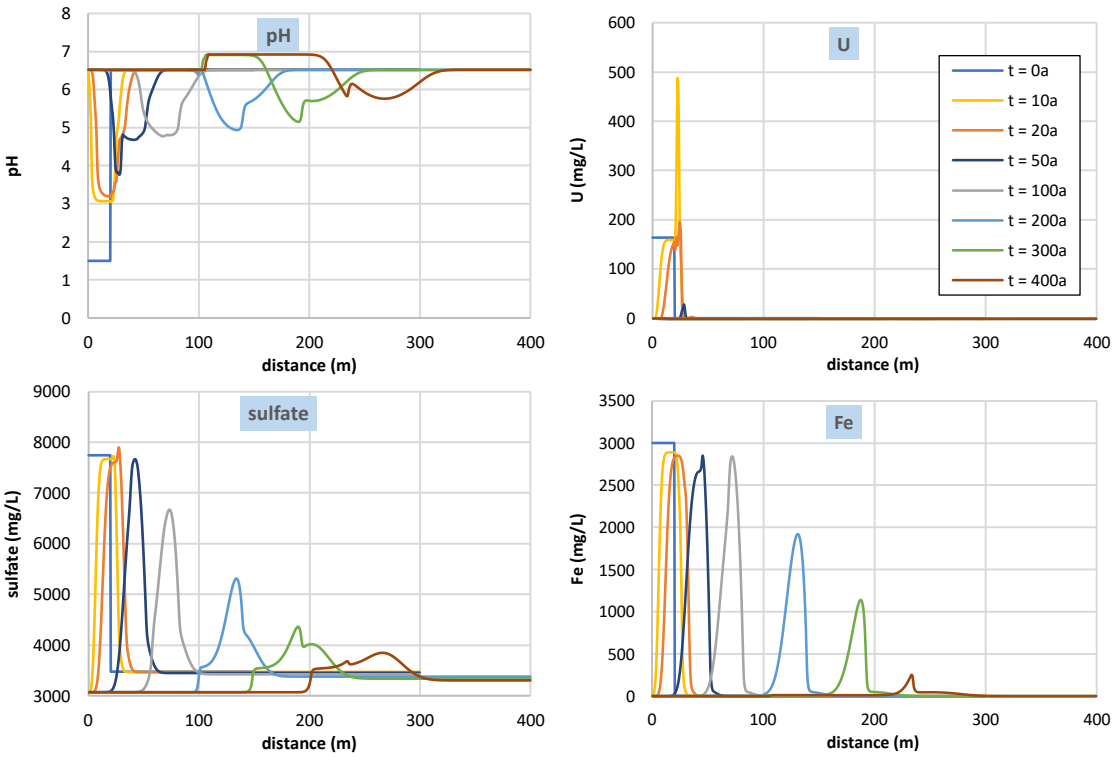


Fig. 3.2 Variant v = 1.3 m/a: pH, U, sulfate, and Fe as a function of distance at t = 0, 10, 20, 50, 100, 200, 300 and 400 years

Also, the scenario with the highest groundwater velocity of 6 m/a experienced the same chemical processes. However, the dilution plays a more important role leading to a larger plume extent. Obviously, the time frame for attenuation is significantly less than for the other scenarios, 75 a. The distance is slightly less than for the other scenarios.

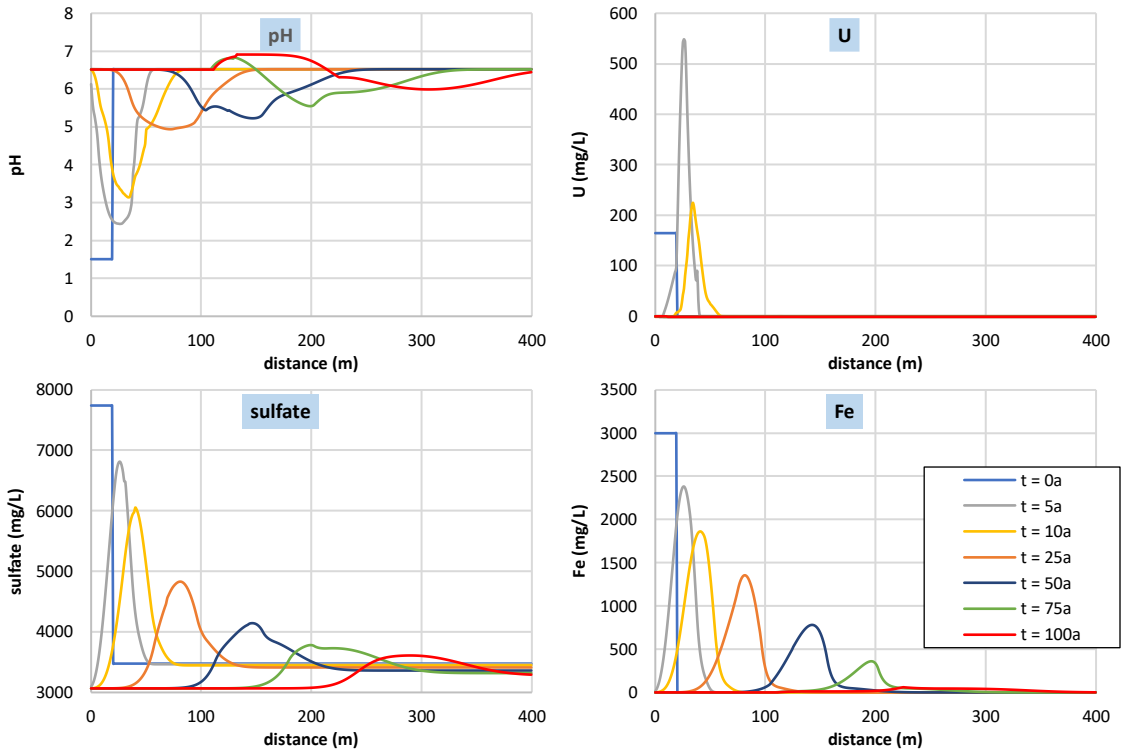


Fig. 3.3 Variant v = 6 m/a: pH, U, sulfate, and Fe as a function of distance at t = 0, 5, 10, 25, 50, 75 and 100 years

Fig. 3.4 presents the same U concentrations from above over a smaller distance and time periods for the scenarios with 1.0 m/a and 6.0 m/a groundwater velocity.

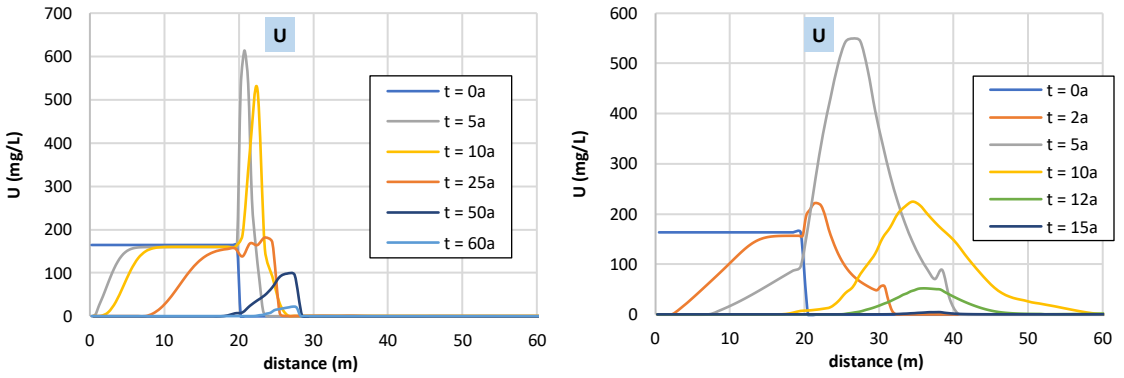


Fig. 3.4 U concentration as a function of distance over 60 m for v=1.0 m/a (left) and v=6.0 m/a (right)

The more detailed presentation shows the fast attenuation of U despite the high concentrations originating from the uranophane dissolution. The higher groundwater velocity results in a significant larger spread of the U concentration while at low groundwater velocity the time increases to produce reducing conditions that immobilize U by precipitation of amorphous UO_2.

Fig. 3.5 compares the three groundwater velocity scenarios plotted together for the time the pH baseline conditions are reached. The pH is significantly slower attenuated than U, pointing to the potential of establishing further reducing conditions for the sulfate reduction process. Therefore, pH is considered as the main relevant baseline parameter.

As mentioned above for the U concentration, the higher dilution at higher groundwater velocity reduces the transect distance until the baseline conditions are reached. However, the difference is only about 15 %. The chemical conditions mainly define the progress of the plume. However, the extent of the plume is larger for higher velocities.

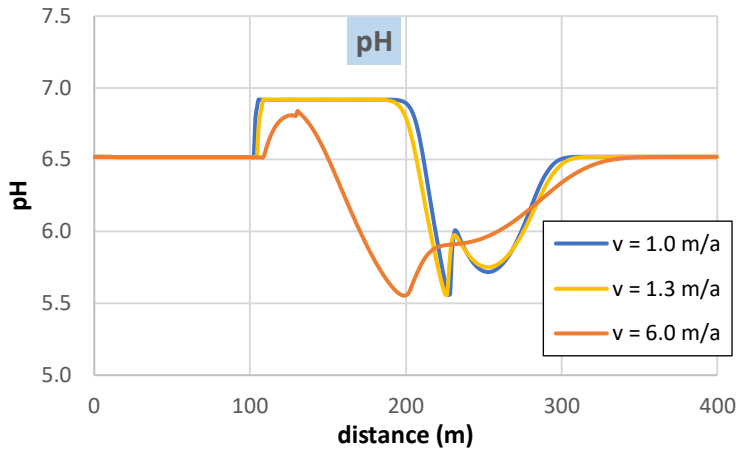


Fig. 3.5 pH as a function of distance for pH value > 5.6 (v 1.0: 490a, v 1.3: 375 a, v 6.0: 75a)

Concentrations and pH vs. Time. Fig. 3.6, Fig. 3.7, and Fig. 3.8 present the time series for the NA transect well into the leach zone and into the gradient zone. The curves are representative for 1.25 m entering the leach zone and 1.25 m entering the downgradient zone. These results present the basis for the post-FRT monitoring strategy.

Again, all three groundwater velocities were simulated, and the results are presented here. Additionally, pH, pe and the concentrations of the simulated elements are listed in the Appendix for the transect distance of 0.75 m, 1.25 m, 2.25 m, 3.25 m and 4.75 m over a time period of about 5 years for all three groundwater velocities.

In general, the inflow of natural groundwater into the leach zone leads to a strong attenuation by dilution. Obviously, the higher the groundwater velocity the higher the dilution the faster the attenuation. Especially the slow exchange from the stagnant pores to the mobile pores is stronger diluted leading to a larger plume extent but simultaneously smaller concentrations.

The attenuation time is obviously faster for the transect into the leach zone than into the downgradient zone since the plume is transported downgradient. The processes described

above are also visible over time but less pronounced. However, the expected time frames for the attenuation are directly observable. Therefore, this kind of graphs can be used to verify the simulation results with monitored data at specific distance to the plume after the FRT.

As described above, the chemical parameters are highly connected to each other. Thus, the comparison of the parameters different from the baseline will be sufficient for a proof of concept. In case of the lixiviant the relevant parameters are pH, redox, U, Fe, sulfate. With time additional main elements can be mobilized that can be included, e.g. Al. Model adaptation might be required, if geometric, hydraulic or initial chemical conditions differ significantly from the model assumptions, e.g. plume size, porosity, initial composition of plume. Otherwise, the observed trends can be interpreted accordingly.

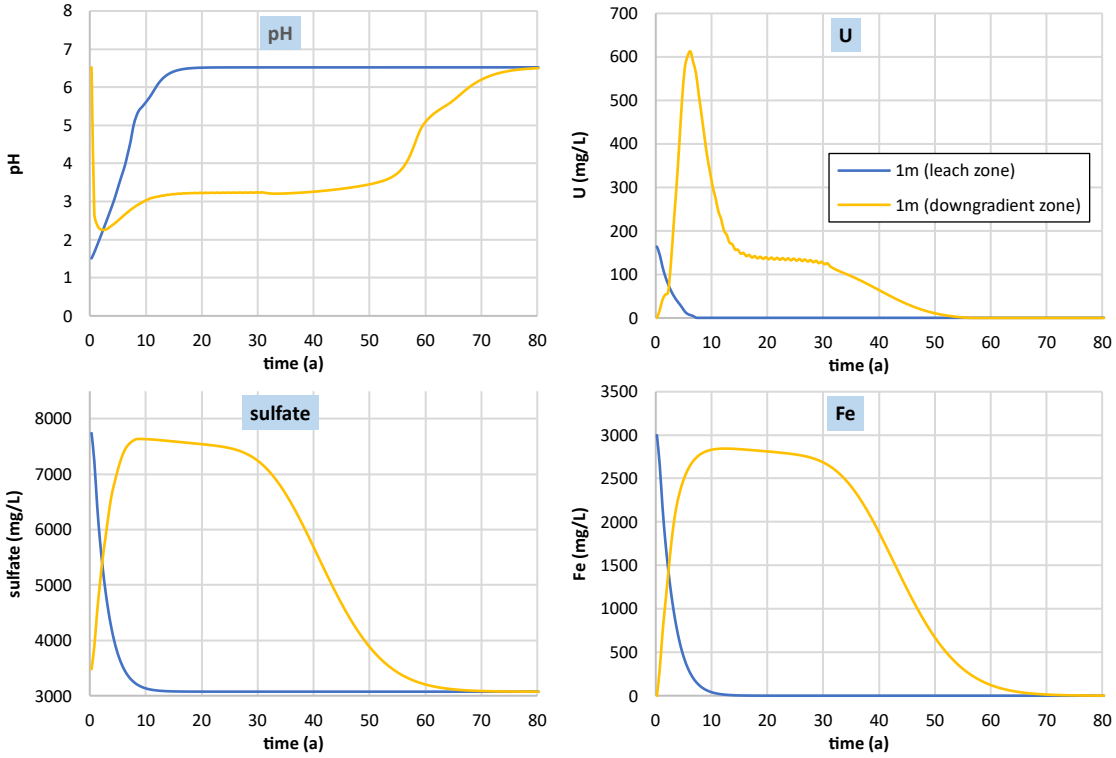


Fig. 3.6 Variant v = 1 m/a: pH, U, sulfate, and Fe as a function of time

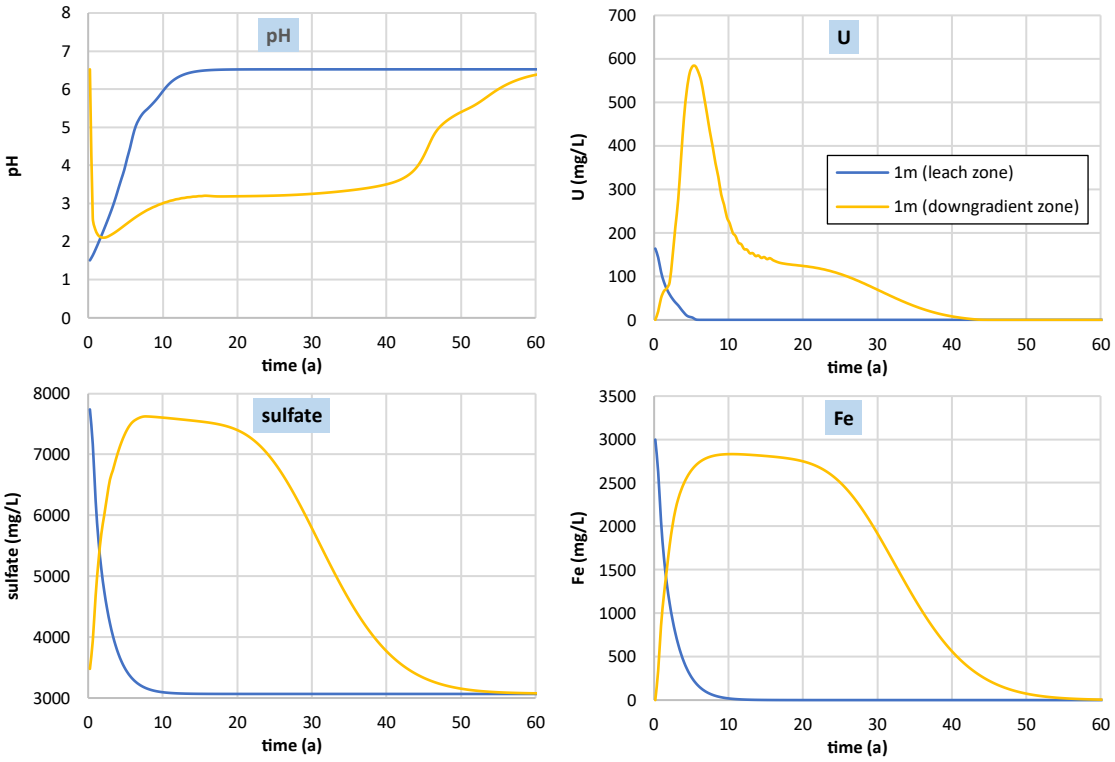


Fig. 3.7 Variant v = 1.3 m/a: pH, U, sulfate, and Fe as a function of time

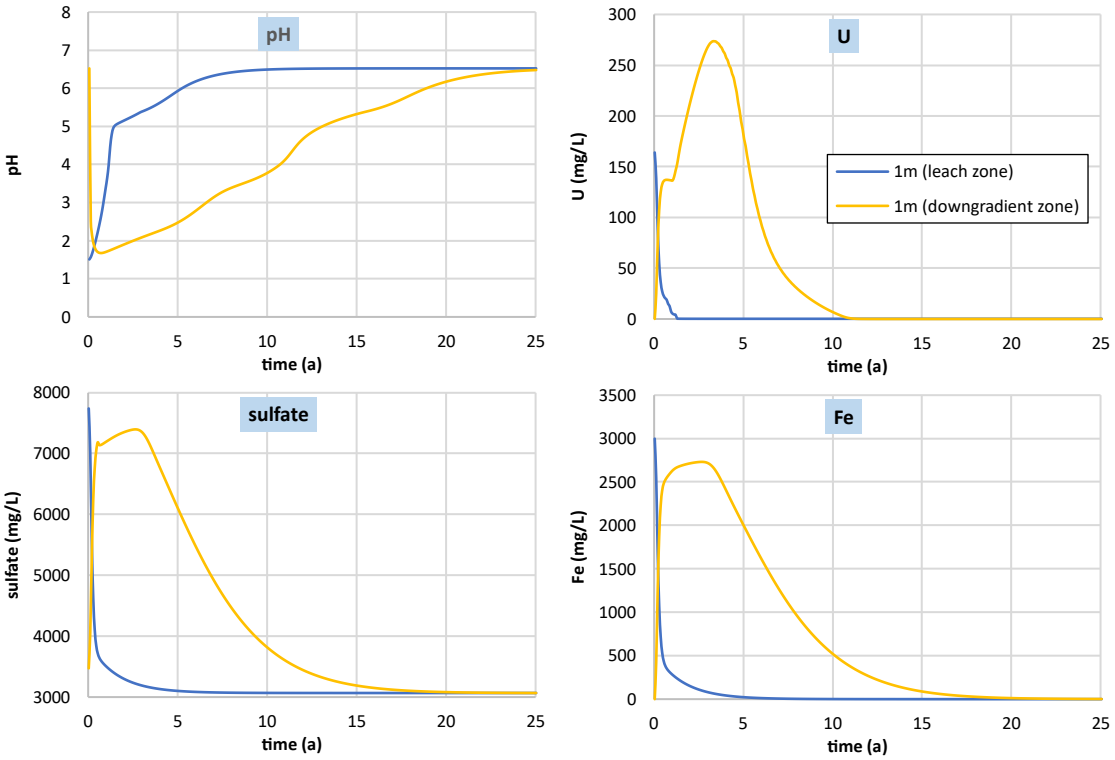


Fig. 3.8 Variant v = 6 m/a: pH, U, sulfate, and Fe as a function of time

3.2.2 Parameter Variation

Pyrite. Fig. 3.9 shows the result of adjusting the amount of pyrite in the downgradient zone, in this case decreasing the amount of pyrite by 50% (using groundwater velocity v = 6 m/a).

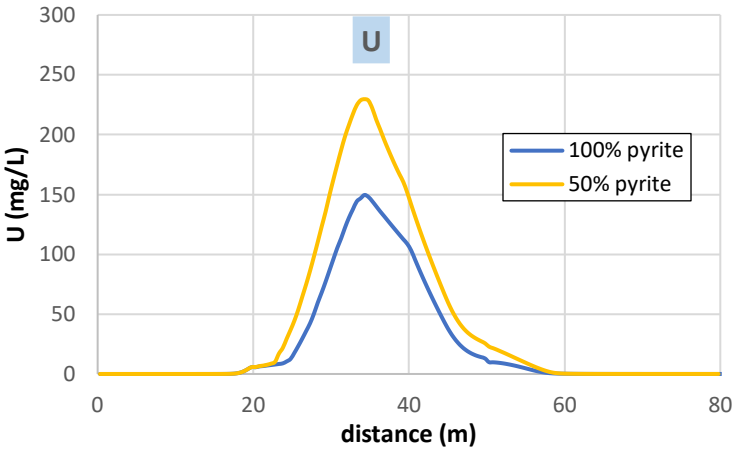


Fig. 3.9 Pyrite decreased by 50%: U as a function of distance at t = 10 years with v = 6 m/a

A decrease in pyrite results in an increase in uranium. This is explained by the oxidizing lixiviant dissolving the pyrite which establishes reducing conditions (pe value declines). This, in turn, triggers the precipitation of amorphous uraninite, and uranium concentration in the aquifer declines. Despite the strong reduction in pyrite the U concentration increases only slightly. Main reason is the presence of coffinite that also establishes reducing conditions leading to a self-inhibition of U dissolution.

Uranophane. Fig. 3.10 shows the results for the scenario that no uranophane is present in the system (the original amount is allocated to coffinite) for the three different groundwater velocities after a 10-year forecast. Thus, dissolution and precipitation of U by uranophane is precluded. The sulfate and Fe concentrations are almost unaffected by this change. The main effect is obviously seen for U and pH. After a distance of 20 m, the amount of U significantly decreases without the presence of uranophane and increases with the presence of uranophanes. The oxidative potential of the remaining lixiviant is able to mobilize a very small amount of coffinite only, while the uranophane in the standard scenario is mobilized in a significant amount by the decrease in pH.

The mobilization and immobilization of U from the uranophane leads to a shift in the pH curve best observable for the highest groundwater velocity. While the impact of the uranophane is small for pH, sulfate and iron, the attenuation of U is accelerated significantly as well as the extent for U.

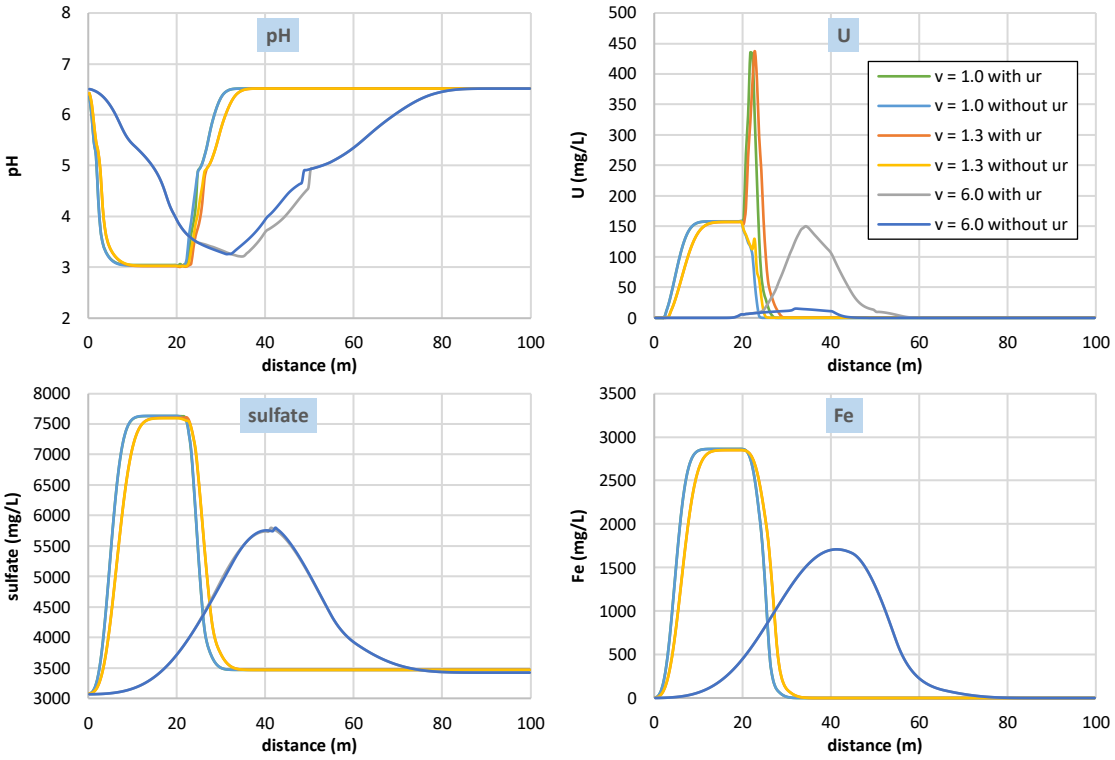


Fig. 3.10 Comparison with and without uranophane: pH, U, sulfate, and Fe as a function of distance at t = 10 years

4 SUMMARY

The present report focuses on the NA post-FRT for the Samphire site in South Australia. 1D reactive transport models were created for the residual mining fluid with long-period forecast of the extent of the plume to baseline conditions. Three different groundwater velocities at 1.0, 1.3, and 6.0 m/a were considered simulating different hydraulic conditions. The models simulated a length of 400 m with 20 m leach zone and 380 m downgradient zone. The models assume the stagnant and mobile pore spaces of the leach zone are occupied by lixiviant whereas the aquifer contains natural groundwater outside the leach zone. Natural groundwater flows into the leach zone and pushes the dissolved minerals and contaminants from the leach zone into the natural groundwater.

The simulations are based on the hydraulic parameters taken from previous works (Jeuken 2011a, 2011b, 2011c), the mineralogy of the Samphire site ore composite sample (Young 2022), and lixiviant and groundwater chemistry data provided by Alligator Energy.

The underlying geochemistry is highly complex and involves numerous processes, e.g. redox reactions and ion exchange. All calculations are performed with the conservative assumption that U^{IV} precipitates only in the form of amorphous UO_2(am), rather than crystalline uraninite or coffinite. Also, the long-term process of sulfate reduction leading to a ferrous sulfide precipitation is conservatively excluded. The model assumes from previously undertaken aquifer testing (Jeuken 2011a) a small vertical dilution. Further estimates are made for the simulations:

- Constant concentration distribution across the ore zone
- Homogeneous flow properties assumed, i.e. the same groundwater velocities are used for the leach zone and downgradient zone
- Assumed bulk density of Kanaka Beds and assumed CEC
- Mass transfer rate (α) and the dissolution rates for pyrite and coffinite are based on UIT's previous knowledge of NA in South Australia

The current 1D reactive transport modeling results show the NA mechanisms for pH, sulfate, Fe, and U expressed in graphs as (i) a function of distance from the leach zone at a fixed time and (ii) a function of time at a fixed distance. The general trends for the simulations for different velocities show that a higher velocity results in an increase in distance traveled by the mining fluid as well as an increase in dilution, as expected. The higher velocity further results in a higher attenuation rate and a larger extent of the plume. However, the distance the plume travels before it reaches baseline conditions defined by a pH>5.6 is almost identical for all three variations.

The uranium curves displayed 2 distinct uranium peaks representing 1) the uranophane dissolution after lixiviant enters the downgradient zone, and 2) the uranium leaving the leach zone which takes longer to attenuate. For the 6 m/a velocity simulation, it was determined that maximum U concentrations reached <1 mg/L after around 20 years.

The mobilization of uranium from uranophane has the highest uncertainty within the modeled chemistry, due to a high uncertainty in the thermodynamic data available. Therefore, a comparative scenario was simulated considering that the total amount of uranium is present as coffinite only, and dissolution and precipitation of uranophane is precluded.

Thus, no mobilization of U^{VI} minerals by change of pH can occur, but only coffinite mobilization by the residual oxidation potential in the lixiviant. Due to the limited amount of oxidation potential left in the recovery zone, U is decreasing significantly in the downgradient zone and attenuated much faster. The mobilization potential of uranophane might be better quantified by an acidic leach test.

Additionally, UO_2(am) starts to precipitate (in small amounts) and steadily increases as reducing conditions become established. The effect of establishing reducing conditions to immobilize U was further investigated by varying the available pyrite in the downgradient zone. The pyrite mainly affects the U attenuation, as expected. The higher the pyrite, the higher the attenuation of U by UO_2(am) precipitation.

The model also determined that gypsum precipitation and redissolution is occurring, causing a decrease of sulfate below baseline concentration. In long term iron is precipitated as siderite if pH conditions are favorable. The precipitation of iron as sulfide was conservatively excluded in the model although very likely in long-term. However, for the short-term monitoring it is irrelevant.

The concentration and pH vs time graphs show the expected concentration and pH values at specific locations, e.g. at potential monitoring wells. The groundwater velocity affects the attenuation rate especially at the inflow transect into the leach zone. The comparison of future monitoring well data with the model can be used to verify the attenuation and potentially its rate. The FRT will further detail the hydraulic conditions within the specific area. If the hydraulic conditions, mainly porosities, significantly differ from the current assumptions, the model can be further adjusted to improve the prediction accuracy. The chemical trends will still be observable and can verify the attenuation processes simulated. The sum parameter pH and pe are essential for evaluating the chemical processes. Furthermore, the concentration of sulfate and iron can act as a tracer to verify the hydraulic conditions. Uranium is the critical element and its mobilization and immobilization dependent on the U mineralization has to be verified. Other elements that can be mobilized might be of interest, e.g. Al. Elements below or close to baseline are of less significance.

In conclusion, the attenuation potential is mainly determined by dilution dependent on the groundwater velocity, and the available neutralizing and reducing potential of the present mineralogy. For the reason, that the downgradient zone is still within the U deposit, a potential mobilization of U impedes its attenuation. The simulations consider two mechanisms for the U mobilization, a pH dependent dissolution of uranophane and an oxidative dissolution of coffinite. The remaining lixiviant in the leach zone has a significantly higher acidity than oxidative potential, thus, the mobilization of uranophane is orders of magnitude higher than of coffinite.

Due to the small groundwater velocities, the region affected by the FRT is still small. The distance from the leach zone is predicted to be about 200 m. For the same reason the concentrations are less affected by dilution and the gradients stay large. Keep in mind that the simulated concentrations represent a streamline through the leach zone and downgradient and are not representative over the complete aquifer depth.

The attenuation of the FRT plume could be accelerated by reducing the remaining lixiviant in the leach zone. However, post-leach activities for an enhanced NA require a holistic evaluation taking all related aspects into account, e.g. the amount of additional disposal water, and the potential mining activities.

5 PUBLICATION BIBLIOGRAPHY

Appelo, C.A.J.; Postma, Dieke (2005): Geochemistry, Groundwater and Pollution. Second Edition. Leiden: A.A. Balkema Publishers.

Jeuken, B. (2011a): Mullaquana Aquifer Testing. UAC-1043-R002. Australian Groundwater Technologies. South Australia.

Jeuken, B. (2011b): Mullaquana Project Hydrogeological Setting. UAC-1043-R003. Australian Groundwater Technologies. South Australia.

Jeuken, B. (2011c): Groundwater Management for the Mullaquana ISR FT. UAC-1043-R005. Australian Groundwater Technologies. South Australia.

Parkhurst, D. L.; Appelo, C. A. J. (2013): Description of Input and Examples for PHREEQC Version 3: A Computer Program for Speciation, Batch-Reaction, One-Dimensional Transport, and Inverse Geochemical Calculations. In *US Geological Survey Techniques and Methods* 6 (A43).

Young, Brian (2022): Mineralogy of Alligator Energy Composite. Technical Memorandum AM/TM. ANSTO. NSW Australia.

APPENDIX

Tab. A.1 Concentrations as a function of time. Variant: v = 1.0 m/a. Position: 0.75 m in leach zone.

t [a]	pH	pE	Ca [mg/L]	Mg [mg/L]	Na [mg/L]	K [mg/L]	Fe [mg/L]	Al [mg/L]	U [mg/L]	sulfate [mg/L]	Cl [mg/L]	DIC [mg/L]	Si [mg/L]	Sr [mg/L]
0.25	1.50	5.00	1136.0	1457.0	8725	95.00	3000.0	4.00	163.99	7740.0	20249	0.000	21.917	21.000
0.75	1.70	4.75	1268.0	1468.4	9293	98.66	2348.2	190.09	127.71	6726.8	21135	4.179	24.443	23.636
1.25	1.92	4.55	1396.1	1490.9	9841	103.58	1801.3	252.90	96.48	5844.1	21912	7.825	24.150	25.939
1.75	2.13	4.50	1503.0	1517.0	10272	108.62	1417.8	245.39	75.11	5234.4	22450	10.347	23.555	27.534
2.25	2.34	5.33	1591.9	1540.9	10615	113.22	1124.6	214.28	59.07	4773.0	22859	12.256	23.015	28.742
2.75	2.56	5.70	1664.9	1560.6	10888	117.16	890.7	178.21	46.45	4408.9	23182	13.764	22.573	29.696
3.25	2.79	5.82	1723.9	1576.4	11106	120.43	702.7	144.04	36.42	4119.3	23439	14.963	22.223	30.456
3.75	3.02	5.92	1771.0	1588.8	11279	123.09	552.0	114.13	28.45	3889.5	23643	15.914	21.948	31.059
4.25	3.29	5.98	1808.4	1598.4	11416	125.21	432.0	89.12	21.95	3708.0	23805	16.666	21.708	31.535
4.75	3.64	6.00	1837.7	1605.8	11523	126.90	337.1	69.03	14.89	3565.3	23932	17.257	21.417	31.909
5.25	4.14	5.65	1860.5	1611.7	11608	128.26	262.3	52.78	3.68	3453.6	24031	17.720	20.560	32.203

Tab. A.2 Concentrations as a function of time. Variant: v = 1.0 m/a. Position: 1.25 m in leach zone.

t [a]	pH	pE	Ca [mg/L]	Mg [mg/L]	Na [mg/L]	K [mg/L]	Fe [mg/L]	Al [mg/L]	U [mg/L]	sulfate [mg/L]	Cl [mg/L]	DIC [mg/L]	Si [mg/L]	Sr [mg/L]
0.25	1.50	5.00	1136.0	1457.0	8725	95.00	3000.0	4.00	163.99	7740.0	20249	0.000	21.917	21.000
0.75	1.62	4.85	1118.9	1440.7	8675	93.04	2970.8	191.10	162.96	7731.0	20249	0.027	29.154	21.011
1.25	1.78	4.70	1197.5	1446.0	9039	94.72	2546.6	314.61	138.07	7035.4	20857	2.897	30.737	22.821
1.75	1.95	4.61	1292.1	1464.5	9447	98.22	2150.8	350.75	115.26	6389.0	21426	5.567	30.642	24.508
2.25	2.13	4.69	1386.5	1487.9	9831	102.46	1809.5	338.21	96.00	5837.5	21914	7.849	30.140	25.951
2.75	2.30	5.42	1474.5	1511.3	10176	106.80	1512.2	304.19	79.52	5363.0	22334	9.812	29.595	27.194
3.25	2.48	5.71	1553.3	1532.5	10476	110.89	1253.8	262.84	65.42	4956.1	22695	11.497	29.103	28.260
3.75	2.66	5.85	1622.0	1550.9	10733	114.56	1031.6	221.15	53.44	4610.6	23002	12.928	28.682	29.167
4.25	2.85	5.94	1680.6	1566.3	10950	117.77	842.9	182.57	43.20	4320.6	23260	14.129	28.310	29.927
4.75	3.04	6.01	1729.7	1579.1	11132	120.52	684.5	148.54	32.87	4079.6	23474	15.127	27.902	30.560
5.25	3.24	6.03	1770.6	1589.6	11281	122.85	553.0	118.97	25.26	3881.2	23651	15.949	27.713	31.080

Tab. A.3 Concentrations as a function of time. Variant: v = 1.0 m/a. Position: 2.25 m in leach zone.

t [a]	pH	pE	Ca [mg/L]	Mg [mg/L]	Na [mg/L]	K [mg/L]	Fe [mg/L]	Al [mg/L]	U [mg/L]	sulfate [mg/L]	Cl [mg/L]	DIC [mg/L]	Si [mg/L]	Sr [mg/L]
0.25	1.50	5.00	1136.0	1457.0	8725	95.00	3000.0	4.00	163.99	7740.0	20249	0.000	21.917	21.000
0.75	1.62	4.85	1118.9	1440.7	8675	93.04	2970.8	191.10	162.96	7731.0	20249	0.027	29.154	21.011
1.25	1.74	4.72	1109.9	1432.1	8652	92.02	2953.8	315.47	162.24	7723.9	20250	0.050	33.968	21.021
1.75	1.85	4.62	1126.5	1429.9	8743	92.02	2830.6	403.14	154.71	7518.7	20427	0.894	36.237	21.552
2.25	1.98	4.57	1164.1	1434.9	8921	93.02	2642.8	450.78	143.30	7197.6	20708	2.219	36.914	22.388
2.75	2.11	4.67	1216.3	1446.2	9150	94.87	2425.5	463.33	130.37	6828.8	21033	3.744	36.853	23.351
3.25	2.24	5.29	1277.4	1461.5	9406	97.36	2195.7	450.69	116.99	6444.0	21374	5.335	36.505	24.358
3.75	2.37	5.64	1342.9	1478.7	9671	100.26	1963.5	422.01	103.73	6061.4	21713	6.919	36.067	25.360
4.25	2.50	5.78	1409.3	1496.5	9932	103.37	1736.4	384.24	90.97	5693.5	22039	8.442	35.620	26.325
4.75	2.64	5.87	1473.8	1513.8	10181	106.53	1520.3	342.39	78.99	5348.7	22345	9.869	35.192	27.229
5.25	2.77	5.93	1534.8	1530.0	10412	109.62	1319.0	299.87	67.56	5032.4	22627	11.179	34.775	28.059

Tab. A.4 Concentrations as a function of time. Variant: v = 1.0 m/a. Position: 3.25 m in leach zone.

t [a]	pH	pE	Ca [mg/L]	Mg [mg/L]	Na [mg/L]	K [mg/L]	Fe [mg/L]	Al [mg/L]	U [mg/L]	sulfate [mg/L]	Cl [mg/L]	DIC [mg/L]	Si [mg/L]	Sr [mg/L]
0.25	1.50	5.00	1136.0	1457.0	8725	95.00	3000.0	4.00	163.99	7740.0	20249	0.000	21.917	21.000
0.75	1.62	4.85	1118.9	1440.7	8675	93.04	2970.8	191.10	162.96	7731.0	20249	0.027	29.154	21.011
1.25	1.74	4.72	1109.9	1432.1	8652	92.02	2953.8	315.47	162.24	7723.9	20250	0.050	33.968	21.021
1.75	1.84	4.60	1104.5	1426.8	8640	91.44	2942.1	403.44	161.70	7717.6	20251	0.072	37.170	21.032
2.25	1.95	4.52	1106.2	1423.8	8659	91.19	2904.7	468.09	159.39	7658.1	20301	0.314	39.048	21.183
2.75	2.06	4.51	1117.7	1423.9	8721	91.34	2830.7	511.87	154.66	7527.1	20415	0.854	39.913	21.522
3.25	2.16	4.69	1139.8	1427.7	8828	91.94	2723.3	535.01	147.91	7335.3	20583	1.645	40.148	22.022
3.75	2.27	5.36	1171.8	1435.0	8972	93.02	2588.5	539.45	139.62	7097.0	20793	2.631	40.046	22.645
4.25	2.38	5.63	1212.2	1445.4	9146	94.53	2432.3	528.42	130.20	6825.4	21033	3.754	39.779	23.356
4.75	2.48	5.75	1258.9	1457.9	9340	96.42	2260.8	505.52	120.06	6532.7	21293	4.965	39.436	24.122
5.25	2.59	5.83	1310.1	1471.8	9548	98.61	2080.0	474.18	109.55	6229.9	21562	6.219	39.063	24.916

Tab. A.5 Concentrations as a function of time. Variant: v = 1.0 m/a. Position: 4.75 m in leach zone.

t [a]	pH	pE	Ca [mg/L]	Mg [mg/L]	Na [mg/L]	K [mg/L]	Fe [mg/L]	Al [mg/L]	U [mg/L]	sulfate [mg/L]	Cl [mg/L]	DIC [mg/L]	Si [mg/L]	Sr [mg/L]
0.25	1.50	5.00	1136.0	1457.0	8725	95.00	3000.0	4.00	163.99	7740.0	20249	0.000	21.917	21.000
0.75	1.62	4.85	1118.9	1440.7	8675	93.04	2970.8	191.10	162.96	7731.0	20249	0.027	29.154	21.011
1.25	1.74	4.72	1109.9	1432.1	8652	92.02	2953.8	315.47	162.24	7723.9	20250	0.050	33.968	21.021
1.75	1.84	4.60	1104.5	1426.8	8640	91.44	2942.1	403.44	161.70	7717.6	20251	0.072	37.170	21.032
2.25	1.95	4.51	1101.0	1423.2	8633	91.07	2933.0	468.19	161.27	7711.8	20254	0.092	39.300	21.042
2.75	2.05	4.46	1098.8	1420.6	8630	90.82	2924.5	517.02	160.85	7704.1	20258	0.122	40.705	21.059
3.25	2.14	4.49	1098.4	1418.8	8635	90.68	2911.1	554.19	160.03	7683.7	20275	0.204	41.579	21.110
3.75	2.24	4.83	1100.9	1418.1	8652	90.65	2887.2	581.52	158.47	7640.5	20311	0.381	42.053	21.221
4.25	2.33	5.44	1107.4	1418.8	8688	90.77	2849.2	599.49	155.95	7568.3	20374	0.679	42.246	21.409
4.75	2.42	5.62	1118.8	1421.1	8744	91.08	2794.8	608.28	152.35	7464.4	20466	1.108	42.255	21.680
5.25	2.50	5.73	1135.6	1425.4	8822	91.61	2722.9	608.21	147.66	7329.1	20585	1.667	42.147	22.033

Tab. A.6 Concentrations as a function of time. Variant: v = 1.0 m/a. Position: 0.75 m in downgradient zone.

t [a]	pH	pE	Ca [mg/L]	Mg [mg/L]	Na [mg/L]	K [mg/L]	Fe [mg/L]	Al [mg/L]	U [mg/L]	sulfate [mg/L]	Cl [mg/L]	DIC [mg/L]	Si [mg/L]	Sr [mg/L]
0.25	6.52	1.64	2110.0	1630.0	11894	133.00	1.5	0.02	0.099	3478.0	24367	19.300	0.015	33.200
0.75	2.37	3.37	1907.9	1605.9	11287	127.75	606.5	0.87	35.38	4304.2	23482	15.149	4.734	30.577
1.25	2.18	3.81	1754.6	1608.7	10711	121.66	1056.3	41.46	60.02	5003.8	22708	30.173	9.723	28.285
1.75	2.12	3.98	1657.6	1601.8	10263	115.89	1426.0	101.54	68.78	5581.6	22171	50.302	13.539	26.702
2.25	2.14	4.04	1573.1	1569.1	9909	110.69	1821.2	170.59	72.02	6095.0	21765	66.531	16.781	25.504
2.75	2.17	4.03	1449.5	1535.9	9630	106.35	2081.9	242.38	178.97	6346.9	21446	61.053	33.849	24.563
3.25	2.22	4.23	1381.5	1509.0	9410	102.90	2260.9	314.77	304.79	6635.7	21192	49.442	39.032	23.815
3.75	2.29	3.92	1340.6	1487.8	9238	100.19	2397.6	375.00	414.20	6891.1	20991	39.028	40.909	23.224
4.25	2.36	4.25	1314.2	1471.0	9103	98.03	2504.3	422.74	524.54	7100.0	20833	30.575	41.785	22.760
4.75	2.43	3.63	1296.2	1458.0	8997	96.35	2588.5	463.22	579.18	7272.3	20709	23.868	42.293	22.397
5.25	2.51	4.38	1282.7	1447.6	8915	95.01	2653.7	498.25	613.96	7410.4	20614	18.591	42.625	22.116

Tab. A.7 Concentrations as a function of time. Variant: v = 1.0 m/a. Position: 1.25 m in downgradient zone.

t [a]	pH	pE	Ca [mg/L]	Mg [mg/L]	Na [mg/L]	K [mg/L]	Fe [mg/L]	Al [mg/L]	U [mg/L]	sulfate [mg/L]	Cl [mg/L]	DIC [mg/L]	Si [mg/L]	Sr [mg/L]
0.25	6.52	1.64	2110.0	1630.0	11894	133.00	1.5	0.02	0.099	3478.0	24367	19.300	0.015	33.200
0.75	6.52	-0.16	2109.8	1630.0	11894	133.00	1.5	0.02	0.077	3477.4	24367	19.300	0.021	33.200
1.25	2.79	2.88	1976.6	1617.5	11512	130.38	390.7	0.59	24.17	4005.2	23760	16.454	3.256	31.401
1.75	2.50	3.33	1858.0	1630.4	11091	126.35	692.8	28.21	38.43	4458.6	23195	33.549	6.392	29.727
2.25	2.40	3.58	1770.6	1647.6	10698	121.65	950.5	67.36	44.94	4874.3	22711	58.807	9.218	28.297
2.75	2.37	3.75	1676.8	1619.9	10347	116.92	1340.4	119.94	71.17	5363.9	22294	73.934	14.241	27.065
3.25	2.39	3.91	1601.6	1585.2	10042	112.53	1689.1	179.76	126.76	5825.7	21936	80.467	20.834	26.010
3.75	2.43	4.06	1544.7	1553.4	9783	108.67	1956.8	246.19	188.96	6240.8	21631	77.589	24.133	25.115
4.25	2.46	3.85	1465.2	1526.2	9567	105.38	2135.7	310.38	272.13	6493.2	21378	64.464	28.836	24.367
4.75	2.50	4.00	1410.2	1504.0	9388	102.62	2276.5	360.35	423.51	6722.3	21168	52.093	39.002	23.747
5.25	2.55	3.82	1378.2	1486.1	9241	100.35	2391.8	404.24	537.07	6946.1	20995	41.760	41.507	23.239

Tab. A.8 Concentrations as a function of time. Variant: v = 1.0 m/a. Position: 2.25 m in downgradient zone.

t [a]	pH	pE	Ca [mg/L]	Mg [mg/L]	Na [mg/L]	K [mg/L]	Fe [mg/L]	Al [mg/L]	U [mg/L]	sulfate [mg/L]	Cl [mg/L]	DIC [mg/L]	Si [mg/L]	Sr [mg/L]
0.25	6.52	1.64	2110.0	1630.0	11894	133.00	1.5	0.02	0.099	3478.0	24367	19.300	0.015	33.200
0.75	6.52	-0.16	2109.8	1630.0	11894	133.00	1.5	0.02	0.077	3477.4	24367	19.300	0.021	33.200
1.25	6.52	1.37	2109.6	1630.0	11894	133.00	1.5	0.02	0.067	3476.9	24367	19.300	0.023	33.200
1.75	4.55	2.54	2074.4	1625.6	11787	132.25	106.4	0.18	5.77	3631.9	24191	18.478	0.820	32.680
2.25	3.41	4.89	2024.3	1630.0	11605	130.91	256.6	8.18	15.40	3859.6	23913	24.859	2.462	31.855
2.75	3.14	4.65	1959.8	1648.1	11372	128.80	392.6	23.27	19.53	4064.8	23592	40.541	3.865	30.905
3.25	3.04	4.73	1894.4	1667.9	11113	126.08	548.9	44.53	27.00	4297.9	23257	61.394	5.933	29.912
3.75	2.95	4.68	1822.6	1672.2	10848	123.06	766.7	71.25	47.61	4582.6	22922	78.354	9.431	28.923
4.25	2.90	4.59	1740.3	1648.3	10587	119.82	1085.3	107.34	76.41	4942.7	22600	90.047	12.267	27.971
4.75	2.89	4.57	1667.8	1619.0	10338	116.57	1390.7	150.57	111.77	5313.3	22298	96.483	14.488	27.079
5.25	2.92	4.49	1607.9	1590.6	10108	113.44	1655.8	197.56	164.60	5672.2	22020	97.529	17.166	26.262

Tab. A.9 Concentrations as a function of time. Variant: v = 1.0 m/a. Position: 3.25 m in downgradient zone.

t [a]	pH	pE	Ca [mg/L]	Mg [mg/L]	Na [mg/L]	K [mg/L]	Fe [mg/L]	Al [mg/L]	U [mg/L]	sulfate [mg/L]	Cl [mg/L]	DIC [mg/L]	Si [mg/L]	Sr [mg/L]
0.25	6.52	1.64	2110.0	1630.0	11894	133.00	1.5	0.02	0.099	3478.0	24367	19.300	0.015	33.200
0.75	6.52	-0.16	2109.8	1630.0	11894	133.00	1.5	0.02	0.077	3477.4	24367	19.300	0.021	33.200
1.25	6.52	1.37	2109.6	1630.0	11894	133.00	1.5	0.02	0.067	3476.9	24367	19.300	0.023	33.200
1.75	6.52	-0.24	2109.4	1630.0	11894	133.00	1.5	0.02	0.054	3476.5	24367	19.300	0.030	33.200
2.25	6.07	2.46	2100.3	1628.6	11866	132.80	28.0	0.06	0.046	3518.5	24320	19.078	0.067	33.060
2.75	5.52	0.79	2081.2	1628.8	11798	132.31	86.7	2.24	0.088	3611.0	24209	21.152	0.249	32.732
3.25	5.00	3.55	2054.6	1635.3	11688	131.46	160.8	7.56	0.383	3732.8	24044	28.272	0.646	32.244
3.75	4.78	3.84	2023.6	1651.4	11543	130.21	233.1	15.88	0.864	3865.3	23838	41.238	1.280	31.634
4.25	4.66	4.05	1978.7	1670.3	11369	128.55	323.7	27.03	1.19	3999.5	23603	57.596	2.056	30.937
4.75	4.62	4.10	1927.7	1687.1	11175	126.57	444.7	41.82	1.43	4164.2	23349	75.704	2.431	30.185
5.25	4.25	4.40	1868.0	1692.2	10970	124.33	614.5	60.67	12.35	4373.7	23085	90.420	3.400	29.405

Tab. A.10 Concentrations as a function of time. Variant: v = 1.0 m/a. Position: 4.75 m in downgradient zone.

t [a]	pH	pE	Ca [mg/L]	Mg [mg/L]	Na [mg/L]	K [mg/L]	Fe [mg/L]	Al [mg/L]	U [mg/L]	sulfate [mg/L]	Cl [mg/L]	DIC [mg/L]	Si [mg/L]	Sr [mg/L]
0.25	6.52	1.64	2110.0	1630.0	11894	133.00	1.5	0.02	0.099	3478.0	24367	19.300	0.015	33.200
0.75	6.52	-0.16	2109.8	1630.0	11894	133.00	1.5	0.02	0.077	3477.4	24367	19.300	0.021	33.200
1.25	6.52	1.37	2109.6	1630.0	11894	133.00	1.5	0.02	0.067	3476.9	24367	19.300	0.023	33.200
1.75	6.52	-0.24	2109.4	1630.0	11894	133.00	1.5	0.02	0.054	3476.5	24367	19.300	0.030	33.200
2.25	6.52	1.20	2109.2	1630.0	11894	133.00	1.5	0.02	0.048	3476.1	24367	19.300	0.033	33.200
2.75	6.49	-0.27	2108.7	1629.9	11893	132.99	2.5	0.02	0.042	3477.4	24365	19.291	0.041	33.194
3.25	6.36	1.29	2106.4	1629.6	11886	132.94	9.1	0.09	0.035	3488.5	24352	19.335	0.056	33.155
3.75	6.13	0.05	2101.2	1629.7	11866	132.80	25.2	0.26	0.031	3516.1	24318	20.190	0.115	33.056
4.25	5.86	1.81	2093.1	1631.6	11829	132.53	51.2	0.70	0.026	3560.9	24259	23.042	0.235	32.881
4.75	5.65	1.80	2082.6	1637.0	11773	132.10	84.5	2.00	0.030	3622.8	24172	28.808	0.451	32.623
5.25	5.51	2.26	2070.4	1647.9	11695	131.48	118.5	4.28	0.036	3695.7	24057	37.834	0.744	32.282
0.25	6.52	1.64	2110.0	1630.0	11894	133.00	1.5	0.02	0.099	3478.0	24367	19.300	0.015	33.200

Tab. A.11 Concentrations as a function of time. Variant: v = 1.3 m/a. Position: 0.75 m in leach zone.

t [a]	pH	pE	Ca [mg/L]	Mg [mg/L]	Na [mg/L]	K [mg/L]	Fe [mg/L]	Al [mg/L]	U [mg/L]	sulfate [mg/L]	Cl [mg/L]	DIC [mg/L]	Si [mg/L]	Sr [mg/L]
0.19	1.50	5.00	1136.0	1457.0	8725	95.00	3000.0	4.00	163.99	7740.0	20249	0.000	21.917	21.000
0.58	1.68	4.77	1290.6	1476.1	9379	99.82	2281.4	146.89	123.80	6610.9	21239	4.661	22.219	23.942
0.96	1.87	4.57	1432.0	1499.9	9985	105.14	1668.8	206.02	88.88	5622.8	22109	8.743	20.733	26.521
1.35	2.07	4.47	1535.4	1523.7	10404	109.99	1290.4	208.30	68.10	5031.0	22631	11.189	19.770	28.068
1.73	2.28	4.98	1614.8	1545.0	10707	114.22	1033.6	188.42	54.30	4635.0	22982	12.828	19.181	29.104
2.12	2.49	5.67	1677.9	1562.8	10940	117.78	839.8	162.33	43.96	4336.9	23246	14.062	18.780	29.885
2.50	2.71	5.81	1728.6	1576.9	11124	120.72	685.0	136.27	35.73	4099.6	23457	15.044	18.478	30.508
2.88	2.95	5.92	1769.6	1588.1	11272	123.11	558.8	112.54	29.05	3906.9	23628	15.842	18.242	31.013
3.27	3.21	5.99	1802.6	1596.8	11391	125.03	455.3	91.93	23.61	3749.7	23768	16.493	18.053	31.425
3.65	3.56	6.02	1829.1	1603.8	11488	126.59	370.5	74.59	16.11	3621.4	23882	17.025	17.589	31.762
4.04	4.07	5.71	1850.5	1609.4	11567	127.86	301.1	59.89	7.27	3516.9	23975	17.458	16.994	32.036
4.42	4.73	4.70	1867.8	1613.9	11631	128.89	244.5	47.74	0.080	3431.9	24050	17.810	16.619	32.259
4.81	5.09	3.95	1882.1	1617.4	11682	129.71	198.3	37.87	0.008	3362.8	24112	18.096	17.098	32.441
5.19	5.20	3.74	1893.4	1620.0	11724	130.35	160.7	29.24	0.004	3306.7	24162	18.329	17.380	32.588

Tab. A.12 Concentrations as a function of time. Variant: v = 1.3 m/a. Position: 1.25 m in leach zone.

t [a]	pH	pE	Ca [mg/L]	Mg [mg/L]	Na [mg/L]	K [mg/L]	Fe [mg/L]	Al [mg/L]	U [mg/L]	sulfate [mg/L]	Cl [mg/L]	DIC [mg/L]	Si [mg/L]	Sr [mg/L]
0.19	1.50	5.00	1136.0	1457.0	8725	95.00	3000.0	4.00	163.99	7740.0	20249	0.000	21.917	21.000
0.58	1.59	4.89	1123.4	1444.8	8688	93.51	2976.5	147.97	163.11	7730.8	20251	0.031	27.473	21.014
0.96	1.73	4.75	1225.7	1454.8	9150	95.98	2452.1	253.73	132.37	6866.8	21009	3.597	27.577	23.266
1.35	1.88	4.64	1331.1	1473.6	9606	99.80	2001.1	292.48	106.66	6138.6	21650	6.606	26.737	25.167
1.73	2.05	4.63	1424.0	1495.6	9984	104.00	1661.1	289.40	87.83	5601.0	22125	8.829	25.984	26.572
2.12	2.21	5.12	1504.6	1517.0	10297	108.09	1393.9	266.56	73.29	5183.1	22495	10.558	25.407	27.667
2.50	2.39	5.68	1574.3	1536.3	10558	111.86	1173.7	236.21	61.41	4840.6	22798	11.976	24.958	28.564
2.88	2.57	5.84	1634.0	1552.9	10778	115.21	987.6	204.41	51.44	4552.8	23054	13.167	24.594	29.318
3.27	2.75	5.95	1684.9	1566.7	10964	118.10	829.0	174.11	43.00	4309.4	23270	14.175	24.294	29.957
3.65	2.94	6.02	1727.8	1578.3	11121	120.58	693.9	146.62	33.08	4103.5	23453	15.028	23.760	30.497
4.04	3.15	6.04	1764.1	1587.8	11253	122.68	579.3	121.95	25.94	3929.8	23608	15.747	23.564	30.953
4.42	3.36	6.05	1794.4	1595.7	11363	124.46	482.5	100.39	19.45	3783.7	23738	16.352	23.360	31.336
4.81	3.59	6.00	1819.7	1602.1	11456	125.93	400.9	82.11	13.82	3661.3	23846	16.860	23.159	31.658
5.19	3.90	5.82	1840.7	1607.3	11532	127.16	332.4	66.83	10.53	3559.0	23937	17.284	23.178	31.926

Tab. A.13 Concentrations as a function of time. Variant: v = 1.3 m/a. Position: 2.25 m in leach zone.

t [a]	pH	pE	Ca [mg/L]	Mg [mg/L]	Na [mg/L]	K [mg/L]	Fe [mg/L]	Al [mg/L]	U [mg/L]	sulfate [mg/L]	Cl [mg/L]	DIC [mg/L]	Si [mg/L]	Sr [mg/L]
0.19	1.50	5.00	1136.0	1457.0	8725	95.00	3000.0	4.00	163.99	7740.0	20249	0.000	21.917	21.000
0.58	1.59	4.89	1123.4	1444.8	8688	93.51	2976.5	147.97	163.11	7730.8	20251	0.031	27.473	21.014
0.96	1.68	4.78	1115.4	1436.9	8667	92.58	2960.3	254.72	162.44	7723.3	20253	0.056	31.595	21.027
1.35	1.77	4.70	1141.2	1436.0	8798	92.79	2792.4	335.86	152.21	7440.8	20499	1.220	33.359	21.760
1.73	1.88	4.64	1189.9	1442.2	9025	94.05	2548.5	384.05	137.53	7027.3	20861	2.927	33.634	22.837
2.12	1.99	4.65	1249.3	1453.9	9287	96.11	2295.1	400.86	122.73	6606.6	21232	4.665	33.331	23.936
2.50	2.11	4.85	1312.7	1469.0	9552	98.71	2054.7	394.64	109.06	6214.7	21578	6.286	32.880	24.961
2.88	2.24	5.50	1376.5	1485.5	9808	101.60	1831.2	373.86	96.57	5854.9	21897	7.775	32.427	25.903
3.27	2.36	5.74	1438.4	1502.2	10048	104.61	1624.3	344.89	85.15	5525.4	22189	9.139	32.009	26.767
3.65	2.50	5.85	1496.9	1518.1	10271	107.60	1433.6	312.06	74.73	5224.9	22456	10.383	31.631	27.554
4.04	2.63	5.93	1551.1	1532.9	10474	110.47	1259.1	278.22	64.63	4952.6	22698	11.510	31.226	28.269
4.42	2.77	5.99	1600.7	1546.2	10658	113.15	1100.7	245.05	55.27	4707.8	22915	12.524	30.873	28.911
4.81	2.91	6.03	1645.3	1558.1	10823	115.63	958.1	213.63	46.50	4489.2	23110	13.430	30.549	29.484
5.19	3.04	6.06	1685.2	1568.6	10969	117.87	830.7	184.65	38.41	4295.4	23282	14.233	30.260	29.993

Tab. A.14 Concentrations as a function of time. Variant: v = 1.3 m/a. Position: 3.25 m in leach zone.

t [a]	pH	pE	Ca [mg/L]	Mg [mg/L]	Na [mg/L]	K [mg/L]	Fe [mg/L]	Al [mg/L]	U [mg/L]	sulfate [mg/L]	Cl [mg/L]	DIC [mg/L]	Si [mg/L]	Sr [mg/L]
0.19	1.50	5.00	1136.0	1457.0	8725	95.00	3000.0	4.00	163.99	7740.0	20249	0.000	21.917	21.000
0.58	1.59	4.89	1123.4	1444.8	8688	93.51	2976.5	147.97	163.11	7730.8	20251	0.031	27.473	21.014
0.96	1.68	4.78	1115.4	1436.9	8667	92.58	2960.3	254.72	162.44	7723.3	20253	0.056	31.595	21.027
1.35	1.76	4.69	1110.0	1431.5	8654	91.97	2948.2	336.23	161.90	7716.7	20255	0.079	34.654	21.038
1.73	1.84	4.62	1114.5	1428.7	8686	91.74	2894.3	399.79	158.53	7627.6	20331	0.444	36.533	21.267
2.12	1.93	4.58	1132.1	1429.3	8778	92.00	2786.9	445.35	151.72	7437.8	20496	1.226	37.352	21.760
2.50	2.02	4.60	1161.2	1433.8	8917	92.77	2643.0	471.51	142.82	7186.1	20717	2.266	37.504	22.417
2.88	2.11	4.81	1199.2	1441.8	9088	94.01	2479.5	479.63	133.02	6905.9	20964	3.424	37.328	23.148
3.27	2.21	5.42	1243.4	1452.4	9277	95.67	2307.0	473.02	122.93	6615.4	21221	4.625	37.018	23.908
3.65	2.31	5.69	1291.6	1464.9	9476	97.66	2131.2	455.44	112.82	6323.9	21479	5.832	36.665	24.672
4.04	2.41	5.81	1341.9	1478.4	9677	99.88	1955.9	430.27	102.89	6037.3	21734	7.018	36.307	25.423
4.42	2.52	5.88	1392.6	1492.1	9876	102.25	1784.1	400.30	93.12	5760.0	21980	8.166	35.943	26.150
4.81	2.62	5.94	1442.6	1505.7	10068	104.68	1618.0	367.71	83.54	5495.3	22215	9.262	35.583	26.844
5.19	2.73	5.99	1491.0	1518.8	10252	107.12	1459.4	334.13	74.23	5245.6	22437	10.296	35.237	27.499

Tab. A.15 Concentrations as a function of time. Variant: v = 1.3 m/a. Position: 4.75 m in leach zone.

t [a]	pH	pE	Ca [mg/L]	Mg [mg/L]	Na [mg/L]	K [mg/L]	Fe [mg/L]	Al [mg/L]	U [mg/L]	sulfate [mg/L]	Cl [mg/L]	DIC [mg/L]	Si [mg/L]	Sr [mg/L]
0.19	1.50	5.00	1136.0	1457.0	8725	95.00	3000.0	4.00	163.99	7740.0	20249	0.000	21.917	21.000
0.58	1.59	4.89	1123.4	1444.8	8688	93.51	2976.5	147.97	163.11	7730.8	20251	0.031	27.473	21.014
0.96	1.68	4.78	1115.4	1436.9	8667	92.58	2960.3	254.72	162.44	7723.3	20253	0.056	31.595	21.027
1.35	1.76	4.69	1110.0	1431.5	8654	91.97	2948.2	336.23	161.90	7716.7	20255	0.079	34.654	21.038
1.73	1.84	4.61	1106.2	1427.6	8646	91.55	2938.6	399.92	161.45	7710.7	20258	0.101	36.923	21.050
2.12	1.92	4.54	1103.9	1424.7	8643	91.26	2928.8	450.56	160.94	7701.2	20264	0.137	38.588	21.071
2.50	2.00	4.51	1104.2	1422.8	8652	91.09	2908.9	491.08	159.67	7668.8	20290	0.269	39.711	21.153
2.88	2.07	4.53	1108.8	1422.1	8681	91.09	2871.1	522.34	157.13	7599.1	20351	0.555	40.351	21.333
3.27	2.15	4.72	1118.8	1423.1	8734	91.28	2813.1	544.06	153.30	7490.8	20445	1.002	40.620	21.615
3.65	2.22	5.32	1134.6	1426.1	8812	91.68	2736.1	556.08	148.35	7348.9	20570	1.588	40.644	21.985
4.04	2.30	5.62	1155.9	1430.9	8911	92.33	2642.8	558.76	142.50	7180.2	20719	2.285	40.522	22.426
4.42	2.37	5.74	1182.4	1437.6	9028	93.23	2535.9	552.99	135.93	6990.6	20886	3.070	40.319	22.922
4.81	2.45	5.82	1213.3	1445.8	9161	94.36	2418.1	539.95	128.81	6785.3	21068	3.919	40.072	23.460
5.19	2.53	5.88	1247.8	1455.2	9305	95.71	2291.8	520.95	121.27	6569.3	21260	4.813	39.798	24.026

Tab. A.16 Concentrations as a function of time. Variant: v = 1.3 m/a. Position: 0.75 m in downgradient zone.

t [a]	pH	pE	Ca [mg/L]	Mg [mg/L]	Na [mg/L]	K [mg/L]	Fe [mg/L]	Al [mg/L]	U [mg/L]	sulfate [mg/L]	Cl [mg/L]	DIC [mg/L]	Si [mg/L]	Sr [mg/L]
0.19	6.52	1.64	2110.0	1630.0	11894	133.00	1.5	0.02	0.099	3478.0	24367	19.300	0.015	33.200
0.58	2.32	3.48	1883.9	1603.2	11217	127.15	676.6	0.96	39.42	4397.3	23380	14.671	5.273	30.274
0.96	2.09	3.96	1709.5	1591.2	10587	120.84	1228.3	36.03	70.17	5236.8	22513	21.806	10.812	27.709
1.35	2.02	4.15	1627.7	1589.5	10148	115.18	1548.0	90.22	82.45	5816.4	21994	36.451	14.792	26.175
1.73	2.01	4.22	1558.3	1563.5	9828	110.20	1866.7	151.72	86.39	6258.4	21646	49.770	17.829	25.149
2.12	2.03	4.28	1432.6	1535.1	9587	106.08	2121.1	212.11	100.29	6420.9	21386	56.255	23.037	24.381
2.50	2.06	4.27	1365.0	1511.9	9402	102.92	2280.8	274.13	194.01	6636.1	21178	49.516	35.000	23.771
2.88	2.11	4.42	1323.6	1492.7	9254	100.41	2397.3	332.03	285.10	6839.5	21010	41.194	38.809	23.277
3.27	2.17	4.18	1296.8	1477.3	9135	98.45	2489.1	381.20	360.89	7016.3	20874	33.740	40.358	22.877
3.65	2.23	4.43	1278.3	1464.9	9040	96.87	2562.6	421.66	438.76	7163.2	20763	27.502	41.194	22.552
4.04	2.29	3.91	1265.4	1455.1	8964	95.63	2622.6	454.99	494.73	7285.7	20674	22.378	41.742	22.290
4.42	2.35	4.42	1255.5	1447.0	8902	94.62	2670.6	484.05	540.26	7386.4	20602	18.196	42.135	22.079
4.81	2.41	3.54	1248.1	1440.7	8853	93.82	2709.8	509.75	545.76	7472.2	20544	14.794	42.428	21.910
5.19	2.47	4.31	1241.2	1435.3	8813	93.16	2740.5	532.43	555.56	7539.0	20498	12.031	42.648	21.775

Tab. A.17 Concentrations as a function of time. Variant: v = 1.3 m/a. Position: 1.25 m in downgradient zone.

t [a]	pH	pE	Ca [mg/L]	Mg [mg/L]	Na [mg/L]	K [mg/L]	Fe [mg/L]	Al [mg/L]	U [mg/L]	sulfate [mg/L]	Cl [mg/L]	DIC [mg/L]	Si [mg/L]	Sr [mg/L]
0.19	6.52	1.64	2110.0	1630.0	11894	133.00	1.5	0.02	0.099	3478.0	24367	19.300	0.015	33.200
0.58	6.52	-0.14	2109.8	1630.0	11894	133.00	1.5	0.02	0.087	3477.4	24367	19.300	0.019	33.200
0.96	2.68	2.99	1939.2	1614.8	11420	129.77	486.2	0.73	30.06	4120.4	23612	15.760	4.040	30.963
1.35	2.36	3.53	1802.3	1616.7	10952	125.48	867.8	27.30	49.91	4684.9	22975	26.269	7.832	29.075
1.73	2.24	3.78	1721.7	1627.2	10560	120.74	1129.0	66.43	58.96	5137.7	22504	45.461	10.847	27.682
2.12	2.19	3.96	1650.6	1609.1	10238	116.17	1440.3	112.83	72.69	5579.3	22137	59.244	15.609	26.600
2.50	2.19	4.08	1591.5	1580.4	9969	111.97	1736.0	165.50	95.95	5980.5	21836	68.022	19.600	25.714
2.88	2.21	4.15	1544.5	1552.9	9746	108.35	1977.1	220.12	142.90	6332.0	21583	70.358	24.586	24.971
3.27	2.24	4.30	1440.7	1527.8	9558	105.22	2143.9	278.00	194.66	6455.0	21372	63.339	27.523	24.345
3.65	2.27	3.88	1389.2	1508.6	9405	102.74	2269.5	325.28	307.74	6650.0	21192	53.716	37.614	23.818
4.04	2.32	4.38	1358.4	1492.2	9275	100.66	2370.7	366.28	434.83	6837.8	21042	44.851	40.489	23.374
4.42	2.37	3.65	1337.8	1478.7	9168	98.94	2455.2	402.55	517.50	7006.7	20915	37.258	41.507	23.003
4.81	2.43	4.36	1322.2	1467.1	9077	97.48	2525.1	435.09	590.98	7150.7	20810	30.880	42.001	22.694
5.19	2.48	3.36	1309.9	1457.9	9004	96.29	2584.2	464.41	611.36	7275.4	20723	25.557	42.311	22.437

Tab. A.18 Concentrations as a function of time. Variant: v = 1.3 m/a. Position: 2.25 m in downgradient zone.

t [a]	pH	pE	Ca [mg/L]	Mg [mg/L]	Na [mg/L]	K [mg/L]	Fe [mg/L]	Al [mg/L]	U [mg/L]	sulfate [mg/L]	Cl [mg/L]	DIC [mg/L]	Si [mg/L]	Sr [mg/L]
0.19	6.52	1.64	2110.0	1630.0	11894	133.00	1.5	0.02	0.099	3478.0	24367	19.300	0.015	33.200
0.58	6.52	-0.14	2109.8	1630.0	11894	133.00	1.5	0.02	0.087	3477.4	24367	19.300	0.019	33.200
0.96	6.52	1.50	2109.5	1630.0	11894	133.00	1.5	0.02	0.077	3476.8	24367	19.300	0.021	33.200
1.35	3.82	3.00	2060.8	1624.5	11748	132.03	147.2	0.25	9.67	3688.6	24123	18.159	1.322	32.479
1.73	3.08	4.06	1983.5	1624.9	11516	130.42	357.6	8.85	21.21	3973.7	23764	22.208	3.264	31.414
2.12	2.81	3.70	1906.0	1637.2	11250	128.13	539.0	26.00	29.42	4244.2	23398	34.122	5.211	30.329
2.50	2.67	3.73	1839.8	1651.7	10982	125.32	712.7	49.15	36.35	4517.6	23056	50.782	7.552	29.317
2.88	2.58	3.93	1777.9	1656.6	10724	122.24	910.6	76.77	45.83	4804.5	22742	66.411	10.152	28.388
3.27	2.54	4.13	1710.7	1637.7	10481	119.04	1184.4	110.32	67.39	5137.5	22453	77.649	13.574	27.537
3.65	2.52	4.62	1651.4	1612.2	10256	115.85	1449.6	150.07	95.89	5469.7	22190	84.447	16.354	26.761
4.04	2.53	4.03	1601.4	1587.2	10053	112.86	1683.8	191.57	140.68	5784.6	21952	87.188	20.136	26.059
4.42	2.56	4.91	1560.5	1563.9	9870	110.10	1880.1	234.68	197.29	6075.6	21738	85.842	22.528	25.428
4.81	2.59	4.02	1528.7	1543.2	9707	107.62	2022.1	283.40	249.78	6343.7	21546	76.936	23.786	24.866
5.19	2.63	5.35	1498.4	1525.0	9564	105.39	2136.4	329.67	309.09	6573.4	21378	66.757	25.618	24.370

Tab. A.19 Concentrations as a function of time. Variant: v = 1.3 m/a. Position: 3.25 m in downgradient zone.

t [a]	pH	pE	Ca [mg/L]	Mg [mg/L]	Na [mg/L]	K [mg/L]	Fe [mg/L]	Al [mg/L]	U [mg/L]	sulfate [mg/L]	Cl [mg/L]	DIC [mg/L]	Si [mg/L]	Sr [mg/L]
0.19	6.52	1.64	2110.0	1630.0	11894	133.00	1.5	0.02	0.099	3478.0	24367	19.300	0.015	33.200
0.58	6.52	-0.14	2109.8	1630.0	11894	133.00	1.5	0.02	0.087	3477.4	24367	19.300	0.019	33.200
0.96	6.52	1.50	2109.5	1630.0	11894	133.00	1.5	0.02	0.077	3476.8	24367	19.300	0.021	33.200
1.35	6.52	-0.20	2109.4	1630.0	11894	133.00	1.5	0.02	0.065	3476.3	24367	19.300	0.025	33.200
1.73	5.92	2.79	2095.5	1628.0	11852	132.70	42.5	0.09	0.053	3540.7	24294	18.956	0.079	32.983
2.12	4.77	1.79	2063.8	1626.6	11753	132.03	133.2	2.70	2.10	3673.6	24131	20.297	0.532	32.501
2.50	3.89	5.29	2025.3	1631.4	11611	131.01	242.7	9.52	20.47	3842.0	23914	25.971	3.155	31.858
2.88	3.46	5.39	1976.6	1644.5	11439	129.62	346.4	20.25	19.61	3998.7	23671	36.764	3.788	31.139
3.27	3.27	5.42	1927.2	1660.6	11250	127.86	455.5	34.10	23.02	4166.2	23419	51.023	5.149	30.393
3.65	3.17	5.44	1876.7	1673.6	11051	125.77	586.2	51.14	31.91	4352.9	23166	66.714	7.109	29.643
4.04	3.07	5.30	1822.4	1676.0	10851	123.49	754.9	71.84	45.68	4571.4	22916	79.578	9.118	28.905
4.42	2.98	4.83	1760.7	1659.5	10654	121.07	991.7	97.18	65.45	4837.8	22675	89.087	11.205	28.191
4.81	2.95	5.02	1702.9	1637.4	10462	118.57	1232.9	127.42	91.91	5117.6	22443	95.995	12.976	27.509
5.19	2.94	4.80	1652.2	1614.6	10280	116.09	1452.4	162.21	121.32	5395.7	22225	98.953	14.137	26.866

Tab. A.20 Concentrations as a function of time. Variant: v = 1.3 m/a. Position: 4.75 m in downgradient zone.

t [a]	pH	pE	Ca [mg/L]	Mg [mg/L]	Na [mg/L]	K [mg/L]	Fe [mg/L]	Al [mg/L]	U [mg/L]	sulfate [mg/L]	Cl [mg/L]	DIC [mg/L]	Si [mg/L]	Sr [mg/L]
0.19	6.52	1.64	2110.0	1630.0	11894	133.00	1.5	0.02	0.099	3478.0	24367	19.300	0.015	33.200
0.58	6.52	-0.14	2109.8	1630.0	11894	133.00	1.5	0.02	0.087	3477.4	24367	19.300	0.019	33.200
0.96	6.52	1.50	2109.5	1630.0	11894	133.00	1.5	0.02	0.077	3476.8	24367	19.300	0.021	33.200
1.35	6.52	-0.20	2109.4	1630.0	11894	133.00	1.5	0.02	0.065	3476.3	24367	19.300	0.025	33.200
1.73	6.52	1.38	2109.2	1630.0	11894	133.00	1.5	0.02	0.057	3475.9	24367	19.300	0.027	33.200
2.12	6.48	-0.21	2108.4	1629.9	11892	132.98	3.2	0.02	0.051	3478.5	24364	19.285	0.035	33.190
2.50	6.27	1.52	2104.2	1629.2	11879	132.89	15.2	0.15	0.039	3498.6	24340	19.268	0.058	33.120
2.88	5.93	0.30	2094.4	1628.7	11846	132.66	44.0	0.52	0.038	3545.1	24283	19.973	0.141	32.952
3.27	5.60	3.02	2079.4	1630.0	11790	132.27	87.6	2.62	0.040	3615.8	24192	22.582	0.311	32.682
3.65	5.42	2.98	2060.0	1634.9	11712	131.69	139.7	7.32	0.047	3701.7	24072	28.016	0.612	32.325
4.04	5.28	3.46	2039.9	1645.7	11613	130.93	189.3	13.04	0.059	3798.2	23927	36.570	1.049	31.897
4.42	5.13	3.22	2013.6	1659.8	11496	129.94	244.8	19.17	0.095	3894.9	23764	47.793	1.546	31.414
4.81	5.05	3.66	1980.5	1675.3	11365	128.73	310.9	27.31	0.126	3994.2	23588	60.847	1.958	30.891
5.19	4.96	3.21	1942.5	1687.9	11223	127.35	399.8	37.49	0.208	4113.8	23401	74.057	2.179	30.338

Tab. A.21 Concentrations as a function of time. Variant: v = 6.0 m/a. Position: 0.75 m in leach zone.

t [a]	pH	pE	Ca [mg/L]	Mg [mg/L]	Na [mg/L]	K [mg/L]	Fe [mg/L]	Al [mg/L]	U [mg/L]	sulfate [mg/L]	Cl [mg/L]	DIC [mg/L]	Si [mg/L]	Sr [mg/L]
0.38	2.11	4.32	1751.9	1572.7	11265	120.06	493.9	60.51	24.72	3780.5	23742	16.367	5.966	31.346
0.79	3.33	6.10	1860.1	1609.6	11604	128.34	259.8	49.27	10.78	3468.5	24017	17.658	4.621	32.163
1.21	5.18	3.72	1885.9	1618.6	11687	130.34	198.1	33.58	0.023	3374.1	24102	18.049	3.630	32.411
1.63	5.23	3.70	1898.8	1621.4	11736	131.02	151.7	23.67	0.015	3302.7	24165	18.345	3.930	32.598
2.04	5.29	3.66	1908.6	1623.5	11774	131.49	116.3	16.28	0.010	3248.1	24214	18.571	4.283	32.742
2.46	5.36	3.56	1916.2	1625.1	11803	131.85	89.2	10.71	0.007	3206.4	24251	18.744	4.506	32.851
2.88	5.44	3.43	1921.9	1626.3	11825	132.13	68.5	6.60	0.005	3174.5	24279	18.876	4.591	32.935
3.29	5.53	3.25	1926.3	1627.2	11842	132.34	52.7	3.70	0.003	3150.1	24301	18.977	4.586	32.999
3.71	5.66	3.02	1929.6	1628.0	11854	132.50	40.6	1.86	0.002	3131.5	24317	19.054	4.566	33.047
4.13	5.80	2.75	1932.2	1628.5	11864	132.62	31.4	0.90	0.001	3117.3	24330	19.113	4.549	33.085
4.54	5.94	2.48	1934.1	1628.9	11872	132.72	24.3	0.50	0.001	3106.5	24340	19.158	4.537	33.113
4.96	6.06	2.26	1935.6	1629.2	11877	132.79	18.9	0.33	0.001	3098.2	24347	19.192	4.527	33.135

Tab. A.22 Concentrations as a function of time. Variant: v = 6.0 m/a. Position: 1.25 m in leach zone.

t [a]	pH	pE	Ca [mg/L]	Mg [mg/L]	Na [mg/L]	K [mg/L]	Fe [mg/L]	Al [mg/L]	U [mg/L]	sulfate [mg/L]	Cl [mg/L]	DIC [mg/L]	Si [mg/L]	Sr [mg/L]
0.38	1.84	4.61	1604.6	1534.5	10722	111.30	951.4	86.87	47.87	4443.1	23156	13.626	9.998	29.612
0.79	2.66	6.10	1805.4	1592.8	11422	124.52	404.9	76.70	18.65	3688.0	23822	16.749	6.960	31.587
1.21	4.20	5.47	1853.3	1610.6	11565	128.47	307.8	55.50	7.80	3541.9	23952	17.354	6.096	31.971
1.63	4.95	4.21	1874.7	1616.1	11644	129.80	237.4	40.65	0.060	3433.7	24049	17.802	5.597	32.255
2.04	5.06	4.06	1889.8	1619.4	11702	130.55	183.1	29.60	0.027	3350.3	24123	18.148	5.997	32.474
2.46	5.18	3.89	1901.5	1621.9	11747	131.12	141.3	21.22	0.013	3286.1	24180	18.414	6.346	32.642
2.88	5.30	3.69	1910.5	1623.8	11781	131.56	109.1	14.97	0.006	3236.6	24224	18.619	6.538	32.772
3.29	5.37	3.57	1917.4	1625.3	11808	131.90	84.3	9.89	0.004	3198.5	24258	18.777	6.616	32.872
3.71	5.45	3.43	1922.7	1626.5	11828	132.16	65.2	6.10	0.003	3169.2	24284	18.898	6.629	32.949
4.13	5.55	3.24	1926.8	1627.3	11844	132.36	50.5	3.42	0.002	3146.6	24304	18.992	6.611	33.008
4.54	5.67	3.01	1930.0	1628.0	11856	132.51	39.2	1.73	0.001	3129.2	24320	19.063	6.591	33.054
4.96	5.81	2.74	1932.4	1628.5	11865	132.63	30.5	0.86	0.001	3115.9	24331	19.119	6.576	33.089

Tab. A.23 Concentrations as a function of time. Variant: v = 6.0 m/a. Position: 2.25 m in leach zone.

t [a]	pH	pE	Ca [mg/L]	Mg [mg/L]	Na [mg/L]	K [mg/L]	Fe [mg/L]	Al [mg/L]	U [mg/L]	sulfate [mg/L]	Cl [mg/L]	DIC [mg/L]	Si [mg/L]	Sr [mg/L]
0.38	1.62	4.88	1310.2	1477.7	9508	99.12	2122.5	112.88	111.66	6263.2	21548	6.100	19.311	24.853
0.79	2.10	5.39	1671.9	1549.9	10983	114.92	733.9	128.12	38.00	4164.9	23399	14.775	11.342	30.337
1.21	2.80	6.14	1777.4	1588.7	11304	123.38	525.8	101.49	20.74	3874.1	23657	15.978	9.930	31.099
1.63	3.78	5.92	1823.4	1603.9	11453	126.89	411.5	77.01	8.72	3698.2	23814	16.707	9.091	31.561
2.04	4.59	4.89	1850.1	1610.6	11553	128.49	322.0	58.47	0.414	3561.1	23936	17.275	8.679	31.921
2.46	4.82	4.54	1869.9	1615.0	11628	129.50	251.8	44.08	0.085	3453.8	24031	17.719	9.118	32.202
2.88	4.99	4.25	1885.4	1618.4	11687	130.28	196.9	32.97	0.026	3369.9	24106	18.067	9.490	32.422
3.29	5.13	4.03	1897.5	1621.0	11733	130.88	154.0	24.29	0.011	3304.3	24164	18.339	9.755	32.594
3.71	5.23	3.84	1907.0	1623.0	11769	131.35	120.4	17.51	0.006	3253.0	24210	18.551	9.891	32.729
4.13	5.33	3.67	1914.4	1624.6	11797	131.72	94.2	12.23	0.004	3213.0	24245	18.717	9.933	32.834
4.54	5.40	3.53	1920.1	1625.9	11819	132.01	73.8	8.03	0.002	3181.7	24273	18.846	9.918	32.916
4.96	5.49	3.38	1924.6	1626.9	11836	132.23	57.8	4.88	0.002	3157.3	24295	18.947	9.892	32.980

Tab. A.24 Concentrations as a function of time. Variant: v = 6.0 m/a. Position: 3.25 m in leach zone.

t [a]	pH	pE	Ca [mg/L]	Mg [mg/L]	Na [mg/L]	K [mg/L]	Fe [mg/L]	Al [mg/L]	U [mg/L]	sulfate [mg/L]	Cl [mg/L]	DIC [mg/L]	Si [mg/L]	Sr [mg/L]
0.38	1.58	4.92	1154.9	1452.6	8825	94.62	2845.0	118.31	154.63	7487.7	20467	1.037	25.184	21.652
0.79	1.83	4.87	1505.3	1505.8	10374	105.27	1238.5	175.10	62.90	4881.0	22765	11.811	16.008	28.462
1.21	2.31	6.07	1677.9	1556.6	10977	116.13	774.9	151.94	37.31	4249.0	23324	14.425	13.772	30.116
1.63	2.93	6.17	1757.5	1585.7	11221	122.57	609.1	119.74	22.62	3998.2	23547	15.464	12.782	30.774
2.04	3.69	6.01	1802.0	1599.1	11374	125.72	483.9	93.21	10.73	3805.6	23718	16.262	12.091	31.279
2.46	4.29	5.41	1831.7	1606.4	11485	127.45	383.6	72.20	2.33	3652.6	23854	16.896	11.734	31.680
2.88	4.59	4.96	1854.4	1611.5	11571	128.64	303.8	55.64	0.297	3531.1	23962	17.399	12.003	31.999
3.29	4.84	4.56	1872.5	1615.5	11639	129.56	240.5	42.61	0.055	3434.8	24048	17.798	12.361	32.252
3.71	5.00	4.28	1886.8	1618.6	11693	130.29	190.3	32.26	0.019	3358.4	24116	18.114	12.664	32.453
4.13	5.13	4.06	1898.1	1621.1	11736	130.87	150.6	24.05	0.009	3297.9	24170	18.365	12.841	32.611
4.54	5.23	3.87	1907.1	1623.0	11770	131.32	119.1	17.57	0.005	3250.1	24212	18.563	12.904	32.737
4.96	5.32	3.71	1914.2	1624.6	11797	131.68	94.2	12.46	0.003	3212.2	24246	18.720	12.896	32.836

Tab. A.25 Concentrations as a function of time. Variant: v = 6.0 m/a. Position: 4.75 m in leach zone.

t [a]	pH	pE	Ca [mg/L]	Mg [mg/L]	Na [mg/L]	K [mg/L]	Fe [mg/L]	Al [mg/L]	U [mg/L]	sulfate [mg/L]	Cl [mg/L]	DIC [mg/L]	Si [mg/L]	Sr [mg/L]
0.38	1.57	4.91	1131.2	1448.8	8716	94.05	2964.3	118.52	162.21	7703.8	20276	0.144	26.198	21.087
0.79	1.69	4.87	1261.9	1461.7	9348	96.47	2241.2	217.72	116.76	6421.2	21404	5.441	24.227	24.433
1.21	1.94	5.43	1500.7	1503.6	10362	104.76	1254.6	225.18	64.34	4939.9	22711	11.565	19.129	28.305
1.63	2.33	6.13	1630.7	1546.1	10797	113.50	941.0	191.53	44.25	4501.5	23100	13.380	17.697	29.453
2.04	2.83	6.20	1709.8	1573.8	11048	119.66	761.2	155.00	29.51	4224.7	23346	14.526	16.851	30.179
2.46	3.38	6.17	1761.2	1589.1	11225	123.24	616.2	123.74	18.24	4002.1	23544	15.448	16.362	30.763
2.88	3.89	5.92	1797.6	1598.3	11359	125.43	497.4	98.19	9.85	3821.5	23704	16.196	16.093	31.237
3.29	4.20	5.59	1825.5	1604.8	11464	126.98	400.8	77.61	3.24	3675.1	23834	16.803	15.893	31.621
3.71	4.48	5.19	1847.9	1609.9	11549	128.17	322.6	61.02	0.470	3556.7	23940	17.293	16.015	31.932
4.13	4.74	4.76	1866.2	1614.0	11618	129.14	259.4	47.63	0.077	3461.0	24025	17.689	16.321	32.183
4.54	4.93	4.45	1880.9	1617.2	11673	129.91	208.4	36.85	0.023	3383.9	24093	18.009	16.588	32.386
4.96	5.06	4.20	1892.8	1619.9	11717	130.53	167.3	28.18	0.010	3321.7	24149	18.266	16.732	32.549

Tab. A.26 Concentrations as a function of time. Variant: v = 6.0 m/a. Position: 0.75 m in downgradient zone.

t [a]	pH	pE	Ca [mg/L]	Mg [mg/L]	Na [mg/L]	K [mg/L]	Fe [mg/L]	Al [mg/L]	U [mg/L]	sulfate [mg/L]	Cl [mg/L]	DIC [mg/L]	Si [mg/L]	Sr [mg/L]
0.38	1.70	4.67	1378.0	1510.9	9339	107.02	2463.1	53.50	136.18	7104.9	20904	7.004	20.225	22.944
0.79	1.67	4.79	1221.9	1475.1	8995	97.43	2655.2	164.18	141.35	7256.6	20657	13.599	25.330	22.218
1.21	1.75	4.76	1193.1	1460.7	8923	95.42	2714.7	253.75	154.52	7316.3	20597	15.704	31.032	22.047
1.63	1.83	4.77	1180.7	1451.4	8878	94.44	2735.2	329.42	183.66	7367.9	20556	12.287	35.298	21.929
2.04	1.91	4.87	1173.7	1444.6	8848	93.79	2747.8	388.46	208.68	7404.8	20528	9.618	37.045	21.851
2.46	1.99	5.21	1170.0	1439.7	8830	93.34	2754.0	434.54	230.08	7427.2	20513	7.606	38.326	21.810
2.88	2.07	5.48	1169.9	1436.6	8831	93.11	2744.8	470.23	246.25	7400.9	20540	6.251	39.095	21.893
3.29	2.14	5.77	1180.6	1436.6	8894	93.24	2676.8	494.64	252.03	7231.6	20694	5.837	39.032	22.349
3.71	2.21	4.83	1207.9	1440.6	9037	93.74	2529.6	504.30	243.77	6951.5	20946	6.153	38.434	23.098
4.13	2.29	5.41	1247.6	1447.8	9221	94.47	2349.1	498.48	229.23	6662.0	21207	6.707	37.860	23.868
4.54	2.37	3.89	1289.7	1458.2	9416	95.59	2171.4	480.43	204.52	6376.4	21455	7.359	37.425	24.601
4.96	2.47	5.32	1334.2	1471.3	9615	97.28	2000.1	456.14	159.81	6098.2	21697	8.101	37.015	25.316

Tab. A.27 Concentrations as a function of time. Variant: v = 6.0 m/a. Position: 1.25 m in downgradient zone.

t [a]	pH	pE	Ca [mg/L]	Mg [mg/L]	Na [mg/L]	K [mg/L]	Fe [mg/L]	Al [mg/L]	U [mg/L]	sulfate [mg/L]	Cl [mg/L]	DIC [mg/L]	Si [mg/L]	Sr [mg/L]
0.38	1.89	4.33	1524.6	1555.6	9908	116.82	1995.4	28.32	113.27	6403.4	21490	8.563	16.196	24.678
0.79	1.69	4.75	1288.9	1496.9	9169	100.92	2490.7	133.00	132.58	7043.5	20852	17.434	23.002	22.793
1.21	1.75	4.74	1230.9	1474.7	9042	97.10	2605.9	224.38	137.74	7139.7	20746	23.269	27.502	22.487
1.63	1.83	4.78	1210.2	1462.0	8970	95.65	2655.0	302.13	182.69	7228.9	20672	19.156	35.010	22.273
2.04	1.91	4.88	1198.7	1452.9	8920	94.72	2685.1	365.67	220.32	7298.7	20619	14.975	36.913	22.120
2.46	1.99	5.22	1192.0	1446.1	8885	94.07	2705.3	415.13	252.96	7348.5	20583	11.775	38.227	22.016
2.88	2.07	5.47	1189.2	1441.4	8869	93.65	2711.4	453.57	279.41	7358.0	20582	9.434	39.086	22.014
3.29	2.14	5.57	1195.4	1439.7	8905	93.58	2669.6	481.12	294.97	7242.3	20690	8.146	39.198	22.338
3.71	2.21	5.55	1217.4	1442.0	9021	93.91	2549.2	495.08	293.50	7000.3	20911	7.798	38.696	22.994
4.13	2.29	5.11	1252.7	1447.7	9187	94.50	2383.8	493.93	280.09	6729.9	21157	7.884	38.137	23.723
4.54	2.37	4.36	1292.4	1456.6	9371	95.40	2213.6	480.13	255.99	6459.3	21396	8.178	37.688	24.428
4.96	2.46	5.15	1332.7	1468.4	9560	96.84	2047.8	458.52	214.21	6186.2	21631	8.641	37.310	25.121

Tab. A.28 Concentrations as a function of time. Variant: v = 6.0 m/a. Position: 2.25 m in downgradient zone.

t [a]	pH	pE	Ca [mg/L]	Mg [mg/L]	Na [mg/L]	K [mg/L]	Fe [mg/L]	Al [mg/L]	U [mg/L]	sulfate [mg/L]	Cl [mg/L]	DIC [mg/L]	Si [mg/L]	Sr [mg/L]
0.38	2.57	3.33	1816.3	1608.2	11126	128.35	797.3	4.91	50.05	4499.9	23098	13.797	6.899	29.438
0.79	1.82	4.51	1515.3	1547.9	9611	111.36	2137.5	83.38	116.28	6776.5	21273	19.287	18.920	24.041
1.21	1.77	4.67	1323.1	1505.7	9292	101.53	2357.9	173.01	118.34	6805.0	21042	30.824	22.817	23.358
1.63	1.83	4.73	1267.9	1484.5	9160	98.37	2490.9	252.07	147.18	6946.1	20908	32.791	29.706	22.967
2.04	1.91	4.89	1245.9	1470.4	9070	96.77	2556.3	320.67	216.04	7073.6	20807	26.277	36.534	22.673
2.46	1.99	5.26	1232.7	1459.9	9004	95.68	2602.7	377.09	268.36	7173.8	20732	20.751	38.014	22.455
2.88	2.07	5.56	1224.8	1452.2	8958	94.90	2634.3	421.09	313.10	7240.4	20685	16.485	38.992	22.320
3.29	2.14	5.26	1223.7	1447.2	8950	94.46	2634.3	454.32	346.98	7218.1	20716	13.467	39.400	22.412
3.71	2.21	5.61	1235.5	1446.2	9012	94.43	2566.6	475.56	362.64	7059.7	20866	11.704	39.135	22.860
4.13	2.28	4.18	1262.2	1449.1	9138	94.73	2437.7	482.98	355.03	6835.1	21077	10.762	38.650	23.484
4.54	2.36	5.37	1297.2	1455.0	9295	95.29	2286.7	477.21	337.23	6597.8	21294	10.271	38.201	24.126
4.96	2.44	3.93	1333.7	1464.1	9465	96.27	2133.7	462.04	297.02	6350.5	21511	10.112	37.849	24.768

Tab. A.29 Concentrations as a function of time. Variant: v = 6.0 m/a. Position: 3.25 m in downgradient zone.

t [a]	pH	pE	Ca [mg/L]	Mg [mg/L]	Na [mg/L]	K [mg/L]	Fe [mg/L]	Al [mg/L]	U [mg/L]	sulfate [mg/L]	Cl [mg/L]	DIC [mg/L]	Si [mg/L]	Sr [mg/L]
0.38	5.06	4.20	2072.7	1625.6	11785	132.29	108.3	0.19	0.720	3638.4	24176	18.407	0.221	32.635
0.79	2.12	4.01	1579.8	1591.2	10254	122.23	1641.1	43.48	93.21	5785.6	21909	16.461	14.265	25.919
1.21	1.85	4.53	1538.6	1548.8	9612	108.98	2055.3	124.41	104.72	6679.1	21373	32.465	19.195	24.340
1.63	1.85	4.66	1349.1	1511.8	9383	102.11	2274.8	202.38	117.15	6639.3	21174	42.059	24.151	23.754
2.04	1.92	4.84	1298.0	1491.6	9247	99.38	2407.0	273.68	169.71	6809.7	21024	39.599	31.434	23.315
2.46	1.99	5.29	1276.4	1476.8	9147	97.71	2481.6	334.20	256.49	6959.5	20909	31.707	37.631	22.977
2.88	2.07	5.46	1262.7	1465.7	9072	96.51	2537.2	384.44	319.94	7076.0	20823	25.318	38.814	22.726
3.29	2.14	4.77	1255.4	1457.6	9028	95.69	2569.5	423.41	370.56	7129.6	20791	20.424	39.440	22.634
3.71	2.21	4.88	1258.4	1453.2	9039	95.28	2549.9	451.08	405.10	7060.0	20866	17.023	39.450	22.860
4.13	2.28	4.27	1275.7	1452.9	9120	95.27	2464.0	466.35	412.34	6893.4	21029	14.814	39.073	23.342
4.54	2.35	5.06	1304.3	1456.0	9245	95.52	2339.2	468.70	401.58	6694.8	21218	13.350	38.653	23.902
4.96	2.43	4.03	1337.2	1462.2	9392	96.10	2202.7	460.30	371.34	6480.0	21414	12.409	38.309	24.481

Tab. A.30 Concentrations as a function of time. Variant: v = 6.0 m/a. Position: 4.75 m in downgradient zone.

t [a]	pH	pE	Ca [mg/L]	Mg [mg/L]	Na [mg/L]	K [mg/L]	Fe [mg/L]	Al [mg/L]	U [mg/L]	sulfate [mg/L]	Cl [mg/L]	DIC [mg/L]	Si [mg/L]	Sr [mg/L]
0.38	6.52	1.70	2108.8	1630.0	11894	133.00	1.5	0.02	0.092	3475.0	24367	19.300	0.016	33.200
0.79	3.06	5.47	1859.4	1614.4	11270	129.57	641.7	9.13	45.16	4292.9	23270	15.873	6.419	29.947
1.21	2.16	4.05	1602.2	1608.2	10257	122.17	1550.0	65.05	84.31	5698.0	21988	26.885	14.122	26.153
1.63	1.95	4.45	1571.3	1569.2	9799	111.40	1860.7	133.38	89.69	6317.0	21620	44.917	17.825	25.073
2.04	1.95	4.70	1505.2	1530.0	9559	104.71	2106.6	202.18	113.95	6601.9	21395	53.662	23.426	24.412
2.46	2.00	5.33	1350.5	1508.0	9404	101.63	2267.8	267.45	172.60	6578.9	21220	51.155	29.792	23.894
2.88	2.07	5.75	1323.5	1491.1	9284	99.66	2361.9	324.94	261.25	6763.3	21080	41.867	35.676	23.483
3.29	2.14	5.16	1307.7	1478.0	9193	98.20	2431.4	370.64	355.01	6901.5	20978	33.940	39.242	23.186
3.71	2.21	5.57	1299.8	1468.6	9142	97.19	2468.3	406.85	423.48	6953.5	20951	27.796	39.637	23.108
4.13	2.28	4.29	1303.8	1463.4	9153	96.63	2449.0	432.34	459.83	6892.6	21025	23.292	39.527	23.327
4.54	2.35	5.52	1320.6	1462.0	9221	96.43	2374.8	446.11	471.39	6763.5	21158	20.016	39.183	23.725
4.96	2.42	4.10	1346.1	1464.1	9326	96.53	2271.2	448.52	456.32	6604.9	21315	17.609	38.888	24.188

F2: Natural Attenuation Modelled Concentrations vs Distances. Modelled Chemistry Outputs for proposed natural attenuation monitor wells, derived from UIT (2024).

Table F1: Key Modelled Chemistry Outputs for proposed natural attenuation monitor wells (1.0 m/a scenario) for the first 5 years post FRT.

Distance from the Plume (m)[5]	Analyte	Unit	Time Elapsed Since FRT Conclusion (Years)																			
			0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75	3.00	3.25	3.50	3.75	4.00	4.25	4.50	4.75	5.00
0.75 m	pH	(pH Units)	6.52	4.00	2.37	2.15	2.18	2.19	2.12	2.13	2.14	2.15	2.17	2.19	2.22	2.25	2.29	2.32	2.36	2.39	2.43	2.47
	U	(mg/L)	0.1	17.5	35.4	50.0	60.0	65.6	68.8	70.0	72.0	108.0	179.0	250.0	304.8	360.0	414.2	470.0	524.5	555.0	579.2	600.0
	Sulphate	(mg/L)	3478	3890	4304	4660	5004	5310	5582	5860	6095	6210	6347	6500	6636	6780	6891	7000	7100	7180	7272	7350
1.0 m	pH	(pH Units)	6.52	5.40	5.00	3.30	2.40	2.20	2.20	2.28	2.24	2.24	2.25	2.28	2.30	2.30	2.35	2.40	2.40	2.44	2.45	2.48
	U	(mg/L)	0.1	3.0	12.0	26.0	38.0	46.0	50.0	54.0	56.0	70.0	115.0	150.0	195.0	250.0	270.0	340.0	380.0	430.0	500.0	570.0
	Sulphate	(mg/L)	3478	3510	3750	4000	4400	4700	4900	5250	5400	5600	5800	6000	6250	6400	6600	6700	6800	7000	7000	7100
1.5 m	pH	(pH Units)	6.52	6.52	6.52	5.35	3.70	3.00	3.00	2.75	2.60	2.50	2.50	2.48	2.50	2.52	2.50	2.49	2.55	2.54	2.55	2.60
	U	(mg/L)	0.1	0.1	0.1	5.0	16.0	21.0	28.0	33.0	36.0	38.0	52.0	70.0	90.0	100.0	140.0	166.0	205.0	250.0	333.0	400.0
	Sulphate	(mg/L)	3478	3478	3478	3570	3800	3910	4180	4280	4550	4700	5000	5200	5400	5650	5800	6000	6100	6210	6350	6500
2.0 m	pH	(pH Units)	6.52	6.52	6.52	6.30	5.80	4.70	4.00	3.40	3.05	2.90	2.80	2.76	2.80	2.82	2.70	2.70	2.70	2.70	2.70	2.76
	U	(mg/L)	0.1	0.1	0.1	0.5	4.0	6.0	12.0	17.0	21.0	23.0	29.0	36.0	43.0	52.0	73.0	90.0	110.0	136.0	180.0	220.0
	Sulphate	(mg/L)	3478	3478	3478	3500	3550	3590	3770	3880	4050	4150	4330	4500	4600	4850	4950	5200	5300	5480	5630	5850
2.5 m	pH	(pH Units)	6.52	6.52	6.52	6.52	6.52	6.10	5.10	4.40	4.00	3.70	3.70	3.60	3.50	3.25	3.35	3.20	3.30	3.20	3.30	3.20
	U	(mg/L)	0.1	0.1	0.1	0.0	0.1	0.3	2.0	7.0	10.0	13.0	12.0	12.0	15.0	22.0	27.0	36.0	45.0	56.0	65.0	68.0
	Sulphate	(mg/L)	3478	3478	3478	3477	3478	3510	3550	3640	3720	3800	3900	3950	4070	4120	4300	4400	4650	4800	4950	5160
3.0 m	pH	(pH Units)	6.52	6.52	6.52	6.52	6.52	6.45	6.20	6.00	5.60	5.20	5.10	4.70	4.60	4.10	4.40	4.10	4.30	4.10	4.30	4.00
	U	(mg/L)	0.1	0.1	0.1	0.1	0.1	0.1	0.5	1.0	2.0	4.0	3.0	1.0	3.0	6.0	6.0	4.0	10.0	9.0	15.0	9.0
	Sulphate	(mg/L)	3478	3478	3478	3477	3478	3480	3500	3520	3570	3600	3680	3700	3800	3840	3980	4000	4150	4300	4350	4540
3.5 m	pH	(pH Units)	6.52	6.52	6.52	6.52	6.52	6.52	6.52	6.52	6.30	6.14	5.80	5.60	5.30	5.40	5.05	5.17	4.95	5.02	4.85	4.88
	U	(mg/L)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.4	0.1	0.3	0.1	0.7
	Sulphate	(mg/L)	3478	3478	3478	3477	3478	3477	3477	3492	3500	3520	3580	3590	3680	3750	3780	3900	3870	3910	4020	4080
4.0 m	pH	(pH Units)	6.52	6.52	6.52	6.52	6.52	6.52	6.52	6.52	6.45	6.46	6.10	6.10	5.75	6.00	5.50	5.78	5.35	5.48	5.20	5.30
	U	(mg/L)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1
	Sulphate	(mg/L)	3478	3478	3478	3477	3478	3477	3477	3484	3478	3490	3500	3530	3600	3700	3660	3860	3750	3700	3850	3860
4.5 m	pH	(pH Units)	6.52	6.52	6.52	6.52	6.52	6.52	6.52	6.52	6.50	6.51	6.35	6.38	6.15	6.21	5.90	5.98	5.70	5.70	5.50	5.50
	U	(mg/L)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Sulphate	(mg/L)	3478	3478	3478	3477	3478	3477	3477	3476	3478	3480	3478	3490	3530	3600	3560	3710	3600	3600	3700	3700
5.0 m	pH	(pH Units)	6.52	6.52	6.52	6.52	6.52	6.52	6.52	6.52	6.52	6.52	6.52	6.45	6.52	6.26	6.30	6.00	6.00	5.78	5.75	5.65
	U	(mg/L)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Sulphate	(mg/L)	3478	3478	3478	3478	3478	3478	3478	3478	3478	3478	3478	3478	3478	3478	3478	3478	3500	3588	3600	3650

Table F2: Key Modelled Chemistry Outputs for proposed natural attenuation monitor wells (1.3 m/a scenario) for the first 5 years post FRT.

Distance from the Plume (m)[5]	Analyte	Unit	Time Elapsed Since FRT Conclusion (Years)																			
			0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75	3.00	3.25	3.50	3.75	4.00	4.25	4.50	4.75	5.00
0.75 m	pH	(pH Units)	5.75	3.00	2.17	2.08	2.03	2.02	2.01	2.02	2.04	2.06	2.10	2.13	2.17	2.21	2.25	2.29	2.33	2.36	2.40	2.44
	U	(mg/L)	6.0	30.0	55.0	75.0	80.0	85.0	86.4	90.0	125.0	180.6	235.0	280.0	325.9	370.0	410.0	444.8	475.0	500.0	505.0	520.0
	Sulphate	(mg/L)	3630	4250	4850	5350	5730	6000	6220	6360	6490	6638	6780	6900	7020	7110	7200	7289	7350	7400	7460	7500
1.0 m	pH	(pH Units)	6.30	5.40	3.80	2.18	2.15	2.13	2.10	2.10	2.10	2.10	2.14	2.17	2.19	2.22	2.26	2.30	2.34	2.38	2.40	2.45
	U	(mg/L)	2.7	13.0	32.0	54.0	63.0	69.0	70.0	75.0	98.0	133.0	175.0	212.0	254.0	310.0	370.0	435.0	470.0	505.0	530.0	550.0
	Sulphate	(mg/L)	3530	3790	4230	4750	5120	5410	5700	5910	6120	6330	6480	6620	6730	6820	6940	7080	7150	7220	7300	7370
1.5 m	pH	(pH Units)	6.62	6.81	5.45	3.45	2.88	2.52	2.38	2.33	2.28	2.30	2.29	2.28	2.30	2.31	2.32	2.37	2.40	2.42	2.45	2.49
	U	(mg/L)	0.1	0.1	6.0	21.0	33.0	44.0	48.0	56.0	61.0	68.0	89.0	112.0	142.0	187.0	240.0	307.0	345.0	395.0	458.0	500.0
	Sulphate	(mg/L)	3465	3450	3600	3950	4280	4580	4830	5100	5340	5600	5820	6000	6190	6340	6500	6610	6700	6820	6920	7050
2.0 m	pH	(pH Units)	6.55	6.62	6.27	5.57	3.94	3.02	2.72	2.60	2.53	2.50	2.46	2.44	2.43	2.44	2.44	2.46	2.48	2.50	2.54	2.56
	U	(mg/L)	0.1	0.1	2.0	5.0	14.0	24.0	30.0	35.0	39.0	43.0	55.0	68.0	88.0	104.0	124.0	160.0	190.0	235.0	285.0	337.0
	Sulphate	(mg/L)	3478	3478	3510	3590	3820	4050	4270	4460	4650	4860	5080	5300	5540	5720	5910	6080	6210	6380	6530	6660
2.5 m	pH	(pH Units)	6.52	6.52	6.64	6.55	5.07	4.18	3.73	3.38	3.10	2.90	2.78	2.71	2.67	2.64	2.62	2.62	2.62	2.62	2.63	2.64
	U	(mg/L)	0.1	0.1	0.1	0.1	2.5	8.0	16.0	22.0	25.0	28.0	33.0	39.0	49.0	60.0	75.0	100.0	120.0	145.0	170.0	200.0
	Sulphate	(mg/L)	3478	3478	3477	3477	3550	3700	3870	4040	4190	4330	4500	4670	4850	5030	5230	5480	5630	5830	6010	6170
3.0 m	pH	(pH Units)	6.52	6.52	6.55	6.54	6.22	5.88	5.38	4.60	4.05	3.50	3.25	3.10	3.00	2.95	2.92	2.85	2.81	2.77	2.77	2.77
	U	(mg/L)	0.1	0.1	0.1	0.1	0.1	2.0	5.0	8.0	14.0	22.0	23.0	25.0	29.0	35.0	44.0	55.0	68.0	83.0	103.0	125.0
	Sulphate	(mg/L)	3478	3478	3477	3477	3480	3540	3620	3740	3880	4000	4130	4250	4390	4510	4680	4850	5020	5200	5400	5580
3.5 m	pH	(pH Units)	6.52	6.52	6.52	6.52	6.52	6.58	6.15	5.43	4.78	4.60	3.93	3.74	3.62	3.55	3.47	3.40	3.34	3.26	3.24	3.25
	U	(mg/L)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	3.0	10.0	11.0	14.0	20.0	25.0	30.0	35.0	40.0	50.0	63.0	78.0
	Sulphate	(mg/L)	3478	3478	3477	3477	3477	3480	3510	3580	3660	3770	3860	3980	4090	4180	4280	4400	4520	4670	4830	5000
4.0 m	pH	(pH Units)	6.52	6.52	6.52	6.52	6.52	6.61	6.34	5.89	5.45	5.65	4.77	4.57	4.42	4.30	4.22	4.15	4.06	3.98	3.95	3.92
	U	(mg/L)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	5.0	9.0	13.0	14.0	14.0	15.0	20.0	23.0	28.0
	Sulphate	(mg/L)	3478	3478	3477	3477	3477	3477	3480	3500	3550	3600	3680	3760	3850	3940	4020	4120	4200	4300	4400	4530
4.5 m	pH	(pH Units)	6.52	6.52	6.52	6.52	6.52	6.53	6.45	6.30	6.10	6.15	5.63	5.42	5.22	5.10	5.00	4.92	4.84	4.75	4.70	4.67
	U	(mg/L)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	1.0	1.0	1.0
	Sulphate	(mg/L)	3478	3478	3477	3477	3477	3477	3477	3480	3500	3520	3570	3610	3700	3750	3830	3910	3990	4060	4130	4210
5.0 m	pH	(pH Units)	6.52	6.52	6.52	6.52	6.52	6.52	6.52	6.52	6.52	6.40	6.40	6.20	6.00	5.85	5.70	5.70	5.60	5.45	5.40	5.35
	U	(mg/L)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Sulphate	(mg/L)	3478	3478	3477	3477	3477	3477	3476	3476	3480	3490	3510	3540	3570	3620	3690	3750	3800	3880	3940	4000

Table F3: Key Modelled Chemistry Outputs for proposed natural attenuation monitor wells (6.0 m/a scenario) for the first 5 years post FRT.

Distance from the Plume (m)[7]	Analyte	Unit	Time Elapsed Since FRT Conclusion (Years)																			
			0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75	3.00	3.25	3.50	3.75	4.00	4.25	4.50	4.75	5.00
0.75 m	pH	(pH Units)	1.70	1.68	1.67	1.70	1.75	1.81	1.85	1.90	1.95	2.00	2.05	2.09	2.14	2.18	2.21	2.26	2.31	2.36	2.42	2.48
	U	(mg/L)	136.2	137.5	141.4	146.3	154.5	173.9	190.0	205.0	220.0	232.0	242.0	250.0	252.0	249.0	243.8	236.0	222.0	208.0	182.0	152.0
	Sulphate	(mg/L)	7105	7150	7257	7291	7316	7354	7380	7410	7420	7427	7415	7350	7232	7100	6952	6750	6570	6400	6240	6050
1.0 m	pH	(pH Units)	1.76	1.74	1.68	1.70	1.75	1.81	1.85	1.90	1.95	2.00	2.05	2.09	2.14	2.18	2.21	2.26	2.31	2.36	2.42	2.48
	U	(mg/L)	124.0	127.0	138.0	141.0	146.0	172.0	195.0	214.0	230.0	246.0	260.0	270.0	275.0	274.0	270.0	260.0	249.0	234.0	210.0	180.0
	Sulphate	(mg/L)	6800	6900	7160	7200	7250	7280	7320	7350	7380	7400	7400	7360	7240	7130	6975	6780	6610	6440	6280	6100
1.5 m	pH	(pH Units)	2.00	1.94	1.70	1.71	1.76	1.80	1.85	1.90	1.95	2.00	2.05	2.09	2.14	2.18	2.21	2.26	2.31	2.36	2.41	2.47
	U	(mg/L)	100.0	104.0	128.0	130.0	132.0	160.0	192.0	218.0	240.0	266.0	282.0	297.0	310.0	312.0	312.0	304.0	295.0	280.0	258.0	230.0
	Sulphate	(mg/L)	6000	6300	6980	7050	7050	7130	7175	7230	7280	7320	7330	7310	7242	7140	7020	6840	6680	6520	6360	6200
2.0 m	pH	(pH Units)	2.34	2.18	1.76	1.75	1.77	1.81	1.86	1.90	1.95	2.00	2.05	2.09	2.14	2.18	2.21	2.26	2.31	2.35	2.41	2.45
	U	(mg/L)	68.0	82.0	119.0	122.0	123.0	142.0	175.0	216.0	245.0	274.0	296.0	318.0	336.0	342.0	348.0	344.0	333.0	320.0	297.0	270.0
	Sulphate	(mg/L)	5000	5600	6850	6900	6850	6980	7050	7120	7175	7230	7260	7270	7230	7150	7050	6890	6740	6580	6440	6290
2.5 m	pH	(pH Units)	2.90	2.70	1.88	1.80	1.78	1.81	1.86	1.90	1.95	2.00	2.05	2.09	2.14	2.18	2.21	2.26	2.31	2.35	2.41	2.44
	U	(mg/L)	36.0	60.0	110.0	114.0	114.5	128.0	156.0	200.0	240.0	273.0	302.0	332.0	356.0	368.0	376.0	374.0	365.0	356.0	340.0	310.0
	Sulphate	(mg/L)	4150	5000	6600	6700	6780	6830	6920	7000	7075	7130	7180	7210	7200	7140	7065	6920	6790	6650	6500	6360
3.0 m	pH	(pH Units)	4.00	3.70	2.00	1.88	1.81	1.83	1.86	1.91	1.95	2.00	2.05	2.09	2.14	2.18	2.21	2.26	2.31	2.34	2.41	2.44
	U	(mg/L)	10.0	40.0	99.0	106.0	106.5	117.0	140.0	176.0	225.0	269.0	300.0	338.0	366.0	384.0	396.0	400.0	395.0	390.0	370.0	346.0
	Sulphate	(mg/L)	3750	4500	6100	6500	6720	6710	6760	6860	6950	7025	7090	7140	7155	7120	7065	6950	6820	6690	6560	6435
3.5 m	pH	(pH Units)	5.60	4.50	2.24	2.00	1.88	1.87	1.86	1.92	1.95	2.00	2.05	2.09	2.14	2.17	2.21	2.26	2.31	2.34	2.41	2.44
	U	(mg/L)	0.1	24.0	86.0	96.0	100.0	105.0	125.0	154.0	200.0	256.0	296.0	335.0	370.0	394.0	410.0	422.0	422.0	416.0	400.0	376.0
	Sulphate	(mg/L)	3550	4100	5500	6150	6600	6570	6630	6750	6830	6920	6990	7050	7095	7080	7045	6950	6850	6730	6610	6500
4.0 m	pH	(pH Units)	6.10	5.00	2.64	2.18	1.98	1.91	1.90	1.93	1.96	2.00	2.05	2.09	2.14	2.17	2.21	2.26	2.30	2.34	2.39	2.43
	U	(mg/L)	0.1	16.0	70.0	86.0	91.0	95.0	110.0	134.0	175.0	230.0	275.0	320.0	366.0	400.0	417.0	438.0	440.0	440.0	425.0	408.0
	Sulphate	(mg/L)	3500	3800	5000	5700	6300	6400	6530	6670	6730	6790	6880	6960	7020	7025	7005	6950	6860	6760	6650	6550
4.5 m	pH	(pH Units)	6.40	5.30	2.95	2.38	2.10	1.95	1.93	1.94	1.96	2.00	2.05	2.09	2.14	2.17	2.21	2.26	2.30	2.34	2.39	2.43
	U	(mg/L)	0.1	14.0	54.0	74.0	86.0	90.0	100.0	118.0	150.0	200.0	248.0	305.0	360.0	396.0	422.0	450.0	455.0	460.0	450.0	438.0
	Sulphate	(mg/L)	3480	3700	4500	5200	5850	6250	6440	6600	6630	6665	6770	6860	6940	6970	6970	6930	6860	6770	6680	6580
5.0 m	pH	(pH Units)	6.62	5.45	3.08	2.58	2.22	2.02	1.96	1.96	1.98	2.01	2.05	2.09	2.14	2.18	2.21	2.26	2.30	2.34	2.39	2.43
	U	(mg/L)	0.1	12.0	36.0	62.0	82.0	86.0	95.0	104.0	135.0	170.0	215.0	286.0	350.0	382.0	423.0	460.0	470.0	480.0	480.0	466.0
	Sulphate	(mg/L)	3460	3660	4100	4800	5600	6120	6400	6590	6550	6510	6630	6750	6860	6920	6940	6910	6850	6760	6670	6585

F3: Mineralogy of Alligator Energy Composite, Young (2022).

Technical Memorandum AM/TM/2022_10_06

Mineralogy of Alligator Energy Composite

Client: Alligator Energy

Date: 6th October 2022

Author: Brian Young
Reviewed By: Bob Ring
Business Unit: Minerals

This document presents results of work in progress and is not a final report. This document may contain confidential information of both the client company and ANSTO and shall not be disseminated outside of these organisations without prior approval in accordance with the agreed terms and conditions.

ANSTO
Minerals Business Unit, Locked Bag 2001 Kirrawee NSW 2232 Australia
Ph: +61 2 9717 3858, E: minerals@ansto.gov.au W: www.ansto.gov.au/minerals

1. Introduction

A uranium ore composite sample from Alligator Energy was submitted for mineralogical characterisation. Mineralogical characterisation of the sample was carried out using QEMSCAN (an automated mineralogical analysis technique) and manual scanning electron microscopy (SEM).

2. Samples

An ore composite sample labelled “Alligator Energy Composite”, crushed to 300 μm was received for examination.

A representative portion of the sample was mixed with similar sized particles of graphite to ensure good separation of the sample particles for examination using QEMSCAN. The sample/graphite blend was impregnated with epoxy resin to form a resin block with a polished surface for examination by SEM/QEMSCAN. The polished surface of the resin block was coated with a thin layer of carbon (a few nanometres thick), prior to analysis, to maintain electrical conductivity during examination.

3. Chemical Analysis

Chemical analysis of the sample was carried out using XRF. The results are presented in **Table 1**.

Table 1
Chemical Analysis of the Alligator Energy Composite (wt%)

Al	Ba	Ca	Fe	K	Mg	Na
0.43	<0.001	0.1	1.01	0.1	0.04	0.15
Ni	**P**	**S**	**Si**	**Ti**	**U**	**Zr**
<0.001	0.003	1.11	43.6	0.15	0.197	0.03

4. QEMSCAN

QEMSCAN particle mineralogical analysis (PMA) was carried out using a Quanta 650 electron microscope with dual Bruker XFlash 5030 energy dispersive detectors, controlled by iDiscover and iMeasure image analysis hardware/software. The SEM was operated at an accelerating voltage of 15 keV with a working distance of 13 mm and using a beam current of approximately 10 nA.

The minerals identified in the samples by QEMSCAN and their modal abundances are presented in **Table 2.**

The QEMSCAN technique is unable to differentiate conclusively between some minerals with similar chemistry. For this reason minerals with similar chemistry have been grouped, e.g. “Fe-oxide/hydroxide” (hematite, magnetite, and goethite).

Some of the U-bearing phases could not be conclusively identified due to their small grain size and/or being intergrown with other phases. The unidentified U containing phases are reported as “Uranium Phase” in the QEMSCAN results.

Table 2.
QEMSCAN Modal Mineralogy (wt%)

Mineral	Chemical Formulae	wt%
Coffinite	$U(SiO_4)_{1-x}(OH)_{4x}$	0.40
Uraninite	UO_2	0.07
Uranophane	$Ca(UO_2)_2(SiO_3OH)_2 \bullet 5H_2O$	0.03
Uranium Phase	U, Si, Ca, O, OH	0.50
Carbonates	$(Ca, Mg)(CO_3)_n$	0.01
Quartz	SiO_2	96.3
Pyrite	FeS_2	1.05
Clay Minerals	$Al_2Si_2O_5(OH)_4$	0.42
Feldspar	$KAlSi_3O_8$	0.27
Halite	NaCl	0.26
Muscovite	$KAl_2(Si_3Al)O_{10}(OH,F)_2$	0.19
Rutile/Ilmenite	TiO_2 / $FeTiO_3$	0.15
Zircon	$ZrSiO_4$	0.09
Monazite	$(Ce,La,Nd,Th)(PO_4)$	0.02
Other	Various	0.10
Unclassified		0.10

Coffinite (0.40 wt%), uraninite (0.07 wt%) and uranophane (0.03 wt%) are the uranium-bearing phases that were identified by QEMSCAN. A slightly higher proportion of U-containing material that could not be conclusively identified on account of its small grain size and/or intermixing with gangue phases was detected in the QEMSCAN analysis, with 0.50 wt% “Uranium Phase” reported.

Quartz (96.3 wt%) is the dominant gangue mineral in the sample. Minor and trace concentrations of pyrite (1.05 wt%), clay minerals (0.42 wt%), feldspar, halite, muscovite, rutile/ilmenite, zircon and monazite were also detected in the sample.

The liberation statistics for the U-containing phases in the sample are presented in **Table 3**. Liberation is calculated for a particular mineral by determining the proportion of the surface area of each grain of that mineral that is in contact with the background (*i.e.* the outer surface of the particle, the epoxy mounting resin). For example, a coffinite grain that exhibits 100% liberation will have its entire surface area in contact with the epoxy mounting resin. 50% liberation means that half of the grain’s surface is in contact with the mounting resin, while the other half of the grain’s surface area is in contact with other minerals. A coffinite grain with 0% liberation is completely surrounded by other minerals.

The horizontal axis in each of the liberation tables is divided into ranges that refer to the degree of liberation. The numbers in the table in each of the liberation ranges refer to the proportion (% in sample) of each mineral that falls in each range. For example, 91.4% of the uraninite in the sample is contained in grains that have a degree of liberation of 0-10%.

Table 3
Liberation Statistics of U-Containing Phases

	0-10%	10-20%	20-30%	30-40%	40-50%	50-60%	60-70%	70-80%	80-90%	90-100%
Uraninite	91.4	4.3	2.4	0.3	0.1	0.0	0.0	0.4	0.0	1.2
Coffinite	12.7	3.4	6.4	32.8	26.8	10.3	3.3	0.2	0.7	3.4
Uranophane	92.3	2.1	1.3	0.4	0.7	1.3	0.3	0.6	0.0	0.9
Uranium Phase	37.1	23.6	13.7	4.8	3.5	2.0	4.3	2.9	2.1	6.1

The liberation statistics in **Table 3** suggest the uraninite and uranophane in the sample are poorly liberated, with over 90% of each mineral in the 0-10% liberation range.

A significant proportion of the coffinite in the sample is partially liberated, with approximately 70% of the coffinite in the sample having a degree of liberation between 30 and 60%. There is a smaller population of poorly liberated coffinite, with 12.7% of the coffinite in the sample in the 0-10% liberation range.

The unidentified U containing material, i.e. “Uranium Phase” is relatively poorly liberated.

Mineral association data for the U-containing phases in the sample was calculated and is presented in **Table 4**. The QEMSCAN analysis software considers two minerals to be “associated” if a pixel of one mineral occurs adjacent to a pixel of the other mineral. The measured particles are scanned, and the mineral transitions or “associations” are counted. The values presented in tables are the proportions of transitions between the phases of interest (listed along the top of the table) with associated minerals (listed down the side of the table). For example, 17% of the transitions of coffinite with other mineral phases occur with pyrite.

The “Background” in the mineral association table represents the epoxy mounting resin. Associations with the background are a result of the mineral being adjacent to the outer edge of the particle or being located adjacent to an internal void in the particle (*i.e.* porosity, a crack, or a sample preparation artefact). “Unclassified” refers to pixels the QEMSCAN could not assign to a particular mineral, possibly due to mixtures of phases within the analysis volume at the boundary between phases.

Table 4
Mineral Associations of U-Containing Phases (%)

	Uraninite	Coffinite	Uranophane	Uranium Phase
Background	35.2	48.1	31.7	45.3
Uraninite	-	6.9	6.3	1.6
Coffinite	36.2	-	41.2	8.6
Uranophane	4.2	5.2	-	1.0
Uranium Phase	13.0	13.7	13.1	-
Carbonates	0.0	0.0	0.0	0.0
Quartz	1.7	6.2	0.7	10.7
Zircon	0.0	0.0	0.0	0.3
Monazite	0.0	0.0	0.0	0.0
Halite	0.1	0.2	0.1	2.7
Pyrite	8.8	17.1	6.1	7.5
Rutile / Ilmenite	0.0	0.0	0.0	0.1
Feldspar	0.1	0.1	0.0	0.5
Muscovite	0.1	0.5	0.2	3.1
Clay Minerals	0.1	1.5	0.2	13.5
Other	0.6	0.4	0.2	2.9
Unclassified	0.0	0.2	0.1	2.1

The mineral associations data shows that coffinite has a higher proportion of associations occurring with the background than uraninite and uranophane. This is consistent with the liberation data, which showed that coffinite has a significant population of partially liberated particles, whereas the uraninite and uranophane are less well liberated.

The main mineral associations of uraninite occur with coffinite and the unidentified U-containing material “Uranium Phase”. Uraninite also has some mineral associations with pyrite and quartz.

The main mineral associations of coffinite occur with pyrite and the unidentified “Uranium Phase”. Minor mineral associations occur with uraninite, quartz, uranophane, clay minerals and muscovite.

Uranophane has a significant proportion of mineral associations with coffinite and the unidentified U-containing material, “Uranium Phase”. Minor mineral associations occur with uraninite, pyrite and quartz.

The main mineral associations for “Uranium Phase” occur with clay minerals, quartz, coffinite and pyrite. Examples of sub-micron U-rich inclusions within clay minerals were observed by manual SEM examination, refer to **Section 5**. These very fine-grained U-rich inclusions are too small to be conclusively identified by the QEMSCAN software and have most likely been classified as “Uranium Phase”, however their appearance is consistent with coffinite. Minor minerals associations of “Uranium Phase” occur with muscovite, halite, uraninite and uranophane.

5. Scanning Electron Microscopy

SEM and X-ray microanalysis were carried out on an epoxy resin impregnated portion of the samples using a Quanta 650F electron microscope with dual Bruker XFlash 5030 energy dispersive detectors. The SEM was operated at an accelerating voltage of 15 keV with a

working distance of 13 mm and using a beam current of approximately 10 nA. The images were acquired in backscattered electron (BSE) imaging modes. BSE imaging is commonly used to examine variation in chemical composition (evidenced through changing mean atomic number) between and within minerals. Lighter grey levels in the micrographs indicate compositions containing higher mean atomic number elements (e.g. U, Pb) than compositions producing the darker grey levels (e.g. Al, Si, Ca). The black background in the images is the epoxy resin grain mount. X-ray analysis (energy dispersive system – EDS) was undertaken to confirm mineralogy.

The detailed results of the SEM examination are presented in **Appendix A**. A summary of findings is given below.

5.1 Summary of Findings

Several large clusters comprised of fine-grained coffinite and pyrite associated with organic material were observed in the sample. BSE images showing examples of these clusters are presented in **Appendix A, Figure 1 A – F**. These clusters are typically several hundred microns in size. Note that the carbonaceous organic material cannot be quantified by the QEMSCAN software. Due to the similar BSE signal of the organic material with the epoxy mounting resin and the added sized graphite particles, it is thresholded out by the QEMSCAN analysis software.

The BSE images presented in **Appendix A, Figure 1 A & B** were taken at successively higher magnifications and show one of the clusters comprising coffinite, pyrite and organic material in greater detail. The organic material appears to exhibit a cellulose structure. EDS spectra taken from the coffinite and organic material are presented in **Appendix A, EDS spectra S1 & S2**.

The BSE images in **Appendix A, Figure 1 C & D** show another example of a cluster comprising coffinite, pyrite and organic material. Once again, evidence of a cellulose structure within the organic material can be seen in the higher magnification image in **D**.

Examples of slightly smaller clusters comprising coffinite, pyrite and organic material are shown in **Appendix A, Figure 1 E & F** An EDS spectrum taken from one of the coffinite particles in **E** is given in **Appendix A, EDS spectrum S3**.

The BSE image presented in **Appendix A, Figure 2 A** shows a cluster of small uraninite particles in association with halite and organic material. An EDS spectrum from the uraninite is given in **Appendix A, EDS spectrum S4**.

A quartz particle with some associated uraninite present at its edge is shown in the BSE image in **Appendix A, Figure 2 B**. An EDS spectrum from the uraninite is presented in **Appendix A, EDS spectrum S5**.

The BSE images shown in **Appendix A, Figure 2 C & D** were taken at successively higher magnifications and show a multiphase cluster comprising quartz along with very fine-grained coffinite dispersed throughout kaolinite/clay minerals. The coffinite grains range from sub-micron in size up to a few microns.

Appendix A, Figure 2 E shows a quartz particle with an outer rim of kaolinite/clay and coffinite.

A multiphase cluster of particles comprising quartz, pyrite, halite, kaolinite/clay and coffinite is shown in the BSE image in **Appendix A, Figure 2 F**. The coffinite is present as fine grains around the edges of the pyrite.

6. Conclusions

- QEMSCAN modal mineralogy analysis detected coffinite (0.40 wt%), uraninite (0.07 wt%) and uranophane (0.03 wt%) within the Alligator Energy Composite sample. A slightly higher proportion of U-containing material that could not be conclusively identified on account of its small grain size and/or intermixing with gangue phases was also detected (0.50 wt% “Uranium Phase”).
- Quartz (96.3 wt%) is the dominant gangue mineral in the sample. Minor and trace concentrations of pyrite (1.05 wt%), clay minerals (0.42 wt%), feldspar, halite, muscovite, rutile/ilmenite, zircon and monazite were also detected.
- Manual SEM examination revealed that the coffinite was often within large clusters in association with pyrite and organic material.
- The uranium minerals in the sample were also observed to be present at the edges of gangue particles, or as fined grained inclusions within gangue phases such as quartz, kaolinite/clay minerals and pyrite.

Appendix A

BSE Images & EDS Spectra

Figure 1: Alligator Energy Composite

Backscattered electron (BSE) micrographs from the Alligator Energy Composite:

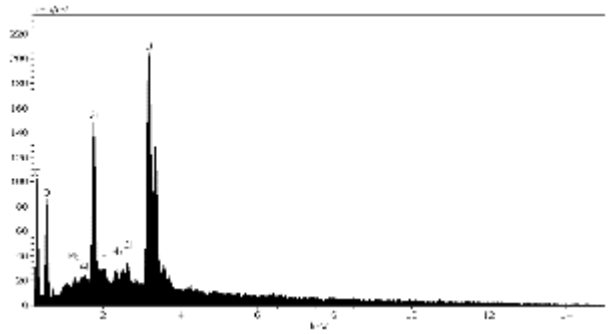
Use the zoom function on the electronic version to view the images in more detail.

A & B BSE images taken at successively higher magnifications showing a large cluster of particles comprising fine-grained coffinite and pyrite along with organic material. The organic material (darker coloured phase) appears to exhibit a cellulose structure in the higher magnification image in **B**. EDS spectra from the coffinite and organic material are given below in **S1** and **S2**.

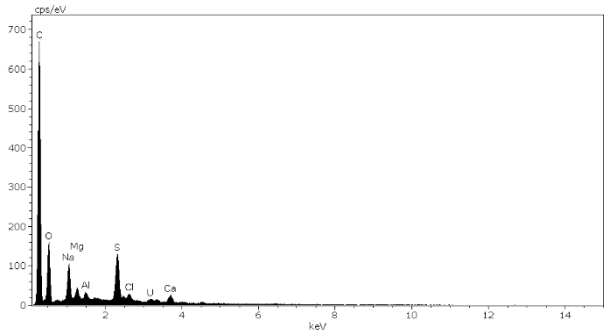
C & D BSE images taken at successively higher magnifications showing a cluster of fine-grained coffinite and pyrite with organic material. The higher magnification image in **D** appears to show evidence of a cellulose structure within the organic material.

E A cluster of fine-grained coffinite and pyrite particles and organic material. An EDS spectrum taken from the coffinite is given in **S3**.

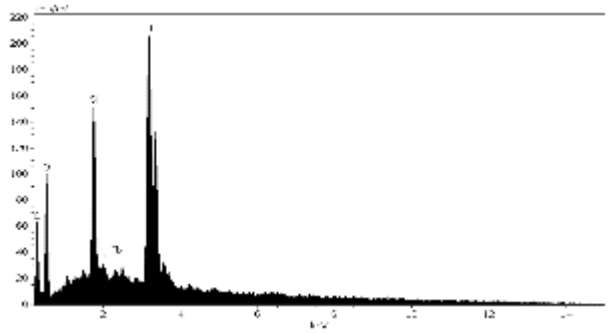
F BSE image showing a cluster of small coffinite and pyrite particles in association with organic material.



S1. EDS spectrum from a coffinite particle in the cluster shown in **Fig. 1A & B**.

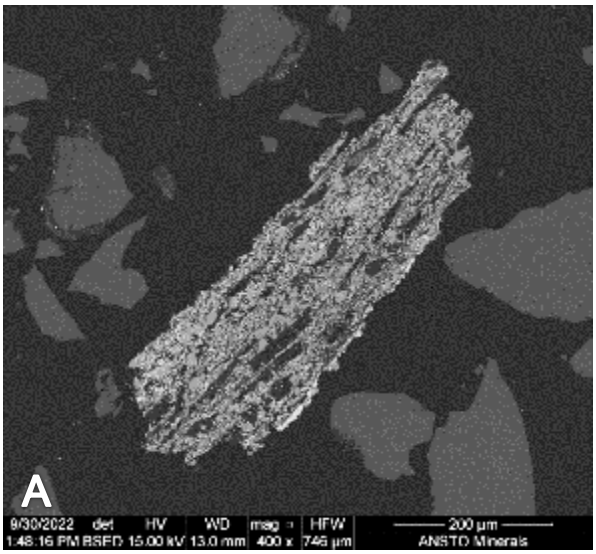


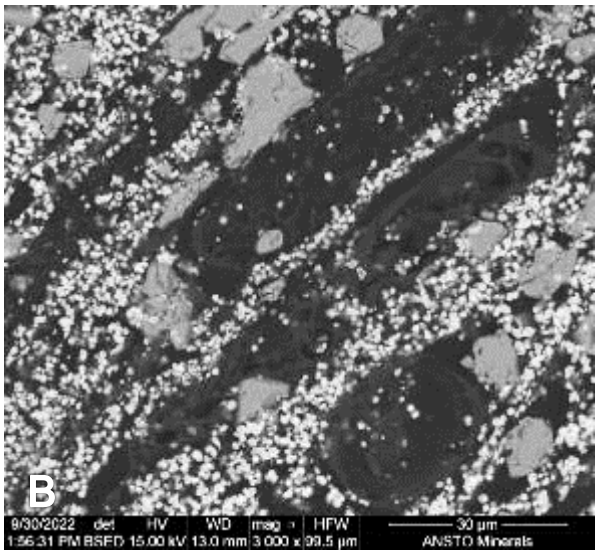
S2. EDS spectrum from the organic material in the cluster shown in **Fig. 1A & B**.

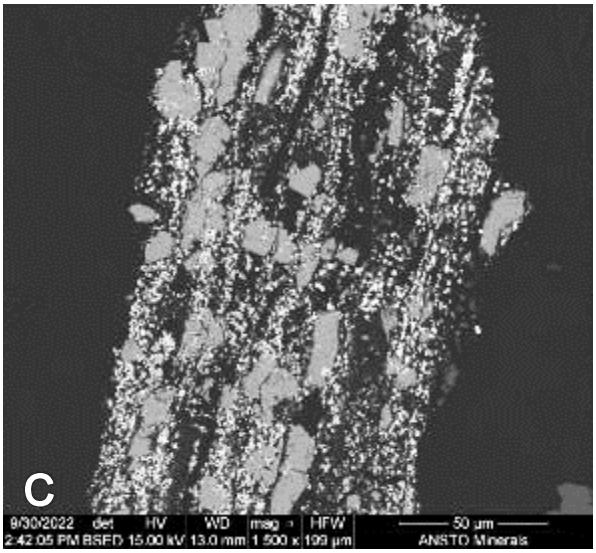


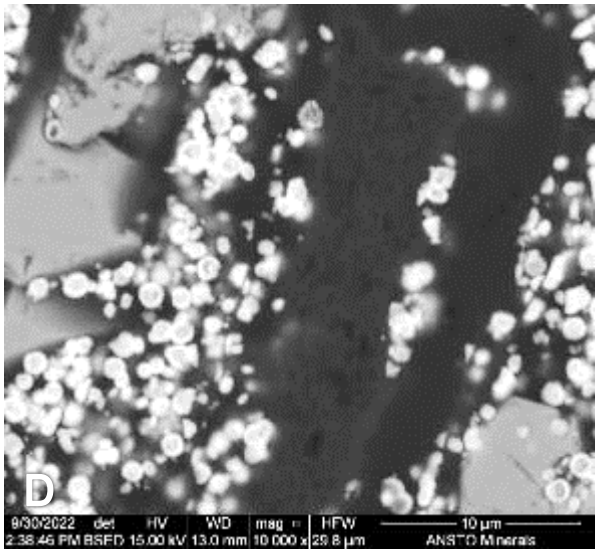
S3. EDS spectrum from a coffinite particle in the cluster shown in **Fig. 1E**.

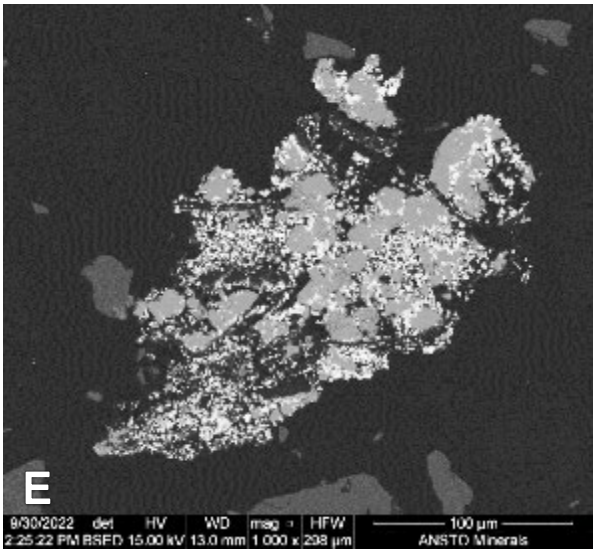
Alligator Energy Composite **Figure 1 A-F**











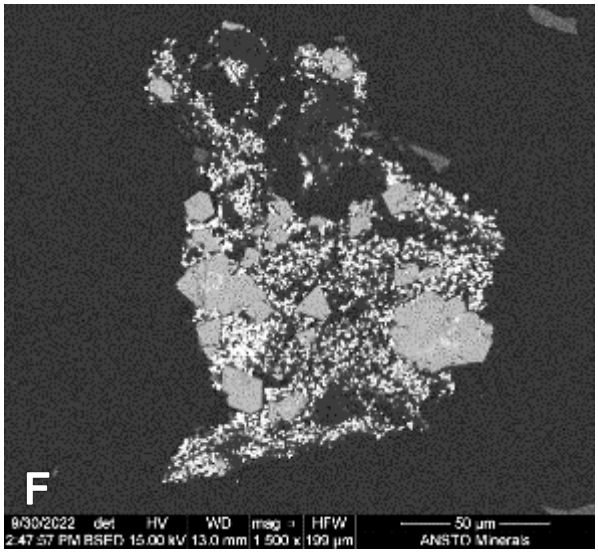


Figure 2: Alligator Energy Composite

Backscattered electron (BSE) micrographs from the Alligator Energy Composite:

Use the zoom function on the electronic version to view the images in more detail.

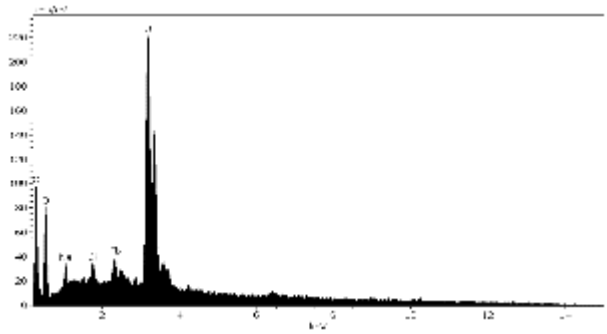
A BSE image showing a cluster of small uraninite particles in association with halite and organic material. An EDS spectrum from the uraninite is given below in **S4**.

B BSE image showing uraninite present at the edge of a quartz particle. An EDS spectrum from the uraninite is given in **S5**.

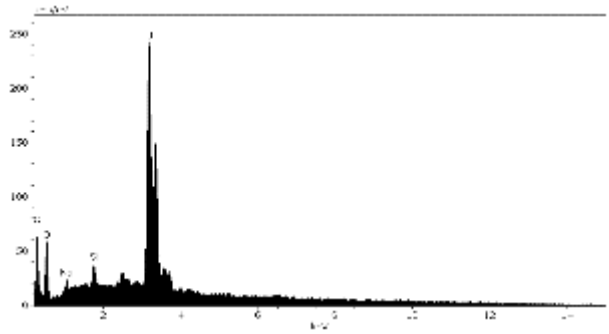
C & D BSE images taken at successively higher magnifications showing very fine-grained coffinite dispersed throughout kaolinite/clay minerals. The coffinite grains range in size from sub-micron up to a few microns.

E Quartz particle with a rim of kaolinite/clay minerals and fine-grained coffinite.

F A multiphase cluster comprising particles of quartz, pyrite, halite, kaolinite/clay and coffinite. The coffinite is present as fine grains around the edges of the pyrite.

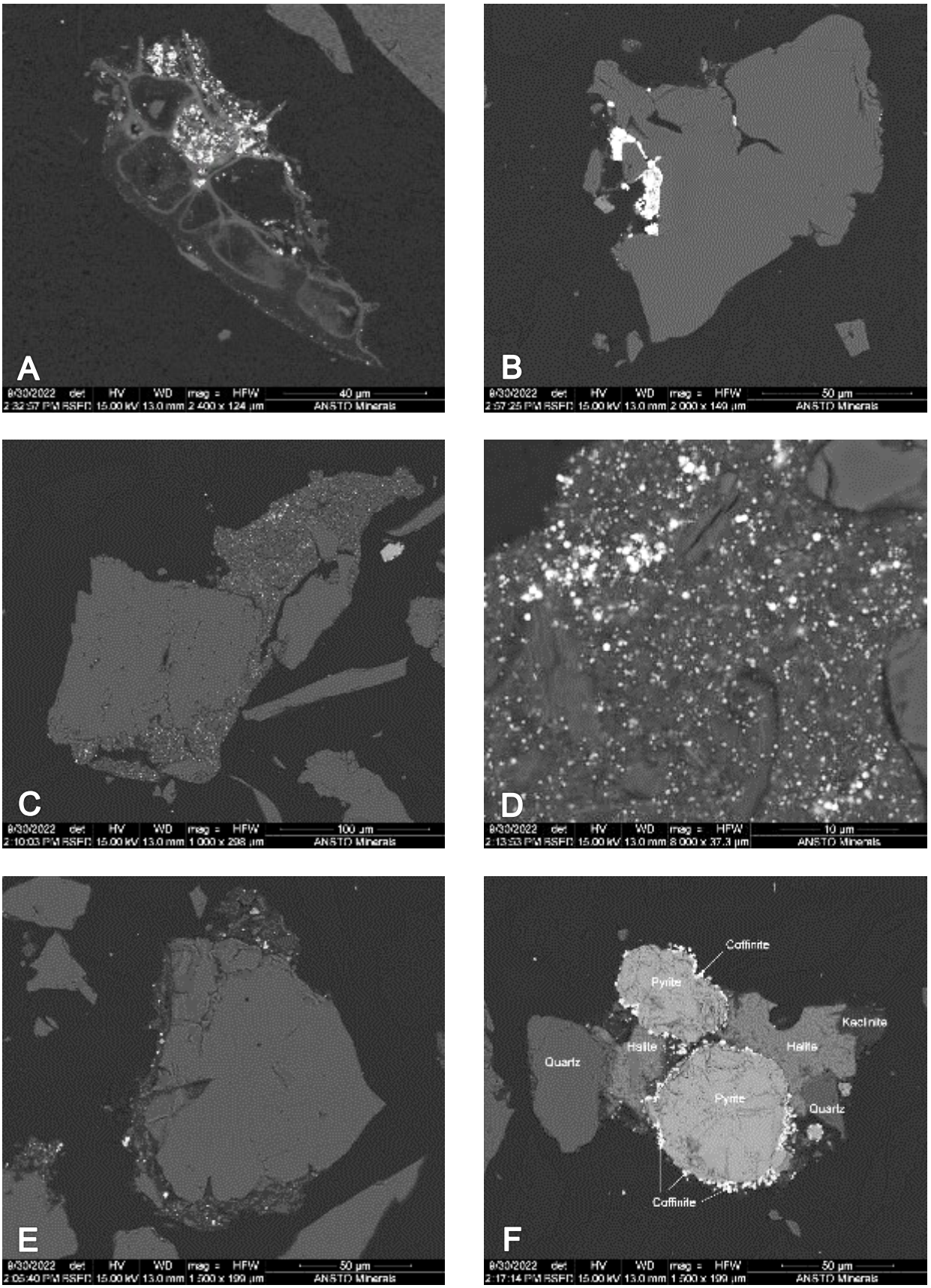


S4. EDS spectrum from a uraninite particle in the cluster shown in **Fig. 2A**.



S5. EDS spectrum from the uraninite at the edge of the particle shown in **Fig. 2B**.

Alligator Energy Composite **Figure 2 A-F**



Appendix G: Revegetation Assessments – Samphire

Appendix G1: Samphire Project – Drill Pad Revegetation: A Review of Treatment and Success. Alligator Energy Internal Report, January 2025.

Samphire project – drill pad revegetation, a review of treatment and success

January 2025

Authors – Matt Daniel, Ashliegh Hisee & Marie-Eve Lambert, Alligator Energy Ltd.

Introduction

Exploration drilling is ongoing at the Samphire project site, approximately 20Km south of Whyalla, within a Pearl bluebush (*Maireana sedifolia*) shrubland habitat. Over 350 drill holes have been completed since 2021 to delineate the Samphire project orebody. Regarding rehabilitation of these drill holes a variety of revegetation techniques have been used and are here assessed to attempt to refine and identify approaches to minimise (a) the impact and (b) the recovery time back to a similar vegetation coverage as prior to impact.

Mineral exploration can result in areas of impact due to heavy equipment access, machine placement and drilling. This impact has been mitigated at Samphire by (a) pre impact access route surveying and adopting a bush rolling technique and (b) where vegetation clearing occurs as part of digging drill sumps for holding drill cuttings and water; applying intensive rehabilitation methods immediately post drilling. A comparison of different strategies and resulting vegetation coverage will confirm the validity of the approach and allow refinement to field procedures to promote rapid revegetation coverage. Vegetation coverage provides the benefits of reducing dust, reducing erosion, increased biodiversity and native species abundance, sequestering carbon and improvements to overall grazing land use quality, important considerations given the multiple land uses in the area (pastoralism, mineral exploration, wind farming).

Research into best practices for reducing development impacts to *Western Myall Woodland* and associated Pearl Bluebush shrubland is limited for Eyre Peninsula and it is anticipated this information can be shared with interested stakeholders.

Landscape Values

The *Western Myall Woodlands* are located west of Port Augusta, north of Goyders rainfall line, and contain chenopod shrubs which have been valuable sheep feed for the pastoral industry since colonisation. As such the 100 years plus of hard hooved animal presence and selective sheep grazing have made some areas, especially around stock water points, more susceptible to vegetation loss and erosion. Western Myall trees can live over 1000 years and juveniles only recruit episodically (Plants of SA website, 2025), Pearl bluebushes are thought to live to 400 years (Andrew & Lange 1986, Lange, et al. 1984), hence careful management of such hard to replace assets is worthy of

consideration. Additionally, the Western grass wren, *Amytornis textilis myall*, and Southern whiteface, *Aphelocephala leucopsis*, are some of the icon birds found on Moonabie Station (EBS 2012, 2023). Our focus is to manage the native vegetation ecosystem and hence the local populations of these birds, by using good natural resource principles to improve habitat health. In particular, the *A. textilis myall* is known to nest in healthy, larger than one metre, Australian boxthorn, *Lycium australe* and Black bluebush, *Maireana pyramidata* plants found in this region and prefers a dense shrubland habitat (Black et al, 2009).

Site Description

The area of the Samphire field work is a “rangeland” chenopod shrubland plain. The plain is located at the base of a north south running ridgeline of approximately 35 metres in height, with the coastline 4.5 km to the east. The soil observed is generally a calcareous sandy silt clay, with a topsoil depth varying from 1-20 cm. The area is currently used for sheep grazing and mineral exploration. Most vegetation consists of less than one metre high chenopod shrubs, Bladder saltbush (*Atriplex vesicaria)*, Pearl bluebush (*Maireana sedifolia)* Black bluebush *(Maireana pyramidata),* with occasional Native boxthorn (*Lycium australe)*, Senna (*Senna artemisioides*), or Spiney Fanflower (*Scaevola spinescens*).

Vegetation Techniques

This report investigates impact sites, the drill pads, and testing the rehabilitation strategies and their potential to improve existing vegetation structure.

Drillhole exploration requires a truck mounted drill rig and crew to travel through the (pre colonialisation) native vegetated paddock to allow access to a pre-selected location and undertake the drilling investigation work. However, by planning to avoid higher value, greater that 75cm high shrubs, when moving heavy equipment and planning the sump location to minimise the clearance impact for sumps only, impacts are minimised. On each exploration drill location, the access path and drill pad vegetation is rolled in with a loader with its bucket held above the vegetation, so only the tyres of the loader impact the vegetation; as opposed to soil grading resulting in actual clearance of vegetation. The drill rig access is thus done whilst retaining plant rootstock within the ground, by driving over the plants, allowing the opportunity for prompt plant regrow once work is complete.

With Bluebushes (the Maireana genus) this allows more rapid vegetation regrowth to occur, as this genus at this location readily reshoots from the remaining rootstock.



***Figure 1: Example of Pearl bluebush rootstock regrowth on a rolled drill pad access track*.**

Drill Sump Construction

Drill sumps are used to hold water and drilling chips during the drilling process, they are typically 2 metres deep, 9m long and 1.5 metre wide and one is constructed per drillhole. When constructing sumps soil is separated into topsoil and deeper free dig material. The topsoil has higher organic material and nutrients than the free dig material. Free dig material onsite contains high quantities of calcium carbonate in the form of calcrete and is saline. Hence, the topsoil is separated to maintain the concentrated values of nutrients, organic material, including cryptograms. If free dig material is incorrectly separated, the resulting soil mixture can be harder to revegetate.

Transplanting Bushes Prior to Sump Construction

AGE has undertaken a transplanting trial for vegetation removed for sump excavation. The aim is to confirm which native species tolerate transplantation and to reduce native vegetation loss by replanting vegetation removed in excavation areas. Transplanting vegetation limits environmental impact by accelerating vegetation regeneration and providing almost instant vegetation in rehabilitated areas. The aim of this trial is to find optimal growing conditions for transplanting vegetation onsite and identify species where confidence in transplant success is high (i.e. the plant continues to live post transplanting). Rapid revegetation provides ongoing habitat to fauna on site and

greatly assists with managing related environmental aspects such as dust and erosion in the longer term.

Site Rehabilitation – Direct Seeding and Hydroseeding

Cleared sites are rehabilitated using either direct seeding or hydroseeding. Direct seeding involves hand spreading and raking a mixture of species (locally collected, typically more than 10 species) of treated native seeds through the topsoil.

Hydroseeding consisted of use of a specialist hydroseeding truck and operators, the machine applies a premixed (native seed, water, nitrogen fertiliser, paper, glue and dye) solution under a pressurised cannon system across areas of rehabilitated drillpads at minimum rate of 20Kg seed per hectare. A large gentle action mixing tank is used to ensure seed is well soaked and not damaged in the process, assisting in overcoming natural germination inhibitors. All treated drillpads were done in one day.

Monitoring Pearl Bluebush Regrowth

Sheep grazing pressure has been removed by installing enclosure fencing around rehabilitated drill sites. The bush height growth rates for remnant uncleared vegetation near the rehabilitated drillhole, in the absence of sheep grazing, are unknown for this species at this site and this knowledge will assist in planning on the timing of optimal fencing removal. Photos with GPS locations have been recorded of Pearl Bluebush higher then 75cm, these will be revisited to determine the time it takes to reach 100cm height, and hence optimal bush habitat for fauna species and above a typical sheep graze line. Time series data is currently not yet collected for this estimate. It is possible that the areas treated with fencing will have plant growth that results in better bush height and density than the previous land condition prior to mineral exploration, however future rainfall amounts will influence this as well.

Fence Construction

Approximately 50m of fencing was constructed around the perimeter of rehabilitated drill sites outside the field trial area (which is also fenced to exclude sheep and assist revegetation). The fences were made from 20mm wire mesh, 1 metre wide, with a 20cm ‘skirt’ and star-droppers. The wire mesh is clipped tightly onto three evenly spaced strainer wires with metal clips to prevent the mesh sagging. An additional piece of wire mesh is placed flat on the ground and clipped to the main fence and pegged into the ground to prevent rabbits and other small animals from digging underneath. Fence construction occurs based on availability of staff and resources. Generally, a target of completion is within 4 weeks after the sumps have been backfilled with sub soil and the topsoil, and the drillholes cement grouted.

A total of 95 fenced drill pads were field observed for their species diversity and soil coverage percentage. 50 pads were from 2023 and 45 pads from 2022. Plant species found within each drill pad were identified by a subject matter expert. The number of plant species were recorded and entered into a spreadsheet. The revegetation soil coverage was calculated by drone photo observations of the rehabilitated areas.

Drone photos were taken from a height of 80m at each of the drill pad vegetation analysis sites. 27 sites with no drilling were selected as a background control for comparison. The background control was used to observe if there is a change in species diversity or coverage between differently treated drill pad rehabbed sites and sites with no land use change (i.e. remaining grazed by sheep and rabbits but not affected by drilling).

Additionally, aerial drone photos and ground photos have been recorded over a time series to record and allow observation of rehabilitation growth of the drillpads. AGE is planning to develop an artificial intelligence software to streamline assessment of plant coverage and biodiversity using time-based drone footage.

The vegetation coverage percentage was calculated using the drone photos by placing an overlaid grid pattern over each photo and the number of pattern boxes either fully or partial covered were subtracted from the maximum boxes present in the observation area. For areas without a fence, a standard size rectangle was used to minimise selection bias. Percentage coverage was compared to 27 background control sites that were not impacted by drilling. Background controls were located approximately 20m to 30m distant from the drill pad.

Climatic conditions

A summary of the regional climatic conditions for the two years of the assessment of the 95 rehabilitated drill holes is illustrated in Figure 2.

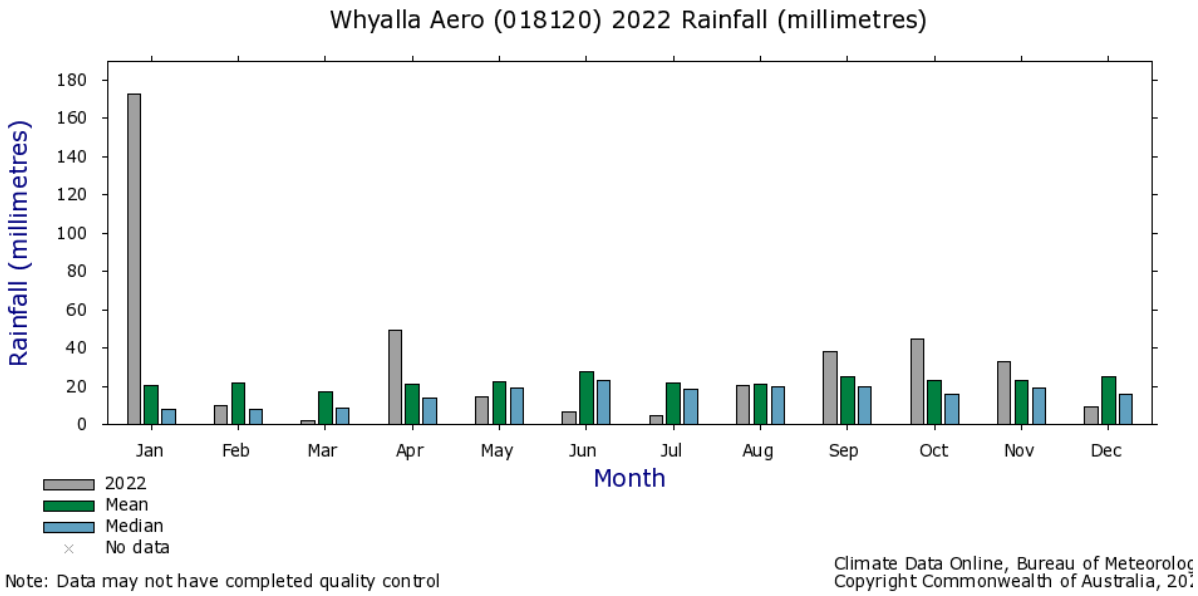
The annual average rainfall (mm) recorded by BOM for the Whyalla aero weather station is 268mm.

A high rainfall was observed in both figures during the summer session. During this time most sites which had been seeded at the time began to germinate from combination of soil moisture and warm weather. Chenopod shrubs generally prefer to germinate in warmer periods, if soil moisture is available.

2022 generally provided better seed germination and subsequent growing conditions due to the water received in January and with good follow up rains being received in April, September, October and November.

Good growing conditions were available in 2023, with good rainfall in December, 96mm as compared to the average of 25mm.

Graph A.



Graph B.

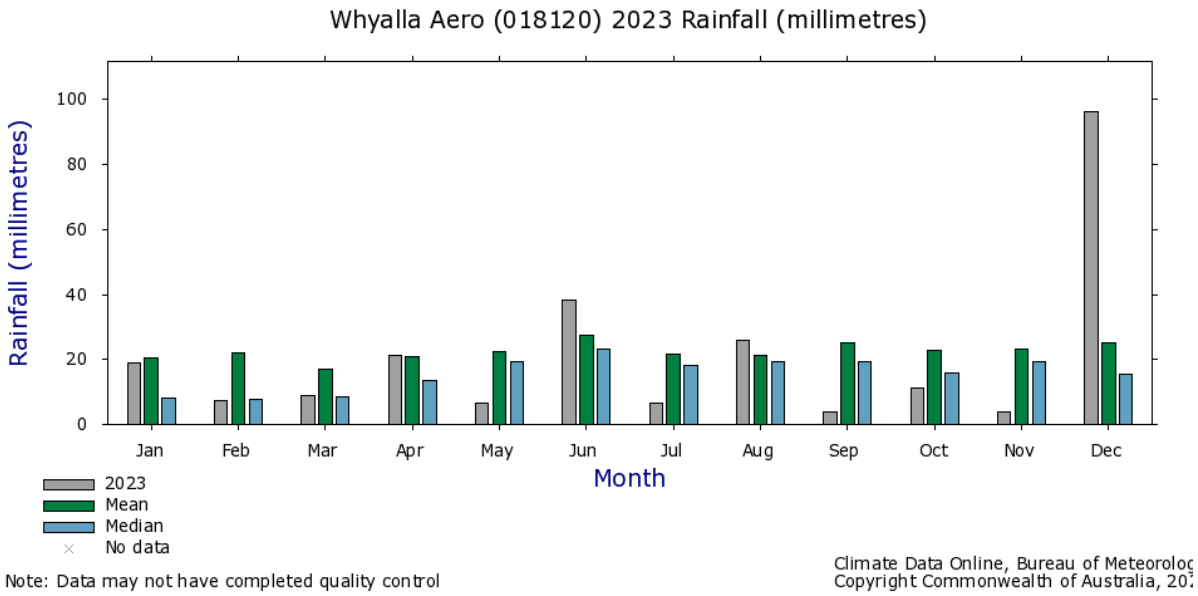


Figure 2. Graph A, 2022 Rainfall recorded at BOM site nearest to trial area – Whyalla aerodrome, had a total of 404mm, with a maximum rainfall in January of 172mm.

Graph B 2023 Rainfall recorded at BOM site nearest to trial area – Whyalla aerodrome, annual recorded was 249mm, with a maximum of 96mm in December 2023.

Native Plant Transplanting Results

Two trials were undertaken.

Ten individuals Pearl Bluebush (*M.sedifolia*) and ten of Native boxthorn (*L.australe*) were transplanted on the 5 April 2024, a number of horticultural practices were trialled such as maintaining the same directional orientation before and after transplant, pre-soaking the root system prior to digging out, pruning foliage prior to transplanting, and fertilizing with Seasol®.

The plants were rechecked to see if they survived after 6 months, generally the Pearl bluebush was more successful with transplanting, with 6 of 10 being still alive and the remaining 4 potentially alive but not appearing healthy. The native boxthorn had 7 out of 10 survive. Overall, a good outcome as transplant viability was an unknown option for this site.

A second trial was also done. Thirty Pearl bluebush were transplanted, following a Moonabie station grader putting in a fence line. These plants were roughly removed by the grading process and were opportunistically transplanted as a trial. None of the horticultural practices were used, and none survived, with 100% mortality being the result.

Table 1: Results of transplant two species using horticultural practices

TRANSPLANTING TRIAL – 2 species chenopods

Plant Species	Pruned (Yes/No)	Plant Pre-soaked (Yes/No)	Seasol Applied	North Orientation Retained	6 Month Check
M. sedifolia	Yes	No	Yes	No	Alive
M. sedifolia	Yes	No	Yes	No	Alive
M. sedifolia	Yes	No	Yes	No	Alive
M. sedifolia	Yes	No	Yes	No	Alive
M. sedifolia	Yes	No	Yes	No	Alive
M. sedifolia	No	Yes	Yes	Yes	Unsure
M. sedifolia	No	Yes	Yes	Yes	Unsure
M. sedifolia	No	Yes	Yes	Yes	Unsure
M. sedifolia	No	Yes	Yes	Yes	Alive
M. sedifolia	No	Yes	Yes	Yes	Unsure
L.australe	Yes	No	Yes	Yes	Alive
L.australe	Yes	No	Yes	Yes	Alive
L.australe	Yes	No	Yes	Yes	Alive
L.australe	Yes	No	Yes	Yes	Dead
L.australe	Yes	No	Yes	Yes	Dead
L.australe	No	Yes	Yes	Yes	Dead
L.australe	No	Yes	Yes	Yes	Alive
L.australe	No	Yes	Yes	Yes	Alive

L.australe	No	Yes	Yes	Yes	Alive
L.australe	No	Yes	Yes	Yes	Alive

Results – Direct Seeding and Hydroseeding

Table 2 and figure 3 describes the 95 rehabilitated drillpads that were assessed in 2024 for vegetation coverage of soil surface, 45 remediated in 2022 and 50 remediated in 2023, and compared with different treatments and 27 control sites. Differences between the two years, regardless of treatment are apparent.

Table 2: Hydroseeding and direct seeding effects on ground coverage

Treatment	Average ground coverage per treatment
hydro seed cover – total average over 2 years	24%
2022 hydroseeded	43%
2023 hydroseeded – fencing delayed	21%
Direct seeding – total average over 2 years	25%
2022 Direct seeding	30%
2023 Direct seeding – fencing delayed	13%
Control no vegetation removed – baseline	36%

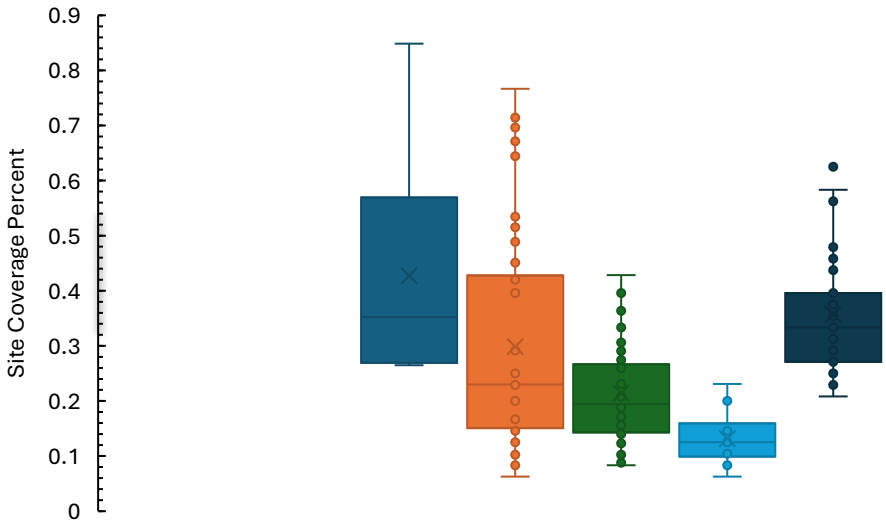


Figure 3: A comparison of percentage vegetation soil coverage between hand direct seeding and hydroseeding undertaken in 2022 and 2023 and assessed in 2024.

As shown in Figure 3 above, Dark blue hydroseeded in 2022, orange direct seeded 2022, green hydroseed in 2023, light blue direct seeded 2023, black background control. The background control is taken from average coverage of multiple sites which are location within approximately 20m to 30m to the testing sites. Background control is used to compare with uncleared areas and is a target coverage.

Hydroseeding within the same year generally has a greater coverage of vegetation than direct seeding. This was the expected result as experience generally shows, all things being equal (i.e. climatic, soil type, seed viability, etc) hydroseeding on other project sites has shown to be more effective at germination and growth than direct seeding. This is due to the increased protection the hardened hydroseeding paper mâché cover provides in holding the seed in place from wind, the maintenance of contact between soil particles and seed permitting germinated seed to gain a foothold, retaining soil moisture and the addition of fertiliser in the hydroseeding mix.

The 2022 direct seeding did perform better in coverage over the 2023 direct seeding. The poor results of the direct and hydro seeded in 2023 seeding generally can be attributed to a combination of lower rainfall and an overly long delay in erecting exclusion fencing, so germinated plants were available for grazing upon emergence. Direct seeding is still effective, however seemingly taking longer for coverage to reach baseline level.

The 2022 hydroseeding provided a higher percentage cover at 43% than the 36% average cover recorded for control sites, an excellent outcome.

The overall trends suggest hydroseeding does improve performance, but the key factor is the reduction of grazing pressure by fencing. The reduced coverage may have due to multiple of factors including grazing pressure from sheep. Some of the sites for the hydroseeding were not fenced with sheep proof fencing before hydroseeding took place and after germination for over 6 months. During this exposure time these sites had clear observations of sheep disturbance (hard hooved footprints, scats and chewed paper mache) and grazing.

The recommendation from this study is to fence off all areas to be rehabilitated to prevent livestock or ferals (goats, rabbits) grazing on newly germinated plants.

Table 3: Percentage vegetation cover, fencing versus no fencing treatment

Treatment- fenced from grazing pressure yes or no	Average ground coverage per treatment
Yes fenced, plant coverage total for 2 years	29%
Yes 2022 fenced	43%
Yes 2023 fenced	21%
No fence, plant coverage total for 2 years	18%
2022 no fence	21%

2023 no fence	11%
Control no vegetation removal	36%

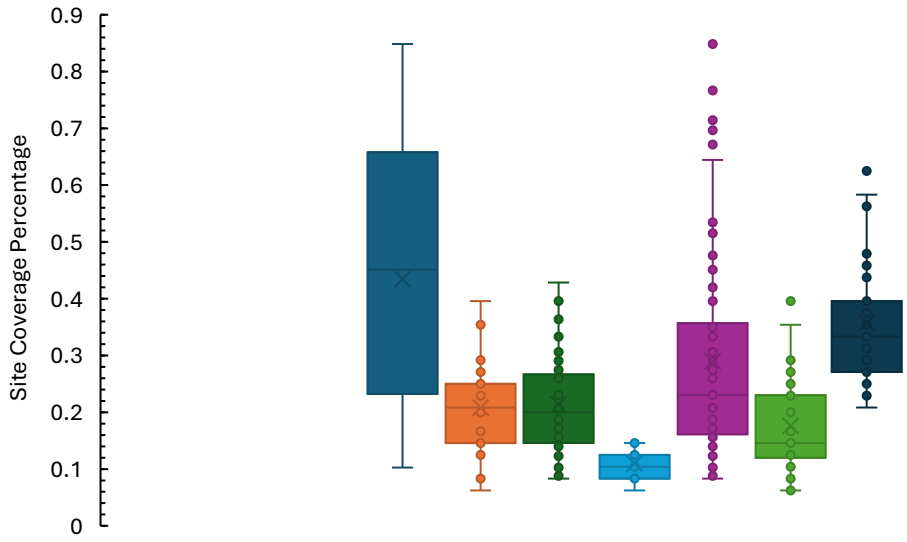


Figure 4: A comparison of percentage vegetation soil coverage between fencing with rabbit and sheep proof material and no fencing in 2022 and 2023 and assessed in 2024.

Dark blue fencing in 2022, orange no fence 2022, dark green fenced with rabbit and sheep proof material 2023, light blue not fenced 2023, purple total fenced using rabbit and sheep proof materials for all accessed sites, light green total for all not fenced sites, black background control. The background control is taken from average coverage of multiple sites which are location within approximately 20m to 30m to the testing sites. Background control is used to compare with uncleared areas with exposure to fauna grazing to drill site regrowth and recovery.

Table 4: Average plant species diversity index for fencing versus no fencing

Fencing and plant species diversity recorded with drill pads	**Plant Species diversity index**
Total average plant species with no fence for the two years	**20**
Total average plant species in fenced areas over two years	**31**
Ave plant species in drill pads not fenced in 2022	21
Ave plant species in drill pads fenced in 2022	32
Ave plant species in drill pads not fenced 2023	17
Ave plant species in drill pads fenced in 2023	31

Fencing provided better regrowth diversity rates than unfenced pads. Fencing overall had a 35.5% increase in species diversity index compared to no fencing. This is most likely due to grazing pressure from sheep and ferals. Ensuring areas are fenced to reduce grazing pressure will increase regrowth and species diversity, all other things being equal.

Regrowth from Rolled Plants

Using rolling, as opposed to excavation or grading, improves the regrowth rate of M. sedifolia compared to direct seeding. Allowing *M. sedifolia* to regrow from rootstock assists reach revegetation coverage targets (baseline coverage rates) with little additional inputs required.

Table 5: Average species diversity index for Hydroseeding

Hydroseeding and plant species diversity recorded in drill pad areas	Species diversity index
Total hydroseeded sites over two years	31
Total no hydroseeding over two years	24
2022 average hydroseeding	26
2022 average no hydroseeding	33
2023 average hydroseeding	30
2023 average no hydroseeding	20

Hydroseeding generally has better vegetation diversity success compared to direct seeding. This is likely due to combination of reasons. These include, the hydro seeded paper mâché cover assists in retaining improved soil moisture over an extended period (perhaps up to 6-12 months), a nitrogen-based fertiliser was added to the hydroseeding mix, and the fulsome soaking of the seeds in the hydroseeding mixing tank process perhaps better primes some of the seed species for germination; these treatments/factors either combined or individually promote germination and growth.

Alternatively, hand broadcast direct seeding can be used, whereby the seed is pretreated, (if appropriate for the species, i.e. Acacias, Atriplex's, Senna) by soaking overnight; then hand spread and raked into the soil at a shallow depth.

Table 6: Average species diversity for each year, combined for all treatments.

Year	Average plant species diversity index for each year
average 2022	27
average 2023	28

Table 7: Plant species most commonly recorded in rehabilitated sites

Top 10 species recorded on the greatest number of sites			
SCIENTIFIC NAME	**Common names**	**2022**	**2023**
Atriplex nummularia	Oldman Saltbush	19	37
Atriplex vesicaria	Bladder Saltbush	41	50
Austrostipa sp.	Speargrass	41	43
Eriochiton sclerolaenoides	Woolly-fruit Bluebush	37	31
Maireana georgei	Satiny Bluebush	35	45
Maireana pyramidata	Black Bluebush	10	40
Maireana sedifolia	Pearl Bluebush	43	43
Sclerolaena obliquicuspis	Oblique-spined Bindyi	41	49
Sclerolaena patenticuspis	Spear-fruit Bindyi	40	48
Vittadinia cuneata var.	Fuzzy New Holland Daisy	32	35

The list of the commonly recorded species found within rehabilitated site was as expected as most of these species are readily available within the paddock except for speargrass. Intact Speargrass producing seed are generally only found in the fenced off rehabilitation areas, due to grazing pressure. An active effort to include perennial spear grasses in the direct seeding and hydroseeding mixes is expected to have resulted in the increased new coverage of spear grass vegetation.

M. sedifolia was the most abundant for 2022. There was some new seedling growth from *M. sedifolia* vegetation; however, the majority is mostly shoot regrowth from intact roots and stumps that were retained in-situ from the rolling process allowing for better recovery. This abundance highlights the effectiveness of rolling shrub vegetation, allowing a much more cost effective/reduced input vegetation recovery as opposed to total vegetation removal and subsequent requirement to reseed or plant vegetation.

A. vesicaria was the most abundant for 2023. This was expected as *A. vesicaria* is abundant in the study area and as seed is bulk vacuum collected within Moonabie station a significant percentage of seed collected will be this species.

Grasses *Austrostipa spp, Chloris truncata, Rytidosperma spp* were present on a large number of hydroseeded sites; however, due to their absence in sites without hydroseeding or fencing they did not make it to the top ten most abundant vegetation.

Atriplex nummularia (Old man saltbush) had a high germination and growth rate in both direct seeding and hydroseeding. This could be due to its high salinity tolerance and/or high viability of fresh seed. In areas of high salinity using Old man saltbush for remediation could be a possible option, with the added bonus of providing excellent stock feed for future pastoral operations.

Acacia papyrocarpa seedlings have been observed in some of the rehabilitated drillpads, outside of the ones assessed for this report. In line with the apparent episodic natural germination events recorded in literature for this species (Ireland 1992).

A total of 371 drillholes have been rehabilitated since 2021, this study assesses 95 of them, opportunistic observations indicate the study results are representative.

An additional observation is that kangaroo grazing is present but any impacts not yet quantifiable, apart from occasional observed 'nibbled' juvenile *Acacia papyrocarpa*.

Many of the *Atriplex, Maireana species* and *Enchylaena tomentosa* produced seed within their second season, contributing to the seed bank in the rehabilitated areas, an indication of ecosystem resilience.

This review concludes that effective and cost efficient rehabilitation of chenopod shrubland has satisfied achievable outcomes namely bush coverage percentage, species diversity and total number of bushes per area of rehabilitated sites in comparison to control areas.

Areas of further study to consider are:

- Compare and confirm baseline species diversity to confirm the visual impression that rehabilitated sites have greater plant diversity than control sites.
- Reduce the drone photo height and see if AI software can be trained to identify and count plants to species level.

References

1. **Acacia papyrocarpa**. https://syzygium.xyz/saplants/Fabaceae/Acacia/Acacia_papyrocarpa.html, accessed 2025.
2. **Andrew, M.H., & Lange, R.T.** (1986). Development of a new biosphere in arid chenopod shrubland grazed by sheep – changes to the vegetation. *Australian Journal of Ecology, 11*, 411–424.
3. **Black, A., Carpenter, G., & Pedler,L.** (2009). Distribution and Habitats of the Thick-Billed Grasswren *Amytornis textilis*, subspecies *myall.* South Australian Ornithologist 35 (7).
4. **EBS Ecology.** (2012). *Samphire Flora and Fauna Spring Report.* Report to Uranium SA. Adelaide, South Australia: EBS Ecology.
5. **EBS Ecology.** (2012). *Samphire Project Flora and Fauna Survey September 2011.* Report to Uranium SA. Adelaide, South Australia: EBS Ecology.
6. **EBS Ecology.** (2023). *Moonabie Samphire Uranium Project – Flora and Fauna Assessment.* Adelaide, South Australia: EBS Ecology.
7. **Ireland, C.** 1992. Recruitment in the Western Myall (Acacia papyrocarpa Benth,): flowering, formation and fate of seed and the regeneration niche. BSc Honours (Botany) Thesis, University of Adelaide.
8. **Lange, R.T., Nicolson, A.D., & Nicolson, D.A.** (1984). Vegetation management of chenopod rangelands in South Australia. *The Rangeland Journal, 6*(1), 46–54.

Appendix 1

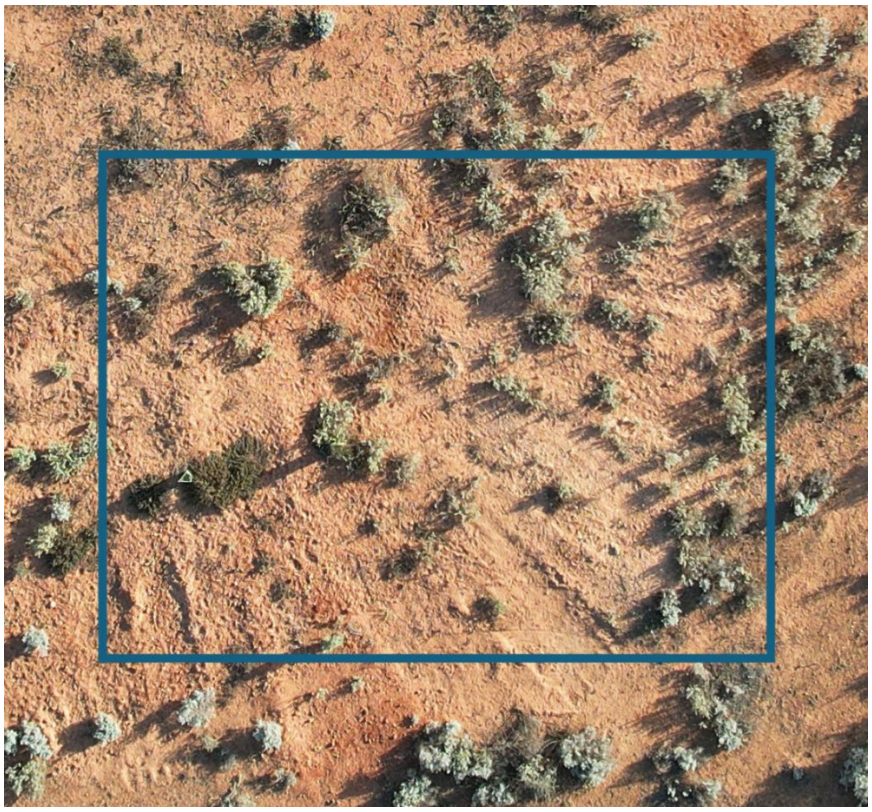
Example photos used to assess drill site vegetation coverage in this assessment.



BBRM23-147. 2023 Hydroseeded and fenced.



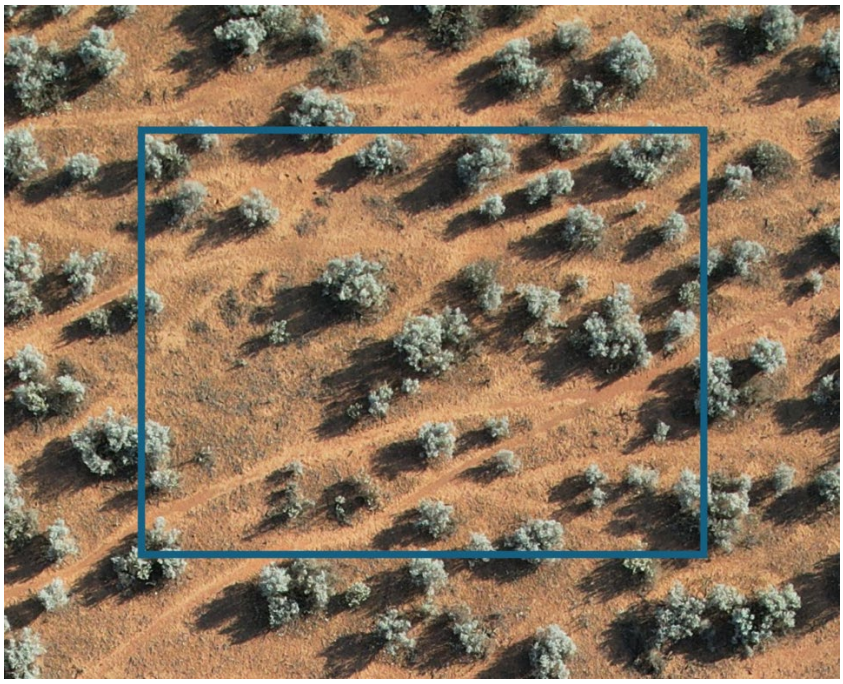
BBRM 23-102. 2023 Direct seeding, fenced.



BBRM22-047. 2022 Directed seeded, not fenced.



BBRM22-064. 2022 Hydroseed, not fenced.



CBBRM22-041, background control. Used to compare vegetation regrowth to baseline conditions. A rectangle of the same size and resolution was used on all the drone photos and vegetation within the area was access and recorded.

Appendix 2

Plant species lists, for different years, locations and the hydroseeding mix applied.

Plant species only found in 2022 assessed rehab	
SCIENTIFIC NAME (2022)	**Common name**
Enchylaena tomentosa var.	Ruby Saltbush
Eremophila scoparia	Broom Emubush
Rhagodia ulicina	Intricate Saltbush
Sida petrophila	Rock Sida

Plant species only found in 2023 assessed rehab	
SCIENTIFIC NAME (2023)	**Common name**
Atriplex paludosa	Marsh Saltbush
Convolvulus remotus	Grassy Bindweed
Dissocarpus biflorus var.	Two-horn Saltbush
Enneapogon nigricans	Black-heads
Lepidium phlebopetalum	Veined papercress
Maireana turbinata x Enchylaena tomentosa	
Ptilotus obovatus	Silver Mulla Mulla
Rhodanthe pygmaea	Pygmy Daisy

Species found within broader paddock but not found in assessed drill sites	
SCIENTIFIC NAME	Common name
Abutilon leucopetalum	Desert Lantern
Acacia oswaldii	Umbrella Wattle
Acacia papyrocarpa	Western Myall
Alectryon oleifolius ssp. canescens	Bullock Bush
Amyema quandang var. quandang	Grey Mistletoe
Amyema sp.	Mistletoe
Austrostipa Eremophila	Rusty Spear-grass
Austrostipa platychaeta	Flat-awn Spear-grass
Calandrinia volubilis	Twining Purslane
Crassula sp.	Crassula/Stonecrop
Disphyma crassifolium ssp. Clavellatum	Round-leaf Pigface
Duma florulenta	Lignum
Exocarpos aphyllus	Leafless Cherry
Frankenia pauciflora var.	Southern Sea-heath
Maireana aphylla	Cotton-bush
Maireana appressa	Pale-fruit Bluebush

Myoporum platycarpum ssp.	False Sandalwood
Pimelea microcephala ssp.	Shrubby Riceflower
Pittosporum angustifolium	Native Apricot
Rhagodia spinescens	Spiny Saltbush
Santalum acuminatum	Quandong
Santalum spicatum	Sandalwood
Scaevola spinescens	Spiny Fanflower
Sclerolaena uniflora	Small-spine Bindyi
Senna artemisioides ssp. artemisioides x ssp. coriacea	Desert Senna
Senna artemisioides ssp. X coriacea	Broad-leaf Desert Senna
Tecticornia pergranulata ssp. divaricate	Blackseed Glasswort
Threlkeldia diffusa	Coast Bonefruit

Hydroseeding mix species – applied at a combined rate of 20 Kg/ hectare		
Genus	Species	Common name
Atriplex	*holocarpa*	Pop Saltbush
Atriplex	*nummularia*	Oldman Saltbush
Atriplex	*vesicaria*	Bladder saltbush
Austrostipa	*sp.*	Speargrass
Bothriochloa	*macra*	Red legged Grass
Chloris	*truncata*	Windmill Grass
Dodonaea	*lobulate*	Lobed Hop Bush
Dodonaea	*viscosa*	Sticky Hop Bush
Maireana	*georgei*	Satiny Bluebush
Maireana	*pyramidata*	Black Bluebush
Maireana	*sedifolia*	Pearl Bluebush
Ptilotus	*obovatus*	Silver Mulla Mulla
Sclerolaena	*patenticuspis*	Spear-fruit Bindyi
Tecticornia	*sp.*	Glasswort
Themeda	*triandra*	Kangaroo grass
Vittadinia	*cuneata*	Fuzzy New Holland Daisy

Appendix H: Hydrology – Baseline Assessments

H1: Hydrology Baseline Assessment – Mullaquana Uranium Project. Report prepared for UraniumSA Ltd by URS Australia Pty Ltd, June 2010.



Report

Hydrology Baseline Investigation

Mullaquana Uranium Project

29 JUNE 2010

Prepared for

UraniumSA Ltd

32 Beulah Road
Norwood SA 5067

42657428

URS

Project Director:

.....
Cliff Allen
Senior Principal

URS Australia Pty Ltd

Level 4, 70 Light Square
Adelaide SA 5000
Australia
T: 61 8 8366 1000
F: 61 8 8366 1001

Project Manager:

.....
Geoff Watson
Senior Mechanical Engineer

Author:

.....
Maria Pham
Civil/Geotechnical Engineer

Reviewer:

.....
Jerome Argue
Senior Principal Civil Engineer

Date: **29 June 2010**
Reference: 42657428/R001/0
Status: Final

© Document copyright of URS Australia Pty Limited.

This report is submitted on the basis that it remains commercial-in-confidence. The contents of this report are and remain the intellectual property of URS and are not to be provided or disclosed to third parties without the prior written consent of URS. No use of the contents, concepts, designs, drawings, specifications, plans etc. included in this report is permitted unless and until they are the subject of a written contract between URS Australia and the addressee of this report. URS Australia accepts no liability of any kind for any unauthorised use of the contents of this report and URS reserves the right to seek compensation for any such unauthorised use.

Document delivery

URS Australia provides this document in either printed format, electronic format or both. URS considers the printed version to be binding. The electronic format is provided for the client's convenience and URS requests that the client ensures the integrity of this electronic information is maintained. Storage of this electronic information should at a minimum comply with the requirements of the Commonwealth Electronic Transactions Act (ETA) 2000.

Where an electronic only version is provided to the client, a signed hard copy of this document is held on file by URS and a copy will be provided if requested.

Table of Contents

Executive Summary 6
1 Introduction 7
2 Site Visit 8
3 Catchment Analysis 10
4 Rainfall 11
5 Streamflow Estimation 12
5.1 Rational Method 12
5.2 Other Methods 12
5.2.1 Eusuff Method 12
5.2.2 Akter and Daniell Method 13
5.2.3 Kemp Method 13
5.3 Results and Comparison of Streamflow Estimation 13
6 Deep Creek Hydraulic Analysis 14
6.1 HEC-RAS 14
6.2 Cross-sectional Information 14
6.3 HEC-RAS Modelling 15
6.4 Interpretation of HEC-RAS Results 15
7 Hydraulic Analysis for A1, A2, A4, A5 and A6 17
8 Discussion and Conclusion 18
8.1 Assessment of Potential Flood Risk 18
8.2 Further Modelling 18
9 References 19
10 Limitations 20

Tables

Table 3-1 Summary of catchment areas 10
Table 5-1 Summary of flow rates for 6 catchment areas 13
Table 7-1 Summary of 10 year ARI flow depths and velocities for A1, A2, A4, A5 and A6 17
Table 7-2 Summary of 100 year ARI flow depths and velocities for A1, A2, A4, A5 and A6 17

Figures

Figure 1-1 Location of proposed Field Leach Trial 7

Plates

Plate 2-1 Typical landscape illustrating upper catchment characteristics 8

Plate 2-2 Sandy soils and sparse vegetation - lower reach 9

Appendices

Appendix A Catchment Definitions

Appendix B Streamflow Estimates

Appendix C Flood Inundation Map and HEC-RAS Output

Appendix D Hydraulic Calculations for A1, A2, A4, A5 and A6

Executive Summary

This report presents the results of the baseline hydrology investigation as part of the approval process for an in-situ recovery trial within the exploration lease 3652. The investigation utilised 1:50,000 scale maps of the area to delineate the catchment boundaries, totalling to an area of approximately 450 km^2. The available maps and on-site observations show that there is a major drainage line running to the south of the tenement, called Deep Creek. The Deep Creek and other catchments are fairly sandy with sparse vegetation characterised by low shrubs and small trees and minimal ground cover. The terrain east of Lincoln Highway is flat with slopes of approximately 0.5%. An escarpment runs in the north-south direction at approximately 50 m above sea level. The area east of this escarpment is flat with no defined channels.

Streamflows for the 10 and 100 year Average Recurrence Interval (ARI) events were determined using various methods. Flows from the Rational Method were used for the hydraulic analysis to determine flow depths, velocities, and hence floodplain limits for the 10 and 100 year ARI events.

The floodplain map shows the flooding limits for Deep Creek based on a detailed hydraulic analysis of the creek. Due to the high flow depths and velocities, the Deep Creek floodplain is considered a high hazard area.

The floodplain map also shows the area prone to shallow flooding east of the escarpment where more detailed modelling could not be performed due to the lack of defined channels. This includes the proposed field leach trial area. Here flows are shallow and slow, thereby posing a low hazard. Flood protection in this area may include constructing a low level bund around sensitive areas or providing building pads for infrastructure. Further detail can be found in the Discussion and Conclusion section and throughout the main body of the report.

The floodplain analysis conducted in this baseline study should be utilised for preliminary information only. If a more refined flood inundation prediction at the area of interest is required, more detailed topographic information should be made available. A more detailed estimation of the flow rates may also be required to refine the floodplain mapping.

1 Introduction

UraniumSA Ltd commissioned URS Australia Pty Ltd (URS) to conduct a hydrology baseline study as part of the approval process for the proposed Field Leach Trial (FLT) and subsequent In-Situ Recovery (ISR) operations to be undertaken as part of the Mullaquana Uranium Project.

The area of interest is located approximately 20 km southwest of Whyalla on the Eyre Peninsula of South Australia and is located within the Exploration Lease (EL) 3652. The extent of the particular area of interest for ISR trial inside the tenement is shown in Figure 1-1.

Based on URS' site visit and the topographical map (1:50,000 scales - 10 m contour) of the area, a major drainage line was identified running to the south of the area of interest, named Deep Creek.

A detailed description of the agreed scopes of work is outlined in URS proposal reference 42657428, dated 29 March 2010. The main objectives include:

- Visit the site to inspect characteristics of the catchment and drainages;
- Delineate the catchment boundaries;
- Prepare baseline hydrology for the 10 and 100 year Average Recurrence Interval (ARI);
- Perform hydraulic analysis of the drainages to determine flood levels and velocities;
- Prepare floodplain maps for the 10 and 100 year ARI event using results from the hydraulic analysis for Deep Creek and other smaller drainages; and,
- Prepare this Hydrology Baseline Investigation Report.

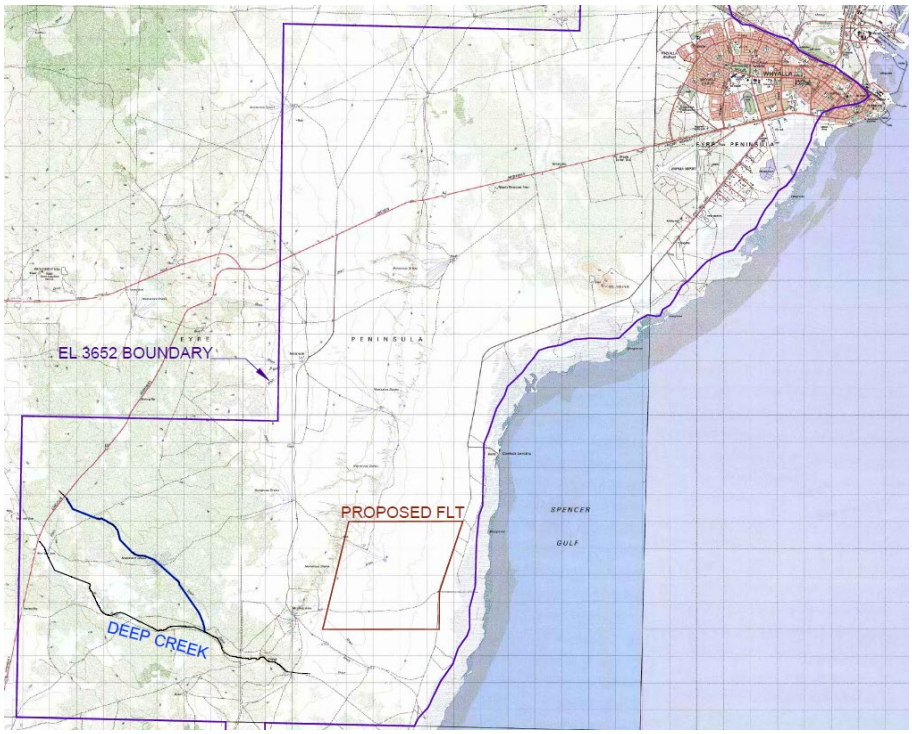


Figure 1-1 Location of proposed Field Leach Trial

2

Site Visit

The purpose of the site visit was to ascertain inputs to the flood modelling and to review the outfall characteristics of the drainages, particularly Deep Creek.

During URS' site visit on 12 April 2010, the observed creeks on the Mullaquana area consisted of dry creek beds. Vegetation in the Deep Creek catchment is mostly sparse and low, with tree growth concentrated along water course routes. The creek bed in the lower reaches of the creek is typically braided, characterised by multiple channels and lined with small rocks and gravelly materials.

Anecdotally, Deep Creek is subject to occasional flood flows where the creek intersects the Lincoln Highway. The creek's catchment slopes vary from typical slopes of about 10% at the Middle Back Range grading to much flatter slope of about 0.5% to the eastern side of Lincoln Highway.

For the lowest reach of Deep Creek, between the escarpment and sea level, the channel formation characteristic was not observed. It is suspected that the flow from the creeks converts to sheet flow from this point onwards. This characteristic is also observed at other areas from Murninnie Beach to the north of the proposed FLT and ISR area.

Numerous man-made drains were also observed on site. These were constructed to direct the sheet flow in flat catchments to collection points.



Plate 2-1 Typical landscape illustrating upper catchment characteristics



Plate 2-2 Sandy soils and sparse vegetation - lower reach

3

Catchment Analysis

Deep Creek, located approximately 5 km south of the FLT, generally drains a catchment area which extends from the Middle Back Range eastward to Spencer Gulf. Catchment boundaries for Deep Creek and other smaller drainages for the area of interest are shown in Figure A1 of Appendix A. Catchment areas are presented in Table 3-1.

Runoff from catchments A4 and A5 may have an impact on the proposed mine exploration area. This and the other catchments are relatively small compared to the Deep Creek catchment. Streamflow estimates for all the catchments listed in Table 3-1 were determined.

A desktop study of the local topography and site photographs (shown on Plates 2-1 and 2-2) indicate that the catchment is fairly sandy with sparse vegetation characterised by low shrubs and small trees and minimal ground cover. This is typical of well-grazed, semi-arid country. The upper reaches are quite steep with typical slopes of approximately 10% near the Middle Back Range, then reducing to much flatter slopes of approximately 0.5% on the eastern side of the Lincoln Highway. The nature of the terrain would suggest that the catchment is characterised by a low to medium runoff coefficient.

Table 3-1 Summary of catchment areas

Catchment ID	Catchment Areas (km^2)
A1	48.5
A2	16.1
A3	252.5
A4	16.8
A5	76.5
A6	38.0

4

Rainfall

Creeks in the Mullaquana area are located in an arid region of South Australia. The area is characterised by wet winter and low summer rainfall, with an average annual rainfall of less than 300 mm. The nearest rainfall recording stations are the Whyalla (Mullaquana), Whyalla (Nonowie), Whyalla (Broad View), Whyalla (Moola) and Iron Knob (Gilles Downs).

Rainfall Intensity-Frequency-Duration (IFD) information for the site, used in calculation of the streamflow estimates, was derived using the methodology described in Australian Rainfall and Runoff (ARR Vol 2, 2007). The results of the IFD analysis are presented in Appendix B.

5

Streamflow Estimation

It is noted that the purpose of this study is to provide a preliminary estimation of the flow rates for the catchment areas within EL3652, as a baseline hydrology study only. A more sophisticated estimation of the flow rate, using techniques such as runoff routing models based on computer software (e.g. RORB) could be performed if required.

5.1 Rational Method

Australian Rainfall and Runoff (ARR) (Institution of Engineers Australia 1987) Rational Method for the south east region (Zone 6) of South Australia was used to estimate the flow rate in the creeks within the vicinity of the tenement. The method as described by the Engineering and Water Supply Department in South Australia is based on the observed flood data from 20 catchments. The design relations are:

$$t_c = 0.5\ A^{0.65}$$

Where:

t_c = time of concentration (hr)

A = catchment area (km^2)

The runoff coefficients for the 1 in 10 and 1 in 100 year ARI are:

$$C_{10} = 0.23$$

$$C_{100} = 0.28$$

The derivation of the runoff coefficient was based on a streamflow record of 16 years, therefore, the 100 year ARI value involved considerable extrapolation (ARR, 1987).

5.2 Other Methods

To assess the flow rates calculated by the Rational Method, a comparison was made with flows estimated by four different regression equations. On the recommendation of Dr David Kemp (Department of Transport, Energy and Infrastructure – DTEI, email dated 10 May 2010), recognised as a leading authority on hydrology in South Australia, other methods such as Eusuff (1995), Akter & Daniell (1993) and Kemp (2003) were used. These calculation techniques were selected because they are based on observed data available for South Australia. These methods are described below:

5.2.1 Eusuff Method

The Eusuff Method was derived for the Mount Lofty Ranges. The method is categorised for high runoff area and low runoff area.

High Runoff Area:

$$Q_{100} = 3.8\ A^{0.73}$$

Low Runoff Area (at the eastern side of the Mount Lofty Range):

$$Q_{100} = 1.09\ A^{0.87}$$

Where: Q_{100} = flow rate for 100 ARI

A = catchment area (km^2)

5.2.2 Akter and Daniell Method

The Akter and Daniell (1993) method was also derived for the Mount Loft Ranges. The design relations are:

$$Q_{100} = 6.2\ A^{0.58}$$

Where: Q_{100} = flow rate for 100 ARI

A = catchment area (km^2)

5.2.3 Kemp Method

The Kemp method was developed for the Upper Onkaparinga River catchment in 2003. This method was derived for the Onkaparinga Catchment Water Management Board by DTEI. The design relations are:

$$Q_{100} = 3.08\ A^{0.91}$$

Where: Q_{100} = flow rate for 100 ARI

A = catchment area (km^2)

5.3 Results and Comparison of Streamflow Estimation

The peak streamflow estimates for each of the creeks for 100 year ARI event in the proposed tenement development site are summarised in Table 5-1. Table 5-1 also includes the 10 year ARI streamflows for the Rational Method. The calculations are attached in Appendix B.

Table 5-1 Summary of flow rates for 6 catchment areas

Catchment ID	Flow Rate (m^3/sec)					
	Rational Method* Q_{10}	Rational Method* Q_{100}	Eusuff High Runoff Q_{100}	Eusuff Low Runoff Q_{100}	Akter & Daniell Q_{100}	Kemp Q_{100}
A1	21.3	49.5	64.6	31.9	58.9	105.3
A2	11.9	27.7	28.9	12.2	31.1	38.6
A3	50.6	116.0	215.5	134.1	153.4	472.7
A4	12.1	28.3	29.8	12.7	31.9	40.1
A5	27.1	62.9	90.1	47.5	76.7	159.5
A6	18.7	43.5	54.1	25.8	51.1	84.4
*Note: The Rational Method was adopted for this report						

In general, the Rational Method, the average of Eusuff Method for high and low runoff catchments and Akter and Daniell Method yielded similar peak flow rates for the 100 year ARI event. Therefore the **Rational Method** flows were used to map the floodplain. The Kemp Method was unsuitable because the formula was empirically derived from the Onkaparinga catchment located in a considerably more humid part of South Australia.

It is acknowledged that these estimates are subject to significant errors and caution should be exercised in their use. Further work is currently being undertaken within the industry to improve these methods.

6

Deep Creek Hydraulic Analysis

The hydraulic analysis of Deep Creek was performed using HEC-RAS. Results from the analysis were used to prepare a first-order estimation of floodplain extent. HEC-RAS models were not developed for other catchment areas (A1, A2, A4, A5 and A6) because there was no obvious channel details based on the 1:50,000 scale topographical information. Since these areas are flat, flood mapping was estimated based on the Manning's formula and engineering judgement. A discussion of the hydraulic analysis for these other catchments is in Section 7.

6.1 HEC-RAS

The HEC-RAS River Analysis System, developed by the U.S. Army Corps of Engineers, Hydrologic Engineering Center is an industry standard, one-dimensional, backwater curve analysis package. The package uses step-wise solution of the energy equation to predict water surface profiles for a range of open-channel flow situations.

HEC-RAS requires, as input, data defining channel cross-sectional shape, roughness and flow rate, to enable it to predict water surface levels associated with the flow.

HEC-RAS outputs were used to generate inundation maps showing flooding extents. Velocity mapping was not created, but limited velocity information can be obtained from HEC-RAS output tables.

Figure C1 in Appendix C shows the flow paths, and cross-sections (labelled) that were used in the HEC-RAS model. The HEC-RAS output tables are provided for reference in Appendix C. If there is a need to confirm flow depth and velocity at any given point in the floodplain (e.g. for design of scour protection or road crossings), this information may be estimated from the HEC-RAS output for the nearest cross-section of the relevant creek channel, from the data tables provided in the Appendix.

The degree of accuracy of contour information to closely define the flow path channel in the lower reaches of the catchment is relatively coarse. As a consequence predicted water surface levels are sufficient for planning purposes, however, it must be expected that actual events may vary significantly from these levels.

Provided that any construction within predicted floodplains is located outside the main flow path, and is able to withstand expected velocities across the overbank area, floodplain maps derived from such an analysis will provide guidance for infrastructure location.

There is considerable uncertainty with respect to the alignment of the flow path of the lower section of the creek (from Lincoln Highway to the escarpment), which is ill-defined at the 10 metre contour resolution. Several possible alignments were modelled, and the most likely alignment has been selected for the final modelling and floodplain mapping. It is highly likely that the flows discharge overland from the main reach as unconfined, shallow sheet flow. The resultant flood maps for this reach should thus be viewed with considerable caution, and a site inspection is strongly recommended to determine actual conditions, particularly if there is potential for construction of any mine infrastructure in the vicinity of Deep Creek.

6.2 Cross-sectional Information

To undertake the HEC-RAS analysis, collation of cross-sectional information along flow paths of interest is necessary. Civil 3D was used to develop a data set containing geo-referenced, 3D cross-sectional information.

Cross-sections are generally located at points of major flow change, such as significant bends, and at relatively regular intervals along individual creek lines. Spacing of cross-sections varies along the extents of the creek reaches, depending on factors such as steepness and variability of the terrain, with sections spaced at approximately 200 metre intervals due to the coarseness of the available topography information.

The selection of a channel roughness value (Manning's *n* parameter) of 0.05 is based upon review of site photographs.

Once cross-sectional information has been extracted, a visual check is made of the resulting profiles, to determine any irregularities, prior to completion of final hydraulic modelling using HEC-RAS. In addition, pre-processing of HEC-RAS import data includes filtering of data to remove superfluous data points, and the additions of Manning's *n* and *reach length* inputs.

6.3 HEC-RAS Modelling

Following the input of cross-sectional information, flow data were entered to the model, which was then used to simulate 100 year ARI event, using flow rates generated from the Rational Method, as discussed in Section 5.

For the minor tributary at the northern side of Deep Creek, with no adjoining streams contributing to flows, the peak flows that were derived by using the whole contributing subcatchment areas were applied from the upstream end of the watercourse. This is a conservative approach; in actual fact, flows typically increase with distance travelled downstream, as the contributing catchment area increases. For this reason, flow rates, depths and velocities shown for the upper reaches of the catchment will typically be greater than can be expected in reality.

Normal depth was defined as the downstream boundary condition for flow modelling.

A floodplain map, indicating approximate flooding extent for the 10 and 100 year ARI events, has been prepared using AutoCAD to plot HEC-RAS modelling outputs. This map is provided as Figure C1 in Appendix C.

6.4 Interpretation of HEC-RAS Results

Of interest are both the extent of flooding, as shown on the floodplain map, and the velocity of flow occurring during a flood event.

Summary tables from the HEC-RAS model run are included in Appendix C for reference. These tables show the predicted water surface level at each cross-section, the analysed flow rate and the predicted average flow velocity across the cross-section. In addition, data such as the width of flow are indicated for each of the analysed flow profiles at each cross-section. Maximum flow depths may be derived from the differences between the minimum channel elevation and the water surface elevation.

It should be noted, with regard to velocity, that the average velocity represents an average taken over the full cross-section. It can be expected, particularly in the event of overbank flow, that the velocity in the channel proper will be higher than in the overbank flow. Therefore the velocities tabulated in Appendix C would be expected to be in excess of the velocity that would be experienced on the bank of the channel.

Flooding extents and depths between cross-sections have been interpolated by HEC-RAS, and these must therefore be regarded as indicative and approximate only, with accuracy greatest in the vicinity of actual cross section locations, and even at these locations dependent upon the contours data used in this study.

A review of the model results shows maximum flow velocities of 3.5 m/s for the 100 year ARI flooding scenario, with the majority of average velocities being less than 1.5 m/s. At most of the locations in which flow velocity is shown exceeding 1 m/s, the flows occur in steeper upper sections of the reach, and in these cases it is also likely that the flow is largely confined to a narrow width near the invert of the flow path. For the 10 year ARI event, the maximum flow velocity is 2.9 m/s with a majority of average velocities being less than 1 m/s.

7

Hydraulic Analysis for A1, A2, A4, A5 and A6

Due to the coarseness of the topography information, it was not possible to define the sub-catchments for the creeks within the catchment areas A1, A2, A4, A5 and A6. Since these areas are flat, with no obvious channel formation, the flow was assumed to spread evenly over the width of the catchment near the escarpment (at approximately 50 m above sea level) and flow towards Spencer Gulf. As a consequence the water surface width, level and velocity are sufficient for planning purposes, however, it must be expected that actual events may vary significantly from these estimated values.

The Manning formula was used to estimate the flow depth and velocity for the 100 year ARI event, using flow rates generated from the Rational Method, as discussed in Section 5.

The Manning formula states:

$$V = \frac{1}{n} R_h^{\frac{2}{3}} S^{\frac{1}{2}}$$

Where:

V = cross-sectional average velocity (m/s)

n = Manning roughness coefficient

R_h = hydraulic radius = A/P (m)

S = channel bed slope

A = cross sectional area of flow (m^2)

P = wetted perimeter (m)

The flow depth and velocity estimates from each of the above mentioned catchment areas for the 10 and 100 year ARI events in the proposed tenement development site are summarised in Table 7-1 and Table 7-2, respectively. The calculations are attached in Appendix D.

Table 7-1 Summary of 10 year ARI flow depths and velocities for A1, A2, A4, A5 and A6

Catchment ID	Assumed Flow Width (m)	Flow Depth (mm)	Flow Velocity (m/sec)
A1	2400	49	0.2
A2	2900	31	0.1
A4	4100	25	0.1
A5	5700	34	0.1
A6	4100	33	0.1

Table 7-2 Summary of 100 year ARI flow depths and velocities for A1, A2, A4, A5 and A6

Catchment ID	Assumed Flow Width (m)	Flow Depth (mm)	Flow Velocity (m/sec)
A1	2400	81	0.3
A2	2900	51	0.2
A4	4100	42	0.2
A5	5700	56	0.2
A6	4100	54	0.2

8

Discussion and Conclusion

8.1 Assessment of Potential Flood Risk

From the flood inundation map for the proposed FLT area as shown in Appendix D, it clearly shows that the Lincoln Highway is intersecting the Deep Creek's flow path, which explains the observed flooding in this section of the highway.

At the upper reaches of Deep Creek (from the eastern side of Lincoln Highway to the junction between Deep Creek and minor tributary creek), higher velocity up to 3.5 m/sec could be expected for the 100 year ARI event. The depth of the water flow for this event could be up to 3 m. At the lower reaches, the flow is slower with flow 100 year ARI velocity of 2.7 m/sec with shallower flow depth and wider flow width. In general, due to these high flow depths and velocities, the 100 year ARI floodplain is considered a high hazard area.

In assessing the impact of predicted flood risk on potential operations within the floodplain, recognition must be made of the likelihood of a flood event occurring. If mining activities are to be located within the Deep Creek floodplain for a short period, a lower flood standard may be appropriate. For example, over a 12 months period, the risk of a 100 year ARI flood is 1%. However, mining infrastructure to remain in one place for a much longer period, for example 15 years, would be exposed to a 14% risk of a 100 year ARI flood.

For other areas, namely A1, A2, A4, A5 and A6, the catchment areas are generally flat with no obvious channel formation as shown on the 1:50,000 scale topographic map. Even though numerous man-made drains and small drainage lines are shown on the map indicating the course of the flow, the sub-catchment areas for these drainage lines could not be identified at such scale. Hence, flow velocity, width and depth for these drainage lines could not be estimated. At the lower side of these catchment areas, the flow from the escarpment (at approximately 50 above sea level) to sea level is assumed to occur as sheet flow. These sheet flows are estimated to be shallow, typically in a range from 50 to 80 mm deep with slow-moving velocity of approximately 0.3 m/sec velocity. Flood protection still needs to be considered in the design of infrastructure within these areas, but due to the shallow depth and low velocity of the flood flow, the hazard posed by a 100 year ARI event and the cost of flood protection are expected to be low. Flood protection from the 100 year ARI event may include constructing a low level bund around sensitive areas or providing building pads for infrastructure. Such bunds or pads probably need not be higher than a half metre.

8.2 Further Modelling

The floodplain analysis within the tenement area as described in this report serves as a baseline study and as such is to be utilised for preliminary information only. It has been noted that there is some uncertainty in the prediction of both flow rates and the accuracy of cross-sectional information along flow paths due to the coarseness of the topographic information. It is acknowledged that these estimates are subject to significant errors and caution should be exercised in their use.

If a more refined flood inundation prediction at the area of interest is required, more detailed topographic information (1 or 2 m contour) for the tenement should be made available. A more sophisticated estimation of the flow rate, using techniques such as runoff routing models based on computer software (e.g. RORB) should also be undertaken.

References

Akter, S. and Daniell, T.M. (1993) "Regional Flood Frequency in the Mount Lofty Ranges" I.E. Aust. Hydrology and Water Resources Symposium, Newcastle, June 1993. pp 281-286.

Australian Rainfall and Runoff ARR, 1987, “A Guide to Flood Estimation” Volume 1, The Institution of Engineers Australia

Australian Rainfall and Runoff ARR, 2007, “A Guide to Flood Estimation” Volume 2, The Institution of Engineers Australia

Eusuff, T.H. (1995) “A Regional Flood Frequency Approach to the Mount Lofty Ranges” Unpublished Thesis, University of Adelaide, June 1995

HEC-RAS River Analysis System, Version 4, March 2008, US Army Corps of Engineers, Hydrologic Engineering Center

Kemp, D (2003) "Hydrological Study of the Upper Onkaparinga River Catchment" Report produced for the Onkaparinga Catchment Water Management Board by Transport SA.

Limitations

URS Australia Pty Ltd (URS) has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of UraniumSA Ltd and only those third parties who have been authorised in writing by URS to rely on the report. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in the Proposal dated 29 March 2010.

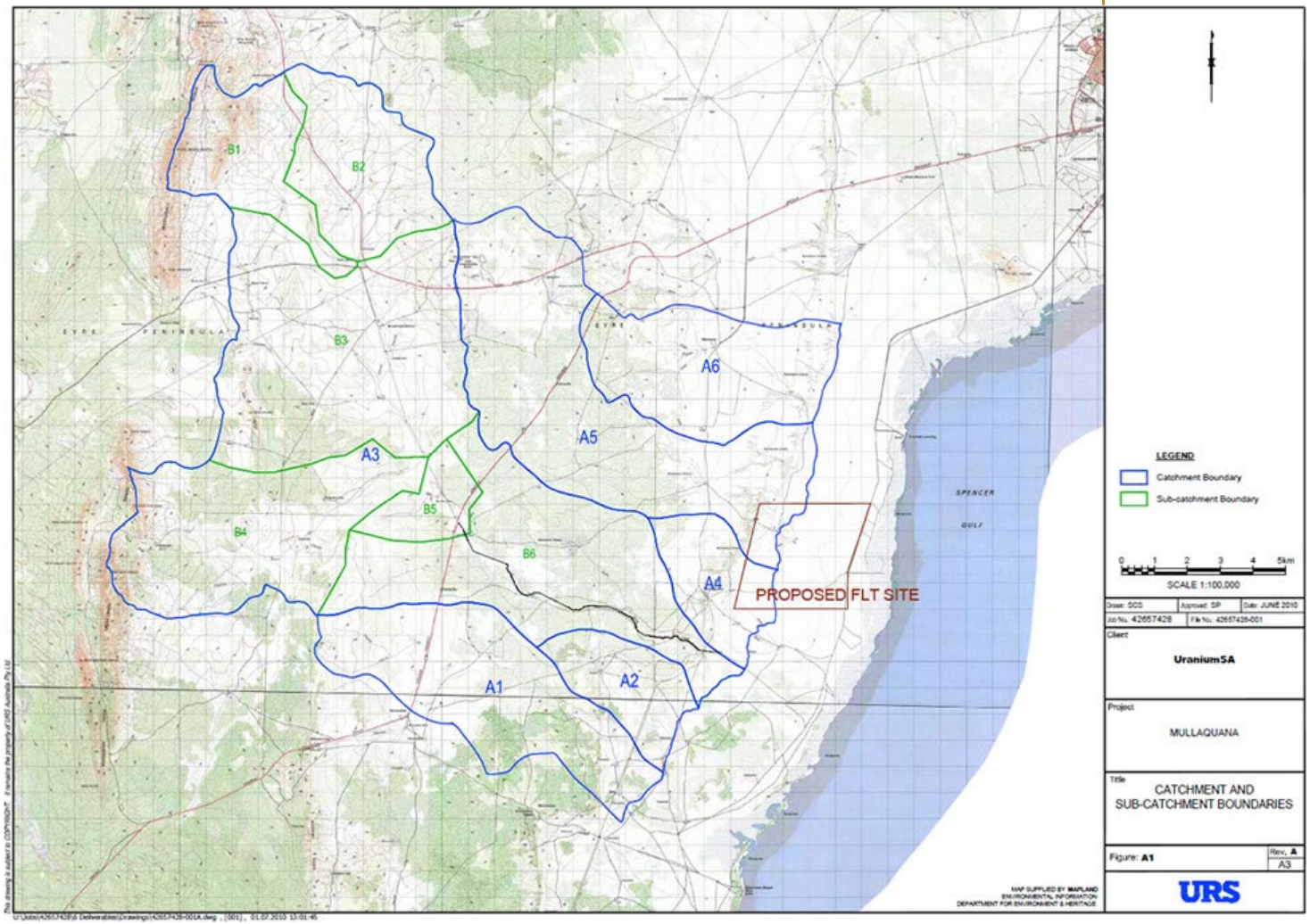
The methodology adopted and sources of information used by URS are outlined in this report. URS has made no independent verification of this information beyond the agreed scope of works and URS assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information contained in this report as provided to URS was false.

This report was prepared between 28 May and 15 June 2010 and is based on the conditions encountered and information reviewed at the time of preparation. URS disclaims responsibility for any changes that may have occurred after this time.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

A

Appendix A Catchment Definitions



B

Appendix B Streamflow Estimates

IFD ANALYSIS BASED ON AUSTRALIAN RAINFALL & RUNOFF (1987)

URS

Job Name: Mullaquana
Job Number: 42657428

Site name: Mullaquana

Site latitude = -33.21 degrees S
longitude = 137.36 degrees E
skewness = .55

2-year ARI, 1 hour intensity = 15.20 mm/hr
12 hour intensity = 2.65 mm/hr
72 hour intensity = .65 mm/hr

50-year ARI, 1 hour intensity = 35.50 mm/hr
12 hour intensity = 6.00 mm/hr
72 hour intensity = 1.39 mm/hr

IFD Table for Various ARIs and Durations

Duration	1 yr	2 yr	5 yr	10 yr	20 yr	50 yr	100 yr	200 yr	500 yr
5 min	41.34	52.74	76.91	95.31	120.23	158.77	193.05	232.56	294.22
6 min	38.51	49.11	71.51	88.53	111.59	147.22	178.89	215.37	272.24
10 min	30.94	39.42	57.11	70.51	88.65	116.6	141.38	169.86	214.18
12 min	28.41	36.17	52.31	64.5	81.02	106.44	128.95	154.81	195
15 min	25.45	32.38	46.72	57.52	72.16	94.66	114.56	137.39	172.84
18 min	23.16	29.46	42.41	52.16	65.36	85.63	103.54	124.06	155.9
20 min	21.9	27.85	40.04	49.21	61.62	80.66	97.48	116.75	146.61
24 min	19.82	25.19	36.14	44.36	55.48	72.53	87.57	104.78	131.44
30 min	17.47	22.18	31.74	38.89	48.57	63.39	76.44	91.36	114.42
45 min	13.73	17.41	24.78	30.27	37.7	49.04	59	70.36	87.88
1.0 hr	11.49	14.56	20.64	25.15	31.26	40.56	48.72	58	72.29
1.5 hr	8.71	11.03	15.61	18.99	23.58	30.56	36.67	43.62	54.3
2.0 hr	7.13	9.03	12.75	15.5	19.23	24.89	29.85	35.48	44.14
3.0 hr	5.36	6.78	9.55	11.6	14.37	18.58	22.26	26.44	32.85
4.5 hr	4.02	5.08	7.15	8.67	10.73	13.85	16.58	19.67	24.42
6.0 hr	3.28	4.15	5.82	7.05	8.72	11.25	13.45	15.95	19.78
9.0 hr	2.46	3.11	4.36	5.28	6.52	8.4	10.03	11.89	14.72
12.0 hr	2.01	2.54	3.55	4.3	5.31	6.83	8.15	9.65	11.94
18.0 hr	1.5	1.89	2.62	3.16	3.89	4.99	5.95	7.03	8.67
24.0 hr	1.21	1.52	2.11	2.54	3.12	3.99	4.74	5.6	6.89
30.0 hr	1.02	1.29	1.78	2.13	2.62	3.34	3.97	4.67	5.75
36.0 hr	0.89	1.12	1.54	1.84	2.26	2.88	3.42	4.02	4.94
48.0 hr	0.7	0.89	1.22	1.45	1.78	2.26	2.68	3.15	3.86
72.0 hr	0.5	0.63	0.85	1.02	1.24	1.57	1.85	2.17	2.65

IFD Polynomial: ln I = a + b*ln(D) + c*ln(D)**2 + d*ln(D)**3 + e*ln(D)**4 + f*ln(D)**5 + g*ln(D)**6
where duration D is in hrs and average intensity I is in mm/hr

ARI	a	b	c	d	e	f	g	Max % error
1	2.4337512	-0.652347	-0.04035	0.0100916	0.0004792	-0.0005053	2.8E-05	0.8
2	2.6707015	-0.654645	-0.039723	0.0101473	0.0004006	-0.0005082	3E-05	0.77
5	3.0206787	-0.664121	-0.037127	0.0103713	0.0000781	-0.0005194	0.00004	0.65
10	3.2191267	-0.669654	-0.035612	0.0105021	-0.00011	-0.0005259	4.6E-05	0.58
20	3.4372957	-0.674536	-0.034274	0.0106175	-0.000276	-0.0005316	5.1E-05	0.53
50	3.6984691	-0.680381	-0.032673	0.0107557	-0.000475	-0.0005385	5.7E-05	0.56
100	3.8821128	-0.68449	-0.031547	0.0108528	-0.000615	-0.0005433	6.1E-05	0.58
200	4.0570076	-0.688404	-0.030475	0.0109453	-0.000749	-0.000548	6.5E-05	0.6
500	4.2778959	-0.693348	-0.029121	0.0110621	-0.000917	-0.0005538	7E-05	0.62

Rational Method

URS

Job Name: Mullaquana
Job Number: 42657428

Area	km^2	tc (hr)	C_{10}	C_{100}	I_{10} (mm/hr)	I_{100} (mm/hr)	Q_{10} (m^3/s	Q_{100} (m^3/sec)
A1	48.5	6.2	0.23	0.28	6.9	13.1	21.3	49.5
A2	16.1	3.0	0.23	0.28	11.5	22.1	11.9	27.7
A3	252.5	18.2	0.23	0.28	3.1	5.9	50.6	116.0
A4	16.8	3.1	0.23	0.28	11.3	21.6	12.1	28.3
A5	76.5	8.4	0.23	0.28	5.6	10.6	27.1	62.9
A6	38.0	5.3	0.23	0.28	7.7	14.7	18.7	43.5

Note:

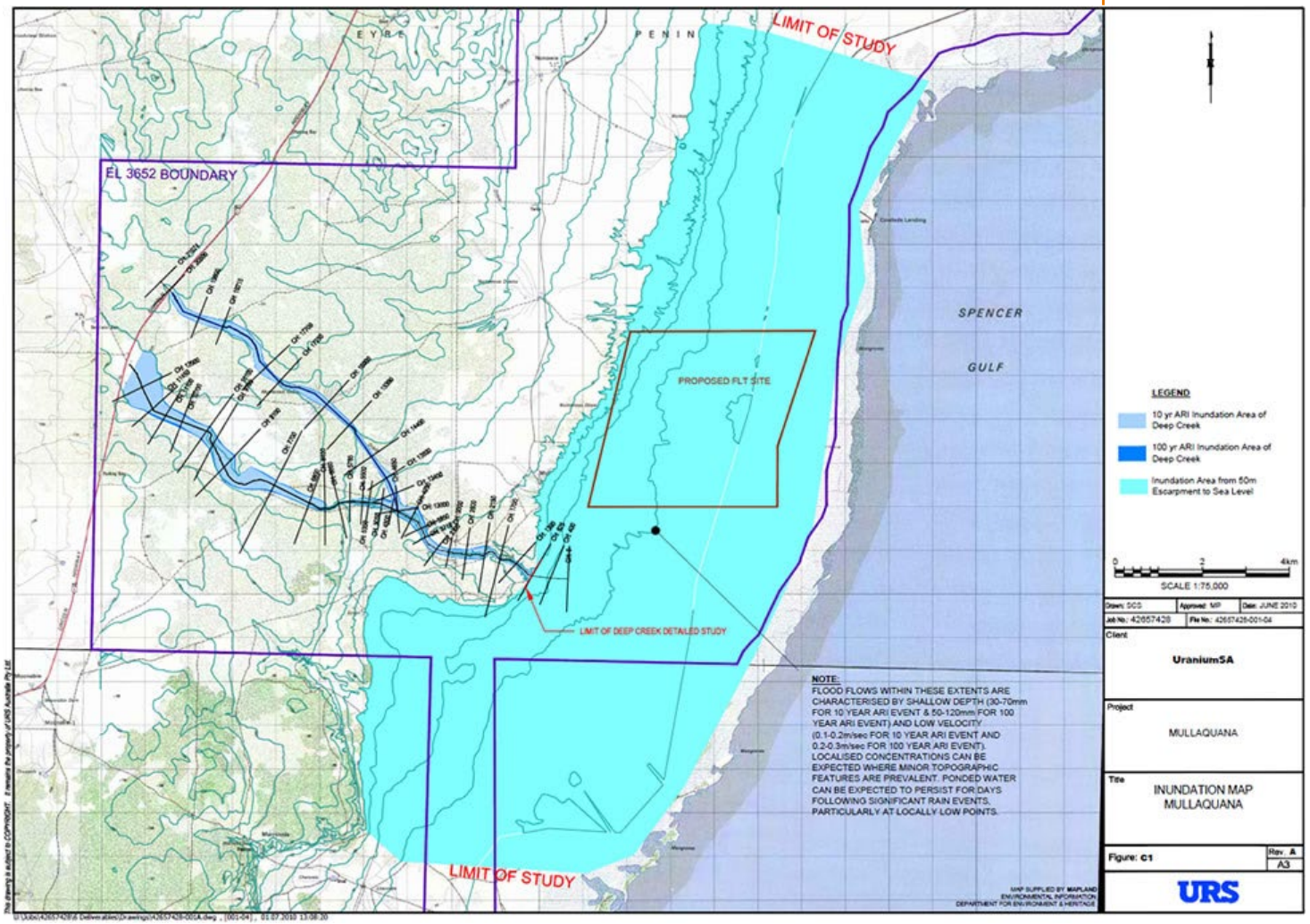
	Reference
tc=0.5 $A^{0.65}$ for South East Region (Zone 6) in South Australia	(Section 5.4.6 ARR 1987)
C10 = 0.23	(Section 5.4.6 ARR 1987)
C100 = 0.28	(Section 5.4.6 ARR 1987)
ln I = a + b*ln(D) + c*ln(D)**2 + d*ln(D)**3 + e*ln(D)**4 + f*ln(D)**5 + g*ln(D)**6	IFD to determine Intensity
Q = CiA	

Sub-Areas of A3

Area	From CAD	Area contribute to each reach	tc	C_{10}	C_{100}	I_{10}	I_{100}	Q_{10}	Q_{100}	
	(m^2)	(km^2)	(hr)			(mm/hr)	(mm/hr)	(m3/sec)	(m3/sec)	
B1	24102496	24.1	4.0	0.23	0.28	9.5	18.3	14.7	34.2	
B2	28979577	29.0	4.5	0.23	0.28	8.8	16.7	16.2	37.7	
B3	75290091	128.4	11.7	0.23	0.28	4.3	8.2	35.7	82.3	
B4	51210930	51.2	6.5	0.23	0.28	6.7	12.8	21.9	51.0	
B5	9606717	189.2	15.1	0.23	0.28	3.6	6.8	43.6	100.3	
B6	58076847	247.3	18.0	0.23	0.28	3.2	6.0	50.1	114.8	
B6a	29795811	219.0	16.6	0.23	0.28	3.4	6.3	47.1	108.0	
B6b	21373302	21.3733	3.7	0.23	0.28	10.1	19.3	13.8	32.1	
B6c	6907734	6.907734	1.8	0.23	0.28	17.0	32.7	7.5	17.6	
CL-01A	218985622	219.0	16.6	0.23	0.28	3.4	6.3	47.1	108.0	At Highway Xing
CL-02	21373302	21.3733	3.7	0.23	0.28	10.1	19.3	13.8	32.1	
CL-02B	247266658	247.3	18.0	0.23	0.28	3.2	6.0	50.1	114.8	At Junction

C

Appendix C Flood Inundation Map and HEC-RAS Output



HEC-RAS Plan: 7Jun10 Profile: 10 yr ARI

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
CL-02	CL-02	21073.65	10 yr ARI	13.80	110.88	111.40		111.42	0.003835	0.55	24.93	83.44	0.32
CL-02	CL-02	20800	10 yr ARI	13.80	109.98	110.17		110.18	0.005358	0.45	30.36	175.47	0.35
CL-02	CL-02	19800	10 yr ARI	13.80	104.53	104.78		104.79	0.007505	0.54	25.78	150.11	0.41
CL-02	CL-02	19215	10 yr ARI	13.80	100.00	100.29		100.30	0.003484	0.39	35.06	182.14	0.29
CL-02	CL-02	17700	10 yr ARI	13.80	94.40	94.71		94.72	0.009781	0.58	23.77	149.43	0.46
CL-02	CL-02	17250	10 yr ARI	13.80	90.00	90.38		90.40	0.004241	0.56	24.59	86.92	0.34
CL-02	CL-02	16000	10 yr ARI	13.80	84.86	85.20		85.22	0.006287	0.47	29.25	180.26	0.37
CL-02	CL-02	15300	10 yr ARI	13.80	80.05	80.57		80.59	0.005927	0.64	21.66	81.37	0.39
CL-02	CL-02	14400	10 yr ARI	13.80	74.56	75.04		75.07	0.007849	0.78	17.70	60.60	0.46
CL-02	CL-02	13800	10 yr ARI	13.80	69.84	70.07		70.09	0.012759	0.62	22.33	156.13	0.52
CL-02	CL-02	13400	10 yr ARI	13.80	64.77	64.97		65.00	0.015373	0.67	20.52	145.25	0.57
CL-02	CL-02	13000	10 yr ARI	13.80	60.00	61.05		61.05	0.000026	0.08	175.11	256.08	0.03
CL-01	CL-01A	12622.86	10 yr ARI	47.10	99.98	100.38		100.38	0.000145	0.13	368.63	954.73	0.07
CL-01	CL-01A	12000	10 yr ARI	47.10	99.95	100.12		100.13	0.003557	0.33	141.25	955.72	0.28
CL-01	CL-01A	11450	10 yr ARI	47.10	96.99	97.48		97.49	0.004793	0.55	85.49	340.60	0.35
CL-01	CL-01A	11100	10 yr ARI	47.10	95.20	95.77		95.79	0.004896	0.63	75.10	250.29	0.37
CL-01	CL-01A	10700	10 yr ARI	47.10	93.16	93.77		93.79	0.004692	0.64	73.66	230.99	0.36
CL-01	CL-01A	10100	10 yr ARI	47.10	90.12	91.15		91.15	0.000940	0.36	131.84	296.46	0.17
CL-01	CL-01A	9700	10 yr ARI	47.10	90.00	90.85		90.85	0.000538	0.33	143.42	240.63	0.14
CL-01	CL-01A	9100	10 yr ARI	47.10	89.97	90.22		90.23	0.003229	0.42	113.02	508.96	0.28
CL-01	CL-01A	7700	10 yr ARI	47.10	85.00	85.54		85.56	0.004936	0.67	70.27	213.27	0.37
CL-01	CL-01A	6800	10 yr ARI	47.10	80.08	81.20		81.21	0.000931	0.43	108.70	181.68	0.18
CL-01	CL-01A	6400	10 yr ARI	47.10	79.89	80.41	80.33	80.49	0.018452	1.30	36.36	110.40	0.72
CL-01	CL-01A	6050	10 yr ARI	47.10	70.00	72.14		72.24	0.002899	1.35	34.80	24.05	0.36
CL-01	CL-01A	5785	10 yr ARI	47.10	69.99	71.31		71.34	0.001332	0.71	66.11	68.45	0.23
CL-01	CL-01A	5500	10 yr ARI	47.10	69.98	70.86		70.88	0.001134	0.50	93.81	145.67	0.20
CL-01	CL-01A	5350	10 yr ARI	47.10	69.97	70.44		70.50	0.011553	1.10	42.68	116.03	0.58
CL-01	CL-01A	5050	10 yr ARI	47.10	66.45	66.84		66.90	0.014547	1.05	44.79	155.61	0.63
CL-01	CL-01A	4800	10 yr ARI	47.10	61.90	62.31	62.31	62.44	0.039284	1.60	29.53	115.67	1.01
CL-01	CL-01B	4650	10 yr ARI	50.10	59.99	61.03		61.05	0.000983	0.46	108.41	171.38	0.19
CL-01	CL-01B	4290	10 yr ARI	50.10	59.94	60.74		60.75	0.000287	0.25	202.84	326.23	0.10
CL-01	CL-01B	3950	10 yr ARI	50.10	59.86	60.37		60.41	0.007577	0.87	57.38	161.56	0.47
CL-01	CL-01B	3300	10 yr ARI	50.10	54.88	55.40		55.45	0.012540	0.94	53.47	197.63	0.57
CL-01	CL-01B	3000	10 yr ARI	50.10	50.00	51.39		51.41	0.001167	0.54	93.29	133.86	0.21
CL-01	CL-01B	2600	10 yr ARI	50.10	50.00	50.94		50.95	0.000827	0.45	110.47	157.70	0.17
CL-01	CL-01B	2150	10 yr ARI	50.10	49.95	50.24		50.27	0.010959	0.78	64.63	286.86	0.52
CL-01	CL-01B	1700	10 yr ARI	50.10	40.00	42.24		42.31	0.002695	1.12	44.89	40.00	0.34
CL-01	CL-01B	1300	10 yr ARI	50.10	39.99	40.61		40.65	0.004176	0.84	59.46	112.92	0.37
CL-01	CL-01B	825	10 yr ARI	50.10	37.48	38.05		38.15	0.022560	1.38	35.22	108.22	0.79
CL-01	CL-01B	400	10 yr ARI	50.10	29.39	29.71		29.72	0.006389	0.50	105.24	697.05	0.38
CL-01	CL-01B	0	10 yr ARI	50.10	26.64	26.96	26.84	26.97	0.007002	0.62	80.89	359.32	0.42

HEC-RAS Plan: 7Jun10 Profile: 100 yr ARI

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
CL-02	CL-02	21073.65	100 yr ARI	32.10	110.88	111.61		111.64	0.004276	0.69	46.53	121.47	0.36
CL-02	CL-02	20800	100 yr ARI	32.10	109.98	110.29		110.31	0.005323	0.62	51.81	187.26	0.38
CL-02	CL-02	19800	100 yr ARI	32.10	104.53	104.90		104.92	0.007440	0.71	45.51	174.03	0.44
CL-02	CL-02	19215	100 yr ARI	32.10	100.00	100.43		100.44	0.003371	0.49	65.03	234.57	0.30
CL-02	CL-02	17700	100 yr ARI	32.10	94.40	94.83		94.86	0.009356	0.68	46.96	223.54	0.48
CL-02	CL-02	17250	100 yr ARI	32.10	90.00	90.59		90.62	0.004166	0.71	45.38	111.86	0.35
CL-02	CL-02	16000	100 yr ARI	32.10	84.86	85.32		85.34	0.005704	0.59	54.15	220.29	0.38
CL-02	CL-02	15300	100 yr ARI	32.10	80.05	80.76		80.79	0.006229	0.82	39.13	104.47	0.43
CL-02	CL-02	14400	100 yr ARI	32.10	74.56	75.25		75.30	0.008172	0.96	33.28	85.38	0.49
CL-02	CL-02	13800	100 yr ARI	32.10	69.84	70.17		70.20	0.013106	0.80	40.04	193.30	0.56
CL-02	CL-02	13400	100 yr ARI	32.10	64.77	65.08		65.12	0.013419	0.84	38.03	172.96	0.57
CL-02	CL-02	13000	100 yr ARI	32.10	60.00	61.45		61.45	0.000034	0.11	288.01	308.31	0.04
CL-01	CL-01A	12622.86	100 yr ARI	108.00	99.98	100.57		100.58	0.000205	0.20	552.34	979.26	0.08
CL-01	CL-01A	12000	100 yr ARI	108.00	99.95	100.22		100.23	0.003391	0.46	236.73	965.62	0.29
CL-01	CL-01A	11450	100 yr ARI	108.00	96.99	97.67		97.69	0.004525	0.67	160.08	450.83	0.36
CL-01	CL-01A	11100	100 yr ARI	108.00	95.20	95.98		96.01	0.005032	0.78	137.68	334.85	0.39
CL-01	CL-01A	10700	100 yr ARI	108.00	93.16	94.00		94.04	0.004537	0.79	137.56	309.17	0.38
CL-01	CL-01A	10100	100 yr ARI	108.00	90.12	91.50		91.51	0.000780	0.44	245.78	352.26	0.17
CL-01	CL-01A	9700	100 yr ARI	108.00	90.00	91.17		91.18	0.000770	0.47	229.76	294.88	0.17
CL-01	CL-01A	9100	100 yr ARI	108.00	89.97	90.38		90.39	0.003148	0.56	193.67	552.80	0.30
CL-01	CL-01A	7700	100 yr ARI	108.00	85.00	85.77		85.81	0.005014	0.85	127.49	275.59	0.40
CL-01	CL-01A	6800	100 yr ARI	108.00	80.08	81.60		81.62	0.001040	0.56	192.35	236.75	0.20
CL-01	CL-01A	6400	100 yr ARI	108.00	79.89	80.67		80.79	0.015702	1.53	70.51	147.54	0.71
CL-01	CL-01A	6050	100 yr ARI	108.00	70.00	72.94		73.13	0.004068	1.91	56.41	29.78	0.44
CL-01	CL-01A	5785	100 yr ARI	108.00	69.99	71.84		71.90	0.001856	1.01	106.48	83.23	0.29
CL-01	CL-01A	5500	100 yr ARI	108.00	69.98	71.24		71.26	0.001487	0.70	154.36	178.62	0.24
CL-01	CL-01A	5350	100 yr ARI	108.00	69.97	70.70		70.80	0.011542	1.42	75.91	140.87	0.62
CL-01	CL-01A	5050	100 yr ARI	108.00	66.45	67.05		67.14	0.015709	1.32	81.84	214.22	0.68
CL-01	CL-01A	4800	100 yr ARI	108.00	61.90	62.51	62.51	62.70	0.034491	1.91	56.40	152.30	1.00
CL-01	CL-01B	4650	100 yr ARI	114.80	59.99	61.42		61.44	0.001266	0.62	184.65	226.09	0.22
CL-01	CL-01B	4290	100 yr ARI	114.80	59.94	61.09		61.10	0.000377	0.35	326.11	378.18	0.12
CL-01	CL-01B	3950	100 yr ARI	114.80	59.86	60.61		60.68	0.007751	1.13	101.68	198.04	0.50
CL-01	CL-01B	3300	100 yr ARI	114.80	54.88	55.58		55.66	0.013362	1.25	92.09	232.60	0.63
CL-01	CL-01B	3000	100 yr ARI	114.80	50.00	51.86		51.88	0.001331	0.69	165.29	177.90	0.23
CL-01	CL-01B	2600	100 yr ARI	114.80	50.00	51.32		51.34	0.001161	0.65	176.92	190.43	0.21
CL-01	CL-01B	2150	100 yr ARI	114.80	49.95	50.40		50.46	0.009286	1.00	114.53	305.33	0.52
CL-01	CL-01B	1700	100 yr ARI	114.80	40.00	42.92		43.03	0.003503	1.52	75.77	51.97	0.40
CL-01	CL-01B	1300	100 yr ARI	114.80	39.99	40.98		41.04	0.004104	1.10	104.63	131.99	0.39
CL-01	CL-01B	825	100 yr ARI	114.80	37.48	38.28	38.22	38.44	0.022003	1.74	65.15	142.35	0.83
CL-01	CL-01B	400	100 yr ARI	114.80	29.39	29.81		29.83	0.006301	0.66	185.29	794.41	0.41
CL-01	CL-01B	0	100 yr ARI	114.80	26.64	27.11	26.95	27.14	0.007003	0.82	140.19	409.53	0.45

D

Appendix D Hydraulic Calculations for A1, A2, A4, A5 and A6

Open channel flow

n 0.06 (very high vegetations----CONSERVATIVE SELECTION of n)
S 0.007 m/m

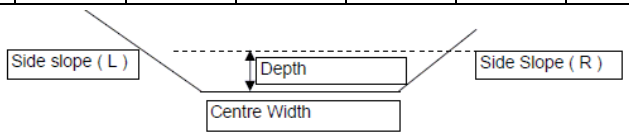
Job Name: Mullaquana
Job Number: 42657428

1 in 10 year event

Area	Q (m^3/s)	Depth, d (m)	Flow width (m)	Side Slope (L) 1:X	Centre Width	Side Slope (R) 1:X	Area, A (m2)	Wetted Perimeter, P (m)	Hydraulic Radius, R_h (m)	$V_{Manning's}$ (m/s)	Q (m^3/s)
A1	21.317	0.049	2400	0	2400	0	117	2400	0.049	0.2	21.3
A2	11.851	0.031	2900	0	2900	0	89	2900	0.031	0.1	11.9
A3	50.621	0.073	2300	0	2900	0	212	2900	0.073	0.2	50.6
A4	12.118	0.025	4100	0	4100	0	103	4100	0.025	0.1	12.1
A5	27.142	0.034	5700	0	5700	0	192	5700	0.034	0.1	27.1
A6	18.717	0.033	4100	0	4100	0	134	4100	0.033	0.1	18.7

1 in 100 year event

Area	Q (m3/s)	Depth, d (m)	Flow width (m)	Side slope (L) 1:X	Centre Width	Side Slope (R) 1:X	Area, A (m2)	Wetted Perimeter, P (m)	Hydraulic Radius, Rh (m)	$V_{Manning's}$ (m/s)	Q (m3/s)
A1	49.521	0.081	2400	0	2400	0	194	2400	0.081	0.3	49.5
A2	27.670	0.051	2900	0	2900	0	148	2900	0.051	0.2	27.7
A3	116.001	0.120	2300	0	2900	0	349	2900	0.120	0.3	116.0
A4	28.288	0.042	4100	0	4100	0	172	4100	0.042	0.2	28.3
A5	62.886	0.056	5700	0	5700	0	317	5700	0.056	0.2	62.9
A6	43.532	0.054	4100	0	4100	0	223	4100	0.054	0.2	43.5



The Manning formula states:

$$V = \frac{k}{n} R_h^{\frac{2}{3}} \cdot S^{\frac{1}{2}}$$

where:

V is the cross-sectional average velocity (ft/s, m/s)
k is a conversion constant equal to 1.486 for U.S. customary units or 1
n is the Manning coefficient of roughness (independent of units)
R_h is the hydraulic radius (ft, m)
S is the slope of the water surface or the linear hydraulic head loss (ft/ft, m/m) ($S = h_f / L$)

$$R_h = \frac{A}{P}$$

where:

R_h is the hydraulic radius (m)
A is the cross sectional area of flow (m^2)
P is wetted perimeter (m)



URS Australia Pty Ltd
Level 4, 70 Light Square
Adelaide SA 5000
Australia
T: 61 8 8366 1000
F: 61 8 8366 1001

www.ap.urscorp.com

Appendix I: Hydrology – Baseline Water Quality Data

Appendix I: Samphire RL 137 - Baseline Surface Water Data

Baseline Surface Water Quality Data - Radionuclides

Monitoring Point	U-238 - Min (Bq/L)	U-238 - Mean (Bq/L)	U-238 - Max (Bq/L)	Th-230 - Min (Bq/L)	Th-230 - Mean (Bq/L)	Th-230 - Max (Bq/L)	Ra-226 - Min (Bq/L)	Ra-226 - Mean (Bq/L)	Ra-226 - Max (Bq/L)	Pb-210 - Min (Bq/L)	Pb-210 - Mean (Bq/L)	Pb-210 - Max (Bq/L)	Po-210 - Min (Bq/L)	Po-210 - Mean (Bq/L)	Po-210 - Max (Bq/L)	Th-232 - Min (Bq/L)	Th-232 - Mean (Bq/L)	Th-232 - Max (Bq/L)	Ra-228 - Min (Bq/L)	Ra-228 - Mean (Bq/L)	Ra-228 - Max (Bq/L)	Sample Count
Nonowie Dam	< 0.0001	< 0.0001	< 0.0001	< 0.03	< 0.03	< 0.03	0.05	0.05	0.05	0.04	0.04	0.04	< 0.03	< 0.03	< 0.03	< 0.0001	< 0.0001	< 0.0001	Not Analysed	Not Analysed	Not Analysed	1
Mullaquana Dam	< 0.0001	< 0.0001	< 0.0001	< 0.03	< 0.03	< 0.03	0.07	0.07	0.07	0.03	0.03	0.03	< 0.03	< 0.03	< 0.03	< 0.0001	< 0.0001	< 0.0001	Not Analysed	Not Analysed	Not Analysed	1
Road Dam	< 0.0001	< 0.0001	< 0.0001	< 0.03	< 0.03	< 0.03	0.08	0.08	0.08	0.03	0.03	0.03	< 0.03	< 0.03	< 0.03	< 0.0001	< 0.0001	< 0.0001	Not Analysed	Not Analysed	Not Analysed	1
South Dam	< 0.0001	< 0.0001	< 0.0001	0.03	0.03	0.03	0.15	0.15	0.15	0.06	0.06	0.06	0.03	0.03	0.03	< 0.0001	< 0.0001	< 0.0001	Not Analysed	Not Analysed	Not Analysed	1
Coronation (North) Dam	< 0.0001	< 0.0001	< 0.0001	< 0.03	< 0.03	< 0.03	0.01	0.06	0.17	0.04	0.065	0.09	< 0.03	< 0.03	< 0.03	< 0.0001	< 0.0001	< 0.0001	< 0.37	< 0.37	< 0.37	13
Total	**< 0.0001**	**< 0.0001**	**< 0.0001**	**0.03**	**0.03**	**0.03**	**0.01**	**0.071**	**0.17**	**0.03**	**0.048333**	**0.09**	**0.03**	**0.03**	**0.03**	**< 0.0001**	**< 0.0001**	**< 0.0001**	**< 0.37**	**< 0.37**	**< 0.37**	**17**

Note:

- Data was collected by OST in 2010, and Alligator Energy during the 2022–2024 monitoring program.
- Analytical methods for OST data are as stated in the OST 2011 Report (Attachment H).
- Alligator Energy collected data was analysed by a NATA-accredited laboratory using ICPMS and gamma spectrometry techniques, with gamma spectrometry detection limits typically below 0.0001 Bq/L.
- Where results are reported as "<0.0001", the measured activity was below the laboratory detection limit.

Baseline Surface Water Quality - Monitoring Locations

Sampling Location	Easting (53H)	Northing (53H)
South Dam	723264	6320767
Operation	723534	6324743
Central Dam	723349	6330407
Coronation (North) Dam	726066	6335896

Appendix J: Flora & Fauna – Baseline Assessments

J1: Mullaquana Flora and Fauna Baseline Survey. Report prepared for UraniumSA Ltd by EBS Ecology, February 2010.

ebs ecology



Mullaquana Flora and Fauna Baseline Survey

Mullaquana Flora and Fauna Baseline Survey

12 FEBRUARY 2010

Version 1.1

Prepared by EBS Ecology for Uranium SA

Document Control					
Revision No.	Date issued	Authors	Reviewed by	Date Reviewed	Revision type
1.0	19/01/2010	S. O'Neill / A. Derry	T. How	19/01/10	Draft
1.1	12/02/2010	S. O'Neill / A. Derry	T. How	12/02/10	Revised Draft

Distribution of Copies			
Revision No.	Date issued	Media	Issued to
1.0	19/01/2010	Electronic	N. Galloway Warland, Uranium SA
1.1	12/02/2010	Electronic	N. Galloway Warland, Uranium SA

COPYRIGHT: Use or copying of this document in whole or in part (including photographs) without the written permission of Environmental and Biodiversity Services constitutes an infringement of copyright.

LIMITATION: This report has been prepared on behalf of and for the exclusive use of Environmental and Biodiversity Services Client, and is subject to and issued in connection with the provisions of the agreement between Environmental and Biodiversity Services and its Client. Environmental and Biodiversity Services accepts no liability or responsibility whatsoever for or in respect of any use of or reliance upon this report by any third party.

CITATION: EBS (2010) *Mullaquana Flora and Fauna Baseline Survey*. Report to Uranium SA. EBS Ecology, Adelaide.

Front cover photo: Site 4.

ebs ecology

ACKNOWLEDGEMENTS

We would like to acknowledge and thank the following people for their assistance with the project:

- Nicole Galloway Warland, Uranium SA
- Russel Bluck, Uranium SA
- Mark Hutchinson, Carolyn Kovach and David Stemmer, South Australian Museum, for advice on mammal and reptile identification
- Dennis Matthews, for analysis of the Anabat data.

The following EBS staff conducted the survey:

- Sally O'Neill
- Alison Derry
- Chris Harrison
- Shay Dury.

The survey was undertaken under the following Department for Environment and Heritage permits:

- Permit to Undertake Scientific Research, permit no: K25613(2).
- Wildlife Ethics Committee: Approval of a Project Involving Animals, app. no. 10/2008-M1.

EXECUTIVE SUMMARY

This report presents the findings of a flora and fauna baseline survey conducted by EBS on behalf of Uranium SA within Mullaquana and Ninowie pastoral leases, and exploration tenements EL3542, EL4242 and EL3652, in November 2009. This survey, the first survey of its kind conducted in the area, identified ten vegetation associations present, and mapped vegetation associations within the study area. A flora species list for each association was created. Five of the vegetation associations were surveyed for mammals, reptiles, frogs, birds and invertebrates for four consecutive nights following standard biological survey methodologies.

No flora species or vegetation associations of conservation significance were identified as occuring within the survey area. No mammal, reptile or frog species of conservation significance, or migratory bird species were observed. However survey adequacy of migratory or conservation significant shorebirds within or adjacent to the survey area was considered inadequate.

Two bird species listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC) were observed within the survey area. The nationally Vulnerable Eastern Thick-billed Grasswren (*Amytornis textilis myall*) and state Rare Striated Grasswren (*Amytornis striatus*) were both observed. A population estimate and distribution across the survey area cannot be determined given the lack of information obtained to date, however it is considered likely both species are widespread throughout the region.

Recommendations highlighted in this report primarily focus on obtaining more detailed information on the Thick-billed Grasswren (*Amytornis textilis myall* and Striated Grasswren (*Amytornis striatus*), including additional surveys of likely habitat and effort to establish a population density. Also recommended are targeted shoreline and adjacent habitat surveys to complete adequate survey effort on the potential presence of EBPC listed migratory (and potentially conservation significant) species in the wider area that may be impacted by further exploration or mining activities. Additional sites to survey mammals, reptiles, frogs, and birds, and to conduct vegetation association mapping and targeted searches for threatened flora are recommended if any exploration activities are planned for the areas immediately north, or south of Munyaroo Conservation Park. The current survey is not considered adequate to cover this area, and Department for Environment and Heritage (DEH) floristic mapping and satellite imagery indicates that different habitats exist.

Table of contents

1 INTRODUCTION 1

1.1 Location 1

2 METHODS 2

2.1 Approach 2

2.2 Vegetation associations and habitats 2

2.2.1 Vegetation condition 2

2.3 Fauna trapping and other detection techniques 4

2.3.1 Trapping 4

2.3.2 Trap effort summary 6

2.3.3 Bird surveys 7

2.3.4 Opportunistic observations and active searching 7

2.3.5 Bat call recording 7

2.3.6 Spotlighting 8

2.4 Identification and nomenclature 8

2.5 Weather encountered during the field survey 8

2.6 Survey limitations 9

3 FAUNA RESULTS 10

3.1 Habitats and site selection 10

3.2 Trap success and survey adequacy 10

3.3 Fauna survey site summary 12

3.3.1 Site 1 12

3.3.2 Site 2 13

3.3.3 Site 3 14

3.3.4 Site 4 15

3.3.5 Site 5 16

3.4 Mammals 17

3.5 Reptiles 19

3.6 Frogs 23

3.7 Birds 24

3.7.1 Conservation significant birds observed 28

3.8 Invertebrates 30

4 VEGETATION AND FLORA RESULTS 32

4.1 Vegetation associations 32

4.1.1 Condition 34

4.1.2 Association 1 – *Maireana sedifolia* (Bluebush), *Maireana pyramidata* (Black Bluebush), *Atriplex vesicaria* (Bladder Saltbush) Low Open Shrubland 36
4.1.3 Association 2 – *Disphyma crassifolium* (Round-leaf Pigface), *Sclerolaena patenticuspis* (Spear-fruit Bindyi), *Maireana enchylaenoides* (Wingless Fissure-plant), *Austrostipa* sp. (Spear Grass) Shrubland 37
4.1.4 Association 3 – *Halosarcia pergranulata* (Black-seed Samphire), *Halosarcia* sp. (Samphire), Low Shrubland 38
4.1.5 Association 4 – *Myoporum platycarpum* (False Sandalwood) Open Woodland 39
4.1.6 Association 5 – *Eucalyptus dumosa* (White Mallee), *Eucalyptus socialis* (Beaked Red Mallee) Mallee 40
4.1.7 Association 6 – *Acacia papyrocarpa* (Western Myall) Open Woodland 42
4.1.8 Association 7 – *Casuarina pauper* (Black Oak) Open Woodland 43
4.1.9 Association 8 – *Senna artemisioides* ssp. *coriacea* (Broad-leaved Desert Senna), *Senna artemisioides* ssp. *petiolaris* (Desert Senna) Shrubland 44
4.1.10 Association 9 – *Avicennia marina* ssp. *marina* (Grey Mangrove) Shrubland 45
4.1.11 Association 10 – *Dodonaea viscosa* ssp. *angustissima* (Narrow-leaf Hop-bush), *Acacia oswaldii* (Umbrella Wattle), *Myoporum insulare* (Common Boobialla) Tall Shrubland 46
4.2 Flora species 47
4.2.1 Exotic species 47

5 DISCUSSION 49

6 RECOMMENDATIONS 51

7 REFERENCES 52

Appendix 1. Abundance of all species recorded during Point Counts (PC) and Opportunistically (OPP) during the Nov 09 survey of Mullaquana. 53
Appendix 2. DEH floristic mapping of the Mullaquana and wider area. 55
Appendix 3. EBS floristic mapping November 2009. 56
Appendix 4. Flora species of the ten vegetation associations identified during the November 2009 survey. 57

List of tables

Table 1. Vegetation condition classification, key indicators and applicable SEB ratios. 3
Table 2. Trap effort conducted during the field survey. 6
Table 3. Weather conditions recorded for Whyalla during the field survey. 8
Table 4. Site 1 summary. 12
Table 5. Site 2 summary. 13
Table 6. Site 3 summary. 14
Table 7. Site 4 summary. 15
Table 8. Site 5 summary. 16
Table 9. Mammal species detected during the field survey. 17
Table 10. Number of mammal captures and observations during the field survey. 18
Table 11. Reptile species detected during the field survey. 19
Table 12. Number of reptile captures and observations during the field survey. 19
Table 13. Frog species detected during the field survey. 23
Table 14. Number of frog captures and observations during the field survey. 23
Table 15. Bird species detected during the field survey. 24
Table 16. Species diversity and abundance of all birds recorded from the 5 revisited Point Count survey sites during Nov 09 surveys at Mullaquana. 26
Table 17. The ten most abundant birds recorded during Point Counts (PC) and Opportunistically (OPP) during the November 09 survey at Mullaquana. 28
Table 18. Summary of the invertebrate types detected during the field survey. 30
Table 19. Summary of the vegetation associations identified as occurring within and adjacent the lease area. 34
Table 20. Summary of Association 1. 36
Table 21. Summary of Association 2. 37
Table 22. Summary of Association 3. 38
Table 23. Summary of Association 4. 39
Table 24. Summary of Association 5. 40
Table 25. Summary of Association 6. 42
Table 26. Summary of Association 7. 43
Table 27. Summary of Association 8. 44
Table 28. Summary of Association 9. 45
Table 29. Summary of Association 10. 46
Table 30. Exotic species observed during the November 2009 survey. 47

List of figures

Figure 1. Standard lay-out of one of the two trap lines established at each of the five sites indicating position of the pitfalls, Elliott, funnel and cage traps. 4
Figure 2. Pit-fall trap with drift fence. 4
Figure 3. Elliott trap. 5
Figure 4. Cage trap. 5
Figure 5. Funnel trap. 6
Figure 6. Micro-pitfall trap. 6
Figure 7. Location of the five Mullaquana survey sites. 11
Figure 8. Site 1 habitat (trap line A). 12
Figure 9. Site 2 habitat (trap line A). 13
Figure 10. Site 3 habitat (trap line A). 14
Figure 11. Site 4 habitat (trap line A). 15
Figure 12. Site 5 habitat (trap line A). 16
Figure 13. Fat-tailed Dunnart (*Sminthopsis crassicaudata*). 17
Figure 14. Stripe-faced Dunnart (*Sminthopsis macura*). 18
Figure 15. Garden Skink (*Lampropholis guichenoti*). 20
Figure 16. Saltbush Ctenotus (*Ctenotus orientalis*). 21
Figure 17. Crested Dragon (*Ctenophorus cristatus*). 21
Figure 18. Bearded Dragon (*Pogona barbata*). 21
Figure 19. Five-lined Earless Dragon (*Tympanocryptis lineata*). 22
Figure 20. Southern Spiny-tailed Gecko (*Strophurus intermedius*). 22
Figure 21. Trilling Frog (*Neobatrachus centralis*). 23
Figure 22. Burrowing Frog (*Neobatrachus pictus*). 23
Figure 23. White-browed Babbler (*Pomatostomus superciliosus*). 27
Figure 24. A soft-bodied Cricket (Family: Gryllidae). 31
Figure 25. Combined DEH and EBS floristic mapping of the Mullaquana survey area. 35
Figure 26. *Maireana sedifolia* (Bluebush), *Maireana pyramidata* (Black Bluebush), *Atriplex vesicaria* (Bladder Saltbush) Low Open Shrubland association. 36
Figure 27. *Disphyma crassifolium* (Round-leaf Pigface), *Sclerolaena patenticuspis* (Spear-fruit Bindyi), *Maireana enchylaenoides* (Wingless Fissure-plant), *Austrostipa* sp. (Spear Grass) Shrubland association. 37
Figure 28. *Halosarcia pergranulata* (Black-seed Samphire), *Halosarcia* sp. (Samphire), Low Shrubland association. 38
Figure 29. *Myoporum platycarpum* (False Sandalwood) Open Woodland association. 39
Figure 30. *Eucalyptus dumosa* (White Mallee), *Eucalyptus socialis* (Beaked Red Mallee) Mallee association. 40
Figure 31. *Acacia papyrocarpa* (Western Myall) Open Woodland association. 42
Figure 32. *Casuarina pauper* (Black Oak) Open Woodland association. 43

Figure 33. *Senna artemisioides* ssp. *coriacea* (Broad-leaved Desert Senna), *Senna artemisioides* ssp. *petiolaris* (Desert Senna) Shrubland. 44
Figure 34 (a and b). *Avicennia marina* ssp. *marina* (Grey Mangrove) Shrubland association. 45
Figure 35. *Dodonaea viscosa ssp. angustissima (Narrow-leaf Hop-bush), Acacia oswaldii (Umbrella Wattle), Myoporum insulare (Common Boobialla) Tall Shrubland* association. 46
Figure 36. *Carrichtera annua* (Wards weed) dominating bare ground within degraded *Maireana* shrubland. 48
Figure 37. A healthy *Carthamus lanatus* (Saffron Thistle) near a dam. 48
Figure 38. *Solanum linnaenum* (Apple of Sodum) at Site 5 Association 5 *Eucalyptus dumosa* (White Mallee), *Eucalyptus socialis* (Beaked Red Mallee) Mallee habitat. 48

1 INTRODUCTION

EBS Ecology was contracted by Uranium SA to conduct a two-phase assessment of its Mullaquana project on the Eyre Peninsula, South Australia. The first phase was to conduct an initial assessment (desktop assessment and brief site visit) to identify flora, fauna and sensitive environments likely to occur within the project area and make recommendations for future survey work. The second phase was to conduct a baseline survey of fauna and flora species and vegetation communities of the project area.

The results of the first phase are reported in *Mullaquana Flora and Fauna Survey – Initial Assessment* (EBS 2009) which includes detailed background information on the environmental landscape and biodiversity of the area. The first phase identified that two fauna species of conservation significance, the nationally Vulnerable Thick-billed Grasswren (*Amytornis textilis myall*) and the state Rare Striated Grasswren (*Amytornis striatus*), likely to occur within the Mullaquana area. Additional conservation significant species were identified in various database searches and a review of available literature, but considered unlikely to occur based on the lack of recent records and unsuitability of the habitats (EBS 2009).

Objectives of this report of the second phase are to:

- describe the main vegetation associations known to occur within the project area
- provide a map of vegetation communities of the project area
- identify flora species known to occur within the project area, and indicate their likely habitats and vegetation communities in which they occur
- identify fauna species known to occur within the project area, and indicate the likely habitats vegetation communities in which they occur
- identify any additional flora and fauna species not identified during the survey but considered likely to occur
- make appropriate recommendations for future survey and monitoring work.

The information and data gathered for this project will assist the environmental assessment process for the Mullaquana project as it progresses from its present exploration/delineation phase through to production. Uranium SA are planning to commence in-situ recovery of a trial field in 2011.

1.1 Location

Mullaquana is located on Eyre Peninsula, South Australia, approximately 20 km south-west of the town of Whyalla. The project lies within the Mullaquana and Ninowie pastoral leases, and exploration tenements EL3542, EL4242 and EL3652. Cowled's Landing, a small shack community, is located adjacent to the lease area, and recreational activities, such as motorbike riding appears to occur within the vicinity. Munyaroo Conservation Park (12,340 ha) is located to the south and shares a boundary with the EL's.

2 METHODS

2.1 Approach

The field survey was conducted following the SA government accepted methodologies of the Biological Survey Method of South Australia (Owens 2000; Heard and Channon 1997) under the Scientific Research permit K25613(2). The desktop and initial assessment completed under phase one of the project (EBS 2009) assisted to identify likely vegetation associations, number of sites necessary to cover a representative sample of the area, and the approximately location of survey sites. A rapid assessment conducted on the first afternoon of the survey confirmed the appropriate site locations.

2.2 Vegetation associations and habitats

Vegetation associations within the survey area were defined, recorded and mapped. Vegetation structural formation classification follows the Biological Survey of South Australia methodology (Heard and Channon 1997) adapted from Specht (1972) and Muir (1977) taking into consideration both the life form, height class and projected foliage cover of the tallest stratum. Vehicle tracks were driven, and boundaries of visibly different vegetation associations were recorded with a hand-held GPS and photographed for reference. Satellite imagery assisted identifying the area extent, and highlighting boundaries in regards to position in the landscape. Three field surveyors conducted a rapid search recording the dominant overstorey and understorey vascular plant species of each of the defined the vegetation associations. Once the field survey was complete, the list of vegetation associations present was finalised and a species list of all vascular plant species compiled. The associations were mapped using GIS.

2.2.1 Vegetation condition

The overall condition of the vegetation of the study area was assessed to assist identifying the suitability and likelihood of fauna and flora species occurring. The vegetation condition was assessed using a Native Vegetation Condition Rating Methodology adapted from Stokes *et al.* (1998) and assigned a condition score using the Significant Environmental Benefit (SEB) ratio. The condition levels are based on the level of intactness of original condition varying from degraded, highly disturbed and low native species diversity condition through to intact vegetation with intact soil crust. The key indicators of the various ratios are summarised in Table 1. Although calculating an SEB is not within the scope of this report, the data aligns with this method should it be required in the future.

Table 1. Vegetation condition classification, key indicators and applicable SEB ratios.

Vegetation Condition	Ratio
• Clearance consists of lopping of limbs, not affecting the health of the tree/shrub	0
Weed-dominated with only scattered areas or patches of native vegetation Indicated by: • vegetation structure no longer intact (eg. removal of one or more vegetation strata) • scope for regeneration , but not to a state approaching good condition without intensive management • dominated by very aggressive weeds • partial or extensive clearing (> 50% of area) • evidence of heavy grazing (tracks, browse limes, species changes, no evidence of soil surface crust)	2:1 (area)
Native vegetation with considerable disturbance Indicated by: • vegetation structure substantially altered (e.g. one or more vegetation strata depleted) • retains basic vegetation structure or the ability to regenerate it • very obvious signs of long-term or severe disturbance • weed dominated with some very aggressive weeds • partial clearing (10 – 50% of area) • evidence of moderate grazing (tracks, browse lines, soil surface crust extensively broken)	4:1 (area)
Native vegetation with some disturbance Indicated by: • vegetation structure altered (e.g. one or more vegetation strata depleted) • most seed sources available to regenerate original structure • obvious signs of disturbance (e.g. tracks, bare ground) • minor clearing (<10% of area) • considerable weed infestation with some aggressive weeds • evidence of some grazing (tracks, soil surface crust patchy)	6:1 (area)
Native vegetation with little disturbance Indicated by: • vegetation structure intact (e.g. all strata intact) • disturbance minor, only affecting individual species • only non-aggressive weeds present • some litter build-up	8:1 (area)
Intact vegetation Indicated by: • all strata intact and botanical composition close to original • little or no signs of disturbance • little or no weed infestation • Soil surface crust intact • substantial litter cover	10:1 (area)

Adapted from *Guidelines for a Native Vegetation Significant Environmental Benefit Policy* (DWLBC 2005).

2.3 Fauna trapping and other detection techniques

2.3.1 Trapping

Trapping followed the Biological Survey methodology for vertebrate surveys (Owens 2000) for pastoral regions. Five survey sites were established. Two trap lines positioned approximately 200 m apart were installed at each site. Each line (Figure 1) consisting of six pitfall traps, 15 Elliott traps and two cage traps were installed at each of the five fauna sites. All traps were open for four consecutive days and nights.

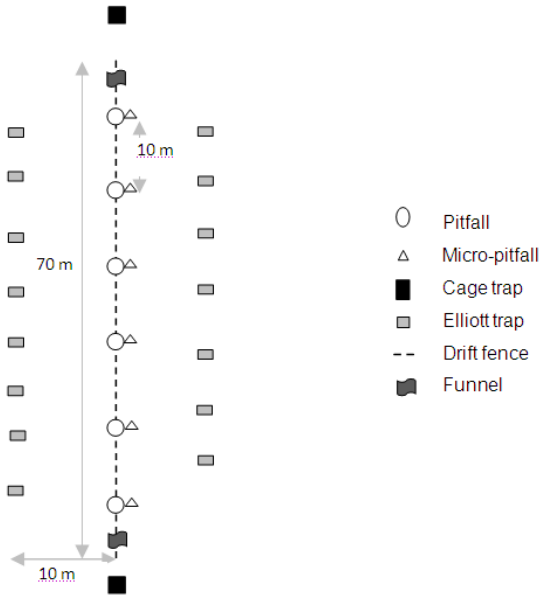


Figure 1. Standard lay-out of one of the two trap lines established at each of the five sites indicating position of the pitfalls, Elliott, funnel and cage traps.

Each trap line consisted of six pitfall traps (140 mm diameter, 400 mm deep) placed at 10 m intervals in a single straight line (where possible, with slight deviations necessary to avoid plant disturbance), and buried so the top of the top of the pitfall trap was level with the ground surface (Figure 2). Connecting the six pitfalls was a continuous 70 m long 400 mm high aluminium screen mesh fence with the bottom edge buried approximately 100 mm to deter animals digging to pass under, encouraging ground-dwelling fauna to move along the drift fence and fall into the pitfalls. The drift fence was maintained morning and night to repair any damage and remove fallen twigs.



Figure 2. Pit-fall trap with drift fence.

Fifteen Elliott traps (Elliott Scientific, Upwey Vic.; type A, 330 mm long, 100 mm high, 90 mm wide, treadle plate operated) (Figure 4) were placed at 10 – 15 m intervals forming a line either side of the pitfall. A small bolus of bait (mixture of peanut butter and rolled oats) was placed in the rear end of all Elliott traps behind the treadle plate to attract animals to enter.



Figure 3. Elliott trap.

Two wire cage traps (Sheffield Wire Products, Welshpool WA, 550 mm long, 220 mm wide, 220 mm high, trip plate mechanism) (Figure 4) were used at each site. A single cage trap was placed approximately 10 m each end of the pitline. A small bolus of bait (mixture of peanut butter, rolled oats, and linseed oil) was placed in the rear end of the cage.



Figure 4. Cage trap.

Two funnel traps (WA Poultry, Sheffield, Western Australia; 77 cm long, 17 cm wide, 17 cm high) (Figure 5) were placed along the drift fence, approximately 2 m from the end. Funnel traps were not baited.

Micro-pitfall traps were used to targeted terrestrial invertebrates. Each trap line consisted of six micro-pitfall traps placed at 10 m intervals, parallel and approximately 1 m from each of the six large pitfall traps (Figure 6). Each micro-pitfall was filled with ethanol to preserve any captured invertebrates. Collected invertebrates were identified to an appropriate level, typically to order or genera for easily identifiable insects.



Figure 5. Funnel trap.



Figure 6. Micro-pitfall trap.

2.3.2 Trap effort summary

A total of 240 pitfall, 300 Elliott, 80 cage and 160 funnel trap nights were conducted during the survey. Survey effort was equal across the five sites. Site 1 and Site 2 were trapped from the 20th November 2009 (traps set) to the 24th November 2009 (traps closed). Site 3-5 were trapped from the 21st November (traps set) to the 25th November 2009 (traps closed).

Table 2. Trap effort conducted during the field survey.

Effort detail	Site 1	Site 2	Site 3	Site 4	Site 5
No. nights surveyed	4	4	4	4	4
Pitfall - per night	12	12	12	12	12
Pitfall - total survey	48	48	48	48	48
Elliott - per night	15	15	15	15	15
Elliott - total survey	60	60	60	60	60
Cage - per night	4	4	4	4	4
Cage - total survey	16	16	16	16	16
Funnel - per night	8	8	8	8	8
Funnel - total survey	32	32	32	32	32
Total trap effort	**156**	**156**	**156**	**156**	**156**

2.3.3 Bird surveys

Bird surveys were conducted at five Point Count survey sites over three days. The time spent at each bird monitoring site was standardised to 2 hours (1 hour AM and 1 hour PM) to collect data at opportune times of the day during the morning and afternoon. A single observer conducted an area search recording all birds that could be positively identified by sight within the site or immediately adjacent if the habitat was similar.

Opportunistic surveys were conducted travelling between study sites as well as at habitats not covered by the five main survey sites (e.g. sand dune habitat, mangrove habitat, and along woodland edges of mangrove habitats). Significant rainfall (see 2.4) during the survey period prevented access to the shoreline to conduct any opportunistic surveys on waders and other shorebirds that may have been present (see 0).

2.3.4 Opportunistic observations and active searching

Field surveyors recorded all fauna observations while on-site. This included animals observed whilst installing the trapping sites, checking the sites, driving between sites, and driving to and from sites morning and night. For each observation, the species, location (GPS waypoint), date, time, number of individuals, and broad habitat type was recorded. Time was spent actively searching each trapping site and noting the presence tracks, nests, scats, diggings and burrows (identified to species level if possible).

2.3.5 Bat call recording

A passive bat survey was conducted using Anabat's (Titley Electronics, Ballina NSW) to record bat ultrasonic echolocation calls. A single Anabat detector was used at each of the five fauna trapping sites for one night. Anabat's were positioned immediately adjacent to the access track (which could act as a fly-way) or within optimal bat flyway zones within the survey site or immediately adjacent. The Anabat microphone was typically positioned 1 – 1.5 m from the ground. Not all sites were surveyed con-currently therefore weather conditions varied between the sites.

Recorded bat echolocation calls were analysed by Dennis Matthews (sub-consultant) using Anaview software. Dennis viewed the unique pulse rates and frequency characteristics, and used his extensive knowledge of the bats of South Australia to identify the calls to species level where possible or species complex.

Although Anabat recordings can assist identifying the presence of selected species, this survey method needs to be complimented by trapping to confirm species presence. Not all bat calls are easily identifiable from Anabat recordings (T. Reardon pers. com. 2008), and therefore a species not being recorded does not necessarily mean that the species is absent. Similarly, a species being recorded only indicates the species was present at a particular time, and it's presence may vary from leaving and

returning to a roost site, visiting a feeding site, or merely passing through the area and not utilising the habitat.

2.3.6 Spotlighting

One hour was spent active searching with spotlights. Three observers conducted a start-stop walk using two hand-held 100 watt spotlights and head torches. Surveyors scanned the ground, small shrubs, and lifted small branches to look for ground dwelling fauna, and scanned shrubs and trees for birds. High rainfall and windy conditions (see 2.4) experienced during the survey limited the amount of spotlight effort able to be conducted.

2.4 Identification and nomenclature

All captured vertebrates were, where possible, identified and released immediately at the point of capture or amongst nearby vegetation cover or burrows to reduce stress. Vertebrate species nomenclature for scientific names and common names follows the *Vertebrates of South Australia* (DEH 2000; DEH unpublished updated draft) using commonly accepted local names.

All captured invertebrates were stored in 70 % alcohol and identified in the laboratory using a x4 magnification microscope. In general, only specimens visible to the naked eye were selected from the sample for identification. Specimens were identified to order, or where possible, to sub-order or family.

2.5 Weather encountered during the field survey

The survey was hampered by high rainfall predominately on the nights of the 21st and 22nd of November, with a total of 59 mm recorded at Whyalla Airport. Temperatures were warm, but not hot as anticipated for a late November survey. Moderate winds occurred during the early evening.

Table 3. Weather conditions recorded for Whyalla during the field survey.

Date	Rain	9:00 am			3:00 pm		
		Temp	Dir	Speed	Temp	Dir	Speed
	mm	°C	km/h		°C	km/h	
20-Nov-09	2	22.5	S	24	26.5	ENE	6
21-Nov-09	25	18.4	W	7	20.5	E	9
22-Nov-09	34	16.9	SW	33	19.5	S	30
23-Nov-09	0	16.5	SSE	26	20.1	SSW	28
24-Nov-09	0	18	SSE	26	22.4	SSW	31
25-Nov-09	0	21	SSE	20	21.2	SE	11
26-Nov-09	2	20.9	NNW	24	26.2	NNW	28
27-Nov-09	0	26.1	NNW	24	23.5	W	39

Source: Weatherzone for Whyalla Airport.

2.6 Survey limitations

Although this fauna and flora survey was designed and conducted to maximise the species diversity detected during a standard four night baseline survey, it cannot be expected that all species present within the survey area were observed. The presence and abundance of both fauna and flora species will vary seasonally and in response to environmental conditions. It is likely that additional species were present at the time of the survey in November 2009, but are either limited in their distribution within the site or occur at such a low abundance that they were not detected. It is also likely that additional species, such as nomadic, vagrant and migratory species, may occur within and rely on habitats of the survey area from time to time but were not present at the time of the current survey. Additional surveys, undertaken at different times of the year and under different environmental conditions, would be required to increase the chance of such species being detected.

The weather conditions during the survey were not optimal. The high rainfall over several days and high cloud cover prevented higher temperatures required for the larger reptiles to increase movements and therefore chance of encountering a trap and being detected. The moderate windy conditions during the early evening resulted in just one hour of spotlight effort being conducted. Warm still nights are more successful for observations, with animals being more active and more readily observed by the surveyors. The rainy conditions during the day, particularly during the morning, is likely to have limited bird activity. The high rainfall also resulted limited access to certain areas within the survey area, particularly low-lying shorelines, and surveyors were encouraged to limit vehicle movements throughout the duration of the survey so as not to damage tracks within the project area.

Some plant specimens could not be identified to species level due to lack of characteristic fruits or seeds necessary to complete identification.

3 FAUNA RESULTS

3.1 Habitats and site selection

Five sites were selected to establish trapping sites (for mammals, reptiles and invertebrates), conduct passive bat surveys, and to conduct point-count bird observations. The sites were selected based on habitat and vegetation associations, with a preference for covering the habitat most likely to be impacted by mining activities in the future (chenopod shrublands and samphire shrublands below the escarpment in the area currently being explored by Uranium SA), and sites considered to have higher species diversity and likely fauna refuges (tall shrublands, woodland and mallee). No sites were located in the far south of the lease area immediately north, or south of Munyaroo Conservation Park. See Figure 7 for location of the five sites, and see below for a summary. See Section 4.1 for details of the vegetation association description for each of the five sites.

3.2 Trap success and survey adequacy

The location of the five survey sites is considered adequate as a baseline survey to identify the main types of mammals, reptiles, and terrestrial (non-marine) birds present. See Section 6 Recommendations for a discussion on how the dataset and understanding of the Mullaquana fauna can be further improved.

The 240 pitfall, 300 Elliott, 80 cage and 80 funnel trap nights conducted during the survey resulted in 56 captures. Pitfalls were the most effective capture method, with 48 captures of small and medium sized reptiles and small mammals. Very few bat calls were recorded (23) which may be due to the wet windy conditions experienced during the survey. Therefore the results obtained can only be considered indicative of the bat fauna present and not a full representation.

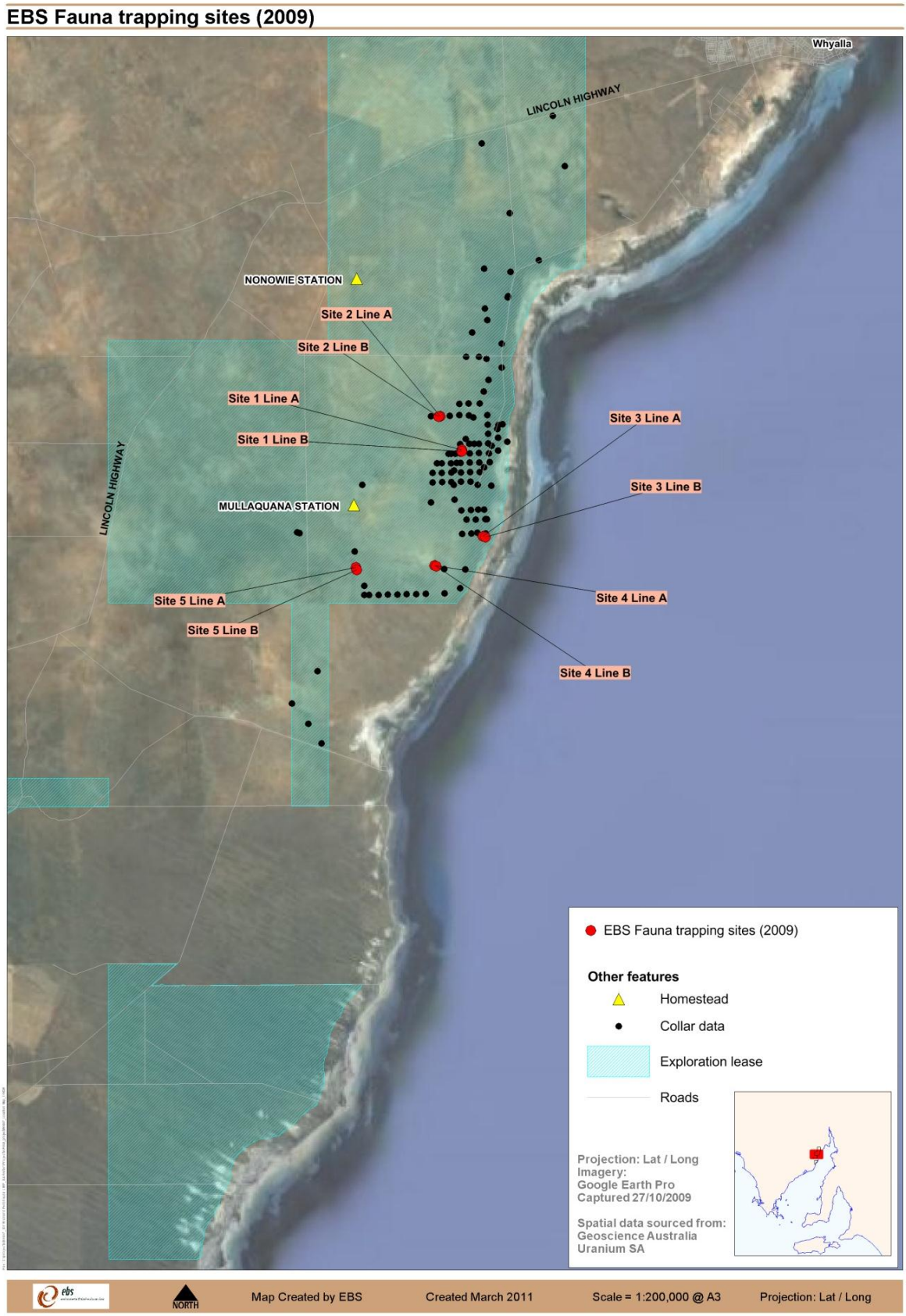


Figure 7. Location of the five Mullaquana survey sites.

3.3 Fauna survey site summary

3.3.1 Site 1

Site 1 was located within *Maireana sedifolia* (Bluebush), *Maireana pyramidata* (Black Bluebush), *Atriplex vesicaria* (Saltbush) Low Open Shrubland (Figure 8). Seven reptile species, one frog, and seven native birds were detected (Table 4). No mammals were detected but evidence of Kangaroo's (*Macropus* sp.) was observed.



Figure 8. Site 1 habitat (trap line A).

Table 4. Site 1 summary.

Site Detail	Description
Location	• 54 H 724872 6325055 (start of line A)
Vegetation Association	• *Maireana sedifolia* (Bluebush), *Maireana pyramidata* (Black Bluebush), *Atriplex vesicaria* (Saltbush) Low Open Shrubland
Landform	• Plain
Mammals	• None caught. Kangaroo's (*Macropus* sp.) detected through tracks or scats.
Reptiles	• 7 species, *Diplodactylus calciolus* (no common name), Garden Skink (*Lampropholis guichenoti*), Dwarf Three-toed Slider (*Lerista timida*), Southern Spiny-tailed Gecko (*Strophurus intermedius*), Sleepy Lizard (*Tiliqua rugosa*), Five-lined Earless Dragon (*Tympanocryptis lineata*), Saltbush Ctenotus (*Ctenotus orientalis*).
Amphibians	• 1 species, Trilling Frog (*Neobatrachus centralis*).
Birds	• 7 native species, White-winged Fairy-wren (*Malurus leucopterus*), Thick-billed Grasswren (*Amytornis textilis myall*), Striated Grasswren (*Amytornis striatus*), Orange Chat (*Epthianura aurifrons*), Nankeen Kestrel (*Falco cenchroides*), Crimson Chat (*Epthianura tricolor*), Masked Lapwing (*Vanellus miles*). • 1 exotic species, Common Starling (**Sturnus vulgaris*).

3.3.2 Site 2

Site 2 was located within *Disphyma crassifolium* (Round-leaf Pigface), *Sclerolaena patenticuspis* (Spear-fruit Bindyi), *Maireana enchylaenoides* (Wingless Fissure-plant), *Austrostipa* sp. (Spear Grass) Shrubland (Figure 9). Three reptile species, one frog, and ten native birds were detected (Table 5). The feral House Mouse (**Mus musculus*) was observed. Kangaroo's (*Macropus* sp.) were detected but no native mammals observed.



Figure 9. Site 2 habitat (trap line A).

Table 5. Site 2 summary.

Site Detail	Description
Location	• 54H 723980 6326487 (start of line A)
Vegetation Association	• *Disphyma crassifolium* (Round-leaf Pigface), *Sclerolaena patenticuspis* (Spear-fruit Bindyi), *Maireana enchylaenoides* (Wingless Fissure-plant), *Austrostipa* sp. (Spear Grass) Shrubland
Landform	• Plain
Mammals	• 1 feral species. House Mouse (**Mus musculus*). Kangaroo's (*Macropus* sp.) detected through tracks or scats.
Reptiles	• 3 native species, *Diplodactylus calciolus* (no common name), Garden Skink (*Lampropholis guichenoti*), Saltbush Ctenotus (*Ctenotus orientalis*).
Amphibians	• 1 species. Trilling Frog (*Neobatrachus centralis*).
Birds	• 10 native species, Australian Magpie (*Cracticus tibicen*), Crested Pigeon (*Ocyphaps lophotes*), Orange Chat (*Epthianura aurifrons*), Nankeen Kestrel (*Falco cenchroides*), Wedge-tailed Eagle (*Aquila audax*), Australasian Pipit (*Anthus novaeseelandiae*), Brown Falcon (*Falco berigora*), Galah (*Eolophus roseicapillus*), Australian Raven (*Corvus coronoides*), Yellow-rumped Thornbill (*Acanthiza chrysorrhoa*).

3.3.3 Site 3

Site 3 was located within *Halosarcia pergranulata* (Black-seed Samphire), *Halosarcia* sp. (Samphire sp). Low Shrubland (Figure 10). Three reptile species, one frog, and five native birds were detected (Table 6). The feral House Mouse (**Mus musculus*) was observed. Kangaroo's (*Macropus* sp.) were detected but no native mammals observed.



Figure 10. Site 3 habitat (trap line A).

Table 6. Site 3 summary.

Site Detail	Description
Location	• 54 H 725681 6321373 (start line A)
Vegetation Association	• *Halosarcia pergranulata* (Black-seed Samphire), *Halosarcia* sp. (Samphire sp). Low Shrubland
Landform	• Plain
Mammals	• 1 feral species, House Mouse (**Mus musculus*). Kangaroo's (*Macropus* sp.) detected through tracks or scats.
Reptiles	• 3 native species, Sandplain Ctenotus (*Ctenotus schomburgkii*), *Diplodactylus calciolus* (no common name), Garden Skink (*Lampropholis guichenoti*).
Amphibians	• 1 native species, Trilling Frog (*Neobatrachus centralis*).
Birds	• 5 native species, Orange Chat (*Epthianura aurifrons*), Striated Grasswren (*Amytornis striatus*), Wedge-tailed Eagle (*Aquila audax*), Australian Raven (*Corvus coronoides*), Spiny-cheeked Honeyeater (*Acanthagenys rufogularis*). • 1 exotic species, Eurasian Skylark (**Alauda arvensis*).

3.3.4 Site 4

Site 4 was located within *Myoporum platycarpum* (False Sandalwood) Open Woodland (Figure 11). Six reptile species, two frog, and ten native birds were detected (Table 7). Two native mammals were observed, and there was evidence of Kangaroo's (*Macropus* sp.).



Figure 11. Site 4 habitat (trap line A).

Table 7. Site 4 summary.

Site Detail	Description
Location	• 53 H 723599 63291 (start of line A)
Vegetation Association	• *Myoporum platycarpum* (False Sandalwood) Open Woodland
Landform	• Plain
Mammals	• 2 native species, Fat-tailed Dunnart (*Sminthopsis crassicaudata*), Stripe-faced Dunnart (*Sminthopsis macura*). Kangaroo's (*Macropus* sp.) detected through tracks or scats. • 1 feral species, House mouse (**Mus musculus*).
Reptiles	• 6 native species, Eastern Desert Ctenotus (*Ctenotus regius*), Sandplain Ctenotus (*Ctenotus schomburgkii*), Garden Skink (*Lampropholis guichenoti*), Eastern Bearded Dragon (*Pogona barbata*), Sleepy Lizard (*Tiliqua rugosa*), Sandplain Ctenotus (*Ctenotus orientalis*).
Amphibians	• 2 native species. Burrowing Frog (*Neobatrachus pictus*), Trilling Frog (Neobatrachus centralis).
Birds	• 10 native species, Australian Magpie (*Cracticus tibicen*), Crested Pigeon (*Ocyphaps lophotes*), White-browed Babbler (*Pomatostomus superciliosus*), Nankeen Kestrel (*Falco cenchroides*), Australian Raven (*Corvus coronoides*), Tawny Frogmouth (*Podargus strigoides*), Yellow-throated Miner (*Manorina flavigula*), Grey Butcherbird (*Cracticus torquatus*), Singing Honeyeater (*Lichenostomus virescens*), Noisy Miner (*Manorina melanocephala*).

3.3.5 Site 5

Site 5 was located within *Eucalyptus dumosa* (White Mallee), *Eucalyptus socialis* (Beaked Red Mallee) Mallee (Figure 12). Seven reptile species, one frog, and 16 native birds were detected (Table 7). One native mammal was observed, calls of four bat species were identified, and there was evidence of Kangaroo's (*Macropus* sp.).



Figure 12. Site 5 habitat (trap line A).

Table 8. Site 5 summary.

Site Detail	Description
Location	• 53 H 720263 6321082 (start of line A)
Vegetation Association	• *Eucalyptus dumosa* (White Mallee), *Eucalyptus socialis* (Beaked Red Mallee) Mallee.
Landform	• Minor ephemeral creekline.
Mammals	• 1 native species, Fat-tailed Dunnart (*Sminthopsis crassicaudata*). Kangaroo's (*Macropus* sp.) detected through tracks or scats. • 3 or 4 native species, White-striped Freetail Bat (*Austronmus australis*), Gould's wattled bat (*Chalinolobus gouldii*), Freetail Bat (*Mormopterus* sp (possible identification only), Lesser long-eared bat (*Nyctphilus geoffroyi*) or Central long-eared bat (*Nyctphilus major*).
Reptiles	• 7 native species, Crested Dragon (*Ctenophorus cristatus*), Eastern Desert Ctenotus (*Ctenotus regius),* Garden Skink (*Lampropholis guichenoti*), Dwarf Skink (*Menetia greyii*), Common Snake-eye (*Morethia boulengeri*), Sleepy Lizard *(Tiliqua rugosa*), Dwarf Three-toed Slider (*Lerista timida*).
Amphibians	• 1 native species, Trilling Frog (*Neobatrachus centralis*).
Birds	• 16 native species, Australian Magpie (*Cracticus tibicen*), Crested Pigeon (*Ocyphaps lophotes*), White-browed Babbler (*Pomatostomus superciliosus*), White-winged Fairy-wren (*Malurus leucopterus*), Nankeen Kestrel (*Falco cenchroides*), Striated Grasswren (*Amytornis striatus)*, Wedge-tailed Eagle (*Aquila audax*), Galah (*Eolophus roseicapillus*), Grey Butcherbird (*Cracticus torquatus*), Australian Ringneck (*Barnardius zonarius*), Spiny-cheeked Honeyeater (*Acanthagenys rufogularis*), Red-rumped Parrot (*Psephotus haematonotus*), Singing Honeyeater (*Lichenostomus virescens*), Black-faced Cuckoo-shrike (*Coracina novaehollandiae*), Variegated Fairy-wren (*Malurus lamberti*), Blue Bonnet (*Northiella haematogaster*). • 1 exotic species, Eurasian Skylark (**Alauda arvensis*).

3.4 Mammals

In total eight mammal species were observed during the survey (Table 9). Sheep (*Ovis aries*) were the most observed mammal (note the number of observations were not accurately counted), with scats indicating a widespread distribution across the survey area. The most observed native species was the Western Grey Kangaroo (*Macropus fuliginosus*), followed by the Red Kangaroo (*Macropus rufus*), and Euro (*Macropus rufus*). Small mammal diversity and abundance was low, with no native rodents caught or observed and just four captures of two dasyurids species (Dasyuridae family); two Fat-tailed Dunnart (*Sminthopsis crassicaudata*) (Figure 13) with one at Site 4 and one at Site 5, and one Stripe-faced Dunnart (*Sminthopsis macura*) (Figure 14) at Site 4, indicating a low abundance. The feral House Mouse (*Mus musculus*) was low in abundance but widespread, with a single capture at Site 2, Site 3 and Site 4. There was just a single observation of the exotic Rabbit (**Oryctolagus cuniculus*), but tracks, warrens and scats, indicate a widespread distribution and high abundance at some stage in the recent past. See Table 10 for a summary of the number of observations for each mammal species at the five survey sites and opportunistic observations within the survey area.

No mammal species of national or state conservation significance were detected during the survey.

Table 9. Mammal species detected during the field survey.

Family	Species	Common name	Aus status	SA status
Dasyuridae	*Sminthopsis crassicaudata*	Fat-tailed Dunnart	-	-
Dasyuridae	*Sminthopsis macura*	Stripe-faced Dunnart	-	-
Macropodidae	*Macropus fuliginosus*	Western Grey Kangaroo	-	-
Macropodidae	*Macropus robustus*	Euro	-	-
Macropodidae	*Macropus rufus*	Red Kangaroo	-	-
Muridae	**Mus musculus*	House Mouse	-	-
Leporidae	**Oryctolagus cuniculus*	Rabbit (European Rabbit)	-	-
Bovidae	**Ovis aries*	Sheep	-	-



Figure 13. Fat-tailed Dunnart (*Sminthopsis crassicaudata*).



Figure 14. Stripe-faced Dunnart (*Sminthopsis macura*).

Table 10. Number of mammal captures and observations during the field survey.

Species	Common name	Site 1	Site 2	Site 3	Site 4	Site 5	Opportune Off-site
Sminthopsis crassicaudata	Fat-tailed Dunnart				1	1	
Sminthopsis macura	Stripe-faced Dunnart				1		
Macropus fuliginosus	Western Grey Kangaroo						7
Macropus robustus	Euro						3
Macropus rufus	Red Kangaroo						2
**Mus muscululs*	House Mouse		1	1	1		3
Macropus sp. (scats, tracks)	Kangaroo species	X	X	X	X		X
**Oryctolagus cuniculus*	Rabbit (European Rabbit)		X			X	X
**Ovis aries* (scats, tracks)	Sheep	X	X	X	X	X	X

* = *feral/grazing species*

X = sign of presence observed (tracks, scats, burrows etc).
Habitat of the survey sites:
Site 1 *Maireana sedifolia* (Bluebush), *Maireana pyramidata* (Black Bluebush) Low Open Shrubland
Site 2 *Disphyma crassifolium* (Round-leaf Pigface), *Sclerolaena patenticuspis* (Spear-fruit Bindyi), *Maireana enchylaenoides* (Wingless Fissure-plant), *Austrostipa* sp. (Spear Grass) Shrubland
Site 3 *Halosarcia pergranulata* (Black-seed Samphire), *Halosarcia* sp. (Samphire sp.) Low Shrubland
Site 4 *Myoporum platycarpum* (False Sandalwood) Open Woodland
Site 5 *Eucalyptus dumosa* (White Mallee), *Eucalyptus socialis* (Beaked Red Mallee) Mallee.

Just 23 ball calls were recorded, all from Site 5 on the 21st November. Two species were identified with certainty, the White-striped Freetail bat (*Austronmus australis*) and Gould's wattled bat (*Chalinolobus gouldii*). Other species detected with less certainty due to the quality of the call or lack of confirmed reference calls specific to the region were a Freetail bat (*Mormopterus* sp.), and either the Lesser long-eared bat (*Nyctophilus geoffroyi*) or the Central long-eared bat (*Nyctophilus major*). Site 5 has potential roosting sites (hollows and loose bark of the mallee Eucalypt trees), and likely prey abundance (insect attracted to the flowering Eucalypts).

3.5 Reptiles

Thirteen reptile species were captured or observed during the field survey (Table 11). No reptile species of national or state conservation significance were detected during the survey. Reptile species diversity ranged from three species to seven species at each of the five sites (Table 12).

Table 11. Reptile species detected during the field survey.

Family	Species	Common name	Aus status	SA status
Agamidae	*Ctenophorus cristatus*	Crested Dragon	-	-
Agamidae	*Pogona barbata*	Eastern Bearded Dragon	-	-
Agamidae	*Tympanocryptis lineata*	Five-lined Earless Dragon	-	-
Diplodactylidae	*Diplodactylus calciolus*	(no common name)	-	-
Diplodactylidae	*Strophurus intermedius*	Southern Spiny-tailed Gecko	-	-
Scincidae	*Ctenotus orientalis*	Saltbush Ctenotus	-	-
Scincidae	*Ctenotus regius*	Eastern Desert Ctenotus	-	-
Scincidae	*Ctenotus schomburgkii*	Sandplain Ctenotus	-	-
Scincidae	*Lampropholis guichenoti*	Garden Skink	-	-
Scincidae	*Lerista timida*	Dwarf Three-toed Slider	-	-
Scincidae	*Menetia greyii*	Dwarf Skink	-	-
Scincidae	*Morethia boulengeri*	Common Snake-eye	-	-
Scincidae	*Tiliqua rugosa*	Sleepy Lizard	-	-

Table 12. Number of reptile captures and observations during the field survey.

Species	Site 1	Site 2	Site 3	Site 4	Site 5	Opp Off-site	Total No. sites
Ctenophorus cristatus					2		1
Pogona barbata				1			1
Tympanocryptis lineata	1						1
Diplodactylus calciolus	3	4	1				3
Strophurus intermedius	1						1
Ctenotus orientalis	2	1		1			3
Ctenotus regius				2	1		2
Ctenotus schomburgkii			1	13			2
Lampropholis guichenoti	6	2	2	9	1		5
Lerista timida	1				1		2
Menetia greyii					1		1
Morethia boulengeri					1		1
Tiliqua rugosa	1			3	2	1	3 + opp
Reptile diversity (no. species)	**7**	**3**	**3**	**6**	**7**		

Habitat of the survey sites:
Site 1 *Maireana sedifolia* (Bluebush), *Maireana pyramidata* (Black Bluebush) Low Open Shrubland
Site 2 *Disphyma crassifolium* (Round-leaf Pigface), *Sclerolaena patenticuspis* (Spear-fruit Bindyi), *Maireana enchylaenoides* (Wingless Fissure-plant), *Austrostipa* sp. (Spear Grass) Shrubland
Site 3 *Halosarcia pergranulata* (Black-seed Samphire), *Halosarcia* sp. (Samphire sp.) Low Shrubland
Site 4 *Myoporum platycarpum* (False Sandalwood) Open Woodland
Site 5 *Eucalyptus dumosa* (White Mallee), *Eucalyptus socialis* (Beaked Red Mallee) Mallee.

The Garden Skink (*Lampropholis guichenoti*) (Figure 15) was the most abundant reptile species with 20 captures and observations, and the most widespread with captures at all five survey sites indicating broad habitat requirements. The Sandplain Ctenotus (*Ctenotus schomburgkii*) was recorded at two sites, Site 3 and Site 4, with 13 captures at Site 4 indicating a high abundance in the *Myoporum platycarpum* (False Sandalwood) Open Woodland habitat. Two other *Ctenotus* species were captured, the Saltbush Ctenotus (*Ctenotus orientalis*) (Figure 16) (four captures in total) and the Eastern Desert Ctenotus (*Ctenotus regius*) (three captures in total). The Sleepy Lizard (*Tiliqua rugosa*) was observed at three sites and opportunistically, indicating a widespread distribution.

Three dragon species (Agamidae family) were observed or captured, all in low abundance and spread across three of the five sites. There were two captures of the Crested Dragon (*Ctenophorus cristatus*) (Figure 17), both at Site 5 within *Eucalyptus dumosa* (White Mallee), *Eucalyptus socialis* (Beaked Red Mallee) Mallee habitat. The Eastern Bearded Dragon (*Pogona barbata*) (Figure 18) was captured at Site 4 within *Myoporum platycarpum* (False Sandalwood) Open Woodland habitat. The Five-lined Earless Dragon (*Tympanocryptis lineata*) (Figure 19) was captured at Site 1 within *Maireana sedifolia* (Bluebush), *Maireana pyramidata* (Black Bluebush) Low Open Shrubland habitat.

Just two nocturnal gecko species (Diplodactylidae family) were captured. *Diplodactyus calciolus* (no common name) was caught at Site 1 (*Maireana sedifolia* Bluebush, *Maireana pyramidata* Black Bluebush Low Open Shrubland habitat), Site 2 (*Disphyma crassifolium* Round-leaf Pigface, *Sclerolaena patenticuspis* Spear-fruit Bindyi), *Maireana enchylaenoides* Wingless Fissure-plant, *Austrostipa* sp. Spear Grass Shrubland and Site 3 (*Halosarcia* sp., *Tetracornia pergranulata* Low Shrubland), indicating a widespread distribution amongst shrubland habitat. The Southern Spiny-tailed Gecko (*Strophurus intermedius*) (Figure 20) was only caught at Site 1.



Figure 15. Garden Skink (*Lampropholis guichenoti*).



Figure 16. Saltbush Ctenotus (*Ctenotus orientalis*).



Figure 17. Crested Dragon (*Ctenophorus cristatus*).



Figure 18. Bearded Dragon (*Pogona barbata*).



Figure 19. Five-lined Earless Dragon (*Tympanocryptis lineata*).



Figure 20. Southern Spiny-tailed Gecko (*Strophurus intermedius*).

3.6 Frogs

Two species of frogs were observed during the survey. No frog species of national or state conservation significance were detected during the survey (Table 13).

Table 13. Frog species detected during the field survey.

Family	Species	Common name	Aus status	SA status
Myobatrachidae	*Neobatrachus centralis*	Trilling Frog	-	-
Myobatrachidae	*Neobatrachus pictus*	Burrowing Frog	-	-

The Trilling Frog (*Neobatrachus centralis*) (Figure 21) was widespread being recorded at all five survey sites, and ranged from low abundance at Sites 1 – 4 (1-4 individuals recorded), and abundant at Site 5 (46 individuals recorded), which consisted of *Eucalyptus dumosa* (White Mallee), *Eucalyptus socialis* (Beaked Red Mallee) Mallee habitat along an ephemeral creekline. The Burrowing Frog (*Neobatrachus pictus*) (Figure 22) was recorded at Site 4 *Myoporum platycarpum* (False Sandalwood) Open Woodland habitat, with just one capture. Both species are burrowing frogs, and the heavy rainfall on the 21st and 22nd November, would have promoted them to come to the surface to feed.

Table 14. Number of frog captures and observations during the field survey.

Species	Site 1	Site 2	Site 3	Site 4	Site 5	Opp Off-site	Tot. No. sites
Neobatrachus pictus				1			1
Neobatrachus centralis	1	1	3	4	46		5

Habitat of the survey sites:
Site 1 *Maireana sedifolia* (Bluebush), *Maireana pyramidata* (Black Bluebush) Low Open Shrubland
Site 2 *Disphyma crassifolium* (Round-leaf Pigface), *Sclerolaena patenticuspis* (Spear-fruit Bindyi), *Maireana enchylaenoides* (Wingless Fissure-plant), *Austrostipa* sp. (Spear Grass) Shrubland
Site 3 *Halosarcia pergranulata* (Black-seed Samphire), *Halosarcia* sp. (Samphire sp.) Low Shrubland
Site 4 *Myoporum platycarpum* (False Sandalwood) Open Woodland
Site 5 *Eucalyptus dumosa* (White Mallee), *Eucalyptus socialis* (Beaked Red Mallee) Mallee.



Figure 21. Trilling Frog (*Neobatrachus centralis*).



Figure 22. Burrowing Frog (*Neobatrachus pictus*).

3.7 Birds

Forty-three bird species were observed during the field survey (Table 15), with a total of 585 observations from both the point count surveys (328) and opportunistic (257) observations. Bird abundance at the sites ranged from 109 individuals to 30 individuals whilst bird species diversity ranged from 19 species to just six species.

One species of National conservation significance, the Vulnerable Eastern Thick-billed Grasswren (*Amytornis textilis myall*) and one species of state conservation significance, the Rare Striated Grasswren (*Amytornis striatus*) were observed (see below for further information and section 6 for recommendations for Uranium SA).

Table 15. Bird species detected during the field survey.

Family	Species	Common name	Aus status	SA status
Acanthizidae	*Acanthiza chrysorrhoa*	Yellow-rumped Thornbill		
Accipitridae	*Aquila audax*	Wedge-tailed Eagle		
Alaudidae	**Alauda arvensis*	Eurasian Skylark		
Anseriformes	*Anas gracilis*	Grey Teal		
Ardeidae	*Egretta novaehollandiae*	White-faced Heron		
Artamidae	*Artamus cinereus*	Black-faced Woodswallow		
Artamidae	*Cracticus tibicen*	Australian Magpie		
Artamidae	*Cracticus torquatus*	Grey Butcherbird		
Cacatuidae	*Eolophus roseicapillus*	Galah		
Campephagidae	*Coracina novaehollandiae*	Black-faced Cuckoo-shrike		
Campephagidae	*Lalage sueurii*	White-winged Triller		
Casuariidae	*Dromaius novaehollandiae*	Emu		
Charadriidae	*Vanellus miles*	Masked Lapwing		
Charadriidae	*Vanellus tricolor*	Banded Lapwing		
Columbidae	*Ocyphaps lophotes*	Crested Pigeon		
Corvidae	*Corvus coronoides*	Australian Raven		
Dicruridae	*Rhipidura leucophrys*	Willie Wagtail		
Falconidae	*Falco berigora*	Brown Falcon		
Falconidae	*Falco cenchroides*	Nankeen Kestrel		
Falconidae	*Falco longipennis*	Australian Hobby		
Hirundinidae	*Petrochelidon nigricans*	Tree Martin		
Laridae	*Chroicocephalus novaehollandiae*	Silver Gull		
Maluridae	*Amytornis striatus*	Striated Grasswren		R
Maluridae	*Amytornis textilis myall*	Thick-billed Grasswren	VU	
Maluridae	*Malurus lamberti*	Variegated Fairy-wren		
Maluridae	*Malurus leucopterus*	White-winged Fairy-wren		
Maluridae	*Malurus splendens*	Splendid Fairy-wren		
Meliphagidae	*Acanthagenys rufogularis*	Spiny-cheeked Honeyeater		
Meliphagidae	*Epthianura albifrons*	White-fronted Chat		
Meliphagidae	*Epthianura aurifrons*	Orange Chat		
Meliphagidae	*Epthianura tricolor*	Crimson Chat		
Meliphagidae	*Lichenostomus virescens*	Singing Honeyeater		

Family	Species	Common name	Aus status	SA status
Meliphagidae	*Manorina flavigula*	Yellow-throated Miner		
Meliphagidae	*Manorina melanocephala*	Noisy Miner		
Motacillidae	*Anthus novaeseelandiae*	Australasian Pipit		
Phasianidae	*Coturnix pectoralis*	Stubble Quail		
Podargidae	*Podargus strigoides*	Tawny Frogmouth		
Pomatostomidae	*Pomatostomus superciliosus*	White-browed Babbler		
Psittacidae	*Barnardius zonarius*	Australian Ringneck		
Psittacidae	*Northiella haematogaster*	Blue Bonnet		
Psittacidae	*Psephotus haematonotus*	Red-rumped Parrot		
Rallidae	*Tribonyx ventralis*	Black-tailed Native-hen		
Sturnidae	**Sturnus vulgaris*	Common Starling		

Habitat of the survey sites:
Site 1 *Maireana sedifolia* (Bluebush), *Maireana pyramidata* (Black Bluebush) Low Open Shrubland
Site 2 *Disphyma crassifolium* (Round-leaf Pigface), *Sclerolaena patenticuspis* (Spear-fruit Bindyi), *Maireana enchylaenoides* (Wingless Fissure-plant), *Austrostipa* sp. (Spear Grass) Shrubland
Site 3 *Halosarcia pergranulata* (Black-seed Samphire), *Halosarcia* sp. (Samphire sp.) Low Shrubland
Site 4 *Myoporum platycarpum* (False Sandalwood) Open Woodland
Site 5 *Eucalyptus dumosa* (White Mallee), *Eucalyptus socialis* (Beaked Red Mallee) Mallee.

Site 5, *Eucalyptus dumosa* (White Mallee), *Eucalyptus socialis* (Beaked Red Mallee) Mallee habitat) recorded the highest bird abundance with 109 individuals of 19 species. This site is dominated by Eucalypt mallees with fringes of low shrubs and native grasses on the outer edges. Five species of honeyeater/parrot were observed at this site, indicative of the species present within the mallee habitat. However there were also a diverse array of other species ranging from three species of wren to high numbers of babblers and recordings of kestrel and emu's Table 16. Seven bird species observed at Site 5 were not recorded at the other four sites.

Site 1, *Maireana sedifolia* (Bluebush), *Maireana pyramidata* (Black Bluebush) Low Open Shrubland had a diversity of just nine species. Five of these species, the Thick-billed Grasswren (*Amytornis striatus),* Black-faced Woodswallow (*Artamus cinereus*), Crimson Chat (*Epthianura tricolor)*, Common Starling (**Sturnus vulgaris*) and Masked Lapwing (*Vanellus miles*) were not recorded at the other sites, however all but the Black-faced Woodswallow were observed opportunistically elsewhere within the survey area.

Ten species were observed at Site 4, *Myoporum platycarpum* (False Sandalwood) Open Woodland. Five of these species were also observed at the other site with tall shrubs, Site 5, *Eucalyptus dumosa* (White Mallee), *Eucalyptus socialis* (Beaked Red Mallee) Mallee. Two species observed at Site 4, the nocturnal Tawny Frogmouth (*Podargus strigoides*) (observed roosting) and the Noisy Miner (*Manorina melanocephala*) were not observed at any other site or opportunistically.

Site 3, *Halosarcia* sp., *Tetracornia pergranulata* Low Shrubland recorded the lowest number of birds with an abundance of 30 and diversity of just six species. The rare Striated Grasswren (*Amytornis striatus*), Orange Chat (*Epthianura aurifrons*) and Australian Raven (*Corvus coronoides*) were recorded in the highest numbers at this site.

Table 16. Species diversity and abundance of all birds recorded from the 5 revisited Point Count survey sites during Nov 09 surveys at Mullaquana.

Species	Common name	Site 1	Site 2	Site 3	Site 4	Site 5	Total
Acanthagenys rufogularis	Spiny-cheeked Honeyeater			5		13	18
Acanthiza chrysorrhoa	Yellow-rumped Thornbill		2				2
Alauda arvensis	Eurasian Skylark			2		1	3
Amytornis striatus	Striated Grasswren	2		8		2	12
Amytornis textilis myall	Thick-billed Grasswren	7					7
Anas gracilis	Grey Teal						
Anthus novaeseelandiae	Australasian Pipit		12				12
Aquila audax	Wedge-tailed Eagle		1	3			4
Artamus cinereus	Black-faced Woodswallow	3					3
Barnardius zonarius	Australian Ringneck, (Ring-necked Parrot)					16	16
Chroicocephalus novaehollandiae	Silver Gull						
Coracina novaehollandiae	Black-faced Cuckoo-shrike					4	4
Corvus coronoides	Australian Raven		4	6	4		14
Coturnix pectoralis	Stubble Quail						
Cracticus tibicen	Australian Magpie		3		8	2	13
Cracticus torquatus	Grey Butcherbird				6	8	14
Dromaius novaehollandiae	Emu					2	2
Egretta novaehollandiae	White-faced Heron						
Eolophus roseicapillus	Galah		6			14	20
Epthianura albifrons	White-fronted Chat						
Epthianura aurifrons	Orange Chat	15	43	6		1	65
Epthianura tricolor	Crimson Chat	2					2
Falco berigora	Brown Falcon		1				1
Falco cenchroides	Nankeen Kestrel	1	5		11	3	20
Falco longipennis	Australian Hobby						
Lalage sueurii	White-winged Triller						
Lichenostomus virescens	Singing Honeyeater				3	6	9
Malurus lamberti	Variegated Fairy-wren					6	6
Malurus leucopterus	White-winged Fairy-wren	17				2	19
Malurus splendens	Splendid Fairy-wren					2	2
Manorina flavigula	Yellow-throated Miner				12		12
Manorina melanocephala	Noisy Miner				1		1
Northiella haematogaster	Blue Bonnet					2	2
Ocyphaps lophotes	Crested Pigeon		1		4	2	7
Petrochelidon nigricans	Tree Martin						
Podargus strigoides	Tawny Frogmouth				2		2
Pomatostomus superciliosus	White-browed Babbler				3	22	25
Psephotus haematonotus	Red-rumped Parrot					1	1
Rhipidura leucophrys	Willie Wagtail						
**Sturnus vulgaris*	Common Starling	8					8
Tribonyx ventralis	Black-tailed Native-hen						

Species	Common name	Site 1	Site 2	Site 3	Site 4	Site 5	Total
Vanellus miles	Masked Lapwing	2					2
Vanellus tricolor	Banded Lapwing						
Abundance		57	78	30	54	109	328
Species Diversity		**9**	**10**	**6**	**10**	**19**	

Habitat of the survey sites:
Site 1 *Maireana sedifolia* (Bluebush), *Maireana pyramidata* (Black Bluebush) Low Open Shrubland
Site 2 *Disphyma crassifolium* (Round-leaf Pigface), *Sclerolaena patenticuspis* (Spear-fruit Bindyi), *Maireana enchylaenoides* (Wingless Fissure-plant), *Austrostipa* sp. (Spear Grass) Shrubland
Site 3 *Halosarcia* sp., *Tetracornia pergranulata* Low Shrubland
Site 4 *Myoporum platycarpum* (False Sandalwood) Open Woodland
Site 5 *Eucalyptus dumosa* (White Mallee), *Eucalyptus socialis* (Beaked Red Mallee) Mallee.

The most common species recorded during point count surveys of the five survey sites were the Orange Chat (*Epthianura aurifrons*), White-browed Babbler (*Pomatostomus superciliosus*) (Figure 23), Galah (*Eolophus roseicapillus*), Nankeen Kestrel (*Falco cenchroides*), White-winged Fairy-wren *(Malurus leucopterus*) and Spiny-cheeked Honeyeater (*Acanthagenys rufogularis*) accounting for 20%, 8%, and 6% of all observations (Table 17). Together these six species accounted for half of all birds recorded within point count surveys. Three species that were recorded in high numbers during opportunistic surveys were the Spiny-cheeked Honeyeater (11%) and the Orange Chat and Australian Raven (both at 6%).



Figure 23. White-browed Babbler (*Pomatostomus superciliosus*).

The nationally Vulnerable Eastern Thick-billed Grasswren (*Amytornis textillis myall*) was not commonly recorded throughout point count surveys, nor opportunistically, with a total of 7 observations (or making up 1% of the total number of birds recorded) (Appendix 1). The rare Striated Grasswren (*Amytornis striatus*) was recorded at both point count surveys and opportunistically with a total count of 12 observations, making up 2% of the total number of birds.

Table 17. The ten most abundant birds recorded during Point Counts (PC) and Opportunistically (OPP) during the November 09 survey at Mullaquana.

Common name	PC - abundance	PC - proportion of total abundance	OPP - abundance	OPP - proportion of total abundance
Orange Chat	65	19.8	15	5.8
White-browed Babbler	25	7.6	10	3.9
Galah	20	6.1	9	3.5
Nankeen Kestrel	20	6.1	3	1.2
White-winged Fairy-wren	19	5.8	2	0.7
Spiny-cheeked Honeyeater	18	5.5	28	10.9
Ring-necked Parrot	16	4.9	0	0.0
Australian Raven	14	4.3	15	5.8
Grey Butcherbird	14	4.3	3	1.2
Australian Magpie	13	4.0	3	1.2

3.7.1 Conservation significant birds observed

Thick-billed Grasswren

The nationally Vulnerable Eastern Thick-billed Grasswren (*Amytornis textilis myall*) was recorded in low numbers (7 individuals) at Site 1 (*Maireana sedifolia* (Bluebush), *Maireana pyramidata* (Black Bluebush) Low Open Shrubland).

While the Thick-billed Grasswren *subspecies A. t. modesta* is now restricted to chenopod shrublands, especially those supporting saltbush and bluebush (Schodde 1982, Garnett and Crowley 2000, Gee *et al.* 1996), their favoured habitats are along drainage lines where shrubs are taller and thicker (Chapman 1996). Many birds undergo seasonal movements into and out of an area, meaning that targeted surveys must be timed to coincide with the relevant species occurrence within a region. Such seasonality is unlikely to be a major issue with the Thick-billed Grasswren, as they are considered likely to be sedentary (Schodde 1982), and territorial throughout the year (Higgins *et al*. 2001). This means that they probably remain within their breeding territories outside of the June to September breeding season (Schodde 1982, Brooker 1988). In some locations pairs remain in an area of four to five hectares, however home ranges may be as large as 20 - 40 ha (Schodde 1982). The size of these home ranges means that birds can inhabit suitable habitat at a very low density. Localised movement within large home ranges also means that a resident pair may be overlooked during a brief period of surveys. Another consideration is that Thick-billed Grasswrens may undertake some nomadic movements during particularly dry periods (Serventy *et al.* 1982). Due to the extremely shy and elusive behaviour of the Thick-billed Grasswren they can be easily overlooked. Unlike other arid land birds they also do not congregate into locally nomadic parties after breeding, meaning that they are less conspicuous. They are most active during the early morning and late afternoon when they move into open areas between shrubs to feed on insects and seeds on the ground (Barker and Vestjens 1990, Morcombe 2000).

Striated Grasswren

The state Rare Striated Grasswren (*Amytornis striatus*) was also observed in low numbers at Site 1 (2 individuals), as well as Site 3 *Halosarcia* sp., *Tetracornia pergranulata* Low Shrubland (8 individuals) and on the edges of Site 5 *Eucalyptus dumosa* (White Mallee), *Eucalyptus socialis* (Beaked Red Mallee) Mallee habitat (2 individuals), and one additional opportunistic observation elsewhere within the survey area.

Striated Grasswrens live in pairs, or occasionally groups of three. They have territories of around three hectares and spend most of their time patrolling the edges of their territory, or interacting with grasswrens from nearby territories (Higgins *et al.* 2001). The normal habitat of Striated Grasswrens is open mallee over a sparse layer of shrubs and a ground layer dominated by spinifex (*Triodia*), though they are sometimes found in association with mallee eucalypts and sandy soils (which has proven the case recording these species in Sites 1 and 3 as well as in the Mallee habitat of Site 5).

3.8 Invertebrates

In total 180 macro-invertebrate specimens and an estimated 10,000 micro-invertebrates collected during the Mullaquana survey were identified to an appropriate level. Overall invertebrate diversity was considered relatively good for a modified pastoral environment. Five invertebrate classes and 11 orders were represented (Table 18). The most abundant invertebrate type present were the tiny (<1.5 mm springtails, Order Collembola). Although micro-invertebrates were not the focus of the survey, an estimated 10,000 were collected in the micro-pitfalls at Site 5. Ants were the most abundant macro-invertebrate, with at least nine different types identified (ants were only identified to family but it is likely nine different species of at least three different sub-families were collected). Five different types of spiders were collected, most of which are likely to be wolf spiders. One moth (Order Lepidoptera) was collected despite flying insects not being the focus of the sampling methods employed. The large soft-bodied crickets (approximately 8 cm in length) (Figure 24) were observed at both Site 2 and Site 4, but were not abundant.

No invertebrates of national conservation significant were observed. The *National Parks and Wildlife Act 1972* does not list threatened invertebrates. No butterfly species un-officially considered threatened in South Australia by Grund (2009) were observed.

Table 18. Summary of the invertebrate types detected during the field survey.

Class	Order	Sub-order	Family	Common name	No. of types
Chilopoda	Scutigeromorpha			Centipede	1
Chilopoda	Scolopendromorpha			Centipede	1
Arachnida	Scorpionida			Scorpion	2
Arachnida	Araneida			Spiders	5
Arachnida	Acarina			Mites	1
Hexapoda	Coleoptera	Adephaga	Carabidae	Ground Beetles	2
Hexapoda	Coleoptera	Polyphaga	Buprestidae	Jewel Bettle	1
Hexapoda	Hymenoptera		Formicidae	Ant	9
Hexapoda	Lepidoptera			Moth	1
Hexapoda	Orthoptera		Gryllidae	Soft-bodied Cricket	1
Collembola	Collembola			Springtail	2
Insecta	Diptera	Brachycera	Muscidae	Bush Fly	1

Specimens were not identified to species level, consequently the number of types indicates the likely number of species but the species name itself cannot be stated.



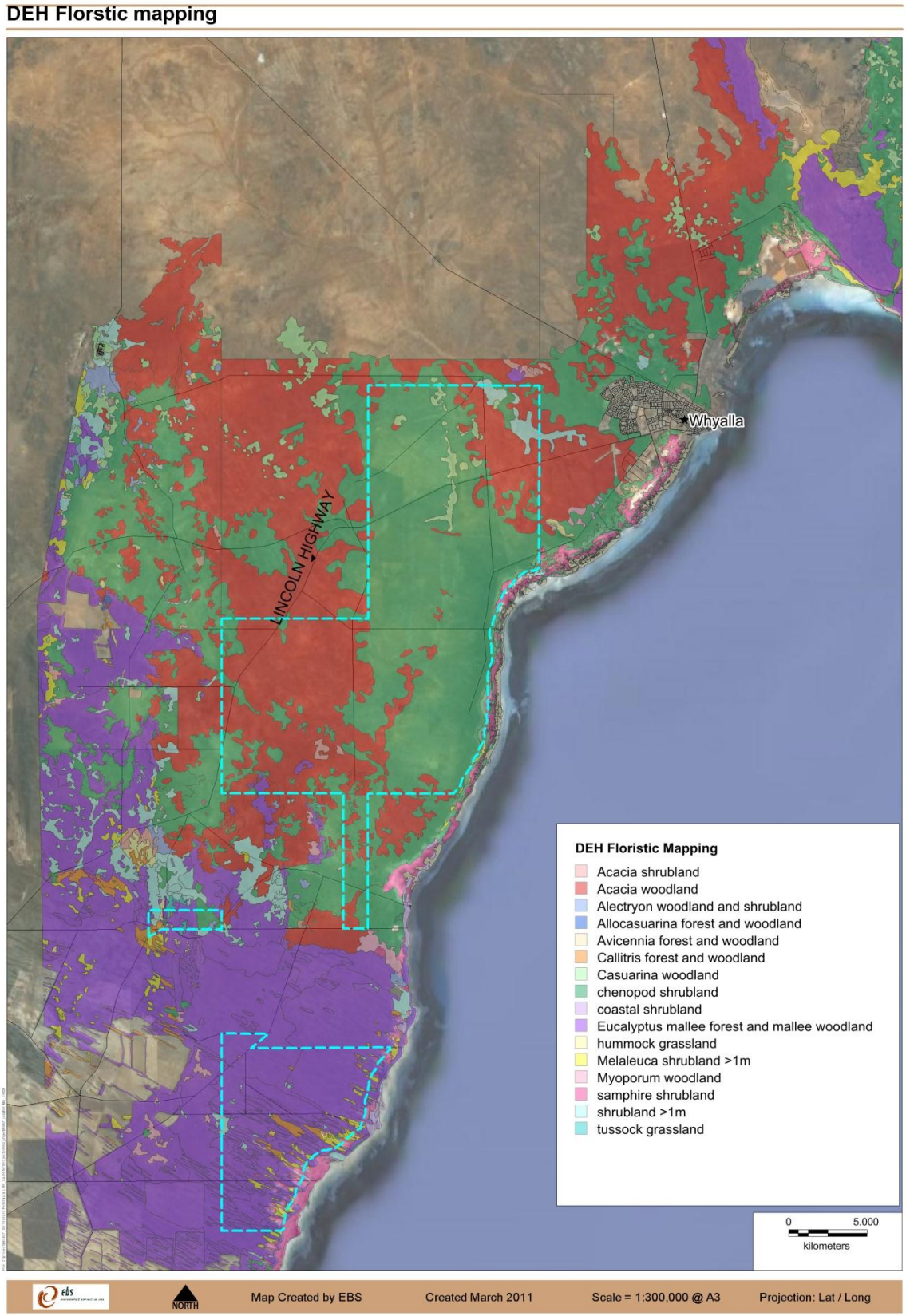
Figure 24. A soft-bodied Cricket (Family: Gryllidae).

4 VEGETATION AND FLORA RESULTS

4.1 Vegetation associations

Ten main vegetation associations were identified during the survey (Table 19). Two of these associations do not occur within the EL area, however their presence within the wider area is considered of interest, particularly as refuge for fauna that may visit areas within the lease area. The vegetation mapping built upon DEH floristic mapping, identifying at least a further three associations not previously identified. The location of the identified vegetation associations together with the DEH floristic mapping is provided in

Figure 25. For comparative reference see Appendix 2 for DEH floristic mapping and



Appendix 3 for EBS vegetation association mapping. The two datasets can be considered to compliment one another, with the DEH floristic mapping covering a wider area, and the EBS mapping being more detailed for the area of interest.

4.1.1 Condition

Condition of the vegetation associations ranged from 4:1 with substantial alteration to the vegetation structure, extensive clearing with evidence of heavy grazing and no evidence of a soil crust (Association 2) through to 8:1 with the vegetation structure intact with some litter build-up (Association 9). The majority of the lease area is considered 6:1 with obvious signs of disturbance (tracks and bare ground), depletion of one of more vegetation strata, considerable weed invasion and a patchy soil surface crust.

Table 19. Summary of the vegetation associations identified as occurring within and adjacent the lease area.

No.	Association description	Area (ha) within lease	Condition SEB ratio
1	*Maireana sedifolia* (Bluebush), *Maireana pyramidata* (Black Bluebush), *Atriplex vesicaria* (Bladder Saltbush) Low Open Shrubland	7320	6:1
2	*Disphyma crassifolium* (Round-leaf Pigface), *Sclerolaena patenticuspis* (Spear-fruit Bindyi), *Maireana enchylaenoides* (Wingless Fissure-plant), *Austrostipa* sp. (Spear Grass) Shrubland	82	4:1
3	*Halosarcia pergranulata* (Black-seed Samphire), *Halosarcia* sp. (Samphire), Low Shrubland	1050	6:1
4	*Myoporum platycarpum* (False Sandalwood) Open Woodland	191	6:1
5	*Eucalyptus dumosa* (White Mallee), *Eucalyptus socialis* (Beaked Red Mallee) Mallee	52	6:1
6	*Acacia papyrocarpa* Open Woodland	2721	6:1
7	*Casuarina pauper* Open Woodland	179	6:1
8	*Senna artemisioides* ssp. *coriacea* (Broad-leaved Desert Senna), *Senna artemisioides* ssp. *petiolaris* (Desert Senna) Shrubland	51	6:1
9	*Avicennia marina* ssp. *marina* (Grey Mangrove) Shrubland	0	8:1
10	*Dodonaea viscosa ssp. angustissima (Narrow-leaf Hop-bush), Acacia oswaldii (Umbrella Wattle), Myoporum insulare* (Common Boobialla) Tall Shrubland	0	6:1

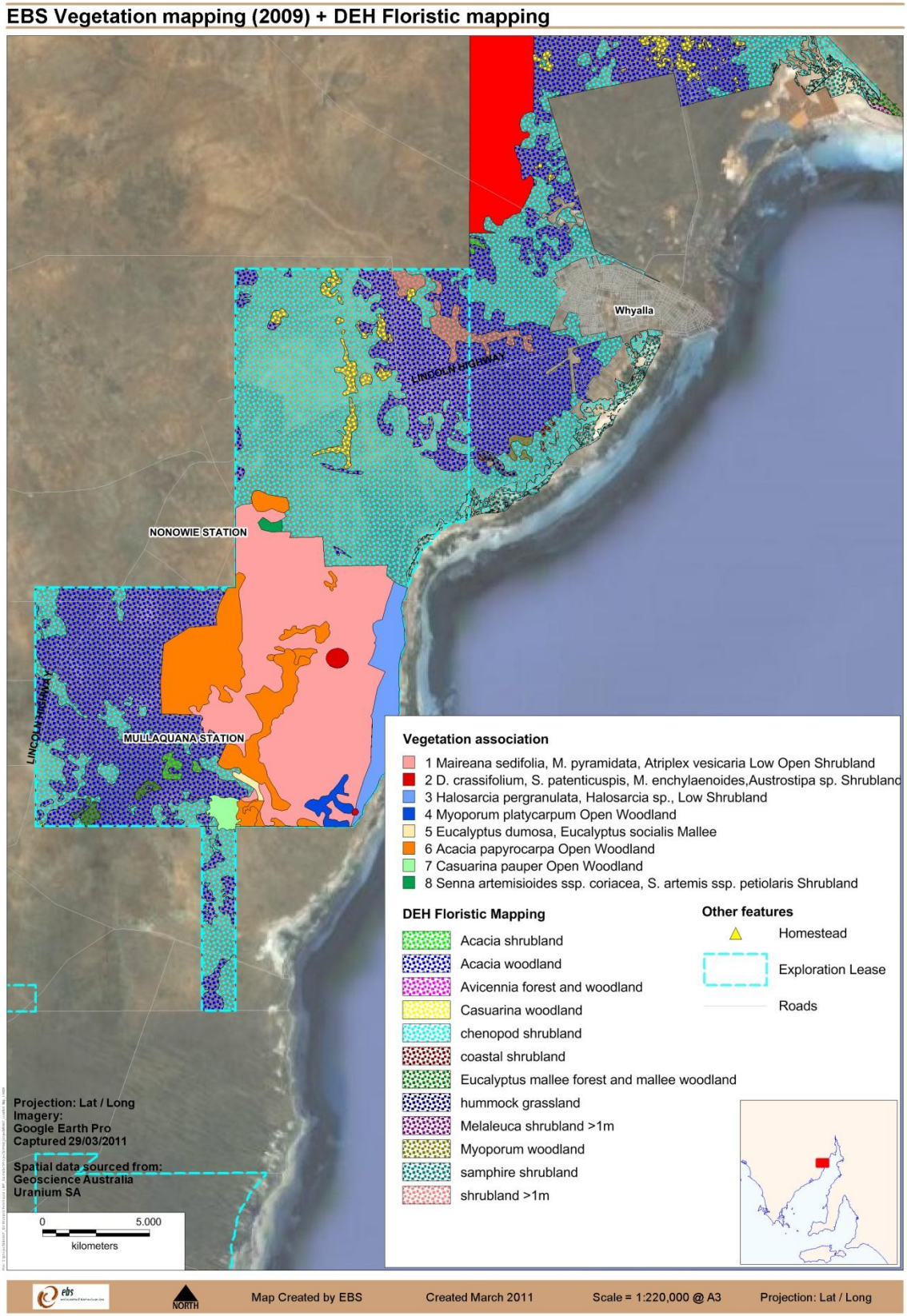


Figure 25. Combined DEH and EBS floristic mapping of the Mullaquana survey area.

4.1.2 Association 1 – *Maireana sedifolia* (Bluebush), *Maireana pyramidata* (Black Bluebush), *Atriplex vesicaria* (Bladder Saltbush) Low Open Shrubland

Maireana sedifolia (Bluebush), *Maireana pyramidata* (Black Bluebush), *Atriplex vesicaria* (Bladder Saltbush) Low Open Shrubland is the dominate vegetation association of the Mullaquana survey area covering an estimated 7,320 ha or 63% of the total 11,647 ha. All three of the dominate species are either co-dominates (equal coverage) or one species dominates. At the level of detail required for this survey it was not possible to separate the association into separate associations depending on which species was dominate. Shrubs are typically less than one metre in height. Note this association is also the understorey of Association 8 *Senna artemisioides* ssp. *coriacea* (Broad-leaved Desert Senna), *Senna artemisioides* ssp. *petiolaris* (Desert Senna) Shrubland. See Figure 26 for a representative photograph.



Figure 26. *Maireana sedifolia* (Bluebush), *Maireana pyramidata* (Black Bluebush), *Atriplex vesicaria* (Bladder Saltbush) Low Open Shrubland association.

Table 20. Summary of Association 1.

Detail	Description
Dominant species	• *Maireana sedifolia* (Bluebush) • *Maireana pyramidata* (Black Bluebush) • *Atriplex vesicaria* (Bladder Saltbush)
Association type	• Low Open Shrubland
Shrubs / Forbs	• *Atriplex vesicaria* (Bladder Saltbush) • *Enchylaena tomentosa* (Ruby Saltbush) • *Lycium australe* (Australian Boxthorn) • *Maireana sedifolia* (Bluebush) • *Maireana pyramidata* (Black Bluebush) • *Nitraria billardierei* (Nitre-bush) • *Rhagodia ulicina* (Intricate Saltbush) • *Sclerolaena patenticuspis* (Spear-fruit Bindyi)
Tall Shrubs	• *Alectryon oleifolius ssp. canescens* (Bullock Bush) (emergent species)
Trees	• None
Grasses	• *Austrostipa sp.* (Spear-grass)
Exotics	• **Carrichtera annua* (Ward's Weed)
Overall Condition	• 6:1 (some disturbance) with a native species diversity of 10.

4.1.3 Association 2 – *Disphyma crassifolium* (Round-leaf Pigface), *Sclerolaena patenticuspis* (Spear-fruit Bindyi), *Maireana enchylaenoides* (Wingless Fissure-plant), *Austrostipa* sp. (Spear Grass) Shrubland

Disphyma crassifolium (Round-leaf Pigface), *Sclerolaena patenticuspis* (Spear-fruit Bindyi), *Maireana enchylaenoides* (Wingless Fissure-plant), *Austrostipa* sp. (Spear Grass) Shrubland covers an estimated 82 ha or .7% of the total 11,647 ha. The association is considered to be highly degraded with such areas likely once dominated by *Atriplex vesicaria* (Bladder Saltbush) which has been removed by the long sheep grazing history. See Figure 27 for a representative photograph.



Figure 27. *Disphyma crassifolium* (Round-leaf Pigface), *Sclerolaena patenticuspis* (Spear-fruit Bindyi), *Maireana enchylaenoides* (Wingless Fissure-plant), *Austrostipa* sp. (Spear Grass) Shrubland association.

Table 21. Summary of Association 2.

Detail	Description
Dominant species	• *Disphyma crassifolium* (Round-leaf Pigface) • *Sclerolaena patenticuspis* (Spear-fruit Bindyi) • *Maireana enchylaenoides* (Wingless Fissure-plant) • *Austrostipa sp.* (Spear-grass)
Association type	• Chenopod Shrubland
Shrubs / Forbs	• *Goodenia sp.* (Goodenia) • *Atriplex vesicaria* (Bladder Saltbush) • *Disphyma crassifolium* (Round-leaf Pigface) • *Euphorbia tannensis* ssp. *eremophila* (Desert Spurge) • *Maireana enchylaenoides* (Wingless Fissure-plant) • *Maireana pyramidata* (Black Bluebush) • *Maireana sedifolia* (Bluebush) • *Sclerolaena patenticuspis* (Spear-fruit Bindyi) • *Sida sp.* (Sida) • *Zygophyllum apiculatum* (Pointed Twinleaf)
Tall Shrubs	• None
Trees	• None
Grasses	• *Austrodanthonia* sp. (Wallaby Grass) • *Austrostipa* sp. (Spear-grass)
Exotics	• **Carrichtera annua* (Ward's Weed)
Overall Condition	• 4:1 (moderate grazing disturbance) with a native species diversity of 13.

4.1.4 Association 3 – *Halosarcia pergranulata* (Black-seed Samphire), *Halosarcia* sp. (Samphire), Low Shrubland

Halosarcia pergranulata (Black-seed Samphire), *Halosarcia* sp. (Samphire) Low Shrubland covers an estimated 1,050 ha or 9% of the total 11,647 ha, typically located in low lying areas which may be at times inundated with water. The association has low species diversity, however small compact shrubs offer valuable refuge for fauna. See Figure 28 for a representative photograph.



Figure 28. *Halosarcia pergranulata* (Black-seed Samphire), *Halosarcia* sp. (Samphire), Low Shrubland association.

Table 22. Summary of Association 3.

Detail	Description
Dominant species	• *Halosarcia pergranulata* (Black-seed Samphire) • *Halosarcia* sp. (Samphire)
Association type	• Low Shrubland
Shrubs / Forbs	• *Atriplex vesicaria* (Bladder Saltbush) • *Disphyma crassifolium (*Round-leaf Pigface) • *Eremophila oppositifolia* (Opposite-leaved Emubush) (sparse) • *Frankenia* sp. (Sea-heath) • *Geijera linearifolia* (Sheep Bush) • *Halosarcia pergranulata* (Black-seed Samphire) • *Halosarcia* sp. (Samphire) • *Maireana oppositifolia* (Salt Bluebush) • *Rhagodia spinescens* (Spiny Saltbush)
Tall Shrubs	• None
Trees	• None
Grasses	• None
Exotics	• **Carrichtera annua* (Ward's Weed)
Overall Condition	• 6:1 (some disturbance) with a native species diversity of nine.

4.1.5 Association 4 – *Myoporum platycarpum* (False Sandalwood) Open Woodland

Myoporum platycarpum (False Sandalwood) Open Woodland covers an estimated 191 ha or 1.6% of the total 11,647 ha. Although dominated by *Myoporum platycarpum* (False Sandalwood) several other tree/tall shrub species are also present. Chenopod shrubs dominate the understorey. See Figure 29 for a representative photograph.



Figure 29. *Myoporum platycarpum* (False Sandalwood) Open Woodland association.

Table 23. Summary of Association 4.

Detail	Description
Dominant species	• *Myoporum platycarpum* (False Sandalwood)
Association type	• Open Woodland
Shrubs / Forbs	• *Enchylaena tomentosa* (Ruby Saltbush) • *Atriplex vesicaria* (Bladder Saltbush) • *Chenopodium desertorum* (Desert Goosefoot) • *Chenopodium* sp. (Goosefoot) • *Disphyma crassifolium* (Round-leaf Pigface) • *Lycium australe* (Australian Boxthorn) • *Maireana enchylaenoides* (Wingless Fissure-plant) • *Maireana sedifolia* (Bluebush) • *Rhagodia ulicina* (Intricate Saltbush) • *Scaevola spinescens* (Spiny Fanflower) • *Sclerolaena patenticuspis* (Spear-fruit Bindyi)
Tall Shrubs	• *Eremophila scoparia* (Broom Emubush)
Trees	• *Myoporum platycarpum* (False Sandalwood) • *Acacia oswaldii* (Umbrella Wattle)
Grasses	• *Austrostipa* sp. (Spear-grass) • *Aristida* sp. (Three-awn/Wire grass)
Exotics	• **Carrichtera annua* (Ward's Weed) • **Carthamus lanatus* (Saffron Thistle • **Medicago* sp. (Medic)
Overall Condition	• 6:1 (some disturbance) with a native species diversity of 11.

4.1.6 Association 5 – *Eucalyptus dumosa* (White Mallee), *Eucalyptus socialis* (Beaked Red Mallee) Mallee

Eucalyptus dumosa (White Mallee), *Eucalyptus socialis* (Beaked Red Mallee) Mallee is un-common within the Mullaquana survey area covering just 52 ha or 0.4% of the total 11,647 ha, and located along a minor drainage line in the southern region. This area may be considered an outlier of the mallee habitat further south within Munyaroo Conservation Park. See Figure 30 for a representative photograph.



Figure 30. *Eucalyptus dumosa* (White Mallee), *Eucalyptus socialis* (Beaked Red Mallee) Mallee association.

Table 24. Summary of Association 5.

Detail	Description
Dominant species	• *Eucalyptus dumosa* (White Mallee) • *Eucalyptus socialis* (Beaked Red Mallee)
Association type	• Mallee
Shrubs / Forbs	• *Atriplex vesicaria* (Bladder Saltbush) • *Eremophila scoparia* (Broom Emubush) • *Lycium australe* (Australian Boxthorn) • *Maireana pyramidata* (Black Bluebush) • *Maireana sedifolia* (Bluebush) • *Maireana* sp. (Bluebush) • *Nitraria billardierei* (Nitre-bush) • *Olearia pimeleoides* (Pimelea Daisy-bush) • *Pimelea microcephala* (Shrubby Riceflower) • *Ptilotus obovatus* var. *obovatus* (Silver Mulla Mulla) • *Salsola kali* (Buckbush) • *Santalum lanceolatum* (Plumbush) • *Scaevola spinescens* (Spiny Fanflower) • *Senna artemisioides ssp. coriacea* (Broad-leaf Desert Senna) • *Sida petrophila* (Rock Sida) • *Sida trichopoda* (High Sida) • *Zygophyllum apiculatum* (Pointed Twinleaf)
Tall Shrubs	• *Exocarpos aphyllus* (Leafless Cherry) • *Geijera linearifolia* (Sheep Bush) • *Acacia oswaldii* (Umbrella Wattle)
Trees	• *Eucalyptus dumosa* (White Mallee) • *Eucalyptus socialis* (Beaked Red Mallee)

Detail	Description
	• *Acacia papyrocarpa* (Western Myall)
Grasses	• *Aristida* sp. (Three-awn/Wire-grass) • *Austrodanthonia sp.* (Wallaby Grass) • *Austrostipa sp.* (Spear-grass)
Exotics	• **Carrichtera annua* (Ward's Weed) • **Carthamus lanatus* (Saffron Thistle) • **Marrubium vulgare* (Horehound) • **Sisymbrium* sp. (Wild Mustard) • **Solanum linnaeanum* (Apple Of Sodom)
Overall Condition	• 6:1 (some disturbance) with a native species diversity of 26.

4.1.7 Association 6 – *Acacia papyrocarpa* (Western Myall) Open Woodland

Acacia papyrocarpa (Western Myall) Open Woodland covers an estimated 2,7121 ha or 23% of the total 11,647 ha. Although dominated by *Acacia papyrocarpa* (Western Myall), several other tree/tall shrub species are also present. Chenopod shrubs dominate the understorey. See Figure 31 for a representative photograph.



Figure 31. *Acacia papyrocarpa* (Western Myall) Open Woodland association.

Table 25. Summary of Association 6.

Detail	Description
Dominant species	• *Acacia papyrocarpa* (Western Myall) • *Maireana sedifolia* (Bluebush)
Association type	• Open Woodland
Shrubs / Forbs	• *Enchylaena tomentosa* (Ruby Saltbush) • *Atriplex vesicaria* (Bladder Saltbush) • *Eremophila scoparia* (Broom Emubush) • *Lycium australe* (Australian Boxthorn) • *Maireana enchylaenoides* (Wingless Fissure-plant) • *Maireana sedifolia* (Bluebush) • *Rhagodia ulicina* (Intricate Saltbush) • *Scaevola spinescens* (Spiny Fanflower) • *Sclerolaena patenticuspis* (Spear-fruit Bindyi)
Tall Shrubs	• *Myoporum platycarpum* (False Sandalwood)
Trees	• *Acacia papyrocarpa* (Western Myall)
Grasses	• *Austrostipa* sp. (Spear-grass)
Exotics	• **Carrichtera annua* (Ward's Weed)
Overall Condition	• 6:1 (some disturbance) with a native species diversity of 12.

4.1.8 Association 7 – *Casuarina pauper* (Black Oak) Open Woodland

Casuarina pauper (Black Oak) Open Woodland covers an estimated 179 ha or 1.5% of the total 11,647 ha. Although dominated by *Casuarina pauper* (Black Oak) several other tree/tall shrub species are also present. Chenopod shrubs dominate the understorey. See Figure 32 for a representative photograph.



Figure 32. *Casuarina pauper* (Black Oak) Open Woodland association.

Table 26. Summary of Association 7.

Detail	Description
Dominant species	• *Casuarina pauper* (Black Oak)
Association type	• Open Woodland
Shrubs / Forbs	• *Atriplex vesicaria* (Bladder Saltbush) • *Enchylaena tomentosa* (Ruby Saltbush) • *Frankenia* sp. (Sea-heath) • *Lycium australe* (Australian Boxthorn) • *Maireana pyramidata* (Black Bluebush) • *Maireana sedifolia* (Bluebush) • *Rhagodia spinescens* (Spiny Saltbush) • *Sclerolaena patenticuspis* (Spear-fruit Bindyi)
Tall Shrubs	• *Alectryon oleifolius ssp. canescens* (Bullock Bush) • *Eremophila oppositifolia* (Opposite-leaved Emubush) • *Eremophila scoparia* (Broom Emubush) • *Exocarpos aphyllus* (Leafless Cherry)
Trees	• *Acacia papyrocarpa* (Western Myall) • *Casuarina pauper* (Black Oak)
Grasses	• *Austrodanthonia* sp.(Wallaby Grass) • *Austrostipa* sp. (Spear-grass)
Exotics	• **Mesembryanthemum crystallinum* (Common Iceplant)
Overall Condition	• 6:1 (some disturbance) with a native species diversity of 16.

4.1.9 Association 8 – *Senna artemisioides* ssp. *coriacea* (Broad-leaved Desert Senna), *Senna artemisioides* ssp. *petiolaris* (Desert Senna) Shrubland

Senna artemisioides ssp. *coriacea* (Broad-leaved Desert Senna), *Senna artemisioides* ssp. *petiolaris* (Desert Senna) Shrubland is not common within the Mullaquana area covering just 51 ha or 0.4% of the total 11,647 ha. Although dominated by *Senna artemisioides* ssp. *coriacea* (Broad-leaved Desert Senna) and *Senna artemisioides* ssp. *petiolaris* (Desert Senna), several other tree/tall shrub species are present. The association can be summarised as being Association 1, *Maireana sedifolia* (Bluebush), *Maireana pyramidata* (Black Bluebush), *Atriplex vesicaria* (Bladder Saltbush) Low Open Shrubland, with a *Senna* overstorey. See Figure 33 for a representative photograph.



Figure 33. *Senna artemisioides* ssp. *coriacea* (Broad-leaved Desert Senna), *Senna artemisioides* ssp. *petiolaris* (Desert Senna) Shrubland.

Table 27. Summary of Association 8.

Detail	Description
Dominant species	• *Senna artemisioides* ssp. *coriacea* (Broad-leaved Desert Senna) • *Senna artemisioides* ssp. *petiolaris* (Desert Senna)
Association type	• Low Open Shrubland
Shrubs / Forbs	• *Atriplex vesicaria* (Bladder Saltbush) • *Enchylaena tomentosa* (Ruby Saltbush) • *Lycium australe* (Australian Boxthorn) • *Maireana sedifolia* (Bluebush) • *Maireana pyramidata* (Black Bluebush) • *Nitraria billardierei* (Nitre-bush) • *Rhagodia ulicina* (Intricate Saltbush) • *Sclerolaena patenticuspis* (Spear-fruit Bindyi)
Tall Shrubs	• *Alectryon oleifolius* ssp. *canescens* (Bullock Bush) (emergent species)
Trees	• None
Grasses	• *Austrostipa* sp. (Spear-grass)
Exotics	• **Carrichtera annua* (Ward's Weed)
Overall Condition	• 6:1 (some disturbance) with a native species diversity of 11.

4.1.10 Association 9 – *Avicennia marina* ssp. *marina* (Grey Mangrove) Shrubland

Avicennia marina ssp. *marina* (Grey Mangrove) Shrubland does not occur within the Mullaquana study area and is situated closer to the shoreline. Although not within the study area, the associations presence within the wider area is of interest as fauna species reliant upon this habitat may also visit the habitats within the survey area. See Figure 34 (a and b) for a representative photograph.





Figure 34(a and b). *Avicennia marina* ssp. *marina* (Grey Mangrove) Shrubland association.

Table 28. Summary of Association 9.

Detail	Description
Dominant species	• *Avicennia marina* ssp. *marina* (Grey Mangrove)
Association type	• Open Shrubland
Shrubs / Forbs	• *Frankenia* sp. (Sea-heath) • *Suaeda australis* (Austral Seablite)
Tall Shrubs	• None
Trees	• None
Grasses	• None
Exotics	• None
Overall Condition	• 8:1 with a native species diversity of at least three at the time of the survey.

4.1.11 Association 10 – *Dodonaea viscosa* ssp. *angustissima* (Narrow-leaf Hop-bush), *Acacia oswaldii* (Umbrella Wattle), *Myoporum insulare* (Common Boobialla) Tall Shrubland

Dodonaea viscosa ssp. *angustissima* (Narrow-leaf Hop-bush), *Acacia oswaldii* (Umbrella Wattle), *Myoporum insulare* (Common Boobialla) Tall Shrubland does not occur within the Mullaquana study area and is situated closer to the shoreline. Although not within the study area, the associations presence within the wider area is of interest as fauna species reliant upon this habitat may also visit the habitats within the survey area. See Figure 35 for a representative photograph.



Figure 35. ***Dodonaea viscosa ssp. angustissima (Narrow-leaf Hop-bush), Acacia oswaldii (Umbrella Wattle), Myoporum insulare (Common Boobialla) Tall Shrubland*** **association.**

Table 29. Summary of Association 10.

Detail	Description
Dominant species	• *Dodonaea viscosa ssp. angustissima* (Narrow-leaf Hop-bush) • *Acacia oswaldii* (Umbrella Wattle) • *Myoporum insulare* (Common Boobialla)
Association type	• Tall Shrubland
Shrubs / Forbs	• *Beyeria lechenaultii* (Pale Turpentine Bush) • *Olearia axillaris* (Coast Daisy-bush) • *Rhagodia candolleana* (Sea-berry Saltbush) • *Scaevola spinescens* (Spiny Fanflower)
Tall Shrubs	• *Acacia oswaldii* (Umbrella Wattle) • *Alectryon oleifolius ssp. canescens* (Bullock Bush) • *Dodonaea viscosa ssp. angustissima* (Narrow-leaf Hop-bush) • *Myoporum insulare* (Common Boobialla) • *Myoporum platycarpum* (False Sandalwood)
Trees	• None
Grasses	• None
Exotics	• **Carpobrotus chilensis* (Angled Pigface)
Overall Condition	• 6:1 with a native species diversity of nine.

4.2 Flora species

In total 63 flora species were identified during the field survey, including 54 native species and nine exotic species (Appendix 4). *Atriplex vesicaria* (Bladder Saltbush) was the most widely distributed species, being recorded in eight of the ten vegetation associations. However this palatable species was not typically dominant, most likely due to a long sheep grazing history of the area. No species of national or state conservation significance were located.

4.2.1 Exotic species

Excluding planted species around the homesteads, nine exotic species were identified during the field survey (Table 30). *Marrubium vulgare* (Horehound) was the only declared species identified. This species was not common and only observed within a confined area of Association 5 *Eucalyptus dumosa* (White Mallee), *Eucalyptus socialis* (Beaked Red Mallee) Mallee. *Carrichtera annua* (Ward's Weed) (Figure 36) was the most widely distributed exotic species being present in seven of the ten vegetation associations. This unpalatable species is considered a serious weed of semi-arid rangelands (Cooke *et al.* 2004) commonly found in disturbed areas, especially areas degraded by overgrazing. This species appears to be taking over disturbed areas, such as the drilling sites, which will assist with limiting top soil erosion. In addition to *Carrichtera annua*, four other weeds considered to be environmental weeds but are not declared, were identified (Table 30). *Carthamus lanatus* (Saffron Thistle) appeared to be confined to vehicle tracks and heavily degraded areas with bare soil (such as around dams) (Figure 37). *Solanum linnaeanum* (Apple of Sodum) (Figure 38) was only noted as occurring within a confined area of Association 5 *Eucalyptus dumosa* (White Mallee), *Eucalyptus socialis* (Beaked Red Mallee) Mallee.

Table 30. Exotic species observed during the November 2009 survey.

Species	Common name	Declared weed	Environmental weed
**Carpobrotus chilensis*	Angled Pigface	No	No
**Carrichtera annua*	Ward's Weed	No	Yes
**Carthamus lanatus*	Saffron Thistle	No	Yes
**Marrubium vulgare*	Horehound	Yes	No
**Medicago* sp.	Medic	No	No
**Mesembryanthemum crystallinum*	Common Iceplant	No	Yes
**Salvia verbenaca*	Wild Sage	No	Yes
**Sisymbrium* sp.	Wild Mustard	No	No
**Solanum linnaeanum*	Apple Of Sodom	No	Yes



Figure 36. *Carrichtera annua* (Wards weed) dominating bare ground within degraded *Maireana* shrubland.



Figure 37. A healthy *Carthamus lanatus* (Saffron Thistle) near a dam.



Figure 38. *Solanum linnaenum* (Apple of Sodum) at Site 5 Association 5 *Eucalyptus dumosa* (White Mallee), *Eucalyptus socialis* (Beaked Red Mallee) Mallee habitat.

5 DISCUSSION

This report on the second phase Mullaquana fauna and flora assessment for Uranium SA has collected, analysed and presented baseline survey data necessary to assist with the environmental assessment process. The report has identified the eight main vegetation associations of the lease area and two immediately adjacent habitats of interest, mapped the location of these associations and provided a list of flora species found within each association. No vegetation associations of state or national conservation significance were identified. None of the 81 threatened flora species identified in the phase 1 initial desktop assessment (EBS 2009) as potentially occurring within the region were identified. Given the results of the field assessment conducted as part of this survey, it is considered highly unlikely that any threatened flora species are present. Nine exotic weed species were identified, including the declared Horehound (*Marribium vulgare*) which requires control and management under the *Natural Resources Management Act 2004*, as well as other weeds of environmental concern due to their current status or ability to degrade the habitats present.

The survey identified five native terrestrial mammal species present, and up to five bat species present. The results highlight the apparent lack of native rodent species, indicating such species are either present but in low abundance or have become locally extinct the area. Thirteen reptile species and two frog species were detected, and 41 native bird species observed.

Of the four conservation significant mammal species, four conservation significant reptile and 45 conservation significant bird species identified in the initial phase 1 desktop assessment (EBS 2009), two were observed during the field survey. The nationally Vulnerable Eastern Thick-billed Grasswren (*Amytornis textilis myall* and state Rare Striated Grasswren (*Amytornis striatus*) were both observed within the Mullaquana survey area. The Thick-billed Grasswren was observed at Site 1 amongst vegetation association 1, *Maireana sedifolia* (Bluebush), *Maireana pyramidata* (Black Bluebush) Low Open Shrubland habitat. This habitat covers an estimated 7,320 ha or 63% of the total 11,647 ha of the lease area. In addition, chenopod shrubland forms the understorey of nearly the entire survey area, consequently the species potentially has a widespread distribution in the area. The Striated Grasswren was observed at Site 3 amongst vegetation association 3, *Halosarcia* sp., *Tetracornia pergranulata* Low Shrubland and on the edges of Site 5 amongst vegetation association 5, *Eucalyptus dumosa* (White Mallee), *Eucalyptus socialis* (Beaked Red Mallee) Mallee habitat (2 individuals), as well as an additional opportunistic location. Together vegetation association 3 and vegetation association 5 cover approximately 1,102 ha, indicating that it is likely that over 1,102 ha of the area may be suitable for the Striated Grasswren. It must be noted that these are very broad habitat requirement assumptions, and at a finer scale other habitat elements may be necessary, thus the area of suitability may be much smaller.

Phase 1 of the Mullaquana fauna and flora project (EBS 2009) identified 24 EPBC listed migratory shorebirds (some of which are also conservation significant) that may be present within the lease area, either as temporary visitors or fly-over species. Access to shorelines was hampered by significant rainfall and reluctance to travel on saturated tracks. It is therefore considered that shorebirds have not been

adequately surveyed, and the presence of migratory shorebirds cannot be ruled out. It is therefore recommended that additional survey effort be completed focusing on shoreline habitats to identify bird species present (see 6 Recommendations).

6 RECOMMENDATIONS

To assist Uranium SA with understanding the potential impacts of further exploration and mining of the Mullaquana lease areas, and to assist with future applications, including an *Environment Protection and Biodiversity Conservation Act* referral necessary due to the presence and potential impact on the nationally Vulnerable Thick-billed Grasswren, further survey effort is recommended.

- Additional bird survey effort targeting habitat of the nationally Vulnerable Thick-billed Grasswren (*Amytornis textilis myall*). Such survey effort would enable a calculation of a population estimate based on the occupancy of habitats and abundance observed. This could then assist identifying the potential impact of future mining developments on the local population. Such information would be of benefit to the *EPBC* referral.
- Additional bird survey effort targeting shorelines and coastal sites immediately adjacent to the lease area. Although the lease area is located approximately 800 m inland, shorebirds may temporarily visit or at least fly over the lease area. Future development may therefore impact shorebird species through impacts as severe as direct habitat clearance, as well as visual barriers and deterrents, noise and vibration. The creation of additional dams (including tailings dams) or a change in water levels of existing dams may attract waterbirds to the lease area. It is necessary to conduct additional survey effort to identify any species of conservation significance that may be found in the wider area. Once the species present are identified, an assessment of potential impacts of future development can be ascertained. Migratory shorebirds are most likely to be present in the area in February, consequently surveys are recommended to be conducted during February.
- Should Uranium SA initiate exploration drilling in the southern portion of the lease area, including immediately north or south of Munyaroo Conservation Park, additional baseline sites should be surveyed for mammal, reptile, frog and bird species. Additional vegetation mapping and targeted threatened flora searches are also required. The current survey focuses on the habitats only of the northern portion, and is not considered an adequate representation of the southern habitats, particularly the areas dominated by mallee and dune habitats.

7 REFERENCES

Barker R.D., Vestjens W.J.M. (1990) *The Food of Australian Birds. 2. Passerines*. CSIRO, Melbourne.

Brooker M.G. (1988) Some aspects of the biology and conservation of the Thick-billed Grasswren *Amytornis textilis* in the Shark Bay area, Western Australia. *Corella* 12, 101-108.

Chapman G.S. (1996) The grasswrens: A brief pictorial. *Wingspan*. 6 20-27.

Cooke J., Ash J., Groves R. (2004) The ecology of Ward's Weed (*Carrichtera anna*): a weed of southern rangelands of Australia. *Ecological Society of Australia Annual Conference* 2004, Adelaide.

DEH (2008) *Biological Database Records of South Australia* (BDBSA). Department of Environment and Heritage, Adelaide.

DWLBC (2005) *Guidelines for a Native Vegetation Significant Environmental Benefit Policy. Department of Water*, Land, and Biodiversity Conservation, Adelaide.

EBS (2009) *Mullaquana Flora and Fauna Survey – Initial Assessment. Report to Uranium SA.* Environmental and Biodiversity Services, Adelaide.

Garnet S.T., Crowley G.M. (2000) *The action plan for Australian birds*. Environment Australia, Canberra.

Gee P., Gee I., Read J. (1996). An annotated bird list from the Davenport Range, South Australia. *South Australian Ornithologist*. 32: 76-81.

Grund, R. (2009) *A checklist of the butterflies to be found in South Australia and details of their conservation status*. Available from the South Australian Butterflies website http://users.sa.chariot.net.au/~rgrund/index.htm. Accessed Feb-2010.

Heard L., Channon B. (eds) (1997) *Guide to A Native Vegetation Survey Using the Biological Survey of South Australia*. Department of Housing and Urban Development, Adelaide.

Higgins P.J., Peter J.M., Steele W.K. (Eds) (2001) Handbook of Australian, New Zealand and Antarctic Birds. Volume 5: Tyrant-flycatchers to Chats. Oxford University Press.

Jessop J.P., Toelken H.R. (Eds) (1986) *Flora of South Australia Parts 1-4*. South Australian Government Printer, Adelaide.

Morcombe M. (2000) *Field Guide to Australian Birds*. Steve Parish Publishing, Archerfield.

Muir B.G. (1977) Biological Survey of the Western Australian Wheatbelt. Part 2: Vegetation and Habitat of Bendering Reserve. *Records of the Western Australian Museum*. Supplement No. 3. WA Museum, Perth.

Schodde R. (1982) *The Fairy-wrens: a Monograph of the Maluridae*. Lansdowne, Melbourne.

Serventy V.N. (Ed) (1982) *The Wrens and Warblers of Australia.* Angus and Robertson and the Australian Photographic Index of Australian Wildlife, Sydney.

Specht R.L. (1972) *The Vegetation of South Australia*. Government Printer, Adelaide.

APPENDICES

Appendix 1. Abundance of all species recorded during Point Counts (PC) and Opportunistically (OPP) during the Nov 09 survey of Mullaquana.

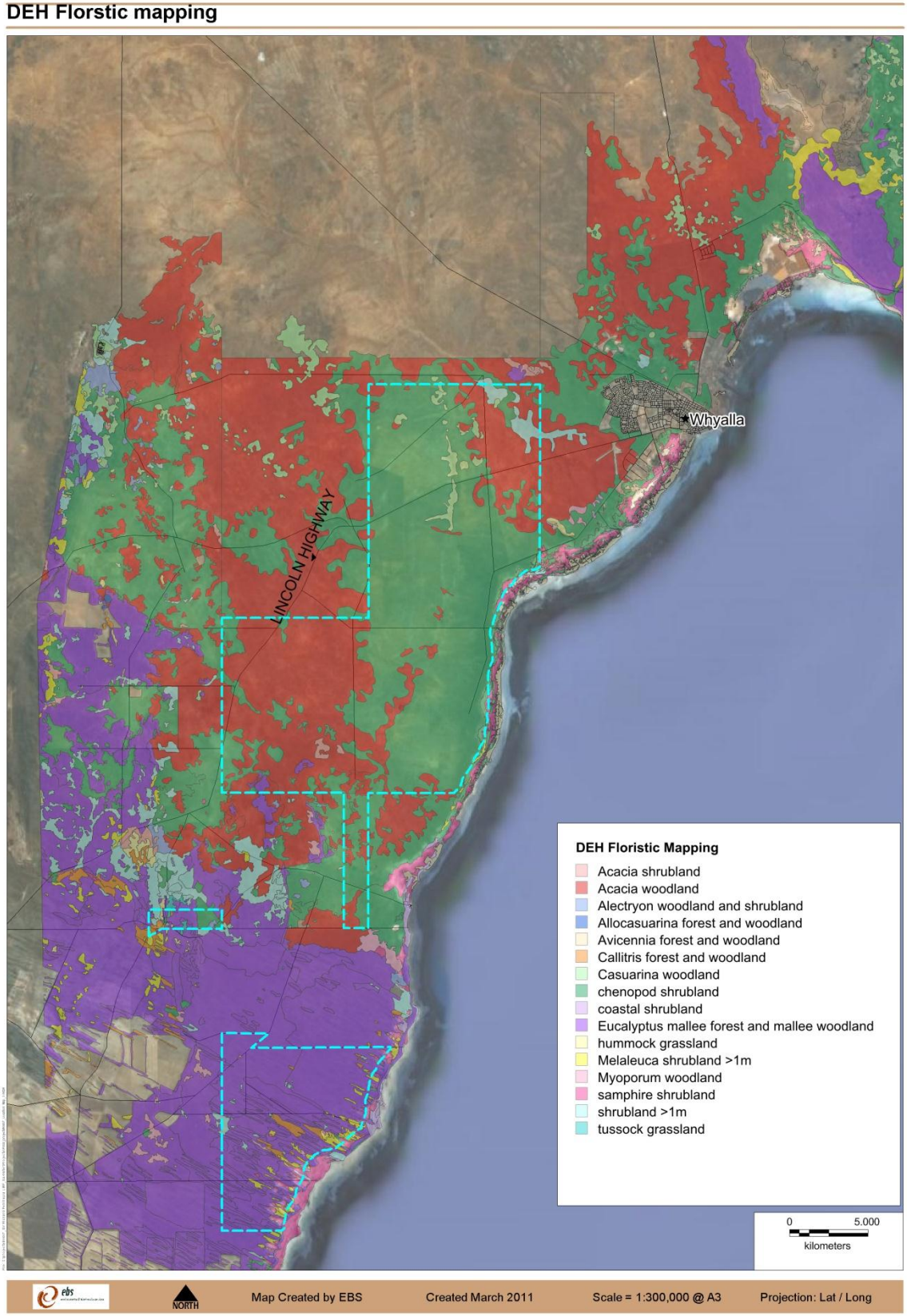
Species recorded OPP that were not seen during PC are highlighted in red.

Scientific name	Common name	PC	OPP	Totals	Aus status	SA status
Acanthagenys rufogularis	Spiny-cheeked Honeyeater	18	28	46		
Acanthiza chrysorrhoa	Yellow-rumped Thornbill	2		2		
**Alauda arvensis*	Eurasian Skylark	3		3		
Amytornis striatus	Striated Grasswren	12	1	13		R
Amytornis textilis myall	Thick-billed Grasswren	7		7	VU	
Anas gracilis	Grey Teal		2	2		
Anthus novaeseelandiae	Australasian Pipit	12		12		
Aquila audax	Wedge-tailed Eagle	4	3	7		
Artamus cinereus	Black-faced Woodswallow	3	5	8		
Barnardius zonarius	Australian Ringneck, (Ring-necked Parrot)	16		16		
Chroicocephalus novaehollandiae	Silver Gull		6	6		
Coracina novaehollandiae	Black-faced Cuckoo-shrike	4		4		
Corvus coronoides	Australian Raven	14	15	29		
Coturnix pectoralis	Stubble Quail		2	2		
Cracticus tibicen	Australian Magpie	13	3	16		
Cracticus torquatus	Grey Butcherbird	14	3	17		
Dromaius novaehollandiae	Emu	2	1	3		
Egretta novaehollandiae	White-faced Heron		1	1		
Eolophus roseicapillus	Galah	20	9	29		
Epthianura albifrons	White-fronted Chat		11	11		
Epthianura aurifrons	Orange Chat	65	15	80		
Epthianura tricolor	Crimson Chat	2	11	13		
Falco berigora	Brown Falcon	1	1	2		
Falco cenchroides	Nankeen Kestrel	20	3	23		
Falco longipennis	Australian Hobby		1	1		
Lalage sueurii	White-winged Triller		1	1		
Lichenostomus virescens	Singing Honeyeater	9		9		
Malurus lamberti	Variegated Fairy-wren	6		6		
Malurus leucopterus	White-winged Fairy-wren	19	2	21		
Malurus splendens	Splendid Fairy-wren	2	9	11		
Manorina flavigula	Yellow-throated Miner	12		12		
Manorina melanocephala	Noisy Miner	1		1		
Northiella haematogaster	Blue Bonnet	2	3	5		
Ocyphaps lophotes	Crested Pigeon	7	7	14		
Petrochelidon nigricans	Tree Martin		9	9		
Podargus strigoides	Tawny Frogmouth	2		2		

Scientific name	Common name	PC	OPP	Totals	Aus status	SA status
Pomatostomus superciliosus	White-browed Babbler	25	10	35		
Psephotus haematonotus	Red-rumped Parrot	1		1		
Rhipidura leucophrys	Willie Wagtail		9	9		
**Sturnus vulgaris*	Common Starling	8	40	48		
Tribonyx ventralis	Black-tailed Native-hen		2	2		
Vanellus miles	Masked Lapwing	2		2		
Vanellus tricolor	Banded Lapwing		44	44		
Abundance		328	257	585		
Species Diversity		32	30	43		

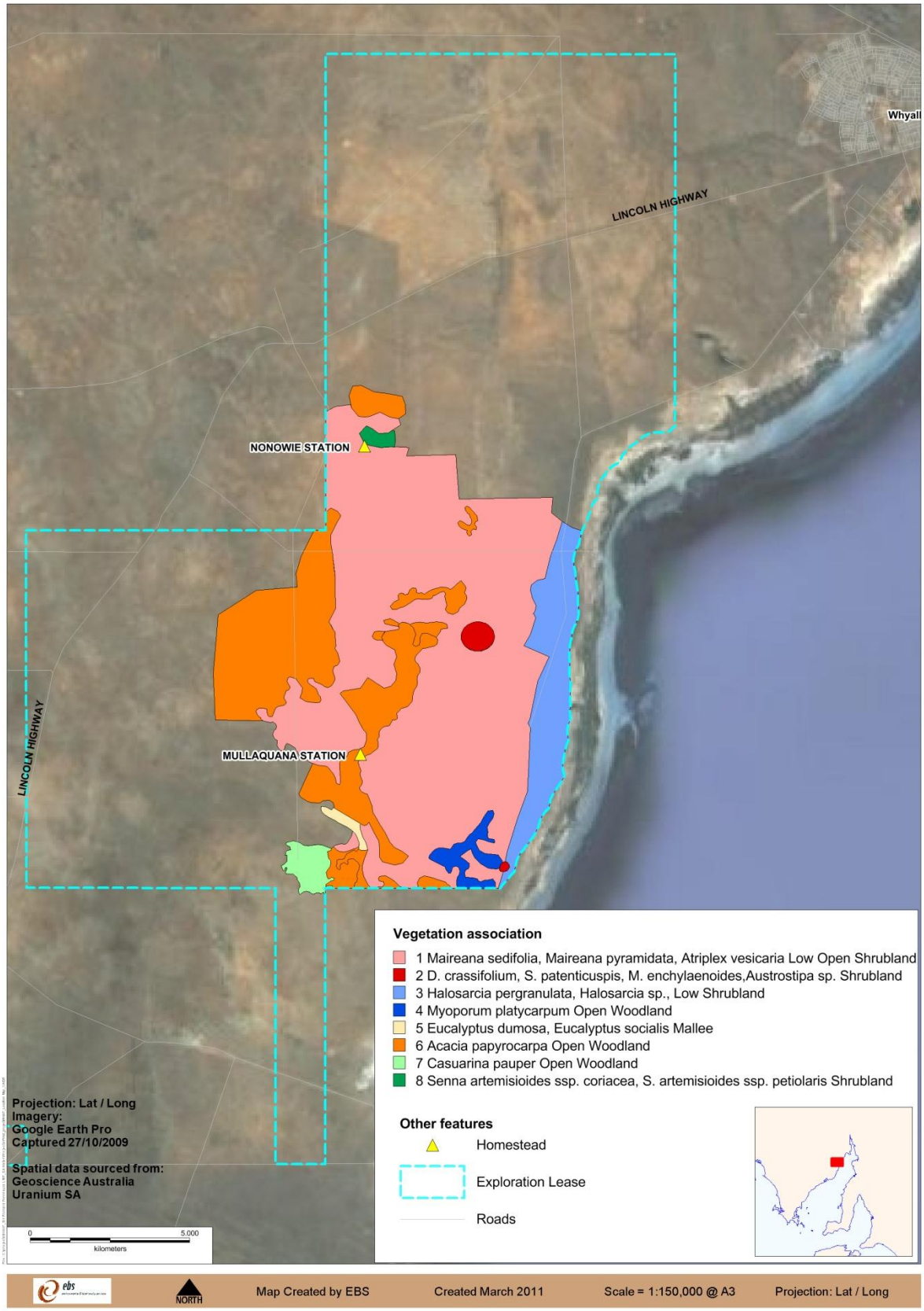
* = feral species.

Appendix 2. DEH floristic mapping of the Mullaquana and wider area.



Appendix 3. EBS floristic mapping November 2009.

EBS Vegetation mapping (2009)



Appendix 4. Flora species of the ten vegetation associations identified during the November 2009 survey.

Species	Common name	Vegetation Association									
		1	2	3	4	5	6	7	8	9	10
Acacia oswaldii	Umbrella Wattle				X	X					X
Acacia papyrocarpa	Western Myall					X	X	X			
Alectryon oleifolius ssp. *canescens*	Bullock Bush	X						X	X		X
Aristida sp.	Three-awn/Wire-grass					X					
Atriplex vesicaria	Bladder Saltbush	X	X	X	X	X	X	X	X		
Austrodanthonia sp.	Wallaby Grass		X			X		X			
Austrostipa sp.	Spear-grass	X	X		X	X	X	X	X		
Avicennia marina ssp. *marina*	Grey Mangrove									X	
Beyeria lechenaultii	Pale Turpentine Bush										X
Casuarina pauper	Black Oak							X			
Chenopodium desertorum	Desert Goosefoot				X						
Chenopodium sp.	Goosefoot				X						
Disphyma crassifolium	Round-leaf Pigface		X	X	X						
Dodonaea viscosa ssp. *angustissima*	Narrow-leaf Hop-bush										X
Enchylaena tomentosa	Ruby Saltbush	X			X		X	X	X		
Eremophila oppositifolia	Opposite-leaved Emubush			X				X			
Eremophila scoparia	Broom Emubush				X	X	X	X			
Eucalyptus dumosa	White Mallee					X					
Eucalyptus socialis	Beaked Red Mallee					X					
Euphorbia tannensis ssp. *eremophila*	Desert Spurge		X								
Exocarpos aphyllus	Leafless Cherry					X		X			
Frankenia sp.	Sea-heath			X				X		X	
Geijera linearifolia	Sheep Bush			X		X					
Goodenia sp.	Goodenia		X								
Halosarcia pergranulata	Black-seed Samphire			X							
Halosarcia sp.	Samphire			X							
Lycium australe	Australian Boxthorn	X			X	X	X	X	X		
Maireana enchylaenoides	Wingless Fissure-plant		X		X		X				
Maireana oppositifolia	Salt Bluebush			X							
Maireana pyramidata	Black Bluebush	X	X			X		X	X		
Maireana sedifolia	Bluebush	X	X		X	X	X	X	X		
Maireana sp.	Bluebush					X					
Myoporum insulare	Common Boobialla										X
Myoporum platycarpum	False Sandalwood				X		X				X
Nitraria billardierei	Nitre-bush	X				X			X		
Olearia axillaris	Coast Daisy-bush										X
Olearia pimeleoides	Pimelea Daisy-bush					X					
Pimelea microcephala	Shrubby Riceflower					X					
Ptilotus obovatus var. *obovatus*	Silver Mulla Mulla					X					
Rhagodia candolleana	Sea-berry Saltbush										X
Rhagodia spinescens	Spiny Saltbush			X				X			
Rhagodia ulicina	Intricate Saltbush	X			X		X		X		
Salsola kali	Buckbush					X					
Santalum lanceolatum	Plumbush					X					
Scaevola spinescens	Spiny Fanflower				X	X	X				X
Sclerolaena patenticuspis	Spear-fruit Bindyi	X	X		X		X	X	X		
Senna artemisioides ssp. *coriacea*	Broad-leaf Desert Senna					X			X		
Senna artemisioides ssp. *petiolaris*	Senna								X		

Species	Common name	Vegetation Association									
		1	2	3	4	5	6	7	8	9	10
Sida petrophila	Rock Sida					X					
Sida sp.	Sida		X								
Sida trichopoda	High Sida					X					
Suaeda australis	Austral Seablite									X	
Tetragonia sp.	False Spinach										X
Zygophyllum apiculatum	Pointed Twinleaf		X			X					
**Carpobrotus chilensis*	Angled Pigface										X
**Carrichtera annua*	Ward's Weed	X	X	X	X	X	X		X		
**Carthamus lanatus*	Saffron Thistle				X	X					
**Marrubium vulgare*	Horehound					X					
**Medicago* sp.	Medic				X						
**Mesembryanthemum crystallinum*	Common Iceplant							X			
**Salvia verbenaca*	Wild Sage								X		
**Sisymbrium* sp.	Wild Mustard					X					
**Solanum linnaeanum*	Apple Of Sodom					X					

* = exotic species.
X = species recorded within association.

Vegetation associations
1. *Maireana sedifolia* (Bluebush), *Maireana pyramidata* (Black Bluebush), *Atriplex vesicaria* (Bladder Saltbush) Low Open Shrubland
2. *Disphyma crassifolium* (Round-leaf Pigface), *Sclerolaena patenticuspis* (Spear-fruit Bindyi), *Maireana enchylaenoides* (Wingless Fissure-plant), *Austrostipa* sp. (Spear Grass) Shrubland
3. *Halosarcia pergranulata* (Black-seed Samphire), *Halosarcia* sp. (Samphire), Low Shrubland
4. *Myoporum platycarpum* (False Sandalwood) Open Woodland
5. *Eucalyptus dumosa* (White Mallee), *Eucalyptus socialis* (Beaked Red Mallee) Mallee
6. *Acacia papyrocarpa* Open Woodland
7. *Casuarina pauper* Open Woodland
8. *Senna artemisioides* ssp. *coriacea* (Broad-leaved Desert Senna), *Senna artemisioides* ssp. *petiolaris* (Desert Senna) Shrubland
9. *Avicennia marina* ssp. *marina* (Grey Mangrove) Shrubland
10. *Dodonaea viscosa ssp. angustissima (Narrow-leaf Hop-bush), Acacia oswaldii (Umbrella Wattle), Myoporum insulare* (Common Boobialla) Tall Shrubland



Environmental & Biodiversity Services

2/48 Barwell Avenue

Kurralta Park, SA 5037

www.ebservices.com.au

t. 08 7127 5607

f. 08 8297 3768

J2: Mullaquana Buffel Grass Survey. Report prepared for UraniumSA Ltd by EBS Ecology, December 2010.

Note: The following report was prepared for previous project owners and is marked as DRAFT, in absence of a finalised document, Alligator Energy consider this the FINAL version.

ebs ecology



Mullaquana
Buffel Grass Survey

Mullaquana Buffel Grass Survey

14th December 2010

Version 1

Prepared by EBS Ecology for UraniumSA

Document Control					
Revision No.	Date issued	Authors	Reviewed by	Date Reviewed	Revision type
1.0	14-Dec-2010	G. Glazier	S. O'Neill	14-Dec-2010	Draft

Distribution of Copies			
Revision No.	Date issued	Media	Issued to
1.0	14-Dec-2010	Electronic	A. Muir, UraniumSA

COPYRIGHT: Use or copying of this document in whole or in part (including photographs) without the written permission of EBS Ecology constitutes an infringement of copyright.

LIMITATION: This report has been prepared on behalf of and for the exclusive use of EBS Ecology's Client, and is subject to and issued in connection with the provisions of the agreement between EBS Ecology and its Client. EBS Ecology accepts no liability or responsibility whatsoever for or in respect of any use of or reliance upon this report by any third party.

CITATION: EBS Ecology (2010) *Mullaquana Buffel Grass Survey*. Report to UraniumSA. EBS Ecology, Adelaide.

Front cover photo: Low Chenopod Shrubland of the Mullaquana survey area.

ACKNOWLEDGMENTS

We would like to acknowledge and thank the following people for their assistance with the project:

- Alistair Muir, UraniumSA
- Julian Snook, UraniumSA.

The following EBS staff conducted the survey:

- Grant Glazier
- Serina Lattanzio.

The survey was undertaken under the following Department for Environment and Heritage permits:

- Permit to Undertake Scientific Research, permit no: Q25906-1

DRAFT

Table of Contents

1 INTRODUCTION 1

2 METHODS 3

2.1 Background research 3

2.2 Field survey 3

3 RESULTS 4

4 DISCUSSION 8

5 RECOMMENDATIONS 8

6 REFERENCES 9

7 APPENDIX 10

Appendix 1. Hygiene procedures to prevent the spread of weed species 10

Appendix 2. Log of major weed species identified during the Mullaquana November 2010 weed survey. 11

DRAFT

List of Tables

Table 1. Major weed species detected during the November 2010 Mullaquana project area. 4

List of Figures

Figure 1. Buffel Grass on the verge of the Stuart Highway, SA. 1

Figure 2. *Carthamus lanatus* (Saffron Thistle). 5

Figure 3. *Marrimbium vulgare* (Horehound), *Carthamus lanatus* (Saffron Thistle) and Nicotiana glauca (Tree Tobacco) (background) adjacent watering point. 5

Figure 4. Regenerating drill pad with *Carrichtera annua* (Wards Weed). 6

1 INTRODUCTION

EBS Ecology was contracted by UraniumSA to conduct an assessment on *Cenchrus ciliaris* (Buffel Grass) densities within the Mullaquana project area (covering tenements EL 3652 and EL 4242), near Whyalla, South Australia.

Buffel Grass is a deep-rooted tussock-forming perennial grass (SAALNRM 2009). The species is native to southern Asia and eastern Africa, and was introduced to Australia as a pasture species and for erosion control (Miller *et al.* 2010). The species is a highly invasive coloniser, displacing native species and creating dense monocultures, particularly within riparian habitats in arid and semi-arid habitats (SAALNRM 2009). Buffel Grass can alter ecosystems in the long-term, by significantly increasing fire fuel loads, fire intensity and fire frequency (Miller *et al.* 2010), which can have a devastating impact on the regeneration of native species, especially both flora and fauna species and communities not adapted to fire.

The distribution of Buffel Grass is largely in arid-areas that receive 100-550 mm of rainfall during the summer months, and less than 400 mm during the winter months (Cox *et al.* 1988). The species is a major weed in central and northern Australia, with known populations within northern South Australia, particularly in the far north-west. The species is thought to be extending in range, particularly along major inland rivers. Other known populations exist in remote areas where seed stock from attempted pasture plantings remain. The Mullaquana area is within the zone identified in the *South Australian Arid Lands Natural Resources Management Boards 2007-2012 Buffel Grass Management Plan* (Greenfield 2007) with potential scattered populations on pastoral properties.

DRAFT

Buffel Grass grows primarily during the summer months, and forms large dense tussocks. The seed heads are dense, white to purple in colour, and grow in spike-like raceme to 15 cm long covered in clusters of bristles giving a fluffy appearance (Figure 1) (SAALNRM 2009).



Figure 1. Buffel Grass on the verge of the Stuart Highway, SA.
Reproduced without permission (Greenfield 2007).

Buffel Grass is primarily spread through wind, water, attached to animal fur/wool and on vehicles and equipment. Early detection and control of Buffel Grass is vital to protect areas of native vegetation, as once the species becomes established it is difficult and costly to control.

The aim of this report is to summarise the results of a survey conducted throughout the Mullaquana project area to identify the presence, determine the level of infestation, and map the location of Buffel Grass. Recommendations for other early detection methods, and general weed hygiene practices are also included.

DRAFT

2 METHODS

2.1 Background research

A literature review was undertaken to determine key identification features allowing Buffel Grass to be distinguished from other grasses. The likely habitats where Buffel Grass is most likely to infest were also identified.

2.2 Field survey

The project area was surveyed over three days in November 2010. Due to the large size of the project area, EBS Ecology utilised a methodology which targeted areas most likely to have infestations, such as disturbance sites: the edges of tracks, stock yards, dams, water points and drainage lines. Field staff were equipped with ArcPad and GPS to record locations and infestation categories. GPS track routes were logged to record the search area.

Although Buffel Grass was the targeted weed species, to maximise the benefit of the survey, all major weed species were surveyed. Each weed infestation found was recorded as a point, line or polygon depending on the size and area of the infestation. The species and density were recorded. Additional notable landscape features (e.g. vegetation community in which it occurs, proximity to an adjacent track or drainage line). Due to the potential for damage to the environment, vehicles were not taken off existing tracks, therefore the survey area was limited to accessible tracks.

DRAFT

3 RESULTS

No Buffel Grass was detected during the November 2010 survey of the Mullaquana project area. However, 12 major weed species (Table 1) were recorded and their distribution and densities were mapped. In addition to the 12 major species, other species were noted, however due to the restraints of the survey, only the most abundant and aggressive weed species were recorded. The distribution of *Carrichtera annua* (Wards Weed) was not recorded as it is locally common within project area.

Table 1. Major weed species detected during the November 2010 Mullaquana project area.

Species name	Common name
Carthamus lanatus	Saffron Thistle
Marrimbium vulgare	Horehound
Rumex sp.	Dock
Lycium ferocissimum	African Boxthorn
Mesembryanthemum crystallinum	Ice Plant
Mesembryanthemum nodiflorum	Slender Ice Plant
Echium plantagineum	Salvation Jane
Asphodelus fistulosus	Onion Weed
Nicotiana glauca	Tree Tobacco
Hordeum vulgare	Barley Grass
Agave americana	Centuary Plant
Opuntia sp.	Prickly Pear

The most abundant weed species recorded during the survey was *Carthamus lanatus* (Saffron Thistle) (**Error! Reference source not found.**). This species was prevalent along all major access tracks and waterpoints indicating it is easily spread through vehicular and stock movement. *Marrimbium vulgare* (Horehound) (**Error! Reference source not found.**) was the second most abundant species, present along all major access tracks and waterpoints, although in lower densities than *Carthamus lanatus* (Saffron Thistle). *Mesembryanthemum crystallinum* (Ice Plant) and *Mesembryanthemum nodiflorum* (Slender Ice Plant) were also well identified, and were generally found adjacent to watering points and in several coastal locations. *Carrichtera annua* (Ward's Weed) was widely distributed, and noted as readily regenerating the drill-pads. Locations of the major weed infestations recorded during the survey are shown in Figure 5**Error! Reference source not found.**. See Appendix 1 for a log of all the major weed infestations recorded.



Figure 2. ***Carthamus lanatus*** **(Saffron Thistle).**



Figure 3. ***Marrimbium vulgare*** **(Horehound),** ***Carthamus lanatus*** **(Saffron Thistle) and Nicotiana glauca (Tree Tobacco) (background) adjacent watering point.**



Figure 4.Regenerating drill pad with *Carrichtera annua* (Wards Weed).

DRAFT

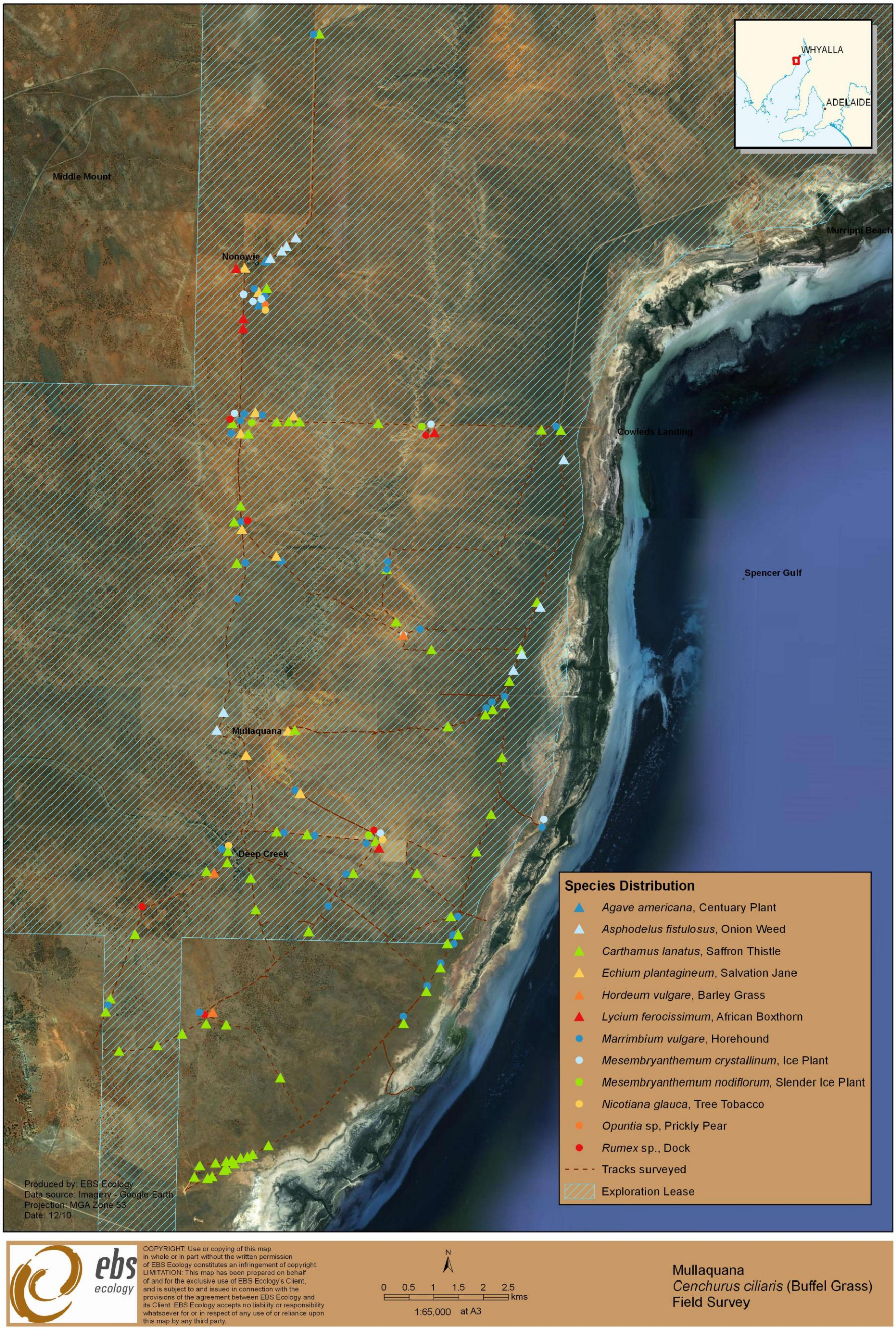


Figure 5. Location and distribution of the major weed species surveyed during the November 2010 survey.

4 DISCUSSION

Even though Buffel Grass was not located during the survey, its presence cannot be entirely discounted within the project area. Although the survey area was thoroughly searched, the survey was limited to designated readily accessible locations, primarily access tracks and watering points adjacent to access tracks. This being said it is highly unlikely this species was present within the project area at the time of the November 2010 survey.

5 RECOMMENDATIONS

Buffel Grass was not recorded during the current survey, however regular monitoring for possible outbreaks of this, and other invasive weed species should be undertaken on a regular basis. As exploration and development within the project area increases, it is likely external factors such as increased machinery and vehicular access will increase the risk of invasive weed species being introduced. Actions should be taken to minimise this threat through the implementation of a standardised hygiene policy. Recommendations for weed management within the Mullaquana project area:

- implementation of a hygiene policy for all vehicles entering project area (see Appendix 1 for general guidelines)
- establishment of a regular monitoring program targeting access tracks, laydown areas and associated infrastructure, for outbreaks of all potential invasive weed species.

DRAFT

6 REFERENCES

Greenfield, B. (2007) *SA Arid Lands Buffel Grass Management Plan,* DRAFT. South Australian Arid Lands Natural Resource Management Board, Port Augusta.

Miller G., Friedel M., Adam P., Chewings, V. (2010) Ecological impacts of Buffel Grass (Cenchrus ciliaris) invasion in central Australia – does field evidence support a fire-invasion feedback? *The Rangeland Journal* 32, 353-365.

Richardson FJ., Richardson RG., Shepherd RCH. (2007) *Weeds of the South-east*. Everbest Printing.

South Australian Arid Lands Natural Resource Management Board (2009) *Buffel Grass Pest Management Fact Sheet.* Government of South Australia, Port Augusta.

DRAFT

7 APPENDIX

Appendix 1. Hygiene procedures to prevent the spread of weed species

In order to restrict or prevent further spread of weeds already present and the introduction of new weeds into sites a number of procedures should be observed.

Cleaning of all vehicles and machinery

- All vehicles and machinery should be inspected for the presence of vegetative material prior to entering project area. If vegetative material present entry should be refused until item is cleaned.
- Undertake hygiene procedures at specifically designed onsite facilities, if available. If no specific facility is available, choose a portion of the infested site or a suitable laydown area to undertake hygiene procedures and contain vegetative material to this location.

Mechanical – brushes, brooms, crowbars and rods may be used to remove mud, soil and seeds from equipment and vehicles.

Air – compressed air may be used to remove mud, soil and seeds from equipment and vehicles.

Water – wash down equipment and vehicles with water from hose, high pressure spray equipment or bucket and brush. Make sure vegetative material is contained then discarded in an appropriate manner.

DRAFT

Appendix 2. Log of major weed species identified during the Mullaquana November 2010 weed survey.

UTM WGS 84 (53 H)		Species	Common name	Number of individuals	Size of patch	Disturbance type	Comment
Easting	Northing						
726642	6328966	*Carthamus lanatus*	Saffron Thistle	3		Major track	Main Gate, Cowards landing
726642	6328966	*Marrimbium vulgare*	Horehound	1		Major track	Main Gate, Cowards landing
726324	6328974	*Carthamus lanatus*	Saffron Thistle		5m x 1m	Major track	
724017	6328906	*Rumex sp.*	Dock		2m x 2m	Watering point	
724017	6328906	*Lycium ferocissimum*	African Boxthorn	1		Watering point	
724017	6328906	*Mesembryanthemum crystallinum*	Ice Plant		50m x 50m	Watering point	
724017	6328906	*Mesembryanthemum nodiflorum*	Slender Ice Plant		50m x 50m	Watering point	
723020	6329041	*Carthamus lanatus*	Saffron Thistle		<25m2	Major track	
721430	6329074	*Carthamus lanatus*	Saffron Thistle		26 - 50m2	Major track	
721430	6329074	*Echium plantagineum*	Salvation Jane		26 - 50m2	Major track	
721159	6329082	*Carthamus lanatus*	Saffron Thistle		<25m2	Major track	
721052	6329082	*Carthamus lanatus*	Saffron Thistle	6 to 10		Major track	
720591	6329092	*Mesembryanthemum nodiflorum*	Slender Ice Plant		100 x 100m2	Watering point	
720591	6329092	*Echium plantagineum*	Salvation Jane		<25m2	Watering point	
720591	6329092	*Marrimbium vulgare*	Horehound		20 x 20m2	Watering point	
720248	6329095	*Marrimbium vulgare*	Horehound		<25m2	Major track	
720248	6329095	*Echium plantagineum*	Salvation Jane		<25m2	Major track	

UTM WGS 84 (53 H)		Species	Common name	Number of individuals	Size of patch	Disturbance type	Comment
Easting	Northing						
720219	6329079	*Echium plantagineum*	Salvation Jane		<25m2	Major track	
720219	6329079	*Marrimbium vulgare*	Horehound		<25m2	Major track	
720219	6329079	*Carthamus lanatus*	Saffron Thistle		<25m2	Major track	
720253	6328835	*Echium plantagineum*	Salvation Jane		<25m2	Major track	
720253	6328835	*Marrimbium vulgare*	Horehound		<25m2	Major track	
720253	6328835	*Carthamus lanatus*	Saffron Thistle		<25m2	Major track	
720247	6327387	*Carthamus lanatus*	Saffron Thistle		<25m2	Major track	
720264	6327060	*Marrimbium vulgare*	Horehound		50m x 50m	Watering point	
720264	6327060	*Carthamus lanatus*	Saffron Thistle		50m x 50m	Watering point	
720264	6327060	*Rumex sp.*	Dock		50m x 50m	Watering point	
720278	6326904	*Echium plantagineum*	Salvation Jane		<25m2	Watering point	
720327	6326231	*Marrimbium vulgare*	Horehound		<25m2	Major track	
720327	6326231	*Carthamus lanatus*	Saffron Thistle		<25m2	Major track	
720191	6325509	*Marrimbium vulgare*	Horehound		<25m2	Major track	
719905	6323230	*Asphodelus fistulosus*	Onion Weed	2 to 5		Major track	
719767	6322859	*Asphodelus fistulosus*	Onion Weed		<25m2	Major track	
720362	6322357	*Echium plantagineum*	Salvation Jane	6 to 10		Major track	
720006	6320539	*Nicotiana glauca*	Tree Tobacco	1		Drainage line	
720006	6320539	*Marrimbium vulgare*	Horehound	>20		Drainage line	

UTM WGS 84 (53 H)		Species	Common name	Number of individuals	Size of patch	Disturbance type	Comment
Easting	Northing						
720004	6320443	*Carthamus lanatus*	Saffron Thistle	11 to 20		Major track	
719982	6320196	*Carthamus lanatus*	Saffron Thistle	6 to 10		Major track	
719708	6319986	*Hordeum vulgare*	Barley Grass		<25m2	Major track	
719708	6319986	*Carthamus lanatus*	Saffron Thistle		<25m2	Major track	
718269	6319311	*Rumex sp.*	Dock		26 x 50m	Watering point	
718127	6318756	*Carthamus lanatus*	Saffron Thistle		<25m2	Minor track	
717625	6317455	*Carthamus lanatus*	Saffron Thistle		<25m2	Minor track	
717573	6317326	*Marrimbium vulgare*	Horehound		<25m2	Minor track	
717573	6317326	*Carthamus lanatus*	Saffron Thistle		<25m2	Minor track	
717799	6316403	*Carthamus lanatus*	Saffron Thistle		<25m2	Minor track	
718564	6316512	*Carthamus lanatus*	Saffron Thistle		<25m2	Minor track	
719031	6316744	*Carthamus lanatus*	Saffron Thistle		<25m2	Minor track	
719518	6317129	*Rumex sp.*	Dock		50m x 50m	Watering point	
719518	6317129	*Hordeum vulgare*	Barley Grass		50m x 50m	Watering point	
719518	6317129	*Marrimbium vulgare*	Horehound		50m x 50m	Watering point	
719518	6317129	*Carthamus lanatus*	Saffron Thistle		50m x 50m	Watering point	
721639	6318793	*Carthamus lanatus*	Saffron Thistle		<25m2	Minor track	
721973	6319324	*Marrimbium vulgare*	Horehound		26 x 50m	Major track	
722514	6319980	*Carthamus lanatus*	Saffron Thistle		<25m2	Minor track	

UTM WGS 84 (53 H)		Species	Common name	Number of individuals	Size of patch	Disturbance type	Comment
Easting	Northing						
722514	6319980	*Marrimbium vulgare*	Horehound		<25m2	Minor track	
722962	6320631	*Carthamus lanatus*	Saffron Thistle		100 x 20m2	Minor track / dam	
722962	6320631	*Marrimbium vulgare*	Horehound		100 x 20m2	Minor track / dam	
722969	6320632	*Lycium ferocissimum*	African Boxthorn	1		Watering point	
722994	6320694	*Nicotiana glauca*	Tree Tobacco	11 to 20		Watering point	
722994	6320694	*Marrimbium vulgare*	Horehound		50m x 50m	Watering point	scattered around dam
722994	6320694	*Rumex sp.*	Dock		50m x 50m	Watering point	scattered around dam
722994	6320694	*Carthamus lanatus*	Saffron Thistle		50m x 50m	Watering point	scattered around dam
722994	6320694	*Mesembryanthemum nodiflorum*	Slender Ice Plant		50m x 50m	Watering point	scattered around dam
722994	6320694	*Mesembryanthemum crystallinum*	Ice Plant		50m x 50m	Watering point	scattered around dam
721445	6321596	*Marrimbium vulgare*	Horehound		50m x 50m	Watering point	scattered around dam
721445	6321596	*Echium plantagineum*	Salvation Jane		50m x 50m	Watering point	scattered around dam
721733	6320743	*Marrimbium vulgare*	Horehound		<25m2	Minor track	
721733	6320743	*Carthamus lanatus*	Saffron Thistle		<25m2	Minor track	
721126	6320797	*Marrimbium vulgare*	Horehound		<25m2	Minor track	
721126	6320797	*Carthamus lanatus*	Saffron Thistle		<25m2	Minor track	
723518	6317099	*Marrimbium vulgare*	Horehound		<25m2	Minor track	
723518	6317099	*Carthamus lanatus*	Saffron Thistle		<25m2	Minor track	

UTM WGS 84 (53 H)		Species	Common name	Number of individuals	Size of patch	Disturbance type	Comment
Easting	Northing						
721033	6315860	*Carthamus lanatus*	Saffron Thistle	2 to 5		Minor Track	
719960	6316943	*Carthamus lanatus*	Saffron Thistle		<25m2	Minor Track	
720545	6319252	*Carthamus lanatus*	Saffron Thistle	2 to 5		Minor track	
720445	6319884	*Carthamus lanatus*	Saffron Thistle	2 to 5		Minor track	
724614	6319107	*Marrimbium vulgare*	Horehound		<25m2	Minor track	intersection with major track
724614	6319107	*Carthamus lanatus*	Saffron Thistle		<25m2	Minor track	intersection with major track
724518	6318733	*Marrimbium vulgare*	Horehound		<25m2	Minor track	
724518	6318733	*Carthamus lanatus*	Saffron Thistle		<25m2	Minor track	
724501	6318671	*Marrimbium vulgare*	Horehound		<25m2	Minor track	
724501	6318671	*Carthamus lanatus*	Saffron Thistle		<25m2	Minor track	
724281	6318173	*Marrimbium vulgare*	Horehound	2 to 5		Minor track	
724281	6318173	*Carthamus lanatus*	Saffron Thistle		<25m2	Minor track	
724004	6317709	*Marrimbium vulgare*	Horehound	2 to 5		Minor track	
724004	6317709	*Carthamus lanatus*	Saffron Thistle	6 to 10		Minor track	
723973	6317658	*Carthamus lanatus*	Saffron Thistle		<25m2	Minor track	
720805	6314499	*Carthamus lanatus*	Saffron Thistle		<25m2	Minor track	
720485	6314323	*Carthamus lanatus*	Saffron Thistle		<25m2	Minor track	
720388	6314271	*Carthamus lanatus*	Saffron Thistle		<25m2	Minor track	
720128	6314130	*Carthamus lanatus*	Saffron Thistle		<25m2	Minor track	

UTM WGS 84 (53 H)		Species	Common name	Number of individuals	Size of patch	Disturbance type	Comment
Easting	Northing						
719967	6314031	*Carthamus lanatus*	Saffron Thistle		<25m2	Minor track	
719916	6314000	*Carthamus lanatus*	Saffron Thistle		<25m2	Minor track	
719673	6313871	*Carthamus lanatus*	Saffron Thistle		<25m2	Minor track	
719576	6313836	*Carthamus lanatus*	Saffron Thistle		26 x 50m	Drainage line	
719320	6313862	*Carthamus lanatus*	Saffron Thistle		26 x 50m	Minor track	
719421	6314093	*Carthamus lanatus*	Saffron Thistle		50m x 50m	Watering point	
719742	6314144	*Carthamus lanatus*	Saffron Thistle	11 to 20		Minor track	
719960	6314179	*Carthamus lanatus*	Saffron Thistle		<25m2	Minor track	
720072	6314203	*Carthamus lanatus*	Saffron Thistle		<25m2	Minor track	
720250	6314243	*Carthamus lanatus*	Saffron Thistle		<25m2	Minor track	
724994	6320419	*Carthamus lanatus*	Saffron Thistle		<25m2	Minor track	
723796	6319980	*Carthamus lanatus*	Saffron Thistle		<25m2	Minor track	
725293	6321172	*Carthamus lanatus*	Saffron Thistle	11 to 20		Major track	
726352	6321010	*Mesembryanthemum crystallinum*	Ice Plant		50m x 50m	Minor track	sand quarry
726352	6321010	*Marrimbium vulgare*	Horehound	2 to 5		Minor track	sand quarry
725504	6322315	*Carthamus lanatus*	Saffron Thistle	>20		Major track	
725558	6323544	*Marrimbium vulgare*	Horehound		<25m2	Major track	
725558	6323544	*Carthamus lanatus*	Saffron Thistle		<25m2	Major track	

UTM WGS 84 (53 H)		Species	Common name	Number of individuals	Size of patch	Disturbance type	Comment
Easting	Northing						
725309	6323428	*Marrimbium vulgare*	Horehound		<25m2	Major track	
725309	6323428	*Carthamus lanatus*	Saffron Thistle		<25m2	Major track	
725194	6323309	*Marrimbium vulgare*	Horehound		<25m2	Major track	
725194	6323309	*Carthamus lanatus*	Saffron Thistle		<25m2	Major track	
724420	6322930	*Carthamus lanatus*	Saffron Thistle		<25m2	Major track	
721200	6322846	*Echium plantagineum*	Salvation Jane	1		Watering point	
721200	6322846	*Carthamus lanatus*	Saffron Thistle		<25m2	Watering point	
725655	6323848	*Carthamus lanatus*	Saffron Thistle		<25m2	Major track	
725735	6324073	*Asphodelus fistulosus*	Onion Weed		<25m2	Major track	
725879	6324490	*Carthamus lanatus*	Saffron Thistle		26 x 50m	Major track	
725879	6324490	*Asphodelus fistulosus*	Onion Weed		26 x 50 m	Major track	
726216	6325450	*Carthamus lanatus*	Saffron Thistle		<25 m^2	Major track	
726216	6325450	*Asphodelus fistulosus*	Onion Weed		<25m^2	Major track	
726700	6328340	*Asphodelus fistulosus*	Onion Weed		26 x 50 m	Major track	
723209	6326252	*Marrimbium vulgare*	Horehound	2 to 5		Minor track	
723186	6326100	*Carthamus lanatus*	Saffron Thistle	>20		Minor track	
723186	6326100	*Marrimbium vulgare*	Horehound	6 to 10		Minor track	
723374	6325045	*Carthamus lanatus*	Saffron Thistle	>20		Minor track	
723517	6324776	*Carthamus lanatus*	Saffron Thistle		100 x 100 m^2	Watering point	heavy weed infestation around dam, significant other weed species present

UTM WGS 84 (53 H)		Species	Common name	Number of individuals	Size of patch	Disturbance type	Comment
Easting	Northing						
723517	6324776	*Rumex sp.*	Dock		100 x 100 m^2	Watering point	
723517	6324776	*Mesembryanthemum crystallinum*	Ice Plant		100 x 100m^2	Watering point	
723517	6324776	*Hordeum vulgare*	Barley Grass		100 x 100m^2	Watering point	
723858	6324895	*Marrimbium vulgare*	Horehound		<25 m^2	Minor track	
724096	6324487	*Carthamus lanatus*	Saffron Thistle		<25 m^2	Minor track	
721076	6326243	*Marrimbium vulgare*	Horehound		<25 m^2	Major track	
721076	6326243	*Echium plantagineum*	Salvation Jane		<25 m^2	Major track	
720220	6329122	*Marrimbium vulgare*	Horehound		<25 m^2	Major track	
720220	6329122	*Mesembryanthemum crystallinum*	Ice Plant		<25 m^2	Major track	
720220	6329122	*Rumex sp.*	Dock		<25 m^2	Major track	
720299	6330950	*Lycium ferocissimum*	African Boxthorn	1		Major track	
720303	6331155	*Lycium ferocissimum*	African Boxthorn	2		Major track	
720312	6331642	*Marrimbium vulgare*	Horehound		<25 m^2	Major track	
720312	6331642	*Mesembryanthemum crystallinum*	Ice Plant		<25 m^2	Major track	
720606	6331688	*Echium plantagineum*	Salvation Jane		<25 m^2	Major track	
720606	6331688	*Marrimbium vulgare*	Horehound		<25 m^2	Major track	
720606	6331688	*Carthamus lanatus*	Saffron thistle		<25 m^2	Major track	

UTM WGS 84 (53 H)		Species	Common name	Number of individuals	Size of patch	Disturbance type	Comment
Easting	Northing						
720619	6331437	*Agave americana*	Centuary Plant		<25 m^2	Dump	
720619	6331437	*Marrimbium vulgare*	Horehound		26 x 50 m	Dump	
720619	6331437	*Opuntia sp*	Prickly Pear		<25 m^2	Dump	
720619	6331437	*Mesembryanthemum crystallinum*	Ice Plant		26 x 50 m	Dump	
720661	6331548	*Opuntia sp*	Prickly Pear		<25 m^2	Dump	
720661	6331548	*Mesembryanthemum crystallinum*	Ice Plant		26 x 50 m	Dump	
720661	6331548	*Nicotiana glauca*	tree tobacco		<25 m^2	Dump	
720334	6332173	*Echium plantagineum*	Salvation Jane	1		Major track	
720334	6332173	*Lycium ferocissimum*	African Boxthorn	1		Major track	
720751	6332320	*Agave americana*	Centuary Plant		<25 m^2	Major track	
720844	6332370	*Asphodelus fistulosus*	Onion Weed	>20		Major track	
721075	6332522	*Echium plantagineum*	Salvation Jane	>20		Major track	
721075	6332522	*Asphodelus fistulosus*	Onion Weed	>20		Major track	
721176	6332613	*Asphodelus fistulosus*	Onion Weed	>20		Major track	
721362	6332782	*Echium plantagineum*	Salvation Jane	>20		Major track	
721362	6332782	*Asphodelus fistulosus*	Onion Weed	>20		Major track	
721835	6336886	*Carthamus lanatus*	Saffron thistle	>20		Major track	
721835	6336886	*Marrimbium vulgare*	Horehound	>20		Major track	



EBS Ecology

4/48 Barwell Avenue

Kurralta Park, SA 5037

www.ebsecology.com.au

t. 08 7127 5607

f. 08 8297 3768

J3: Mullaquana Follow-up Flora and Fauna Survey, November 2010. Report prepared for UraniumSA Ltd by EBS Ecology, February 2011.



Mullaquana

Follow-up Flora and Fauna Survey

November 2010

Mullaquana Follow-up Flora and Fauna Survey November 2010

2 FEBRUARY 2011

Version 2

Prepared by EBS Ecology for UraniumSA

Document Control					
Revision No.	Date issued	Authors	Reviewed by	Date Reviewed	Revision type
1	11-Jan-2011	S. O'Neill, G. Glazier, A. Derry	T. How	10-Jan-2011	First draft
2	2-Feb-2011	S. O'Neill, G. Glazier, A. Derry	T. How	2-Feb-2011	Final draft

Distribution of Copies			
Revision No.	Date issued	Media	Issued to
1	11-Jan-2011	Electronic	A. Muir, UraniumSA
2	2-Feb-2011	Electronic	A. Muir, UraniumSA

COPYRIGHT: Use or copying of this document in whole or in part (including photographs) without the written permission of Environmental and Biodiversity Services constitutes an infringement of copyright.

LIMITATION: This report has been prepared on behalf of and for the exclusive use of Environmental and Biodiversity Services Client, and is subject to and issued in connection with the provisions of the agreement between Environmental and Biodiversity Services and its Client. Environmental and Biodiversity Services accepts no liability or responsibility whatsoever for or in respect of any use of or reliance upon this report by any third party.

CITATION: EBS Ecology (2010) *Mullaquana Follow-up Flora and Fauna Survey, November 2010.* Report to UraniumSA. EBS Ecology, Adelaide.

Front cover photo: *Tecticornia pergranulata* ssp. (Black-seed Samphire) Shrubland, Mullaquana, November 2010.

ebs ecology

ACKNOWLEDGEMENTS

We would like to acknowledge and thank the following people for their assistance with the project:

- Alistair Muir, UraniumSA
- Julian Snook, UraniumSA
- Mark Hutchinson, Carolyn Kovach and David Stemmer, South Australian Museum, for advice on mammal and reptile identification
- Terry Reardon, South Australian Museum, for identification of the bat echolocation calls.

The following EBS staff conducted the survey:

- Sally O'Neill (Survey Co-ordinator)
- Alison Derry
- Grant Glazier
- Serina Lattanzio.

The survey was undertaken under the following Department of Environment and Natural Resources permits:

- Permit to Undertake Scientific Research, permit no: Q25906-1
- Wildlife Ethics Committee: Approval of a Project Involving Animals, app. no. 10/2008.

ABBREVIATIONS AND ACRONYMS

BDBSA	Biological Databases of South Australian (managed by DENR)
DEH	Department of Environment and Heritage (now known as DENR)
DENR	Department of Environment and Natural Resources (Government of South Australia)
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth legislation)
NPW Act	National Parks and Wildlife Act 1972 (South Australian legislation)
NRM	Natural Resources Management
PIRSA	Primary Industries and Resources South Australia (Government of South Australia)
SEB	Significant Environmental Benefit
SEWPaC	Department of Sustainability, Environment, Water, Population and Communities
ssp.	subspecies
sp.	species (singular)
spp.	species (plural)

EXECUTIVE SUMMARY

This report presents the findings of a flora and fauna baseline survey conducted by EBS on behalf of UraniumSA within Mullaquana and Nonowie pastoral leases, and exploration tenements EL3542, EL4242 and EL3652, in November 2010. This survey is a follow-up to the baseline surveys conducted within the Mullaquana project area in November 2009 and targeted bird surveys conducted in February 2010.

The field survey established flora monitoring sites within representative vegetation communities, distributed across the project area landscape, and collected data on the flora species diversity, community structure, abundance and percentage cover of native and exotic vascular plant species. The diversity, abundance and distribution of exotic weeds was examined. The species diversity, community structure, abundance and distribution of native and exotic fauna species was also examined. The project area was broadly assessed to identify areas of suitable habitat for two nationally threatened bird species, the Thick-billed Grasswren (*Amytornis textilis myall*) and Slender-billed Thornbill (*Acanthiza iredalei iridalei*).

Eighty-nine native flora species, four terrestrial native mammal species, 19 reptiles, one frog, and 60 native bird species were recorded. At least three bat species utilise the project area, with call analysis suggesting another four species may also be found.

Two bird species listed under the *Environment Protection and Biodiversity Conservation Act 1999* were observed. The nationally vulnerable Thick-billed Grasswren (*Amytornis textilis myall*) was recorded in low abundance, and the Slender-billed Thornbill (*Acanthiza iredalei iredalei)* in relatively high abundance. Abundance levels of both species is consistent with the previous surveys conducted. Three species of South Australian conservation significance listed under the *National Parks and Wildlife Act 1972* were also recorded. These were the Little Egret (*Egretta garzetta*), Sooty Oystercatcher (*Haematopus fuliginosus*), and Striated Grasswren (*Amytornis striatus*).

Recommendations highlighted in this report primarily focus on identifying the core habitat areas of the Thick-billed Grasswren and Slender-billed Thornbill, as well as continuing with annual monitoring of vegetation and fauna communities by replicating the methods, techniques, and sites established during the current survey.

Table of contents

1 INTRODUCTION 1

1.1 Aim and objectives 1

2 BACKGROUND INFORMATION 3

2.1 Location 3

2.2 Previous surveys 3

3 METHODS 4

3.1 Survey approach and site selection 4

3.1.1 Fauna 4

3.1.2 Vegetation 4

3.2 Fauna communities 7

3.2.1 Trapping 7

3.2.2 Opportunistic observations 7

3.2.3 Bat call recording 8

3.2.4 Spotlighting 8

3.2.5 Bird surveys 8

3.2.6 Identification and nomenclature 9

3.2.7 Weather encountered during the field survey 10

3.3 Vegetation communities and species abundance 10

3.3.1 Community composition and cover abundance 12

3.3.2 Perennial species abundance 13

3.3.3 Condition 13

3.4 Survey limitations 13

3.4.1 Fauna 13

3.4.2 Flora 14

4 FAUNA RESULTS 15

4.1 Site locations 15

4.2 Survey adequacy 15

4.3 Mammals 16

4.3.1 Terrestrial mammals 16

4.3.2 Bats 17

4.4 Reptiles 19

4.5 Frogs 23

4.6 Birds 24

4.6.1 Threatened bird habitat assessment and targeted surveys 30

5 FLORA RESULTS 35

5.1 Native species 35

5.1.1 Diversity 35
5.1.2 Species distribution 36
5.1.3 Conservation significant species 37
5.2 Exotic weeds 37
5.2.1 Diversity 37
5.2.2 Species distribution and abundance 39
5.3 Vegetation monitoring sites 40
5.3.1 Vegetation Site 1 40
5.3.2 Vegetation Site 2 42
5.3.3 Vegetation Site 3 44
5.3.4 Vegetation Site 4 46
5.3.5 Vegetation Site 5 48
5.3.6 Vegetation Site 6 50
5.3.7 Vegetation Site 7 52
5.3.8 Vegetation Site 8 54
5.3.9 Vegetation Site 9 56
5.3.10 Vegetation Site 10 58

6 DISCUSSION 60
6.1 Flora and fauna communities of Mullaquana 60
6.2 Conservation significant birds 60
6.2.1 Thick-billed Grasswren 60
6.2.2 Slender-billed Thornbill 61
6.2.3 Threatened bird habitat assessment 61
6.2.4 Little Egret 61
6.2.5 Sooty Oystercatcher 61

7 RECOMMENDATIONS 63

8 REFERENCES 65

9 APPENDICES 67

Appendix 1. Survey site co-ordinates 67
Appendix 2. Native Vegetation Council SEB Ratio table. 69
Appendix 3. Example bat calls (as viewed in AnaLook) recorded during the November 2010 survey. 72
Appendix 4. Flora species recorded in the 100 x 100 m quadrats and/or Jessup transects during the November 2010 survey. 75
Appendix 5. Distribution of weed species recorded during the November 2010 survey. 80
Appendix 6. Flora species and percentage cover category recorded within the 100 x 100 m quadrats at each vegetation site, November 2010. 81
Appendix 7. Flora species abundance recorded within the Jessup transects, November 2010. 84

List of tables

Table 1. Trap effort conducted during the November 2010. 7
Table 2. Weather conditions recorded for Whyalla during the field survey. 10
Table 3. Scale used to assign flora species cover abundance. 12
Table 4. Vegetation associations of the fauna and bird survey sites. 15
Table 5. Terrestrial mammal species detected during the November 2009 and 2010 field survey. 16
Table 6. Number of mammal captures and observations during the field survey. 17
Table 7. Bat species detected during the November 2010 field survey. 18
Table 8. Bat species identified as occurring with the project area as identified through call identification. 19
Table 9. Reptile species detected during the November 2009 and 2010 field survey. 20
Table 10. Number of reptile captures and observations during the field survey. 21
Table 11. Frog species detected during the November 2009 and 2010 survey. 23
Table 12. Site abundance of frog observations during the November 2009 and 2010 surveys. 23
Table 13. Bird species detected during the November 2009 baseline survey, February 2010 targeted survey, and the current survey November 2010 follow-up survey. 25
Table 14. Number of bird observations during the bird surveys, and site species abundance recorded during the November 2010 survey. 27
Table 15. Threatened bird observations during the November 2010 survey. 29
Table 16. Weed species recorded during the November 2010 survey and maximum cover abundance recorded (all sites combined). 37
Table 17. Vegetation Site 1 flora summary, November 2010. 40
Table 18. Vegetation Site 2 flora summary, November 2010. 42
Table 19. Vegetation Site 3 flora summary, November 2010. 44
Table 20. Vegetation Site 4 flora summary, November 2010. 46
Table 21. Vegetation Site 5 flora summary, November 2010. 48
Table 22. Vegetation Site 6 flora summary, November 2010. 50
Table 23. Vegetation Site 7 flora summary, November 2010. 52
Table 24. Vegetation Site 8 flora summary, November 2010. 54
Table 25. Vegetation Site 9 flora summary, November 2010. 56
Table 26. Vegetation Site 10 flora summary, November 2010. 58

List of figures

Figure 1. Location of the five fauna sites and three bird monitoring sites, established in 2009 and re-surveyed in November 2010. 5
Figure 2. Location of the ten vegetation monitoring sites established and surveyed in November 2010. 6
Figure 3. Example Slender-billed Thornbill habitat, Bird Site 15, used as a guide when creating the habitat assessment criteria. 9
Figure 4. Vegetation monitoring site layout indicating the position of the 100 m x 100 m quadrat and 100 m x 4 m transect. 11
Figure 5. Short (60 cm) star dropper indicating a corner of a 100 m x 100 m quadrat. 11
Figure 6. Wooden peg indicating the photo monitoring point location, and 1.8 m star dropper indicating the start of the 100 m Jessup transect. 12
Figure 7. Little Long-tailed Dunnart (Sminthopsis dolichura) caught at Site 5 during the November 2010 survey. 16
Figure 8. Ranges Stone Gecko (*Diplodactylus furosus*). 22
Figure 9. Spotted Ctenotus (*Ctenotus orientalis*). 22
Figure 10. Hooded Scaly-foot (*Pygopus schraderi*). 22
Figure 11. Nankeen Kestrel (*Falco cenchroides*) chicks on a nest at Site 5. 24
Figure 12. Slender-billed Thornbill observed within the Mullaquana project area in November 2010. 30

Figure 13. Location of sites surveyed for birds (survey sites and opportune locations) from the November 2009, February 2010 and November 2009 surveys, and location of the Slender-bill Thornbill and Thick-billed Grasswren observations. 31
Figure 14. Habitat assessed as suitable for the threatened birds (located between Bird Site 15 and dam). 32
Figure 15. Habitat assessed as suitable for the threatened birds, and confirmed suitable with the observation of both the Thick-billed Grasswren and Slender-billed Thornbill. 32
Figure 16. Potentially suitable threatened bird habitat located 1 km from Nonowie Station, adjacent to the track. 33
Figure 17. Potentially suitable habitat at Moonabie Station (outside the Mullaquana project area). 33
Figure 18. Habitat considered not suitable for the threatened bird species, located close to the boundary of Mullaquana and Nonowie Stations (within the Mullaquana project area). 34
Figure 19. Native species site diversity, November 2010. 35
Figure 20. Native species family diversity recorded during the November 2010 survey. 36
Figure 21. Frequency distribution of native species. 36
Figure 22. *Marrubium vulgare* (Horehound). 38
Figure 23. *Anagallis arvensis* (Pimpernel). 38
Figure 24. Exotic weed species family diversity recorded during the November 2010 survey. 38
Figure 25. Exotic flora diversity recorded during the November 2010 survey. 39
Figure 26. Frequency distribution of exotic species. 39
Figure 27. Site monitoring photograph – Vegetation Site 1, November 2010. 41
Figure 28. Site monitoring photograph – Vegetation Site 2, November 2010. 43
Figure 29. Site monitoring photograph – Vegetation Site 3, November 2010. 45
Figure 30. Site monitoring photograph – Vegetation Site 4, November 2010. 47
Figure 31. Site monitoring photograph – Vegetation Site 5, November 2010. 49
Figure 32. Site monitoring photograph – Vegetation Site 6, November 2010. 51
Figure 33. Site monitoring photograph – Vegetation Site 7, November 2010. 53
Figure 34. Site monitoring photograph – Vegetation Site 8, November 2010. 55
Figure 35. Site monitoring photograph – Vegetation Site 9, November 2010. 57
Figure 36. Site monitoring photograph – Vegetation Site 10, November 2010. 59

1 INTRODUCTION

EBS Ecology was contracted by UraniumSA to conduct a fauna and flora survey as a follow-up to the baseline surveys conducted within the Mullaquana project area in November 2009. The baseline surveys were conducted in three phases: 1) desktop assessment, 2) field flora and fauna survey, 3) follow-up targeted bird survey. The desktop assessment identified the likely vegetation communities of the project area, as well as the flora and fauna species whose distribution falls within the area. The field surveys mapped the vegetation communities, defined overall habitat quality, surveyed to confirm the species present at the time of the survey, and assessed the likelihood of significant species utilising the area at other times of the year.

As a follow-up, EBS were contracted to build upon the baseline surveys by re-surveying the fauna sites and incorporating a wider search area to target significant birds species and their preferred habitats. This follow-up also involves the establishment of permanent flora monitoring sites to document the current condition of the vegetation communities, detail the flora species present, the abundance of key perennial flora species, and cover-abundance of all vascular plant species. These surveys will aid documenting the flora and fauna communities of UraniumSA's Mullaquana project in the exploration phase prior to greater levels of disturbance with the anticipated commencement of an in-situ recovery field trial in 2011.

1.1 Aim and objectives

The aim of this report is to present the information collected during the follow-up survey, document the data collected, and discuss the vegetation and fauna communities of the project area in their present state.

Objectives of the follow-up flora and fauna survey are to:

- establish flora monitoring sites within representative vegetation communities, distributed across the project area landscape, with a key emphasis on the communities most likely to be impact by future works
- collect data on the flora species diversity, community structure, abundance, and percentage cover of native and exotic vascular plant species, of each monitoring site
- identify the diversity, abundance, and distribution of exotic weed species within the project area
- collect data on the fauna species diversity, community structure, abundance, and distribution of native and exotic fauna species
- assess the habitat suitability both within and adjacent to the project area for the nationally threatened bird species, the Thick-billed Grasswren (*Amytornis textilis myall*) and Slender-billed Thornbill (*Acanthiza iredalei iridalei*)
- survey any additional sites either within and adjacent to the project area identified as being of suitable habitat for the threatened bird species.

Objectives of this follow-up survey report are therefore to:

- summarise the vegetation communities within the project area, and detail information on the species diversity, community structure, abundance, and percentage cover of native and exotic vascular plant species
- map the location of all monitoring sites
- provide photographs as a photographic record of the sites
- summarise the fauna communities within the project area, and detail information on the species diversity, community structure, abundance and distribution of fauna species
- identify and discuss the fauna species known to occur within the project area
- assess key habitats of significant fauna species known to occur within the project area, or species that are considered likely to occupy the area intermittently
- discuss the habitat suitability as an indication of likely distribution of the Thick-billed Grasswren and Slender-bill Thornbill.

2 BACKGROUND INFORMATION

2.1 Location

Mullaquana is located on Eyre Peninsula, South Australia, approximately 20 km south-west of the town of Whyalla. The project lies within the Mullaquana and Nonowie pastoral leases, and exploration tenements EL3542, EL4242 and EL3652 held by UraniumSA. Cowled's Landing, a small shack community, is located adjacent to the lease area, and recreational activities, such as motorbike riding appears to occur within the vicinity. Munyaroo Conservation Park (12,340 ha) is located to the south and shares a boundary with the EL's.

2.2 Previous surveys

The results of the desktop assessment are reported in *Mullaquana Flora and Fauna Survey – Initial Assessment* (EBS 2009) which includes detailed background information on the environmental landscape and biodiversity of the area. Results of the baseline survey are reported in *Mullaquana Baseline Flora and Fauna Survey* (EBS Ecology 2010), while the results targeted bird survey are presented in the *Mullaquana Follow-up Bird Surveys February 2010* (EBS Ecology). The combined results of the November 2009 baseline survey, and February 2010 targeted bird surveys, recorded 63 flora species (57 native, nine exotic), ten vegetation associations (eight within the project area, and two immediately adjacent), eight mammal species (five native and 3 exotic), 14 reptile species, and 57 bird species (55 native and two exotic).

No flora species or vegetation associations of conservation significance were identified as occurring within the survey area. No mammal, reptile or frog species of conservation significance were observed, or are likely to inhabit the area. Two bird species of national conservation significance listed under the EPBC Act, the vulnerable Eastern Thick-billed Grasswren (*Amytornis textilis myall*) and Slender-billed Thornbill (*Acanthiza iredalei iredalei*), were observed. Two species of South Australian conservation significance under the NPW Act were recorded. These were the rare Striated Grasswren (*Amytornis striatus*), and Shy Hylacola (*Hylacola cauta*). No EPBC Act listed migratory bird species were recorded in the baseline survey, and just one, the Great Egret (*Ardea alba*), was observed in the follow-up bird surveys. Despite this, the habitats of the area, particularly those adjacent to the shoreline, were considered likely to be suitable for visiting migratory species.

3 METHODS

3.1 Survey approach and site selection

The field survey was conducted using the methodologies of the *Biological Survey Method of South Australia* (Owens 2000; Heard and Channon 1997) as a guide. These methods are intended for baseline surveys to obtain a snapshot of the range of vegetation communities and floristic associations, and the types of mammals, reptiles and birds present. This is information builds an understanding of the natural environments of the Mullaquana project area. As the development of Mullaquana expands, the potential for impacts to the natural environment, including and flora and fauna community structure, increases. The field survey program was designed to obtain a baseline understanding during the early phases of exploration and development, and then convert to a monitoring program, where detailed data examines how the environment is potentially changing as a result of the mine developments. The current survey expands on the baseline data, and set-ups the vegetation sites intended for long-term monitoring implementing standardised, repeatable methods and techniques.

3.1.1 Fauna

The desktop and initial assessment completed under phase one of the project (EBS 2009) and baseline survey conducted in November 2009 identified the vegetation associations of the project area, and from this the number of fauna sites necessary to cover a representative sample of the area was identified. Five fauna sites were surveyed during the baseline survey, and three of the fauna sites and an additional 15 bird sites were surveyed in the follow-up bird survey in February 2010. The current survey re-surveyed all five of the fauna sites and three of the bird survey sites (Figure 1).

3.1.2 Vegetation

A rapid assessment conducted in the first few days of the current follow-up survey confirmed suitable locations of the vegetation monitoring sites to be established. In total, ten vegetation sites were established during the current survey (Figure 2). Five vegetation sites were established at the existing fauna sites (Fauna Sites 1-5). For the purposes of vegetation monitoring, these sites are referred to as Vegetation Sites 1-5. Two vegetation sites were also established at bird sites (Bird Site 15 and Bird Site 6), which are referred to as Vegetation Site 7 and Vegetation Site 9. One additional site was established in close proximity to the proposed developments to replicate and strengthen the dataset of any potential impacts of the proposed developments. This is Vegetation Site 10. Two sites were selected to replicate the main habitats potentially to be impacted by the proposed developments but are located at distance relatively far from the proposed developments and thus are intended to act as controls in the future allowing comparisons to sites close in proximity to the impacts to sites at a further distance. These control sites are referred to as Vegetation Site 6 (located just south of the lease area) and Vegetation Site 8 (in the northern section of the lease area near Cowled's Landing).

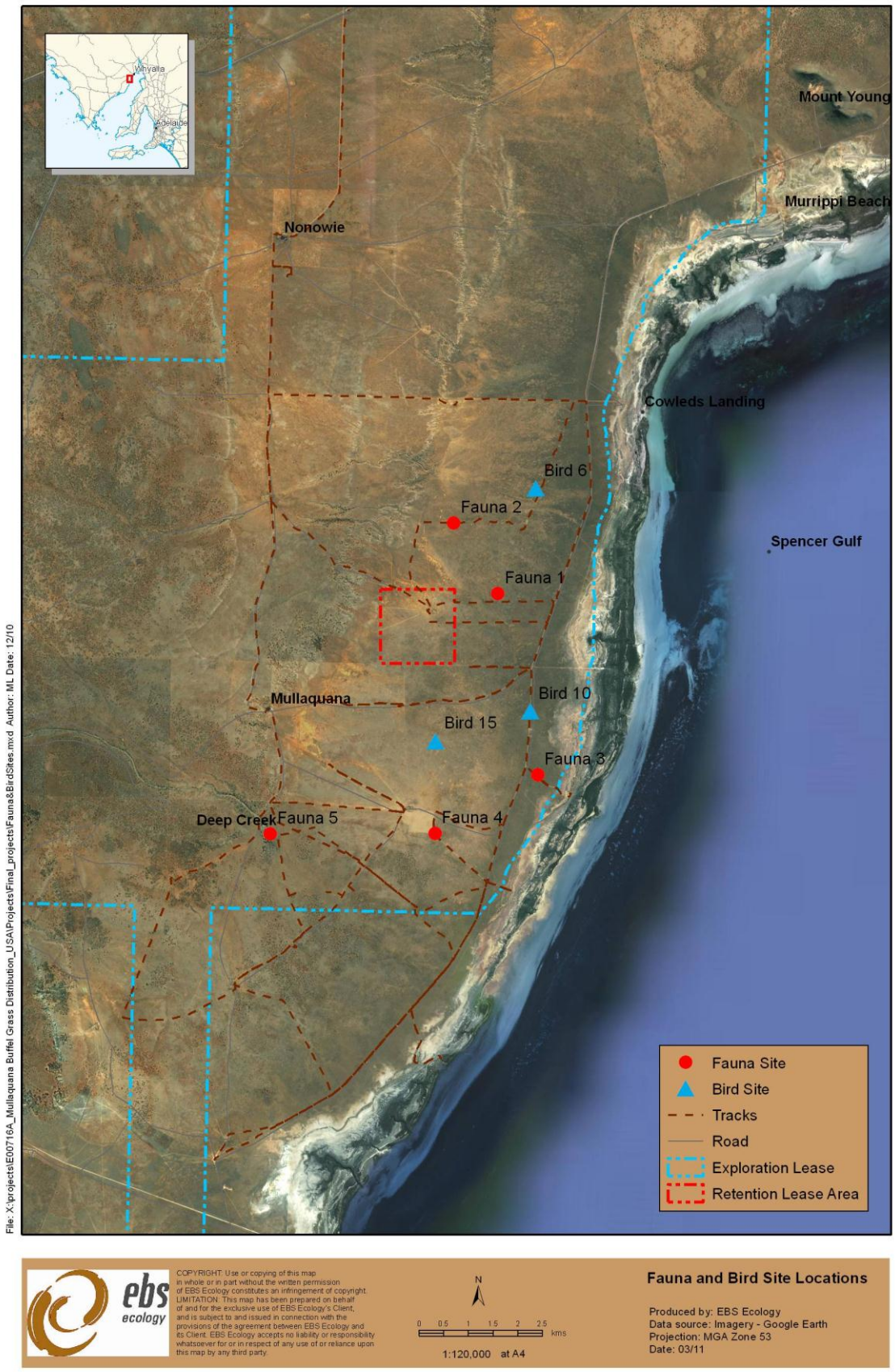


Figure 1. Location of the five fauna sites and three bird monitoring sites, established in 2009 and re-surveyed in November 2010.

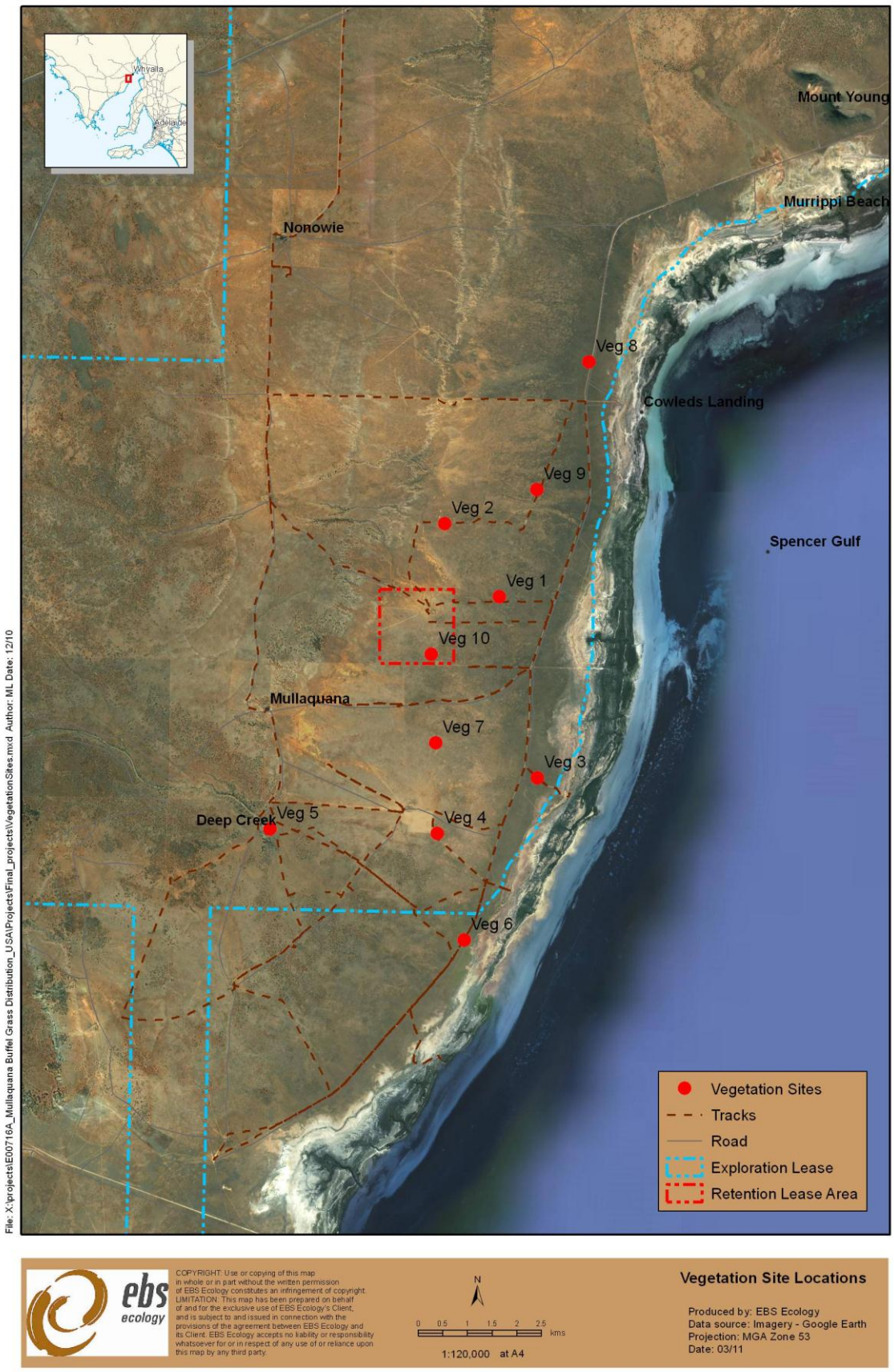


Figure 2. Location of the ten vegetation monitoring sites established and surveyed in November 2010.

3.2 Fauna communities

3.2.1 Trapping

Trapping followed the Biological Survey methodology for vertebrate surveys (Owens 2000) with the addition of funnel traps. Five survey sites were re-established (lidded pitfalls were in situ from previous baseline survey). Two trap lines positioned approximately 200 m apart were installed at each site. Each line consisting of six pitfall traps (140 mm diameter, 400 mm deep, placed at 10 m intervals), 15 medium Elliott traps (Elliott Scientific, Upwey Vic.; type A, 330 mm long, 100 mm high, 90 mm wide, treadle plate operated), two cage traps (Sheffield Wire Products, Welshpool WA, 550 mm long, 220 mm wide, 220 mm high, trip plate mechanism), and four funnel traps (WA Poultry, Sheffield, Western Australia; 77 cm long, 17 cm wide, 17 cm high) were installed at each of the five fauna sites. All traps were open for four consecutive nights, with Elliott and cage traps closed during the day to avoid animal distress in the heat of the day.

A harp trap was erected at two of the sites with trees present, Fauna Site 4 and Fauna Site 5, to target bats flying amongst the canopy.

Trap effort summary

A total of 240 pitfall, 300 Elliott, 80 cage, 160 funnel, and four harp trap nights were conducted during the survey. Survey effort was equal across the five sites. Fauna Site 1 and Fauna Site 2 were trapped from the 5th November 2010 (traps set) to the 9th November 2010 (traps closed). Fauna Sites 3-5 were trapped from the 6th November (traps set) to the 10th November 2010 (traps closed).

Table 1. Trap effort conducted during the November 2010.

Effort detail	Site 1	Site 2	Site 3	Site 4	Site 5
No. nights surveyed	4	4	4	4	4
No. pits per site	12	12	12	12	12
Total pitfall effort for 4 nights	*48*	*48*	*48*	*48*	*48*
No. Elliott's per site	30	30	30	30	30
Total Elliott effort for 4 nights	*120*	*120*	*120*	*120*	*120*
No. cages per site	4	4	4	4	4
Total cage effort for 4 nights	*16*	*16*	*16*	*16*	*16*
No. funnels per site	8	8	8	8	8
Total funnel effort for 4 nights	*32*	*32*	*32*	*32*	*32*
Total trap effort	**216**	**216**	**216**	**216**	**216**

3.2.2 Opportunistic observations

Field surveyors recorded all fauna observations while on-site. For each observation, the species, location (GPS waypoint), date, number of individuals, and broad habitat type was recorded. Presence of tracks, nests, scats, diggings and burrows (identified to species level if possible) were also recorded as opportune observations.

3.2.3 Bat call recording

A passive bat survey was conducted using AnaBat's (Titley Electronics, Ballina NSW) to record bat ultrasonic echolocation calls. A single Anabat detector was used at each of the five fauna trapping sites for one night. Recorded bat echolocation calls were analysed by Terry Reardon (South Australian Museum expert) using AnalookW and compared with known reference calls for the region held by the SA Museum.

3.2.4 Spotlighting

Two hours was spent active searching with spotlights. Two teams of two observers conducted a start-stop walk using two hand-held 100 watt spotlights and head torches. Surveyors scanned the ground, small shrubs, and lifted small branches to look for ground dwelling fauna, and scanned shrubs and trees for birds. Mild and windy conditions experienced during the survey limited the amount of spotlight effort able to be conducted.

3.2.5 Bird surveys

Standardised surveys

Standardised bird surveys were conducted at the five fauna sites (Sites 1-5) and bird sites (Sties 6, 10 and 15) (site naming follows that of the baseline survey and follow-up bird survey conducted in November 2009). See Figure 1 for site locations, and Appendix 1 for co-ordinates. Each site was surveyed for 60 minutes in the morning and 60 minutes in the afternoon. The repeat visits allow for maximising the species likely to be present, assuming species use the habitats for different purposes at different times of the day, as well as increasing the chance of presence and detection as most species are relatively mobile. A single observer conducted an area search recording all birds that could be positively identified by sight within the site or immediately adjacent if the habitat was similar. A portable MP3 player and speaker unit was used to play recorded calls of several species (Slender-billed Thornbill, Thick-billed Grasswren, Shy Hylacola and Striated Heathwren, Rufous Fieldwren) to encourage these species to call-back, therefore making their presence at the site known to the observer.

Threatened bird species habitat assessment and bird surveys

To identify the potential distribution of the Thick-billed Grasswren and Slender-billed Thornbill nationally threatened bird species, the project area and adjacent areas accessible by vehicle were assessed to identify areas of suitable habitat. Habitat criteria were formed based on both Black *et al.* (2009), and using Bird Site 15 (Figure 3), where the Slender-billed Grasswren was previously observed in February 2010, as a guide. The habitat assessment focused on the following criteria:

- chenopod shrubland dominated by *Maireana sedifolia* (Bluebush)
- overall minimum shrub height of ~75 cm
- high foliage density of the shrubs (leaf coverage ensuring the inside branch structure was not clearly visible
- shrubs in close proximity (ideally <3 m between shrubs).

Sites meeting the habitat criteria were then surveyed as per the standardised methodology (60 minutes in the morning and 60 minutes in the afternoon).



Figure 3. Example Slender-billed Thornbill habitat, Bird Site 15, used as a guide when creating the habitat assessment criteria.

Opportunistic bird observations

To ensure all or most of the bird species present at the time of the survey were recorded, all birds observed opportunistically were identified, a waypoint taken to note the location, and habitat details noted. Opportunistic observations includes birds seen whilst the field surveyor was undertaking other activities (e.g. driving between sites, assisting with flora surveys), as well as birds seen within habitats and sites particularly targeted for short non-standardised surveys of short duration. Targeted locations included shorelines, mangrove habitats, and woodland edges, and sites of interest (significant birds recorded) previously surveyed in either November 2009 or February 2009.

3.2.6 Identification and nomenclature

All captured vertebrates were, where possible, identified and released immediately at the point of capture or amongst nearby vegetation cover or burrows to reduce stress. Vertebrate species nomenclature for scientific names and common names follows the *Vertebrates of South Australia* (DEH 2010) using commonly accepted local names.

3.2.7 Weather encountered during the field survey

Weather during the survey was near optimal for a spring survey. Significant rain fell during the week prior to the survey, but there was no rainfall during the survey. Day time temperatures were warm, and overnight temperatures were mild (Table 2). Winds during the day were light, suitable for bird surveys, however moderate winds picked up in the late afternoon and early evening on most days, hampering optimal conditions for spotlight surveys.

Table 2. Weather conditions recorded for Whyalla during the field survey.

Date	Rain	Temperature		9 am Wind		3 pm Wind	
	mm	Min °C	Max °C	Dir	Speed	Dir	Speed
5-Nov-2010	0	7.3	23.9	ENE	11	ESE	22
6-Nov-2010	0	12.2	29.7	N	19	NW	20
7-Nov-2010	0	15.1	20.6	SW	15	SSE	24
8-Nov-2010	0	11.3	24.3	SSW	19	SE	22
9-Nov-2010	0	10.0	32.9	S	13	E	20
10 -Nov-2010	0	16.2	32.1	NNW	9	SE	26

Source: Bureau of Meteorology Whyalla Aero (station 018120)..

3.3 Vegetation communities and species abundance

Vegetation monitoring sites were established to record the species composition, abundance, and condition of vegetation communities of Mullaquana prior to major development works. The habitats and areas most likely to be in close proximity to future works were targeted. Additional sites of similar habitat but at a distance from the proposed works were also established to act as controls in the future.

At each site two monitoring methods were conducted. A 100 metre x 100 metre quadrat (Figure 4) was established and permanently marked with star droppers to ensure repeatability of the same size and location (Figure 5, Figure 6). Also contained within the quadrat is a 100 m transect, referred to as a Jessup transect (the start and ends points are also permanently marked). Five of the vegetation sites are located in close proximity (between 100 – 200 m) to the fauna sites. Three sites are located at bird monitoring sites.

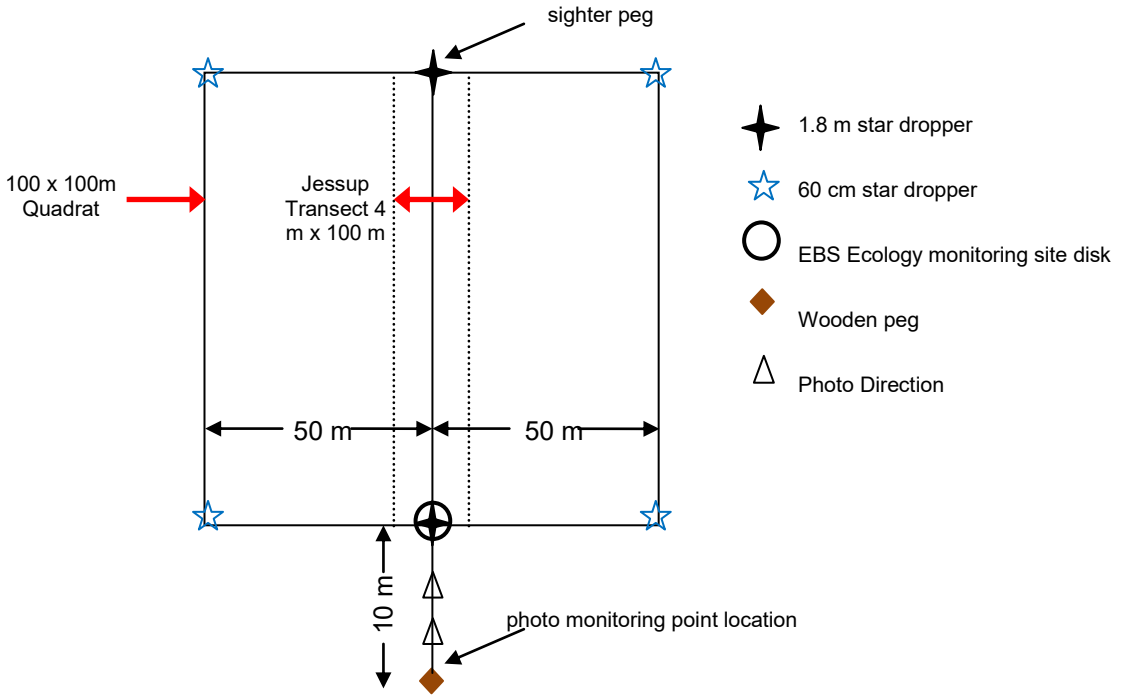


Figure 4. Vegetation monitoring site layout indicating the position of the 100 m x 100 m quadrat and 100 m x 4 m transect.



Figure 5. Short (60 cm) star dropper indicating a corner of a 100 m x 100 m quadrat.



Figure 6. Wooden peg indicating the photo monitoring point location, and 1.8 m star dropper indicating the start of the 100 m Jessup transect.

3.3.1 Community composition and cover abundance

Community composition and cover abundance of the vegetation sites was surveyed using a modification of the standard South Australian Biological Survey Method used by the Department of Environment and Natural Resources as a standard, repeatable method (Heard and Channon 1997). The presence of all vascular plant species was recorded (vouchers were taken for later identification when necessary), with one or two surveyors scanning the entire area until the species list is exhausted (typically taking 60 minutes for one surveyor or 30 minutes if there were two surveyors). For each species, the cover abundance was recorded using a standard scale (Table 3), and a condition status identified (for example flowering, seeding, fruiting, vegetation, dead).

Table 3. Scale used to assign flora species cover abundance.

Modified from Braun-Blanquet (Heard and Channon 1997).

Cover abundance scale	Cover abundance description
N	Not many, 1-10 plants and <5%
T	Sparsely present and <5%
1	Plentiful but of small cover, <5%
2	Any number of individuals covering 5-25%
3	Any number of individuals covering 25-50%
4	Any number of individuals covering 50-75%
5	Any number of individuals >75%

3.3.2 Perennial species abundance

The abundance of perennial plant species was measured along a Jessup transect. Effectively the Jessup transect is 100 m x 4 metres, split into twenty 10 m x 2 m quadrants for ease of surveying. Within each quadrant the number of live individuals of each species is counted, with a separate count for established adults, and for juveniles (typically non-woody plants less than 10 cm in height). The total for all quadrats is then totalled for each species. Over time, repeating the Jessup method provides an indication of how the community composition is changing, particularly if recruitment of juveniles is poor, adults become senescent, or if number of adults decline.

3.3.3 Condition

Each vegetation site was assigned a condition score by assigning a Significant Environmental Benefit (SEB) ratio. The SEB assessment process identifies the naturalness of the site, with specific elements of the overstorey and understorey examined, and anthropogenic impacts identified. See Appendix 2 for the SEB ratio table used in the assessment.

3.4 Survey limitations

3.4.1 Fauna

Although this fauna and flora survey was designed and conducted to maximise the species diversity detected during a standard four night baseline survey, it cannot be expected that all species present within the survey area were observed. The presence and abundance of both fauna and flora species will vary seasonally and in response to environmental conditions. It is likely that additional species were present at the time of the survey in November 2010, but are either limited in their distribution within the site or occur at such a low abundance that they were not detected. It is also likely that additional species, such as nomadic, vagrant and migratory species, may occur within and rely on habitats of the survey area from time to time but were not present at the time of the current survey. Additional surveys, undertaken at different times of the year and under different environmental conditions, would be required to increase the chance of such species being detected.

Although AnaBat recordings can assist identifying the presence of selected species, the analysis is complex and many species cannot be indentified by call alone. This survey method needs to be complimented by trapping to confirm species presence. Call analysis is affected by many factors, these include the suite of species present, the quality of the calls (equipment settings, microphone quality, background noise from wind, insects, echoes), the quality of the reference call database for the region and the experience of the analyst (T. Reardon pers. com. 2010).

Not all bat calls are easily identifiable from AnaBat recordings (T. Reardon pers. com. 2008), and therefore a species not being recorded does not necessarily mean that the species is absent. Similarly, a species being recorded only indicates the species was present at a particular time, and it's presence may vary from leaving and returning to a roost site, visiting a feeding site, or merely passing through the area and not utilising the habitat.

3.4.2 Flora

At the time the survey was undertaken not all plant species may have been visibly present. Some species such as native orchids and lilies are particularly hard to detect when not flowering, and grasses are difficult to identify without seed heads. Some plants could only be indentified to genus level and it is possible that some species present were not detected.

4 FAUNA RESULTS

4.1 Site locations

The five fauna sites and three additional birds sites that were established and first surveyed for baseline survey in November 2009 and targeted bird survey in February 2010 were re-established. The sites were originally selected based on habitat and vegetation associations, with a preference for covering the habitat most likely to be impacted by mining activities in the future. The vegetation association descriptions for each site were further refined during the current survey as a full vegetation and floristic survey was undertaken, providing more detailed information. Table 4 outlines the vegetation association for each of the five fauna sites and the three additional bird sites. See section 5.3 (page 40) for detailed descriptions of these vegetation associations.

Table 4. Vegetation associations of the fauna and bird survey sites.

Site name	Aligns with vegetation site	Vegetation association
Fauna 1	Veg 1	*Maireana sedifolia* (Bluebush), *Maireana pyramidata* (Black Bluebush) Low Open Shrubland
Fauna 2	Veg 2	*Maireana pyramidata* (Black Bluebush), *Disphyma crassifolium ssp. clavellatum* (Round-leaf Pigface) Low Shrubland
Fauna 3	Veg 3	*Tecticornia pergranulata* (Black-seed Samphire), *Disphyma crassifolium ssp. clavellatum* (Round-leaf Pigface) Low Shrubland
Fauna 4	Veg 4	*Myoporum platycarpum* (False Sandalwood) Open Woodland
Fauna 5	Veg 5	*Eucalyptus socialis* (Beaked Red Mallee), *Eucalyptus dumosa*, (White Mallee) Open Mallee.
Bird 6	Veg 9	*Maireana pyramidata* (Black Bluebush), *Atriplex vesicaria* (Bladder Saltbush), Shrubland
Bird 10	Veg 10	*Maireana sedifolia* (Bluebush) Shrubland
Bird 15	Veg 7	*Maireana sedifolia* (Bluebush), *Atriplex vesicaria* (Bladder Saltbush) Shrubland

4.2 Survey adequacy

The fauna trapping resulted in 92 captures in the pitfall traps, 10 in the Elliott traps, 15 in the funnel traps and two in the cage traps. There were five hand captures of reptiles, an additional nine reptile observations, and three mammal observations (excluding sheep). There was a total of 1,183 bird observations, and an addition 22 calls recorded. Ninety-four bat echolocation calls were identified. There were no observations during the spotlighting activities.

Although overall trap success and number of mammal captures was low, it is assumed this is representative of the low mammal diversity and abundance in the area. The diversity of mammals caught is consistent with the expected fauna species of the region. Overall reptile diversity was much higher than that experienced in the November 2009 survey. This is likely due to the more suitable (warmer, sunnier) weather conditions of the current survey.

4.3 Mammals

4.3.1 Terrestrial mammals

Four native terrestrial mammal species were recorded during the November 2010 survey, two small terrestrial species, the Fat-tailed Dunnart (*Sminthopsis crassicaudata*) and Little Long-tailed Dunnart (*Sminthopsis dolichura*), and two Kangaroos, the Red Kangaroo (*Macropus rufus*) and Euro (*Macropus robustus*). None of these species are considered of conservation significance under either South Australian or Commonwealth legislation (Table 5). All native mammals were in low abundance. All five of the Little Long-tailed Dunnart captures were at Site 5 within *Eucalyptus socialis* (Beaked Red Mallee), *Eucalyptus dumosa*, (White Mallee) Open Mallee. This suggests the species distribution may be confined to areas of similar habitat value. Just two feral House Mouse (*Mus musculus*) were caught, indicating this species was also in low abundance.

Two species, the Stripe-faced Dunnart (*Sminthopsis macroura*) and Western Grey Kangaroo (*Macropus fuliginosus*) were recorded in low abundance in November 2009, but not in November 2010. Both species are expected to still remain within the project area in low abundance.

Table 5. Terrestrial mammal species detected during the November 2009 and 2010 field survey.

Family	Species	Common name	Status	EPBC status	NWP status	No. obs 2009	No. obs 2010
Bovidae	*Ovis aries*	Sheep	Exotic	-	-	3	
Dasyuridae	*Sminthopsis crassicaudata*	Fat-tailed Dunnart	Native	-	-	2	3
Dasyuridae	*Sminthopsis dolichura*	Little Long-tailed Dunnart	Native	-	-		5
Dasyuridae	*Sminthopsis macroura*	Stripe-faced Dunnart	Native	-	-	1	
Leporidae	*Oryctolagus cuniculus*	Rabbit	Exotic	-	-	2	
Macropodidae	*Macropus rufus*	Red Kangaroo	Native	-	-	2	1
Macropodidae	*Macropus robustus*	Euro	Native	-	-	3	2
Macropodidae	*Macropus fuliginosus*	Western Grey Kangaroo	Native	-	-	7	
Muridae	*Mus musculus*	House Mouse	Exotic	-	-	3	2



Figure 7. Little Long-tailed Dunnart (Sminthopsis dolichura) caught at Site 5 during the November 2010 survey.

Table 6. Number of mammal captures and observations during the field survey.

Species	Common name	Site 1		Site 2		Site 3		Site 4		Site 5		Off-site	
		2009	2010	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010
*Ovis aries**	Sheep	1		1			10	1					20+
Sminthopsis crassicaudata	Fat-tailed Dunnart				1		1	1	1	1			
Sminthopsis dolichura	Little Long-tailed Dunnart										5		
Sminthopsis macroura	Stripe-faced Dunnart							1					
*Oryctolagus cuniculus**	Rabbit									1		1	
Macropus fuliginosus	Western Grey Kangaroo											7	3
Macropus robustus	Euro										2	3	2
Macropus rufus	Red Kangaroo		1									2	1
*Mus musculus**	House Mouse			1		1		1	1		1		
	Native site diversity	**0**	**1**	**2**	**1**	**0**	**1**	**2**	**1**	**1**	**2**	**3**	**3**
	Exotic site diversity	**1**	**0**	**0**	**0**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**

Habitat of the fauna survey sites:
Site 1 *Maireana sedifolia* (Bluebush), *Maireana pyramidata* (Black Bluebush) Low Open Shrubland.
Site 2 *Maireana pyramidata* (Black Bluebush), *Disphyma crassifolium ssp. clavellatum* (Round-leaf Pigface) Low Shrubland.
Site 3 *Tecticornia pergranulata* (Black-seed Samphire), *Disphyma crassifolium ssp. clavellatum* (Round-leaf Pigface) Low Shrubland.
Site 4 *Myoporum platycarpum* (False Sandalwood) Open Woodland.
Site 5 *Eucalyptus socialis* (Beaked Red Mallee), *Eucalyptus dumosa*, (White Mallee) Open Mallee.

4.3.2 Bats

No bats were caught during the November 2010 survey, however 74 echolocation calls were recorded on the AnaBats. Unfortunately many of the calls were of poor quality (for reasons not especially clear). Some calls fell within frequencies that were not easily assigned to species, and some calls fall into the overlap of parameters between two species, resulting in uncertain identification.

Calls of three species were identified with certainty. The confirmed species were Southern Forest Bat (*Vespadelus regulus*), Gould's Wattled Bat (*Chalinolobus gouldii*) and White-striped Freetail-bat (*Tadarida australis*). Calls of a species of Long-eared Bat (*Nyctophilus* genus) were identified, however the calls could not be distinguished between *Nyctophilus geoffroyi* or *N. major tor*. One additional call of uncertainty was recorded that may be of the Inland Forest Bat (*Vespadelus baverstocki*). Caution is given to the identification of the Inland Forest Bat, as just one potential call was recorded, and Mullaquana is at the extreme southern edge of the species known distribution on eastern Eyre Peninsula. None of the bat species either identified with certainty, or uncertainty, are considered of conservation significance under either South Australian or Commonwealth legislation (Table 7). Graphs of the calls are included in Appendix 3.

Table 7. Bat species detected during the November 2010 field survey.

Family	Species	Common name	Status	EPBC status	NPW status	Level of identification certainty
Vespertilionidae	*Chalinolobus gouldii* or *Mormopterus 4*	Gould's Wattled Bat or Southern Freetail-bat	Native	-	-	Questionable
	Vespadelus regulus	Southern Forest Bat	Native	-	-	Near certain
	Vespadelus baverstocki	Inland Forest Bat	Native	-	-	Uncertain
	Chalinolobus gouldii	Goulds Wattled Bat	Native	-	-	Near certain
	Nyctophilus geoffroyi or *Nyctophilus major tor*	Lesser Long-eared-Bat species	Native	-	-	Uncertain
	Vespadelus species	Forest Bat species	Native	-	-	Uncertain
Molossidae	*Tadarida australis*	White-striped Freetail-bat	Native	-	-	Near certain
Vespertilionidae or Molossidae	*Chalinolobus gouldii* or *Mormopterus 4*	Goulds Wattled Bat or Southern Freetail-bat	Native	-	-	Uncertain

Table 8. Bat species identified as occurring with the project area as identified through call identification.

X = calls recorded and identified.

Common name	Site 1	Site 2	Site 3	Site 4	Site 5
Southern Forest Bat	X	X			X
Gould's Wattled Bat	X			X	X
White-striped Freetail-bat	X	X		X	X
Forest Bat species					X
Gould's Wattled Bat or Southern Freetail-bat		X			
Inland Forest Bat		X			
Lesser Long-eared-Bat species				X	X
Gould's Wattled Bat or Southern Freetail-bat	X			X	X

Habitat of the fauna survey sites:
Site 1 *Maireana sedifolia* (Bluebush), *Maireana pyramidata* (Black Bluebush) Low Open Shrubland.
Site 2 *Maireana pyramidata* (Black Bluebush), *Disphyma crassifolium ssp. clavellatum* (Round-leaf Pigface) Low Shrubland.
Site 3 *Tecticornia pergranulata* (Black-seed Samphire), *Disphyma crassifolium ssp. clavellatum* (Round-leaf Pigface) Low Shrubland.
Site 4 *Myoporum platycarpum* (False Sandalwood) Open Woodland.
Site 5 *Eucalyptus socialis* (Beaked Red Mallee), *Eucalyptus dumosa*, (White Mallee) Open Mallee.

4.4 Reptiles

Nineteen reptile species were recorded during the November 2010 survey, including twelve skink species, three dragons, two pygopod, one elapid snake, and one gecko (Ranges Stone Gecko, *Diplodactylus furcosus* Figure 8). None of these species are considered of conservation significance under either South Australian or Commonwealth legislation (Table 9). Eight of the species were not recorded in the previous baseline survey in November 2009. This is likely to be due to the more suitable weather conditions of the 2010 survey, with less cloud cover and higher daytime temperatures being more ideal for reptile activity and thus chance of being encountered.

Fourteen of the species were in low abundance, with less than ten records each. Two skink species, the Saltbush Ctenotus (*Ctenotus olympicus*) and Sandplain Ctenotus (*Ctenotus schomburgkii*) were in high abundance, with over 20 captures each. Four species, the Five-lined Earless Dragon (*Tympanocryptis lineata*), Spotted Ctenotus (*Ctenotus orientalis*) (Figure 9), Adelaide Snake-eye (*Morethia adelaidensis*), and Sleepy Lizard (*Tiliqua rugosa*) were in moderate abundance.

Table 9. Reptile species detected during the November 2009 and 2010 field survey.

Family	Species	Common name	Status	EPBC status	NPW status	No. obs 2009	No. obs 2010
Agamidae	*Ctenophorus cristatus*	Crested Dragon	Native	-	-	2	1
	Pogona barbata	Eastern Bearded Dragon	Native	-	-	1	
	Pogona minor	Dwarf Bearded Dragon	Native	-	-		1
	Tympanocryptis lineata	Five-lined Earless Dragon	Native	-	-	1	10
Diplodactylidae	*Diplodactylus furcosus*	Ranges Stone Gecko	Native	-	-	8	3
	Strophurus intermedius	Southern Spiny-tailed Gecko	Native	-	-	1	
Elapidae	*Pseudonaja aspidorhyncha*	Patch-nosed Brown Snake	Native	-	-		2
Pygopodidae	*Delma australis*	Barred Snake-lizard	Native	-	-	1	1
	Pygopus schraderi	Hooded Scaly-foot	Native	-	-		1
Scincidae	*Ctenotus olympicus*	Saltbush Ctenotus	Native	-	-		25
	Ctenotus orientalis	Spotted Ctenotus	Native	-	-	4	12
	Ctenotus regius	Eastern Desert Ctenotus	Native	-	-	3	
	Ctenotus schomburgkii	Sandplain Ctenotus	Native	-	-	14	22
	Lampropholis guichenoti	Garden Skink	Native	-	-	20	1
	Lerista edwardsae	Myall Slider	Native	-	-		2
	Lerista taeniata	Ribbon Slider	Native	-	-		1
	Lerista timida	Dwarf Three-toed Slider	Native	-	-	2	1
	Menetia greyii	Dwarf Skink	Native	-	-	1	4
	Morethia adelaidensis	Adelaide Snake-eye	Native	-	-		17
	Morethia boulengeri	Common Snake-eye	Native	-	-	1	2
	Tiliqua rugosa	Sleepy Lizard	Native	-	-	7	10
	Tiliqua scincoides	Eastern Bluetongue	Native	-	-		5

The five sites surveyed during the current survey had similar overall reptile diversity, ranging from six species at Site 4 *Myoporum platycarpum* (False Sandalwood) Open Woodland, to nine species at Site 3 *Halosarcia pergranulata* (Black-seed Samphire), *Halosarcia* sp. (Samphire sp.) Low Shrubland. The Hooded Scaly-foot (*Pygopus schraderi*) (Figure 10), Ribbon Slider (*Lerista taeniata*), and Dwarf Bearded Dragon (*Pogona minor*) were only recorded at one site each. This may indicate that these species are not widespread across the project area, and may have preferences for particular landforms, vegetation associations, and/or soil types. All three species were only recorded in very low abundance (one record each), and therefore may be more widespread but at low abundance beyond a detectable level at the other sites.

Table 10. Number of reptile captures and observations during the field survey.

Species	Common name	Site 1		Site 2		Site 3		Site 4		Site 5		Bird Site 13
		2009	2010	2009	2010	2009	2010	2009	2010	2009	2010	2010
Ctenophorus cristatus	Crested Dragon									2	1	
Pogona barbata	Eastern Bearded Dragon							1				
Pogona minor	Dwarf Bearded Dragon											1
Tympanocryptis lineata	Five-lined Earless Dragon	1	5		3		2					
Diplodactylus furcosus	Ranges Stone Gecko	3		4	3	1						
Strophurus intermedius	Southern Spiny-tailed Gecko	1										
Pseudonaja aspidorhyncha	Patch-nosed Brown Snake								1			1
Delma australis	Barred Snake-lizard							1			1	
Pygopus schraderi	Hooded Scaly-foot				1							
Ctenotus olympicus	Saltbush Ctenotus		6		9		7		3			
Ctenotus orientalis	Spotted Ctenotus	2	4	1	3		2	1	1		2	
Ctenotus regius	Eastern Desert Ctenotus							2		1		
Ctenotus schomburgkii	Sandplain Ctenotus		6		3	1	2	13	11			
Lampropholis guichenoti	Garden Skink	6	1	2		2		9		1		
Lerista edwardsae	Myall Slider						1				1	
Lerista taeniata	Ribbon Slider						1					
Lerista timida	Dwarf Three-toed Slider	1					1			1		
Menetia greyii	Dwarf Skink		1				1		2	1		
Morethia adelaidensis	Adelaide Snake-eye		4		1		5		7			
Morethia boulengeri	Common Snake-eye									1	2	
Tiliqua rugosa	Sleepy Lizard	1	2		1			3		2	7	
Tiliqua scincoides	Eastern Bluetongue										5	
Species diversity		**7**	**8**	**3**	**8**	**3**	**9**	**7**	**6**	**7**	**7**	**1**
No. species unique to site (not recorded elsewhere)		**1**	**0**	**0**	**1**	**0**	**1**	**1**	**0**	**0**	**0**	**1**

Habitat of the survey sites:
Site 1 *Maireana sedifolia* (Bluebush), *Maireana pyramidata* (Black Bluebush) Low Open Shrubland.
Site 2 *Maireana pyramidata* (Black Bluebush), *Disphyma crassifolium ssp. clavellatum* (Round-leaf Pigface) Low Shrubland.
Site 3 *Tecticornia pergranulata* (Black-seed Samphire), *Disphyma crassifolium ssp. clavellatum* (Round-leaf Pigface) Low Shrubland.
Site 4 *Myoporum platycarpum* (False Sandalwood) Open Woodland.
Site 5 *Eucalyptus socialis* (Beaked Red Mallee), *Eucalyptus dumosa*, (White Mallee) Open Mallee.



Figure 8. Ranges Stone Gecko (*Diplodactylus furosus*).



Figure 9. Spotted Ctenotus (*Ctenotus orientalis*).



Figure 10. Hooded Scaly-foot (*Pygopus schraderi*).

4.5 Frogs

One frog species, the Trilling Frog (*Neobatrachus centralis*) was recorded during the current survey. This species is not considered of conservation significance under either South Australian or Commonwealth legislation (Table 11). One capture was made a Site 3 *Halosarcia pergranulata* (Black-seed Samphire), *Halosarcia* sp. (Samphire sp.) Low Shrubland (within a low-lying area, subject to water logging), and one at Site 5 *Eucalyptus dumosa* (White Mallee), *Eucalyptus socialis* (Beaked Red Mallee) Mallee (along a dry creekline) (Table 12). Both captures were made following light rainfall, which likely promoted this burrowing species to surface. The Trilling Frog abundance and distribution was much lower than the November 2009 survey. However, significant rain fell over several days during the previous survey, triggering frogs to become active and thus caught in the pitfall traps.

Table 11. Frog species detected during the November 2009 and 2010 survey.

Family	Species	Common name	Status	EPBC status	NPW status	No. obs 2009	No. obs 2010
Myobatrachidae	*Neobatrachus centralis*	Trilling Frog	Native	-	-	54	2
Myobatrachidae	*Neobatrachus pictus*	Burrowing Frog	Native	-	-	1	0

Table 12. Site abundance of frog observations during the November 2009 and 2010 surveys.

Species	Common name	Site 1		Site 2		Site 3		Site 4		Site 5	
		2009	2010	2009	2010	2009	2010	2009	2010	2009	2010
Neobatrachus centralis	Trilling Frog	1		1		3	1	3		46	1
Neobatrachus pictus	Borrowing Frog							1			

Habitat of the survey sites:
Site 1 *Maireana sedifolia* (Bluebush), *Maireana pyramidata* (Black Bluebush) Low Open Shrubland.
Site 2 *Maireana pyramidata* (Black Bluebush), *Disphyma crassifolium ssp. clavellatum* (Round-leaf Pigface) Low Shrubland.
Site 3 *Tecticornia pergranulata* (Black-seed Samphire), *Disphyma crassifolium ssp. clavellatum* (Round-leaf Pigface) Low Shrubland.
Site 4 *Myoporum platycarpum* (False Sandalwood) Open Woodland.
Site 5 *Eucalyptus socialis* (Beaked Red Mallee), *Eucalyptus dumosa*, (White Mallee) Open Mallee.

4.6 Birds

Sixty native bird species and two exotic species were recorded during the November 2010 survey, including 20 species that were not recorded during the previous surveys in November 2009 and February 2010 (Table 13). Forty-three species were recorded in low abundance, with less than five observations. The Budgerigar (*Melopsittacus undulatus*) was the most abundant species, with 109 observations. Evidence of breeding was observed, including three Nankeen Kestrel (*Falco cenchroides*) chicks in a nest (Figure 11) at Site 5, and a Collared Sparrowhawk (*Accipiter cirrhocephalus*) was observed on-nest also at Site 5.

Five species of conservation significance were recorded during the current survey, three species within the Mullaquana project area and two species were only recorded in adjacent areas. The Slender-billed Thornbill (*Acanthiza iredalei iredalei)* and Thick-billed Grasswren (*Amytornis textilis myall*) are vulnerable under Commonwealth legislation (EPBC Act). While the Striated Grasswren (*Amytornis striatus*), Little Egret (*Egretta garzetta*) and Sooty Oystercatcher (*Haematopus fuliginosus*) are rare under South Australian legislation (NPW Act). The Little Egret and Sooty Oystercatcher were observed along the coastline at Cowled's Landing (just outside the lease area), and neither were observed during the previous surveys.

The Shy Hylacola (*Hylacola cauta*), which is Rare under the NPW Act, and recorded during the February 2010 survey at Sites 2, 4, 5 and opportunistically (total six observations), was not recorded during the current survey.



Figure 11. Nankeen Kestrel (*Falco cenchroides*) chicks on a nest at Site 5.

Table 13. Bird species detected during the November 2009 baseline survey, February 2010 targeted survey, and the current survey November 2010 follow-up survey.

VU = Vulnerable status under the EPBC Act. R = Rare status under the NPW Act.

Family	Species	Common name	EPBC status	NPW status	Nov 2009	Feb 2010	Nov 2010
Acanthizidae	*Acanthiza apicalis*	Inland Thornbill	-	-			2
	Acanthiza chrysorrhoa	Yellow-rumped Thornbill	-	-	2	4	16
	Acanthiza iredalei iridalei	Slender-billed Thornbill	VU	-		73	61
	Aphelocephala leucopsis	Southern Whiteface	-	-		5	83
	Calamanthus campestris	Rufous Fieldwren	-	-		2	47
	Hylacola cauta	Shy Hylacola	-	-		6	
Accipitridae	*Accipiter cirrocephalus*	Collared Sparrowhawk	-	-			2
	Elanus axillaris	Black-shouldered Kite	-	-			5
Alaudidae	*Alauda arvensis*	Eurasian Skylark	-	-	3		
Anatidae	*Anas gracilis*	Grey Teal	-	-	2		
	Anas superciliosa	Pacific Black Duck	-	-		1	
Ardeidae	*Ardea alba*	Great Egret	-	-		2	4
	Egretta garzetta	Little Egret	-	R			10
	Egretta novaehollandiae	White-faced Heron	-	-	1	12	8
Artamidae	*Artamus cinereus*	Black-faced Woodswallow	-	-	8	18	13
	Cracticus tibicen	Australian Magpie	-	-	16	10	21
	Cracticus torquatus	Grey Butcherbird	-	-	17	13	25
Cacatuidae	*Eolophus roseicapillus*	Galah	-	-	29	38	32
Campephagidae	*Coracina novaehollandiae*	Black-faced Cuckoo-shrike	-	-	4		3
	Lalage sueurii	White-winged Triller	-	-	1		
Casuariidae	*Dromaius novaehollandiae*	Emu	-	-	3		
Charadriidae	*Charadrius ruficapillus*	Red-capped Plover	-	-			5
	Vanellus miles	Masked Lapwing	-	-	2	5	
	Vanellus tricolor	Banded Lapwing	-	-	44		11
Columbidae	*Ocyphaps lophotes*	Crested Pigeon	-	-	14	4	12
	Phaps chalcoptera	Common Bronzewing	-	-			1
Corvidae	*Corvus bennetti*	Little Crow	-	-			11
	Corvus coronoides	Australian Raven	-	-	29		16
	Corvus mellori	Little Raven	-	-		3	
Cuculidae	*Chalcites basalis*	Horsfield's Bronze-cuckoo	-	-			3
Estrildidae	*Taeniopygia guttata*	Zebra Finch	-	-			40
Falconidae	*Falco berigora*	Brown Falcon	-	-	2		9
	Falco cenchroides	Nankeen Kestrel	-	-	23	4	16
	Falco longipennis	Australian Hobby	-	-	1		
Haematopodidae	*Haematopus fuliginosus*	Sooty Oystercatcher	-	R			1
Hirundinidae	*Hirundo neoxena*	Welcome Swallow	-	-			5
	Petrochelidon nigricans	Tree Martin	-	-	9	198	6
Laridae	*Chroicocephalus novaehollandiae*	Silver Gull	-	-	6	63	17

Family	Species	Common name	EPBC status	NPW status	Nov 2009	Feb 2010	Nov 2010
	Larus pacificus	Pacific Gull	-	-		7	4
	Thalasseus bergii	Crested Tern	-	-		29	12
Maluridae	*Amytornis striatus*	Striated Grasswren	-	R	13	17	1
	Amytornis textilis myall	Thick-billed Grasswren	VU	-	7	5	2
	Malurus cyaneus	Superb Fairy wren	-	-		15	
	Malurus lamberti	Variegated Fairy-wren	-	-	6	2	14
	Malurus leucopterus	White-winged Fairy-wren	-	-	31	139	95
	Malurus splendens	Splendid Fairy-wren	-	-	11		
Megaluridae	*Cincloramphus cruralis*	Brown Songlark	-	-			61
Meliphagidae	*Acanthagenys rufogularis*	Spiny-cheeked Honeyeater	-	-	46	26	45
	Anthochaera carunculata	Red Wattlebird	-	-		2	10
	Epthianura albifrons	White-fronted Chat	-	-	11	18	78
	Epthianura aurifrons	Orange Chat	-	-	79	3	6
	Epthianura tricolor	Crimson Chat	-	-	13		15
	Lichenostomus virescens	Singing Honeyeater	-	-	9	16	20
	Manorina flavigula	Yellow-throated Miner	-	-	12		
	Manorina melanocephala	Noisy Miner	-	-	1		26
Monarchidae	*Grallina cyanoleuca*	Magpie-lark	-	-			3
Motacillidae	*Anthus novaeseelandiae*	Australasian Pipit	-	-	12	4	63
Pachycephalidae	*Colluricincla harmonica*	Grey Shrike-thrush	-	-			1
	Oreoica gutturalis	Crested Bellbird	-	-			1
	Pachycephala rufiventris	Rufous Whistler	-	-			2
Pardalotidae	*Aquila audax*	Wedge-tailed Eagle	-	-	8	5	4
	Pardalotus punctatus	Spotted Pardalote	-	-			2
Pelecanidae	*Pelecanus conspicillatus*	Australian Pelican	-	-		16	7
Phalacrocoracidae	*Microcarbo melanoleucos*	Little Pied Cormorant	-	-		32	11
	Phalacrocorax carbo	Great Cormorant	-	-		9	1
	Phalacrocorax varius	Pied Cormorant	-	-			34
Phasianidae	*Coturnix pectoralis*	Stubble Quail	-	-	2	1	
Podargidae	*Podargus strigoides*	Tawny Frogmouth	-	-	2		
Pomatostomidae	*Pomatostomus superciliosus*	White-browed Babbler	-	-	35	13	36
Psittacidae	*Barnardius zonarius*	Australian Ringneck	-	-	16	4	7
	Melopsittacus undulatus	Budgerigar	-	-			109
	Northiella haematogaster	Blue Bonnet	-	-	5		4
	Northiella haematogastor	Blue Bonnet	-	-		3	
	Psephotus haematonotus	Red-rumped Parrot	-	-	1		
	Psephotus varius	Mulga Parrot	-	-			3
Rallidae	*Tribonyx ventralis*	Black-tailed Native-hen	-	-	2		
Rhipiduridae	*Rhipidura leucophrys*	Willie Wagtail	-	-	9	3	1
Sturnidae	*Sturnus vulgaris*	Common Starling	-	-	48		6
Turnicidae	*Turnix velox*	Little Button-quail	-	-			41

The eight sites surveyed during the current survey differed in overall bird species diversity, ranging from nine species at Site 2 *Disphyma crassifolium* (Round-leaf Pigface), *Sclerolaena patenticuspis* (Spear-fruit Bindyi), *Maireana enchylaenoides* (Wingless Fissure-plant), *Austrostipa* sp. (Spear Grass) Shrubland, to 23 species at Site 5 *Eucalyptus dumosa* (White Mallee), *Eucalyptus socialis* (Beaked Red Mallee) Mallee. The high diversity of the Mallee site is expected due to the high plant species diversity, with a mix of overstorey species (including flowering *Eucalyptus*), mid-storey species, and understorey species.

Nine species were confined to just one site, all of which had less than ten observations, indicating these species may be in low abundance within the project area. Alternatively, these species may be more abundant than the survey data suggests, but have preferences for habitats not surveyed, or the species may be cryptic in behaviour.

One species, the Black-faced Cuckoo-shrike was confined to Site 1 *Maireana sedifolia* (Bluebush), *Maireana pyramidata* (Black Bluebush) Low Open Shrubland. One species, the Striated Grasswren was confined to Site 6 *Maireana sedifolia* (Bluebush), *Maireana pyramidata* (Black Bluebush), *Atriplex vesicaria* (Saltbush) Low Open Shrubland. Two species, Blue Bonnet and the exotic Common Starling, were confined to Site 4 *Myoporum platycarpum* (False Sandalwood) Open Woodland. Five species were confined to *Eucalyptus dumosa* (White Mallee), *Eucalyptus socialis* (Beaked Red Mallee) Mallee.

Table 14. Number of bird observations during the bird surveys, and site species abundance recorded during the November 2010 survey.

Family	Common name	Bird survey sites								Opportune within project area	Total observations
		1	2	3	4	5	6	10	15		
Acanthizidae	Inland Thornbill									2	2
	Yellow-rumped Thornbill					7				9	16
	Slender-billed Thornbill	14						2	5	40	61
	Southern Whiteface	8	5	5				7	6	52	83
	Rufous Fieldwren	7	3	6			8	6	2	15	47
Accipitridae	Collared Sparrowhawk					2				0	2
	Black-shouldered Kite	4					1			0	5
Artamidae	Black-faced Woodswallow									13	13
	Australian Magpie			7	2	5				7	21
	Grey Butcherbird			1	5	7				12	25
Cacatuidae	Galah	1	18		1	6		2		4	32
Meliphagidae	Spiny-cheeked Honeyeater			2		22				21	45
	Red Wattlebird					9				1	10
	White-fronted Chat					2	6	6	8	56	78
	Orange Chat			3				3		0	6
	Crimson Chat	2				1			10	2	15
	Singing Honeyeater			1	3	5				11	20

Family	Common name	Bird survey sites								Opportune within project area	Total observations
		1	2	3	4	5	6	10	15		
	Noisy Miner				23	2				1	26
Motacillidae	Australasian Pipit	7	4	15	2		3	4	2	26	63
Pardalotidae	Wedge-tailed Eagle					2				2	4
	Spotted Pardalote					2				0	2
Psittacidae	Australian Ringneck					7				0	7
	Budgerigar	30	9	2		5	4	6	8	45	109
	Blue Bonnet				4					0	4
	Mulga Parrot									3	3
Falconidae	Brown Falcon	4					1		1	3	9
	Nankeen Kestrel	1		1		5			4	5	16
Maluridae	Striated Grasswren						1			0	1
	Thick-billed Grasswren									2	2
	Variegated Fairy-wren					10				4	14
	White-winged Fairy-wren	16	8	5			11	23		32	95
Campephagidae	Black-faced Cuckoo-shrike	3								0	3
Estrildidae	Zebra Finch	13	8	3			6			10	40
Turnicidae	Little Button-quail	6	8	8			8		1	10	41
Megaluridae	Brown Songlark	3	9	2	6		6	5	5	25	61
Pomatostomidae	White-browed Babbler					24				12	36
Hirundinidae	Welcome Swallow	1						1	2	1	5
	Tree Martin									6	6
Corvidae	Australian Raven				2	4				10	16
	Little Crow									11	11
Columbidae	Crested Pigeon				4	5				3	12
	Common Bronzewing					1				0	1
Sturnidae	Common Starling				6					0	6
Charadriidae	Red-capped Plover					1				4	5
	Banded Lapwing									11	11
Rhipiduridae	Willie Wagtail					1				0	1
Monarchidae	Magpie-lark									3	3
Phalacrocoracidae	Little Pied Cormorant									11	11
	Great Cormorant									1	1
	Pied Cormorant									34	34
Laridae	Silver Gull									17	17
	Pacific Gull									4	4
	Crested Tern									12	12
Ardeidae	Great Egret									4	4
	Little Egret									10	10
	White-faced Heron									8	8
Cuculidae	Horsfield's Bronze-cuckoo			1						2	3

Family	Common name	Bird survey sites								Opportune within project area	Total observations
		1	2	3	4	5	6	10	15		
Pachycephalidae	Crested Bellbird									1	1
	Rufous Whistler									2	2
	Grey Shrike-thrush									1	1
Haematopodidae	Sooty Oystercatcher									1	1
Pelecanidae	Australian Pelican									7	7

Habitat of the survey sites:
Site 1 *Maireana sedifolia* (Bluebush), *Maireana pyramidata* (Black Bluebush) Low Open Shrubland.
Site 2 *Maireana pyramidata* (Black Bluebush), *Disphyma crassifolium ssp. clavellatum* (Round-leaf Pigface) Low Shrubland.
Site 3 *Tecticornia pergranulata* (Black-seed Samphire), *Disphyma crassifolium ssp. clavellatum* (Round-leaf Pigface) Low Shrubland.
Site 4 *Myoporum platycarpum* (False Sandalwood) Open Woodland.
Site 5 *Eucalyptus socialis* (Beaked Red Mallee), *Eucalyptus dumosa*, (White Mallee) Open Mallee.

Of the conservation significant species, the Slender-billed Thornbill was the most abundant and widespread species of all, with a total of 61 observations, 21 of which were during the standard 30 minute morning and afternoon surveys at the eight sites surveys, 19 at other locations briefly visiting, and 21 opportunistic observations elsewhere within the project area (Table 15). See Figure 13 (page 31) for locations where the Slender-billed Thornbill was observed. There were just two observations of the Thick-billed Grasswren, both were at the same location. Just a single Striated Grasswren was recorded, and a single Sooty Oystercatcher (however additional observations were made outside of the project area, including the Whyalla foreshore), indicating the species is perhaps widespread but in the low abundance in the area. The Shy Hylacola was not observed.

Table 15. Threatened bird observations during the November 2010 survey.
VU = Vulnerable status under the EPBC Act. R = Rare status under the NPW Act.

Common name	EPBC status	NPW status	Bird survey sites								Other opportune observations						Total Nov 2010 survey period
			1	2	3	4	5	6	10	15	11	14	16	17	18	Other locations	
Slender-billed Thornbill	VU		14	-	-	-	-	-	2	5	4	5	4	-	6	21	61
Thick-billed Grasswren	VU		-	-	-	-	-	-	-	-	-	-	-	-	2	-	2
Little Egret		R	-	-	-	-	-	-	-	-	-	-	-	-	-	10	10
Striated Grasswren		R	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1
Sooty Oystercatcher		R	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Shy Hylocola		R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0



Figure 12. Slender-billed Thornbill observed within the Mullaquana project area in November 2010.

4.6.1 Threatened bird habitat assessment and targeted surveys

The project area and adjacent areas accessible by vehicle were assessed to identify areas of suitable habitat for the Slender-billed Thornbill and Thick-billed Grasswren. The assessment found that habitat meeting the criteria (chenopod shrubland dominated by *Maireana sedifolia* with an overall minimum shrub height of ~75 cm, high foliage density and shrubs in close proximity), were not widespread. Chenopod Shrubland dominated by *Maireana sedifolia* was widespread, however shrub height, foliage density and proximity of shrubs was not suitable.

The assessment and associated bird surveys of suitable habitat, resulted in four new locations of the Slender-billed Thornbill and one location of the Thick-billed Grasswren. Locations of the sightings are mapped in Figure 13. The overall habitats of a selection of sites visited and surveyed are illustrated in Figure 14 - Figure 18.

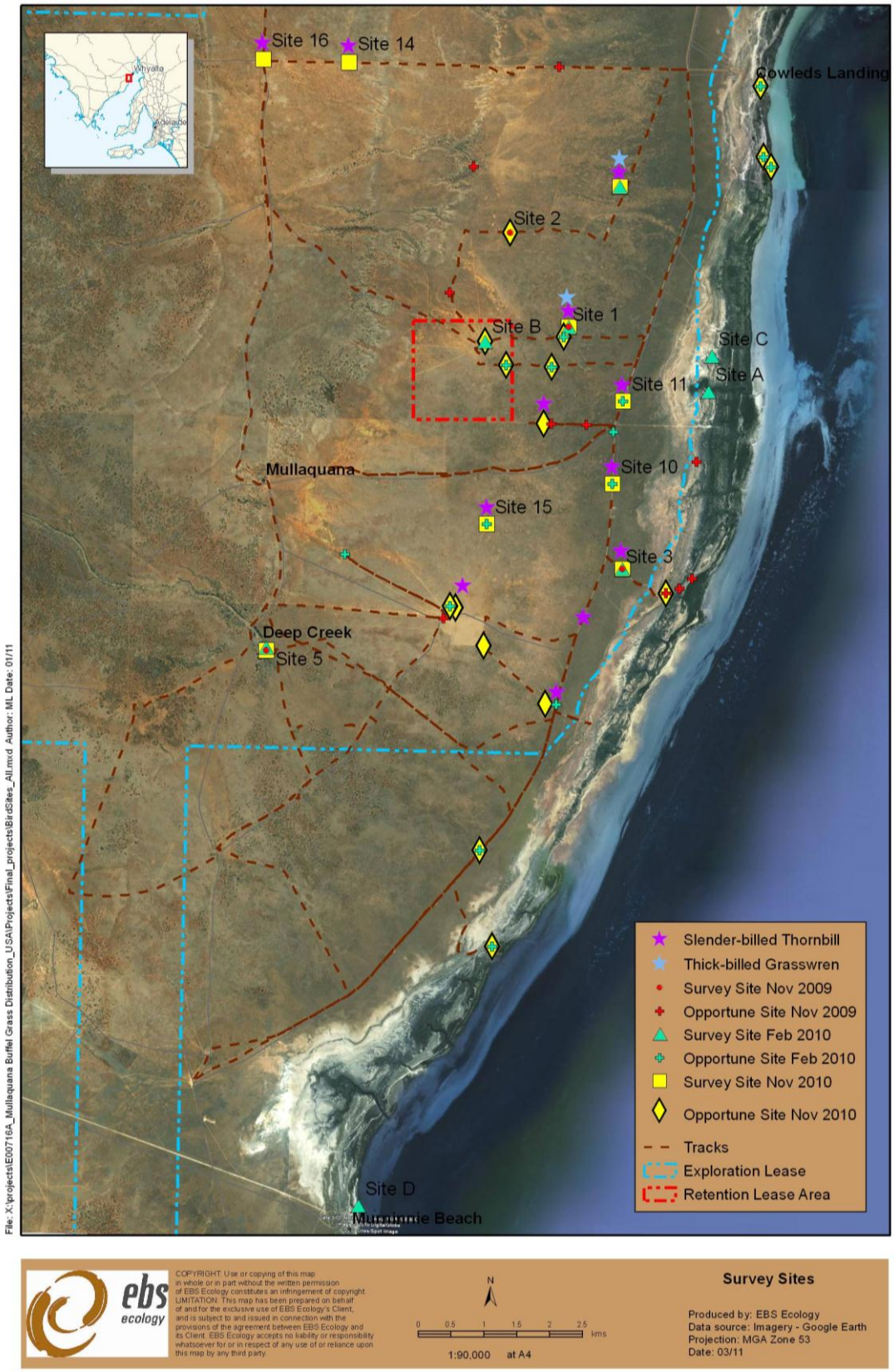


Figure 13. Location of sites surveyed for birds (survey sites and opportune locations) from the November 2009, February 2010 and November 2009 surveys, and location of the Slender-bill Thornbill and Thick-billed Grasswren observations.

Note: star symbols indicating the bird species presence are placed above the site symbol. Site symbols indicating survey method and time are overlaid.



Figure 14. Habitat assessed as suitable for the threatened birds (located between Bird Site 15 and dam).



Figure 15. Habitat assessed as suitable for the threatened birds, and confirmed suitable with the observation of both the Thick-billed Grasswren and Slender-billed Thornbill.



Figure 16. Potentially suitable threatened bird habitat located 1 km from Nonowie Station, adjacent to the track.



Figure 17. Potentially suitable habitat at Moonabie Station (outside the Mullaquana project area).



Figure 18. Habitat considered not suitable for the threatened bird species, located close to the boundary of Mullaquana and Nonowie Stations (within the Mullaquana project area).

The habitat is not suitable as shrubs do not meet the height criteria, are too spread out, and not dense/compact enough.

5 FLORA RESULTS

5.1 Native species

5.1.1 Diversity

Eighty-nine native flora species were recorded within 100 x 100 m quadrats of each of the ten vegetation sites surveyed. Eighty were identified to the species level (with certainty) and the remaining nine were identified only to genus due to lack of distinguishing features allowing for full identification. Thirty-seven native species were recorded within the Jessup transects (all these species were also recorded in the 100 x 100 m quadrat methods). See Appendix 4 for a full list of the flora species recorded during the current survey.

Vegetation Site 5 recorded the highest diversity, with 50 native species (Figure 19). Three sites recorded a diversity of less than 20. Site diversity of the remaining sites was typically around 20 species.

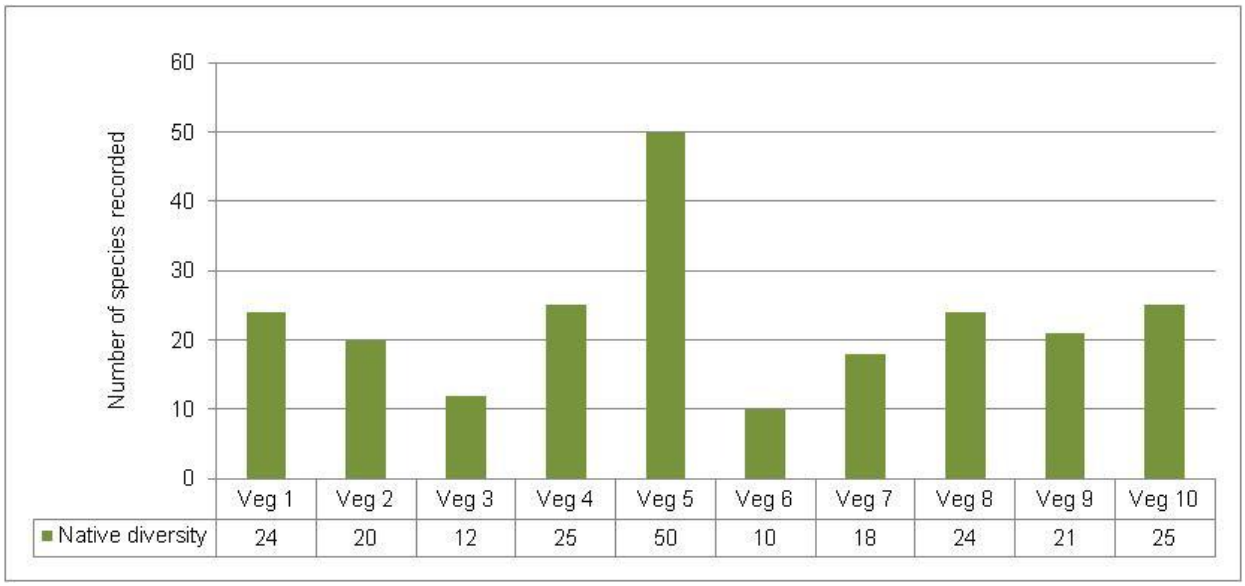


Figure 19. Native species site diversity, November 2010.

Chenopods were the highest family represented (family Chenopodiaceae), with 27 species recorded. There was also high diversity of the Compositae family of daisies and everlastings, and Gramineae family of grasses. Most families were represented by less than five species (Figure 20).

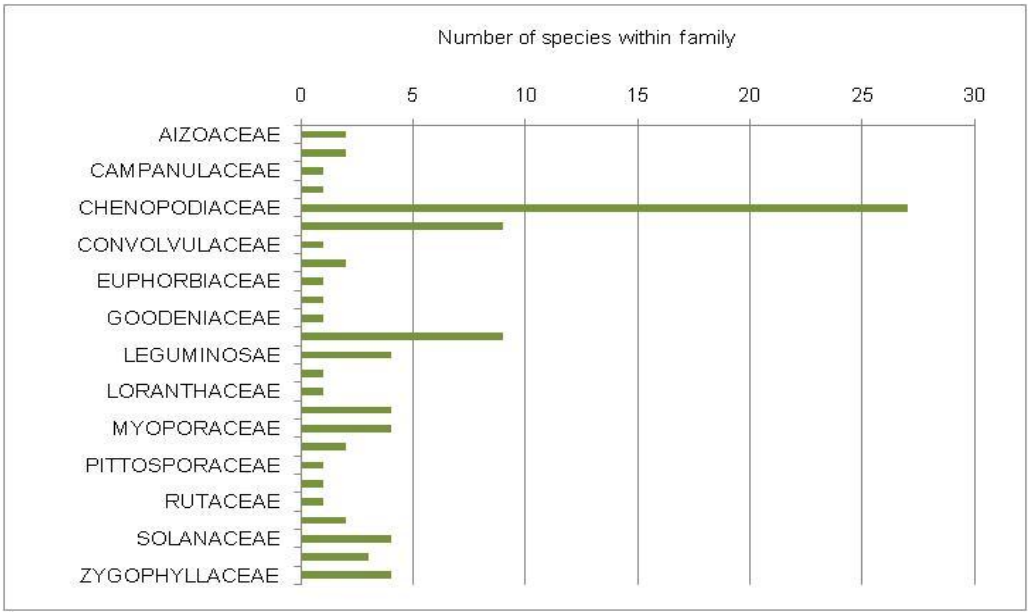


Figure 20. Native species family diversity recorded during the November 2010 survey.

5.1.2 Species distribution

Forty-one native species were recorded at just one site (Figure 21), indicating their distribution may be limited, or were not conspicuous at some sites allowing for identification. Most of these species were recorded in low abundance / low cover abundance (not many to plentiful presence of less than 5%). Seven species were considered plentiful but of low cover (less than 5%), and just one species, *Sclerolaena divaricata* (Tangled Bindyi), was recorded at higher abundance of 5-25%.

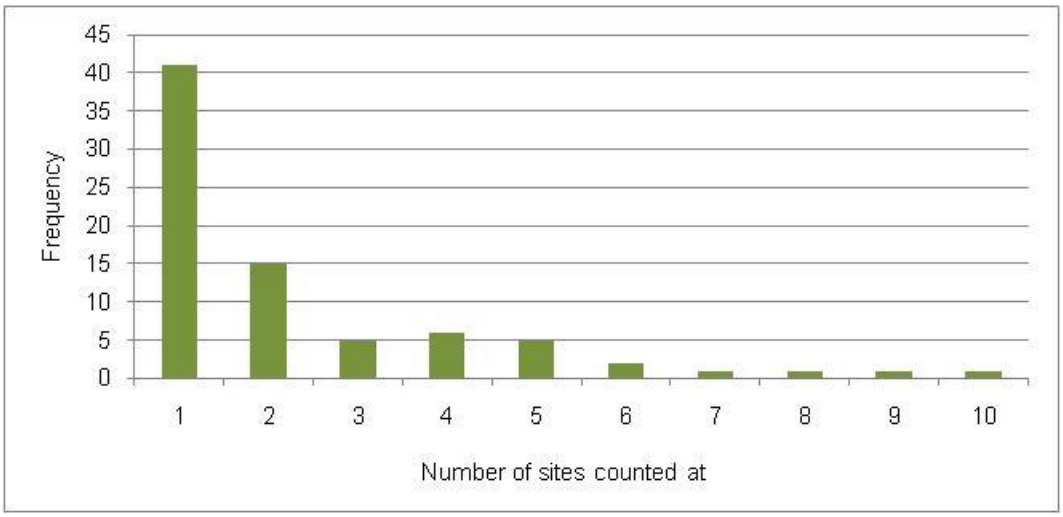


Figure 21. Frequency distribution of native species.

Graph shows the number of species that were recorded at 1 site, 2 sites, 3 sites etc. (maximum of 10 sites).

Atriplex vesicaria (Bladder Saltbush) was the most widely spread species, being found at all ten sites. *Sclerolaena obliquicuspis* (Oblique-spined Bindyi) was also widespread being recorded at nine sites. Four other species were recorded at eight of the ten sites, these were *Eriochiton sclerolaenoides* (Woolly-fruit Bluebush), *Maireana turbinata* (Top-fruit Bluebush), *Sclerolaena patenticuspis* (Spear-fruit Bindyi), and *Austrostipa nodosa* (Tall Spear-grass).

5.1.3 Conservation significant species

No species of conservation significance under either the *Environment Protection and Biodiversity Conservation Act 1999* or *National Parks and Wildlife Act 1972* were recorded during the survey.

5.2 Exotic weeds

5.2.1 Diversity

Eighteen exotic weed species were recorded during the survey within the 100 x 100 m quadrats (Table 16, Appendix 5). The majority of species were from the Caryophyllaceae and Cruciferae families (Figure 24). Two species, *Marrubium vulgare* (Horehound) (Figure 22) and *Oxalis pes-caprae* (Soursob) are declared weeds requiring control and management under the *Natural Resources Management Act 2004*. Four other species are environmental concern due to their ability to degrade habitats by out-competing with native species. These environmental weeds are *Vinca major* (Blue Periwinkle) (Figure 23), *Centaurea calcitrapa* (Star Thistle), *Carrichtera annua* (Ward's Weed), and *Salvia verbenaca* (Wild Sage).

Table 16. Weed species recorded during the November 2010 survey and maximum cover abundance recorded (all sites combined).

Family	Species	Common name	Status: Exotic	Maximum cover abundance score recorded
AIZOACEAE	*Mesembryanthemum nodiflorum*	Slender Iceplant	Concern	Trace
APOCYNACEAE	*Vinca major*	Blue Periwinkle	Environmental	Trace
CARYOPHYLLACEAE	*Silene nocturna*	Mediterranean Catchfly	Low concern	Trace
	Spergularia diandra	Lesser Sand-spurrey	Low concern	Plentiful,<5% cover
COMPOSITAE	*Centaurea calcitrapa*	Star Thistle	Environmental	Trace
	Hypochaeris glabra	Smooth Cat's Ear	Low concern	Trace
	Reichardia tingitana	False Sowthistle	Low concern	Not many
CRUCIFERAE	*Brassica sp*	Turnip species	Low concern	Plentiful,<5% cover
	Carrichtera annua	Wards Weed	Environmental	Plentiful,<5% cover
	Sisymbrium erysimoides	Smooth Mustard	Low concern	Trace
GRAMINEAE	*Schismus barbatus*	Arabian Grass	Low concern	Plentiful,<5% cover
LABIATAE	*Marrubium vulgare*	Horehound	Declared	Trace
	Salvia verbenaca	Wild Sage	Environmental	Trace
LEGUMINOSAE	*Medicago polymorpha polymorpha*	Burr-medic	Low concern	5-25% cover
MALVACEAE	*Malva parviflora*	Small-flower Marshmallow	Low concern	Trace
OXALIDACEAE	*Oxalis pes-caprae*	Soursob	Declared	Plentiful,<5% cover
SOLANACEAE	*Nicotiana glauca*	Tree Tobacco	Concern	Trace



Figure 22. *Marrubium vulgare* (Horehound).



Figure 23. *Anagallis arvensis* (Pimpernel).

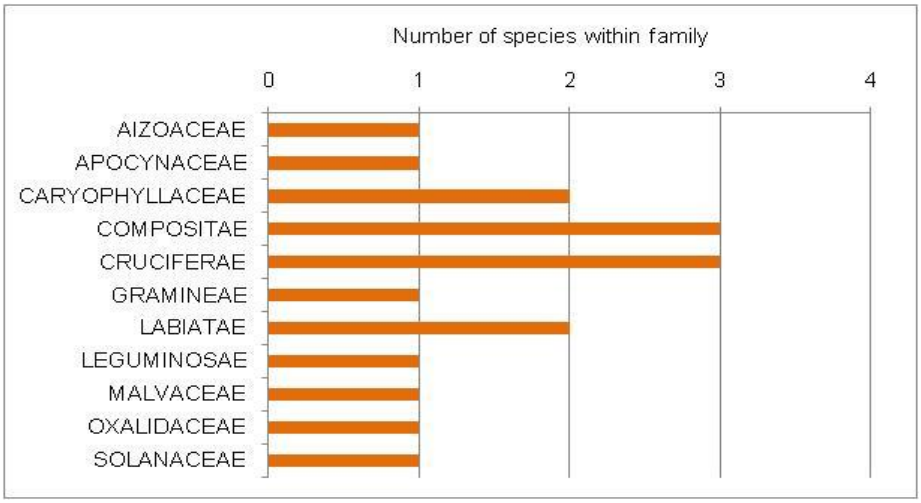


Figure 24. Exotic weed species family diversity recorded during the November 2010 survey.

Vegetation Site 5 recorded the highest diversity, with 10 weed species (Figure 25) (this site also recorded the highest native species diversity). Site 6 recorded the lowest exotic weed diversity, with just one species. Site diversity of the remaining sites was typically around three species.

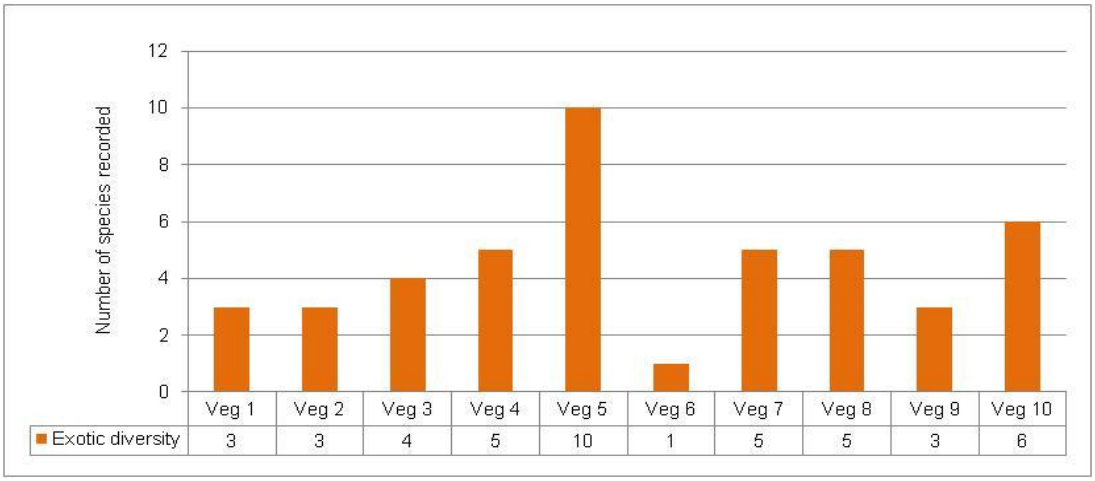


Figure 25. Exotic flora diversity recorded during the November 2010 survey.

5.2.2 Species distribution and abundance

Eleven exotic weed species were recorded at just one site (Figure 26), indicating their distribution may be limited, or were not conspicuous at some sites allowing for identification. No species were recorded at all ten sites, but two species, *Spergularia diandra* (Lesser Sand-spurrey) and *Carrichtera annua* (Ward's Weed) were recorded at eight sites each.

Most of the weed species were recorded in low abundance / low cover abundance (not many to plentiful presence of less than 5%). Seven species were considered plentiful but of low cover (less than 5%), and just one species, *Medicago polymorpha var polymorpha* (Burr Medic), was recorded at higher abundance of 5-25%.

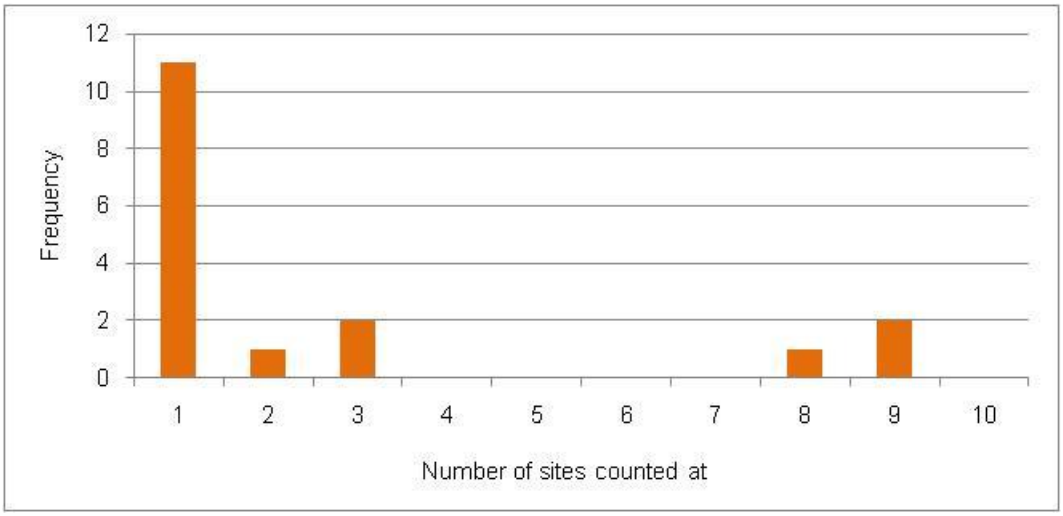


Figure 26. Frequency distribution of exotic species.

Graph shows the number of species that were recorded at 1 site, 2 sites, 3 sites etc. (maximum of 10 sites).

5.3 Vegetation monitoring sites

5.3.1 Vegetation Site 1

Species diversity and cover percentage

Twenty-four native species were recorded at Vegetation Site 1, including the dominant species *Maireana sedifolia* (Bluebush) and *Atriplex vesicaria* (Bladder Saltbush). *Sclerolaena obliquicuspis* (Oblique-spined Bindyi) *Lawrencia squamata* (Thorny Lawrencia), *Minuria cunninghamii* (Bush Minuria) and *Eriochiton sclerolaenoides* (Wooly-fruit Bluebush) were also well represented (plentiful but of less than 5% cover). The dominant grass species was *Austrostipa nodosa* (Tall Spear-grass) (cover abundance 5-25%) with *Austrostipa eremophila* (Rusty Spear-grass) and *Austrodanthonia caespitosa* (Common Wallaby-grass) being plentiful but of less than 5% cover. Two weed species were plentiful, *Carrichtera annua* (Ward's Weed) and *Medicago polymorpha var. polymorpha* (Burr-medic). See Table 17 for a summary of the flora species recorded at Site 1 and Appendix 4 for a full species list. Figure 27 illustrates the appearance of Site 1 at the time of the survey.

Species abundance

Ten perennial plant species were recorded along the Jessup transect. *Atriplex vesicaria* (Bladder Saltbush) was the most abundant species (277 established plants) followed by *Maireana sedifolia* (Bluebush) (179 established, 40 juvenile) and *Sclerolaena obliquicuspis* (Oblique-spined Bindyi) (171 established). See Appendix 5 for cover abundance raw data

Table 17. Vegetation Site 1 flora summary, November 2010.

Only species with a cover abundance score of 1 or greater are shown, with a maximum of three species per category. See Appendix 4 for a full species list.

Details	Description
Vegetation association description	*Maireana sedifolia* (Bluebush), *Atriplex vesicaria* (Bladder Saltbush) Shrubland
Species diversity	24 native, 1 exotic
Shrubs / forbs	*Sclerolaena obliquicuspis* (Oblique-spined Bindyi) *Lawrencia squamata* (Thorny Lawrencia) *Minuria cunninghamii* (Bush Minuria) *Eriochiton sclerolaenoides* (Woolly-fruit Bluebush) *Maireana turbinata* (Top-fruit Bluebush)
Tall shrubs	None
Trees	None
Grasses	*Austrostipa nodosa* (Tall Spear-grass) *Austrostipa eremophila* (Rusty Spear-grass) *Austrodanthonia caespitosa* (Common Wallaby-grass)
Exotics	*Carrichtera annua* (Ward's Weed) *Medicago polymorpha var. polymorpha* (Burr-medic)
Vegetation condition (SEB)	6:1

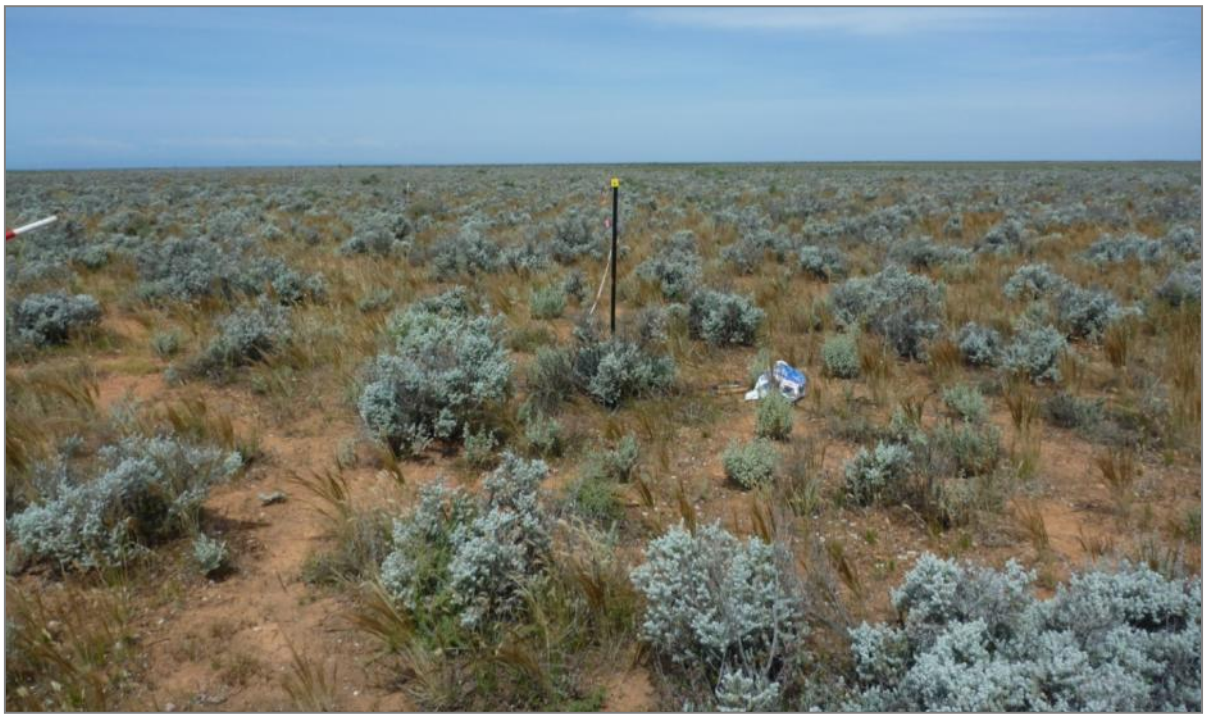


Figure 27. Site monitoring photograph – Vegetation Site 1, November 2010.

5.3.2 Vegetation Site 2

Species diversity and cover abundance

Twenty native species were recorded at Vegetation Site 2. The site contained a diverse mix of small shrub species of equal cover abundance, with *Maireana pyramidata* (Black Bluebush) defining the vegetation association type based on height class category. Other co-dominant species included *Disphyma crassifolium ssp. clavellatum* (Round-leaf Pigface), *Sida intricata* (Twiggy Sida), *Sclerolaena obliquicuspis* (Oblique-spined Bindyi), *Sclerolaena patenticuspis* (Spear-fruit Bindyi) and *Atriplex vesicaria* (Bladder Saltbush). Dominant grass species included *Austrostipa nodosa* (Tall Spear-grass) and *Austrodanthonia sp* (Wallaby-grass) both being plentiful but less than 5% cover, with *Austrostipa eremophila* (Rusty Spear-grass) sparsely present. Two weed species were plentiful, *Medicago polymorpha var. polymorpha* (Burr-medic) 5-25% cover and *Carrichtera annua* (Ward's Weed) plentiful but less than 5% cover. See Table 18 for a summary of the flora species recorded at Site 2 and Appendix 4 for a full species list. Figure 28 illustrates the appearance of Site 2 at the time of the survey.

Species abundance

Ten perennial plant species were recorded along the Jessup transect. *Sida intricata* (Twiggy Sida) was the most abundant species (363 established plants) followed by *Sclerolaena obliquicuspis* (Oblique-spined Bindyi) (324 established), *Sclerolaena patenticuspis* (Spear-fruit Bindyi) (220 established) and *Maireana pyramidata* (Black Bluebush) (100 established). See Appendix 5 for cover abundance raw data

Table 18. Vegetation Site 2 flora summary, November 2010.

Only species with a cover abundance score of 1 or greater are shown, with a maximum of three species per category. See Appendix 4 for a full species list.

Details	Description
Vegetation association description	*Maireana pyramidata* (Black Bluebush), *Disphyma crassifolium ssp. clavellatum* (Round-leaf Pigface) Low Shrubland
Species diversity	20 native, 3 exotic
Shrubs / forbs	*Sclerolaena obliquicuspis* (Oblique-spined Bindyi) *Sclerolaena patenticuspis* (Spear-fruit Bindyi) *Maireana turbinata* (Top-fruit Bluebush)
Tall shrubs	None
Trees	None
Grasses	*Austrostipa nodosa* (Tall Spear-grass)
Exotics	*Carrichtera annua* (Ward's Weed) *Medicago polymorpha var. polymorpha* (Burr-medic)
Vegetation condition (SEB)	6:1



Figure 28. Site monitoring photograph – Vegetation Site 2, November 2010.

5.3.3 Vegetation Site 3

Species diversity and cover abundance

Just eleven native species were recorded at Vegetation Site 3. *Tecticornia pergranulata* (Black-seed Samphire) was the dominant species having a cover abundance of between 50-75%. *Disphyma crassifolium ssp. clavellatum* (Round-leaf Pigface) and *Atriplex vesicaria* (Bladder Saltbush) were also well represented, both having a cover abundance of between 5-25%. *Sclerolaena uniflora* (Small spine Bindyi), *Frankenia sp* (Sea-heath) and *Maireana appressa* (Pale-fruit Bluebush) were sparsely present. The weed species *Medicago polymorpha var. polymorpha* (Burr-medic) and *Carrichtera annua* (Ward's Weed) were sparsely present. See Table 19 for a summary of the flora species recorded at Site 3 and Appendix 4 for a full species list. Figure 29 illustrates the appearance of Site 3 at the time of the survey.

Species Abundance

Seven perennial plant species were recorded along the Jessup transect. *Disphyma crassifolium ssp. clavellatum* (Round-leaf Pigface) was the most abundant species (615 established plants, 158 juvenile). Juvenile recruitment of *Disphyma crassifolium ssp. clavellatum* was deemed to be moderate to high at 20% of the population. In total 518 *Tecticornia pergranulata* (Black-seed Samphire) were recorded, with 269 established and six juvenile *Atriplex vesicaria* (Bladder Saltbush). All other species were recorded 16 times or less. See Appendix 5 for cover abundance raw data

Table 19. Vegetation Site 3 flora summary, November 2010.

Only species with a cover abundance score of 1 or greater are shown, with a maximum of three species per category. See Appendix 4 for a full species list.

Details	Description
Vegetation association description	*Tecticornia pergranulata* (Black-seed Samphire), *Disphyma crassifolium ssp. clavellatum* (Round-leaf Pigface) Low Shrubland
Species diversity	12 native, 4 exotic
Shrubs / forbs	*Atriplex vesicaria* (Bladder Saltbush) *Frankenia sp* (Sea-heath)
Tall shrubs	None
Trees	None
Grasses	None
Exotics	*Carrichtera annua* (Ward's Weed) *Medicago polymorpha var. polymorpha* (Burr-medic)
Vegetation condition (SEB)	8:1



Figure 29. Site monitoring photograph – Vegetation Site 3, November 2010.

5.3.4 Vegetation Site 4

Species diversity and cover abundance

Twenty-five native species were recorded at Vegetation Site 4. *Myoporum platycarpum* (False Sandalwood) was the dominant overstorey species. Two tall shrub species were present, *Eremophila scoparia* (Broom Emubush) and *Acacia oswaldii* (Umbrella Wattle). The understorey shrub layer was dominated by *Maireana sedifolia* (Bluebush) (25-50% cover), *Lycium australe* (Australian Boxthorn) (5-25% cover). *Austrostipa nodosa* (Tall Spear-grass) was the dominant grass species, while *Austrostipa platychaeta* (Flat-awn Spear-grass) and *Austrodanthonia* sp. (Wallaby-grass) were sparsely present. *Medicago polymorpha var. polymorpha* (Burr-medic) was widespread covering 5-25% of the area, and *Carrichtera annua* (Ward's Weed) was plentiful but less than 5% cover. See Table 20 for a summary of the flora species recorded at Site 4 and Appendix 4 for a full species list. Figure 30 illustrates the appearance of Site 4 at the time of the survey.

Species abundance

Twelve perennial plant species were recorded along the Jessup transect. *Maireana sedifolia* (Bluebush) was the most abundant species (150 established, 28 juveniles). Juvenile recruitment of *Maireana sedifolia* was deemed to be moderate to high at 15.7% of the population. *Sclerolaena patenticuspis* (Spear-fruit Bindyi) (113 established, two juvenile) and *Sclerolaena obliquicuspis* (Oblique-spined Bindyi) (101 established) were also in high abundance. Sixty-three established *Enchylaena tomentosa* (Ruby Saltbush) and 53 established *Rhagodia ulicina* (Intricate Saltbush) were recorded. All other species were recorded 29 times or less. See Appendix 5 for cover abundance raw data.

Table 20. Vegetation Site 4 flora summary, November 2010.

Only species with a cover abundance score of 1 or greater are shown, with a maximum of three species per category. See Appendix 4 for a full species list.

Details	Description
Vegetation association description	*Myoporum platycarpum* (False Sandalwood) Open Woodland
Species diversity	25 native, 5 exotic
Shrubs / forbs	*Maireana sedifolia* (Bluebush) *Enchylaena tomentosa* (Ruby Saltbush) *Lycium australe* (Australian Boxthorn)
Tall shrubs	*Eremophila scoparia* (Broom Emubush)
Trees	*Myoporum platycarpum* (False Sandalwood)
Grasses	*Austrostipa nodosa* (Tall Spear-grass)
Exotics	*Carrichtera annua* (Ward's Weed) *Medicago polymorpha var. polymorpha* (Burr-medic) *Schismus barbatus* (Arabian Grass)
Vegetation condition (SEB)	6:1



Figure 30. Site monitoring photograph – Vegetation Site 4, November 2010.

5.3.5 Vegetation Site 5

Species diversity and cover abundance

Fifty native species were recorded at Vegetation Site 5. *Eucalyptus socialis* (Beaked Red Mallee) and *Eucalyptus dumosa* (White Mallee) dominated the overstorey. The mid-storey comprised of mixed tall shrubs including *Eremophila alternifolia* (Narrow-leaf Emubush) and *Pittosporum angustifolium* (Native Apricot). *Maireana pyramidata* (Black Bluebush), *Enchylaena tomentosa* (Ruby Saltbush), and *Solanum petrophilum* (Rock Nightshade) were in the understorey. Several weed species were prevalent, including *Marrubium vulgare* (Horehound). See Table 21 for a summary of the flora species recorded and Appendix 4 for a full species list. Figure 31 illustrates the appearance of Site 5 at the time of the survey.

Species abundance

Fifteen perennial plant species were recorded along the Jessup transect. *Enchylaena tomentosa* (Ruby Saltbush) and *Sclerolaena obliquicuspis* (Oblique-spined Bindyi) were the most abundant species. All other species were recorded 15 times or less. See Appendix 5 for cover abundance raw data

Table 21. Vegetation Site 5 flora summary, November 2010.

Only species with a cover abundance score of 1 or greater are shown, with a maximum of three species per category. See Appendix 4 for a full species list.

Details	Description
Vegetation association description	*Eucalyptus socialis* (Beaked Red Mallee), *Eucalyptus dumosa*, (White Mallee) Open Mallee
Species diversity	50 native, 10 exotic
Shrubs / forbs	*Maireana pyramidata* (Black Bluebush) *Lycium australe* (Australian Boxthorn) *Sclerolaena obliquicuspis* (Oblique-spined Bindyi)
Tall shrubs	*Eremophila oppositifolia* (Opposite-leaved Emubush)
Trees	*Myoporum platycarpum* (False Sandalwood) (sparse only) *Acacia papyrocarpa* (Western Myall) (sparse only)
Grasses	*Austrostipa nodosa* (Tall Spear-grass) *Aristida contorta* (Curly Wire-grass)
Exotics	*Carrichtera annua* (Ward's Weed) *Medicago polymorpha* var. polymorpha (Burr-medic) *Marrubium vulgare* (Horehound)
Vegetation condition (SEB)	5:1



Figure 31. Site monitoring photograph – Vegetation Site 5, November 2010.

5.3.6 Vegetation Site 6

Species diversity and cover abundance

Fifty native species were recorded at Vegetation Site 6. *Tecticornia pergranulata* (Black-seed Samphire) was the dominant species. *Disphyma crassifolium ssp. clavellatum* (Round-leaf Pigface), *Atriplex vesicaria* (Bladder Saltbush) and *Maireana cannonii* (Cannon's Bluebush) were also plentiful. *Sclerolaena uniflora* (Small spine Bindyi), *Frankenia sp* (Sea-heath) and *Maireana appressa* (Pale-fruit Bluebush) were sparsely present. One weed species was recorded, *Spergularia diandra* (Lesser Sand-spurrey). See Table 22 for a summary of the flora species recorded at Site 6 and Appendix 4 for a full species list. Figure 32 illustrates the appearance of Site 6 at the time of the survey.

Species abundance

Eight perennial plant species were recorded along the Jessup transect. *Disphyma crassifolium ssp. clavellatum* (Round-leaf Pigface) was the most abundant species. Juvenile recruitment of *Disphyma crassifolium ssp. clavellatum* was moderate to high. *Tecticornia pergranulata* (Black-seed Samphire) was the second most abundant species with *Maireana cannonii* (Cannon's Bluebush), *Atriplex vesicaria* (Bladder Saltbush), and *Frankenia sp* (Sea-heath) also well represented. Significant juvenile recruitment was recorded for *Maireana appressa* (Pale-fruit Bluebush). See Appendix 5 for cover abundance raw data

Table 22. Vegetation Site 6 flora summary, November 2010.

Only species with a cover abundance score of 1 or greater are shown, with a maximum of three species per category. See Appendix 4 for a full species list.

Details	Description
Vegetation association description	*Tecticornia pergranulata* (Black-seed Samphire), *Disphyma crassifolium ssp. clavellatum* (Round-leaf Pigface) Low Shrubland
Species diversity	10 native, 1 exotic
Shrubs / forbs	*Atriplex vesicaria* (Bladder Saltbush) *Maireana cannonii* (Cannon's Bluebush)
Tall shrubs	None
Trees	None
Grasses	None
Exotics	*Spergularia diandra* (Lesser Sand-spurrey)
Vegetation condition (SEB)	9:1



Figure 32. Site monitoring photograph – Vegetation Site 6, November 2010.

5.3.7 Vegetation Site 7

Species diversity and cover abundance

Eighteen native species were recorded at Vegetation Site 7. *Maireana sedifolia* (Bluebush) and *Atriplex vesicaria* (Bladder Saltbush) were the dominant species. *Sclerolaena obliquicuspis* (Oblique-spined Bindyi) and *Sclerolaena patenticuspis* (Spear-fruit Bindyi) were also plentiful. *Austrostipa nodosa* (Tall Spear-grass) was the dominant grass species *Austrodanthonia caespitosa* (Common Wallaby-grass) was plentiful but of less than 5% cover. Three weed species were plentiful within the quadrat, *Carrichtera annua* (Ward's Weed), *Medicago polymorpha var. polymorpha* (Burr-medic) and *Sisymbrium erysimoides* (Smooth Mustard) all recording a cover abundance of 5% or less. See Table 23 for a summary of the flora species recorded at Site 7 and Appendix 4 for a full species list. Figure 33 illustrates the appearance of Site 7 at the time of the survey.

Species abundance

Nine perennial plant species were recorded along the Jessup transect. Based on individual counts *Maireana sedifolia* (Bluebush) was the most abundant species. *Sclerolaena obliquicuspis* (Oblique-spined Bindyi) was the second most common species recorded followed by *Atriplex vesicaria* (Bladder Saltbush). All other species were recorded 27 times or less. See Appendix 5 for cover abundance raw data

Table 23. Vegetation Site 7 flora summary, November 2010.

Only species with a cover abundance score of 1 or greater are shown, with a maximum of three species per category. See Appendix 4 for a full species list.

Details	Description
Vegetation association description	*Maireana sedifolia* (Bluebush), *Atriplex vesicaria* (Bladder Saltbush) Shrubland
Species diversity	18 native, 5 exotic
Shrubs / forbs	*Sclerolaena obliquicuspis* (Oblique-spined Bindyi)*Lycium australe* (Australian Boxthorn) *Sclerolaena patenticuspis* (Spear-fruit Bindyi) *Eriochiton sclerolaenoides* (Woolly-fruit Bluebush) *Maireana turbinata* (Top-fruit Bluebush)
Tall shrubs	None
Trees	None
Grasses	*Austrostipa nodosa* (Tall Spear-grass) *Austrodanthonia caespitosa* (Common Wallaby-grass)
Exotics	*Carrichtera annua* (Ward's Weed) *Medicago polymorpha var. polymorpha* (Burr-medic) *Sisymbrium erysimoides* (Smooth Mustard)
Vegetation condition (SEB)	6:1

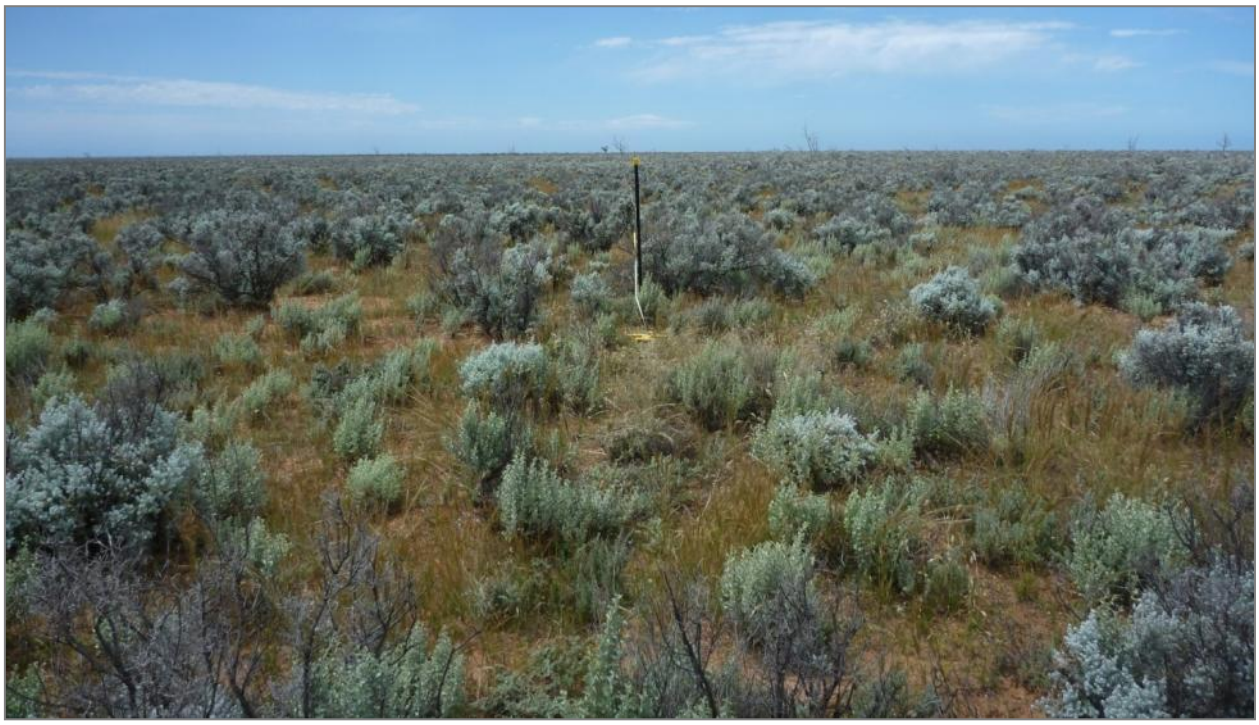


Figure 33. Site monitoring photograph – Vegetation Site 7, November 2010.

5.3.8 Vegetation Site 8

Species diversity and cover abundance

Eighteen native species were recorded at Vegetation Site 8. *Atriplex vesicaria* (Bladder Saltbush) was the dominant species. *Disphyma crassifolium ssp. clavellatum* (Round-leaf Pigface) and *Sclerolaena obliquicuspis* (Oblique-spined Bindyi) were also present. Several other species were plentiful but of small cover, including *Sclerolaena divaricata* (Tangled Bindyi), *Tecticornia pergranulata* (Black-seed Samphire), *Sclerolaena patenticuspis* (Spear-fruit Bindyi), and *Minuria cunninghamii* (Bush Minuria). Two *Austrostipa nodosa* (Tall Spear-grass) and *Austrodanthonia caespitosa* (Common Wallaby-grass) were plentiful, while *Austrostipa eremophila* (Rusty Spear-grass) was sparsely present. The weed species *Carrichtera annua* (Ward's Weed) and *Medicago polymorpha var. polymorpha* (Burr-medic) were common throughout the site. See Table 24 for a summary of the flora species recorded at Site 8 and Appendix 4 for a full species list. Figure 34 illustrates the appearance of Site 8 at the time of the survey.

Species abundance

Seven perennial plant species were recorded along the Jessup transect. *Atriplex vesicaria* (Bladder Saltbush) was the most abundant species. Juvenile recruitment of *Atriplex vesicaria* was moderate at 12.6% of the population. *Disphyma crassifolium ssp. clavellatum* (Round-leaf Pigface) was the second most abundant species followed by *Sclerolaena obliquicuspis* (Oblique-spined Bindyi). All other species were recorded three times or less. See Appendix 5 for cover abundance raw data.

Table 24. Vegetation Site 8 flora summary, November 2010.

Only species with a cover abundance score of 1 or greater are shown, with a maximum of three species per category. See Appendix 4 for a full species list.

Details	Description
Vegetation association description	*Atriplex vesicaria* (Bladder Saltbush), *Disphyma crassifolium ssp. clavellatum* (Round-leaf Pigface) Low Shrubland
Species diversity	24 native, 5 exotic
Shrubs / forbs	*Sclerolaena divaricata* (Tangled Bindyi) *Sclerolaena obliquicuspis* (Oblique-spined Bindyi) *Eriochiton sclerolaenoides* (Woolly-fruit Bluebush)
Tall shrubs	None
Trees	None
Grasses	*Austrostipa nodosa* (Tall Spear-grass) *Austrodanthonia caespitosa* (Common Wallaby-grass)
Exotics	*Carrichtera annua* (Ward's Weed) *Medicago polymorpha var. polymorpha* (Burr-medic)
Vegetation condition (SEB)	8:1



Figure 34. Site monitoring photograph – Vegetation Site 8, November 2010.

5.3.9 Vegetation Site 9

Species diversity and cover abundance

Twenty-one native species were recorded at Vegetation Site 9. *Maireana pyramidata* (Black Bluebush), and *Atriplex vesicaria* (Bladder Saltbush) were the dominant species. *Sclerolaena obliquicuspis* (Oblique-spined Bindyi), *Sclerolaena patenticuspis* (Spear-fruit Bindyi) and *Maireana turbinata* (Top-fruit Bluebush) were also present. *Austrostipa nodosa* (Tall Spear-grass), *Austrodanthonia caespitosa* (Common Wallaby-grass) and *Eragrostis* sp. (Love Grass) were present but recorded in low densities. Three weed species were common throughout the site, including *Spergularia diandra* (Lesser Sand-spurrey), *Carrichtera annua* (Ward's Weed) and *Medicago polymorpha var. polymorpha* (Burr-medic). See Table 25 for a summary of the flora species recorded at Site 9 and Appendix 4 for a full species list. Figure 35 illustrates the appearance of Site 9 at the time of the survey.

Species abundance

Six perennial plant species were recorded along the Jessup transect. *Maireana pyramidata* (Black Bluebush) was the most abundant species with 273 established plants recorded, followed by *Atriplex vesicaria* (Bladder Saltbush). Juvenile recruitment of *Atriplex vesicaria* was moderate to high at 25.5% of the population. *Sclerolaena obliquicuspis* (Oblique-spined Bindyi) recorded 215 established individuals, with all other species being recorded 28 times or less. See Appendix 5 for cover abundance raw data.

Table 25. Vegetation Site 9 flora summary, November 2010.

Only species with a cover abundance score of 1 or greater are shown, with a maximum of three species per category. See Appendix 4 for a full species list.

Details	Description
Vegetation association description	*Maireana pyramidata* (Black Bluebush), *Atriplex vesicaria* (Bladder Saltbush), Shrubland
Species diversity	21 native, 3 exotic
Shrubs / forbs	*Sclerolaena obliquicuspis* (Oblique-spined Bindyi) *Sclerolaena patenticuspis* (Spear-fruit Bindyi) *Maireana turbinata* (Top-fruit Bluebush)
Tall shrubs	None
Trees	None
Grasses	*Austrodanthonia caespitosa* (Common Wallaby-grass)
Exotics	*Carrichtera annua* (Ward's Weed) *Medicago polymorpha var. polymorpha* (Burr-medic) *Spergularia diandra* (Lesser Sand-spurrey)
Vegetation condition (SEB)	6:1



Figure 35. Site monitoring photograph – Vegetation Site 9, November 2010.

5.3.10 Vegetation Site 10

Species diversity and cover abundance

Twenty-one native species were recorded at Vegetation Site 10. *Maireana sedifolia* (Bluebush) was the dominant species. Several other shrub species were plentiful, including *Atriplex vesicaria* (Bladder Saltbush), *Sclerolaena obliquicuspis* (Oblique-spined Bindyi), *Lycium australe* (Australian Boxthorn) and *Rhagodia ulicina* (Intricate Saltbush). *Austrostipa nodosa* (Tall Spear-grass) was the most abundant grass species, while other grass species were recorded in lower densities. Three weed species, *Spergularia diandra* (Lesser Sand-spurrey), *Carrichtera annua* (Ward's Weed) and *Medicago polymorpha var. polymorpha* (Burr-medic) were plentiful but less than 5% cover. See Table 26 for a summary of the flora species recorded at Site 10 and Appendix 4 for a full species list. Figure 36 illustrates the appearance of Site 10 at the time of the survey.

Species abundance

Ten perennial plant species were recorded along the Jessup transect. *Maireana sedifolia* (Bluebush) was the most abundant species. *Sclerolaena obliquicuspis* (Oblique-spined Bindyi) was the second most abundant species followed by *Atriplex vesicaria* (Bladder Saltbush), *Lycium australe* (Australian Boxthorn), *Rhagodia ulicina* (Intricate Saltbush) and *Eriochiton sclerolaenoides* (Woolly-fruit Bluebush) 44 established. All other species were recorded 23 times or less. See Appendix 5 for cover abundance raw data.

Table 26. Vegetation Site 10 flora summary, November 2010.

Only species with a cover abundance score of 1 or greater are shown, with a maximum of three species per category. See Appendix 4 for a full species list.

Details	Description
Vegetation association description	*Maireana sedifolia* (Bluebush) Shrubland
Species diversity	25 native, 6 exotic
Shrubs / forbs	*Atriplex vesicaria* (Bladder Saltbush) *Rhagodia ulicina* (Intricate Saltbush) *Sclerolaena patenticuspis* (Spear-fruit Bindyi)
Tall shrubs	None
Trees	None
Grasses	*Austrostipa nodosa* (Tall Spear-grass)
Exotics	*Carrichtera annua* (Ward's Weed) *Medicago polymorpha var. polymorpha* (Burr-medic) *Spergularia diandra* (Lesser Sand-spurrey)
Vegetation condition (SEB)	6:1

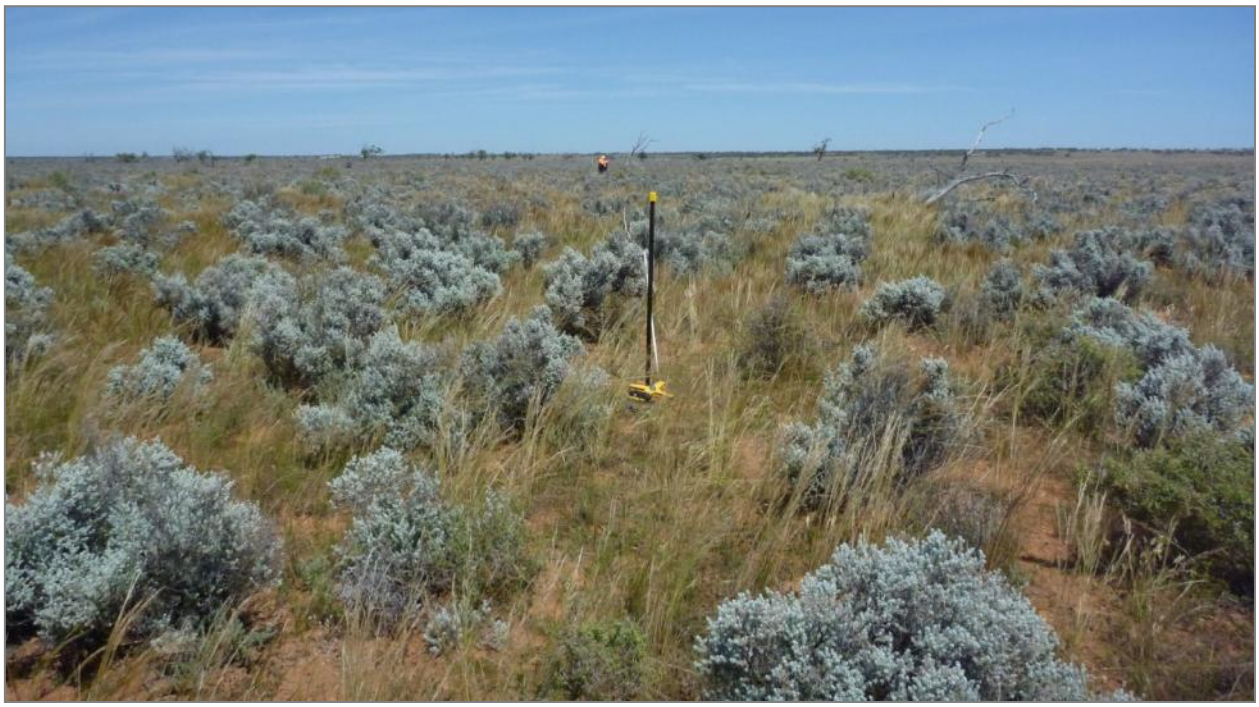


Figure 36. Site monitoring photograph – Vegetation Site 10, November 2010.

6 DISCUSSION

6.1 Flora and fauna communities of Mullaquana

The flora and fauna species recorded during the survey are those that would be expected to occur in the region. Overall condition of the vegetation was considered significantly better than expected of a pastoral lease, with no sites considered to be of very poor or poor condition. The lowest condition noted was a SEB ratio of 5:1 (moderate condition), recorded for just one site. The majority of sites (6 sites) were considered to be in moderate condition. Two sites were of good condition, and one site was considered to be of excellent condition. *Tecticornia pergranulata* (Black-seed Samphire), *Disphyma crassifolium ssp. clavellatum* (Round-leaf Pigface) Low Shrubland and *Atriplex vesicaria* (Bladder Saltbush), *Disphyma crassifolium ssp. clavellatum* (Round-leaf Pigface) Low Shrubland vegetation associations were considered excellent and assigned a 9:1 SEB condition score. Vegetation of these associations was intact and botanical composition close to original, with little or no signs of disturbance and little or no weed infestation.

The lack of small native mammals, particularly rodents, is consistent with previous survey work in the area. No species were identified in the desktop assessment of BDBSA records as likely to occur in the area. The survey has built on the known bat species of the area, however several species need to be confirmed through capture (and specimen lodgement with the South Australian Museum).

6.2 Conservation significant birds

6.2.1 Thick-billed Grasswren

Two nationally vulnerable Thick-billed Grasswren (*Amytornis textilis myall*) were observed during the November 2010 survey within Mullaquana Station (Figure 13, page 31). Although the number of individuals observed is low, it does compare with the two observed in October 2009 during the baseline survey, and seven observed during the follow-up bird survey in February 2010. The detection of the species over three survey periods indicates Thick-billed Grasswrens are a resident of the project area, with the low observation rate, particularly during the current survey period despite increased survey effort, indicating the population numbers in the area are low.

All observations during the current survey were within *Maireana sedifolia* (Bluebush), *Maireana pyramidata* (Black Bluebush) Low Open Shrubland. This habitat type is consistent with the species known habitat preferences. Black *et al.* 2009, identified that the presence of Thick-billed Grasswrens could largely be predicted by the total cover of *Maireana pyramidata* (Blackbush), *Lycium australe* (Australian Boxthorn), *Enchylaena tomentosa* (Ruby Saltbush) and taller shrubs over 0.75 m. These species can often grow as compact dense shrubs, offering protection for the birds. This preference for taller dense shrubs also suggests that the Thick-billed Grasswrens association with drainage lines (as typically highlighted as the species preferred habitats), may also be due to the higher level of protection offered by shrubs within drainage lines, rather than any other habitat element. The research conducted

by Black *et al.* (2009) also indicated that overall percentage cover, and therefore distance between shrubs, of *Maireana pyramidata* (Blackbush) was important to the species.

6.2.2 Slender-billed Thornbill

Slender-billed Thornbills were recorded in high numbers (61 records), 21 of which were observed opportunistically within the survey area, and 40 were observed over seven sites. The species was recorded at five locations where they were previously not recorded (Bird Sites 11, 14, 15, 16 and 18). All observations were within *Maireana sedifolia* (Bluebush), *Maireana pyramidata* (Black Bluebush) Low Open Shrubland, and *Halosarcia pergranulata* (Black-seed Samphire), *Halosarcia* sp. (Samphire sp) Low Shrubland.

The Slender-billed Thornbill myall sub-species is not known to take any long-distance movements, making it typically a sedentary species (Higgins and Peter 2002). This behaviour, together with the high numbers observed to date at Mullaquana, suggests the species is a resident of the project area. It is difficult to estimate an accurate population size within the study area.

6.2.3 Threatened bird habitat assessment

The habitat assessment against key criteria conducted during the current survey does suggest the Thick-billed Thornbill has a strong habitat requirements for high, compact and dense *Maireana* shrubs, in close proximity to other similar valued shrubs, likely to be sought after for protection. The Slender-billed Thornbill also has similar requirements, but may not be as strict. The assessment process identified that such habitat areas are limited to isolated pockets within Mullaquana, are almost non-existent within Nonowie, and were not located outside of the Mullaquana/Nonowie project area on adjacent pastoral leases that were briefly assessed. This knowledge significantly reduces the total area thought to be suitable for Thick-billed Grasswrens, as it is now known that merely chenopod shrublands dominated by *Maireana sedifolia* and *Maireana pyramidata* may not be suitable as shrub height, density and distance between shrubs may not meet the species requirements.

6.2.4 Little Egret

The Little Egret (rare NPW Act) was observed outside the project area at Cowled's Landing and also along shorelines near Whyalla. Although not observed specifically within the project area, these observations in the wider area, within habitat that is also found within the project area, suggests the species is likely to visit the Mullaquana project area. This species is likely to remain within the shallow margins of the tidal areas within the project area, and only visit the area rather than permanently occupy. The species is considered nomad, and can frequent tidal mudflats, mangroves, salt works and shallow margins of tidal estuaries and inland rivers and lakes (Emison 1978).

6.2.5 Sooty Oystercatcher

The Sooty Oystercatcher (rare under the NPW Act) was observed only at Cowled's Landing. Although not observed specifically within the project area, the observation close by, within habitat that is also found within the project area, suggests the species is likely to visit the Mullaquana project area.

The Sooty Oystercatcher is endemic to Australia, and is strictly a coastal species, usually only found within 50 m of the ocean. It prefers rocky shores, but will be seen on coral reefs or sandy beaches near mudflats (Marchant and Higgins 1990). This species is likely to remain near sandy beaches near mudflats.

7 RECOMMENDATIONS

To assist UraniumSA to understand the potential impacts of further exploration and mining of the Mullaquana lease areas, and to assist with future applications, including an EPBC Act referral necessary due to the presence and potential impact on the nationally vulnerable Thick-billed Grasswren and Slender-billed Field Wren, further field surveys focussing on habitat are recommended.

Despite the dominance of chenopod shrublands across the Mullaquana area, the current survey identified the limited areas that meet the strict habitat criteria of the threatened bird species. Of importance is shrub height, foliage density, and distance between suitable shrubs. Effectively this means that the Thick-billed Grasswren and Slender-billed Thornbill are limited to isolated 'islands' within the project area. These islands would form the species core habitat areas, possibly for most of the year. At other times of the year, particularly when resources levels were high, their criteria may be less strict, and their distribution may be expanded into adjacent areas that would normally be considered un-suitable.

A field survey to identify the location of the core habitat areas is recommended. Ideally, the locations should be mapped, and a full habitat assessment completed to describe the habitat elements in detail. Such details would include shrub species, average and maximum shrub height, shrub foliage density, and distance between individual shrubs. The area of each individual patch of core habitat should be determined. Once the locations have been mapped, an assessment should be undertaken to identify important corridors of near-suitable habitat that link the core habitat areas, allowing the birds to travel between the core habitats.

The areas of core habitat should be surveyed to confirm the use by the Slender-billed Thornbill and/or Thick-billed Grasswren. The bird survey should incorporate a behaviour survey to note how the habitat is used, and for what period of time. Ideally a single observer would locate a group of birds, record their behaviour (activities such as perching, feeding, resting, preening etc), and record the time interval spent within the core habitat boundaries. Time spent outside the boundaries would also be noted, as well as the behaviours undertaken. Where possible, the group of birds would be monitored and followed to determine flight direction, location where the individuals move to, and the habitat moved through versus flown through. This would assist to confirm the use of the identified habitat corridors linking the patches of core habitat.

Identifying the core habitat areas will inform UraniumSA on the location of important habitat areas and corridors between the important habitat areas. This information could then be taken into consideration when planning the location of mine related infrastructure, including tracks, as well as any conservation efforts to protect the species through habitat conservation.

The bird surveys conducted to date have provided a good baseline on the types of species utilising the project area. Unfortunately the nomadic behaviour of some species makes it difficult to assess the importance of the Mullaquana area, particularly the adjacent coastline, to such species as they are likely to infrequently visit the area. Knowledge of the nomadic birds will be built over time, as surveys continue.

It is recommended that the shorelines remain a priority to detect the migratory species that may use the area, even though this is slightly out of the Mullaquana lease area.

The surveys conducted to date have provided a good baseline of the types of vegetation and fauna communities present with the Mullaquana area. It is recommended the project now progresses into a monitoring phase, with replication of the methods and techniques undertaken, at 12 month intervals (ideally during November each year). This data collected would allow for identifying changes over time, which could be interpreted to explain why the changes have occurred, and whether then changes are natural trends, or attributable to impacts of the mine development. The methods, techniques, and site locations, conducted for the current survey should be repeated.

8 REFERENCES

Barker R.D., Vestjens W.J.M. (1990) *The Food of Australian Birds. 2. Passerines*. CSIRO, Melbourne.

Black, A., Carpenter, G., Pedler, L. (2009) Distribution and habitats of the Thick-billed Grasswren Amytornis textilis, subspecies myall. *South Australian Ornithologist*, 35, 161-173.

Brooker M.G. (1988) Some aspects of the biology and conservation of the Thick-billed Grasswren *Amytornis textilis* in the Shark Bay area, Western Australia. *Corella* 12, 101-108.

Chapman G.S. (1996) The grasswrens: A brief pictorial. *Wingspan*. 6 20-27.

Cooke J., Ash J., Groves R. (2004) The ecology of Ward's Weed (*Carrichtera anna*): a weed of southern rangelands of Australia. *Ecological Society of Australia Annual Conference* 2004, Adelaide.

DEH (2008) *Biological Database Records of South Australia* (BDBSA). Department of Environment and Heritage, Adelaide.

DWLBC (2005) *Guidelines for a Native Vegetation Significant Environmental Benefit Policy. Department of Water*, Land, and Biodiversity Conservation, Adelaide.

EBS (2009) *Mullaquana Flora and Fauna Survey – Initial Assessment. Report to Uranium SA.* Environmental and Biodiversity Services, Adelaide.

Garnet S.T., Crowley G.M. (2000) *The action plan for Australian birds*. Environment Australia, Canberra.

Gee P., Gee I., Read J. (1996). An annotated bird list from the Davenport Range, South Australia. *South Australian Ornithologist*. 32: 76-81.

Grund, R. (2009) *A checklist of the butterflies to be found in South Australia and details of their conservation status*. Available from the South Australian Butterflies website http://users.sa.chariot.net.au/~rgrund/index.htm. Accessed Feb-2010.

Heard L., Channon B. (eds) (1997) *Guide to A Native Vegetation Survey Using the Biological Survey of South Australia*. Department of Housing and Urban Development, Adelaide.

Higgins P.J., Peter J.M., Steele W.K. (Eds) (2001) Handbook of Australian, New Zealand and Antarctic Birds. Volume 5: Tyrant-flycatchers to Chats. Oxford University Press.

Jessup J.P., Toelken H.R. (Eds) (1986) *Flora of South Australia Parts 1-4*. South Australian Government Printer, Adelaide.

Morcombe M. (2000) *Field Guide to Australian Birds*. Steve Parish Publishing, Archerfield.

Muir B.G. (1977) Biological Survey of the Western Australian Wheatbelt. Part 2: Vegetation and Habitat of Bendering Reserve. *Records of the Western Australian Museum*. Supplement No. 3. WA Museum, Perth.

Schodde R. (1982) *The Fairy-wrens: a Monograph of the Maluridae*. Lansdowne, Melbourne.

Serventy V.N. (Ed) (1982) *The Wrens and Warblers of Australia.* Angus and Robertson and the Australian Photographic Index of Australian Wildlife, Sydney.

Specht R.L. (1972) *The Vegetation of South Australia*. Government Printer, Adelaide.

9 APPENDICES

Appendix 1. Survey site co-ordinates.

Fauna sites.

Site number	Detail	Zone	Easting	Northing
Site 1	Line A start	53 H	724872	6325055
Site 1	Line A end	53 H	724911	6325072
Site 1	Line B start	53 H	724861	6324982
Site 1	Line B end	53 H	724899	6324986
Site 2	Line A start	53 H	723980	6326487
Site 2	Line A end	53 H	723990	6326442
Site 2	Line B start	53 H	723920	6326476
Site 2	Line B end	53 H	723927	6326435
Site 3	Line A start	53 H	725681	6321373
Site 3	Line A end	53 H	725709	6321397
Site 3	Line B start	53 H	725785	6321342
Site 3	Line B end	53 H	725763	6321309
Site 4	Line A start	53 H	723599	6320189
Site 4	Line A end	53 H	723628	6320199
Site 4	Line B start	53 H	723676	6320160
Site 4	Line B end	53 H	723714	6320165
Site 5	Line A start	53 H	720263	6320182
Site 5	Line A end	53 H	720264	6320227
Site 5	Line B start	53 H	720291	6320084
Site 5	Line B end	53 H	720310	6320049

Bird sites.

Site number	Zone	Easting	Northing
Standard bird survey sites (in addition to the fauna sites)			
6	53 H	725646	6327183
10	53 H	725530	6322666
15	53 H	723617	6322059
Additional locations visited			
11	53 H	725694	6323925
14	53 H	727943	6327485
16	53 H	723062	6320807
17	53 H	724789	6324899
18	53 H	723593	6324829

Vegetation sites.

Site number	Zone	Easting	Northing
Veg 1	53H	724921	6324997
Veg 2	53H	723818	6326477
Veg 3	53H	725693	6321311
Veg 4	53H	723667	6320183
Veg 5	53H	720268	6320276
Veg 6	53H	724210	6318022
Veg 7	53H	723636	6322029
Veg 8	53H	726742	6329754
Veg 9	53H	725685	6327170
Veg 10	53H	723547	6323821

Appendix 2. Native Vegetation Council SEB Ratio table.

Con	SEB ratio	% total indigenous cover	Native Vegetation Council SEB Ratio			
			Overstorey condition description	Understorey condition description	Indicators	NVC Interim Policy (1.2.11)
Very Poor	0:1	<10%	No overstorey stratum remaining.	Complete destruction of indigenous understorey* (by grazing &/or introduced plants).	Vegetation structure no longer intact (e.g. removal of one or more vegetation strata). Scope for regeneration, but not to a state approaching good condition without intensive management. Dominated by very aggressive weeds. Partial or extensive clearing (> 50% of area). Evidence of heavy grazing (tracks, browse lines, species changes, complete depletion of soil surface crust).	Where proposed clearance is considered to be minor and of limited biodiversity impact, eg lopping of overhanging limbs only or minor clearance of shrubs in areas otherwise considered as highly disturbed.
	1:1	10-19%	Scattered trees in poor health and/or representing an immature stand.	Almost complete destruction of indigenous understorey* (by grazing &/or introduced plants) - reduced to scattered clumps and individual plants.		
	2:1	20-29%	Scattered trees either immature in good health, or mature in poor/moderate health. Alternatively, the dominant overstorey stratum is largely intact and an immature stand (or regrowth), and is generally in poor health.			Where proposed clearance is in areas dominated by introduced species, the area of native vegetation is largely reduced to scattered trees, indigenous understorey reduced to scattered clumps and individual plants
Poor	3:1	30-39%	Dominant overstorey stratum is largely intact and a moderately healthy mature stand.	Heavy loss of native plant species (by grazing &/or introduced plants). The understorey* consists predominately of alien species, although a small number of natives persist.	Vegetation structure substantially altered (e.g. one or more vegetation strata depleted). Retains basic vegetation structure or the ability to regenerate it. Very obvious signs of long-term or severe disturbance. Weed dominated with some very aggressive weeds. Partial clearing (10 – 50% of area). Evidence of moderate grazing (tracks, browse lines, soil surface crust extensively broken).	
	4:1	40-49%	Dominant overstorey stratum is largely intact and is a healthy mature stand with high wildlife habitat value (eg. hollows).			Where the proposed clearance is of mostly intact overstorey vegetation but there is still considerable weed infestation amongst the understorey flora

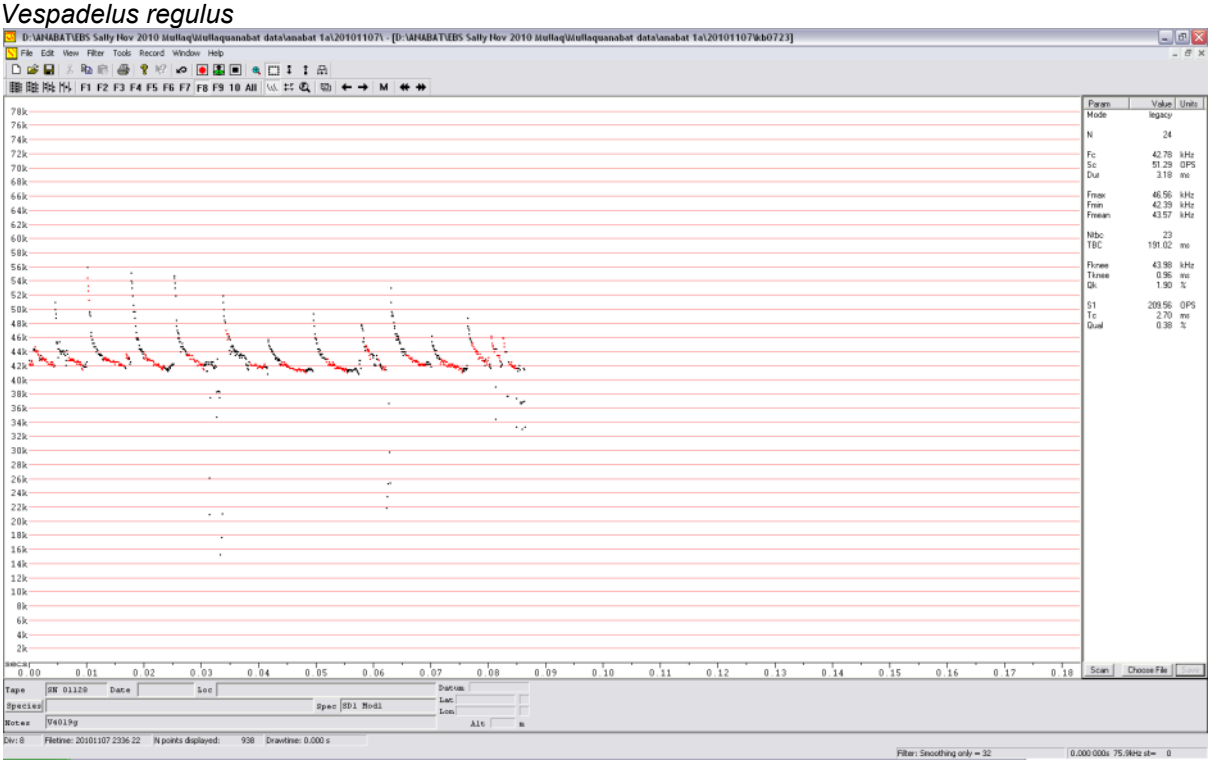
Con	SEB ratio	% total indigenous cover	Native Vegetation Council SEB Ratio			
			Overstorey condition description	Understorey condition description	Indicators	NVC Interim Policy (1.2.11)
Moderate	5:1	50-59%	Dominant overstorey stratum is largely intact – any condition+	Moderate loss of native understorey diversity. Weed-free areas small. Substantial invasion of aliens resulting in significant competition, but native understorey* persists; for example, may be a low proportion of native species and a high native cover, or a high proportion of native species and low native cover.	Vegetation structure altered (e.g. one or more vegetation strata depleted). Most seed sources available to regenerate original structure. Obvious signs of disturbance (e.g. tracks, bare ground). Minor clearing (<10% of area). Considerable weed infestation with some aggressive weeds. Evidence of some grazing (tracks, soil surface crust patchy).	
	6:1	60-69%	Dominant overstorey stratum is largely intact – any condition+	Moderate but not severe weed infestation amongst the understorey flora.		Where the proposed clearance is of mostly intact overstorey vegetation with moderate but not severe weed infestation amongst the understorey flora. Clearance is not seriously at variance with the Principles
Good	7:1	70-79%	Original overstorey stratum is still dominant and intact – any condition+	Understorey only slightly modified. High proportion of native species and native cover in the understorey*; reasonable representation of probable pre-European vegetation.	Vegetation structure intact (e.g. all strata intact). Disturbance minor, only affecting individual species. Only non-aggressive weeds present. Some litter build-up.	
	8:1	80-89%	Original overstorey stratum is still dominant and intact – any condition+	Understorey only slightly modified. High proportion of native species and native cover in the understorey*; reasonable representation of probable pre-European vegetation.		Where the proposed clearance is of mostly intact overstorey and understorey vegetation, weed infestation is moderate to low, but the original vegetation is still dominant. Clearance is assessed by the Native Vegetation Council to be at variance with the Principles

Con	SEB ratio	% total indigenous cover	Native Vegetation Council SEB Ratio			
			Overstorey condition description	Understorey condition description	Indicators	NVC Interim Policy (1.2.11)
Excellent	9:1	>89%	Original vegetation is still dominant and intact. Overstorey individuals in good condition and represent a mature stand.	Diverse vegetation with very little weed infestation. Understorey largely undisturbed, minimal loss of plant species diversity. Very little or no sign of alien vegetation in the understorey*; resembles probable pre-European condition.	All strata intact and botanical composition close to original. Little or no signs of disturbance. Little or no weed infestation. Soil surface crust intact. Substantial litter cover.	
	10:1		Original vegetation is still dominant and intact. Overstorey individuals in good condition and represent a mature stand, with high habitat value (eg. hollows).			Where the proposed clearance is of diverse vegetation with very little weed infestation. Clearance is assessed by the Native Vegetation Council to be seriously at variance with the Principles

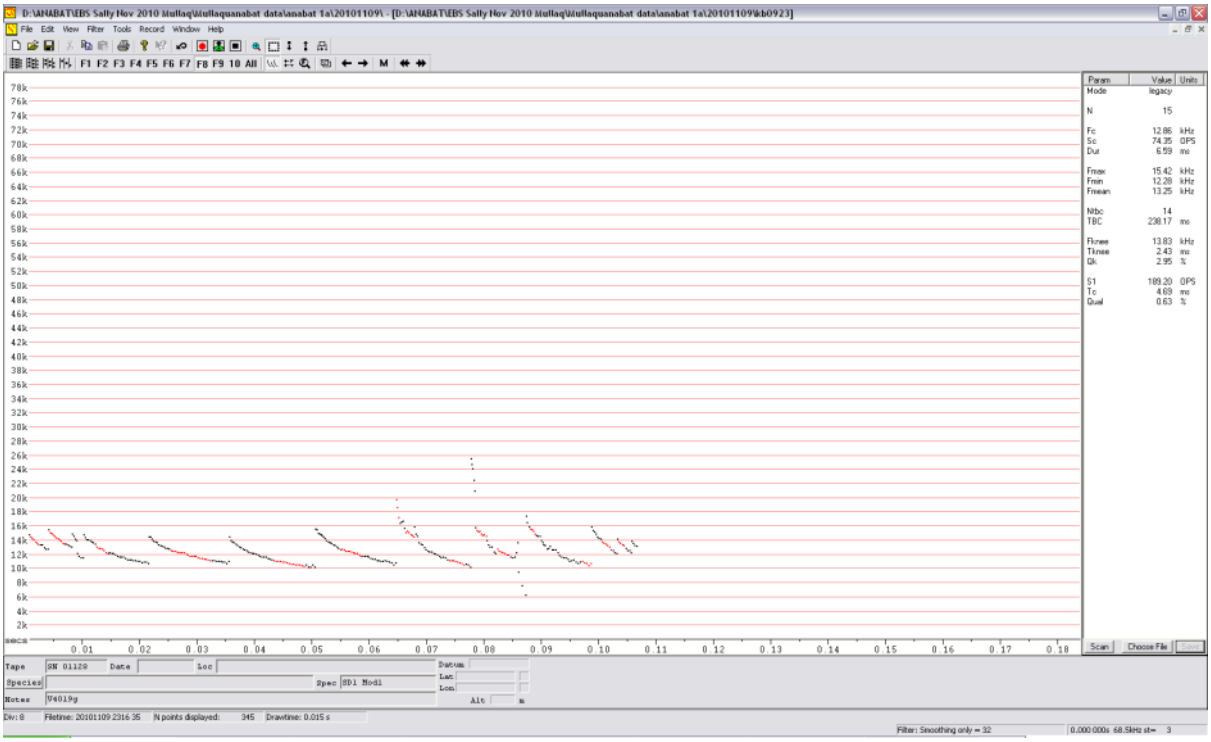
*Or all strata if the upper and lower strata are difficult to distinguish
+ Ratio assessment will largely depend upon condition of understorey associated with an intact overstorey stratum.
Adapted from '*Guide to Roadside Vegetation Survey Methodology for South Australia*', (Stokes *et al.* 1998) and '*Guidelines for a Native Vegetation Significant Environmental Benefit Policy*', (DWLBC 2005).

Appendix 3. Example bat calls (as viewed in AnaLook) recorded during the November 2010 survey.

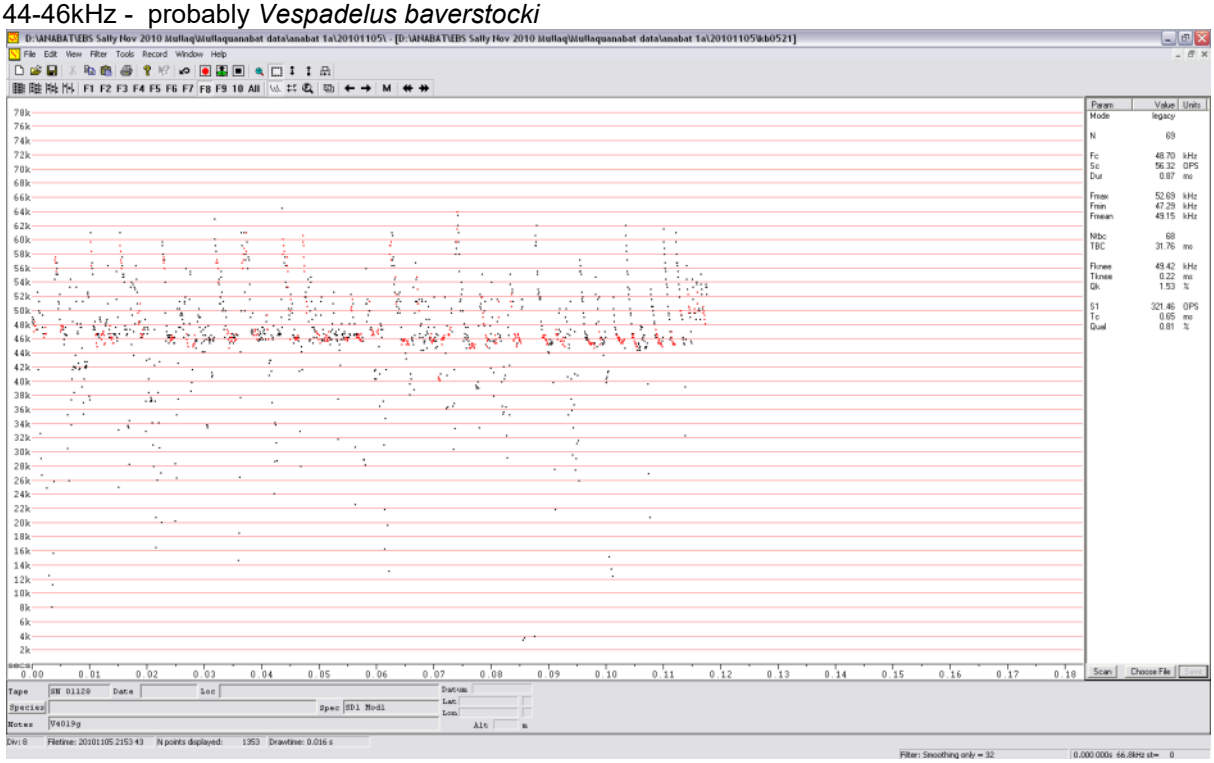
Vespadelus regulus



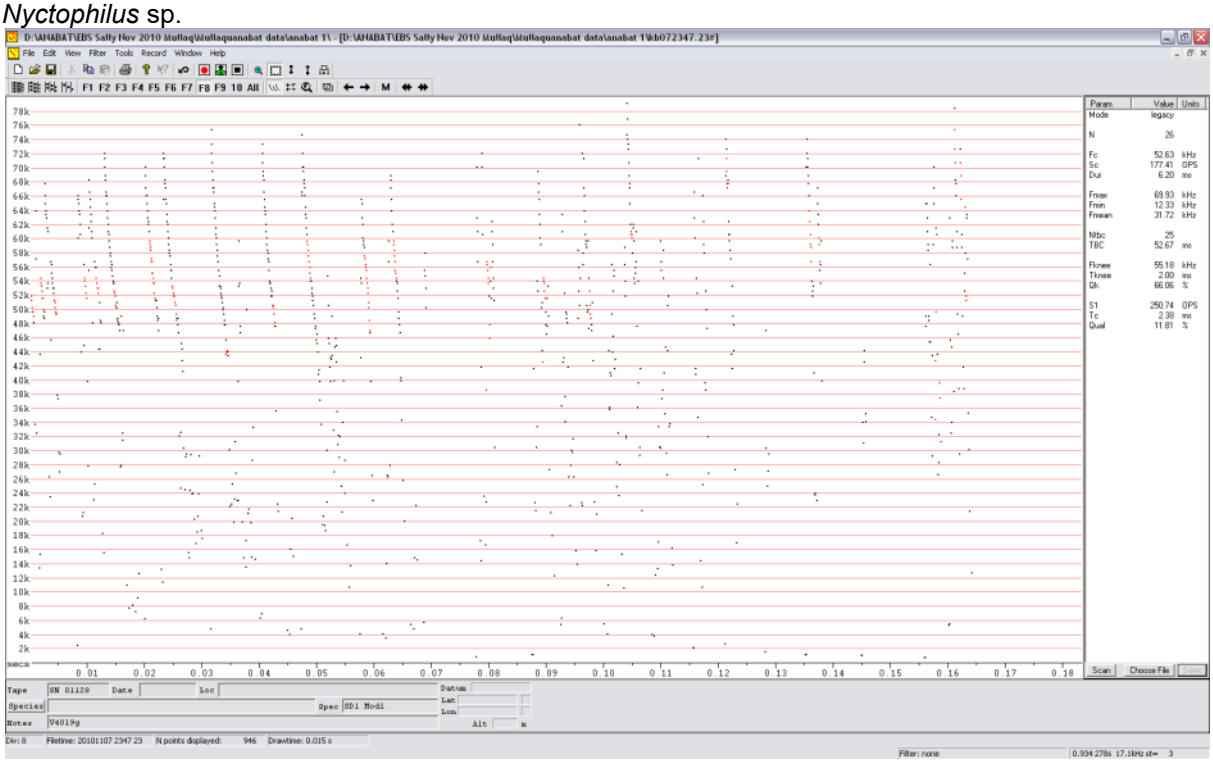
Tadarida australis



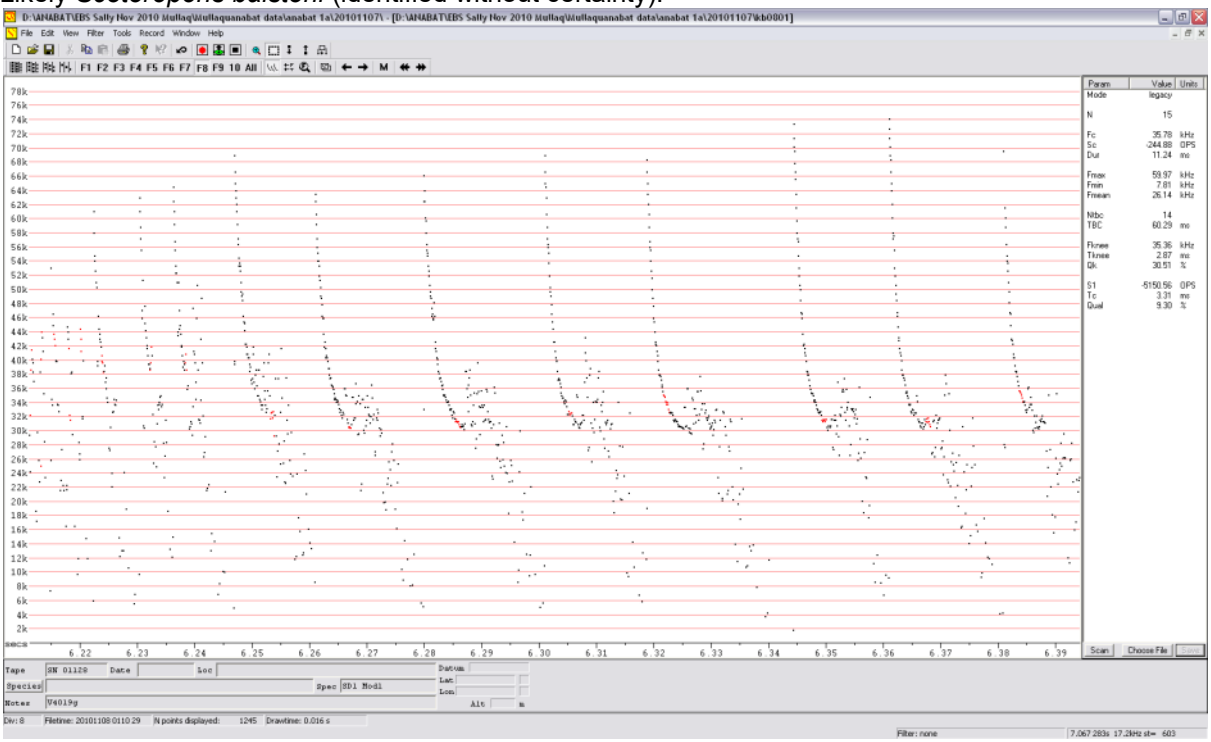
44-46kHz - probably *Vespadelus baverstocki*



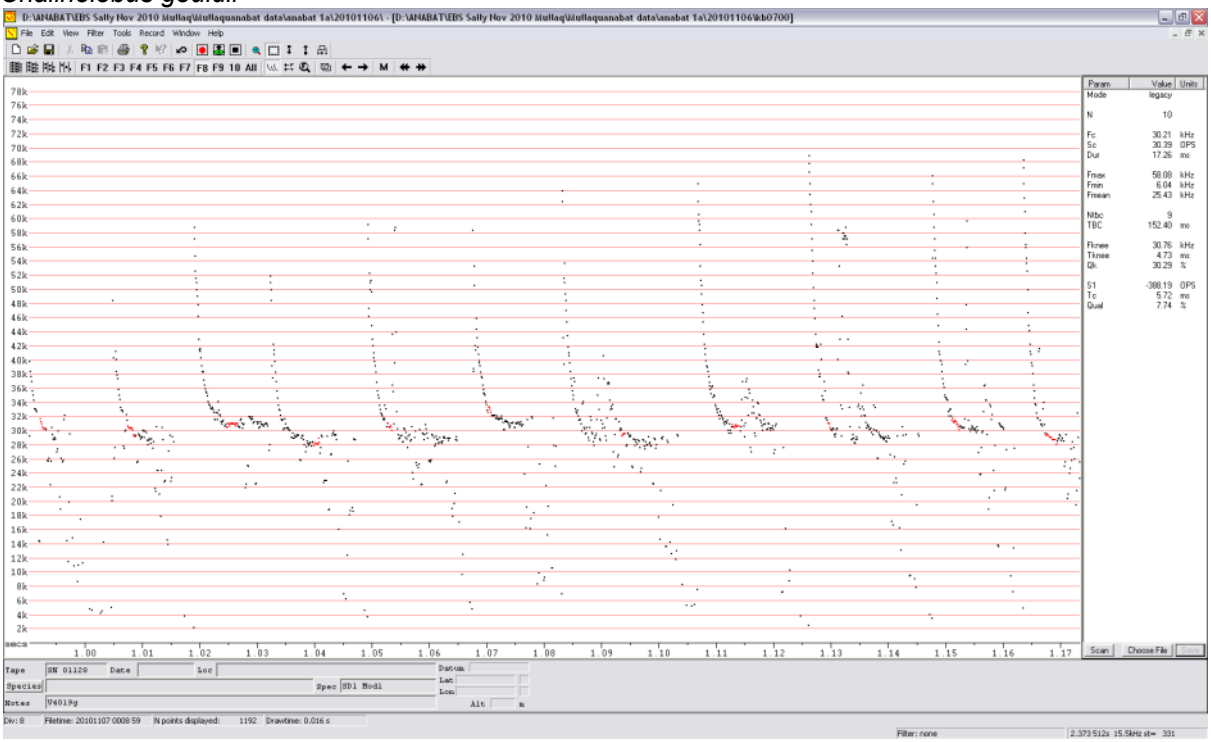
Nyctophilus sp.



Likely *Scotorepens balstoni* (identified without certainty).



Chalinolobus gouldii



Appendix 4. Flora species recorded in the 100 x 100 m quadrats and/or Jessup transects during the November 2010 survey.

Family	Species	Common name	Certain	Status	NPW conservation status	100 x 100 m quadrat	Jessup transect
AIZOACEAE	*Disphyma crassifolium ssp clavellatum*	Round-leaf Pigface	Yes	Native	Not listed	✓	
	Mesembryanthemum nodiflorum	Slender Iceplant	Yes	Exotic	Not listed	✓	
	Tetragonia eremaea	Desert Spinach	Yes	Native	Not listed	✓	
AMARANTHACEAE	*Hemichroa diandra*	Mallee Hemichroa	Yes	Native	Not listed	✓	
	Ptilotus obovatus var obovatus	Silver Mulla Mulla	Yes	Native	Not listed	✓	✓
APOCYNACEAE	*Vinca major*	Blue Periwinkle	Yes	Exotic	Not listed	✓	
CAMPANULACEAE	*Wahlenbergia gracilenta*	Annual Bluebell	Yes	Native	Not listed	✓	
CARYOPHYLLACEAE	*Herniaria cinerea*	Rupturewort	Yes	Native	Not listed	✓	
	Silene nocturna	Mediterranean Catchfly	Yes	Exotic	Not listed	✓	
	Spergularia diandra	Lesser Sand-spurrey	Yes	Exotic	Not listed	✓	
CHENOPODIACEAE	*Atriplex spongiosa*	Pop Saltbush	Yes	Native	Not listed	✓	
	Atriplex stipitata	Bitter Saltbush	Yes	Native	Not listed	✓	✓
	Atriplex vesicaria ssp	Bladder Saltbush	Yes	Native	Not listed	✓	
	Chenopodium curvispicatum	Cottony Goosefoot	Yes	Native	Not listed	✓	✓
	Dysphania pumilio	Clammy Goosefoot	Yes	Native	Not listed	✓	✓
	Dysphania sp	Crumbweed/Rat Tails	Genus	Native	Not listed	✓	✓
	Enchylaena tomentosa var	Ruby Saltbush	Yes	Native	Not listed	✓	✓
	Eriochiton sclerolaenoides	Woolly-fruit Bluebush	Yes	Native	Not listed	✓	✓
	Maireana appressa	Pale-fruit Bluebush	Yes	Native	Not listed	✓	
	Maireana cannonii	Cannon's Bluebush	Yes	Native	Not listed	✓	
	Maireana integra	Entire-wing Bluebush	Yes	Native	Not listed	✓	✓
	Maireana oppositifolia	Heathy Bluebush	Yes	Native	Not listed	✓	✓
	Maireana pyramidata	Black Bluebush	Yes	Native	Not listed	✓	✓
	Maireana radiata	Radiate Bluebush	Yes	Native	Not listed	✓	

Family	Species	Common name	Certain	Status	NPW conservation status	100 x 100 m quadrat	Jessup transect
	Maireana sedifolia	Bluebush	Yes	Native	Not listed	✓	✓
	Maireana turbinata	Top-fruit Bluebush	Yes	Native	Not listed	✓	✓
	Mairena sp	Bluebush species	Yes	Native	Not listed		✓
	Osteocarpum salsuginosum	Inland Bonefruit	Yes	Native	Not listed	✓	
	Rhagodia parabolica	Mealy Saltbush	Yes	Native	Not listed	✓	✓
	Rhagodia spinescens	Spiny Saltbush	Yes	Native	Not listed	✓	✓
	Rhagodia ulicina	Intricate Saltbush	Yes	Native	Not listed	✓	✓
	Salsola tragus	Buckbush	Yes	Native	Not listed	✓	✓
	Sclerolaena brachyptera	Short-wing Bindyi	Yes	Native	Not listed	✓	
	Sclerolaena divaricata	Tangled Bindyi	Yes	Native	Not listed	✓	
	Sclerolaena obliquicuspis	Oblique-spined Bindyi	Yes	Native	Not listed	✓	✓
	Sclerolaena patenticuspis	Spear-fruit Bindyi	Yes	Native	Not listed	✓	✓
	Sclerolaena uniflora	Small-spine Bindyi	Yes	Native	Not listed	✓	✓
	Tecticornia pergranulata ssp	Black-seed Samphire	Yes	Native	Not listed	✓	✓
	Tecticornia sp	Samphire species	Genus	Native	Not listed	✓	✓
	Brachyscome ciliaris var	Variable Daisy	Yes	Native	Not listed	✓	
COMPOSITAE	*Centaurea calcitrapa*	Star Thistle	Yes	Exotic	Not listed	✓	
	Hypochaeris glabra	Smooth Cat's Ear	Yes	Exotic	Not listed	✓	
	Minuria cunninghamii	Bush Minuria	Yes	Native	Not listed	✓	✓
	Olearia pimeleoides ssp	Pimelea Daisy-bush	Yes	Native	Not listed	✓	
	Pycnosorus pleiocephalus	Soft Billy-buttons	Yes	Native	Not listed	✓	
	Reichardia tingitana	False Sowthistle	Yes	Exotic	Not listed	✓	
	Rhodanthe floribunda	White Everlasting	Yes	Native	Not listed	✓	
	Sonchus sp	Sow-thistle	Genus	Native	Not listed	✓	
	Vittadinia cervicularis var cervicularis	Waisted New Holland Daisy	Yes	Native	Not listed	✓	
	Vittadinia dissecta var hirta	Dissected New Holland Daisy	Yes	Native	Not listed	✓	

Family	Species	Common name	Certain	Status	NPW conservation status	100 x 100 m quadrat	Jessup transect
	Vittadinia sp	New Holland Daisy	Genus	Native	Not listed	✓	
	Convolvulus remotus	Grassy Bindweed	Yes	Native	Not listed	✓	
CONVOLVULACEAE	*Arabidella sp*	Cress species	Genus	Native	Not listed	✓	
CRUCIFERAE	*Arabidella trisecta*	Shrubby Cress	Yes	Native	Not listed	✓	
	Brassica sp	Turnip species	Genus	Exotic	Not listed	✓	
	Carrichtera annua	Wards Weed	Yes	Exotic	Not listed	✓	
	Sisymbrium erysimoides	Smooth Mustard	Yes	Exotic	Not listed	✓	
	Chamaesyce drummondii	Spurge species	Yes	Native	Not listed	✓	✓
EUPHORBIACEAE	*Frankenia sp*	Sea-heath	Yes	Native	Not listed	✓	✓
FRANKENIACEAE	*Scaevola spinescens*	Spiny Fanflower	Yes	Native	Not listed	✓	
GOODENIACEAE	*Aristida contorta*	Curly Wire-grass	Yes	Native	Not listed	✓	
GRAMINEAE	*Austrodanthonia caespitosa*	Common Wallaby-grass	Yes	Native	Not listed	✓	
	Austrodanthonia sp	Wallaby-grass sp	Genus	Native	Not listed	✓	
	Austrostipa elegantissima	Feather Spear-grass	Yes	Native	Not listed	✓	
	Austrostipa eremophila	Rusty Spear-grass	Yes	Native	Not listed	✓	
	Austrostipa nodosa	Tall Spear-grass	Yes	Native	Not listed	✓	
	Austrostipa platychaeta	Flat-awn Spear-grass	Yes	Native	Not listed	✓	
	Eragrostis sp	Love-grass	Genus	Native	Not listed	✓	
	Schismus barbatus	Arabian Grass	Yes	Exotic	Not listed	✓	
	Setaria constricta	Knotty-butt Paspalidium	Yes	Native	Not listed	✓	
	Marrubium vulgare	Horehound	Yes	Exotic	Not listed	✓	
LABIATAE	*Salvia verbenaca*	Wild Sage	Yes	Exotic	Not listed	✓	
	Acacia ligulata	Umbrella Bush	Yes	Native	Not listed	✓	
LEGUMINOSAE	*Acacia oswaldii*	Umbrella Wattle	Yes	Native	Not listed	✓	✓
	Acacia papyrocarpa	Western Myall	Yes	Native	Not listed	✓	
	Medicago polymorpha var polymorpha	Burr-medic	Yes	Exotic	Not listed	✓	

Family	Species	Common name	Certain	Status	NPW conservation status	100 x 100 m quadrat	Jessup transect
	Senna artemisioides ssp artemisioides x ssp coriacea	Desert Senna	Yes	Native	Not listed	✓	
	Thysanotus sp	Fringe-lily	Genus	Native	Not listed	✓	
LILIACEAE	*Lysiana exocarpi ssp exocarpi*	Harlequin Mistletoe	Yes	Native	Not listed	✓	
LORANTHACEAE	*Lawrencia squamata*	Thorny Lawrencia	Yes	Native	Not listed	✓	✓
MALVACEAE	*Malva parviflora*	Small-flower Marshmallow	Yes	Exotic	Not listed	✓	
	Sida fibulifera	Pin Sida	Yes	Native	Not listed	✓	✓
	Sida intricata	Twiggy Sida	Yes	Native	Not listed	✓	
	Sida petrophila	Rock Sida	Yes	Native	Not listed	✓	
	Sida sp	Sida species	Genus	Native	Not listed		✓
	Eremophila alternifolia	Narrow-leaf Emubush	Yes	Native	Not listed	✓	✓
MYOPORACEAE	*Eremophila oppositifolia ssp*	Opposite-leaved Emubush	Yes	Native	Not listed	✓	
	Eremophila scoparia	Broom Emubush	Yes	Native	Not listed	✓	✓
	Myoporum platycarpum ssp	False Sandalwood	Yes	Native	Not listed	✓	
	Eucalyptus dumosa	White Mallee	Yes	Native	Not listed	✓	
MYRTACEAE	*Eucalyptus socialis ssp*	Red Mallee	Yes	Native	Not listed	✓	
	Oxalis pes-caprae	Soursob	Yes	Exotic	Not listed	✓	
OXALIDACEAE	*Pittosporum angustifolium*	Native Apricot	Yes	Native	Not listed	✓	
PITTOSPORACEAE	*Calandrinia eremaea*	Dryland Purslane	Yes	Native	Not listed	✓	
PORTULACACEAE	*Geijera linearifolia*	Sheep Bush	Yes	Native	Not listed	✓	✓
RUTACEAE	*Exocarpos aphyllus*	Leafless Cherry	Yes	Native	Not listed	✓	
SANTALACEAE	*Santalum lanceolatum*	Plumbush	Yes	Native	Not listed	✓	
	Lycium australe	Australian Boxthorn	Yes	Native	Not listed	✓	✓
SOLANACEAE	*Nicotiana glauca*	Tree Tobacco	Yes	Exotic	Not listed	✓	
	Nicotiana maritima	Coast Tobacco	Yes	Native	Not listed	✓	
	Solanum petrophilum	Rock Nightshade	Yes	Native	Not listed	✓	

Family	Species	Common name	Certain	Status	NPW conservation status	100 x 100 m quadrat	Jessup transect
	Solanum quadriloculatum	Plains Nightshade	Yes	Native	Not listed	✓	✓
	Pimelea microcephala ssp	Shrubby Riceflower	Yes	Native	Not listed	✓	
THYMELAEACEAE	*Pimelea simplex*	Desert Riceflower	Yes	Native	Not listed	✓	
	Pimelea simplex ssp continua	Desert Riceflower	Yes	Native	Not listed	✓	
	Nitraria billardierei	Nitre-bush	Yes	Native	Not listed	✓	✓
ZYGOPHYLLACEAE	*Zygophyllum apiculatum*	Pointed Twinleaf	Yes	Native	Not listed	✓	
	Zygophyllum billardierei	Coast Twinleaf	Yes	Native	Not listed	✓	
	Zygophyllum ovatum	Dwarf Twinleaf	Yes	Native	Not listed	✓	
	Zygophyllum sp	Twinleaf species	Genus	Native	Not listed		✓

Appendix 5. Distribution of weed species recorded during the November 2010 survey.

Family	Species	Common name	Status: Exotic	Veg 1	Veg 2	Veg 3	Veg 4	Veg 5	Veg 6	Veg 7	Veg 8	Veg 9	Veg 10
AIZOACEAE	*Mesembryanthemum nodiflorum*	Slender Iceplant	Concern								✓		
APOCYNACEAE	*Vinca major*	Blue Periwinkle	Environmental					✓					
CARYOPHYLLACEAE	*Silene nocturna*	Mediterranean Catchfly	Low concern					✓					
	Spergularia diandra	Lesser Sand-spurrey	Low concern	✓	✓	✓	✓		✓	✓	✓	✓	✓
COMPOSITAE	*Centaurea calcitrapa*	Star Thistle	Environmental					✓					
	Hypochaeris glabra	Smooth Cat's Ear	Low concern					✓					
	Reichardia tingitana	False Sowthistle	Low concern							✓	✓		✓
CRUCIFERAE	*Brassica sp*	Turnip species	Low concern			✓	✓						✓
	Carrichtera annua	Wards Weed	Environmental	✓	✓	✓	✓	✓		✓	✓	✓	✓
	Sisymbrium erysimoides	Smooth Mustard	Low concern					✓		✓			
GRAMINEAE	*Schismus barbatus*	Arabian Grass	Low concern					✓					
LABIATAE	*Marrubium vulgare*	Horehound	Declared					✓					
	Salvia verbenaca	Wild Sage	Environmental					✓					
LEGUMINOSAE	*Medicago polymorpha var polymorpha*	Burr-medic	Low concern	✓	✓	✓	✓			✓	✓	✓	✓
MALVACEAE	*Malva parviflora*	Small-flower Marshmallow	Low concern										✓
OXALIDACEAE	*Oxalis pes-caprae*	Soursob	Declared					✓					
PRIMULACEAE	*Anagallis arvensis*	Pimpernel	Low concern					✓					
SOLANACEAE	*Nicotiana glauca*	Tree Tobacco	Concern				✓						

Appendix 6. Flora species and percentage cover category recorded within the 100 x 100 m quadrats at each vegetation site, November 2010.

Family	Species	Veg 1	Veg 2	Veg 3	Veg 4	Veg 5	Veg 6	Veg 7	Veg 8	Veg 9	Veg 10
AIZOACEAE	*Disphyma crassifolium ssp clavellatum*	T	1	2			1		2		
	Mesembryanthemum nodiflorum								T		
	Tetragonia eremaea	T			T	T		T	T	T	1
AMARANTHACEAE	*Hemichroa diandra*						T				
	Ptilotus obovatus var obovatus					T					
APOCYNACEAE	*Vinca major*					T					
CAMPANULACEAE	*Wahlenbergia gracilenta*								T		
CARYOPHYLLACEAE	*Herniaria cinerea*				T	T		T		T	1
	Silene nocturna					T					
	Spergularia diandra	T	1	T	T		1	1	1	1	1
CHENOPODIACEAE	*Atriplex spongiosa*						T		T	T	1
	Atriplex stipitata					1					
	Atriplex vesicaria ssp	2	1	2	1	1	1	3	4	2	2
	Chenopodium curvispicatum							T	T	T	
	Dysphania pumilio					T					
	Dysphania sp			T					T	T	T
	Enchylaena tomentosa var	T			2	T			T		T
	Eriochiton sclerolaenoides	1	T		T	1		1	1	T	1
	Maireana appressa	T		T			T				
	Maireana cannonii						1				
	Maireana integra	T			T						
	Maireana oppositifolia			T							
	Maireana pyramidata		1			1			T	3	T
	Maireana radiata									T	
	Maireana sedifolia	3	T		3			4		T	3
	Maireana turbinata	T	1		T	T		1	T	1	1
	Osteocarpum salsuginosum			T							
	Rhagodia parabolica					T					
	Rhagodia spinescens	T	T		1						T
	Rhagodia ulicina				T						2
	Salsola tragus					T				T	
	Sclerolaena brachyptera		T								
	Sclerolaena divaricata								2		
	Sclerolaena obliquicuspis	2	1	T	1	1		2	2	2	2
	Sclerolaena patenticuspis	T	1		1	T		2	1	2	2
	Sclerolaena uniflora			T			T		1		
	Tecticornia pergranulata ssp	T		4			4		1		

Family	Species	Veg 1	Veg 2	Veg 3	Veg 4	Veg 5	Veg 6	Veg 7	Veg 8	Veg 9	Veg 10
	Tecticornia sp			T			1				
COMPOSITAE	*Brachyscome ciliaris var*	T						1	1	T	T
	Centaurea calcitrapa					T					
	Hypochaeris glabra					T					
	Minuria cunninghamii	1	T						1		
	Olearia pimeleoides ssp					T					
	Pycnosorus pleiocephalus	T						T			T
	Reichardia tingitana							T	T		T
	Rhodanthe floribunda	T	T								
	Sonchus sp		T		T	T					
	Vittadinia cervicularis var cervicularis		1								
	Vittadinia dissecta var hirta								T		1
	Vittadinia sp					T					
CONVOLVULACEAE	*Convolvulus remotus*		T		T						
CRUCIFERAE	*Arabidella sp*		T								
	Arabidella trisecta										T
	Brassica sp			T	1						1
	Carrichtera annua	1	1	T	1	1		1	2	1	1
	Sisymbrium erysimoides					T		1			
EUPHORBIACEAE	*Chamaesyce drummondii*				T	T					
FRANKENIACEAE	*Frankenia sp*			1			1				
GOODENIACEAE	*Scaevola spinescens*				T	T					
GRAMINEAE	*Aristida contorta*					1					
	Austrodanthonia caespitosa	1				T		1	1	1	T
	Austrodanthonia sp		1		T	1					
	Austrostipa elegantissima					T					
	Austrostipa eremophila	1	T						T		T
	Austrostipa nodosa	2	1		1	1		2	1	T	2
	Austrostipa platychaeta				T						
	Eragrostis sp	1		T	1			1		1	1
	Schismus barbatus					1					
	Setaria constricta					T					
LABIATAE	*Marrubium vulgare*					T					
	Salvia verbenaca					T					
LEGUMINOSAE	*Acacia ligulata*					T					
	Acacia oswaldii				T	T					
	Acacia papyrocarpa					T					
	Medicago polymorpha var polymorpha	1	2	T	2			1	1	1	T
	Senna artemisioides ssp artemisioides x ssp coriacea					T					

Family	Species	Veg 1	Veg 2	Veg 3	Veg 4	Veg 5	Veg 6	Veg 7	Veg 8	Veg 9	Veg 10
LILIACEAE	*Thysanotus sp*								T	T	
LORANTHACEAE	*Lysiana exocarpi ssp exocarpi*					T					
MALVACEAE	*Lawrencia squamata*	1									
	Malva parviflora										T
	Sida fibulifera					T					
	Sida intricata		1			T					
	Sida petrophila					T					
MYOPORACEAE	*Eremophila alternifolia*					T					
	Eremophila oppositifolia ssp					1					
	Eremophila scoparia				1						
	Myoporum platycarpum ssp				2	T					
MYRTACEAE	*Eucalyptus dumosa*					T					
	Eucalyptus socialis ssp					T					
OXALIDACEAE	*Oxalis pes-caprae*					T					
PITTOSPORACEAE	*Pittosporum angustifolium*					T					
PORTULACACEAE	*Calandrinia eremaea*								1	T	
RUTACEAE	*Geijera linearifolia*					T					
SANTALACEAE	*Exocarpos aphyllus*					T					
	Santalum lanceolatum					T					
SOLANACEAE	*Lycium australe*				2	1		1			2
	Nicotiana glauca				T						
	Nicotiana maritima				T	T					
	Solanum petrophilum					1					
	Solanum quadriloculatum					T					
THYMELAEACEAE	*Pimelea microcephala ssp*					T					
	Pimelea simplex							T			
	Pimelea simplex ssp continua										T
ZYGOPHYLLACEAE	*Nitraria billardierei*	1				T					
	Zygophyllum apiculatum					T					
	Zygophyllum billardierei					T		T		T	T
	Zygophyllum ovatum	T						T			

N = Not many, 1-10 plants and <5%. T = Sparsely present and <5%. 1 = Plentiful but of small cover, <5%. 2 = Any number of individuals covering 5-25%. 3 = Any number of individuals covering 25-50%. 4 = Any number of individuals covering 50-75%. 5 = Any number of individuals >75%.

Appendix 7. Flora species abundance recorded within the Jessup transects, November 2010.

Ad = Adult established plants counted
Ju = Juvenile plants counted (non-woody stems, typically less than 10 cm in height).

Species	Common name	Veg 1		Veg 2		Veg 3		Veg 4		Veg 5		Veg 6		Veg 7		Veg 8		Veg 9		Veg 10	
		Ad	Ju	Ad	Ju	Ad	Ju	Ad	Ju	Ad	Ju	Ad	Ju	Ad	Ju	Ad	Ju	Ad	Ju	Ad	Ju
Acacia oswaldii	Umbrella Wattle							2													
Atriplex stipitata	Bitter Saltbush									4											
Atriplex vesicaria ssp	Bladder Saltbush	277		27		269	6	1		5		106	9	181		963	136	196	67	66	
Chenopodium curvispicatum	Cottony Goosefoot													6		3		2			
Dysphania pumilio	Clammy Goosefoot											118									
Dysphania sp	Crumbweed/Rat Tails					615	158					809	190			704	2				
Enchylaena tomentosa var	Ruby Saltbush							63		52											
Eremophila alternifolia	Narrow-leaf Emubush									1											
Eremophila scoparia	Broom Emubush							3													
Eriochiton sclerolaenoides	Woolly-fruit Bluebush	92		7				2						13						44	
Frankenia sp	Sea-heath					16						107									
Geijera linearifolia	Sheep Bush									1											
Tecticornia sp	Samphire species					2						20									
Lawrencia squamata	Thorny Lawrencia	54																			
Lycium australe	Australian Boxthorn							29						5						65	
Maireana integra	Entire-wing Bluebush	10						4						2						3	
Maireana oppositifolia	Heathy Bluebush					3						44	40								
Maireana pyramidata	Black Bluebush			100						12						1		273			
Maireana sedifolia	Bluebush	179	40	6	1			150	28					264	2					175	2
Maireana turbinata	Top-fruit Bluebush	1								1				14		1				4	
Mairena sp	Bluebush species																	2			
Minuria cunninghamii	Bush Minuria	16		3																	

Species	Common name	Veg 1		Veg 2		Veg 3		Veg 4		Veg 5		Veg 6		Veg 7		Veg 8		Veg 9		Veg 10	
		Ad	Ju	Ad	Ju	Ad	Ju	Ad	Ju	Ad	Ju	Ad	Ju	Ad	Ju	Ad	Ju	Ad	Ju	Ad	Ju
Nitraria billardierei	Nitre-bush	13																			
Ptilotus obovatus var obovatus	Silver Mulla Mulla									3											
Rhagodia parabolica	Mealy Saltbush									12											
Rhagodia spinescens	Spiny Saltbush			1				2													
Rhagodia ulicina	Intricate Saltbush							53												46	
Salsola tragus	Buckbush									1											
Sclerolaena obliquicuspis	Oblique-spined Bindyi	171		324				101		39				215		115		215		118	
Sclerolaena patenticuspis	Spear-fruit Bindyi			220				113	2					27				28		1	
Sclerolaena uniflora	Small-spine Bindyi					15						8									
Sida fibulifera	Pin Sida									5											
Sida sp	Sida species			363						11											
Solanum petrophilum	Rock Nightshade									9											
Solanum quadriloculatum	Plains Nightshade									15											
Tecticornia pergranulata ssp	Black-seed Samphire					518						404	25			1					
Zygophyllum sp	Twinleaf species																			23	



Environmental & Biodiversity Services
4/48 Barwell Avenue
Kurralta Park, SA 5037
www.ebservices.com.au
t. 08 7127 5607
f. 08 8297 3768

J4: Samphire Project Flora & Fauna Survey – September 2011. Report prepared for UraniumSA Ltd by EBS Ecology, February 2012.

Note: The following report was prepared for previous project owners and is marked as DRAFT, in absence of a finalised document, Alligator Energy consider this the FINAL version.

ebs ecology



Samphire Project
Flora and Fauna Survey
September 2011

Samphire Project Flora and Fauna Survey September 2011

14 February 2012

Version 1

Prepared by EBS Ecology for UraniumSA

Document Control					
Revision No.	Date issued	Authors	Reviewed by	Date Reviewed	Revision type
1	13/02/2012	S. Lattanzio / A. Derry	D. Frazer	13/02/2012	Draft

Distribution of Copies			
Revision No.	Date issued	Media	Issued to
1	14/02/2012	Electronic	Russel Bluck, UraniumSA

COPYRIGHT: Use or copying of this document in whole or in part (including photographs) without the written permission of EBS Ecology constitutes an infringement of copyright.

LIMITATION: This report has been prepared on behalf of and for the exclusive use of EBS Ecology's Client, and is subject to and issued in connection with the provisions of the agreement between EBS Ecology and its Client. EBS Ecology accepts no liability or responsibility whatsoever for or in respect of any use of or reliance upon this report by any third party.

CITATION: EBS Ecology (2012) *Samphire Project Flora and Fauna Survey September 2011.* Report to UraniumSA. EBS Ecology, Adelaide.

Front cover photo: Flowering *Eucalyptus socialis* (Beaked Red Mallee).

ebs ecology

ACKNOWLEDGMENTS

We would like to acknowledge and thank the following people for their assistance with the project:

- Russ Bluck, UraniumSA
- Julian Snook, UraniumSA
- Mark Hutchinson, Carolyn Kovach and David Stemmer, South Australian Museum, for advice on mammal and reptile identification
- Terry Reardon, South Australian Museum, for identification of the bat echolocation calls.

The following EBS staff conducted the survey:

- Sally O'Neill (Survey Coordinator)
- Alison Derry
- Deb Frazer
- Tali Moyle
- Matt Launer
- Rob Kelman

DRAFT

GLOSSARY AND ABBREVIATION OF TERMS

BDBSA	Biological Databases of South Australian (managed by DENR)
DEH	Department of Environment and Heritage (now known as DENR)
DENR	Department of Environment and Natural Resources (Government of South Australia)
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth legislation)
NPW Act	National Parks and Wildlife Act 1972 (South Australian legislation)
NRM	Natural Resources Management
PIRSA	Primary Industries and Resources South Australia (Government of South Australia)
SEB	Significant Environmental Benefit
SEWPaC	Department of Sustainability, Environment, Water, Population and Communities
ssp.	subspecies
sp.	species (singular)
spp.	species (plural)

DRAFT

EXECUTIVE SUMMARY

A flora and fauna survey was conducted at the Samphire Project area in spring 2011 as part of the annual monitoring program. Established survey methodologies were repeated at all monitoring sites, including 13 flora sites, five fauna sites and 11 bird sites (this includes three new flora and bird sites established during the current spring 2011 survey). Vegetation mapping was completed within the USA purchased land boundary, with regard to condition mapping.

Diversity and abundance had decreased within flora monitoring sites during the spring 2011 survey. Seven out of ten sites recorded decreases in diversity between spring 2010 and spring 2011 and one site (V5) remained the same as the previous year. Many annual species have died off and continue to die off, lowering diversity and abundance. The number of perennial individuals recorded within Jessop transects decreased within 5 of the 10 quadrats.

Seventy-six fauna species were detected at monitoring sites and opportunistically during the spring 2011 survey, including seven mammals (four native and three exotic), five bats, 14 reptiles and 50 birds. Native mammal species diversity during the spring 2011 survey remained consistent with 2009 and 2010 surveys. However, native mammal abundance was higher in spring 2011 with 18 observations recorded. Reptile diversity and abundance was slightly below average.

Exotic fauna species diversity has remained consistent over time however exotic fauna abundance was highest during the spring 2011 survey. Increased pest species abundance is attributed to large numbers of House Mouse (*Mus musculus*) following the good seasonal rainfalls, which most likely increased food resources for pest species.

A total of 7678 individual bird observations of 50 species were recorded during the spring 2011 survey; 1923 observations were recorded at monitoring sites and 5754 were observed opportunistically. Species observed in the highest abundance during point count surveys were the Budgerigar (*Melopsittacus undulatus*) with 1596 observations, Zebra Finch (*Taeniopygia guttata*) with 77 observations, White-winged Fairy-wren (*Malurus leucopterus*) with 43 observations, Brown Songlark (*Cincloramphus cruralis*) with 39 observations and the Slender-billed Thornbill (*Acanthiza iredalei iredalei*) with 36 observations.

Three threatened bird species were detected during the spring 2011 survey: Thick-billed Grasswren (*Amytornis textilis modestus*), Slender-billed Thornbill (*Acanthiza iredalei iredalei*) and the Rock Parrot (*Neophema petrophila*). Five individual Thick-billed Grasswren were observed, while 36 observations of the Slender-billed Thornbill were recorded across five sites, and 17 records were observed opportunistically. The state rare Rock Parrot was observed for the first time during the spring 2011 survey. The Rock Parrot, state rare was observed for the first time during the spring 2011 survey at sites 2, 3, 6 and 15. A total of 34 records were observed for this species as well as seven individuals recorded opportunistically.

DRAFT

Nine new bird species were observed for the first time during the spring 2011 survey which include: the Australasian Grebe (*Tachybaptus novaehollandiae*), Brush Bronzewing (*Phaps elegans*), Chestnut-rumped Thornbill (*Acanthiza uropygialis*), Cockatiel (*Nymphicus hollandicus*), Hardhead (*Aythya australis*), Red-backed Kingfisher (*Todiramphus pyrrhopygius*), Straw-necked Ibis (*Threskiornis spinicollis*), Swamp Harrier (*Circus approximans*) and the White-backed Swallow (*Cheramoeca leucosterna*).

DRAFT

Table of Contents

1 INTRODUCTION 1

1.1 Aim and objectives 1

2 BACKGROUND INFORMATION 3

2.1 Location 3

2.2 Previous surveys 3

3 METHODS 4

3.1 General 4

3.2 Flora 4

3.2.1 Vegetation mapping of the UraniumSA purchased land boundary 5

3.3 Fauna 7

3.3.1 Bird surveys 8

3.4 Analysis 10

3.4.1 Comparisons to previous monitoring surveys 10

3.5 Survey Limitations 10

3.5.1 Flora 10

3.5.2 Fauna 10

4 GENERAL RESULTS 12

4.1 Weather encountered during the field survey 12

4.2 Survey effort 12

5 FLORA RESULTS 14

5.1.1 100 x 100 metre quadrats 14

5.1.2 Comparison to previous years 15

5.2 Flora abundance 16

5.2.1 Jessup transects 16

5.2.2 Comparison to previous years 17

5.3 Conservation significant species 18

5.4 Exotic flora species 18

5.4.1 Diversity 18

5.5 Vegetation monitoring sites 22

5.5.1 Vegetation Site 11 22

5.5.2 Vegetation Site 12 24

5.5.3 Vegetation Site 13 26

5.6 Vegetation mapping of the UraniumSA purchased land boundary 28

5.6.1 Overview 28

DRAFT

5.6.2 Vegetation Condition 28
5.6.3 Vegetation Associations 29

6 FAUNA RESULTS 35
6.1 Fauna species diversity and abundance 35
6.1.1 Mammals 35
6.1.2 Exotic fauna 38
6.1.3 Opportunistic terrestrial fauna observations 40
6.1.4 Bats 41
6.1.5 Reptiles 42
6.1.6 Amphibians 45
6.1.7 Birds 45

7 DISCUSSION 54
7.1 Flora 54
7.1.1 Vegetation mapping of the UraniumSA purchased land boundary 54
7.1.2 Additional vegetation monitoring sites 55
7.2 Fauna 55
7.2.1 Native mammals 55
7.2.2 Reptiles 55
7.2.3 Birds 56
7.2.4 Additional bird monitoring sites 56
7.3 Exotic species 56
7.4 Threatened Fauna species 56
7.4.1 Thick-billed Grasswren (*Amytornis textilis myall*) 56
7.4.2 Slender-billed Thornbill (*Acanthiza iredalei iredalei*) 57
7.4.3 Rock Parrot (*Neophema petrophila*) 57

8 RECOMMENDATIONS 58

9 REFERENCES 59

10 APPENDICES 61

Appendix 1. Survey site coordinates. 61
Appendix 2. Comparative flora site photographs 63
Appendix 3. Overall flora species list and abundance from the spring 2011 survey (100 x 100 metre quadrat data). 73
Appendix 4. Flora abundance, Jessup data all sites, spring 2011 76
Appendix 5. DEH and EBS floristic vegetation mapping 78

DRAFT

Appendix 6. Flora species observed during the field survey by vegetation association for the UranuimSA purchased land boundary 81
Appendix 7. Example bat calls (as viewed in AnaLook) recorded during the November 2011 survey. 83
Appendix 8. Abundance of all bird species recorded during point count (PC) and opportunistically/other methods (OPP) during the spring 2011 survey. 86

List of Tables

Table 1. Permanent flora, fauna and bird monitoring site descriptions 5
Table 2. SEB ratios used to rate condition of vegetation communities. 6
Table 3. Weather conditions recorded for Whyalla during the field survey. 12
Table 4. Fauna survey effort conducted during the September 2011 survey. 12
Table 5. New flora species not recorded within the 100 x 100 metre quadrat prior to spring 2011. 15
Table 6. Total average species diversity per year. 16
Table 7. New flora species not recorded within the Jessup transects prior to spring 2011. 17
Table 8. Total number of established perennials in Jessup transects 18
Table 9. Weed species recorded during the November 2011 survey and maximum cover abundance recorded (all sites combined). 20
Table 10. Vegetation Site 11 flora summary, November 2010. 22
Table 11. Vegetation Site 12 flora summary, November 2011. 24
Table 12. Vegetation Site 13 flora summary, November 2011. 26
Table 13. Summary of the vegetation associations identified as occurring within and adjacent the lease area 28
Table 14. Vegetation Association 1 floristic description 30
Table 15. Vegetation Association 2 floristic description 32
Table 16. Vegetation Association 3 floristic description 33
Table 17. Vegetation Association 4 floristic description 34
Table 18. Summary of fauna observations from the spring 2011 monitoring survey (Monitoring sites and opportune records) 35
Table 19. Terrestrial mammal diversity and abundance recorded at the fauna monitoring sites during the autumn 2011 survey. 36
Table 20. Exotic species diversity and abundance recorded during the spring 2011 survey. 39
Table 21. Opportunistic native terrestrial fauna observations 40
Table 22. Bat species identified as occurring with the project area as identified through call identification. 41
Table 23. Reptile diversity and abundance recorded at the fauna monitoring sites during the spring 2011 survey. 42

DRAFT

Table 24. Number of bird observations during the bird surveys, and site species abundance recorded during the November 2011 survey. 48

List of Figures

Figure 1. Location of permanent flora, fauna and bird monitoring sites .. **Error! Bookmark not defined.**
Figure 2. Species diversity recorded within the 100 x 100 metre quadrats. 14
Figure 3. Species diversity recorded within the 100 x 100 metre quadrats during all surveys. 16
Figure 4. Total number of perennial individuals recorded in the Jessup transects. 17
Figure 5. Total number of established perennial individuals recorded in the Jessup transects during all surveys. 18
Figure 6. Exotic flora species family diversity recorded during the November 2010 survey. 21
Figure 7. Exotic flora diversity recorded during the spring 2010 and 2011 survey. 21
Figure 8. Site monitoring photograph – Vegetation Site 11, November 2011. 23
Figure 9. Site monitoring photograph – Vegetation Site 12, November 2011. 25
Figure 10. Site monitoring photograph – Vegetation Site 13, November 2010. 27
Figure 11. Western Myall Woodland over chenopod shrubland 30
Figure 12. Western Myall Woodland over tall shrubland 31
Figure 13. Western Myall Woodland over Spinifex tussocks 31
Figure 14. Chenopod Low Open Shrubland 32
Figure 15. Samphire / Saltbush Very Low Shrubland 33
Figure 16. Samphire Very Low Shrubland 34
Figure 17. Native mammal species diversity recorded at the fauna monitoring sites during the spring 2011 survey 36
Figure 18. Native mammal abundance recorded at the fauna monitoring sites during the spring 2011 survey. 36
Figure 19. Bolam's Mouse (*Pseudomys bolami*) 37
Figure 20. Native terrestrial mammal species diversity (all sites combined) 2009 to 2011. 38
Figure 21. Native terrestrial mammal abundance (all sites combined) 2009 to 2011. 38
Figure 22. Exotic fauna species diversity recorded during the spring 2011 survey. 39
Figure 23. Exotic fauna species diversity (all sites combined) 2009 to 2011. 40
Figure 24. Exotic fauna species abundance (all sites combined) 2009 to 2011. 40
Figure 25. Lesser Long-eared Bat (*Nyctophilus geoffroyi*) 42
Figure 26. Reptile species diversity recorded at the fauna monitoring sites during the spring 2011 survey. 43
Figure 27. Reptile abundance recorded at the fauna monitoring sites during the spring 2011 survey. 43
Figure 28. Crested Dragon (*Ctenophorus cristatus*) 44
Figure 29. Ranges Stone Gecko (*Diplodactylus furcosus*) 44

DRAFT

Figure 30. Reptile species diversity (all sites combined) 2009 to 2011. 45
Figure 31. Reptile abundance (all sites combined) 2009 to 2011. 45
Figure 32. Cockatiel (*Nymphicus hollandicus*) 46
Figure 33. Bird species diversity at monitoring sites during the spring 2011 survey. 49
Figure 34. Bird abundance recorded at the bird monitoring sites during the spring 2011 survey..... 49
Figure 35. Budgerigar (*Melopsittacus undulatus*)..... 51
Figure 36. Bird species diversity (all sites combined) 2009 to 2011. 53
Figure 37. Bird species abundance (all sites combined) 2009 to 2011..... 53

DRAFT

1 INTRODUCTION

EBS Ecology was contracted by UraniumSA to conduct a flora and fauna survey of its Samphire Project site in spring 2011. The survey builds on previous flora and fauna surveys conducted within the same area. A Baseline survey was conducted in November 2009, where vegetation communities were mapped, habitat quality was defined, species presence was confirmed and the likelihood of significant species utilising the area at other times of the year was assessed. A follow-up survey was undertaken in November 2010, where flora monitoring sites were established to collect data on flora species diversity, community structure, abundance and percentage cover of native and exotic vascular plant species. Additionally, the fauna monitoring sites were resurveyed in November 2010 for birds, mammals and reptiles.

The current spring (September 2011) survey involved the establishment of a further three permanent bird and flora monitoring sites. The additional sites covered land systems (above the escarpment) and vegetation associations not currently sampled. The same survey methods and techniques were used as the previous surveys.

Vegetation communities of the entire UraniumSA purchased land boundary were mapped in detail, with a flora species list compiled for each vegetation association identified, and the condition of each vegetation unit (specific area of a vegetation association) assessed.

1.1 Aim and objectives

The aim of this report is to present the information collected during the spring 2011 survey, document the data collected, and discuss the vegetation and fauna communities of the project area in their present state, and compare current results to previous survey years.

Objectives of the spring 2011 flora and fauna survey were to:

- undertake vegetation mapping of the UraniumSA purchased land boundary
- establish three additional flora/bird monitoring sites within representative vegetation communities and distributed across the project area landscape
- collect data on the flora species diversity, community structure, abundance, and percentage cover of native and exotic vascular plant species, of each monitoring site
- identify the diversity, abundance, and distribution of exotic weed species within the project area
- collect data on the fauna species diversity, community structure, abundance, and distribution of native and exotic fauna species
- determine presence/absence of the nationally threatened Thick-billed Grasswren (*Amytornis textilis myall*) and Slender-billed Thornbill (*Acanthiza iredalei iridalei*) across the project area and identify habitat suitable for both species
- survey any additional sites either within and adjacent to the project area identified as being of suitable habitat for the threatened bird species.

Objectives of the spring 2011 survey report are to:

- summarise the vegetation communities within the purchased land boundary, and detail information on the species diversity, community structure, abundance, and percentage cover of native and exotic vascular plant species
- map the location of all monitoring sites and any threatened species observed on site
- provide photographs as a record of the sites
- summarise the fauna communities within the project area, and detail information on the species diversity, community structure, abundance and distribution of fauna species
- identify and discuss the fauna species known to occur within the project area
- assess key habitats of significant fauna species known to occur within the project area, or species that are considered likely to occupy the area intermittently
- discuss the habitat suitability as an indication of likely distribution of the Thick-billed Grasswren and Slender-bill Thornbill.

2 BACKGROUND INFORMATION

2.1 Location

The Samphire Project is located on Eyre Peninsula, South Australia, approximately 20 km southwest of the town of Whyalla. The project lies within the Samphire and Nonowie pastoral leases, and exploration tenements EL3542, EL4242 and EL3652 held by UraniumSA. Cowled's Landing, a small shack community, is located adjacent to the lease area. Munyaroo Conservation Park (12,340 ha) is located to the south and shares a boundary with the Exploration Leases.

2.2 Previous surveys

Previous surveys conducted as part of the flora and fauna monitoring program are reported in:

- *Samphire Flora and Fauna Survey – Initial Assessment October 2009* (EBS 2009)
- *Samphire Baseline Flora and Fauna Survey November 2009* (EBS Ecology 2010a)
- *Samphire Additional Birds Surveys February 2010* (EBS Ecology 2010b).
- *Samphire Follow-up Flora and Fauna Survey November 2010* (EBS Ecology 2010c)

These biological surveys typically follow the standard biological survey methodology of pitfall, Elliott and cage trapping, and recording opportunistic sightings of signs of animals (scats, diggings, tracks etc). Full details of this methodology are detailed in the *Guidelines for Vertebrate Surveys in South Australia* (Owens 2000).

3 METHODS

3.1 General

The fauna survey was conducted from 19 – 24 September 2011. The same methodologies and techniques used for the November 2009 (EBS Ecology 2010a) and November 2010 (EBS Ecology 2010c) surveys were repeated.

Justification for the survey design and associated methodologies of the fauna monitoring program are outlined in the *Samphire Flora and Fauna Baseline Survey* (EBS Ecology 2010a). The field survey was conducted using the methodologies of the standard *Biological Survey Method of South Australia* (Owens 2000; Heard and Channon 1997) as a guide. See Figure 1 for flora, fauna and bird site locations and Appendix 1 for GPS co-ordinates.

The survey was undertaken under the following Department of Environment and Natural Resources permits:

- Permit to Undertake Scientific Research, permit no: Q259061
- Wildlife Ethics Committee: Approval of a Project Involving Animals, app. no. 17/2011.

3.2 Flora

Ten permanent sites were established in November 2010 and a further three were established during the current survey (September 2011), making 13 permanent flora monitoring sites in total. The flora monitoring sites are located within representative vegetation communities, distributed across the project area landscape, and in areas impacted by proposed developments (Table 1). The additional three flora sites were surveyed as part of ongoing monitoring; progressing from the retention lease to a mining lease as part of the development of the project i.e. field trial to an operational mine.

Established survey methodology (see EBS 2010c for details) was replicated at the 13 flora monitoring sites (Figure 1). The flora methods used at each of the sites included:

- 100 x 100 metre quadrats for species diversity (both annual and perennial species) and broad-scale species cover abundance
- Jessup transects for species abundance of established adult individuals and juveniles (focusing on perennial species)
- The three additional flora monitoring sites recorded species composition, abundance, and condition

3.2.1 Vegetation mapping of the UraniumSA purchased land boundary

Within the USA purchased land boundary, vegetation associations were identified, locations mapped, and a species list collated, where access was possible. As some areas were non-accessible detailed floristic surveys were not conducted in these locations. To overcome this limitation, recorded vegetation associations that were identified in the field were mapped first, data was then extrapolated into unsurveyed areas, based on the knowledge of the field observer and understanding of aerial imagery.

The condition of the native vegetation within the entire land boundary was recorded as per the ratings in Table 2. The ratio is required to assist in the calculation of an appropriate Significant Environment Benefit (SEB) offset to accommodate the proposed vegetation clearance associated with the proposal (if required).

Table 1. Permanent flora, fauna and bird monitoring site descriptions

Monitoring sites			Vegetation association	Distance to retention lease area (m)
Flora	Fauna	Bird		
V1	F1	B1	*Maireana sedifolia* (Bluebush), *Atriplex vesicaria* (Bladder Saltbush) Shrubland	861
V2	F2	B2	*Maireana pyramidata* (Black Bluebush), *Disphyma crassifolium ssp. clavellatum* (Round-leaf Pigface) Low Shrubland	1285
V3	F3	B3	*Tecticornia pergranulata* (Black-seed Samphire), *Disphyma crassifolium ssp. clavellatum* (Round-leaf Pigface) Low Shrubland	2827.8
V4	F4	B4	*Myoporum platycarpum* (False Sandalwood) Open Woodland	3451
V5	F5	B5	*Eucalyptus socialis* (Beaked Red Mallee), *Eucalyptus dumosa*, (White Mallee) Open Mallee	4088.6
V6			*Tecticornia pergranulata* (Black-seed Samphire), *Disphyma crassifolium ssp. clavellatum* (Round-leaf Pigface) Low Shrubland	5631.92
V7		B15	*Maireana sedifolia* (Bluebush), *Atriplex vesicaria* (Bladder Saltbush) Shrubland	1621
V8			*Atriplex vesicaria* (Bladder Saltbush), *Disphyma crassifolium ssp. clavellatum* (Round-leaf Pigface) Low Shrubland	5358.68
V9		B6	*Maireana pyramidata* (Black Bluebush), *Atriplex vesicaria* (Bladder Saltbush), Shrubland	2630.52
V10			*Maireana sedifolia* (Bluebush) Shrubland	Within retention lease
V11 (new)		B11 (new)	*Maireana sedifolia* (Bluebush) / *Sclerolaena patenticuspis* (Spear-fruit Bindyi) Low Shrubland	4010.87
V12 (new)		B12 (new)	*Maireana sedifolia* (Bluebush) / *Austrostipa nodosa* (Tall Spear-grass) Low Shrubland	2503
V13 (new)		B13 (new)	*Maireana sedifolia* (Bluebush) / *Austrostipa nodosa* (Tall Spear-grass) Low Shrubland	3441
		B10	*Maireana sedifolia* (Bluebush) Shrubland	1819.11

Table 2. SEB ratios used to rate condition of vegetation communities.

Condition	SEB Ratio	% total indigenous cover	Native Vegetation Council SEB Ratio Interim Policy	Understorey condition description	Indicators
Very Poor	0:1	<10%	Any potential clearance consists of lopping of overhanging limbs only &/or no indigenous understorey present.	Complete or almost complete destruction of understorey (by grazing &/or introduced plants). The understorey* consists mainly of alien species.	Vegetation structure no longer intact (e.g. removal of one or more vegetation strata). Scope for regeneration, but not to a state approaching good condition without intensive management. Dominated by very aggressive weeds. Partial or extensive clearing (> 50% of area). Evidence of heavy grazing (tracks, browse lines, species changes, no evidence of soil surface crust).
	1:1	1019%	Areas are dominated by introduced species. Native vegetation is largely reduced to scattered trees, indigenous understorey flora reduced to scattered clumps and individual plants.		
	2:1	2029%	Weeds dominate, scattered trees with indigenous understorey reduced to scattered clumps and individual plants.		
Poor	3:1	3039%	Mostly intact overstorey vegetation but there is still considerable weed infestation amongst the understorey flora.	Heavy loss of plant species. The understorey* consists predominately of alien species, although a small number of natives persist.	Vegetation structure substantially altered (e.g. one or more vegetation strata depleted). Retains basic vegetation structure or the ability to regenerate it. Very obvious signs of long-term or severe disturbance. Weed dominated with some very aggressive weeds. Partial clearing (10 – 50% of area). Evidence of moderate grazing (tracks, browse lines, soil surface crust extensively broken).
	4:1	4049%	Mostly intact overstorey vegetation but there is still considerable weed infestation amongst the understorey flora.		
Moderate	5:1	5059%	Mostly intact, weed free areas small, indigenous vegetation dominant.	Moderate loss of plant species. Substantial invasion of aliens resulting in significant competition, but native understorey* persists; for example, may be a low proportion of native species and a high native cover, or a high proportion of native species and low native cover.	Vegetation structure altered (e.g. one or more vegetation strata depleted). Most seed sources available to regenerate original structure. Obvious signs of disturbance (e.g. tracks, bare ground). Minor clearing (<10% of area). Considerable weed infestation with some aggressive weeds. Evidence of some grazing (tracks, soil surface crust patchy).
	6:1	6069%	Mostly intact overstorey vegetation with moderate but not severe weed infestation amongst the understorey flora.		
Good	7:1	7079%	Mostly intact overstorey and understorey vegetation, weed infestation is moderate to low, but the original vegetation is still dominant.	Understorey only slightly modified. High proportion of native species and native cover in the understorey*; reasonable representation of probable pre-European vegetation.	Vegetation structure intact (e.g. all strata intact). Disturbance minor, only affecting individual species. Only nonaggressive weeds present. Some litter build-up.
	8:1	8089%			
Excellent	9:1	> 89%	Diverse vegetation with very little weed infestation.	Understorey largely undisturbed, minimal loss of plant species diversity. Very little or no sign of alien vegetation in the understorey*; resembles probable pre-European condition.	All strata intact and botanical composition close to original. Little or no signs of disturbance. Little or no weed infestation. Soil surface crust intact. Substantial litter cover.
	10:1		Diverse vegetation with no weed infestation.		

*Or all strata if the upper and lower strata are difficult to distinguish
Adapted from '*Guide to Roadside Vegetation Survey Methodology for South Australia*', (Stokes *et al.* 1998) and '*Guidelines for a Native Vegetation Significant Environmental Benefit Policy*', *(*DWLBC 2005).

3.3 Fauna

Established survey methodology (see EBS 2010a for details) was replicated at five fauna monitoring sites and eight bird survey sites (Table 1) (Figure 1). Three additional bird sites were established during the current September 2011 survey, making 11 permanent bird monitoring sites in total. At each of the five fauna trapping sites, and the 11 bird survey sites, the following fauna methods were conducted:

- pitfall, Elliott, cage, and funnel trapping targeting small to medium mammals and reptiles
- AnaBat detectors to record bat echolocation calls
- bird surveys using a point-count technique of 60 minutes per site in the morning and 60 minutes per site in the afternoon. A portable handheld mp3 player and speaker were used where practical to encourage species to call-back to the observer, allowing for confirmed identification. This was useful when calling in Slender-billed Thornbill, a species which is particularly sensitive to responding to bird call noises.

Trapping

Five survey sites were resurveyed (lidded pitfalls were in situ from previous baseline survey). Two trap lines positioned approximately 200 m apart were installed at each site. Each line consisting of six pitfall traps (140 mm diameter, 400 mm deep, placed at 10 m intervals), 15 medium Elliott traps (Elliott Scientific, Upwey Vic.; type A, 330 mm long, 100 mm high, 90 mm wide, treadle plate operated), two cage traps (Sheffield Wire Products, Welshpool WA, 550 mm long, 220 mm wide, 220 mm high, trip plate mechanism), and four funnel traps (WA Poultry, Sheffield, Western Australia; 77 cm long, 17 cm wide, 17 cm high) were installed at each of the five fauna sites. All traps were open for four consecutive nights, with Elliott and cage traps closed during the day to avoid animal distress in the heat of the day.

Bat call recording

A passive bat survey was conducted using AnaBat's (Titley Electronics, Ballina NSW) to record bat ultrasonic echolocation calls. A single Anabat detector was used at each of the five fauna trapping sites for one night. Recorded bat echolocation calls were analysed by Terry Reardon (South Australian Museum expert) using AnalookW and compared with known reference calls for the region held by the SA Museum.

Opportunistic observations

Field surveyors recorded all fauna observations while onsite. For each observation, the species, location (GPS waypoint), date, number of individuals, and broad habitat type was recorded. Presence of tracks, nests, scats, diggings and burrows (identified to species level if possible) were also recorded as opportune observations.

Identification and nomenclature

All captured vertebrates were, where possible, identified and released immediately at the point of capture or amongst nearby vegetation cover or burrows to reduce stress. Vertebrate species nomenclature for

scientific names and common names follows the *Vertebrates of South Australia* (DEH 2010) using commonly accepted local names.

3.3.1 Bird surveys

Standardised surveys

Standardised bird surveys were conducted at the 11 permanent bird monitoring sites. Out of the 11 bird sites, five coincide with the five fauna sites (F1-F5), five coincide with five flora sites (V7, V9, V11-13) and one site is bird only (B10) (Table 1). Bird monitoring sites are mapped in Figure 1 and site coordinates are listed in Appendix 1. Each site was surveyed for 60 minutes in the morning and 60 minutes in the afternoon. The repeat visits maximise the chance of detecting species, particularly in the case of birds, which are highly mobile at different times of the day. A single observer conducted an area search recording all birds that could be positively identified by sight. A portable MP3 player and speaker unit was used to entice birds, by playing replica bird calls. This encouraged bird species to call-back, therefore making their presence known to the observer.

The three new flora sites that were established during the 2011 spring survey were also surveyed for birds. This contributes to the ongoing monitoring of birds on site and follows the progression from the retention lease to a mining lease as part of the development of the project. As the project area progresses from field trial based to an operational mine, bird monitoring remains an essential tool in measuring potential impacts, particularly with regard to threatened bird species recorded on site.

Distribution of threatened bird species

The Thick-billed Grasswren, Slender-billed Thornbill, and other potential threatened bird species, were targeted during point count and opportunistic surveying within the project area. This included assessing suitable habitat and detecting presence/absence across the site; individuals recorded contributed to the overall predicted distribution of threatened bird species across the site.

Opportunistic bird observations

To ensure all, or most of the bird species present at the time of the survey were recorded, all birds observed opportunistically were identified. Opportunistic observations are defined as birds recorded whilst undertaking other activities e.g. driving between sites or assisting with flora surveys.

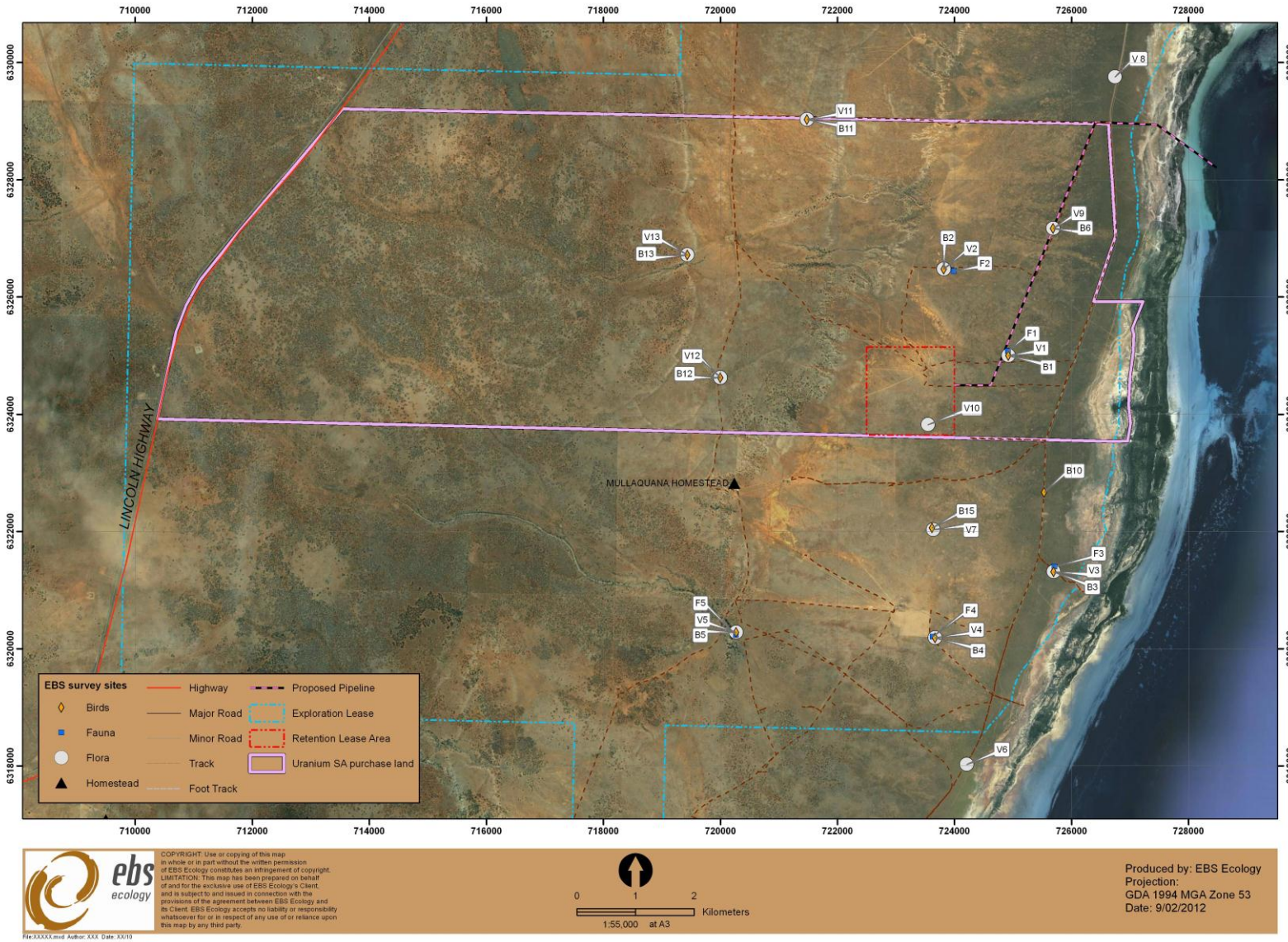


Figure 1. Location of permanent flora, fauna and bird monitoring sites

3.4 Analysis

3.4.1 Comparisons to previous monitoring surveys

Flora

To identify fluctuations in flora species diversity during the current 2011 survey, overall percentage cover (broad scale), percentage cover (fine scale) and species abundance of flora communities was compared with previous surveys, allowing for a comparison over time. Of interest were the exotic weed species (particularly changes in abundance and distribution) and threatened species (changes in abundance, distribution, and cover percentage).

Fauna

To identify fluctuations in the diversity and abundance of mammal, reptile, and bird communities, number of captures and observations for each species was examined to identify overall trends. The overall diversity of each fauna group was examined, by highlighting the presence/absence of species recorded in previous surveys, compared to the current survey.

To examine abundance, the number of fauna captures (excluding recaptures, which are marked by permanent texture on the tail) and observations are used to indicate population abundance, or abundance of the trappable/observable proportion of the population, assuming home ranges, activity levels and behaviour are equal across all sites. Consequently, increases and decreases are seen as an indicator of fluctuations of the populations. Total capture and observation numbers were examined for each species and focal key families within each site. Number were also examined by habitat types, and where possible, by impact and control classification.

3.5 Survey Limitations

3.5.1 Flora

At the time the survey was undertaken not all plant species may have been visibly present. Some species such as native orchids and lilies are particularly hard to detect when not flowering, and grasses are difficult to identify without seed heads. Some plants could only be indentified to genus level and it is possible that some species present were not detected. Of the 13 vegetation monitoring sites visited during the current survey, ten have been visited for three consecutive years (2009 - 2011) and have been reviewed for analysis.

3.5.2 Fauna

Although this fauna and flora survey was designed and conducted to maximise the species diversity detected during a standard four night survey, it cannot be expected that all species present within the survey area were observed. The presence and abundance of both fauna and flora species will vary seasonally and in response to environmental conditions. It is likely that additional species were present at the time of the survey in September 2011, but are either limited in their distribution within the site or

occur at such a low abundance that they were not detected. It is also likely that additional species, such as nomadic, vagrant and migratory species, may occur within and rely on habitats of the survey area from time to time but were not present at the time of the current survey. Additional surveys, undertaken at different times of the year and under different environmental conditions, would be required to increase the chance of such species being detected.

Although AnaBat recordings can assist identifying the presence of selected species, the analysis is complex and many species cannot be identified by call alone. This survey method needs to be complimented by trapping to confirm species presence. Call analysis is affected by many factors, these include the suite of species present, the quality of the calls (equipment settings, microphone quality, background noise from wind, insects, echoes), the quality of the reference call database for the region and the experience of the analyst (T. Reardon pers. com. 2010).

Not all bat calls are easily identifiable from AnaBat recordings (T. Reardon pers. com. 2008), and therefore a species not being recorded does not necessarily mean that the species is absent. Similarly, a species being recorded only indicates the species was present at a particular time, and its presence may vary from leaving and returning to a roost site, visiting a feeding site, or merely passing through the area and not utilising the habitat.

Inter-year comparisons of diversity and abundance are most valuable when data is recorded from the same location, and under the same survey effort. Therefore data collected from the recently established monitoring sites, have not been included in inter-year comparisons. Comparisons were limited to sites that have been surveyed over the entire monitoring period.

Of the 11 bird monitoring sites visited during the current survey, eight have been visited for three consecutive years (2009 - 2011) and have been reviewed for analysis. All five fauna monitoring sites have also been visited for three consecutive years (2009 - 2011) and their results have also be analysed and discussed in this report.

4 GENERAL RESULTS

4.1 Weather encountered during the field survey

Weather conditions during the survey were cool to warm during the day and cool during the nights (Table 3). Days varied from clear and sunny to light cloud extending from the south on cooler days to overcast. No rain was experienced during the survey. Winds during the day were light to moderate, the winds picked up in the late afternoon and early evening on most days.

Table 3. Weather conditions recorded for Whyalla during the field survey.

	Rain	Temperature		9 am Wind		3 pm Wind	
Date	mm	Min °C	Max °C	Dir	Speed	Dir	Speed
19Sep11	0	11.6	26.5	N	31	N	31
20Sep11	0	8.7	19.2	W	24	ESE	19
21Sep11	0	6.2	26.5	N	13	ESE	15
22Sep11	0	12	32.2	N	41	NW	44
23Sep11	0	7.7	17.9	SE	22	S	31
24Sep11	0	11.7	71.1	S	22	SSE	35

Source: Bureau of Meteorology Whyalla Aero (station 018120).

4.2 Survey effort

The flora survey methodology was conducted once at each flora monitoring site throughout the survey period. The fauna survey methodology was undertaken at each fauna monitoring site for four trapping nights (Elliott, pitfalls and cage traps), one night of AnaBat recording and two hours of bird survey (one hour in the morning and one hour in the afternoon) (Table 4). Total traps nights for each trap type included: 240 pitfall, 600 Elliott, 80 cage and 160 funnel (Table 4). Survey effort was equal across the five sites. Fauna Site 1 and Fauna Site 2 were trapped from the 19th September 2011 (traps set) to the 23rd September 2011 (traps closed). Fauna Sites 3 to 5 were trapped from the 20th September (traps set) to the 24th November 2010 (traps closed).

Table 4. Fauna survey effort conducted during the September 2011 survey.

Site	Elliott traps		Pitfall traps		Cage traps		Funnel traps		AnaBat detector	Bird survey
	nights	trap nights	nights	trap nights	nights	trap nights	Nights	trap nights	nights	hours
F1/B1	4	120	4	48	4	16	4	8	1	2
F1/B2	4	120	4	48	4	16	4	8	1	2
F1/B3	4	120	4	48	4	16	4	8	1	2
F1/B4	4	120	4	48	4	16	4	8	1	2
F1/B5	4	120	4	48	4	16	4	8	1	2
B6										2
B10										2

Site	Elliott traps		Pitfall traps		Cage traps		Funnel traps		AnaBat detector	Bird survey
	nights	trap nights	nights	trap nights	nights	trap nights	Nights	trap nights	nights	hours
B11										2
B12										2
B13										2
B15										2
TOTAL	**20**	**600**	**20**	**240**	**20**	**80**	**20**	**160**	**5**	**22**

5 FLORA RESULTS

The results of the spring 2011 flora monitoring are presented, followed by comparisons with previous years. . The comparison between years does not include the new vegetation monitoring sites (V11, V12 and V13). See Appendix 2 for comparative site photographs.

5.1.1 100 x 100 metre quadrats

Of the 13 vegetation monitoring sites, a total of 112 flora species were recorded from the 100 x 100 m quadrats, of which 97 were native species and 14 were exotic species.

Species diversity recorded within the 100 x 100 m quadrats in spring 2011 had decreased slightly since the spring 2010 survey. The number of species detected varied considerably between sites (ranging from 10 to 61 species) (Figure 2). The highest diversity was recorded at *Eucalyptus* Mallee Site V5 (61 species). The lowest species diversity was recorded at the *Maireana* / *Atriplex* Shrubland Site V6 (10 species).

Twenty-five new flora species were recorded during this survey that had not been previously recorded (See Table 5). The presence and cover abundance of all flora species recorded for each site is provided in Appendix 3.

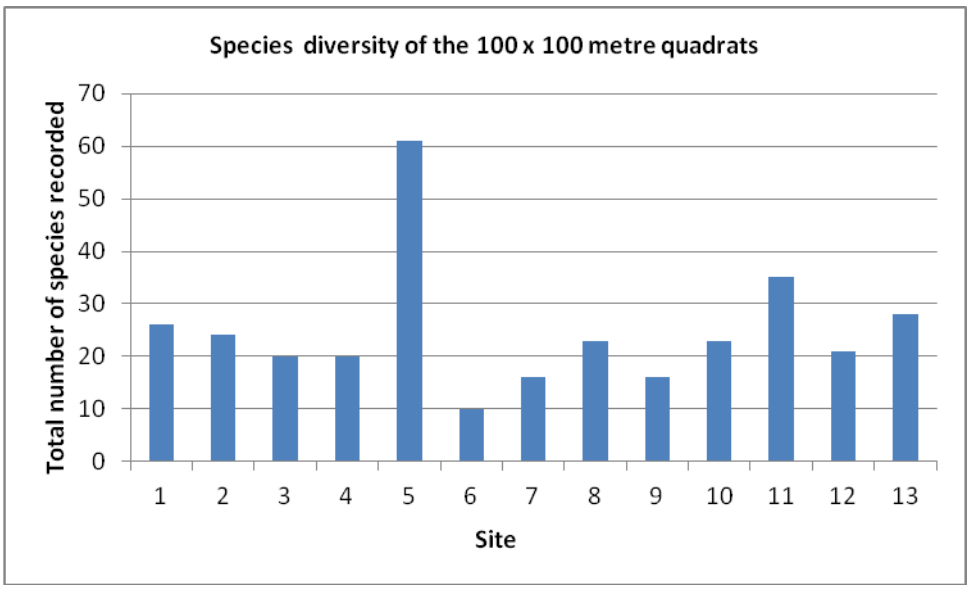


Figure 2. Species diversity recorded within the 100 x 100 metre quadrats.

Note: This includes both native and exotic species and those species that were only able to be identified to genus level. This number may therefore be a slight overrepresentation as unidentifiable species may be duplicates.

Table 5. New flora species not recorded within the 100 x 100 metre quadrat prior to spring 2011.

Species name	Common name
Alectryon oleifolius ssp. *canescens*	Bullock Bush
Amyema quandang var. *quandang*	Grey Mistletoe
Austrostipa scabra ssp. *scabra*	Rough Spear-grass
**Carthamus lanatus*	Saffron Thistle
Dodonaea lobulata	Lobed-leaf Hopbush
Dysphania plantaginella	Plantain Crumbweed
Eremophila deserti	Turkey-bush
Euphorbia tannensis ssp. *eremophila*	Desert Spurge
Frankenia pauciflora	Southern Sea-heath
Lepidium oxytrichum	Green Peppercress
**Lycium ferocissimum*	African Boxthorn
Maireana aphylla	Cottonbush
Maireana trichoptera	Hairy-fruit Bluebush
**Medicago minima* var. *minima*	Little Medic
Oxalis perennans	Native Sorrel
Plantago drummondii	Dark Plantain
Poa crassicaudex	Thick-stem Tussock-grass
Sclerolaena cuneata	Tangled Bindyi
**Sonchus oleraceus*	Common Sowthistle
Tecticornia pergranulata ssp. *pergranulata*	Black-seed Samphire
Tecticornia tenuis	Slender Samphire
Vittadinia condyloides	Club-hair New Holland Daisy
Vittadinia gracilis	Woolly New Holland Daisy
Wahlenbergia luteola	Yellow-wash Bluebell
Westringia rigida	Stiff Westringia
Zygophyllum ammophilum	Sand Twinleaf
Zygophyllum iodocarpum	Violet Twinleaf

* denotes exotic species

5.1.2 Comparison to previous years

Average species diversity decreased from 27.5 species in spring 2010 to 23.9 species in spring 2011 (Table 6). Seven out of the 10 monitoring sites showed a decrease in diversity during the spring 2011 survey compared with the spring 2010 survey. Site V5 recorded the exact number of species between the two years (61 species).

Two sites had a slight increase in diversity, which were the *Maireana* / *Disphyma* Shrubland Site V2 and the Samphire Shrubland Site V3, which had an increase by one and four species, respectively. Sites with the highest decrease in species diversity since spring 2010 were V4 (*Myoporum* Woodland, 10 less species), V9 (Maireana / Atriplex Shrubland, 8 less species) and V10 (*Maireana* Shrubland, 8 less species). Figure 3 details flora species diversity for each quadrat.

Table 6. Total average species diversity per year.

Average number of flora species in all 100x100 metre quadrats	
Spring 2010	Spring 2011
27.5	23.9

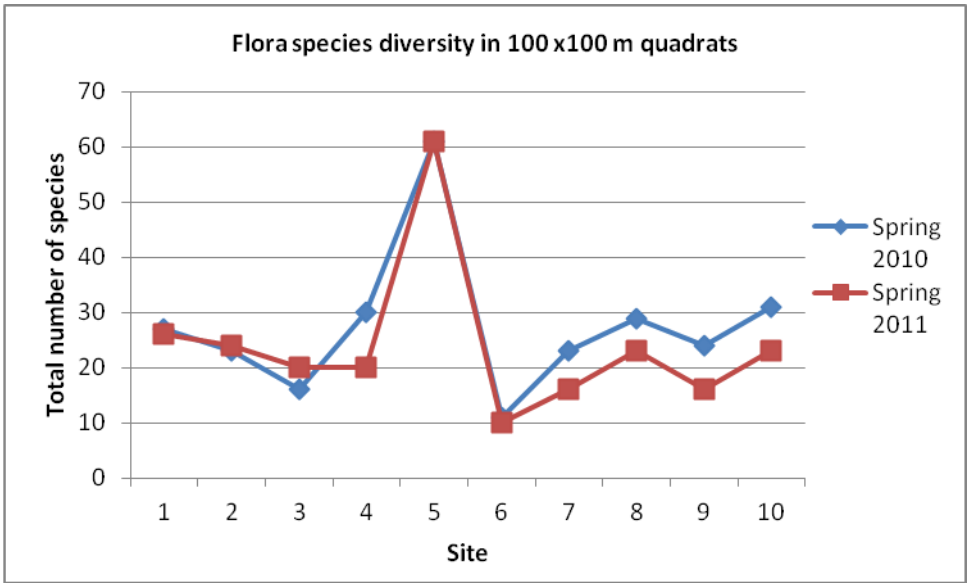


Figure 3. Species diversity recorded within the 100 x 100 metre quadrats during all surveys.

5.2 Flora abundance

5.2.1 Jessup transects

The total number of established native perennial species increased between the spring 2010 and spring 2011 survey, from 9,388 individuals to 10,118 individuals. Sites V11, V12 and V 13 had a total of 1,936 individuals recorded, bringing the total up to 12,054 individuals for all vegetation monitoring sites for spring 2011. Juvenile recruitment decreased significantly during this period from 708 individuals to 223 individuals. The sites with the largest number of juveniles occurred at site V3 (62 individuals, primarily *Frankenia pauciflora*) and site V8 (60 individuals, *Atriplex vesicaria* ssp.).

Considerable variation in the abundance of individuals was observed between sites (Figure 4). The highest abundance of established native perennials occurred in Samphire Shrubland Sites V3 (2,139 individuals) and V6 (2,169 individuals). The lowest abundance occurred at Mallee Woodland Site V5 (313 individuals) and *Maireana* Shrubland Sites V10 (393 individuals), V12 (321 individuals) and V13 (297 individuals). Eight new perennial species were recorded during the spring 2011 survey. The Jessup transect data is summarised in Figure 4 and Appendix 4.

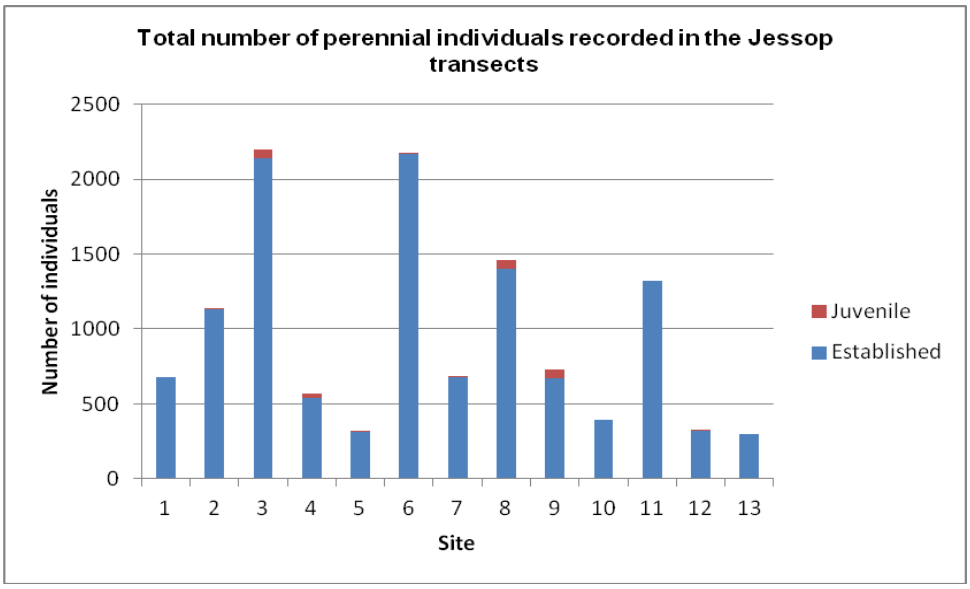


Figure 4. Total number of perennial individuals recorded in the Jessup transects.

Table 7. New flora species not recorded within the Jessup transects prior to spring 2011.

Species name	Common name
Maireana aphylla	Cottonbush
Maireana appressa	Pale-fruit Bluebush
Maireana radiata	Radiate Bluebush
Osteocarpum salsuginosum	Inland Bonefruit
Sclerolaena cuneata	Tangled Bindyi
Sida intricata	Twiggy Sida
Sida petrophila	Rock Sida
Zygophyllum billardierei	Coast Twinleaf

5.2.2 Comparison to previous years

At the 10 flora monitoring sites, abundance of established perennial flora species increased at five sites and decreased at five sites during spring 2011 compared to spring 2010 (Figure 5).

The highest decrease was found within the *Atriplex* / *Disphyma* Shrubland Site V8, from 1788 perennials in spring 2010 to 1403 in spring 2011. The sites with the highest increase in established perennials between spring 2010 and 2011 occurred at Site V3 (701 individuals, primarily *Disphyma crassifolium ssp. clavellatum*) and Site V6 (553 individuals, primarily *Disphyma crassifolium ssp. clavellatum*). Some of these variations are likely attributed to personal variations in observers counting techniques. Table 8 outlines total numbers of established perennials through all surveys.

Only two sites had a slight increase of juveniles when compared to the spring 2010 survey. The biggest increase occurred at V5 (5 individuals, primarily *Solanum petrophilum*) and V2 (4 individuals, primarily

Sclerolaena lanicuspis). The biggest decrease occurred at site V6 (255 individuals) and V3 (102 individuals).

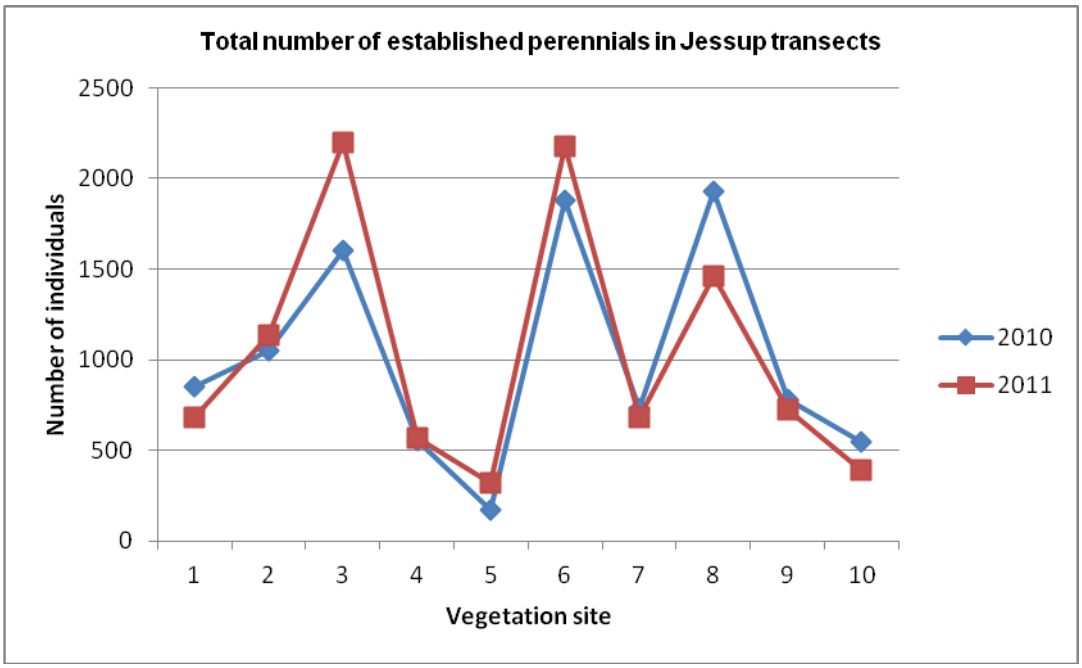


Figure 5. Total number of established perennial individuals recorded in the Jessup transects during all surveys.

Table 8. Total number of established perennials in Jessup transects

Total number of established perennials in Jessup transect	
Spring 2010	Spring 2011
9,388	10,118

5.3 Conservation significant species

No species of conservation significance under either the *Environment Protection and Biodiversity Conservation Act 1999* or *National Parks and Wildlife Act 1972* were recorded during the survey.

5.4 Exotic flora species

5.4.1 Diversity

Fourteen exotic weed species were recorded during the 2011 survey within the 100 x 100 m quadrats (Table 9, Appendix 3). The majority of species recorded in 2011 were from the Compositae family. In 2010 the majority of the species were from the Compositae and the Cruciferae families (Figure 6). Two species, *Marrubium vulgare* (Horehound) and *Lycium ferocissimum* (African Boxthorn) are declared weeds requiring control and management under the *Natural Resources Management Act 2004*. Four other species are of environmental concern due to their ability to degrade habitats by outcompeting with

native species. These environmental weeds are *Vinca major* (Blue Periwinkle), *Carthamus lanatus* (Saffron Thistle), *Sonchus oleraceus* (Common Sowthistle) and *Carrichtera annua* (Ward's Weed). Four new species were detected during the 2011 survey compared to the 2010 survey and eight species from the 2010 survey were not detected during the 2011. Three species were located within the new vegetation monitoring sites (sites 11, 12 and 13) they include *Carrichtera annua* (Wards Weed) (2 of new sites), *Sisymbrium erysimoides* (Smooth Mustard) (3 of new sites) and *Medicago polymorpha* var. *polymorpha* (Burr-medic) (2 of new sites).

Table 9. Weed species recorded during the November 2011 survey and maximum cover abundance recorded (all sites combined).

Family	Species name	Common name	Status: Exotic	Maximum cover abundance score recorded	Number of sites where present Spring 2010	Number of sites where present Spring 2011
AIZOACEAE	*Mesembryanthemum nodiflorum*	Slender Iceplant	Concern	plentiful, <%5 cover	1	1
APOCYNACEAE	*Vinca major*	Blue Periwinkle	Environmental	sparsely present, <%5 cover	1	1
CARYOPHYLLACEAE	*Silene nocturna*	Mediterranean Catchfly	Low concern	sparsely present, <%5 cover	1	
	Spergularia diandra	Lesser Sand-spurrey	Low concern	Not many	9	1
COMPOSITAE	*Carthamus lanatus*	Saffron Thistle	Environmental	sparsely present, <%5 cover		2
	Centaurea calcitrapa	Star Thistle	Environmental	sparsely present, <%5 cover	1	
	Hypochaeris glabra	Smooth Cat's Ear	Low concern	sparsely present, <%5 cover	1	1
	Reichardia tingitana	False Sowthistle	Low concern	Not many	3	
	Sonchus oleraceus	Common Sowthistle	Environmental	sparsely present, <%5 cover		1
CRUCIFERAE	*Brassica sp.*	Turnip species	Low concern	plentiful, <%5 cover	3	
	Carrichtera annua	Wards Weed	Environmental	plentiful, <%5 cover	9	9
	Sisymbrium erysimoides	Smooth Mustard	Low concern	sparsely present, <%5 cover	2	4
GRAMINEAE	*Schismus barbatus*	Arabian Grass	Low concern	plentiful, <%5 cover	1	2
LABIATAE	*Marrubium vulgare*	Horehound	Declared	sparsely present, <%5 cover	1	2
	Salvia verbenaca	Wild Sage	Environmental	sparsely present, <%5 cover	1	
LEGUMINOSAE	*Medicago minima* var. *minima*	Little Medic	Low concern	sparsely present, <%5 cover		1
	Medicago polymorpha var. *polymorpha*	Burr-medic	Low concern	5 25% cover	8	9
MALVACEAE	*Malva parviflora*	Small-flower Marshmallow	Low concern	sparsely present, <%5 cover	1	
OXALIDACEAE	*Oxalis pes-caprae*	Soursob	Declared	plentiful, <%5 cover	1	
PRIMULACEAE	*Anagallis arvensis*	Pimpernel	Low concern	sparsely present, <%5 cover	1	1
SOLANACEAE	*Lycium ferocissimum*	African Boxthorn	Declared	Not many		1
	Nicotiana glauca	Tree Tobacco	Concern	sparsely present, <%5 cover	1	

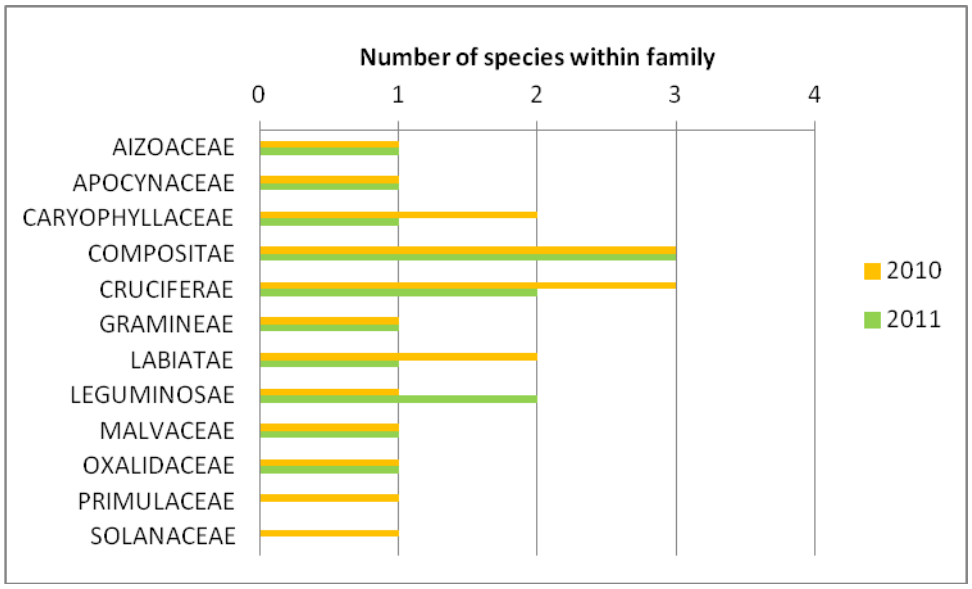


Figure 6. Exotic flora species family diversity recorded during the November 2010 survey.

Vegetation Site 5 recorded the highest diversity in 2010; with 11 weed species (Figure 7) (this site also recorded the highest native species diversity). Sites 5 and 11 recorded the highest diversity in 2011, with seven weed species each. There are fewer weeds species in 2011 compared to 2010. Site 6 recorded the lowest exotic weed diversity for both years, with just one species in 2010 and none in 2011. Site diversity of the remaining sites was typically around three species.

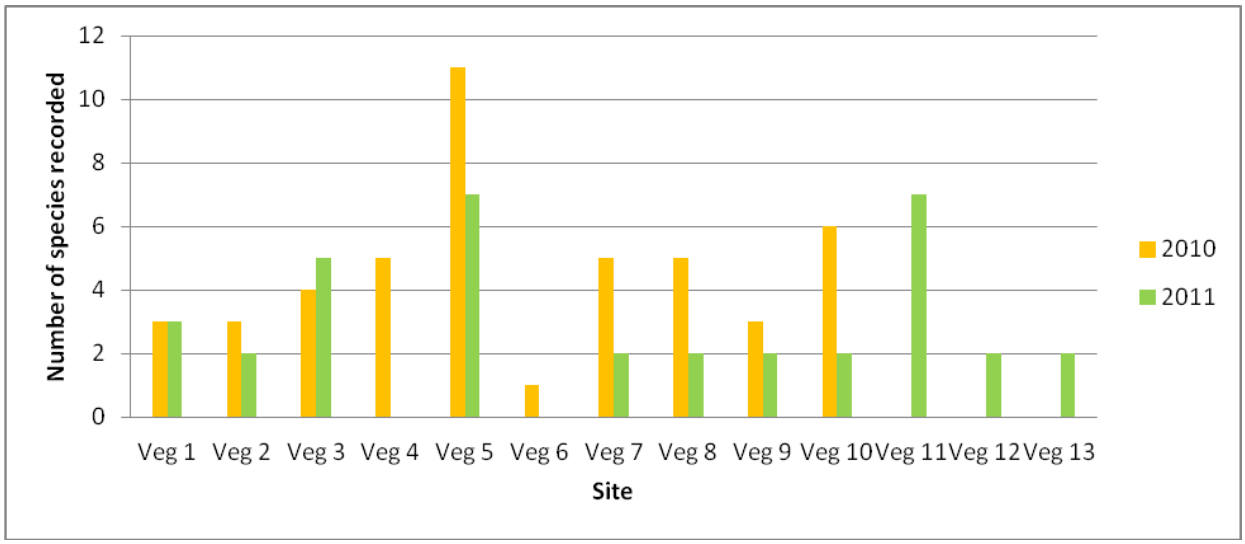


Figure 7. Exotic flora diversity recorded during the spring 2010 and 2011 survey.

5.5 Vegetation monitoring sites

Only the results for the vegetation monitoring sites (sites 11, 12 and 13) established during the current 2011 survey are displayed below. The original descriptions of vegetation monitoring sites (1 - 10) can be located in the *Samphire Follow-up Flora and Fauna Survey November 2010* (EBS Ecology 2010c).

5.5.1 Vegetation Site 11

Species diversity and cover percentage

Twenty-eight native species were recorded at V11, including the dominant species *Maireana sedifolia* (Bluebush), *Sclerolaena patenticuspis* (Spear-fruit Bindyi). *Sclerolaena obliquicuspis* (Oblique-spined Bindyi) and *Maireana pyramidata* (Black Bluebush) were also well represented (cover abundance 5-25%). The dominant grass species was *Austrostipa nodosa* (Tall Spear-grass) (cover abundance 5-25%) with *Austrodanthonia caespitosa* (Common Wallaby-grass) being plentiful but of less than 5% cover. The most dominant weed species was *Medicago polymorpha var. polymorpha* (Burr-medic) (cover abundance 5-25%), followed by *Mesembryanthemum nodiflorum* (Slender Iceplant) and *Carrichtera annua* (Ward's Weed) both being plentiful but of less than 5% cover. See Table 9 for a summary of the flora species recorded at Site 11 and Appendix 3 for a full species list. Figure 8 illustrates the appearance of Site 11 at the time of the survey.

Species abundance

Nine perennial plant species were recorded along the Jessup transect. *Sclerolaena patenticuspis* (Spear-fruit Bindyi) was the most abundant species (858 established plants) followed by *Maireana pyramidata* (Black Bluebush) (151 established plants).

Table 10. Vegetation Site 11 flora summary, November 2010.

Details	Description
Vegetation association description	*Maireana sedifolia* (Bluebush) / *Sclerolaena patenticuspis* (Spear-fruit Bindyi) Low Shrubland
Species diversity	28 native, 7 exotic
Shrubs / forbs	*Atriplex vesicaria* ssp. (Bladder Saltbush) *Sclerolaena patenticuspis* (Spear-fruit Bindyi) *Maireana pyramidata* (Black Bluebush)
Tall shrubs	None
Trees	*Acacia papyrocarpa* (Western Myall)
Grasses	*Austrostipa nodosa* (Tall Spear-grass) *Austrodanthonia caespitosa* (Common Wallaby-grass)
Exotics	*Carrichtera annua* (Ward's Weed) *Medicago polymorpha var. polymorpha* (Burr-medic) *Mesembryanthemum nodiflorum* (Slender Iceplant)
Vegetation condition (SEB)	6:1



Figure 8. Site monitoring photograph – Vegetation Site 11, November 2011.

5.5.2 Vegetation Site 12

Species diversity and cover abundance

Nineteen native species were recorded at V12. The site contained a diverse mix of small shrub species of equal cover abundance, with *Maireana sedifolia* (Bluebush) defining the vegetation association type based on height class category. Other co-dominant species included *Sclerolaena obliquicuspis* (Oblique-spined Bindyi), *Eriochiton sclerolaenoides* (Woolly-fruit Bluebush), *Rhagodia ulicina* (Intricate Saltbush) and *Maireana turbinata* (Top-fruit Bluebush) all are plentiful but less than 5%.

Dominant grass species included *Austrostipa nodosa* (Tall Spear-grass) (cover abundance 5-25%), *Austrodanthonia caespitosa* (Common Wallaby-grass) (plentiful but less than 5% cover) and *Austrostipa eremophila* (Rusty Spear-grass) is sparsely present. Two weed species were sparsely present, *Carrichtera annua* (Ward's Weed) and *Sisymbrium erysimoides* (Smooth Mustard). See Table 10 for a summary of the flora species recorded at Site 12 and Appendix 3 for a full species list. Figure 9 illustrates the appearance of Site 12 at the time of the survey.

Species abundance

Seven perennial plant species were recorded along the Jessup transect. *Maireana sedifolia* (Bluebush) was the most abundant species (237 established plants, 2 juvenile) followed by *Sclerolaena obliquicuspis* (Oblique-spined Bindyi) (41 established plants) and *Atriplex vesicaria* ssp. (Bladder Saltbush) (31 established plants).

Table 11. Vegetation Site 12 flora summary, November 2011.

Details	Description
Vegetation association description	*Maireana sedifolia* (Bluebush) / *Austrostipa nodosa* (Tall Spear-grass) Low Shrubland
Species diversity	19 native, 2 exotic
Shrubs / forbs	*Eriochiton sclerolaenoides* (Woolly-fruit Bluebush) *Rhagodia ulicina* (Top-fruit Bluebush) *Maireana turbinata* (Top-fruit Bluebush)
Tall shrubs	*Senna artemisioides* ssp. *artemisioides x* ssp. *coriacea* (Desert Senna)
Trees	*Acacia papyrocarpa* (Western Myall)
Grasses	*Austrostipa nodosa* (Tall Spear-grass)
Exotics	*Carrichtera annua* (Ward's Weed) *Sisymbrium erysimoides* (Smooth Mustard)
Vegetation condition (SEB)	6:1

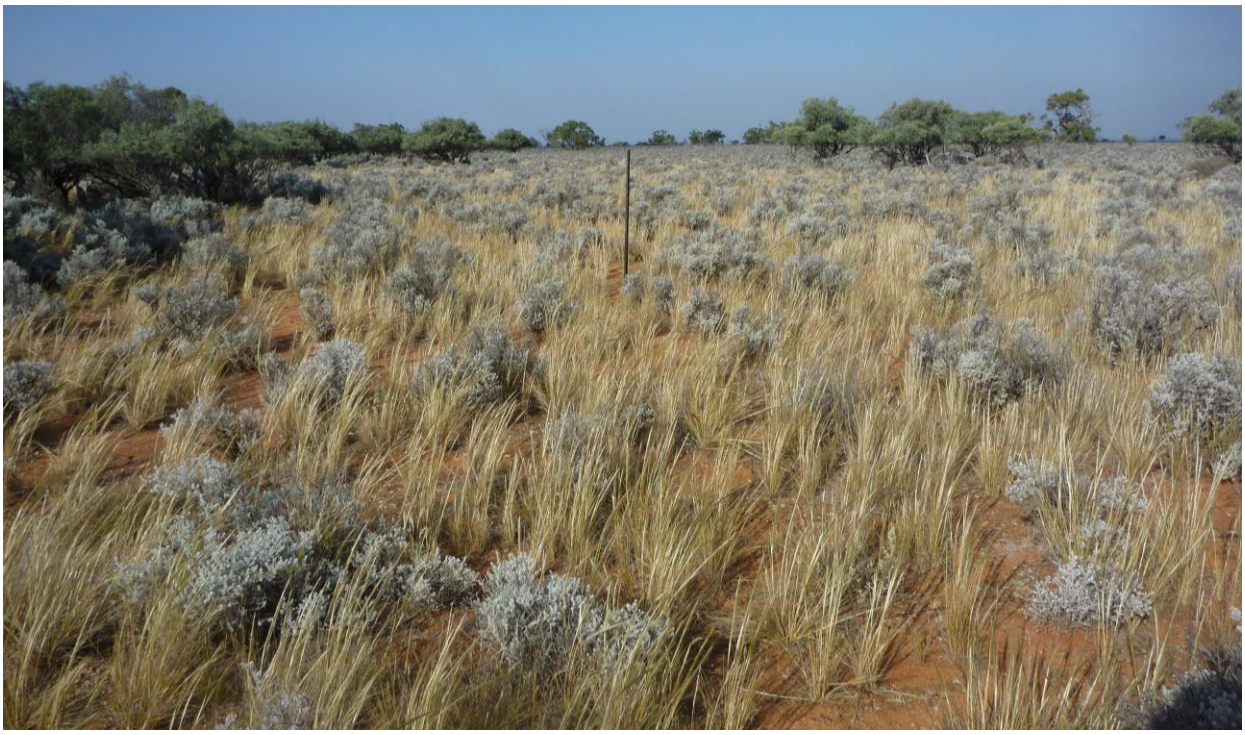


Figure 9. Site monitoring photograph – Vegetation Site 12, November 2011.

5.5.3 Vegetation Site 13

Species diversity and cover abundance

Nineteen native species were recorded at V13. *Maireana sedifolia* (Bluebush) was the dominant species having a cover abundance of between 25-50%. The site contained a diverse mix of small shrub species of equal cover abundance (plentiful but less than 5%), including *Maireana pyramidata* (Black Bluebush), *Sclerolaena obliquicuspis* (Oblique-spined Bindyi), *Eriochiton sclerolaenoides* (Woolly-fruit Bluebush), *Maireana turbinata* (Top-fruit Bluebush), *Vittadinia dissecta* var. *hirta* (Dissected New Holland Daisy) and *Sclerolaena patenticuspis* (Spear-fruit Bindyi).

Dominant grass species included *Austrostipa nodosa* (Tall Spear-grass) (cover abundance 5-25%), *Austrodanthonia caespitosa* (Common Wallaby-grass) (plentiful but less than 5% cover). The most dominant weed species was *Medicago polymorpha var. polymorpha* (Burr-medic) (cover abundance 5-25%), followed by *Sisymbrium erysimoides* (Smooth Mustard) being sparsely present. See Table 11 for a summary of the flora species recorded at Site 13 and Appendix 3 for a full species list. Figure 10 illustrates the appearance of Site 13 at the time of the survey.

Species Abundance

Ten perennial plant species were recorded along the Jessup transect. *Maireana sedifolia* (Bluebush) was the most abundant species (155 established plants) and closely followed by *Sclerolaena obliquicuspis* Oblique-spined Bindyi) (106 established plants). All other species were between one and 13 established plants.

Table 12. Vegetation Site 13 flora summary, November 2011.

Details	Description
Vegetation association description	*Maireana sedifolia* (Bluebush) / *Austrostipa nodosa* (Tall Spear-grass) Low Shrubland
Species diversity	26 native, 2 exotic
Shrubs / forbs	*Maireana pyramidata* (Black Bluebush) *Sclerolaena obliquicuspis* (Oblique-spined Bindyi) *Eriochiton sclerolaenoides* (Woolly-fruit Bluebush)
Tall shrubs	None
Trees	*Acacia papyrocarpa* (Western Myall) *Myoporum platycarpum* ssp. (False Sandalwood)
Grasses	*Austrostipa nodosa* (Tall Spear-grass)
Exotics	*Medicago polymorpha var. polymorpha* (Burr-medic)
Vegetation condition (SEB)	6:1

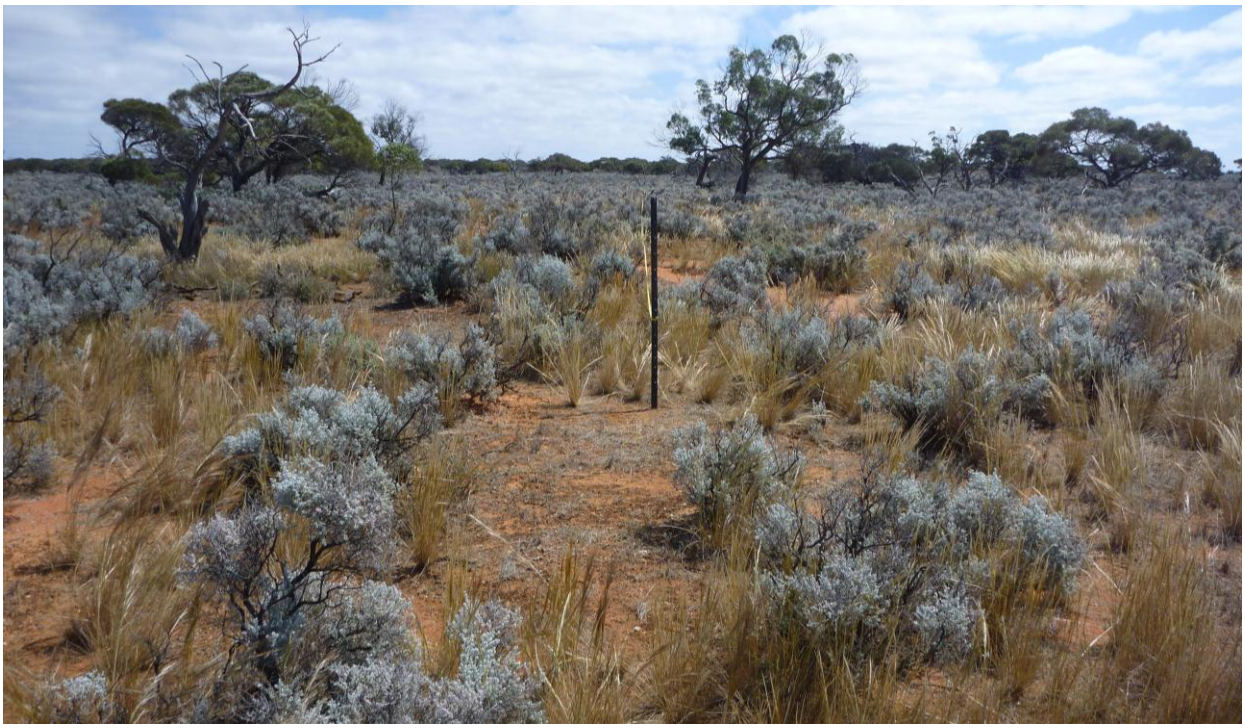


Figure 10. Site monitoring photograph – Vegetation Site 13, November 2010.

5.6 Vegetation mapping of the UraniumSA purchased land boundary

5.6.1 Overview

Four main vegetation associations were identified during vegetation mapping of the USA purchased land boundary (Table 13). The vegetation mapping built upon vegetation mapping completed prior to this survey by EBS, which is detailed within *Samphire Flora and Fauna Baseline Survey 2010*. For comparative reference see Appendix 5 for previous EBS and DEH floristic vegetation mapping (which covers a larger area than the USA purchased land boundary), as well as updated floristic vegetation mapping of the USA purchased land boundary. Appendix 6 provides species list for each vegetation association recorded.

5.6.2 Vegetation Condition

Condition of the vegetation associations within the USA purchased land boundary ranged from 1:1 to 8:1 (Appendix 5). However, most of the area is considered to be in moderate to good condition, with patches of areas in poor conditions. As expected, condition was poor in and around already developed or heavily used areas, such as the retention lease area and vehicle tracks. Weed infestations were most noticeable around dam sites, heavily grazed areas, well-used tracks, and within creeks or drainage channels. Thick weed patches consisting of several declared exotic species were recorded immediately adjacent dams and appear to be subject to ongoing disturbance due to high stock levels in these areas. Vegetation condition improves away from these disturbed areas, with species abundance and cover increasing.

Table 13. Summary of the vegetation associations identified as occurring within and adjacent the lease area.

No.	Association description	Area (ha) within lease	Condition SEB ratio
1	*Acacia papyrocarpa* (Western Myall) +/- *Myoporum platycarpum* (False Sandalwood) +/- *Alectryon oleifolius ssp. canescens* (Bullock Bush) Open Woodland over Chenopod Shrubland or Tall Shrubland	77.86	0:1
1	*Acacia papyrocarpa* (Western Myall) +/- *Myoporum platycarpum* (False Sandalwood) +/- *Alectryon oleifolius ssp. canescens* (Bullock Bush) Open Woodland over Chenopod Shrubland or Tall Shrubland	138.52	1:1
1	*Acacia papyrocarpa* (Western Myall) +/- *Myoporum platycarpum* (False Sandalwood) +/- *Alectryon oleifolius ssp. canescens* (Bullock Bush) Open Woodland over Chenopod Shrubland or Tall Shrubland	17.09	3:1
1	*Acacia papyrocarpa* (Western Myall) +/- *Myoporum platycarpum* (False Sandalwood) +/- *Alectryon oleifolius ssp. canescens* (Bullock Bush) Open Woodland over Chenopod Shrubland or Tall Shrubland	779.16	6:1
1	*Acacia papyrocarpa* (Western Myall) +/- *Myoporum platycarpum* (False Sandalwood) +/- *Alectryon oleifolius ssp. canescens* (Bullock Bush) Open Woodland over Chenopod Shrubland or Tall Shrubland	3441.59	8:1
2	*Maireana sedifolia* (Bluebush) / *Maireana pyramidata* (Black Bluebush) / *Atriplex vesicaria* (Bladder Saltbush) Open Low Shrubland over *Austrostipa nodosa* (Tall spear-grass) +/ *Sclerolaena obliquicuspis* (Oblique-spined Bindyi)	230.72	2:1
2	*Maireana sedifolia* (Bluebush) / *Maireana pyramidata* (Black Bluebush) / *Atriplex vesicaria* (Bladder Saltbush) Open Low Shrubland over *Austrostipa*	22.59582	3:1

No.	Association description	Area (ha) within lease	Condition SEB ratio
	nodosa (Tall spear-grass) +/ *Sclerolaena obliquicuspis* (Oblique-spined Bindyi)		
2	*Maireana sedifolia* (Bluebush) / *Maireana pyramidata* (Black Bluebush) / *Atriplex vesicaria* (Bladder Saltbush) Open Low Shrubland over *Austrostipa nodosa* (Tall spear-grass) +/ *Sclerolaena obliquicuspis* (Oblique-spined Bindyi)	2983.281	6:1
2	*Maireana sedifolia* (Bluebush) / *Maireana pyramidata* (Black Bluebush) / *Atriplex vesicaria* (Bladder Saltbush) Open Low Shrubland over *Austrostipa nodosa* (Tall spear-grass) +/ *Sclerolaena obliquicuspis* (Oblique-spined Bindyi)	31.95	8:1
3	*Tecticornia pergranulata* (Black-seed Samphire) / *Tecticornia* sp. (Samphire) / *Atriplex vesicaria* (Bladder Saltbush) Low Shrubland +/ *Austrostipa nodosa* (Tall Spear-grass)	342.65	8:1
4	*Tecticornia pergranulata* (Black-seed Samphire) / *Tecticornia* sp. (Samphire) Very Low Shrubland	144.67	8:1

5.6.3 Vegetation Associations

Association 1 – *Acacia papyrocarpa* (Western Myall) / *Myoporum platycarpum* (False Sandalwood) Open Woodland over *Maireana pyramidata* (Black Bluebush) *Maireana sedifolia* (Bluebush) *Atriplex vesicaria* (Bladder Saltbush) +/ *Austrostipa nodosa* (Tall Spear-grass)

Acacia papyrocarpa (Western Myall) / *Myoporum platycarpum* (False Sandalwood) Open Woodland covers an estimated 4454 ha or 54% of the total 8210 ha USA land boundary area. This vegetation association occurs within the western half of the land boundary, with the upper stratum species increasing in abundance closer towards the Lincoln Highway.

Acacia papyrocarpa is the dominant species in the upper stratum, with *Myoporum platycarpum* or *Alectryon oleifolius ssp. canescens* sometimes occurring as a second dominant. *Eucalyptus socialis* (Beaked Red Mallee) and/or *Eucalyptus oleosa* (White Mallee) were observed on occasion, but were not recorded as a dominant species within the surveyed area.

The mid-stratum varies within this association and is either typically characterised by: 1) an open chenopod shrub layer or, 2) a tall shrub layer.

The chenopod shrubland is usually dominated by *Maireana pyramidata* (Black Bluebush), *M. sedifolia* (Bluebush) and/or *Atriplex vesicaria* (Bladder Saltbush) (Figure 11). The tall shrub layer is typically characterised by 12m tall shubs consisting primarily of *Senna*, *Acacia*, and *Dodonaea* genera. *Senna artemisioides* spp. *petiolaris* (Desert Senna) was the dominant species recorded (Figure 12).

The ground-layer is generally dominated by Graminae spp., especially species within the *Austrostipa* (Spear-grass) and *Austrodanthonia* (Wallaby Grass) genera. In patches, *Triodia irritans* (Spinifex) tussocks were observed (Figure 13).

Conservation Value

Alectryon oleifolius ssp. *canescens* (Bullock Bush) Tall Shrubland on alluvial soils of plains is a widespread ecological community of semiarid and arid regions, where it grows on sandy soils (Neagle 2003) and is recognised as a vulnerable community at the state level (DEH 2001). While this community was not recorded according to the strict definition of DEH (2001) within the current survey, it is possible this community could be defined within the USA land boundary if a more detailed survey were undertaken. According to Neagle (2003) this community is rarely recorded as it is often included as a component of broader vegetation groups, as indicated in this report. It is commonly recorded as an emergent within shrubland vegetation associations, or within *Acacia* woodlands in which it forms dense localised patches.

EBS recommends that any dense, localised patches of Bullock Bush are avoided or measures to mitigate disturbance to these patches are implemented when planning development works / activities.

Table 14. Vegetation Association 1 floristic description

Detail	Description
Dominant species	• *Acacia papyrocarpa* (Western Myall) • *Myoporum platycarpum* (False Sandalwood) • *Alectryon oleifolius ssp. canescens* (Bullock Bush)
Association type	• Open Woodland
Shrubs / Forbs	• *Maireana pyramidata* (Black Bluebush) • *Marieana sedifolia* (Bluebush) • *Atriplex vesicaria* (Bladder Saltbush)
Tall Shrubs	• *Senna artemisioides ssp. petiolaris* (Desert Senna) • *Dodonaea viscosa ssp. angustissima* (Narrow-leaf Hop-bush)
Grasses	• *Austrostipa* sp • *Austrodanthonia* sp.
Overall Condition	• Moderate – Good. Some small patches of poor condition in already degraded areas.



Figure 11. Western Myall Woodland over chenopod shrubland



Figure 12. Western Myall Woodland over tall shrubland



Figure 13. Western Myall Woodland over Spinifex tussocks

Association 2 – *Maireana sedifolia* (Bluebush) / *Maireana pyramidata* (Black Bluebush) / *Atriplex vesicaria* (Bladder Saltbush) Open Low Shrubland over *Austrostipa nodosa* (Tall spear-grass) +/ *Scleroleana obliquicuspis* (Oblique-spined Bindyi)

Maireana sedifolia (Bluebush) / *Maireana pyramidata* (Black Bluebush) / *Atriplex vesicaria* (Bladder Saltbush) Open Low Shrubland covers an estimated 3268 ha or 40% of the total 8210 ha USA land boundary area. The three dominant species often vary in abundance but generally always occur together within this association. This vegetation association occurs throughout the land boundary and is the second most dominant association of all recorded, however most of the impact areas associated with mining operations currently fall within this vegetation type.

The ground-layer is typically characterised by Graminae spp., especially species within the *Austrostipa* (Spear-grass) and *Austrodanthonia* (Wallaby Grass) genera. *Scleroleana* spp. (Poverty Bush) are recorded in the understorey in dense patches, with *Scleroleana obliquicuspis* (Oblique-spined Bindyi) generally being the most commonly recorded within this genus.

Emergent species are commonly observed including *Acacia papyrocarpa* (Western Myall), *Alectryon oleifolius* ssp. *canescens* (Bullock Bush) or *Myoporum platycarpum* (False Sandalwood).

Few to no weeds were observed within this vegetation type and condition was considered moderate overall.

Table 15. Vegetation Association 2 floristic description

Detail	Description
Dominant species	• *Maireana sedifolia* (Bluebush) • *Maireana pyramidata* (Black Bluebush) • *Atriplex vesicaria* (Bladder Saltbush)
Association type	• Low Open Shrubland
Shrubs / Forbs	• *Sclerolaena obliquicuspis* (Oblique-spined Bindyi)
Tall Shrubs	• N/A
Grasses	• *Austrostipa* sp • *Austrodanthonia* sp.
Emergent species	• *Acacia papyrocarpa* (Western Myall) • *Alectryon oleifolius ssp. canescens* (Bullock Bush) • *Myoporum platycarpum* (False Sandalwood)
Overall Condition	• Moderate – Good. Some small patches of poor condition in already degraded areas.



Figure 14. Chenopod Low Open Shrubland

Association 3. *Tecticornia pergranulata* (Black-seed Samphire) / *Tecticornia* sp. (Samphire) / *Atriplex vesicaria* (Bladder Saltbush) Low Shrubland +/ *Austrostipa nodosa* (Tall Spear-grass)

Tecticornia pergranulata (Black-seed Samphire) / *Tecticornia* sp. (Samphire) / *Atriplex vesicaria* (Bladder Saltbush) Very Low Shrubland covers an estimated 342 ha or 4% of the total 8210 ha USA land boundary area. This association is located on the plains towards the seaward side of the USA land boundary area.

Similar to association 6, this association has low species diversity due to the high salt gradient, but also consists of a few more ground layer species, such as *Disphyma crassifolium ssp. clavellatum* (Round-leaf Pigface).

Table 16. Vegetation Association 3 floristic description

Detail	Description
Dominant species	• *Tecticornia pergranulata* (Black-seed Samphire)
Association type	• Very Low Open Shrubland
Shrubs / Forbs	• *Atriplex vesicaria* (Bladder Saltbush) • *Disphyma crassifolium* ssp. *clavellatum* (Round-leaf Pigface)
Grasses	• *Austrostipa nodosa* (Tall Spear-grass)
Overall Condition	• Good. No weeds or degraded patches observed.



Figure 15. Samphire / Saltbush Very Low Shrubland

Association 4: *Tecticornia pergranulata* (Black-seed Samphire) / *Tecticornia* sp. (Samphire) Very Low Shrubland

Tecticornia pergranulata (Black-seed Samphire) / *Tecticornia* sp. (Samphire) Very Low Shrubland covers an estimated 144 ha or 1.7% of the total 8210 ha USA land boundary area. This association is typically located in low lying areas within sabkhas which are at times inundated with water. The association has low species diversity due to the high salt gradient and therefore consists only of Samphire species.

Avicennia marina (Mangroves) border this association nearby the foreshore and are located within the tidal zone of Gulf St Vincent.

Table 17. Vegetation Association 4 floristic description

Detail	Description
Dominant species	• *Tecticornia pergranulata*
Association type	• Very Low Open Shrubland
Emergent species	• *Avicennia marina* juveniles near foreshore
Overall Condition	• Good. No weeds or degraded patches observed.



Figure 16. Samphire Very Low Shrubland

6 FAUNA RESULTS

In total, 7894 observations of 72 fauna species were recorded during the spring 2011 survey. Table 18 summarises the total number of fauna observations from all five trap sites as well as opportunistic records. The terrestrial fauna results in the following sections, report on species that were only recorded at the five fauna monitoring sites and eleven bird sites. For a list of opportunistic fauna records from all sites see Appendix 5.

Table 18. Summary of fauna observations from the spring 2011 monitoring survey (Monitoring sites and opportune records)

Fauna Record	Number
Native Mammal species [1]	4
Native Mammal observations [2]	21
Exotic Mammal species	3
Exotic Mammal observations	124
Reptile species	14
Reptile observations	77
Bird species	50
Bird observations	7678
TOTAL species	71
TOTAL observations	7900

1 includes only positively identified bat species
2 does not include AnaBat records

6.1 Fauna species diversity and abundance

6.1.1 Mammals

A total of two native terrestrial mammal species were detected at the fauna monitoring sites (combined trapping and opportunistic records) during the spring 2011 survey, the Bolam's Mouse (*Pseudomys bolami*) and the Fat-tailed Dunnart (*Sminthopsis crassicaudata*) (Table 19). The Bolam's Mouse was caught for the first time during the current spring 2011 survey. All fauna sites had low species diversity, with two species observed at each site apart from site F3 and F5 where only one species was observed (Figure 17). *Maireana* Shrubland site F1 recorded the highest number of observations (8 observations). The lowest abundance was recorded at the *Maireana* / *Disphyma* Shrubland site F2 and the *Myoporum* woodland site F4, both sites with two 2 individuals captured (Figure 18).

The most common native terrestrial mammal recorded was Bolam's Mouse (*Pseudomys bolami*) with 12 observations (Figure 19), followed by the Fat-tailed Dunnart (*Sminthopsis crassicaudata*) with six observations. The Fat-tailed Dunnart was recorded at the majority of the monitoring sites (4 out of the 5 sites). The mammal data for spring 2011 is summarised in Table 18.

Table 19. Terrestrial mammal diversity and abundance recorded at the fauna monitoring sites during the autumn 2011 survey.

Species name	Common name	F1	F2	F3	F4	F5	Total per species
Pseudomys bolami	Bolam's Mouse	7	1		1	3	12
Sminthopsis crassicaudata	Fat-tailed Dunnart	1	1	3	1		6
Number of native individuals		**8**	**2**	**3**	**2**	**3**	**21**
Number of native species		**2**	**2**	**1**	**2**	**1**	**3**

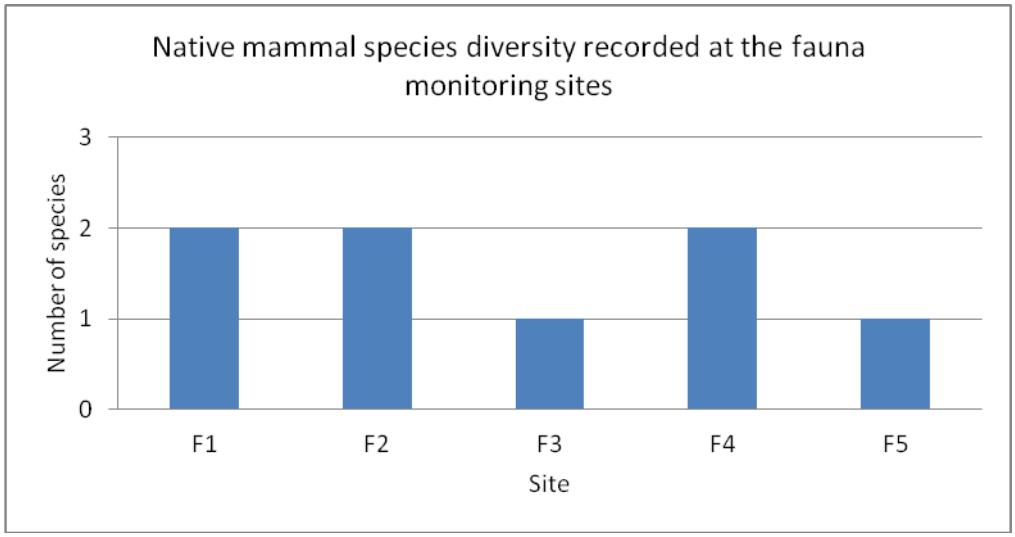


Figure 17. Native mammal species diversity recorded at the fauna monitoring sites during the spring 2011 survey

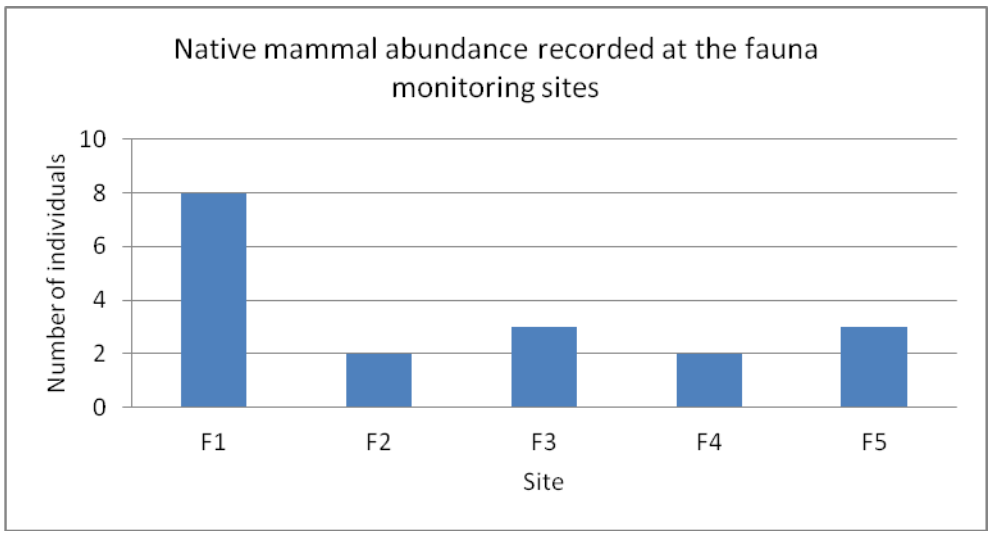


Figure 18. Native mammal abundance recorded at the fauna monitoring sites during the spring 2011 survey.



Figure 19. Bolam's Mouse (*Pseudomys bolami*)

Comparison of mammals to previous years

Native mammal species diversity recorded during the spring 2011 survey was slightly below average in comparison to spring 2010 (Figure 20). The Stripe-faced Dunnart (*Sminthopsis macroura*) (observed in 2009) and the Little Long-tailed Dunnart (*Sminthopsis dolichura*) (observed in 2010) were not recorded during the current survey. The Fat-tailed Dunnart (*Sminthopsis crassicaudata*) has been observed for all three years that monitoring has occurred. The additional two species observed in 2010 were the Euro (*Macropus robustus*) and the Red Kangaroo (*Macropus rufus*), both have not been observed any other year, except opportunistically offsite.

Abundance of native mammal species increased noticeably from spring 2009 (2 observations) and spring 2010 (3 observations) to spring 2011 (18 observations) (Figure 21). This result is likely attributed to the abundance of food resources following sustained high rainfall events in the months prior to the spring 2011 survey.

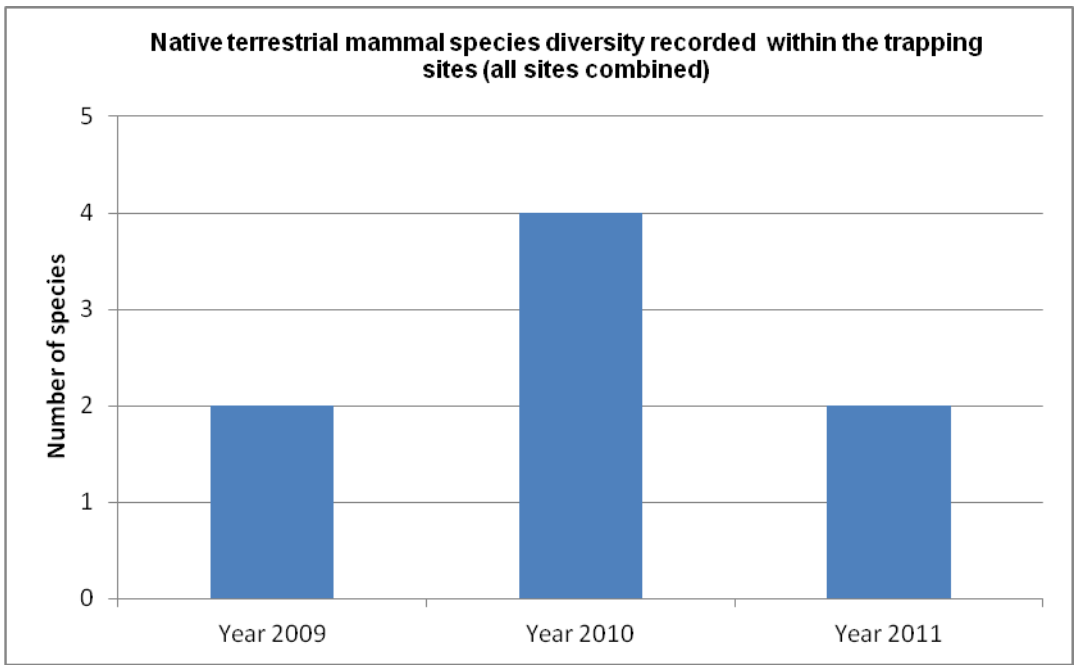


Figure 20. Native terrestrial mammal species diversity (all sites combined) 2009 to 2011.

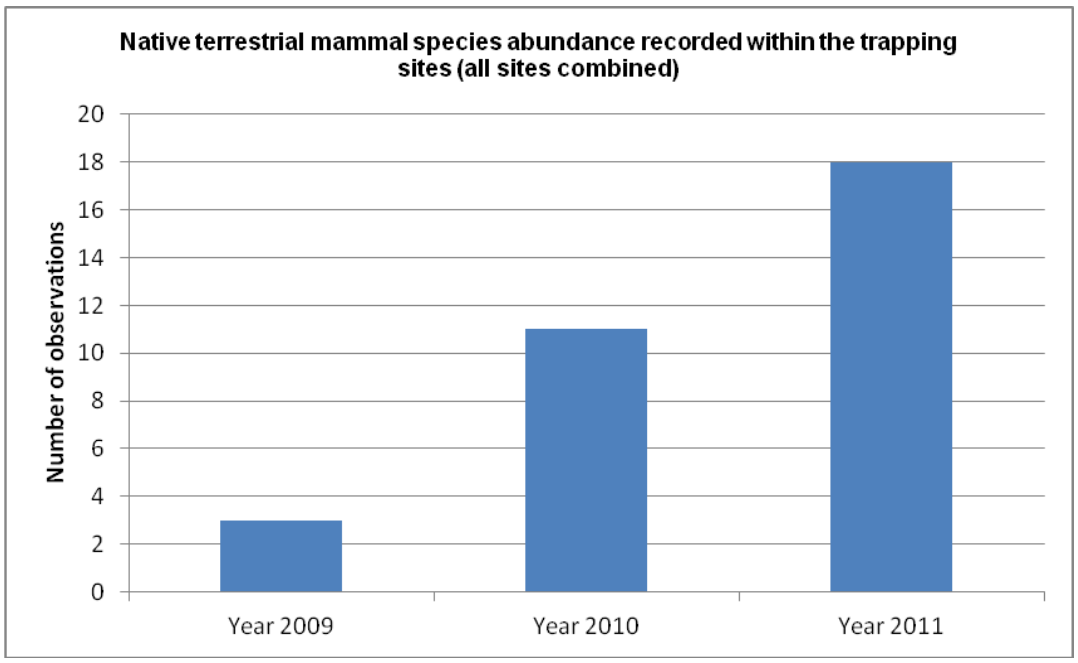


Figure 21. Native terrestrial mammal abundance (all sites combined) 2009 to 2011.

6.1.2 Exotic fauna

Three exotic mammal species were detected during the spring 2011 survey (Table 20). The House Mouse (*Mus musculus*) was detected at all trapping sites with a total of 120 observations recorded. *Maireana* / *Disphyma* Shrubland Site F2 recorded the highest number of exotic fauna observations while *Myoporum* Woodland Site F4 recorded the least (Figure 33). The Rabbit (*Oryctolagus cuniculus*) and the Fox (*Vulpes Vulpes*) were only detected opportunistically not within trapping sites.

Table 20. Exotic species diversity and abundance recorded during the spring 2011 survey.

Species name	Common name	F1	F2	F3	F4	F5	Offsite
**Mus musculus*	House Mouse	33	35	15	13	24	
**Oryctolagus cuniculus*	Rabbit						2
**Vulpes vulpes*	Fox						2
Number of exotic individuals		33	35	15	13	24	4
Number of exotic species		1	1	1	1	1	2

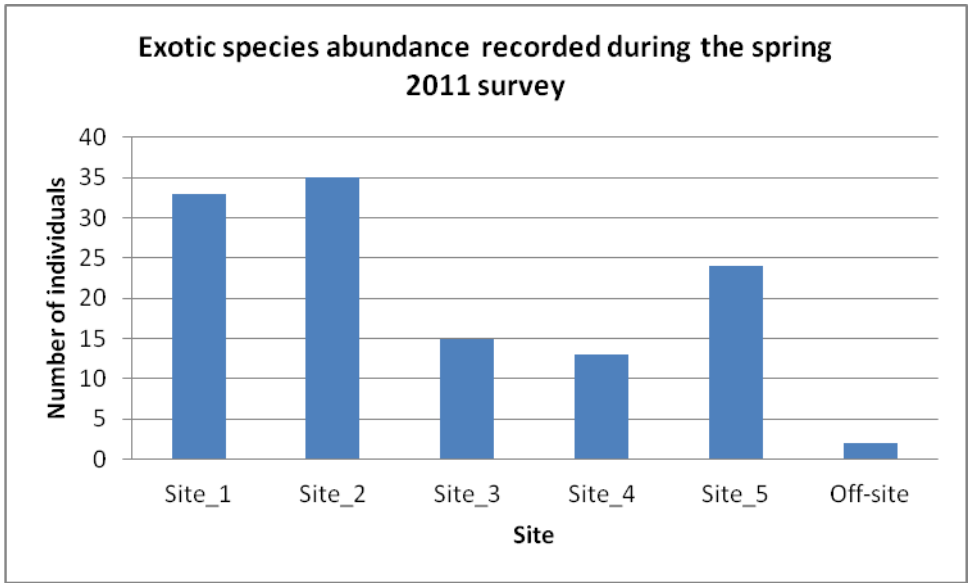


Figure 22. Exotic fauna species diversity recorded during the spring 2011 survey.

Comparison to previous years

Exotic fauna species diversity has remained consistent over the monitoring program (Figure 23), however exotic fauna abundance was highest during the spring 2011 survey (Figure 24). Increased pest species abundance is attributed to large numbers of House Mouse (*Mus musculus*) following the good seasonal rainfalls, which most likely a food resource for pest species.

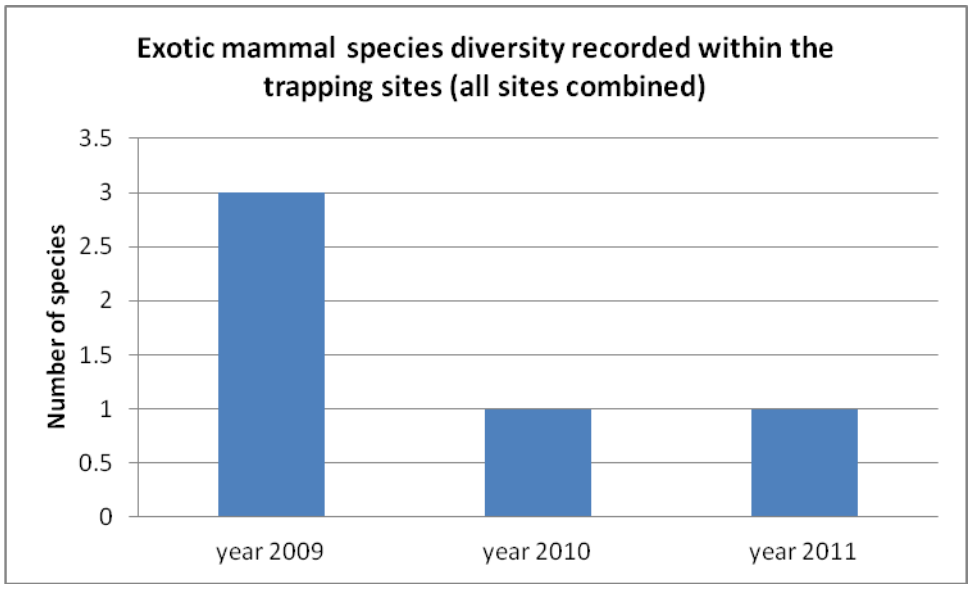


Figure 23. Exotic fauna species diversity (all sites combined) 2009 to 2011.

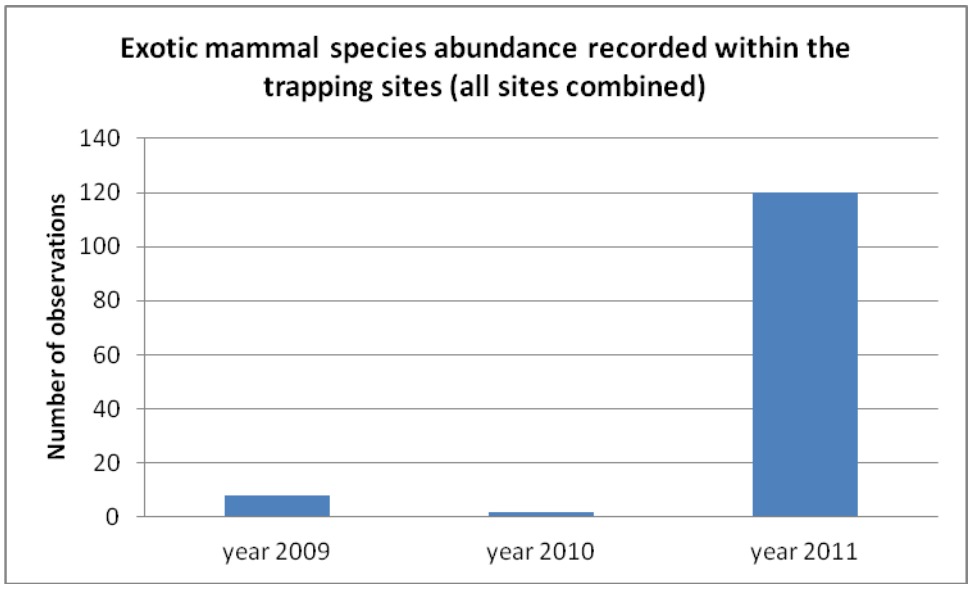


Figure 24. Exotic fauna species abundance (all sites combined) 2009 to 2011.

6.1.3 Opportunistic terrestrial fauna observations

Two species were recorded opportunistically outside of established monitoring sites (Table 21).

Table 21. Opportunistic native terrestrial fauna observations

Species name	Common name	Observations
Macropus rufus	Red Kangaroo	1
Macropus robustus	Euro	4
Number of observations		**5**
Number of species		**2**

6.1.4 Bats

AnaBat detectors were utilised for one night at each of the fauna monitoring sites. AnaBat recordings cannot be interpreted as an abundance measure in the same way as other mammal trapping results; however they are able to provide an indication of the minimum diversity of bat species present at that time. A total of potentially six species were recorded during the survey (Table 2222). Example call files for the bat species are shown in Appendix 7.

Many of the calls were of poor quality (due to windy weather during survey nights). Some calls fell within frequencies that were not easily assigned to species, and some calls fall into the overlap of parameters between two species, resulting in uncertain identification. Calls of four species were identified with certainty. The confirmed species were Gould's Wattled Bat (*Chalinolobus gouldii*), Southern Forest Bat (*Vespadelus regulus*), White-striped Free-tail Bat (*Austronomus australis*) and Inland Free-tail Bat (*Mormopterus sp3*). Calls of a species of Long-eared Bat (*Nyctophilus* genus) were identified; however the calls could not be distinguished between *Nyctophilus geoffroyi* and *Nyctophilus major tor*. Additionally, calls between Gould's Wattled Bat (*Chalinolobus gouldii*) and Western Broad-nosed Bat (*Scotorepens balstoni*) also could not be distinguished.

The highest diversity of bat species was at Samphire site 3 (5 species detected), followed by the Myoporum Woodland site F4 and *Eucalyptus* Mallee site F5 (both with 4 species detected). The Gould's Wattled Bat was the only species detected at all monitoring sites.

A harp trap was set up for one night at F5, with three Lesser Long-eared Bats' (*Nyctophilus geoffroyi*) captured (Figure 25).

Table 22. Bat species identified as occurring with the project area as identified through call identification.

Species name	Common name	F1	F2	F3	F4	F5	Total per species
Chalinolobus gouldii	Gould's Wattled Bat	x	x	x	x	x	**5**
Nyctophilus geoffroyi or *Nyctophilus major tor*	Lesser Long-eared Bat or Central Long-eared Bat	x		x	x	x	**4**
Chalinolobus gouldii or *Scotorepens balstoni*	Gould's Wattled Bat or Western Broad-nosed Bat	x					**1**
Vespadelus regulus	Southern Forest Bat			x			**1**
Austronomus australis	White-striped Freetail Bat		x	x	x	x	**4**
Mormopterus sp3	Inland Freetail Bat			x	x	x	**3**
	Number of species per site	**3**	**2**	**5**	**4**	**4**	**18**

X = calls recorded and identified.



Figure 25. Lesser Long-eared Bat (*Nyctophilus geoffroyi*)

6.1.5 Reptiles

A total of 14 native reptile species were detected at the fauna monitoring sites (Table 23). Reptile species diversity was highest at *Maireana* Shrubland site F1 and *Eucalyptus* Mallee site F5, with seven species recorded at both sites. The Samphire Shrubland site F3 and *Myoporum* Woodland Site F4 recorded the lowest diversity, with four species recorded at both sites (Figure 26). The highest reptile abundance was recorded at *Maireana* Shrubland Site F1 with 21 records. The Samphire Shrubland site F3 recorded the lowest species abundance with 8 records (Figure 27).

The most common reptile species recorded was the Adelaide Snake-eye (*Morethia adelaidensis*) with 26 records, followed by Saltbush Ctenotus (*Ctenotus olympicus*) (10 records) and the Crested Dragon (*Ctenophorus cristatus*) (8 records) (Figure 28). Several species were recorded once and include Ranges Stone Gecko (*Diplodactylus furcosus*) (Figure 29), Tree Dtella (*Gehyra variegata*), Garden Skink (*Lampropholis guichenoti*), Myall Slider (*Lerista edwardsae*) and the Patch-nosed Brown Snake (*Pseudonaja aspidorhyncha*).

No new reptile species were recorded during the spring 2011 survey. The reptile data for spring 2011 is summarised in Table 25.

Table 23. Reptile diversity and abundance recorded at the fauna monitoring sites during the spring 2011 survey.

Species name	Common name	F1	F2	F3	F4	F5	Total per species
Ctenophorus cristatus	Crested Dragon			1		7	**8**
Ctenotus olympicus	Saltbush Ctenotus		3	1	5	1	**10**
Ctenotus regius	Eastern Desert Ctenotus	1	2				**3**
Ctenotus schomburgkii	Sandplain Ctenotus				6		**6**
Diplodactylus furcosus	Ranges Stone Gecko	1					**1**
Gehyra variegata	Tree Dtella					1	**1**

Species name	Common name	F1	F2	F3	F4	F5	Total per species
Lampropholis guichenoti	Garden Skink					1	**1**
Lerista edwardsae	Myall Slider					1	**1**
Menetia greyii	Dwarf Skink	1	1				**2**
Morethia adelaidensis	Adelaide Snake-eye	6	7	5	3	5	**26**
Pogona minor	Dwarf Bearded Dragon	2					**2**
Pseudonaja aspidorhyncha	Patch-nosed Brown Snake		1				**1**
Tiliqua rugosa	Sleepy Lizard	2			2	2	**6**
Tympanocryptis lineata	Five-lined Earless Dragon	8		1			**9**
Number of individuals		**21**	**14**	**8**	**16**	**18**	**77**
Number of species		**7**	**5**	**4**	**4**	**7**	**14**

Table does not include opportune observations

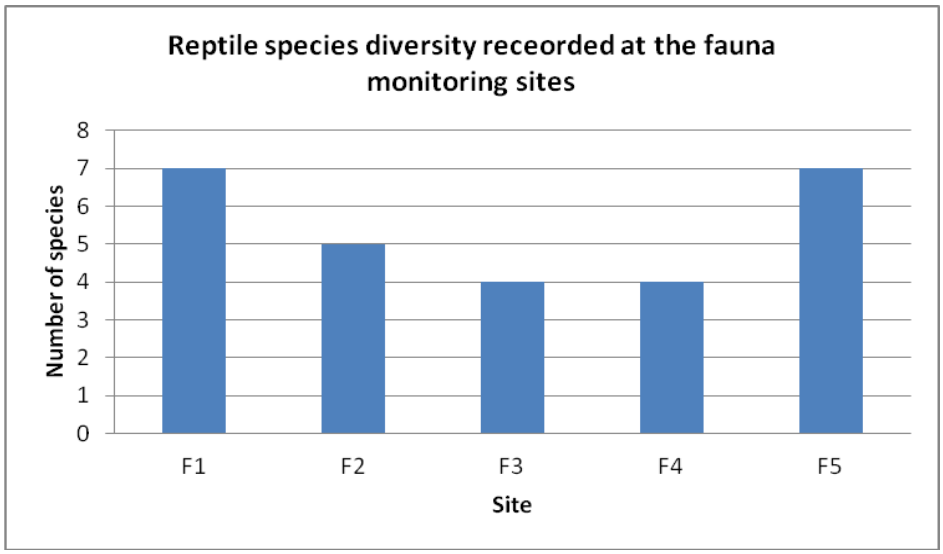


Figure 26. Reptile species diversity recorded at the fauna monitoring sites during the spring 2011 survey.

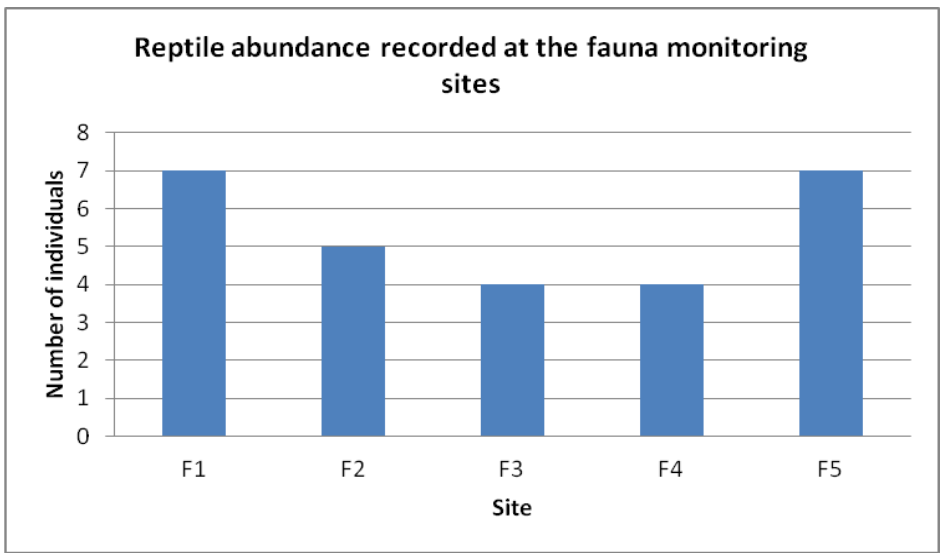


Figure 27. Reptile abundance recorded at the fauna monitoring sites during the spring 2011 survey.



Figure 28. Crested Dragon (*Ctenophorus cristatus*)



Figure 29. Ranges Stone Gecko (*Diplodactylus furcosus*)

Comparison of reptiles to previous years

Reptile species diversity and abundance during the spring 2011 survey was slightly below average compared to previous years. Reptile diversity was the same for the spring 2009 and the spring 2011 surveys (14 species recorded). The spring 2010 survey recorded a total of 20 reptile species (Figure 30). Reptile abundance slightly increased during the spring 2011 survey when compared to spring 2009 (an increase of 10 individuals). However, numbers are significantly lower during the spring 2011 survey when compared to the spring 2010 survey; the current survey had a decrease of 46 individuals (Figure 31).

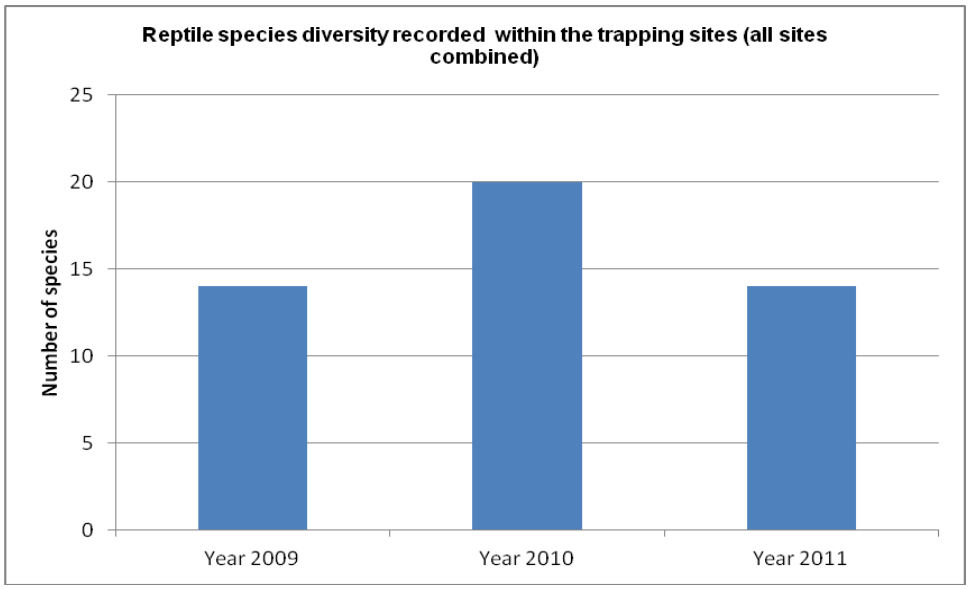


Figure 30. Reptile species diversity (all sites combined) 2009 to 2011.

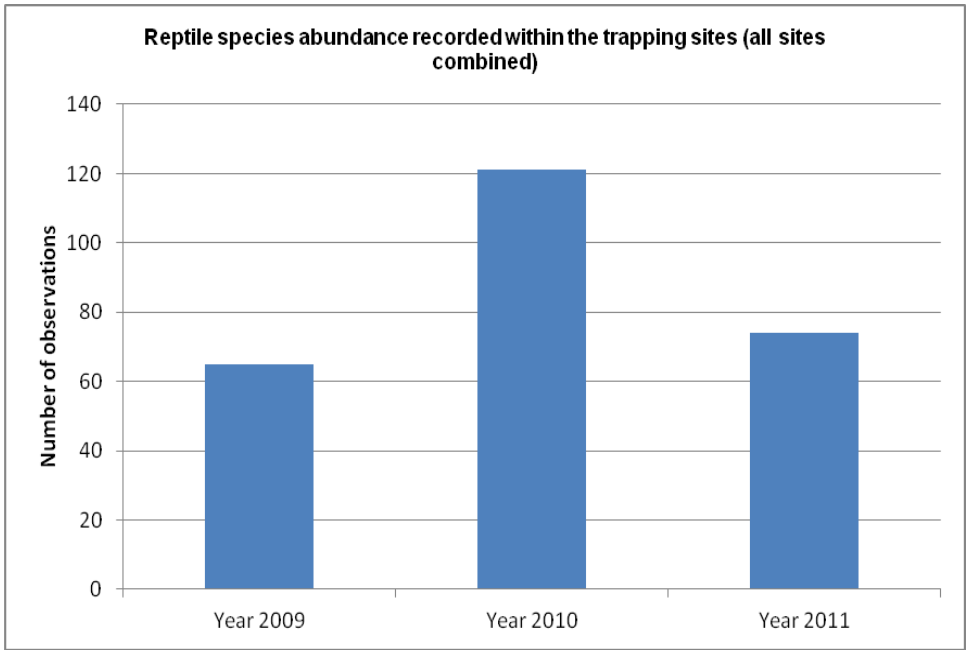


Figure 31. Reptile abundance (all sites combined) 2009 to 2011.

6.1.6 Amphibians

No frogs were observed during the current 2011 spring survey.

6.1.7 Birds

Fifty species of birds were recorded during the spring 2011 survey, 39 of which were recorded at bird monitoring sites (Table 24). No shorebird surveys were completed during the current survey.

Nine bird species were observed for the first time during the spring 2011 survey:

- Australasian Grebe (*Tachybaptus novaehollandiae*) – two individuals observed
- Brush Bronzewing (*Phaps elegans*) – one individual observed
- Chestnut-rumped Thornbill (*Acanthiza uropygialis*) – two individuals observed
- Cockatiel (*Nymphicus hollandicus*) – 23 individuals observed (Figure 32)
- Hardhead (*Aythya australis*) – four individuals observed
- Red-backed Kingfisher (*Todiramphus pyrrhopygius*) – three individuals observed
- Straw-necked Ibis (*Threskiornis spinicollis*) – 20 individuals observed
- Swamp Harrier (*Circus approximans*) – five individuals observed
- White-backed Swallow (*Cheramoeca leucosterna*) – two individuals observed.



Figure 32. Cockatiel (*Nymphicus hollandicus*)

Five out of the nine new bird species listed above were observed at bird monitoring sites. These included the Chestnut-rumped Thornbill, Cockatiel, Red-backed Kingfisher, Swamp Harrier and White-backed Swallow. The Cockatiel and Red-backed Kingfisher were also observed opportunistically during the spring 2011 survey. Figure 32 shoes a flock of eight Cockatiel flying over a dam site on-route to a bird monitoring site. Twenty Straw-necked Ibis were observed opportunistically, flying as a flock which then landed in samphire habitat.

Of the total 7677 birds recorded during the spring 2011 survey, 2094 were recorded at monitoring sites and 5583 were observed opportunistically (Appendix 8). Species observed in the highest abundance during point count surveys were the Budgerigar (*Melopsittacus undulatus*) with 1596 observations, Zebra Finch (*Taeniopygia guttata*) with 77 observations, White-winged Fairy-wren (*Malurus leucopterus*) with

43 observations, Brown Songlark (*Cincloramphus cruralis*), with 39 observations and the Slender-billed Thornbill (*Acanthiza iredalei iredalei*), with 36 observations.

A single observation of both the Collared Sparrowhawk (*Accipiter cirrocephalus)* and the Brush Bronzewing were recorded during the spring 2011 survey; the sparrowhawk was observed at bird monitoring site B5 and the Brush Bronzewing was recorded during opportunistic observations.

Bird diversity was highest at *Eucalyptus* Mallee site B5, with 19 species detected (Figure 33). Bird abundance was greatest within *Maireana* Shrubland at B12 with 666 birds detected, followed closely by *Maireana* Shrubland B13 with 655 birds detected (Figure 34). The large number of birds detected at sites B12 and B13 were due to large flocks of Budgerigar (*Melopsittacus undulatus*). *Maireana* Shrubland site B1, *Myoporum* Woodland site B4 and *Maireana* Shrubland site B6 recorded the lowest bird diversity; eight species were recorded at site B1 and nine species were detected at both sites B4 and B6 during the spring 2011 survey.

Table 24. Number of bird observations during the bird surveys, and site species abundance recorded during the November 2011 survey.

Species name	Common name	Bird survey sites											Total no. of individuals
		1	2	3	4	5	6	10	11	12	13	15	
Acanthagenys rufogularis	Spiny-cheeked Honeyeater			1	1	6				2			10
Acanthiza chrysorrhoa	Yellow-rumped Thornbill										2		2
Acanthiza iredalei iridalei	Slender-billed Thornbill	8						1	3		15	9	36
Acanthiza uropygialis	Chestnut-rumped Thornbill									2			2
Accipiter cirrocephalus	Collared Sparrowhawk					1							1
Amytornis textilis myall	Thick-billed Grasswren					4							4
Anthochaera carunculata	Red Wattlebird					3							3
Anthus novaeseelandiae	Australasian Pipit	2	2	3		2		2				3	14
Aphelocephala leucopsis	Southern Whiteface										2		2
Aquila audax	Wedge-tailed Eagle		3										3
Artamus cinereus	Black-faced Woodswallow	5						6		8	7		26
Barnardius zonarius	Australian Ringneck					11							11
Calamanthus campestris	Rufous Fieldwren	3	1	1			4	6	3			7	25
Cincloramphus cruralis	Brown Songlark	6	6	2	2	1	4	4	4	2	1	7	39
Circus approximans	Swamp Harrier		1				1	1			2		5
Cheramoeca leucosterna	White-backed Swallow										2		2
Corvus coronoides	Australian Raven		1	1	1	5		3		3		2	16
Coturnix pectoralis	Stubble Quail		4	2				2			3		11
Cracticus tibicen	Australian Magpie			1		3		2			2	2	10
Cracticus torquatus	Grey Butcherbird	3			2	1	1	1	3	3	1	2	17
Eolophus roseicapillus	Galah					8							8
Falco berigora	Brown Falcon	1		2				1					4
Falco cenchroides	Nankeen Kestrel						2		1		3	1	7
Lichenostomus virescens	Singing Honeyeater					6				3	2		11
Malurus lamberti	Variegated Fairy-wren					8			1	6	11		26
Malurus leucopterus	White-winged Fairy-wren	10	2				4	10	6			11	43
Manorina melanocephala	Noisy Miner				5	2							7
Melopsittacus undulatus	Budgerigar			10	50	36	100	5	170	615	600	10	1596
Neophema petrophila	Rock Parrot		20	1			4					9	34
Northiella haematogaster	Blue Bonnet				4				1		1		6
Nymphicus hollandicus	Cockatiel									8			8
Ocyphaps lophotes	Crested Pigeon				4	2							6
Pomatostomus superciliosus	White-browed Babbler					4				3			7
Psephotus varius	Mulga Parrot									5			5
Rhipidura leucophrys	Willie Wagtail					1							1
Taeniopygia guttata	Zebra Finch		15	7		8	13	5	9	4		16	77
Todiramphus pyrrhopygius	Red-backed Kingfisher										1		1
Turnix velox	Little Button-quail									2			2
Vanellus tricolor	Banded Lapwing				6								6
	Number of native individuals	38	55	31	75	112	133	49	201	666	655	79	2094
	Number of native species	8	10	11	9	19	9	14	10	14	16	12	39

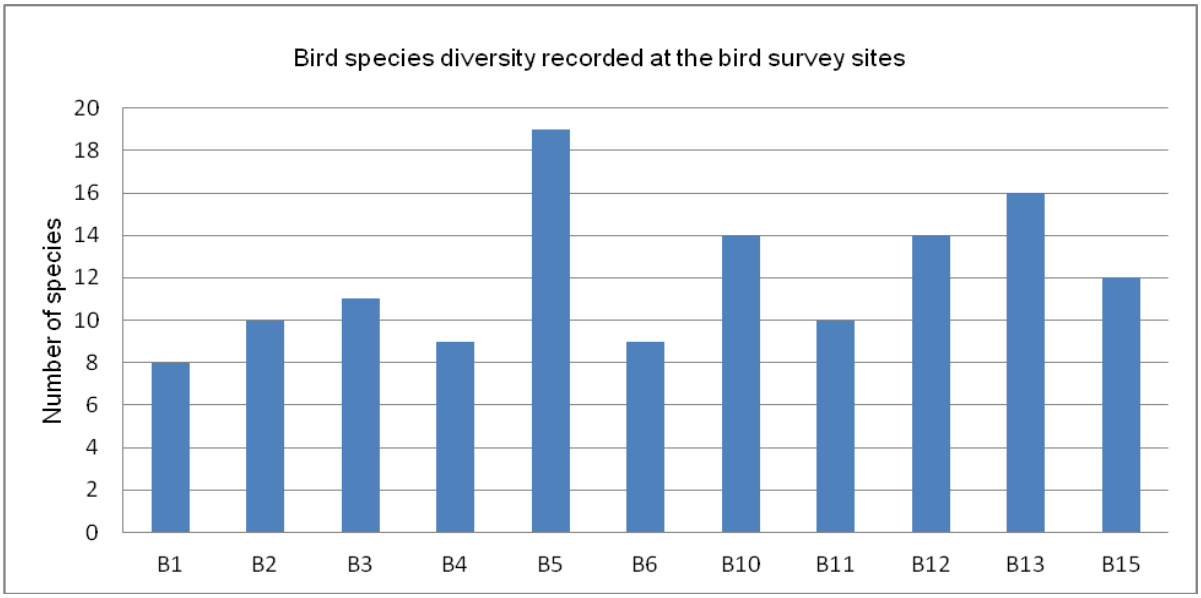


Figure 33. Bird species diversity at monitoring sites during the spring 2011 survey.

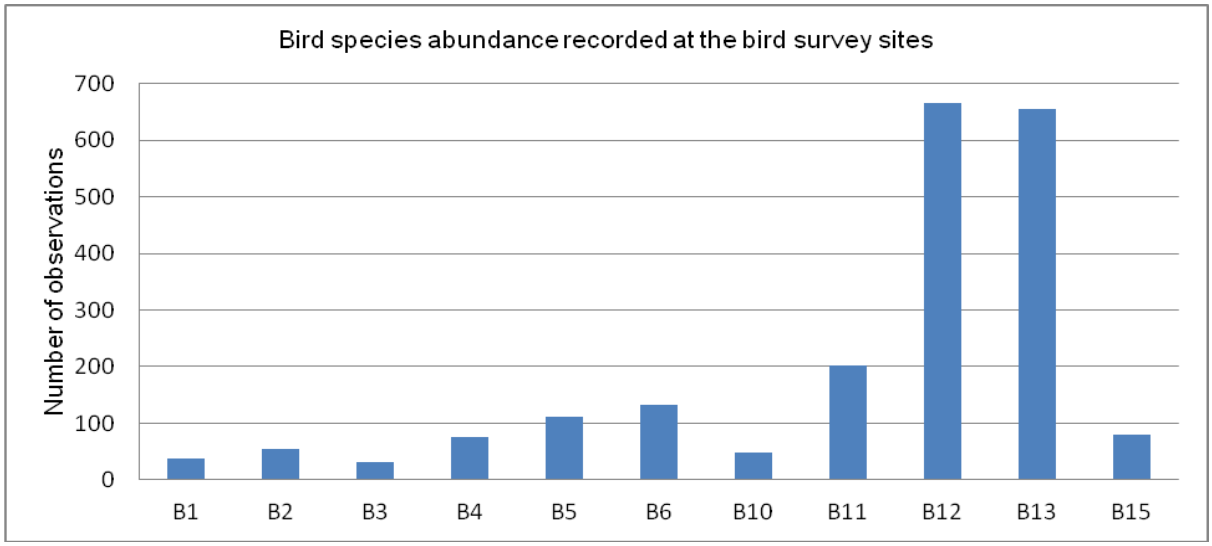


Figure 34. Bird abundance recorded at the bird monitoring sites during the spring 2011 survey.

Opportunistic

Eleven out of the 50 bird species recorded on-site were recorded during opportunistic observations only. These included: the Hardhead, Little Raven (*Corvus mellori),* Emu (*Dromaius novaehollandiae*), White-faced Heron (*Egretta novaehollandiae*), White-fronted Chat (*Epthianura albifrons*), White-winged Triller (*Lalage sueurii*), Splendid Fairy-wren (*Malurus splendens*), Brush Bronzewing, Australasian Grebe (*Tachybaptus novaehollandiae),* Straw-necked Ibis and Black-tailed Native-hen (*Tribonyx ventralis*).

Of interest, only two records of the Little Raven and White-faced Heron were observed (Appendix 8); the latter of which was recorded at the turn around area near site B3 where samphire habitat was under water. Waterbirds, Australasian Grebe and Black-tailed Native-hen, were also recorded in low numbers (again with only two records observed). Both the grebe and native-hen were observed at opportunistic dam sites. Eleven Emu were observed opportunistically; the adult male and 10 chicks were recorded on the drive into Nonowie Station. Thirty White-fronted Chat were observed flying approximately 188m from site B16, and yet they were not recorded again for the duration of the spring survey.

Five thousand five hundred and eighty-three birds from 36 species were recorded opportunistically during the spring 2011 survey (Appendix 8). Bird Species observed in the highest abundance during opportunistic surveys were the Budgerigar (Figure 35) with 5330 observations, White-fronted Chat with 30 observations, Zebra Finch with 25 observations and Straw-necked Ibis with 20 observations.

Threatened birds

Three birds of conservation significance were detected during the current 2011 spring survey:

- Rock Parrot (*Neophema petrophila*) – state rare
- Slender-billed Thornbill (*Acanthiza iredalei iredalei*) – nationally vulnerable and state rare
- Thick-billed Grasswren (*Amytornis textilis myall*) – nationally vulnerable.

Out of the three conservation significant species, the Slender-billed Thornbill was the most abundant and widespread species of all, with a total of 53 observations. Thirty-six were recorded during the standard 60 minute morning and afternoon surveys at bird monitoring sites B1, B10, B11 and B15 (Table 24) (Figure 36) and 17 were recorded opportunistically throughout the project area. Some of the opportunistic records were observed adjacent to vehicle tracks on site, approximately 188m from site B16 and within similar habitat to site B15.

The Thick-billed Grasswren was observed at site B5 only, where four individuals were recorded (Table 24). Forty-one observations of the Rock Parrot were recorded, 34 of which were made during point count surveying at sites B2, B3, B6 and B15 and seven were recorded opportunistically. The latter were observed as a flock flying away from a paddock dam whereby one parrot perched on a livestock fence.



Figure 35. Budgerigar (*Melopsittacus undulatus*)

Comparison of birds to previous years

Comparisons were only made between five sites, across three years of data; bird monitoring sites B1 to B5 have been consistently surveyed since the monitoring began. Over three spring monitoring periods, spring 2010 recorded the highest diversity of bird species (34 species), followed closely behind by spring 2009 (31 species) and spring 2011 (30 species) (Figure 37). Spring 2009 recorded the highest abundance of birds (320 birds) compared with the second highest abundance of 315 birds in spring 2010 (Figure 38). Spring 2011 recorded a significantly low abundance of observations (311 birds). It is unclear why the spring 2011 survey recorded both the lowest diversity and abundance of birds.

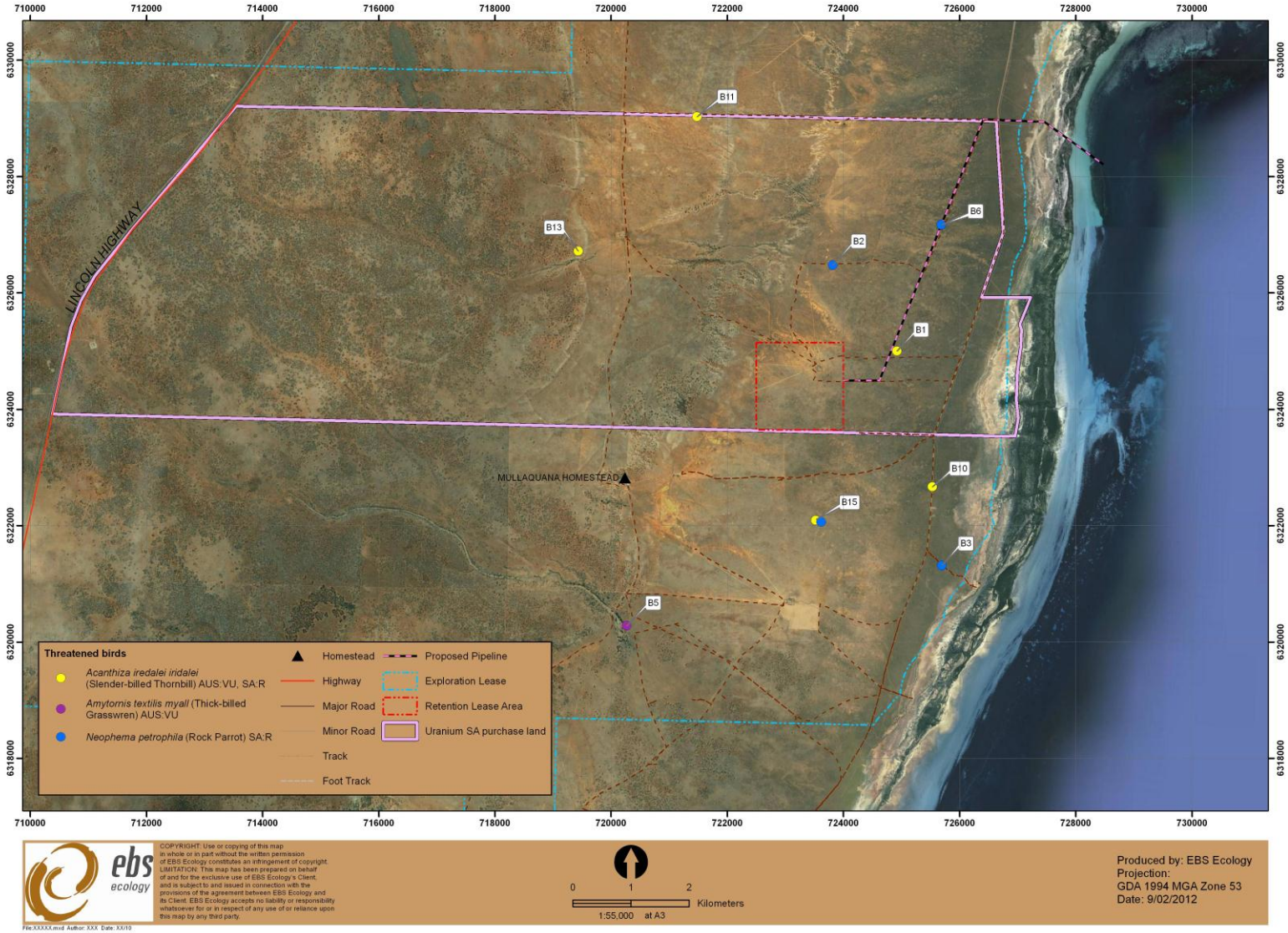


Figure 36. Location of threatened bird species across the Samphire project area.

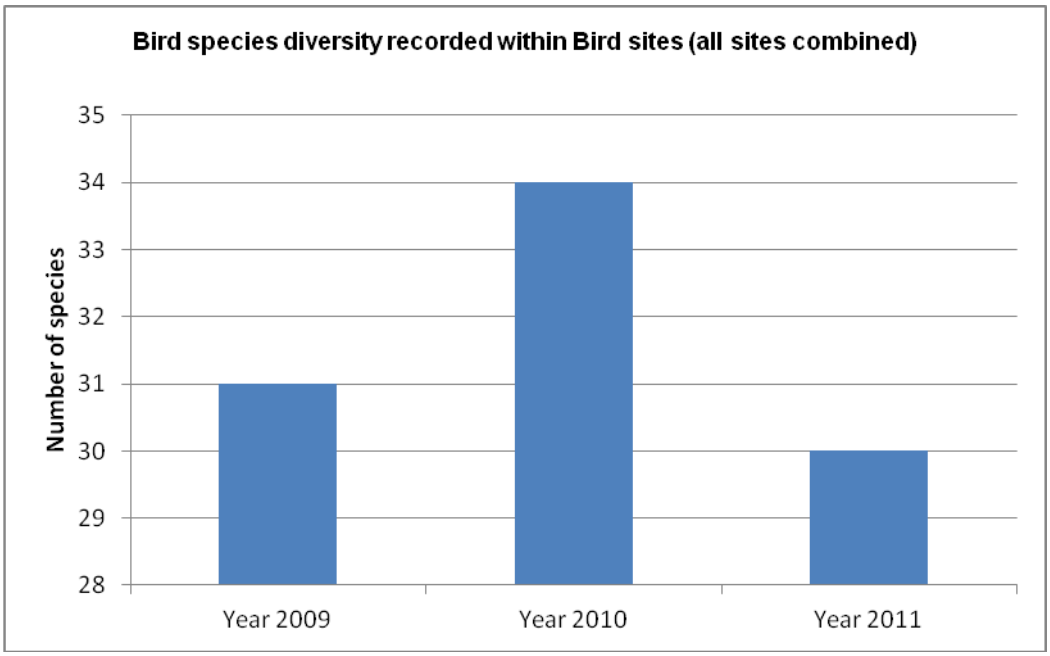


Figure 37. Bird species diversity (all sites combined) 2009 to 2011.

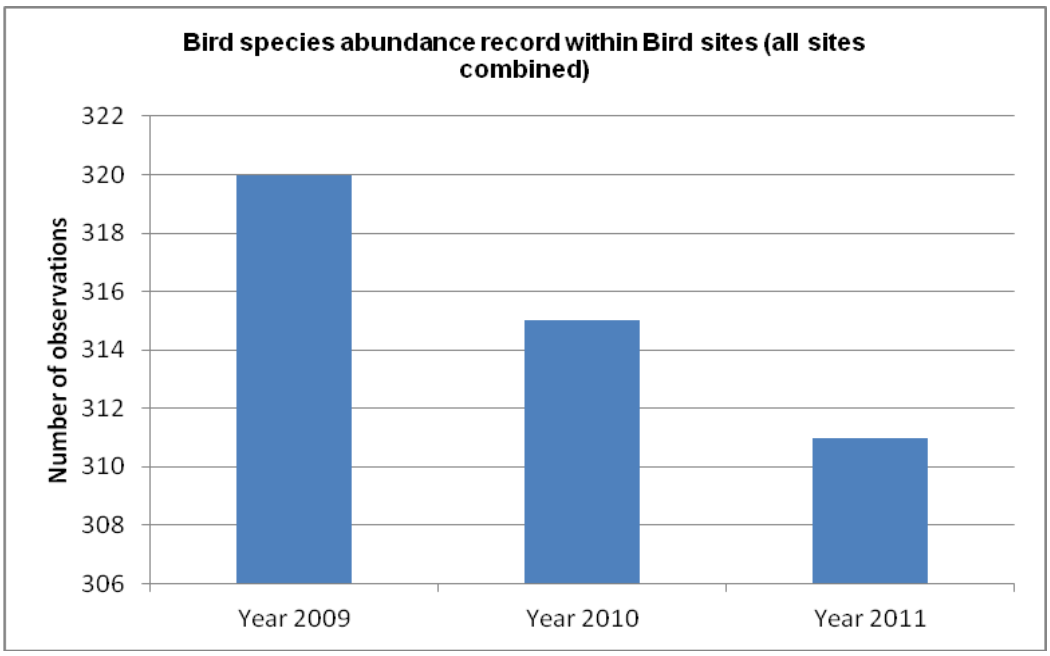


Figure 38. Bird species abundance (all sites combined) 2009 to 2011.

7 DISCUSSION

Overall flora diversity and abundance within this current survey has decreased compared to the spring 2010 surveys. In general, mammal abundance was higher; reptiles were slightly lower, exotic species remained low and birds decreased in numbers compared to spring 2010.

7.1 Flora

Within this current spring 2011 survey, species diversity decreased from the spring 2010 survey at all but two of the monitoring sites. The decrease in species diversity ranged on average between 1 - 10 % across the majority of the sites. Many of the sites recorded low numbers of annuals reducing the species numbers found on site. One site (site V5) had the same diversity of species compared to previous surveys. Many of the plants had reproduced and shed large amounts of seed, this was evident by the build up of seed scattered all over the ground.

The abundance of established native perennial species increased at five sites of the 10 sites and also decreased at the other five since the spring 2010 survey. Numbers of perennial species increased more significantly than they decreased.

Juvenile recruitment decreased significantly across the majority of monitoring sites between spring 2010 and spring 2011. The biggest decrease occurred at site V6 (255 individuals) and V3 (102 individuals). The numbers of juveniles that persist within the monitoring sites will depend on the weather conditions experienced in the coming year.

7.1.1 Vegetation mapping of the UraniumSA purchased land boundary

Vegetation mapping was completed across the entire USA purchased land boundary to build upon previous vegetation mapping completed by EBS. Four vegetation associations within this current survey were added to existing vegetation associations, as completed by EBS prior (Appendix 5). In general, the four vegetation associations included: Acacia woodland over chenopod shrubland or tall shrubland; chenopod shrubland over grassland; samphire and chenopod shrubland; or, samphire shrubland. The Acacia woodland and chenopod shrubland vegetation associations are dominant within the USA purchased land boundary.

Vegetation condition ranged from 1:1 to 8:1. However, areas of poor condition were confined to generally isolated patches or small areas in which man-induced disturbance has already occurred. For example, most weed infestations occur around water-points (dams) in which sheep were observed or nearby existing vehicle tracks. In general, vegetation condition is moderate to good in other well vegetated areas, especially within areas supporting Acacia woodland and along the coast supporting Samphire shrublands.

7.1.2 Additional vegetation monitoring sites

An additional three flora monitoring sites were established during the current 2011 survey to get a better representative of the survey area as it proceeds from a retention lease to a mining lease. The sites were chosen to ensure monitoring sites were more equally spread across the USA purchased land boundary, with regard to impact areas. The methods carried out at the additional sites followed on from previous methodology. These new sites will value add to the existing monitoring program and changes in abundance and diversity of species will be tracked overtime in future monitoring years.

7.2 Fauna

7.2.1 Native mammals

Species diversity of native mammals (excluding bats) in spring 2011 was below average compared to previous survey results. The species diversity numbers have stayed the same between monitoring years, however the actual species captured have differed. The Stripe-faced Dunnart (*Sminthopsis macroura*) (observed in 2009) and the Little Long-tailed Dunnart (*Sminthopsis dolichura*) (observed in 2010) were not recorded during spring 2011. The Bolam's Mouse (*Pseudomys bolami*) was recorded for the first time across four of the fauna sites. The change in species diversity is expected, given the low densities over the last three years of trapping. Five bat species were also positively identified.

Species abundance was above average with 18 observations during the spring 2011 survey compared to an overall average of 9.6. It is presumed that the high abundance of native mammals is related to the sustained rainfall that occurred from mid 2010 until April 2011 where there was prolific growth of flora. A lag period between the growth, seed dropping and breeding time for the mammals may explain why abundance is higher now, while the flora has decreased.

Fauna monitoring *Maireana* / *Atriplex* site F1 recorded the highest native mammal diversity and abundance during the spring 2011 survey compared to all other monitoring sites and can be attributed to large amounts of seed at this site.

7.2.2 Reptiles

Reptile species diversity during the spring 2011 survey was slightly below average at 14 compared to an average of 16 for all surveys. Reptile species abundance was also slightly below average at 75 observations, below the average of 87.3. It is unclear why reptile diversity and abundance were below average, while native mammal abundance was above average. It may be attributed to an increase in native and exotic predators, or cooler weather experienced at the time of the survey.

7.2.3 Birds

Bird diversity during the spring 2011 survey was below average compared with earlier years; 30 species were recorded compared to an average of 31 birds. It is difficult to determine why there was a decrease in bird diversity, particularly with the spring 2011 survey recording nine bird species for the first time during this survey period. Bird abundance in spring 2011 decreased in number from previous surveys; 311 individuals were recorded compared with an average of 302. The change in bird diversity and abundance may have been due to seasonal variation across the site; continued monitoring of the Samphire project area will provide future trends on abundance and diversity across the site.

7.2.4 Additional bird monitoring sites

An additional three bird monitoring sites were established during the current 2011 survey. These sites were set up in the same location as the flora monitoring sites. See section 7.1.2 for justification for the selection of sites.

7.3 Exotic species

One exotic species the House Mouse (*Mus musculus*) was captured at all fauna monitoring sites. The House Mouse was the most abundant species recorded with 120 observations which is a high increase compared to three and two observations during the spring 2009 and 2010 survey, respectively. The substantial population is attributed to the abundant food resources and beneficial environmental factors in the region leading up to each survey.

It is too early within the monitoring program to ascertain any certain trends of exotic flora species abundance or diversity. Some new weeds species were detected this year, while other species previously recorded within the 2009 and 2010 surveys were undetected this year. Future yearly comparisons of the Samphire project area will provide future trends on abundance of exotic species across the site.

7.4 Threatened Fauna species

7.4.1 Thick-billed Grasswren (*Amytornis textilis myall*)

Four individual Thick-billed Grasswren (TBGW), were observed at monitoring site B5. These individuals were recorded during opportunistic observations at the end of a point count survey period. TBGW abundance during spring 2011 was higher compared to spring 2010 but lower than spring 2009 (Table 25). Monitoring sites B11, B12 and B13 were surveyed for the first time, partly to determine the spread of TBGW across the Samphire project area.

Table 25. Abundance of threatened birds across three survey periods.

Species name	Common name	Survey year / season		
		2009 Spr	2010 Spr	2011 Spr
Acanthiza iredalei iridalei	Slender-billed Thornbill		61	53
Amytornis textilis myall	Thick-billed Grasswren	7	2	4

7.4.2 Slender-billed Thornbill (*Acanthiza iredalei iredalei*)

The Slender-billed Thornbill was observed at monitoring sites B1, B10, B11, B13 and B15 with a total of 53 individuals recorded. Whilst this species was not observed during the spring 2009 survey, numbers were high in the spring 2010 survey, with 61 individuals recorded (Table 25). It would appear evident, by the numbers recorded in both the 2010 and 2011 spring periods, that the Samphire project area is a strong hold for the Slender-billed Thornbill.

This species generally inhabits treeless chenopod shrublands dominated by bluebush *Maireana* and saltbush *Atriplex*, and saline flats associated with salt lakes, particularly where there is glasswort *Halosarcia*. Its preferred habitat is dominant throughout the Samphire project area. Slender-billed Thornbill forages in low shrubs and on the ground seeking insects and other small prey from the foliage of samphire and saltbush shrubs, and from the surrounding ground.

7.4.3 Rock Parrot (*Neophema petrophila*)

The state rare Rock Parrot was observed for the first time during the spring 2011 survey at monitoring sites B2, B3, B6 and B15. There have been few *Neophema* sp. previously recorded across the Samphire project area, however a total of 41 observations of the Rock Parrot were recorded.

The Rock Parrot is restricted to coastlines and offshore rocky islands, frequenting windswept coastal dunes, mangroves, saline swamps and rocky islets. Their preferred habitat is consistent with where the parrots were observed at both the monitoring sites and opportunistically. The Rock Parrot is mainly sedentary, moving about locally in pairs or small flocks during the breeding season (Higgins 1999). The Rock Parrot feeds on seeds and fruits of a wide variety of grasses, rushes, shrubs and salt-tolerant plants. It forages quietly, mainly in the early morning and late afternoon. Through continued bird monitoring across the Samphire project area a broader picture of the types of *Neophema sp*. visiting the area can be ascertained.

8 RECOMMENDATIONS

The following recommendations have been made based on the results of the previous surveys and this current spring 2011 survey.

Continuation of flora and fauna monitoring program:

- Continued, annual monitoring of all permanent vegetation monitoring sites
- Continued, annual monitoring of all permanent fauna monitoring sites
- Continued protection of the permanent monitoring sites from disturbance. Avoid placement of any new access tracks or infrastructure through or immediately adjacent to the sites
- Review future mining activities and location of new infrastructure when the mine site becomes operational to ensure the spread of monitoring sites adequately represent impact areas

Pest Species Control

- Control and/or rehabilitation of weed infestations and degraded areas, as depicted in Appendix 6 (low condition ratios of 1:1 indicate weed infestations or degraded areas).
- Implement a record register to be maintained by Uranium SA Resources staff for exotic species including: new weed infestations, or feral animals (Cats, Foxes, Rabbits and House Mice). Monitoring is necessary to ensure mining activities has not increased the local abundance of pest species.

Native Vegetation Clearance

- *Alectryon oleifolius* ssp. *canescens* (Bullock Bush) Tall Shrubland on alluvial soils of plains is recognised as a vulnerable community at the state level (DEH 2001).
- Avoid any dense localised patches of *Alectryon oleifolius ssp. canescens* (Bullock Bush) as these may contribute to the state rare community, or install measures to mitigate disturbance to these patches when planning future development works / activities.

Continuation of threatened bird monitoring:

- Continued, annual monitoring of all permanent bird monitoring sites with the aim of determining trends in abundance of both the Thick-billed Grasswren and the Slender-billed Thornbill.

9 REFERENCES

Barker R.D., Vestjens W.J.M. (1990) *The Food of Australian Birds. 2. Passerines*. CSIRO, Melbourne.

Black, A., Carpenter, G., Pedler, L. (2009) Distribution and habitats of the Thick-billed Grasswren Amytornis textilis, subspecies myall. *South Australian Ornithologist*, 35, 161173.

Brooker M.G. (1988) Some aspects of the biology and conservation of the Thick-billed Grasswren *Amytornis textilis* in the Shark Bay area, Western Australia. *Corella* 12, 101108.

Chapman G.S. (1996) The grass-wrens: A brief pictorial. *Wingspan*. 6 2027.

Cooke J., Ash J., Groves R. (2004) The ecology of Ward's Weed (*Carrichtera anna*): a weed of southern rangelands of Australia. *Ecological Society of Australia Annual Conference* 2004, Adelaide.

DEH (2001). *Provisional Threatened Ecosystems of South Australia.* Unpublished provisional list compiled with the aid of Department of Environment and Heritage staff.

DEH (2008) *Biological Database Records of South Australia* (BDBSA). Department of Environment and Heritage, Adelaide.

DWLBC (2005) *Guidelines for a Native Vegetation Significant Environmental Benefit Policy. Department of Water*, Land, and Biodiversity Conservation, Adelaide.

EBS (2009) *Samphire Flora and Fauna Survey – Initial Assessment.* Report to Uranium SA. Environmental and Biodiversity Services, Adelaide.

EBS (2010a) *Samphire Baseline Flora and Fauna Survey November 2009.* Report to Uranium SA. Environmental and Biodiversity Services, Adelaide.

EBS (2010b) *Samphire Additional Birds Surveys February 2010.* Report to Uranium SA. Environmental and Biodiversity Services, Adelaide.

EBS (2010c) *Samphire Follow-up Flora and Fauna Survey November 2010.* Report to Uranium SA. Environmental and Biodiversity Services, Adelaide.

Garnet S.T., Crowley G.M. (2000) *The action plan for Australian birds*. Environment Australia, Canberra.

Gee P., Gee I., Read J. (1996). An annotated bird list from the Davenport Range, South Australia. *South Australian Ornithologist*. 32: 7681.

Grund, R. (2009) *A checklist of the butterflies to be found in South Australia and details of their conservation status*. Available from the South Australian Butterflies website http://users.sa.chariot.net.au/~rgrund/index.htm. Accessed Feb2010.

Heard L., Channon B. (eds) (1997) *Guide to A Native Vegetation Survey Using the Biological Survey of South Australia*. Department of Housing and Urban Development, Adelaide.

Higgins, P.J. (ed) 1999. *Handbook of Australian, New Zealand and Antarctic Birds, Volume 4 (Parrots to Dollarbird)*. Oxford University Press, Melbourne.

Higgins P.J., Peter J.M., Steele W.K. (Eds) (2001) *Handbook of Australian, New Zealand and Antarctic Birds*. Volume 5: Tyrant-flycatchers to Chats. Oxford University Press.

Jessup J.P., Toelken H.R. (Eds) (1986) *Flora of South Australia Parts 14*. South Australian Government Printer, Adelaide.

Morcombe M. (2000) *Field Guide to Australian Birds*. Steve Parish Publishing, Archerfield.

Muir B.G. (1977) Biological Survey of the Western Australian Wheat-belt. Part 2: Vegetation and Habitat of Bendering Reserve. *Records of the Western Australian Museum*. Supplement No. 3. WA Museum, Perth.

Neagle. N. (2003). *An Inventory of the Biological Resources of the Rangelands of South Australia.* Department for Environment and Heritage, South Australia.

Schodde R. (1982) *The Fairy-wrens: a Monograph of the Maluridae*. Lansdowne, Melbourne.

Serventy V.N. (Ed) (1982) *The Wrens and Warblers of Australia.* Angus and Robertson and the Australian Photographic Index of Australian Wildlife, Sydney.

Specht R.L. (1972) *The Vegetation of South Australia*. Government Printer, Adelaide.

10 APPENDICES

Appendix 1. Survey site coordinates.

Fauna sites

Site number	Detail	Zone	Easting	Northing
F1	Line A start	53 H	724872	6325055
F1	Line A end	53 H	724911	6325072
F1	Line B start	53 H	724861	6324982
F1	Line B end	53 H	724899	6324986
F2	Line A start	53 H	723980	6326487
F2	Line A end	53 H	723990	6326442
F2	Line B start	53 H	723920	6326476
F2	Line B end	53 H	723927	6326435
F3	Line A start	53 H	725681	6321373
F3	Line A end	53 H	725709	6321397
F3	Line B start	53 H	725785	6321342
F3	Line B end	53 H	725763	6321309
F4	Line A start	53 H	723599	6320189
F4	Line A end	53 H	723628	6320199
F4	Line B start	53 H	723676	6320160
F4	Line B end	53 H	723714	6320165
F5	Line A start	53 H	720263	6320182
F5	Line A end	53 H	720264	6320227
F5	Line B start	53 H	720291	6320084
F5	Line B end	53 H	720310	6320049

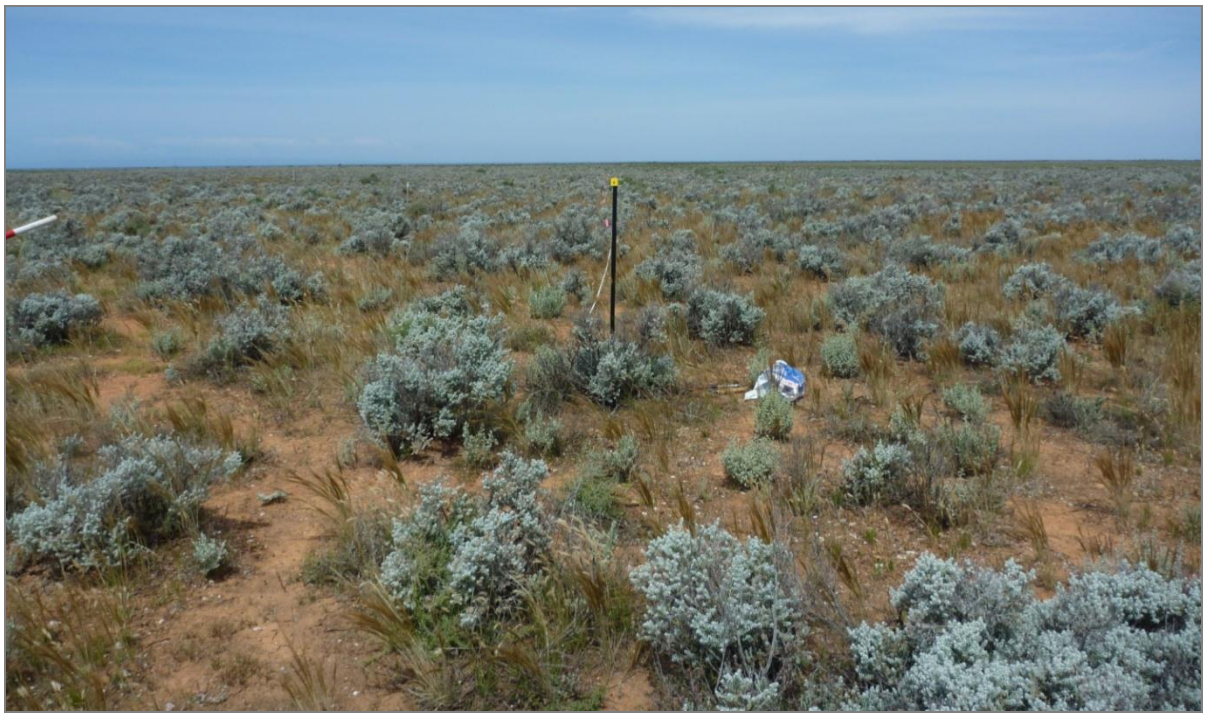
Bird sites

Site number	Zone	Easting	Northing
Standard bird survey sites (in addition to the fauna sites)			
B6	53 H	725646	6327183
B10	53 H	725530	6322666
B11	53 H	721480	6329029
B12	53 H	719997	6324620
B13	53 H	719436	6326716
B15	53 H	723617	6322059

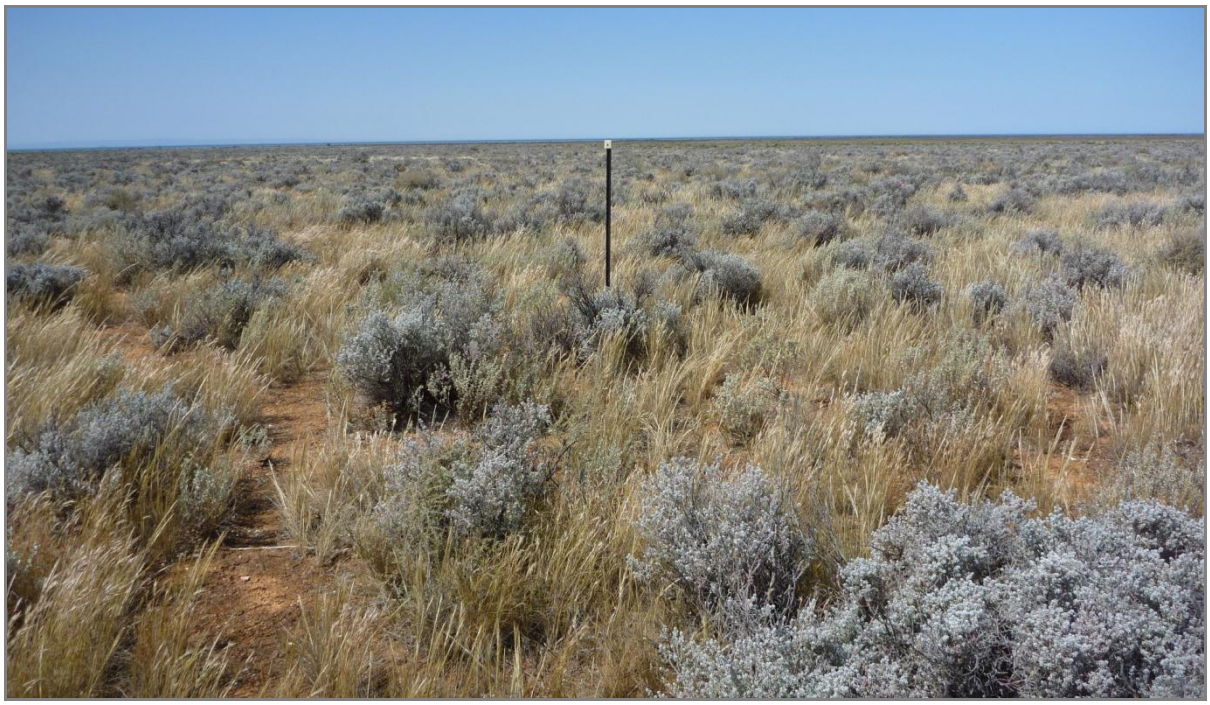
Vegetation sites

Site number	Zone	Easting	Northing
V1	53H	724921	6324997
V2	53H	723818	6326477
V3	53H	725693	6321311
V4	53H	723667	6320183
V5	53H	720268	6320276
V6	53H	724210	6318022
V7	53H	723636	6322029
V 8	53H	726742	6329754
V9	53H	725685	6327170
V10	53H	723547	6323821
V11	53H	721480	6329029
V12	53H	719997	6324620
V13	53H	719436	6326716

Appendix 2. Comparative flora site photographs



Vegetation Site 1 (2010)



Vegetation Site 1 (2011)



Vegetation Site 2 (2010)



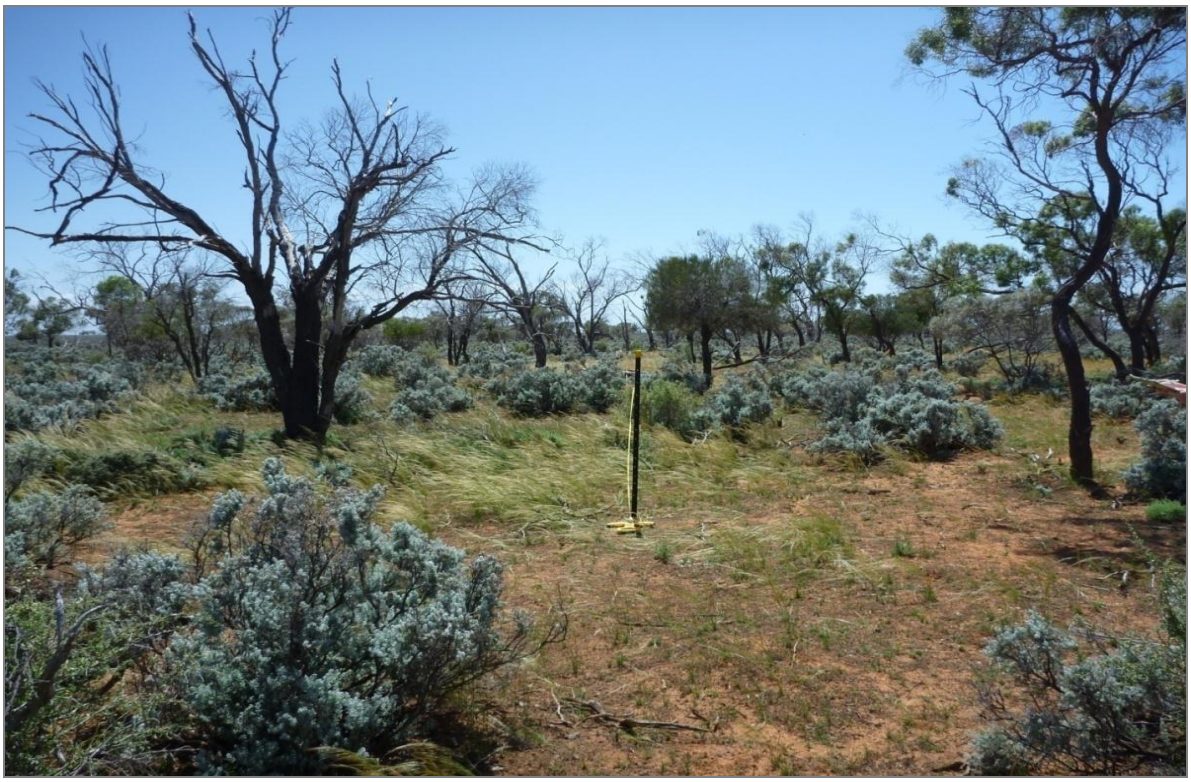
Vegetation Site 2 (2011)



Vegetation Site 3 (2010)



Vegetation Site 3 (2011)



Vegetation Site 4 (2010)



Vegetation Site 4 (2011)



Vegetation Site 5 (2010)



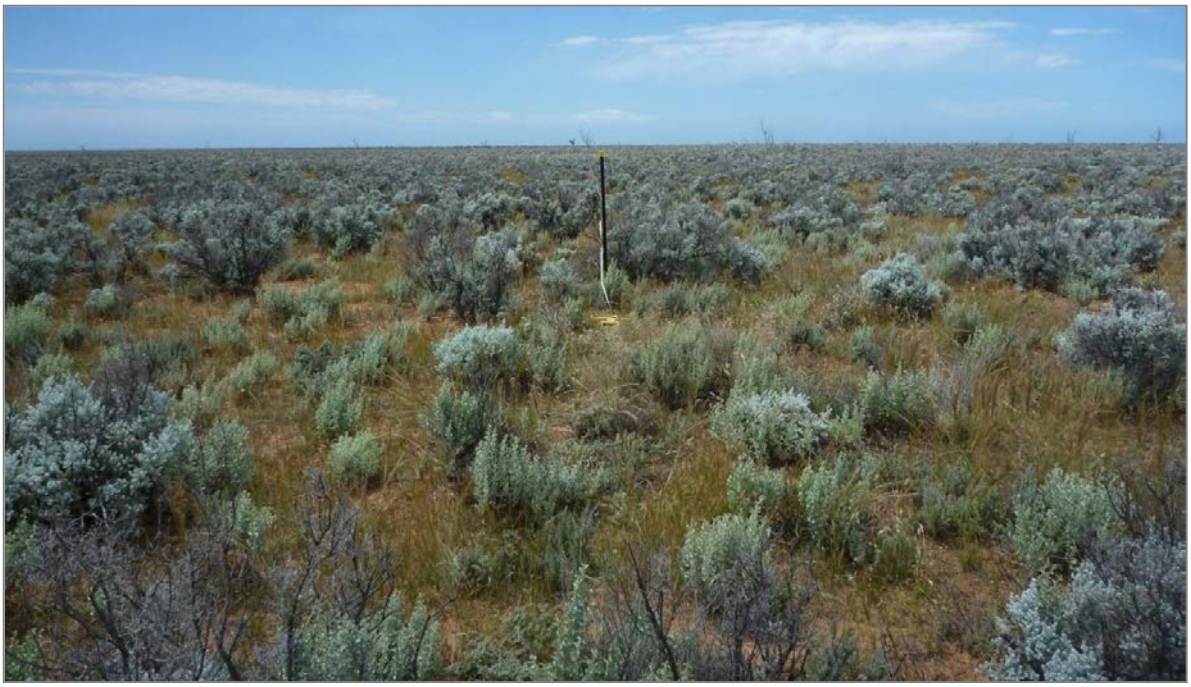
Vegetation Site 5 (2011)



Vegetation Site 6 (2010)



Vegetation Site 6 (2011)



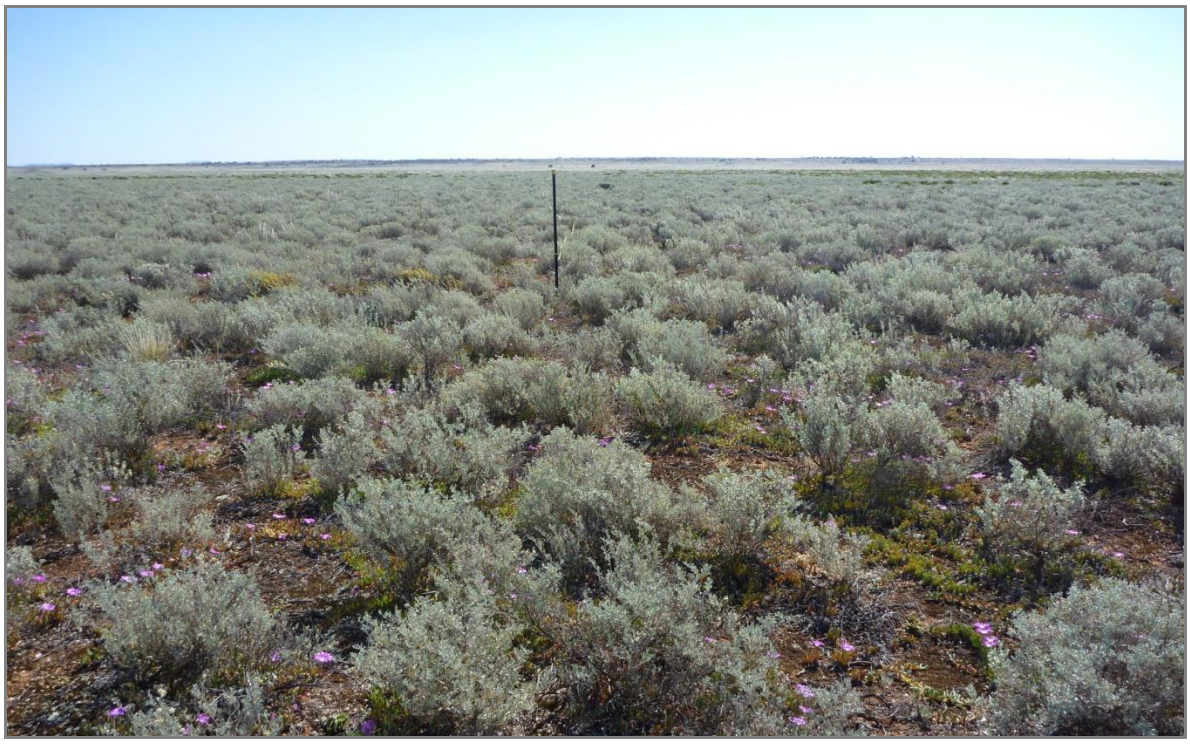
Vegetation Site 7 (2010)



Vegetation Site 7 (2011)



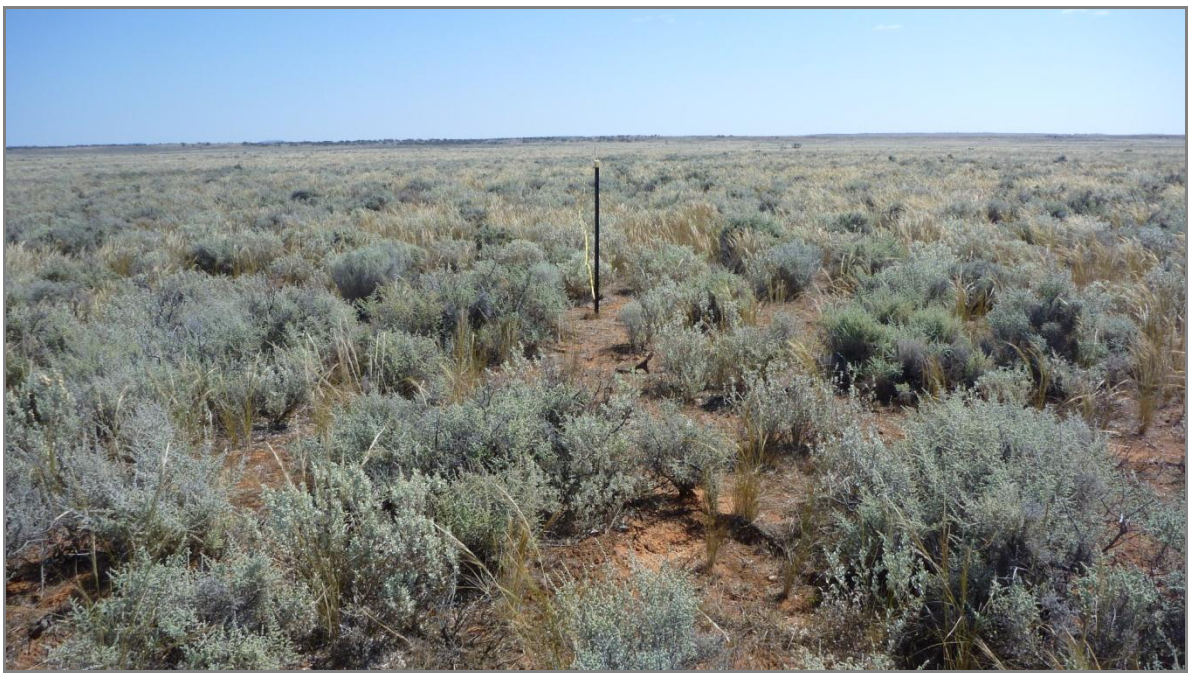
Vegetation Site 8 (2010)



Vegetation Site 8 (2011)



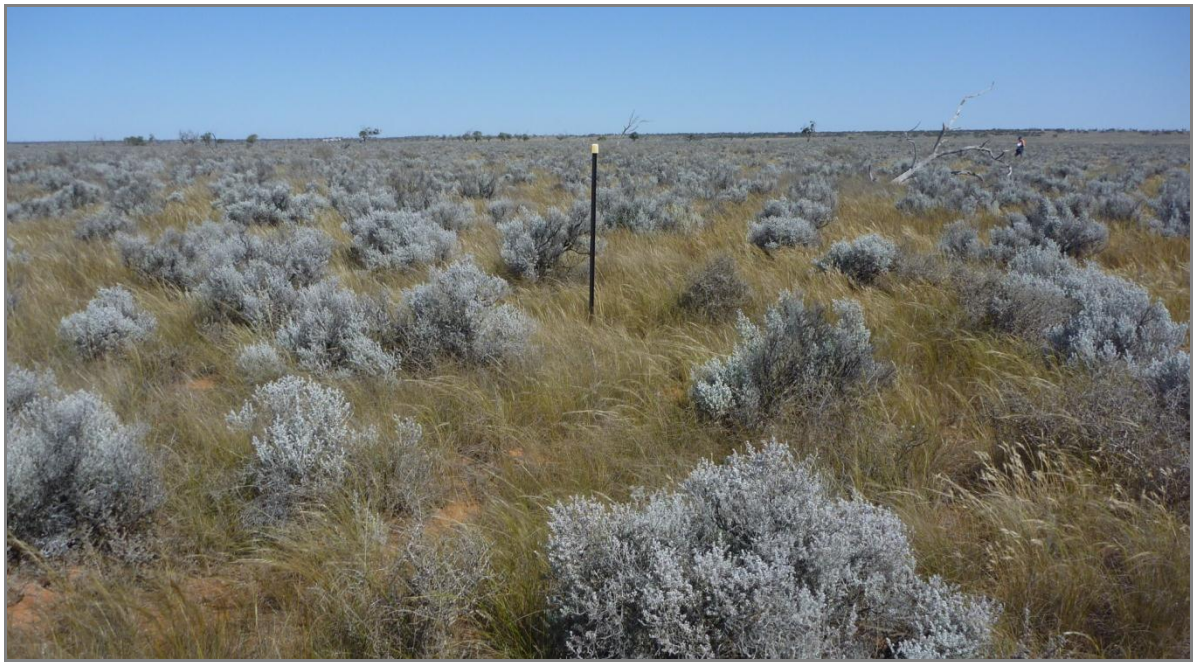
Vegetation Site 9 (2010)



Vegetation Site 9 (2011)



Vegetation Site 10 (2010)



Vegetation Site 10 (2011)

Appendix 3. Overall flora species list and abundance from the spring 2011 survey (100 x 100 metre quadrat data).

Species name	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12	V13
Acacia ligulata					T								
Acacia oswaldii				N	T								
Acacia papyrocarpa					N						N	N	N
Alectryon oleifolius ssp. *canescens*												N	
Amyema quandang var. *quandang*													N
**Anagallis arvensis*					T								
Aristida contorta					1								
Atriplex stipitata					1								
Atriplex vesicaria ssp.	2	1	2		1	1	3	4	2	1	1	0	T
Austrodanthonia caespitosa	1	1	N	1	T		1	1	1	T	1	1	1
Austrostipa elegantissima					T								
Austrostipa eremophila	1	T						T		T	T	T	T
Austrostipa nodosa	2	1	N	1	1		2	1	T	2	2	2	2
Austrostipa platychaeta				T									N
Austrostipa scabra ssp. *scabra*					T								
Brachyscome ciliaris var.											T		
Calandrinia eremaea						N		1					
Calotis hispidula	T							N	N				
**Carrichtera annua*	1	1	T				1	1	1	1	1	T	
**Carthamus lanatus*	T										T		
Chamaesyce drummondii					T				N				
Chenopodium curvispicatum							N	T	N		0	N	T
Convolvulus remotus	T	N			T						T		
Disphyma crassifolium ssp. *clavellatum*		1	2			1		2					
Dodonaea lobulata					N								
Dysphania plantaginella								T					
Dysphania pumilio					T								
Enchylaena tomentosa var.	T			2	T					T	T	N	T
Eremophila alternifolia					N								
Eremophila deserti					N								
Eremophila oppositifolia ssp.					1								
Eremophila scoparia				1						N	N		
Eriochiton sclerolaenoides	1	T		T	1		1			1	1	1	1
Eucalyptus dumosa					N								
Eucalyptus socialis ssp.					T								
Euphorbia tannensis ssp. eremophila		N			T					N		N	
Exocarpos aphyllus					T								
Frankenia pauciflora			1										
Frankenia sp.						1							
Geijera linearifolia				N	T								
Herniaria cinerea					T								
**Hypochaeris glabra*					T								
Lawrencia squamata	1												
Lepidium oxytrichum		T									N		
Lycium australe				2	1		1			1	N		T
**Lycium ferocissimum*											N		
Lysiana exocarpi ssp. *exocarpi*					T								
Maireana aphylla						N							
Maireana appressa	T		T			T							
Maireana integra	T			T			T			N	T		

Species name	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12	V13
Maireana oppositifolia			T			T							
Maireana pyramidata		1	N		1			N	3		2	N	1
Maireana radiata									N				
Maireana sedifolia	3	T		3			4	N	N	3	3	3	3
Maireana trichoptera													N
Maireana turbinata	T	1		T	T		1	N	1	1	1	1	1
**Marrubium vulgare*					T						T		
**Medicago minima* var. *minima*					T								
**Medicago polymorpha* var. *polymorpha*	1	2	T				1	1	1	T	2		2
**Mesembryanthemum nodiflorum*											1		
Minuria cunninghamii	1	T					N	T		N			
Myoporum platycarpum ssp.	N			2	T								N
Nicotiana maritima				N							T		
Nitraria billardierei	1												
Olearia pimeleoides ssp.					N								
Osteocarpum salsuginosum			T					T					
Oxalis perennans											N		
Pimelea microcephala ssp.					T								
Pittosporum angustifolium				N	T								
Plantago drummondii	T		N										
Poa crassicaudex			T		T		1		1	1	T		T
Ptilotus obovatus var. *obovatus*					T						T		T
Rhagodia parabolica					T								
Rhagodia spinescens	N	T		1	T					T	T	N	T
Rhagodia ulicina				T						1	1	1	N
Rhodanthe floribunda										N			
Salsola australis					T				N				
Santalum lanceolatum					T								
Scaevola spinescens				N	T								
**Schismus barbatus*			N		2								
Sclerolaena brachyptera		T						N					
Sclerolaena cuneata								2					
Sclerolaena obliquicuspis	2	1	T	1	1	N	2	2	2	1	2	1	1
Sclerolaena patenticuspis	T	1		1	T		2	1	2	1	3		1
Sclerolaena uniflora			T			T		1					
Senna artemisioides ssp. *artemisioides x* ssp. *coriacea*					T							N	
Setaria constricta					T								
Sida fibulifera					T								
Sida intricata		1			T						1		
Sida petrophila					T								
**Sisymbrium erysimoides*					T						T	T	T
Solanum petrophilum					1								
Solanum quadriloculatum					T							N	N
**Sonchus oleraceus*			T										
**Spergularia diandra*			N										
Tecticornia pergranulata ssp. *pergranulata*		N											
Tecticornia pergranulata ssp.	T		4			5		1					
Tecticornia tenuis			T										
Tetragonia eremaea											N		N
**Vinca major*					T								
Vittadinia cervicularis var. cervicularis											1		
Vittadinia condyloides		T											
Vittadinia dissecta var. *hirta*	N				T			N		1		N	1

Species name	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12	V13
Vittadinia gracilis					T								
Wahlenbergia luteola					N								
Westringia rigida					T								
Zygophyllum ammophilum		N											
Zygophyllum apiculatum					T								
Zygophyllum billardierei							T			T			N
Zygophyllum iodocarpum		N											
Zygophyllum ovatum	T												
Total species diversity per site	**26**	**25**	**20**	**20**	**61**	**10**	**16**	**23**	**16**	**23**	**35**	**21**	**28**

* denotes exotic species

Cover Abundance

N = not many (1-10 plants and <5%)

T = sparsely present, cover small (less than 5%)

1 = plentiful, but of small cover (less than 5%)

2 = any number of individuals covering 5-25% of area

3 = any number of individuals covering 25-50% of area

4 = any number of individuals covering 50-75% of area

5 = covering more than 75% or area

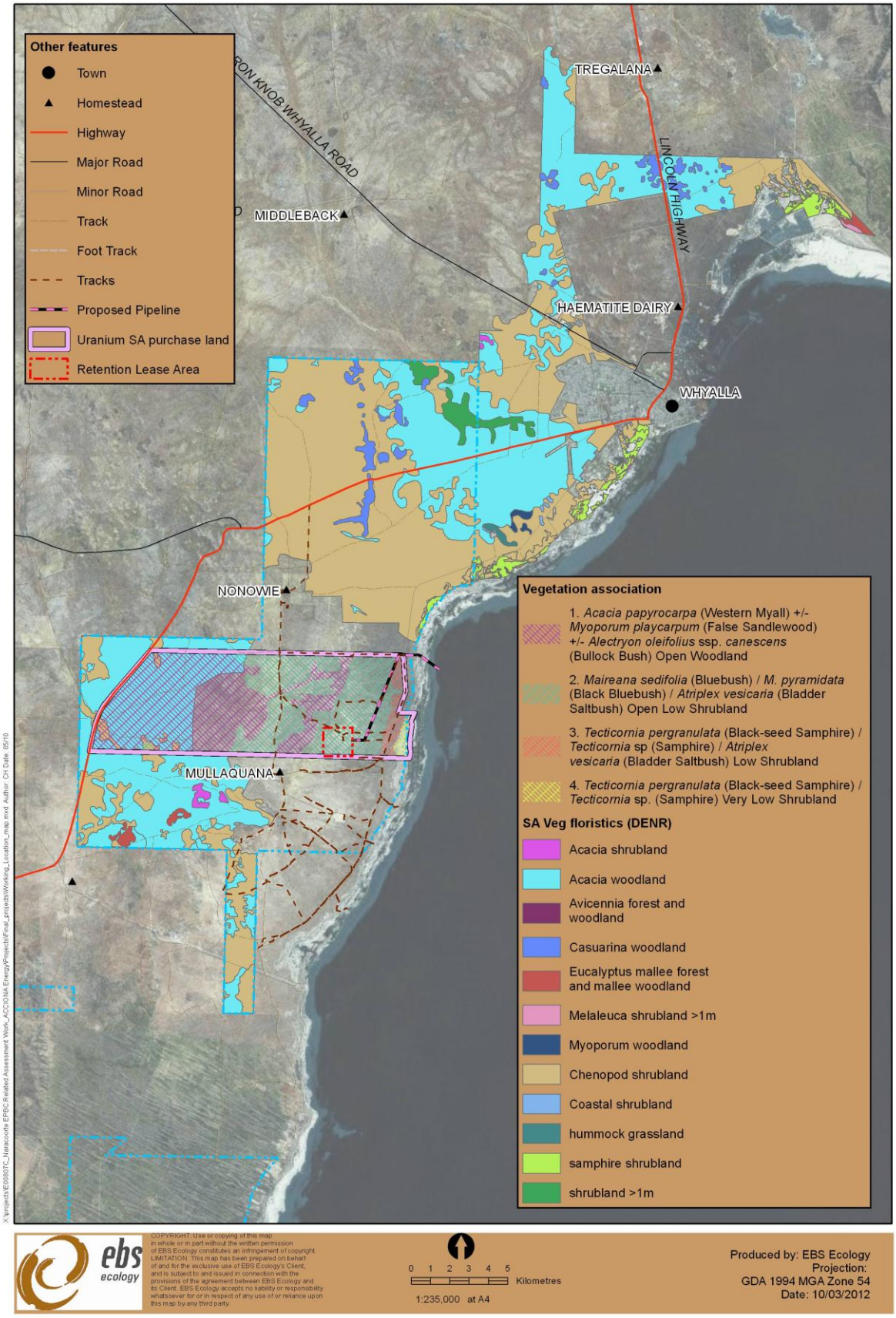
Appendix 4. Flora abundance, Jessup data all sites, spring 2011

Species	Stage	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12	V13
Acacia oswaldii	EST				4									
Atriplex stipitata	EST					7								
Atriplex vesicaria ssp.	EST	471	65	552	3	12	227	305	1846	445	117	77	31	4
	JUV		1	19			9	1	179	118				
Chenopodium curvispicatum	EST							20	5	2		1	1	7
Disphyma crassifolium ssp. *clavellatum*	EST		405	908			807		380					
Dysphania pumilio	EST						118							
Dysphania sp.	EST			615			809		704					
	JUV			158			190		2					
Enchylaena tomentosa var.	EST	2			122	113								1
Eremophila alternifolia	EST					1								
Eremophila scoparia	EST				9									
	JUV				1									
Eriochiton sclerolaenoides	EST	170	38		7			33			63	83	8	5
Frankenia pauciflora	EST			246										
	JUV			46										
Frankenia sp.	EST			16			475							
Geijera linearifolia	EST					1								
Lawrencia squamata	EST	98												
Lycium australe	EST				46			6			81			
	JUV				1									
Maireana aphylla	EST						7							
Maireana appressa	EST						105							
	JUV						8							
Maireana integra	EST	15			8			10			3	80		
Maireana oppositifolia	EST			4			167							
	JUV						40							
Maireana pyramidata	EST		181			30			1	509		151		4
	JUV		3			2				2				
Maireana radiata	EST									9				
Maireana sedifolia	EST	326	16		282		1	489			305	17	237	155
	JUV	40	1		53		1	2			2		2	
Maireana turbinata	EST	2	96			2		35	2		6		1	13
Maireana sp.	EST									2				
Minuria cunninghamii	EST	37	3						1					
Nitraria billardierei	EST	24												
Osteocarpum salsuginosum	EST								2					
Ptilotus obovatus var. obovatus	EST					6								1
Rhagodia parabolica	EST					21								
Rhagodia spinescens	EST		2		4	1						2		
	JUV				2									
Rhagodia ulicina	EST				118						83		2	1
Salsola australis	EST					2								
Sclerolaena cuneata	EST								2					
Sclerolaena obliquicuspis	EST	348	695		252	140	1	471	245	389	218	49	41	106
	JUV								17					
Sclerolaena patenticuspis	EST		317		209			35		33	1	858		
	JUV				2									
Sclerolaena uniflora	EST			43			68							
	JUV			2										
Sida fibulifera	EST					63								
Sida intricata	EST					3								
Sida petrophila	EST					14								
Sida sp.	EST		363			11								

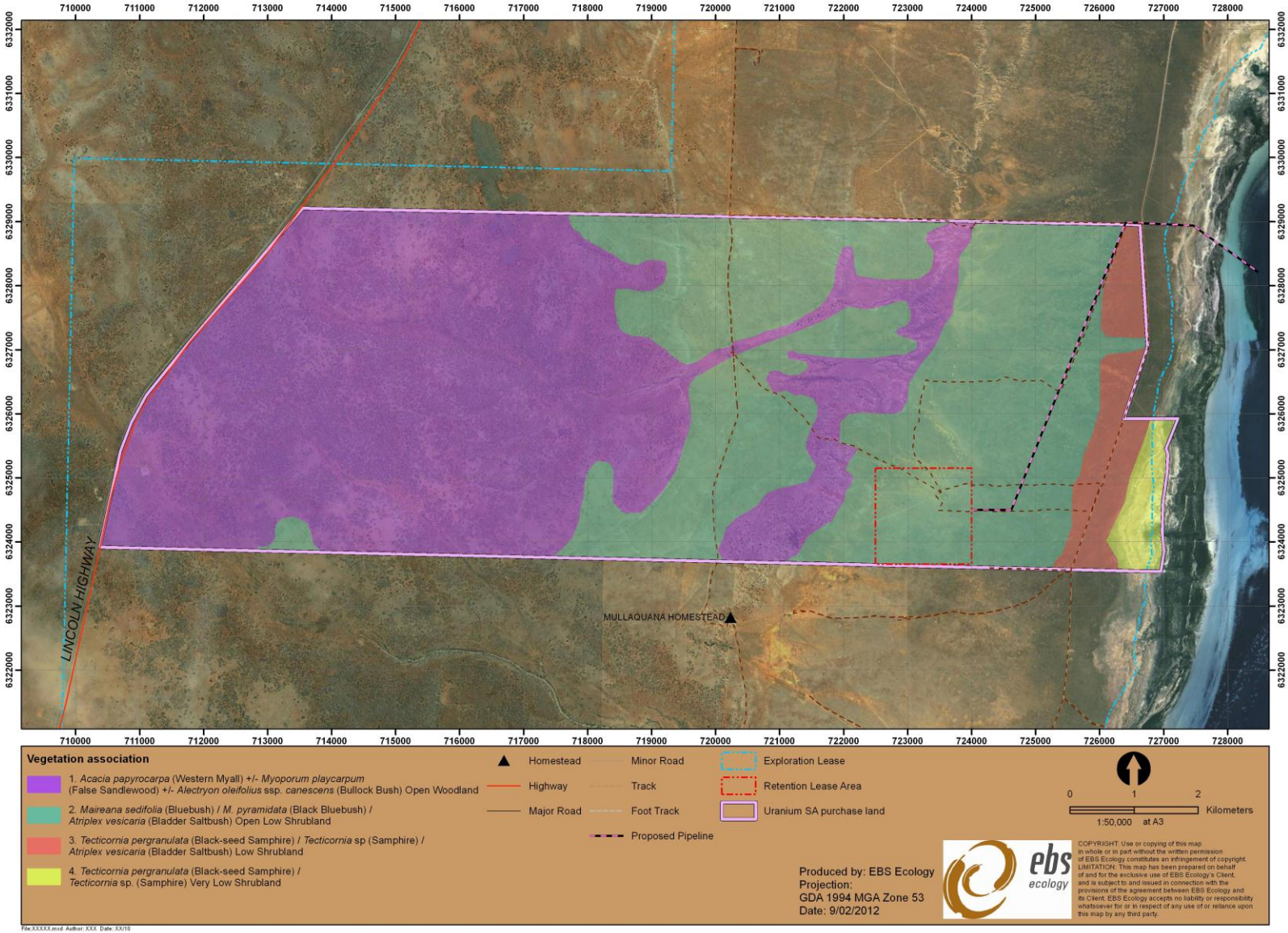
Species	Stage	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12	V13
Solanum petrophilum	EST					22								
	JUV					3								
Solanum quadriloculatum	EST					35								
Tecticornia pergranulata ssp.	EST			1191			980		3					
	JUV			1			25							
Tecticornia sp	EST			2			20							
Zygophyllum billardierei	EST										38			
Zygophyllum sp	EST										23			

Appendix 5. DEH and EBS floristic vegetation mapping

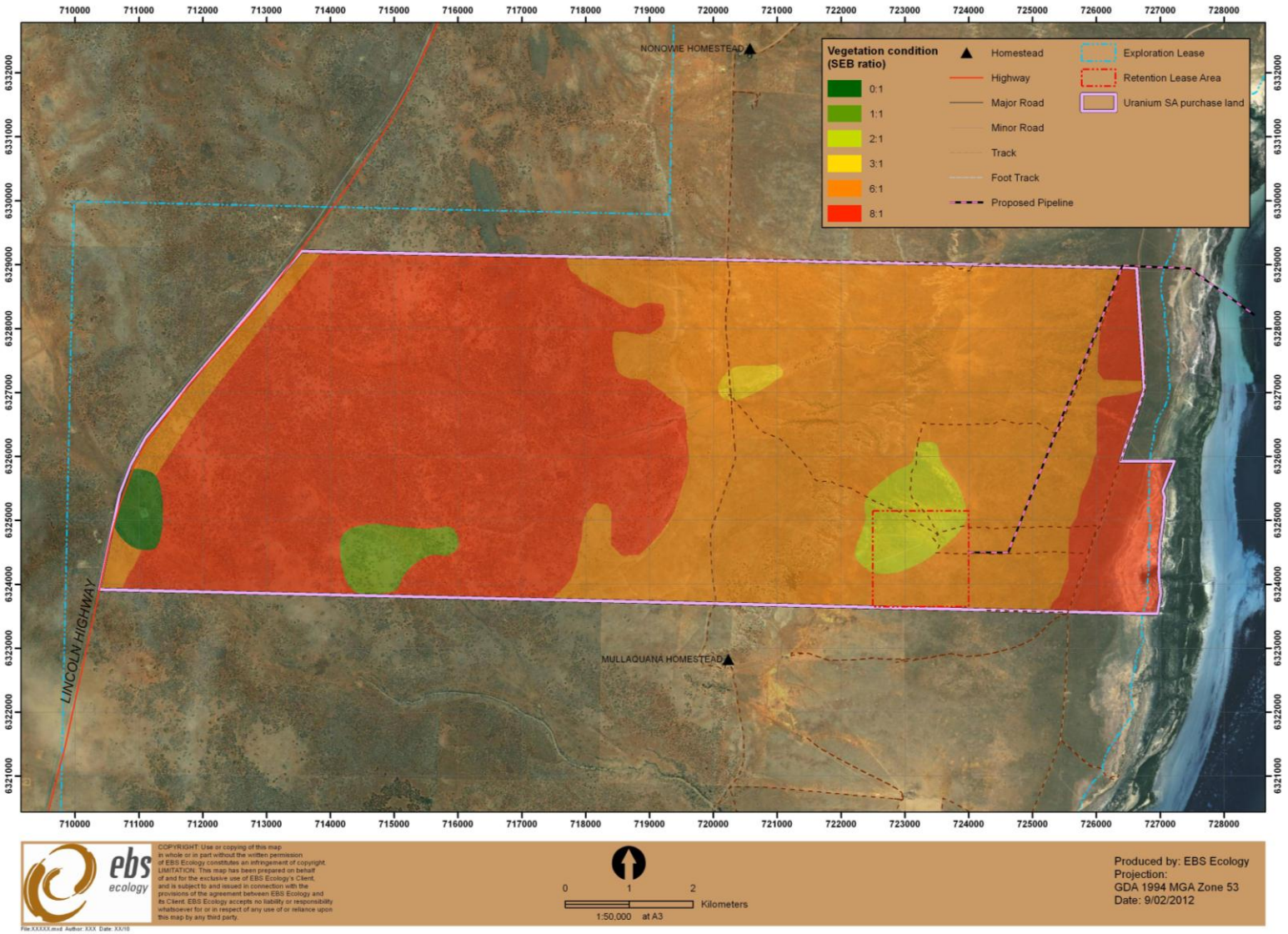
Previous DEH and EBS Floristic mapping



Current EBS floristic mapping of USA purchased land boundary (Spring 2011)



Appendix 6. ***Vegetation condition of USA purchased land boundary (Spring 2011)***



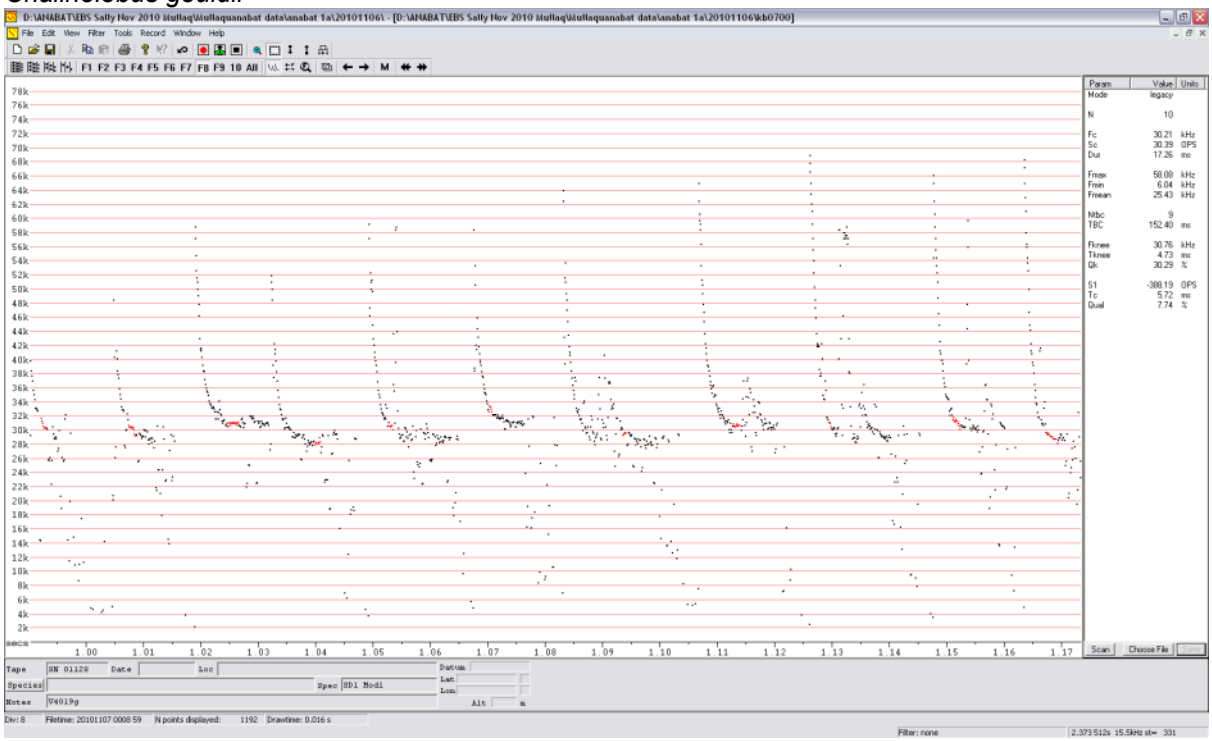
Appendix 7. Flora species observed during the field survey by vegetation association for the UranuimSA purchased land boundary

Species name	Association 1	Association 2	Association 3	Association 4
Acacia ligulata	✓			
Acacia papyrocarpa	✓			
Alectryon oleifolius ssp. *canescens*	✓			
Aristida contorta	✓	✓		
Atriplex vesicaria ssp.	✓	✓	✓	
Austrodanthonia sp.	✓	✓	✓	
Austrodanthonia caespitosa	✓	✓	✓	
Austrostipa sp.	✓	✓		
Austrostipa elegantissima			✓	
Austrostipa nodosa	✓	✓	✓	
**Brassica sp.*	✓			
**Carrichtera annua*	✓	✓		
**Carthamus lanatus*	✓	✓		
Centaurea calcitrapa	✓			
Convolvulus remotus	✓	✓		
Disphyma crassifolium ssp. *clavellatum*	✓	✓	✓	✓
Dodonaea lobulata	✓			
Dysphania plantaginella		✓		
**Echium plantagineum*	✓	✓		
Enchylaena tomentosa var.	✓			
Eremophila alternifolia	✓			
Eremophila scoparia	✓			
Eucalyptus dumosa	✓			
Eucalyptus socialis ssp.	✓			
Exocarpos aphyllus	✓			
Frankenia sp.	✓			
Geijera linearifolia	✓			
**Hypochaeris glabra*	✓	✓		
**Lycium ferocissimum*	✓			
Maireana aphylla	✓	✓		
Maireana oppositifolia		✓		
Maireana pyramidata	✓	✓		
Maireana sedifolia		✓		
**Marrubium vulgare*	✓	✓		
**Medicago minima* var. *minima*		✓		
**Mesembryanthemum nodiflorum*	✓			
Myoporum platycarpum ssp.	✓			
Nitraria billardierei	✓			
Olearia pimeleoides ssp.	✓			
Oxalis perennans	✓			
Pimelea microcephala ssp.	✓			
Pittosporum angustifolium	✓			
Plantago drummondii		✓		
Poa sp.	✓	✓		
Ptilotus obovatus var. *obovatus*	✓	✓		
Rhagodia parabolica	✓			
Rhagodia spinescens	✓			
Salsola australis	✓	✓		
Santalum lanceolatum	✓			
**Schismus barbatus*	✓	✓		

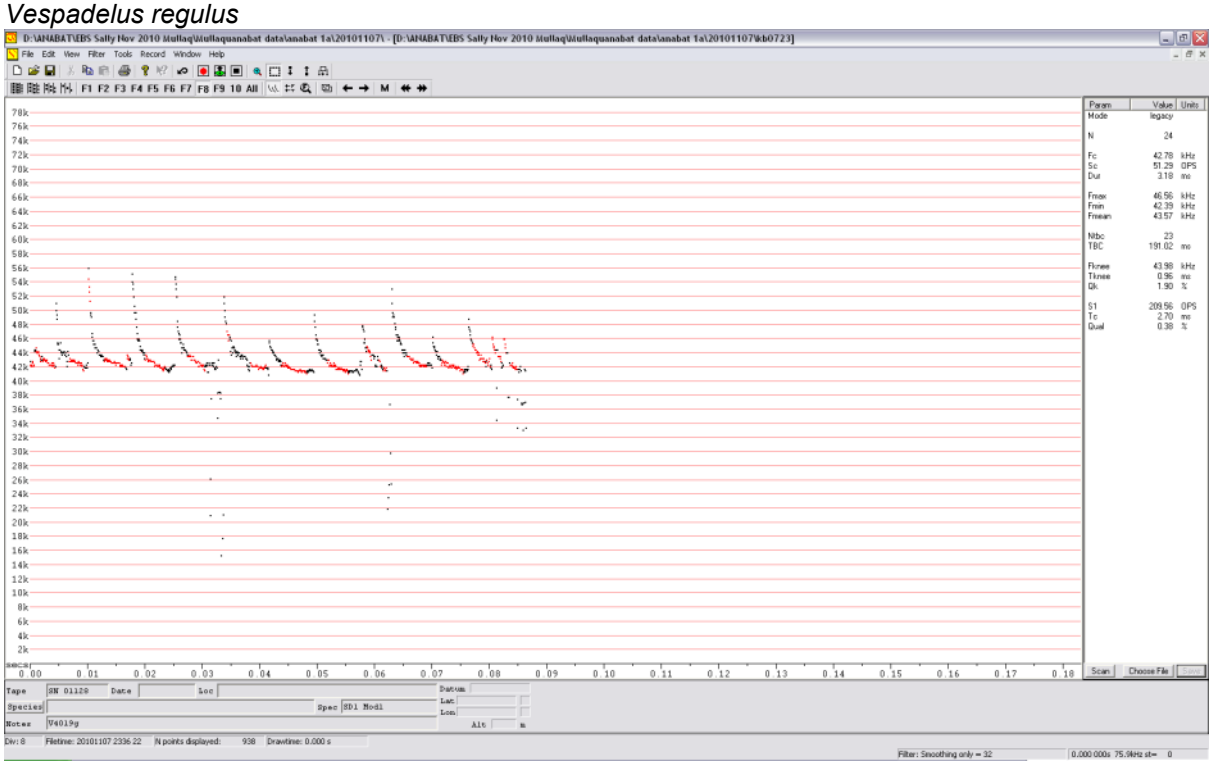
Species name	Association 1	Association 2	Association 3	Association 4
Sclerolaena cuneata		✓		
Sclerolaena obliquicuspis	✓	✓		
Sclerolaena patenticuspis	✓	✓		
Sclerolaena uniflora		✓		
Senna artemisioides ssp. *artemisioides x* ssp. *coriacea*	✓			
Setaria sp.		✓		
Sida fibulifera	✓	✓		
Sida intricata	✓	✓		
**Sonchus oleraceus*	✓			
Tecticornia sp.			✓	✓
Tecticornia pergranulata ssp. *pergranulata*			✓	✓
Tecticornia pergranulata ssp.			✓	✓
Tetragonia eremaea			✓	
**Vinca major*	✓	✓		
Vittadinia dissecta var. *hirta*	✓	✓		
Vittadinia gracilis	✓	✓		
Westringia rigida	✓			
Zygophyllum ammophilum	✓	✓		
Zygophyllum sp.	✓	✓		
Total species diversity per site	**26**	**25**	**20**	**20**

Appendix 8. Example bat calls (as viewed in AnaLook) recorded during the November 2011 survey.

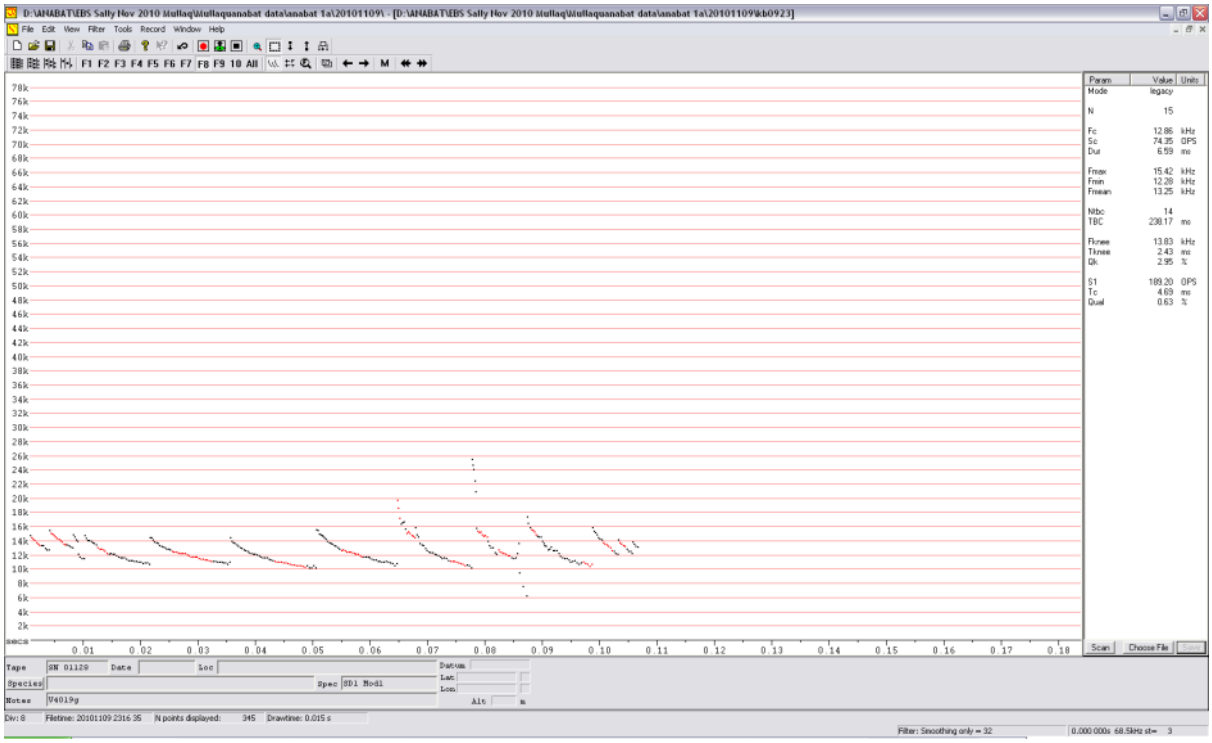
Chalinolobus gouldii



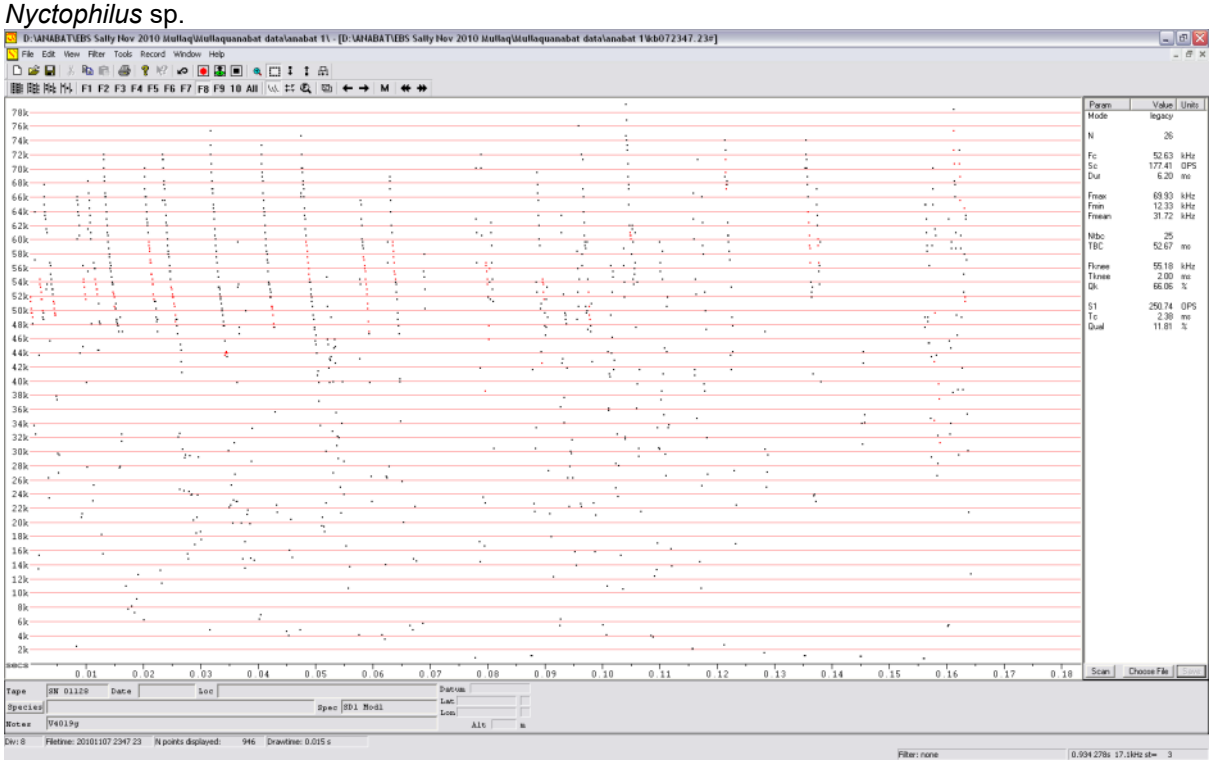
Vespadelus regulus



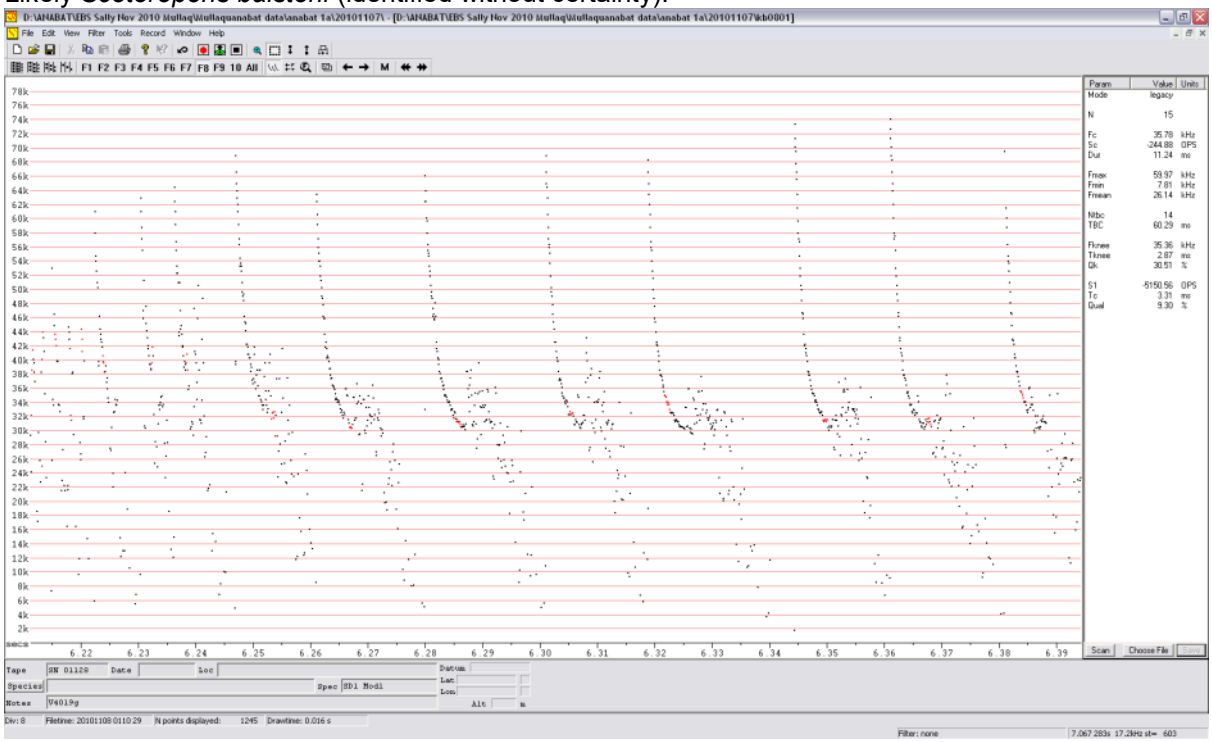
Austronomus australis



Nyctophilus sp.



Likely *Scotorepens balstoni* (identified without certainty).



Appendix 9. Abundance of all bird species recorded during point count (PC) and opportunistically/other methods (OPP) during the spring 2011 survey.

Species name	Common name	Aus status	SA status	PC	OPP	Total
Acanthagenys rufogularis	Spiny-cheeked Honeyeater			10	5	**15**
Acanthiza chrysorrhoa	Yellow-rumped Thornbill			2		**2**
Acanthiza iredalei iridalei	Slender-billed Thornbill	VU	R	36	17	**53**
Acanthiza uropygialis	Chestnut-rumped Thornbill			2		**2**
Accipiter cirrocephalus	Collared Sparrowhawk			1		**1**
Amytornis textilis myall	Thick-billed Grasswren	VU		4		**4**
Anthochaera carunculata	Red Wattlebird			3		**3**
Anthus novaeseelandiae	Australasian Pipit			14	3	**17**
Aphelocephala leucopsis	Southern Whiteface			2	7	**9**
Aquila audax	Wedge-tailed Eagle			3	2	**5**
Artamus cinereus	Black-faced Woodswallow			26	7	**33**
Aythya australis	Hardhead				4	**4**
Barnardius zonarius	Australian Ringneck			11	14	**25**
Calamanthus campestris	Rufous Fieldwren			25	1	**26**
Cheramoeca leucosterna	White-backed Swallow			2		**2**
Cincloramphus cruralis	Brown Songlark			39	5	**44**
Circus approximans	Swamp Harrier			5		**5**
Corvus coronoides	Australian Raven			16	2	**18**
Corvus mellori	Little Raven				2	**2**
Coturnix pectoralis	Stubble Quail			11	5	**16**
Cracticus tibicen	Australian Magpie			10		**10**
Cracticus torquatus	Grey Butcherbird			17	4	**21**
Dromaius novaehollandiae	Emu				11	**11**
Egretta novaehollandiae	White-faced Heron				2	**2**
Eolophus oseic apillus	Galah			8		**8**
Epthianura albifrons	White-fronted Chat				30	**30**
Falco berigora	Brown Falcon			4	1	**5**
Falco cenchroides	Nankeen Kestrel			7	3	**10**
Lalage sueurii	White-winged Triller				3	**3**
Lichenostomus irescens	Singing Honeyeater			11		**11**
Malurus lamberti	Variegated Fairy-wren			26		**26**
Malurus leucopterus	White-winged Fairy-wren			43	14	**57**
Malurus splendens	Spledid Fairy-wren				11	**11**
Manorina melanocephala	Noisy Miner			7		**7**
Melopsittacus undulatus	Budgerigar			1596	5330	**6926**
Neophema petrophila	Rock Parrot		R	34	7	**41**
Northiella haematogaster	Blue Bonnet			6	10	**16**
Nymphicus hollandicus	Cockatiel			8	15	**23**
Ocyphaps lophotes	Crested Pigeon			6	3	**9**
Phaps elegans	Brush Bronzewing				1	**1**
Pomatostomus superciliosus	White-browed _Babbler			7	2	**9**
Psephotus varius	Mulga Parrot			5		**5**
Rhipidura leucophrys	Willie Wagtail			1	1	**2**
Taeniopygia guttata	Zebra Finch			77	25	**102**
Tachybaptus novaehollandiae	Australasian Grebe				2	**2**
Threskiornis spinicollis	Straw-necked Ibis				20	**20**
Todiramphus pyrrhopygius	Red-backed Kingfisher			1	2	**3**
Tribonyx ventralis	Black-tailed Native-hen				2	**2**
Turnix velox	Little Button-quail			2		**2**
Vanellus tricolor	Banded Lapwing			6	10	**16**
			Total abundance	**2094**	**5583**	**7677**
			Total diversity	**39**	**36**	**50**

EBS Ecology
4/48 Barwell Avenue
Kurralta Park, SA 5037
www.ebsecology.com.au
t. 08 7127 5607
f. 08 8297 3768



J5: Mullaquana Additional Bird Survey. Report prepared for UraniumSA Ltd by EBS Ecology, March 2011.



Mullaquana Additional Bird Survey

Mullaquana Additional Bird Survey

24 MARCH 2011

Version 1.2

Prepared by EBS Ecology for UraniumSA

Document Control					
Revision No.	Date issued	Authors	Reviewed by	Date Reviewed	Revision type
1.0	07/04/2010	A. Derry	S. O'Neill	08/04/10	Draft
1.1	19/04/2010	A. Derry	T. How	16/04/10	Revised draft
1.2	24/04/2011	A. Derry	S. O'Neill	24/04/11	Final draft

Distribution of Copies			
Revision No.	Date issued	Media	Issued to
1.0	09/04/2010	Electronic	N. Galloway-Warland, UraniumSA
1.1	19/04/2010	Electronic	N. Galloway-Warland, UraniumSA
1.2	24/04/2011	Electronic	A. Muir, UraniumSA

COPYRIGHT: Use or copying of this document in whole or in part (including photographs) without the written permission of Environmental and Biodiversity Services constitutes an infringement of copyright.

LIMITATION: This report has been prepared on behalf of and for the exclusive use of Environmental and Biodiversity Services Client, and is subject to and issued in connection with the provisions of the agreement between Environmental and Biodiversity Services and its Client. Environmental and Biodiversity Services accepts no liability or responsibility whatsoever for or in respect of any use of or reliance upon this report by any third party.

CITATION: EBS Ecology (2010) *Mullaquana Additional Bird Survey*. Report to UraniumSA. EBS Ecology, Adelaide.

Front cover photo: Pacific Gulls and Crested Tern resting by the shoreline at Cowled's Landing.

ebs ecology

EXECUTIVE SUMMARY

A total of 819 bird observations of 40 species were recorded at both point count areas (454 individuals of 30 species) and at a number of opportunistic locations (365 individuals of 28 species). The survey was conducted over four days during February 2010; thirteen point count areas as well as an additional fifteen locations were surveyed opportunistically during this period.

Two nationally vulnerable species were recorded during the latest survey; the Thick-billed Grasswren (*Amytornis textillis myall*) recorded in low numbers at one site and the Slender-billed Thornbill (*Acanthiza iredalei iredalei*) recorded in high numbers throughout the study area. Two state rare species were also recorded during the survey; the Striated Grasswren (*Amytornis striatus*) and the Shy Heathwren (*Calamanthus cautus*), both recorded in relatively low numbers. The Slender-billed Thornbill and Shy Heathwren were not detected in the previous survey conducted by EBS Ecology in November 2009. High abundance of the former was determined by direct observations as well as the use of call-back techniques which enabled small numbers of this species, at any one site, to be attracted toward the observer.

Considering the location of the study area in relation to the coastline as well as situated within the Eyre Peninsula (a well-known fly-way for migratory species), a low number of shorebirds and waders were recorded e.g. White-faced Heron (*Egretta novaehollandiae*), Pacific Gull (*Larus pacificus*), Australian Pelican (*Pelecanus conspicillatus*), Great and Little Pied Cormorant (*Phalacrocorax carbo* and *Phalacrocorax melanoleucos*) and Crested Tern (*Sterna bergii*). One nationally listed migratory/marine species was recorded opportunistically; the Great Egret (*Ardea alba*).

Contents

1 INTRODUCTION 1
1.1 Objectives 1
1.2 Location 1

2 BACKGROUND SEARCHES 3
2.1 EPBC and BDBSA searches 3
2.2 Migratory species 5

3 METHODS 6
3.1 Point count surveys 6
3.2 Opportunistic observations 6
3.3 Habitats and site selection 6

4 RESULTS 9
4.1 Bird survey site summary 9
4.1.1 Site 1 9
4.1.2 Site 3 10
4.1.3 Site 5 11
4.1.4 Site 7 12
4.1.5 Site 18 13
4.1.6 Site 8 14
4.1.7 Site 9 15
4.1.8 Bird Site OPP 16
4.1.9 Site 6 17
4.1.10 Site 10 18
4.1.11 Site 11 19
4.1.12 Site 15 20
4.1.13 Site 22 21
4.2 Point count results 22
4.2.1 Bird abundance and diversity 22
4.2.2 Bird abundance and habitat 25
4.2.3 Abundance of threatened species across point count sites 26
4.3 Opportunistic results 28

5 DISCUSSION 30
5.1 Conservation significant and migratory species observed 30
5.2 Shorebird species 33

6 MITIGATION MEASURES 35

7 REFERENCES AND BIBLIOGRAPHY 36

8 APPENDICES 37

List of Figures

Figure 1. Bird sites surveyed at point count sites during the November 2009 and February 2010 survey. 2
Figure 2. Site 1 located within Low Open Shrubland (Bluebush, Black Bluebush and Saltbush). 9
Figure 3. Site 3 located within samphire habitat. 10
Figure 4. Site 5 located within mallee habitat. 11
Figure 5. Site 7 located within coastal mangroves. 12
Figure 6. Site 18 Dam bird site. 13
Figure 7. Site 8 located within *Acacia* and *Dodonaea* species. 14
Figure 8. Site 9 located at a tidal mangrove vegetation community. 15
Figure 9. Bird Site OPP located within Bluebush, Black Bluebush and Saltbush shrubland. 16
Figure 10. Site 6 located within Bluebush, Black Bluebush and Saltbush shrubland. 17
Figure 11. Site 10 located within samphire shrubland. 18
Figure 12. Site 11 located within samphire and saltbush shrubland. 19
Figure 13. Site 11 located within chenopod shrubland. 20
Figure 14. Site 22 located within Mallee woodland and saltbush shrubland. 21
Figure 15. Site 25 within mallee and samphire shrubland. 28
Figure 16. Site 14 situated just south of Cowleds Landing. 29
Figure 17. Site 21 situated 3 km north of Site 9 (Murninnie Beach). 29
Figure 18. Shorebird sign situated at Site 9 Murninnie Beach. 34

List of Tables

Table 1. Threatened fauna species identified in EPBC Protected Matters Report and BDBSA search as occurring within the Mullaquana and wider area. 3
Table 2. Migratory bird species or species with habitat that may occur within the region protected under the EPBC Act 1999. 5
Table 3. Summary of the survey effort, habitat and locations of the point count and opportunistic surveys conducted at sites across the Mullaquana study area. 7
Table 4. Site 1 summary. 9
Table 5. Site 3 summary. 10

Table 6. Site 5 summary. 11
Table 7. Site 7 summary. 12
Table 8. Site 18 summary. 13
Table 9. Site 8 summary. 14
Table 10. Site 9 summary. 15
Table 11. Bird Site OPP summary. 16
Table 12. Site 6 summary. 17
Table 13. Site 10 summary. 18
Table 14. Site 11 summary. 19
Table 15. Site 15 summary. 20
Table 16. Site 22 summary. 21
Table 17. Bird abundance and diversity for the five highest recorded species during point count (PC) and opportunistic surveys (OPP). 22
Table 18. Species diversity and abundance of all birds recorded from the thirteen point count sites during the February 2010 survey at Mullaquana project area. 23
Table 19. Comparison of bird abundance and diversity across habitat types. 26
Table 20. Abundance of threatened species across point count sites and during opportunistic surveying. 27

1 INTRODUCTION

A three-phase assessment of the Mullaquana project on the Eyre Peninsula has been undertaken by EBS Ecology on behalf of UraniumSA. The first phase, conducted in October 2009, involved an initial assessment (desktop assessment and brief site visit) identifying flora, fauna and sensitive environments likely to occur within the project area and making recommendations for future survey work. The second phase, conducted in November 2009, involved a baseline survey of fauna and flora species and vegetation communities of the project area. Access to shorelines during the second phase was hampered by significant rainfall and reluctance to travel on saturated tracks. It was therefore considered that shorebirds had not been adequately surveyed, and the presence of migratory shorebirds may occur within the study area. Consequently, an outcome of the second phase was the recommendation for a third phase allowing for additional bird surveys to be completed at shoreline and coastal sites within the study area and adjacent to the lease area; as well as surveys targeting the habitat of the nationally vulnerable Thick-billed Grasswren (*Amytornis textilis myall*) and state rare Striated Grasswren (*Amytornis striatus*), both of which were recorded during the second phase. This report presents the findings of the third phase, which was conducted in February 2010, focusing on shoreline habitats to identify bird species present.

1.1 Objectives

Objectives of the additional bird survey were to:

- increase survey effort targeting the habitat of Thick-billed Grasswren and Striated Grasswren
- enable calculations to be made of a population estimate based on occupancy of habitats and abundance observed of these two state rated species
- assist identification of potential impacts of future mining developments on local populations
- determine threatened shoreline or coastal birds that may inhabit the study area or adjacent to the lease area.

1.2 Location

Mullaquana is located on Eyre Peninsula, South Australia, approximately 20 km south-west of the town of Whyalla. The project lies within the Mullaquana and Nonowie pastoral leases, and exploration tenements EL3542, EL4242 and EL3652. Cowled's Landing, a small shack community, is located adjacent to the lease area as well as Murninnie Beach where the shorebird bird site is situated at the end of Eight Mile Creek Road (Figure 1). Munyaroo Conservation Park (12,340 ha) is located to the south and shares a boundary with the ELs.

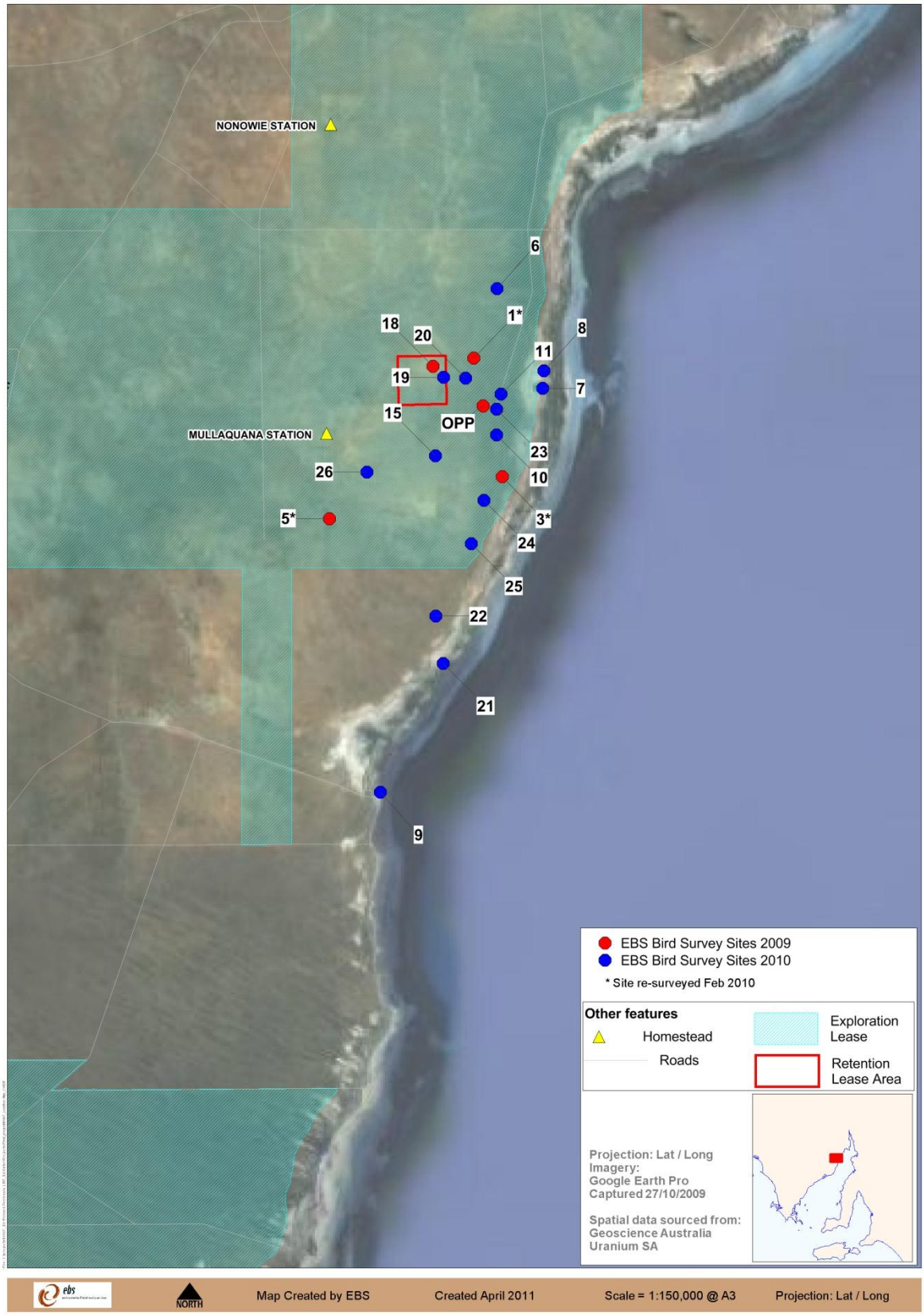


Figure 1. Bird sites surveyed at point count sites during the November 2009 and February 2010 survey.

2 BACKGROUND SEARCHES

2.1 EPBC and BDBSA searches

It is worthwhile highlighting the background searches conducted as part of the *Mullaquana Flora and Fauna – Initial Assessment* (EBS 2009) (phase one). The *Environment Protection and Biodiversity Conservation* (EPBC) online *Protected Matters Search Tool* (DEWHA 2004) search was undertaken a 5km radius as directed by the client (UraniumSA) centred on a point located at latitude and longitude -33.19305, 137.3974. Biological Database of South Australia (BDBSA) were also undertaken. The database searches identified 45 bird species of conservation significance with records in the Mullaquana, Nonowie or adjacent areas (Table 1). A further 17 bird species have records in the wider region, and may have been present in the Mullaquana area. Given the high number of threatened bird species recorded in the wider area it can be assumed that bird species, particularly those with recent records (last 10 years), would be recorded during the February 2010 survey.

Table 1. Threatened fauna species identified in EPBC Protected Matters Report and BDBSA search as occurring within the Mullaquana and wider area.

Species	Common name	Aus status	SA status	No. records	Earliest record	Latest record	Approx proximity to site
Acanthiza iredalei iredalei	Slender-billed Thornbill	VU	R	25	1925	2006	Adjacent
Actitis hypoleucos	Common Sandpiper		R	8	1981	2003	Adjacent
Amytornis striatus	Striated Grasswren		R	5	1975	2008	Adjacent
Amytornis textilis	Thick-billed Grasswren	VU		22	1991	2008	Wider
Amytornis textilis myall	Thick-billed Grasswren	VU		56	1990	2006	Wider
Ardea ibis	Cattle Egret		R	1	1990	1990	Adjacent
Ardea intermedia	Intermediate Egret		R	3	2000	2001	Adjacent
Ardeotis australis	Australian Bustard		V	4	2003	2006	Adjacent
Arenaria interpres	Ruddy Turnstone		R	23	1981	2000	Adjacent
Biziura lobata	Musk Duck		R	6	2000	2001	Adjacent
Calidris tenuirostris	Great Knot		R	5	1981	2000	Adjacent
Cereopsis novaehollandiae	Cape Barren Goose		R	1	1986	1986	Adjacent
Charadrius leschenaultii	Greater Sand Plover		R	2	1983	1984	Adjacent
Charadrius mongolus	Lesser Sand Plover		R	3	1973	2000	Adjacent
Cinclosoma castanotum	Chestnut Quail-thrush		R	16	1935	2008	Adjacent
Cladorhynchus leucocephalus	Banded Stilt		V	21	1981	2006	Adjacent
Corcorax melanorhamphos	White-winged Chough		R	4	1900	2000	Adjacent
Coturnix ypsilophora	Brown Quail		V	1	2001	2001	Wider
Egretta garzetta	Little Egret		R	26	1998	2005	Adjacent
Egretta sacra	Eastern Reef Egret		R	5	2000	2006	Adjacent
Elanus scriptus	Letter-winged Kite		R	1	1970	1970	Wider
Emblema pictum	Painted Finch		R	1	1974	1974	Adjacent
Falco peregrines	Peregrine Falcon		R	7	1991	2003	Adjacent
Falcunculus frontatus	Crested Shrike-tit		R	1	1999	1999	Wider
Glossopsitta pusilla	Little Lorikeet		E	1	1900	1900	Wider

Species	Common name	Aus status	SA status	No. records	Earliest record	Latest record	Approx proximity to site
Haematopus fuliginosus	Sooty Oystercatcher		R	42	1981	2005	Adjacent
Haematopus longirostris	Australian Pied Oystercatcher		R	102	1981	2006	Adjacent
Haliaeetus leucogaster	White-bellied Sea-Eagle		E	2	1900	2000	Adjacent
Hylacola cauta	Shy Heathwren		R	9	1977	2008	Adjacent
Hylacola pyrrhopygia	Chestnut-rumped Heathwren	VU	V	3	1998	1999	Wider
Larus dominicanus	Kelp Gull		R	1	1982	1982	Wider
Leipoa ocellata	Malleefowl	VU	V	178	1900	2007	Adjacent
Lichenostomus cratitius	Purple-gaped Honeyeater		R	9	1991	2005	Adjacent
Limosa lapponica	Bar-tailed Godwit		R	13	1981	2004	Adjacent
Limosa limosa	Black-tailed Godwit		R	1	1982	1982	Adjacent
Lophocroa leadbeateri	Major Mitchell's Cockatoo		R	3	1982	2000	Adjacent
Lophoictinia isura	Square-tailed Kite		E	1	1972	1972	Adjacent
Melanodryas cucullata	Hooded Robin		R	20	1998	2006	Wider
Myiagra inquieta	Restless Flycatcher		R	11	1987	2008	Adjacent
Neophema chrysogaster	Orange-bellied Parrot	CR	E	2	1992	1992	Wider
Neophema chrysostoma	Blue-winged Parrot		V	4	1992	2005	Wider
Neophema elegans	Elegant Parrot		R	41	1900	2006	Adjacent
Neophema petrophila	Rock Parrot		R	2	1998	2000	Wider
Neophema splendid	Scarlet-chested Parrot		R	3	1996	2005	Adjacent
Numenius madagascariensis	Eastern Curlew		V	10	1981	2004	Adjacent
Numenius phaeopus	Whimbrel		R	1	1973	1973	Adjacent
Oxyura australis	Blue-billed Duck		R	2	2001	2004	Adjacent
Pachycephala inornata	Gilbert's Whistler		R	10	1925	2006	Adjacent
Pandion cristatus	Eastern Osprey		E	2	1900	1900	Wider
Petroica boodang	Scarlet Robin		V	25	1955	2004	Wider
Philomachus pugnax	Ruff		R	2	1978	1981	Adjacent
Plegadis falcinellus	Glossy Ibis		R	1	2000	2000	Adjacent
Pluvialis fulva	Pacific Golden Plover		R	1	1983	1983	Wider
Porzana tabuensis	Spotless Crake		R	2	1999	1999	Adjacent
Stagonopleura guttata	Diamond Firetail		V	3	1998	2000	Wider
Sterna hirundo	Common Tern		R	2	2000	2000	Adjacent
Sternula nereis	Fairy Tern		E	2	1987	1999	Adjacent
Stictonetta naevosa	Freckled Duck		V	7	1980	2003	Adjacent
Strepera versicolour	Grey Currawong		E	45	1925	2008	Wider
Tringa brevipes	Grey-tailed Tattler		R	3	1987	2000	Adjacent
Turnix varius	Painted Button-quail		R	8	1992	1999	Adjacent

AUS Status – CR = Critically Endangered; EN = Endangered; VU = Vulnerable

SA Status – E = Endangered; V = Vulnerable; R = Rare

Adjacent = BDBSA search of the Ninowie, Mullaquana areas and the adjacent area

Wider = BDBSA search of the wider region (including Middleback Ranges and eastern Spencer Gulf).

2.2 Migratory species

The EPBC search identified 24 migratory bird species with records or areas of suitable habitat within the wider Mullaquana region (Table 2). Given the high number of migratory species with recent records in the wider Mullaquana area, it is considered likely that at least some species are present or at times present and are likely to be confined to the coastline or open water (dams). An investigation of shoreline habitat was necessary during the February 2010 survey to further assess the likelihood of specific species occurring. It is again worthwhile highlighting this background search as the Great Egret (*Ardea alba*) was listed as having habitat within the region and was in fact observed during the latest survey.

Table 2. Migratory bird species or species with habitat that may occur within the region protected under the EPBC Act 1999.

Species name	Common name	EPBC migratory status	BDBSA records Yes/No (No. of records; date of most recent)
Haliaeetus leucogaster	White-bellied Sea-eagle	Migratory terrestrial	Yes (2: 2000)
Hirundapus caudactus	White-throated Needletail	Migratory terrestrial / Over-fly	No
Leipoa ocellata	Malleefowl	Migratory terrestrial	Yes (178; 2007)
Merops ornatus	Rainbow Bee-eater	Migratory terrestrial / Over-fly	Yes (33; 2005)
Ardea alba	Great Egret	Migratory wetland / marine / Over-fly	Yes (20; 2006)
Ardea ibis	Cattle Egret	Migratory wetland / marine / Over-fly	Yes (1;1990)
Arenaria interpres	Ruddy Turnstone	Migratory wetland / Over-fly	Yes (23; 2000)
Calidris acuminata	Sharp-tailed Sandpiper	Migratory wetland / Over-fly	Yes (23; 2001)
Calidris alba	Sanderling	Migratory wetland / Over-fly	No
Calidris canutus	Red Knot	Migratory wetland / Over-fly	Yes (12; 2004)
Calidris ferruginea	Curlew Sandpiper	Migratory wetland / Over-fly	Yes (17; 2004)
Calidris ruficollis	Red-necked Stint	Migratory wetland / Over-fly	Yes (88; 2005)
Charadrius veredus	Oriental Plover	Migratory wetland / Over-fly	Yes (1; 1996)
Gallinago hardwicki	Latham's Snipe	Migratory wetland / Over-fly	No
Pluvialis squatarola	Grey Plover	Migratory wetland / Over-fly	Yes (19; 2004)
Tringa nebularia	Common Greenshank	Migratory wetland / Over-fly	Yes (44; 2004)
Apus pacificus	Fork-tailed Swift	Migratory Marine / Over-fly	No
Diomedea gibsoni	Gibson's Albatross	Migratory Marine	No
Macronectes giganteus	Southern Giant-Petrel	Migratory Marine	No
Macronectes halli	Northern Giant-Petrel	Migratory Marine	No
Thalassarche bulleri	Buller's Albatross	Migratory Marine	No
Thalassarche cauta	Shy Albatross	Migratory Marine	No
Thalassarche impavida	Campbell Albatross	Migratory Marine	No
Thinornis rubricollis rubricollis	Hooded Plover (eastern)	Migratory marine / Over-fly	No

3 METHODS

3.1 Point count surveys

Bird surveys were conducted at thirteen point count survey sites over four days in February 2010. Nine new sites were surveyed using the point count method for the first time (Sites 6, 7, 8, 9, 10, 11, 15, 22 and Site Opp). Four sites (Sites 1, 3, 5 and 18) previously surveyed in November 2009 were re-surveyed. Site Opp was surveyed as a point count site, and had been previously been opportunistically visited in November 2009.

The time spent at each site was dependant on the size of the area to be covered, the abundance of birds, and the likelihood of the habitat being suitable for species of interest. Duration of each site visit ranged from 15 minutes to 40 minutes. Number of visits per site ranged from just once (Site 18, dam site) to four times (Site 1, Site OPP, Site 10). Three sites were visited three times (Site 1, 3, and 6), and four sites were visited twice (Sites 7, 11, 15 and 22). A single observer conducted an area search recording all birds that could be positively identified by sight within the site or immediately adjacent if the habitat was similar. Bird call-back techniques (using a portable sound player and speaker with relevant bird calls for the Mullaquana region) were used to identify threatened species as well as provoke a call or movement response in a particular area.

3.2 Opportunistic observations

Birds observed at times or locations other than during the point count surveys were also recorded. These locations were termed sites, as the observer deliberately targeted these locations based on the suitability of the habitat for particular species of interest. These sites were not typically visited for particular time duration, with the amount of time spent in each area dependent on the diversity and abundance of species observed and the likelihood of the habitat being suitable. Opportunistic survey sites were typically located between the point count sites (therefore taking advantage of travel routes). These sites were situated at targeted locations (accessible shorelines) or were an extension of the area covered by the thirteen point count survey sites (Table 3); incorporating different habitat. The opportunistic sites included shoreline and mangrove habitats, chenopod shrubland and samphire vegetation where bird activity was high.

3.3 Habitats and site selection

Four out of the six point count sites surveyed as part of the November 2009 survey were again revisited during the recent survey (Sites 1, 3, 5 and 18). Site 2 and Site 4 that were surveyed in November 2009 were not included in the current survey as they were considered least likely to meet the habitat requirements of the targeted species (Slender-billed Thornbills, Thick-billed Grasswrens, and shorebirds). One site (Site OPP) was previously surveyed as an opportune site. Three shoreline sites originally planned for the November 2009 survey (but not completed due to weather conditions), were visited during the February 2010 survey. These were Sites 7, 8 and 9 which were principally located within mangrove or shoreline habitats (Table 3). Five new sites were established and surveyed to

determine the distribution and abundance of two threatened species recorded during the November 2009 survey; the Thick-billed Grasswren (*Amytornis textilis myall*) and Striated Grasswren (*Amytornis striatus)*. These were sites 6, 10, 11, 15 and 22 (Table 3).

Table 3. Summary of the survey effort, habitat and locations of the point count and opportunistic surveys conducted at sites across the Mullaquana study area.

(see Appendix 3 for location co-ordinates).

Site No	Type	Date	Time	Comments (habitat, location)	Total Visits 2010 visit
1	PC	22/02/2010	8:30-9:00	Bluebush, Black bluebush and saltbush in low open scrubland	3
		23/02/2010	9:20-9:40		
		23/02/2010	18:15-18:35		
3	PC	22/02/2010	10:30-11:00	300 m south of poles marked (saltbush in samphire) Halosarcia sp.	3
		23/02/2010	7:10-7:40		
		23/02/2010	18:45-19:05		
5	PC	22/02/2010	18:50-19:20	although termed point count, only surveyed once (no Striated Grasswren found and habitat deemed not suitable) Mallee Shrubland.	1
6	PC	22/02/2010	7:15-8:00	2.41 km north of Site 1, same vegetation as Site 1, established site as heard birds as travelled through the area; Chenopod Shrubland	3
7	PC	22/02/2010	12:00-12:30	edge of coastal mangrove	2
		23/02/2010	15:40-16:10		
8	PC	23/02/2010	16:30-16:50	SEB bird site – mangroves/shoreline	1
9	PC	24/02/2010	13:30-15:00	Shore line bird site (Murninnie Beach), walked north and south of ramp, estimated 400 m each way	1
10	PC	22/02/2010	11:15-11:40	1.28km north of Site 3, similar to Site 3 (3 important birds at site); Samphire Shrubland	4
		23/02/2010	8:00-8:30		
		23/02/2010	19:10-19:30		
		24/02/2010	8:20-8:40		
11	PC	22/02/2010	12:20-13:00	heading south before gate btw Cowled's Landing and Mullaquana turnoff, similar to Site 3 mix of saltbush and Samphire Shrubland	2
12	OPP	22/02/2010	13:30 - 13:50	Cowled's Landing (4km north from Site 8), tracks leading north & south, conservation zone (Whyalla-Cowled's), access difficult to water's edge, coastal mangroves and shoreline	1
13	OPP	22/02/2010	14:00-15:00	Mangroves (south of Cowled's Landing)	1
14	OPP	22/02/2010	14:00-15:00	Walked in through mangroves to shoreline, just south of Cowled's Landing (200m)	1
15	PC	22/02/2010	18:00-18:20	Chenopod habitat, directly in line with Mullaquana station (can see the dam near the homestead) on way to Site 5, Black Bluebush	2
16	OPP	22/02/2010	16:00	Dam	1
17	OPP	23/02/2010	10:20-10:35	near site 1; Chenopod Shrubland	1
18	PC	23/02/2010	10:45-11:00	Dam Site	1

Site No	Type	Date	Time	Comments (habitat, location)	Total Visits 2010 visit
19	OPP	23/02/2010	11:00-11:20	leaving dam site at wpt 18; Chenopod Shrubland	1
20	OPP	23/02/2010	12:00	500 m off wpt 17; Chenopod Shrubland	1
21	OPP	23/02/2010	12:30-13:45	within 3 km north of Site 9 (Murninnie Beach), gate locked on Mullaquana side, had to walk in 500-800 m to scope birds at waterline, none in mangroves	1
22	PC	23/02/2010	14:40-15:00	south of Mullaquana, mallee and saltbush	2
23	OPP	24/02/2010	8:00 - 8:20	800 m north of wpt 10; Samphire Shrubland	1
24	OPP	24/02/2010	9:00	2 km south from wpt 10; Samphire Shrubland	1
25	OPP	24/02/2010	9:00-9:30	near gate site on eastern side, heading south; Samphire Shrubland	1
26	OPP	24/02/2010	11:40-12:00	Dam	1
Site OPP	PC	22/02/2010	9:30-10:00	similar to Site 1 - Chenopod Shrubland	4
		22/02/2010	19:30-19:50		
		23/02/2010	8:30-9:00		
		23/02/2010	9:30-10:00		
		23/02/2010	9:50-10:20		
		23/02/2010	17:50-18:10		
		24/02/2010	7:10 - 8:00		
		24/02/2010	11:00-11:30		
		24/02/2010	10:00-10:20		
827 m south of site 1	OPP	22/02/2010	15:45	827 m south of Site 1; Chenopod Shrubland	1
near 6	OPP	23/02/2010	10:00	180 m S of wpt 6 (arriving), 150m south of wpt 6 (leaving) and 1km south of wpt 6 (leaving); Chenopod Shrubland	1
467 m from wpt 15	OPP	24/02/2010	10:45	on route to Site 5; Chenopod Shrubland	1

PC = point count survey; OPP = opportunistic survey

4 RESULTS

4.1 Bird survey site summary

4.1.1 Site 1

Site 1 was revisited during the February 2010 survey to determine the abundance of both Thick-billed Grasswren and Striated Grasswren that were detected at this site during the previous survey. It was located within *Maireana sedifolia* (Bluebush), *Maireana pyramidata* (Black Bluebush) and *Atriplex vesicaria* (Saltbush) within Low Open Shrubland (Figure 2).



Figure 2. Site 1 located within Low Open Shrubland (Bluebush, Black Bluebush and Saltbush).

Table 4. Site 1 summary.

Site Detail	Description
Location	• 54 H 724872 6325055
Vegetation Association	• *Maireana sedifolia* (Bluebush), *Maireana pyramidata* (Black Bluebush), *Atriplex vesicaria* (Saltbush) Low Open Shrubland
Landform	• Plain
Birds	• 7 native species: Slender-billed Thornbill (*Acanthiza iredalei iredalei*), Galah (*Eolophus roseicapillus*), Shy Heathwren (*Calamanthus cautus*), Grey Butcherbird (*Cracticus torquatus*), White-winged Fairy-wren (*Malurus leucopterus*), Crested Pigeon (*Ocyphaps lophotes*), Tree Martin (*Petrochelidon nigricans*).

4.1.2 Site 3

Site 3 was revisited during the February 2010 survey to determine the abundance of Striated Grasswren that was detected at this site during the previous survey. It was located within *Halosarcia pergranulata* (Black-seed Samphire), *Halosarcia* sp. (Samphire sp) Low Shrubland (Figure 3).



Figure 3. Site 3 located within samphire habitat.

Table 5. Site 3 summary.

Site Detail	Description
Location	• 54 H 725681 6321373
Vegetation Association	• *Halosarcia pergranulata* (Black-seed Samphire), *Halosarcia* sp. (Samphire sp). Low Shrubland
Landform	• Plain
Birds	• 5 native species: Slender-billed Thornbill (*Acanthiza iredalei iredalei*), Galah (*Eolophus roseicapillus*), Grey Butcherbird (*Cracticus torquatus*), Nankeen Kestrel (*Falco cenchroides*), Singing Honeyeater (*Lichenostomus virescens*).

4.1.3 Site 5

Site 5 was revisited during the February 2010 survey to determine the abundance of Striated Grasswren that was detected on the perimeters of this woodland during the previous survey. It was located within *Eucalyptus dumosa* (White Mallee), *Eucalyptus socialis* (Beaked Red Mallee) Mallee (Figure 4).



Figure 4. Site 5 located within mallee habitat.

Table 6. Site 5 summary.

Site Detail	Description
Location	• 53 H 720263 6321082
Vegetation Association	• *Eucalyptus dumosa* (White Mallee), *Eucalyptus socialis* (Beaked Red Mallee) Mallee.
Landform	• Minor ephemeral creekline.
Birds	• 6 native species: Spiny-cheeked Honeyeater (*Acanthagenys rufogularis*), Red Wattlebird (*Anthochaera carunculata*), Australian Ringneck (*Barnardius zonarius*), Singing Honeyeater (*Lichenostomus virescens*), Variegated Fairy-wren (*Malurus lamberti*), White-winged Fairy-wren (*Malurus leucopterus*).

4.1.4 Site 7

Site 7 was visited during the February 2010 survey to determine the presence of migratory birds inhabiting wetland, mangrove and estuary habitats. It was located within *Avicennia marina* (Grey Mangrove) (Figure 5).



Figure 5. Site 7 located within coastal mangroves.

Table 7. Site 7 summary.

Site Detail	Description
Location	• 53 H 726993 6324067
Vegetation Association	• *Avicennia marina (*Grey Mangrove*)*
Landform	• Coastal mangrove
Birds	• 6 native species: Spiny-cheeked Honeyeater (*Acanthagenys rufogularis*), Singing Honeyeater (*Lichenostomus virescens*), Crested Pigeon (*Ocyphaps lophotes*), Tree Martin (*Petrochelidon nigricans*), Great Cormorant (*Phalacrocorax carbo*) and Willie Wagtail (*Rhipidura leucophrys*).

4.1.5 Site 18

Site 18 was revisited during the February 2010 survey to determine the presence of migratory birds reliant upon water after a flock of Black-tailed Native-hen (*Gallinula ventralis*) were observed opportunistically at the dam during the November 2009 survey (Figure 6).



Figure 6. Site 18 Dam bird site.

Table 8. Site 18 summary.

Site Detail	Description
Location	• 53 H 723593 6324829
Landform	• Dam bird site
Birds	• 2 native species: Pacific Black Duck (*Anas superciliosa),* Tree Martin (*Petrochelidon nigricans*).

4.1.6 Site 8

Site 8 was visited during the February 2010 survey to determine the presence of migratory birds outside of the proposed potential SEB area within the wider Mullaquana study area (Figure 7). It was located within mixed shrubland, dominated by *Acacia* species and *Dodonaea* species, on minor shoreline dunes.



Figure 7. Site 8 located within *Acacia* and *Dodonaea* species.

Table 9. Site 8 summary.

Site Detail	Description
Location	• 53 H 727047 6324612
Vegetation Association	• *Acacia* and *Dodonaea* species
Landform	• Mixed Shrubland on minor shoreline dunes
Birds	• 1 native species: Great Cormorant (*Phalacrocorax carbo*).

4.1.7 Site 9

Site 9 was visited during the February 2010 survey to determine the presence of migratory shorebirds birds such as Oyster catchers, red-capped and hooded plovers that frequent similar beaches such as Murninnie Beach, throughout the Eyre Peninsula. Surveys were targeted at shorebirds feeding in the intertidal zone or roosting above the high water mark (Figure 8).



Figure 8. Site 9 located at a tidal mangrove vegetation community.

Table 10. Site 9 summary.

Site Detail	Description
Location	• 53 H 725133 6323568
Landform	• Shoreline (southern extent of study area)
Birds	• 5 native species: White-faced Heron (*Egretta novaehollandiae*), Silver Gull (*Larus novaehollandiae*), Australian Pelican (*Pelecanus conspicillatus*), Little Pied Cormorant (*Phalacrocorax melanoleucos*), Crested Tern (*Sterna bergii*).

4.1.8 Bird Site OPP

Bird Site OPP was revisited during the February 2010 survey to determine the abundance of Striated Grasswren that was detected at this site during the previous survey. It was located within similar vegetation to Site 1 - Bluebush, Black Bluebush and Saltbush within Low Open Shrubland (Figure 9)



Figure 9. Bird Site OPP located within Bluebush, Black Bluebush and Saltbush shrubland.

Table 11. Bird Site OPP summary.

Site Detail	Description
Location	• 53 H 725133 6323568
Vegetation Association	• *Maireana sedifolia* (Bluebush), *Maireana pyramidata* (Black Bluebush), *Atriplex vesicaria* (Saltbush) Low Open Shrubland
Landform	• Plain
Birds	• 7 native species: Slender-billed Thornbill (*Acanthiza iredalei iredalei*), Striated Grasswren (Amytornis striatus), Southern Whiteface (*Aphelocephala leucopsis*), Rufous Fieldwren (*Calamanthus campestris*), Shy Heathwren (*Calamanthus cautus*), Grey Butcherbird (*Cracticus torquatus*), White-winged Fairy-wren (*Malurus leucopterus*).

4.1.9 Site 6

Site 6 was established and surveyed in February 2010 to determine the abundance of both Thick-billed Grasswren and Striated Grasswren; both of which were found in similar habitat at Site 1. It was located 2.4km north of Site 1 within similar chenopod shrubland (Figure 10).



Figure 10. Site 6 located within Bluebush, Black Bluebush and Saltbush shrubland.

Table 12. Site 6 summary.

Site Detail	Description
Location	• 54 H 725646 6327183
Vegetation Association	• *Maireana sedifolia* (Bluebush), *Maireana pyramidata* (Black Bluebush), *Atriplex vesicaria* (Saltbush) Low Open Shrubland
Landform	• Plain
Birds	• 8 native species: Slender-billed Thornbill (*Acanthiza iredalei iredalei*), Thick-billed Grasswren (*Amytornis textilis myall)*, Wedge-tailed Eagle (*Aquila audax*), Shy Heathwren (*Calamanthus cautus*), Little Raven (*Corvus mellori*), White-fronted Chat (*Epthianura albifrons*), Nankeen Kestrel (*Falco cenchroides*), Australian Magpie (*Gymnorhina tibicen*).

4.1.10 Site 10

Site 10 was established and surveyed in February 2010 to determine the abundance of Striated Grasswren that was detected at a similar habitat at Site 3. It was located 1.28 km north of Site 3 within similar samphire shrubland (Figure 11).



Figure 11. Site 10 located within samphire shrubland.

Table 13. Site 10 summary.

Site Detail	Description
Location	• 54 H 725530 6322666
Vegetation Association	• *Halosarcia pergranulata* (Black-seed Samphire), *Halosarcia* sp. (Samphire sp). Low Shrubland
Landform	• Plain
Birds	• 6 native species: Slender-billed Thornbill (*Acanthiza iredalei iredalei*), Striated Grasswren (Amytornis striatus), Richards Pipit (*Anthus novaeseelandiae*), Wedge-tailed Eagle (*Aquila audax*), Shy Heathwren (*Calamanthus cautus*), White-winged Fairy-wren (*Malurus leucopterus*).

4.1.11 Site 11

Site 11 was established and surveyed in February 2010 to determine the abundance of Striated Grasswren that was detected at a similar habitat at Site 3. It was located within similar samphire and saltbush shrubland (Figure 12).



Figure 12. Site 11 located within samphire and saltbush shrubland.

Table 14. Site 11 summary.

Site Detail	Description
Location	• 54 H 725694 6323925
Vegetation Association	• *Halosarcia* sp. (Samphire sp) and *Atriplex vesicaria* (Saltbush)
Landform	• Plain
Birds	• 5 native species: Striated Grasswren (Amytornis striatus), Grey Butcherbird (*Cracticus torquatus*), Australian Magpie (*Gymnorhina tibicen*), White-winged Fairy-wren (*Malurus leucopterus*), and Tree Martin (*Petrochelidon nigricans*).

4.1.12 Site 15

Site 15 was established and surveyed in February 2010 to determine the abundance of both Thick-billed Grasswren and Striated Grasswren; both of which were found in similar habitat at Site 1. It was located within similar chenopod shrubland (Figure 13).



Figure 13. Site 11 located within chenopod shrubland.

Table 15. Site 15 summary.

Site Detail	Description
Location	• 54 H 723617 6322059
Vegetation Association	• *Maireana sedifolia* (Bluebush), *Maireana pyramidata* (Black Bluebush), *Atriplex vesicaria* (Saltbush) Low Open Shrubland
Landform	• Plain
Birds	• 2 native species: Slender-billed Thornbill (*Acanthiza iredalei iredalei*), Nankeen Kestrel (*Falco cenchroides*).

4.1.13 Site 22

Site 22 was established and surveyed in February 2010 to determine the abundance of Striated Grasswren that was detected at similar habitats at Sites 1 and 5. It was located within similar Mallee Woodland and Saltbush Shrubland (Figure 14).



Figure 14. Site 22 located within Mallee woodland and saltbush shrubland.

Table 16. Site 22 summary.

Site Detail	Description
Location	• 54 H 723512 6317100
Vegetation Association	• *Eucalyptus socialis* (Beaked Red Mallee) Mallee and *Atriplex vesicaria* (Saltbush) Shrubland.
Landform	• Plain
Birds	• 5 native species: Spiny-cheeked Honeyeater (*Acanthagenys rufogularis*), Grey Butcherbird (*Cracticus torquatus*), White-fronted Chat (*Epthianura albifrons*), Australian Magpie (*Gymnorhina tibicen*), White-winged Fairy-wren (*Malurus leucopterus*).

4.2 Point count results

4.2.1 Bird abundance and diversity

Forty bird species were observed during the February 2010 field survey (Appendix 1), with a total of 819 observations from both the point count surveys (454) and opportunistic (365) observations. The most common species recorded during point count surveys of the thirteen survey sites were the Tree Martin (*Petrochelidon nigricans*), White-winged Fairy-wren *(Malurus leucopterus*) and of significance due to its vulnerable rating and the fact it occurred in such high numbers; the Slender-billed Thornbill (*Acanthiza iredalei iredalei*). These three species accounted for 21%, 20%, and 12% respectively of all point count observations and were also observed in high numbers during opportunistic surveys (Table 17). Bird abundance at the point count sites ranged from 81 individuals to two individuals whilst bird species diversity ranged from eight species to just one species (Table 18).

Table 17. Bird abundance and diversity for the five highest recorded species during point count (PC) and opportunistic surveys (OPP).

Common Name	PC - Abundance	PC - Proportion of total abundance	OPP - Abundance	OPP - Proportion of total abundance
Tree Martin	96	21.1	102	27.9
White-winged Fairy-wren	92	20.3	31	8.5
Slender-billed Thornbill	56	12.3	19	5.2
Galah	38	8.4	0	0.0
Little Pied Cormorant	32	7.0	0	0.0

Two species of national conservation significance, the vulnerable Thick-billed Grasswren (*Amytornis textilis myall*) and the vulnerable Slender-billed Thornbill (*Acanthiza iredalei iredalei*) were recorded during point count surveys. Two species of state conservation significance were also observed; the rare Striated Grasswren (*Amytornis striatus*) and the rare Shy Heathwren (*Calamanthus cautus*). One migratory species of national conservation significance was recorded opportunistically during the study area; the Great Egret (*Ardea alba*) (see Section 4.5 further information on threatened species).

Table 18. Species diversity and abundance of all birds recorded from the thirteen point count sites during the February 2010 survey at Mullaquana project area.

Scientific name	Common name	1	3	5	6	10	11	15	22	A	B	C	D	OPP	Grand total
Acanthagenys rufogularis	Spiny-cheeked Honeyeater			6					2	9					17
Acanthiza iredalei	Slender-billed Thornbill	17	8		11	6		6						8	56
Amytornis striatus	Striated Grasswren					4	9							4	17
Amytornis textilis myall	Thick- billed Grasswren				5										5
Anas superciliosa	Pacific Black Duck										1				1
Anthochaera carunculata	Red Wattlebird			2											2
Anthus novaeseelandiae	Richard's Pipit					3									3
Aphelocephala leucopsis	Southern Whiteface													5	5
Aquila audax	Wedge-tailed Eagle				3	1									4
Barnardius zonarius	Australian Ringneck			4											4
Cacatua roseicapilla	Galah	30	8												38
Calamanthus campestris	Rufous Fieldwren													2	2
Calamanthus cautus	Shy Heathwren	2			1	1								2	6
Corvus mellori	Little Raven				1										1
Cracticus torquatus	Grey Butcherbird	2	1				2		1					1	7
Egretta novaehollandiae	White-faced Heron												4		4
Epthianura albifrons	White-fronted chat				2				3						5
Falco cenchroides	Nankeen Kestrel		1		1			1							3
Gymnorhina tibicen	Australian Magpie				1		2		4						7
Larus novaehollandiae	Silver gull												11		11
Lichenostomus virescens	Singing honeyeater		2	9						3					14
Malurus lamberti	Variegated Fairy-wren			2											2
Malurus leucopterus	White-winged Fairy-wren	15		4		36	17		15					5	92

Scientific name	Common name	1	3	5	6	10	11	15	22	A	B	C	D	OPP	Grand Total
Ocyphaps lophotes	Crested Pigeon	3								1					4
Pelecanus conspicillatus	Australian Pelican												2		2
Petrochelidon nigricans	Tree Martin	1					9			6	80				96
Phalacrocorax carbo	Great Cormorant									2		2			4
Phalacrocorax melanoleucos	Little Pied cormorant												32		32
Rhipidura leucophrys	Willie Wagtail									2					2
Sterna bergii	Crested Tern												8		8
Total Abundance		70	20	27	25	51	39	7	25	23	81	2	57	27	454
Total Diversity of species		7	5	6	8	6	5	2	5	6	2	1	5	7	30

Habitat of the survey sites:
Site 1 *Maireana sedifolia* (Bluebush), *Maireana pyramidata* (Black Bluebush) Low Open Shrubland
Site 3 *Halosarcia pergranulata* (Black-seed Samphire), *Halosarcia* sp. (Samphire sp.) Low Shrubland
Site 5 *Eucalyptus dumosa* (White Mallee), *Eucalyptus socialis* (Beaked Red Mallee) Mallee.
Site 6 *Maireana sedifolia* (Bluebush), *Maireana pyramidata* (Black Bluebush) Low Open Shrubland
Site 10 *Halosarcia pergranulata* (Black-seed Samphire), *Halosarcia* sp. (Samphire sp.) Low Shrubland
Site 11 *Halosarcia* sp. (Samphire sp.) and Atriplex vesicaria *(Saltbush)*
Site 15 *Maireana sedifolia* (Bluebush), *Maireana pyramidata* (Black Bluebush) Low Open Shrubland
Site 22 Minor Mallee woodland and *Atriplex vesicaria (*Saltbush*)*
Bird A *Avicennia marina* (Grey Mangrove)
Bird B Dam bird site
Bird C *Acacia* and *Dodonaea* species
Bird D Shoreline (southern extent of study area)
Site OPP *Maireana sedifolia (*Bluebush*), Maireana pyramidata* (Black Bluebush*), Atriplex vesicaria (*Saltbush*)* Low Open Shrubland.

4.2.2 Bird abundance and habitat

Site 18 (dam) recorded the highest bird abundance with 81 individuals of two species; high abundance was biased due to the large number of Tree Martins observed skimming the water's surface (Table 18). Site 1, *Maireana sedifolia* (Bluebush), *Maireana pyramidata* (Black Bluebush) Low Open Shrubland recorded the second highest bird abundance with 70 individuals of seven species; the most of which were the Galah (30 individuals) and the Slender-billed Thornbill (17 individuals), which was also the highest number recorded for this species out of all thirteen point count sites (Table 18). Although previously recorded in the November 2009 survey, both the Thick-billed Grasswren and the Striated Grasswren were not observed at this at Site 1.

Site 9 recorded an abundance of 57 individuals of five species; with high numbers of Silver Gull (*Larus novaehollandiae*) and Little Pied Cormorant (*Phalacrocorax melanoleucos*). A number of species were not widespread, and recorded only at one site. For instance; the Red Wattlebird (*Anthochaera carunculata*) and Australian Ringneck (*Barnardius zonarius*) were only recorded at Site 5 (*Eucalyptus dumosa* (White Mallee) and *Eucalyptus socialis* (Beaked Red Mallee) Mallee). The Richards Pipit (*Anthus novaeseelandiae*) was only recorded at Site 10 (*Halosarcia pergranulata* (Black-seed Samphire) and *Halosarcia* sp. (Samphire sp.)). The Southern Whiteface (*Aphelocephala leucopsis*) and Rufous Fieldwren (*Calamanthus campestris*) were only recorded at Site OPP (*Maireana sedifolia* (Bluebush), *Maireana pyramidata* (Black Bluebush) and *Atriplex vesicaria* (Saltbush)).

Site 8, dominated by *Acacia* species and *Dodonaea* species in mixed shrubland recorded the lowest number of birds with an abundance of two and diversity of just one species (Great Cormorant – Table 18). This species was only recorded at one other site during point count surveys; Site 7 (mangroves).

Site 1 (chenopod shrubland) previously recorded Thick-billed Grasswren and Striated Grasswren; however during the latest survey neither were observed and two new threatened species, Slender-billed Thornbill and Shy Heathwren were recorded for the first time. Similarly Striated Grasswren was previously recorded at Site 3 (samphire habitat) however not during the February 2010 survey; with the Slender-billed Thornbill again being recorded. Site 5 (Mallee Woodland) recorded a lower diversity of species during the latest survey including no Striated Grasswren; both White-winged Fairy-wren and Variegated Wren were recorded within the study site. Site OPP (Chenopod Shrubland) recorded a high diversity of threatened species; Slender-billed Thornbill, Striated Grasswren and Shy Heathwren (Table 18).

Of the eight habitat types surveyed as part of the additional bird surveys, only two habitats (Chenopod Shrubland and Samphire Shrubland) had more than one survey site (Table 19). This makes comparing between habitats difficult as the number of replicates varies, however, general observations can be made. The Dam (Site 18) had the highest abundance of all habitat types, however, it had one of the lower species diversity counts with only two species recorded (Table 19). The shoreline habitat (Site 9) had the second highest abundance count and a total of five species recorded. The Chenopod Shrubland

and Samphire Shrubland had a similar average abundance (27.3 and 36.7 respectively) as well as similar species diversity (6 and 5.3 species respectively) (Table 19). The results for the Samphire Shrubland were more consistent between sites, particularly for the species diversity.

Table 19. Comparison of bird abundance and diversity across habitat types.

Habitat	Site No	Total Abundance	Proportion of total abundance	Species diversity	Proportion of all species recorded
Chenopod Shrubland (Bluebush, Black Bluebush and Saltbush)	1	70	15.4	7	23.3
	6	5	1.1	8	26.7
	15	7	1.5	2	6.7
	Site OPP	27	5.9	7	23.3
	Average	27.3	6.0	6	20.0
Samphire Shrubland	3	20	4.4	5	16.7
	10	51	11.2	6	20.0
	11	39	8.6	5	16.7
	Average	36.7	8.1	5.3	17.8
Mallee Woodland	5	27	5.9	6	20.0
	Average	27	5.9	6	20.0
Mallee and Saltbush	22	25	5.5	5	16.7
	Average	25	5.5	5	16.7
Mangroves	7	23	5.1	6	20.0
	Average	23	5.1	3	20.0
Dam	18	81	17.8	2	6.7
	Average	81	17.8	2	6.7
Acacia and *Dodonaea* species	8	2	0.4	1	3.3
	Average	2	0.4	1	3.3
Shoreline	9	57	12.6	5	16.7
	Average	57	12.6	5	16.7
					Total abundance = 454
					Total diversity of sp for PC = 30

4.2.3 Abundance of threatened species across point count sites

The nationally vulnerable Thick-billed Grasswren was not commonly recorded throughout point count surveys or opportunistically, with a total of five observations (making up 0.6% of the total number of birds recorded) (Table 18 and Appendix 1). Thick-billed Grasswren were observed only at Site 1 during the previous survey and only at Site 6 (also of similar habitat to that of Site 1) during the February 2010 survey.

The nationally vulnerable Slender-billed Thornbill was not recorded during the previous survey but found in high numbers during the February 2010 survey; with a total of 56 observations made during point

count surveys and 19 observations during opportunistic surveys (Table 20). Slender-billed Thornbills were recorded at nine out of 13 point count areas surveyed; marking up 9% of the total number of birds recorded, with Site 1 recording the highest number of observations within Chenopod Shrubland (Appendix 1).

The state rare Striated Grasswren was recorded at both point count surveys and opportunistically with a total count of 19 observations, making up 2% of the total number of birds. Site 11 (Samphire Shrubland) recorded the highest number of observations (9) with a total of three new sites established during the February 2010 survey to determine the distribution of this species (Table 20).

The state rare Shy Heathwren was not recorded during the previous survey but observed in low numbers during the February 2010 survey; with a total of six observations made over four point count surveys and none recorded during opportunistic surveys (Table 20).

Table 20. Abundance of threatened species across point count sites and during opportunistic surveying.

Species	Site	PC	OPP
Slender-billed Thornbill	1	17	0
	3	8	0
	6	11	0
	10	6	0
	15	6	0
	Site OPP	8	0
	17	0	1
	24	0	8
	25	0	10
	Total	**56**	**19**
Striated Grasswren	10	**4**	**0**
	11	9	0
	Site OPP	4	0
	23	0	2
	Total	**17**	**2**
Shy Heathwren	1	2	0
	6	1	0
	10	1	0
	Site OPP	2	0
	Total	**6**	0
Thick-billed Grasswren	6	5	0
Total		**5**	0

4.3 Opportunistic results

Twenty-eight bird species were observed during opportunistic surveys (Appendix 1), with a total of 365 observations. Seven species were recorded only as opportunistic observations and not during the point count surveys. These included Yellow-rumped Thornbill (*Acanthiza chrysorrhoa*), Black-faced Woodswallow (*Artamus cinereus*), Stubble Quail (*Coturnix pectoralis*), Blue Bonnet (*Northiella haematogaster haematogaster*), White-browed Babbler (*Pomatostomus superciliosus*), Masked Lapwing (*Vanellus miles*), and the Great Egret (*Ardea alba*). Slender-billed Thornbills and low numbers of Blue Bonnets were recorded at Site 25 (minor Mallee Woodland within Samphire Shrubland) where diversity of species was high (Figure 15). The Great Egret, listed as migratory/marine under the EPBC Act, was recorded at Site 14; just south of Cowled's Landing (Figure 16).

An additional fifteen areas were surveyed opportunistically (Appendix 3) to investigate the presence of shorebirds/waders and to determine an approximate local population for the two threatened species observed during the previous survey. A number of sites were investigated along the coastline within the study area as well as within the wider area with the observer walking considerable distances to be able to use the spotting scope to view shorebirds along the intertidal zone (Figure 17).



Figure 15. Site 25 within mallee and samphire shrubland.



Figure 16. Site 14 situated just south of Cowleds Landing.



Figure 17. Site 21 situated 3 km north of Site 9 (Murninnie Beach).

5 DISCUSSION

5.1 Conservation significant and migratory species observed

Of the 45 conservation significant bird species identified in the initial phase one desktop assessment (EBS 2009), five were observed during the field survey. The nationally vulnerable Thick-billed Grasswren (*Amytornis textilis myall)*, nationally vulnerable Slender-billed Thornbill (*Acanthiza iredalei iredalei*), state rare Striated Grasswren (*Amytornis striatus*), state rare Shy Heathwren (*Calamanthus cautus*) and the nationally listed migratory/marine Great Egret (*Ardea alba*).

The Thick-billed Grasswren, Slender-billed Thornbill, Striated Grasswren and Shy Heathwren were observed amongst chenopod or samphire vegetation associations. Chenopod shrubland is the dominant understorey of survey area, with an estimated 63% coverage. The favourable habitat of the Slender-billed Thornbill; *Halosarcia* sp., *Tecticornia pergranulata* Low Shrubland also covers an extensive area across the study site. It would appear that the Slender-billed Thornbill in particular, is resident to the area as it is unknown to undertake long-distance movements and was observed in high numbers during the latest survey. Due to the observations in the chenopod and samphire areas, and the species' known habitat preference, all four species potentially have a widespread distribution in the area.

Three point count sites recorded three bird species of conservation significance including Site 6, Site 10 and Site Opp. Site 6 recorded Slender-billed Thornbill, Thick-billed Grasswren and Shy Heathwren. Site 10 and Site Opp recorded Slender-billed Thornbill, Shy Heathwren and Striated Grasswren. These three sites should be given particular consideration when minimising ground disturbance and limiting prolonged exploration and mining activities within this habitat type.

Call-back methodology to gain response by threatened species was particularly effective for recording Slender-billed Thornbills within the study site and accounts for the high abundance documented in this report.

Thick-billed Grasswren

Five records of the nationally vulnerable Thick-billed Grasswren (*Amytornis textilis myall*) were observed during the February 2010 survey (phase three). This is slightly lower than the seven individuals observed during phase two in October 2009. All observations were within *Maireana sedifolia* (Bluebush), *Maireana pyramidata* (Black Bluebush) Low Open Shrubland.

Thick-billed Grasswren are likely to be sedentary (Schodde 1982), and territorial throughout the year (Higgins *et al*. 2001). This means that they probably remain within their breeding territories outside of the June to September breeding season (Schodde 1982, Brooker 1988). In some locations pairs are expected to remain in an area of four to five hectares, however home ranges may be as large as 20 - 40 ha (Schodde 1982). The size of these home ranges means that birds can inhabit suitable habitat at a very low density. We can assume this is the case within the Mullaquana study area where seven individuals were recorded in the first instance (phase two survey in October 2009) and five observations

within the second survey (phase three survey in February 2010). One reason for such low numbers might be that Thick-billed Grasswrens may undertake some nomadic movements during particularly dry periods (Serventy *et al.* 1982). Due to the extremely shy and elusive behaviour of the Thick-billed Grasswren, they can be easily overlooked. Unlike other arid land birds they also do not congregate into locally nomadic groups after breeding, meaning that they are less conspicuous. Both sites where the Thick-billed Grasswren were recorded (Sites 1 and 6) were within chenopod shrubland; a habitat which constitutes a large portion of the overall study site.

A number of records for this species have been found between 1990 and 2006 (EBS 2010); across a wider distribution of the study area as well as during the *Mullaquana Flora and Fauna Baseline Survey.* Whilst the preferred habitat of the Thick-billed Grasswren is considered widespread, it is difficult to estimate an accurate population size within the study area. There may be some localised impact to this species however the impact is unlikely to be significant. Further investigation into the wider distribution of this species would be beneficial in determining its population size and likely impacts.

Striated Grasswren

The state rare Striated Grasswren (*Amytornis striatus*) was observed in low numbers at Site 10 (four individuals), Site 11 (nine individuals) and Site OPP (four individuals) as well as two observations made during opportunistic surveys. Sites 10 and 11 were situated within samphire shrubland and Site OPP within chenopod shrubland (Table 19).

Striated Grasswrens live in pairs, or occasionally groups of three. They have territories of around three hectares and spend most of their time patrolling the edges of their territory, or interacting with grasswrens from nearby territories (Higgins *et al.* 2001). The normal habitat of Striated Grasswrens is open mallee over a sparse layer of shrubs and a ground layer dominated by spinifex (*Triodia*), though they are sometimes found in association with mallee eucalypts and sandy soils. This has proven the case at Sites 10 and 11; both of which share similar habitat to Site 3 where Striated Grasswrens were recorded in the previous survey, as well as at Site OPP which shares similar habitat to Site 1 (where this species was again observed in the first instance).

The preferred habitat of mallee eucalypt and sandy soils appears to be more widespread outside the study area. It is difficult to estimate an accurate population size of this species without undertaking further investigation into the wider distribution of this species. There may be some localised impact to this species however the impact is unlikely to be significant.

Slender-billed Thornbill

Slender-billed Thornbills were recorded in high numbers (17 individuals) at Site 1; *Maireana sedifolia* (Bluebush), *Maireana pyramidata* (Black Bluebush) Low Open Shrubland as well as at Sites 3 and 10 (14 individuals) situated within *Halosarcia pergranulata* (Black-seed Samphire), *Halosarcia* sp. (Samphire sp) Low Shrubland (Table 20). Individuals were noted as little as 5-15 m from the observer whereby their song was positively verified when using call-back techniques.

The western race of the Slender-billed Thornbill (*A. iredalei iredalei*) is sparsely distributed across arid and semi-arid southern WA, and western SA. In SA they occur near Port Pirie, Gawler Ranges and upper Eyre Peninsula, with a stronghold across the Nullabour (Schodde and Mason 1999). There is also a population in samphire communities on the shores of the Spencer Gulf. The sub-species generally inhabits treeless chenopod shrublands dominated by bluebush *Maireana* and saltbush *Atriplex*, and saline flats associated with salt lakes, particularly where there is glasswort *Halosarcia* (Baxter and Paton 1998). The sub-species have also been recorded in shrublands and mangroves at coastal sites where these habitat types occur adjacent to more preferred samphire shrublands (Baxter and Paton 1998). Slender-billed Thornbills forages in low shrubs and on the ground seeking insects and other small prey from the foliage of samphire and saltbush shrubs, and from the surrounding ground (Hall 1974).

Because of the lack of targeted surveys, the inconspicuous nature of the bird, and the inaccessibility of its preferred habitats, the distribution and, even more so, the population size of the Slender-billed Thornbill (western) are poorly known. For these reasons, current estimates of the distribution and population size possibly underestimate the actual distribution and population size. The total population size of the Slender-billed Thornbill (western) is likely to be stable at present (Garnett & Crowley 2000).

From the numbers recorded during the latest survey, it can be suggested that this species may be resident as chenopod and samphire shrubland are the dominant habitat of the Mullaquana study area. This can be substantiated by the fact the Slender-billed Thornbill (western) is a resident or sedentary subspecies that is not known to undertake any long-distance movements (Higgins & Peter 2002).

A number of records for this species have been found between 1925 and 2006 (EBS 2010); adjacent to the study area as well as observed during the latest survey. Given that the population size of this subspecies is poorly known, it is difficult to estimate an accurate population size within the study area. The field trial area will encompass 250 ha central to a 4 km square referral area. There may be some localised impact to this species however the impact is unlikely to be significant. Further investigation into the wider distribution of this species would be beneficial in determining its population size and likely impacts.

Shy Heathwren

The Shy Heathwren was recorded in low numbers (six individuals) across four point count areas; three of which were located within *Maireana sedifolia* (Bluebush), *Maireana pyramidata* (Black Bluebush) Low Open Shrubland and one site within *Halosarcia pergranulata* (Black-seed Samphire), *Halosarcia* sp. (Samphire sp) Low Shrubland (Table 20).

The Shy Heathwren is a small bird superficially similar in appearance to fairy-wrens, though larger in size. The rump and tail coverts (both above and below) have a striking, fiery rufous-chestnut colour. The nominate subspecies (*cauta*) occurs in north west Victoria and eastern South Australia as far west as the Flinders Ranges (Higgins & Peter 2002). Shy Heathwren feed mostly on the ground on insects such grasshoppers, beetles, caterpillars and spiders and rarely feed on seeds, including those of saltbush. They generally occur singly or in pairs, where they can be secretive, keeping within dense understorey of

shrubs and heath plants within Mallee Woodlands (Higgins & Peter 2002). Further investigation into the wider distribution of this species would be beneficial in determining its population size and likely impacts. There may be some localised impact to this species however the impact is unlikely to be significant.

Great Egret

Two individuals were sighted opportunistically flying overhead when the observer was walking through mangroves to the shoreline, south of Cowleds Landing (within the study area).

Great Egrets prefer shallow water particularly when flowing but may be seen on any watered area, including damp grasslands. The Great Egret has been reported in a wide range of wetland habitats (e.g. inland and coastal, freshwater and saline, permanent and ephemeral, open and vegetated, large and small, natural and artificial) (Kushlan & Hancock 2005). Great Egrets can be seen alone or in small flocks, often with other egret species, and roost at night in groups. The Great Egret usually hunts in water, wading through the shallows, or standing motionless before stabbing at prey (Pringle 1985).

The Great Egret is partially migratory, with northern hemisphere birds moving south from areas with cold winters. The overall population trends of the Great Egret is not well understood (Maddock 2000). This may be attributed in part to the difficulty associated with assessing trends for a species that occupies individual sites erratically, and often in highly variable numbers, across a wide geographic area (Wetlands International 2006). Populations across Australia are considered to fluctuate in size in recognition of the highly variable availability of suitable wetland habitat. This species is most likely to fly-over the study area rather than use the site for any other reason. Impact is unlikely to be significant.

5.2 Shorebird species

Although a small number of shorebirds were recorded during the survey period, no conservation significant species were observed. One EPBC listed migratory species was observed, the Great Egret (*Ardea alba*) (see above). The non-detection of conservation significant shorebirds may have been influenced by the extreme low tide that occurred during the study; with low tide at approximately 20:00 hrs. The observer walked between 500-800m to reach the inter-tidal zone and a spotting scope was used to identify shorebirds along the water's edge or amongst mangroves. Site 9 (Murninnie Beach) was documented as being favourable habitat for Pied Oystercatchers and Hooded Plovers on the shorebird sign at Murninnie Beach (Figure 18), however neither of these species were observed.

Although the inter-tidal zone was surveyed, the late high tide may have influenced the number of birds recorded as many could have been returning to wade along the shoreline at dusk. Similarly the conservation zone at Cowleds Landing also recorded a low diversity of shorebirds; with the Crested Tern (*Sterna bergii*) and Pacific Gull (*Larus pacificus*) being two of the few species recorded. Two unidentifiable sandpipers were observed on 22 February 2010 at Site 14 which was located just south of Cowled's Landing.



Figure 18. Shorebird sign situated at Site 9 Murninnie Beach.

6 MITIGATION MEASURES

Future exploration, mining activities and development may impact upon the threatened bird species that have been found during two on-site surveys of the Mullaquana and Nonowie region. Such impacts may be a result of direct habitat clearance of important habitat, or through construction of infrastructure creating visual barriers, noise and vibration impacts. Recommended preventative measures are:

- where possible, limit site disturbance at locations where the Thick-billed Grasswren, Striated Grasswren and Shy Heathwren were observed (namely at Sites 1, 6, 10, 11 and site OPP).
- where possible, limit prolonged activities when undertaking drilling and other works in areas of known habitat of the Thick-billed Grasswren, Striated Grasswren and Shy Heathwren. Work small areas at a time, and move all equipment as soon as possible.
- where possible, avoid all activities in areas where large numbers of Slender-billed Thornbills were recorded (namely at Sites 1, 3, 6, 10, 15 and site OPP).
- minimise ground disturbance by utilising existing tracks when travelling through chenopod and samphire habitat where threatened species were recorded.

The occurrence of the EPBC listed Thick-billed Grasswren, Slender-billed Thornbill and Great Egret should be taken into consideration when preparing and revising EPBC referral requirements.

7 REFERENCES AND BIBLIOGRAPHY

Baxter, C., Paton, P.A. (1998). Further notes on the birds of the Gawler Ranges. *South Australian* Ornithologist. 33:1-15.

Brooker, M.G. (1988) Some aspects of the biology and conservation of the Thick-billed Grasswren Amytornis textilis in the Shark Bay area, Western Australia. Corella 12, 101-108.

DEH (2008) Biological Database Records of South Australia (BDBSA). Department of Environment and Heritage, Adelaide.

EBS (2010) *Mullaquana Flora and Fauna Baseline Survey.* Report to UraniumSA. EBS Ecology, Adelaide.

EBS (2009) Mullaquana Flora and Fauna Survey – Initial Assessment. Report to UraniumSA. Environmental and Biodiversity Services, Adelaide.

Garnet, S.T., Crowley, G.M. (2000) *The action plan for Australian birds*. Environment Australia, Canberra.

Hall, B.P. (Ed.) (1974). Birds of the Harold Hall Australian Expeditions, 1962-70. London: British Museum (Natural History).

Higgins, P.J., Peter, J.M. (Eds). (2002) Handbook of Australian, New Zealand and Antarctic Birds

Volume 6: Pardalotes to Shrike-thrushes. Melbourne: Oxford University Press.

Higgins P.J., Peter, J.M., Steele W.K. (Eds) (2001) *Handbook of Australian, New Zealand and Antarctic*

Birds. Volume 5: Tyrant-flycatchers to Chats. Oxford University Press.

Kushlan, J.A., Hancock, J. (2005) *Herons*. Oxford, United Kingdom: Oxford University Press.

Pringle, J.D. (1985) *The Waterbirds of Australia*. Angus and Robertson/National Photographic Index of Australian Wildlife, Sydney.

Schodde, R. (1982) The Fairy-wrens: a Monograph of the Maluridae. Lansdowne, Melbourne.

Schodde, R., Mason, I.J. (1999) The Directory of Australian Birds: Passerines. CSIRO, Melbourne.

Serventy, V.N. (Ed) (1982) *The Wrens and Warblers of Australia.* Angus and Robertson and the Australian Photographic Index of Australian Wildlife, Sydney.

Wetlands International (2006) Waterbird Population Estimates. Fourth Edition. Wetlands International. Wageningen, The Netherlands.

8 APPENDICES

Appendix 1. Abundance of all species recorded during Point Counts (PC) and Opportunistically (OPP) during the Feb 10 survey of Mullaquana.

Species recorded OPP that were not seen during PC are highlighted in red.

Scientific name	Common name	PC	OPP	Totals	Aus status	SA status
Acanthagenys rufogularis	Spiny-cheeked Honeyeater	17	9	26		
Acanthiza chrysorrhoa	Yellow-rumped Thornbill		4	4		
Acanthiza iredalei	Slender-billed Thornbill	56	19	75	VU	R
Amytornis striatus	Striated Grasswren	17	2	19		R
Amytornis textilis myall	Thick- billed Grasswren	5		5	VU	
Anas superciliosa	Pacific Black Duck	1		1		
Anthochaera carunculata	Red Wattlebird	2		2		
Anthus novaeseelandiae	Richard's Pipit	3	1	4		
Aphelocephala leucopsis	Southern Whiteface	5		5		
Aquila audax	Wedge-tailed Eagle	4	1	5		
Ardea alba	Great Egret		2	2	Migratory*	
Artamus cinereus	Black-faced Woodswallow		18	18		
Barnardius zonarius	Australian Ringneck	4		4		
Cacatua roseicapilla	Galah	38		38		
Calamanthus campestris	Rufous Fieldwren	2		2		
Calamanthus cautus	Shy Heathwren	6		6		R
Corvus mellori	Little Raven	1	2	3		
Coturnix pectoralis	Stubble Quail		1	1		
Cracticus torquatus	Grey Butcherbird	7	6	13		
Egretta novaehollandiae	White-faced Heron	4	8	12		
Epthianura albifrons	White-fronted chat	5	13	18		
Epthianura aurifrons	Orange Chat		3	3		
Falco cenchroides	Nankeen Kestrel	3	1	4		
Gymnorhina tibicen	Australian Magpie	7	5	12		
Larus novaehollandiae	Silver gull	11	52	63		
Larus pacificus	Pacific Gull		7	7		
Lichenostomus virescens	Singing honeyeater	14	2	16		
Malurus cyaneus	Superb Fairy-wren		15	15		
Malurus lamberti	Variegated Fairy-wren	2		2		
Malurus leucopterus	White-winged Fairy-wren	92	31	123		
Northiella h. haematogaster	Blue Bonnet		3	3		
Ocyphaps lophotes	Crested Pigeon	4		4		
Pelecanus conspicillatus	Australian Pelican	2	14	16		
Petrochelidon nigricans	Tree Martin	96	102	198		
Phalacrocorax carbo	Great Cormorant	4	5	9		
Phalacrocorax melanoleucos	Little Pied cormorant	32		32		
Pomatostomus superciliosus	White-browed Babbler		13	13		
Rhipidura leucophrys	Willie Wagtail	2		2		
Sterna bergii	Crested Tern	8	21	29		
Vanellus miles	Masked Lapwing		5	5		

Scientific name	Common name	PC	OPP	Totals	Aus status	SA status
	Totals	454	365	819		
	Diversity of species	30	28	40		

***Migratory wetland / marine / Over-fly, VU = vulnerable, R= rare.**

Appendix 2. Bird species recorded for the wider Mullaquana area as identified in the Biological Database of South Australia search (EBS 2009).

Species	Common name	Aus status	SA status
Acanthagenys rufogularis	Spiny-cheeked Honeyeater		
Acanthiza apicalis	Inland Thornbill		
Acanthiza chrysorrhoa	Yellow-rumped Thornbill		
Acanthiza iredalei	Slender-billed Thornbill	VU	R
Acanthiza lineata	Striated Thornbill		
Acanthiza nana	Yellow Thornbill		
Acanthiza uropygialis	Chestnut-rumped Thornbill		
Acanthorhynchus tenuirostris	Eastern Spinebill		
Accipiter cirrocephalus	Collared Sparrowhawk		
Accipiter fasciatus	Brown Goshawk		
Acrocephalus australis	Australian Reed-Warbler		
Actitis hypoleucos	Common Sandpiper		R
Aegotheles cristatus	Australian Owlet-nightjar		
Alauda arvensis	Eurasian Skylark		
Amytornis striatus	Striated Grasswren		R
Amytornis textilis	Thick-billed Grasswren	VU	
Amytornis textilis myall	Thick-billed Grasswren	VU	
Anas castanea	Chestnut Teal		
Anas gracilis	Grey Teal		
Anas platyrhynchos	Northern Mallard		
Anas superciliosa	Pacific Black Duck		
Anthochaera carunculata	Red Wattlebird		
Anthus novaeseelandiae	Australasian Pipit		
Aphelocephala leucopsis	Southern Whiteface		
Aphodroma brevirostris	Kerguelen Petrel		
Apus pacificus	Fork-tailed Swift		
Aquila audax	Wedge-tailed Eagle		
Ardea alba	Eastern Great Egret		
Ardea ibis	Cattle Egret		R
Ardea intermedia	Intermediate Egret		R
Ardea pacifica	White-necked Heron		
Ardeotis australis	Australian Bustard		V
Arenaria interpres	Ruddy Turnstone		R
Artamus cinereus	Black-faced Woodswallow		
Artamus cyanopterus	Dusky Woodswallow		
Artamus minor	Little Woodswallow		
Artamus personatus	Masked Woodswallow		
Artamus superciliosus	White-browed Woodswallow		
Aythya australis	Hardhead		
Barnardius sp.			
Barnardius zonarius	Australian Ringneck		
Biziura lobata	Musk Duck		R
Cacatua galerita	Sulphur-crested Cockatoo		
Cacatua sanguinea	Little Corella		

Species	Common name	Aus status	SA status
Cacomantis flabelliformis	Fan-tailed Cuckoo		
Cacomantis pallidus	Pallid Cuckoo		
Calamanthus campestris	Rufous Fieldwren		
Calidris acuminata	Sharp-tailed Sandpiper		
Calidris canutus	Red Knot		
Calidris ferruginea	Curlew Sandpiper		
Calidris ruficollis	Red-necked Stint		
Calidris tenuirostris	Great Knot		R
Cereopsis novaehollandiae	Cape Barren Goose		R
Certhionyx variegatus	Pied Honeyeater		
Chalcites basalis	Horsfield's Bronze-cuckoo		
Chalcites lucidus	Shining Bronze-Cuckoo		
Chalcites osculans	Black-eared Cuckoo		
Charadrius australis	Inland Dotterel		
Charadrius leschenaultii	Greater Sand Plover		R
Charadrius mongolus	Lesser Sand Plover		R
Charadrius ruficapillus	Red-capped Plover		
Charadrius veredus	Oriental Plover		
Chenonetta jubata	Australian Wood Duck		
Cheramoeca leucosterna	White-backed Swallow		
Chlidonias hybrida	Whiskered Tern		
Chroicocephalus novaehollandiae	Silver Gull		
Cincloramphus cruralis	Brown Songlark		
Cincloramphus mathewsi	Rufous Songlark		
Cinclosoma castanotum	Chestnut Quail-thrush		V
Cinclosoma cinnamomeum	Cinnamon Quail-thrush		
Circus approximans	Swamp Harrier		
Circus assimilis	Spotted Harrier		
Cladorhynchus leucocephalus	Banded Stilt		V
Climacteris picumnus	Brown Treecreeper		
Climacteris rufus	Rufous Treecreeper		
Colluricincla harmonica	Grey Shrike-thrush		
Columba livia	Rock Dove		
Coracina maxima	Ground Cuckoo-shrike		
Coracina novaehollandiae	Black-faced Cuckoo-shrike		
Corcorax melanorhamphos	White-winged Chough		R
Corvus bennetti	Little Crow		
Corvus coronoides	Australian Raven		
Corvus mellori	Little Raven		
Corvus sp.			
Coturnix pectoralis	Stubble Quail		
Coturnix ypsilophora	Brown Quail		V
Cracticus tibicen	Australian Magpie		
Cracticus torquatus	Grey Butcherbird		
Cygnus atratus	Black Swan		

Species	Common name	Aus status	SA status
Dacelo novaeguineae	Laughing Kookaburra		
Daphoenositta chrysoptera	Varied Sittella		
Dicaeum hirundinaceum	Mistletoebird		
Dromaius novaehollandiae	Emu		
Drymodes brunneopygia	Southern Scrub-robin		
Egretta garzetta	Little Egret		R
Egretta novaehollandiae	White-faced Heron		
Egretta sacra	Eastern Reef Egret		R
Elanus axillaris	Black-shouldered Kite		
Elanus scriptus	Letter-winged Kite		R
Elseyornis melanops	Black-fronted Dotterel		
Emblema pictum	Painted Finch		R
Eolophus roseicapillus	Galah		
Eopsaltria griseogularis	Western Yellow Robin		
Epthianura albifrons	White-fronted Chat		
Epthianura aurifrons	Orange Chat		
Epthianura sp.			
Epthianura tricolor	Crimson Chat		
Erythrogonys cinctus	Red-kneed Dotterel		
Eudyptula minor	Little Penguin		
Eurostopodus argus	Spotted Nightjar		
Eurostopodus sp.			
Falco berigora	Brown Falcon		
Falco cenchroides	Nankeen Kestrel		
Falco longipennis	Australian Hobby		
Falco peregrinus	Peregrine Falcon		R
Falco subniger	Black Falcon		
Falcunculus frontatus	Crested Shrike-tit		R
Fulica atra	Eurasian Coot		
Gallinago stenura	Pintail Snipe		
Gallinula tenebrosa	Dusky Moorhen		
Gallirallus philippensis	Buff-banded Rail		
Gelochelidon nilotica	Gull-billed Tern		
Geopelia placida	Peaceful Dove		
Glossopsitta concinna	Musk Lorikeet		
Glossopsitta porphyrocephala	Purple-crowned Lorikeet		
Glossopsitta pusilla	Little Lorikeet		E
Glyciphila melanops	Tawny-crowned Honeyeater		
Grallina cyanoleuca	Magpie-lark		
Haematopus fuliginosus	Sooty Oystercatcher		R
Haematopus longirostris	Australian Pied Oystercatcher		R
Haliaeetus leucogaster	White-bellied Sea-Eagle		E
Haliastur sphenurus	Whistling Kite		
Hieraaetus morphnoides	Little Eagle		
Himantopus himantopus	Black-winged Stilt		

Species	Common name	Aus status	SA status
Hirundo neoxena	Welcome Swallow		
Hydroprogne caspia	Caspian Tern		
Hylacola cauta	Shy Heathwren (Shy Hylacola)		R
Hylacola pyrrhopygia	Chestnut-rumped Heathwren		V
Lalage sp.			
Lalage sueurii	White-winged Triller		
Larus dominicanus	Kelp Gull		R
Larus pacificus	Pacific Gull		
Leipoa ocellata	Malleefowl	VU	V
Lichenostomus chrysops	Yellow-faced Honeyeater		
Lichenostomus cratitius	Purple-gaped Honeyeater		R
Lichenostomus leucotis	White-eared Honeyeater		
Lichenostomus ornatus	Yellow-plumed Honeyeater		
Lichenostomus penicillatus	White-plumed Honeyeater		
Lichenostomus plumulus	Grey-fronted Honeyeater		
Lichenostomus virescens	Singing Honeyeater		
Limosa lapponica	Bar-tailed Godwit		R
Limosa limosa	Black-tailed Godwit		R
Lophocroa leadbeateri	Major Mitchell's Cockatoo		R
Lophoictinia isura	Square-tailed Kite		E
Malacorhynchus membranaceus	Pink-eared Duck		
Malurus lamberti	Variegated Fairy-wren		
Malurus leucopterus	White-winged Fairy-wren		
Malurus pulcherrimus	Blue-breasted Fairy-wren		
Malurus splendens	Splendid Fairy-wren		
Manorina flavigula	Yellow-throated Miner		
Megalurus gramineus	Little Grassbird		
Melanodryas cucullata	Hooded Robin		
Melithreptus brevirostris	Brown-headed Honeyeater		
Melopsittacus undulatus	Budgerigar		
Merops ornatus	Rainbow Bee-eater		
Microcarbo melanoleucos	Little Pied Cormorant		
Microeca fascinans	Jacky Winter		
Milvus migrans	Black Kite		
Mirafra javanica	Horsfield's Bushlark		
Morus serrator	Australasian Gannet		
Myiagra inquieta	Restless Flycatcher		R
Neophema chrysogaster	Orange-bellied Parrot	CE	E
Neophema chrysostoma	Blue-winged Parrot		V
Neophema elegans	Elegant Parrot		R
Neophema petrophila	Rock Parrot		R
Neophema sp.			
Neophema splendida	Scarlet-chested Parrot		R
Neopsephotus bourkii	Bourke's Parrot		
Ninox novaeseelandiae	Southern Boobook		

Species	Common name	Aus status	SA status
Northiella haematogaster	Blue Bonnet		
Numenius madagascariensis	Eastern Curlew		V
Numenius phaeopus	Whimbrel		R
Nycticorax caledonicus	Nankeen Night-Heron		
Nymphicus hollandicus	Cockatiel		
Ocyphaps lophotes	Crested Pigeon		
Oreoica gutturalis	Crested Bellbird		
Oxyura australis	Blue-billed Duck		R
Pachycephala inornata	Gilbert's Whistler		R
Pachycephala pectoralis	Golden Whistler		
Pachycephala rufiventris	Rufous Whistler		
Pachyptila desolata	Antarctic Prion		
Pandion cristatus	Eastern Osprey		E
Pardalotus punctatus	Spotted Pardalote		
Pardalotus striatus	Striated Pardalote		
Passer domesticus	House Sparrow		
Pelecanus conspicillatus	Australian Pelican		
Petrochelidon ariel	Fairy Martin		
Petrochelidon nigricans	Tree Martin		
Petroica boodang	Scarlet Robin		V
Petroica goodenovii	Red-capped Robin		
Petroica rosea	Rose Robin		
Phalacrocorax carbo	Great Cormorant		
Phalacrocorax fuscescens	Black-faced Cormorant		
Phalacrocorax sulcirostris	Little Black Cormorant		
Phalacrocorax varius	Pied Cormorant		
Phalaropus lobatus	Red-necked Phalarope		
Phaps chalcoptera	Common Bronzewing		
Phaps elegans	Brush Bronzewing		
Phaps sp.			
Philomachus pugnax	Ruff		R
Phylidonyris albifrons	White-fronted Honeyeater		
Phylidonyris novaehollandiae	New Holland Honeyeater		
Platalea flavipes	Yellow-billed Spoonbill		
Platalea regia	Royal Spoonbill		
Platycercus elegans	Crimson Rosella		
Plegadis falcinellus	Glossy Ibis		R
Pluvialis fulva	Pacific Golden Plover		R
Pluvialis squatarola	Grey Plover		
Podargus strigoides	Tawny Frogmouth		
Poliocephalus poliocephalus	Hoary-headed Grebe		
Pomatostomus superciliosus	White-browed Babbler		
Porphyrio porphyrio	Purple Swamphen		
Porzana fluminea	Australian Spotted Crake		
Porzana pusilla	Baillon's Crake		

Species	Common name	Aus status	SA status
Porzana tabuensis	Spotless Crake		R
Psephotus haematonotus	Red-rumped Parrot		
Psephotus varius	Mulga Parrot		
Psophodes cristatus	Chirruping Wedgebill		
Pyrrholaemus brunneus	Redthroat		
Recurvirostra novaehollandiae	Red-necked Avocet		
Rhipidura albiscapa	Grey Fantail		
Rhipidura leucophrys	Willie Wagtail		
Sericornis frontalis	White-browed Scrubwren		
Smicrornis brevirostris	Weebill		
Stagonopleura guttata	Diamond Firetail		V
Sterna hirundo	Common Tern		R
Sternula nereis	Fairy Tern		E
Stictonetta naevosa	Freckled Duck		V
Stigmatopelia chinensis	Spotted Dove		
Strepera versicolor	Grey Currawong		
Struthidea cinerea	Apostlebird		
Sturnus vulgaris	Common Starling		
Sugomel niger	Black Honeyeater		
Tachybaptus novaehollandiae	Australasian Grebe		
Taeniopygia guttata	Zebra Finch		
Thalasseus bergii	Crested Tern		
Threskiornis molucca	Australian White Ibis		
Threskiornis spinicollis	Straw-necked Ibis		
Todiramphus pyrrhopygius	Red-backed Kingfisher		
Todiramphus sanctus	Sacred Kingfisher		
Tribonyx ventralis	Black-tailed Native-hen		
Trichoglossus haematodus	Rainbow Lorikeet		
Tringa brevipes	Grey-tailed Tattler		R
Tringa nebularia	Common Greenshank		
Tringa stagnatilis	Marsh Sandpiper		
Tringa totanus	Common Redshank		
Turdus merula	Common Blackbird		
Turnix varius	Painted Button-quail		R
Turnix velox	Little Button-quail		
Tyto javanica	Eastern Barn Owl		
Vanellus miles	Masked Lapwing		
Vanellus tricolor	Banded Lapwing		
Zosterops lateralis	Silvereye		

Appendix 3. Easting and Northing coordinates for sites surveyed during the February 2010 survey.

Site No	Zone	Easting	Northing
1	53 H	724872	6325055
3	53 H	725681	6321373
5	53 H	720263	6320182
6	53 H	725646	6327183
7 (Bird A)	53 H	726993	6324067
8 (Bird C)	53 H	727047	6324612
9 (Bird D)	53 H	721668	6311693
10	53 H	725530	6322666
11	53 H	725694	6323925
12	53 H	727787	6328713
13	53 H	727834	6327635
14	53 H	727943	6327485
15	53 H	723617	6322059
16	53 H	723062	6320807
17	53 H	724789	6324899
18 (Bird B)	53 H	723593	6324829
19	53 H	723918	6324476
20	53 H	724609	6324441
21	53 H	723706	6315637
22	53 H	723512	6317100
23	53 H	725548	6323458
24	53 H	725087	6320647
25	53 H	724675	6319315
26	53 H	721463	6321601
OPP	53 H	725133	6323568



EBS Ecology

4/48 Barwell Avenue

Kurralta Park, SA 5037

www.ebservices.com.au

t. 08 7127 5607

f. 08 8297 3768

J6: Samphire Flora & Fauna Survey – Spring 2012. Report prepared for UraniumSA Ltd by EBS Ecology, December 2012.

ebs ecology



Samphire Flora and Fauna Survey
Spring 2012

Samphire Flora and Fauna Survey Spring 2012

5 December 2012

Version 1.2

Prepared by EBS Ecology for Uranium SA

Document Control					
Revision No.	Date issued	Authors	Reviewed by	Date Reviewed	Revision type
1	18/10/2012	J. Green / A. Derry	M. Launer	23/10/2012	Draft
1.1	15/11/2012	A. Derry	A. Derry	15/11/2012	Draft
1.2	5/12/12	A. Derry	J. Green	5/12/12	Final

Distribution of Copies			
Revision No.	Date issued	Media	Issued to
1	23/10/2012	Electronic	Russel Bluck, UraniumSA
1.1	15/11/2012	Electronic	Russel Bluck, UraniumSA

COPYRIGHT: Use or copying of this document in whole or in part (including photographs) without the written permission of EBS Ecology's client and EBS Ecology constitutes an infringement of copyright.

LIMITATION: This report has been prepared on behalf of and for the exclusive use of EBS Ecology's Client, and is subject to and issued in connection with the provisions of the agreement between EBS Ecology and its Client. EBS Ecology accepts no liability or responsibility whatsoever for or in respect of any use of or reliance upon this report by any third party.

CITATION: EBS Ecology (2012) *Samphire Flora and Fauna Spring Report.* Report to Uranium SA, EBS Ecology, Adelaide.

Front cover photo: Rufous Fieldwren (*Calamanthus campestris*) singing whilst using call-broadcasting to solicit responses from the birds.

Table of Contents

1 INTRODUCTION 2

1.1 Objectives 2

2 METHODS 3

2.1 Field survey 3

2.1.1 Vegetation 3

2.1.2 Fauna 3

2.2 Survey Limitations 4

3 RESULTS 5

3.1 Flora species 5

3.2 Fauna species 5

3.2.1 Reptiles and Mammals 5

3.2.2 Birds 6

3.2.3 Bats 7

List of Tables

Table 1. Mammal and Reptile observations for spring 2012 survey (including animals captured at the F1 and F2 fauna trapping sites over five days and opportune animal sightings on the Samphire property area). 5

Table 2. Bird species observed during spring 2012 across six monitoring sites. 6

List of Figures

Figure 1. Example calls from the survey for each species recorded. 8

1 INTRODUCTION

A revisit to long-term sampling sites on the Samphire project site was conducted by EBS Ecology in Spring 2012. During this survey only sites on the Nonowie property were surveyed (previous surveys by EBS had included sites on the adjacent Mullaquanna property).

1.1 Objectives

The objectives of the project were to:

- revisit eight vegetation, two fauna and six bird monitoring sites on Nonowie Station that had been established in previous surveys
- identify and map any threatened species that may be present
- identify other fauna and flora of interest (including pest plants and animals) opportunistically whilst on the property
- provide a summary of the data collected during this survey.

2 METHODS

2.1 Field survey

2.1.1 Vegetation

Vegetation monitoring sites V1, V2, V8, V9, V10, V11, V12 and V13 were revisited during the spring 2012 survey. At each site two monitoring methods were conducted. A 100 metre x 100 metre quadrat was established and permanently marked with star droppers to ensure repeatability of the same size and location. Also contained within the quadrat is a 100 m transect, referred to as a Jessup transect (the start and ends points are also permanently marked). Two of the vegetation sites (V1 and V2) are located in close proximity (between 100 – 200 m) to the fauna sites.

2.1.2 Fauna

Trapping

Trapping followed the Biological Survey methodology for vertebrate surveys (Owens 2000) with the addition of funnel traps. Survey sites F1 and F2 were re-established (lidded pitfalls were in situ from previous baseline survey). Two trap lines positioned approximately 200 m apart were installed at each site. Each line consisting of six pitfall traps, 15 medium Elliott traps, two cage traps and four funnel traps were installed at each of the two fauna sites. All traps were open for four consecutive nights, with Elliott and cage traps closed during the day to avoid animal distress in the heat of the day.

Opportunistic Observations

Field surveyors recorded all fauna observations while on-site. For each observation, the species, location (GPS waypoint), date, number of individuals, and broad habitat type was recorded. Presence of tracks, nests, scats, diggings and burrows (identified to species level if possible) were also recorded as opportune observations.

Bat call recording

A passive bat survey was conducted using AnaBat's to record bat ultrasonic echolocation calls. A single Anabat detector was used at each of the two fauna trapping sites for one night. Recorded bat echolocation calls were analysed and compared with known reference calls for the region held by the SA Museum.

Bird surveys

Standardised bird surveys were conducted at six sites (Sites 1, 2, 6, 11, 12 & 13) (site naming follows that of the baseline survey and follow-up bird survey conducted in November 2009). Each site was surveyed for 60 minutes in the morning and 60 minutes in the afternoon. The repeat visits allow for maximising the species likely to be present, assuming species use the habitats for different purposes at

different times of the day, as well as increasing the chance of presence and detection as most species are relatively mobile. A single observer conducted an area search recording all birds that could be positively identified by sight within the site or immediately adjacent if the habitat was similar. A portable MP3 player and speaker unit was used to play recorded calls of several species (in particular the Slender-billed Thornbill) to encourage these species to call-back, therefore making their presence at the site known to the observer.

2.2 Survey Limitations

In comparison to earlier fauna and flora surveys at this site, this survey was restricted to sites that had previously been established on Nonowie Station, and not those sites on Mullaquanna Station; hence the survey is not consistent with the original intent of including survey sites in the full range of ecological communities across the geographical extent of the area of interest. The implications of this are that variations between this survey and previous surveys can only be considered at a site level rather than broad ecological communities or for the area overall. As with all surveys, it cannot be expected that all species present within the survey area were observed. The presence and abundance of both fauna and flora species will vary seasonally and in response to environmental conditions.

3 RESULTS

3.1 Flora species

In comparison to previous surveys, the condition of vegetation on site indicated that it has been a drier spring this year, as fewer annual plants were observed and many perennial plants such as the Oblique-spined Bindyi (*Sclerolaena obliquicuspis*) were already drying off. Some of the flora study sites showed higher numbers of juvenile Bluebush (*Maireana sedifolia*) and Bladder Saltbush (*Atriplex vesicaria*) than recorded in previous years indicating favourable seedling establishment conditions over the preceding months.

Two individuals of the shrub Sandalwood (*Santalum spicatum*) which is listed as vulnerable in South Australia were opportunistically identified in woodland at the following locations:
33°11'11.40"S:137°19'41.48"E and 33°11'8.25"S:137°22'42.28"E

Several invasive weeds occur on the property with most concentrations occurring adjacent to tracks and dams, these included Star Thistle (*Centaurea solstitialis*), Wards Weed (*Carrichtera annua*), Horehound (*Marrubium vulgare*), Burr-medic (*Medicago polymorpha var polymorpha*), False Sowthistle (*Reichardia tingitana*), African Boxthorn (*Lycium ferocissimum*) (a weed of national significance) and Slender Iceplant (*Mesembryanthemum nodiflorum*).

3.2 Fauna species

3.2.1 Reptiles and Mammals

The mammal and reptile records are broadly consistent with previous surveys, however an additional species that had not been recorded on site previously was identified in this survey; the Mulga Snake (*Pseudechis australis*).

Feral animal species on site included the House Mouse (*Mus musculus*) and two rabbit warrens (one of these was in the centre of the vegetation site V8). Likely evidence of foxes (scats) was observed but no foxes were sighted.

A summary of mammal and reptile records is provided in Table 1.

Table 1. Mammal and Reptile observations for spring 2012 survey (including animals captured at the F1 and F2 fauna trapping sites over five days and opportune animal sightings on the Samphire property area).

Class	Species	Common name	Number
Mammal	*Sminthopsis crassicaudata*	Fat-tailed Dunnart	1
Mammal	*Macropus rufus*	Red Kangaroo	24*
Mammal	*Pseudomys bolami*	Bolam's Mouse	9
Mammal	*Mus musculus*	House Mouse	3

Class	Species	Common name	Number
Mammal	*Oryctolagus cuniculus*	Rabbit	X**
Mammal	*Ovis aries*	Sheep	X***
Reptile	*Ctenotus olympicus*	Saltbush Ctenotus	9
Reptile	*Diplodactylus furcosus*	Ranges Stone Gecko	5
Reptile	*Lerista*	Southern Three-toed Slider	1
Reptile	*Morethia adelaidensis*	Adelaide Snake-eye	8
Reptile	*Tiliqua rugosa*	Sleepy Lizard	5
Reptile	*Tympanocryptis*	Five-lined Earless Dragon	2
Reptile	*Pogona vitticeps*	Central Bearded Dragon	3
Reptile	*Pseudechis australis*	Mulga Snake	1
Reptile	*Pseudonaja aspidorhyncha*	Patch-nosed Brown Snake	3

*Kangaroo observations were summed over the duration of the field trip and will include repeat observations of some of the same animals.

**Rabbit warrens were observed but no rabbits were sighted

***Sheep were present grazing in small flocks throughout the survey area

3.2.2 Birds

During the spring 2012 survey, 164 birds from 28 species were recorded across six sites (Table 2). The species with the most number of records was the Budgerigar (*Melopsittacus undulatus*) with 43 observations. Seven species were recorded singularly during the point count surveys. Site B13 recorded the most number of birds (50 records) and site B6 recorded the lowest abundance with only eight birds observed across the site. The nationally/regionally vulnerable Slender-billed Thornbill (Gulf St Vincent) (*Acanthiza iredalei rosinae*) was recorded at only one out of the six monitoring sites: B13, where six birds were observed. An additional seven records of this species were observed opportunistically across the site and four records of the vulnerable (IUCN listing) Western Grasswren (Gawler Ranges) (*Amytornis textilis myall*) was also observed opportunistically during the spring 2012 survey.

Table 2. Bird species observed during spring 2012 across six monitoring sites.

Species Name	Common Name	Site number						Total
		B1	B2	B6	B11	B12	B13	
Acanthagenys rufogularis	Spiny-cheeked Honeyeater				2	3	3	8
Acanthiza iredalei iridalei	Slender-billed Thornbill						6	6
Anthus novaeseelandiae	Australasian Pipit	3						3
Aphelocephala leucopsis	Southern Whiteface	7				4	5	16
Aquila audax	Wedge-tailed Eagle		2					2
Artamus cinereus	Black-faced Woodswallow						5	5
Calamanthus campestris	Rufous Fieldwren	2	1	3	1			7
Chalcites basalis	Horsfield's Bronze-cuckoo					1		1
Cheramoeca leucosterna	White-backed Swallow						6	6
Cincloramphus cruralis	Brown Songlark		2	1				3
Circus assimilis	Spotted Harrier			1				1
Corvus coronoides	Australian Raven	4	2	2			1	9
Coturnix pectoralis	Stubble Quail		1					1

Species Name	Common Name	Site number						Total
		B1	B2	B6	B11	B12	B13	
Cracticus tibicen	Australian Magpie						1	1
Cracticus torquatus	Grey Butcherbird					1	1	2
Dromaius novaehollandiae	Emu						1	1
Eolophus roseicapillus	Galah				3		2	5
Falco cenchroides	Nankeen Kestrel	1			1		1	3
Lichenostomus virescens	Singing Honeyeater					2	2	4
Malurus lamberti	Variegated Fairy-wren						2	2
Malurus leucopterus	White-winged Fairy-wren	8	1	1	2		5	17
Manorina flavigula	Yellow-throated Miner					1		1
Melopsittacus undulatus	Budgerigar				30	13		43
Ocyphaps lophotes	Crested Pigeon						1	1
Phaps elegans	Brush Bronzewing						2	2
Pomatostomus superciliosus	White-browed Babbler					6	3	9
Rhipidura leucophrys	Willie Wagtail					2	1	3
Todiramphus pyrrhopygius	Red-backed Kingfisher						2	2
	Total Abundance	25	9	8	39	33	50	164

3.2.3 Bats

Ten bat species were determined most likely to be present within the Samphire project site*: Austromomus australis (*White-striped Free-tail Bat*), Chalinolobus gouldii (*Gould's Wattled Bat*), Nyctophilus geoffroyi* (Lesser Long-eared Bat), *Nyctophilus major tor* (Western Long-eared Bat) *Vespadelus baverstocki* (Inland Forest Bat), *Vespadelus regulus* (Southern Forest Bat), *Mormopterus sp 4* (Southern Freetail-bat) *Mormopterus sp 3* (Inland Freetail-bat), *Saccolaimus flaviventris* (Yellow-bellied Sheathtail-bat) (unlikely but possible) and *Scotorepens balstoni* (Inland Broad-nosed Bat) (D. Matthews 2012).

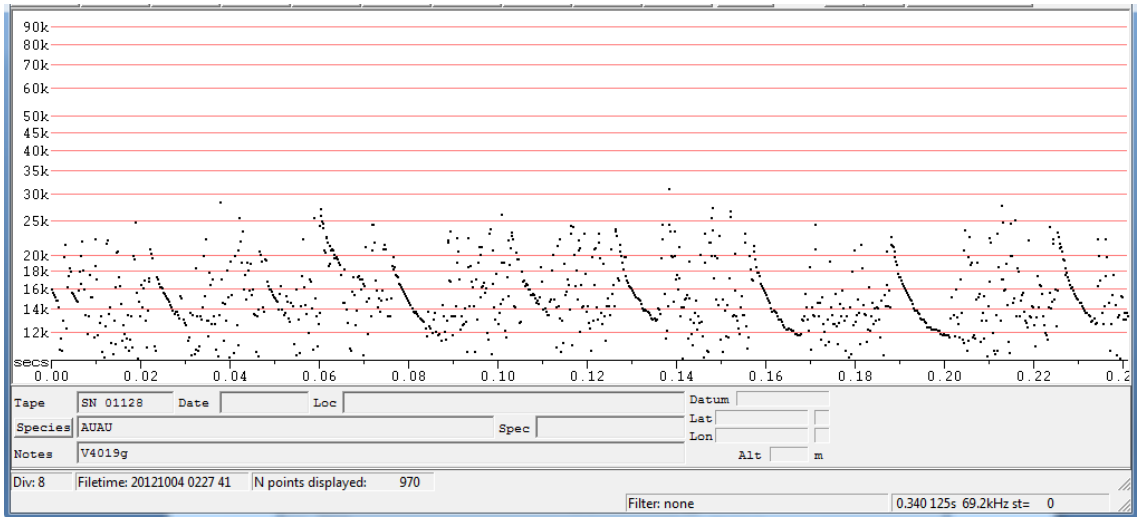
Out of 103 files recorded, 76 bat calls were identified for analysis. *Mormopterus* sp4 and sp3 are difficult to separate to species with the calls most likely to be *Mormopterus* sp4. *Nyctophilus geoffroyi* and *Nyctophilus major tor* are both known to be in the area and cannot be identified by Anabat calls.

Two calls were recorded for *Austromomus australis*. *Chalinolobus gouldii* recorded the most number of calls with 32, followed by either *Mormopterus sp 4* or *sp 3* with 23 calls. A single record of either *Nyctophilus geoffroyi* or *Nyctophilus major tor* was observed.

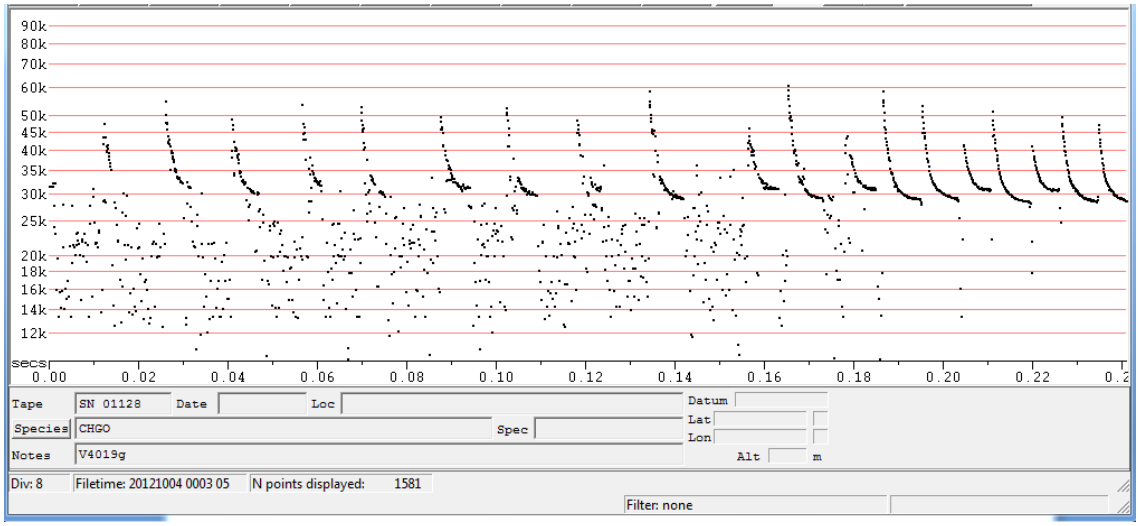
Example calls of each of these four species are provided in Figure 1.

Figure 1. Example calls from the survey for each species recorded.

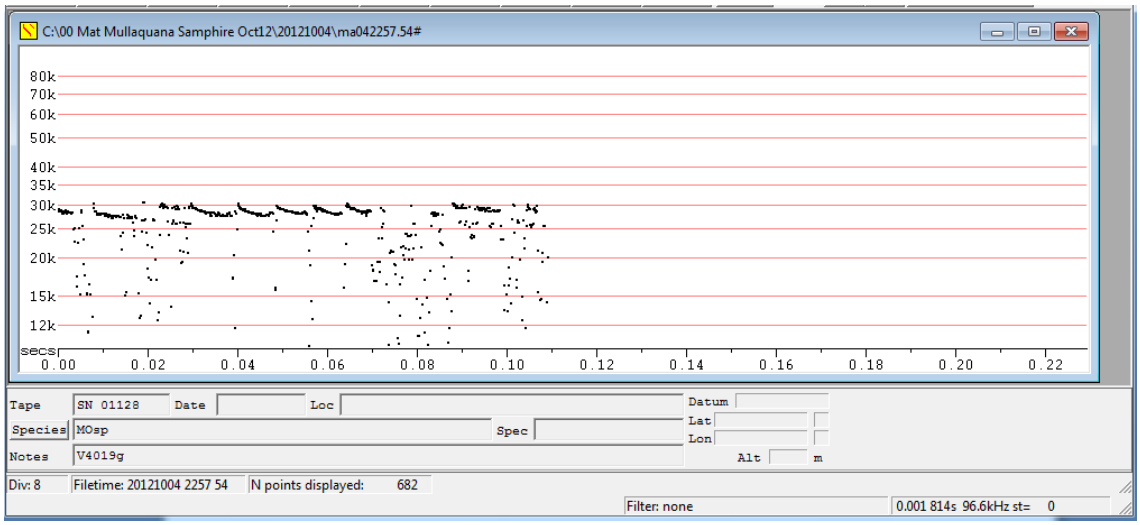
Austromomus australis



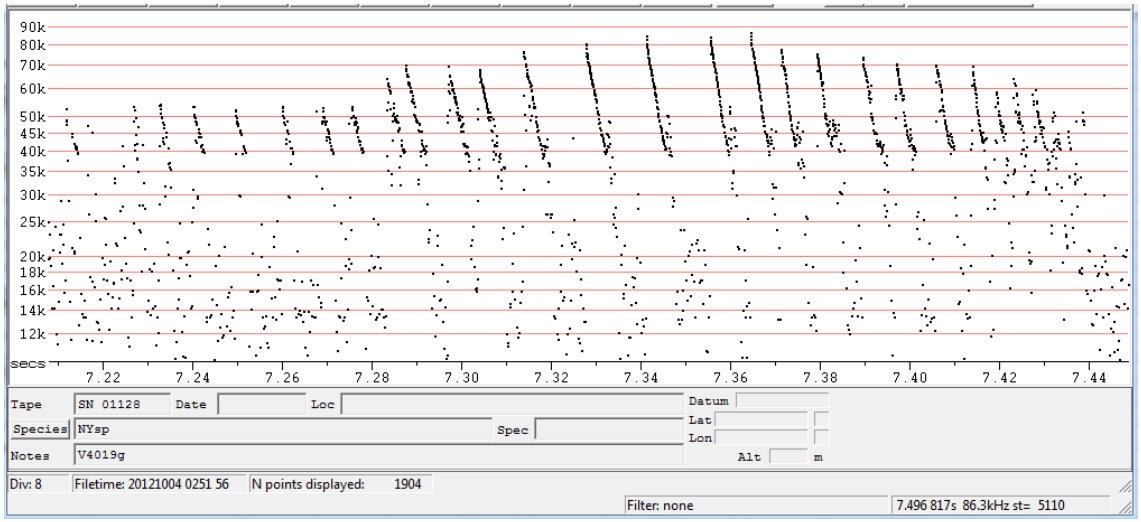
Chalinolobus gouldii



***Mormopterus* sp4 or sp3**



Nyctophilus geoffroyi/major

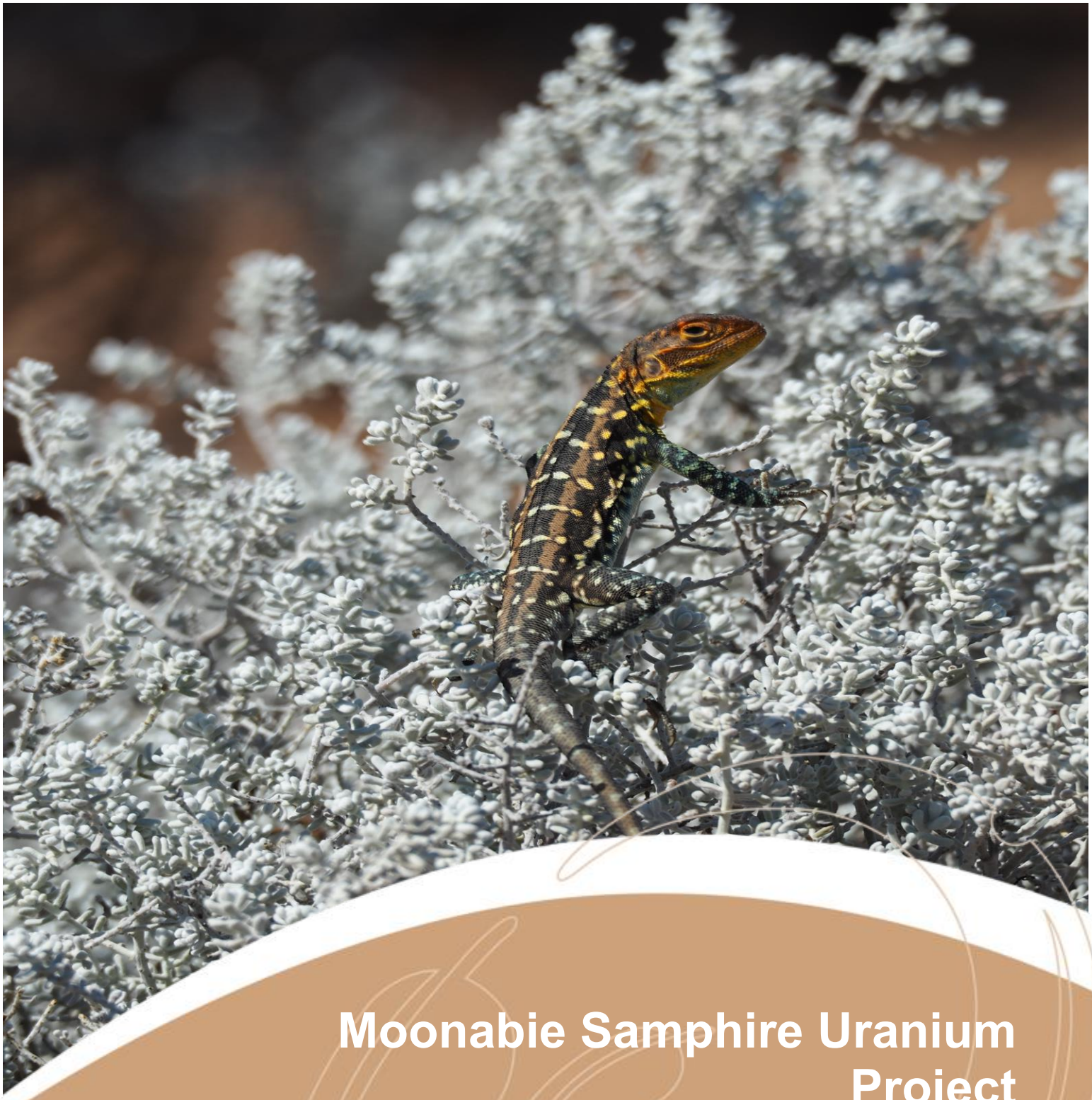




EBS Ecology
3/107 Hayward Avenue
Torrensville, SA 5031
www.ebsecology.com.au
t. 08 7127 5607
f. 08 8354 2403

J7: Moonabie Samphire Uranium Project - Fauna and Fauna Assessment. Report prepared for Alligator Energy Ltd by EBS Ecology, March 2024.

ebs ecology



Moonabie Samphire Uranium Project

Flora and Fauna Assessment

Moonabie Samphire Uranium Project Flora and Fauna Assessment

5 March 2024

Version 3

Prepared by EBS Ecology for Alligator Energy Limited ASX: AGE

Document Control					
Revision No.	Date issued	Authors	Reviewed by	Date Reviewed	Revision type
1	20/12/2023	S. Greer	Dr M. Louter	20/12/2023	Draft
2	31/01/2024	S. Greer	-	-	Draft
3	05/03/2024	S. Greer	-	-	Final

Distribution of Copies			
Revision No.	Date issued	Media	Issued to
1	22/12/2023	Electronic	Matt Daniel, Alligator Energy Limited ASX: AGE
2	31/01/2024	Electronic	Matt Daniel, Alligator Energy Limited ASX: AGE
3	05/03/2024	Electronic	Matt Daniel, Alligator Energy Limited ASX: AGE

EBS Ecology Project Number: EX230307

COPYRIGHT: Use or copying of this document in whole or in part (including photographs) without the written permission of EBS Ecology's client and EBS Ecology constitutes an infringement of copyright.

LIMITATION: This report has been prepared on behalf of and for the exclusive use of EBS Ecology's client, and is subject to and issued in connection with the provisions of the agreement between EBS Ecology and its client. EBS Ecology accepts no liability or responsibility whatsoever for or in respect of any use of or reliance upon this report by any third party.

CITATION: EBS Ecology (2024) Moonabie Samphire Uranium Project Flora and Fauna Assessment. Report to Alligator Energy Limited ASX: AGE, EBS Ecology, Adelaide.

Cover photograph: Painted Dragon (*Ctenophorus pictus*) sunning on *Maireana sedifolia* (Bluebush) shrub.

EBS Ecology
112 Hayward Avenue
Torrensville, South Australia 5031
t: 08 7127 5607
http://www.ebsecology.com.au
email: info@ebsecology.com.au

GLOSSARY AND ABBREVIATION OF TERMS

%%	Percent
<<	Less than
Alligator Energy	Alligator Energy Limited ASX: AGE
BOM	Bushland Assessment Method
BCM	Bushland Condition Monitoring
BDBSA	Biological Databases of South Australia
BOM	Bureau of Meteorology
CEMP	Construction Environmental Management Plan
cm	Centimetres
DCCEEW	Department of Climate Change, Energy, the Environment and Water (Commonwealth)
DEM	Department for Energy and Mining
DEWW	Department for Environment and Water
EBS	Environment and Biodiversity Services Pty Ltd – trading as EBS Ecology
ELAA	Exploration Licence Agreement
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
EXT	Extraction Well Array (combination of injection and extraction per array)
ha	hectare(s)
IBRAA	Interim Bio-regionalisation of Australia
km	Kilometre(s)
LSAA Act	*Landscape South Australia Act 2019*
m	Metre(s)
MNES	Matters of National Environmental Significance, as defined under the EPBC Act
Native vegetation	A plant or plants of a species indigenous to South Australia (including dead trees >600 mm diameter, and planted vegetation protected under the *Native Vegetation Act 1991* such as Significant Environmental Benefit or Heritage Agreements)
NPW Act	*National Parks and Wildlife Act 1972*
NV Act	*Native Vegetation Act 1991*
NVC	Native Vegetation Council
°C	Degrees Celsius
OEMPP	Operational Environmental Management Plan
PDI Act	*Planning, Development and Infrastructure Act 2016*
PMST	Protected Matters Search Tool
Project Area	The area (or boundary) in which the Project will be located, as shown in mapping.
Project	The Samphire Uranium Project
RL	Retention Lease
SAA	South Australia / South Australian
Search Area	A 5 km buffer of the Project Area used for database searches.
SEB	Significant Environmental Benefit
sp.	Species (singular)
spp.	Species (plural)
ssp.	Subspecies
TEC	Threatened Ecological Community
UBS	Unit biodiversity score
VAA(s)	Vegetation Association(s)

EXECUTIVE SUMMARY

Alligator Energy Limited ASX: AGE (Alligator Energy) is investigating the potential for the future development of the Blackbush Deposit, Samphire Uranium Project, south of the town of Whyalla in South Australia. A scoping study for the proposal was conducted in 2023, and a Pilot Test is proposed for 2024.

The Samphire Uranium Project is located on Moonabie Station, 20 kilometres (km) south of Whyalla in regional South Australia (SA) and was acquired by the Alligator Energy in October 2020. Samphire comprised at that time two historical uranium prospects (Blackbush and Plumbush) on Exploration Licence (EL) 5926. Post acquisition Alligator Energy acquired EL 6350 and took out Exploration Licence Applications (ELA's) surrounding these licences which have now been granted.

EBS Ecology (EBS) was contracted by Alligator Energy to undertake baseline flora and fauna surveys of The Samphire Project at Moonabie Station (the Project). The key objectives include the following:

- Establish the likelihood of presence of any flora and/or fauna species listed as threatened under the *Environment Protection and Biodiversity Conservation Act 19999*(EPBC Act) or *National Parks and Wildlife Act 1972* (NPW Act).
- Identify the key ecological constraints within the Project Area.
- Identify sensitive areas, which if impacted are likely to impact on any matters of National and State Environmental Significance (MNES).
- Establish repeatable flora and fauna monitoring sites and collect baseline data from each site.
- Collect and map vegetation data that can be used to calculate the Significant Environmental Benefit (SEB) associated with the Project for a future Native Vegetation Data Report.
- Identify legislative requirements that will inform the Project design and approvals.

The Desktop assessment database searches identified three MNES relevant to the Project Area including threatened flora and fauna species, threatened migratory species, and Threatened Ecological Communities (TECs) as follows:

- One EPBC listed TEC, Subtropical and Temperate Coastal Saltmarsh (EPBC Act: Vulnerable) was identified as potentially occurring within the Project Area. The field survey confirmed this TEC does not occur within the Project Area.
- Two flora species listed as threatened under the EPBC Act as potentially occurring or having suitable habitat within 5 km of the Project Area. None of these flora species were deemed likely to occur within the Project Area.
- No flora species listed as threatened under the NPW Act were identified during the Biological Database of South Australia (BDBSA) search.
- 34 fauna species listed as threatened under the EPBC Act were identified as potentially occurring or having suitable habitat within 5 km of the Project Area:

  - two species, Western Grasswren (Gawler Ranges) (*Amytornis textilis myall*) (EPBC Act: Vulnerable) and Southern Whiteface (*Aphelocephala leucopsis*) (EPBC Act: Vulnerable) were identified during the field survey.

  - two species, Grey Falcon (*Falco hypoleucos*) (EPBC Act: Vulnerable, NPW Act Rare) and Blue-winged Parrot (*Neophema chrysostoma*) (EPBC Act: Vulnerable, NPW Act Vulnerable) were assessed as possibly occurring within the Project Area.

- Three fauna species listed as threatened under the NPW Act were identified as potentially occurring or having suitable habitat within 5 km of the Project Area. No species were assessed as likely to occur within the Project Area.

- Six additional migratory species were identified as potentially occurring within 5 km of the Project Area. No migratory species were assessed as likely to occur within the Project Area.

The survey identified and mapped five vegetation associations (VAs) across the Project Area across approximately 4,374 ha of vegetation:

- **A1** *Tecticornia pergranulata* and *Atriplex vesicaria* low shrubland
- **A2** *Maireana sedifolia* shrubland
- **A3** *Atriplex vesicaria* shrubland
- **A4** *Acacia papyrocarpa* woodland
- **B1** *Acacia papyrocarpa* woodland.

Five fauna trapping sites were established across representative vegetation associations. All sites were surveyed for four nights, with traps checked every morning and afternoon. An additional mid-day check was completed on 10 November due to high temperatures. A total of 92 captures were recorded, representing 17 species (four mammal species at 29 individuals, and 13 reptile species at 63 individuals). The highest species diversity occurred at Site 3 (three mammal and 10 reptile species). The highest abundance of captures occurred at Site 1 with a total of 31 individuals captured. Based on trapping results, Bolam's Mouse (*Pseudomys bolami*) was most the most abundant mammal species and Southern Spiny-tailed Gecko (*Strophurus intermedius*) was most the most abundant reptile species. No threatened fauna species were captured during the field survey.

Nine Bird Sites were established at fauna sites and across representative vegetation associations, recording a total of 155 individuals across 32 bird species in total. The highest species diversity occurred at Bird Site 4 with 16 species recorded. Birds were most abundant at Bird Site 6, where a total of 35 individuals were counted. The most abundant bird species recorded was the White-winged Fairywren (*Malurus leucopterus leuconotus*), with a total of 18 observations across 5 sites.

A total of five (one flora, four fauna) threatened species were identified during the field survey:

- Australian Sandalwood (*Santalum spicatum*) (NPW Act: Vulnerable)
- Slender-billed Thornbill (*Acanthiza iredalei*) (NPW Act: Rare);

- Western Grasswren (*Amytornis textilis myall*) (EPBC Act: Vulnerable; NPW Act: Vulnerable);
- Southern Whiteface (*Aphelocephala leucopsis leucopsis*) (EPBC Act: Vulnerable); and
- Australian Bustard (*Ardeotis australis*) (NPW Act: Vulnerable).

Alligator Energy has applied to the SA Department for Energy and Mining (DEM) for a Retention Lease (RL) to conduct a pilot Field Recovery Trial. Three Extraction Wells (EXTs) and a plant area are proposed within the RL, located off the southern boundary of the Project Area. A series of road widening and track upgrades are also proposed, to allow truck access within the proposed RL. A total of 10 clearance activities are proposed within the RL, which require the clearance of approximately 0.98 ha of *Maireana sedifolia* shrubland. The SEB offset required under the *Native Vegetation Act 1991,* for the proposed actions within the RL is either an on-ground offset generating 40.29 points, or a payment of $3,615.47 into the Native Vegetation Fund. An EPBC referral has been submitted to the Department of Climate Change, Energy, the Environment and Water (DCCEEW) for the RL.

The following broad recommendations and considerations should be taken into account for future planning in the Project Area.

- Consider the Native Vegetation mitigation hierarchy at all stages of the Project design phase.
- Submit a Native Vegetation Clearance report to the Native Vegetation Council (NVC) for approval once the Project design and infrastructure footprint has been finalised.
- Undertake an assessment of potential impacts against Western Grasswren and Southern Whiteface for the EPBC Act *Significant Impact Guidelines* and refer the Mining Lease application to DCCEEW for assessment, should an ML application occur.
- Prior to the commencement of construction, develop a Construction Environmental Management Plan (CEMP) that implements measures to minimise unavoidable impacts to habitat.

Table of Contents

1 INTRODUCTION 1

1.1 Objectives 1
1.2 Project details 1
1.3 Scope of works 1

2 COMPLIANCE AND LEGISLATIVE SUMMARY 3

2.1 Environment Protection and Biodiversity Conservation Act 1999 3
2.2 Native Vegetation Act 1991 3
2.3 National Parks and Wildlife Act 1972 4
2.4 Landscape South Australia Act 2019 4
2.5 Planning, Development and Infrastructure Act 2016 4

3 BACKGROUND INFORMATION 6

3.1 Administrative boundaries 6
3.2 Interim Biogeographical Regionalisation of Australia 6
3.3 Wetlands and watercourses 7

4 DESKTOP METHODS 8

4.1 Desktop assessment 8
4.1.1 EPBC Act Protected Matters Search Tool 8
4.1.2 Biological Databases of South Australia 8
4.1.3 Literature review 8
4.1.4 Assessment of the likelihood of occurrence 9
4.1.5 Limitations 10

5 FIELD SURVEY METHODS 11

5.1 Vegetation associations and condition 11
5.1.1 Vegetation survey sites 12
5.2 Fauna trapping 13
5.2.1 Fauna trapping survey sites 14
5.3 Avian surveys 15
5.3.1 Timed area search 15
5.3.2 Bird voice broadcast surveys (call playback) 15
5.3.3 Bat surveys 16
5.4 Opportunistic sightings 18
5.5 Limitations 18

6 DESKTOP RESULTS 19

6.1 Matters of National Environmental Significance 19
6.2 Threatened ecological communities 19

6.3 Threatened flora 19
6.3.1 EPBC Act listed threatened flora 19
6.3.2 NPW Act listed threatened flora 19
6.4 Threatened fauna 20
6.4.1 EPBC Act listed threatened fauna 20
6.4.2 NPW Act listed threatened fauna 20
6.5 Migratory fauna 22

7 FIELD RESULTS 24
7.1 Climate and weather 24
7.2 Vegetation associations and condition 24
7.3 Fauna trapping 31
7.3.1 Diversity 32
7.3.2 Abundance 34
7.4 Avian surveys 36
7.4.1 Diversity 37
7.4.2 Abundance 37
7.5 Threatened species 38

8 EXPLORATION AREA IMPACTS 40
8.1 Proposed activities 40
8.2 Summary of impacts 40
8.3 Offset requirements 43

9 DISCUSSION OF CONSTRAINTS 44
9.1 Native vegetation 44
9.2 EPBC Act threatened species and habitat 44
9.3 NPW Act threatened species 46
9.3.1 NPW Act listed flora 46
9.3.2 NPW Act listed fauna 46
9.4 LSA Act Declared species 46

10 RECOMMENDATIONS 47

11 REFERENCES 48

12 APPENDICES 49
Appendix 1 - Likelihood assessment. 49
Appendix 2 – Pitall trap line photographs. 63
Appendix 3 - Fauna recorded during the survey. 66
Appendix 4 – Flora recorded during the field survey. 68

List of Tables

Table 1. Commonwealth and South Australian legislation relevant to the Project Area. 3
Table 2. Administrative boundaries of the Project Area. 6
Table 3. IBRA bioregion, subregion, and environmental association environmental landscape summary. 6
Table 4. Criteria for the likelihood of occurrence of threatened species. 9
Table 5. Factors that influence the value in the BAM scoresheet (NVC 2020a). 12
Table 6. The locations of vegetation survey sites (BAM sites). 13
Table 7. Trapping effort at Moonabie Samphire Project. 14
Table 8. Location of fauna monitoring sites. 14
Table 9. The locations of bird survey sites. 16
Table 10. Threatened species identified in the database searches within a 5 km buffer, and previously conducted EBS surveys nearby (Green shading: likely, orange shading: possible). 20
Table 11. Migratory species identified in the database searches within a 5 km buffer, and previously conducted EBS surveys nearby. 23
Table 12. Weather conditions during the survey. 24
Table 13. Vegetation Associations (VA) within the Project Area. 24
Table 14. Summary of A1 - *Tecticornia pergranulata* and *Atriplex vesicaria* low shrubland. 26
Table 15. Summary of A2 - *Maireana sedifolia* shrubland. 27
Table 16. Summary of A3 - *Atriplex vesicaria* shrubland. 28
Table 17. Summary of A4 - *Acacia papyrocarpa* Woodland. 29
Table 18. Summary of B1 - *Acacia papyrocarpa* Woodland. 30
Table 19. Fauna species captured during the survey. 31
Table 20. Bird species recorded during the survey at each site. 36
Table 21. Threatened species observed during the field survey. 38
Table 22. Impact summary table. 41
Table 23. Clearance summary and total Significant Environmental Benefit (SEB) obligations for vegetation associations impacted by the Project. 43
Table 24. Mitigation Hierarchy for native vegetation clearing applications. 44
Table 25. Summary of significance of impact to EPBC listed species. 45
Table 26. Declared plants under the LSA Act recorded in the Project Area. 46
Table 27. Recommendations to address ecological constraints. 47

List of Figures

Figure 1. Location of the Project Area. 2
Figure 2. Diagram of fauna trap layout example. 15
Figure 3. Survey locations of BAM, Bat, fauna and avian sites. 17
Figure 4. Vegetation Associations in the Project Area. 25
Figure 5. Species diversity captured across 5 fauna trapping sites. 33
Figure 6. Family diversity of species captured across 5 fauna trapping sites. 33

Figure 7. Abundance of fauna captures per site. 34
Figure 8. Abundance of mammals and reptiles captured across 5 fauna trapping sites. 35
Figure 9. Abundance of genus captured across 5 fauna trapping sites. 35
Figure 10. Threatened species observed in each VA within the Project Area during the field survey. 39
Figure 11. Project Area containing Retention Lease Area (blue) and exclusion zone (orange) (supplied to EBS by Alligator Energy on 11/12/2023). 40
Figure 12. Diagram of proposed impact locations (Supplied by Alligator Energy 15/12/2023). 41
Figure 13. Areas proposed for clearance within the Retention Lease. 42

1 INTRODUCTION

Alligator Energy Limited ASX: AGE (Alligator Energy) is investigating the potential for the future development of the Blackbush Deposit, Samphire Uranium Project, south of the town of Whyalla in South Australia. A scoping study for the proposal was conducted in 2023, and a Pilot Test is proposed for 2024. If this Pilot Test proves successful, Alligator Energy intends to undertake a Feasibility Study in 2024, with all activity requiring further State and Federal Government approvals, and the securing of project financing amongst other key matters, before the uranium mine could be developed.

1.1 Objectives

EBS Ecology was contracted by Alligator Energy to undertake baseline flora and fauna surveys of the Samphire Project at Moonabie Station (the Project). The key objectives include the following:

- Establish the likelihood of presence of any flora and/or fauna species listed as threatened under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) or *National Parks and Wildlife Act 1972* (NPW Act).
- Identify the key ecological constraints within the Project Area.
- Identify sensitive areas, which if impacted are likely to impact on any matters of National and State Environmental Significance (MNES).
- Establish repeatable flora and fauna monitoring sites and collect baseline data from each site.
- Collect and map vegetation data that can be used to calculate the Significant Environmental Benefit (SEB) associated with the Project for a future Native Vegetation Data Report.
- Identify legislative requirements that will inform the project design and approvals.

1.2 Project details

The Samphire Uranium Project is located on Moonabie Station, approximately 20 kilometres (km) south of Whyalla in regional South Australia (SA) and was acquired by the Alligator Energy in October 2020. Samphire comprised at that time two historical uranium prospects (Blackbush and Plumbush) on Exploration Licence (EL) 5926. Post acquisition, Alligator Energy acquired EL 6350 and took out Exploration Licence Applications (ELA's) surrounding these licences which have now been granted. Alligator Energy is proposing to undertake a short-term (approximately 3 months) small-scale Field Recovery Trial in early 2024 to test the use of the In-Situ Recovery method for the Project.

1.3 Scope of works

EBS Ecology (EBS) has been engaged to undertake a flora and fauna assessment for the potential future development of the Project, depicted in Figure 1 below.

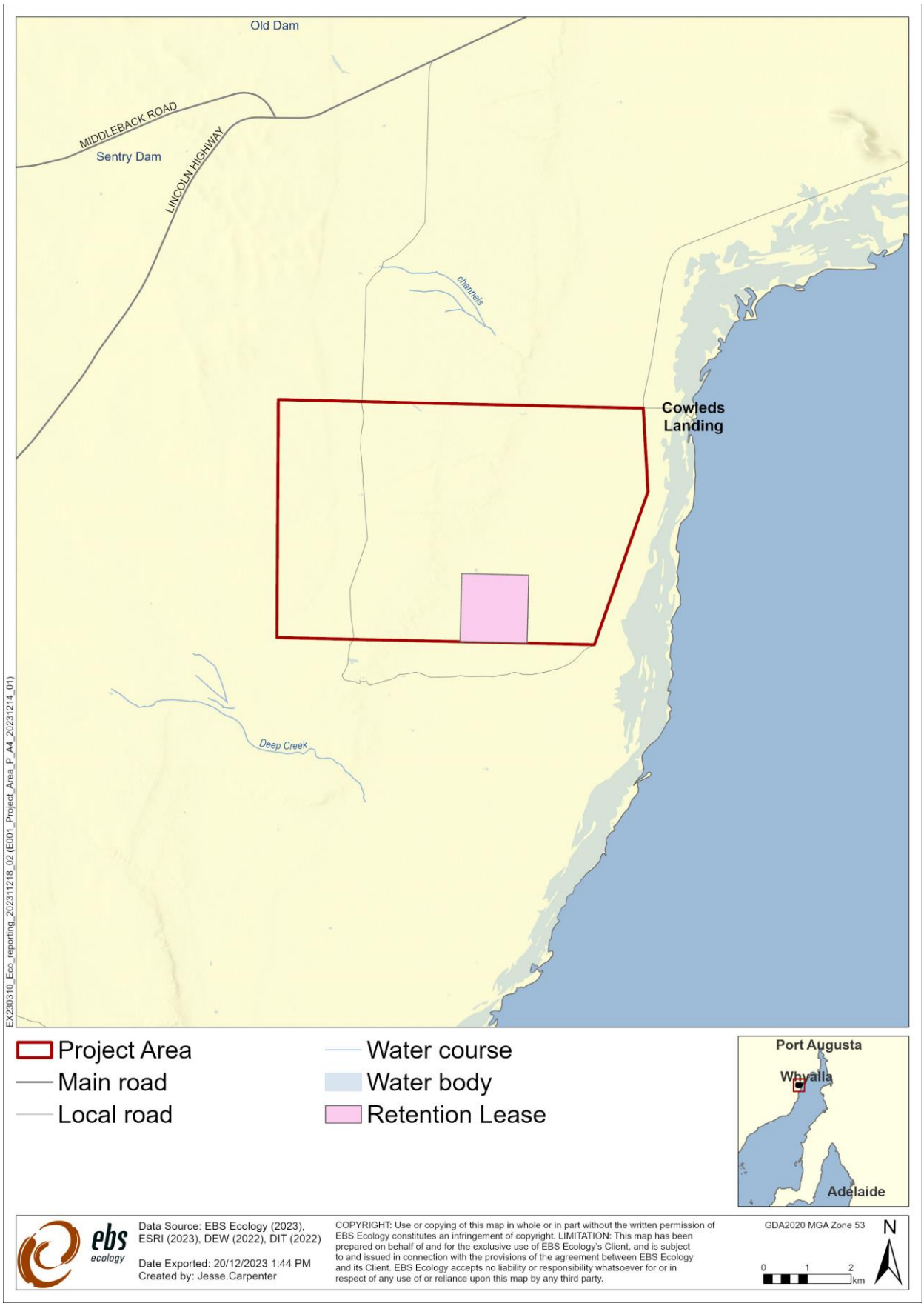


Figure 1. Location of the Project Area.

2 COMPLIANCE AND LEGISLATIVE SUMMARY

Impacts on biodiversity caused by the proposed Project, including clearing of native vegetation and impact to threatened species and ecological communities, are subject to Commonwealth and State legislation listed in Table 1.

Table 1. Commonwealth and South Australian legislation relevant to the Project Area.

Jurisdiction	Legislation
Commonwealth	*Environment Protection and Biodiversity Conservation Act 1999*
South Australia	*Native Vegetation Act 1991* *National Parks and Wildlife Act 1972* *Landscape South Australia Act 2019* *Planning Development and Infrastructure Act 2016*

Note: This summary is not intended to be a substitute for particular legal advice and does not address the legal implications of every set of circumstances.

2.1 Environment Protection and Biodiversity Conservation Act 1999

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and the *Environment Protection and Biodiversity Conservation Regulations 2000* provide a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places – defined in the Act as 'matters of national environmental significance'. Any action that has, will have, or is likely to have a significant impact on MNES requires referral under the EPBC Act.

2.2 Native Vegetation Act 1991

Native vegetation in South Australia is protected by the *Native Vegetation Act 1991* (NV Act) and the *Native Vegetation Regulations 2017*. This legislation prevents broad-scale clearance and minimises smaller scale clearance; enhances and restores the State's native vegetation; and outlines certain procedures and assessments that need to be undertaken before any clearance of native vegetation can proceed.

Any proposed clearance of native vegetation in South Australia (unless exempt under the *Native Vegetation Regulations 2017* or within the Greater Adelaide region) requires approval from the Native Vegetation Council (NVC). Approval must be obtained before performing any activity that could cause damage to native vegetation. This also applies to dead trees that may provide habitat for fauna. The NV Act does not apply to the Greater Adelaide Region and there is overlap with *the Planning, Development and Infrastructure Act 2016* (PDI Act) applies. The Project Area falls across the boundary of the NV Act and the PDI Act.

The *Native Vegetation Regulations 2017* outline the circumstances where clearing native vegetation is permitted, outside of the clearance controls in the NV Act. The *Native Vegetation Regulations 2017* place a great emphasis on the proponent applying the Mitigation Hierarchy, a fundamental principle which encourages proponents to consider all possible ways to avoid and minimise clearance to reduce the level of clearance required. Reducing the level of clearance also reduces the SEB offset (where required) and

associated cost to the proponent. The NVC assesses whether proponents have adequately applied the Mitigation Hierarchy.

2.3 National Parks and Wildlife Act 1972

Native plants and animals in South Australia are protected under the *National Parks and Wildlife Act 1972* (NPW Act). It is an offence to take a native plant or protected animal without approval. Threatened plant and animal species are listed in Schedules 7 (Endangered species), 8 (Vulnerable species) and 9 (Rare species) of the Act. Persons must not:

- Take a native plant on a reserve, wilderness protection area, wilderness protection zone, land reserved for public purposes, a forest reserve or any other Crown land;
- Take a native plant of a prescribed species on private land;
- Take a native plant on private land without the consent of the owner (such plants may also be covered by the NV Act);
- Take a protected animal or the eggs of a protected animal without approval;
- Keep protected animals unless authorised to do so; and
- Use poison to kill a protected animal without approval.

Conservation rated flora and fauna species listed on Schedules 7, 8, or 9 of the NPW Act are known to or may occur within the Project Area. Persons must comply with the conditions imposed upon permits and approvals.

2.4 Landscape South Australia Act 2019

Under the *Landscape South Australia Act 2019* (LSA Act), new regional landscape boards have been established. The aim is to deliver NRM related services to regional communities, including effective water management, pest plant and animal control, soil and land management and support for broader sustainable primary production programs. Under the LSA Act, landholders have a legal responsibility to manage declared pest plants and animals and prevent land and water degradation.

2.5 Planning, Development and Infrastructure Act 2016

The *Planning, Development and Infrastructure Act 2016* (PDI Act) repealed the *Development Act 1993* and was brought into operation in stages over a five-year implementation program to reform and modernise the State's planning system. The PDI Act, the *Planning, Development and Infrastructure (General) Regulations 2017* and *Planning and Design Code,* provide the legislative framework for carrying out planning and development works within the state. No development can be undertaken without an appropriate Development Approval being obtained from the relevant authority after an application and assessment process.

In accordance with the PDI Act, any development within a State Heritage Area (declared under the *Heritage Places Act 1993*) must be approved by the relevant (planning) authority. Development is defined by the PDI Act and PDI Regulations and includes building work and any work that could materially affect the heritage value of the place. The PDI Act also considers any tree damaging activity in relation to a regulated tree as development.

3 BACKGROUND INFORMATION

3.1 Administrative boundaries

The Project Area is located in the administrative regions of SA as indicated in Table 2.

Table 2. Administrative boundaries of the Project Area.

Administration	Region / boundary
State Government Region	Eyre and Western
Local Government Area (s)	Whyalla
Landscape Management Region (LMR)	Eyre Peninsula
Soil Conservation District (s)	Gawler Ranges
Hundred (s)	Poynton

3.2 Interim Biogeographical Regionalisation of Australia

The Interim Biogeographical Regionalisation of Australia (IBRA) identifies geographically distinct bioregions based on common climate, geology, landform, native vegetation, and species information. The bioregions are further refined into subregions and environmental associations. The Project Area is located within the Gawler IBRA bioregion and the Myall Plains IBRA subregion. The Project Area spans two IBRA associations: Buckleboo and Whyalla (Table 3).

Table 3. IBRA bioregion, subregion, and environmental association environmental landscape summary.

Gawler IBRA bioregion	
Semi-arid to arid, flat topped to broadly rounded hills of the Gawler Range Volcanics and Proterozoic sediments, low plateaux on sandstone and quartzite with an undulating surface of aeolian sand or gibbers and rocky quartzite hills with colluvial footslopes, erosional and depositional plains and salt encrusted lake beds, with black oak (belah) and Myall low open woodlands, open mallee scrub, bluebush/saltbush open chenopod shrublands and tall mulga shrublands on shallow loams, calcareous earths and hard red duplex soils.	
Myall Plains IBRA subregion	
Gently undulating calcrete plains and occasional quartzite or granite hills. Includes a zone of salt lakes and gypsum dunes at Lake Gillies and steep strike ranges at the Middleback Ranges. To the east out cropping conglomerate occurs with mangrove flats along the coastal margin. Acacia papyrocarpa / Casuarina pauper low woodland is found on grey brown calcareous earths, red calcareous earths and dense brown loams on the plains. Rocky outcrops support *Eucalyptus incrassata / Melaleuca uncinata* open scrub and Allocasuarina verticillata low woodland on dense brown loams. The lowest areas support chenopod shrubland of *Halosarcia halocnemoides* on grey calcareous loams. Light grazing occurs in most areas.	
Remnant vegetation	Approximately 97% (1050684 ha) of the subregion is mapped as remnant native vegetation, of which 8% (86146 ha) is formally conserved.
Landform	Gently undulating calcrete plains and occasional hills. Includes a zone of salt lakes and gypsum dunes at Lake Gillies and steep strike ranges at the Middleback Ranges.
Geology	Calcrete development; gypsum dunes; play lakes with silt & clay deposits & evaporites.
Soil	Red calcareous earths, Sandy soils with mottled yellow clayey subsoils.
Vegetation	Assumed native vegetation cover.

Conservation significance	59 species of threatened fauna, 40 species of threatened flora. 4 wetlands of national significance.
Buckleboo IBRA environmental association	
Landform	Gently undulating calcrete plains and occasional quartzite or granite hills.
Geology	Calcrete, quartzite, granite and alluvium.
Soil	Grey-brown calcareous earths, hard pedal red duplex soils, dense brown loams and black calcareous loams.
Vegetation	Low woodland of myall and black oak, open scrub of beaked red mallee and yorrell, low open woodland of myall and chenopod shrubland of samphire.
Whyalla IBRA environmental association	
Landform	Easterly sloping calcreted plain with occasional hills on outcropping conglomerate, and with mangrove flats along the coastal margin.
Geology	Calcrete, conglomerate, silts, metasediments and sands.
Soil	Red calcareous earths, dense brown loams, grey calcareous loams and whitish calcareous sands.
Vegetation	Low open woodland of black oak and myall sometimes with false sandalwood, low woodland of mangrove and chenopod shrubland of samphire.

3.3 Wetlands and watercourses

The Project Area extends to within 1 km of the shores of Spencer Gulf in an area characterised by mangrove forest and shallow, tidal sand and mud flats. These tidal flats are inundated during high tide but are exposed during low tides. Other than dams constructed for watering stock, there are no wetlands inside the Project Area boundaries. A dry creek bed is present within mid-north of the Project Area, which showed signs of irregular flash-flooding indicated by vegetation type and debris.

4 DESKTOP METHODS

4.1 Desktop assessment

A desktop assessment was undertaken to determine the potential for any additional threatened flora and fauna species and TECs (both Commonwealth and State listed) to occur within the Project Area. This was achieved by undertaking database searches using a 5-kilometre (km) buffer of the Project Area (Search Area). The Search Area is in line with vegetation survey requirements under the NV Act for vegetation assessments under the Bushland Assessment Method.

The updated desktop assessment was used to refine the species and species habitat to target during the field assessment. EPBC and NPW Act listed threatened species and communities considered likely to occur in the Project Area were broadly assessed for habitat suitability in the field survey.

4.1.1 EPBC Act Protected Matters Search Tool

The Protected Matters Search Tool (PMST) was used to generate a report on 14 November 2023 and again on 31 January 2024 (DCCEEW 2024a) to identify nationally threatened flora and fauna, migratory fauna and TECs under the EPBC Act within a 5 km Search Area. Species and TECs identified in the PMST report that are known or likely to occur within the Search Area were assessed for their likelihood of occurrence within the Project Area. All species considered exclusively marine (including whales, sharks, fish, dolphins, marine turtles and marine birds) were not assessed in this desktop assessment report as the Project Area is terrestrial.

4.1.2 Biological Databases of South Australia

A Biological Database of South Australia (BDBSA) search was obtained from the NatureMaps (DEW 2023) on 14 November 2023 to identify threatened flora and fauna species previously recorded within 5 km of the Project Area (as per Bushland Assessment Methodology survey requirements under the NV Act) and to incorporate records of species which have recently been listed (in March 2023) as threatened under the EPBC Act.

The BDBSA is comprised of an integrated collection of species records from the South Australian Museum, conservation organisations, private consultancies, Birds SA, Birdlife Australia and the Australasian Wader Study Group, which meet the Department for Environment and Water (DEW)'s standards for data quality, integrity and maintenance.

4.1.3 Literature review

Existing information and literature relevant to the Project Area was reviewed, including:

- Aerial imagery;

- Spatial datasets, e.g., DEW biological survey sites, IBRA, vegetation cover, protected areas, vegetation floristic mapping, surface and ground water and roadside significant sites from NatureMaps (DEW 2023); and
- Reports, plans and web-based information, including:
    - SA Planning and Design Code, Part 10;
    - SA Planning and Property Atlas;
    - EPBC Act species profiles, conservation advice and recovery plans; and
    - Previous EBS reports.

The aforementioned information was used to assess:

- Vegetation cover within the Project Area and immediate surrounds;
- Potential Vegetation Associations (VAs) present (including TECs); and
- Flora and fauna species of conservation significance known or likely to occur within the Project Area.

4.1.4 Assessment of the likelihood of occurrence

Threatened species and ecological communities identified as potentially occurring in the Project Area by desktop research were assessed as to their likelihood of occurrence. This assessment followed the field survey, which confirmed the habitat available in the Project Area and whether any threatened species were observed. Each threatened species and ecological community has been rated as either 'Known', 'Likely', 'Possible', or 'Unlikely' to occur in the Project Area according to the criteria listed in Table 4.

Table 4. Criteria for the likelihood of occurrence of threatened species.

Likelihood	Criteria
Known	• Records in the Project Area in the last 10 years, the species does not necessarily have highly specific needs, and the habitat is largely intact.
Likely	• Records in the last 10 years, the species does not have highly specific habitat needs and the habitat is largely intact, or • Records in the last 10 years, the species does have highly specific habitat needs and these needs occur in the area.
Possible	• No records, survey effort is considered not adequate, suitable habitat does occur (or isn't known if it does occur) and species of similar habitat needs have been recorded in the area, or • Records within the last 40 years, and the area is not largely intact, or • Records in the last 10 years, the species does not have highly specific needs, and habitat is largely intact.
Unlikely	• No records despite survey effort considered adequate, or • No records and survey effort is considered not adequate, and no suitable habitat is known to occur in the area, or • No records and survey effort is not considered adequate, and no suitable is known to occur in the area, and species of similar habitat needs have no records either.

4.1.5 Limitations

The desktop assessment was based on existing datasets and references from a range of sources. EBS has not attempted to verify the accuracy of any such information. The findings and conclusions expressed by EBS are based solely upon information in existence at the time of the assessment.

Flora and fauna records were sourced from both the EPBC Act Protected Matters Database via the PMST, and the BDBSA via NatureMaps. The BDBSA only includes verified flora and fauna records recorded by DEW or submitted to DEW by partner organisations. It is recognised that knowledge is poorly captured, and that the spatial reliability of the data varies. It is possible that significant species occur that are not reflected by database records. Although much of the BDBSA data has been through a variety of validation processes, the lists may contain errors and should be used with caution. DEW give no warranty that the data is accurate or fit for any particular purpose of the user or any person to whom the user discloses the information.

BDBSA flora and fauna records were limited to a 5 km buffer around the Project Area boundary. The reliability of the BDBSA data ranges from 100 m to over 100 km. Only records with a spatial reliability of less than (<) 1 km were included as part of the desktop assessment. Fauna species, in particular birds, can traverse distances more than the 5 km search buffer, and therefore, additional species may occur. It is also acknowledged that the presence of species may not be adequately represented by database records. Hence, the BDBSA results that have been clipped to a 5 km buffer of the Project Area may not highlight all potential threatened flora and fauna species that may occur.

5 FIELD SURVEY METHODS

A field survey was undertaken on 6 – 11 November 2023 by NVC accredited consultants J. Skewes, Dr T. How and Ecologist S. Greer. The fauna survey was conducted utilising methods consistent with Department of Environment and Water (DEW) biological survey (Owens 2000). The flora survey was conducted as per the requirements under the *Native Vegetation Act 1991.* Field surveys were conducted under the following research and ethics permits/licenses:

- Scientific Research Permit No. How_K25613-23 (Department for Environment and Water);
- Wildlife Ethics Committee (WEC) Approval How_27-2022_Statewide Fauna Surveys, (Wildlife Ethics Committee); and
- Scientific Licence no. 158 (Animal Welfare, National Parks and Wildlife SA).

The survey methods for flora and fauna used are summarised in the following Sections.

5.1 Vegetation associations and condition

Vegetation associations and condition were surveyed according to the Bushland Assessment Method (BAM). The SA Government's Native Vegetation Management Unit developed the BAM to assess areas of native vegetation requiring clearance and to calculate SEB requirements. The method is derived from the Nature Conservation Society of South Australia's Bushland Condition Monitoring (BCM) methodology (Croft *et al.* 2005-2009). The BAM requires quantitative on ground and desktop assessments of native vegetation and ecological values.

When using the BAM, each area to be assessed (i.e., each application area) is termed a 'Block', which is further stratified into 'Sites'. Each Site relates to a vegetation association found within the Block, which are assessed in representative 1- ha quadrats and compared to BCM 'benchmark' vegetation communities. Multiple BAMs are undertaken in VAs which occur extensively over a Block, to account for changes in composition and vegetation condition of the VA across a large area.

Three components of the biodiversity value of the Site are measured and scored:

- Landscape context;
- Vegetation condition; and
- Conservation significance.

The factors that influence each of these components and their score ranges are described in Table 5 The scores of these three components are combined to provide the Unit Biodiversity Score (UBS) (per ha) and then multiplied by the size (ha) of each Site to provide the Total Biodiversity Score for each Site.

Table 5. Factors that influence the value in the BAM scoresheet (NVC 2020a).

Component	Factors	Score range
Landscape context	• Percentage vegetation cover within 5 km. • Block shape (cleared perimeter: area ratio). • Native vegetation rampancy of IBRA Association. • Percentage of native vegetation protected within the IBRA Association; and • The presence of riparian vegetation, swamps, or wetlands.	1.00-1.25
Vegetation condition	• Native plant species diversity. • Number of native lifeforms and their cover. • Number of regenerating species. • Weed cover and the level of invasiveness of dominant weed species. • Mature tree health, fallen timber, hollow bearing trees, and tree canopy; and • Native: exotic understorey biomass.	max 80.00
Conservation significance	• The presence of federal or state listed threatened ecological communities, and their conservation rating. • Number of threatened plant species recorded at the site, and their conservation rating; and • Number of threatened fauna species and their conservation rating or potential habitat occurs within the site.	1.00-1.50
Mean annual rainfall	• The mean annual rainfall for the site.	-
Area of clearance	• The area of native vegetation (ha) to be cleared for the Project.	-

BAM assessments were undertaken in all identified patches of native vegetation within the Project Area. Conservation significance scores were calculated using direct observations of flora and direct and historical observations of fauna species of conservation significance (i.e., desktop analysis results). Historical fauna observations within 5 km of the Project Area were obtained from the PMST and BDBSA. For the PMST, only species or species habitat *known to occur* within a 5 km buffer were included (as per the BAM manual; NVC 2020a). Marine and/or wetland species were omitted from the SEB scoresheets given the Project Area impacts terrestrial habitats only.

The mean annual rainfall used for the BAM scoresheets was obtained from the climate overlay on NatureMaps 'Mean Annual Rainfall 1976 – 2005' (DEW 2023).

Due to the variation in vegetation across the Project Area, Blocks were determined after the field survey. Sites within each block were based on the BCM Community and dominant species within each site.

5.1.1 Vegetation survey sites

A total of nine sites were surveyed using this method, with locations chosen based on differences in vegetation composition and condition, with some regard to the proximity of pastoral infrastructure such as watering points. The locations of vegetation survey sites (or BAM sites) are listed in Table 6 and shown on the map in Figure 3 (page 17).

Table 6. The locations of vegetation survey sites (BAM sites).

BAM ID	Vegetation Association	Location	
		Easting	Northing
A1	*Tecticornia pergranulata* and *Atriplex vesicaria* low shrubland	726316	6328898
A2a	*Maireana sedifolia* shrubland	724759	6324833
A2b	*Maireana sedifolia* shrubland	722178	6328991
A2c	*Maireana sedifolia* shrubland	720154	6326302
A2d	*Maireana sedifolia* shrubland (degraded)	722673	6323655
A3	*Atriplex vesicaria* shrubland	725604	6326898
A4a	*Acacia papyrocarpa* woodland	721761	6325663
A4b	*Acacia papyrocarpa* woodland	720507	6324328
B1	*Acacia papyrocarpa* woodland	718885	6326164

5.2 Fauna trapping

Five fauna trapping sites were established across representative vegetation associations. All sites were surveyed for four nights, with traps checked every morning and afternoon (in accordance with the Animal Ethics Standard Operating Procedure) (DEH 2000). Captured fauna were temporarily marked with a texta mark along the underside of the tail to distinguish first and subsequent recapture of individuals. This enables a better estimation of population sizes. Each captured individual was checked for the presence of previous texta markings. If present, the individual will be recorded as a 'recapture'.

Datasheets will be used to record capture details, such as:

- monitoring site number;
- date of trapping session;
- trap session (morning or afternoon session);
- capture method;
- species;
- sex;
- age-class (adult, sub-adult, juvenile);
- first capture (no texta markings) or recapture (animal with marked tail);
- comments on reproductive status, health, condition or markings, and
- Voucher number (if held for collection).

Three trap types were utilised during the field survey at each of the five sites:

- **Pitfall traps** – used to survey for mammals and reptiles. Five temporary monitoring sites were established, each site consisting of one line of six pits. Pits were 600 millimetres (mm) deep and spaced approximately 10 metres (m) apart with a drift fence running between all pits. Traps were checked in the early morning and late afternoon over a four-night period. Data was recorded on a standard datasheet, with species, number of individuals, age (if known) and sex (if known) recorded. Captured animals were marked before release so that re-captures could be recorded.

- **Funnel traps** – used to survey reptiles. Two funnel traps were positioned at each end of the pit line drift fence. Traps were checked in the early morning and late afternoon over a four-night period. Data was recorded on a standard datasheet, with species, number of individuals, age (if known) and sex (if known) recorded. Captured animals were marked before release so that re-captures could be recorded.
- **Elliot traps** – used to survey mammals. Fifteen Elliott traps were positioned at each end of the pit line drift fence. Traps were checked in the early morning and late afternoon over a four-night period. Data was recorded on a standard datasheet, with species, number of individuals, age (if known) and sex (if known) recorded. Captured animals were marked before release so that re-captures could be recorded.

5.2.1 Fauna trapping survey sites

The trap set-up is presented in Table 7 and Figure 2. The locations of fauna monitoring sites are presented in Table 8 and Figure 3 (page 17).

Table 7. Trapping effort at Moonabie Samphire Project.

Monitoring technique	No. of Sites	Traps per Site	Total number of traps for all 5 sites combined	Trap nights	Trap effort
Pitfall trap	5	6	30	4	120
Funnel trap	5	4	20	4	80
Elliot trap	5	15	75	4	300

Table 8. Location of fauna monitoring sites.

Survey Site ID	Vegetation Association	Location	
		Easting	Northing
1	*Maireana sedifolia* and *Atriplex vesicaria* Shrubland	720525	6324306
2	*Acacia papyrocarpa* woodland	725509	6326955
3	*Maireana sedifolia* Shrubland	724751	6324836
4	*Atriplex vesicaria* shrubland	726352	6328857
5	*Tecticornia pergranulata* and *Atriplex vesicaria* low shrubland	722193	6329038

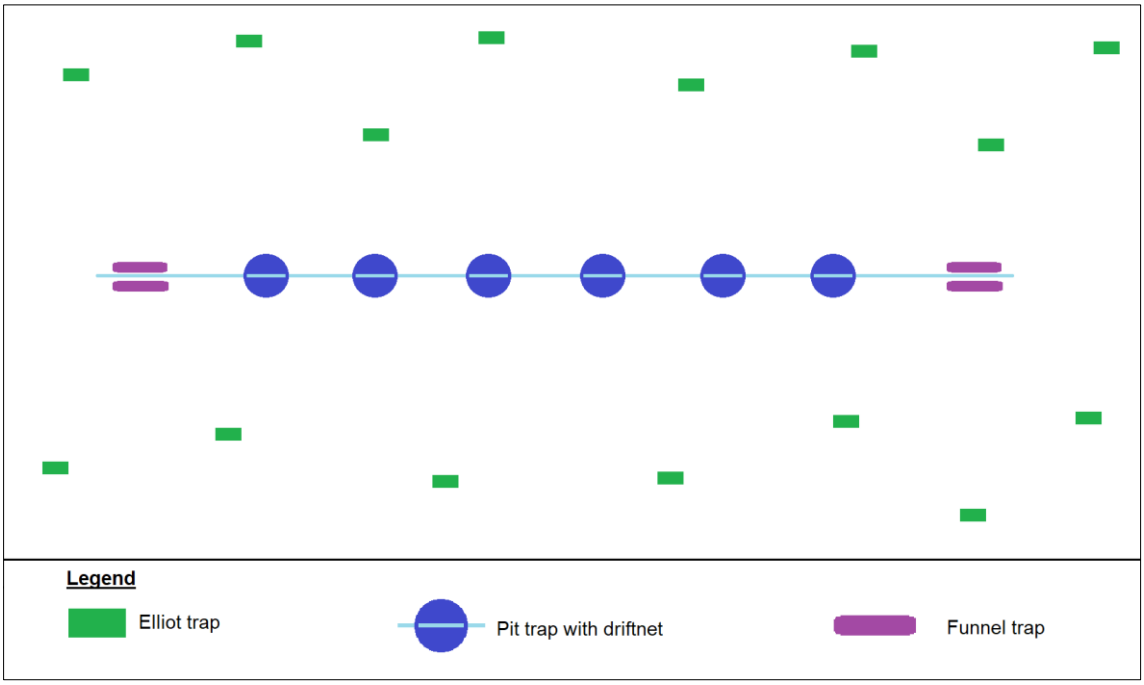


Figure 2. Diagram of fauna trap layout example.

5.3 Avian surveys

5.3.1 Timed area search

Timed area searches were conducted utilising methods consistent with Birdlife Australia Systematic Bird surveys (2-ha, 20-minute search) (Birdlife 2022) recommended survey method, as per the Guidelines for Detecting Birds Listed as Threatened under the *Environment Protection and Biodiversity Conservation Act 1999* (Magrath *et al.* 2010) and DEW biological survey methods (Owens 2000).

Timed area searches were used to survey birds at all sites. An area search for birds was conducted at each of the five semi-permanent fauna sites as well as an additional four sites. A search was conducted over a 2-hectare (ha) area for a period of 20 minutes in the morning and again in the evening (AM/PM survey). Data was recorded on a standard datasheet, with species, feeding guild, number of individuals and activity recorded.

5.3.2 Bird voice broadcast surveys (call playback)

Targeted species-specific call playback was used at each bird site within a designated area of suitable habitat (e.g. dense chenopod shrubs) to assess the presence of the nationally Vulnerable Western Grasswrens (*Amytornis textilis myall*). Call Playback is the recommended survey method for Western Grasswrens, as per the Guidelines for Detecting Birds Listed as Threatened under the *Environment Protection and Biodiversity Conservation Act 1999* (Magrath *et al.* 2010) and DEW biological survey methods (Owens 2000).

Species-specific call playback was broadcasted for up to 3 minutes at each site, with the songs/calls of the focal bird species transmitted from a speaker linked to a mobile phone. The surveyor would sit approximately 10-15 metres away from the speaker, obscured behind vegetation where possible. After the period of 3 minutes observations, the number of birds were recorded on datasheets.

The Southern Whiteface (*Aphelocephala leucopsis*) was listed as Vulnerable under the EPBC Act on 31 March 2023. Since this species was already identified during timed area search surveys, this species was not targeted during call playback surveys.

The locations of the nine bird survey sites are presented in Table 9 and Figure 3 (page 17).

Table 9. The locations of bird survey sites.

Survey Site ID	Vegetation Association	Location	
		Easting	Northing
B1	*Maireana sedifolia* shrubland	722248	6328983
B2	*Acacia papyrocarpa* woodland	720542	6324317
B3	*Maireana sedifolia* shrubland	724740	6324813
B4	*Atriplex vesicaria* shrubland	725502	6327134
B5	*Tecticornia pergranulata* and *Atriplex vesicaria* low shrubland	726423	6328852
B6	*Acacia papyrocarpa* woodland	721774	6325579
B7	*Acacia papyrocarpa* woodland	718938	6325941
B8	*Maireana sedifolia* shrubland	720158	6326244
B9	*Maireana sedifolia* shrubland	722683	6323657

5.3.3 Bat surveys

Bats were surveyed by recording calls of bats flying over the Project Area at night. Two AnaBat recorders were used to detect the high frequency contact and hunting calls of micro-bat species. One recorder was placed at a dry creek bed in a woodland and the other at a water tank, which are location likely to be used by bats as a flyway or roosting habitat.

The recorders were set to record continuously between sunset and sunrise and were placed securely near ground level with microphone pointing towards the sky. The AnaBats recorded for a period of two nights throughout the duration of the survey and was set at the locations shown in Figure 3.

Sonograms collected by the AnaBat recorders were analysed using Analook software. They were compared to reference calls of bat species known to occur in the relevant region of South Australia for identification.

As no threatened bat species were identified by database searches, no targeted trapping surveys were undertaken.

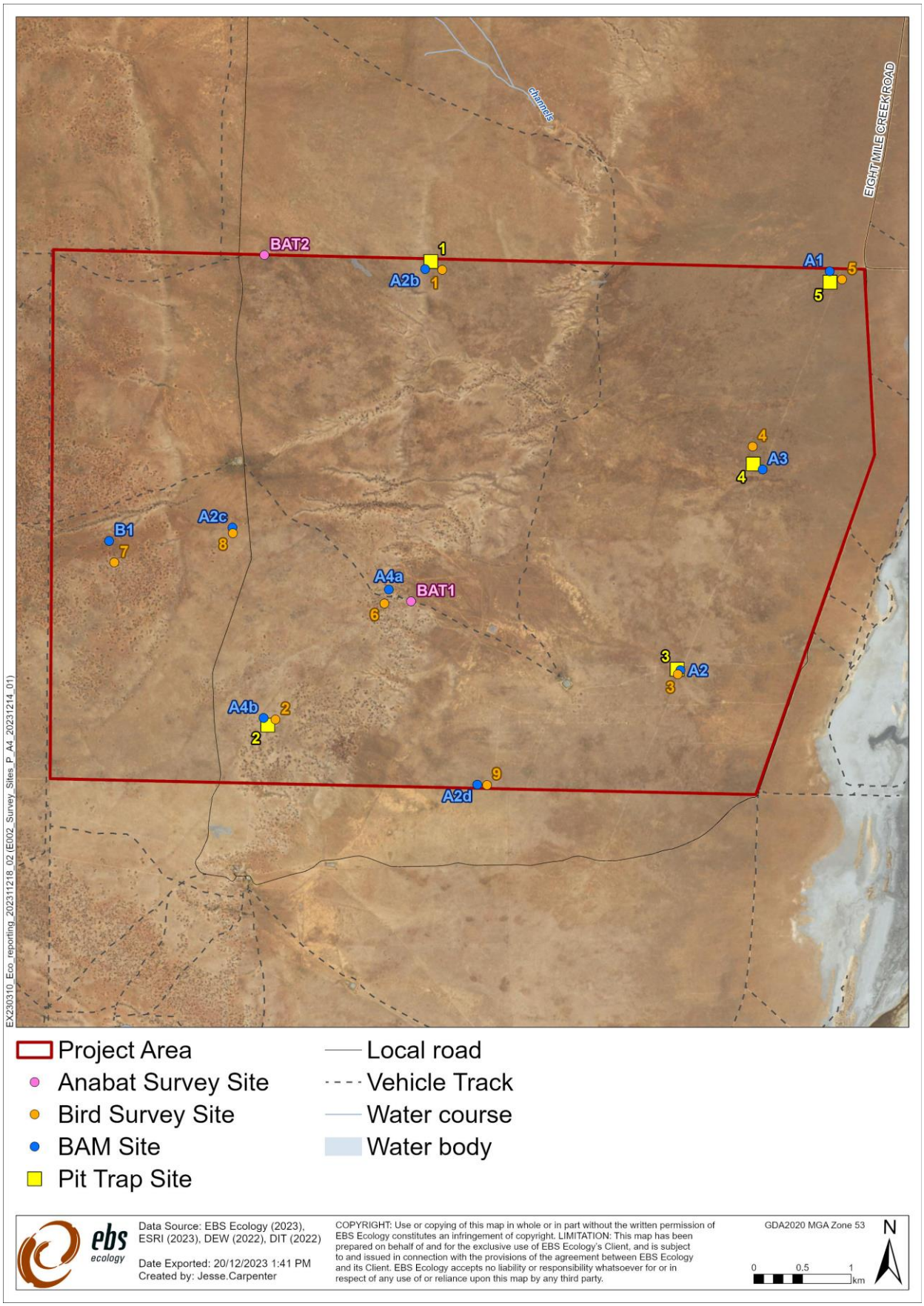


Figure 3. Survey locations of BAM, Bat, fauna and avian sites.

5.4 Opportunistic sightings

All native and exotic vertebrate fauna species opportunistically encountered during the field survey (directly observed, or tracks, scats, burrows, nests, and other signs of presence) were recorded across the Project Area. Potential fauna refuge sites, such as hollows, rock crevices and creek lines were noted as an indication of availability of suitable habitat. Particular attention was given to identifying potential habitat for threatened species. For each opportunistic fauna observation, the species, number of individuals, GPS location, detection methodology (sight, sound, or sign) and habitat were recorded.

5.5 Limitations

The field survey was conducted in Spring, which is the ideal time to identify annual forbs. However, due to the early timing within the season, it is possible that some flora species were present but not detected.

Conditions during the survey period were typically ideal for bird observations, with generally moderate temperatures and low winds. The exception to these conditions was day 5 (10 November), where the maximum temperature reached over 44 ^{o}C. No lids were available to temporarily close the pitfall traps, however additional refuge material was added to each trap, the base of each trap was watered, and the traps were monitored during the peak heat of the day to ensure no animals were captured. This heat is likely to have influenced bird and mammal behaviour and detectability of fauna species on this survey day.

The bat survey was performed using AnaBat Express units, which recorded echolocation sonograms. Performing bat surveys through the analysis of sonograms has the following limitations:

- Abundance cannot be determined;
- Not all regional bat species have readily identifiable echolocation sonograms, with multiple species having sonograms with overlapping characteristics; and
- The range at which an AnaBat Express unit can record an echolocation call is estimated to be 30 m, however this varies species to species. Therefore, the bat activity recorded does not provide data on the species and activity of bats.

6 DESKTOP RESULTS

6.1 Matters of National Environmental Significance

The PMST identified four MNES that might occur in the Search Area including:

1. National Heritage Places
2. Listed Threatened Ecological Communities;
3. Listed Threatened Species; and
4. Listed Migratory Species.

Of these, MNES 2, 3, and 4 are of relevance to the Project Area as no National Heritage Places occur within the Project Area. Other matters protected by the EPBC Act include Commonwealth Lands and Listed Marine Species. Commonwealth Lands do not occur within the Project Area. Species listed as marine under the EPBC Act were excluded since the protection afforded to these species is restricted to within Commonwealth marine areas which do not occur in the Project Area.

The relevant MNES, other matters protected under the EPBC Act, and threatened species listed under the NPW Act with records in the Search Area are discussed in detail in the following sections.

6.2 Threatened ecological communities

The PMST search (DCCEEW 2024a) identified one TEC as potentially occurring within the Project Area:

- Subtropical and Temperate Coastal Saltmarsh (EPBC Act: Vulnerable).

Based on the key diagnostic characteristics stipulated in the approved conservation advice for the Subtropical and Temperate Coastal Saltmarsh (DCCEEW 2024b), this TEC was deemed not to occur within the Project Area.

6.3 Threatened flora

6.3.1 EPBC Act listed threatened flora

The PMST search identified two EPBC Act listed threatened plant species as potentially occurring within the Search Area (Table 10). Neither species were assessed as likely to occur within the Project Area.

6.3.2 NPW Act listed threatened flora

The BDBSA search identified no NPW Act listed threatened plant species as potentially occurring within the Search Area.

6.4 Threatened fauna

6.4.1 EPBC Act listed threatened fauna

The PMST search identified 34 EPBC Act listed threatened fauna species as potentially occurring within the Search Area (Table 10). Of these, two species were observed during the field survey:

- Western Grasswren (Gawler Ranges) (*Amytornis textilis myall*) (EPBC Act: Vulnerable); and
- Southern Whiteface (*Aphelocephala leucopsis*) (EPBC Act: Vulnerable).

An additional two species were assessed as possibly occurring within the Project Area:

- Grey Falcon (*Falco hypoleucos*) (EPBC Act: Vulnerable, NPW Act Rare); and
- Blue-winged Parrot (*Neophema chrysostoma*) (EPBC Act: Vulnerable, NPW Act Vulnerable).

The remaining 30 threatened fauna species identified by the PMST were assessed as unlikely to occur within the Project Area. However, one species, the EPBC Act endangered Common Greenshank (*Tringa nebularia*) was identified during a nearby coastal shorebird survey (EBS 2023a).

Due to the proximity to the coast, marine and wetland birds may occur as a fly-over occurrence. If water collection points contain mineral contaminants as a result of the Project, they may attract shorebirds and depending on the composition of those water sources, may impact on the health of birds visiting the site.

Due to the terrestrial nature of the Project Area, marine species have been excluded from the report. However, a full list of species, including marine species, identified during the database searches is presented in Appendix 1.

6.4.2 NPW Act listed threatened fauna

The BDBSA search identified three additional fauna species listed under the NPW Act as potentially occurring within the Search Area (Table 10). All three species were assessed as unlikely to occur within the Project Area. However, two State Rare species, Sooty Oystercatcher (*Haematopus fuliginosus fuliginosus*) and Pied Oystercatcher (*Haematopus longirostris*) were identified during a nearby coastal shorebird survey (EBS 2023a). As mentioned above, shorebirds may occur as a fly-over occurrence. If water collection points contain mineral contaminants as a result of the Project, they may attract shorebirds and depending on the composition of those water sources, may impact on the health of birds visiting the site.

Table 10. Threatened species identified in the database searches Within a 5 km buffer, and previously conducted EBS surveys nearby (Green shading: likely, orange shading: possible).

Species	Common name	Conservation status		Source	PMST Likelihood / Date of last record	Likelihood of use for habitat – Comments
		EPBC Act	NPW Act			
FLORA						
Pterostylis xerophila	Desert Greenhood	VU	V	1	May	**Unlikely**
Swainsona pyrophila	Yellow Swainson-pea	VU	R	1	Likely	**Unlikely**
AVES						

Species	Common name	Conservation status		Source	PMST Likelihood / Date of last record	Likelihood of use for habitat – Comments
		EPBC Act	NPW Act			
Amytornis textilis myall	Western Grasswren (Gawler Ranges)	VU		1, 4	Likely, 2023	**Known** - Observed in *Lycium ferocissimum* habitat within the Project Area.
Aphelocephala leucopsis	Southern Whiteface	VU		1, 4	Known, 2023	**Known** - Observed in *Lycium ferocissimum* habitat within the Project Area.
Arenaria interpres	Ruddy Turnstone	VU, Mi (W)	R	1	Likely	**Unlikely**
Calidris acuminata	Sharp-tailed Sandpiper	VU, Mi (W)		1	Known	**Unlikely**
Calidris canutus	Red Knot	EN, Mi (W)		1	Known	**Unlikely**
Calidris ferruginea	Curlew Sandpiper	CR, Mi (W)	E	1	Known	**Unlikely**
Charadrius leschenaultii	Greater Sand Plover	VU, Mi (W)	R	1	Likely	**Unlikely**
Cladorhynchus leucocephalus	Banded Stilt		V	2	1981	**Unlikely**
Diomedea antipodensis	Antipodean Albatross	VU, Mi (M)		1	Likely	**Unlikely**
Diomedea epomophora	Southern Royal Albatross	VU, Mi (M)	V	1	May	**Unlikely**
Diomedea exulans	Wandering Albatross	VU, Mi (M)	V	1	Likely	**Unlikely**
Falco hypoleucos	Grey Falcon	VU	R	1	Likely	**Possible** - Hunting may occur across shrubland but breeding is unlikely.
Gallinago hardwickii	Latham's Snipe	VU, Mi (W)	R	1	May	**Unlikely**
Grantiella picta	Painted Honeyeater	VU	R	1	May	**Unlikely**
Haematopus fuliginosus fuliginosus	Sooty Oystercatcher		R	2, 3	1984, 2023	**Unlikely**
Haematopus longirostris	Pied Oystercatcher		R	2, 3	1982, 2023	**Unlikely**
Leipoa ocellata	Malleefowl	VU	V	1	Likely	**Unlikely**
Limosa lapponica baueri	Nunivak Bar-tailed Godwit	VU, Mi (W)	R	1	May	**Unlikely**
Macronectes giganteus	Southern Giant-Petrel	EN, Mi (M)	V	1	May	**Unlikely**
Macronectes halli	Northern Giant Petrel	VU, Mi (M)		1	Likely	**Unlikely**
Neophema chrysostoma	Blue-winged Parrot	VU	V	1	Likely	**Possible** - potentially suitable habitat occurs, though minimal grassy

Species	Common name	Conservation status		Source	PMST Likelihood / Date of last record	Likelihood of use for habitat – Comments
		EPBC Act	NPW Act			
						habitat is found within Project Area.
Numenius madagascariensis	Eastern Curlew	CE, Mi (W)	E	1	Known	**Unlikely**
Pachyptila turtur subantarctica	Fairy Prion (southern)	VU		1	Likely	**Unlikely**
Pedionomus torquatus	Plains-wanderer	CE	E	1	May	**Unlikely**
Pezoporus occidentalis	Night Parrot	EN	E	1	May	**Unlikely**
Phoebetria fusca	Sooty Albatross	VU, Mi (M)	E	1	May	**Unlikely**
Rostratula australis	Australian Painted Snipe	EN	E	1	May	**Unlikely**
Stagonopleura guttata	Diamond Firetail	VU	V	1	May	**Unlikely**
Sternula nereis nereis	Australian Fairy Tern	VU	E	1	Likely	**Unlikely**
Thalassarche carteri	Indian Yellow-nosed Albatross	VU	E	1	Likely	**Unlikely**
Thalassarche cauta	Shy Albatross	EN		1	Likely	**Unlikely**
Thalassarche impavida	Campbell Albatross	VU	V	1	May	**Unlikely**
Thalassarche melanophris	Black-browed Albatross	VU		1	Likely	**Unlikely**
Thalassarche steadi	White-capped Albatross	VU		1	Known	**Unlikely**
Thinornis cucullatus cucullatus	Eastern Hooded Plover	VU	V	1	May	**Unlikely**
Tringa nebularia	Common Greenshank	EN, Mi (W)		1, 3	Likely, 2023	**Unlikely**
MAMMALIAA						
Sminthopsis psammophila	Sandhill Dunnart	EN	V	1	Likely	**Unlikely**

Conservation status: **EPBC Act:** ***Environment Protection and Biodiversity Conservation Act 1999.*** **NPW Act:** ***Native Vegetation Act 1991*****.**
Conservation Codes: **CR/CE: Critically Endangered. EN/E: Endangered. VU/V: Vulnerable. R: Rare. Mi: Migratory. (M): Marine. (W): Wetland).**
Source of Information:

1. **PMST (DCCEEW 2024a) – 5 km buffer applied to Project Area;**
2. **BDBSA (DEW 2023a) – 5 km buffer applied to Project Area;**
3. **Avian field survey (EBS 2023a);**
4. **Ecological field survey (EBS 2023b).**

6.5 Migratory fauna

The database searches identified 25 migratory species as potentially occurring within the Search Area, of which 15 have are listed as threatened under the EPBC Act and NPW Act. These species have already been addressed in Section 6.4.

Of the remaining six migratory species identified as potentially occurring within the 5 km Search Area, no species were assessed as likely to occur within the Project Area (Table 11). As mentioned above, shorebirds may occur as a fly-over occurrence. If water collection points contain mineral contaminants as a result of the Project, they may attract shorebirds and depending on the composition of those water sources, may impact on the health of the birds, if they visit the site.

Due to the terrestrial nature of the Project Area, five migratory marine species have been excluded from the report. However, a full list of species, including marine species, identified during the database searches are presented in Appendix 1.

Table 11. Migratory species identified in the database searches within a 5 km buffer, and previously conducted EBS surveys nearby.

Species	Common name	Migratory category	Source	PMST Likelihood / Date of last record	Likelihood of use for habitat – Comments
AVES					
Apus pacificus	Fork-tailed Swift	Mi (M)	1	Likely	**Unlikely**
Ardenna grisea	Sooty Shearwater	Mi (M)	1	May	**Unlikely**
Calidris ruficollis	Red-necked Stint	Mi (W)	1	Likely	**Unlikely**
Charadrius veredus	Oriental Plover	Mi (W)	1	May	**Unlikely**
Motacilla cinerea	Grey Wagtail	Mi (T)	1	May	**Unlikely**
Motacilla flava	Yellow Wagtail	Mi (T)	1	May	**Unlikely**

Migratory category: M: Marine; W: Wetland; T: Terrestrial.
Source of Information:

1. **PMST (DCCEEW 2024a) – 5 km buffer applied to Project Area;**
2. **BDBSA (DEW 2023a) – 5 km buffer applied to Project Area;**
3. **Avian field survey (EBS 2023a);**
4. **Ecological field survey (EBS 2023b).**

7 FIELD RESULTS

7.1 Climate and weather

The survey period was warm and dry with cool nights, with the exception of one particularly hot day. Typical day time temperatures were around 25 ºC, spiking to 44.2 ºC on day 5 (10 November). Minimum temperatures by 4 ºC throughout the survey period (Table 12). Large droplets of rain fell sporadically over the evening of day 5 but was not heavy enough to be captured by the Bureau of Meteorology (BOM 2023).

Table 12. Wweather conditions during the survey.

Date	Temperature (ºC)		Humidity (%)		Wind Speed
	Minimum	Maximum	High	Low	Maximum (km/h)
06/11/2023	13.3	25.1	70	46	50
07/11/2023	14.0	25.8	75	33	48
08/11/2023	13.0	25.4	78	39	43
09/11/2023	14.3	28.7	71	33	28
10/11/2023	16.0	44.2	34	10	57
11/11/2023	16.5	22.6	72	54	59

7.2 Vegetation associations and condition

Vegetation across the Project Area is predominantly *Maireana sedifolia* shrubland on flat terrain with silty soils. Several low-lying depressions in the east hosted stands of samphire shrubland, while the low ranges to the central and west of the Project Area consisted of open woodland over chenopod shrubs.

Five man-made stock-water dams and several bore holes occur at drainage lines throughout the Project Area. These areas are highly degraded with a high coverage of weeds not found elsewhere.

The survey identified and mapped five vegetation associations (VAs) across the Project Area across approximately 4,374 ha of vegetation in Block A and Block B, as presented in Table 13 and Figure 4. Vegetation conditions are predominantly in good condition and are summarised in Table 14 to Table 18.

Table 13. Vegetation Associations (VA) within the Project Area.

VA	Description	Area (ha) in Project Area	Block
A1	*Tecticornia pergranulata* and *Atriplex vesicaria* low shrubland	247.46	A
A2	*Maireana sedifolia* shrubland	2626.69	A
A3	*Atriplex vesicaria* shrubland	620.33	A
A4	*Acacia papyrocarpa* woodland	441.93	A
B1	*Acacia papyrocarpa* woodland	437.53	B
	TOTAL	**4,373.95**	

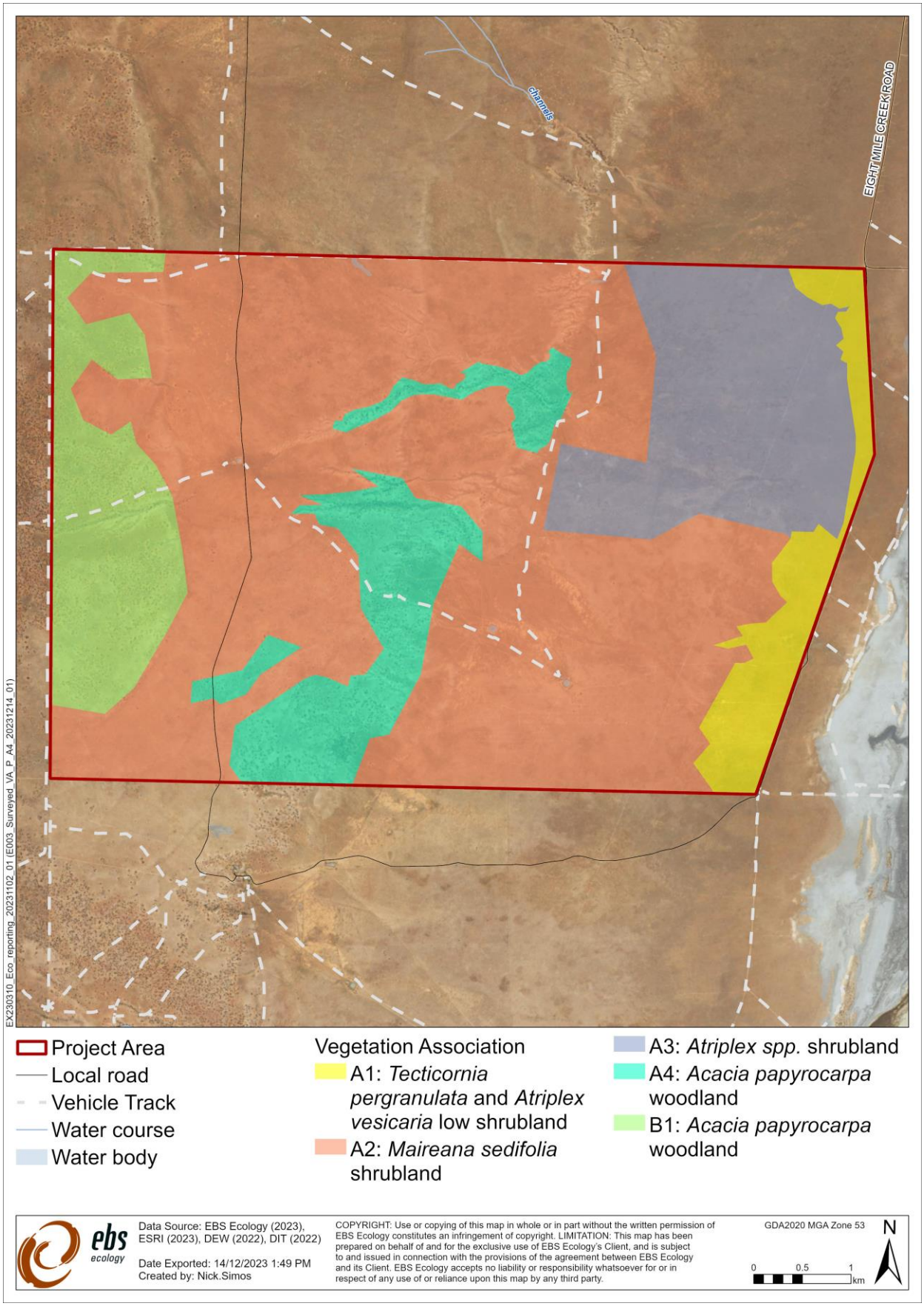


Figure 4. Vegetation Associations in the Project Area.

Table 14. Summary of A1 - *Tecticornia pergranulata* and *Atriplex vesicaria* low shrubland.

Vegetation Association	*Tecticornia pergranulata* and *Atriplex vesicaria* low shrubland.		
 **A1 – Photo direction West, 726315.65”E, 6328898.08”N.**			
General description	Very low samphire and bluebush shrubland in fair to good condition.		
	Overstorey	Midstorey	Understorey
	--	– *Atriplex vesicaria* – *Tecticornia pergranulata* ssp. *divaricate*	– *Austrostipa Eremophila* – *Austrostipa nítida* – *Calandrinia volubilis* – *Crassula* sp. – *Disphyma crassifolium* ssp. *Clavellatum* – *Dissocarpus biflorus* var. – *Minuria cunninghami* – *Rytidosperma* sp. – *Sclerolaena diacantha* – *Sclerolaena uniflora* – *Threlkeldia diffusa* – *Vittadinia cuneata* var.
Threatened species or community	This VA is not part of a TEC. Threatened species which may utilise this VA, as identified in the desktop assessment and observed within the Project Area include: • Southern Whiteface (*Aphelocephala leucopsis leucopsis)* (EPBC Act: Vulnerable); • Western Grasswren (*Amytornis textilis myall*) (EPBC Act: Vulnerable; NPW Act: Vulnerable); • Slender-billed Thornbill (western) (*Acanthiza iredalei iredalei*) (NPW Act: Rare); and • Australian Bustard (*Ardeotis australis*) (NPW Act: Vulnerable).		
Landscape context score	**1.06**	**Conservation significance score**	**1.10**
Unit biodiversity Score	**59.41**	**Vegetation Condition Score**	**50.96**

Table 15. Summary of A2 - *Maireana sedifolia* shrubland.

Vegetation Association	*Maireana sedifolia* shrubland.			
	 **A2a – Photo direction North, 724758.67"E, 6324832.57"N.**		 **A2b – Photo direction South, 722177.56"E, 6328991"N.**	
	 **A2c – Photo direction North, 720154.49"E, 6326301.72"S.**		 **A2d – Photo direction East, 722673.05"E, 6323655.41"N.**	
General description	Generally heavy grazing in between shrubs, evidence of vehicle and livestock tracks, scats and other disturbance under shrubs. Weeds are sparse, consisting of *Carrichtera annua* and *Medicago minima.*			
	Overstorey	Midstorey	Understorey	
	– *Lycium australe*	– *Atriplex holocarpa* – *Atriplex vesicaria* – *Eriochiton sclerolaenoides* – *Eriochiton sclerolaenoides* – *Maireana georgei* – *Maireana pyramidata* – *Maireana sedifolia* – *Maireana trichopteran* – *Rhagodia spinescens* – *Scaevola spinescens*	– *Austrostipa nitida* – *Austrostipa platychaeta* – *Minuria cunninghamii* – *Roepera billardierei* – *Rytidosperma* sp. – *Salsola australis* – *Sclerolaena obliquicuspis* – *Sclerolaena patenticuspis* – *Sida intricata* – *Tetragonia eremaea* – *Vittadinia cuneata var.*	
Threatened species or community	This VA is not part of a TEC. Threatened species which may utilise this VA, as identified in the desktop assessment and observed within the Project Area include: • Southern Whiteface (*Aphelocephala leucopsis leucopsis)* (EPBC Act: Vulnerable); • Western Grasswren (*Amytornis textilis myall*) (EPBC Act: Vulnerable; NPW Act: Vulnerable); • Slender-billed Thornbill (western) (*Acanthiza iredalei iredalei*) (NPW Act: Rare); and • Australian Bustard (*Ardeotis australis*) (NPW Act: Vulnerable).			
Landscape context score	**A2a: 1.06 A2b: 1.06 A2c: 1.06 A2d: 1.06**		**Conservation significance score**	**A2a: 1.10 A2b: 1.10 A2c: 1.10 A2d: 1.10**
Unit biodiversity Score	**A2a: 33.45 A2b: 34.93 A2c: 59.17 A2d: 32.47**		**Vegetation Condition Score**	**A2a: 28.699 A2b: 29.95 A2c: 50.75 A2d: 26.16**

Table 16. Summary of A3 - *Atriplex vesicaria* shrubland.

<table>
<tr><td>Vegetation Association</td><td colspan="3">Atriplex vesicaria shrubland.</td></tr>
<tr><td colspan="4"> 
A3 – Photo direction South-west, 725604.02”E, 6326897.59”N.</td></tr>
<tr><td rowspan="3">General description</td><td colspan="3">Generally heavy grazing in between shrubs. Weeds are sparse, consisting of Carrichtera annua and Medicago minima.</td></tr>
<tr><td>Overstorey</td><td>Midstorey</td><td>Understorey</td></tr>
<tr><td>-</td><td>– Atriplex vesicaria
– Eriochiton sclerolaenoides
– Maireana appressa
– Maireana georgei
– Maireana pyramidata
– Maireana sedifolia</td><td>– Austrostipa nítida
– Crassula sp.
– Minuria cunninghami
– Rhodanthe pygmaea
– Roepera billardierei
– Rytidosperma sp.
– Sclerolaena obliquicuspis
– Sclerolaena patenticuspis
– Sida intricata
– Vittadinia cuneata var.</td></tr>
<tr><td>Threatened species or community</td><td colspan="3">This VA is not part of a TEC. Threatened fauna species which may utilise this VA, as identified in the desktop assessment and observed within the Project Area include:
• Southern Whiteface (Aphelocephala leucopsis leucopsis) (EPBC Act: Vulnerable);
• Western Grasswren (Amytornis textilis myall) (EPBC Act: Vulnerable; NPW Act: Vulnerable);
• Slender-billed Thornbill (western) (Acanthiza iredalei iredalei) (NPW Act: Rare); and
• Australian Bustard (Ardeotis australis) (NPW Act: Vulnerable).</td></tr>
<tr><td>Landscape context score</td><td>1.06</td><td>Conservation significance score</td><td>1.10</td></tr>
<tr><td>Unit biodiversity Score</td><td>60.92</td><td>Vegetation Condition Score</td><td>52.25</td></tr>
</table>

Table 17. Summary of A4 - *Acacia papyrocarpa* Woodland.

Vegetation Association	*Acacia papyrocarpa* Woodland.		
			
	A4a – Photo direction East, 720507.34 "E, 6324328.24 "N.	**A4b - Photo direction west, -33.579692, 138.17265.**	
General description	A4b is located at a fauna trapping site. There is evidence of heavy grazing. All trees utilised by stock for shelter and grazing. Weeds are sparse, consisting of *Carrichtera annua* and *Medicago minima.*		
	Overstorey	Midstorey	Understorey
	– *Acacia papyrocarpa* – *Alectryon oleifolius* ssp. *canescens* – *Amyema quandang var. quandang* – *Amyema* sp. – *Eremophila scoparia* – *Lycium australe* – *Myoporum platycarpum* ssp. – *Santalum spicatum* – *Senna artemisioides* ssp. *X coriacea*	– *Atriplex vesicaria* – *Enchylaena tomentosa* var. – *Frankenia pauciflora var.* – *Maireana georgei* – *Maireana pyramidata* – *Maireana sedifolia* – *Maireana trichopteran* – *Rhagodia ulicina* – *Scaevola spinescens*	– *Austrostipa Eremophila* – *Austrostipa nítida* – *Austrostipa platychaeta* – *Chenopodium desertorum* ssp. – *Roepera billardierei* – *Rytidosperma* sp. – *Sclerolaena brachyptera* – *Sclerolaena patenticuspis* – *Sida intricata* – *Sida petrophila* – *Solanum quadriloculatum* – *Vittadinia cuneata* var.
Threatened species or community	This VA is not part of a TEC. Threatened fauna species which may utilise this VA, as identified in the desktop assessment and observed within the Project Area include: • Southern Whiteface (*Aphelocephala leucopsis leucopsis)* (EPBC Act: Vulnerable); • Western Grasswren (*Amytornis textilis myall*) (EPBC Act: Vulnerable; NPW Act: Vulnerable); • Slender-billed Thornbill (western) (*Acanthiza iredalei iredalei*) (NPW Act: Rare); and • Australian Bustard (*Ardeotis australis*) (NPW Act: Vulnerable). One threatened fauna species was observed within the Project Area: • Sandalwood (*Santalum spicatum*) (NPW Act: Vulnerable).		
Landscape context score	**A4a: 1.06** **A4b: 1.06**	**Conservation significance score**	**A4a: 1.18** **A4b: 1.06**
Unit biodiversity Score	**A1a: 74.86** **A4b: 55.71**	**Vegetation Condition Score**	**A1a: 59.85** **A4b: 47.78**

Table 18. Summary of B1 - *Acacia papyrocarpa* Woodland.

Vegetation Association	*Acacia papyrocarpa* Woodland.		
 **B1 – Photo direction South, 718884.69"E, 6326163.86"N.**			
General description	Located in Buckleboo IBRA association. Dominated by *M. pyramidata* in the understorey. Patchy overstorey of Myall and Myoporum. Ephemeral creekline contained higher diversity of species. Weeds are sparse, consisting only of *Medicago minima* and one individual *Nicotiana glauca.*		
	Overstorey	Midstorey	Understorey
	– *Acacia oswaldii* – *Acacia papyrocarpa* – *Alectryon oleifolius* ssp. *canescens* – *Amyema quandang var. quandang* – *Eremophila scoparia* – *Exocarpos aphyllus* – *Lycium australe* – *Myoporum platycarpum* ssp. – *Pittosporum angustifolium* – *Santalum acuminatum* – *Senna artemisioides* ssp. *artemisioides x* ssp. *coriacea* – *Senna artemisioides* ssp. *X coriacea*	– *Atriplex vesicaria* – *Duma florulenta* – *Enchylaena tomentosa* var. – *Maireana aphylla* – *Maireana georgei* – *Maireana pyramidata* – *Maireana sedifolia* – *Pimelea microcephala* ssp. – *Rhagodia spinescens* – *Rhagodia ulicina*	– *Abutilon leucopetalum* – *Austrostipa nítida* – *Chenopodium desertorum* ssp. – *Convolvulus remotus* – *Eriochiton sclerolaenoides* – *Ptilotus obovatus* – *Rytidosperma* sp. – *Sclerolaena diacantha* – *Sclerolaena obliquicuspis* – *Solanum quadriloculatum* – *Vittadinia cuneata* var.
Threatened species or community	This VA is not part of a TEC. Threatened fauna species which may utilise this VA, as identified in the desktop assessment and observed within the Project Area include: • Southern Whiteface (*Aphelocephala leucopsis leucopsis)* (EPBC Act: Vulnerable); • Western Grasswren (*Amytornis textilis myall*) (EPBC Act: Vulnerable; NPW Act: Vulnerable); • Slender-billed Thornbill (western) (*Acanthiza iredalei iredalei*) (NPW Act: Rare); and • Australian Bustard (*Ardeotis australis*) (NPW Act: Vulnerable).		
Landscape context score	**1.05**	**Conservation significance score**	**1.10**
Unit biodiversity Score	**63.63**	**Vegetation Condition Score**	**55.09**

7.3 Fauna trapping

All tapping sites were surveyed for four days and four nights, with traps checked every morning and afternoon, in accordance with standard survey methodologies and the Animal Ethics permit requirements. An additional mid-day check was completed on 10 November due to high temperatures. Photographs of each trap site taken during the 2023 monitoring are provided in Appendix 3.

Ninety-two captures (including re-captures) were recorded, representing the 17 species listed in Table 19. Three Elliot, five funnel and 84 pitfall trap captures were made. Species caught included four mammals and 13 reptiles. One introduced species, House Mouse (*Mus musculus*) was captured, occurring at Site 2 and Site 4. Three re-captures were recorded:

- Bolam's Mouse (*Pseudomys bolami*) – One individual at site 1; and
- Painted Dragon (*Ctenophorus pictus*) – One individual at site 1 and one individual at site 5.

Table 19. Fauna species captured during the survey.

Scientific Name	Common Name	Method	Trap site ID					Grand total
			1	2	3	4	5	
Mammals								
*Mus musculus**	House Mouse	Elliot				1	1	**2**
		Pitfall		1		1		**2**
Pseudomys bolami	Bolam's Mouse	Elliot			1			**1**
		Pitfall	11		2	3	2	**18**
Sminthopsis crassicaudata	Fat-tailed Dunnart	Pitfall	2		1	2		**5**
Sminthopsis dolichura	Little Long-tailed Dunnart	Pitfall			1			**1**
Reptiles								
Ctenophorus pictus	Painted Dragon	Pitfall	5		1		2	**8**
Ctenotus olympicus	Saltbush Ctenotus	Funnel				1		**1**
		Pitfall	1		3			**4**
Ctenotus regius	Eastern Desert Ctenotus	Pitfall	2		1	4	2	**9**
Ctenotus schomburgkii	Sandplain Ctenotus	Pitfall		2	1			**3**
Diplodactylus calcicolus	South Coast Stone Gecko	Funnel	1					**1**
		Pitfall			1		1	**2**
Diplodactylus furcosus	Ranges Stone Gecko	Funnel					2	**2**
		Pitfall		2	2	2	1	**7**
Eremiascincus richardsonii	Broad-banded Sandswimmer	Pitfall		1	1			**2**
Lerista dorsalis	Southern Four-toed Slider	Pitfall					1	**1**
Lerista terdigitata	Southern Three-toed Slider	Pitfall			1			**1**
Morethia adelaidensis	Adelaide Snake-eye	Pitfall					1	**1**
Strophurus intermedius	Southern Spiny-tailed Gecko	Funnel	1					**1**
		Pitfall	4	6	2		1	**13**
Tympanocryptis lineata complex	Lined Earless Dragon	Pitfall	2		2		1	**5**

Scientific Name	Common Name	Method	Trap site ID					Grand total
			1	2	3	4	5	
Underwoodisaurus milii	Common Barking Gecko	Pitfall	2					**2**
Total abundance			**31 (13M, 18R)**	**12 (1M, 11R)**	**20 (5M, 15R)**	**14 (7M, 7R)**	**15 (3M, 12R)**	**92 (29M, 63R)**
Total Diversity			**8 (2M, 8R)**	**5 (1M, 4R)**	**14 (4M, 10R)**	**7 (4M, 3R)**	**11 (2M, 9R)**	**17 (4M, 13R)**

M = Mammal; R = Reptile.

7.3.1 Diversity

A total of 17 species were captured, including four mammal and 13 reptile species (Figure 5). Two mammal families, Dasyuromorphia and Rodentia, were represented, while reptiles from one family, Squamata, were captured (Figure 6).

Mammals

Of the four mammal species captured, the highest mammal diversity occurred at Site 3 (*Maireana sedifolia* Shrubland) and Site 4 (*Atriplex vesicaria* shrubland) with three species each (with 5 and 7 total mammal captures, respectively). The lowest mammal diversity occurred at Site 2 (*Acacia papyrocarpa* woodland), with only one mammal species (the introduced House Mouse (*Mus musculus*)) captured throughout the survey.

Reptiles

Of the 13 reptile species captured, the highest reptile diversity occurred at Site 3, with a total of 10 species (with 15 total reptile captures). The lowest reptile diversity occurred at Site 2, with four reptile species (with a total of 11 captures) throughout the survey.

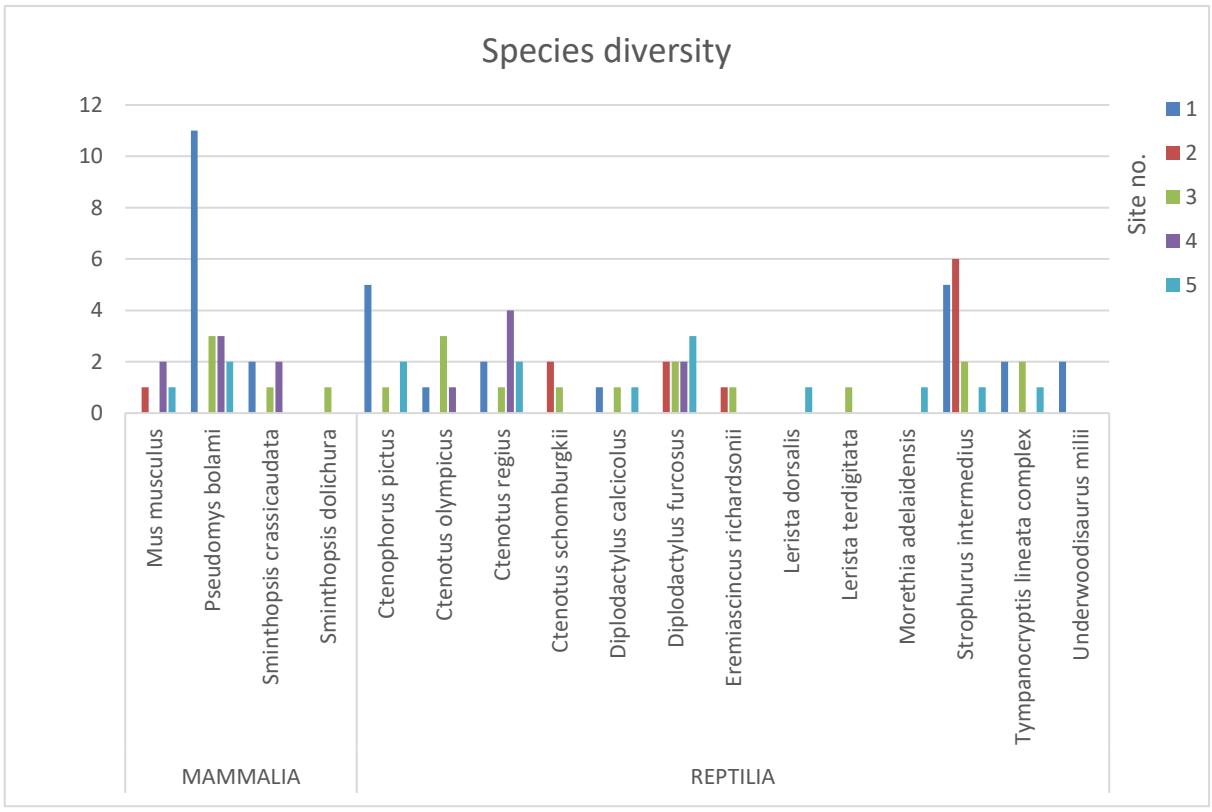


Figure 5. Species diversity captured across 5 fauna trapping sites.

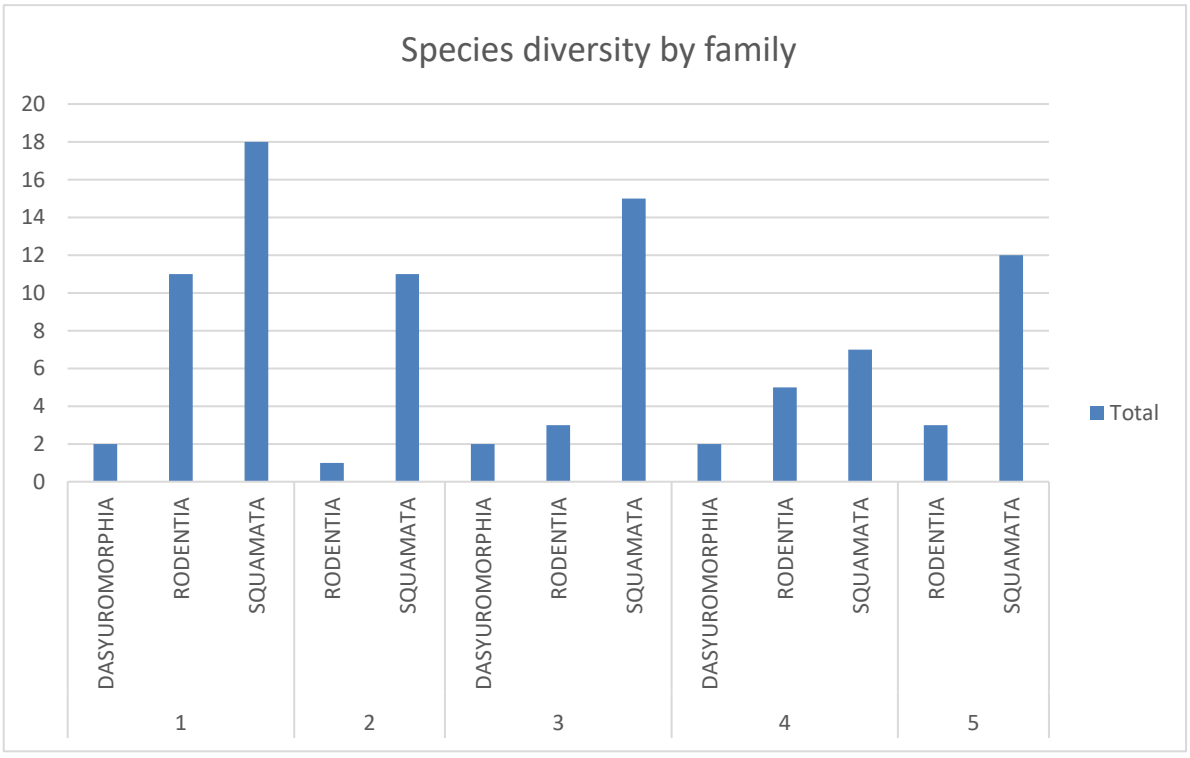


Figure 6. Family diversity of species captured across 5 fauna trapping sites.

7.3.2 Abundance

Of the 92 captures recorded across all five survey sites, the most fauna captures occurred at Site 1 (*Maireana sedifolia* and *Atriplex vesicaria* Shrubland) with 31 individuals and the lowest occurred at Site 2 (*Acacia papyrocarpa* woodland) with 12 individuals (Figure 7).

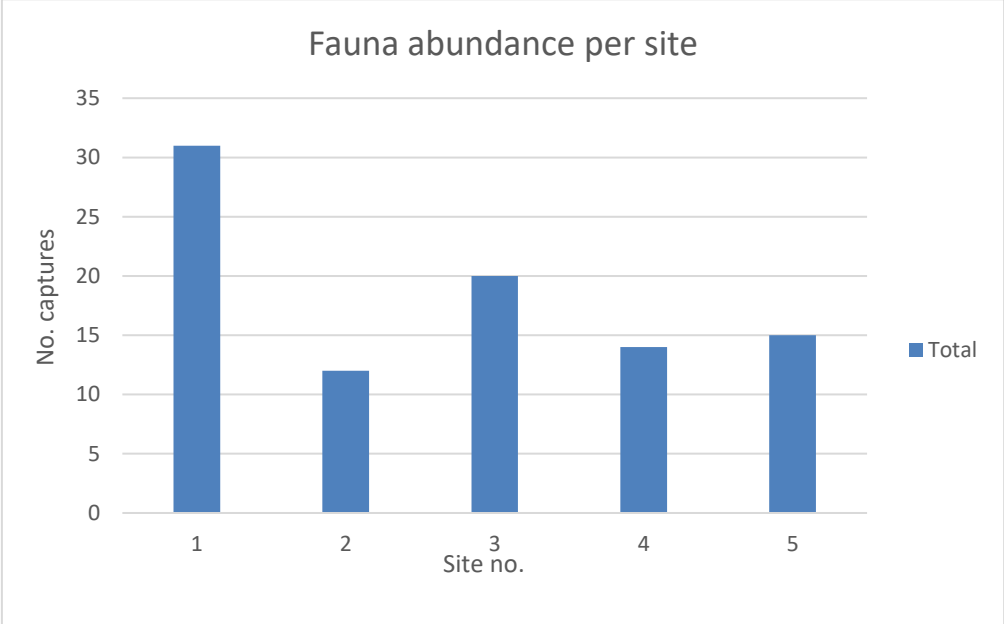


Figure 7. Abundance of fauna captures per site.

Mammals

Based on trapping results, mammals are less abundant than reptiles (Figure 8). Mammals made up 29 of the 92 captures in total. Based on trapping results, Bolam's Mouse (*Pseudomys bolami*) was the most abundant species, with a total of 19 captures (including one re-capture). Of these 19 captures, 11 occurred at Site 1 (*Maireana sedifolia* and *Atriplex vesicaria* Shrubland).

Reptiles

Reptiles made up 63 of the 92 captures in total. Reptile captures were higher than mammal captures at all sites except Site 4, where the mammal to reptile ratio was equal. Most reptiles were caught at Site 1. Based on trapping results, Southern Spiny-tailed Gecko (*Strophurus intermedius*) was the most abundant reptile species, with a total of 14 captures. Lizards belonging to the genus *Ctenotus* were the most abundant and were captured at all five sites (Figure 9).

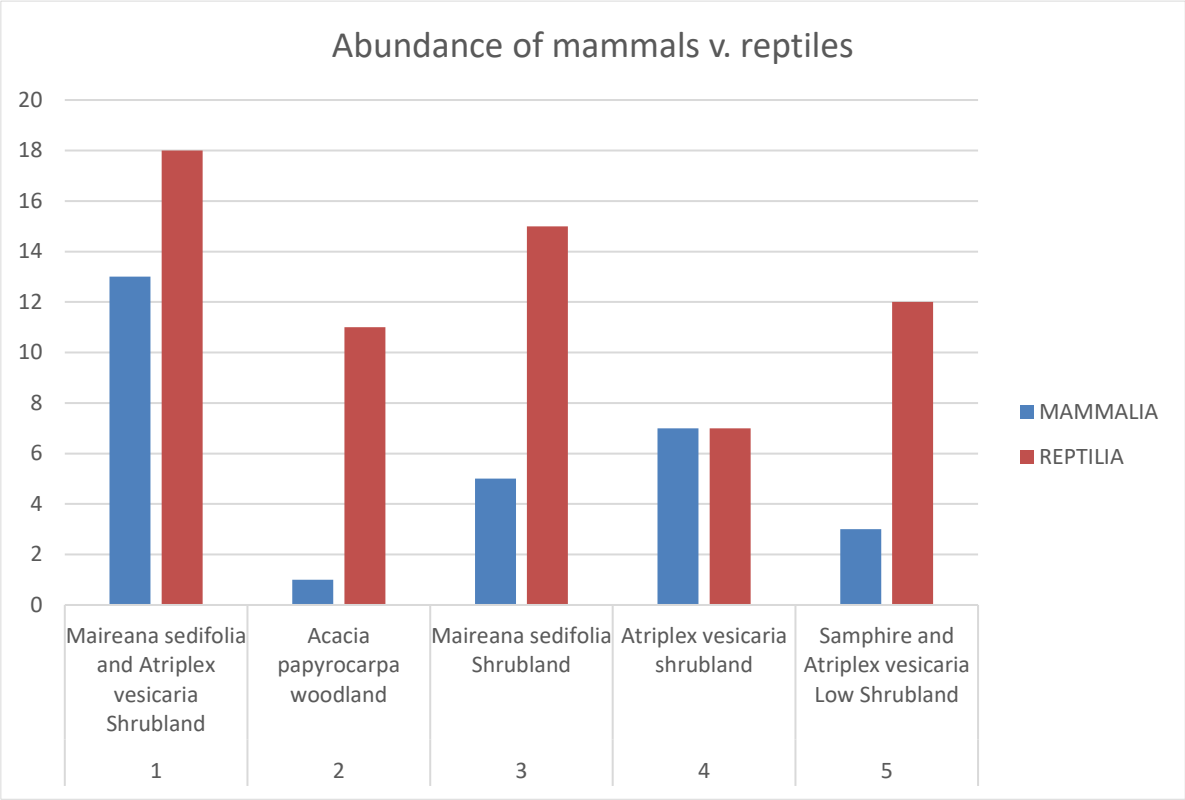


Figure 8. Abundance of mammals and reptiles captured across 5 fauna trapping sites.

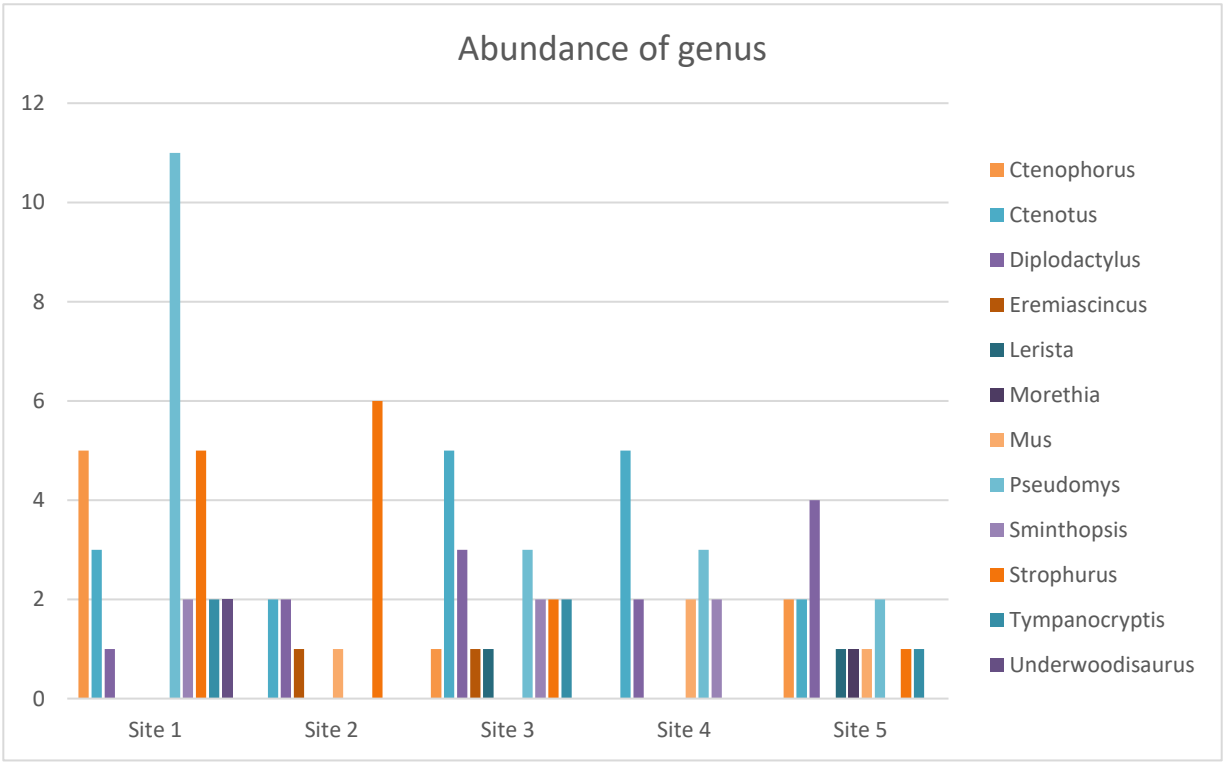


Figure 9. Abundance of genus captured across 5 fauna trapping sites.

7.4 Avian surveys

A total of 32 bird species were recorded across all nine survey sites (Table 20). Bird activity was generally low throughout the Project Area, with most species being unobtrusive and singing/calling rarely. No introduced species were recorded during the avian surveys. One species listed as Vulnerable under the EPBC Act, Southern Whiteface (*Aphelocephala leucopsis leucopsis*), was recorded at sites 6, 7, 8 and 9.

Table 20. Bird species recorded during the survey at each site.

Scientific Name	Common Name	Conservation status		Survey Site									Total
		EPBC	NPW	B1	B2	B3	B4	B5	B6	B7	B8	B9	
Acanthagenys rufogularis	Spiny-cheeked Honeyeater							1	2	1			**4**
Acanthiza chrysorrhoa	Yellow-rumped Thornbill								7				**7**
Acanthiza pusilla	Brown Thornbill				7								**7**
Acanthiza uropygialis	Chestnut-rumped Thornbill				3				4				**7**
Anthus australis	Australian Pipit			2			1					2	**5**
Aphelocephala leucopsis leucopsis	Southern Whiteface	VU							2	4	2	7	**15**
Aquila audax audax	Wedge-tailed Eagle						2						**2**
Artamus cinereus	Black-faced Woodswallow								2		3	1	**6**
Calamanthus campestris	Rufous Fieldwren			6		1	2	3					**12**
Chalcites osculans	Black-eared Cuckoo				1								**1**
Cincloramphus cruralis	Brown Songlark						3	2					**5**
Colluricincla harmonica	Grey Shrikethrush									1			**1**
Coracina novaehollandiae	Black-faced Cuckooshrike								2				**2**
Corvus mellori	Little Raven						3	1	2				**6**
Cracticus torquatus leucopterus	Grey Butcherbird				2				1	1			**4**
Dicaeum hirundinaceum hirundinaceum	Mistletoebird								1	2			**3**
Epthianura albifrons	White-fronted Chat						4						**4**
Epthianura tricolor	Crimson Chat										2		**2**
Falco cenchroides cenchroides	Nankeen Kestrel				1	1	1		1	1			**5**
Gavicalis virescens	Singing Honeyeater				3				2	2			**7**
Gymnorhina tibicen	Australian Magpie			4		3							**7**

Scientific Name	Common Name	Conservation status		Survey Site									Total
		EPBC	NPW	B1	B2	B3	B4	B5	B6	B7	B8	B9	
Hirundo neoxena neoxena	Welcome Swallow					1						2	**3**
Malurus assimilis assimilis	Purple-backed Fairywren								3	6			**9**
Malurus leucopterus leuconotus	White-winged Fairywren			4		1				5	6	2	**18**
Northiella haematogaster	Eastern Bluebonnet			1									**1**
Northiella haematogaster haematogaster	Eastern Bluebonnet (eastern and central SA)									1			**1**
Ocyphaps lophotes lophotes	Crested Pigeon				1				3				**4**
Oreoica gutturalis	Crested Bellbird								1		1		**2**
Pomatostomus superciliosus	White-browed Babbler					3							**3**
Psephotellus varius	Mulga Parrot				2								**2**
Pyrrholaemus brunneus	Redthroat								1				**1**
Rhipidura leucophrys leucophrys	Willie Wagtail								1				**1**
Total abundance				**17**	**20**	**10**	**16**	**7**	**35**	**24**	**14**	**14**	**157**
Total diversity				**5**	**8**	**6**	**7**	**4**	**16**	**10**	**5**	**5**	**32**

Conservation status: **EPBC Act:** ***Environment Protection and Biodiversity Conservation Act 1999.*** **NPW Act:** ***Native Vegetation Act 1991*****.**

7.4.1 Diversity

Of the 32 bird species recorded, the highest diversity occurred at Bird Site 4 (*Atriplex vesicaria* shrubland) with 16 species (Table 20). The lowest bird diversity occurred at Bird Site 5 (*Tecticornia pergranulata* and *Atriplex vesicaria* low shrubland), with four species recorded throughout the survey.

7.4.2 Abundance

A total of 157 bird observations were recorded across all survey sites (Table 20). In total, birds were most abundant at Bird Site 6, where a total of 35 birds were counted. The lowest species abundance occurred at Bird Site 5, with 7 birds in total. The most abundant bird species recorded was the White-winged Fairywren (*Malurus leucopterus leuconotus*), with a total of 18 observations across 5 sites.

7.5 Threatened species

A total of five (one flora, four fauna) threatened species were identified during the field survey (Table 21, Figure 10). Four species were recorded as opportunistic observations only. One threatened species, Southern Whiteface (*Aphelocephala leucopsis leucopsis)* was observed during a bird survey. Western Grasswrens were not observed during targeted bird surveys despite call playback efforts within appropriate habitat locations.

Table 21. Threatened species observed during the field survey.

Scientific Name	Common Name	Conservation Status		Observation Method	No. of individuals	Comments
		EPBC Act	NPW Act			
FLORA						
Santalum spicatum	Australian Sandalwood			V O	2	In VA A4
FAUNA						
Acanthiza iredalei	Slender-billed Thornbill		R	O	10	In VA A3
Amytornis textilis myall	Western Grasswren	VU	V	O	1	In VA A2
Aphelocephala leucopsis leucopsis	Southern Whiteface	VU		B, O	21	In VA A2 and A4, in multiple groups
Ardeotis australis	Australian Bustard		V	O	1	In VA A2

Conservation status: EPBC Act: *Environment Protection and Biodiversity Conservation Act 1999.* NPW Act: *Native Vegetation Act 1991*.
Conservation codes: R: Rare; V/VU: Vulnerable.
Observation Method: B: bird survey; O: opportunistic observation.

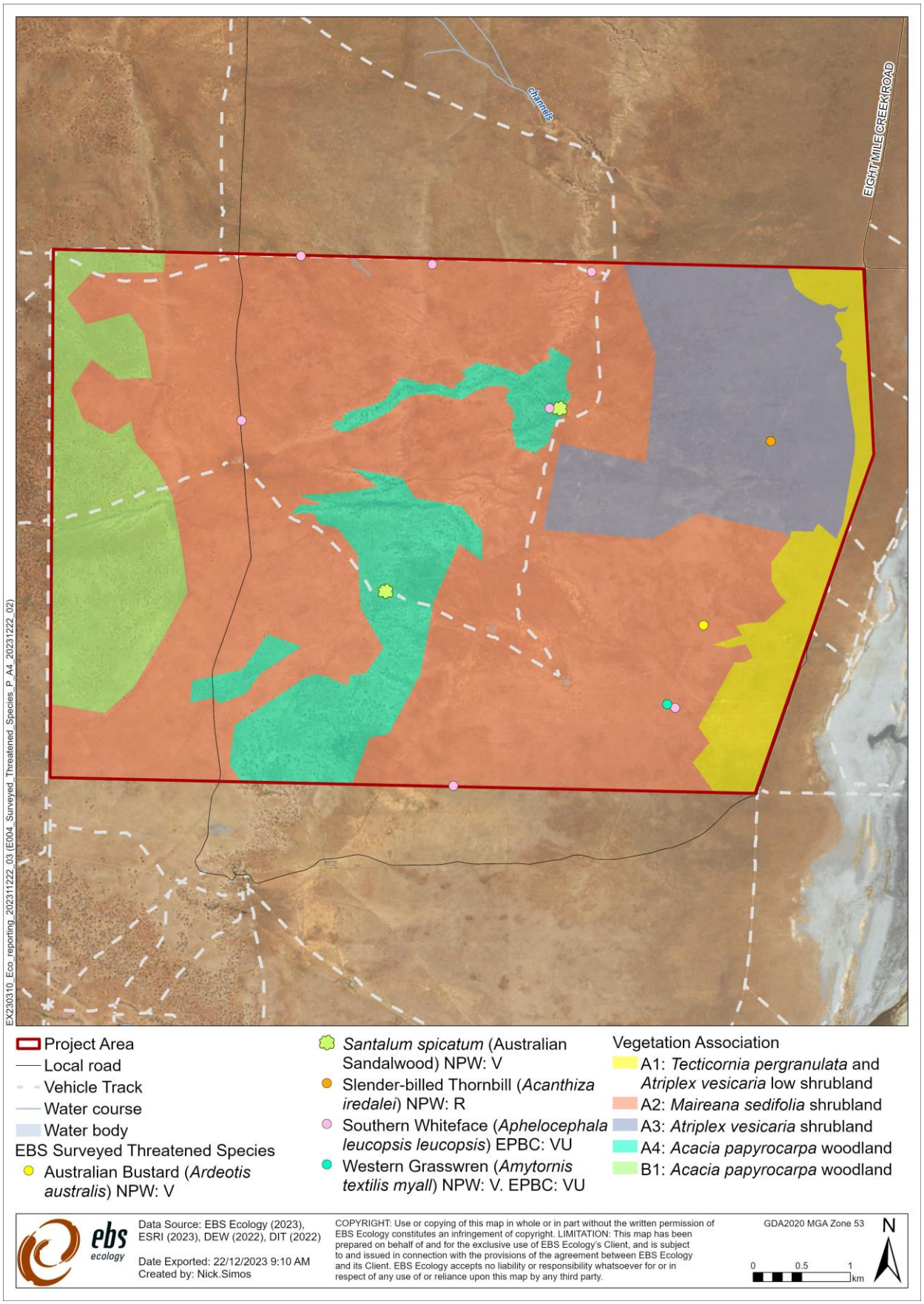


Figure 10. Threatened species observed in each VA within the Project Area during the field survey.

8 EXPLORATION AREA IMPACTS

8.1 Proposed activities

Alligator Energy has applied to the SA Department for Energy and Mining (DEM) for a Retention Lease (RL) to conduct a pilot Field Recovery Trial (Figure 11). The proposed RL is 2.35 km2 (235 Ha) and situated within Alligator's Exploration Lease (EL) 5926 (Project Area). The pilot Field Recovery Trial will look at many of the previously bench-scale tested and modelled technical, hydrogeological, environmental and economic aspects of the Project, and provide input into the planned Feasibility Study.

Alligator Energy is proposing to implement three Extractions Wells (EXTs) and a plant area within the proposed RL, located off the southern boundary of the Project Area. A series of road widening and track upgrades are also proposed, to allow truck access within the proposed RL.

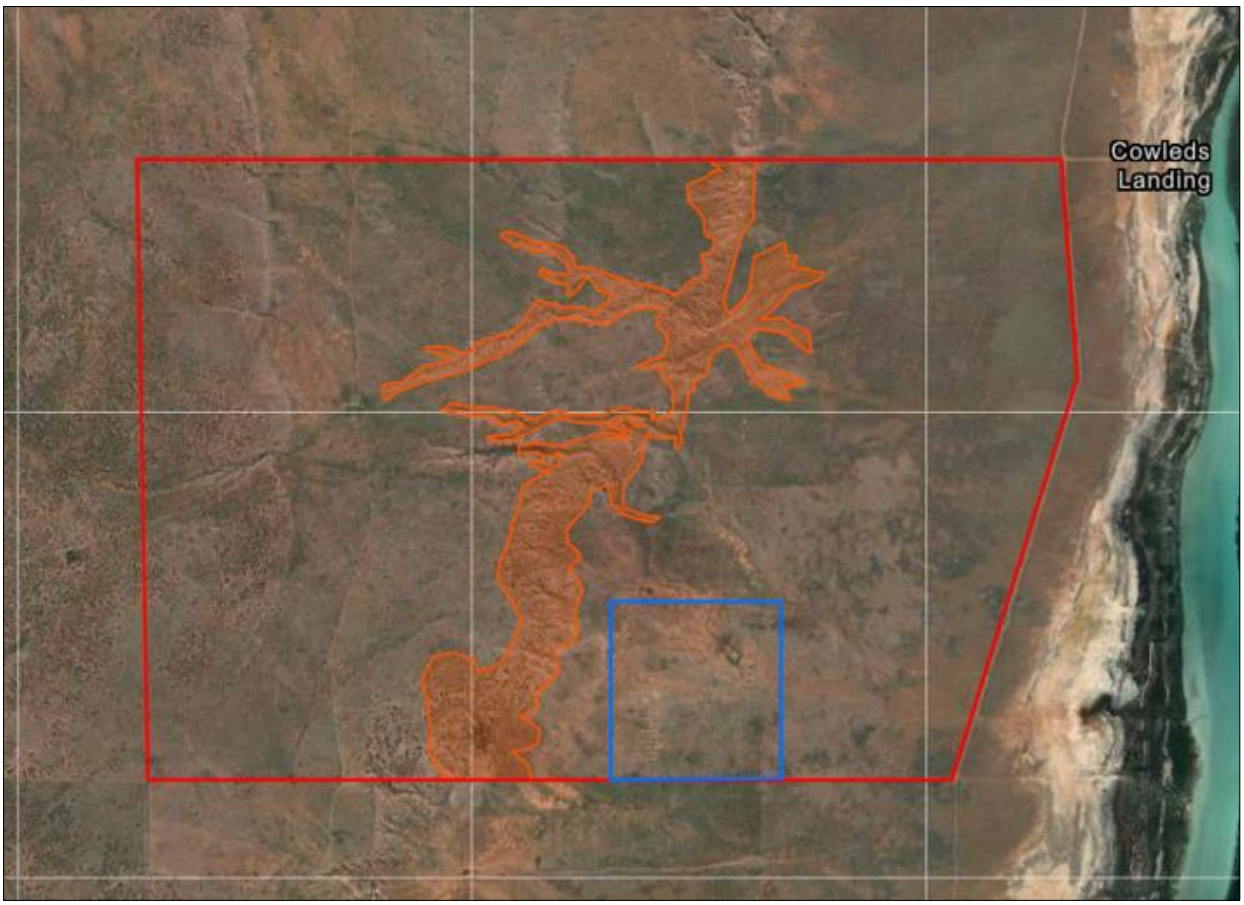


Figure 11. Project Area containing Retention Lease Area (blue) and exclusion zone (orange) (supplied to EBS by Alligator Energy on 11/12/2023).

8.2 Summary of impacts

A total of 10 clearance activities are proposed within the retention lease area, which require the clearance of approximately 0.98 ha of *Maireana sedifolia* shrubland. These impacts are summarised in Table 22and displayed in Figure 12 and Figure 13.

Table 22. Impact summary table.

Clearence Sequence	Area Description	Purpose	Total Area (m2)
Clearence 1	North-east turn off	Truck access road	297
Clearence 2	Northern Turn off	Truck access road	203
Clearence 3	South-east turn off	Truck access road	443
Clearence 4	Southern Turn off	Truck access road	186
Clearence 5	Plant Area	Plant equipment	5013
Clearence 6	Road divergence + widening	Truck access road	1158
Clearence 7	EXT-1	Injection and extraction	804
Clearence 8	EXT-2	Injection and extraction	722
Clearence 9	EXT-3	Injection and extraction	737
Clearence 10	Disposal	Drainage well for groundwater post Uranium recovery	149
		Total	**9712**

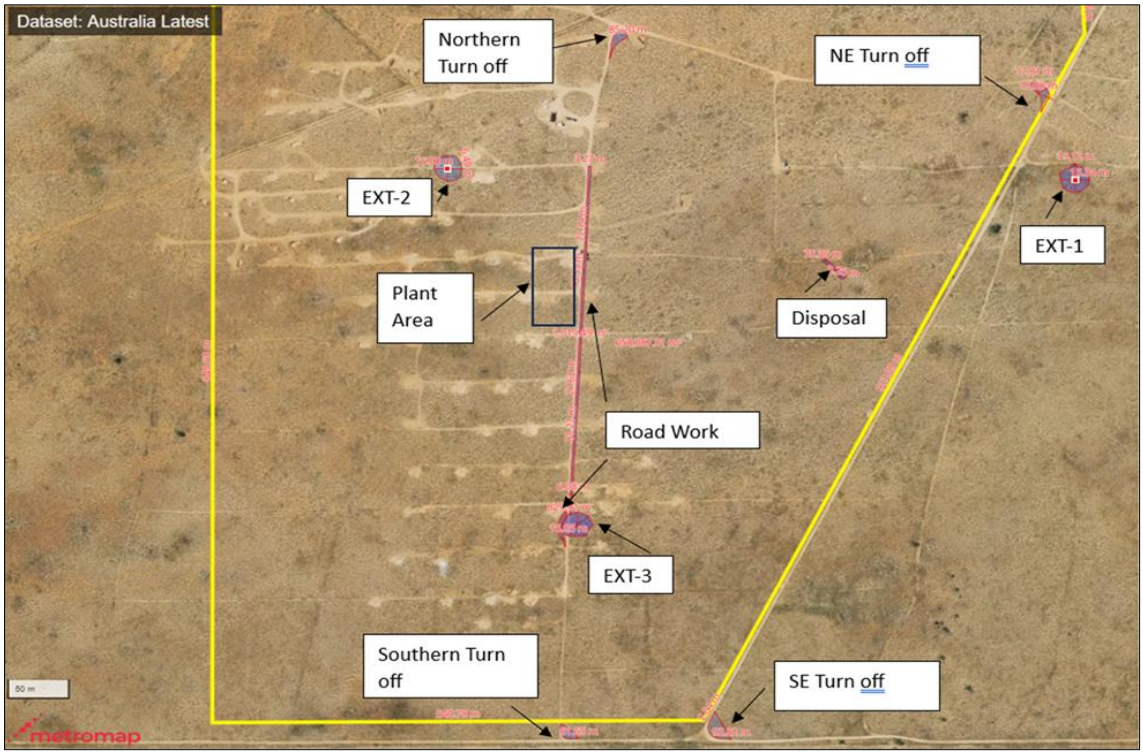


Figure 12. Diagram of proposed impact locations (Supplied by Alligator Energy 15/12/2023).

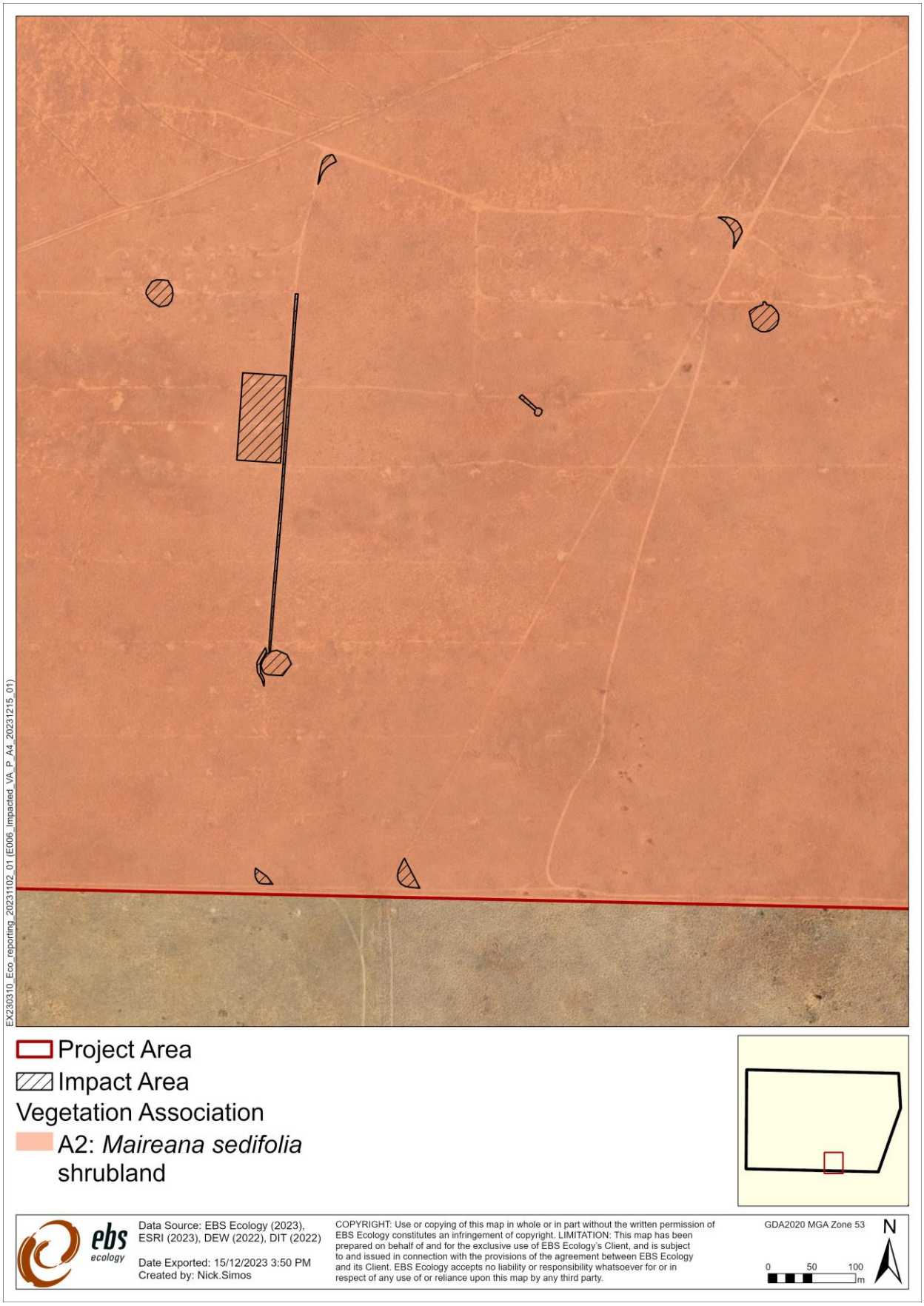


Figure 13. Areas proposed for clearance within the Retention Lease.

8.3 Offset requirements

A summary of offset requirements required under the *Native Vegetation Act 1991,* for the proposed actions within the retentional lease area, are summarised in Table 23.

Table 23. Clearance summary and total Significant Environmental Benefit (SEB) obligations for vegetation associations impacted by the Project.

Block	Site	Species diversity score	TEC score	Threatened flora score	Threatened fauna score	UBS	Area (ha)	Total Biodiversity score	Loss factor	Loadings	Reductions	SEB Points required	SEB payment	Admin Fee
A	2	18.5	1	0	0.1	40.01	0.97	38.33	1	0	0	40.29	$3428.88	$188.59
												Total	**$3,615.47**	

9 DISCUSSION OF CONSTRAINTS

9.1 Native vegetation

The Vegetation Associations present in the Moonabie Samphire Project Area and their condition are representative of those widespread throughout the neighbouring region. Majority of the Project Area is chenopod shrubland dominated by *Maireana sedifolia* (Bluebush) on fine, silty soils. Signs of grazing by livestock, kangaroos and introduced species such as the European Rabbit (*Oryctolagus cuniculus*) is widespread. Minimal regeneration of flora species is present. Vegetation showed a noticeable response to recent climatic and dry seasonal conditions, with only eight spring flowering annual forbs recorded throughout the Project Area.

Under the NV Act, clearing of native vegetation associated with the mining development can occur under Regulation 12(28) of the *Native Vegetation Regulations 2017*. For approval, the Proponent will be required to offset the clearance by contributing to a SEB, as either an on-ground offset or payment into the SEB Fund. The SEB can be calculated once final Project design is complete and the extent of impact known. The SEB also accounts for impact to species listed as threatened under the NPW Act.

In addition to offsetting the clearance through achieving the SEB, the Native Vegetation Council will approve the Project only if the Proponent can demonstrate that the Mitigation Hierarchy, as defined in Table 24, has been properly addressed. Approval may also be conditional on other measures, such as long-term impact monitoring.

Table 24. Mitigation Hierarchy for native vegetation clearing applications.

Hierarchy	Definition
Avoidance	Measures must be taken to avoid clearance of native vegetation wherever possible.
Minimisation	If clearance cannot be avoided, measures must be taken to minimise the extent, duration and intensity of impacts to the fullest possible extent.
Rehabilitation or restoration	Measures must be taken to rehabilitate ecosystems that will be degraded/impacted due to clearance that cannot be avoided or minimised.
Offset	Any adverse impacts on native vegetation that cannot be avoided or minimised must be offset by implementing an SEB that outweighs the impact.

9.2 EPBC Act threatened species and habitat

Two species listed as Vulnerable under the EPBC Act were present within the Project Area during the field survey:

- Western Grasswren (Gawler Ranges) (*Amytornis textilis myall*) and
- Southern Whiteface (*Aphelocephala leucopsis*).

An additional two species listed as Vulnerable under the EPBC Act have been assessed as possibly occurring in the Project Area. Considering the Significant Impact Guidelines, it is unlikely that any significant impact to these species would result from the proposed mining activities for reasons summarised in Table 25.

As there is unlikely to be a significant impact on any EPBC Act listed species, referral of the Project under the Act would not be required. However, this summary is based on survey results and information available at the time of writing. It does not constitute a full assessment against significant impact criteria or consider future Project designs.

Table 25. Summary of significance of impact to EPBC listed species.

Species	EPBC Act Status	Assessment
Amytornis textilis myall **Western Grasswren (Gawler Ranges)**	Vulnerable	Typical habitat components required by the Gawler Ranges subspecies of the Thick-billed Grasswren include open chenopod shrublands, often where dense stands of Dead Finish (*Acacia tetragonophylla*) or Blackbush (*Maireana pyramidata*) surround drainage lines. The species also occurs in saltbush (*Atriplex* spp.) and bluebush (*Maireana* spp.) shrublands with a sparse or open overstorey of low trees or shrubs, such as Western Myall (*Acacia papyrocarpa*) and Black Oak (*Casuarina cristata pauper*), Australian Boxthorn (*Lycium australe*), Bullock Bush (*Alectryon oleaefolium*) and Sugarwood (*Myoporum platycarpum*) (DCCEEW 2024c). Majority of the shrubland within the Project Area lacks drainage lines and / or open overstorey of low trees. While many of the above flora species are present within the Project Area, the density does not constitute critical habitat levels. If impact to the flora species listed above are avoided, impact to the Western Grasswren will be unlikely.
Aphelocephala leucopsis **Southern Whiteface**	Vulnerable	Habitat critical to the survival of the Southern Whiteface includes areas of relatively undisturbed open woodlands and shrublands with an understorey of grasses and / or shrubs; habitat with low tree densities and an herbaceous understory litter cover; living and dead trees with hollows and crevices which are essential for roosting and nesting (DCCEEW 2024c). Habitat criterion is met across the Project Area, and similar suitable habitat is widespread in the surrounding landscape. Minor impacts to this habitat will not fragment critical habitat and is unlikely to impact the survival of the Southern Whiteface. However, when the Project design and impact area is known, a self-assessment for this species is likely to be required to determine if a significant impact is likely.
Falco hypoleucos **Grey Falcon**	Vulnerable	Typical habitat for the Grey Falcon includes *Acacia* spp. shrublands that are crossed by tree-lined water courses. Birds hunt over treeless areas, tussock grasslands and in open woodlands. The species requires tall trees along watercourses, usually *Eucalyptus camaldulensis* (River Red Gum), but also *E. coolibah* (Coolabah) (TSSC 2020). Crucial elements of breeding habitat (tree lined watercourses and tall timber) are absent from the Project Area. While shrublands are suitable foraging habitat, this habitat is widespread beyond the Project Area, with the relatively small extent of impact unlikely to cause habitat loss sufficient to cause a decline in the species or impact any critical breeding habitat.
Neophema chrysostoma **Blue-Winged Parrot**	Vulnerable	Habitat critical to the survival of the blue-winged parrot include areas that include foraging and staging habitats found from coastal, sub-coastal and inland areas of grasslands, grassy woodlands and semi-arid chenopod shrubland with native and introduced grasses, herbs and shrubs; Wetlands both near the coast and in semi-arid zones; Eucalypt forests and woodlands within the breeding range in Tasmania, coastal southeastern South Australia and southern Victoria; Live and dead trees and stumps with suitable hollows within the breeding range (DCCEEW 2024c). This species was not present during the field survey. However, habitat criterion is met across the Project Area, and similar suitable habitat is widespread in the surrounding landscape. Minor impacts to this habitat will not fragment critical habitat and is unlikely to impact the survival of the Southern Whiteface.

Species	EPBC Act Status	Assessment
		However, when the Project design and impact area is known, a self-assessment for this species is likely to be required to determine if a significant impact is likely.

9.3 NPW Act threatened species

9.3.1 NPW Act listed flora

The only threatened flora species recorded, *Santalum spicatum* (Australian Sandalwood), is limited to small numbers of trees, often single individuals, at discrete locations. The species is long-lived, slow-growing and has a low reproductive rate and is steadily declining in South Australia due to natural mortality combined with low recruitment and grazing impacts (McLellan *et al.* 2021).

Given that the species is easily detected and exists in small, discrete locations, and is unlikely to recover through natural recruitment once cleared, avoidance is the best approach to limiting impacts to this species.

9.3.2 NPW Act listed fauna

Based on the Vegetation Associations mapped and the flora and fauna species recorded, all native vegetation in the Project Area is suitable habitat for the NPW Act listed fauna species either recorded during field surveys or assessed as at least likely to occur.

Given the extent of native vegetation, fauna species are unlikely to be restricted to the discrete locations where they were recorded during the 2023 survey. An appropriate way to address possible impacts to habitat for these fauna species (and thus these species) is to follow the mitigation hierarchy, as outlined in Section 9.1.

9.4 LSA Act Declared species

Under the LSA Act, landowners have responsibilities to control and/or eradicate Declared plants in South Australia. Declared plants recorded in the Project Area and their management requirements under the LSA Act are listed in Table 26.

Table 26. Declared plants under the LSA Act recorded in the Project Area.

Scientific Name	Common Name	LSA Act Requirements
Lycium ferocissimum	African Boxthorn	• Take reasonable steps to kill plants and prevent spread. • Must not be traded or sold in any way, including as a contaminant of anything. • Must not be transported on a public road including as a contaminant of anything.
Marrubium vulgare	Horehound	• Take reasonable steps to kill plants and prevent spread. • Must not be traded or sold in any way, including as a contaminant of anything. • Must not be transported on a public road including as a contaminant of anything.

10 RECOMMENDATIONS

Several recommendations have been made, considering the findings of this report; these are discussed in Table 27.

Table 27. Recommendations to address ecological constraints.

Constraint Summary	Constraint Details	Recommendations
Native vegetation	• Five vegetation associations occur in the Project Area.	• Consider the mitigation hierarchy at all stages of the Project design phase. • Seek native vegetation clearance approval under the NV Act. This includes the preparation of a Native Vegetation Clearance Data Report and calculation of SEB offset requirements. • Prior to the commencement of construction, develop a Construction Environmental Management Plan (CEMP) that implements measures to minimise, rehabilitate and offset unavoidable impacts to native vegetation.
EPBC Act listed species and habitat	• Western Grasswren. • Southern Whiteface. • Migratory and marine bird species.	• Minimise impact to native vegetation by applying the mitigation hierarchy during the project design phase and implementing a CEMP. • Undertake an assessment of potential impacts against Western Grasswren and Southern Whiteface for the EPBC Act *Significant Impact Guidelines* and refer the Mining Lease application to DCCEEW for assessment, should an ML application occur. • Prepare and implement a Western Grasswren and Southern Whiteface Management Plan during construction and operational phases of the Project. • Consider the potential requirement for the establishment of an on-ground offset to mitigate unavoidable impacts to habitat of the Western Grasswren and the Southern Whiteface.
NPW Act listed fauna	• Slender-billed Thornbill. • Australian Bustard.	• Consider the mitigation hierarchy at all stages of the Project design phase. • Prior to the commencement of construction, develop a CEMP that implements measures to minimise unavoidable impacts to habitat.
NPW Act listed flora	• Australian Sandalwood.	• Avoid impact to Australian Sandalwood trees by implement 20 m protection buffers around known trees during the Project design phase where practicable. • Survey the proposed Project impact footprint for Australian Sandalwood. • Microsite infrastructure to avoid trees and maintain 20 m protection buffers as far as practicable.
Declared weeds	• African Boxthorn. • Horehound.	• Any CEMP or Operational Management Plan (OEMP) should include biosecurity measures. • Comply with any legislative requirements during Project construction and operation.
Watercourses	• Erosion in ephemeral watercourses.	• Avoid clearing vegetation within 10 m of a watercourse.

11 REFERENCES

Atlas of Living Australia (ALA) (2023). *Search the Atlas of Living Australia*. Available at: https://bie.ala.org.au/ [Accessed 11 December 2023].

Benshemesh, J. (2007). *National Recovery Plan for Malleefowl*. Department for Environment and Heritage, South Australia.

Birdlife Australia (2023). *Find a Bird*. Available at: https://birdlife.org.au/bird-profiles/ [Accessed 11 December 2023].

Birdlife. (2022, November 3). *Survey Techniques - 2-ha, 20 minute Search*. Available at: https://birdata.birdlife.org.au/survey-techniques.

Bureau of Meteorology (BOM) (2023). *Whyalla, South Australia November 2023 Daily Weather Observations*. Available at: http://www.bom.gov.au/climate/dwo/202311/html/IDCJDW5071.202311.shtml [Accessed 5 December 2023]

Croft, S.J., Pedler, J.A., & Milne, T.I. (2007). *Bushland Condition Monitoring Manual - Northern Agricultural and Yorke Peninsula Region.* Adelaide: Nature Conservation Society of South Australia.

Department of Climate Change, Energy, the Environment and Water (DCCEEW) (2024a). Protected Matters Search Tool. Available at: https://www.environment.gov.au/epbc/protected-matters-search-tool [Accessed 31 January 2024].

Department of Climate Change, Energy, the Environment and Water (DCCEEW) (2024b). *Subtropical and Temperate Coastal Saltmarsh Conservation Advice*. Available at: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.environment.gov.au/biodiversity/threatened/communities/pubs/118-conservation-advice.pdf [Accessed 31 January 2024].

Department of Climate Change, Energy, the Environment and Water (DCCEEW) (2024c). Species Profile and Threats Database. Available at: http://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl [Accessed 31 January 2024].

Department of Environment. (2013). *Matters of National Environmental Significance Significant Impact Guidelines 1.1.* Canberra: Commonwealth of Australia.

eBird (2023). Grey Wagtail. Powered by Merlin. Available at: https://ebird.org/species/grywag?siteLanguage=en_AU [Accessed 11 December 2023].

EBS Ecology (2023a). *Samphire Marine and Shorebird Report*. Report to Alligator Energy. EBS Ecology, Adelaide.

EBS Ecology (2023b). *Whyalla South Preliminary Ecological Constraints Report*. Report to Total Eren. EBS Ecology, Adelaide.

Magrath, M., Weston, M., Olsen, P., & Antos, M. (2010). *Survey Guidelines for Australia's Threatened Birds - Guidelines for detecting birds listed as threatened under the Environment Protection and Biodiversity Conservation Act 1999*. Canberra: Commonwealth of Australia.

Native Vegetation Council (2017). *Guide to the Native Vegetation Regulations 2016.* Adelaide: Government of South Australia.

Native Vegetation Council (2020a). *Bushland Assessment Manual July 2020.* Adelaide: Government of South Australia.

Owens, H. (2000). *Guidelines for Vertebrate Surveys in South Australia using the Biological Survey of South Australia*. Adelaide: Department for Environment and Heritage.

McLellan, R.C., Dixon, K., & Watson, D.M. (2021). Prolific or precarious: a review of the status of Australian Sandalwood (*Santalum spicatum*). *The Rangeland Journal*, **43**, 211-222.

12 APPENDICES

Appendix 1 - Likelihood assessment.

Species	Common name	Conservation status		Source	PMST Likelihood / Date of last record	Habitat preference	Likelihood of use for habitat – Comments
		EPBC Act	NPW Act				
FLORA							
Pterostylis xerophila	Desert Greenhood	VU	V	1	May	The Desert Greenhood is endemic to inland south-eastern Australia, where it occurs in Victoria and SA, in the Murray-Darling Depression, Eyre-York Block, Gawler, and Great Victoria Desert IBRA bioregions. In SA, *P. xerophila* occurs in dry woodland on fertile red loamy soils, on or around granite or quartzite rock outcrops. Species commonly found in areas where *P. xerophila* occurs on the EP include *Melaleuca uncinata*, *Eucalyptus incrassata, Eucalyptus socialis* and/or *Eucalyptus leptophylla* (DCCEEW 2024c).	**Unlikely** - No suitable loamy/rocky habitat with associated species within Project Area.
Swainsona pyrophila	Yellow Swainson-pea	VU	R	1	Likely	Found in SA in EP with a few records from YP and the Murray region. The Yellow Swainson-pea grows in mallee scrub on sandy or loamy soil and is usually found to germinate only after fire and subsequent rain, although scraping of seed via soil disturbances such as grading can also stimulate germination. The species has been found after fires in a range of areas in SA where not previously seen.	**Unlikely** – No suitable mallee habitat and not present during field survey
AVES							
Actitis hypoleucos	Common Sandpiper	Mi (W)	R	1, 2	Known, 1981	Habitat is muddy banks, rocks and sandy beaches near water. Found in coastal or inland wetlands, both saline or fresh. The Common Sandpiper has been recorded in estuaries and deltas of streams, as well as on banks farther upstream; around lakes,	**Unlikely** - No suitable habitat within Project Area. However, known wetland habitat occurs within 5 km of the Project Area.

Species	Common name	Conservation status		Source	PMST Likelihood / Date of last record	Habitat preference	Likelihood of use for habitat – Comments
		EPBC Act	NPW Act				
						pools, billabongs, reservoirs, dams and claypans, and occasionally piers and jetties (DCCEEW 2024c).	
Amytornis textilis myall	Western Grasswren (Gawler Ranges)	VU		1, 4	Likely, 2023	This Gawler Ranges subspecies of the Thick-billed Grasswren occurs in open chenopod shrublands, often where dense stands of *Acacia tetragonophylla* or *Maireana pyramidata* surround drainage lines. It also occurs in *Atriplex* spp. and *Maireana* spp. shrublands with a sparse or open overstorey of low trees or shrubs, such as *Acacia papyrocarpa, Casuarina cristata pauper, Lycium australe, Alectryon oleaefolium* and *Myoporum platycarpum* (DCCEEW 2024c).	**Known** - Observed in *Lycium ferocissimum* habitat within the Project Area.
Aphelocephala leucopsis	Southern Whiteface	VU		1, 4	Known, 2023	Occur in a wide range of open woodlands and shrublands where there is an understorey of grasses or shrubs, or both. These areas are usually in habitats dominated by acacias or eucalypts on ranges, foothills and lowlands, and plains (DCCEEW 2024c).	**Known** - Observed in *Lycium ferocissimum* habitat within the Project Area.
Apus pacificus	Fork-tailed Swift	Mi (M)		1	Likely	Widespread but almost exclusively aerial. Mostly occur over inland plains, over cliffs and beaches and sometimes well out to sea or in dry or open habitats (DCCEEW 2024c).	**Unlikely** - Possible as fly-over only.
Ardenna carneipes	Flesh-footed Shearwater, Fleshy-footed Shearwater	Mi (M)	R	1	Likely	Mainly occurs in the subtropics over continental shelves and slopes and occasionally inshore waters. Individuals also pass through the tropics and over deeper waters when on migration (DCCEEW 2024c).	**Unlikely** - No suitable habitat within Project Area. However, known habitat occurs within 5 km of the Project Area.
Ardenna grisea	Sooty Shearwater	Mi (M)		1	May	The Sooty Shearwater forages in pelagic waters and breeds mainly on subtropical and sub-Antarctic islands. The birds nest in burrows or rock crevices on coastal slopes, ridges and cliff tops, in herbfields, tussock	**Unlikely** - No suitable habitat within Project Area. However, known habitat occurs within 5 km of the Project Area.

Species	Common name	Conservation status		Source	PMST Likelihood / Date of last record	Habitat preference	Likelihood of use for habitat – Comments
		EPBC Act	NPW Act				
						grassland or forest. Areas with waterlogged or shallow soils and/or dense vegetation are avoided (DCCEEW 2024c).	
Arenaria interpres	Ruddy Turnstone	VU, Mi (W)	R	1	Likely	The Ruddy Turnstone is widespread within Australia during its non-breeding period of the year. It is found in most coastal regions, with occasional records of inland populations. It strongly prefers rocky shores or beaches where there are large deposits of rotting seaweed (DCCEEW 2024c).	**Unlikely** - No suitable habitat within Project Area. However, known wetland habitat occurs within 5 km of the Project Area.
Calidris acuminata	Sharp-tailed Sandpiper	VU, Mi (W)		1	Known	Muddy edges of shallow fresh or brackish wetlands, with inundated or emergent sedges, grass, saltmarsh or other low vegetation. This includes lagoons, swamps, lakes and pools near the coast, and dams, waterholes, soaks, bore drains and bore swamps, saltpans and hypersaline saltlakes inland (DCCEEW 2024c).	**Unlikely** - No suitable habitat within Project Area. However, known wetland habitat occurs within 5 km of the Project Area.
Calidris alba	Sanderling	Mi (W)	R	1	Likely	In Australia, the species is almost always found on the coast, mostly on open sandy beaches exposed to open sea-swell, and also on exposed sandbars and spits, and shingle banks, where they forage in the wave-wash zone and amongst rotting seaweed (DCCEEW 2024c).	**Unlikely** - No suitable habitat within Project Area. However, known wetland habitat occurs within 5 km of the Project Area.
Calidris canutus	Red Knot, Knot	EN, Mi (W)		1	Known	In Australasia the Red Knot mainly inhabit intertidal mudflats, sandflats and sandy beaches of sheltered coasts, in estuaries, bays, inlets, lagoons and harbours; sometimes on sandy ocean beaches or shallow pools on exposed wave-cut rock platforms or coral reefs. They are occasionally seen on terrestrial saline wetlands near the coast, such as lakes, lagoons, pools and pans, and recorded on sewage ponds and saltworks, but rarely use freshwater swamps (DCCEEW 2024c).	**Unlikely** - No suitable habitat within Project Area. However, known wetland habitat occurs within 5 km of the Project Area.

Species	Common name	Conservation status		Source	PMST Likelihood / Date of last record	Habitat preference	Likelihood of use for habitat – Comments
		EPBC Act	NPW Act				
Calidris ferruginea	Curlew Sandpiper	CR, Mi (W)	E	1	Known	Intertidal mudflats in sheltered coastal areas, such as estuaries, bays, inlets and lagoons, and also around non-tidal swamps, lakes and lagoons near the coast, and ponds in saltworks and sewage farms. They are also recorded inland, though less often, including around ephemeral and permanent lakes, dams, waterholes and bore drains, usually with bare edges of mud or sand. They occur in both fresh and brackish waters. Occasionally they are recorded around floodwaters (DCCEEW 2024c).	**Unlikely** - No suitable habitat within Project Area. However, known wetland habitat occurs within 5 km of the Project Area.
Calidris melanotos	Pectoral Sandpiper	Mi (W)	R	1	Known	In Australasia, the Pectoral Sandpiper prefers shallow fresh to saline wetlands. The species is found at coastal lagoons, estuaries, bays, swamps, lakes, inundated grasslands, saltmarshes, river pools, creeks, floodplains and artificial wetlands (DCCEEW 2024c).	**Unlikely** - No suitable habitat within Project Area. However, known habitat occurs within 5 km of the Project Area.
Calidris ruficollis	Red-necked Stint	Mi (W)		1	Likely	In Australasia, the Red-necked Stint is mostly found in coastal areas, including in sheltered inlets, bays, lagoons and estuaries with intertidal mudflats, often near spits, islets and banks and, sometimes, on protected sandy or coralline shores. Occasionally they have been recorded on exposed or ocean beaches, and sometimes on stony or rocky shores, reefs or shoals. They also occur in saltworks and sewage farms; saltmarsh; ephemeral or permanent shallow wetlands near the coast or inland, including lagoons, lakes, swamps, riverbanks, waterholes, bore drains, dams, soaks and pools in saltflats (DCCEEW 2024c).	**Unlikely** - No suitable habitat within Project Area. However, known wetland habitat occurs within 5 km of the Project Area.
Charadrius leschenaultii	Greater Sand Plover, Large Sand Plover	VU, Mi (W)	R	1	Likely	In the non-breeding grounds in Australasia, the species is almost entirely coastal, inhabiting littoral and estuarine habitats.	**Unlikely** - No suitable habitat within Project Area. However, known wetland habitat occurs

Species	Common name	Conservation status		Source	PMST Likelihood / Date of last record	Habitat preference	Likelihood of use for habitat – Comments
		EPBC Act	NPW Act				
						They mainly occur on sheltered sandy, shelly or muddy beaches with large intertidal mudflats or sandbanks, as well as sandy estuarine lagoons and inshore reefs, rock platforms, small rocky islands or sand cays on coral reefs (DCCEEW 2024c).	within 5 km of the Project Area.
Charadrius veredus	Oriental Plover, Oriental Dotterel	Mi (W)		1	May	Immediately after arriving in non-breeding grounds in northern Australia, Oriental Plovers spend a few weeks in coastal habitats such as estuarine mudflats and sandbanks, on sandy or rocky ocean beaches or nearby reefs, or in near-coastal grasslands, before dispersing further inland. Thereafter they inhabit semi-arid to arid grasslands, where the grass is short and sparse, and interspersed with hard, bare ground, such as claypans and dry paddocks, playing fields, or open areas that have been recently burnt (DCCEEW 2024c).	**Unlikely** - No suitable habitat within Project Area. However, known wetland habitat occurs within 5 km of the Project Area.
Cladorhynchus leucocephalus	Banded Stilt		V	2	1981	Banded Stilts are found mainly in saline and hypersaline (very salty) waters of the inland and coast, typically large, open and shallow (Birdlife Australia 2023).	**Unlikely** - No suitable habitat within Project Area. However, known habitat occurs within 5 km of the Project Area.
Diomedea antipodensis	Antipodean Albatross	VU, Mi (M)		1	Likely	The Antipodean Albatross is marine, pelagic and aerial. It nests in open patchy vegetation, such as among tussock grassland or shrubs on ridges, slopes and plateaus (DCCEEW 2024c).	**Unlikely** - Possible as fly-over only.
Diomedea epomophora	Southern Royal Albatross	VU, Mi (M)	V	1	May	The Southern Royal Albatross can be encountered in the southern and southeastern waters of Australia. The Southern Royal Albatross is well adapted to a pelagic, oceanic lifestyle and spends most of its life soaring over open waters, particularly in the cold, nutrient-rich waters of the Southern Ocean (DCCEEW 2024c).	**Unlikely** - Possible as fly-over only.

Species	Common name	Conservation status		Source	PMST Likelihood / Date of last record	Habitat preference	Likelihood of use for habitat – Comments
		EPBC Act	NPW Act				
Diomedea exulans	Wandering Albatross	VU, Mi (M)	V	1	Likely	The Wandering Albatross breeds on Macquarie Island. A single breeding pair has also been recorded on Heard Island. It feeds in Australian portions of the Southern Ocean. The Wandering Albatross is marine, pelagic and aerial (DCCEEW 2024c).	**Unlikely** - Possible as fly-over only.
Falco hypoleucos	Grey Falcon	VU	R	1	Likely	The species occurs in arid and semi-arid Australia, including the Murray-Darling Basin, Eyre Basin, central Australia and WA. The species frequents timbered lowland plains, particularly Acacia shrublands that are crossed by tree-lined water courses. The species has been observed hunting in treeless areas and frequents tussock grassland and open woodland, especially in winter (DCCEEW 2024c).	**Possible** - Hunting may occur in B1 and in areas with scattered *A. nyssophylla.*
Gallinago hardwickii	Latham's Snipe	VU, Mi (W)	R	1	May	Latham's Snipe is a non-breeding visitor to south-eastern Australia and is a passage migrant through northern Australia. The species has been recorded along the east coast of Australia from Cape York Peninsula through to south-eastern South Australia (including the Adelaide plains and Mount Lofty Ranges, and the Eyre Peninsula). They usually inhabit open, freshwater wetlands with low, dense vegetation (e.g. swamps, flooded grasslands or heathlands, around bogs and other water bodies). However, they can also occur in habitats with saline or brackish water, in modified or artificial habitats, and in habitats located close to humans or human activity (DCCEEW 2024c).	**Unlikely** - No suitable habitat within Project Area. However, known wetland habitat occurs within 5 km of the Project Area.
Grantiella picta	Painted Honeyeater	VU	R	1	May	The painted honeyeater is sparsely distributed from south-eastern Australia to north-western Queensland and the eastern	**Unlikely -** Outside of known / accepted range and minimal suitable habitat occurs.

Species	Common name	Conservation status		Source	PMST Likelihood / Date of last record	Habitat preference	Likelihood of use for habitat – Comments
		EPBC Act	NPW Act				
						Northern Territory, being more common west of the Great Dividing Range. The painted honeyeater lives in dry, open forests and woodlands (Box, Ironbark, Yellow Gum, Melaleuca, Casuarina, Callitris and / or Acacia). The species usually occurs in areas with flowering and fruiting mistletoe and flowering eucalypts (DCCEEW 2024c).	
Haematopus fuliginosus fuliginosus	Sooty Oystercatcher		R	2, 3	1984, 2023	The Sooty Oystercatcher is endemic to Australia and is widespread in coastal eastern, southern and western Australia. Is strictly coastal, usually within 50 m of the ocean. It prefers rocky shores but will be seen on coral reefs or sandy beaches near mudflats. It breeds on offshore islands and isolated rocky headlands (ALA 2023).	**Unlikely** - No suitable habitat within Project Area. However, known wetland habitat occurs within 5 km of the Project Area.
Haematopus longirostris	Pied Oystercatcher		R	2, 3	1982, 2023	The species is distributed around the entire Australian coastline, although it is most common in coastal Tasmania and parts of Victoria, such as Corner Inlet. In NSW the species is thinly scattered along the entire coast, with fewer than 200 breeding pairs estimated to occur in the State. Coastal bays, offshore islands and intertidal mudflats (ALA 2023).	**Unlikely** - No suitable habitat within Project Area. However, known wetland habitat occurs within 5 km of the Project Area.
Leipoa ocellata	Malleefowl	VU	V	1	Likely	The Malleefowl is found principally in the semi-arid to arid zone in shrublands and low woodlands dominated by mallee and associated habitats such as Broombush (*Melaleuca uncinata*) and Scrub Pine (*Callitris verrucosa*). Malleefowl also occur in Red Ironbark (*E. sideroxylon*) woodland at the eastern limit of their distribution and in Brown Stringybark (*E. baxteri/E. araneosa*) woodland in the south of Victoria and South Australia (Benshemesh 2007).	**Unlikely** - No suitable habitat within Project Area.
Limosa lapponica baueri	Nunivak Bar-tailed Godwit, Western	VU, Mi (W)	R	1	May	The Bar-tailed Godwit is a migratory wader which undertakes the largest non-stop	**Unlikely** - No suitable habitat within Project Area. However,

Species	Common name	Conservation status		Source	PMST Likelihood / Date of last record	Habitat preference	Likelihood of use for habitat – Comments
		EPBC Act	NPW Act				
	Alaskan Bar-tailed Godwit					flight of any bird. The trans-Pacific route from its breeding grounds in the Arctic to its non-breeding grounds in the southern hemisphere covers over 11,000 km. It is found mainly in coastal habitats such as large intertidal sandflats, banks, mudflats, estuaries, inlets, harbours, coastal lagoons and bays. Less frequently it occurs in salt lakes and brackish wetlands, sandy ocean beaches and rock platforms (DCCEEW 2024c).	known wetland habitat occurs within 5 km of the Project Area.
Macronectes giganteus	Southern Giant-Petrel, Southern Giant Petrel	EN, Mi (M)	V	1	May	The Southern Giant-Petrel is marine bird that occurs in Antarctic to subtropical waters. In summer, it mainly occurs over Antarctic waters, and it is widespread south as far as the pack-ice and onto the Antarctic continent (DCCEEW 2024c).	**Unlikely** - No suitable habitat within Project Area. However, known habitat occurs within 5 km of the Project Area.
Macronectes halli	Northern Giant Petrel	VU, Mi (M)		1	Likely	The Northern Giant-Petrel is marine and oceanic. It mainly occurs in sub-Antarctic waters, but regularly occurs in Antarctic waters of the southwestern Indian Ocean, the Drake Passage and west of the Antarctic Peninsula (DCCEEW 2024c).	**Unlikely** - No suitable habitat within Project Area. However, known habitat occurs within 5 km of the Project Area.
Motacilla cinerea	Grey Wagtail	Mi (T)		1	May	Woodland, often near flowing water with nearby rocks or surrogate rocky habitat, from mountain streams to weirs in suburban parklands (eBird 2023).	**Unlikely** - No suitable habitat within Project Area.
Motacilla flava	Yellow Wagtail	Mi (T)		1	May	This species occupies a range of damp or wet habitats with low vegetation, from damp meadows, marshes, waterside pastures, sewage farms and bogs to damp steppe and grassy tundra. In the north of its range it is also found in large forest clearings (Birdlife 2023).	**Unlikely** - No suitable habitat within Project Area. However, known habitat occurs within 5 km of the Project Area.
Neophema chrysostoma	Blue-winged Parrot	VU	V	1	Likely	Blue-winged Parrots breed on mainland Australia south of the Great Dividing Range in southern Victoria from Port Albert in Gippsland west to Nelson, and sometimes	**Possible** - potentially suitable habitat occurs, though minimal grassy habitat is found within Project Area.

Species	Common name	Conservation status		Source	PMST Likelihood / Date of last record	Habitat preference	Likelihood of use for habitat – Comments
		EPBC Act	NPW Act				
						in the far south-east of SA, and the north-western, central and eastern parts of Tasmania. Blue-winged Parrots inhabit a range of habitats from coastal, sub-coastal and inland areas, through to semi-arid zones. They tend to favour grasslands and grassy woodlands and are often found near wetlands both near the coast and in semi-arid zones. The species can also be seen in altered environments such as airfields, golf-courses and paddocks (DCCEEW 2024c).	
Numenius madagascariensis	Eastern Curlew	CE, Mi (W)	E	1	Known	In SA, the species is scarce between the Victorian border and Cape Jaffa and patchily distributed from the Coorong north-west to the Streaky Bay area, and has previously been recorded in Lake Alexandrina and Lake Albert. During the non-breeding season in Australia, the eastern curlew is most commonly associated with sheltered coasts, especially estuaries, bays, harbours, inlets and coastal lagoons, with large intertidal mudflats or sandflats, often with beds of seagrass. Occasionally, the species occurs on ocean beaches (often near estuaries), and coral reefs, rock platforms, or rocky islets. The birds are often recorded among saltmarsh and on mudflats fringed by mangroves, and sometimes within the mangroves (DCCEEW 2024c).	**Unlikely** - No suitable habitat within Project Area. However, known habitat occurs within 5 km of the Project Area.
Pachyptila turtur subantarctica	Fairy Prion (southern)	VU		1	Likely	The fairy prion (southern) breeds on Macquarie Island and a number of other subantarctic islands outside of Australia. The subspecies digs burrows among rocks or low vegetation in which to nest. Burrows may be dug below mat forming herbs. Feeds by plucking food from the ocean surface. Some individuals may migrate	**Unlikely** - No suitable habitat within Project Area. However, known habitat occurs within 5 km of the Project Area.

Species	Common name	Conservation status		Source	PMST Likelihood / Date of last record	Habitat preference	Likelihood of use for habitat – Comments
		EPBC Act	NPW Act				
						towards New Zealand and southern Australia in winter (DCCEEW 2024c).	
Pedionomus torquatus	Plains-wanderer	CE	E	1	May	Plains-wanderers occur at scattered sites in New South Wales and Victoria, which encompass the core sites for the species; and Queensland and SA, which appear to encompass more marginal habitat for the species. Plains-wanderers inhabit sparse, treeless, lowland native grasslands which usually occur on hard red-brown clay soils (DCCEEW 2024c).	**Unlikely** - No suitable habitat of grassy clay soils within Project Area.
Pezoporus occidentalis	Night Parrot	EN	E	1	May	In SA, the Night Parrot's distribution is extremely limited, and specific details about their exact range and numbers might not be widely known or publicly disclosed to protect their conservation. Night Parrots are primarily found in arid and semi-arid regions of Australia, particularly in areas with spinifex grasslands, shrublands, and tussock grasslands. These habitats are often characterized by low vegetation, open woodlands, and sparse vegetation cover (DCCEEW 2024c).	**Unlikely** - No nearby records and no suitable habitat. Extinct in SA.
Phoebetria fusca	Sooty Albatross	VU, Mi (M)	E	1	May	The Sooty Albatross has sometimes been observed foraging in inshore waters in southern Australia. The Sooty Albatross is a rare, but probably regular migrant to Australia, mostly in the autumn-winter months, occurring north to south-east Queensland, NSW, Victoria, Tasmania and SA. The Sooty Albatross is marine and pelagic (DCCEEW 2024c).	**Unlikely** - No suitable habitat within Project Area. However, known habitat occurs within 5 km of the Project Area.
Rostratula australis	Australian Painted Snipe	EN	E	1	May	The Australian Painted Snipe prefers shallow freshwater wetlands, including swamps, marshes, and shallow lakes with dense vegetation, reeds, and mudflats. In SA, the Australian Painted Snipe can be found in suitable wetland habitats across the state. Specific locations may include	**Unlikely** - No suitable habitat within Project Area. However, known habitat occurs within 5 km of the Project Area.

Species	Common name	Conservation status		Source	PMST Likelihood / Date of last record	Habitat preference	Likelihood of use for habitat – Comments
		EPBC Act	NPW Act				
						wetlands along the Murray-Darling Basin and other river systems, coastal lagoons, and freshwater marshes (DCCEEW 2024c).	
Stagonopleura guttata	Diamond Firetail	VU	V	1	May	Endemic to Australia, occurring mainly on the inland slopes of the Great Dividing Range and in the AMLR/Eyre Peninsula region of SA. Reside in a wide range of Eucalypt dominated vegetation communities that have a grassy understorey, including woodland, forest and mallee. Most occur on the inland slopes of the Great Dividing Ranges, with only small pockets near the coast (DCCEEW 2024c).	**Unlikely** - No suitable grassy woodland habitat within Project Area.
Sternula nereis nereis	Australian Fairy Tern	VU	E	1	Likely	Within Australia, the Fairy Tern occurs along the coasts of Victoria, Tasmania, SA and WA. The Fairy Tern nests on sheltered sandy beaches, spits and banks above the high tide line and below vegetation. The subspecies has been found in embayments of a variety of habitats including offshore, estuarine or lacustrine (lake) islands, wetlands and mainland coastline. The bird roosts on beaches at night (DCCEEW 2024c).	**Unlikely** - No suitable habitat within Project Area. However, known habitat occurs within 5 km of the Project Area.
Thalassarche carteri	Indian Yellow-nosed Albatross	VU	E	1	Likely	The Indian Yellow-nosed Albatross forages mostly in the southern Indian Ocean where it is particularly abundant off WA. In the Australasian region, the species occupies inshore and offshore waters, particularly where there are calm seas and light winds. The birds fly low or at medium heights over the sea, using air currents rising off swells for lift (DCCEEW 2024c).	**Unlikely** - No suitable habitat within Project Area. However, known habitat occurs within 5 km of the Project Area.
Thalassarche cauta	Shy Albatross	EN		1	Likely	The Shy Albatross is the only albatross species that is endemic to Australia. The species has breeding colonies on three small islands off Tasmania. The Shy	**Unlikely** - No suitable habitat within Project Area. However, known habitat occurs within 5 km of the Project Area.

Species	Common name	Conservation status		Source	PMST Likelihood / Date of last record	Habitat preference	Likelihood of use for habitat – Comments
		EPBC Act	NPW Act				
						Albatross primarily inhabits open ocean environments. They are commonly seen in pelagic waters (DCCEEW 2024c).	
Thalassarche impavida	Campbell Albatross, Campbell Black-browed Albatross	VU	V	1	May	The Campbell Albatross is a non-breeding visitor to Australian waters. Non-breeding birds are most commonly seen foraging over the oceanic continental slopes off Tasmania, Victoria and NSW. After breeding, birds move north and may enter Australia's temperate shelf waters. The Campbell Albatross is a marine sea bird inhabiting sub-Antarctic and subtropical waters from pelagic to shelf-break water habitats (DCCEEW 2024c).	**Unlikely** - No suitable habitat within Project Area. However, known habitat occurs within 5 km of the Project Area.
Thalassarche melanophris	Black-browed Albatross	VU		1	Likely	The Black-browed Albatross is a marine species that inhabits Antarctic, subantarctic and temperate waters and occasionally enters the tropics. It forages around the breaks of continental and island shelves and across nearby underwater banks but also frequents other marine habitats, such as oceanic waters. In the non-breeding season it follows cold water currents north to the continental shelves of Australia, South America and Africa where it can occur in coastal and inshore waters and sometimes enter fjords and channels (DCCEEW 2024c).	**Unlikely** - No suitable habitat within Project Area. However, known habitat occurs within 5 km of the Project Area.
Thalassarche steadi	White-capped Albatross	VU		1	Known	Thalassarche steadi is endemic to offshore islands of New Zealand. Breeding Colonies are generally located on rock islands. This species forages in Tasmania and Southern Africa/Namibia, and immature birds are thought to occur regularly throughout the South Atlantic and south-west Indian Ocean (Birdlife 2023).	**Unlikely** - No suitable habitat within Project Area. However, known habitat occurs within 5 km of the Project Area.
Thinornis cucullatus cucullatus	Eastern Hooded Plover, Eastern Hooded Plover	VU	V	1	May	In SA, Eastern Hooded Plovers are distributed along the coastline, particularly in areas such as the Coorong, EP, and the	**Unlikely** - No suitable habitat within Project Area. However,

Species	Common name	Conservation status		Source	PMST Likelihood / Date of last record	Habitat preference	Likelihood of use for habitat – Comments
		EPBC Act	NPW Act				
						FP. These birds are often found in areas where there is a mix of sand, shell fragments, and open spaces. They prefer nesting in open areas with sparse vegetation (DCCEEW 2024c).	known habitat occurs within 5 km of the Project Area.
Tringa nebularia	Common Greenshank, Greenshank	EN, Mi (W)		1, 3	Likely, 2023	The Common Greenshank does not breed in Australia; however, the species occurs in all types of wetlands and has the widest distribution of any shorebird in Australia. The Common Greenshank is found in a wide variety of inland wetlands and sheltered coastal habitats of varying salinity. It occurs in sheltered coastal habitats, typically with large mudflats and saltmarsh, mangroves or seagrass. The species uses both permanent and ephemeral terrestrial wetlands (DCCEEW 2024c).	**Unlikely** - No suitable habitat within Project Area. However, known habitat occurs within 5 km of the Project Area.
MAMMALIA							
Balaenoptera edeni	Bryde's Whale	Mi (M)	R	1	May	N/A - Marine.	N/A - Marine.
Caperea marginata	Pygmy Right Whale	Mi (M)	R	1	May	N/A - Marine.	N/A - Marine.
Eubalaena australis	Southern Right Whale	EN, Mi (M)	V	1	Known	N/A - Marine.	N/A - Marine.
Lagenorhynchus obscurus	Dusky Dolphin	Mi (M)		1	May	N/A - Marine.	N/A - Marine.
Megaptera novaeangliae	Humpback Whale	Mi (M)	V	1	Likely	N/A - Marine.	N/A - Marine.
Neophoca cinerea	Australian Sea-lion, Australian Sea Lion	EN	V	1	May	N/A - Marine.	N/A - Marine.
Sminthopsis psammophila	Sandhill Dunnart	EN	V	1	Likely	Sandhill dunnarts occupy sandy, semi-arid and arid areas of southern central Australia, especially where sand dunes occur and when the vegetation is dominated by spinifex hummock grassland (*Triodia* spp.). Overstorey vegetation is	**Unlikely** - No suitable spinifex grassland habitat within Project Area.

Species	Common name	Conservation status		Source	PMST Likelihood / Date of last record	Habitat preference	Likelihood of use for habitat – Comments
		EPBC Act	NPW Act				
						variable, with groves of desert oak (*Allocasuarina decaisneana*), or low, open Eucalyptus and Callitris woodlands being recorded (DCCEEW 2024c).	
REPTILIA							
Caretta caretta	Loggerhead Turtle	EN, Mi (M)	E	1	Known	N/A - Marine.	N/A - Marine.
Chelonia mydas	Green Turtle	VU, Mi (M)	V	1	May	N/A - Marine.	N/A - Marine.
Dermochelys coriacea	Leatherback Turtle, Leathery Turtle, Luth	EN, Mi (M)	V	1	Known	N/A - Marine.	N/A - Marine.
FISH							
Seriolella brama	Blue Warehou	CD		1	Likely	N/A - Marine.	N/A - Marine.
Thunnus maccoyii	Southern Bluefin Tuna	CD		1	Likely	N/A - Marine.	N/A - Marine.
SHARK							
Carcharodon carcharias	White Shark, Great White Shark	VU, Mi (M)		1	Known	N/A - Marine.	N/A - Marine.
Galeorhinus galeus	School Shark, Eastern School Shark, Snapper Shark, Tope, Soupfin Shark	CD		1	May	N/A - Marine.	N/A - Marine.
Lamna nasus	Porbeagle, Mackerel Shark	Mi (M)		1	Likely	N/A - Marine.	N/A - Marine.

Conservation status: **EPBC Act:** ***Environment Protection and Biodiversity Conservation Act 1999.*** **NPW Act:** ***Native Vegetation Act 1991.***
Conservation Codes: **CE: Critically Endangered. EN/E: Endangered. VU/V: Vulnerable. R: Rare. CD: Conservation Dependant. Migratory category: M: Marine; W: Wetland; T: Terrestrial.**
Source of Information:

1. **PMST (DCCEEW 2024) – 5 km buffer applied to Project Area;**
2. **BDBSA (DEW 2023a) – 5 km buffer applied to Project Area;**
3. **Avian field survey (EBS 2023a);**
4. **Total Eren field survey (EBS 2023b).**

Appendix 2 – Pitall trap line photographs.



Site 1 – Photo direction South.



Site 2 – Photo direction South.



Site 3 – Photo direction West.



Site 4 – Photo direction West.



Site 5 – Photo direction East.

Appendix 3 - Fauna recorded during the survey.

Group	Int.	Scientific Name	Common Name	Status		Observation Method
				NPW Act	EPBC Act	
B		*Acanthagenys rufogularis*	Spiny-cheeked Honeyeater			B
B		*Acanthiza chrysorrhoa*	Yellow-rumped Thornbill			B
B		*Acanthiza iredalei*	Slender-billed Thornbill		R	O
B		*Acanthiza pusilla*	Brown Thornbill			B
B		*Acanthiza uropygialis*	Chestnut-rumped Thornbill			B
B		*Amytornis textilis myall*	Western Grasswren	VU	V	O
B		*Anthus australis*	Australasian Pipit			B, O
B		*Aphelocephala leucopsis leucopsis*	Southern Whiteface	VU		B, O
B		*Aquila audax*	Wedge-tailed Eagle			B, O
B		*Ardeotis australis*	Australian Bustard		V	O
B		*Artamus cinereus*	Black-faced Woodswallow			B, O
B		*Artamus personatus*	Masked Woodswallow			O
B		*Barnardius zonarius*	Australian Ringneck			O
B		*Calamanthus campestris*	Rufous Fieldwren			B, O
B		*Chalcites osculans*	Black-eared Cuckoo			B
B		*Cincloramphus cruralis*	Brown Songlark			B, O
B		*Circus approximans*	Spotted Harrier			O
B		*Colluricincla harmonica*	Grey Shrikethrush			B, O
B		*Coracina novaehollandiae*	Black-faced Cuckooshrike			B
B		*Corvus mellori*	Little Raven			B
B		*Coturnix pectoralis*	Stubble Quail			O
B		*Cracticus torquatus*	Grey Butcherbird			B, O
B		*Dicaeum hirundinaceum hirundinaceum*	Mistletoebird			B
B		*Dromaeus novaehollandiae*	Emu			O
B		*Epthianura albifrons*	White-fronted Chat			B, O
B		*Epthianura aurifrons*	Orange Chat			O
B		*Epthianura tricolor*	Crimson Chat			B
B		*Falco cenchroides*	Nankeen Kestrel			B, O
B		*Gavicalis virescens*	Singing Honeyeater			B, O
B		*Gymnorhina tibicen*	Australian Magpie			B, O
B		*Hirundo neoxena*	Welcome Swallow			B, O
B		*Malurus assimilis assimilis*	Purple-backed Fairywren			B
B		*Malurus leucopterus*	White-winged Fairywren			O, B
B		*Malurus splendens*	Splendid Fairywren			O
B		*Manorina flavigula*	Yellow Throated Miner			O
B		*Northeilla haematogaster*	Bluebonnet			B, O
B		*Northiella haematogaster haematogaster*	Eastern Bluebonnet (eastern and central SA)			B
B		*Ocyphaps lophotes*	Crested Pigeon			B, O
B		*Oreoica gutturalis*	Crested Bellbird			B

Group	Int.	Scientific Name	Common Name	Status		Observation Method
				NPW Act	EPBC Act	
B		*Pomatostomus superciliosus*	White-browed Babbler			B, O
B		*Psephotellus varius*	Mulga Parrot			B, O
B		*Pyrrholaemus brunneus*	Redthroat			B, O
B		*Rhipidura leucophrys leucophrys*	Willie Wagtail			B
B		*Taeniopygia guttata*	Zebra Finch			O
M		*Macropus fuliginosus*	Western Grey Kangaroo			O
M		*Macropus rufus*	Red Kangaroo			O
M	*	*Mus musculus*	House Mouse			E, P
M		*Pseudomys bolami*	Bolam's Mouse			E, P
M		*Sminthopsis crassicaudata*	Fat-tailed Dunnart			P
M		*Sminthopsis dolichura*	Little Long-tailed Dunnart			P
M	*	*Vulpes vulpes*	European Red Fox			O
R		*Ctenophorus pictus*	Painted Dragon			P
R		*Ctenotus olympicus*	Saltbush Ctenotus			F, P
R		*Ctenotus regius*	Eastern Desert Ctenotus			P
R		*Ctenotus schomburgkii*	Sandplain Ctenotus			P
R		*Diplodactylus calcicolus*	South Coast Stone Gecko			F, P
R		*Diplodactylus furcosus*	Ranges Stone Gecko			F, P
R		*Eremiascincus richardsonii*	Broad-banded Sandswimmer			P
R		*Lerista dorsalis*	Southern Four-toed Slider			P
R		*Lerista terdigitata*	Southern Three-toed Slider			P
R		*Morethia adelaidensis*	Adelaide Snake-eye			P
R		*Pogona vitticeps*	Bearded Dragon			O
R		*Strophurus intermedius*	Southern Spiny-tailed Gecko			F, P
R		*Tiliqua rugosa*	Shingleback			O
R		*Tympanocryptis lineata complex*	Lined Earless Dragon			P
R		*Underwoodisaurus milii*	Common Barking Gecko			P
B		*Acanthagenys rufogularis*	Spiny-cheeked Honeyeater			B

Group: B, Bird; M, Mammal; R, Reptile.
Int.: Introduced; *: yes.
Status: NPW Act (*National Parks and Wildlife Act 1972*)/EPBC Act (*Environment Protection and Biodiversity Conservation Act 1999).* R, Rare; V/VU, Vulnerable; E/EN, Endangered; Mi, Migratory.
Observation Method: B, bird survey; E, Elliot trap; F, Funnel Trap; O, opportunistic observation; P, Pitfall trap.

Appendix 4 – Flora recorded during the field survey.

Int.	Scientific Name	Common Name	Status	
			NPW Act	EPBC Act
	Abutilon leucopetalum	Desert Lantern		
	Acacia oswaldii	Umbrella Wattle		
	Acacia papyrocarpa	Western Myall		
	Alectryon oleifolius ssp. *canescens*	Bullock Bush		
	Amyema quandang var. *quandang*	Grey Mistletoe		
	Amyema sp.	Mistletoe		
	Atriplex holocarpa	Pop Saltbush		
	Atriplex vesicaria	Bladder Saltbush		
	Austrostipa Eremophila	Rusty Spear-grass		
	Austrostipa nitida	Balcarra Spear-grass		
	Austrostipa platychaeta	Flat-awn Spear-grass		
	Calandrinia volubilis	Twining Purslane		
	Chenopodium desertorum ssp.	Desert Goosefoot		
	Convolvulus remotus	Grassy Bindweed		
	Crassula sp.	Crassula/Stonecrop		
	Disphyma crassifolium ssp. *Clavellatum*	Round-leaf Pigface		
	Dissocarpus biflorus var.	Two-horn Saltbush		
	Duma florulenta	Lignum		
	Enchylaena tomentosa var.	Ruby Saltbush		
	Eremophila scoparia	Broom Emubush		
	Eriochiton sclerolaenoides	Woolly-fruit Bluebush		
	Exocarpos aphyllus	Leafless Cherry		
	Frankenia pauciflora var.	Southern Sea-heath		
	Lycium australe	Australian Boxthorn		
*	*Lycium ferocissimum*	African Boxthorn		
	Maireana aphylla	Cotton-bush		
	Maireana appressa	Pale-fruit Bluebush		
	Maireana georgei	Satiny Bluebush		
	Maireana pyramidata	Black Bluebush		
	Maireana sedifolia	Bluebush		
	Maireana trichopteran	Mallee Bluebush		
	Minuria cunninghamii	Bush Minuria		
	Myoporum platycarpum ssp.	False Sandalwood		
	Pimelea microcephala ssp.	Shrubby Riceflower		
	Pittosporum angustifolium	Native Apricot		
	Ptilotus obovatus	Silver Mulla Mulla		
	Rhagodia spinescens	Spiny Saltbush		
	Rhagodia ulicina	Intricate Saltbush		
	Rhodanthe pygmaea	Pigmy Daisy		
	Roepera billardierei	Coast Twinleaf		
	Rytidosperma sp.	Wallaby-grass		

Int.	Scientific Name	Common Name	Status	
			NPW Act	EPBC Act
	Salsola australis	Buckbush		
	Santalum acuminatum	Quandong		
	Santalum spicatum	Sandalwood		V
	Scaevola spinescens	Spiny Fanflower		
	Sclerolaena brachyptera	Short-wing Bindyi		
	Sclerolaena diacantha	Grey Bindyi		
	Sclerolaena obliquicuspis	Oblique-spined Bindyi		
	Sclerolaena patenticuspis	Spear-fruit Bindyi		
	Sclerolaena uniflora	Small-spine Bindyi		
	Senna artemisioides ssp. artemisioides x ssp. *coriacea*	Desert Senna		
	Senna artemisioides ssp. *X coriacea*	Broad-leaf Desert Senna		
	Sida intricata	Twiggy Sida		
	Sida petrophila	Rock Sida		
	Solanum quadriloculatum	Plains Nightshade		
	Tecticornia pergranulata ssp. *divaricate*	Blackseed Glasswort		
	Tetragonia eremaea	Desert Spinach		
	Threlkeldia diffusa	Coast Bonefruit		
	Vittadinia cuneata var.	Fuzzy New Holland Daisy		

Status: NPW Act (*National Parks and Wildlife Act 1972*)/EPBC Act (*Environment Protection and Biodiversity Conservation Act 1999*). V/VU: Vulnerable.

EBS Ecology
112 Hayward Avenue
Torrensville, SA 5031
www.ebsecology.com.au
t. 08 7127 5607



Appendix K: Flora & Fauna – Baseline Data

K1: List of Declared Weed Species Identified in Baseline Surveys

Appendix K: Samphire RL 137 - Baseline Weed Species

Baseline - Invasive Weed Species

ID Location	Common Name ▲	Scientific Name	Classification
RL 137	African Boxthorn	Lycium ferocissimum	Weed of National Significance; Declared weed
RL 137	Apple of Sodom	Solanum linnaeanum	Declared weed
RL 137	Barley grass	Hordeum vulgare	Not declared
RL 137	Bathurst Burr	Xanthium spinosum	Declared weed
RL 137	Blue Periwinkle	Vinca major	Not declared
RL 137	Burr-medic	Medicago polymorpha var polymorpha	Not declared
RL 137	Dyers weed	Reseda luteola	Not declared
RL 137	Horehound	Marrubium vulgare	Declared weed
RL 137	Ice Plant	Mesembryanthemum crystallinum	Not declared
RL 137	Little Medic	Medicago minima	Not declared
RL 137	Onion weed	Asphodelus fistulosus	Not declared
RL 137	Paddy melon	Cucumis myriocarpus	Not declared
RL 137	Saffron Thistle	Carthamus lanatus	Not declared
RL 137	Slender Ice Plant	Mesembryanthemum nodiflorum	Not declared
RL 137	Soursob	Oxalis pes-caprae	Not declared
RL 137	Tree tobacco	Nicotiana glauca	Not declared
RL 137	Ward's Weed	Carrichtera annua	Not declared
RL 137	Wild sage	Salvia verbenaca	Not declared

Reference ▲

EBS Ecology. (2012). Samphire Flora and Fauna Spring Report. Report to Uranium SA. Adelaide, South Australia: EBS Ecology.

EBS Ecology. (2012). Samphire Project Flora and Fauna Survey September 2011. Report to Uranium SA. Adelaide, South Australia: EBS Ecology.

EBS Ecology. (2023). Moonabie Samphire Uranium Project – Flora and Fauna Assessment. Adelaide, South Australia: EBS Ecology.

Staff observation.

K2: List of Pest Species Identified in Baseline Surveys

Appendix K: Samphire RL 137 - Baseline Pest Species

Baseline - Pest Species

Location	Common Name	Scientific Name
RL 137	Fox	Vulpes vulpes
RL 137	Common Starling	Sturnus vulgaris
RL 137	Rabbit	Oryctolagus cuniculus
RL 137	House mouse	Mus musculus
RL 137	Cat	Felis catus
RL 137	Goat	Capra hircus
RL 137	Eurasian Skylark	Alauda arvensis

Reference

EBS Ecology. (2012). Samphire Flora and Fauna Spring Report. Report to Uranium SA. Adelaide, South Australia: EBS Ecology.

EBS Ecology. (2012). Samphire Project Flora and Fauna Survey September 2011. Report to Uranium SA. Adelaide, South Australia: EBS Ecology.

EBS Ecology. (2023). Moonabie Samphire Uranium Project – Flora and Fauna Assessment. Adelaide, South Australia: EBS Ecology.

Staff observation.

Appendix L: Native Vegetation Management Plan

Appendix L1: Samphire Project – Native Vegetation Management Plan. Prepared by Alligator Energy, January 2025.

Appendix B in the following report has not been included as it is already provided in this document as Appendix J7.

Native Vegetation Management Plan

Samphire Retention Lease 137



Western Desert Myall (Acacia papyrocarpa) in Flower

CONTACT DETAILS

Alligator Energy Limited	ACN:140 575 604 ABN: 79 140 575 604
Website:	https://alligatorenergy.com.au/
Contact Person:	Matt Daniel
Email:	md@alligatorenergy.com.au
Phone:	+61 (0)4 07 010 605
Address:	Level 1 103 King William Street, KENT TOWN SA 5067

DOCUMENT HISTORY

Revision:	1.0
Status:	Issued as part of the Samphire PEPR v3.0
Date:	11/08/2025
Author:	Matt Daniel
Checked by Staff:	A Marsland-Smith

1 EXECUTIVE SUMMARY

The Samphire Retention Lease 137 is located on Moonabie Station, 25 km south of Whyalla, a pastoral chenopod property, the station predominately has a Western Desert Myall Woodland vegetation association, however the RL 137 is predominately Pearl Bluebush shrubland.

Alligator Energy Ltd is conducting an In-Situ Recovery (ISR) uranium Field Recovery Trial (FRT) to assess the technical and economic feasibility of extracting uranium from the Kanaka Bed sands 80-130 metres below surface. This Native Vegetation Management Plan (NVMP) accompanies the Program for Environment Protection and Rehabilitation (PEPR) and provides a comprehensive framework for managing vegetation clearance during project activities.

The NVMP adheres to the *Native Vegetation Act 1991*, associated regulations, and relevant guidelines, including the Terms of Reference (TOR24) for Uranium In-Situ Recovery Applications PEPR's (DEM, 2020). The plan includes detailed measures to avoid, minimise, rehabilitate, and offset vegetation impacts.

Table of Contents

1 EXECUTIVE SUMMARY 2

2 INTRODUCTION 5

2.1 Background 5

2.2 Scope & Purpose 5

2.3 Key References 6

3 REGULATORY FRAMEWORK 8

3.1 Mining Act 1971 8

3.2 Native Vegetation Act 1991 8

4 SITE & VEGETATION DESCRIPTION 9

4.1 Land Use History 9

4.2 Vegetation Baseline Survey Summary 9

5 NATIVE VEGETATION SEB ASSESSMENT 13

5.1 Rangeland Vegetation Assessment Method 13

6 NATIVE VEGETATION MITIGATION HIERARCHY 14

6.1 Background 14

6.2 Mitigation Measures 14

7 NATIVE VEGETATION CLEARANCE & SEB PROVISIONS 18

7.1 Clearance Areas 18

7.2 SEB Requirements 24

8 MANAGEMENT, AUDITS & REPORTING 27

8.1 Land Disturbance & Native Vegetation Clearance Management 27

8.2 Audits, Reconciliation & Compliance Reporting 27

9 SIGNIFICANT OPERATIONAL CHANGES 29

9.1 Changes to Clearance Extents and Amounts 29

10 DEFINITIONS AND ABBREVIATIONS 30

11 REFERENCES 32

12 APPENDIX A: RANGELAND SCORESHEETS 33

13 APPENDIX B: RANGELAND REPORT 37

List of Tables

Table 4:1 Vegetation Associations Identified in the RL Area 10

Table 6:1 Mitigation Hierarchy for Native Vegetation Clearance Applications 14

Table 6:2 Revegetation Phases and Purposes 17

Table 7:1 Native Vegetation - Maximum Clearance Area 19

Table 7:2 Vegetation Associations & SEB Points 24

Table 7:3 Clearance Summary & Total Significant Environmental Benefit (SEB) Obligations – Maireana sedifola Shrubland only 26

List of Figures

Figure 2.1: Location of the Alligator Energy's Retention Lease 6

Figure 4.1: Vegetation Associations & pre-existing station tracks within the RL area, Moonabie Station 11

Figure 4.2: Vegetation Associations Surrounding the RL - Moonabie, Mullaquanna and Nonowie Stations. 12

Figure 7.1: Clearance Extents (black) with 10m contingency buffer (yellow) - Samphire RL 20

Figure 7.2: Clearance Extents with infrastructure detail - Samphire RL 21

Figure 7.3: Resource infill drilling vegetation clearance areas 22

Figure 7.4: Vegetation clearance areas, exploration 2021-2025 23

2 INTRODUCTION

2.1 Background

Alligator Energy Ltd (Alligator Energy) holds Retention Lease (RL) 137 for the Blackbush Deposit, encompassing 235 hectares within Exploration Lease (EL) 5926. The lease is situated approximately 20 km southwest of Whyalla and 3.5 km west of the Spencer Gulf coastline in South Australia.

The RL has been granted to facilitate the development of an In-Situ Recovery (ISR) uranium Field Recovery Trial (FRT). This trial is a crucial step in assessing the feasibility of ISR technology, which allows for the extraction of uranium with minimal surface disturbance. The FRT aims to evaluate both the technical and economic viability of full-scale uranium mining operations at the Blackbush Deposit.

As part of the regulatory requirements under the Mining Act 1971, a Program for Environment Protection and Rehabilitation (PEPR) is required to govern the activities undertaken within the RL. The PEPR outlines the environmental management framework for the FRT, including native vegetation clearance, rehabilitation, and compliance with relevant legislation.

To support the PEPR, a Native Vegetation Management Plan (NVMP) has been developed. The NVMP serves as a key document for managing native vegetation during the FRT, ensuring:

- The minimisation of vegetation clearance impacts through best-practice management.
- Compliance with the *Native Vegetation Act 1991* and associated regulations.
- Implementation of offset and rehabilitation strategies to achieve a net environmental benefit.

The NVMP aligns with the goals of the PEPR, demonstrating Alligator Energy's commitment to balancing project development with environmental stewardship and regulatory compliance.

2.2 Scope & Purpose

The NVMP outlines the framework for managing native vegetation clearance, rehabilitation, and compliance during the FRT at the Blackbush Deposit. It has been developed to support the Samphire PEPR and ensure adherence to the *Native Vegetation Act 1991* and associated regulations.

The scope of the NVMP includes:

- Defining procedures for native vegetation clearance within the RL.
- Outlining strategies to minimise environmental impacts through the mitigation hierarchy (avoid, minimise, rehabilitate, and offset).
- Establishing the framework for fulfilling Significant Environmental Benefit (SEB) offset obligations, including payment into the Native Vegetation Fund or on-ground offsets.
- Detailing processes for vegetation rehabilitation and restoration to ensure a net environmental benefit.
- Providing mechanisms for monitoring, auditing, and reporting on native vegetation management to demonstrate compliance with regulatory requirements.

The purpose of the NVMP is to:

- Ensure all vegetation clearance and rehabilitation activities are conducted in compliance with the *Mining Act 1971*, the PEPR, and the *Native Vegetation Act 1991*.
- Support the successful implementation of the FRT by integrating environmental management best practices.

Demonstrate Alligator Energy's commitment to protecting biodiversity and achieving sustainable project outcomes.

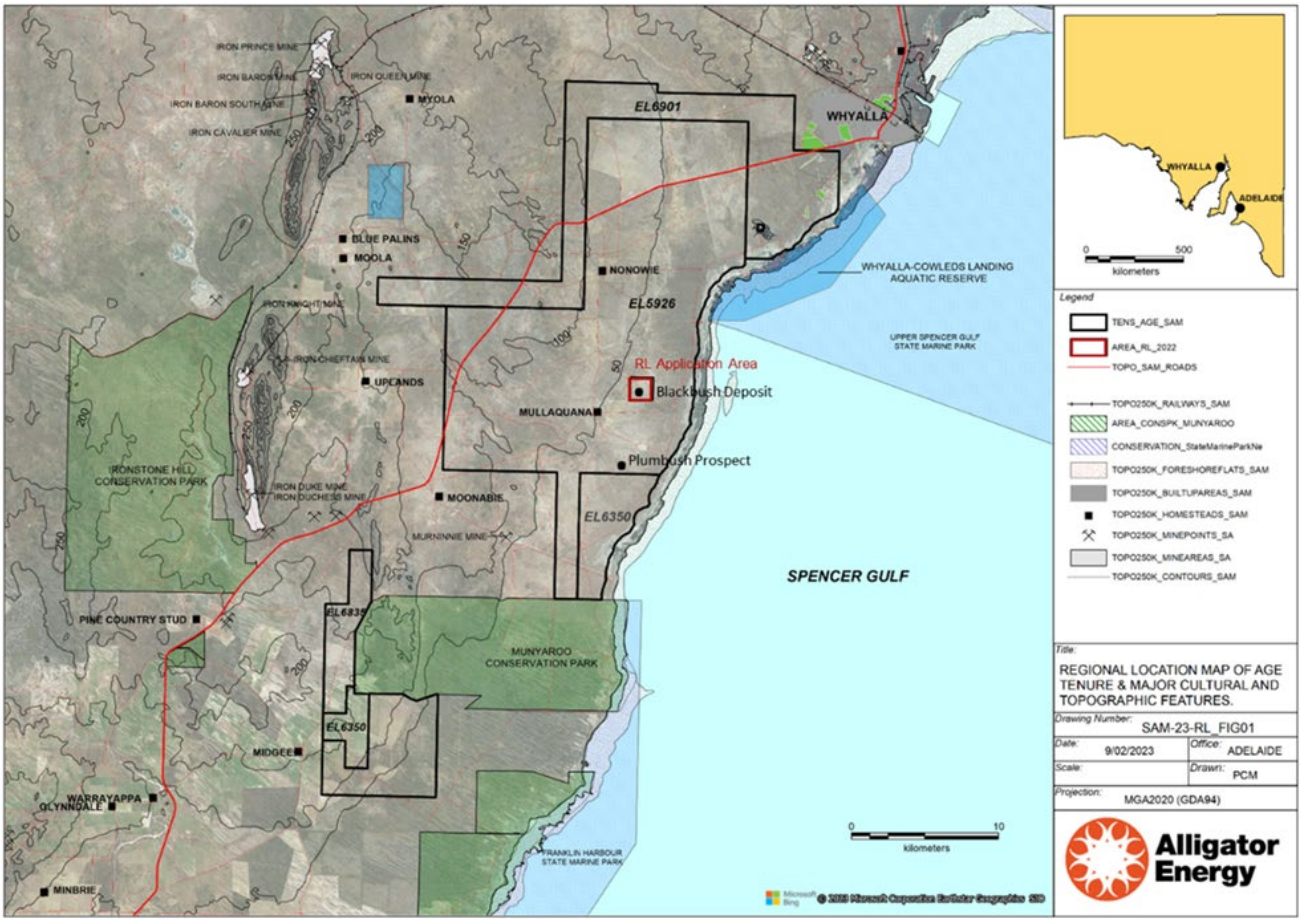


Figure 2.1: Location of the Alligator Energy's Retention Lease

2.3 Key References

The Samphire NVMP has been developed using a range of legislative, policy, technical, and project-specific sources to ensure compliance and alignment with best practices. These references provide the regulatory, ecological, and procedural framework for the plan and its implementation during the FRT.

Legislative & Regulatory References

- Native Vegetation Act 1991 and Native Vegetation Regulations 2017: Regulates the clearance and offsetting of native vegetation.
- *National Parks and Wildlife Act 1972*: Protects flora and fauna of conservation significance.
- *Landscape South Australia Act 2019*: Provides for sustainable land and water management.
- Planning, Development and Infrastructure Act 2016: Oversees planning and development approvals.
- *Mining Act 1971 and Regulations 2020*: Sets out requirements for retention leases, PEPRs, and environmental management in mining activities.

Technical Guidelines and Manuals

- Bushland Assessment Manual (NVC, 2024): Used for biodiversity assessment in bushland environments.

- Guide for a significant environmental benefit for the clearance of native vegetation associated with the minerals and petroleum industry (NVC, 2025).
- Guide for Calculating a Significant Environmental Benefit (SEB) (NVC, 2024): Under the Native Vegetation Act 1991 and Native vegetation Regulations 2017.
- Terms of Reference for Uranium In-Situ Recovery PEPRs (DEM, 2020): Establishes requirements for environmental management in ISR projects.

Project-Specific References

- EBS Ecology (2024), Moonabie Samphire Uranium Project – Flora and Fauna Assessment: Provides baseline vegetation and biodiversity data for the Samphire RL area.
- EBS Ecology reports from 2009–2012 on vegetation and fauna surveys across the broader Samphire project area.

3 REGULATORY FRAMEWORK

3.1 Mining Act 1971

The Mining Act 1971, administered by the Department for Energy and Mining (DEM), is the principal legislation governing mining activities in South Australia.

Under the Act:

- Proponents must obtain a Mining Lease (ML) to proceed with mining operations or a Retention Lease (RL) to undertake preliminary field trial work critical to future mining development.
- Applications for an ML or RL require submission of a proposal outlining project risks and management measures to minimise those risks.

Before commencing on-ground works, proponents must obtain approval for a Program for Environment Protection and Rehabilitation (PEPR). The PEPR:

- Details specific environmental management measures and establishes outcome-based performance criteria.
- Includes a Native Vegetation Clearance Management Plan and a Significant Environmental Benefit (SEB) Management Plan, which are reviewed by the Native Vegetation Council (NVC).

Once approved, the PEPR becomes the primary operational document used by DEM to regulate project construction, ongoing operations, and vegetation clearance compliance.

3.2 Native Vegetation Act 1991

The Native Vegetation Act 1991, administered by the Native Vegetation Council (NVC), protects native vegetation in South Australia. The Act provides incentives for landowners to preserve and enhance native vegetation while regulating its clearance.

Mining activities authorized under the Mining Act 1971 are exempt from the Native Vegetation Act if native vegetation clearance is conducted in accordance with an approved management plan that delivers a Significant Environmental Benefit (SEB).

The aim of an SEB is to offset vegetation loss and ensure a net environmental gain. Proponents can meet SEB requirements through:

- Revegetation: Establishing and managing native vegetation on approved land.
- Protection: Protecting and managing existing native vegetation through activities like excluding grazing, managing pests and weeds, and restricting access.
- Heritage Agreements: Entering into agreements for perpetual protection and management of native vegetation.
- Third-Party or Credit Options: Achieving SEB obligations by using an accredited third-party provider or purchasing existing SEB credits.

All SEB activities must comply with the requirements of Part 4A of the Native Vegetation Act.

4 SITE & VEGETATION DESCRIPTION

4.1 Land Use History

The RL 137 area, part of Moonabie Station, has a history of pastoral activities dating back to the 1860s. Evidence of wood harvesting, historic overgrazing, and obvious sheep 'grazing lines' on most remaining trees, can be observed. As noted in the March 2024 EBS report (Appendix B), the reduction of the vegetation structure and condition over time is reflected in the assessment weighing. The dominance of Pearl Bluebush and the lower density of bushes per hectare than that recorded by Dr. Peter Waite in the 1890's, indicates preferential bush/understory grazing over time by stock. It is expected rabbit impacts to vegetation structure prior to Myxomatosis and Calicivirus virus has also altered the vegetation structure from pre-colonial times.

4.2 Vegetation Baseline Survey Summary

The vegetation within and surrounding the Samphire RL, has been assessed through a series of comprehensive flora and fauna surveys conducted between 2009 and 2023, across an 11,000-hectare area.

These surveys include:

- Flora and Fauna Baselines (November 2009, EBS 2010a)
- Mullaquana Follow-up Flora and Fauna Survey (November 2010, EBS 2010b)
- Mullaquana Buffel Grass Survey (EBS, 2010c)
- Flora and Fauna Survey (September 2011, EBS 2012)
- Flora and Fauna Survey (Spring 2012, EBS 2012b)
- Moonabie Samphire Uranium Project – Flora and Fauna Assessment (March 2024, EBS Ecology), with a specific focus on the 'Coronation Dam' paddock vegetation condition and potential Significant Environmental Benefits (SEBs) for offsets related to Retention Lease (RL) activities. See Appendix A for SEB calculations and Appendix B for the vegetation assessment report.

Across these surveys, a total of 111 flora species were recorded in the study area, including 97 native species and 14 exotics.

Two distinct vegetation associations were identified within the RL area:

Vegetation Association 1: *Maireana sedifolia* (Bluebush) / *Maireana pyramidata* (Black Bluebush) / *Atriplex vesicaria* (Bladder Saltbush) Open Low Shrubland

This vegetation association covers approximately 212.8 hectares or 91% of the 235-hectare RL area, making it the dominant vegetation type. The three dominant species, *Maireana sedifolia* (Pearl Bluebush), *Maireana pyramidata* (Black Bluebush), and *Atriplex vesicaria* (Bladder Saltbush) vary in abundance but are consistently present together within this association.

The ground layer is typically characterised by species from the Graminae family, particularly *Austrostipa* (Spear-grass) and *Austrodanthonia* (Wallaby Grass). Dense patches of Sclerolaena spp. (Poverty Bush) are common in the understorey, with *Sclerolaena obliquicuspis* (Oblique-spined Bindyi) being the most frequently recorded species. Emergent species include *Acacia papyrocarpa* (Western Myall), *Alectryon oleifolius ssp. canescens* (Bullock Bush), and *Myoporum platycarpum* (False Sandalwood).

Weed presence is minimal, and the overall condition of this vegetation type is considered moderate. Many of the project-related disturbances, including mining operations, occur within this vegetation type.

Vegetation Association 2: Acacia papyrocarpa (Western Myall) / Myoporum platycarpum (False Sandalwood) / Alectryon oleifolius ssp. canescens (Bullock Bush) Open Woodland

This vegetation association spans approximately 22.2 hectares or 9.5% of the RL area and is found in scattered outcrops, particularly toward the western sections of the RL. The upper stratum is dominated by *Acacia papyrocarpa* (Western Myall), with *Myoporum platycarpum* (False Sandalwood) or *Alectryon oleifolius ssp. canescens* (Bullock Bush) occasionally present as co-dominants.

The mid-stratum varies and may feature:

- An open chenopod shrub layer dominated by Maireana pyramidata (Black Bluebush), *Maireana sedifolia* (Pearl Bluebush), and/or *Atriplex vesicaria* (Bladder Saltbush).
- A taller shrub layer of approximately 1.2 m height, often comprising *Senna artemisioides ssp. petiolaris* (Desert Senna), Acacia spp., and Dodonaea spp.
- The ground layer is dominated by Graminae species, particularly *Austrostipa* (Spear-grass) and *Austrodanthonia* (Wallaby Grass), with occasional patches of *Triodia irritans* (Spinifex) tussocks. This association's overall condition is moderate, with minimal disturbance.

Table 4:1 Vegetation Associations Identified in the RL Area

No.	Association description	Area (ha) within RL
1	*Acacia papyrocarpa* (Western Myall) +/- *Myoporum platycarpum* (False Sandalwood) +/- *Alectryon oleifolius ssp. canescens* (Bullock Bush) Open Woodland over Chenopod Shrubland or Tall Shrubland	22.2
2	*Maireana sedifolia* (Bluebush) / *Maireana pyramidata* (Black Bluebush) / *Atriplex vesicaria* (Bladder Saltbush) Open Low Shrubland over *Austrostipa nodosa* (Tall spear-grass) +/ *Sclerolaena obliquicuspis* (Oblique-spined Bindyi)	212.8

4.2.1 Conservation Value

Alectryon oleifolius ssp. canescens (Bullock Bush) Tall Shrubland on alluvial soils of plains is a widespread ecological community of semiarid and arid regions, where it grows on sandy soils (Neagle 2003) and is recognised as a vulnerable community at the state level (DEH 2001). While this community was not recorded according to the strict definition of DEH (2001) within the current survey, it is possible this community could be defined at a very small scale (10's of metres).

According to Neagle (2003) this community is rarely recorded as it is often included as a component of broader vegetation groups, as indicated in this report. It is commonly recorded as an emergent within shrubland vegetation associations, or within Acacia woodlands in which it forms dense localised patches. EBS recommended that any dense, localised patches of Bullock Bush are avoided or measures to mitigate disturbance to these patches are implemented when planning development works / activities; and Alligator Energy have committed to this.

4.2.2 Flora of Conservation Significance

No flora of Conservation Significance was listed within the Retention Lease.

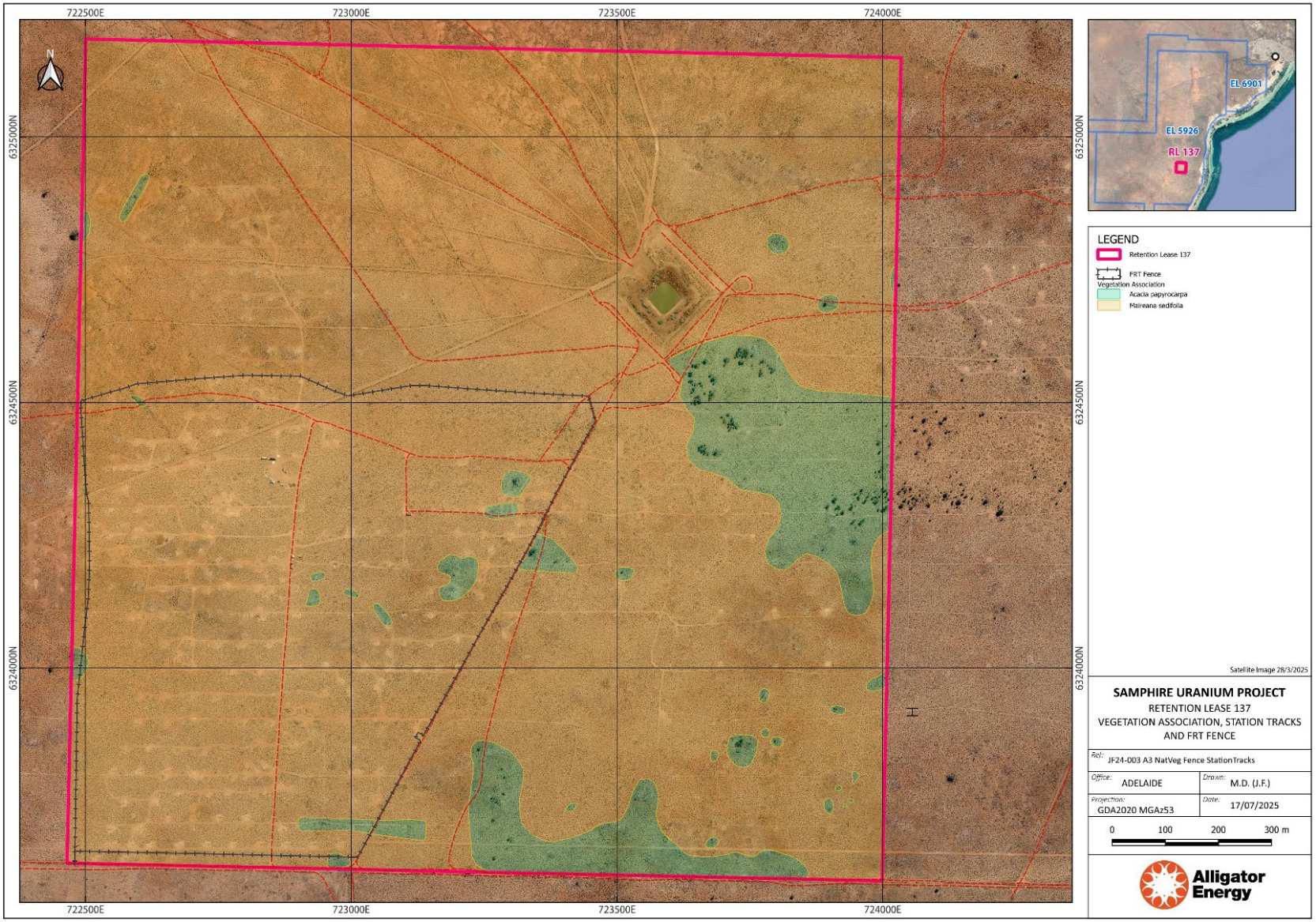


Figure 4.1: Vegetation Associations & pre-existing station tracks within the RL area, Moonabie Station

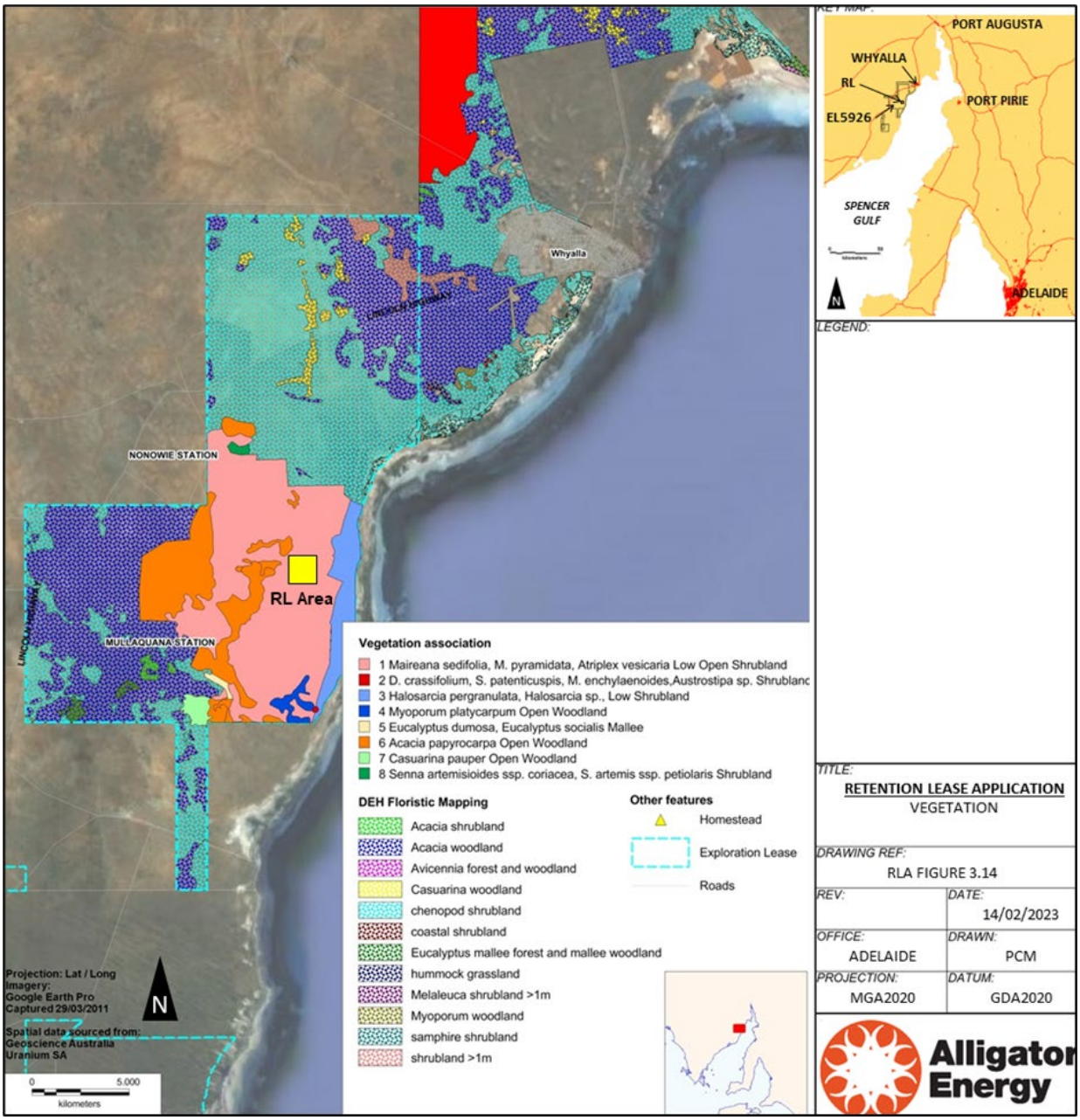


Figure 4.2: Vegetation Associations Surrounding the RL - Moonabie, Mullaquanna and Nonowie Stations.

5 NATIVE VEGETATION SEB ASSESSMENT

5.1 Rangeland Vegetation Assessment Method

EBS Ecology conducted a vegetation assessment for the proposed native vegetation clearance in 2023 (EBS, 2023) in accordance with the Native Vegetation Council (NVC) guidelines, including:

- Rangelands Assessment Manual (NVC, 2020a),
- Guide for Applications to Clear Native Vegetation (NVC, 2020b), and
- Guide for Calculating a Significant Environmental Benefit (NVC, 2017).

The assessment used Rangelands Assessment scoresheets as prescribed in the Rangelands Assessment Manual. In November 2023, surveys were conducted at nine sites within the Moonabie Pastoral Lease (Coronation Dam Paddock). These sites were selected to represent the vegetation within and near the expected clearance areas for the FRT site.

Key contextual definitions were determined following the NVC guidelines:

- Landscape Region: South Australian Eyre Peninsula
- IBRA Sub-region: GAW01, Myall Plains
- Property: Moonabie Pastoral Lease, Coronation Dam Paddock

The landforms assessed included gently undulating calcrete plains and occasional hills, consistent with regional characteristics. Clearance costs were calculated in November 2023 using the Rangelands Assessment scoresheets and reviewed and updated in 2025, and the results are presented in Appendix A, along with the detailed Rangelands Assessment report.

5.1.1 Vegetation Structure and Condition

The surveys conducted by EBS Ecology characterised the vegetation within the RL site as native but degraded, primarily due to grazing pressure. This aligns with the conditions outlined in the Native Vegetation SEB Guidelines (NVC, 2005) and exhibits the following attributes:

- Vegetation structure altered (e.g., one or more vegetation strata depleted).
- Most seed sources available to regenerate original structure.
- Obvious signs of disturbance (e.g., tracks, bare ground).
- Minor Clearing (<10% of area).
- Considerable weed infestation with some aggressive weeds.
- Evidence of some grazing (tracks, soil surface crust patchy).

These findings reflect the widespread degradation of vegetation in the region, which is predominantly chenopod shrubland, dominated by:

- *Maireana sedifolia* (Pearl Bluebush),
- *Maireana pyramidata* (Black Bluebush), and
- *Atriplex vesicaria* (Bladder Saltbush).

Minimal vegetation regeneration has been observed over the past 30 years, primarily due to grazing pressures from livestock, kangaroos, and introduced species like the European Rabbit (*Oryctolagus cuniculus*).

6 NATIVE VEGETATION MITIGATION HIERARCHY

6.1 Background

This NVMP ensures that all native vegetation clearance associated with construction, operational, and/or decommissioning activities within the RL complies with the Native Vegetation Mitigation Hierarchy (NVC, 2025). The mitigation hierarchy provides a structured framework to manage and mitigate environmental impacts, prioritising avoidance, minimisation, rehabilitation, and offsetting, as detailed in Table 6:1.

Table 6:1 Mitigation Hierarchy for Native Vegetation Clearance Applications

Priority	Hierarchy	Description
1	Avoidance	Measures must be taken to avoid clearance of native vegetation wherever possible.
2	Minimisation	If clearance cannot be avoided, measures must be taken to minimise the extent, duration and intensity of impacts to the fullest possible extent.
3	Rehabilitation or restoration	Measures must be taken to rehabilitate ecosystems that will be degraded/impacted due to clearance that cannot be avoided or minimised.
4	Offset	Any adverse impacts on native vegetation that cannot be avoided or minimised must be offset by implementing an SEB that outweighs the impact.

This NVMP applies the principles of the mitigation hierarchy to ensure that vegetation clearance is managed responsibly, reducing environmental impacts and achieving a net environmental benefit.

Specific strategies include:

- Avoiding clearance wherever possible through careful planning and design.
- Implementing measures to minimise unavoidable impacts on native vegetation.

Rehabilitating degraded or impacted areas through revegetation and ecosystem restoration.

- Offsetting any residual impacts by fulfilling SEB requirements as mandated under the Native Vegetation Act 1991.

By following this framework, the NVMP demonstrates Alligator Energy's commitment to sustainable environmental management and regulatory compliance, ensuring that all vegetation clearance is conducted responsibly and with minimal environmental disruption.

6.2 Mitigation Measures

6.2.1 Avoidance Measures

Key methods employed to avoid the clearance of native vegetation during operational actives within the Samphire RL include:

- Use of existing pastoral infrastructure where possible, e.g., pastoral roads (site access road) and pastoral tracks.
- Careful site selection and infrastructure placement and design.
- Ensuring all proposed clearance areas are reviewed through a formal process and assessed by the Environment Manager to determine if they are necessary.

6.2.2 Minimisations Measures

The project adopts a proactive environmental strategy aligned with best practices for biodiversity conservation, ensuring the protection of key environmental features. Vegetation and habitat quality on-site will be maintained or improved through the following minimisation measures:

Key Minimisation Measures:

- Infrastructure Design and Operational Refinement:
  - Trial works infrastructure is designed to be modular and minimal impact, resulting in a modest construction footprint.
- Operational Controls:
  - Drill pads will not all be graded; rather shrubs will be rolled, and disturbance will be limited to sump excavations and immediate wellhead areas.
  - Blanket surface clearance of vegetation (surface grading) is avoided except in specific circumstances. Clearance is limited to precise locations for necessary infrastructure (e.g., wellheads).
  - Infrastructure will be lain directly on the ground surface were possible (e.g., bore pump pipework) with minimal disturbance of native vegetation.
- A Landscape and Vegetation Permit is required for any new ground-disturbing activities. Permits ensure that:
  - Areas of disturbance remain within approved operational extents (Native Vegetation Plan and SEB offset area).
  - Disturbance areas are not excessive for the proposed task/activity.
  - Disturbance does not occur in areas with threatened or listed species.
- Fencing and Grazing Exclusion:
  - Exclude stock grazing pressure wherever possible by fencing operational areas.
- Minimise New Track Installation:
  - Use existing station tracks whenever possible.
- Preventive Soil and Erosion Management, use of hydroseeding and organic ‘dustbinding’ water applications
  - Implement proactive measures such as whoa-boys on tracks, contour lines, direct seeding, bush transplanting and traffic management.
- Vegetation Clearance Policy.
  - Internal policy restricting the clearance of trees or shrubs taller than 1 metre.

6.2.3 Rehabilitation & Restoration

Vegetation and habitat quality on site is maintained/improved within the RL by using standard natural resource management techniques for the rangelands, these measures to rehabilitate ecosystems that have been impacted from long term grazing impacts, partial or full clearance of native vegetation.

Key rehabilitation and restoration measures include:

- Progressive Rehabilitation:
  - Implement a rigorous system of progressive rehabilitation, which has been trialled under approved Exploration PEPR’s to date within the immediate and surrounding area, and proven successful.
  - Monitor revegetation coverage growth (ie drone photogrammetry) and iteratively active manage as required

- Vegetation and Soil Management:
  - Rolling chenopod bushes for heavy vehicle access preserves topsoil, enabling rapid regrowth from root stock.
  - Reseeding disturbed areas (e.g., drill sumps) using native species like *Maireana sedifolia*, *Maireana pyramidata*, *Lycium australe*, and *Acacia papyrocarpa*.
  - Collect, treat, and store native seeds annually to ensure fresh, viable seeds for revegetation. A seeding rate of at least 20 kg/ha is used.
- Trialled Innovations:
  - Trialled transplanting chenopod bushes from construction areas to rehabilitation sites, rapidly increasing vegetation coverage.
- Weed and Pest Management:
  - Conduct ongoing weed and feral animal management, including summer/winter weeds `and rabbit warren & goat surveillance.
  - Rigorous weed clearance protocols for vehicles entering the site.
  - Integrated pest and weed management principles to prevent introduction of new weed species.
- Collaboration and Risk Mitigation:
  - Assist neighbouring properties with weed control to prevent windborne seed dispersal across boundaries.
  - Share information on successful vegetation strategies with other developers and land managers in the region
- Short-Duration Activities:
  - Trial works are limited to approximately three – six months, followed by monitoring, natural resource management, and rehabilitation.
- Rehabilitation Priorities:
  - Fence woodland vegetation under threat from overgrazing by rabbits, kangaroos, sheep, or goats. Target threatened species such as *Allocasuarina verticillata*, *Santalum spicatum*, and *Cratystylis conocephala* (note these are outside of RL).
  - Revegetation of all areas post FRT construction that have been affected by heavy equipment, but are not required for FRT operations
  - Eradicate weeds in the project area and along the access road corridor, focusing on controlling known infestations and preventing new introductions.

There are several phases and specific purposes of revegetation works; these are described in Table 6:2.

Table 6:2 Revegetation Phases and Purposes

ID	Description	Timing & Progress
1	General revegetation to improve land impacted by 150 years of grazing pressure.	Ongoing
2	Amenity and biodiversity planning adjacent to Mullaquana boundary.	2022- ongoing
3	UraniumSA historic drill pads and tracks.	2020- ongoing
4	Exploration drilling/infrastructure installation.	2023-ongoing
5	RL 137 infrastructure installation	2025 - ongoing
6	RL137 Post FRT trial, removal & revegetation of all infrastructure no longer required – pipe works.	2026 - ongoing
7	RL 137 closure revegetation works	TBA

Management Recommendations for Habitat Quality Improvement

Building on the rehabilitation and restoration measures outlined above, additional management actions are proposed to improve habitat quality and address long-term ecological challenges within the RL area. These measures aim to mitigate the impacts of historical land use and promote sustainable land management practices.

Key management recommendations include:

- Reducing Grazing Pressure: Implementing stock exclusion fencing to protect vulnerable vegetation and promote natural regeneration.
- Weed and Pest Management: Conducting targeted removal of invasive weeds and pests, including rabbit control, to reduce competitive pressures on native species.
- Soil Stabilisation: Implementing erosion control measures near degraded areas, particularly around historic stock water points.
- Promoting Vegetation Regeneration: Monitoring natural regeneration processes and undertaking active revegetation, supplementary direct seeding and/or use of additives where necessary to promote the restoration of vegetation structure and ecosystem function.

6.2.4 SEB Offset

Under the Native Vegetation Act 1991 and associated SEB Guidelines, offsets for native vegetation clearance can be achieved through one of three methods:

- On-ground Offset: Establishing and maintaining restoration or conservation activities on suitable land that generate the required SEB points to offset the impacts of the clearance.
- Purchase of SEB Credits: Purchasing existing SEB credits from an approved third-party provider (e.g., the Nature Foundation) that match the vegetation communities impacted by the clearance.
- Direct Contribution to the Native Vegetation Fund: Providing a financial contribution to the fund, which is then allocated by the Native Vegetation Council (NVC) to approved conservation projects that achieve the necessary SEB outcomes.

7 NATIVE VEGETATION CLEARANCE & SEB PROVISIONS

7.1 Clearance Areas

The maximum potential native vegetation clearance within the Retention Lease associated with the FRT and resource infill drilling is 71,250 m² (7.125 hectares), as detailed in Table 7:1 and illustrated in Figures 7.1-7.4.

Additionally, as per the Mining Act 1971, Sect 10A the 76,330m^2 (7.633 hectares) cleared during exploration drilling (2021-2025) within the retention lease area is also added to the SEB total. The area has been assessed as low risk under the *Native Vegetation Act*, and only one vegetation association will be cleared within this area: *Maireana sedifolia* (Bluebush) / *Maireana pyramidata* (Black Bluebush) / *Atriplex vesicaria* (Bladder Saltbush).

This vegetation association forms an open low shrubland and is commonly distributed throughout the region. However, it has experienced prolonged grazing pressure, resulting in a degraded condition with some weed infestations.

This maximum clearance area has been divided into three distinct clearance categories:

1. **Operational Clearance Footprint (5.125 ha)**

   This clearance is for the core infrastructure required to support the FRT, including:

   - FRT plant area
   - Wells and associated drilling sumps
   - Pipelines
   - Track upgrades and road widening to facilitate truck access
   - Water storage pond.

   The FRT site map (Figure 7.1) identifies the primary infrastructure clearance, including widening of existing tracks for pipeline routes, the probable extent of vegetation clearance for exploration drilling and associated sumps. Figure 7.1 shows the footprints of the areas to be cleared and includes a ‘contingency buffer’ of 10m around each area. This contingency buffer allows some flexibility in clearance location, required for operational flexibility, but the total surface area cleared will not exceed the approved maximum clearance area. The total cumulative clearance will not exceed 5.125 hectares. Figure 7.2 shows some infrastructure that will be built within the clearance footprints.

2. **Resource infill drilling footprint (2.0 ha)**

   This clearance is for drill pads and tracks planned for a total of 125 exploration holes to further delineate the orebody. These holes will be within the two areas shown on Figure 7.4.

3. **Historic EPEPR vegetation clearing (7.633 ha).**

   The clearing that has historically been undertaken as part of Exploration Lease exploration activities, i.e. drill pads, laydown and tracks, that are within the RL 137 area is also considered as part of SEB calculations (Figure 7.3). This previous clearance, under approved EPEPR’s from 2021-2025, is now subsumed into the RL137 SEB area, as per Mining Act 1971, sect 10A, clause 2.3.

No other vegetation associations, including those of conservation significance, will be affected (Table 6.2). Notably, no flora species of conservation importance have been identified within the proposed clearance area.

Table 7:1 Native Vegetation - Maximum Clearance Area

Area	Clearance Size (Ha)
FRT Plant Area, Wellfields & Support Infrastructure Footprint	5.125
Planned resource infill drilling vegetation clearance for drillpads and tracks	2.0
Historic EPEPR clearance, drilling pads, tracks, 2020-2025	7.633
Total Maximum Clearance	14.758

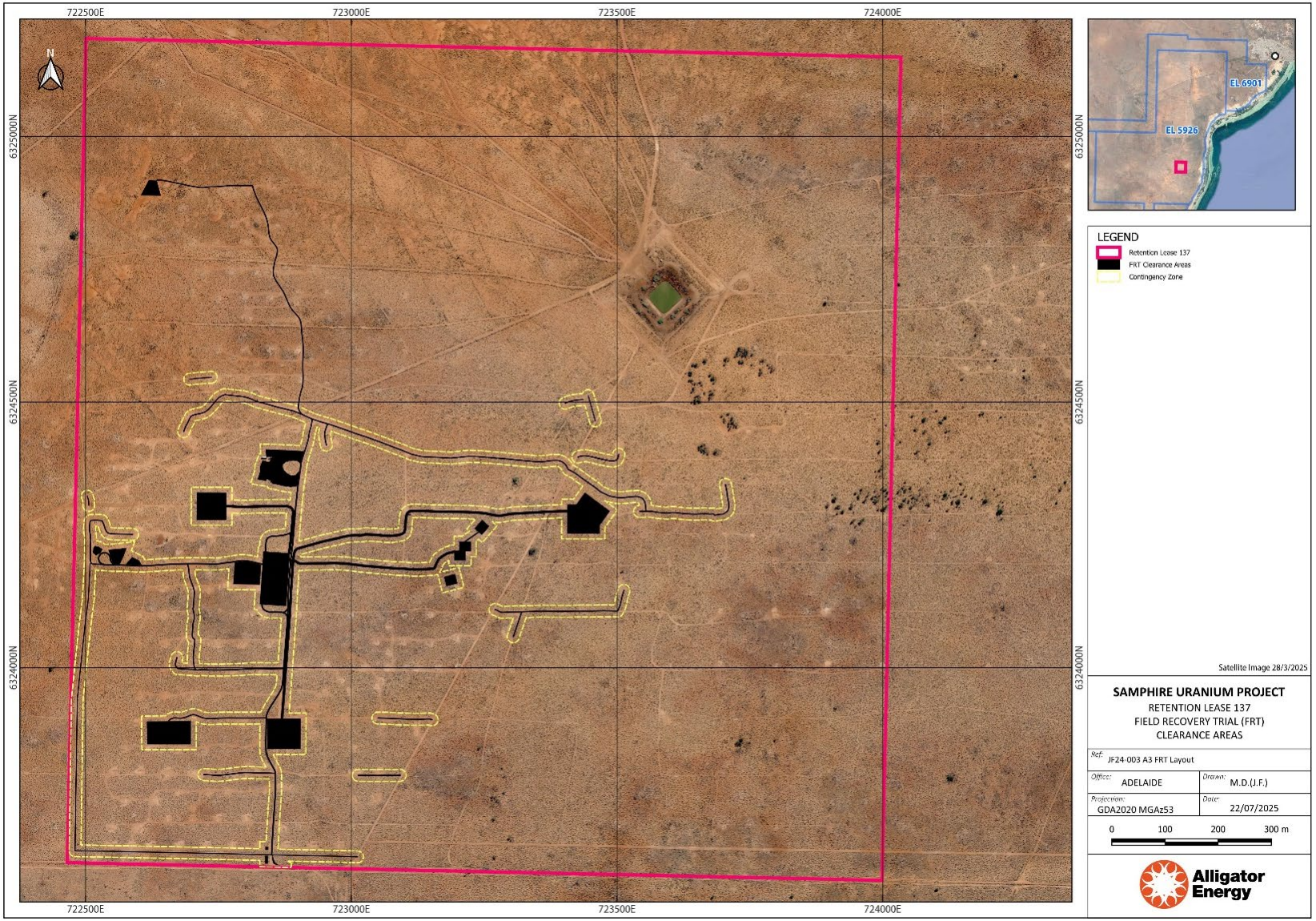


Figure 7.1: Clearance Extents (black) with 10m contingency buffer (yellow) - Samphire RL

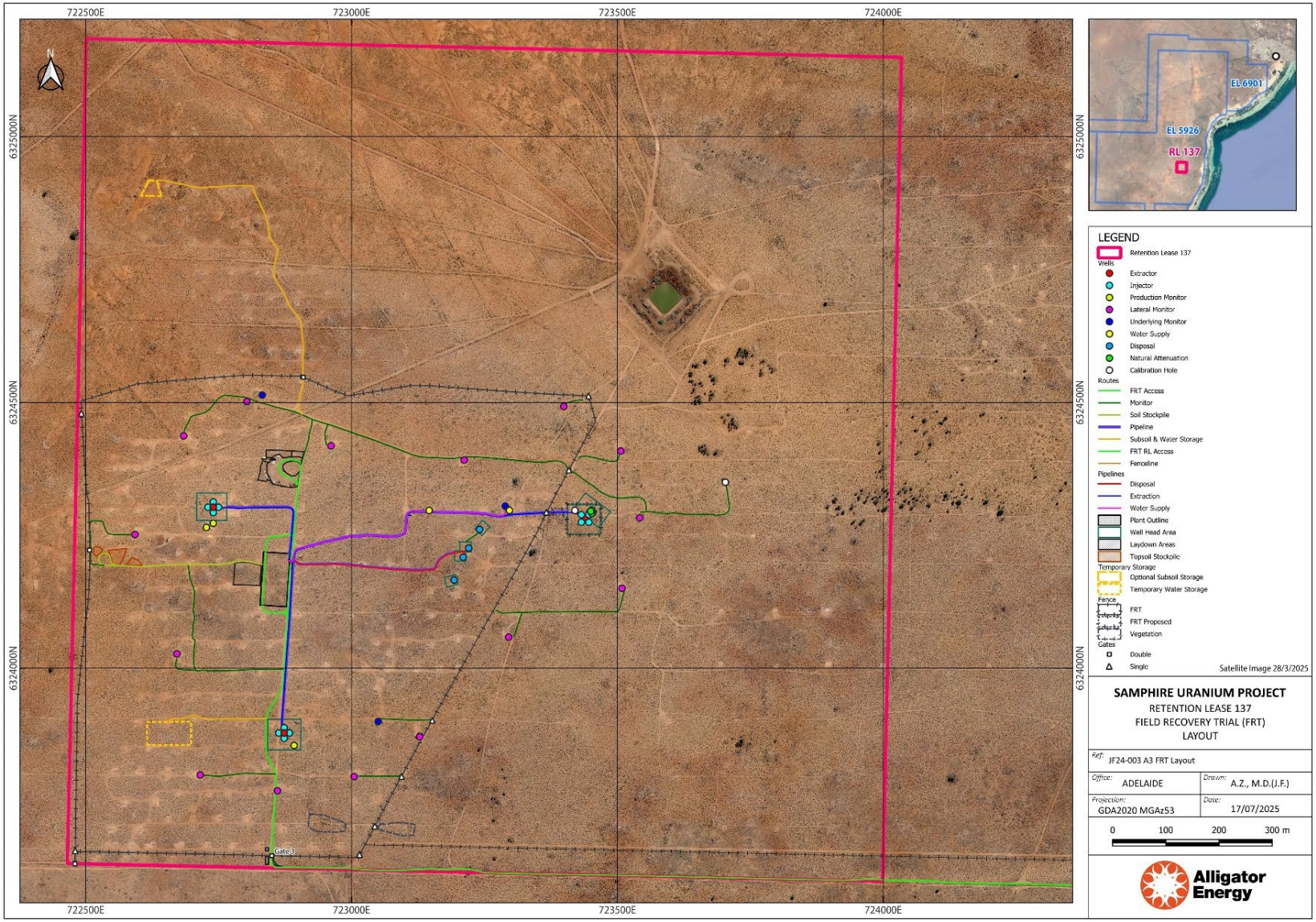


Figure 7.2: Clearance Extents with infrastructure detail - Samphire RL

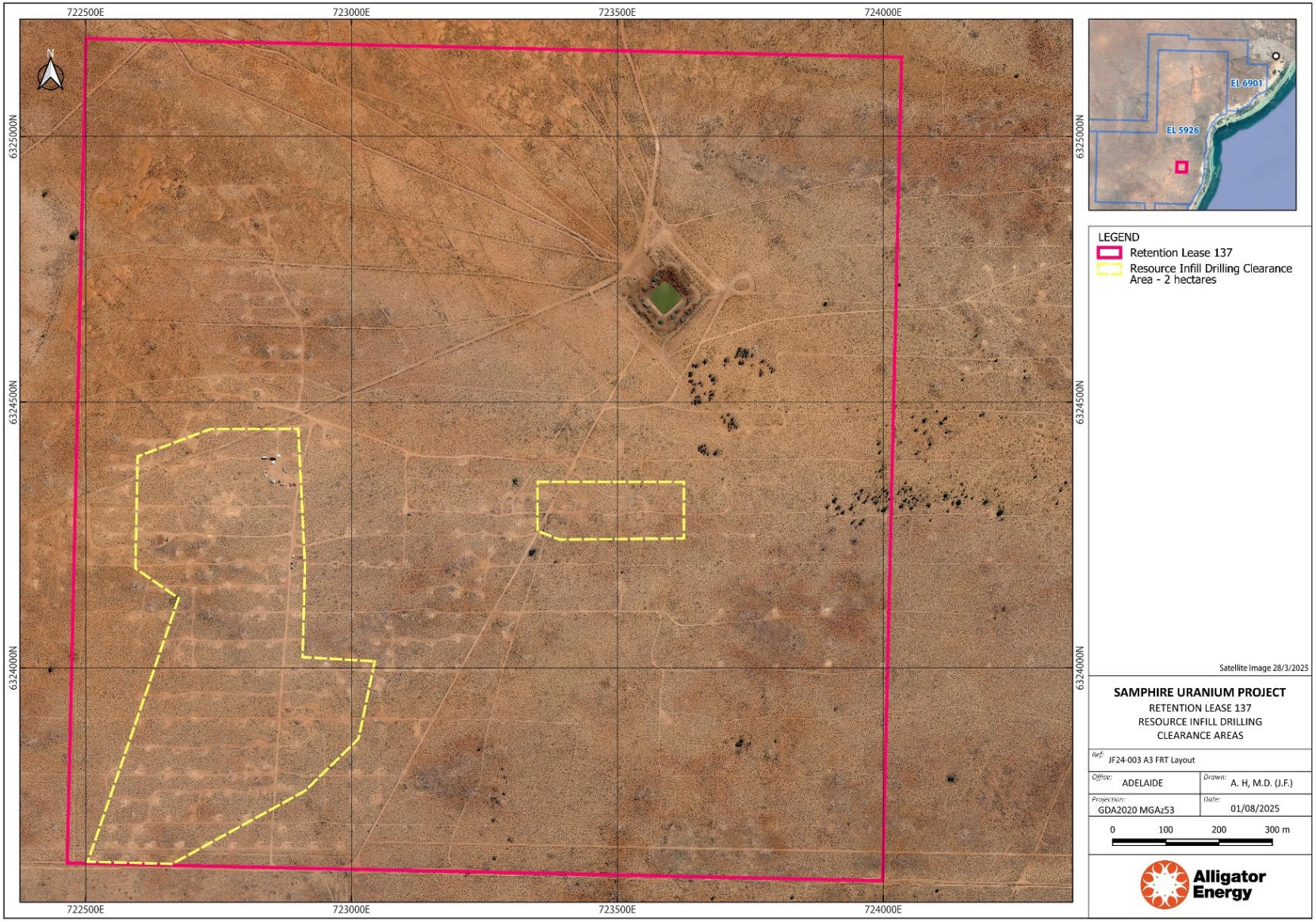


Figure 7.3: Resource infill drilling vegetation clearance areas

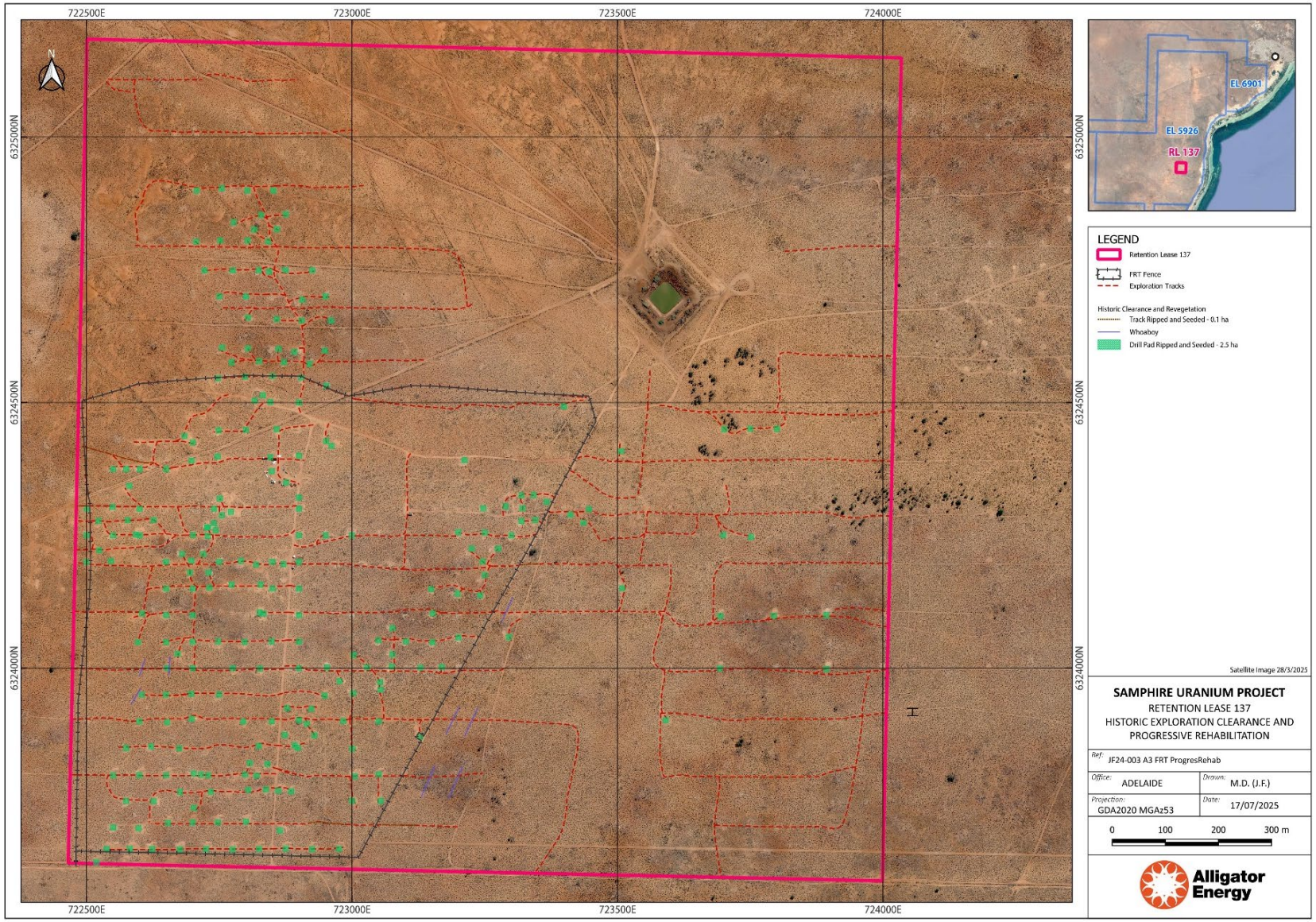


Figure 7.4: Vegetation clearance areas, exploration 2021-2025

7.2 SEB Requirements

To fulfill the requirements of the *Native Vegetation Act 1991* and associated regulations, the proposed clearance of native vegetation for the RL must achieve a SEB. The clearance requirements were calculated using the Rangelands Assessment detailed in Section 5, and associated scoresheets. This assessment considered the condition, biodiversity value, and ecological characteristics of the *Maireana sedifolia* (Bluebush), *Maireana pyramidata* (Black Bluebush), and *Atriplex vesicaria* (Bladder Saltbush) shrubland, ensuring a transparent and scientifically robust determination of the SEB offset obligations.

Based on the maximum potential clearance of 5.125 Ha for the FRT area, 2.0 Ha for infill drilling and 7.633 Ha previously clear during exploration, a total of 14.758 Ha, the SEB obligations for the project are below (Table 7:2).

Table 7.2 links the vegetation associations with their respective SEB points and disturbance areas and further broken down (Table 7:3), providing detailed scoring from the Rangelands Assessment Scoresheet.

Table 7:2 Vegetation Associations & SEB Points

No.	Association description	Total Disturbance (Ha)	SEB Points
1	Acacia papyrocarpa (Western Myall) +/- Myoporum platycarpum (False Sandalwood) +/- Alectryon oleifolius ssp. canescents' (Bullock Bush) Open Woodland over Chenopod Shrubland or Tall Shrubland	0	0
2	Maireana sedifolia (Bluebush) / Maireana pyramidata (Black Bluebush) / Atriplex vesicaria (Bladder Saltbush) Open Low Shrubland over Austrostipa nodosa (Tall spear-grass) +/ Sclerolaena obliquicuspis (Oblique-spined Bindyi)	14.758	623.98

The SEB calculation incorporates adjustments for biodiversity values, loss factors, vegetation condition, and management costs to comprehensively address the ecological impacts of the proposed clearance.

The SEB requirement for this project can be met through one of the following options:

- On-ground Offset: Generate 623.98 SEB points by securing and managing an appropriate offset site.
- Purchase of SEB Credits: Acquire 623.98 SEB points from an approved third-party provider.
- Direct Contribution to the Native Vegetation Fund: Provide a financial contribution of $67,023.71, including administration fees.

7.2.1 SEB Offset Approach for the Retention Lease

Alligator Energy will prioritise the purchase of SEB credits as the preferred offset method. If suitable SEB credits for the impacted vegetation communities (*Maireana sedifolia* shrubland and *Acacia papyrocarpa* open woodland) are available for purchase through an approved third-party provider.

However, if no suitable SEB credits are available for purchase, Alligator Energy will instead undertake a direct financial contribution to the Native Vegetation Fund to meet its SEB obligations. This ensures compliance while allowing the Native Vegetation Council (NVC) to allocate funds to high-priority conservation projects.

7.2.2 Justification for SEB Offset Approach

The selection of this approach is based on the following key considerations:

- Land Availability: Alligator Energy does not own or manage land within the project area or surrounding region that could be utilised for an on-ground offset.

- Native Vegetation Credit Register Review: A review of the Native Vegetation Credit Register (January 2025) found no available credits for the vegetation communities impacted by the proposed clearance—namely, *Maireana sedifolia* shrubland and *Acacia papyrocarpa* open woodland.
- Third-Party SEB Credits: Discussions were held in January 2025 with a potential third-party provider of SEB credits. The feasibility of purchasing credits is being assessed, though demand for their offsets remains high due to other development pressures in the Whyalla region.

Given these constraints, Alligator Energy is prioritising the purchase of SEB credits as the preferred offset method. If suitable SEB credits become available, they will be purchased to fulfil SEB obligations. However, if no appropriate credits can be secured, a direct contribution to the Native Vegetation Fund will be undertaken as an alternative.

This approach ensures regulatory compliance while supporting conservation efforts in South Australia. Alligator Energy remains committed to implementing the most effective offset strategy, aligning with the mitigation hierarchy and broader biodiversity conservation objectives.

7.2.3 SEB Timing

Alligator Energy will fulfill its SEB obligations through the purchase of SEB credits or a direct payment into the Native Vegetation Fund prior to any clearance activities occurring. This will be a one-off purchase or payment given the project is of limited duration.

Table 7:3 Clearance Summary & Total Significant Environmental Benefit (SEB) Obligations – Maireana sedifola Shrubland only

Block	Site	Species diversity score	TEC Score	Threatened flora	Threatened fauna score	UBS	Area (ha)	Total Biodiversity score	Loss factor	Loadings	Reductions	SEB Points required	SEB payment	Admin Fee
A	2	16	1	0	0.1	54.91	14.758	810.36	1	0	0.3	623.98	$63,529.58	$3,494.13
Total														$67,023.71

8 MANAGEMENT, AUDITS & REPORTING

8.1 Land Disturbance & Native Vegetation Clearance Management

All native vegetation clearance within the RL will be restricted to the areas shown in Figure 7.1 and the total area provided in Table 7:1). However some minor flexibility in precise clearance location is planned for, but no exceedance of total area cleared is permitted, except by obtaining further SEB credits. This is not anticipated.

Before any new vegetation disturbance or clearance (e.g., during construction, operations, or closure), an approved Landscape and Vegetation Clearance Permit must be obtained. This permit ensures a formal and structured process to verify that the proposed clearance location:

- Falls within the approved clearance extents within the FRT fenced area shown in Figure 7.1.
- Remains within the FRT & infill drilling maximum allowable clearance of 7.125 hectares, as outlined in Table 7:1.
- Is adequately offset by pre-purchased SEB credits or payments made directly to the Native Vegetation Fund.

The Climate, Environment, Safety & Radiation Department at Alligator Energy will be responsible for issuing, approving, and maintaining all permits to ensure compliance with these requirements.

8.2 Audits, Reconciliation & Compliance Reporting

8.2.1 Audits & Reconciliation

All issued Landscape and Vegetation Clearance Permits will be reviewed biannually to:

- Confirm that native vegetation clearance has been conducted within the approved physical extents as approved by the Permit.
- Verify that total clearance remains within the geographic extents and total area approved by this plan.
- Ensure sufficient SEB credits or payments are held for all clearance activities.

This reconciliation process is essential to maintaining compliance with regulatory requirements and ensuring all clearance activities are accurately documented.

8.2.2 Compliance Reporting

Findings from the internal audits and assessments will be included in the annual compliance report for the RL. This report will demonstrate adherence to the approved management plan and the conditions of the *Native Vegetation Act*.

The annual report will include:

- Total area of native vegetation cleared during the reporting period (m²/ha).
- Maps showing actual clearance area compared to approved extents.
- Evidence of sufficient SEB credits held for all clearances conducted during the reporting period.
- Updated cumulative total of native vegetation cleared.
- Proposed vegetation clearance for the next reporting period (if applicable).
- Confirmation of SEB credits held for future clearances.

- Rehabilitation progress for previously cleared areas, including commencement or completion updates.

This report ensures transparency and accountability for native vegetation management under the RL.

9 SIGNIFICANT OPERATIONAL CHANGES

9.1 Changes to Clearance Extents and Amounts

If operational changes require clearance activities outside the approved extents, see Section 7.1 & Figure 7.1, or beyond the maximum allowable area (Table 7:1), the following steps must be taken:

- Submit a formal request to update this document, including justification for the changes.
- Obtain approval for the revised clearance plan as part of a PEPR (Program for Environment Protection and Rehabilitation) review in accordance with regulatory requirements.

No clearance activities may occur outside approved extents or amounts until the updated documentation has been reviewed and approved.

10 DEFINITIONS AND ABBREVIATIONS

%	Percent
<	Less than
AGE	Alligator Energy Limited
Alligator Energy	Alligator Energy Limited
BAM	Bushland Assessment Method
BCM	Bushland Condition Monitoring
BDBSA	Biological Databases of South Australia
BOM	Bureau of Meteorology
CEMP	Construction Environmental Management Plan
cm	Centimetres
DCCEEW	Dep. of Climate Change, Energy, the Environment and Water (Commonwealth)
DEM	Department for Energy and Mining
DEW	Department for Environment and Water
EBS	Environment and Biodiversity Services Pty Ltd – trading as EBS Ecology
EL	Exploration Lease
FRT	Field Recovery Trial
ha	hectare(s)
IBRA	Interim Bio-regionalisation of Australia
km	Kilometre(s)
LSA Act	Landscape South Australia Act 2019
m	Metre(s)
mm	Millimetre(s)
Native vegetation	A plant or plants of a species indigenous to South Australia (including dead trees >600 mm diameter, and planted vegetation protected under the *Native Vegetation Act 1991* such as Significant Environmental Benefit or Heritage Agreements)
NPW Act	National Parks and Wildlife Act 1972

NV Act	Native Vegetation Act 1991
NVC	Native Vegetation Council
NVMP	Native Vegetation Management Plan
oC	Degrees Celsius
OEMP	Operational Environmental Management Plan
PDI Act	Planning, Development and Infrastructure Act 2016
PEPR	Program for Environment Protection and Rehabilitation
PMST	Protected Matters Search Tool
Project Area	The area (or boundary) in which the Project will be located, as shown in mapping.
Project	The Samphire Uranium Project
RL	Retention Lease
SA	South Australia / South Australian
Search Area	A 5 km buffer of the Project Area used for database searches.
SEB	Significant Environmental Benefit
sp.	Species (singular)
spp.	Species (plural)
ssp.	Subspecies
TEC	Threatened Ecological Community
UBS	Unit biodiversity score
VA(s)	Vegetation Association(s)

11 REFERENCES

Andrew, M.H., & Lange, R.T. (1986). Development of a new biosphere in arid chenopod shrubland grazed by sheep – changes to the vegetation. *Australian Journal of Ecology, 11*, 411–424.

Department for Energy and Mining (DEM). (2020). *Terms of Reference – Uranium In-Situ Recovery PEPRs*. Adelaide, South Australia: Department for Energy and Mining.

Department for Energy and Mining (DEM). (2023). *Guidelines for Operational Changes and PEPR Reviews*. Adelaide, South Australia.

Department for Environment and Heritage (DEH). (2001). *Conservation of South Australian Flora and Fauna*. Adelaide, South Australia.

EBS Ecology. (2012). *Samphire Flora and Fauna Spring Report.* Report to Uranium SA. Adelaide, South Australia: EBS Ecology.

EBS Ecology. (2012). *Samphire Project Flora and Fauna Survey September 2011.* Report to Uranium SA. Adelaide, South Australia: EBS Ecology.

EBS Ecology. (2023). *Moonabie Samphire Uranium Project – Flora and Fauna Assessment.* Adelaide, South Australia: EBS Ecology.

Lange, R.T., Nicolson, A.D., & Nicolson, D.A. (1984). Vegetation management of chenopod rangelands in South Australia. *The Rangeland Journal, 6*(1), 46–54.

Landscape South Australia Act 2019. Government of South Australia. Provides for sustainable land and water management practices.

Mazourek, P. (2019). *Murninnie Graves Report.* Whyalla, South Australia: Whyalla City Council.

Mining Act 1971 & Regulations 2020. Government of South Australia.

National Parks and Wildlife Act 1972. Government of South Australia. Protects flora and fauna of conservation significance.

Native Vegetation Act 1991 and Native Vegetation Regulations 2017. Government of South Australia.

Native Vegetation (Credit for Environmental Benefits) Regulations 2015. Government of South Australia.

Native Vegetation Council. (2025). *Guide for a Significant Environmental Benefit for the Clearance of Native Vegetation Associated with the Minerals and Petroleum Industry.* Adelaide, South Australia: Native Vegetation Council.

Native Vegetation Council. (2017). *Guide to the Native Vegetation Regulations 2017.* Adelaide, South Australia: Native Vegetation Council.

Native Vegetation Council. (2024). *Bushland Assessment Manual.* Adelaide, South Australia: Native Vegetation Council.

Native Vegetation Council. (2020). *Guide for Applications to Clear Native Vegetation Under the Native Vegetation Act 1991 and Native Vegetation Regulations 2017.* Adelaide, South Australia: Native Vegetation Council.

Neagle, N. (2003). *The Environmental Assessment of Vegetation Communities in South Australia.* Adelaide, South Australia: Department for Environment and Heritage.

Planning, Development and Infrastructure Act 2016. Government of South Australia. Oversees planning and development approvals.

12 APPENDIX A: RANGELAND SCORESHEETS

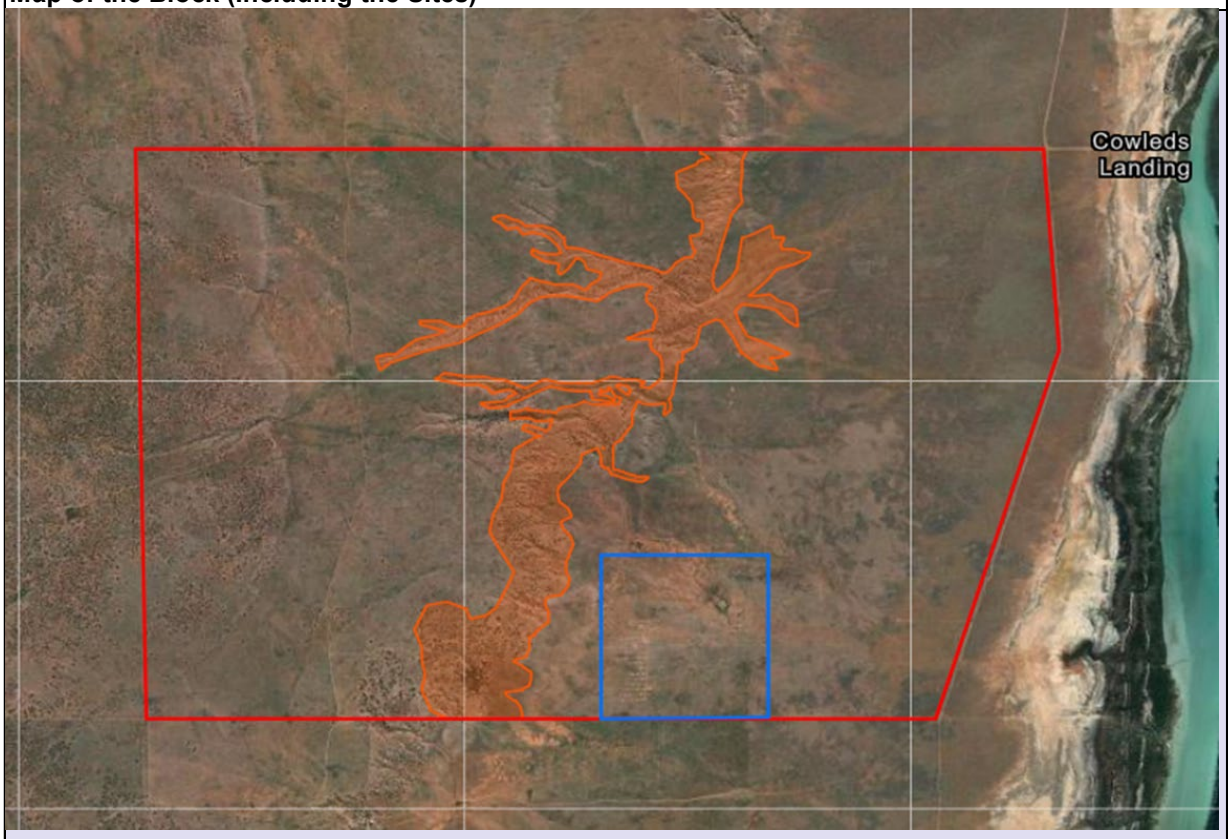
Bushland Assessment Scoresheet

(SEB Policy 1 Sept 2024; Scoresheet updated 1 July 2025)

Block	A: Moonabie, Coronation Dam Paddock
Size of Block (Ha)	4373.0
Landscapes Region	Eyre Peninsula
BCM Region	Eyre Peninsula
IBRA Association	Whyalla
IBRA Subregion	Myall Plains

ASSESSOR(S) (Insert Full Name/s)	J. Skewes
DATE OF ASSESSMENT	7/11/2023

Map of the Block (Including the Sites)



Landscape Context Scores

% native veg. remaining in IBRA Assoc.	95
% native veg. remaining in IBRA subregion	97
0 - 10% = 0.05 pts; >10-20% = 0.04 pts; >20-30% = 0.03 pts; >30-60% = 0.02 pts; > 60 = 0 pts — **Score**	0

Score received for both IBRA assoc. and subregion then summed

Percent Vegetation Cover (5km radius) (%)	99
0-5% = 0 pts; >5-10% = 0.02 pts; >10-25% = 0.04 pts; >25-50% = 0.06 pts; >50-75% = 0.03 pt; >75-100% = 0 pts — **Score**	0

% native veg. protected IBRA Assoc.	3
0-10% = 0.03 pts; >10-20% = 0.02 pts; >20-40% = 0.01 pt; >40% = 0 — **Score**	0.03

Block Shape Cleared perimeter:Area (km/km2)	
Cleared Perimeter (m) =	0
Cleared Perimeter to area ratio	0.00
<6 = 0.03 pts; 6 to <12 = 0.02 pts; 12 to <18 = 0.01 pt — **Score**	0.03

Wetland or Riparian Habitat present	
Riparian zone present (Yes/No) = 0.02 pt	No
Swamp/wetland present (Yes/No) = 0.03 pts	No
(Swamp/wetland may be +/- riparian zone) — **Score**	0

Note; Blocks will score a minimum Landscape Context Score of 1

LANDSCAPE CONTEXT SCORE (max 1.25)	**1.06**

Plant Species Recorded (Native and Introduced)		Listed Species			Natives only		
Species	Common Name	EPBC	SA	Not in quadrat	Regen	Annual Herbs Spring survey	Introduced Species
Maireana sedifolia	Bluebush						
Atriplex vesicaria	Bladder Saltbush				Yes		
Rytidosperma sp.	Wallaby-grass						
Sclerolaena obliquicuspis	Oblique-spined Bindyi						
Austrostipa nitida	Balcarra Spear-grass						
Lycium australe	Australian Boxthorn						
Maireana pyramidata	Black Bluebush						
Maireana georgei	Satiny Bluebush						
Vittadinia cuneata var.	Fuzzy New Holland Daisy					Yes	
Eriochiton sclerolaenoides	Woolly-fruit Bluebush					Yes	
Austrostipa platychaeta	Flat-awn Spear-grass						
Solanum quadriloculatum	Plains Nightshade						
Medicago minima	Little Medic						*
Carrichtera annua	Ward's Weed						*
Atriplex holocarpa	Pop Saltbush			Yes			
Tetragonia eremaea	Desert Spinach			Yes			
Rytidosperma sp.	Wallaby-grass			Yes			
Maireana trichoptera	Hairy-fruit Bluebush			Yes			
Minuria cunninghamii	Bush Minuria			Yes		Yes	

Threatened or Introduced Fauna Species Recorded or Observed (Native and Introduced)		Threatened Species				Introduced Species
Species	Common Name	EPBC	SA	Past Record	Observed	
Aphelocephala leucopsis leucopsis	Southern Whiteface	VU		Yes	Yes	
Amytornis textilis myall	Western Grasswren	VU	V	Yes	Yes	
Acanthiza iredalei	Slender-billed Thornbill		R		Yes	
Ardeotis australis	Australian Bustard		V		Yes	

SITE:	A2d
BCM COMMUNITY	EP 9.2 Chenopod Open Shrublands
VEGETATION ASSOCIATION DESCRIPTION	*Maireana sedifolia schrubland*
SIZE OF SITE (Ha)	14.758

Is the vegetation association considered a Threatened Ecological community or Ecosystem?	Yes/No
State (Provisional List of Threatened Ecosystems of SA) **Rare** community (0.1 pt)	☐
State (Provisional List of Threatened Ecosystems of SA) **Vulnerable** community (0.2 pts)	☐
State (Provisional List of Threatened Ecosystems of SA) **Endangered** community (0.3 pts)	☐
Nationally (EPBC Act) **Vulnerable** community (0.35 pts)	☐
Nationally (EPBC Act) **Endangered** or **Critically Endangered** community (0.4 pts)	☐
Note; all sites will score a minimum Conservation Significance Score of 1 **Threatened Community Score**	1

Benchmarked attributes
(Scores determined by comparing to a Benchmark community)

Number of Native Species (Minus herbaceous annuals for spring Surveys)	9
Native Plant Species Diversity Score (max 30) from benchmark score *weighted by a factor of 2*	16.0
Number of regenerating native species	1
Regeneration Score (max 12) from benchmark community weighted by a factor of 1.5	4.5

Weed species (Top 5 Cover x Invasiveness)	Cover (max 6)	Weed Threat Rating (max 5)	C x I
			0
			0
			0
			0
			0
	Cover x Threat		0
Weed Score (max 15) from benchmark community			15

Native Plant Life Forms	Cover rating
Trees > 15m	0
Trees 5 - 15 m	0
Trees < 5m	0
Mallee > 5m	0
Mallee < 5m	0
Shrubs > 2m	0
Shrubs 0.5 - 2m	3
Shrubs <0.5m	4
Forbs	1
Mat Plants	0
Grasses > 0.2m	1
Grasses < 0.2m	2
Sedges > 1m	0
Sedges < 1m	0
Hummock grasses	0
Vines, scramblers	0
Mistletoe	0
Ferns	0
Grass-tree	0
Total	11
Native Plant Life Forms (max 20) from benchmark score *weighted by a factor of 2*	16.0

Number of Threatened Flora Species recorded for the site (within the site)	Number
**If a species has both a State (NP&W Act) and National (EPBC Act) rating, it's only recorded for its National rating.*	
State **Rare** species recorded (1 pt each)	0
State **Vulnerable** species recorded (2.5 pt each)	0
State **Endangered** recorded (5 pts each)	0
Nationally **Vulnerable** species recorded (10 pts each)	0
Nationally **Endangered** or **Critically endangered** species recorded (20 pts each)	0
0 = 0 pts; <2 = 0.04 pts; 2 - <5 = 0.08 pts; 5 - <10 = 0.12 pts; 10 - <20 = 0.16 pts; 20 or > = 0.2 pts	0
Threatened Flora Score	0

Potential habitat for Threatened Fauna Species (number observed or previously recorded)	Number
**If a species has both a State (NP&W Act) and National (EPBC Act) rating, it's only recorded for its National rating.*	
State **Rare** species observed or locally recorded (1 pt each)	1
State **Vulnerable** species observed or locally recorded (2.5 pt each)	1
State **Endangered** species observed or locally recorded (5 pt each)	0
Nationally **Vulnerable** species observed or locally recorded (10 pts each)	2
Nationally **Endangered** or **Critically endangered** species observed or locally recorded (20 pts each)	0
0 = 0 pts; <2 = 0.02 pts; 2 - <5 = 0.04 pts; 5 - <10 = 0.06 pts; 10 - <20 = 0.08pts; 20 or > = 0.1 pts	23.5
Threatened Fauna Score	0.1
CONSERVATION SIGNIFICANCE SCORE	1.1

Non-Benchmarked Attributes
(Scores determined from direct field observations)

Native: exotic Understorey biomass Score (max 5)	5

Is the community naturally treeless?	☐
Tree attributes not scored for treeless	
communities or communities with only	
emergent trees	

Total Scores for the Site

	Score
LANDSCAPE CONTEXT SCORE	1.06
VEGETATION CONDITION SCORE	47.09
CONSERVATION SIGNIFICANCE SCORE	1.10

Vegetation Condition x Landscape Context x Conservation Significance =	
UNIT BIODIVERSITY SCORE	54.91
Total Biodiversity Score (Biodiversity Score x hectares)	810.36

Vegetation Condition Score calculation

Positive Vegetation Attributes Score = Native species diversity + Regeneration + Native Plant Life Forms Fallen timber/debris + Hollow-bearing trees	
- If the community Score is Not Benchmarked (SNB) for regeneration this score is multiplied 1.24	
- If the community is naturally treeless this score is multiplied by 1.29	47.09
Negative Vegetation Attributes Score = (15 - Weeds) + ((10 - (Biomass score x 2))exp2/2)	0.00
VEGETATION CONDITION SCORE (Positive veg attributes x ((80 - Negative vegetation attributes) / 80))	47.09

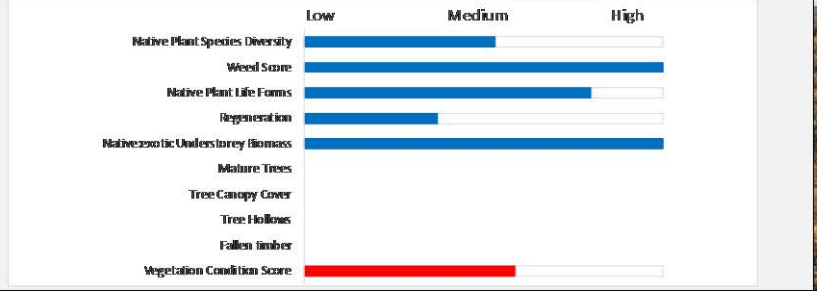


Photo Point and Vegetation Survey Location



Direction of the Photo	
East	
GPS Reference	
Datum	GDA20
Zone (52, 53 or 54)	53
Easting (6 digits)	722673
Northing (7 digits)	6323655
Description	
Livestock tracks, heavy grazing, dust impacts.	

SEB Offset Calculations (when a proposed clearance site is assessed)	
SEB Points required for offset	
Loss Factor	1.0
Loadings for clearance of protected areas	
Reductions for rehabilitation of impact site	0.3
SEB Uplift Factor	1.10
Total SEB Points Required	**623.98**

SEB - Payment in the Native Vegetation Fund	
SEB Points of Gain/ha Factor	7.0
Approximate SEB hectares required	89.14
Management Cost Factor ($/ha)	$25,408
Economies of Scale Factor	0.11
Mean annual rainfall for the site (mm)	255
Payment into the Fund (GST exclusive)	$63,529.58
Administration fee (GST inclusive)	$3,494.13
Total Payment Required	**$67,023.71**

13 APPENDIX B: RANGELAND REPORT

Appendix B has been provided as part of the main PEPR Appendices - as Appendix J7.

Appendix M: Radiation – Baseline Assessments

Appendix M1: Baseline Radiation Survey - Mullaquana Project. Report No. 10070, prepared by On Site Technology for UraniumSA Limited, February 2011.

On Site Technology Pty Ltd
ACN 079 329 025
PO Box 5143
ALBERTON
SA 5014

Telephone 08 8241 2078
Facsimile 08 8241 2079
Mobile 0417 846 826

Our Ref. 10070_Fr.doc/pjw

8th February 2011

Mr. Alistair Muir
General Manager
Uranium SA Ltd
32 Beulah Road
Norwood SA 5067

Report Number 10070

Your Order letter dated 21st May 2010

Report Title Baseline Radiation Survey Mullaquana Project

Report by John Waters

Authorized



DipAppSc(Chem), CChem, MRACI, MARPS

Contents

1	Introduction	3
2	Environmental Context	3
3	Radiological Context	3
4	Sensitive Receptors	4
5	Reference Sites	5
6	Water Analysis	5
	6.1 Ground Water	5
	6.2 Surface Water	6
7	Soil Analysis	6
8	Dust	7
9	Radon and Radon Daughters	8
10	Plant Analysis	8
11	Regulatory Context of Baseline Results	9
12	Discussion	11

Tables

1	Summary Ground Water Results	5
2	Summary of Soils Results	7
3	Radon Daughters at Other Locations	8
4	National Directory Exemption Levels	10
5	Drinking Water Guidelines	10

Appendices

1 Sample Locations
2 Water Analysis
3 Soil Analysis
4 Dust
5 Radon and Radon Daughters
6 Plant Analysis

1 Introduction

Uranium SA Ltd is currently developing a uranium prospect referred to as the "Mullaquana Project" approximately 25km south west of Whyalla in South Australia.

This report details the results of a baseline radiological investigation undertaken between September and December 2010.

The mineralization is located in an aquifer at a depth between 40 and 70m.

The proposed mining process is In Situ Recovery.

The purpose of this baseline investigation is to provide a set of data against which potential future radiological impacts can be measured.

Note that the investigation of the current radiological status of the marine environment is beyond the scope of the current investigation.

2 Environmental Context

The project is located on pastoral land primarily used for sheep grazing. The two properties involved are the Nonowie and Mullaquana stations.

The exploration area is located in a coastal plain with the sparsely inhabited cost of Spencer Gulf to the east and low hills (running in a north south direction) to the west.

There are a number of seasonal drainage creeks that run from the west to the east across the exploration area but, other than stock watering dams there are no permanent surface water features.

Three aquifers have been identified at the site, these have been designated as:

B	Quaternary Aquifer
A	Miocene Aquifer
C	Eocene Aquifer

The quaternary upper aquifer "B" is isolated. It has been assumed that the "A" and "C" aquifers are confined but interconnected. A detailed hydrological investigation of the area is being undertaken by another organisation and is the subject of a separate report. This report deals with the radionuclide content of groundwater samples collected by URS Australia Ltd in May 2010.

3 Radiological Context

The In Situ Recovery process being considered for development of the project is, compared to other mining techniques, a relatively low impact process. Because the uranium is mined in solution and the solution is returned to the mineralized zone after extraction there is little surface impact with respect to tailings and waste disposal.

The primary potential mechanisms for environmental contamination with radionuclides are:

1) Release of radon (and consequently radon daughters) into the atmosphere when the leachate is brought to the surface
2) Increased surface deposition or plant uptake of Pb^{210} (and Po^{210} by ingrowth) due to elevated radon and radon daughter levels in the local environment
3) Contamination of surface soil with spilt leach liquor
4) Contamination of surface water (dams or seasonal drainage channels) with redistributed contaminated surface soil
5) Increased dust levels due to site preparation or operational activities (for example earthworks, vehicular traffic etc)
6) Contamination of groundwater with radionuclides released by either a change in water chemistry or the fugitive release of leachate solution

The issue of occupational exposure to ionizing radiation is beyond the scope of this investigation and will be monitored and controlled by the project occupational health and safety procedures.

The establishment of typical baseline levels of radionuclides in the environment is an important part of the ongoing assessment of the projects environmental impact. Baseline radiological conditions must be established because the presence of low levels of radionuclides in the environment is ubiquitous. Exposure to background radiation is unavoidable irrespective of the development or avoidance of uranium prospects.

For the purposes of measuring possible future radiological impacts this investigation has identified a number of sensitive receptors and reference sites.

4 Sensitive Receptors

Sensitive receptors are chosen on the basis of members of the public (i.e. not workers involved in the project) that are the most likely to be exposed to elevated radiological impacts from the proposed development. The identification of a sensitive receptor does not imply or suggest that an impact will occur, it only identifies the person or persons that would be most impacted if any impact occurred.

In the context of the Mullaquana project three sensitive receptors have been identified, these are:

1) Occupants of the Mullaquana Homestead approximately 4km to the SW of the development area. At present there are two permanent residents at this location, however, this may increase on a seasonal basis to provide a workforce for various activities undertaken on the property.

2) Occupants of the Nonowie Homestead approximately 8km NNW of the development area. At present there are between 7 and 10 occupants of the site, the majority of these are employees of Uranium SA Ltd.

3) Cowleds Landing, on the coast approximately 6km to the NE of the development area. This site consists of a number of approximately a dozen shacks. There appears to be no permanent residents and the shacks appear to be used as holiday accommodation.

5 Reference Sites

Three reference sites have been identified for baseline and ongoing monitoring. These were selected, as far as practical, to represent a similar geological, meteorological and land use setting as the proposed development site.

The selected reference sites are located between the coast and the low hills on the same sheep grazing properties as the proposed development. They have similar drainage patterns to the proposed development site and also have a stock watering dam.

In addition to the reference sites three dams were included for monitoring. The monitoring sites include:

1) The Northern Reference Site approximately 12km north of the development area.
2) The Central Reference Site approximately 6km north of the development area. The dam at this site has been damaged and does not hold any water.
3) The Southern Reference Site approximately 4km south of the development area
4) The "Road Dam" approximately 4km north west of the development area
5) The dams at the Mullaquana and Nonowie homesteads
6) The "Operational Dam" located in the development area

It is proposed that any future measured elevation of environmental radionuclides in the development area would be compared with levels at the reference sites to confirm if the measured impact is local (due to operational activity) or regional (due to natural variation).

The location of the proposed development and details of sensitive receptor and reference sites are provided in Appendix 1.

6 Water Analysis

Detailed results of the water analysis is provided in Appendix 2.

6.1 Ground Water

Th^{230}, Pb^{210}, Po^{210} and Th^{232} in groundwater samples are low and results do not provide sufficient numerical data to undertake a statistical analysis. Sample "MHR 1C" does have detectable levels of Th^{230}, Pb^{210} and Po^{210}, however in the context of the Ra^{226} result these are not radiologically significant.

The U^{238} and Ra^{226} results are highly variable both within and between aquifers. A summary of the results for each aquifer is provided in Table 1.

Aquifer	U^{238} Bq/l		Ra^{226} Bq/l	
	Average	Std Dev	Average	Std Dev
A	1.17	1.02	5.2	8.8
B	0.05	0.03	2.2	2.0
C	0.66	0.81	304	404

Table 1 Summary Ground Water Results

The spread of results is such that it may be difficult (on the available data) to identify future changes due to mining activities. It is recommended that an investigation be undertaken to identify the temporal and special variability of dissolved uranium and Ra^{226} in the three aquifers. The regular analysis of other radionuclides is not warranted at this time, however, periodic check should be undertaken once pilot trials commence.

6.2 Surface Water

Other than the stock watering dams there are no permanent surface water features (creeks, rivers or dams) in the investigation area. Opportunistic sampling of creeks and pools during rain events was not considered necessary because the dams provide a valid surface water sample and represent water collected from a wide area around the dam.

The dam water results collected to date (and presented in Appendix 2) provide a sufficient baseline against which to assess future operational impacts. Low levels of Ra^{226} and Pb^{210} were detected in the samples.

It is suggested that periodic sampling be undertaken with analysis for U^{238}, Ra^{226} and Pb^{210} being conducted to further define the special and temporal variation in these samples. Ongoing analysis is suggested because of the significant water level changes in the dams as they periodically dry out and are refilled by rain events.

7 Soil Analysis

Detailed results of soil analysis are provided in Appendix 3.

A summary of the results is provided in Table 2.

A number of general comments can be made concerning the soils results:

1) There is no statistically significant difference between sample location or sample type except that Pb^{210} is elevated in the surface and sediment samples compared to the 5-15cm soil samples. This is not unexpected because the natural elevation of Pb^{210} in undisturbed surface soil and sediments due to atmospheric Pb^{210} deposition is well documented.

2) Except as noted above the samples are in approximate secular equilibrium with respect to the uranium and thorium decay chains.

It is considered that the soil data collected to date is sufficient to provide the baseline radiological data required for this investigation.

Possible future operational impacts can be assessed by use of the current data and the re-sampling of the reference and operational sites during and after the proposed pilot plant.

Parameter	Th^{232}	Ra^{228}	Th^{228}	U^{238}	Ra^{226}	Pb^{210}
	Bq/g	Bq/g	Bq/g	Bq/g	Bq/g	Bq/g
Soil						
Average	0.046	0.067	0.064	0.023	0.023	0.039
Std Dev	0.012	0.015	0.018	0.006	0.013	0.023
Surface Soil						
Average	0.050	0.068	0.053	0.021	0.030	0.077
Std Dev	0.010	0.013	0.015	0.006	0.008	0.059
Dam Sediment						
Average	0.047	0.044	0.052	0.025	0.025	0.071
Std Dev	0.014	0.015	0.018	0.008	0.013	0.034
All Sample						
Average	0.047	0.059	0.056	0.023	0.026	0.062
Std Dev	0.011	0.018	0.016	0.006	0.011	0.042

Table 2 Summary of Soils Results

8 Dust

Detailed results of dust analysis are provided in Appendix 4.

In summary the Total Suspended Particulate (TSP) monitoring undertaken at Mullaquana Homestead confirm that ambient dust levels are low (average 0.016 mg/m^3, standard deviation 0.007 mg/m^3) and that the long lived alpha activity is consistent similarly low (average 0.029 mBq/m^3, standard deviation 0.013 mBq/m^3).

The natural radioactivity in the local dust contributes between 5% and 50% of the long lived alpha activity with the remainder coming from atmospheric Po^{210} derived from natural atmospheric radon daughter product.

PM_{10} particulate matter is similarly low (at both the Nonowie and Mullaquana homesteads) with typical levels between 0 and 0.004 mg/m^3.

Peaks of up to 0.2 mg/m^3 associated with local vehicular traffic have been identified. These peaks are characterized by their short duration, generally one to five minutes. These peaks are of such a short duration that they have no real impact on average 24 hour PM_{10} levels which range from 0.001 to 0.003 mg/m^3.

It is recommended that high volume (TSP) sampling be continued at Mullaquana Homestead and that a monitor be deployed at the proposed development site as soon as 240 volt power is available.

Continued monitoring of PM_{10} is recommended using a single instrument that can be deployed at rotating locations around the investigation area. The continued use of two monitors is not considered necessary.

9 Radon and Radon Daughters

Complete results for radon and radon daughter monitoring are provided in Appendix 5.

Radon levels at the Nonowie homestead vary from 10 to 30 Bq/m^3 with occasional elevated levels up to 45 Bq/m^3. Variation in the radon concentration at Nonowie shows a diurnal variation that is typical of ambient atmospheric radon.

Grab samples taken at other locations are consistent with those measured at Nonowie showing little statistically significant variation (average 16 Bq/m^3, standard deviation 4 Bq/m^3) except that the Cowleds Landing (average 8 Bq/m^3, standard deviation 4 Bq/m^3) results are statistically lower than the other sites. This is consistent with the coastal location of Cowleds Landing.

Radon daughter levels show a similar trend in that the Cowleds Landing values (average 10 nJ/m3, standard deviation 3 nJ/m3) are statistically lower than the other sites (average 17 nJ/m3, standard deviation 6 nJ/m3).

As shown in Table 3 radon daughter levels are similar to those reported for other South Australian arid inland locations.

Location	Radon Daughters nJ/m^3 PAEC			
	Minimum	Maximum	Average	Std Dev
Cowled Landing	6	14	10	3
Mullaquana Area	8	27	17	6
Olympic Dam	10	40		
Honeymoon	17	22	19	2
Woomera	37	60	50	8
Edinburgh	1	8	4	2

Table 3 Radon Daughters at Other Locations

At this stage there has not been sufficient data collected to quantify seasonal variations in radon or radon daughter concentrations, however, ongoing monitoring will provide this data as the project progresses.

Continued monitoring for radon and radon daughters is recommended to collect additional special and temporal data.

10 Plant Analysis

Complete results for the analysis of plant samples are provided in Appendix 6.

Blue Bush, tentatively identified as *Maireana Sedifolia*, was sampled form the three reference sites and the proposed development area in September 2010. Fleshy recent growth and woody old growth sub samples were analysed for radionuclides.

Th^{232} and Pb^{210} were consistently detected above the analytical detection limit. Other nuclides were generally at or below the detection limit.

The woody sample from the proposed development area (operations area) had a significantly elevated Th^{232} content. It is of note that the soil Th^{232} at the operational site is elevated (average 0.056 Bq/g, standard deviation 0.007 Bq/g) compared to the other sites (average 0.045 Bq/g, standard deviation 0.011 Bq/g). However, this is not sufficient to account for the 6 fold difference in the plant samples (woody plant from the operational area 0.06 Bq/g ash, all other plant samples average 0.011 Bq/g ash, standard deviation 0.002 Bq/g ash)

The operational site will be re-sampled to establish if the September sample is an anomaly or there is a real elevation of Th^{232} in the area.

11 Regulatory Context of Baseline Results

In South Australia, the regulation of radioactivity is implemented through the Radiation "Protection and Control Act (1982)" and the associated regulations Radiation Protection and Control (Ionising Radiation) Regulations (2000)".

The South Australian regulations are primarily aimed at occupational exposure and specify an exemption level in terms of activity (35kBq/kg) for the sum of individual isotopes and a mass concentration (0.02% uranium and 0.05% thorium) for minerals and ores.

In the exploration phase the regulations are most likely applicable to mineral samples and recovered core. However, non of the environmental samples collected during the baseline study exceed the regulatory exemption limit.

There is little applicability of the regulations to environmental assessment which is usually done on a case by case basis taking into account the typical environmental values (baseline values) for the area. The intended use of the data provided in this report is to establish those baseline values for the Mullaquana area.

Nationally, the radiological protection framework is described in the "National Directory for Radiation Protection" published by ARPANSA. This document provides exemption levels for individual isotopes. For samples with radionuclide concentrations below these exemption levels it is considered that:

a) the health risks associated with the source, practice, or type of person using a source are sufficiently low as to be of no regulatory concern; and
b) radiation protection, including the cost of regulatory control, has been optimised.

As with the South Australian regulations, the National Directory is not aimed at providing a level of environmental protection, it is targeted at protection of humans from the effects of exposure to ionising radiation, particularly occupational exposure.

The exemption limits for radionuclides of relevance to Mullaquana project are provided in Table 4. These exemption levels are lower than the corresponding South Australian level, however, it is still true that none of the samples collected in this study are above the exemption level.

Isotope	National Directory Exemption Level (Bq/g)
U^{238}	10
Th^{232}	1
Th^{230}	1
Ra^{226}	10
Ra^{228}	10
Pb^{210}	10
Po^{210}	10

Table 4 National Directory Exemption Levels

Assessment for the environmental impact of radionuclides at background levels is typically done on a case by case basis using typical regional, national or local background levels. As discussed elsewhere in this report the radionuclide levels found in samples collected from the study area are considered typical for the environmental setting.

With respect to radon and radon daughters in air the values reported in this study are considered lower than average values reported for inland Australia and average world levels. This is considered to be due to the coastal setting of the area. To put the reported radon levels in context, the intervention limit[1)] for Radon in dwelling is 200Bq/m^3, an order of magnitude higher than the ambient levels found in this study.

The criteria generally applied to water samples is the Australian drinking water guidelines[2)] however, in the case of groundwater, these must be interpreted in the context of the suitability of the water for beneficial use. In the case of groundwater at the Mullaquana site, the water is generally not suitable for beneficial use because of the salinity. In this case, the radionuclide content (and any impact from uranium mining) must be assessed in the context of natural regional and temporal variation. The drinking water guideline limits are provided in Table 5.

Radionuclide	Guideline Limit (Bq/l)
Uranium	0.02 mg/l (0.24 Bq/l U^{238})
Gross Alpha Activity	0.5
Gross Beta Activity	0.5
Ra^{226}, Ra^{228}	0.5

Table 5 Drinking Water Guidelines

All of the surface water samples comply with the drinking water guidelines. The majority of the groundwater samples do not comply with the drinking water guidelines, generally with respect to uranium and Ra^{226}.

1) National standard for limiting occupational exposure to ionizing radiation
Appendix C
[NOHSC:1013(1995)]

2) AUSTRALIAN DRINKING WATER GUIDELINES 6
2004
Endorsed by NHMRC 10 – 11 April 2003

12 Discussion

The data provided in this report provides sufficient detail to establish a radiological baseline against which to measure potential future impacts of the Mullaquana uranium project.

Sensitive receptors have been identified and monitored and data has been collected from three reference sites.

The requirement for ongoing or confirmatory monitoring has been identified in the following areas:

1) On going Total Suspended Particulate Monitoring (TSP) using a high volume sampler should continue at Mullaquana homestead as this is the closest sensitive receptor to the proposed development area.

2) Establishment of a TSP monitoring site within the proposed development area once 240 volt power is available.

3) Continued PM_{10} monitoring using a single unit to be rotated through the various monitoring locations.

4) Continued continuous radon monitoring. The radon monitor will be moved to the Mullaquana homestead in January 2011.

5) Continued grab samples for radon and radon daughters at all monitoring locations. Continuous track etch monitors for radon will be deployed to provide average levels of radon over quarterly intervals.

6) Re-sampling of plant material at the proposed development site to confirm the elevated Th^{232} in the September sample.

7) Establishment of a regular groundwater U^{238} and Ra^{226} monitoring program to further define the temporal and spatial variation of these parameters.

8) Continued monitoring of dam water samples for U^{238}, Ra^{226} and Pb^{210}.

ON SITE TECHNOLOGY

Radiation Baseline Study

Uranium SA Ltd

Mullaquana Project

Report 10070

Appendix 1

Sample Locations

The context of the investigation area is provided in Figures 1 and 2

Groundwater sample locations are shown in Figure 3.

Details for the Mullaquana and Nonowie homesteads are provided in Figures 4 and 5.



Figure 1 Investigation Area Location

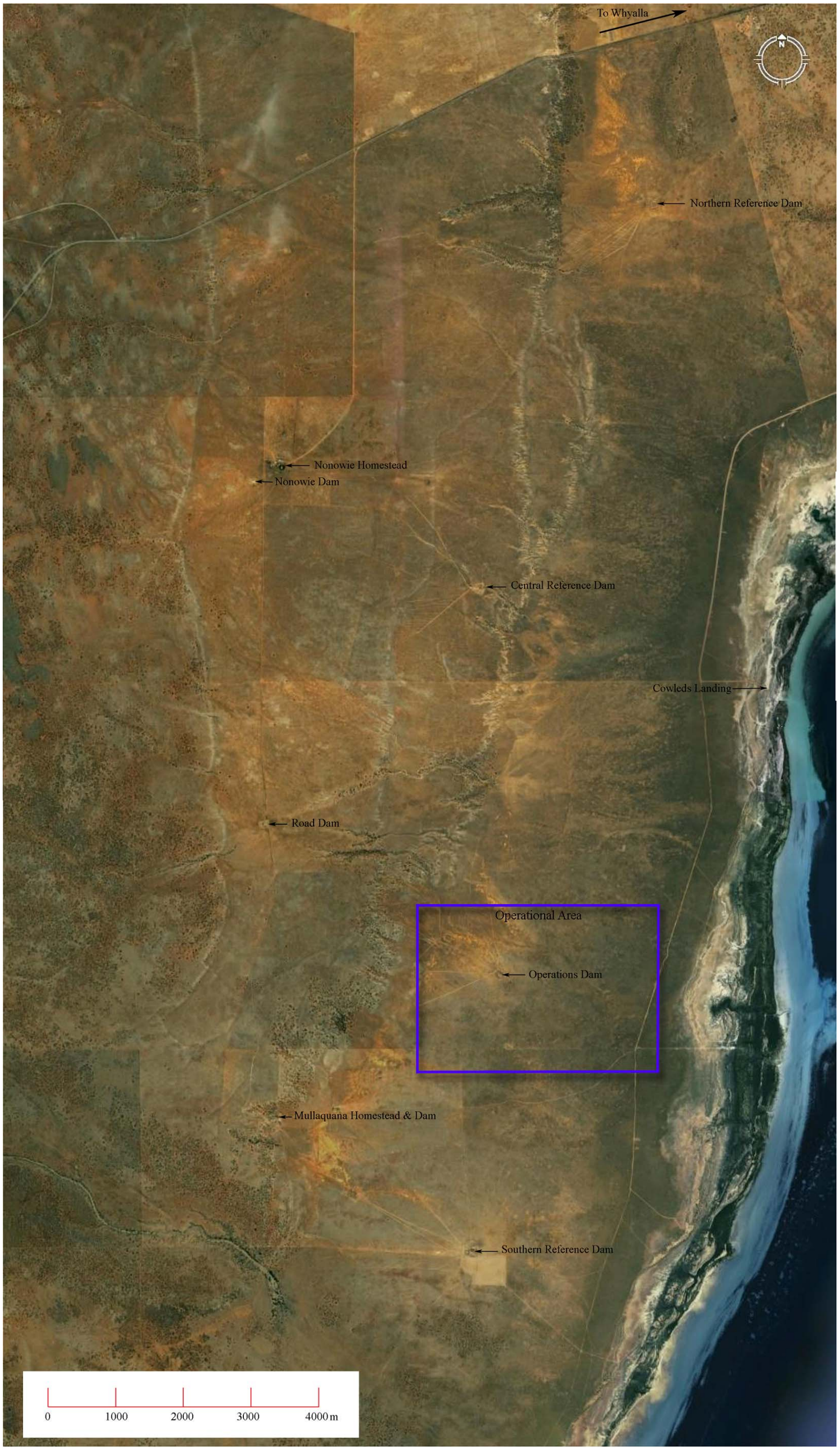


Figure 2 Investigation Area

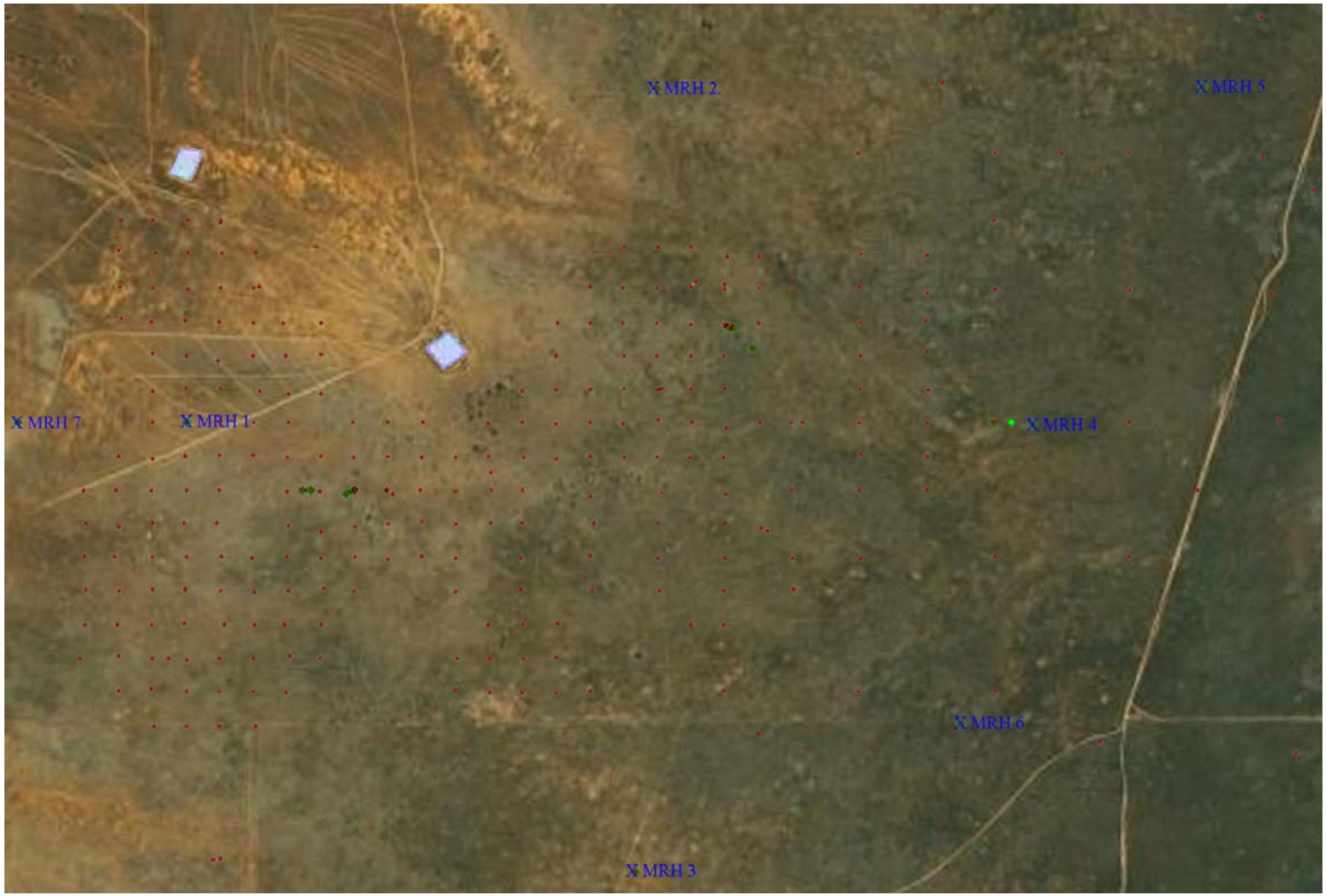


Figure 3 Ground Water Sample Locations

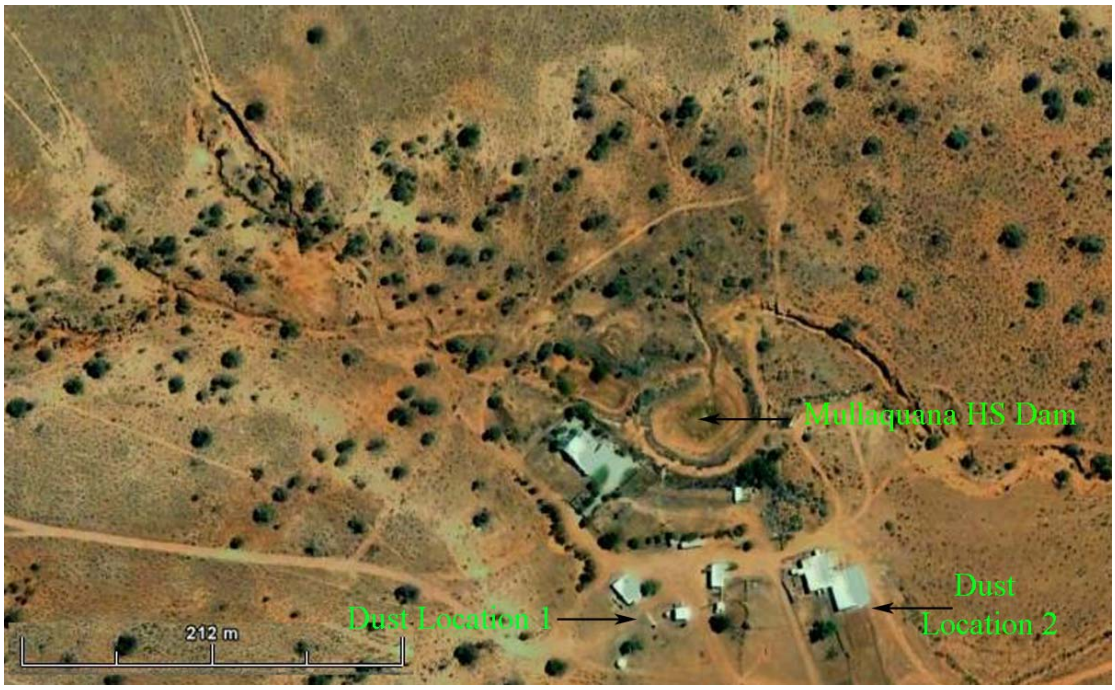


Figure 4 Mullaquana Homestead

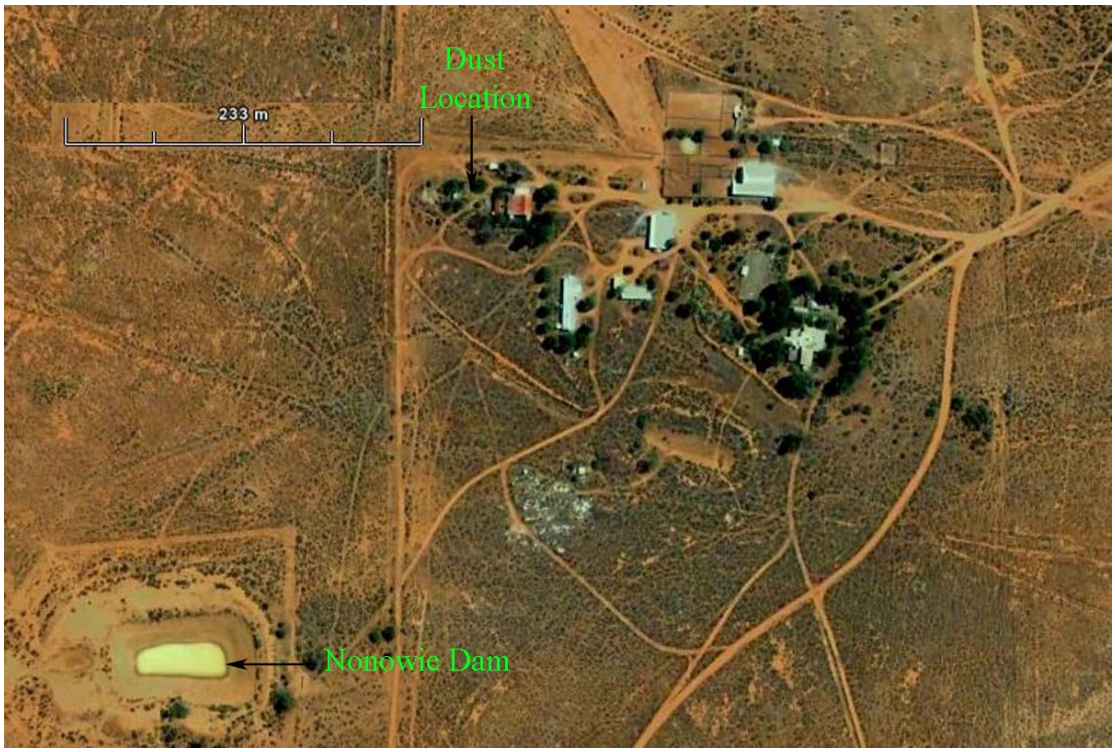


Figure 5 Nonowie Homestead

ON SITE TECHNOLOGY

Radiation Baseline Study

Uranium SA Ltd

Mullaquana Project

Report 10070

Appendix 2

Water Analysis

Groundwater Samples

Sixteen groundwater samples were received for URS Australia Pty Ltd. The sample details are provided in Table 1.

URS Project	Sample ID	Sample Date
42637428	MRH 1A	24/5/2010
42637428	MRH 2A	23/5/2010
42637428	MRH 3A	21/5/2010
42637428	MRH 4A	22/5/2010
42637428	MRH 5A	23/5/2010
42637428	MRH 6A	22/5/2010
42637428	MRH 7A	24/5/2010
42637428	MRH 3B	21/5/2010
42637428	MRH 4B	22/5/2010
42637428	MRH 5B	23/5/2010
42637428	MRH 6B	21/5/2010
42637428	MRH 1C	24/5/2010
42637428	MRH 4C	22/5/2010
42637428	Tap Water	24/5/2010
42637428	QC-1	23/5/2010
42637428	QC-2	23/5/2010

Table 1 Ground Water Sample Information

Detailed sample locations are provided in Appendix 1

Samples were received as collected without filtration or preservation by On Site Technology Pty Ltd on 26th May 2010. Samples were filtered through 0.45 µm membrane filters and acidified to pH less than 2 with nitric acid within 24 hours of receipt. The sample containers were leached for 24 hours at room temperature with AR grade concentrated hydrochloric acid. The containers were agitated to ensure all of the internal surface came into regular contact with the acid. The container leachate was added to the filtered sample. When analysis was undertaken an adjustment in the sample volume was made to account for the increase in volume due to the container leachate addition.

Sample aliquots were submitted to Amdel Ltd for the determination of uranium and thorium by inductively coupled plasma mass spectrometry. These results were compared to those determined by ALS Environmental Pty Ltd on separate samples filtered and preserved in the field by URS Australia Ltd. This comparison provides confidence that the laboratory filtering and container leaching procedure adequately recovers dissolved metals. Comparative results are provided in Table 2 and Figure 1.

Sample	ALS	Amdel
Filtered and Preserved	in field	in lab
	µg/l	µg/l
MRH 1A	229	225
MRH 1C	84.2	100
MRH 2A	37.7	36
MRH 3A	59.3	60
MRH 3B	5.2	6.5
MRH 4A	54.2	55
MRH 4B	2.1	2.1
MRH 4C	6.6	7.0
MRH 5A	24	25.5
MRH 5B	1.8	2.0
MRH 6A	55.4	60
MRH 6B	4.3	4.5
MRH 7A	174	205

Table 2 “In Field” vs “In Lab” Preservation

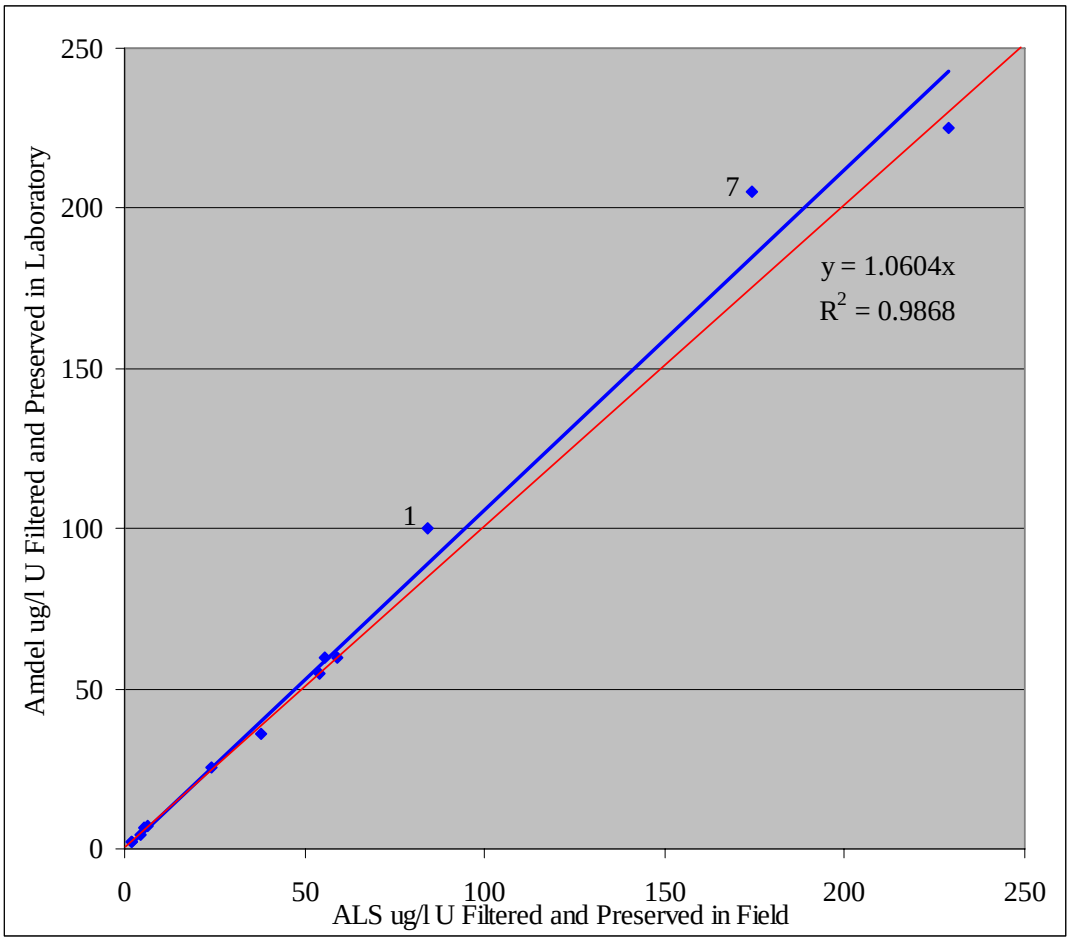


Figure 1 “In Lab” vs “In Field” Preservation

Surface Water Samples

Surface water sample were collected from numerous dams by On Site Technology Pty Ltd on 2nd September and 12th November 2010. Details are provided in Table 3.

Unfiltered samples were acidified to 1M hydrochloric acid and heated to 90°C to facilitate digestion of nuclides absorbed onto colloidal material. The samples were then filtered prior to analysis. When analysis was undertaken an adjustment in the sample volume was made to account for the increase in volume due to acid addition.

Sample aliquots were submitted to Amdel Ltd for the determination of uranium and thorium by inductively coupled plasma mass spectrometry

Radiochemical Analysis

Radionuclide determination was undertaken by On Site Technology Pty Ltd using the following procedures:

Pb^{210}, Bi^{210} and Po^{210} were extracted into 1% Diethyl ammonium diethyldithiocarbamate in chloroform from a sample aliquot acidified with hydrochloric acid. Po^{210} was autodeposited onto silver and determined by alpha spectrometry using Po^{208} as an internal standard. Po^{210} results have been corrected to sampling time for ingrowth from Pb^{210} where appropriate. Pb^{210} was determined by gross beta counting after precipitation of lead and bismuth as the chromate.

Ra^{226} was determined by gross alpha counting of a sulphate precipitate obtained from the aqueous phase of the lead, bismuth polonium extraction. Radium was initially co-precipitated with lead followed by clean up with EDTA and final co-precipitation with barium carrier. Counting was undertaken after ingrowth of radon and radon daughters.

Th^{230} was determined by alpha spectrometry after extraction with Thenoyltrifluoroacetone in Xylene. Th^{228} derived from a certified U^{232} solution was used as an internal standard.

U^{238} and Th^{232} values were calculated from the ICP-MS uranium and thorium results.

Quality control was maintained by the analysis of a sample digest of certified reference material NBL-6A supplied by the US Department of Energy New Brunswick Laboratory. Traceability is provided through this certified reference material.

Results for radiochemical analysis are provided in Table 3 (Ground Water) and Table 4 (Surface Water).

Sample	U^{238}	Th^{230}	Ra^{226}	Pb^{210}	Po^{210}	Th^{232}
	Bq/l	Bq/l	Bq/l	Bq/l	Bq/l	Bq/l
MRH 1A	2.77	<0.03	5.60	0.06	<0.03	0.002
MRH 2A	0.44	<0.03	24.8	0.37	<0.03	0.001
MRH 3A	0.74	<0.03	0.76	0.07	<0.03	0.001
MRH 4A	0.68	<0.03	1.01	0.04	<0.03	<0.001
MRH 5A	0.31	0.03	1.27	0.11	<0.03	<0.001
MRH 6A	0.74	<0.03	1.09	<0.05	<0.03	<0.001
MRH 7A	2.53	<0.03	1.58	<0.05	<0.03	<0.001
MRH 3B	0.080	<0.03	4.93	<0.05	<0.03	<0.001
MRH 4B	0.026	<0.03	1.55	0.06	<0.03	<0.001
MRH 5B	0.025	<0.03	0.22	<0.05	<0.03	<0.001
MRH 6B	0.055	<0.03	2.10	<0.05	<0.03	<0.001
MRH 1C	1.23	0.10	590	7.65	1.0	0.001
MRH 4C	0.086	<0.03	18.1	0.32	<0.03	<0.001
MRH 4C Duplicate	0.086	<0.03	19.4	0.18	<0.03	<0.001
QC1	0.34	<0.03	1.25	0.10	<0.03	<0.001
QC2	0.33	<0.03	1.16	0.06	<0.03	<0.001
Tap Water	0.02	<0.03	0.03	<0.05	<0.03	<0.001
Detection Limit	0.001	0.03	0.01	0.05	0.03	0.05

Table 3 Radionuclide Analysis of Ground Water

Sample	Date	U^{238}	Th^{230}	Ra^{226}	Pb^{210}	Po^{210}	Th^{232}
		Bq/l	Bq/l	Bq/l	Bq/l	Bq/l	Bq/l
Mullaquana Dam	12/11/10	<0.0001	<0.03	0.07	0.03	<0.03	<0.0001
Nonowie Dam	12/11/10	<0.0001	<0.03	0.05	0.04	<0.03	<0.0001
North Dam	2/09/10	<0.0001	<0.03	0.17	0.09	<0.03	<0.0001
North Dam	12/11/10	<0.0001	<0.03	0.04	0.04	<0.03	<0.0001
Operations Dam	2/09/10	<0.0001	<0.03	0.04	0.04	<0.03	<0.0001
Operations Dam	12/11/10	<0.0001	<0.03	0.02	0.06	<0.03	<0.0001
South Dam	2/09/10	<0.0001	0.03	0.15	0.06	0.03	<0.0001
Road Dam	12/11/10	<0.0001	<0.03	.0.08	0.03	<0.03	<0.0001
Blank		<0.0001	<0.03	0.03	<0.05	<0.03	<0.0001
Detection Limit		0.0001	0.03	0.01	0.05	0.03	0.0001

Table 4 Radionuclide Analysis of Surface Water

ON SITE TECHNOLOGY

Radiation Baseline Study

Uranium SA Ltd

Mullaquana Project

Report 10070

Appendix 3

Soil Analysis

Samples

Samples were collected from four locations by On Site Technology Pty Ltd on 2nd September 2010. At each location a surface sample (0-2cm) a sub surface sample (5-15cm) and a dried dam sediment sample was collected. Plant matter was excluded from the surface soil samples.

Sample locations were selected to provide reference sites that are unlikely to be impacted by operational activities (North, Central and South Dams) and the operational area (operations dam).
Sample details are provided in Table 1 and typical surface and dam sediment sample locations are shown in Figures 1 and 2.

Sample ID	Location	E	N	Description	Note	Th	U
		53H	53H			mg/kg	mg/kg
10019-001	South Dam	723264	6320767	Soil	5-15cm	8.0	1.2
10019-002	South Dam	723264	6320767	Surface	0-1cm	9.9	1.4
10019-003	South Dam	723264	6320767	Dam Sediment	0-1cm	7.3	1.2
10019-007	Operation	723534	6324743	Soil	5-15cm	14	2.0
10019-008	Operation	723534	6324743	Surface	0-1cm	15	2.3
10019-009	Operation	723534	6324743	Dam Sediment	0-1cm	12	1.9
10019-004	Central Dam	723349	6330407	Soil	5-15cm	9.5	2.3
10019-005	Central Dam	723349	6330407	Surface	0-1cm	10	1.6
10019-006	Central Dam	723349	6330407	Dam Sediment	0-1cm	11	2.1
10019-010	North Dam	726066	6335896	Soil	5-15cm	13	1.9
10019-011	North Dam	726066	6335896	Surface	0-1cm	13	1.4
10019-012	North Dam	726066	6335896	Dam Sediment	0-1cm	16	2.8

Table 1 Sample Information, Thorium and Uranium Results



Figure 1 Typical Surface Soil



Figure 2 Typical Dam Sediment

Analysis

Samples were submitted to Genalysis Laboratory Services Pty Ltd for drying, pulverizing and determination of uranium and thorium by inductively coupled plasma mass spectrometry (ICP-MS) following total digestion of the sample.

Prepared samples were returned to On Site Technology Pty Ltd for determination of Th^{228}, Ra^{226}, Ra^{228} and Pb^{210} by gamma spectrometry.

Calibration and traceability was provided by the analysis of the following certified reference materials:

U^{238} and Th^{232} were calculated from the ICP-MS uranium and thorium results.

Results are provided in Table 2.

Sample ID	Th^{232}	Ra^{228}	Th^{228}	U^{238}	Ra^{226}	Pb^{210}
	Bq/g	Bq/g	Bq/g	Bq/g	Bq/g	Bq/g
10019-001	0.033	0.045	0.040	0.015	0.008	0.044
10019-002	0.041	0.061	0.054	0.017	0.024	0.005
10019-003	0.030	0.022	0.026	0.015	0.009	0.025
10019-007	0.056	0.072	0.082	0.024	0.024	0.068
10019-008	0.062	0.086	0.067	0.029	0.028	0.117
10019-009	0.049	0.052	0.055	0.024	0.028	0.065
10019-004	0.039	0.068	0.062	0.029	0.022	0.017
10019-005	0.043	0.069	0.033	0.020	0.041	0.133
10019-006	0.044	0.046	0.067	0.025	0.022	0.097
10019-010	0.054	0.081	0.072	0.024	0.039	0.025
10019-011	0.055	0.056	0.057	0.017	0.026	0.052
10019-012	0.064	0.055	0.060	0.034	0.039	0.098

Table 2 Radionuclide Results for Soil Samples

ON SITE TECHNOLOGY

Radiation Baseline Study

Uranium SA Ltd

Mullaquana Project

Report 10070

Appendix 4

Dust

Samples

Dust sampling locations have been established at two of the identified sensitive receptors, these being;

Nonowie Homestead

TSI Dustrack II recording PM_{10} at one minute intervals

Mullaquana Homestead

TSI Dustrack II recording PM_{10} at one minute intervals

High Volume air sampler collecting Total Suspended Particulate (TSP) over 1 to 2 week intervals

Data was collected at Nonowie between 11/11/10 and 26/11/10. Data was not collected between 26/11/10 and 23/12/10 because the power to the equipment was switched off at 12:48 on 26/11/10.

Data has been collected at Mullaquana between 12/11/10 and 23/12/10 except for the period 7/12/10 to 13/12/10 which was impacted by a prolonged power failure.

High volume samples were analysed for gross alpha activity, gross beta activity and sample weight by On Site Technology Pty Ltd. Samples have been retained for future analysis if required.

Results

Table 1 provides results for high volume filter analysis including alpha activity expressed as mBq/m^3 and Bq/g of collected dust.

Filter	Sample Start		Sample Stop		Dust	Alpha	Beta	Alpha
Number	Date	Time	Date	Time	mg/m^3	mBq/m^3	mBq/m^3	Bq/g
37 [1)]	12/11/10	10:30	23/11/10	11:00	0.015	0.016	0.229	1.03
37 [2)]						0.015	0.221	0.97
37 [3)]						0.013	0.135	0.86
39	25/11/10	11:26	02/12/10	15:03	0.012	0.027	0.150	2.25
41	02/12/10	15:10	07/12/10	18:00	0.012	0.027	0.153	2.13
43	13/12/10	10:44	23/12/10	12:07	0.024	0.048	0.392	2.00
	Soil							0.47
	95% CI							0.03
	Average				0.016	0.029	0.231	1.85
	Std Dev				0.007	0.013	0.113	0.56

Table 1 High Volume Sample Results

Note that for filter number 37 three counts were undertaken to provide an estimate of error in alpha concentration determination. Counts 1 and 2 were undertaken 15 days after sampling and are effectively duplicate counts, count 3 was undertaken 42 days after sampling.

The results for filter 37 demonstrate that:

1) The determination of alpha activity is reproducible and independent of counting delay.

2) The determination of beta activity is dependent on count delay. The reason for this is discussed below.

Gross alpha activity in the high volume samples is derived from two sources.

1) Natural activity originating from the uranium and thorium decay chains in the local soil making up the dust.

2) Naturally elevated atmospheric Po^{210} originating from the decay of Rn^{222} in the atmosphere. It is of note that alpha emitting decay products from atmospheric Rn^{220} and Rn^{219} are not determined because the sample are counted 5 days or more after sampling. This delay allows for the complete decay of Rn^{220} and Rn^{219} daughter products.

The gross alpha activity (in Bq/g) reported in Table 1 is elevated compared to the typical soil activity for the area (derived from data in Appendix 3) and indicates that the contribution from atmospheric Po^{210} is between 55% and 80% of the measured activity.

This calculation provides an estimate for atmospheric Po^{210} in the range 0.01 to 0.04 mBq/m^3 which is somewhat lower than the world average of 0.05 mBq/m^3 used in the Report of the United Nations Scientific Committee on the Effects of Atomic Radiation. Annex B Exposure from Natural Radiation Sources (UNSCEAR).

.

The gross beta activity in the high volume samples is derived from four sources:

1) Natural activity originating from the uranium and thorium decay chains in the local soil making up the dust.

2) Naturally elevated atmospheric Pb^{210} originating from the decay of Rn^{222} in the atmosphere. It is of note that beta emitting decay products from atmospheric Rn^{220} and Rn^{219} are not determined because the sample are counted 5 days or more after sampling. This delay allows for the complete decay of Rn^{220} and Rn^{219} daughter products.

3) Naturally occurring K^{40} in the soil making up the dust

4) Naturally occurring cosmogenic beta emitters present in the atmosphere. These are predominantly long lived Be^{10} and short lived (14 to 90 day half life) Be^{7}, P^{32}, P^{35} and S^{35}.

UNSCEAR reports typical average atmospheric concentration of Pb^{210} of 0.5 mBq/m^3 and cosmogenic nuclide activity of 0.73 mBq/m^3 (dropping to approximately 0.2 to 0.4 mBq/m^3 by natural decay for the counting times used in Table 1). The decay of the short lived cosmogenic nuclides is evident when comparing count 3 to counts 1 and 2 for filter 37.

Approximately 10% of the beta activity on the filters can be accounted for by uranium thorium and potassium in the local soil.

At this time it is difficult to assess the natural range of atmospheric Pb^{210} for this site from gross beta counting however it can be confidently concluded that the Pb^{210} level is significantly lower than the UNSCEAR reported world average of 0.5 mBq/m^3. More detailed analysis of the filters will provide a more precise estimate of local atmospheric Pb^{210} concentration.

Considering the TSP results for the sampling period (four filters) the average dust loading of 0.016 mg/m^3 (standard deviation 0.007 mg/m^3) is typical of arid rural environments and will provide a suitable baseline against which to measure operational dust impacts.

Figures 1 and 3 provide data for the Dustrak II PM_{10} results at Mullaquana homestead. The one minute measurements of PM_{10} are plotted against the time of day for the sampling period. When interpreting individual PM_{10} results it is important to consider the measurement error of 0.002 mg/m^3.

Similar plots for the Nonowie Homestead data are provided in Figures 4 and 5. Figure 6 provides the daily range of dust levels (blue) compared to the daily rainfall (crimson) for the Nonowie Homestead site.

Figure 1 provides data for the first monitoring site at Mullaquana Homestead. The equipment was moved to the second site on 25/11/10 because of noise complaints from the landholder. The main differences between the two sites is that location 1 was away from significant dust generating traffic and sheep movements. Location 2 is adjacent to a vehicular track and in an area frequented by sheep.

The single high result depicted in Figure 1 is the result of vehicular dust produced during equipment maintenance.

The Nonowie homestead site is behind the buildings used by Uranium SA as office and accommodation. This site is subject to dust generated by vehicular and road maintenance traffic on the surrounding unsealed roads and tracks.

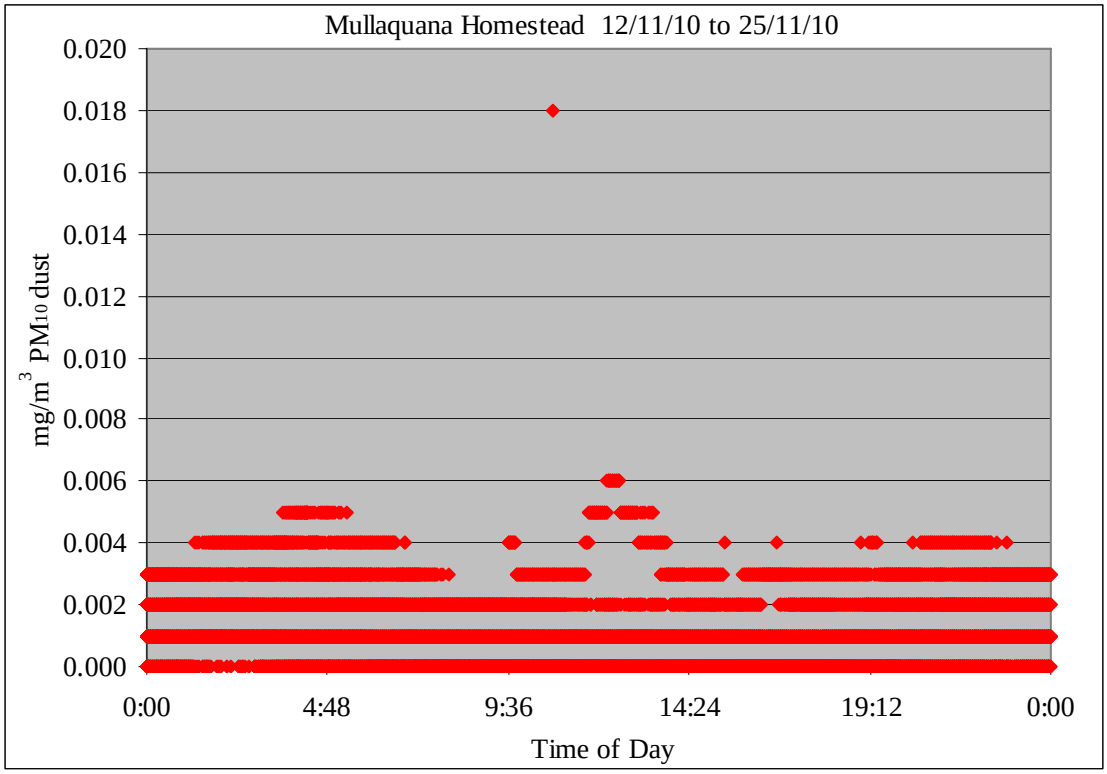


Figure 1

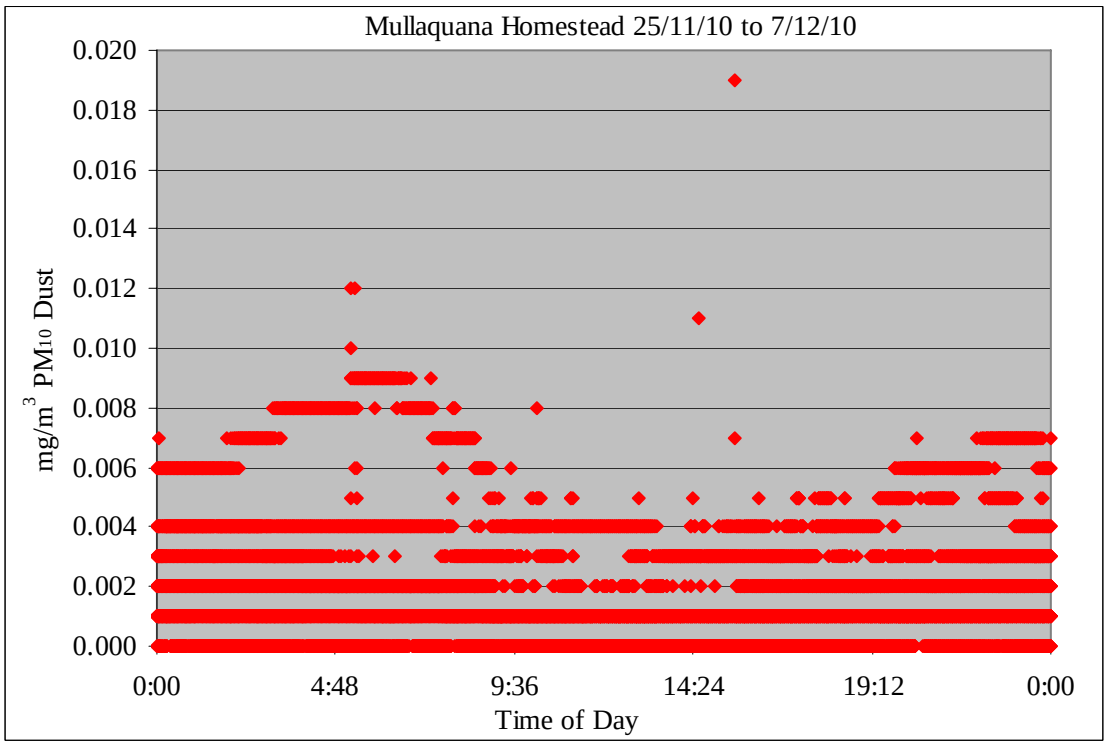


Figure 2

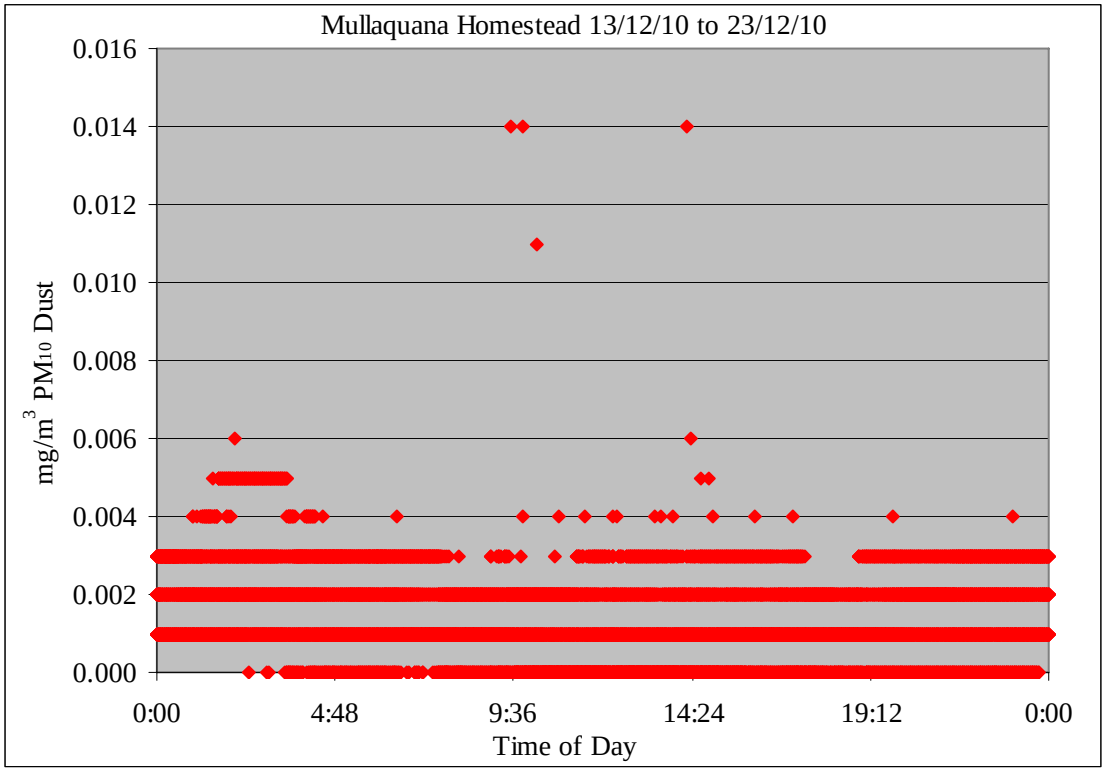


Figure 3

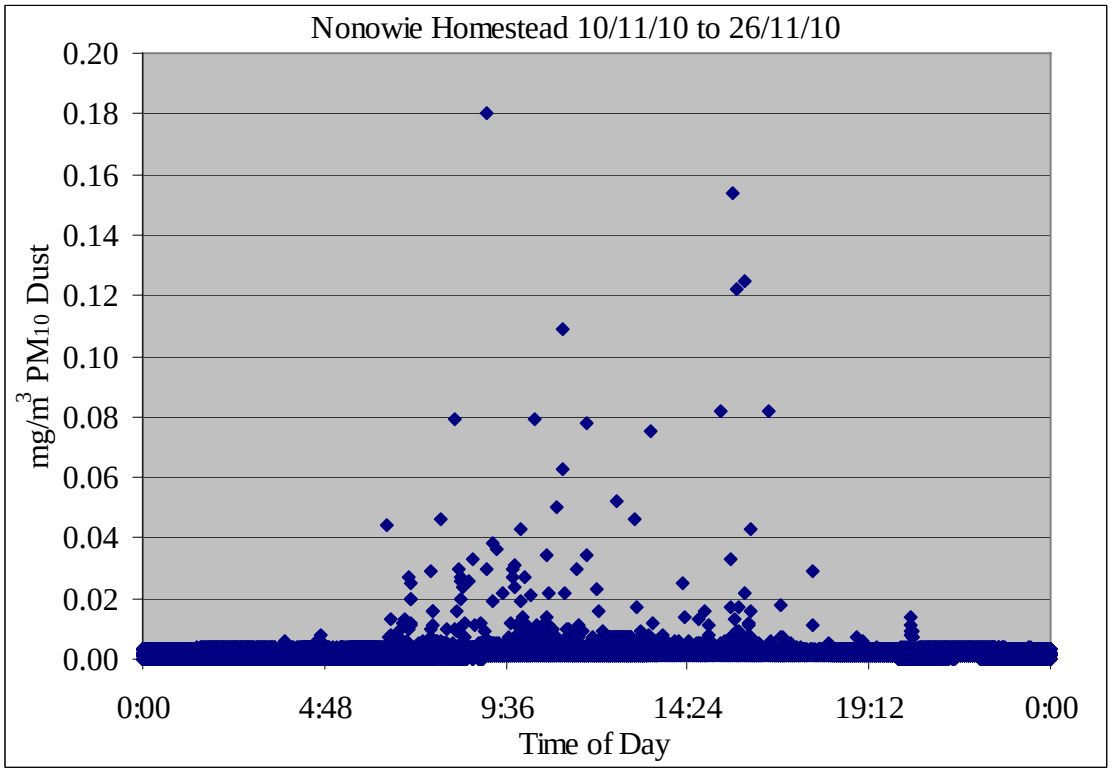


Figure 4

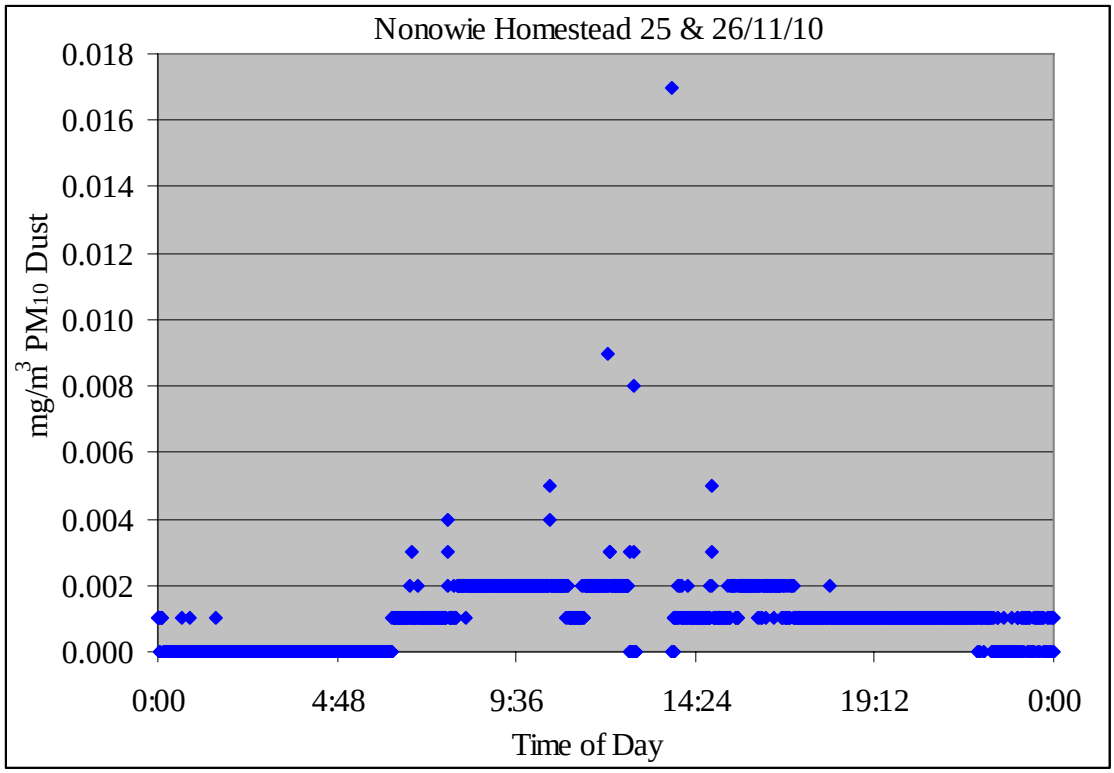


Figure 5

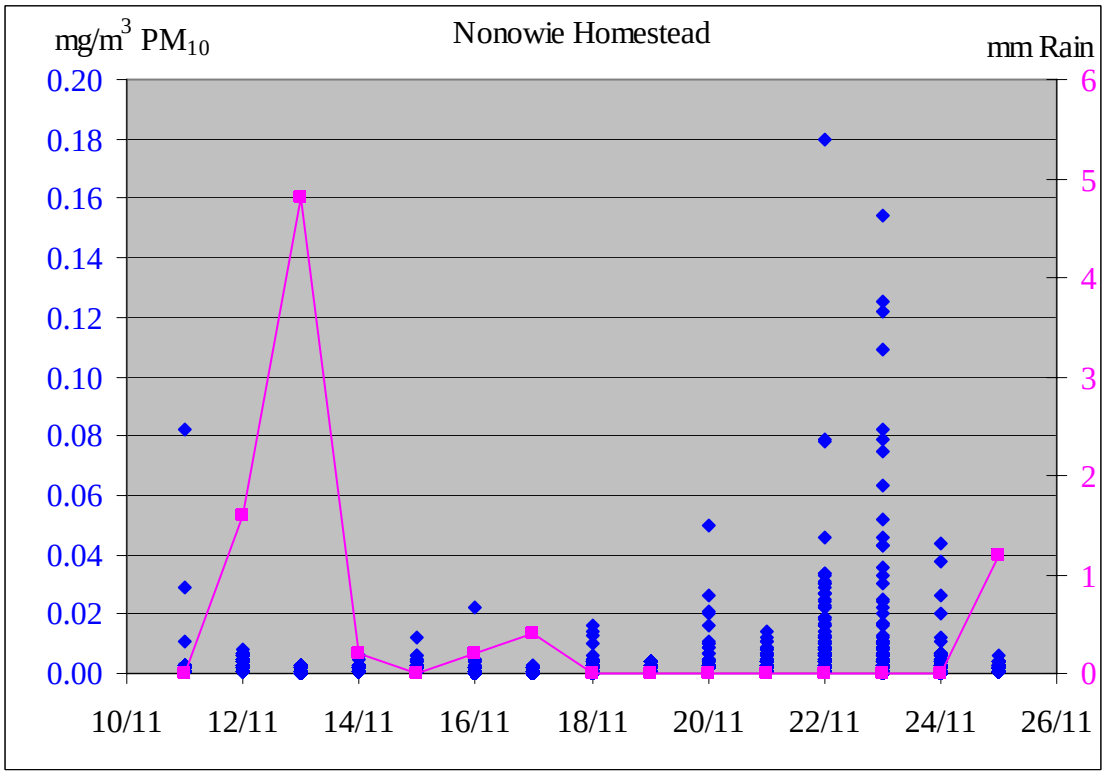


Figure 6

Discussion

PM10 dust levels at both monitoring sites appear to be characterized by three components shown in Figure 7 as;

A. Low level ambient dust on the range 0 to 0.004 mg/m3, these levels represent the lower limit range of the measurement method.
B. Elevated dust levels over extended period (hours to days) in the range 0.003 to 0.010 mg/m3and are most probably dominated by local meteorological conditions (surface soil moisture and wind turbulence and speed.
C. Significantly elevated short duration (generally over one to several minutes) dust levels. These are most probably related to vehicle activity (and possibly sheep movements) near the monitoring sites. This conclusion is supported by;
    1) The occurrence of these spikes in predominantly daylight (working) hours, i.e. 6am to 8pm
    2) The higher incidence of these spikes at Nonowie where vehicular traffic is more frequent
    3) The increased frequency at the Mullaquana site when the monitoring location was moved

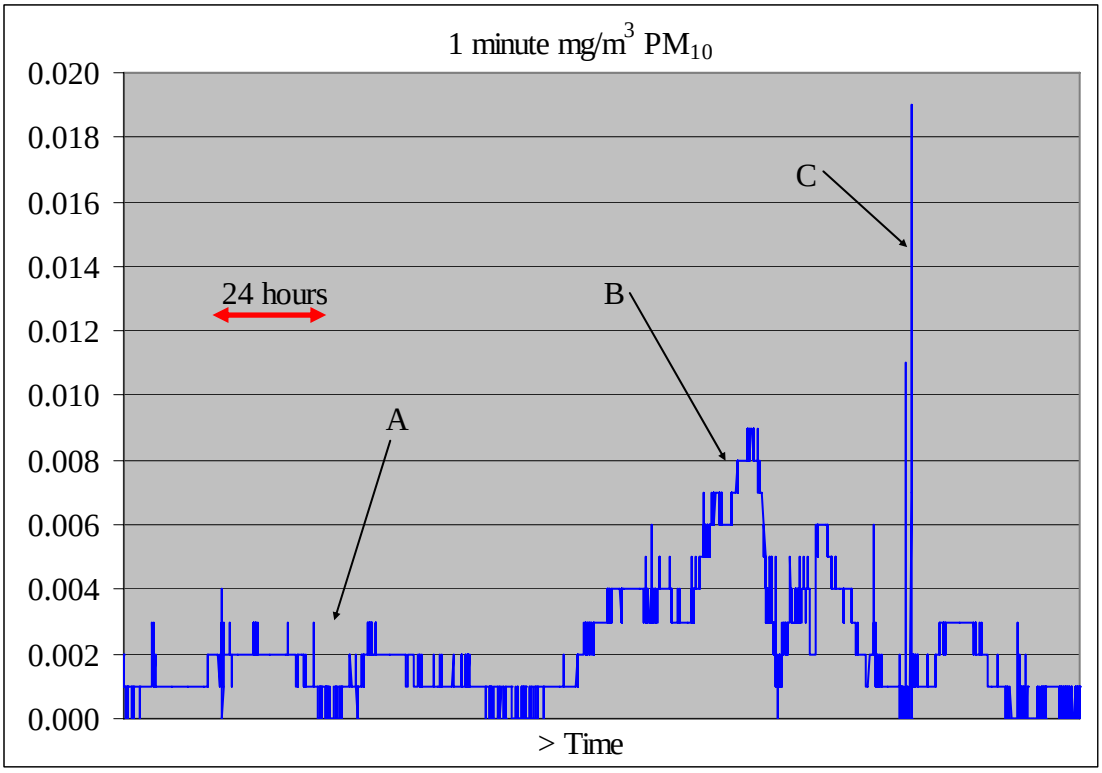


Figure 7

The data presented in Table 1 and Figures 1 to 6 is consistent with the following conclusions:

1) The typical dust level at two of the sensitive receptors (Mullaquana and Nonowie homesteads) is low and peak dust levels are dominated by local meteorological conditions and local vehicular traffic.

2) There is probably the potential for regional meteorological conditions to impact on dust levels over a wide area but this phenomenon was not observed during the monitoring period covered by this report.

3) As would be expected dust levels are generally lower during and just after rain (see Figure 6) than in dry periods.

ON SITE TECHNOLOGY

Radiation Baseline Study

Uranium SA Ltd

Mullaquana Project

Report 10070

Appendix 5

Radon and Radon Daughters

Grab Sampling

Grab samples were collected in lucas cells for spot determination of radon.

Radon daughters were determined using the "Rolle SCAMP" method on a 100l sample collected over a ten minute period.

Sample collection dates, locations and results are provided in Table 1.

Date	Time	Location	Rn^{222} Bq/m^3	Rn Daughters nJ/m^3 PAEC
1/09/2010	15:00	Cowleds Landing	6	6
3/09/2010	11:00	Cowleds Landing	6	8
12/11/2010	17:00	Cowleds Landing	13	14
23/12/2010	16:30	Cowleds Landing	6	10
3/09/2010		Mullaquana Homestead	Rained in, no access	
12/11/2010	12:15	Mullaquana Homestead	18	16
25/11/2010	11:10	Mullaquana Homestead	17	23
23/12/2010	11:10	Mullaquana Homestead	11	12
23/12/2010	12:10	Mullaquana Homestead	18	9
2/09/2010	10:30	Nonowie Homestead	7	10
3/09/2010	9:30	Nonowie Homestead	7	8
12/11/2010	10:30	Nonowie Homestead	19	27
25/11/2010	13:20	Nonowie Homestead	19	12
23/12/2010	10:30	Nonowie Homestead	16	17
2/09/2010	11:34	North Reference Dam	19	21
12/11/2010	15:00	North Reference Dam	14	16
23/12/2010	14:30	North Reference Dam	16	21
2/09/2010	15:11	Operational Area	19	12
12/11/2010	13:00	Operational Area	13	17
25/11/2010	12:00	Operational Area	17	26
23/12/2010	13:30	Operational Area	19	18
2/09/2010	14:30	Southern Reference Site	16	19

Table 1 Radon and Radon Daughter Grab Samples

Although the data set is relatively small there appears to be no statistically significant difference (with a 95% confidence coefficient) between any of the sites except the Cowleds landing site. At Cowleds Landing the radon and radon daughter levels are lower than at the other sites. This is probably consistent with the coastal location of this site.

Statistical analysis was undertaken using the Wilcoxon-Mann-Whitney test implemented by the US-EPA ProUCL4.0 software.

Continuous Monitoring

Continuous Radon monitoring was undertaken at Nonowie Homestead between 11/11/2010 and 26/11/2010 using a flow through lucas cell connected to a counter-timer set up to record counts over one hour periods.

Data was not collected after 26/11/2010 because the power was disconnected form the monitor on 26/11/2010.

Figure 1 provides one hour average Radon level at Nonowie homestead.

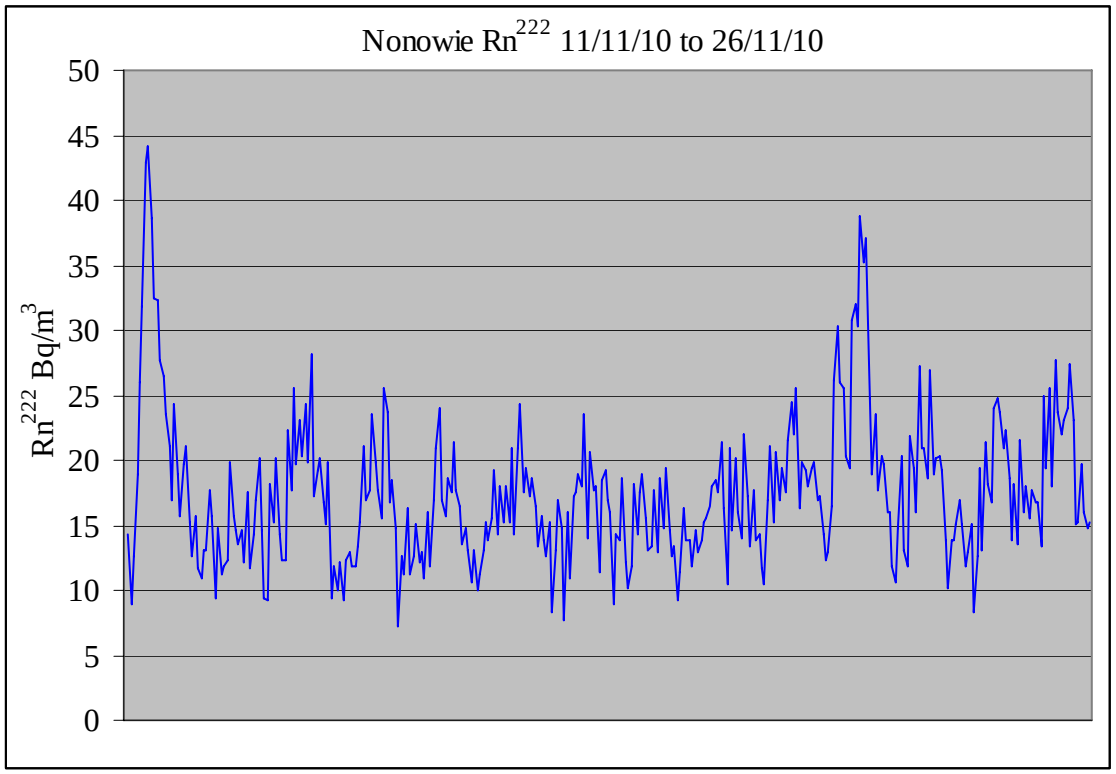


Figure 1 Rn^{222} at Nonowie Homestead

The radon levels display the typical diurnal variation that is characteristic of ambient atmospheric radon concentration. This is shown more clearly in Figure 2 which shows the data from Figure 1 plotted against time of day.

In fact analysis of this data demonstrates that the most likely time of day for a high radon level is between 4am and 9am (centered on 6am) and the most likely time for a low radon level is between 3pm and 10pm (centered on 6pm).

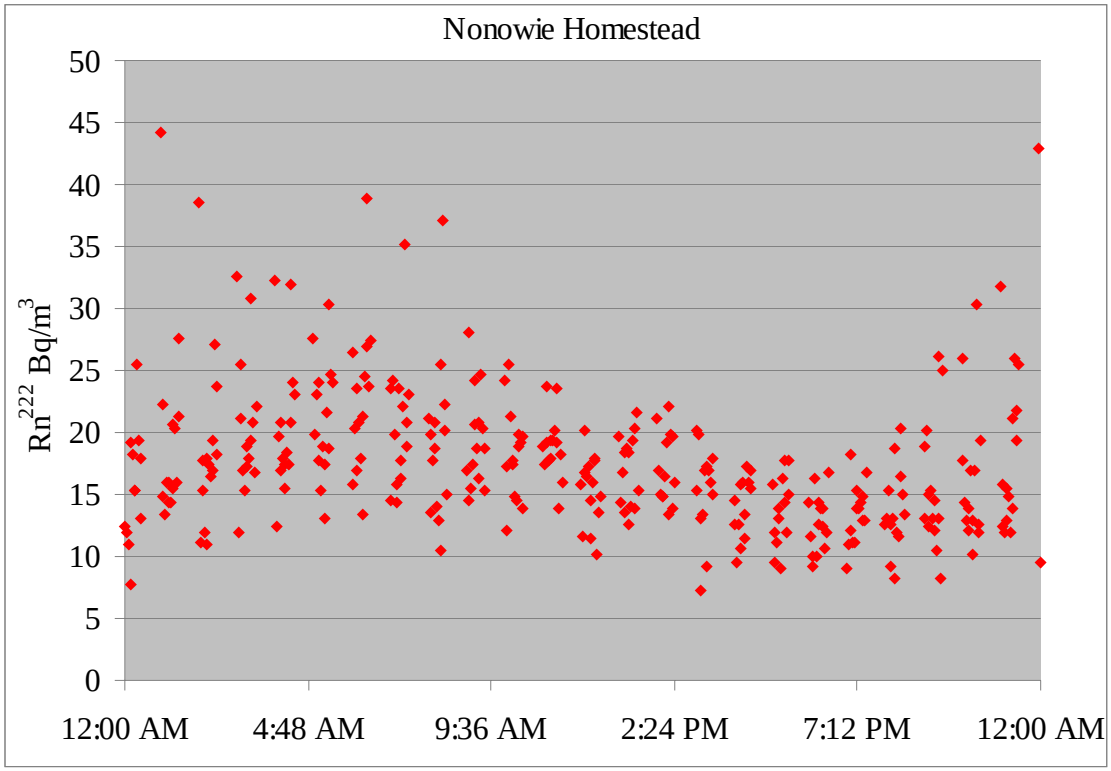


Figure 2 Diurnal Variation in Rn^{222} at Nonowie Homestead

ON SITE TECHNOLOGY

Radiation Baseline Study

Uranium SA Ltd

Mullaquana Project

Report 10070

Appendix 6

Plant Analysis

Samples

Plant samples were collected from across the investigation area (at locations corresponding to soils samples reported in Appendix 3) on 2nd and 3rd September 2010. The plant selected is commonly referred to as "Blue Bush" (tentatively identified as Maireana Sedifolia) and was chosen for the following reasons:

1) The plant is found across the whole area of interest for this baseline study and is therefore easily collected in sufficient quantities for analysis.
2) The plant is available even after prolonged period of low or no rainfall.
3) Sheep (and probably native herbivorous animals) use the plant as a food source.
4) The plant consists of a soft "flesh" part that represents the last seasons growth and a "woody" part that represents a number of seasons growth. This would facilitate identifying recent changes in radionuclide levels in the plants.

The selected plant is shown in Figures 1 and 2.



Figure 1



Figure 2

Samples were washed to remove adhering soil and dust, air dried at 75°C and separated into "flesh" and "woody" sub samples before being pulverized for analysis.

Analysis for Pb^{210} (beta counting) and Po^{210} (alpha spectrometry) was undertaken on an acid digest (nitric, hydrochloric) of the dried sample.

Analysis for uranium and thorium (ICP-MS), Th^{230} (alpha spectrometry) and Ra^{226} (Gamma spectrometry) was undertaken on a sample that had been ashed in air at 500°C. U^{238} and Th^{232} were calculated from the ICP-MS uranium and thorium values.

All results are reported on a dry weight basis, results are provided in Tables 1 and 2.

Results

Sample	Ash %	mN 53H	mE 53H	U µg/g	Th µg/g
Op Dam Flesh	23.3	6324759	723522	<0.1	0.53
Op Dam Wood	13.8	6324759	723522	0.15	2.05
WPT 386 Flesh	24.2	6335853	725973	<0.1	0.47
WPT 386 Wood	8.5	6335853	725973	<0.1	0.22
WPT 388 Flesh	23.7	6330425	723398	<0.1	0.73
WPT 388 Wood	10.1	6330425	723398	0.05	0.33
WPT 390 Flesh	20.0	6320736	723116	<0.1	0.50
WPT 390 Wood	10.2	6320736	723116	<0.1	0.24

Table 1 Sample Locations, Ash, Uranium and Thorium (dry weight basis)

Sample	U^{238} Bq/g	Th^{230} Bq/g	Ra^{226} Bq/g	Pb^{210} Bq/g	Po^{210} Bq/g	Th^{232} Bq/g
Op Dam Flesh	<0.001	<0.005	<0.005	0.018	<0.02	0.002
Op Dam Wood	0.002	<0.002	<0.002	0.016	<0.02	0.008
WPT 386 Flesh	<0.001	<0.005	<0.005	0.037	0.02	0.002
WPT 386 Wood	<0.001	<0.002	<0.002	0.048	0.04	0.001
WPT 388 Flesh	<0.001	<0.005	<0.005	0.018	<0.02	0.003
WPT 388 Wood	0.001	<0.002	<0.002	0.019	0.020	0.001
WPT 390 Flesh	<0.001	<0.005	<0.005	0.052	0.03	0.002
WPT 390 Wood	<0.001	<0.002	<0.002	0.051	0.04	0.001

Table 2 Radionuclide Results (dry weight basis)

Appendix N: Radiation – Baseline Data

Appendix N: Samphire RL 137 - Baseline Long Lived Alpha Activity Data

Baseline Data Summary - Airborne Long Lived Alpha Activity

Location	Minimum LLAA (mBq/m³)	Average LLAA (mBq/m³)	Maximum LLAA (mBq/m³)	No. Samples
RM1	0.058	0.223	0.446	7
RM2	0.097	0.161	0.292	6
RM3	0.038	0.082	0.144	7
RM4	0.004	0.146	0.268	7
RM5	0.008	0.079	0.274	15
RM6	0.008	0.139	0.450	7
RM7	0.035	0.178	0.355	8
RM8	0.031	0.135	0.302	8

Note:

- All Long-Lived Alpha Activity (LLAA) concentrations are expressed in mBq/m³ (millibecquerels per cubic metre), representing gross alpha activity in airborne particulate matter.
- Recent samples (2024-2025) were collected using low-volume air sampling pumps operated over 24–48 hour durations, drawing air through impermeable membrane filters to capture suspended particulates. Alpha activity was quantified using a low-background alpha counter supplied and operated by Radiation Detection Systems (RDS), South Australia.
- Results reflect cumulative alpha activity from long-lived radionuclides (e.g. uranium decay chain progeny) adsorbed to particulates. Short-lived radon progeny were excluded from these measurements.

Appendix N: Samphire RL 137 - Baseline Long Lived Alpha Activity Data

Baseline Data - Long Lived Alpha Airborne Activity (mBq/m³)

Sample Date	Location	LLAA (mBq/m³)
11/11/2010	RM5	0.016
24/11/2010	RM5	0.027
1/12/2010	RM5	0.027
12/12/2010	RM5	0.048
16/10/2024	RM1	0.443
16/10/2024	RM2	0.292
16/10/2024	RM3	0.093
17/10/2024	RM5	0.274
19/10/2024	RM6	0.066
20/10/2024	RM7	0.118
20/10/2024	RM8	0.066
2/11/2024	RM1	0.063
2/11/2024	RM2	0.109
2/11/2024	RM3	0.038
4/11/2024	RM4	0.135
4/11/2024	RM5	0.043
12/11/2024	RM6	0.008
12/11/2024	RM7	0.035
14/11/2024	RM8	0.183
1/12/2024	RM1	0.261
1/12/2024	RM2	0.137
1/12/2024	RM3	0.048
1/12/2024	RM5	0.039
3/12/2024	RM4	0.131
3/12/2024	RM6	0.114
3/12/2024	RM7	0.076
3/12/2024	RM8	0.031

Appendix N: Samphire RL 137 - Baseline Long Lived Alpha Activity Data

Baseline Data - Long Lived Alpha Airborne Activity (mBq/m³)

Sample Date	Location	LLAA (mBq/m³)
10/01/2025	RM1	0.129
10/01/2025	RM2	0.183
10/01/2025	RM3	0.097
12/01/2025	RM4	0.268
12/01/2025	RM5	0.112
21/01/2025	RM6	0.075
21/01/2025	RM7	0.116
21/01/2025	RM8	0.071
4/02/2025	RM1	0.159
4/02/2025	RM3	0.053
6/02/2025	RM4	0.102
6/02/2025	RM5	0.008
8/02/2025	RM6	0.231
8/02/2025	RM7	0.344
8/02/2025	RM8	0.102
13/03/2025	RM4	0.134
13/03/2025	RM5	0.137
20/03/2025	RM7	0.355
20/03/2025	RM8	0.302
3/04/2025	RM1	0.446
3/04/2025	RM2	0.097
5/04/2025	RM3	0.099
5/04/2025	RM4	0.004
5/04/2025	RM5	0.152
8/04/2025	RM6	0.450
8/04/2025	RM7	0.258
17/04/2025	RM8	0.272
1/05/2025	RM1	0.058
1/05/2025	RM3	0.144
1/05/2025	RM6	0.030
3/05/2025	RM2	0.148
3/05/2025	RM4	0.250
18/05/2025	RM5	0.145
18/05/2025	RM7	0.119
18/05/2025	RM8	0.049

Appendix N: Samphire RL 137 - Baseline Radon Decay Product Data

Baseline Summary - Potential Alpha Energy Concentration (PAEC)

Location	Minimum PAEC (µJ/m³)	Mean PAEC (µJ/m³)	Maximum PAEC (µJ/m³)	No. Samples	Source Info
RM1	0.009	0.022	0.110	8	Alligator Energy, Jan-2023 to Apr-2025
RM2	0.012	0.020	0.100	7	Alligator Energy, Jan-2023 to Apr-2025
RM3	0.007	0.018	0.100	8	Alligator Energy, Jan-2023 to Apr-2025
RM4	0.000	0.007	0.120	361	Alligator Energy, Jan-2023 to Apr-2025
RM5	0.002	0.025	0.280	240	Alligator Energy, Jan-2023 to Apr-2025
RM6	0.000	0.011	0.170	405	Alligator Energy, Jan-2023 to Apr-2025
RM7	0.006	0.015	0.540	6	Alligator Energy, Jan-2023 to Apr-2025
RM8	0.011	0.021	0.170	5	Alligator Energy, Jan-2023 to Apr-2025

Note:

- Radon decay product concentrations (PAEC, µJ/m³) were measured using an Environmental Radon Decay Product Monitor (ERDM) supplied and serviced by Radiation Detection Systems (RDS), South Australia.

Appendix N: Samphire RL 137 - Baseline Radon Data

Baseline Radon Concentration Summary

Minimum Radon Concentration (Bq/m³)	Average Radon Concentration (Bq/m³)	Maximum Radon Concentration (Bq/m³)	Count of Samples
5.66	13.30	18.26	8

Baseline Radon Concentrations

Location	Monitoring Start Date	Monitoring End Date	Radon Concentration (Bq/m³)	Comments
RM1	19/05/2024	8/04/2025	5.66	ARPANSA Annual Monitors 2024-2025
RM2	19/05/2024	8/04/2025	11.45	ARPANSA Annual Monitors 2024-2025
RM3	19/05/2024	8/04/2025	18.26	ARPANSA Annual Monitors 2024-2025
RM4	19/05/2024	8/04/2025	14.15	ARPANSA Annual Monitors 2024-2025
RM5	19/05/2024	8/04/2025	14.15	ARPANSA Annual Monitors 2024-2025
RM6	19/05/2024	8/04/2025	13.25	ARPANSA Annual Monitors 2024-2025
RM7	19/05/2024	8/04/2025	14.92	ARPANSA Annual Monitors 2024-2025
RM8	19/05/2024	8/04/2025	14.53	ARPANSA Annual Monitors 2024-2025

Note:

- All radon concentrations presented in the summary and data tables are expressed in Bq/m³ (becquerels per cubic metre), representing time-averaged radon gas concentrations measured via passive alpha track monitoring.
- No values were below the method detection limit (MDL). All results exceeded the minimum reportable level (MRL) of 24 kBq·h·m^{-3}.

Appendix N: Samphire RL 137 - Baseline Airborne Radionuclide Concentrations

Baseline Airborne Radionuclide Concentrations - Summary Data

Min of Th-234 (µBq/m³)	Ave of Th-234 (µBq/m³)	Max of Th-234 (µBq/m³)	Min of Th-230 (µBq/m³)	Ave of Th-230 (µBq/m³)	Max of Th-230 (µBq/m³)	Min of Ra-226 (µBq/m³)	Ave of Ra-226 (µBq/m³)	Max of Ra-226 (µBq/m³)	Min of Pb-210 (µBq/m³)	Ave of Pb-210 (µBq/m³)	Max of Pb-210 (µBq/m³)	Min of Be-7 (µBq/m³)	Ave of Be-7 (µBq/m³)	Max of Be-7 (µBq/m³)
51.00	83.00	150.00	460.00	771.43	1,400.00	13.00	21.57	37.00	100.00	191.43	330.00	1,700.00	3,371.43	5,700.00

Baseline Airborne Radionuclide Concentrations

Sample Month	Point ID	Th-234 (µBq/m³)	Th-230 (µBq/m³)	Ra-226 (µBq/m³)	Pb-210 (µBq/m³)	Be-7 (µBq/m³)
November 2024	RM9	<69	<640	<19	180 ±32	2,200 ±290
December 2024	RM9	<51	<460	<13	100 ±20	3,100 ±290
January 2025	RM9	<73	<690	<20	160 ±30	4,100 ±360
February 2025	RM10	<89	<820	<23	220 ±37	5,700 ±460
February 2025	RM9	<93	<850	<24	140 ±33	3,500 ±320
May 2025	RM10	<150	<1400	<37	330 ±61	3,300 ±310
May 2025	RM9	<56	<540	<15	210 ±30	1,700 ±150

Note:

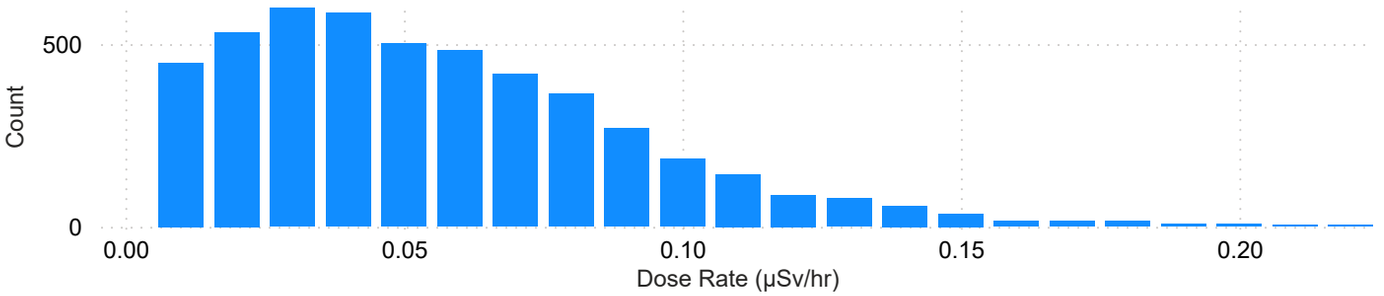
- All radionuclide concentrations were measured by high-resolution gamma spectrometry (HPGe) at a NATA-accredited laboratory. Values are reported in µBq/m³ and represent activity concentrations in airborne particulate samples collected via high-volume air samplers.
- Summary statistics are based on a limited monitoring dataset (n = 7) collected from RM9 and RM10 between Nov 2024 and May 2025. These values represent indicative baseline concentrations and may not capture full seasonal variability.

Appendix N: Samphire RL 137 - Baseline Gamma Data

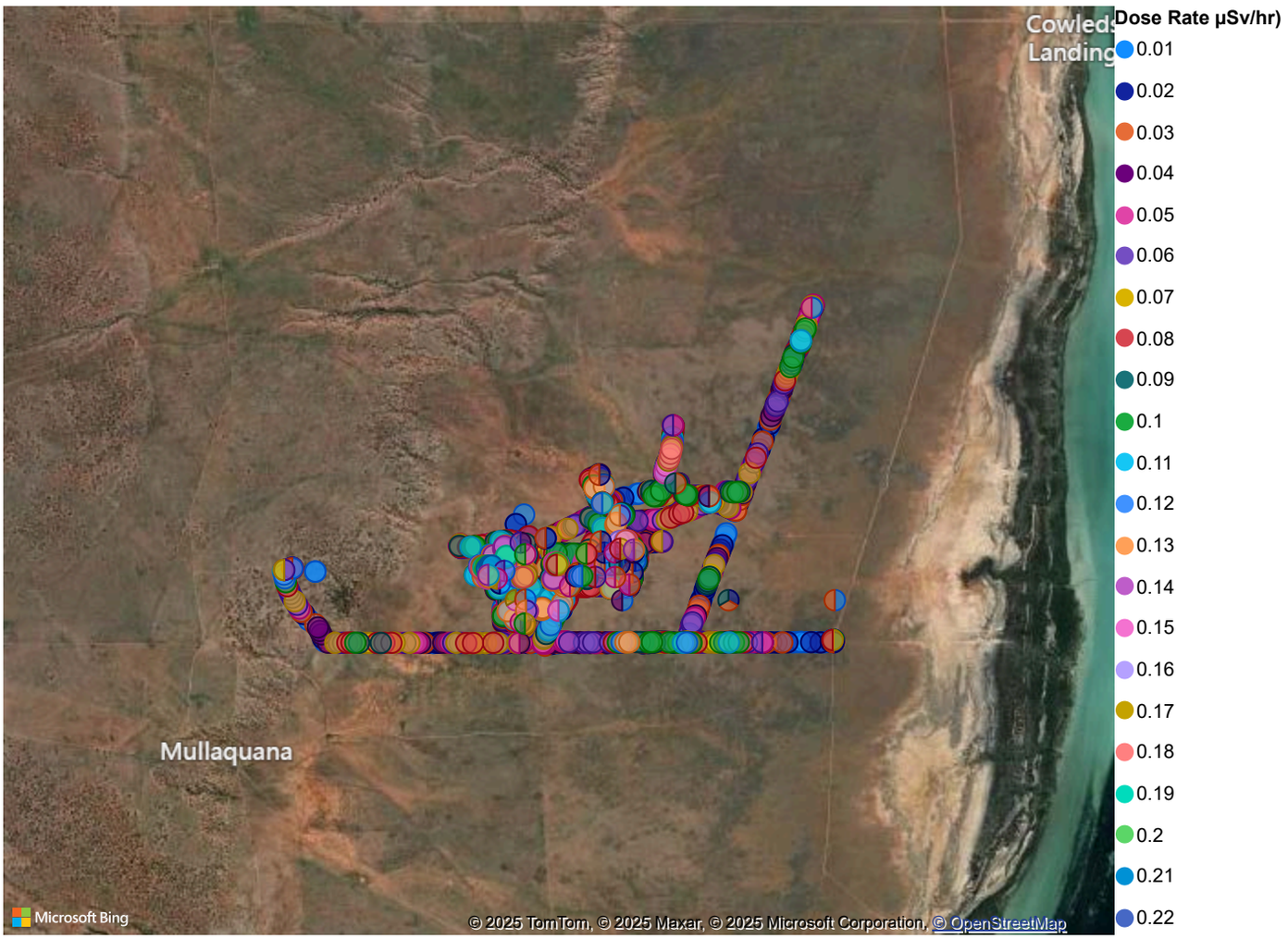
Baseline - Gamma Survey Data

Location	Average of Dose Rate (µSv/hr)	Min of Dose Rate (µSv/hr)	Max of Dose Rate (µSv/hr)	No. of Monitoring Points
RL 137	0.06	0.01	0.22	4852

Baseline Gamma Radiation Dose Rate Distribution (µSv/hr)



Aerial Distribution of Gamma Survey Data



Note:

- All dose rates represent ambient gamma radiation at approximately 1 metre above ground level.
- Baseline gamma radiation dose rate data is sourced from Appendix G, Alligator Energy RL Proposal (2023). Measurements were obtained via in-situ portable gamma survey using a calibrated handheld detector, with dose rate output in µSv/hr

Appendix N: Samphire RL 137 - Baseline Gamma Data

Summary of Quarterly Environmental OSL Results — Hp(10) per 3-month deployment (mSv)

Minimum Hp(10) Dose Equivalent (mSv)	Average Hp(10) Dose Equivalent (mSv)	Maximum Hp(10) Dose Equivalent (mSv)
<0.5	0.14	0.23

Note: Passive OSL dosimeters were deployed at fixed locations (RM1–RM9) for nominal three-month periods (≈90 days) and report cumulative Hp(10) per deployment. Values '<0.05 mSv' are below the Minimum Reportable Dose.

Quarterly Environmental OSL Results by Location — Hp(10) per 3-month deployment (mSv)

Monitoring Start Month	RM1	RM2	RM3	RM4	RM5	RM6	RM7	RM8	RM9
March 2024	<0.05	0.07	<0.05	<0.05	0.07	<0.05	<0.05	<0.05	
January 2024	<0.05	<0.05	<0.05	<0.05	<0.05	0.20	0.11	0.11	<0.05
October 2023	<0.05	<0.05	0.21	<0.05	0.11	<0.05	<0.05	0.10	0.13
July 2023	0.10	<0.05	0.12	<0.05	<0.05	<0.05	0.23	0.20	<0.05
April 2023	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
January 2023	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05

Note: Passive OSL dosimeters were deployed at fixed locations (RM1–RM9) for nominal three-month periods (≈90 days) and report cumulative Hp(10) per deployment. Values '<0.05 mSv' are below the Minimum Reportable Dose.

Appendix O: Air Quality – Baseline Records

Appendix O1: Baseline Air Quality Records

Appendix O: Samphire RL 137 - Baseline Dust Deposition Data

Baseline Summary Deposited Dust (g/m²/month)

Monitoring Location	Minimum - Total Insoluble Matter	Average - Total Insoluble Matter	Maximum - Total Insoluble Matter	No. Samples
RM1	0.03	0.61	1.70	10
RM2	0.20	0.39	0.80	10
RM3	0.20	0.61	1.20	10
RM4	0.30	0.95	1.70	10
RM5	0.30	1.70	10.40	10
RM6	0.20	0.87	2.30	10
RM7	0.30	0.94	1.80	10
RM8	0.10	0.65	1.20	10

Baseline Deposited Dust Monitoring Data - Total Insoluble Matter (g/m²/month)

Sample Month	RM1	RM2	RM3	RM4	RM5	RM6	RM7	RM8
April 2024	0.50	0.30	0.40	1.00	0.70	0.40	0.70	0.50
June 2024	0.03	0.40	0.80	1.70	0.70	0.50	1.70	0.60
July 2024	0.30	0.20	0.40	0.30	0.60	0.20	0.40	1.00
August 2024	1.50	0.80	1.20	1.60	1.40	1.90	1.10	1.20
September 2024	0.30	0.20	0.20	1.60		1.00	0.30	0.20
October 2024	1.70	0.80	0.40	0.40	10.40	0.60	1.20	1.00
November 2024	0.20	0.20	0.40	0.30	0.40	0.40	0.70	0.40
January 2025	0.50	0.20	0.50	0.70	0.40	0.30	1.80	0.10
February 2025	0.60	0.40	0.70	0.80	0.80	1.10	0.50	0.70
March 2025	0.50	0.40	1.10	1.10	1.30	2.30	1.00	0.80

Note:

- Dust deposition results are reported as total insoluble matter (g/m²/month), measured using passive dust deposition gauges in accordance with AS/NZS 3580.10.1:2016.
- Gauges used standard 150 mm diameter cylindrical collection bottles with a collection area of 0.0177 m².
- Deposition results are normalised to g/m²/month in accordance with *AS 3580.10.1–2016* using the formula: g/m²\month= mass (g) / area (m²) × actual days) × 30.
- All samples were analysed gravimetrically following drying and weighing under controlled laboratory conditions.

Appendix P: Visual Amenity – Baseline Records

Appendix P1: RL Baseline Photopoint Records. Completed by Alligator Energy, January 2025.



Photopoint 1 – Looking west from Moonabie station access gate.



Photopoint 2 – Looking north towards gate 3 from Mullaquana boundary.



Photopoint 3 – Looking North from gate 8 from Mullaquanna boundary

Appendix Q: Noise – Baseline Assessment

Appendix Q1: Samphire Uranium Project – Mullaquana Station Noise Monitoring. Report No. S7888C2, prepared for Alligator Energy by Sonus Pty Ltd, Adelaide.

Samphire Uranium Project

Mullaquana Station Noise Monitoring

S7888C2

December 2023

sonus.

Sonus Pty Ltd
17 Ruthven Ave
Adelaide SA 5000
Phone: +61 (8) 8231 2100
Email: info@sonus.com.au
www.sonus.com.au

Document Title	: Samphire Uranium Project Mullaquana Station Noise Monitoring
Client	: Alligator Energy
Document Reference	: S7888C2
Date	: December 2023
Author	: Simon Moore, MAAS

© Sonus Pty Ltd. All rights reserved.

This report may not be reproduced other than in its entirety. The report is for the sole use of the client for the particular circumstances described in the report. Sonus accepts no responsibility to any other party who may rely upon or use this report without prior written consent.

1 INTRODUCTION

Sonus has been engaged by Alligator Energy (**Alligator**) to conduct noise monitoring for the Samphire Uranium Project (the **Project**). The Project is located approximately 20 km south of Whyalla on the Eyre Peninsula (the **Site**).

Alligator proposes to undertake a Field Recovery Trial in early 2024 to test the use of In-Situ Recovery (**ISR**) method of extracting uranium for the Project. The ISR trial would take place on two hectares of land and would consist of three rings of injection and recovery wells. Currently exploratory drilling program are undertaken on the Site for the Project.

The noise monitoring was undertaken at Mullaquana Station, Douglas Point SA from 15 to 29 September 2023. The monitoring location was selected to provide background noise data at the homestead of the nearest landholders to the proposed retention lease of the ISR trial for the Samphire Uranium Project. In addition to the background noise data, an assessment of the noise during exploratory drilling that is occurring within the proposed retention lease was also undertaken. The monitoring location is shown relative to the subject site and the nearby homestead in Appendix A.

This assessment is conducted for the following:

- To provide an indication of the baseline noise levels prior to any site activity associated with the Project
- To check compliance of the exising exploratory drilling program against the requirements of the *Environment Protection (Commercial and Industrial Noise) Policy 2023* (the **Policy**).

2 BASELINE NOISE LEVELS

2.1 Measurement Summary

To provide an indication of the baseline noise levels prior to any site activity associated with the Project and to quantify the existing noise level at the nearby homestead, the noise monitoring results for the period between 15 and 25 September 2023 were analysed. No drilling activity was being undertaken on the proposed retention lease during this period. The noise monitoring results between 15 and 25 September are displayed in Appendix B.

The following observations are made[1]:

Table 1: Summary of Noise Logging Results, Daytime (7:00am to 10:00pm), in dB(A)

Date	Highest $L_{Aeq,15min}$	Lowest $L_{Aeq,15min}$	Median $L_{Aeq,15min}$
15/09/2023	55	18	44
16/09/2023	55	26	43
17/09/2023	63	27	46
18/09/2023	69	26	50
19/09/2023	84	21	47
20/09/2023	67	26	46
21/09/2023	61	21	46
22/09/2023	68	20	45
23/09/2023	67	21	47
24/09/2023	55	29	42
25/09/2023	63	23	46
Median Daytime	**63**	**23**	**46**

[1] Extraneous noise has been excluded from the dataset.

Table 2: Summary of Noise Logging Results, Night Time (10:00pm to 7:00am), in dB(A)

Date	Highest $L_{Aeq,15min}$	Lowest $L_{Aeq,15min}$	Median $L_{Aeq,15min}$
15/09/2023	31	19	20
16/09/2023	53	18	24
17/09/2023	54	19	26
18/09/2023	62	21	29
19/09/2023	55	19	31
20/09/2023	57	18	24
21/09/2023	54	17	22
22/09/2023	51	17	28
23/09/2023	53	18	22
24/09/2023	58	19	26
25/09/2023	54	21	38
Median Night Time	**54**	**19**	**26**

3 COMPLIANCE OF THE EXPLORATROY DRILLING PROGRAM

3.1 Measurement Summary

During the measurement period, exploratory drilling occurred from 25 to 28 September 2023. The noise monitoring results from this period which indicates the times of operation of the drill rig are shown in Appendix C.

3.2 Criteria

The subject site and nearby homestead are located within the Remote Ares Zone of the *South Australian Planning and Design Code* (the **Code**).

The Policy provides goal noise levels to be achieved at noise sensitive receivers based on the Code zones that the noise source and receivers are located in. Based on the zoning of the site and the receivers, the Policy provides the following goal noise levels to be achieved at the homestead:

- An equivalent noise level of 57 dB(A) during the day period (7:00am to 10:00pm).
- An equivalent noise level of 49 dB(A) during the night period (10:00pm to 7:00am).

When measuring noise levels for comparison with the Policy, adjustments may be made to the measured noise levels for each 'annoying' characteristic of tonality, impulsiveness, low frequency, intermittency, and modulation of the noise source. The characteristic must be dominant in the acoustic environment and therefore the application of a penalty varies depending on a number of factors, including, the measurement location, time of day, the noise source being assessed, and the measured noise level. The application of a penalty is discussed further in the discussion section of this report.

3.3 Discussion

Analysis of the graph enables the influence of the on-site activities on the ambient noise environment to be determined. This is done by observing any noticeable change in the noise during the period of operation, which cannot be explained by an increase in wind speed or the natural variation in noise during the day. Trends which would indicate that the drilling activities are contributing to the noise environment include a sharp rise or fall coinciding with the drill rig being switched on or off, or consistently lower noise levels when the drill rig is not operating. Conversely, an increase in noise prior to the drill rig operating, or elevated noise levels continuing after the completion of the drilling operation would indicate that another noise source is responsible for the

elevated noise. Where a noticeable change associated with the drill rig is not observed, it can be concluded that the contribution of noise from the Site would be deemed to be in compliance with the Policy.

During the drilling operation on 25 September, the graph follows a similar trend to what is expected during a drilling operation. However, upon review of the audio recording data, it was concluded that the noise was most likely from a small water pump located near the noise monitoring location that was operating intermittently at the homestead.

Following analysis of the graph and audio recording data, it is concluded that the drilling activities were inaudible at the noise measurement location during the measurement period. As the site activities are not dominant in the acoustic environment, no penalties are warranted.

A summary of the results is presented in tables below:

Table 3: Summary of the Result

DATE	EVENTS	NOTICEABLE CHANGE		COMPLIANCE
		L_{Aeq}	L_{A90}	
25/09/2023	Drilling from 1600 - 1715	N	N	Yes
26/09/2023	Drilling from 0745 - 1330	N	N	Yes
	Drilling from 1430 - 1730	N	N	Yes
27/09/2023	Drilling from 0800 - 1215	N	N	Yes
	Drilling from 1330 - 1715	N	N	Yes
	Drilling from 1030 - 1715	N	N	Yes
28/09/2023	Drilling from 0800 - 1030	N	N	Yes
	Drilling from 1115 - 1600	N	N	Yes
	Drilling from 1700 - 1730	N	N	Yes
	Drilling from 0800 - 0900	N	N	Yes
	Drilling from 1000 - 1445	N	N	Yes
	Drilling from 1600 - 1700	N	N	Yes

4 CONCLUSION

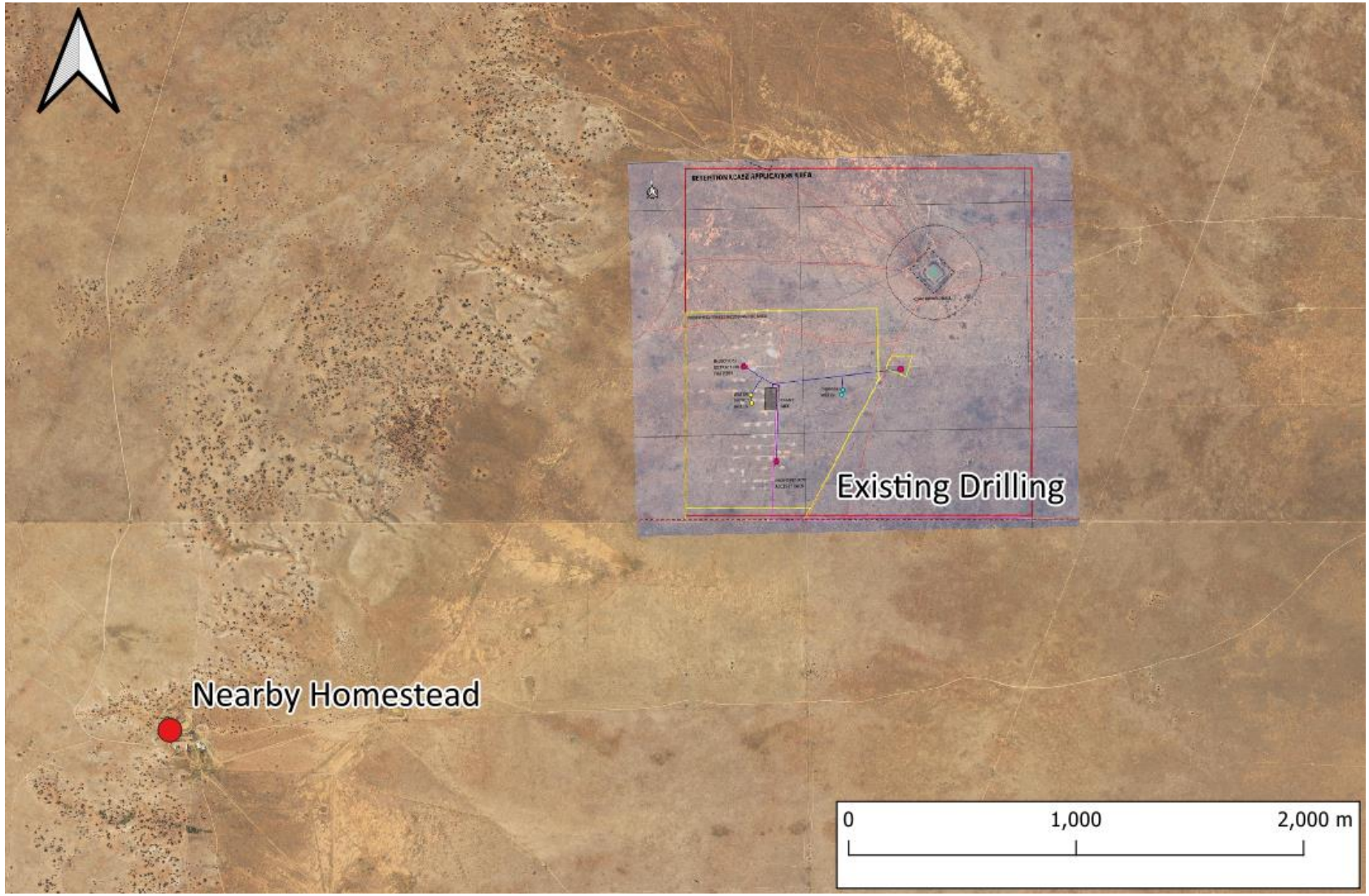
Sonus has been engaged by Alligator Energy to conduct background noise monitoring for the Samphire Uranium Project. The Project is located approximately 20 km south of Whyalla on the Eyre Peninsula.

Monitoring results from 15 to 25 September 2023 has been used provide an indication of the baseline noise levels prior to any site activity associated with the Project and to quantify the existing noise level at the nearby homestead, as no activity was being undertaken on the proposed retention lease during this period.

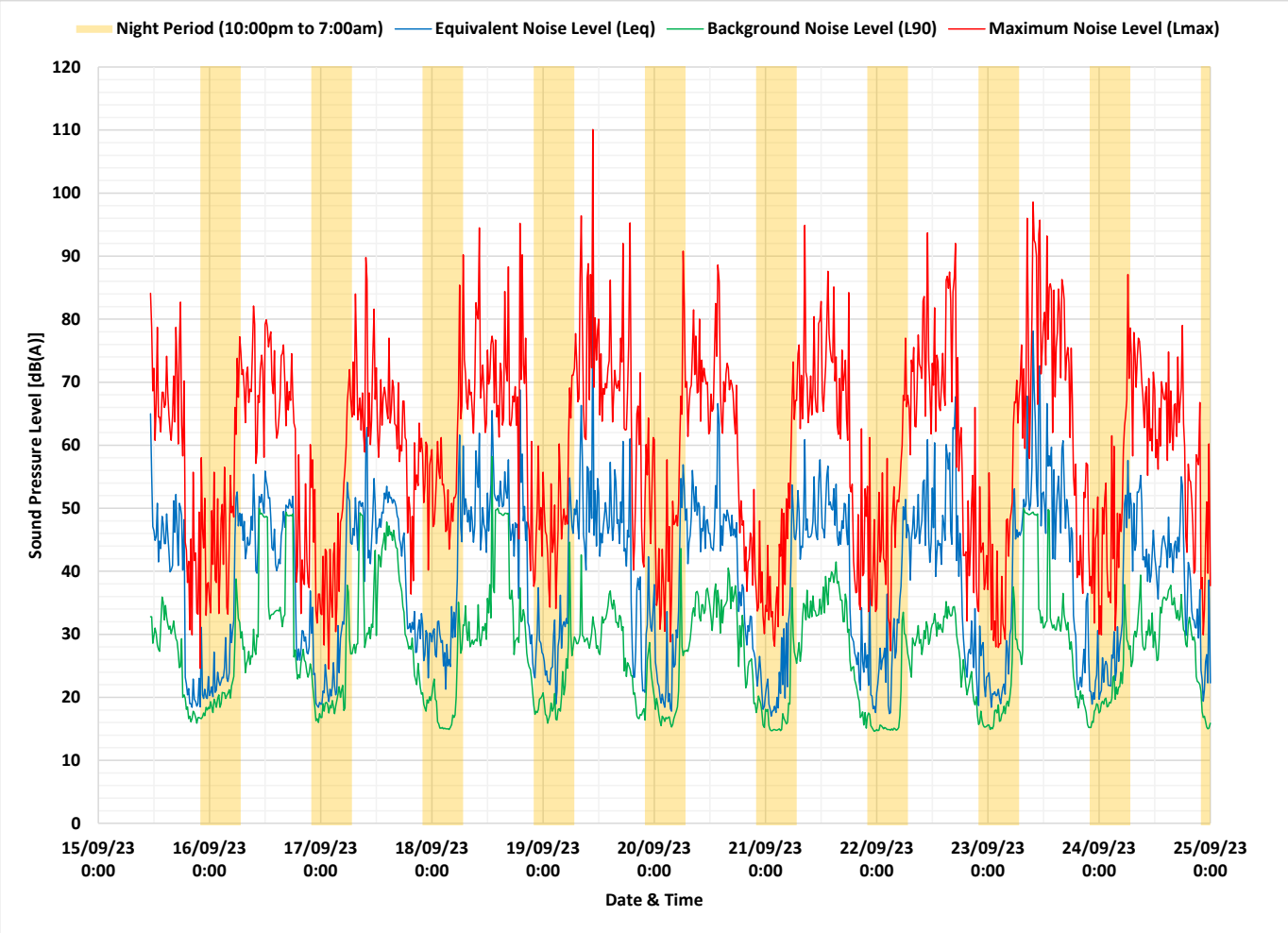
During the monitoring period from 25 to 28 September 2023, the Site had drilling operations for 4 days and 12 separate operational periods. For each operational period, the analysis showed the drilling activities did not result in a noticeable increase in the noise measured at the homestead. Therefore, during the monitoring period, the drilling activities were compliant with the *Environment Protection (Commercial and Industrial Noise) Policy 2023*.

APPENDIX A: SITE AND SURROUNDINGS

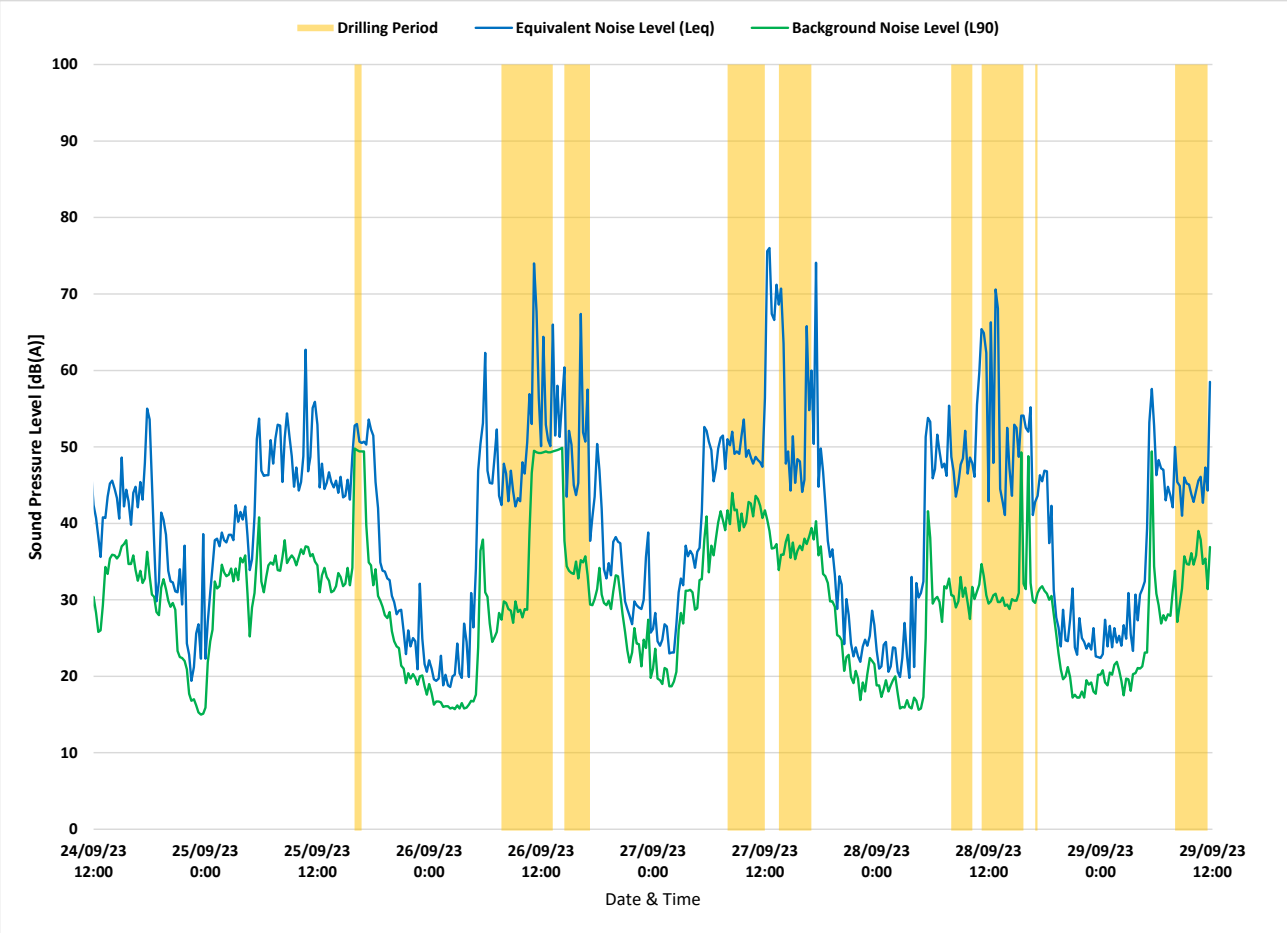



Existing Drilling
Nearby Homestead
0
1,000
2,000 m

APPENDIX B: BACKGROUND NOISE MONITORING RESULTS



APPENDIX C: NOISE MONITORING RESULTS DURING DRILLING OPERATION



Appendix Q2: Alligator Energy Samphire Field Noise Monitoring Noise Propagation Modelling. Prepared by Resonate Consultants. June, 2025.

Wednesday, 11 June 2025

Project number: A250511
Reference: A250511LT1

Matt Daniel
Alligator Energy
PO Box 338
Spring Hill QLD 4004

Dear Matt,

Alligator Energy Samphire Field Noise Monitoring
Nosie Propagation Modelling

We provide a summary of our modelling of noise propagation from the Samphire Field Recovery Trial.

Noise monitoring has previously been undertaken at the Mullaquana Homestead, as documented in Sonus Report S7888C2, dated December 2023. The previous monitoring campaign included background noise monitoring and an assessment noise during exploratory drilling that was occurring intermittently within the retention lease. The results of that assessment were impacted more by noise occurring at the homestead location than noise on the retention lease. There were times when noise levels at the homestead exceeded the environmental noise criteria from the site, but no occasions that a start or stop of activity on the lease was found to change noise levels at the house. As a result compliance with the noise criteria was found to have been achieved, but it was not straight forward to demonstrate.

Proposed Monitoring Approach

It is proposed that a new noise monitoring methodology is adopted for the upcoming recovery trial, which it is anticipated will simplify checking of compliance against the noise criteria. Rather than monitoring adjacent to loud intermittent noise sources at the Homestead, it is proposed that noise monitoring will be undertaken at the south west corner of the retention lease boundary where noise levels are far more likely to be controlled by recovery operations.

The proposed monitoring location at the corner of the retention lease boundary is in a similar direction to the homestead but only 600 m from the central plant area, rather than 3 km like the Mullaquana Homestead. As a result, operations noise levels will be much higher at the monitoring location than at the Homestead. Noise propagation modelling has been used to determine the difference in noise level between the retention lease boundary and homestead location, so that results at the monitoring location can be transferred to the Homestead.

Noise Modelling

In accordance with the *Guidelines for use of the Environment Protection (Commercial and Industrial Noise) Policy 2023*, predictions of the source noise levels for distances over 100 metres have been modelled using the Conservation of Clean Air and Water in Europe (CONCAWE) algorithms. The model takes into consideration:

- attenuation of noise source due to distance
- barrier effects from buildings, topography and the like
- air absorption
- ground effects
- weather conditions (wind speed, wind direction, time of day, and cloud cover)

CONCAWE has six different meteorological categories—CONCAWE meteorological category 1 represents weather conditions that are least conducive to noise propagation (best case situation with the lowest predicted noise levels),

CONCAWE meteorological category 4 represents neutral weather conditions, and CONCAWE meteorological category 6 represents weather conditions that are the most conducive to noise propagation (the worst case situation with the highest predicted noise levels).

In accordance with the *Guidelines for the use of the Environmental Protection (Commercial and Industrial Noise) Policy 2023*, CONCAWE meteorological category 5 has been used for day time noise emissions and CONCAWE meteorological category 6 has been used for night time noise emissions.

During the operational phase, noise sources are concentrated at the central plant location. For the purposes of the modelling we have included several 15 kW pumps and a truck moving at low speed at the central plant area, with the truck providing some low frequency content to the modelled sources.

Noise levels were predicted to both the proposed retention lease boundary location and the Mullaquana Homestead, and it was found that the noise level at the boundary monitoring location was 22 dB higher than at the Mullaquana Homestead, under both category 5 and category 6 conditions.

Resulting Noise Criteria at Boundary Location

Based on the above modelling result, compliance with the noise criteria at the Homestead will be achieved if a noise level 22 dB above the Homestead noise criteria is achieved at the south west boundary of the retention lease.

We are advised that a Rural Industry land use category is applicable for both source and receiver locations under the *SA Environment Projection (Commercial and Industrial Noise) Policy 2023* (the Noise Policy). This results in a night time noise limit of 50 dB(A), and day time noise limit of 57 dB(A) at the Homestead location.

Adjusting the above Homestead noise limits by 22 dB to determine the noise limits at the boundary monitoring location provides a night time limit of 72 dB(A), and daytime limit of 79 dB(A) at the boundary monitoring location. Achieving these limits at the boundary is predicted result in compliance with the requirements of the Noise Policy.

Please let me know if you have any queries or wish to discuss the above.

Yours sincerely,



Jon Cooper
Technical Director
p +61 8 8155 5888
m +61 407 605 692
jon.cooper@resonate-consultants.com

Appendix Q3: Alligator Energy Samphire Field Noise Monitoring Noise Propagation Modelling. Prepared by Resonate Consultants. July, 2025.

Tuesday, 22 July 2025

Project number: A250511
Reference: A250511LT1A

Matt Daniel
Alligator Energy
PO Box 338
Spring Hill QLD 4004

Dear Matt,

Alligator Energy Samphire Field Noise Monitoring
Nosie Propagation Modelling

We provide a summary of our modelling of noise propagation from the Samphire Field Recovery Trial.

Noise monitoring has previously been undertaken at the Mullaquana Homestead, as documented in Sonus Report S7888C2, dated December 2023. The previous monitoring campaign included background noise monitoring and an assessment noise during exploratory drilling that was occurring intermittently within the retention lease. The results of that assessment were impacted more by noise occurring at the homestead location than noise on the retention lease. There were times when noise levels at the homestead exceeded the environmental noise criteria from the site, but no occasions that a start or stop of activity on the lease was found to change noise levels at the house. As a result compliance with the noise criteria was found to have been achieved, but it was not straight forward to demonstrate.

1 Proposed Monitoring Approach

It is proposed that a new noise monitoring methodology is adopted for the upcoming recovery trial, which it is anticipated will simplify checking of compliance against the noise criteria. Rather than monitoring adjacent to loud intermittent noise sources at the Homestead, it is proposed that noise monitoring will be undertaken at the south west corner of the retention lease boundary where noise levels are far more likely to be controlled by recovery operations.

The proposed monitoring location at the corner of the retention lease boundary is in a similar direction to the homestead but only 600 m from the central plant area, rather than 3 km like the Mullaquana Homestead. As a result, operations noise levels will be much higher at the monitoring location than at the Homestead. Noise propagation modelling has been used to determine the difference in noise level between the retention lease boundary and homestead location, so that results at the monitoring location can be transferred to the Homestead.

2 Noise Modelling

In accordance with the *Guidelines for use of the Environment Protection (Commercial and Industrial Noise) Policy 2023*, predictions of the source noise levels for distances over 100 metres have been modelled using the Conservation of Clean Air and Water in Europe (CONCAWE) algorithms. The model takes into consideration:

- attenuation of noise source due to distance
- barrier effects from buildings, topography and the like
- air absorption
- ground effects
- weather conditions (wind speed, wind direction, time of day, and cloud cover).

CONCAWE has six different meteorological categories—CONCAWE meteorological category 1 represents weather conditions that are least conducive to noise propagation (best case situation with the lowest predicted noise levels), CONCAWE meteorological category 4 represents neutral weather conditions, and CONCAWE meteorological category 6 represents weather conditions that are the most conducive to noise propagation (the worst case situation with the highest predicted noise levels).

In accordance with the *Guidelines for the use of the Environmental Protection (Commercial and Industrial Noise) Policy 2023*, CONCAWE meteorological category 5 has been used for day time noise emissions and CONCAWE meteorological category 6 has been used for night time noise emissions.

During the operational phase, noise sources are concentrated at the central plant location. For the purposes of the modelling we have included several 15 kW pumps and a truck moving at low speed at the central plant area, with the truck providing some low frequency content to the modelled sources.

Noise levels were predicted to both the proposed retention lease boundary location and the Mullaquana Homestead, and it was found that the noise level at the boundary monitoring location was 22 dB higher than at the Mullaquana Homestead, under both category 5 and category 6 conditions.

3 Noise criteria at the Homestead location

Environmental noise emissions from the subject site should comply with the *Environment Protection (Commercial and Industrial Noise) Policy* 2023 (the Noise Policy).

The noise goals in the Noise Policy are based on the zoning of the development and the closest noise affected premises. The relevant land uses primarily promoted in the source and receiver noise designated areas are used to determine the environmental noise criteria. As per Clause 4 (5) of the Noise Policy, allocation of the noise designated area to a particular land use category are determined in accordance with the *Indicative noise factor guidelines for the Environment Protection (Commercial and industrial Noise) Policy 2023* (the Indicative noise factor guidelines).

We note that Clause 3 of the Noise Policy, provides the following definition for a noise designated area;

> ***noise designated area*** means an area to which the Planning and Design Code applies (whether described in the Code as a zone or subzone or otherwise) that is—
>
> (a) made subject to a set of land use rules by the provisions of the Code; and
>
> (b) not itself further divided by the Code into areas that are made subject to separate sets of land use rules;

We understand that the Mullaquana Station spans across the Remote Areas, Conservation, and Costal Waters and Offshore Islands Planning and Development Code zones. Although we note both the source location and the homestead receiver location are within the Remote Areas zone.

As per the definition of a noise designated area provided above, the receiver noise designated area must be an area ‘not itself further divided by the Code into areas that are made subject to separate sets of land use rules’. On this basis the noise designated area for neither the source nor the receiver locations is permitted to span across two or more zones. As both the homestead and the source location are in the Remote Areas zone, this zone is adopted for both the source and receiver noise designated areas.

Under the Indicative noise factor guidelines, the Indicative noise factors and so environmental noise criteria applicable for source and receiver in the Remote Areas zone is 57 dB(A) during the day and 49 dB(A) during the night. These criteria are applicable at the homestead location where people normally reside and work, rather than at the uninhabited mining lease boundary.

4 Resulting Criteria at Boundary Location

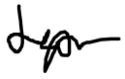
Based on the noise modelling result provided in Section 2, compliance with the noise criteria at the Homestead will be achieved if a noise level 22 dB above the Homestead noise criteria is achieved at the south west boundary of the retention lease.

Under the *SA Environment Projection (Commercial and Industrial Noise) Policy 2023* (the Noise Policy), a day time noise limit of 57 dB(A) and a night time noise limit of 49 dB(A) are applicable at the Homestead location.

Adjusting the above Homestead noise limits by 22 dB to determine the noise limits at the boundary monitoring location provides a daytime limit of 79 dB(A) and a night time limit of 71 dB(A) at the boundary monitoring location. Achieving these limits at the boundary is predicted to result in compliance with the requirements of the Noise Policy at the location of the Homestead.

Please let me know if you have any queries or wish to discuss the above.

Yours sincerely,



Jon Cooper
Technical Director
p +61 8 8155 5888
m +61 407 605 692
jon.cooper@resonate-consultants.com

Appendix R: Noise – Baseline Data

Appendix R: Samphire RL 137 - Baseline Noise Data

Baseline Noise Monitoring Data - Mullaquana Homestead

Time	Monitoring Point	Median LAeq, 15min	Lowest LAeq,15min	Highest LAeq,15min	No. Sampling Events/Points
Day (7am-10pm)	N1	45.64	18.00	84.00	11
Night (10pm-7am)	N1	25.56	17.00	58.00	9

Baseline Noise Monitoring Data - Mullaquana Homestead

Date	Lowest LAeq,15min	Median LAeq, 15min	Highest LAeq,15min	Time
14/09/2023	19.00	20.00	31.00	Night (10pm-7am)
14/09/2023	18.00	44.00	55.00	Day (7am-10pm)
15/09/2023	18.00	24.00	53.00	Night (10pm-7am)
15/09/2023	26.00	43.00	55.00	Day (7am-10pm)
16/09/2023	19.00	26.00	54.00	Night (10pm-7am)
16/09/2023	27.00	46.00	63.00	Day (7am-10pm)
17/09/2023	21.00	29.00	62.00	Night (10pm-7am)
17/09/2023	26.00	50.00	69.00	Day (7am-10pm)
18/09/2023	19.00	31.00	55.00	Night (10pm-7am)
18/09/2023	21.00	47.00	84.00	Day (7am-10pm)
19/09/2023	18.00	24.00	57.00	Night (10pm-7am)
19/09/2023	26.00	46.00	67.00	Day (7am-10pm)
20/09/2023	17.00	22.00	54.00	Night (10pm-7am)
20/09/2023	21.00	46.00	61.00	Day (7am-10pm)
21/09/2023	17.00	28.00	51.00	Night (10pm-7am)
21/09/2023	20.00	45.00	68.00	Day (7am-10pm)
22/09/2023	18.00	22.00	53.00	Night (10pm-7am)
22/09/2023	21.00	47.00	67.00	Day (7am-10pm)
23/09/2023	19.00	26.00	58.00	Night (10pm-7am)
23/09/2023	29.00	42.00	55.00	Day (7am-10pm)
24/09/2023	21.00	38.00	54.00	Night (10pm-7am)
24/09/2023	23.00	46.00	63.00	Day (7am-10pm)

Note:

- Noise levels were measured in accordance with the *Environment Protection (Commercial and Industrial Noise) Policy 2023 (SA)* using unattended logging instrumentation configured for 15-minute LAeq intervals.
- The monitoring site (N1) is located at the Mullaquana Homestead, representative of the nearest sensitive receptor to the project boundary.
- Values reflect ambient noise conditions with no confirmed project-related activity during the monitoring period.
- Day and night periods are defined as:

  Day: 7:00 am – 10:00 pm

  Night: 10:00 pm – 7:00 am

Source: Sonus Pty Ltd (2023), Acoustic Baseline Report – Samphire Project

Appendix S: Stakeholder Engagement Records

ALLIGATOR ENERGY – ENGAGEMENT REGISTER (SUMMARY)

Stakeholder Group/Name	Date	Purpose	Type of Communication
SA Government- Department of Energy and Mining (DEM)	9/06/2020	Update on Project/ exploration status	Telephone
SA Government- Department of Energy and Mining (DEM)	9/06/2020	Update on Project/ exploration status	Telephone
Local Government- Whyalla	10/06/2020	Update on Project/ exploration status	Virtual Engagement/ Virtual Room
Political - State Local MP	10/06/2020	Update on Project/ exploration status	Telephone
Political - Federal Local MP	10/06/2020	Update on Project/ exploration status	Telephone
Local Government- Whyalla	6/10/2020		
Political - State Local MP	21/10/2020	Update on Project/ exploration status	Face to Face Meeting
Landowner - Adjacent	5/09/2023	Update on Project/ exploration status	Telephone
Landowner - Adjacent	11/11/2024	To advise of damaged fence	Telephone
Landowner - Adjacent	16/08/2021	Update on Project/ exploration status	Telephone
Landowner - Immediate	14/01/2025	Update	Phone call
SA Government- Department of Energy and Mining (DEM)	10/12/2024	PEPR review meetings	Email
SA Government- Department of Energy and Mining (DEM)	26/11/2024	PEPR review meetings	Email
SA Government- Department of Energy and Mining (DEM)	13/11/2024	Update on FRT approval	Email
SA Government- Department of Energy and Mining (DEM)	12/11/2024	Update on FRT approval	Email
SA Government- Department of Energy and Mining (DEM)	4/11/2024	Update on FRT approval	Email
Landowner - Immediate	4/11/2024	Contacted about grading laneway fence in early to mid November	text
Landowner - Adjacent	30/10/2024	Installed dust samplers	in person
Landowner - Immediate	23/10/2024	Stock hazard management	Telephone
Landowner - Immediate	21/10/2024	called to ask on timeline for fence grading	telephone
Traditional Owners/ Native Title Parties- Barngarla Determination Aboriginal Corporation (BDAC)	30/09/2021	Site access and likely timing (Inform, involve and consult)	Face to Face Meeting
Landowner - Adjacent	21/10/2024	Text Message	Text
Landowner - Immediate	19/10/2024	access to reset enviro monitoring equipment	text

Stakeholder Group/Name	Date	Purpose	Type of Communication
Landowner - Immediate	18/10/2024	requesting to fence a rare plant, collect woody debris for rehab and fence/seed dam	text
Landowner - Adjacent	14/10/2021	Update on Project/ exploration status	Telephone
SA Government- Department of Energy and Mining (DEM)	9/10/2024	RL Approval	Teams Meeting
Landowner - Adjacent	25/10/2021	Update on Project/ exploration status	Face to Face Meeting
Landowner - Adjacent	25/10/2021	Update on Project/ exploration status	Face to Face Meeting
Landowner - Adjacent	26/10/2021	Setting up communication channels and processes	Face to Face Meeting
LAMS - Land Access & Management Services	7/10/2024	Land Access	Telephone
Landowner - Immediate	4/10/2024	RL compensation discussion	Face to Face Meeting
Landowner - Adjacent	15/11/2021	Site access and likely timing (Inform, involve and consult)	Telephone
Landowner - Immediate	27/09/2024	Update on Project/ exploration status	Face to Face Meeting
Landowner - Immediate	10/09/2024	Update on Project/ exploration status	Face to Face Meeting
Landowner - Immediate	10/09/2024	Update on Project/ exploration status	Telephone
Landowner - Immediate	4/09/2024		Telephone
SA Government- Department of Environment and Water (DEW)	28/08/2024	Update on Project/ exploration status	Email
SA Government- Environmental Protection Agency (EPA)	27/08/2024	Meeting request re RWMP and RMP - for RL	Email
Landowner - Adjacent	26/08/2024	Call to followuip on email sent on 21.08/24 as have hd no reply from the Joyce's	Phone Call
Landowner - Adjacent	21/08/2024	Email to formalise paymnet of fencing quote $68K in exchange for comittment to meet to discuss access.	Email
Landowner - Adjacent	15/02/2022	Social Impact Issue	Telephone
Landowner - Adjacent	16/08/2024		Telephone
SA Government- Department of Environment and Water (DEW)	16/08/2024	Update on Project/ exploration status	Email
SA Government- Department of Energy and Mining (DEM)	9/08/2024	Update on Project/ exploration status	Email
Landowner - Adjacent	2/08/2024	Environmental Issues/ queries	Face to Face Meeting

Stakeholder Group/Name	Date	Purpose	Type of Communication
Traditional Owners/ Native Title Parties- Barngarla Determination Aboriginal Corporation (BDAC)	18/03/2022	Community Consultation	Email
Landowner - Adjacent	25/03/2022	Update on Project/ exploration status	Face to Face Meeting
Landowner - Adjacent	31/03/2022	Update on Project/ exploration status	Telephone
Landowner - Adjacent	8/04/2022		
Landowner - Immediate	1/08/2024	Update on Project/ exploration status	Telephone
Landowner - Immediate	31/07/2024	Update on Project/ exploration status	Telephone
Traditional Owners/ Native Title Parties- BDAC lawyers (Norman Waterhouse)	8/05/2022	Organise site visit	Email
Landowner - Immediate	29/07/2024	Update on Project/ exploration status	Face to Face Meeting
Landowner - Immediate	29/07/2024	Update on Project/ exploration status	Face to Face Meeting
Landowner - Adjacent	1/06/2022	Setting up communication channels and processes	Face to Face Meeting
Landowner - Adjacent	1/06/2022	Setting up communication channels and processes	Face to Face Meeting
Landowner - Immediate	29/07/2024		Face to Face Meeting
SA Government- Department of Energy and Mining (DEM)	24/07/2024	Update on Project/ exploration status	Email
Local Government- Whyalla	22/07/2024	Update on Project/ exploration status	Email
Landowner - Adjacent	30/06/2024	Update on Project/ exploration status	Face to Face Meeting
Landowner - Immediate	28/06/2024	Update on Project/ exploration status	Email
Landowner - Immediate	26/06/2024	Update on Project/ exploration status	Email
Landowner - Immediate	26/06/2024	Update on Project/ exploration status	Email
Landowner - Immediate	20/06/2024	Update on Project/ exploration status	Telephone
Landowner - Immediate	16/06/2024	Update on Project/ exploration status	Telephone
Landowner - Adjacent	2/06/2024	Environmental Issues/ queries	Face to Face Meeting
Landowner - Adjacent	30/05/2024	Goods/ equipment purchase and/or quotes	Email

Stakeholder Group/Name	Date	Purpose	Type of Communication
Traditional Owners/ Native Title Parties- Barngarla Determination Aboriginal Corporation (BDAC)	11/07/2022	Heritage Survey	Email
Landowner - Adjacent	11/07/2022	Update on Project/ exploration status	Face to Face Meeting
Landowner - Adjacent	2/05/2024	Environmental Issues/ queries	Telephone
Landowner - Adjacent	12/07/2022	Setting up communication channels and processes	Telephone
Landowner - Adjacent	12/07/2022	Update on Project/ exploration status	Telephone
Landowner - Adjacent	19/07/2022	Update on Project/ exploration status	Face to Face Meeting
Internal Stakeholders- AGE Employees	21/07/2022	Update on Project/ exploration status	Letter
Landowner - Adjacent	14/03/2024	Government processes, queries and submissions	Email
Conference/Workshop	22/02/2024	Update on Project/ exploration status	Face to Face Meeting
Business and Industry- Service Providers (ie tyres, petrol, hardware, labour hire, equipment hire)	16/08/2022	Update on Project/ exploration status	Face to Face Meeting
SA Government- Department of Energy and Mining (DEM)	12/06/2024	Update on Project/ exploration status	Email
Landowner - Immediate	22/02/2024	Goods/ equipment purchase and/or quotes	Email
Traditional Owners/ Native Title Parties- Barngarla Determination Aboriginal Corporation (BDAC)	27/08/2022	Barngarla Determination Aboriginal Corporation (BDAC) Directors meeting – AGE presentation	Face to Face Meeting
Conference/Workshop	21/02/2024	Update on Project/ exploration status	Face to Face Meeting
Landowner - Immediate	20/02/2024	Update on Project/ exploration status	Face to Face Meeting
Landowner - Adjacent	16/02/2024	Environmental Issues/ queries	Face to Face Meeting
Landowner - Adjacent	11/11/2022		Face to Face Meeting
Landowner - Adjacent	14/02/2024	Update on Project/ exploration status	Email
Landowner - Adjacent	29/11/2022	Update on Project/ exploration status	Face to Face Meeting
Landowner - Adjacent	7/02/2024	Environmental Issues/ queries	Face to Face Meeting
Landowner - Immediate	6/02/2024	Update on Project/ exploration status	Face to Face Meeting
Landowner - Adjacent	26/01/2024	Environmental Issues/ queries	Face to Face Meeting
Local Government- Whyalla	30/11/2022	Update on Project/ exploration status	Face to Face Meeting
Business and Industry- Local Miners/ Explorers	30/11/2022	Update on Project/ exploration status	Face to Face Meeting

Stakeholder Group/Name	Date	Purpose	Type of Communication
Business and Industry- Tourism Industry Council of SA	29/11/2022	Update on Project/ exploration status	Face to Face Meeting
Local Government- Whyalla	29/11/2022	Update on Project/ exploration status	Face to Face Meeting
Business and Industry- Local Miners/ Explorers	29/11/2022	Update on Project/ exploration status	Face to Face Meeting
Landowner - Adjacent	25/01/2024	Environmental Issues/ queries	Face to Face Meeting
Landowner - Adjacent	2/12/2022	Update on Project/ exploration status	Email
Landowner - Adjacent	2/12/2022	Update on Project/ exploration status	Email
Landowner - Adjacent	24/01/2024	Environmental Issues/ queries	Face to Face Meeting
Landowner - Immediate	23/01/2024	Update on Project/ exploration status	Telephone
Landowner - Adjacent	23/01/2024	Environmental Issues/ queries	Face to Face Meeting
Traditional Owners/ Native Title Parties- Barngarla Determination Aboriginal Corporation (BDAC)	7/12/2022	Update on Project/ exploration status	Email
General Public	12/12/2022	Community Consultation	Community information meetings
Business and Industry- Service Providers (ie tyres, petrol, hardware, labour hire, equipment hire)	12/12/2022	Employment Opportunity	Face to Face Meeting
General Public	13/12/2022	Community Consultation	Community information meetings
Landowner - Adjacent	13/12/2022	Update on Project/ exploration status	Telephone
Landowner - Adjacent	19/01/2024	Update on Project/ exploration status	Face to Face Meeting
Landowner - Adjacent	12/01/2024	Update on Project/ exploration status	Telephone
SA Government - Infrastructure SA	15/12/2022	Update on Project/ exploration status	Web based meeting
Conference/Workshop	15/12/2023	Update on Project/ exploration status	Face to Face Meeting
Landowner - Adjacent	22/12/2022	Update on Project/ exploration status	Email
SA Government - Infrastructure SA	16/01/2023	Update on Project/ exploration status	Email
Political - Federal Local MP	17/02/2023	Update on Project/ exploration status	Email
SA Government - Infrastructure SA	23/01/2023	Update on Project/ exploration status	Email
SA Government - Infrastructure SA	23/01/2023	Update on Project/ exploration status	Email
Landowner - Adjacent	24/01/2023	Update on Project/ exploration status	Telephone

Stakeholder Group/Name	Date	Purpose	Type of Communication
Landowner - Adjacent	24/01/2023	Community Consultation	Telephone
SA Government - Infrastructure SA	31/01/2023	Followup from prior meeting	Telephone
Landowner - Adjacent	31/01/2023	Site access and likely timing (Inform, involve and consult)	Telephone
Political - State Local MP	31/01/2023	Update on Project/ exploration status	Face to Face Meeting
SA Government- Regional Natural Resource Management (NRM) - Eyre Penninsula Landscape Board	31/1/2023	Update on Project/ exploration status	Face to Face Meeting
SA Government- Regional Natural Resource Management (NRM) - Eyre Penninsula Landscape Board	2/01/2023	Environmental Issues/ queries	Email
Landowner - Immediate	15/12/2023	Update on Project/ exploration status	Face to Face Meeting
Conference/Workshop	14/12/2023	Update on Project/ exploration status	Face to Face Meeting
Landowner - Immediate	25/10/2023	Update on Project/ exploration status	Telephone
Landowner - Adjacent	29/09/2023	Update on Project/ exploration status	Telephone
General Public	31/01/2023	Community Consultation	Community information meetings
General Public	1/02/2023	Community Consultation	Community information meetings
Landowner - Adjacent	1/02/2023	Followup from prior meeting	Email
Landowner - Adjacent	2/02/2023	Feedback from Stakeholder	Telephone
Landowner - Adjacent	2/02/2023	Feedback from Stakeholder	Telephone
Landowner - Adjacent	2/02/2023	Feedback from Stakeholder	Telephone
SA Government- Regional Natural Resource Management (NRM) - Eyre Penninsula Landscape Board	7/02/2023	Followup from prior meeting	Email
Landowner - Adjacent	9/02/2023	Feedback from Stakeholder	Telephone
Landowner - Adjacent	14/02/2023	Followup from prior meeting	Email
Landowner - Adjacent	28/02/2023	Reponse to stakeholder query	Telephone
Landowner - Adjacent	29/09/2023	Goods/ equipment purchase and/or quotes	Email
Landowner - Adjacent	25/08/2023	Update on Project/ exploration status	Email
SA Government- Environmental Protection Agency (EPA)	1/03/2023	Update on Project/ exploration status	Face to Face Meeting
Landowner - Immediate	24/08/2023	Update on Project/ exploration status	Email
Landowner - Immediate	23/08/2023	Update on Project/ exploration status	Telephone

Stakeholder Group/Name	Date	Purpose	Type of Communication
Landowner - Immediate	23/08/2023	Update on Project/ exploration status	Email
Landowner - Adjacent	23/08/2023	Update on Project/ exploration status	Email
Landowner - Adjacent	23/08/2023	Update on Project/ exploration status	Email
Landowner - Adjacent	23/08/2023	Update on Project/ exploration status	Email
Landowner - Immediate	22/08/2023	Heritage Survey	Email
SA Government- Environmental Protection Agency (EPA)	26/04/2023	Update on Project/ exploration status	Email
SA Government- Department of Energy and Mining (DEM)	26/04/2023	Update on Project/ exploration status	Email
Local Government- Whyalla	27/04/2023	Update on Project/ exploration status	Email
Landowner - Immediate	22/08/2023	Heritage Survey	Telephone
Landowner - Immediate	22/08/2023	Heritage Survey	Telephone
Landowner - Immediate	15/08/2023	Update on Project/ exploration status	Telephone
Landowner - Immediate	15/07/2023	Update on Project/ exploration status	Telephone
Landowner - Adjacent	11/07/2023	Update on Project/ exploration status	Telephone
Landowner - Adjacent	13/06/2023	Update on Project/ exploration status	Email
Landowner - Immediate	2/07/2023	Update on Project/ exploration status	Face to Face Meeting
Landowner - Immediate	24/05/2023	Update on Project/ exploration status	Email
Landowner - Immediate	19/05/2023	Update on Project/ exploration status	Telephone
Landowner - Adjacent	28/07/2023	Update on Project/ exploration status	Face to Face Meeting
Landowner - Adjacent	14/08/2023	Update on Project/ exploration status	Telephone
Landowner - Adjacent	10/05/2023	Update on Project/ exploration status	Email
Traditional Owners/ Native Title Parties- Barngarla Determination Aboriginal Corporation (BDAC)	15/08/2023	Heritage Survey	Email
Landowner - Adjacent	10/05/2023	Update on Project/ exploration status	Email
Landowner - Immediate	10/05/2023	Update on Project/ exploration status	Face to Face Meeting
Landowner - Immediate	24/04/2023	Update on Project/ exploration status	Email
Landowner - Immediate	3/04/2023	Update on Project/ exploration status	Email

Stakeholder Group/Name	Date	Purpose	Type of Communication
Traditional Owners/ Native Title Parties- Barngarla Determination Aboriginal Corporation (BDAC)	23/08/2023	Update on Project/ exploration status	Email
Landowner - Immediate	31/03/2023	Update on Project/ exploration status	Email
Landowner - Immediate	31/03/2023	Update on Project/ exploration status	
Landowner - Immediate	29/03/2023	Update on Project/ exploration status	Face to Face Meeting
Landowner - Immediate	20/03/2023	Update on Project/ exploration status	Face to Face Meeting
Local Government- Whyalla	23/08/2023	Update on Project/ exploration status	Email
Business and Industry- Local Miners/ Explorers	24/08/2023	Update on Project/ exploration status	Email
Landowner - Adjacent	24/08/2023	Update on Project/ exploration status	Email
Business and Industry- Local Miners/ Explorers	24/08/2023	Update on Project/ exploration status	Email
Landowner - Immediate	14/03/2023	Update on Project/ exploration status	Telephone
Landowner - Immediate	28/02/2023	Update on Project/ exploration status	Telephone
Local Government- Whyalla	25.08.2023	Update on Project/ exploration status	Email
Local Community- Whyalla	27.08.2023	Update on Project/ exploration status	Face to Face Meeting
Traditional Owners/ Native Title Parties- Barngarla Determination Aboriginal Corporation (BDAC)	29.08.2023 30.08.2023	Heritage Survey	Face to Face Meeting
Landowner - Immediate	28/02/2023	Update on Project/ exploration status	Email
Conference/Workshop	1/02/2023	Update on Project/ exploration status	Face to Face Meeting
Landowner - Immediate	1/02/2023	Update on Project/ exploration status	Face to Face Meeting
Conference/Workshop	31/01/2023	Update on Project/ exploration status	Face to Face Meeting
Media- Local	30/11/2023	Update on Project/ exploration status	Email
Local Community- Whyalla	2/12/2023	Update on Project/ exploration status	Letter
Landowner - Adjacent	8/12/2023	Update on Project/ exploration status	Telephone
Media- Local	6/12/2023	Update on Project/ exploration status	Email
Media- Local	6/12/2023	Update on Project/ exploration status	Email
Media- Local	7/12/2023	Update on Project/ exploration status	Email
Media- Local	12/12/2023	Update on Project/ exploration status	Email

Stakeholder Group/Name	Date	Purpose	Type of Communication
Media- Local	12/12/2023	Update on Project/ exploration status	Email
Local Community- Whyalla	14/12/2023 15/12/2023	Update on Project/ exploration status	Face to Face Meeting
Landowner - Immediate	1/01/2023	Update on Project/ exploration status	Email
Landowner - Immediate	24/12/2022	Update on Project/ exploration status	Telephone
Landowner - Immediate	23/12/2022	Update on Project/ exploration status	Telephone
Landowner - Immediate	19/12/2022	Update on Project/ exploration status	Telephone
Local Community- Cowell	12/01/2024	Update on Project/ exploration status	Letter
Local Government- Whyalla		Update on Project/ exploration status	Letter
Landowner - Immediate	13/12/2022	Update on Project/ exploration status	Telephone
Landowner - Immediate	13/12/2022	Update on Project/ exploration status	Telephone
Landowner - Immediate	2/12/2022	Reponse to stakeholder query	Telephone
Landowner - Immediate	2/12/2022	Reponse to stakeholder query	Telephone
Landowner - Immediate	2/12/2022	Update on Project/ exploration status	Email
Landowner - Immediate	2/12/2022	Reponse to stakeholder query	Telephone
Landowner - Immediate	2/12/2022	Reponse to stakeholder query	Telephone
Landowner - Immediate	29/11/2022	Update on Project/ exploration status	Face to Face Meeting
Landowner - Adjacent	6/02/2024	Environmental Issues/ queries	Face to Face Meeting
Landowner - Immediate	29/11/2022	Update on Project/ exploration status	Face to Face Meeting
Landowner - Immediate	28/11/2022	Setting up communication channels and processes	Telephone
Landowner - Immediate	29/09/2022	PEPR status and updates	Email
Local Community- Whyalla	8/02/2024	Update on Project/ exploration status	Social Media (ie Twitter, Facebook)
Landowner - Immediate	5/09/2022		Telephone
Local Community- Whyalla	15/02/2024	Update on Project/ exploration status	Social Media (ie Twitter, Facebook)
Landowner - Immediate	5/09/2022	Project impacts and benefits to the community- delivery of information	Letter
Landowner - Immediate	25/08/2022	Project impacts and benefits to the community- delivery of information	Telephone
Local Community- Whyalla	21/02/2024	Update on Project/ exploration status	Face to Face Meeting
Local Community- Whyalla	22/02/2024	Update on Project/ exploration status	Face to Face Meeting
Local Community- Whyalla	23/02/2024	Update on Project/ exploration status	Email

Stakeholder Group/Name	Date	Purpose	Type of Communication
	29/02/2024	Environmental Issues/ queries	Telephone
Landowner - Immediate	16/08/2022	Update on Project/ exploration status	Face to Face Meeting
Landowner - Immediate	22/07/2022	Disturbance and minimisation plan (Inform, involve and consult)	Electronic Direct mail (EDM)
Landowner - Immediate	11/07/2022	Update on Project/ exploration status	Face to Face Meeting
Local Community- Whyalla	7/03/2024	Update on Project/ exploration status	Email
Local Community- Whyalla	7/03/2024	Update on Project/ exploration status	Email
	7/03/2024	Update on Project/ exploration status	Email
Landowner - Immediate	8/07/2022	Project impacts and benefits to the community- delivery of information	Face to Face Meeting
Interest Groups	13/06/2024	Update on Project/ exploration status	Face to Face Meeting
Business and Industry- Local Miners/ Explorers	13/06/2024	Update on Project/ exploration status	Face to Face Meeting
Interest Groups	13/06/2024	Update on Project/ exploration status	Face to Face Meeting
Landowner - Immediate	6/07/2022	Update on Rehabilitation and/or Rehab approach	Face to Face Meeting
Landowner - Immediate	6/07/2022	Accounting/ payment issues	Email
Interest Groups	16/06/2024	Update on Project/ exploration status	Telephone
Landowner - Immediate	6/07/2022	Heritage Survey	Email
Landowner - Immediate	5/07/2022	Update on Project/ exploration status	Face to Face Meeting
Landowner - Immediate	4/07/2022	Site access and likely timing (Inform, involve and consult)	Telephone
Local Community- Cowleds Landing	27/06/2024	Update on Project/ exploration status	Email
Landowner - Immediate	24/06/2022	Site access and likely timing (Inform, involve and consult)	Telephone
Landowner - Immediate	24/06/2022	Site access and likely timing (Inform, involve and consult)	Telephone
Local Government- Whyalla	22/07/2024	Update on Project/ exploration status	Face to Face Meeting
Landowner - Immediate	17/06/2022	Update on Project/ exploration status	Email
Landowner - Immediate	16/06/2022	Site access and likely timing (Inform, involve and consult)	Telephone

Stakeholder Group/Name	Date	Purpose	Type of Communication
Landowner - Immediate	15/06/2022	Site access and likely timing (Inform, involve and consult)	Telephone
Landowner - Immediate	31/05/2022	Site access and likely timing (Inform, involve and consult)	Telephone
Landowner - Immediate	31/05/2022	Site access and likely timing (Inform, involve and consult)	Face to Face Meeting
Landowner - Immediate	20/04/2022	Update on Rehabilitation and/or Rehab approach	Telephone
Landowner - Immediate	10/04/2022	Update on Rehabilitation and/or Rehab approach	Face to Face Meeting
Landowner - Immediate	18/02/2022	PEPR status and updates	Email
Landowner - Immediate	17/02/2022	Update on Project/ exploration status	Face to Face Meeting
Landowner - Immediate	17/02/2022	Onsite conversation.	Face to Face Meeting
Landowner - Immediate	17/02/2022	Site access and likely timing (Inform, involve and consult)	Telephone
Landowner - Immediate	13/02/2022	Site access and likely timing (Inform, involve and consult)	Telephone
Landowner - Immediate	8/02/2022	Organise site visit	Face to Face Meeting
Landowner - Immediate	5/01/2022	Update on Project/ exploration status	Letter
Landowner - Immediate	9/12/2021	Update on Project/ exploration status	Telephone
Landowner - Immediate	8/12/2021	Update on Project/ exploration status	Telephone
Landowner - Immediate	18/11/2021	Feedback from Stakeholder	Face to Face Meeting
Landowner - Immediate	15/11/2021	Site access and likely timing (Inform, involve and consult)	Telephone
Landowner - Immediate	3/11/2021	Site access and likely timing (Inform, involve and consult)	Face to Face Meeting
Landowner - Immediate	25/10/2021	Site access and likely timing (Inform, involve and consult)	Telephone
Landowner - Immediate	14/10/2021	Update on Project/ exploration status	Telephone
Landowner - Immediate	12/10/2021	Site access and likely timing (Inform, involve and consult)	Email
Landowner - Immediate	5/10/2021	Site access and likely timing (Inform, involve and consult)	Telephone
Landowner - Immediate	23/09/2021	Site access and likely timing (Inform, involve and consult)	Telephone
Landowner - Immediate	12/09/2021	Setting up communication channels and processes	Telephone
Landowner - Immediate	27/08/2021	Site access and likely timing (Inform, involve and consult)	Email
Landowner - Immediate	16/08/2021	Update on Project/ exploration status	Telephone
Landowner - Immediate	9/01/2021	Update on Project/ exploration status	Telephone

Stakeholder Group/Name	Date	Purpose	Type of Communication
Business and Industry- Service Providers (ie tyres, petrol, hardware, labour hire, equipment hire)	21/10/2020	Setting up communication channels and processes	Face to Face Meeting
SA Government- Department of Energy and Mining (DEM)	10/02/2025	Government processes, queries and submissions	Telephone
Landowner - Immediate	11/02/2025		Telephone
Landowner - Immediate	3/03/2025		Telephone
Landowner - Immediate	1/03/2025		Telephone
Landowner - Immediate	5/03/2025		Telephone
Local Community- Whyalla	8/01/2025	Update on Project/ exploration status	Social Media (ie Twitter, Facebook)
Political - Federal Local MP	20/11/2024	Update on Project/ exploration status	Email
Political - Federal Local MP	15/01/2025	Update on Project/ exploration status	Email
Political - Federal Local MP	29/01/2025	Update on Project/ exploration status	Email
Political - Federal Local MP	14/02/205	Update on Project/ exploration status	Meeting
Local Community- Whyalla	5/02/2025	Update on Project/ exploration status	Face to Face Meeting
Local Community- Whyalla	6/02/2025	Update on Project/ exploration status	Face to Face Meeting
Local Agencies- State Emergency Service	5/02/2025	Update on Project/ exploration status	Face to Face Meeting
Local Community- Whyalla	26/01/2025	Update on Project/ exploration status	Face to Face Meeting
Local Community- Whyalla	12/12/2024	Environmental Issues/ queries	Face to Face Meeting

Appendix T: Internal Management Plans



Alligator Energy

Spill Management Plan – Samphire FRT

Document No: CE_SAM_MP_Spill Management Plan v2

Contents

1 Introduction 6
1.1 Purpose and Scope 6
1.2 Key Objectives 6
1.3 Supporting Documents and References 6
2 Responsibilities 8
2.1 FRT Site Supervisor / Manager 8
2.2 Radiation Safety Officer / Environmental Advisor 8
2.3 Operators and Field Staff 8
2.4 Contractors 9
3 Spill Prevention and Readiness 10
3.1 Infrastructure Controls 10
3.2 Fuel & Reagent Storage Areas 13
3.3 Operational Practices 13
3.4 Spill Kits and SDS Access 13
3.5 Training and Competency 14
3.6 Risk Assessment and Hazard Identification 14
4 Spill Classification 16
4.1 Volume 16
4.2 Type 16
4.3 Location 17
5 Spill Response Procedure 19
5.1 Immediate Response Actions 19
5.1.1 Situation Assessment and Alarm Raising 19
5.1.2 Personnel Assistance 19
5.1.3 Initial Containment and Area Security 19
5.2 Spill Material Identification and Hazard Control 19
5.2.1 Material Confirmation 19
5.2.2 PPE Selection and Use 20

5.3 Incident Recording and Severity Assessment 20
5.4 Containment, Clean-up, and Waste Handling 20
5.4.1 Spill Containment and Recovery 20
5.4.2 Excavation of Contaminated Soils 20
5.4.3 Waste Management 21
5.5 Site Remediation and Verification 21
5.5.1 Radiological Spill Remediation 21
5.5.2 Chemical Spill Remediation 21
5.5.3 Soil Replacement and Stabilisation 22
6 Reporting and Documentation 23
6.1 Internal Reporting via DoneSafe 23
6.2 External Notifications 23
6.3 Spill Reporting and Disposal Form 25
6.4 Record Keeping Requirements 25
7 Post Incident Review and Improvement 26
7.1 Toolbox Review and Lessons Learnt 26
7.2 Procedure Updates and Change Control 26
8 Inspections and Audits 28
8.1 Spill Kit and SDS Register Checks 28
8.2 Infrastructure and Storage Reviews 28
8.3 Audit Readiness and Compliance Evidence 29
Appendix A: Acronyms and Definitions 31
Appendix B: Spill Response Flowchart 33
Appendix C: Spill Reporting and Disposal Management Form Example 35
Appendix D: Spill Kit Inspection Checklist 38

List of Figures

Figure 1 - Layout of Processing Plant..... 12
Figure 2 - Samphire FRT – Location of Key Infrastructure Areas 18
Figure 3 - Samphire FRT – Approved Vegetation Impact Area **Error! Bookmark not defined.**

List of Tables

Table 1 - Reagent Storage Details 13
Table 2 - Spill Classification by Volume & Response Summary 16
Table 3 – Material Type & Risk and Primary Response Summary 16
Table 4 – Example PPE Requirements by Material Type 20
Table 5 - Material-Specific Disposal Guidance 21
Table 6 - Regulatory Reporting & Recording Triggers and Timeframes 23
Table 7 - Post Incident Review: Action Categories and Leads 26
Table 8 - Inspection and Review Responsibilities 28

Document Control

Rev	Description	Date	Author	Approver
1	Initial document	25/3/2025	M Daniel, K Levingstone	Andrea Marsland-Smith
2	Updated for PEPR	18/06/2025	M Daniel, K Levingstone	Andrea Marsland-Smith

1 Introduction

1.1 Purpose and Scope

This Spill Management Plan (SMP) outlines the framework for preventing, responding to, remediating, and reporting spills during the Samphire Field Recovery Trial (FRT). It applies to all Alligator Energy personnel, contractors, and visitors undertaking work on the Samphire Retention Lease (RL) site during construction, operations and decommissioning phases.

This plan covers spills involving both hazardous and non-hazardous substances, including uranium-bearing process fluids, lixiviants, sulphuric acid, hydrogen peroxide, hydrocarbons, industrial chemicals, raw water, saline water, and wastewater. While raw water is not classified as a hazardous chemical under relevant legislation, its elevated salinity presents a risk of localised environmental impacts. Accordingly, spills involving raw or saline water are managed under the scope of this Plan.

This SMP is to be implemented in conjunction with the Samphire Program for Environment Protection and Rehabilitation (PEPR), Samphire FRT Radiation Management Plan (RMP), Alligator Energy Emergency Management Plan (EMP), and the Alligator Energy Incident Management and Reporting Procedure (IMRP).

Where a spill has the potential to cause harm to human health, result in an offsite release, breach environmental compliance limits, or trigger significant reputational impact or stakeholder concern, it must be escalated in accordance with the EMP In such cases, this plan continues to apply in support of the site's broader emergency response framework but does not override the EMP's command structure or escalation pathways.

1.2 Key Objectives

The key objectives of this plan are to:

- Minimise the risk of environmental harm from chemical, radiological, or other material spills (including non-hazardous discharges such as raw water) through preventative controls.
- Provide structured response procedures for rapid containment, clean-up, and remediation of spills.
- Maintain compliance with all project approval commitments, and regulatory conditions.
- Ensure internal incident reporting and regulatory notification obligations are met.
- Facilitate environmental monitoring, soil assessments and data collection to validate spill remediation.
- Integrate baseline environmental data and ensure post-remediation conditions meet approved closure criteria.

1.3 Supporting Documents and References

Document / Reference	
PEPR – Samphire (v1.0)	Alligator Energy, 2025.
Radiation Management Plan – Samphire (v1.0)	Alligator Energy, 2025.
Emergency Management Plan – Samphire	Alligator Energy, 2025.
Health, Safety and Wellbeing Management Plan (WSWMP)	Alligator Energy, 2025.
Mining Act 1971 (SA)	
Mining Regulations 2020 (SA)	
Bachmann Reporting Criteria	

Document / Reference
Radiation Protection and Control Act 2021 (SA)
Environment Protection Act 1993 (SA)
EPA Guideline 080/16 – Bunding and Spill Management
Work Health and Safety Act 2012 (SA) and WHS Regulations 2012 (SA)
EPA Guideline 080/16 – Bunding and Spill Management
AS1940: Storage and Handling of Flammable and Combustible Liquids

2 Responsibilities

2.1 FRT Site Supervisor / Manager

The FRT Site Supervisor / Manager has overarching responsibility for:

- Ensuring spill response readiness at all times, including inspections of spill kits and containment infrastructure.
- Initiating and coordinating spill response activities, including deployment of personnel and engagement with the Radiation Safety Officer (RSO) or Environmental Advisor, as required.
- Overseeing containment, clean-up and remediation activities in accordance with this plan, the PEPR, RMP and the EMP.
- Ensuring compliance with PEPR and RMP
- Ensuring incident reporting and regulatory notifications are completed within required timeframes.
- Authorising excavation or disposal of contaminated material, following consultation with the Environmental Advisor / RSO or delegate.
- Maintaining record-keeping and evidence to demonstrate compliance with PEPR and RL conditions.

2.2 Radiation Safety Officer / Environmental Advisor

The duty RSO and/or Environmental Advisors are responsible for the technical direction and oversight for spills involving radiologically contaminated material or hazardous chemicals respectively.

Responsibilities include:

- Confirming appropriate personal protective equipment (PPE) and decontamination procedures are followed for spills involving uranium-bearing solutions or radioactive process fluids.
- Ensuring spill sites are assessed and where required radiological monitoring is undertaken.
- Determining disposal and remediation requirements for materials impacted by radiological or chemical / hydrocarbon substances, in accordance with the RMP and PEPR.
- Approving final clearance of affected areas, using radiation monitoring equipment and baseline comparison data.
- Advising on appropriate waste handling pathways (e.g. disposal to a licensed low-level radioactive waste facility).
- Participating in incident investigations and contributing to environmental compliance reporting.
- Reviewing the incident and spill register
- Verifying radiation clearance for decontaminated areas, vehicles, and materials post-spill.

2.3 Operators and Field Staff

All field staff, including wellfield technicians and plant operators, are responsible for:

- Following approved procedures for handling, storage, and transfer of hazardous materials.
- Using PPE and spill response tools as required under site safety instructions and Safety Data Sheet (SDS) guidance.
- Immediately reporting spills or suspected leaks to the FRT Site Supervisor / Manager.
- Assisting with initial containment where safe to do so, including shutting down equipment, using spill kits, and erecting barriers.
- Tagging and isolating faulty equipment to prevent recurrence.
- Participating in spill response training and toolbox debriefs after incidents.

2.4 Contractors

Contractors must comply with all site-specific procedures, including this Spill Management Plan.

Responsibilities include:

- Induction and task-specific training covering chemical handling, PPE requirements and emergency response protocols.
- Maintaining control of their equipment and work areas to prevent accidental releases of fuel, hydraulic fluids, or chemicals.
- Immediately reporting any incidents or near misses to the FRT Site Supervisor / Manager or delegate.
- Cooperating fully with spill response and clean-up activities, including following direction from authorised Alligator Energy personnel.
- Providing evidence of licensing and competency, where applicable, for handling dangerous goods.

3 Spill Prevention and Readiness

3.1 Infrastructure Controls

Spill prevention infrastructure at the Samphire FRT has been designed to isolate, contain and manage potential discharges of process fluids, reagents, and hydrocarbons. The site incorporates engineered containment features in accordance with EPA Guideline 080/16, PEPR Section 4.4, and project-specific bunding standards.

Figure 1 provides an annotated plan of the pilot process plant, highlighting key containment zones, bunded areas, chemical storage locations, and spill control infrastructure. This drawing supports regulatory alignment and clearly distinguishes between production and non-production areas for the purpose of containment classification.

Bunded Chemical and Process Storage

- All bulk liquid reagents (including sulphuric acid, hydrogen peroxide, and ferric sulphate) are stored within impermeable HDPE-lined bunds, designed to contain a minimum of 110% of the largest vessel volume.
- The Acid Containment Bund and Hazardous Chemicals Storage Area have been designed with sufficient freeboard to accommodate rainfall events without overtopping, in accordance with project-specific stormwater and containment requirements.
- Bunds are delineated by compacted earth walls & HDPE liner, with no direct drainage to the environment.
- Refer to Figure 1: Acid Bund, Ferric Sulphate Bund, Hydrogen Peroxide Storage Area.

Process Area Drainage and Containment

- The reagent and IX processing area features sloped floors that direct any spills towards collection sumps and lined containment zones.
- Sump pumps are installed to enable controlled recovery and prevent accumulation of process fluids.
- Key spill capture points are marked in Figure 1 (e.g. PL-504 Pump Skid, Spillage Containment Sump, Manifold/Transfer Zone).

Tanker Unloading and Refuelling Areas

- Unloading of water and reagents (e.g. Water Delivery Tanker) is restricted to designated hardstand zones fitted with bunded containment and spill trays.
- Fuel storage (Diesel Tank) is isolated within its own dedicated bunded area and monitored for leaks.
- Refuelling of mobile plant is only conducted under supervision and over impervious surfaces.

Spill Segregation and Traffic Management

- Trafficable areas and reagent transfer zones are clearly delineated in the site layout to separate chemical handling from routine vehicle movements.
- The site includes multiple personnel egress mats and controlled access to bunded zones.
- Spill kit stations are located at key points (not shown on the drawing), including the Wellfield Hut and Control Room.

Containment and Infrastructure Integrity

- All bunded areas, storage tanks (e.g. IK-401 to IK-412), and reagent pipelines are subject to inspection and maintenance in accordance with PEPR and this procedure.

- The spillage containment sump area (refer Figure 1, lower right) is designed as a terminal containment point for any uncontained process fluid releases, providing a critical barrier before environmental exposure.

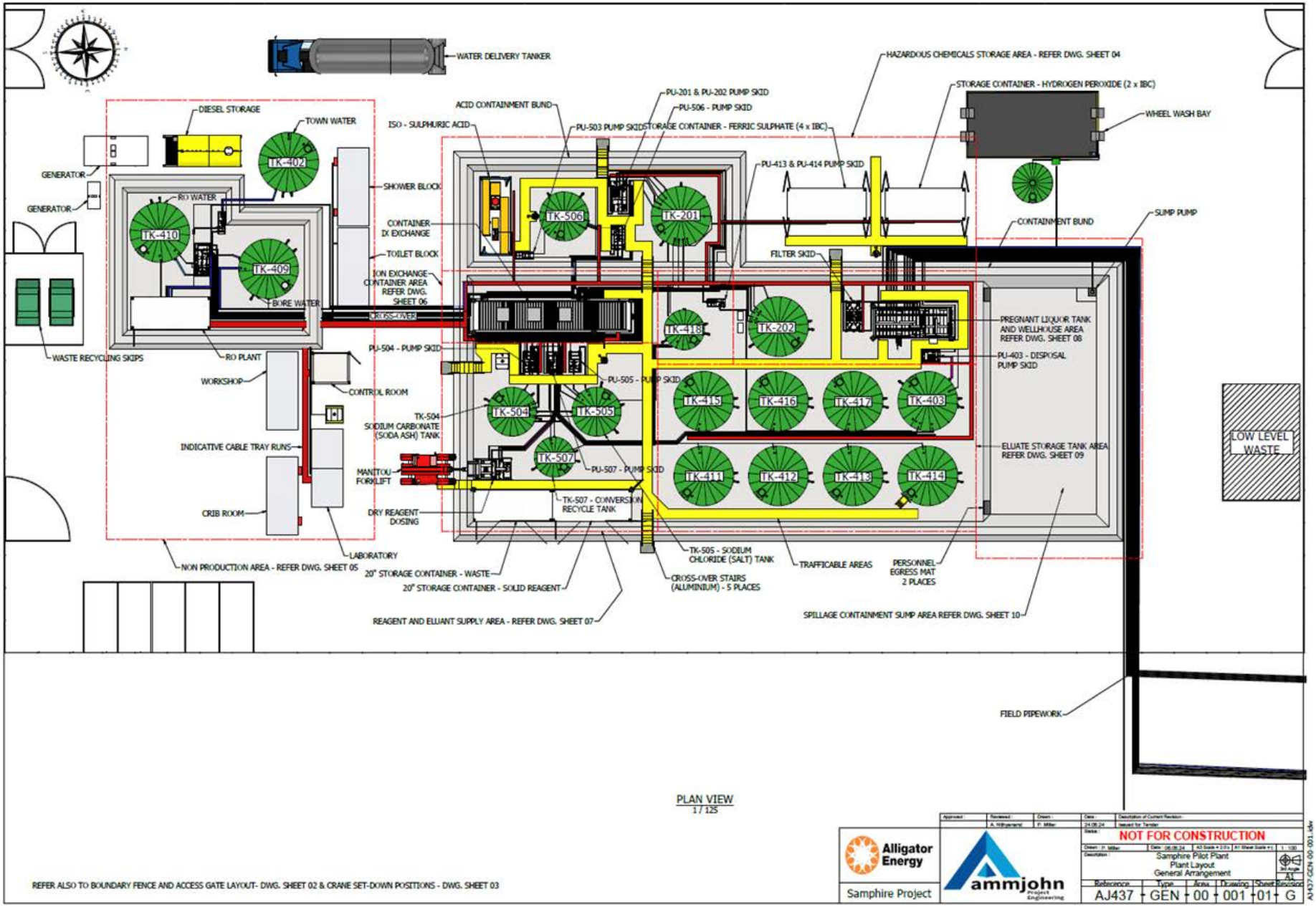


Figure 1 - Layout of Processing Plant

3.2 Fuel & Reagent Storage Areas

As detailed in Section 4.8 of the PEPR, a number of reagents and fuels are stored within the FRT operational area to support the field trial. These are detailed in Table 1 below.

Table 1: Reagent Storage Details

Chemical/Fuel	Storage Vessel	Location
Sulphuric Acid (H_2SO_4) 98% w/v	Self-bunded stainless steel Class-8 ISO tank.	Process Plant Area
Sodium Carbonate (Na2CO3)	Bulk bag in 20' container (1T)	Process Plant Area
Sodium Chloride (NaCl)	Bulk bag in 20' container (1T)	Process Plant Area
Ferric Sulphate $Fe_2(SO4)_3$ 42% w/v	Plastic, rigid, IBC (1,000 L).	Process Plant Area
Hydrogen peroxide	Plastic, rigid, IBC (1,000 L).	Process Plant Area
Diesel	Mobile self-bunded diesel tank (10,000L)	Process Plant Area

3.3 Operational Practices

Procedural spill prevention measures include:

Supervised Chemical Handling and Refuelling:

- All refuelling of generators or mobile plant must be attended at all times.
- Transfer of process fluids or reagents must follow pre-start checks, with a spill kit in close proximity.

Plant and Equipment Inspections:

- Daily pre-starts and routine inspections target hoses, tanks, seals, and valves for wear or leakage.
- Any plant found to be leaking is immediately shut down, tagged out, and reported.

Maintenance on Impervious Surfaces:

- Any equipment servicing must occur on hardstands or over drip trays.
- Waste oils and filters are collected in sealed containers and stored in bunded waste areas.

Securing Hazardous Goods:

- All IBCs, drums, and portable fuel containers must be stored upright with intact lids and secondary containment.
- Incompatible chemicals (oxidisers and organics) are segregated.

3.4 Spill Kits and SDS Access

Spill Kit Location and Contents:

- Spill kits are strategically located throughout the FRT including:
    - Reagent unloading areas
    - Processing plant entrances
    - Wellfield control hut
    - Mobile refuelling vehicles
- Kits include absorbent pads, booms, neutralisers (for acid/alkali), PPE, and disposal bags.
- Inspections shall be conducted by the FRT Site Supervisor / Manager; items are restocked as required.

Safety Data Sheets (SDS):

- SDS for all hazardous materials onsite are maintained in hard copy at the site office and process control room.
- Electronic copies are available via DoneSafe safety management system for reference during incidents.
- SDSs are used to determine PPE, containment methods, and decontamination steps in a spill response.

3.5 Training and Competency

All personnel involved in FRT activities must be trained to prevent, identify, and respond to spill incidents.

Spill Awareness and Response Training:

- Inductions cover spill classification, PPE requirements, and reporting protocols.
- Refresher training or toolbox talks are delivered quarterly or after any spill event.

Role-Specific Training:

- FRT Site Supervisor / Manager and Radiation/Environmental Advisors receive detailed training on incident coordination and regulatory reporting.
- Operators receive hands-on training with spill kits, chemical compatibility awareness, and emergency shutdown systems.

Emergency Response Drills:

- A spill response drill shall be conducted prior to the start of the FRT to simulate realistic scenarios (chemical and radiological).
- Outcomes reviewed for continuous improvement.

3.6 Risk Assessment and Hazard Identification

As part of Alligator Energy's commitment to proactive environmental management at the Samphire FRT, risk assessments must be conducted to minimise the likelihood and severity of potential spill events, and to manage the potential impacts to workers or the environment following any spill events during associated spill containment and cleanup.

Risk assessments, either standalone or as part of a standard work instruction/procedure must be completed for:

- Pre-mobilisation works, construction activities and chemical deliveries.
- High-risk tasks such as bulk reagent transfers, acid handling, and fuel unloading.
- Wellfield activities involving lixiviant, barren/pregnant solutions, or IX operations.
- Design and modification of containment infrastructure (e.g. bunds, pipelines).
- Significant changes to reagent type, equipment, or process flow.

Risk assessment processes must consider:

- Nature of the material involved (radiological, corrosive, flammable).
- Proximity to environmental receptors (e.g. groundwater, surface drainage, vegetation).
- Worker exposure potential (chemical or radiation).
- SDS requirements (where relevant).
- Volume scenarios and escalation potential.
- Potential reputational, community or compliance impacts.

These assessments inform:

- Nature and order of tasks.
- PPE requirements.
- Spill kit placement and content.
- Operator training and certification requirements.
- Incident response planning and inspection focus areas.

Completed risk assessments must be retained on DoneSafe and reviewed periodically or following any significant operational change.

4 Spill Classification

Spills at the Samphire FRT are classified for internal management purposes based on the spill volume, material type, and location. This classification system informs the immediate response, resource deployment, and risk profile.

Spill classification should be made by or confirmed with the RSO/Environmental Advisor.

4.1 Volume

Volume is recorded to guide internal escalation, clean-up planning and documentation. The following categories support site-level decision-making and resourcing.

Table 2 - Spill Classification by Volume & Response Summary

Spill Type	Volume Range	Examples	Internal Response
Minor	< 5 L	Diesel drip inside bund, reagent splash	Local clean-up, DoneSafe record, unless outside secondary containment.
Moderate	5–20 L	Bunded chemical leak, small acid spill	Supervisor-led response, minimum DoneSafe entry if within secondary containment.
Severe	> 20 L or uncontrolled	Process fluid pipeline rupture, fuel tank breach	Full response, internal investigation

Note: Any volume of radioactive or hazardous material that enters unsealed ground or could migrate beyond containment is classified as severe and must be escalated accordingly.

4.2 Type

Different spill types carry distinct potential environmental and health risks, requiring specific control and clean-up procedures. These risks are directly tied to the FRT's process design and reagent inventory, as detailed in PEPR Section 4.5 (Table 4.1) and the Radiation Management Plan.

Table 3 – Material Type & Risk and Primary Response Summary

Material Type	Key Risks	Primary Response Considerations
Diesel / Hydrocarbons	Soil contamination, flammability	- Immediate use of spill kit absorbents, containment booms, offsite disposal.
Sulphuric Acid (H_2SO_4)	Corrosive to skin and soil, pH alteration	- Immediate equipment isolation, spill or release containment, specialist assessment under full PPE, lime neutralisation, secure disposal.
Hydrogen Peroxide (H_2O_2)	Oxidising, reacts violently with organics	- Immediate equipment isolation, spill or release containment. - Avoid reactive materials, isolate spill, flush and neutralise.
Uranium-bearing Process Fluids - Barren Lixiviant	Radiological exposure, groundwater contamination	- Immediate equipment isolation, fluid recovery, spill containment. - RSO oversight, immediate soil penetration (depth) and extent logging, fluid characterisation, radiation assessment, material removal for offsite disposal.

Material Type	Key Risks	Primary Response Considerations
- Pregnant Lixiviant		
RO Brine Raw Water	Soil contamination.	- Spill containment. - Immediate spill extent and penetration logging. - Soil excavation.

The presence of radionuclides in process fluids where spills occur outside primary containment, warrants immediate involvement of the RSO for assessment.

4.3 Location

The physical location of a spill is a critical determinant of its potential environmental impact, radiological exposure risk, and regulatory consequence.

Spills are assessed relative to being:

1. Within primary containment (e.g., HDPE lined areas or sumps) (Figure 1).
2. Outside primary containment (if present) but within secondary containment (e.g., perimeter earthen berms around well arrays, connecting pipework corridors and the process plant area and footprint of exploration works) (Figure 2).
3. Outside any primary or secondary containment (where present) but within the approved (maximum) disturbance footprint – as indicated by the operational vegetation clearance footprint (Figure 2).
4. Outside the approved (maximum) vegetation disturbance footprint (Figure 2).

Spills occurring outside or breaching secondary bunds or outside the approved disturbance footprint, must be escalated for immediate regulatory assessment and review by the Environment Advisor / RSO as these incidents may typically trigger external regulatory reporting regardless of the spill volume.

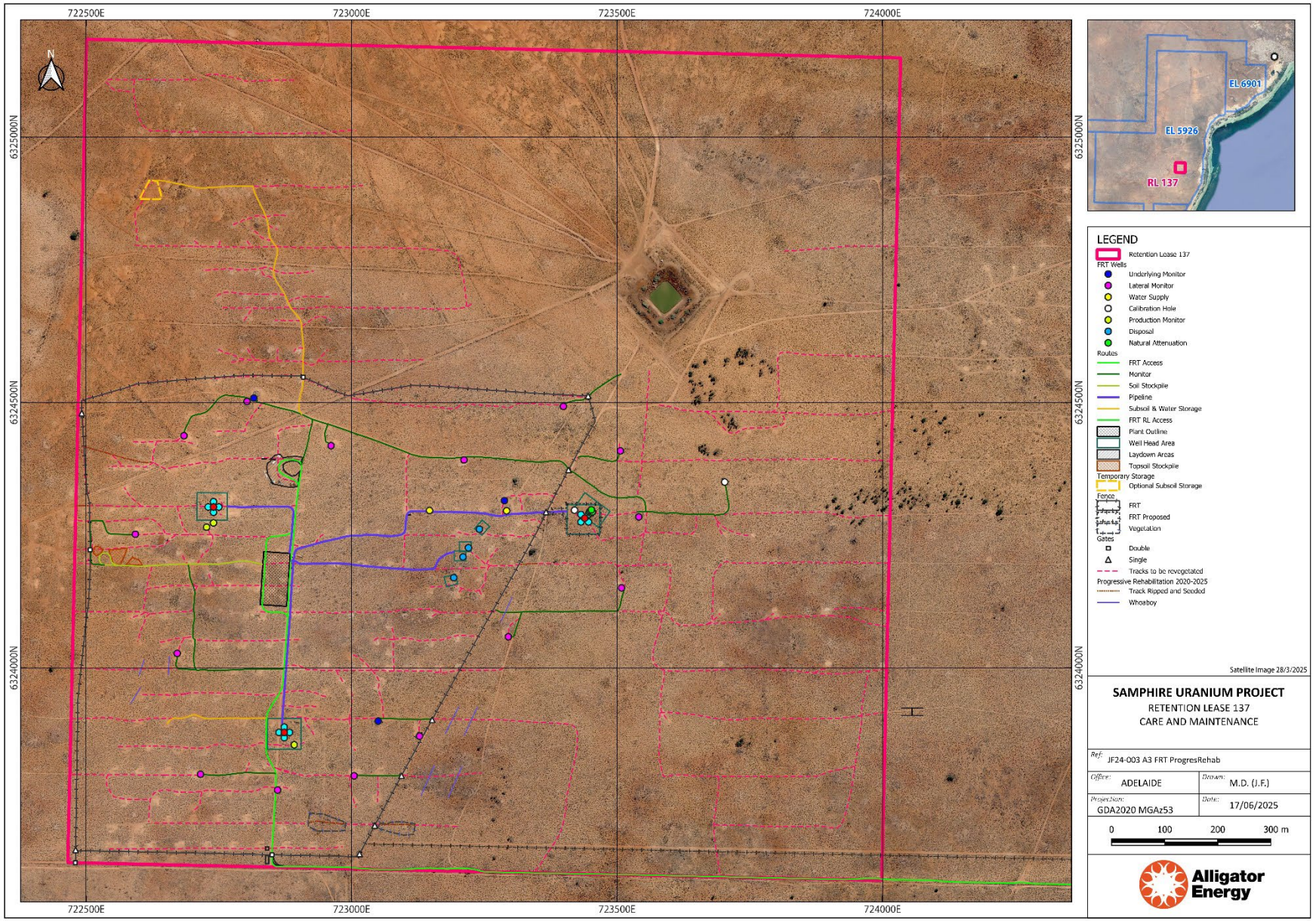


Figure 2 - Samphire FRT – Operational Disturbance Areas (excludes potential exploration sites)

5 Spill Response Procedure

This section outlines the required actions following a spill incident at the Samphire FRT. The objective is to minimise harm to personnel, the environment, and infrastructure by enabling a rapid, structured, and effective response. This procedure applies to all spill types and locations as defined in Section 4.

All spill response activities must prioritise safety, comply with site-specific procedures, and meet obligations under the PEPR, RMP, and relevant regulatory frameworks.

5.1 Immediate Response Actions

5.1.1 Situation Assessment and Alarm Raising

When a spill occurs:

1. Assess the Situation: Identify immediate risks to personnel and the environment. Confirm the material(s) involved if possible.
2. Raise the Alarm: Notify site emergency response via radio or phone without delay.

If the material identity is unknown, assume worst-case conditions and escalate accordingly.

5.1.2 Personnel Assistance

If safe to do so:

- Assist injured personnel and provide first aid.
- Use safety showers or apply Diphoterine® for chemical exposures where appropriate.
- Never compromise personal safety when rendering assistance.

5.1.3 Initial Containment and Area Security

Where trained and competent:

- Undertake basic containment actions such as stopping pumps, isolating leaks, or deploying spill kits.
- Erect barricades, signage, or use spotters to restrict area access.
- Prevent further spread of contaminants into sensitive environments.

If radioactive materials are involved or suspected, the Radiation Safety Officer (RSO) must be notified immediately.

5.2 Spill Material Identification and Hazard Control

5.2.1 Material Confirmation

Identify the spilled material through:

- Container or pipe labelling;
- Safety Data Sheet (SDS) review;
- Consultation with personnel who handled the material.

If material identity remains uncertain, treat the spill as hazardous until confirmed.

5.2.2 PPE Selection and Use

Before engaging in further containment or clean-up:

- Refer to the relevant SDS for hazard controls.
- Don appropriate Personal Protective Equipment (PPE) for the material type.

Table 4 – Example PPE Requirements by Material Type

Material	Example PPE Requirements[1]
Hydrocarbons (e.g. diesel)	Nitrile gloves, long sleeves (other PPE assessed on a case-by-case basis)
Acids (e.g. H_2SO_4)	Acid-resistant gloves, face shield, respirator, external protective apron/suit, goggles
Hydrogen Peroxide	Full face shield, chemical gloves (other PPE assessed on a case-by-case basis).
Uranium-bearing fluids	Nitrile gloves, safety glasses, (other PPE assessed on a case-by-case basis)
Unknown/Multiple substances	Treat as hazardous.

5.3 Incident Recording and Severity Assessment

All spill events must be logged in DoneSafe, recording:

- Material type;
- Volume, extent and penetration depth of the spill;
- Initial response actions taken.

Severity must be assessed based on the potential or actual environmental and human health impacts.

Initial severity ratings are assigned by the Site Supervisor/Manager and validated by the Environmental Advisor or RSO.

Severity ratings determine:

- The level of investigation required;
- Whether corrective actions are necessary;
- Whether regulatory reporting obligations are triggered.

5.4 Containment, Clean-up, and Waste Handling

5.4.1 Spill Containment and Recovery

Containment efforts must aim to prevent further environmental harm:

- Deploy absorbents and booms around the spill perimeter.
- Redirect flow to collection points (e.g. sumps) if on hardstand.
- Construct earth bunds or trenches if spill is on unsealed ground.
- Solid and liquid residues must be collected using non-reactive tools.

5.4.2 Excavation of Contaminated Soils

Where visible staining, radiation monitoring, or chemical screening indicates soil impact:

[1] PPE requirements should be based on a spill specific assessment.

- Delineate the extent of contamination horizontally and vertically.
- Excavate to clean material as confirmed by field measurements (radiation, pH, TPH).
- Temporarily store contaminated soils in bunded areas pending disposal.
- No disposal or burial onsite is permitted.

5.4.3 Waste Management

All contaminated materials must be:

- Bagged, sealed, and clearly labelled;
- Stored in designated bunded areas;
- Disposed of through licensed contractors.

Table 5 - Material-Specific Disposal Guidance

Waste Type	Handling Method	Disposal Pathway
Hydrocarbon-contaminated soils or absorbents	Bagged or containerised; segregated from general waste	EPA-licensed landfill or offsite treatment facility
Acid / Hydrogen Peroxide residues	Neutralised in containment; pH tested prior to removal	EPA-licensed landfill or offsite treatment facility
Uranium-bearing residues or contaminated soils	Bagged or containerised; radiation screened	Approved low-level radioactive waste facility.
Contaminated PPE/equipment	Sealed bags or containers.	
Decontamination fluids (e.g. water rinse, neutraliser)	Collected in IBCs or sump; reviewed by Environmental Advisor or RSO	Discharged to lined containment if compliant, or offsite disposal if contaminated

5.5 Site Remediation and Verification

5.5.1 Radiological Spill Remediation

Where uranium-bearing materials are involved:

- Remediation must be completed immediately, unless physical access constraints (e.g. spill is beneath fixed infrastructure or pipework) preventing safe or practicable access. In such cases, remediation will occur as soon as reasonably practicable following the completion of the FRT operational phase.
- If full remediation is not achievable within 72 hours (e.g. spill under permanent infrastructure), a radiological risk assessment must be undertaken to demonstrate no credible impacts to the environment or human health will occur.
- Remediation techniques are to be designed by the RSO based on the nature and location of the spill.
- Remediations should occur while the spill site is still saturated/damp to ensure visual ques guide the accurate and complete removal of affected soils.
- The RSO must conduct radiation monitoring once the site has been remediated to ensure all affected materials have been removed.
    - This must be undertaken on completely dry materials using calibrated gamma dose rate meters and alpha contamination probes and must confirm baseline dose rate and surface contamination values.

5.5.2 Chemical Spill Remediation

Where hazardous chemicals are involved:

- The Environmental Advisor will confirm remediation effectiveness through visual inspections, pH testing, and/or laboratory screening.
- Impacted soils must be removed and site surfaces neutralised as appropriate.
- Similar 72-hour remediation timeframes apply, with regulatory escalation if required.

5.5.3 Soil Replacement and Stabilisation

Following successful radiological or non-radiological remediation works:

- Excavations must be backfilled with clean material.
- Areas must be stabilised to prevent erosion or sediment transport.
- Photographic evidence, remediation details, verification works, and any other details must be recorded, and logged.

6 Reporting and Documentation

Accurate and timely reporting of spills is essential to ensure regulatory compliance, track environmental performance, and facilitate continuous improvement. Reporting must occur for all spill events, regardless of their size or location, to maintain accountability and ensure that trends can be monitored through incident reviews and audits.

This section outlines the procedures for internal reporting through Alligator Energy's systems, as well as the thresholds and timelines for external regulatory notifications. All reporting must be supported by clear documentation, including forms, photographs, investigation outcomes, and disposal records.

6.1 Internal Reporting via DoneSafe

All spills, including near misses or minor events, must be reported through the DoneSafe incident management platform within 12 hours of occurrence. The initial report should include:

- Date, time, and location of the spill;
- Material type and estimated volume;
- Immediate response actions taken;
- Personnel involved or present;
- Preliminary assessment of impact (e.g. containment success, ground contact).

The FRT Site Supervisor / Manager is responsible for ensuring the entry is completed and that follow-up actions (e.g. clean-up, inspection, and documentation) are attached to the record.

For moderate and severe spills, a formal Spill Reporting and Disposal Management Form must also be completed and uploaded to the DoneSafe record.

6.2 External Notifications

Spill incidents that result in an uncontrolled release, environmental harm, a radiological release, or breach regulatory conditions must be reported in accordance with the following statutory instruments:

- Mining Act 1971 (SA) and Mining Regulations 2020
- Radiation Protection and Control Act 2021 (SA)
- Environment Protection Act 1993 (SA)
- Work Health and Safety Act 2012 (SA)
- Bachmann Reporting Criteria

Notification must be made by the most relevant Senior Manager to the relevant authority and followed up with written documentation as required.

Table 6 - Regulatory Reporting & Recording Triggers and Timeframes

Area		Criteria	Reporting Requirements
Bachman Reporting	General	Any defect, due to design or malfunction, discovered in the mine, mill, plant, equipment or working procedure, that is likely to lead to an urgent change in plant, equipment or work procedure in order to keep radiation doses as low as reasonably achievable.	A verbal report in the first instance, followed by a written report by email or fax within 24 hours.
		Release or loss of control of radioactive process materials, liquids or wastes, leading to the accidental exposure of a	

Area		Criteria	Reporting Requirements
		worker to radioactive materials through inhalation, ingestion or significant contact.	Report forms can be accessed via the following link: Incident reporting | Energy & Mining (energymining.sa.gov.au)
		Unplanned dispersal to the atmosphere of any radioactive process materials through failure of a section of the plant or by an abnormal event (e.g. fire or explosion).	
	Undisturbed Environment	Unexpected degradation or defect in the in-situ recovery (ISR) trunklines, tailings retention system (TRS) pipelines and structures, pipelines or structures associated with evaporation ponds or storage ponds that, unless remedied, is likely to lead to a reportable release of radioactive process materials, liquids or wastes.	
		Any unplanned release of radioactive process materials, liquids or wastes to the undisturbed environment.	
		Release of radioactive process materials, liquids or wastes which enter or threaten to enter an ephemeral watercourse.	
	Wellfields	Any unplanned release of more than 10 m^3 of radioactive liquids.	
	Processing Plant	Release of more than 50 m^3 of radioactive process materials, liquids or wastes beyond secondary containment, but contained within the engineered controls of the plant perimeter.	
	Pipework Corridors	Unplanned release of more than 50 m^3 radioactive process materials, liquids or wastes within TRS bunded areas and pipeline corridors.	
		Unexpected degradation or defect in the TRS or evidence of leakage from evaporation ponds or storage ponds that, unless remedied, is likely to lead to a reportable release of radioactive process materials, liquids or wastes.	
RPC Act 2021		Incidents that cause or may lead to radiation injuries or radiation doses exceeding the annual dose limits to workers or members of the public.	A soon as reasonably practicable and not later than 7 days after the incident occurred. Report forms can be accessed via the following link: https://www.epa.sa.gov.au/environmental_info/radiation/radiation-incident-report/radiation-incident-form
		Incidents relating to the transport of radioactive material	
		Unintentional or unauthorised discharges of radioactive material into the environment.	
		Any unplanned release of radioactive process materials, liquids or wastes to the undisturbed environment.	
Mining Act 1971		Breach of Mining Lease Condition.	Within 24 hours. A comprehensive report provided within 1 month of the incident. Report forms: Incident reporting | Energy & Mining (energymining.sa.gov.au) Online reporting: https://forms.sa.gov.au/#/form/
		Failure to achieve, or a breach of environmental outcomes.	
		Contravention of, or a failure to comply with, a condition of a program.	
		Triggering of any leading indicator criteria set out in a program	
		Action that causes undue damage to the environment.	

Area	Criteria	Reporting Requirements
		5ebcf5f5ad9c5c0a087bc25c
Work Health and Safety Act 2012	Dangerous Incident - An uncontrolled escape, spillage or leakage of a substance.	Immediate. Notify SafeWork SA (24/7 on 1800 777 209)

6.3 Spill Reporting and Disposal Form

The Spill Reporting and Disposal Management Form (provided in Appendix C) is a structured record required for any spill classified as moderate or severe. This form ensures that all relevant details are captured and verified.

The form must include:

- Event description and timeline;
- Classification of spill (type, material, location);
- Details of the response and containment actions;
- Materials used in clean-up and estimated waste volume;
- Method and location of waste disposal;
- Photographic evidence before and after clean-up;
- Sign-off by FRT Site Supervisor / Manager and Environmental or Radiation Advisor (as relevant).

These forms are retained in both digital and hardcopy format as part of the site's environmental recordkeeping system.

6.4 Record Keeping Requirements

All spill-related documentation must be retained for the duration of the Retention Lease to meet regulatory and audit requirements. Records must include:

- DoneSafe reports and follow-up actions;
- Completed Spill Reporting and Disposal Forms;
- Waste disposal manifests and contractor documentation;
- Laboratory or field data from post-spill monitoring;
- Correspondence with regulators (if applicable);
- Internal reviews and investigation findings.

7 Post Incident Review and Improvement

Post-incident review is a critical component of spill management, enabling lessons learned to be identified and embedded into site operations, procedures, and training programs. For the Samphire FRT, all moderate and severe spills must undergo a structured post-incident process, led by the FRT Site Supervisor / Manager with support from the Environmental Advisor or RSO, as appropriate.

This process ensures that the root cause of the incident is identified, corrective and preventive actions are implemented, and that the findings contribute to improved environmental performance and risk management.

7.1 Toolbox Review and Lessons Learnt

As soon as practicable following clean-up and remediation, a post-incident review must be conducted with the relevant crew(s) involved in the event. This review should:

- Summarise the event in plain language, outlining the spill type, cause, and response actions;
- Encourage open discussion on what went well and what could have been improved;
- Reinforce correct response protocols and safe material handling practices;
- Identify any gaps in equipment availability, communication, or supervision.

The findings of the review are to be documented in the Toolbox Talk Register and uploaded as an attachment to the DoneSafe record. Where broader issues are identified, outcomes may also be shared across crews or shifts as a Lessons Learnt Brief.

Where the spill involves a contractor or third-party operator, a representative from that company should be included in the review process to ensure shared accountability and alignment on future improvements.

7.2 Procedure Updates and Change Control

Spill incidents often highlight opportunities for improvement in procedures/work instructions, training content, inspection regimes, or equipment configuration. Following the review, the FRT Site Supervisor / Manager and Environmental Advisor must assess whether:

- The Spill Management Plan requires revision (e.g. to improve clarity or response sequencing);
- Site inductions or spill response training packages need updating;
- Equipment or infrastructure upgrades (e.g. improved bunding, revised storage locations) are warranted.
- Additional inspections, audits, or preventive controls should be scheduled.

Any updates to the Spill Management Plan must be reviewed and endorsed by the CERS Manager and included in the controlled document register. Changes are to be communicated via toolbox talks and formally incorporated into the site induction system where relevant.

Table 7 - Post Incident Review: Action Categories and Leads

Review Element	Action Required	Responsible Party
Response timeline or sequence issue	Update section in Spill Management Plan	Environmental Advisor / CERS Team
Gaps in training or understanding	Toolbox refresher or induction content revision	FRT Site Supervisor / Manager / CERS Team
Equipment or containment failure	Engineering review and upgrade (e.g. bunds, pumps, shut-offs)	FRT Site Supervisor / Manager
Repeated issue of similar type	Trend review and inclusion in monthly Health, Safety and environmental performance reporting	CERS Manager

All actions arising from post-incident reviews must be tracked in DoneSafe or the site action management system until completion. These are to be reviewed at the monthly HSE meeting and, if significant, escalated to the Alligator Energy Management Team.

This structured improvement process ensures that Samphire FRT not only meets its regulatory obligations under the PEPR and Mining Regulations but also drives continuous enhancement of operational performance and environmental stewardship.

8 Inspections and Audits

Routine inspections and structured audits form the foundation of proactive spill management at the Samphire FRT. These activities are essential for verifying the adequacy of spill prevention infrastructure, confirming spill response readiness, and ensuring continuous alignment with regulatory requirements and broader environmental performance objectives.

The inspection and audit regime outlined in this section supports both internal assurance and regulatory compliance obligations.

8.1 Spill Kit and SDS Register Checks

Spill response equipment and safety documentation must be regularly inspected to ensure readiness in the event of an incident.

- Spill kits located across the FRT must be checked weekly by the FRT Site Supervisor / Manager or delegated personnel. The inspection must confirm:
    - Absorbents are stocked and within expiry dates (where applicable);
    - PPE (gloves, goggles, etc.) is in good condition and sealed;
    - Labels are intact and clearly visible;
    - Disposal bags and sealing ties are available.
- Completed checklists are to be logged in the site spill kit register and retained for a minimum of 12 months.
- The Safety Data Sheet (SDS) register must be reviewed monthly to ensure:
    - All hazardous substances onsite have current SDSs available in both hard copy and electronic formats;
    - SDSs are accessible at all locations where chemicals are handled or stored;
    - No unauthorised or expired chemicals are present onsite.

Deficiencies identified during these checks must be rectified immediately or escalated to the FRT Site Supervisor / Manager.

8.2 Infrastructure and Storage Reviews

A routine inspection of all chemical storage, transfer, and bunded areas will be undertaken. This includes:

- Integrity of bund walls and linings (e.g. HDPE);
- Freeboard levels and evidence of accumulated rainwater or product residue;
- Drainage controls, including sump pumps and isolation valves;
- Physical condition of tanks, IBCs, hose couplings, and valve seals;
- Presence of warning signage and secondary containment measures.

The inspection must also include mobile plant and fuel storage units, particularly those used for generator supply and wellfield operations. These reviews ensure early identification of potential spill sources and reinforce the maintenance and housekeeping standards required under the HS&W Management Plan.

Table 8 - Inspection and Review Responsibilities

Inspection Type	Responsible Person	Recorded In
Spill Kit Readiness Check	FRT Site Supervisor / Manager	Spill Kit Register
SDS Register Review	CERS Manager	SDS Master Register
Chemical Storage/Bunding Inspection	CERS Advisor	Site Infrastructure Log

Inspection Type	Responsible Person	Recorded In
Mobile Fuel and Transfer Review	FRT Site Supervisor / Manager	Mobile Plant Inspection Record

8.3 Audit Readiness and Compliance Evidence

Formal audits provide a mechanism for verifying implementation of this Spill Management Plan and identifying opportunities for improvement. Two categories of audit are relevant:

Internal Environmental Audits:

- Conducted by the Environmental Advisor or CERS personnel;
- Focused on spill response training, incident documentation, form use, waste tracking, and signage;
- May include simulation of spill response scenarios to verify readiness.

Regulatory Audits (e.g. DEM or EPA):

- May occur periodically or following a reportable incident;
- Require presentation of PEPR compliance evidence, such as:
- Spill reporting records and disposal manifests;
- Completed remediation forms;
- Inspection checklists and maintenance logs;
- Evidence of post-incident reviews and procedure updates.

To ensure audit readiness, all documentation must be centrally stored, accessible, and linked to the relevant incident records.

This inspection and audit framework ensures that Alligator Energy’s operations at Samphire remain aligned with regulatory obligations and internal standards.

Appendix A

Acronyms and Definitions



Appendix A: Acronyms and Definitions

Acronym / Term	Definition
Alligator Energy	Operator responsible for the Samphire Field Recovery Trial.
DEM	Department for Energy and Mining (South Australia) – primary regulator under the Mining Act 1971 (SA).
EPA SA	Environment Protection Authority South Australia – regulator for environmental harm under the EP Act.
EMP	Emergency Management Plan – site-specific plan outlining escalation, notification and response procedures for major incidents.
EP Act	Environment Protection Act 1993 (SA) – state legislation governing environmental protection and pollution control.
FRT	Field Recovery Trial – the in-situ recovery (ISR) trial conducted at the Samphire Project.
IBC	Intermediate Bulk Container – used for storing and transporting liquid chemicals.
ISR	In Situ Recovery – a mining method involving the injection of lixiviant into an orebody and recovery of metal-bearing fluids via wells.
IX	Ion Exchange – process used to extract uranium from pregnant liquor in ISR operations.
Lixiviant	An acidic solution (typically sulphuric acid-based) injected into the orebody to mobilise uranium for recovery.
PEPR	Program for Environment Protection and Rehabilitation – a regulatory document required under the Mining Act 1971 (SA) outlining environmental controls and commitments.
PPE	Personal Protective Equipment – clothing and equipment worn to minimise exposure to hazards.
Pregnant / Barren Solutions	In ISR operations, "pregnant" refers to uranium-loaded process fluid; "barren" refers to fluid after uranium extraction.
RMP	Radiation Management Plan – site-specific plan defining controls, monitoring and response to radiological risks.
RPCA	Radiation Protection and Control Act 2021 (SA) – state legislation governing the use and control of radioactive substances.
RSO	Radiation Safety Officer – the appointed person responsible for radiation safety management at the site.
SDS	Safety Data Sheet – document outlining the properties, hazards, and safe handling instructions for hazardous substances.
SMP	Spill Management Plan – this document; outlines controls, responsibilities, and reporting for spill incidents.
SWI	Safe Work Instruction – task-specific procedural document for safe execution of work activities.
TPH	Total Petroleum Hydrocarbons – used in soil and water testing to quantify hydrocarbon contamination.
WHS Act	Work Health and Safety Act 2012 (SA) – legislation governing workplace health and safety.
WSWMP	Health, Safety and Wellbeing Management Plan – site-specific plan addressing general safety requirements.

Appendix B

Spill Response Flowchart



Appendix B: Spill Response Flowchart

Step	Action	Responsible	Linked Section
1	Identify spill or leak (e.g. visible fluid, odour, pressure loss)	Any person on site	5.1
2	Stop the source if safe (close valve, isolate pump, upright drum)	Operator / Technician	5.1
3	Raise the alarm and notify FRT Site Supervisor / Manager	Operator / Witness	5.1
4	Evacuate and secure area if spill involves hazardous or radiological material	FRT Site Supervisor / Manager / First Responders	5.1
5	Assess spill type, volume, material, and location (including whether within primary containment, secondary containment, or outside containment structures). Confirm escalation requirements with Environmental Advisor or RSO.	FRT Site Supervisor / Manager	4.1 – 4.3
6	Deploy PPE and spill kit (as per SDS and material type)	Responders / Operators	5.2
7	Contain the spill (booms, bunding, pads, trenches, shut valves)	Responders / Supervisor	5.3
8	Identify material and assess hazards (labels, SDS, consult advisors)	Supervisor / RSO / Env. Advisor	5.4
9	Clean up and decontaminate (remove waste, neutralise, test)	Supervisor + clean-up crew	5.5
10	Dispose of waste appropriately (based on material type)	Supervisor / Waste Contractor	5.6 / 6.2
11	Complete Spill Report and DoneSafe entry	FRT Site Supervisor / Manager	7.1 / 7.3
12	Notify regulator if required (based on trigger criteria)	FRT Site Supervisor / Manager / Advisor	7.2
13	Initiate remediation (e.g. excavation, radiation scan, soil testing)	RSO / Environmental Advisor	6.1 / 6.2
14	Verify remediation complete (monitoring or radiation clearance)	RSO / Environmental Advisor	6.3
15	Conduct post-incident review (toolbox, lessons learnt, improvements)	Supervisor / HSE / Advisor	8.1 / 8.2

Appendix C

Spill Reporting and Disposal Management Form



Appendix C: Spill Reporting and Disposal Management Form Example

Section 1: Spill Summary

Field	Details
Date and Time of Spill	[DD/MM/YYYY HH:MM]
Location	[GPS / Site zone / Description]
Discovered By	[Name + Role]
Reported To	[Name + Role]
Weather Conditions	[e.g. clear, light rain, 38°C, winds SW 20 km/h]

Section 2: Spill Classification

Field	Details
Estimated Volume	[Litres or m^3]
Material Type	[E.g. Diesel, Lixiviant, H_2SO_4, Uranium fluid]
Classification (Minor/Mod/Severe)	[Select one based on matrix]
Was it within containment?	[Yes / No]
Is it a radiological substance?	[Yes / No]

Section 3: Immediate Response Actions

Action	Completed?	Notes / Details
Source isolated	[Y/N]	[Valve closed, pump shutdown, etc.]
Area secured / access restricted	[Y/N]	
Spill contained	[Y/N]	[Describe containment method used]
PPE worn per SDS	[Y/N]	
RSO / Environmental Advisor notified	[Y/N]	[Name + Time]
Radiation survey completed (if required)	[Y/N/NA]	

Section 4: Waste and Disposal

Waste Type	Volume / Weight	Handling Method	Disposal Location / Contractor
Absorbents		Bagged / Drummed	
Contaminated soil		Excavated, stored	
PPE and contaminated gear		Sealed bags	
Other			

Section 5: Remediation and Validation

Activity	Completed?	Details
Area excavated	[Y/N/NA]	[Depth / Method]
Surface cleaned / neutralised	[Y/N/NA]	[Agent used]
Soil or radiation monitoring completed	[Y/N/NA]	[Attach data if applicable]
Area approved for re-use by advisor	[Y/N]	[Name + Role + Date]

Section 6: Reporting and Sign-off

Field	Details
Entered into DoneSafe?	[Yes / No / Pending]
External Notification Required?	[Yes / No] – If yes, who? [DEM / EPA / SafeWork SA]

Mines Record Book Entry Complete	[Yes / No]
Final Sign-Off – Supervisor	[Name + Date + Signature]
Final Sign-Off – Env/RSO	[Name + Date + Signature]

Appendix D

Spill Kit Inspection Checklist



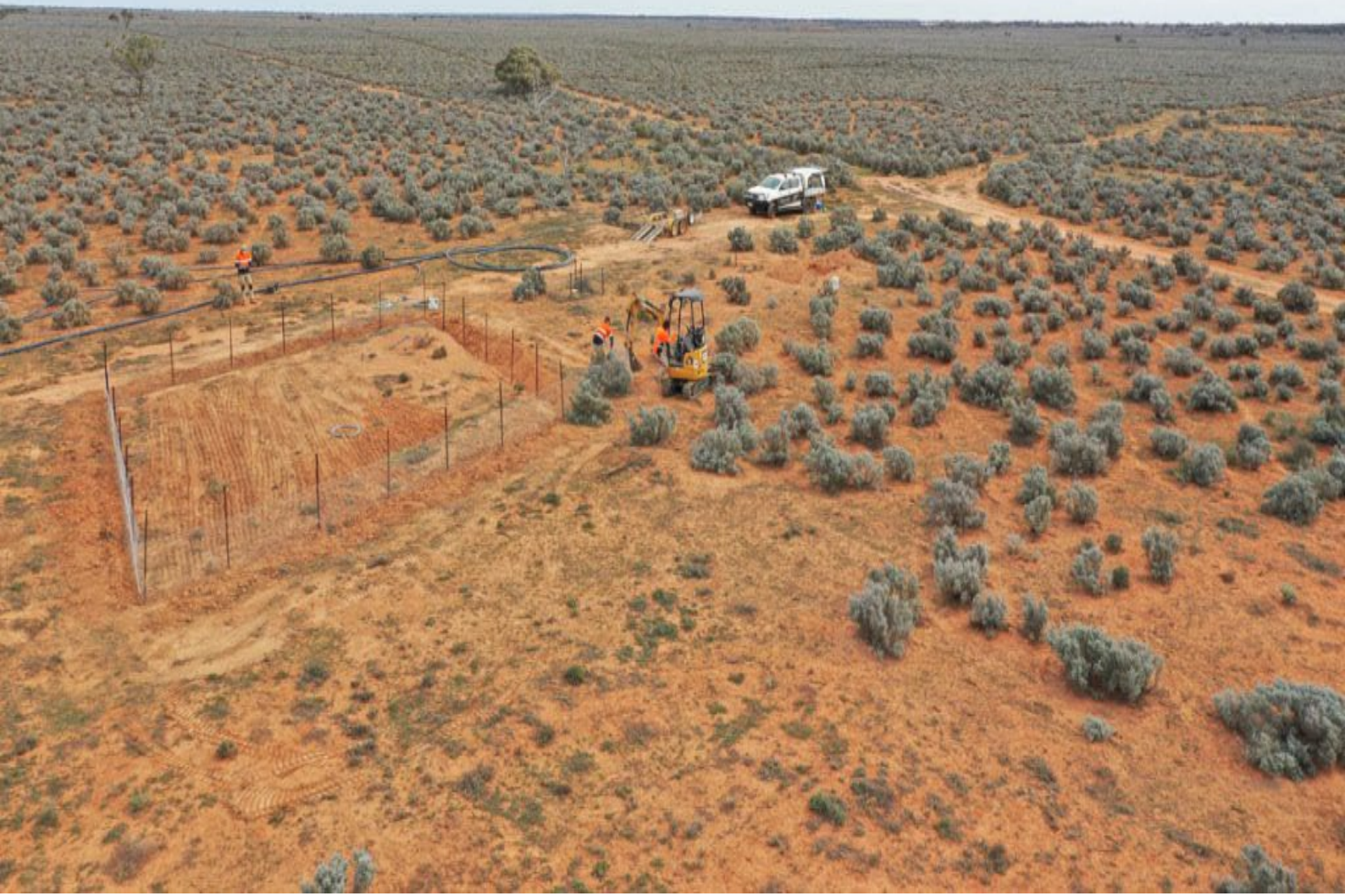
Appendix D: Spill Kit Inspection Checklist

Field	Value
Inspection Date	[DD/MM/YYYY]
Spill Kit Location	[e.g. Wellfield hut, plant pad]
Inspected By (Name & Role)	
Signature	
Defects Found?	[Yes / No]
If Yes, Corrective Action Taken	[Date / Action / Person Responsible]

Inspection Item	Required?	Condition / Quantity	Comments / Action Required
Spill kit clearly labelled and accessible	Yes	[✔ / ✘]	
Location signage present and visible	Yes	[✔ / ✘]	
Absorbent pads (hydrocarbon)	Yes	Qty: ____	
Absorbent booms/socks	Yes	Qty: ____	
Neutraliser for acid spills (e.g. lime, soda ash)	Yes	[✔ / ✘]	
Contaminated waste bags and cable ties	Yes	Qty: ____	
PPE (gloves, goggles, coveralls)	Yes	[✔ All items present]	
Spill kit stock is dry, sealed and in-date	Yes	[✔ / ✘]	
SDS folder or QR code available nearby	Yes	[✔ / ✘]	
No expired or damaged materials	Yes	[✔ / ✘]	
Recent use documented / kit restocked if used	N/A	[✔ / ✘ / N/A]	

Alligator Energy

Alligatorenergy.com.au
Suite 2, 128 Bowen Street
Spring Hill, QLD 400
07 3839 3904
info@alligatorenergy.com.au





Alligator Energy

Traffic Management & Track Management Plan

Samphire Project

13/06/2025

Alligator energy.com.au

Contents

1 Introduction 4
1.1 Background 4
1.2 Purpose and Scope 4
1.3 Referenced Documents 4
2 Site Location 5
2.1 Location Overview 5
2.2 Field Recovery Trial Plant Location 6
3 Traffic Management 8
3.1 Designated Road Layout and Traffic Flow 8
3.2 Speed Management 10
3.3 Parking 11
3.4 Minimum Safety Requirements for Site Vehicles 11
3.5 Traffic Safety Protocols and Pastoralists Activities 12
3.6 Training 12
Site Inductions for Staff and Contractors & Visitors 12
Staff Training 12
Training & Competency Matrices 13
3.7 Incident Reporting & Management 13
3.8 Emergency Response for Traffic Incidents 13
3.9 Drug and Alcohol Policies 13
3.10 Hazardous Material Transport & Compliance 14
3.11 Site Signage 14
4 Track Maintenance 19
5 Monitoring & Compliance Verification 20
5.1 Compliance Monitoring 20
5.2 Record-Keeping & Audits 20
5.3 Community Engagement & Feedback 20

Document Control

Rev	Description	Date	Author	Approver
A	Draft for Review	23/1/2025	BH	
B	Updated for PEPR submission	11/6/25	BH	
C	Updated for PEPR submission	13/6/25	BH	AMS

1 Introduction

1.1 Background

Alligator Energy Ltd has secured a Retention Lease over the Blackbush Deposit at the Samphire Uranium Project, located about 20 kilometres southwest of Whyalla on the Eyre Peninsula and 3.5 kilometres west of Spencer Gulf, entirely within the Moonabie Pastoral Lease. This lease was obtained to conduct an in-situ recovery (ISR) uranium Field Recovery Trial (FRT) on a small portion of the deposit. The purpose of the trial is to assess the technical and financial feasibility of developing a full-scale uranium mine over a three-month period.

1.2 Purpose and Scope

Alligator Energy's Traffic Management & Track Maintenance Plan details the processes and procedures implemented during construction and operation to ensure no traffic accidents occur involving members of the public and mine related traffic that could have been reasonably prevented.

This plan is intended for use by all employees, contractors, and visitors to Samphire Project site during the exploration and Field Recovery Trail phases of the site only.

1.3 Referenced Documents

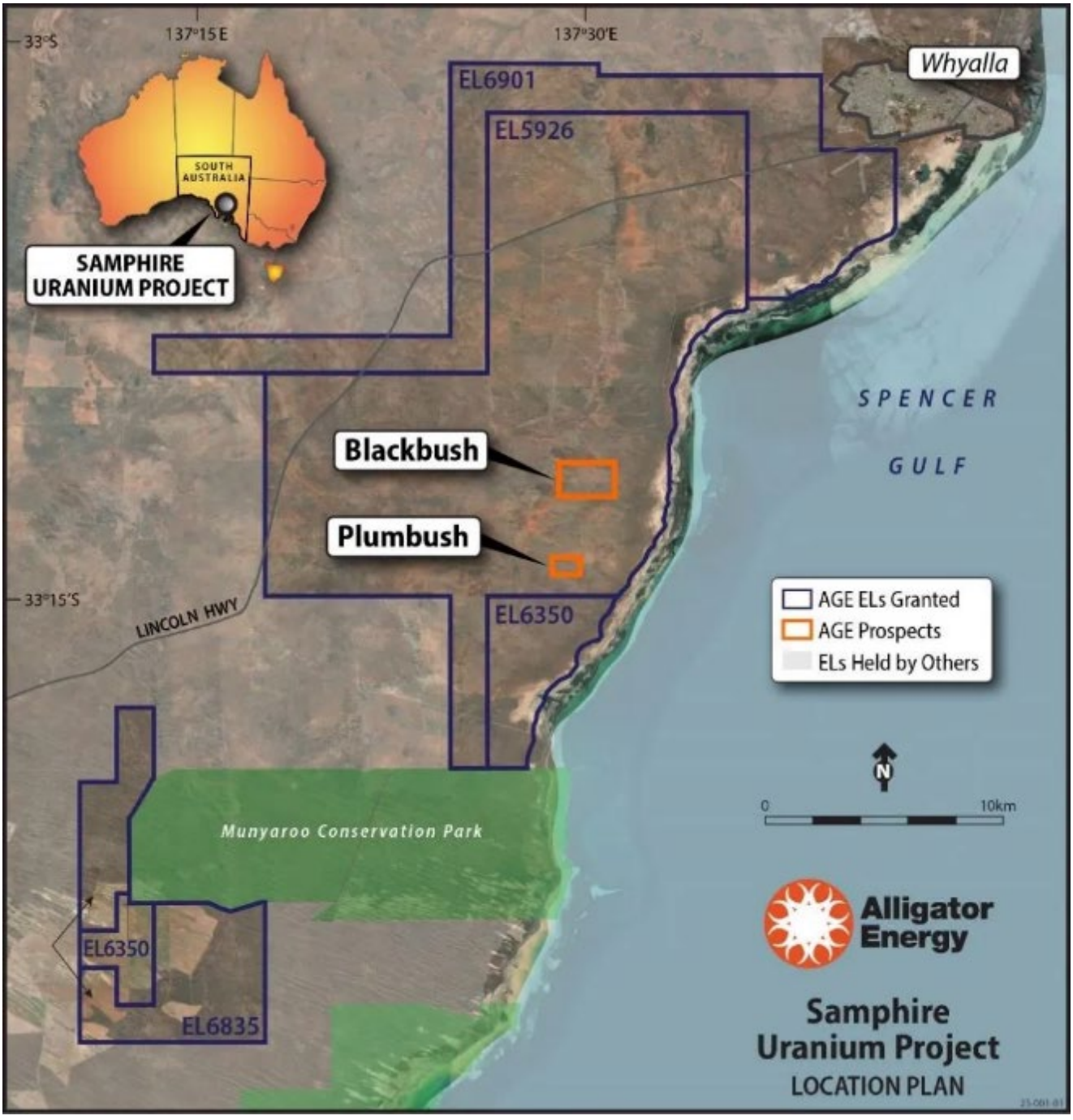
ACTS AND REGULATIONS
N/A

STANDARDS AND DOCUMENTS
N/A

2 Site Location

This section covers information about the Field Recovery Trial Location, specifying the geographical and operational context of the trial site. Additionally, details about the Whyalla Office are included, providing a clear understanding of traffic flow.

2.1 Location Overview



2.2 Field Recovery Trial Plant Location

The RL area is accessible via Eight Mile Creek Road from the east or a track from Nonowie Homestead, which leads to Lincoln Highway to the northwest (Figure 1.1). Intersection turn-offs which must currently be negotiated to enter/exit the RL area include:

- Junction of Eight Mile Creek Road and the east-west access track to the RL area.
- Junction of the tracks within the RL area.
- Junction of the track to Nonowie Homestead and to Boundies Dam.
- Junction of track from Nonowie Homestead and Lincoln Highway.
- Junction of track between Nonowie Homestead and Boundies Dam and Lincoln Highway.

Access to the RL from Eight Mile Creek Road is via three gates;

- Gate 1, located approximately 18 kilometres from the Lincoln Highway along Horseshoe Road, Mullaquana Road and then Eight Mile Creek Road.
- Gate 2, located 5.6 km South from Gate 1.
- Gate 3, located approx. 2.5km West of Gate 2.

Please note that all gates are normally locked to prevent unauthorised access. Gate 1 may be unlocked pending pastoralist activities.

A lockbox will be located on Gates1, 2 and 3 which will contain the key to the gate in the event of an emergency. Refer Figure 1.

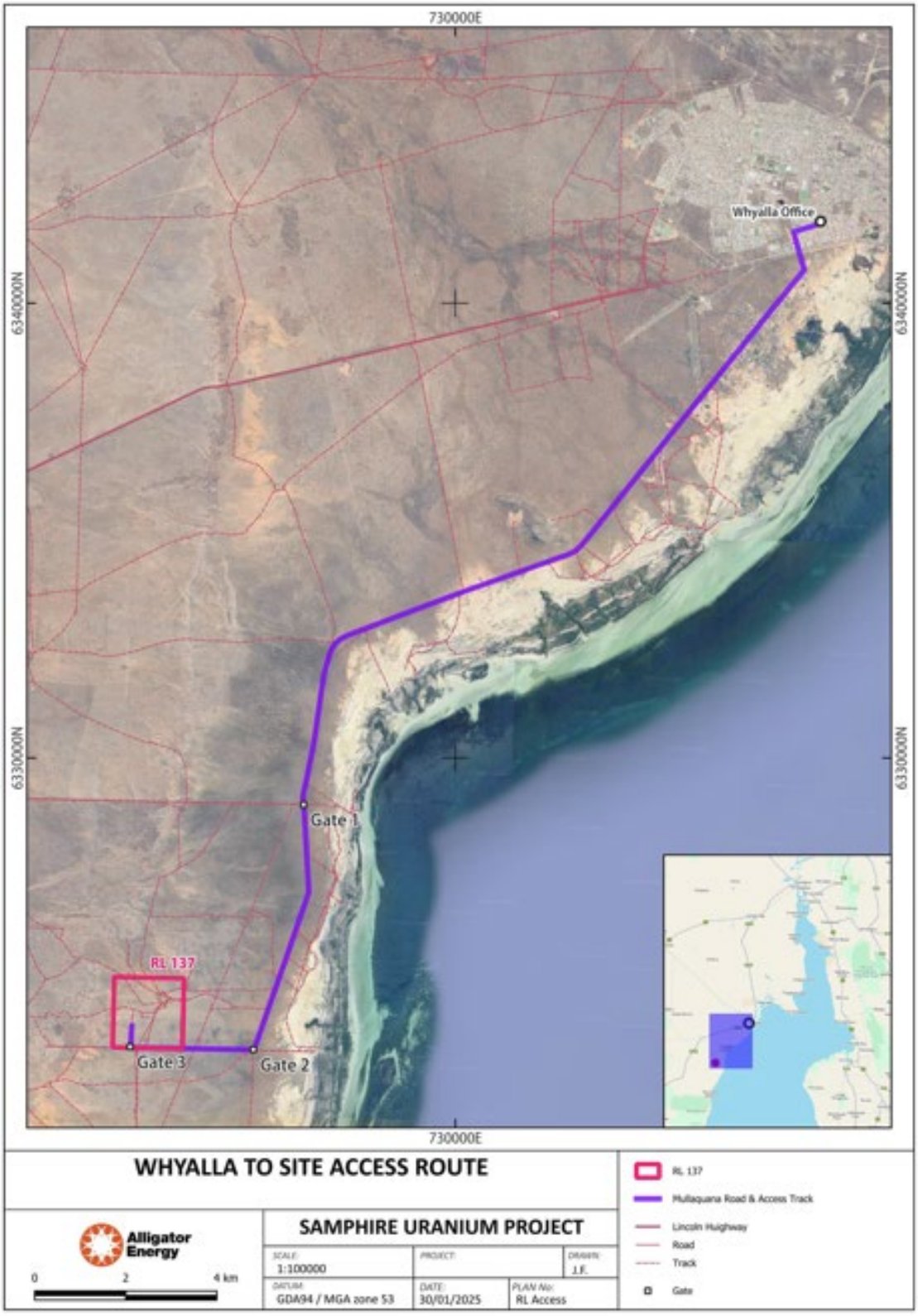


Figure 1 – Main access route from Whyalla with gate locations

3 Traffic Management

Effective traffic management on site is essential for ensuring the safety and efficiency of all operations and personnel working on the Samphire Project's Field Recovery Trial (FRT) project. Properly managing vehicle movement minimises the risk of accidents, protects workers, and enhances operational flow. Key strategies include the establishment of a designated route, clear signage, and the implementation of communication protocols such as UHF Radio coordination.

During the construction, operation, and decommissioning phases of the FRT, Alligator Energy will utilise the existing Eight Mile Creek Road and an unnamed private road to access the RL, no new access roads will be constructed. Existing tracks within the RL will be utilised, with maintenance or minimal upgrades undertaken as necessary in consultation with the landholder. Access routes to the FRT are illustrated in Figure 4.

During the FRT, vehicle movements are estimated to include two–five light vehicle trips per day and an average of one heavy vehicle trips per week. During the mobilisation phase, up to two heavy vehicle movement per day may be required. A land access agreement is in place with the operator of the Moonabie Pastoral Lease, where the RL is situated, ensuring all activities are conducted in accordance with the agreed terms and conditions.

3.1 Designated Road Layout and Traffic Flow

Once a vehicle enters the Samphire Project site (Gate 2) it will need to communicate via UHF Channel 38 to alert personnel of a vehicle movement on the multi-directional one-way road. Radio communication should state the direction of movement and what type of vehicle is about to move. An example of this is “LV (Light Vehicle) about to move West”. A period of 30 seconds should be provided before proceeding with a vehicle movement to allow site-based staff to advise whether the multi-directional one-way road is not clear for use. Radio silence shall be taken as it is satisfactory to move.

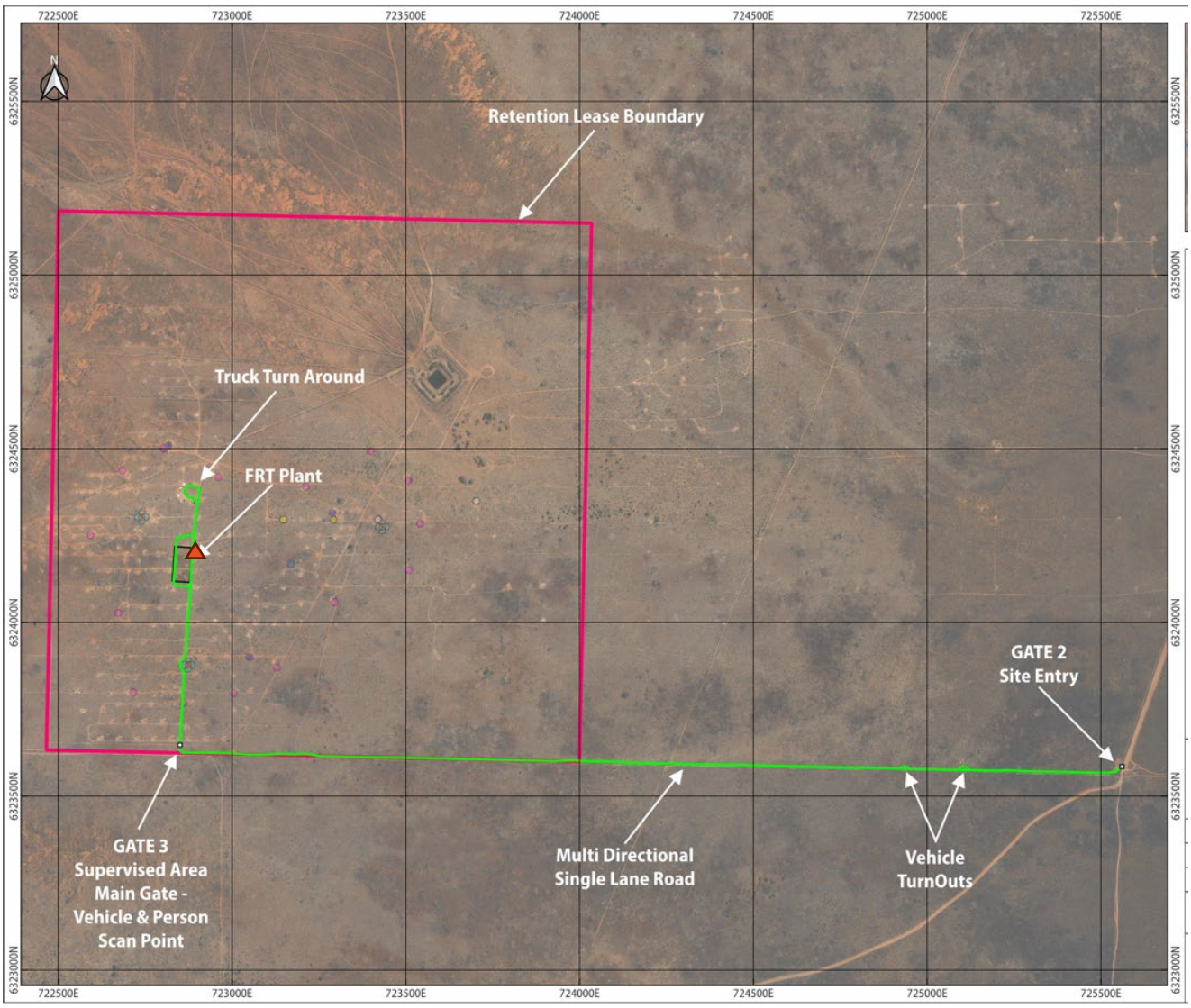


Figure 2 - Designated Road Layout with Key Features

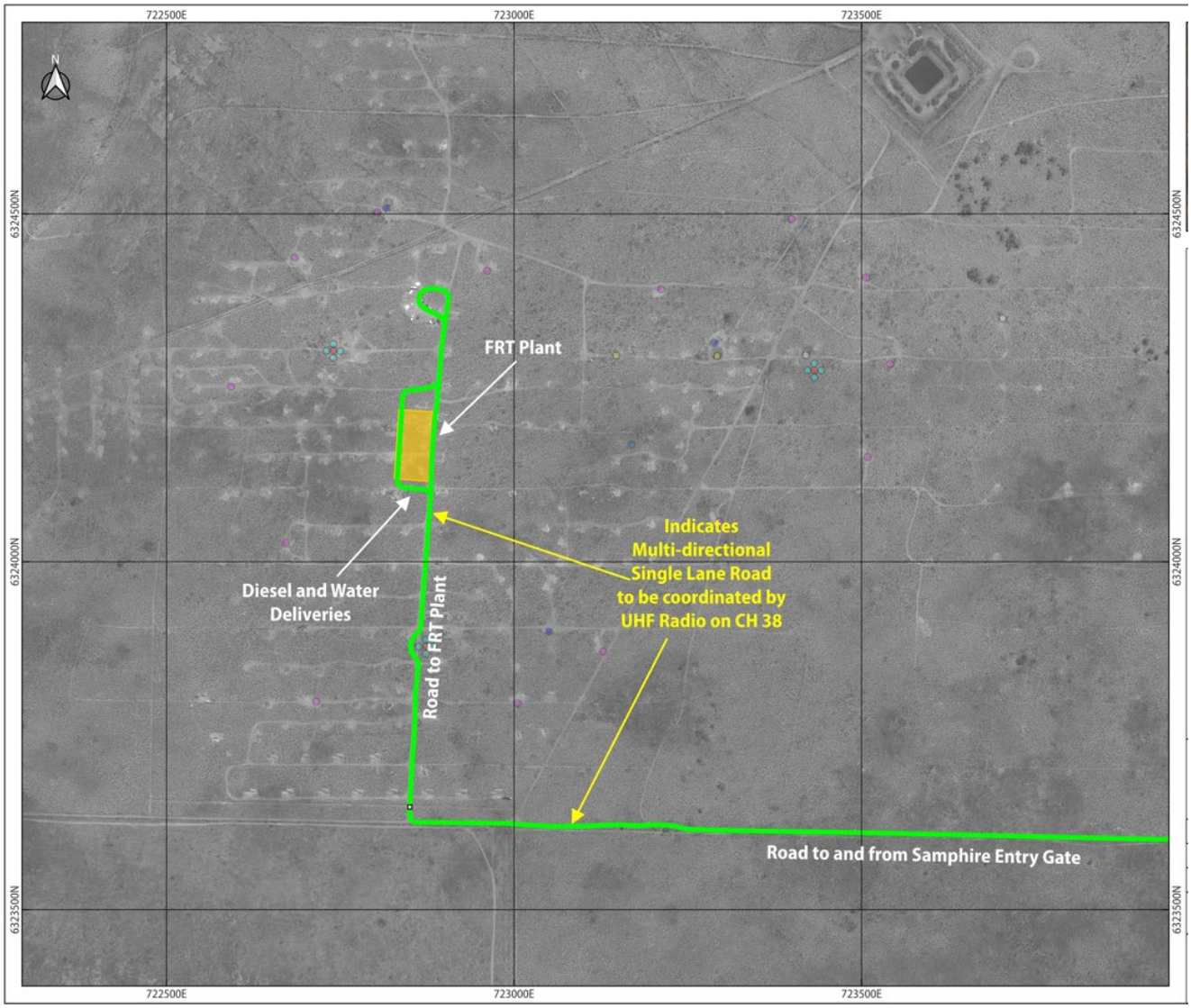


Figure 3 – Samphire Road Layout

3.2 Speed Management

Maintaining appropriate traffic speed is crucial for ensuring safety on a mine site. Within the site, the speed limit is strictly set at 20 km/hr to minimise the risk of accidents and ensure the safety of all personnel and equipment.

However, during periods of increased dust, which can significantly reduce visibility and create hazardous driving conditions, it is imperative to reduce speed even further. Drivers must exercise heightened caution and adjust their speed to suit the prevailing conditions, ensuring that they can stop safely if necessary and avoid potential collisions with vehicles or wildlife. Other applicable speed limits are as per the table below.

Road	Max Speed Limit
One-way multidirectional Road	
Un-named road from Gate 1 (Cowled's Landing Gate) to Gate 2 (Entry Gate)	
Horseshoe Road	
Mullaquana Road	

3.3 Parking

FRT site parking will reside outside the process plant boundary on the southern eastern corner. All vehicles are required to reverse park into designated parking bays to enhance visibility and safety during vehicle entry and exit. Additionally, a parking bay should always be left vacant to serve as an emergency response vehicle spot, ensuring immediate access for emergency services if needed.

3.4 Minimum Safety Requirements for Site Vehicles

The minimum safety requirements for site vehicles shall be the following:

Flashing Lights: Amber flashing lights are required to enhance visibility.

Reversing Alarms: Audible alarms to alert nearby workers and equipment of a reversing vehicle.

Fire Extinguishers: Appropriately rated extinguishers, of the ABC type, readily accessible in the vehicle.

First Aid Kit: A well-stocked first aid kit tailored to potential site-specific injuries.

Seat Belts: Functional seat belts for all seating positions.

Radio: UHF Radio (handheld acceptable)

3.5 Traffic Safety Protocols and Pastoralists Activities

The land owners, who are operating a pastoral enterprise have been briefed on the proposed outlined the traffic management procedures during land access negotiations and have agreed to abide by the same speed limit and traffic flow restrictions mandated within the approved PEPR and hence this plan.

3.6 Training

Site Inductions for Staff and Contractors & Visitors

The induction process ensures all workers, contractors and visitors to the Samphire site are provided with a thorough induction to the site, specific safety requirements, a discussion of relevant policies and procedures that apply to workers and an overview of Work, Safety and Wellbeing requirements.

The Alligator Energy General Induction will include but is not limited to:

- General Safety
- Site-specific road use requirements.
- Emergency response procedures for vehicle incidents.
- Traffic safety protocols for shared road use with pastoral operations.
- Emergency and Evacuation
- Drug & Alcohol Testing
- First Aid
- PPE Requirements
- Handling Chemicals and Safety Showers
- Site Security
- Radiation Safety
- Environmental Protection

Contractors coming to the site are required to undertake a full site induction, ensuring they are aware of the safety protocols and site-specific requirements for the Samphire Project. Contractor inductions are integrated into the Site Access Request process and completed online via AGE safety system.

Visitors coming to the site will receive a condensed site induction, ensuring they are aware of the essential safety protocols and site-specific requirements. All visitors must be always escorted on site, a responsibility that lies with the site sponsor facilitating the visitor's presence. Visitor inductions are also integrated into the Site Access Request process,

Staff Training

Alligator Energy has established procedures and allocated sufficient resources, to identify and provide the training needs and assessment of competence of personnel on site.

Alligator Energy will:

- Identify training requirements.
- Ensure all vehicle operators are licensed and trained for their specific vehicle class.
- Meet all training specified in licensing and compliance criteria as per regulatory mining approvals.
- Ensure that where required by legislation or Australian Standards such training is conducted by a Registered Training Organisation (RTO).
- Provide training on PPE use and care.
- Maintain documented records of training and assessment.
- Have approved training relevant to the work being performed, i.e. Working at Heights, Isolations and Confined Space,

Key training required for routine activities includes, first aid training, site safety induction, radiation induction and hazard and risk management training.

Training & Competency Matrices

Alligator Energy maintains a Training and Competency Matrix which specifies the mandatory and recommended training and competence requirements for each individual position.

3.7 Incident Reporting & Management

The AGE safety system will be used to;

- Log and investigate traffic-related incidents.
- Implement corrective actions to prevent future occurrences.
- Ensure timely response to stakeholder concerns or complaints.
- Log and review of stakeholder complaints regarding traffic impacts and improvement areas.

3.8 Emergency Response for Traffic Incidents

Vehicle accidents can occur on-site due to the movement of heavy machinery and transport vehicles. Response actions include

Action	Details
Immediate Response	Secure the scene and provide first aid to any injured individuals including coordination with emergency services if required.
Notification	Report the accident to the AGE Manager / Supervisor immediately
Investigation	Conduct a thorough investigation to determine the cause of the accident.
Documentation	Record details of the accident, including personnel involved, time, and conditions within the AGE safety system.
Coordination with Emergency Services	Contact external emergency services if necessary.

3.9 Drug and Alcohol Policies

Alligator Energy operates under a strict policy of ‘zero tolerance’ to alcohol and drugs within all exploration tenements / licences in which it operates. Alligator employees and contractors are not permitted to work while under the influence of alcohol or drugs (including undeclared prescription medications).

Prescription and Non-Prescription Medication Disclosures

Some prescription or over counter medications and/or supplements can have adverse side effects that can affect a person. This can lead to the person working in a manner that is unsafe to themselves or others.

All employees/contractors are required to list their current medications and supplements on the Site Access Request application prior to being granted access to site.

All employees/contractors are encouraged to inform their immediate manager of any short-term consumption of medications such as cold and flu tablets, pain relief etc.

Possession of Drugs and Alcohol

No alcohol or drugs is to be consumed on an Alligator Energy site.

Drugs and Alcohol testing

Drug and Alcohol testing will be in place to ensure that all employees/contractors performing work at a Company site are not under the influence of:

- Illicit drugs: e.g. Marijuana, Opiates etc.
- Undeclared and potentially impairing prescription medications: sleeping & anxiety, heavy pain meds etc.
- Alcohol (BAC 0.000g/100ml).

3.10 Hazardous Material Transport & Compliance

All chemical reagent transfers are conducted by licensed specialist operators, ensuring:

- Safe handling, loading, and unloading procedures.
- Compliance with transport regulations for hazardous materials.
- Waste transfers are managed by EPA-licensed operators using EPA transport certificates to ensure proper documentation and disposal.

The transport of radioactive materials will comply with an EPA approved Radiation Management Plan specifically for the Samphire Field Recovery Trial, which will comply with:

- The Radiation Protection and Control Act 2021.
- Requirements for a valid Radiation Management Licence.
- Radioactive waste and material transport follows strict protocols, including:
    - Sealed and labelled containers.
    - Approved transport routes to licensed disposal facilities.

3.11 Site Signage

Recommendations for site signage are identified below:

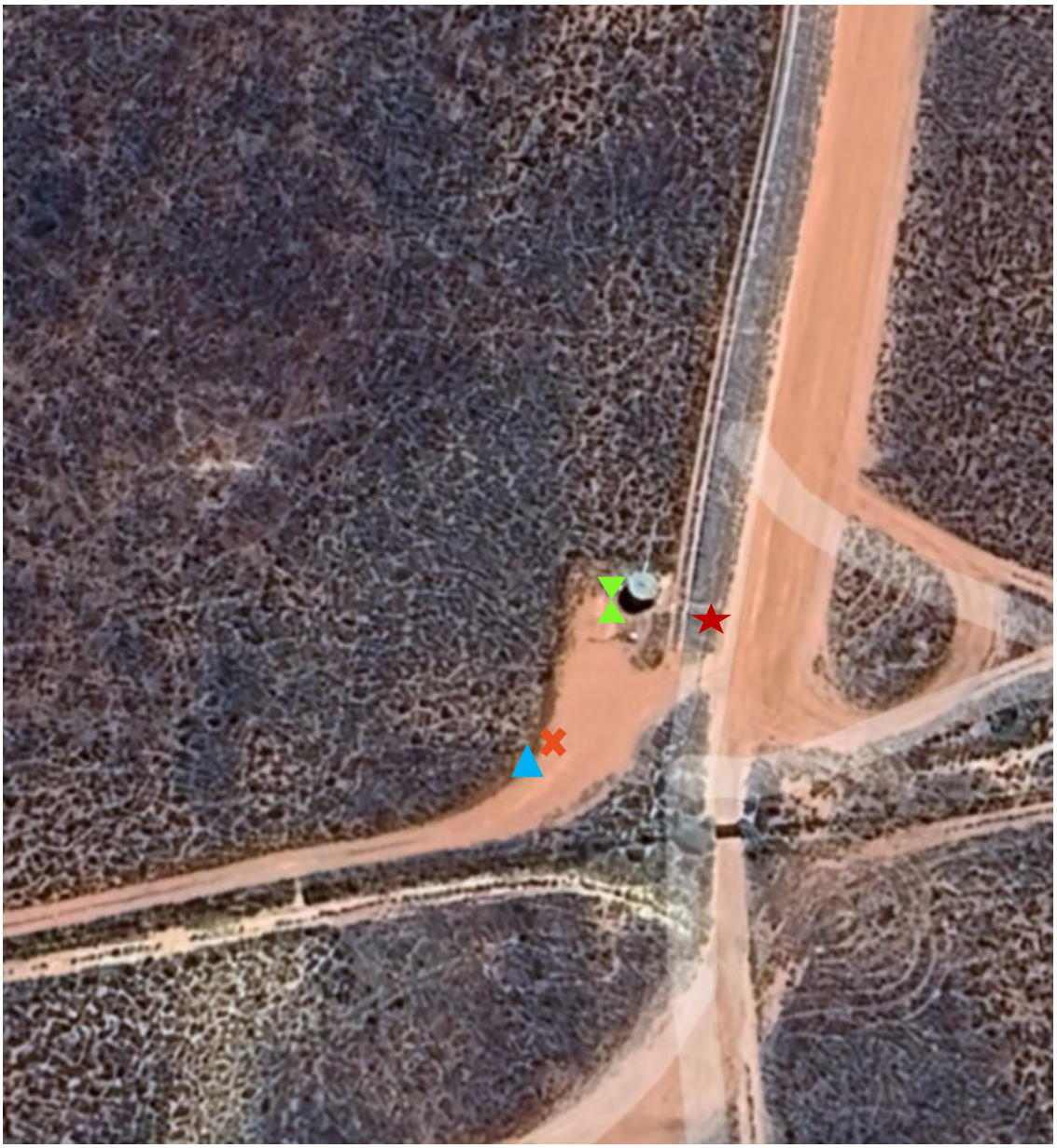


Figure 4 - Gate 2 (Site Entry Gate) Aerial View

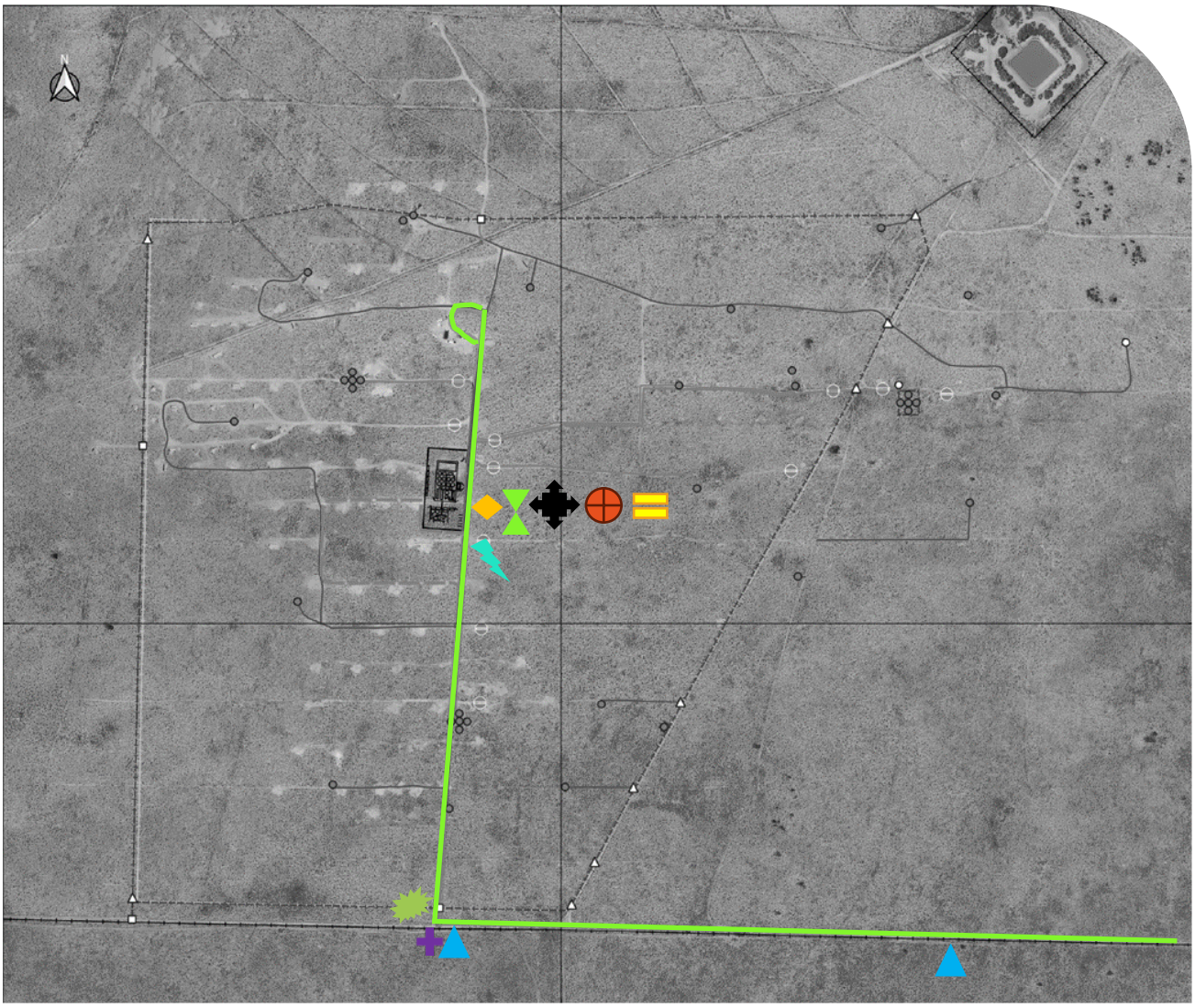


Figure 5 - Samphire Aerial View with signage

Sign ID	Description	Type
✚	Call up point sign	

Call up point sign	
20km/hr speed sign	
To be installed before entering the Supervised Area	
Vehicle Wash Down Point	
Typical example of a gate identification sign	

	Emergency Muster Point	
	Fire extinguishers: Always consult the MSDS or safety data sheets (SDS) for each chemical to understand the specific firefighting measures recommended for that substance.	
	FRT Plant specific PPE sign to go on access gate as required	
	Radiation sign – required as per Radiation Management Plan	
	Placards should be installed at all entry and exit points of the FRT Plant enclosure to inform personnel and visitors of the potential hazards they may encounter upon entering the site. All relevant placards to be shown.	

4 Track Maintenance

The track maintenance plan developed for the FRT in collaboration with relevant landowners is as follows:

- Monitor and maintain private access roads leading to and within the RL.
- Repair unsealed roads and tracks subject to increased traffic loads to a 'like for like' standard.
- Ensure road conditions remain suitable for both light and heavy vehicles throughout the FRT.

Maintenance activities will include:

- Grading and resurfacing where necessary to prevent track degradation.
- Dust binding where necessary
- Drainage maintenance to prevent surface water pooling and minimise erosion where necessary.
- Preventative erosion works where required.

Some useful reference materials for the maintenance of tracks and roads on pastoral lands can be found here;

- Preventative erosion works such as installation of diversion banks and/or infill of compacted depressions will be undertaken as required. Guidance for undertaking these works is found in 'Whoaboy Construction, Edition 1 – April 2011, ISBN 978-1-921937-13-2'.

- Managing Outback tracks to fit the landscape. Pringles. H & Clunies-Ross M. https://www.emulandrecovery.org.au/files/OutbackTracks_Factsheet_Jan18_v4.pdf

- Managing outback roads. Pringle. H, Hill. D, Theakston. P, Stanton. C, Grant. R.https://cdn.environment.sa.gov.au/landscape/docs/saal/rangelands-a5-outback-roads-book.pdf ISBN: 978-0-9943781-2-5

5 Monitoring & Compliance Verification

5.1 Compliance Monitoring

Traffic and road use monitoring will be conducted within the RL to ensure:

- Adherence to traffic management protocols.
- Proper maintenance of access roads.
- Safe transport of hazardous materials.

5.2 Record-Keeping & Audits

All records related to traffic, incidents and hazards, community complaints, road maintenance, and hazardous transport will be:

- Retained in Alligator Energy's internal safety and stakeholder management databases.
- Reviewed annually as part of compliance audits.
- Audited to confirm timely resolution of traffic hazards and complaints.

5.3 Community Engagement & Feedback

Regular engagement with adjacent landowners and road users to:

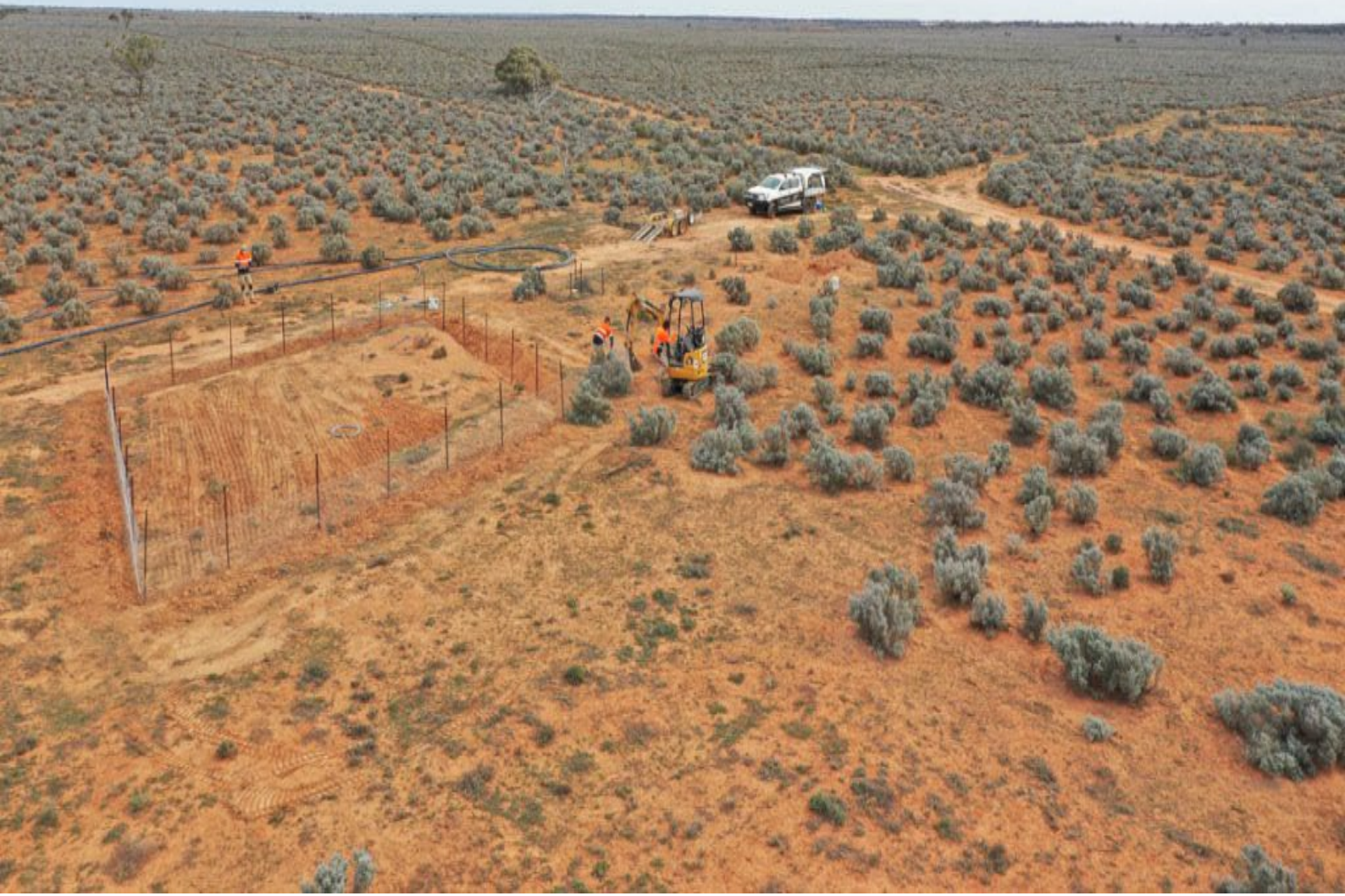
- Assess potential traffic concerns.
- Ensure transparency in project-related road use.
- Address feedback through adaptive traffic management measures.

Appendix A

Alligator Energy

Suite 2, 128 Bowen Street
Spring Hill, QLD 400

07 3839 3904
info@alligatorenergy.com.au





Alligator Energy

Community Engagement Plan (CEP)

Samphire Uranium Project –

Retention Lease 137

Alligatorenergy.com.au

Contents

1 Purpose, Objectives and Parameters of Engagement 3

1.1 Purpose 3

1.2 Objectives 3

1.3 Parameters 3

2 Key References and Frameworks 3

3 Stakeholder Identification 4

4 Engagement Tools and Techniques 4

4.1 Parameters 5

Identifying Community Attitudes and Expectations 5

Providing Information to the Community 5

Receiving Feedback from the Community 5

Analysing and Considering Community Feedback 5

Registering, Documenting and Responding to Communications 5

5 Roles and Responsibilities 5

6 Action Plan for Engagement Activities 6

7 Regulatory Advice & Implementation 7

8 Monitoring & Evaluation 7

9 Annual Review and Change Management 8

Document Control

Rev	Description	Date	Author	Approver
A	Draft for Review	23/1/2025	Jeffrey Sterlson (Stakeholder Engagement Manager)	
B	Updated for RFI and FRT PEPR resubmission	11/6/2025	Jeffrey Sterlson (Stakeholder Engagement Manager)	Andrea Marsland-Smith (COO)

1 Purpose, Objectives and Parameters of Engagement

1.1 Purpose

The purpose of this Community Engagement Plan (CEP) is to establish a structured, transparent, and responsive approach to community engagement during the term of the Samphire Retention Lease (RL) 137, including the proposed Field Recovery Trial (FRT). This plan ensures compliance with regulatory requirements and reflects Alligator Energy's commitment to respectful and inclusive stakeholder engagement.

1.2 Objectives

- Build and maintain trusted relationships with community stakeholders.
- Proactively inform stakeholders about the Retention Lease activities and potential impacts.
- Ensure community concerns are heard, understood, recorded, and addressed.
- Integrate community feedback into project planning and decision-making processes.
- Promote cultural respect, environmental responsibility, and operational transparency.
- Establish clear, two-way feedback channels, including a 24/7 complaints line, to ensure concerns are heard, recorded and addressed.
- Ensure the safety of workers, community members and the environment by communicating rigorous health, safety and environmental protocols.
- Manage stakeholder expectations on timing, impacts and outcomes via regular updates and transparent reporting.

1.3 Parameters

This CEP covers all authorised operations associated with the Samphire Retention Lease. It applies throughout the life of the lease, with engagement activities scaled appropriately depending on the stage and nature of project activities.

Engagement activities will scale in line with project phases and may be updated to reflect significant operational changes, Ministerial directions or stakeholder feedback.

2 Key References and Frameworks

This CEP draws on both regulatory requirements, external guidance and Alligator Energy's internal documentation to ensure a robust, best-practice approach. The key references underpinning our strategy are:

- **Government of South Australia Tenement Document: Retention Lease RL 137** (Mining Act 1971) 10 January 2025
- **Samphire Program for Environment Protection and Rehabilitation (PEPR, 2025)** - Details environmental management, rehabilitation and stakeholder-engagement timeframes.

- **Better Together SA Multiple Land Use Framework** (Government of South Australia, 2016) – provides principles for balanced land-use decision-making across industry, government and community.
- **IAP2 Spectrum of Public Participation** (International Association for Public Participation, 2014) – defines levels of engagement from Inform through to Empower, guiding our choice of tools and techniques.
- **Consultation Manager** – Central system for logging, categorising and tracking all stakeholder communications, enquiries and complaints—including entries in the Community Engagement Register & Complaints Register, which provide master logs ensuring full auditability of engagement events and the resolution of any grievances via our 24/7 complaints line and online channels.

These documents and frameworks collectively ensure that our engagement is transparent, systematic and aligned with both regulatory expectations and industry best practice.

3 Stakeholder Identification

To engage meaningfully, we first define who holds an interest in or is potentially affected by activities within the Samphire RL. This section outlines the key individuals, groups and organisations we will consult, recognising their varying needs, rights and expectations throughout the project lifecycle.

The following stakeholders have been identified as likely to be affected by, or have an interest in, authorised operations under the RL:

- Barngarla Determination Aboriginal Corporation (BDAC) – Native Title holders
- Local residents and community members in Whyalla and surrounding rural properties
- Pastoral leaseholders and landowners near the tenement
- City of Whyalla and other regional government representatives
- State regulatory agencies, including the Department for Energy and Mining (DEM), and the South Australian Environmental Protection Authority (EPA).
- Environmental and heritage groups with interest in the region
- Emergency services, local police, and health service providers
- Local schools and educational institutions
- Local businesses and employment networks
- Stakeholder mapping will be reviewed and updated periodically, especially prior to any significant change in project activities.

4 Engagement Tools and Techniques

Effective engagement will rely on a mix of proven methods for two-way communication. This section outlines the approaches we will employ to gauge community sentiment, share information, gather feedback and ensure all inputs are tracked, analysed and addressed in a systematic, transparent manner.

4.1 Parameters

Identifying Community Attitudes and Expectations

- Baseline community sentiment surveys
- Stakeholder interviews and small group discussions
- Ongoing sentiment analysis using Consultation Manager CRM
- Regular engagement with BDAC through formal correspondence and meetings

Providing Information to the Community

- Community newsletters and factsheets
- Project webpage with accessible updates and resources
- Public displays and noticeboards at local centres (e.g. Whyalla Library)
- One-on-one briefings and community presentations
- Social media updates on Alligator Energy channels
- Regular engagement with Traditional Owners under cultural heritage protocols

Receiving Feedback from the Community

- Dedicated 1800 number for enquiries and complaints
- Feedback email and online contact form
- Community drop-in sessions (scheduled quarterly or as required)
- Feedback opportunities at all public meetings
- In-person discussions

Analysing and Considering Community Feedback

- Feedback is recorded and tracked in Consultation Manager CRM, categorised by theme.
- Feedback reports are generated quarterly for internal review.
- Material concerns or issues are escalated to project leadership and addressed in action plans.
- Trends in sentiment or repeated concerns inform modifications to engagement strategy or operational planning.

Registering, Documenting and Responding to Communications

- All engagement and complaints are logged in Consultation Manager.
- Acknowledgement of complaints occurs within 2 business days.
- Response timelines are standardised: 10 business days for full resolution or update.
- All records are securely stored, auditable, and available to the Minister or delegate upon request.

5 Roles and Responsibilities

To ensure clear ownership and accountability for each element of our engagement programme, key roles and their primary duties are summarised in Table 5-1. This structure underpins effective delivery, oversight and coordination of all community engagement activities.

Table 5-1: Key Roles and Responsibilities

Role	Primary Responsibilities
Stakeholder Engagement Manager	• Maintain and update stakeholder register • Lead community sessions, drop-in forums and FRT consultations • Oversee CRM logging, tracking and reporting of all feedback • Manage the project webpage and social media channels • Coordinate media releases, signage and public notices • Maintain the 24/7 complaints line and email inbox • Support cultural heritage consultations
Environmental Manager	• Advise on environmental protocols • Ensure environmental controls are communicated and understood by stakeholders
All Staff	• Contribute content to newsletters and factsheets • Support pop-up updates and site tours • Escalate any community issues or enquiries to the Engagement Manager promptly
Project Leadership Team	• Review quarterly feedback reports • Approve updates to the CEP in response to major issues or Ministerial directions • Allocate resources for engagement activities

6 Action Plan for Engagement Activities

A clear timetable and allocation of responsibilities ensure our engagement commitments translate into concrete actions. Table 6-1 details each activity, its scheduling and the lead role accountable for delivery, enabling us to engage in a timely and effective manner while monitoring progress and potential issues.

Table 6-1: Engagement Action Plan

Phase/Timeframe	Action(s)	Responsible Party
Phase 1: Pre FRT Construction	• Host a community session in Whyalla to introduce the project and gather feedback. • Meet with local leaders, Indigenous groups (BDAC) and stakeholders. • Update stakeholder mapping; release project FAQs and newsletter.	Stakeholder Engagement Manager
Phase 2: During FRT Construction	• Provide bi-weekly pop-up updates (maps, charts, photos). • Offer site tours for Traditional Owners and nearby landholders.	All Staff lead by Stakeholder Engagement Manager

Phase/Timeframe	Action(s)	Responsible Party
	• Conduct community sentiment survey; launch next newsletter.	
Phase 3: FRT Operation	• Host a session on operational transition and monitoring processes. • Facilitate site visits for transparent reporting. • Schedule quarterly drop-in sessions; maintain CRM issue tracking.	Stakeholder Engagement Manager
Phase 4: Post FRT Operation	• Conduct a forum to share outcomes, next steps (e.g. rehabilitation). • Collect “lessons learned” feedback. Provide final project summary to stakeholders.	Stakeholder Engagement Manager
Ongoing Support	• **CRM reporting and issue-tracking review.** • **Promote 1800 number via media and signage.** • **Respond to incoming enquiries and complaints per standard timelines.**	**Stakeholder Engagement Manager, Environmental Manager**

7 Regulatory Advice & Implementation

Alligator Energy will promptly respond to and integrate any additional engagement requirements provided in writing by the Minister or an authorised delegate. Any such directions will be reflected in the next CEP revision and communicated to stakeholders where relevant.

8 Monitoring & Evaluation

To ensure our engagement activities remain effective, compliant with the PEPR and aligned with stakeholder expectations, we will systematically track key performance indicators, review feedback and adjust our strategy as required, as summarised in Table 8-1.

Table 8-1: Key Monitoring & Evaluation Indicators

Metric	Description	Frequency
Engagement Metrics	Track attendance at meetings, website traffic, social-media engagement and survey feedback to assess the level of community involvement.	Continuous / Quarterly
Stakeholder Feedback	Regular review of comments, concerns and suggestions from advisory panel,	Quarterly

Metric	Description	Frequency
	survey results and social media to identify areas for improvement.	
Complaints / Grievance Management	**Acknowledge all enquiries and complaints**, record and investigate, then document corrective actions. **Provide a full resolution or substantive update.**	• **Logged and acknowledged within 24 hours.** • **Record & investigated within 7 days** • **Close-out within 14 days**

9 Annual Review and Change Management

This CEP will be reviewed annually, or:

- When significant operational changes occur,
- When requested by the Minister, or
- Following stakeholder feedback indicating the need for change.

Review outcomes will be documented and shared with the Department if requested.

Engagement success will be measured by:

- Responsiveness to community issues,
- Feedback quality and quantity,
- Resolution rate of complaints,
- Stakeholder satisfaction via surveys or interviews.

Alligator Energy

Suite 2, 128 Bowen Street
Spring Hill, QLD 400

07 3839 3904
info@alligatorenergy.com.au

