

# Unconventional Gas SELGA Forum

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## South Australian Regulatory Provisions

By

Michael Malavazos

Director Engineering Operations Branch  
Energy Resources Division



# Purpose of Briefing

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1) Who am I?

2) Part 1

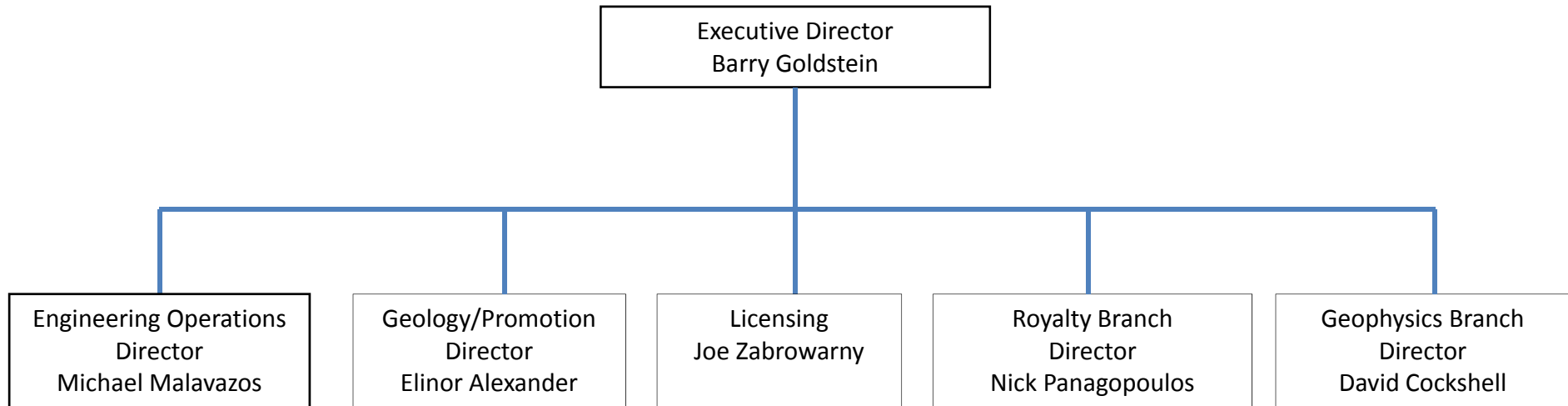
- What is unconventional gas?
  - What is hydraulic fracturing?
- Background and history of gas extraction and drilling in SE
- State Government approval and regulatory processes, including the information requirements and local consultation

3) Part 2

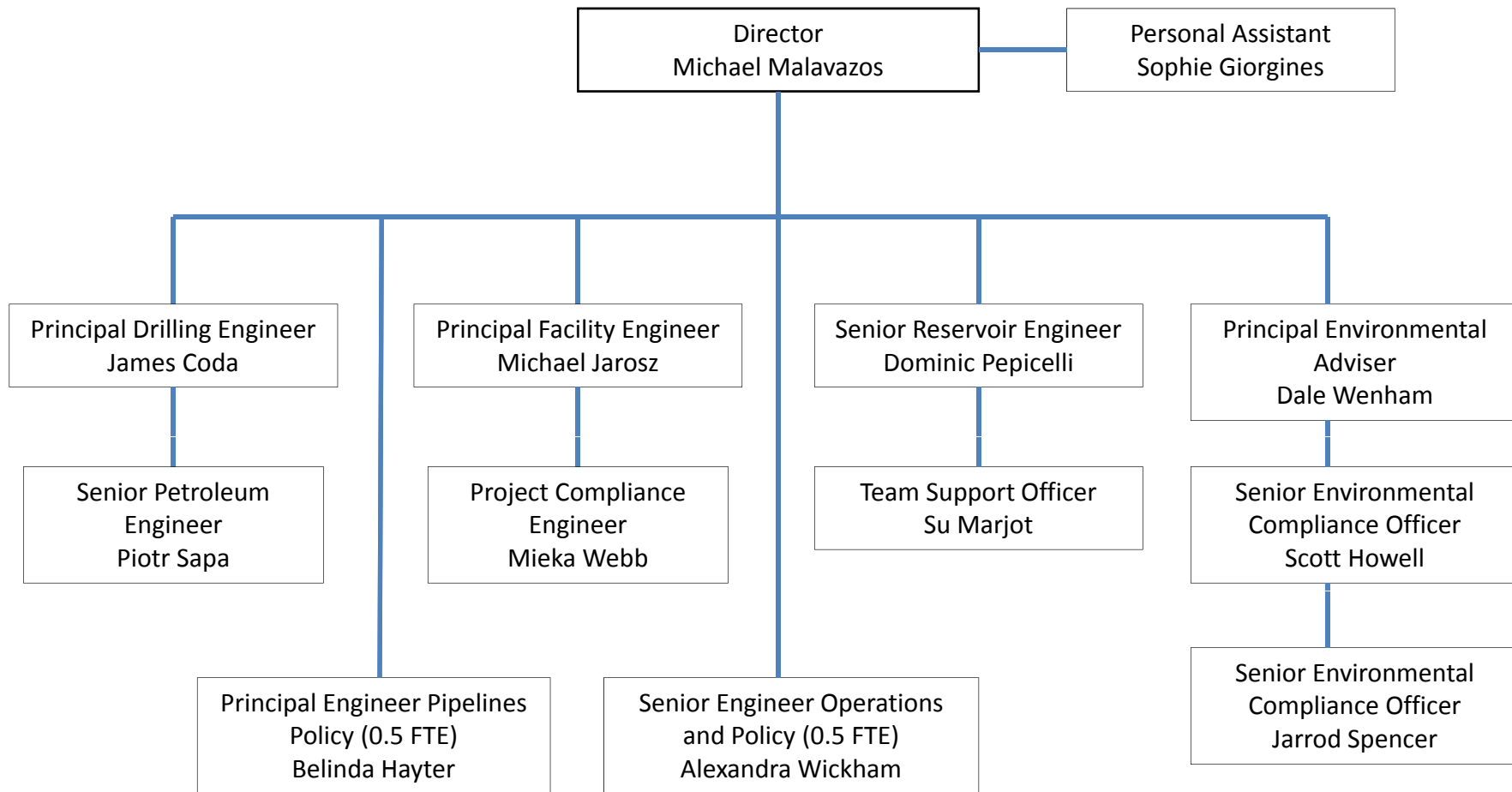
- What are the Risks associated with unconventional gas exploration, drilling and related activities



# Energy Resources Division



# Engineering Operations Branch







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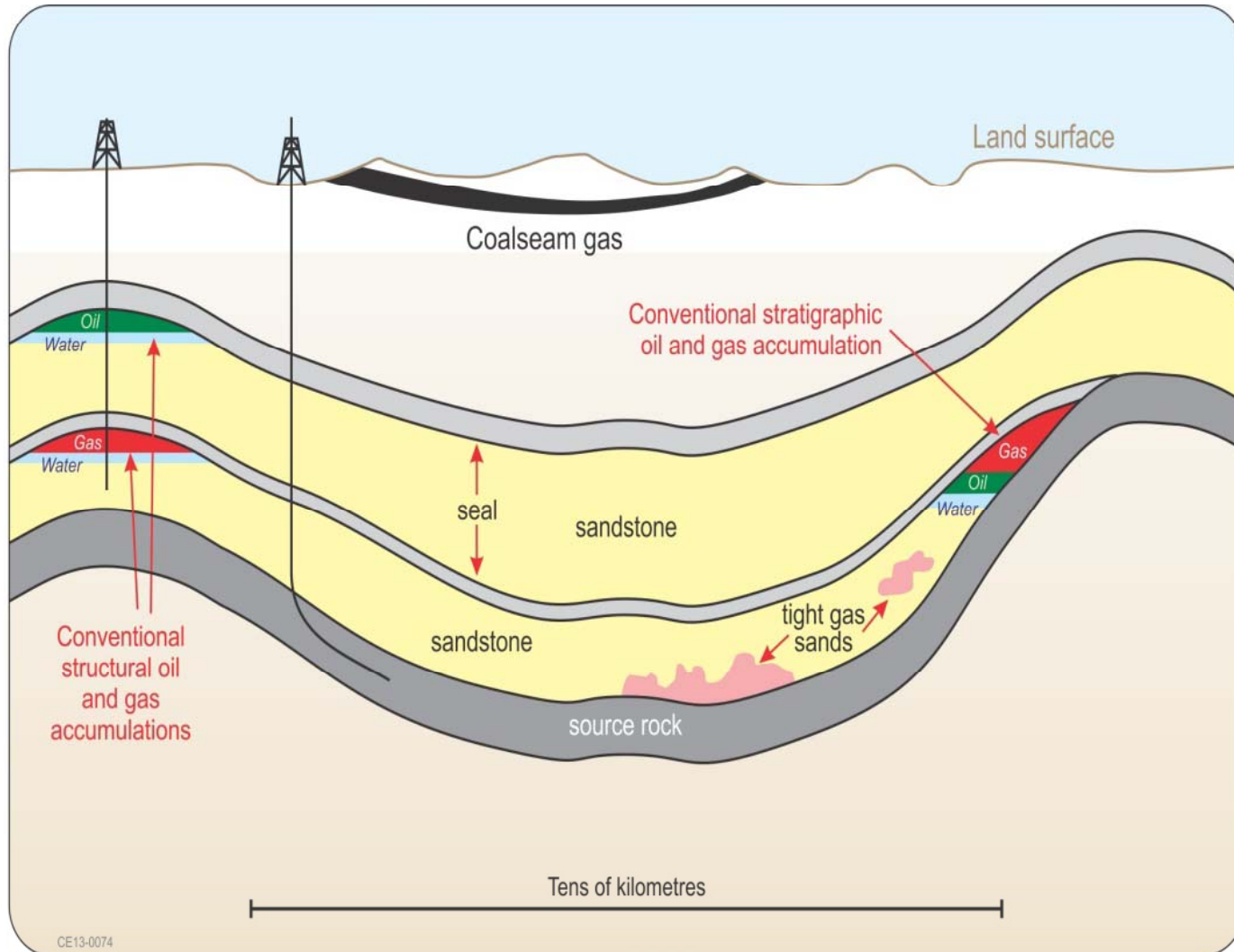
# **Part 1**

## **What is unconventional gas and oil?**



# Oil and Gas

## Conventional and Unconventional



# What is Hydraulic Fracturing

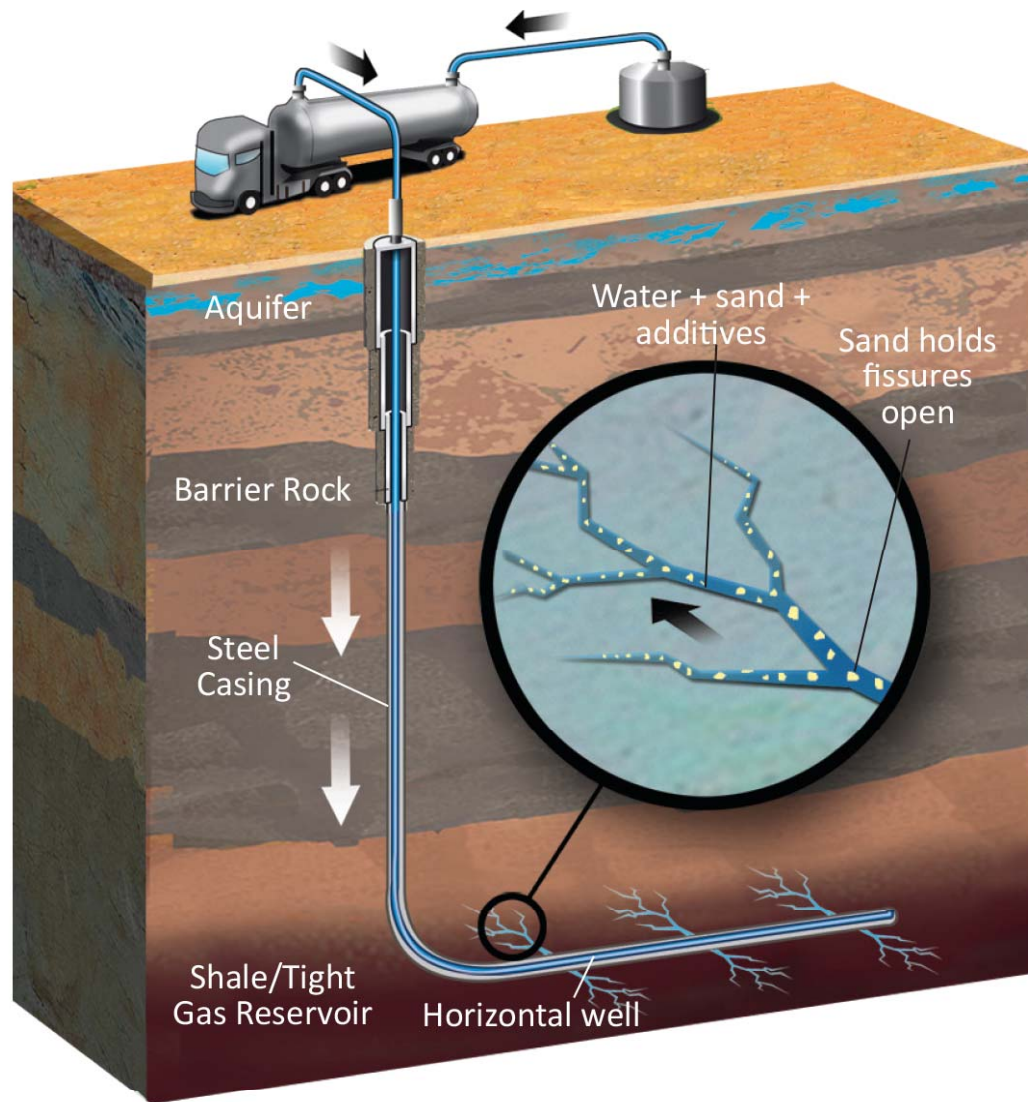
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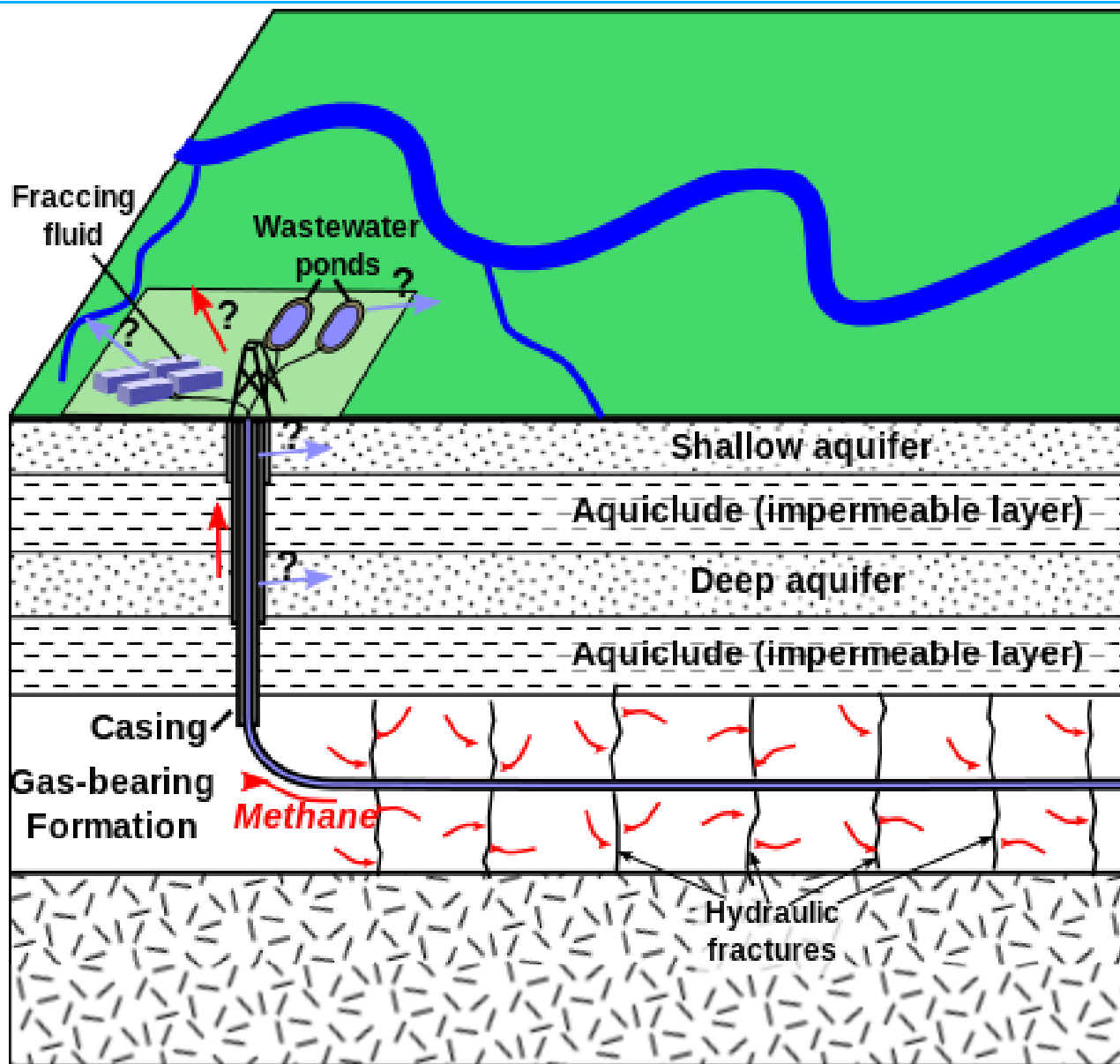


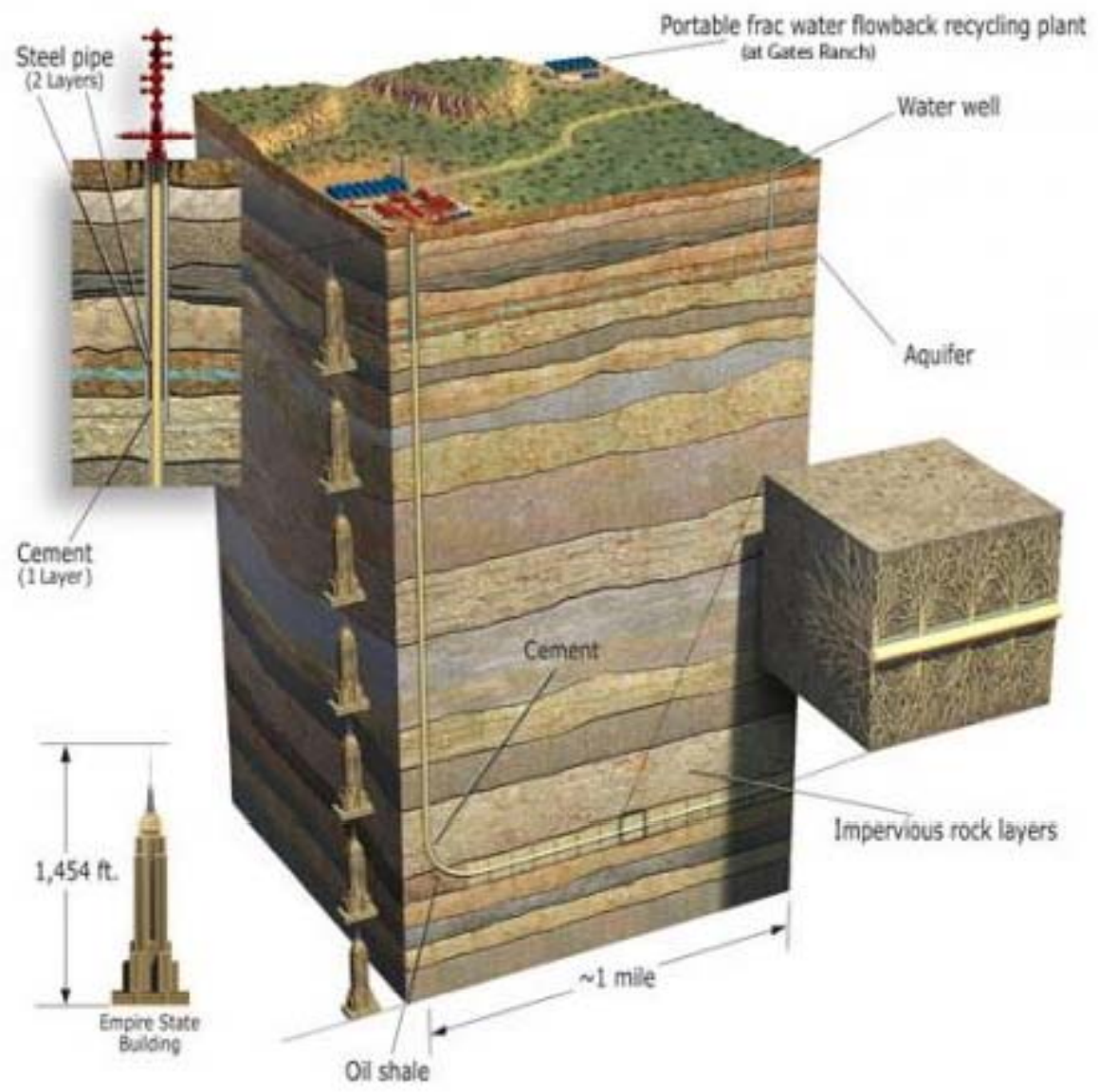
“..is a technique in which a mixture of mainly water mixed with sand (99.5% vol.) and chemicals (0.5% vol.) is injected at high pressure into a well to create small fractures (typically less than 1-2 mm), along which fluids such as gas and oil may migrate to the well.”

**In SA Cooper Basin over 700 wells (circa 1400 stages) have been fracture stimulated**

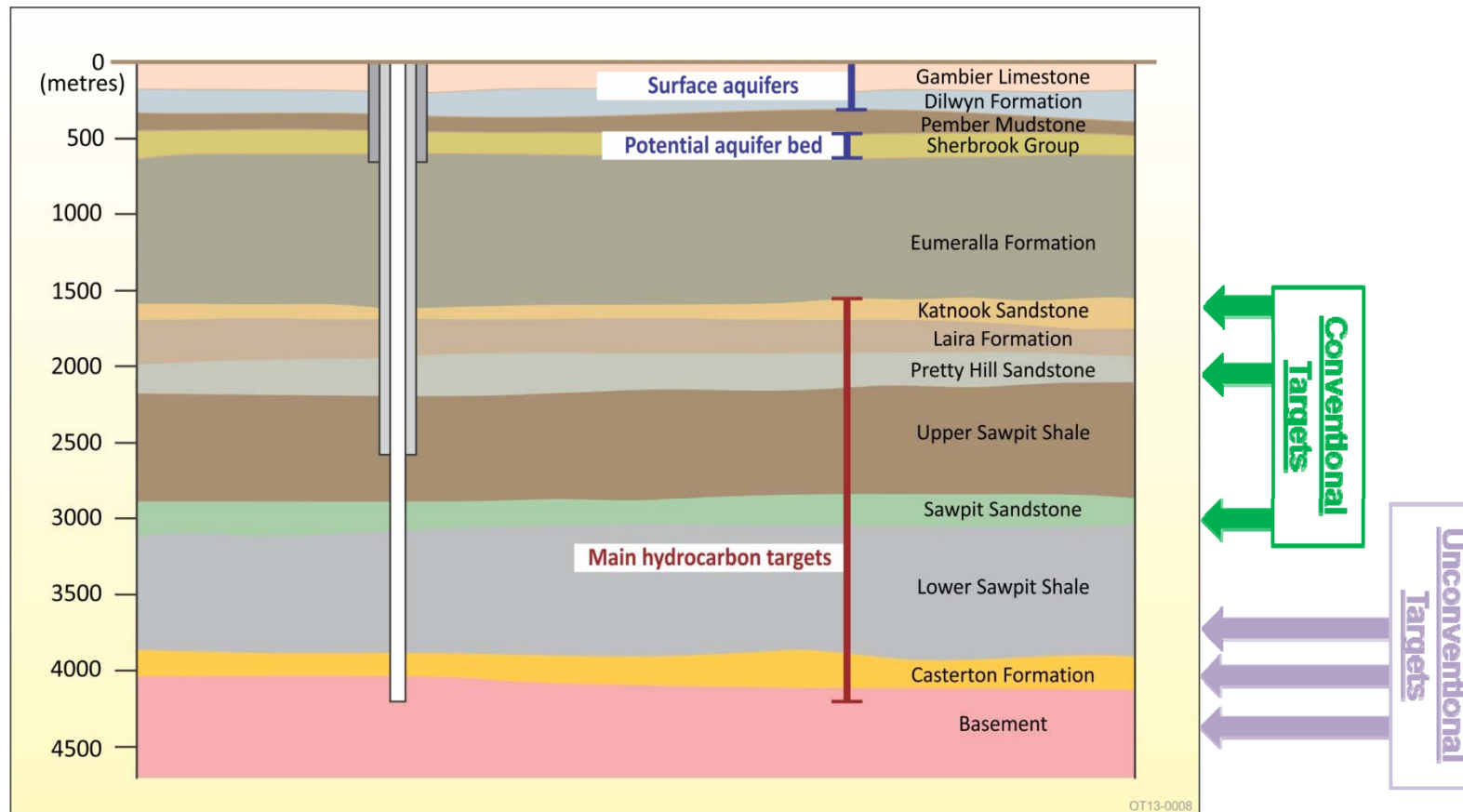






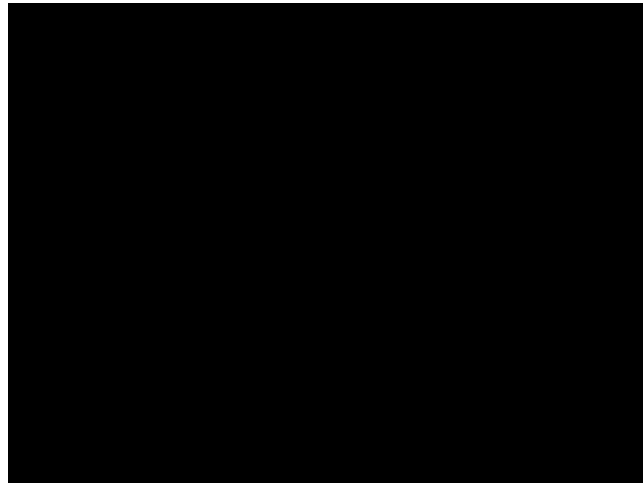


# South East Source of Gas

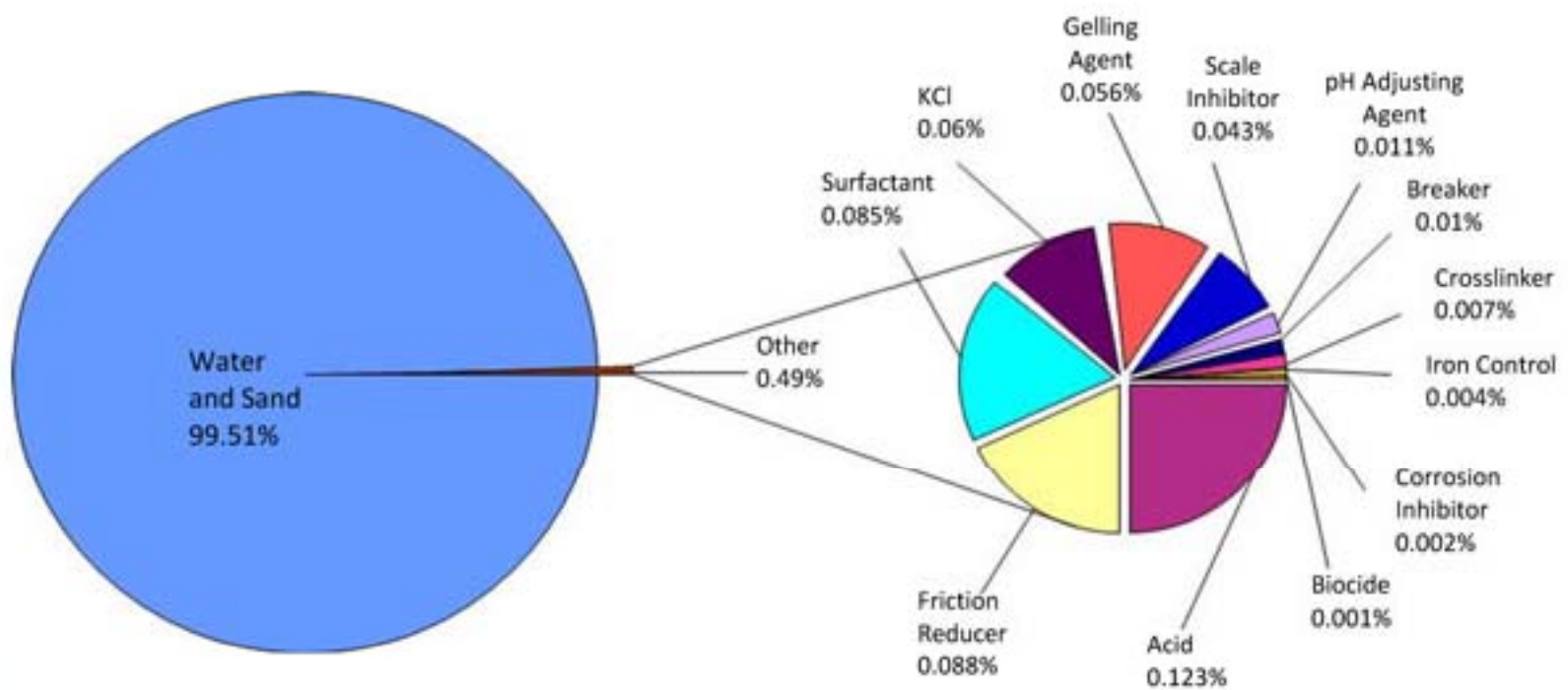


# Hydraulic Fracturing Animation

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Additive Type	Main Compound(s)	Purpose	Common Use of Main Compound
Diluted Acid (15%)	Hydrochloric acid or muriatic acid	Help dissolve minerals and initiate cracks in the rock	Swimming pool chemical and cleaner
Biocide	Glutaraldehyde	Eliminates bacteria in the water that produce corrosive byproducts	Disinfectant; sterilize medical and dental equipment
Breaker	Ammonium persulfate	Allows a delayed break down of the gel polymer chains	Bleaching agent in detergent and hair cosmetics, manufacture of household plastics
Corrosion inhibitor	N, n-dimethyl formamide	Prevents the corrosion of the pipe	Used in pharmaceuticals, Acrylic fibers, plastics
Crosslinker	Borate salts	Maintains fluid viscosity as temperature increases	Laundry detergents, hand soaps, and cosmetics
Friction reducer	Polyacrylamide	Minimizes friction between the fluid and the pipe	Water treatment, soil conditioner
	Mineral oil		Make up remover, laxatives, candy
Gel	Guar gum or hydroxyethyl	Thickens the water in order to suspend the sand	Cosmetics, toothpaste, sauces, baked goods, ice cream
Iron control	Citric acid	Prevents precipitation of metal oxides	Food additive, flavouring in food and beverages; lemon juice ~7% Citric Acid
KCl	Potassium chloride	Creates a brine carrier fluid	Low sodium table salt substitute
Oxygen Scavenger	Ammonium bisulfite	Removes oxygen from the water to protect the pipe from corrosion	Cosmetics, food and beverage processing, water treatment
pH Adjusting Agent	Sodium or potassium carbonate	Maintains the effectiveness of other components, such as crosslinkers	Washing soda, detergents, soap, water softener, glass and ceramics
Proppant	Silica, quartz sand	Allows the fractures to remain open so the gas can escape	Drinking water filtration, play sand, concrete, brick mortar
Scale inhibitor	Ethylene glycol	Prevents scale deposits in the pipe	Automotive antifreeze, household cleansers, and de-icing agent
Surfactant	Isopropanol	Used to increase the viscosity of the fracture fluid	Glass cleaner, antiperspirant, and hair color

Source: Engineering Energy: Unconventional Gas Production, ACOA, 2013



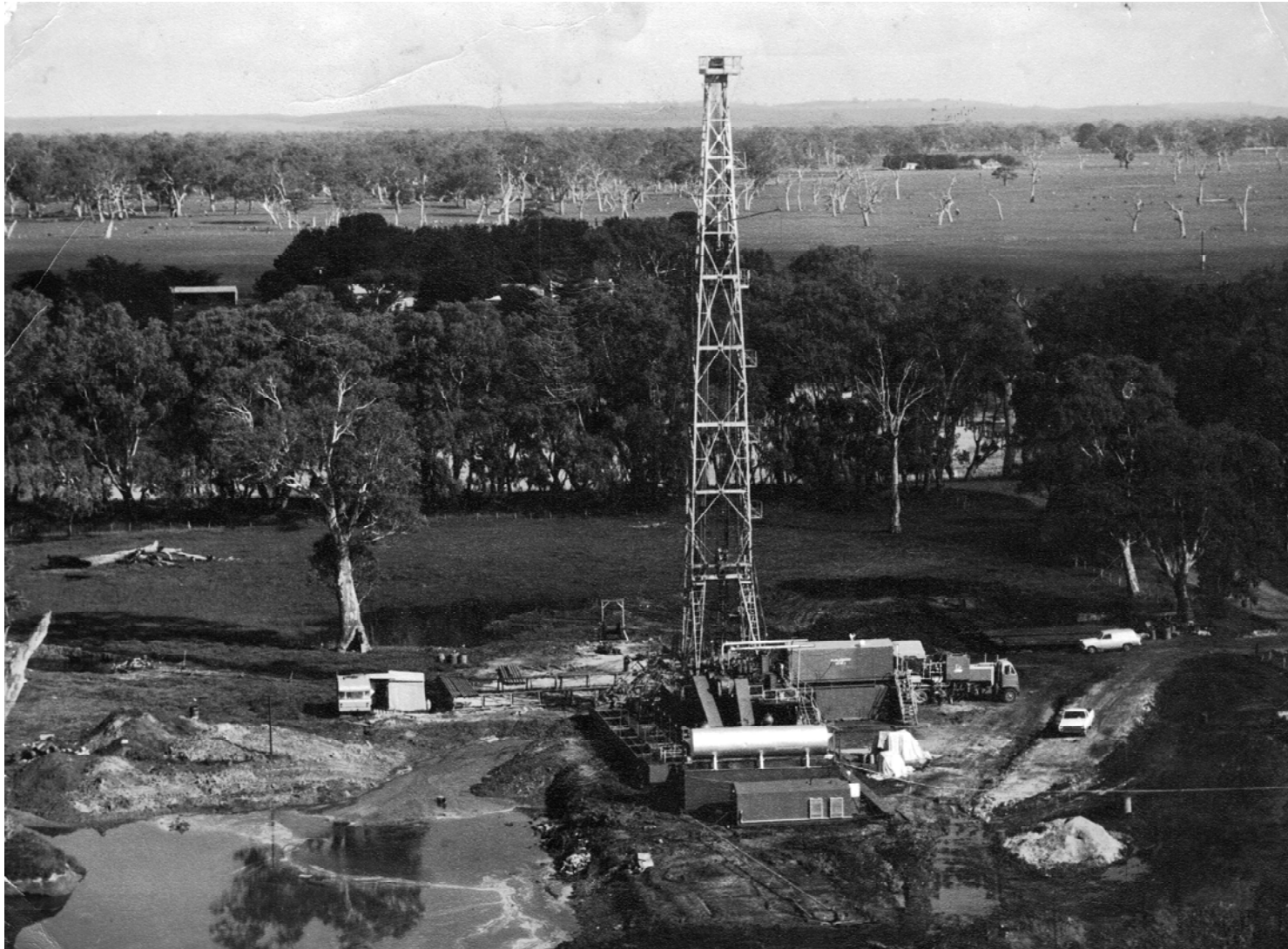
# History of Gas Extraction in SE

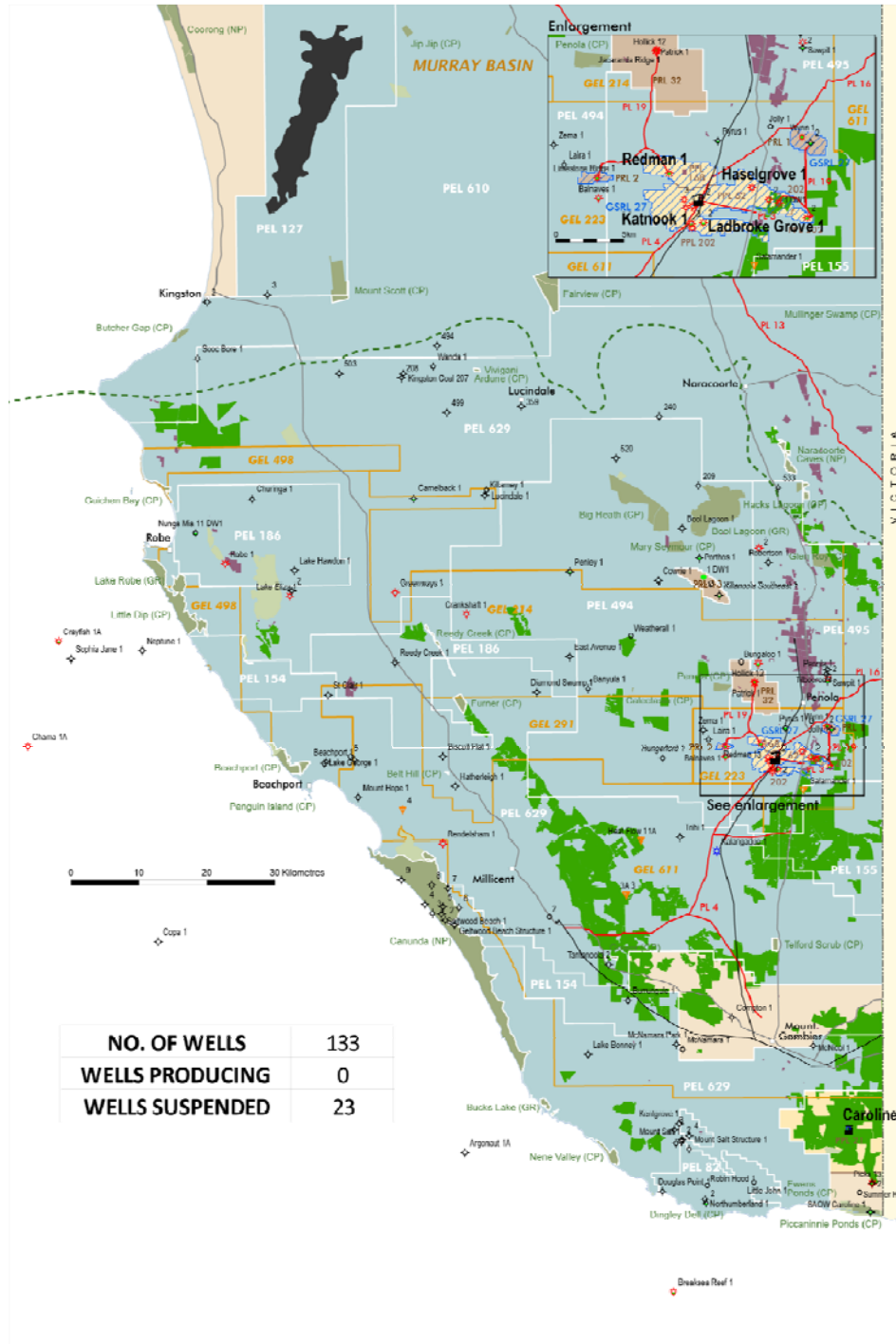




# Otway Basin

Kalangadoo #1 1964





**Petroleum wells**

- CO2 well
- CO2 well with oil shows
- Dry hole
- Dry hole with oil shows
- Gas shows
- Gas well
- Gas well with oil shows
- Oil and gas well
- Oil and gas shows
- Oil well
- Proposed or currently drilling

**Geothermal wells**

- Abandoned well
- Suspended well

**Infrastructure**

- Processing plant
- Town
- Principal road
- Railway

**Petroleum tenements**

- Gas pipeline
- Petroleum Exploration Licence (PEL)
- Petroleum Production Licence (PPL)
- Petroleum Retention Licence (PRL)

**Geothermal tenements**

- Geothermal Exploration Licence (GEL)

**Gas storage tenements**

- Gas Storage Retention Licence (GSRL)

**Land use**

- Coal deposit
- Vines
- Forest Reserves
- National Parks and Reserves - with petroleum access
- National Parks and Reserves - no petroleum access

## Conventional Oil and Gas Exploration Nothing New

YEAR SPUDDED	NO. OF WELLS DRILLED
1910 to 1919	2
1920 to 1929	5
1930 to 1939	1
1960 to 1969	28
1970 to 1979	12
1980 to 1989	20
1990 to 1999	37
2000 to present	12

# Key History Milestones

- Exploration commenced in 1866 in the South East with a well drilled near Salt Creek
- First flow at Kalangadoo-1 in 1965 and Caroline-1 in 1966 – both CO<sub>2</sub>
- First commercial flow of hydrocarbons in 1987 at Katnook-1
- Katnook Plant built and commissioned in 1991 – now mothballed
- Oil recovered from Sawpit-1 in 1992, flowed from Wynn-1 in 1994 – neither well commercial





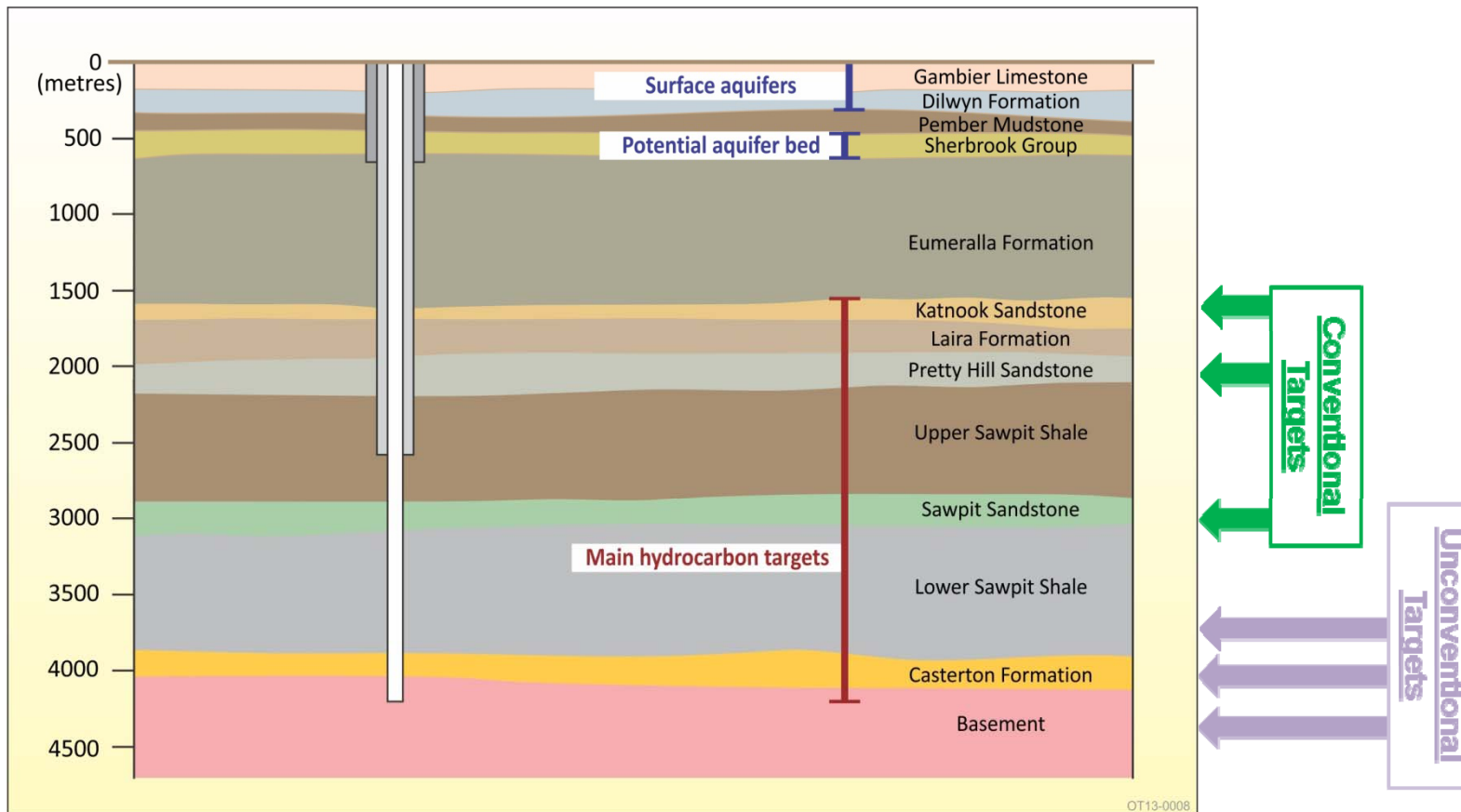
# Gas Supply

## SOUTH EAST PIPELINE SYSTEM - 2003



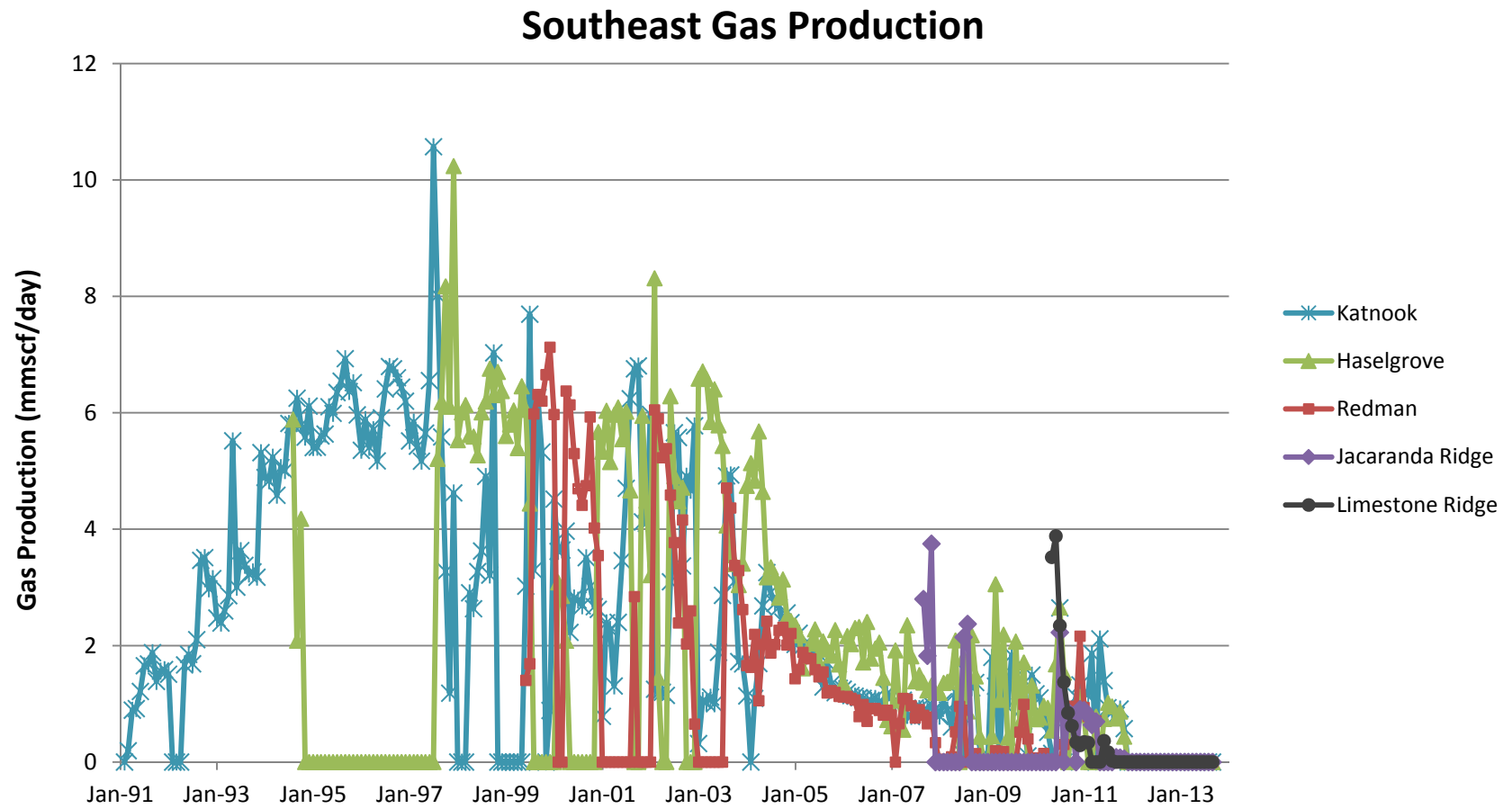
							
PROJECT: PROPOSED OLYMPIC DAM PIPELINE							
DESCRIPTION: PROPOSED GAS PIPELINE FROM COMPRESSOR STATION 2 TO OLYMPIC DAM							
DRAWN BY: RJF							
DATE: 25/02/02	SCALE: NT9			A	25/02/02	Issued for Information	RJF
				Rev	Date	Issue Description	By
							Chk
							Appr

# Source of Gas

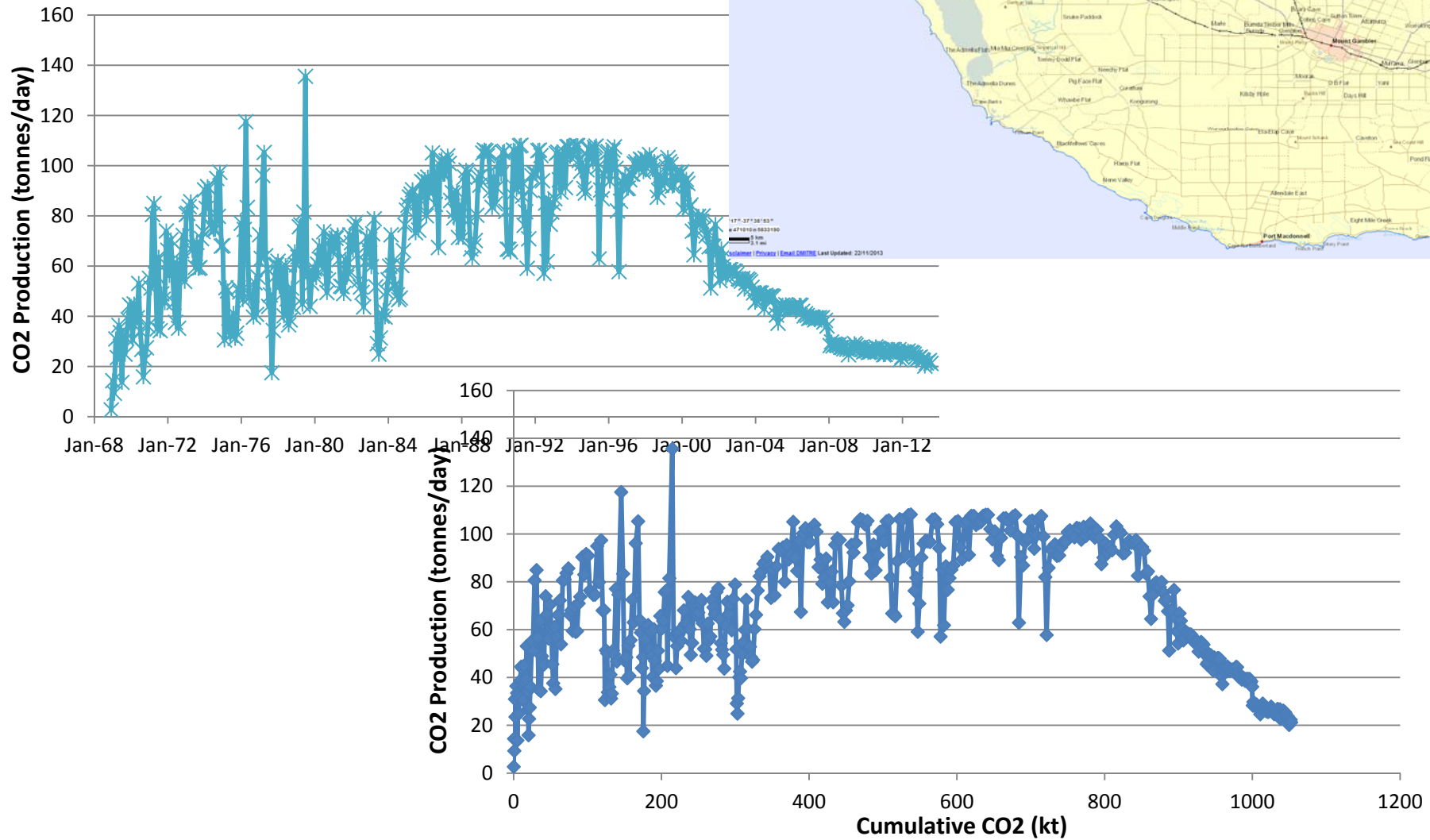




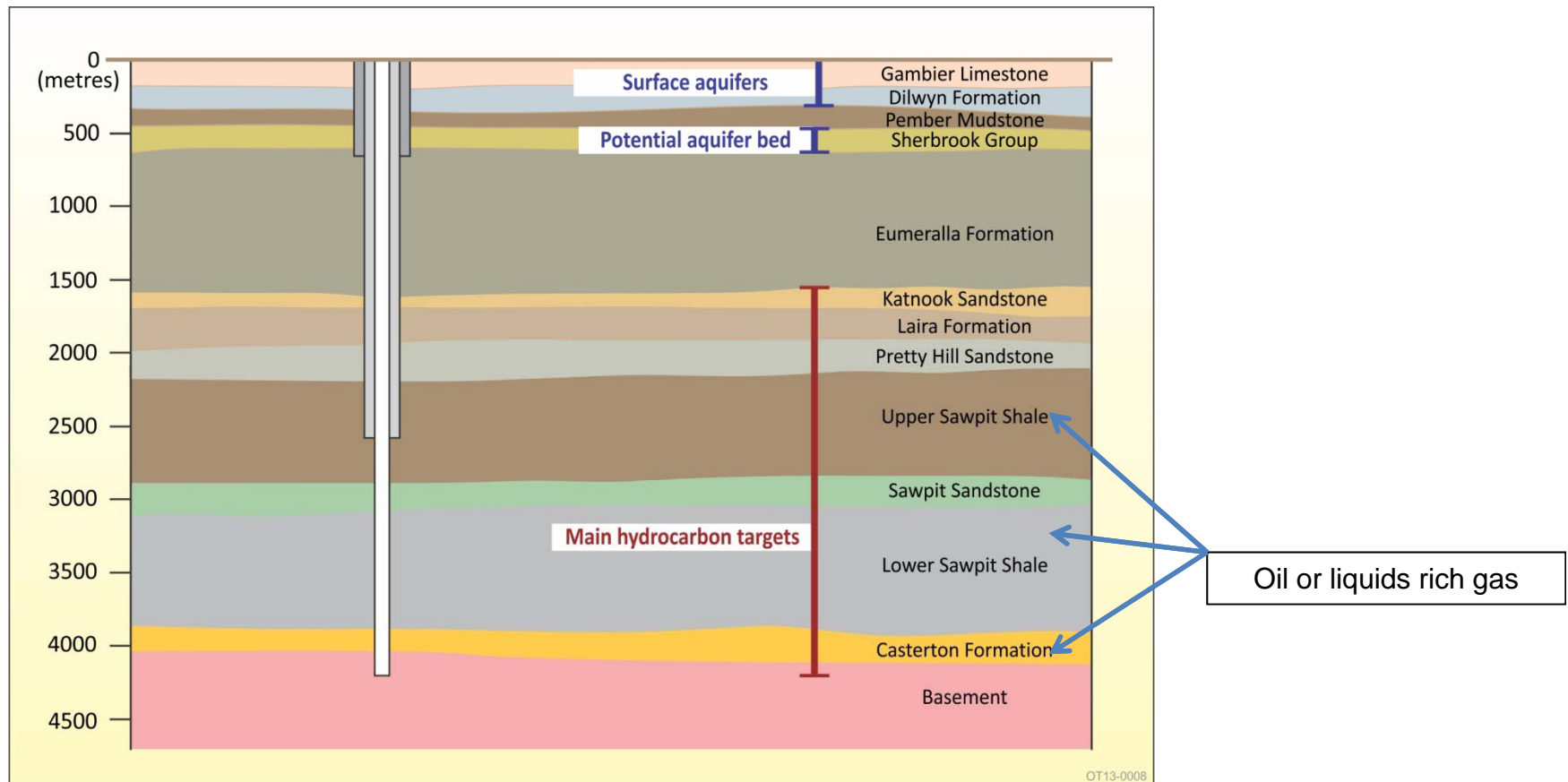
# Historical Gas Production



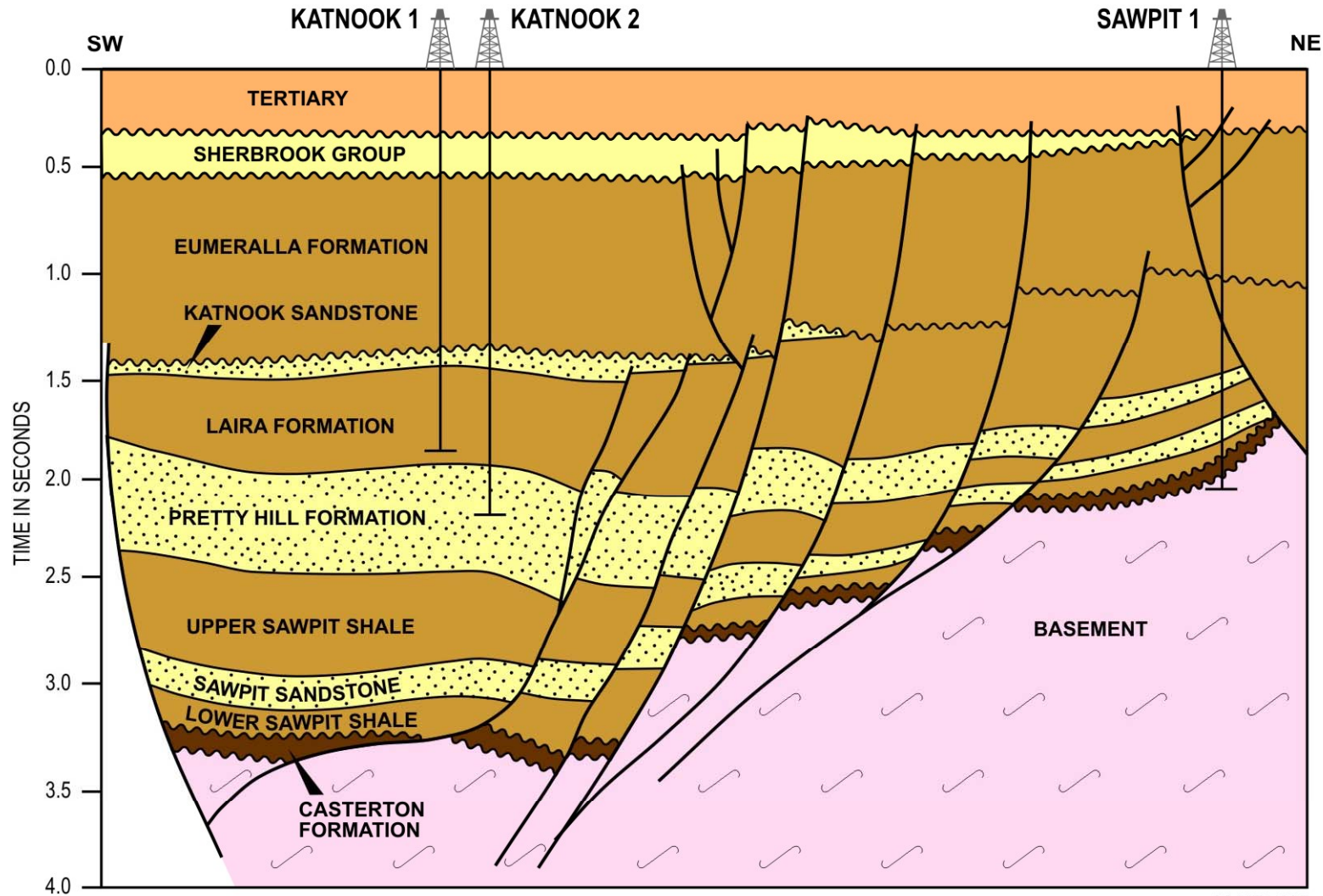
# Caroline#1 CO2 Production



# Where to Next?



# South East Geology



# South East Geology



SPE 23009

## Pressure-Transient Response in Compartmentalised Gas Reservoirs: A South Australian Field Example

M. Malavazos and R.C.M. McDonough, South Australia Dept. of Mines & Energy

SPE Members

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This paper was prepared for presentation at the SPE Asia-Pacific Conference held in Perth, Western Australia, 4-7 November 1991.

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### Abstract

The long-term, production tests of the Katnook gas field in the South-East of South Australia are analysed to enable a better understanding of the reservoir geometry.

The pressure-transient responses are interpreted to indicate a compartmentalised reservoir, comprising a series of high-permeability sand bodies in relatively poor communication. This is consistent with the geological model, which describes the stacked-channel reservoirs having been formed in a low-sinuosity, braided-stream palaeo-environment.

Estimates of channel width and reservoir permeability are made using the correlation of type

The initial discovery was made in the Windermere Sandstone of the basal Eumeralla Formation. The subsequent drilling of Katnook #2 and #3 discovered and confirmed that the major gas reserves are located in a faulted anticlinal structure of the Pretty Hill Sandstone, covering an area of about 4 km<sup>2</sup>.

A drill stem test gas flow of 16.4 MMscfd (462,000 m<sup>3</sup>/d) on a half inch (12.7 mm) choke was measured during DST #12 in Katnook #2. This is a record for a well drilled onshore in South Australia.

Delivery of natural gas from Katnook to the industrial, commercial and domestic markets in the South-East of South Australia commenced in March 1991. Under the terms of the contract the producers will supply 22.5 PJ over a 15 year period.



# South East Geology

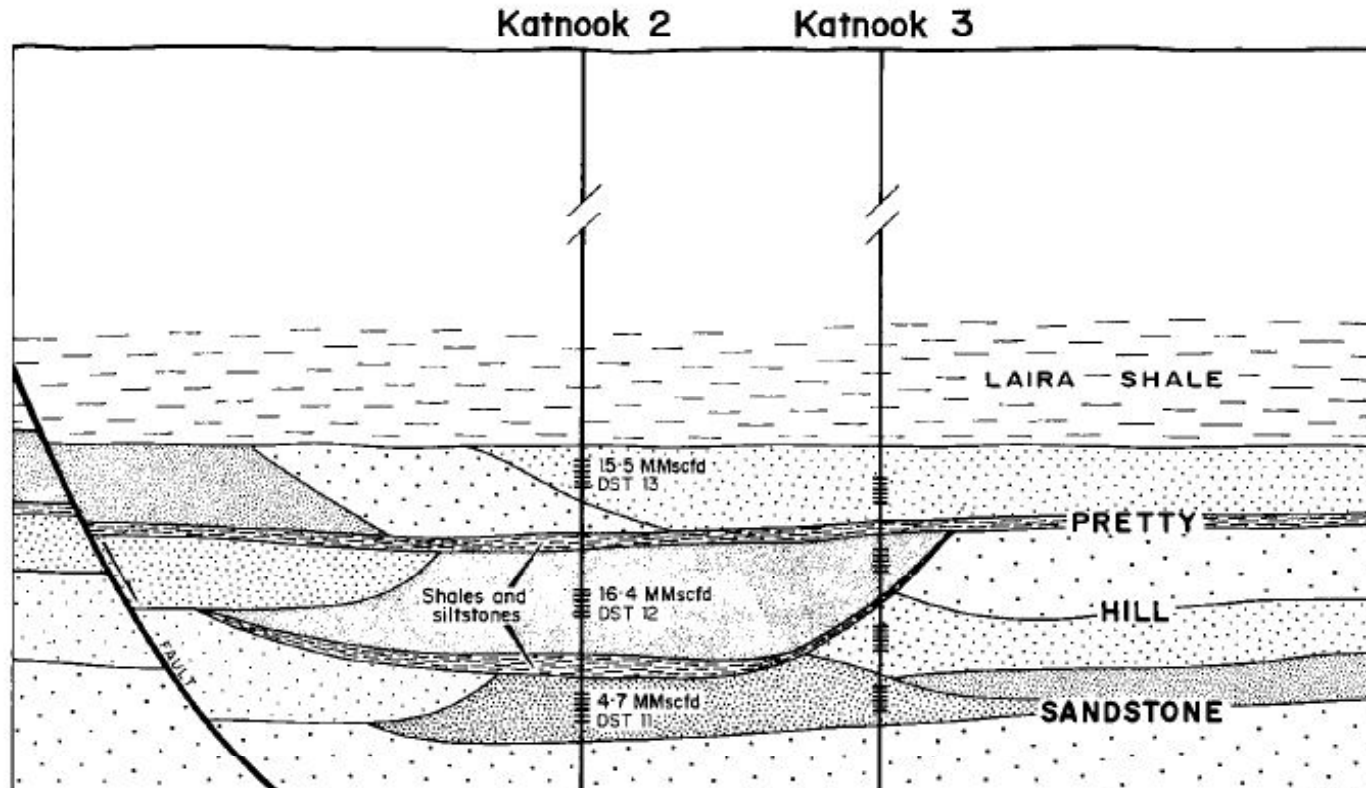
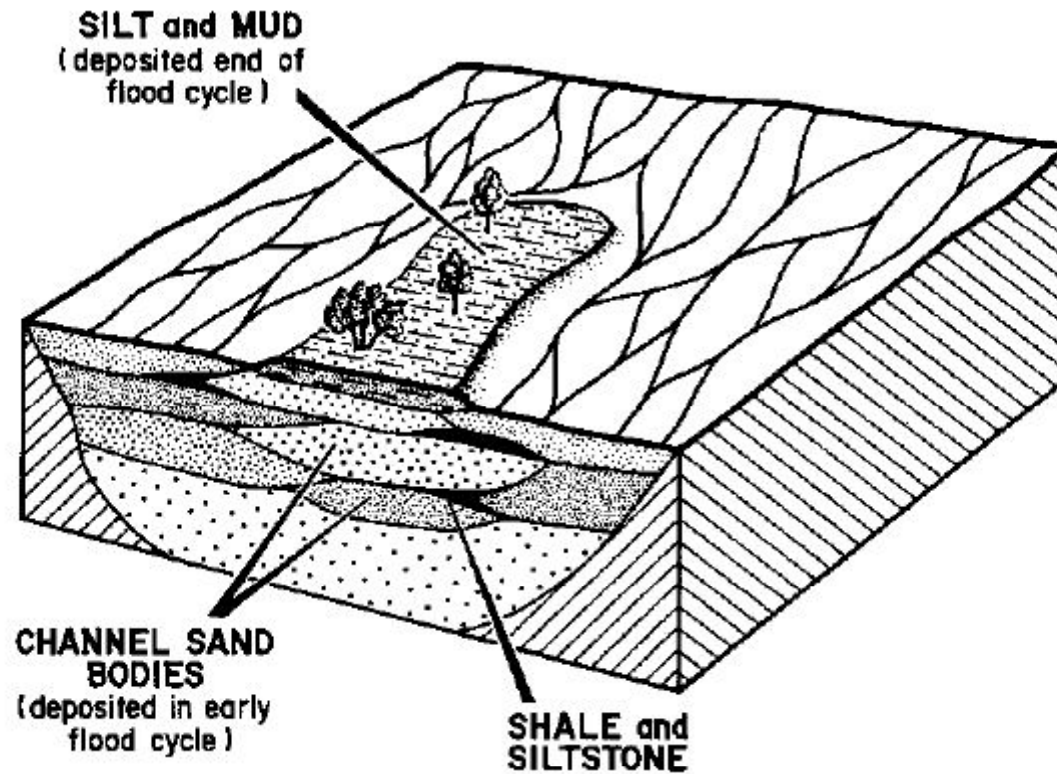


Fig. 2 Schematic section of the Katnook field (Pretty Hill Sandstone reservoir).

# South East Geology



**Fig. 3** Block diagram of channel sands in a braided fluvial environment (Scholle and Spearing<sup>1</sup>).



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# Legislative Controls

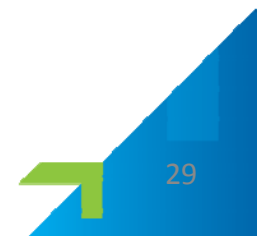




# VISION: Deep unconventional gas delivering decades of safe, secure and competitive gas

## To reach this vision

- **Must demonstrate:** Potential risks to social, natural and economic environments are *reduced to as low as reasonably practical (ALARP)*; and meet community expectations;
- Stakeholders get timely information describing risks to enable informed opinions/decisions



# Regulatory Objectives/Conditions

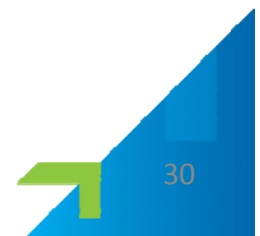
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Avoid:

- Contamination of aquifers
- Adversely impacting other land users and uses
- Contamination of soil
- Disturbance of heritage sites
- Adversely impacting vegetation
- etc

Aim of regulatory processes is to have licensees demonstrate that they can and are achieving these objectives



# Regulatory Framework



## In South Australia

Petroleum Exploration and Production Activities regulated under:

- *Petroleum and Geothermal Energy Act 2000 (PGE Act);*
- *Environment Protection Act 1993;*
- *Natural Resources Management Act 2004;*
- *National Parks and Wildlife Act 1972;*
- *Aboriginal Heritage Act, 1988;*
- *Development Act, 1993;*
- *Work Health and Safety Act 2012;*
- *Public and Environmental Health (Waste Control) Regulations 2010;*
- *EPBC Act 1999*

Interaction between PGE Act and other South Australian Acts administered through Administrative Arrangements with respective agencies



# Petroleum and Geothermal Act 2000

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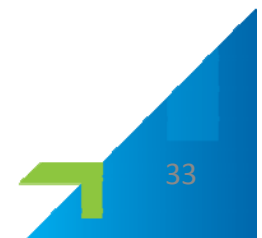
PGE Act defines the *environment* as:

- land, air, water, soil;
- plants & animals;
- social, cultural & heritage features;
- visual amenity;
- economic & other land uses.

# Statements of Environmental Objectives (SEO)

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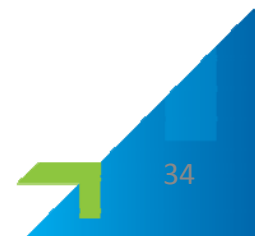
- Regulated Activities cannot be carried out unless there is an approved SEO in place.
- SEO's set approval conditions for regulated activities e.g. seismic, well operations, production, processing, pipelines, gas storage, etc.
- Activity notifications – licensee demonstrates how it will achieve SEO before approval granted





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# Approval Process



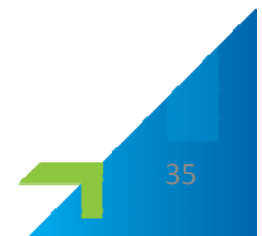
# PGE Act Approval Processes

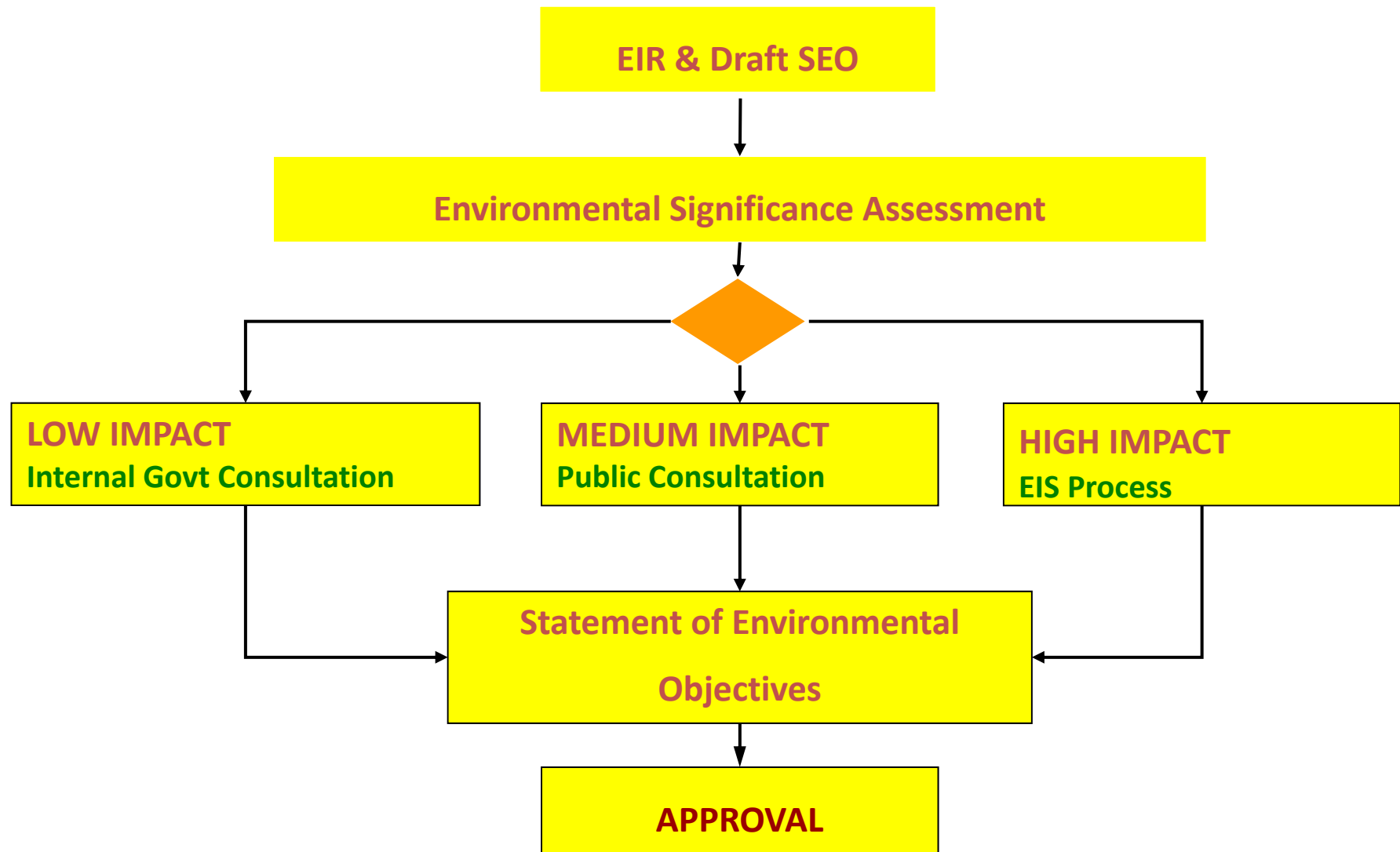
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Two approval stages – Petroleum & Geothermal Act:

1. Licence approvals
  - Exploration, Retention
  - Production, Gas Storage, Pipeline, Special Facility Licences
  
2. Activity approvals
  - SEO Approval Process
    - what they must achieve
  - Activity Notification Process
    - demonstrate how they will achieve







# Significance Criteria

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## PREDICTABILITY

Level of confidence that for each impact and consequence these issues have been addressed:

- Size
- Scope
- Duration
- Likelihood/Frequency
- Stakeholder Concerns

## MANAGEABILITY

Extent to which consequences can be managed:

- Avoidance
- Probability
- Duration
- Size
- Scope
- Cumulative Effects
- Stakeholder concerns



# Significance Criteria

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# SEO Objectives Include:

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Avoid:

- Contamination of aquifers
- Adverse impacts on other land users and uses
- Contamination of soil
- Disturbance to heritage sites
- Adverse impacts on vegetation
- etc

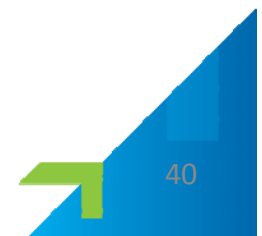
Breaching these objectives is a PGE Act offence



## Notices of Entry (NoEs)



- **Owners of land** means all persons and enterprises potentially directly affected by regulated activities,
- **NoEs** must provide timely information to enable potentially affected people and enterprises to reach informed views regarding impacts on their interests.
- **Owners of land** must be given **NoEs** at least 21 days in advance of the start of any activities – and have 14 days to lodge objections
- All potentially directly affected people and enterprises have **rights to object** to the approval of land access for regulated activities, and **all such objections are a show-stopper** until objections are resolved.

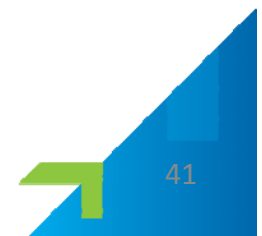


## Notices of Entry (NoEs)

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- These **Owner of Land** rights are sustained without support for vexatious objections.
- **Owners of land** are due compensation from relevant PGE Act licence holders for reasonable costs of assessing NoEs (including the cost of legal advice) and for any loss or deprivation that might result from activities regulated pursuant to the PGE Act.
- The **dispute resolution process** for objections to NoEs
  - starts with **engagement** between the concerned stakeholder and the relevant PGE Act Licence holder;
  - can escalate to **mediation** stewarded by the Minister; but
  - **court proceedings** are the ultimate dispute resolution process.



# Best Practice Regulatory Principles

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## Delivering Regulatory Best Practice through 6 Principles:

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- 1) Certainty
- 2) Openness
- 3) Transparency

- 4) Practicality
- 5) Flexibility
- 6) Efficiency

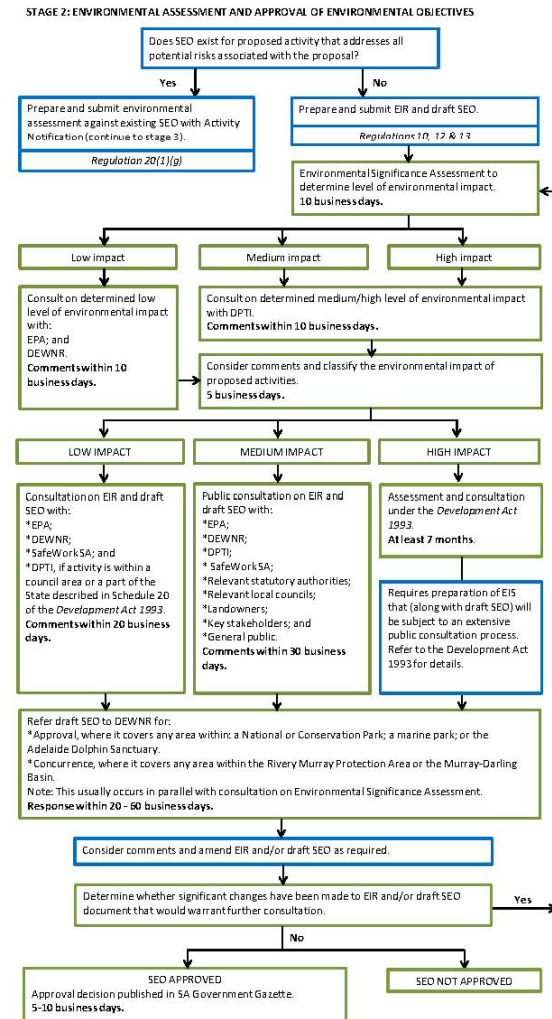




# Openness



- Inclusive stakeholder consultation in establishing regulatory objectives, broad community engagement on addressing potential environmental, economic and social/cultural impacts.



# Transparency

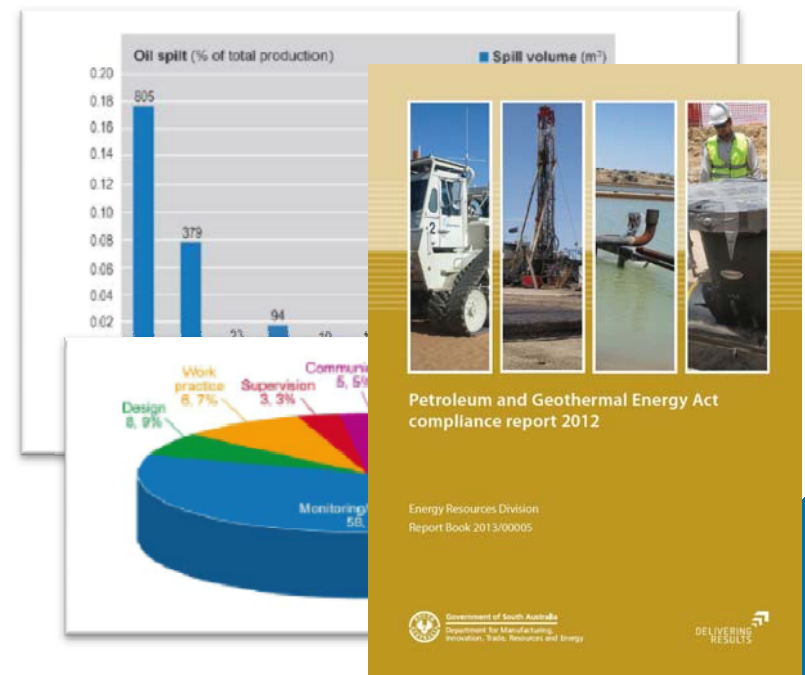


## Public Access to regulatory decision making.

- [Criteria for classifying the level of Environmental Impact](#)
- [All Environmental Impact Reports, assessments and Statements of Environmental Objectives \(Approval Conditions\) are online](#)

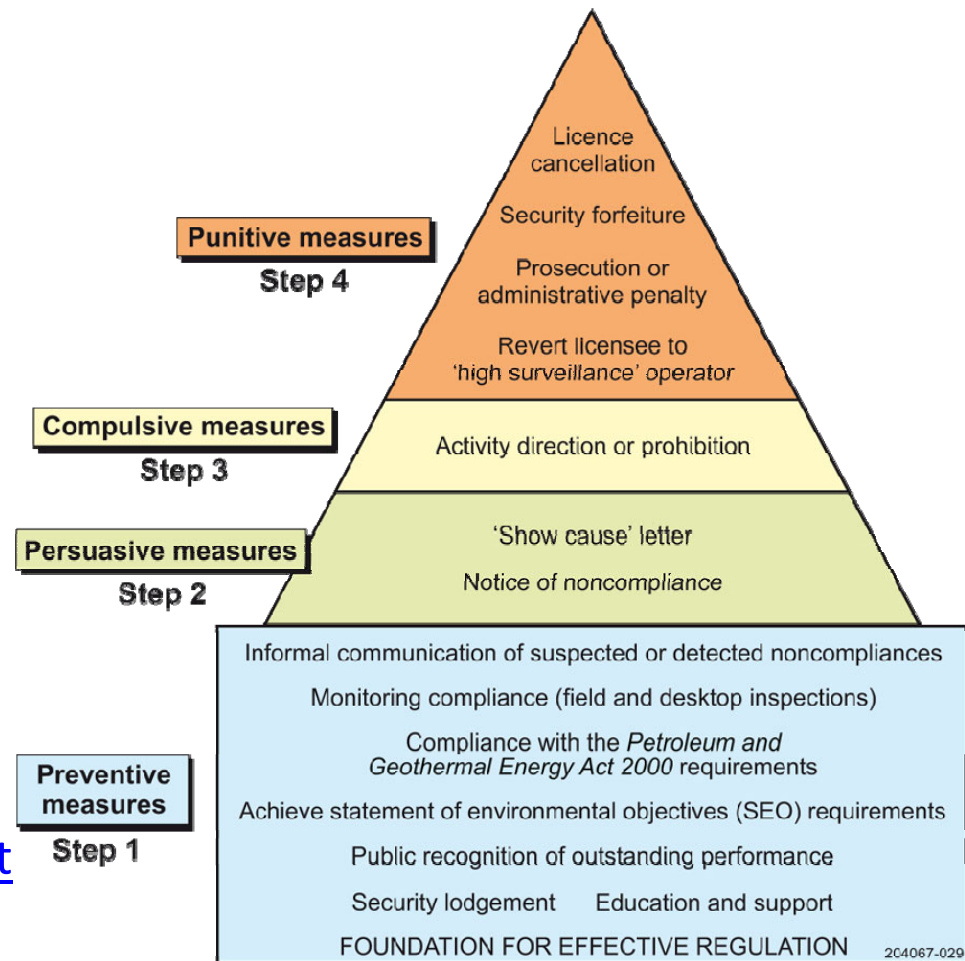
## Community access to industry performance information:

- environmental performance
- regulatory enforcement actions
- surveillance activity information
- [Licensee Annual Compliance Reports](#)
- [PGE Act compliance policy](#)
- [PGE Act Annual Compliance report](#)



Appropriate range of regulatory enforcement tools to elicit compliant behaviour.

- [PGE Act compliance policy](#)
- [PGE Act Annual Compliance report](#)

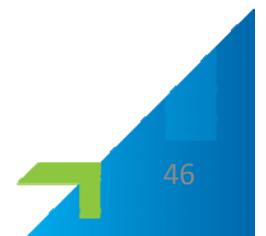




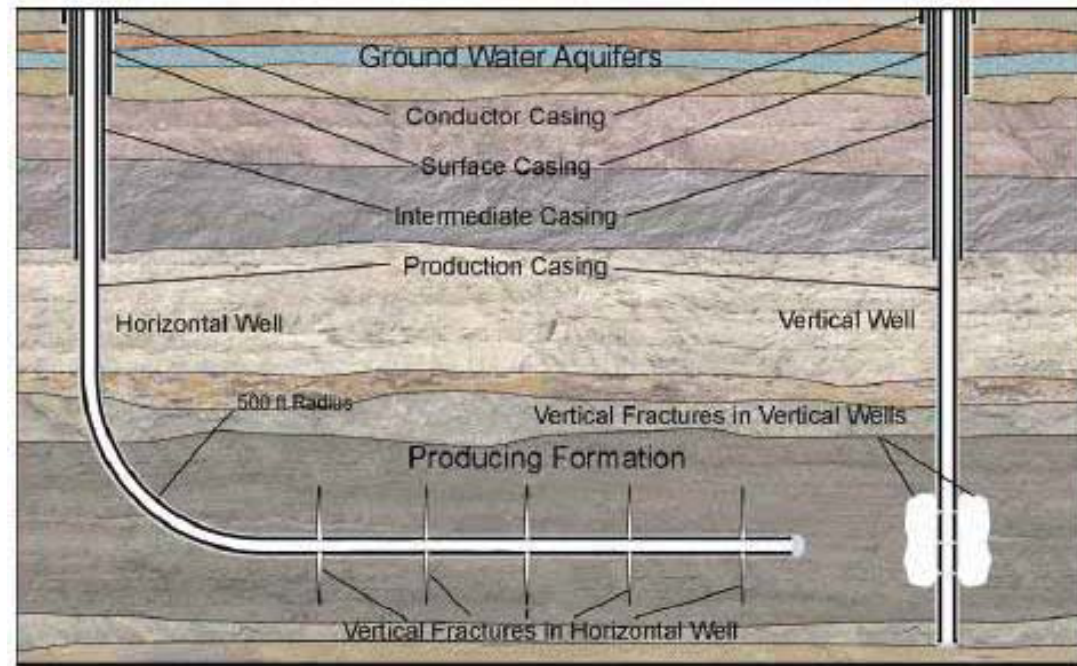
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## **Part 2**

# **What are the risks?**



# How do we identify and manage the risks?



[Beach Energy Shale Gas Fraccing - EIR](#)

[Beach Energy Shale Gas Fraccing - SEO](#)

# EIR Summary

HAZARDOUS EVENTS	POTENTIAL CONSEQUENCES	MITIGATION MEASURES
Access & pad construction, vehicle & people movement.	Intrusion or physical damage to areas of Aboriginal heritage significance.	Scouting for such sites to be undertaken ahead of activity.
Crossflow from hydrocarbon zones or lesser quality aquifers.	Contamination of aquifers.  Pollute water source of other users	Identified aquifers isolated behind casing.
Drilling through fresh water aquifers.		Use of non-toxic muds.
Fracking into adjacent and overlying aquifers		Non-toxic frac fluid.  Monitor frac through micro seismic and control pump pressures accordingly



# EIR Summary

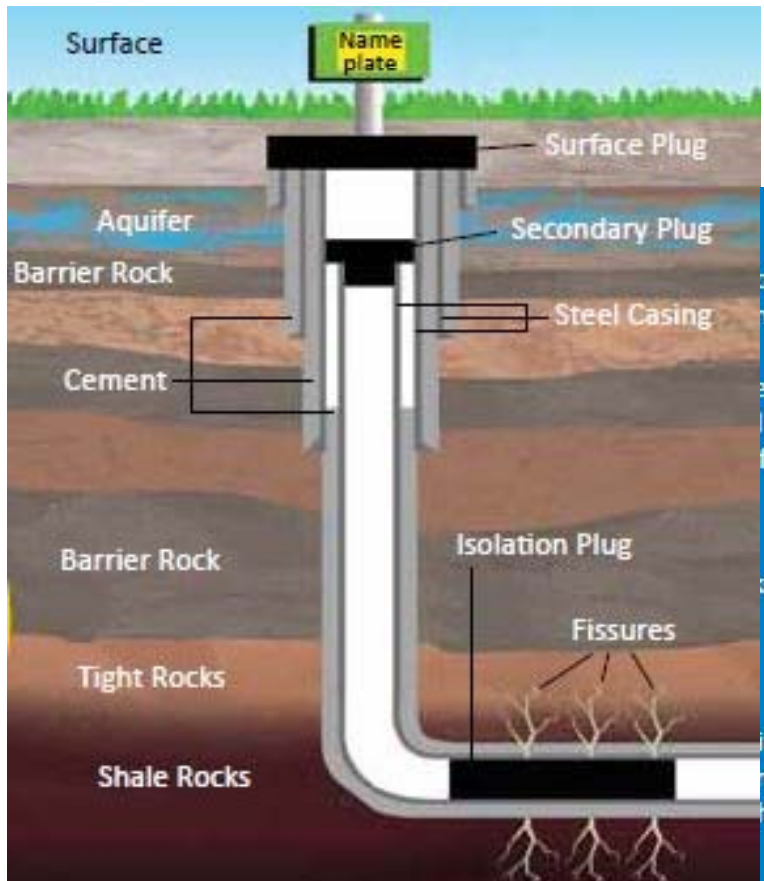
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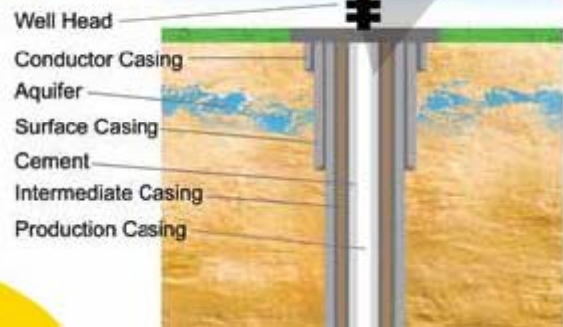
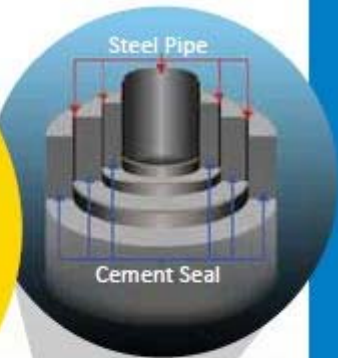
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**Contained**  
 Wells have as many as eight layers of steel casing and cement that form a continuous, protective barrier between the well and the surrounding rock. The well design and program is reviewed, approved and monitored by the State or Territory regulator.



Courtesy: APPEA Natural Gas Revolution Brochure, 2013

# Best Practice Industry Standards

<http://www.shalegas.energy.gov/resources/HF1.pdf>

## Hydraulic Fracturing Operations— Well Construction and Integrity Guidelines

API GUIDANCE DOCUMENT HF1  
FIRST EDITION, OCTOBER 2009



# Recommended Well Construction Practice

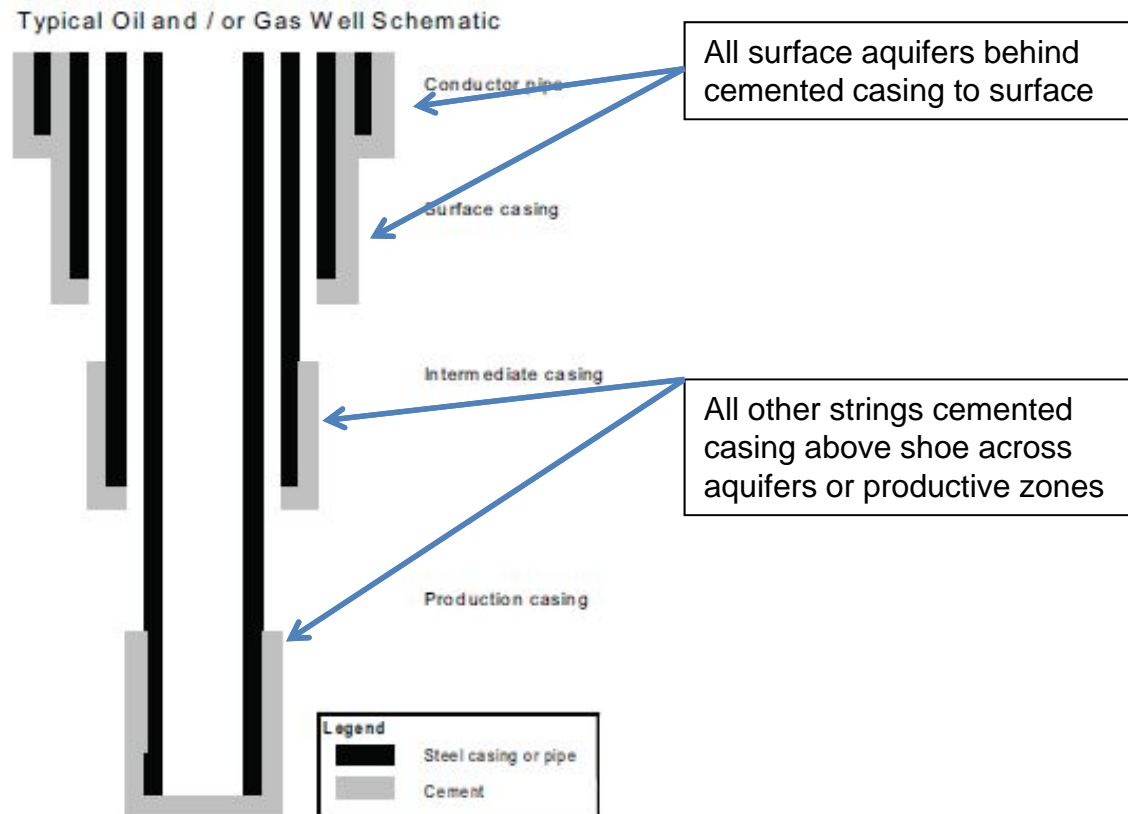
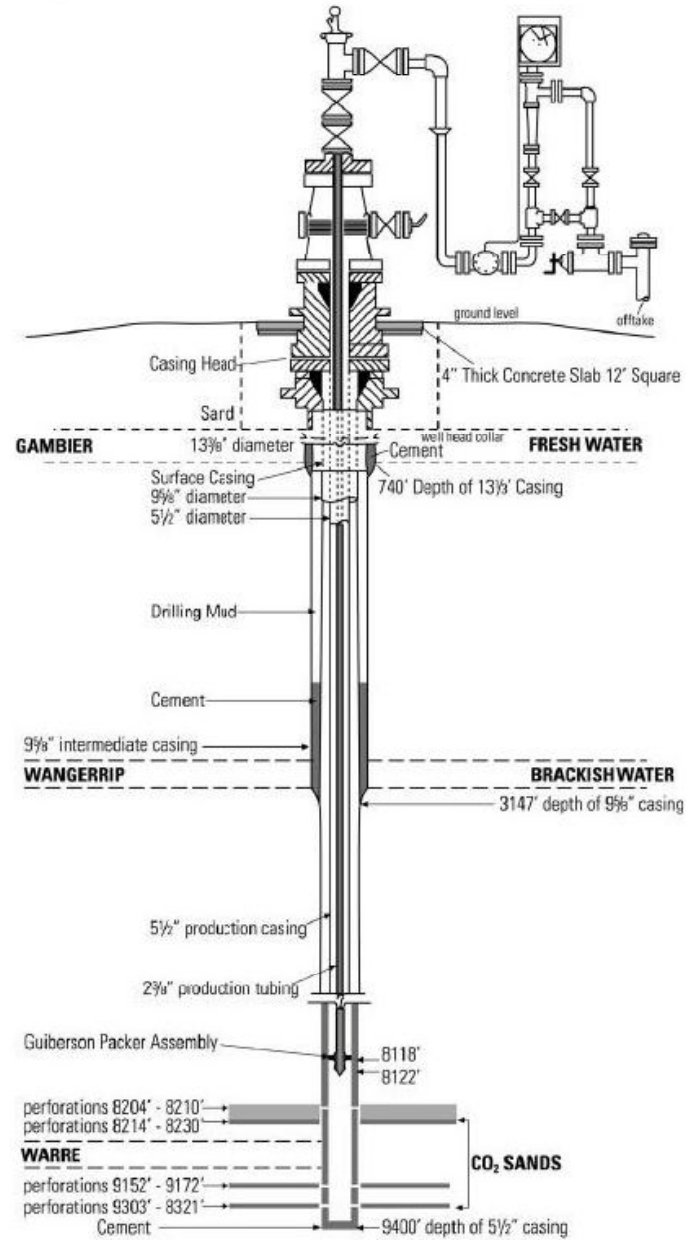


Figure 1—Typical Well Schematic

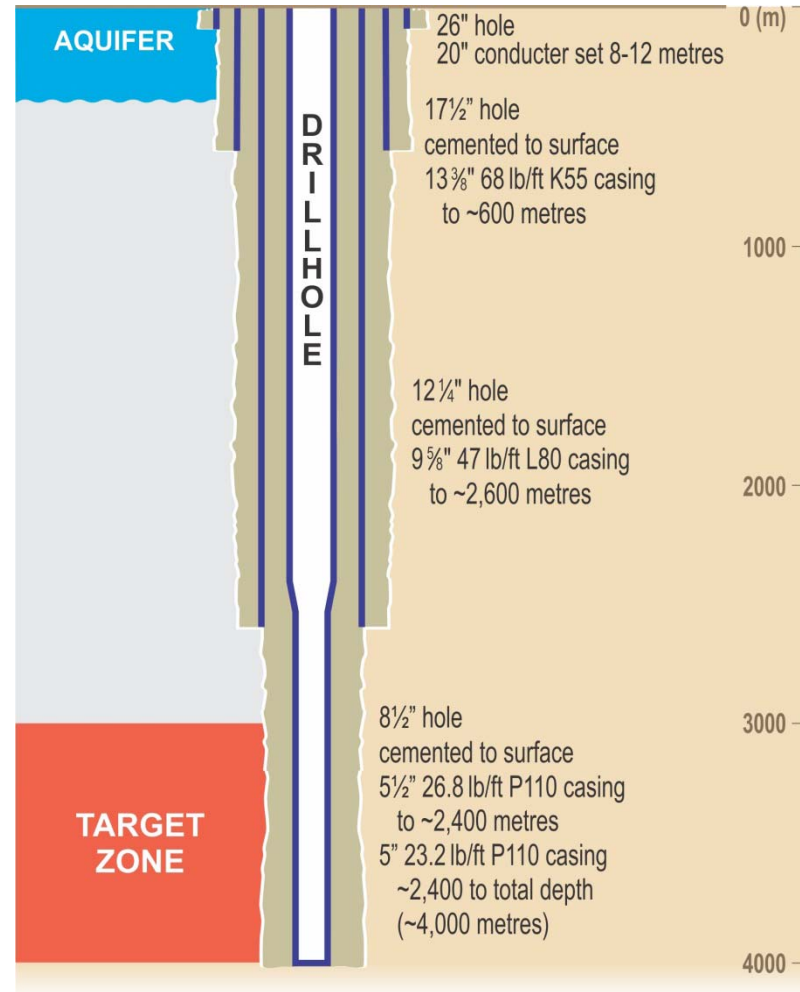


# CAROLINE CO<sub>2</sub> COMPLETION DIAGRAM



# Approved Practice for All future Wells

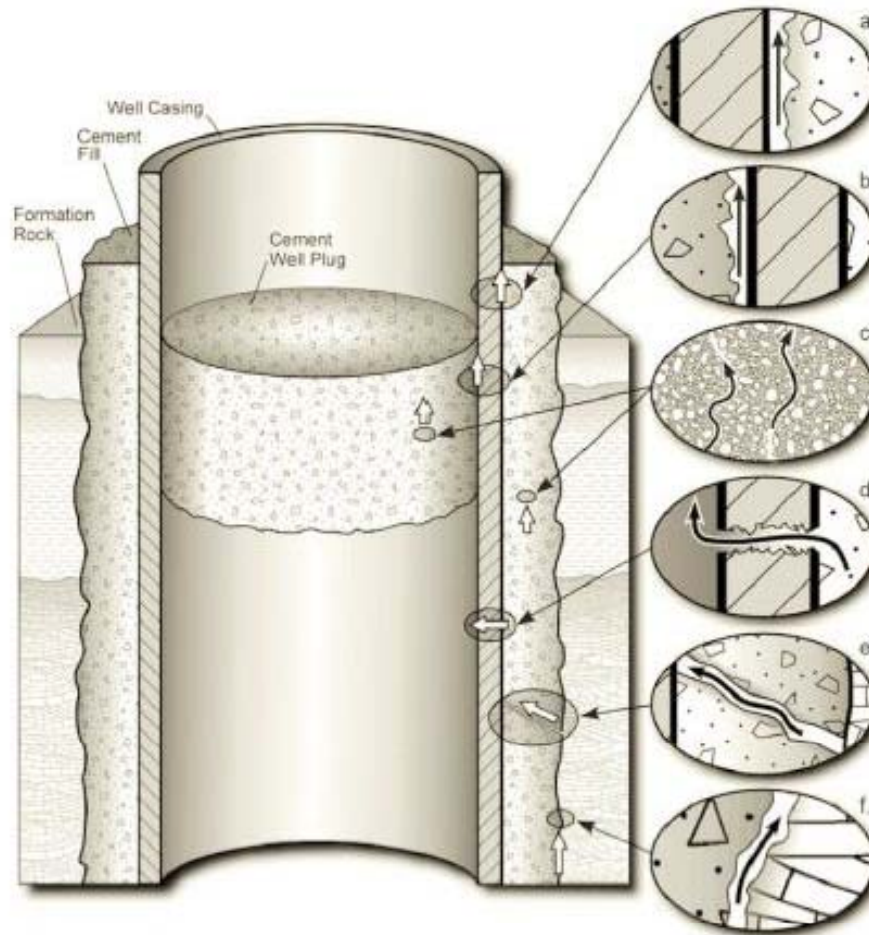
- Well will be drilled through the surface sediments into the Eumeralla Formation and casing run so that the surface aquifers are not in communication with the well bore
- All casing strings will be cemented to surface
- **Beyond recommended practice**



# What are the risks



## Casing and cement integrity



Not acceptable or tolerable...

# BRIEF OF EVIDENCE

Investigation into the circumstances surrounding the Uncontrolled Release of Oil and Gas from the Montara Wellhead Platform

## MONTARA DEVELOPMENT PROJECT

located in the Timor Sea approximately 250 km north-west of the Western Australian coast, almost 700 km from Darwin in the offshore area of the Territory of Ashmore and Cartier Islands



**Owned and Operated**

**By**

**PTTEPAA Australasia (Ashmore Cartier) Pty Ltd  
PTTEPAA**

**(ACN 004 210 164)**

**On**

**21<sup>st</sup> AUGUST 2009**

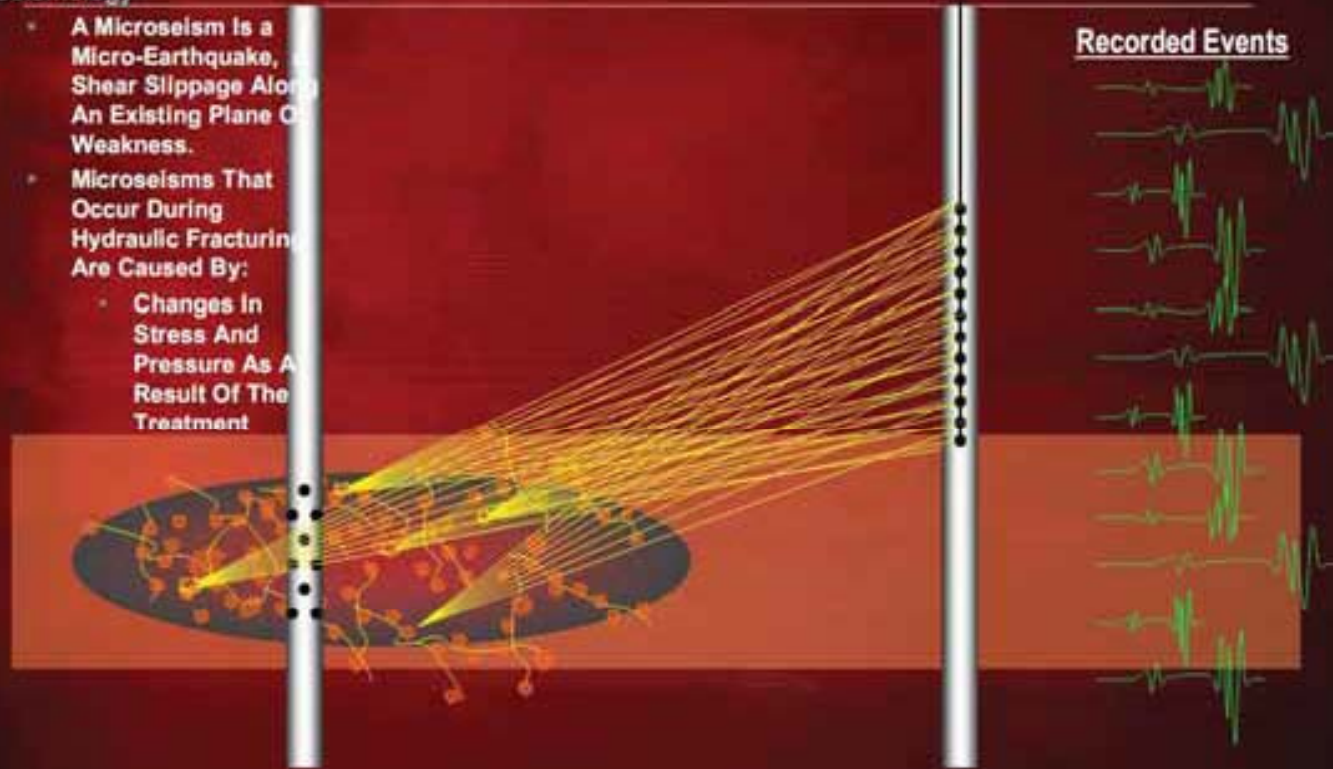
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Crossflow from hydrocarbon zones or lesser quality aquifers.	Contamination of aquifers.	Identified aquifers isolated behind casing.
Drilling through fresh water aquifers.	Pollute water source of other users	Use of non-toxic muds.
Fracking into adjacent and overlying aquifers		Non-toxic frac fluid. Monitor frac through micro seismic and control pump pressures accordingly

# Offset -Well Microseismic Mapping

Microseismic Monitoring Is  
Applied Earthquake  
Seismology

- A Microseism Is a Micro-Earthquake, A Shear Slippage Along An Existing Plane Of Weakness.
- Microseisms That Occur During Hydraulic Fracturing Are Caused By:
  - Changes In Stress And Pressure As A Result Of The Treatment

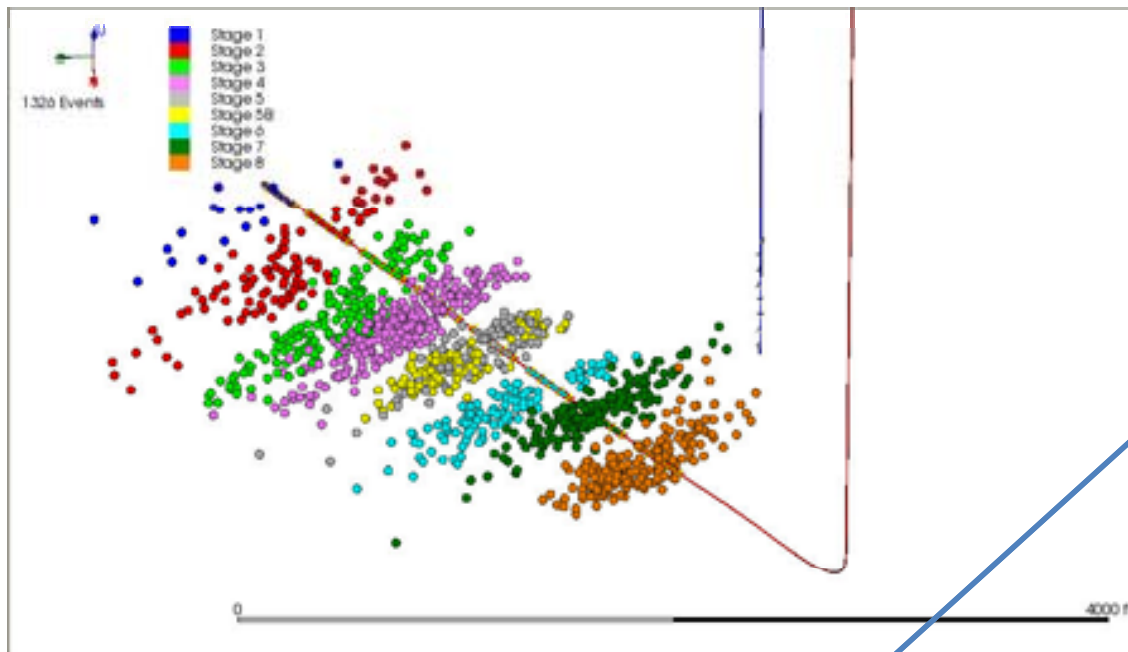




# Specialised extraction Technology

Stimulated rock volume in horizontal well (from  
microseismic monitoring)

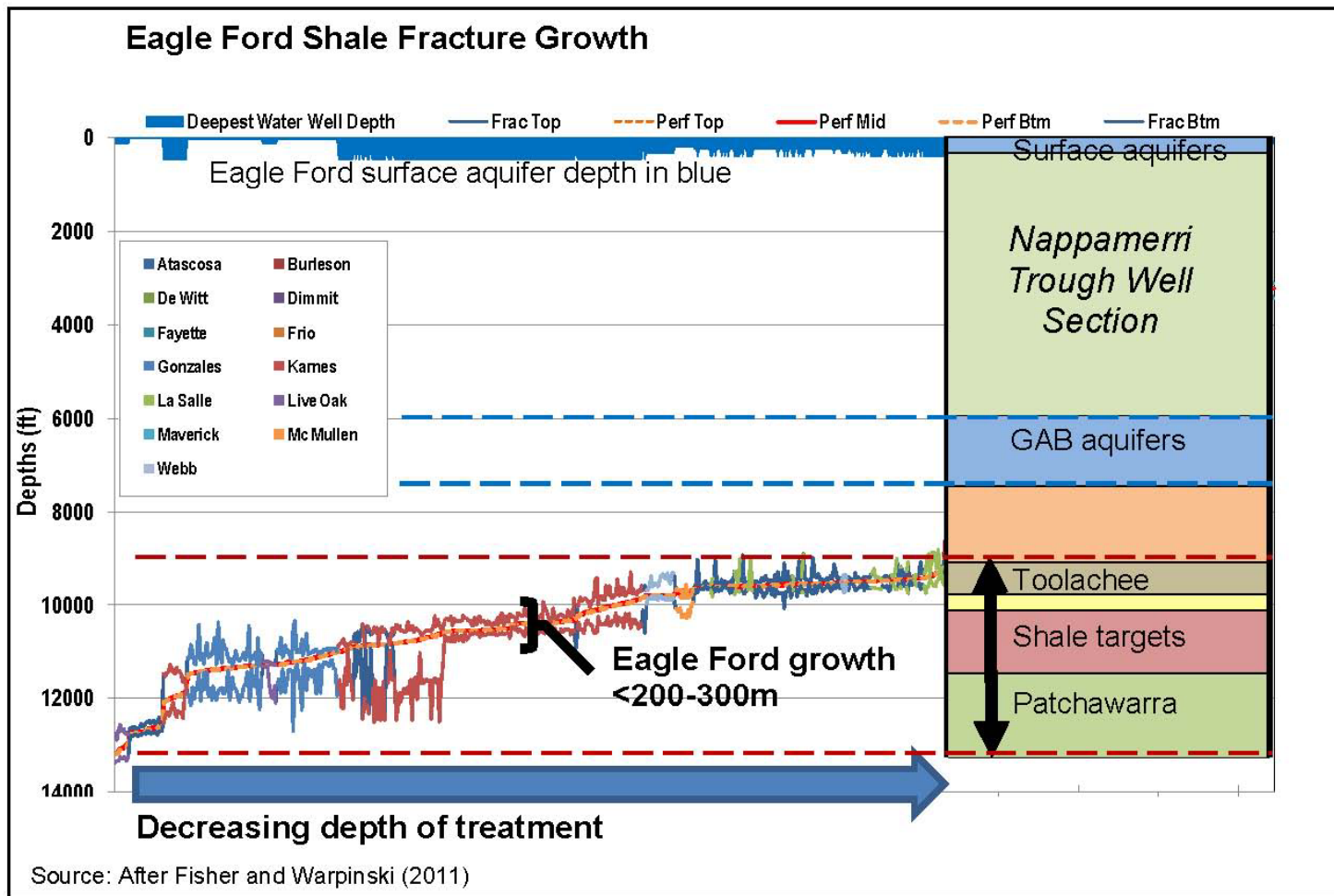
*Coloured dots indicate fracture events related to hydraulic stimulation  
of each perforated stage*



Fracture half length and complexity is controlled by:

- Frac fluid viscosity (gel vs “slickwater”)
- Pump rate
- Pump pressure
- Proppant “mesh” size
- In situ stresses
- Existing natural fractures
- Natural frac barriers (ductile rocks that don’t break easily)
- Rock brittleness

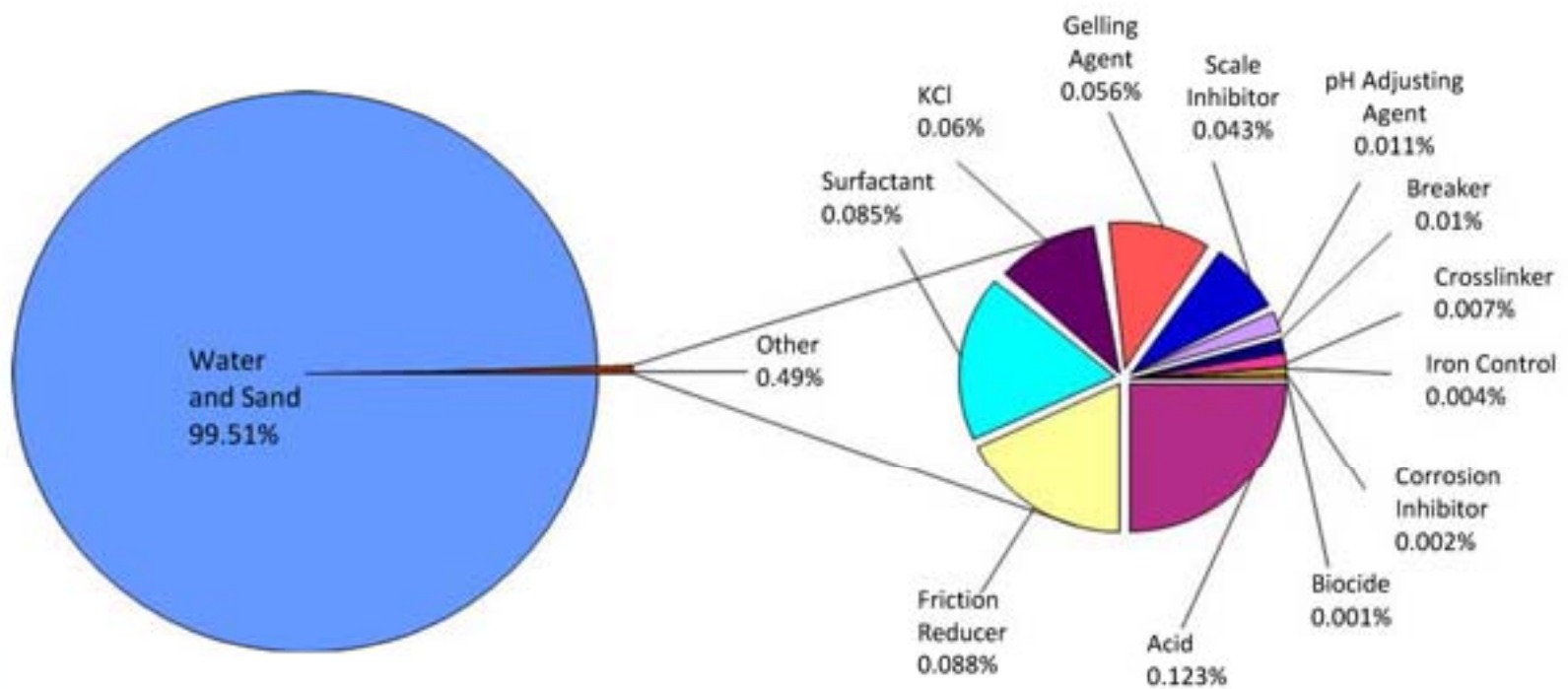




**Figure 24: Typical fracture height growth measured during shale gas stimulation in the Eagle Ford (USA) with Nappamerri Trough well section superimposed**

# EIR Summary

HAZARDOUS EVENTS	POTENTIAL CONSEQUENCES	MITIGATION MEASURES
Access & pad construction, vehicle & people movement.	Intrusion or physical damage to areas of Aboriginal heritage significance.	Scouting for such sites to be undertaken ahead of activity.
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Fracking into adjacent and overlying aquifers		Non-toxic frac fluid.  Monitor frac through micro seismic and control pump pressures accordingly



Additive Type	Main Compound(s)	Purpose	Common Use of Main Compound
Diluted Acid (15%)	Hydrochloric acid or muriatic acid	Help dissolve minerals and initiate cracks in the rock	Swimming pool chemical and cleaner
Biocide	Glutaraldehyde	Eliminates bacteria in the water that produce corrosive byproducts	Disinfectant; sterilize medical and dental equipment
Breaker	Ammonium persulfate	Allows a delayed break down of the gel polymer chains	Bleaching agent in detergent and hair cosmetics, manufacture of household plastics
Corrosion inhibitor	N, n-dimethyl formamide	Prevents the corrosion of the pipe	Used in pharmaceuticals, Acrylic fibers, plastics
Crosslinker	Borate salts	Maintains fluid viscosity as temperature increases	Laundry detergents, hand soaps, and cosmetics
Friction reducer	Polyacrylamide	Minimizes friction between the fluid and the pipe	Water treatment, soil conditioner
	Mineral oil		Make up remover, laxatives, candy
Gel	Guar gum or hydroxyethyl	Thickens the water in order to suspend the sand	Cosmetics, toothpaste, sauces, baked goods, ice cream
Iron control	Citric acid	Prevents precipitation of metal oxides	Food additive, flavouring in food and beverages; lemon juice ~7% Citric Acid
KCl	Potassium chloride	Creates a brine carrier fluid	Low sodium table salt substitute
Oxygen Scavenger	Ammonium bisulfite	Removes oxygen from the water to protect the pipe from corrosion	Cosmetics, food and beverage processing, water treatment
pH Adjusting Agent	Sodium or potassium carbonate	Maintains the effectiveness of other components, such as crosslinkers	Washing soda, detergents, soap, water softener, glass and ceramics
Proppant	Silica, quartz sand	Allows the fractures to remain open so the gas can escape	Drinking water filtration, play sand, concrete, brick mortar
Scale inhibitor	Ethylene glycol	Prevents scale deposits in the pipe	Automotive antifreeze, household cleansers, and de-icing agent
Surfactant	Isopropanol	Used to increase the viscosity of the fracture fluid	Glass cleaner, antiperspirant, and hair color

Source: Engineering Energy: Unconventional Gas Production, ACOLA, 2013

# EIR Summary (cont)

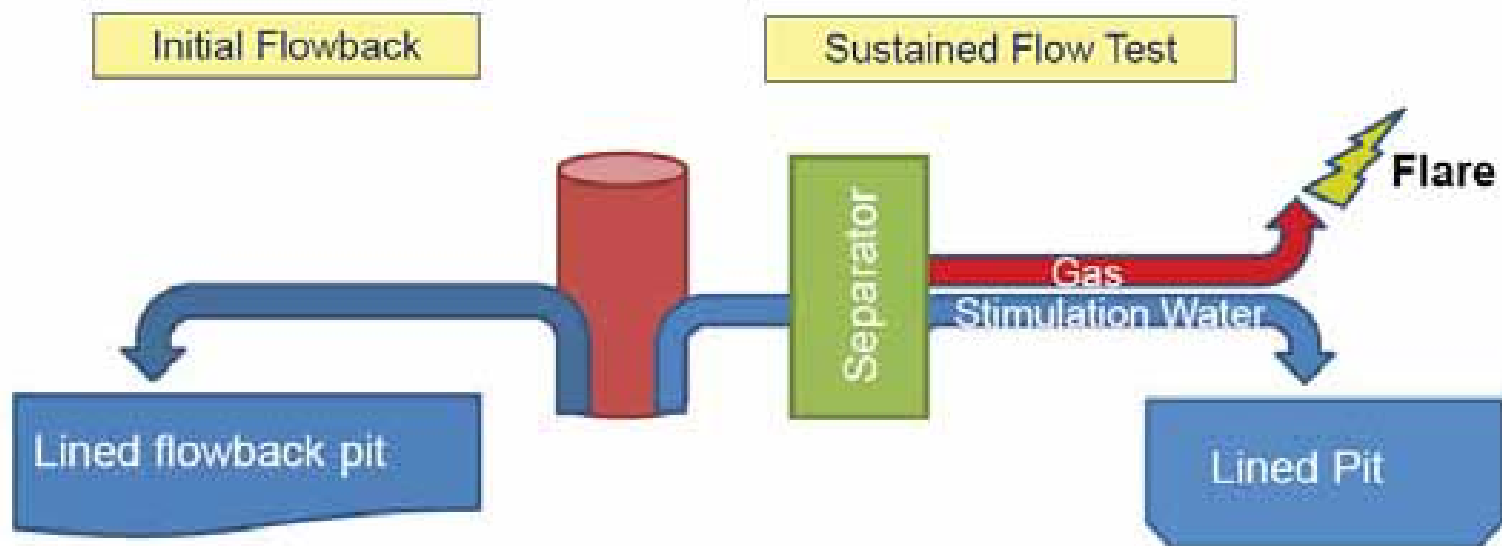
HAZARDOUS EVENTS	POTENTIAL CONSEQUENCES	MITIGATION MEASURES
Flow back of frac fluids	Contamination of soil, impact vegetation and potential contamination of surface aquifers	Frac fluid contained within lined pits
Vehicle and plant refuelling during operations.	Oil spill damage to soil & vegetation.	Refuel in designated bunded area.
Seed importation on vehicles and equipment.	<ul style="list-style-type: none"> <li>• Introducing alien vegetation species (weeds).</li> <li>• Impact on other land users, eg farmers, pastoralists</li> </ul>	All vehicles steam cleaned prior to entering district.

# EIR Summary (cont)

HAZARDOUS EVENTS	POTENTIAL CONSEQUENCES	MITIGATION MEASURES
Flow back of frac fluids	Contamination of soil, impact vegetation and potential contamination of surface aquifers	Frac fluid contained within lined pits
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# Green Completion

## Its all about Containment





# Well and Fraccing Operation Standards

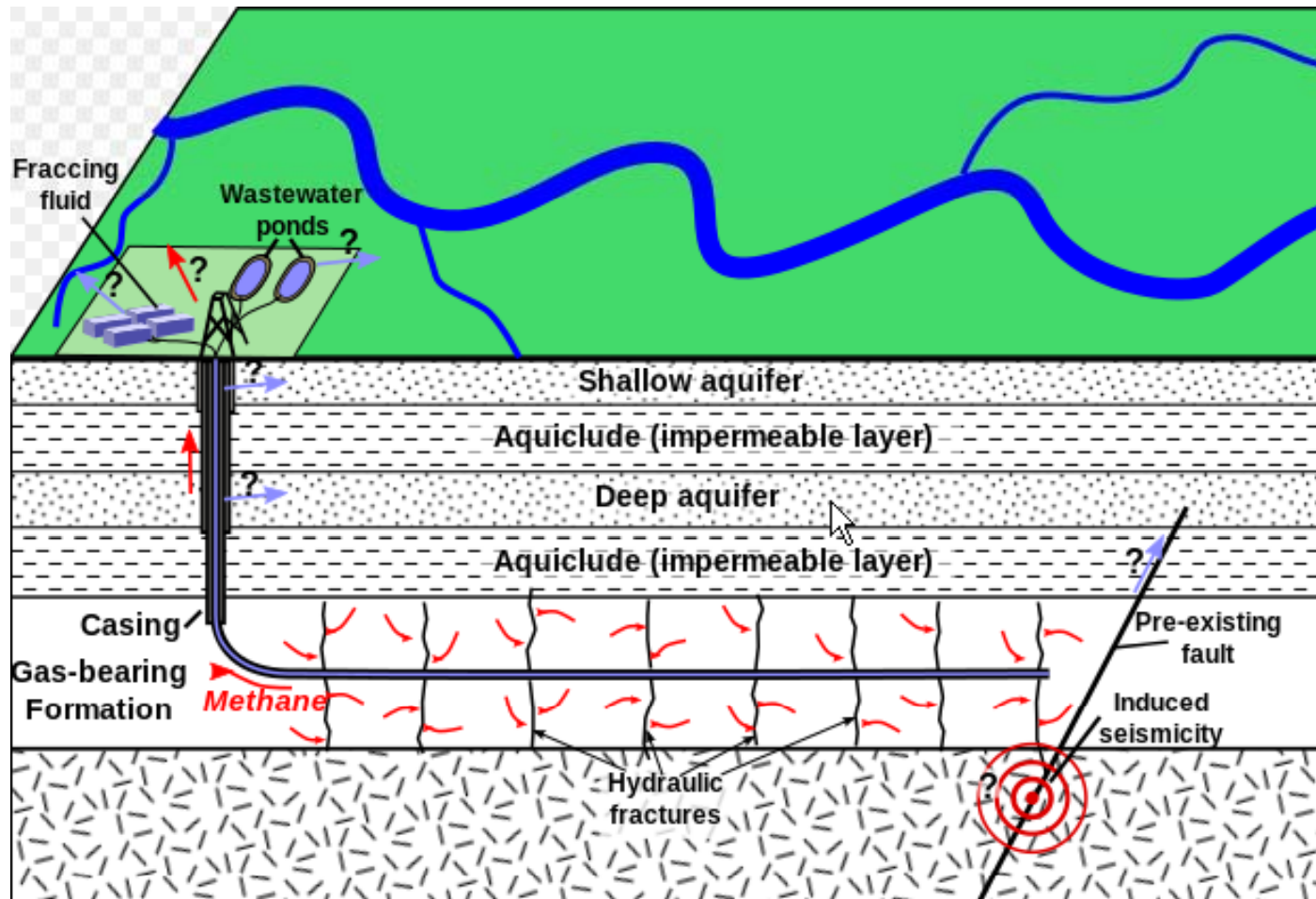
## Overview of Industry | Guidance/Best Practices Supporting Hydraulic Fracturing (HF)

<p>API Spec 4F Drilling and Well Servicing Structures                  API RP 4G Drilling and Well Servicing Structure (Inspection and Maintenance)                  API Spec 6A Wellhead and Christmas Tree Equipment                  API Spec 7K Drilling Equipment                  API RP 8B Hoisting equipment (Inspection and Maintenance)                  API Spec 9C Hoisting Equipment                  API Spec 16A Drill-through Equipment                  API Spec 16C Choke and Kill Systems                  API Spec 16D Control Systems for Drilling/Well Control Equipment                  API RP 16ST Coiled Tubing Well Control Equipment Systems                  API Std 53 Blowout Prevention Equipment Systems                  API RP 62U Underbalanced Drilling Operations                  API Std 689 Reliability/Maintenance Data                  API Spec 02 OMS Requirements for Service Organizations for the Petroleum and Natural Gas Industry                  API Spec 12B Production Liquid Storage Tanks (Bolted)                  API Spec 12D Production Liquid Storage Tanks (Shop welded)                  API Spec 12F Oil and Gas Separators                  API Spec 12J Indirect Type Oilfield Heaters                  API Spec 12K Vertical and Horizontal Emulsion Treaters                  API Spec 12L Flame Arresters Operations, Testing and Maintenance</p>	<p>API Spec 12P Fiberglass Reinforced Plastic Tanks                  API RP 1281 Production Service Tanks (Inspection and Maintenance)                  API RP 2359 Storage Tanks Overfill Protection                  API Pub 4663 Remediation of Salt-Affected Soils                  API Bull D16 Spill Prevention Control and Countermeasure Plan                  API RP 49 Drilling and Servicing Involving Hydrogen Sulfide                  API RP 54 Drilling and Servicing Operations Occupational Safety                  API RP 95 Gas Processing Involving Hydrogen Sulfide                  API RP 99 Well Control Operations                  API RP 64 Diverter Systems Equipment and Operations                  API RP 67 Offfield Explosives Safety                  API RP 68 Oil and Well Servicing and Workover Operations Involving Hydrogen Sulfide                  API RP 74 Production Operations Occupational Safety                  API RP 75L Safety and Environmental Management Systems                  API RP 76 Contractor Safety Management                  API Std 63-2 Isolating Potential Flow Zones                  API RP 90-2 Annular Casing Pressure for Onshore Wells                  API RP 100-1 Well Integrity and Fracture Containment                  API RP 100-2 Environmental Aspects Related to Onshore Operations                  API RP 60 Environmental Protection Natural Gas Processing Plant Practices                  API RP 61B Environmental Protection for Operations</p>	<p>API RP 52 Environmental Protection Land Drilling Practices                  API Bull E2 NORM Management                  API Bull E3 Well Abandonment and Inactive Wells                  API Bull E5 Waste Management                  API Bull HF4 Community Engagement                  API Spec 5L Line Pipe                  API Spec 6D Pipeline Valves                  API RP 60R Repair and Remanufacture of Pipeline Valves                  API 6FA Fire Testing for Valves                  API Std 1104 Pipeline Welding                  API RP 1110 Steel Pipeline Pressure Testing                  API RP 1133 Guidelines for Onshore Hydrocarbon Pipelines Affecting High Consequence Floodplains                  API RP 1160 Managing System Integrity                  API RP 1162 Public Awareness Programs                  API RP 1169 Pipeline Inspection - New Construction                  API Spec 1173 Pipeline SMS                  API Spec 11B Sucker Rods                  API Spec 11E Pumping Units                  API RP 11ER Guarding Pumping Units</p>
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<p>API RP 5A3 Thread Compounds                  API RP 5A5 Casing, Tubing, Drill Pipe Field Inspection                  API Spec 5B Threading, Gauges and Thread Inspection                  API RP 5B1 Thread Gauging and Inspection Practices                  API RP 5C1 Casing and Tubing Care and Use                  API TR 5C3 Tubular Performance property calculations                  API RP 5C5 Casing and Tubing Connections Testing                  API RP 5C6 Welding Connections to Pipe                  API Spec 5CRA Corrosion Resistant Alloy Pipe                  API Spec 5C1 Casing and Tubing                  API Spec 5DP Drill Pipe                  API Spec 7-1 Drill Stem Elements                  API Spec 7-2 Rotary Shouldered Connection Threading and Gauges                  API RP 7C Drill Stem Design                  API RP 7C-2 Drill Stem Elements (Inspection and Classification)                  API Spec 10A Well Cements                  API RP 10B-2 Well Cement Testing                  API RP 10B-4 Formed Cement Testing                  API RP 10B-6 Well Cement Shrinkage and Expansion Determination                  API RP 10B-6 Cement Slurry Gel Strength Determination                  API Spec 100 Blow-Spring Casing Centralizers                  API RP 100-2 Centralizer Placement and Stop-Collar Testing                  API RP 10F Cement Float Equipment                  API TR 10TR1 Cement Sheath Evaluation                  API TR 10TR2 Cement Shrinkage and Expansion</p>	<p>API TR 10TR3 Cement Thickening Time Tests                  API TR 10TR4 Selection of Centralizers                  API TR 10TR5 Sols and Rigil Centralizer Testing                  API Spec 13A Drilling Fluids                  API RP 13B-1 Water-based Drilling Fluids Testing                  API RP 13B-2 Oil-based Drilling Fluids Testing                  API RP 13C Drilling Fluids Processing System Evaluation                  API RP 13D Drilling Fluids Rheology                  API RP 13I Drilling Fluids Lab Testing                  API RP 13J Heavy Drives Testing                  API RP 13M Composite Fluids Viscosity Properties                  API RP 13M-4 Gravel-pack Fluid Leak-off                  API RP 19B Well Performance Evaluation                  API RP 19C Proppants Properties                  API RP 19D Long-term Conductivity of Proppants                  API Spec 1101 Packers and Bridge Plugs                  API Std 1102 Progressive Cavity Pump Systems                  API Std 1103 Progressive Cavity Pump Surface Drive Systems                  API Spec 14A Subsurface Safety Valves                  API RP 14B Subsurface Safety Valves (Inspection and Maintenance)                  API Spec 14L Lock Mallocks and Landing Nipples                  API Spec 19G1 Side-Pocket Mandrels                  API Spec 19G2 Side-Pocket Mandrel Flow Control Devices                  API Spec 19G3 Side-Pocket Mandrel Latches and Seals                  API RP 19G4 Side-Pocket Mandrel Related Equipment                  API Spec 19V Barrier Valves</p>	<div style="border: 1px solid black; padding: 10px; background-color: #FFF9C4;"> <p><b>API is the world's leading standard-developing organization for the oil and natural gas industry.</b></p> <p>Since 1924, API has developed standards for oil and natural gas operations.</p> <p>API's formal consensus process is accredited by the American National Standards Institute (ANSI), the same institute that accredits U.S. national laboratories for their science and technology processes.</p> <p>API standards are developed in an open process that requires regular review of its more than 600 standards covering all segments of the industry.</p> <p>Nearly 200 API standards are cited over 3300 times in state regulations, and more than 100 standards are cited 270 times in federal regulations.</p> </div> <p style="font-size: small; margin-top: 10px;">energy <b>API</b> <span style="float: right;">Copyright © 2019 - American Petroleum Institute, All Rights Reserved. IAS013-001   0-13 www.api.org</span></p>
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# Are Earthquakes are risk?





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## Impacts on Other Landowners



# Environmental Footprint

Its not CSG



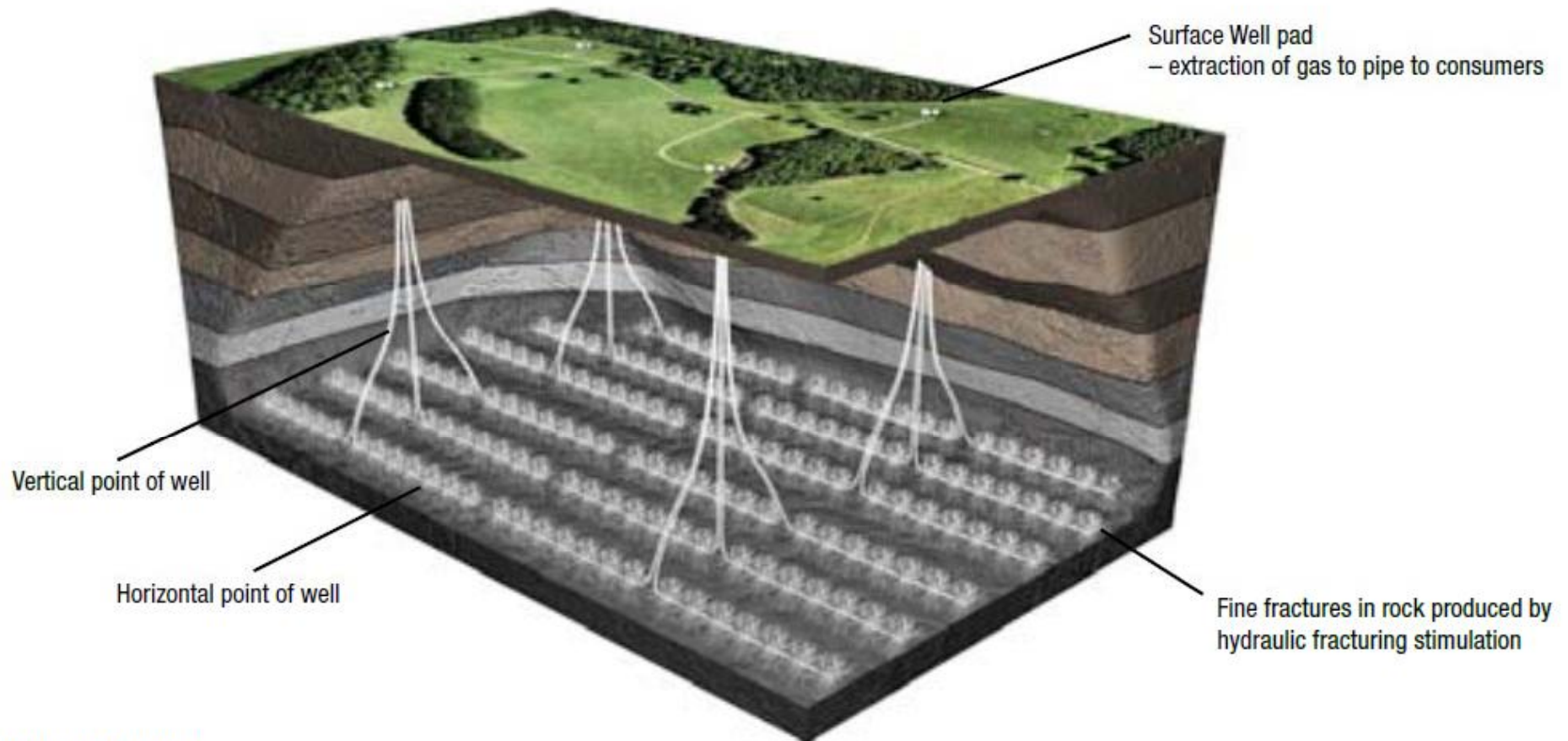
6.8 km





# Environmental Footprint

Its not CSG



*(Diagram not to scale)*

Source: Styles, Keele University, UK



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# Presence of Hydrocarbon in Shallow Aquifers



# Water Bore Sampling



DEPARTMENT OF MINES AND ENERGY

SOUTH AUSTRALIA

REPORT BOOK 95/17

GAS SAMPLING FROM WATER BORES  
IN THE NORTHERN GAMBIER BASIN,  
SOUTH AUSTRALIA

by

A.J. HILL  
Petroleum Division

D.R. VINALL  
Petroleum Division

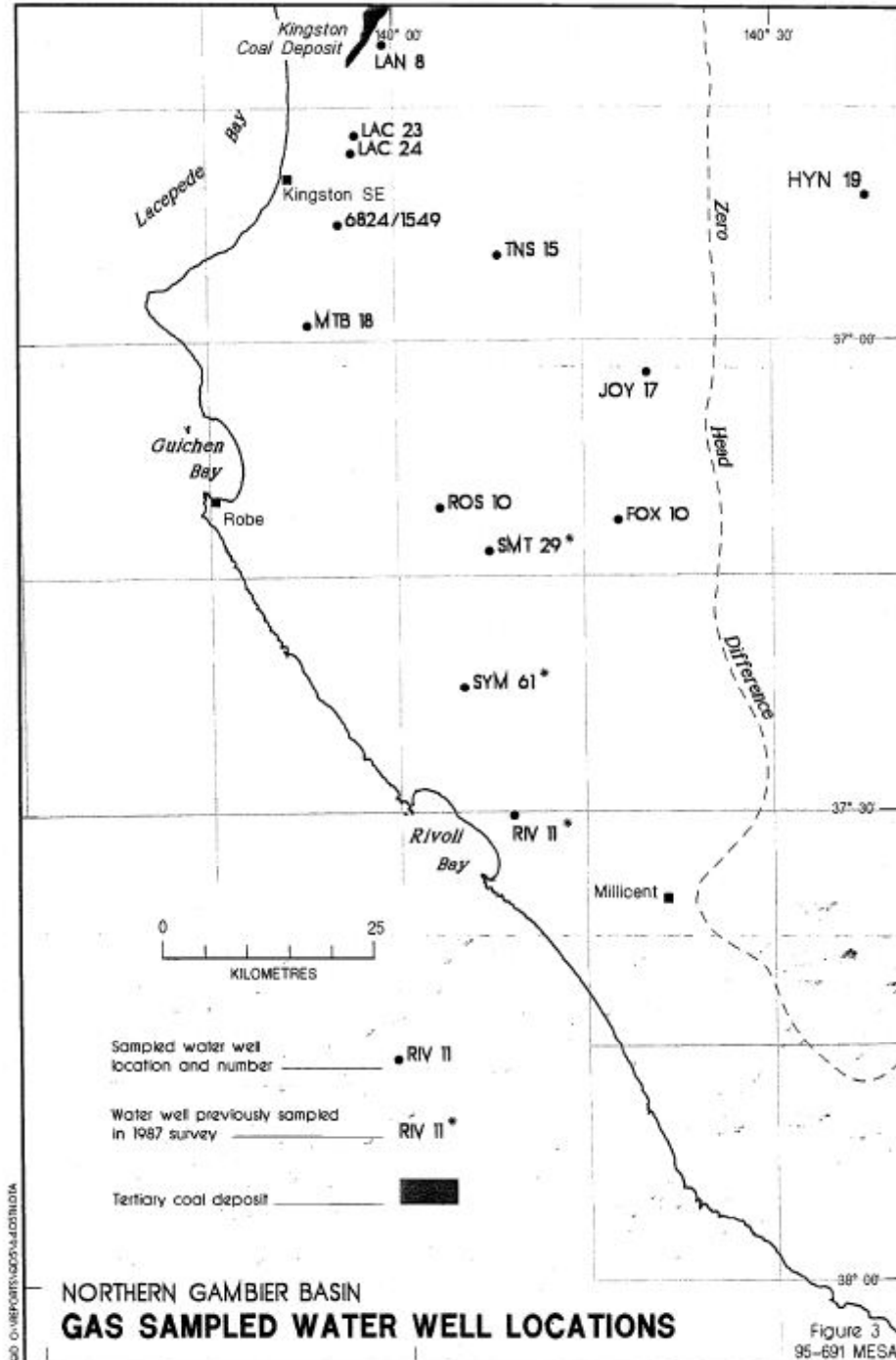
JUNE 1995

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Available on DMITRE SARIG  
Web site







60 OVERPOSTS/000/000/000/000

# Head Space Gas Sampling

Dilwyn Formation

**Table 1:** Compositional analysis of water bores sampled in 1987 survey.

Sample	RIV 11 sample 1	SYM 61 sample 1	SMT 29 sample 2	SMT 29 sample 1
N <sub>2</sub> + O <sub>2</sub>	92.67	99.39	94.51	98.92
CO <sub>2</sub>	0.96	0.32	3.12	0.39
CH <sub>4</sub>	5.39	0.29	0.00	0.00
C <sub>2</sub> H <sub>6</sub>	0.30	0.00	0.00	0.02
C <sub>3</sub> H <sub>8</sub>	0.00	0.00	0.00	0.00
C <sub>4+</sub>	0.68	0.00	2.37	0.00
Total	100	100	100	100





**Table 2.** Headspace gas volumes, 1993 survey.

Sample	Volume (mL)
JOY-17-1	100
JOY-17-2A	800
SMT-29-1	50
SMT-29-2	450
SMT-29-1A	950
6824-1549-1	100
6824-1549-2	1100
FOX-10-2	1150
SYM-61-1	400
MTB-18-1	1000



# Methane

## Dilwyn Formation



**Table 3:** Bulk composition, water bore gases

Components	JOY-17-1	JOY-17-2A	SMT25-1	SMT29-2	SMT29-1A	6824-1549-1	6824-1549-2	FOX10-2	SYM61-1	MTB18-1
N <sub>2</sub> (mol %)	52.3	50.9	47.2	46.2	48.3	7.74	10.2	35.1	72.5	95.5
O <sub>2</sub> +Ar (mol %)	4.79	1.03	2.46	2.87	1.17	0.42	0.50	0.80	1.38	1.45
CO <sub>2</sub> (mol %)	0.18	1.86	0.05	0.15	0.09	0.04	0.06	0.08	0.56	2.90
C <sub>1</sub> (mol %)	42.7	46.2	50.3	50.8	50.4	91.8	90.2	64.0	25.6	0.16
C <sub>2</sub> (μL/L)	<30	<30	<30	<30	<30	<30	<30	<30	<30	3
C <sub>3</sub> (μL/L)	<1	1	1	<1	1	4	1	<1	<1	<1
C <sub>4</sub> (μL/L)	<1	1	1	<1	2	4	6	2	1	2
C <sub>5</sub> (μL/L)	<1	<1	<1	<1	1	5	5	2	3	1
C <sub>6</sub> (μL/L)	<1	60	30	2	4	11	20	4	15	10



# Methane

Dilwyn Formation



**Table 4.** Stable Carbon isotope analyses,  $\delta^{13}\text{C}/_{\infty}$  PDB

Sample	Methane $\delta^{13}\text{C}$	Carbon Dioxide $\delta^{13}\text{C}$
JOY-17-2A	-77.7	-20.2
SMT-29-1A	-72.4	-
6824-1549-2	-52.4	-
FOX-10-2	-64.1	-
SYM-61-1	-99.8	-
MTB-18-1	-63.3	-18.6

## Carbon Isotope Thresholds

- < -60 Biogenic Source
- > -60 Thermogenic Source



# Salamander #1 Geothermal Well

