CarbonNet Storage Site Selection Process and Certification to DNV-RP-J203*

George Carman[1] and Nick Hoffman[2]

Search and Discovery Article #80509 (2016)**
Posted February 1, 2016

*Adapted from oral presentation given at AAPG/SEG International Conference & Exhibition, Melbourne, Australia, September 13-16, 2015.
Editor's note: Search and Discovery Article #80507 (2016), #80508 (2016), # 80509 (2016), and #80510 (2016) are contributions from The CarbonNet Project, Gippsland Basin, Australia.

[1]Geodirect Resources, Bellbrae, VIC, Australia.
[2]The CarbonNet Project, Victorian State Department of Economic Development, Melbourne, VIC, Australia (nick.hoffman@ecodev.vic.gov.au)

Abstract

The CarbonNet Project is seeking CO_2 storage sites in the nearshore area of the Gippsland Basin that provide permanent and safe storage for 25 to 125 Mt of CO_2. The process used by CarbonNet for site selection follows international best practice, aligned to DNV GL Recommended Practice (DNV-RP-J203) to provide decision makers and stakeholders with independent expert assurance of environmentally safe, long-term geological storage. The DNV-RP-J203 requires a systematic approach based on understanding and minimising storage risks and analysis of diverse geoscience and environmental factors. The main areas of investigation include selection and qualification of storage sites, 0 documentation of site characterization and site development plans, risk management throughout the life cycle of CO_2 geological storage projects, monitoring and storage performance verification, well assessment and management planning, planning for site closure, and subsequent stewardship. The CarbonNet Project reviewed more than twenty five (25) storage concepts at fourteen (14) locations, within 25 km of the coastline. These were quantified for prospective storage volume, and risk for capacity, containment, and injectivity. A portfolio of three sites was shortlisted. CarbonNet has had its storage site selection process endorsed by an Independent Scientific Peer Review and the site selection process was assessed by DNV GL and a Statement of Feasibility issued for the portfolio in January 2013. Detailed site-specific risk analyses and data gap analyses of key elements were prepared for each site. As a result, a prioritised site was selected for further analysis and the development of a site appraisal plan. The challenges of completing the work under exacting technical conditions to the satisfaction of a wide range of stakeholders has resulted in an excellent prioritised site. The site selection process represents approximately 20 man-years of geoscience work for an estimated expenditure of ~ $20 million.

Reference Cited

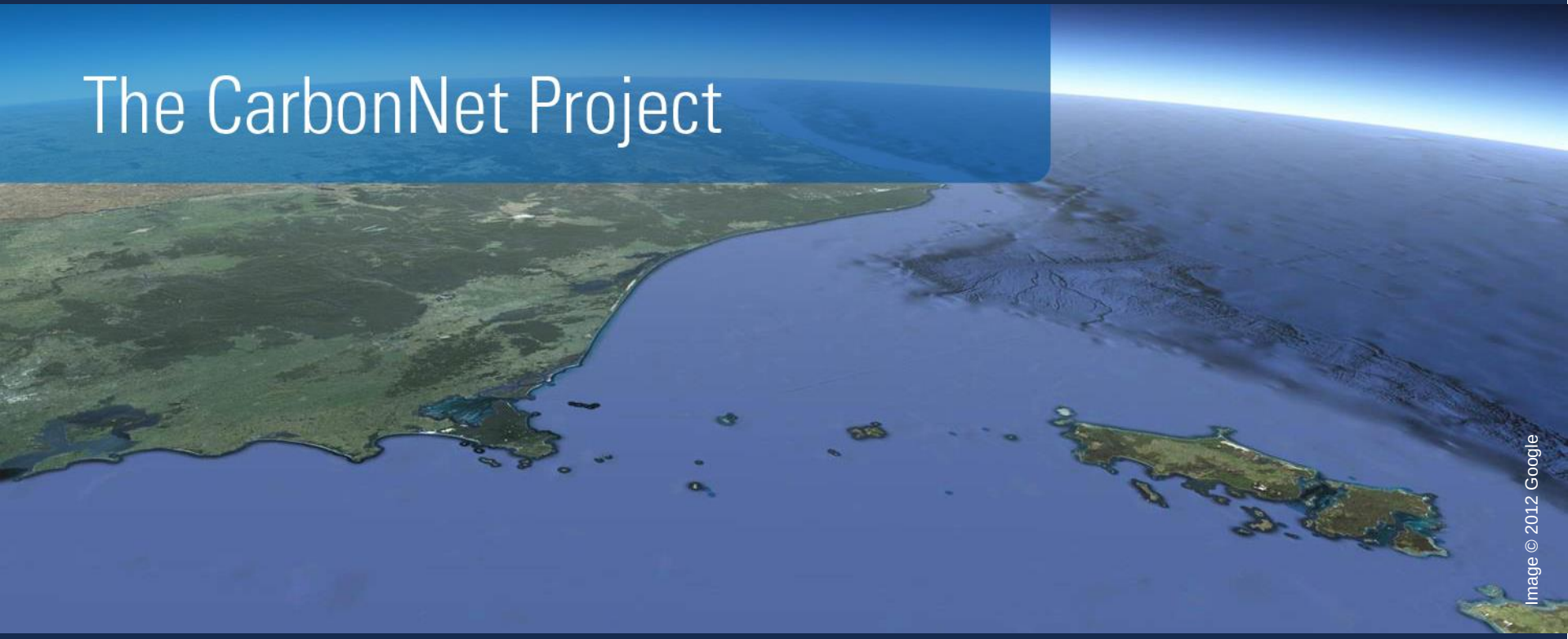
CO2CRC, 2011, A Review of Existing Best Practice Manuals for Carbon Dioxide Storage and Regulation: Cooperative Research Centre for Greenhouse Gas Technologies (CO2CRC), Canberra, ACT, 12 p.

AAPG SEG
International Conference & Exhibition 2015
13-16 September • Melbourne, Australia
PESA Incorporating PESA's Eastern Australasian Basins Symposium

CarbonNet storage site selection Process & certification to DNV-RP-J203:

Dr. Nick Hoffman, CarbonNet Storage Advisor

15th September 2015



CarbonNet storage site selection Process & certification to DNV-RP-J203:

Dr. Nick Hoffman, CarbonNet Storage Advisor

15th September 2015

ACKNOWLEDGEMENTS and Support

The CarbonNet Project

Funding

Australian Government
Department of Industry and Science

Department of Economic Development, Jobs, Transport & Resources

State Government Victoria

Technical collaboration and review

Acknowledgements

& many consultants, specialists and researchers

Outline

- Background/Historical
- External Reviews
  - International Best Practice- Certification
  - Peer Reviews
- Site Selection Process - Workflow
- Modelling
- Risk Analysis
- Appraisal Plan
- Lessons Learned: Issues & Challenges

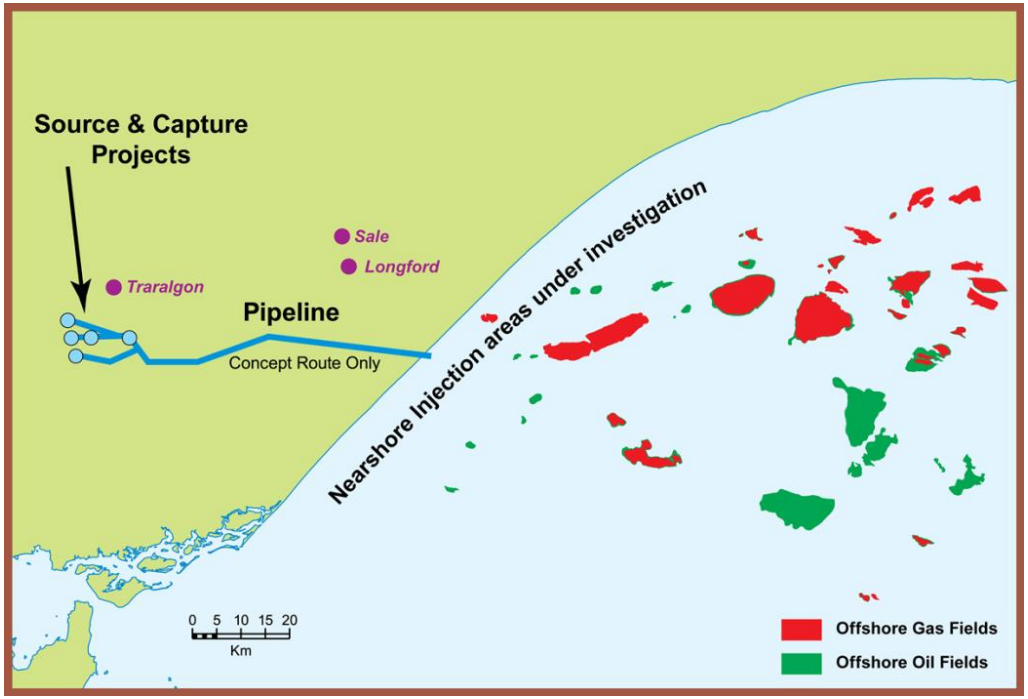
The CarbonNet Project

Index Map:
Location of Gippsland Basin in Victoria, Australia

Image: Google Earth

The CarbonNet Project

- Investigating the potential for a commercial-scale, multi-user CCS network in Gippsland, Victoria, Australia
- Jointly funded by Australian and Victorian governments, with support from GCCSI
- Aim is to eliminate or reduce barriers to future industry participation
- Collaborating with industry
- 2015 is a key year for the Project

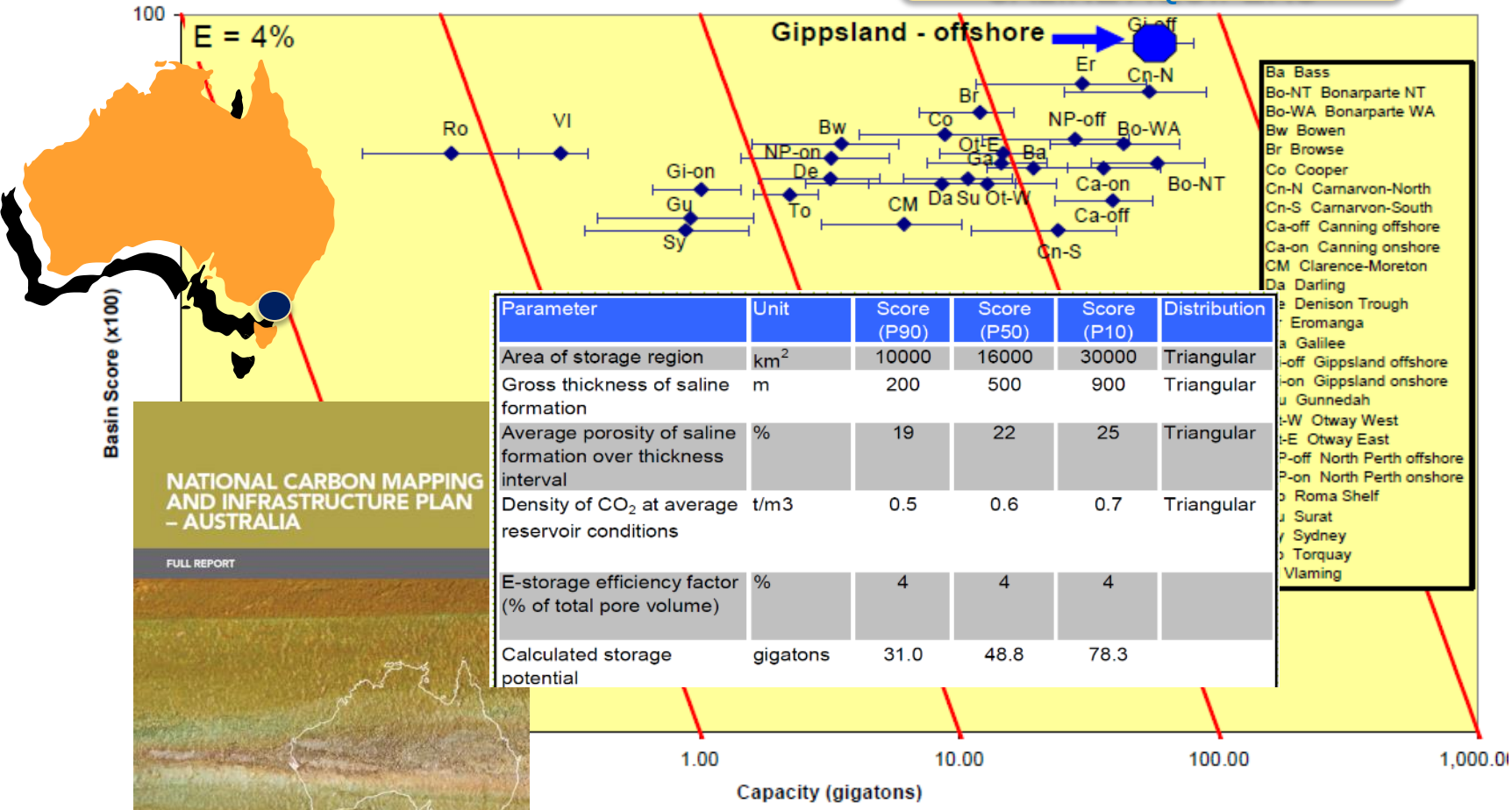


The CarbonNet Project

- Provide scalable infrastructure to underpin growth and development of a commercial scale CCS network
  - Foundation project: 1 to 5 mtpa of CO_2 for 25 years
  - Expansion phase: up to 20 mtpa of CO_2 (2030 and beyond)
- Common user transportation (pipeline) and storage infrastructure
  - Hub based concept
- Minimise conflicts with petroleum activities
  - Foundation storage sites focused on near shore zone
  - Longer term strategy to use depleted oil and gas fields as production ceases (or possible EOR opportunities)

National Carbon Task Force 2009

Gippsland Basin Offshore
SALINE AQUIFERS



Parameter	Unit	Score (P90)	Score (P50)	Score (P10)	Distribution
Area of storage region	km^2	10000	16000	30000	Triangular
Gross thickness of saline formation	m	200	500	900	Triangular
Average porosity of saline formation over thickness interval	%	19	22	25	Triangular
Density of CO_2 at average reservoir conditions	t/m3	0.5	0.6	0.7	Triangular
E-storage efficiency factor (% of total pore volume)	%	4	4	4	
Calculated storage potential	gigatons	31.0	48.8	78.3	

http://www.ret.gov.au/resources/resources_programs/nleci/cst/pages/default.aspx

+ CO2CRC Gippsland studies
+ GSV CCS Programme

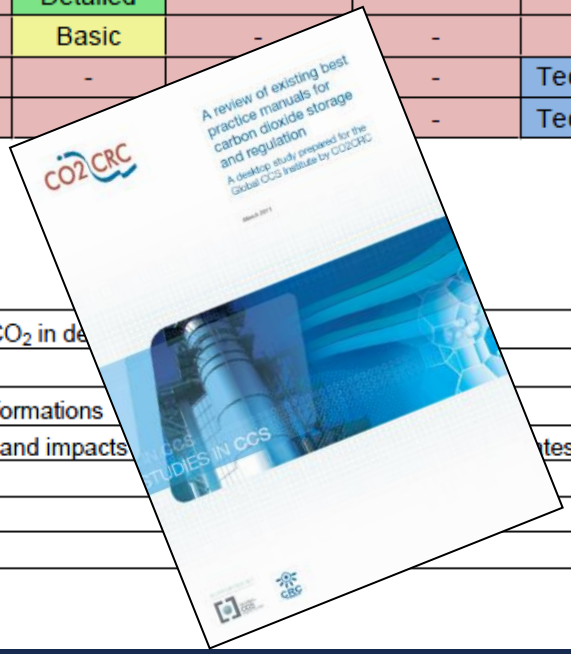
Outline

- Background/Historical
- External Reviews
  - International Best Practice- Certification
  - Peer Reviews
- Site Selection Process - Workflow
- Modelling
- Risk Analysis
- Appraisal Plan
- Lessons Learned: Issues & Challenges

	Pre-feasibility	Site Selection	Capacity Estimation	Simulation and Modelling	Construction	Operation	Closure	Monitoring and Verification	Risk Assessment	Community Consultation	Regulation
SACS	Basic	Technical	Technical	Technical	-	Basic	Detailed	Technical	Detailed	Basic	Basic
NETL (SS)	Basic	Detailed	Technical	Basic	-	-	-	-	Basic	Basic	Detailed
NETL (RA)	-	-	-	Technical	-	-	-	-	Technical	-	-
NETL (MV)	-	-	-	-	-	Technical	Technical	Technical	Basic	-	Basic
NETL (GS)	Technical	Technical	-	-	-	-	-	-	-	-	-
NETL (PO)	-	-	-	-	-	-	-	-	-	Technical	-
WRI (CCS)	Basic	Detailed	Basic	Basic	Basic	Basic	Detailed	Detailed	Detailed	Basic	Detailed
WRI (CE)	Basic	Basic	-	-	Basic	Basic	Basic	Basic	-	Detailed	Basic
DNV *	Detailed	Detailed	Detailed	Basic	-	Detailed	Detailed	Basic	Detailed	-	Detailed
CO2Cap	-	Basic	Basic	-	Detailed	Detailed	Basic	Technical	Basic	-	-
GEOSEQ	-	Basic	Basic	Basic	-	-	-	Detailed	-	-	-
CO2NET	-	Basic	Basic	Basic	-	Basic	-	Basic	-	-	-
IEA	-	-	-	-	-	-	-	-	-	-	Technical
CO2Cap (R)	-	-	-	-	-	-	-	-	-	-	Technical

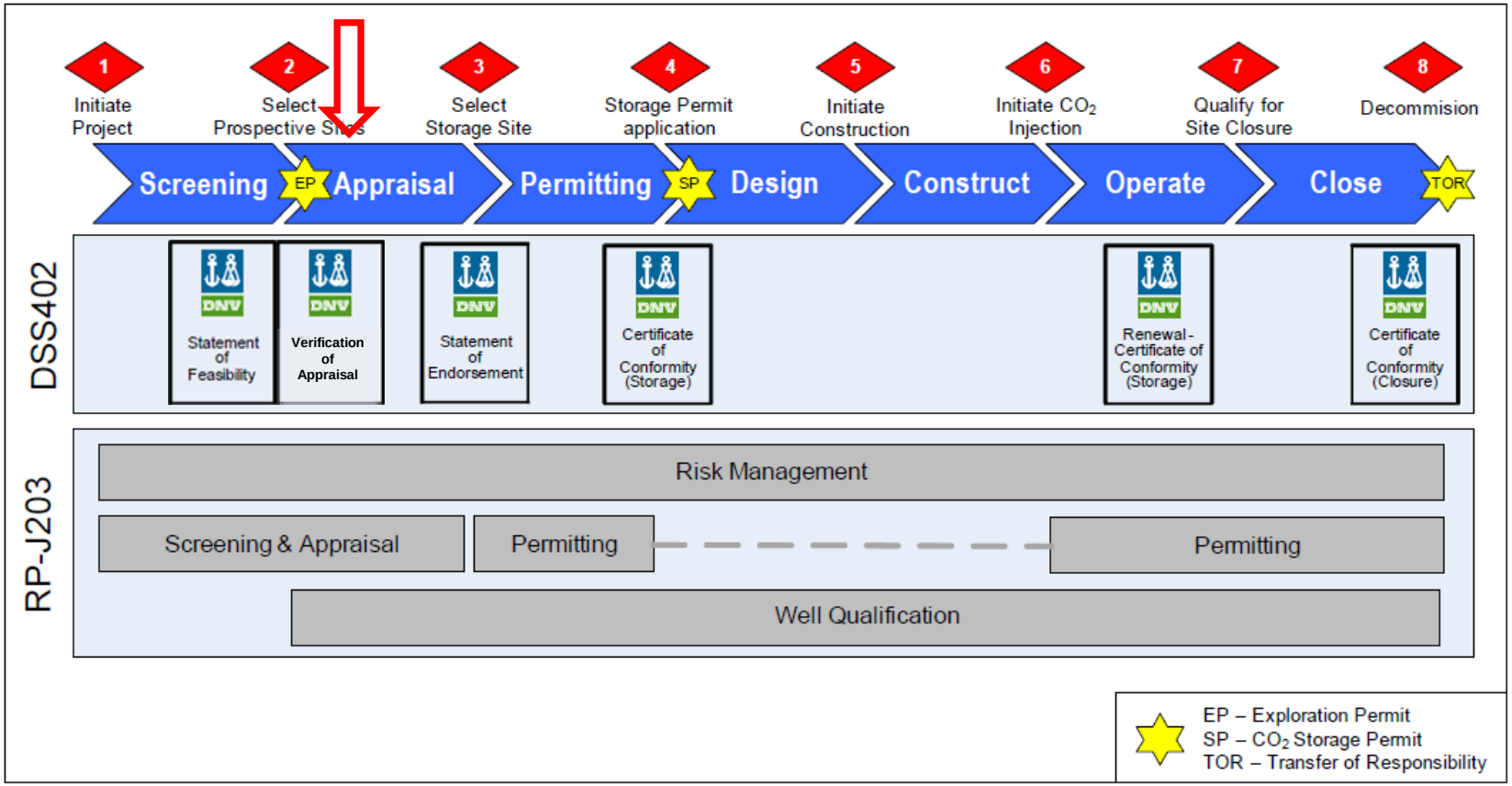
-	Not covered
Basic	Briefly covered in a generic way
Detailed	Comprehensive discussion, generally generic
Technical	Provides technical detail of projects, generally comprehensive

NETL (SS)	Best Practices for: Site screening, site selection, and initial characterization for storage of CO_2 in de
NETL (RA)	Risk analysis and Simulation for geologic storage of CO_2
NETL (MV)	Best Practices for: Monitoring, verification, and accounting of CO_2 stored in deep geologic formations
NETL (GS)	Best Practices for: Geologic storage formation classification: Understanding its importance and impacts
NETL (PO)	Best Practices for: Public outreach and education for carbon storage projects
WRI (CCS)	Guidelines for CCS
WRI (CE)	Guidelines for community engagement in CCS



CO2CRC 2011 A Review of existing best practice manuals for carbon dioxide storage and regulation
** DNV CO2QUALSTORE & CO2WELLS*

Det Norske Veritas (DNV) Certification



Outline

- Background/Historical
- External Reviews
  - International Best Practice- Certification
  - Peer Reviews
- Site Selection Process - Workflow
- Modelling
- Risk Analysis
- Appraisal Plan
- Lessons Learned: Issues & Challenges

Peer Reviews

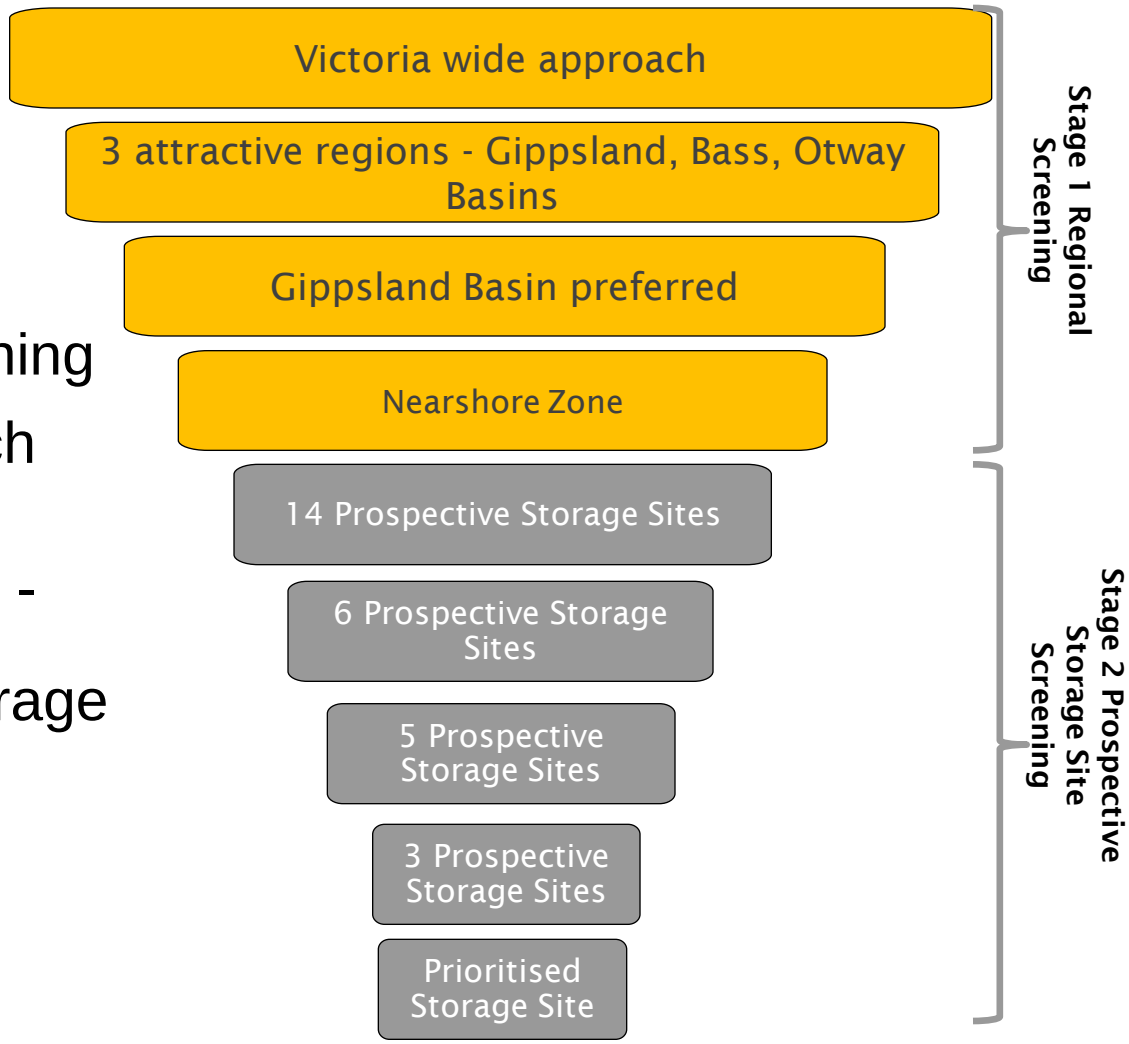
- 4Q 2011 12 expert panel* to endorse selection of 6 sites from 24
- 2Q 2012 Independent Storage Peer Review (10 members*) to endorse ranking of top 3 sites
- 4Q 2012 DNV Statement of Feasibility (3 sites) (1st Stage Certification under DNV-RP-J203)
- 1Q 2013 CarbonNet Management Team (PWC facilitators) to consider whole-of-project influences on Site Selection
- 1Q 2014 Senergy International facilitated workshops* endorsing Site Risk & Data Gap Analyses
- 1H 2014 Schlumberger Carbon Services CarbonNet development of Appraisal Plan
- 2H 2014 DNV Verification of Appraisal Plan

Outline

- Background/Historical
- External Reviews
  - International Best Practice- Certification
  - Peer Reviews
- Site Selection Process - Workflow
- Modelling
- Risk Analysis
- Appraisal Plan
- Lessons Learned: Issues & Challenges

Storage certainty

- Two-stage process
  - regional
  - site specific
- Initial technical screening
- Play Fairway approach
- Technical and non-technical assessment - criteria developed to identify prioritised storage sites
- Consolidation of site characteristics
- DNV endorsement



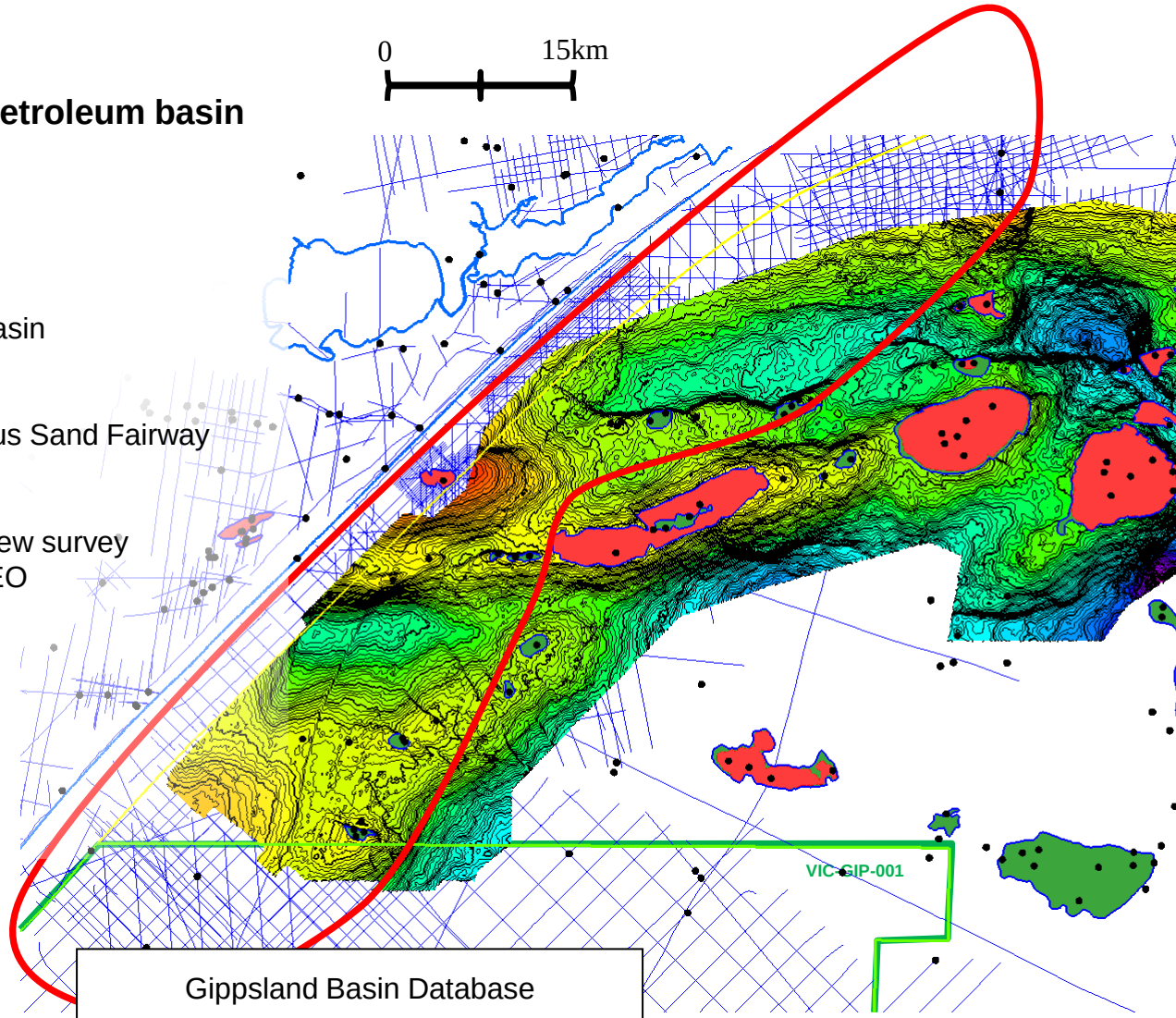
Working in a known and prolific petroleum basin

+ Lots of data (open access)
- Resource interaction

WELL DATA
- 1562 wells and boreholes in whole basin
- 811 wells with basic geological data
- 546 wells with relevant log data
- 50 local E&P wells in Upper *N*.asperus Sand Fairway

SEISMIC DATA
- 69 X 2D surveys including GDPI10 new survey
- 34 X 3D surveys – merged by 3D-GEO

3 CONTINGENT SITES
- Site A : 2 wells 2D & 3D seismic
- Site B : >2 wells 3D seismic
- Site C : 1-3 wells 2D seismic



Gippsland Basin Database

Data spans 50+ years – quality varies!

DATA BASE

Prospect Inventory: 14 Areas

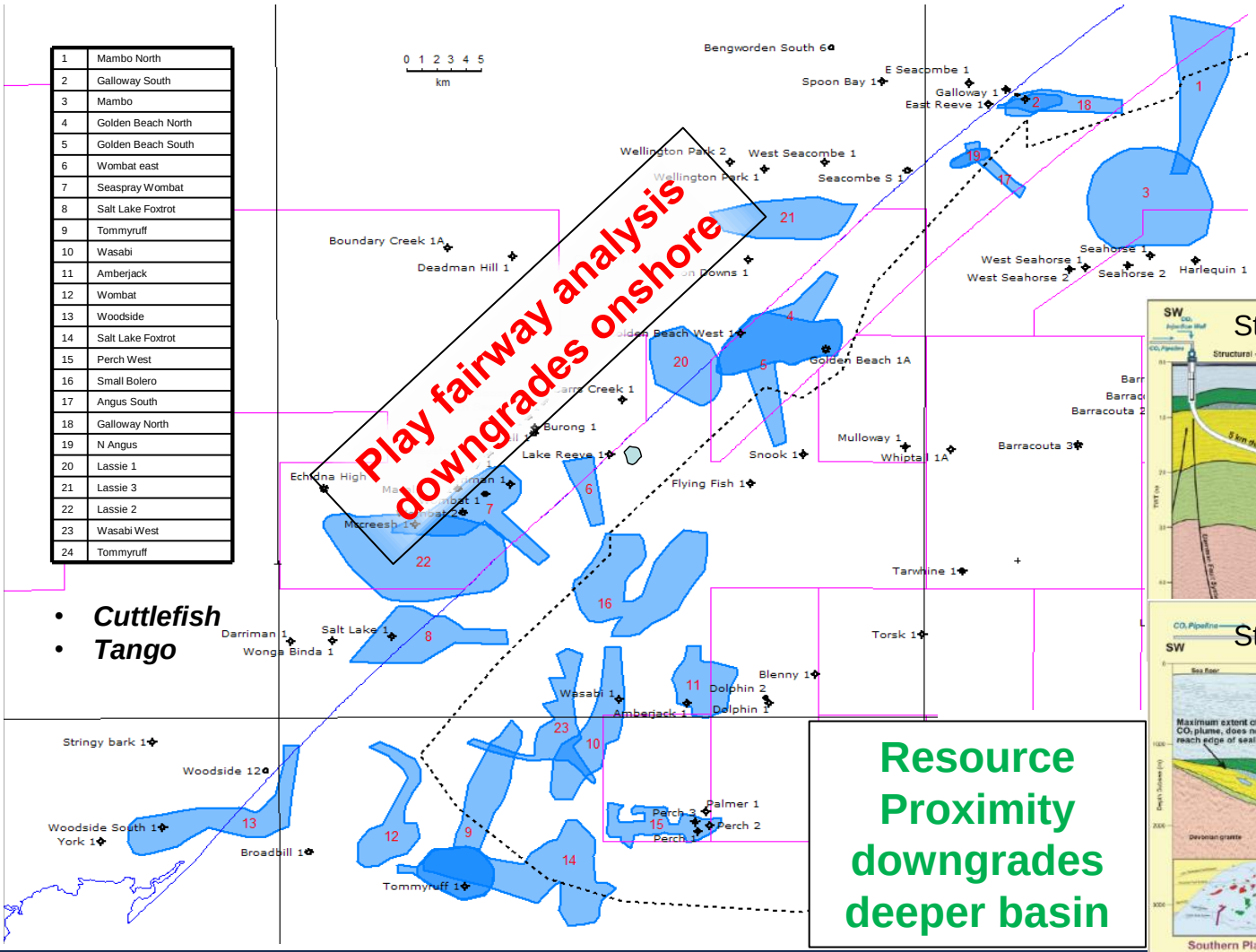
with 2 stratigraphic horizons

Diverse Portfolio
Many trap concepts
Including:-

Structural traps
- Anticlines
- Fault traps

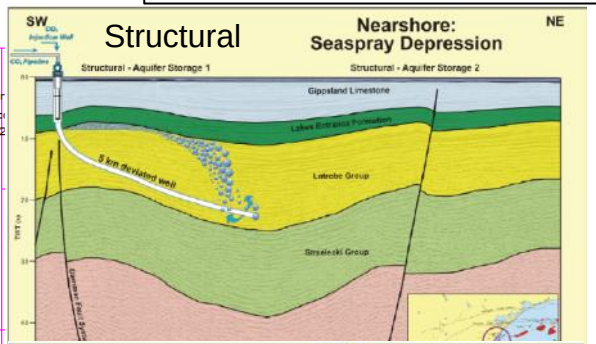
Aquifer traps
Stratigraphic traps
Depleting oil/gas fields
(future availability)

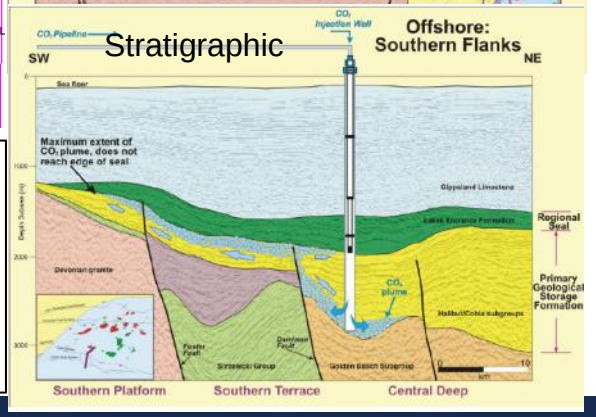
1	Mambo North
2	Galloway South
3	Mambo
4	Golden Beach North
5	Golden Beach South
6	Wombat east
7	Seaspray Wombat
8	Salt Lake Foxtrot
9	Tommyruff
10	Wasabi
11	Amberjack
12	Wombat
13	Woodside
14	Salt Lake Foxtrot
15	Perch West
16	Small Bolero
17	Angus South
18	Galloway North
19	N Angus
20	Lassie 1
21	Lassie 3
22	Lassie 2
23	Wasabi West
24	Tommyruff



- ***Cuttlefish***
- ***Tango***

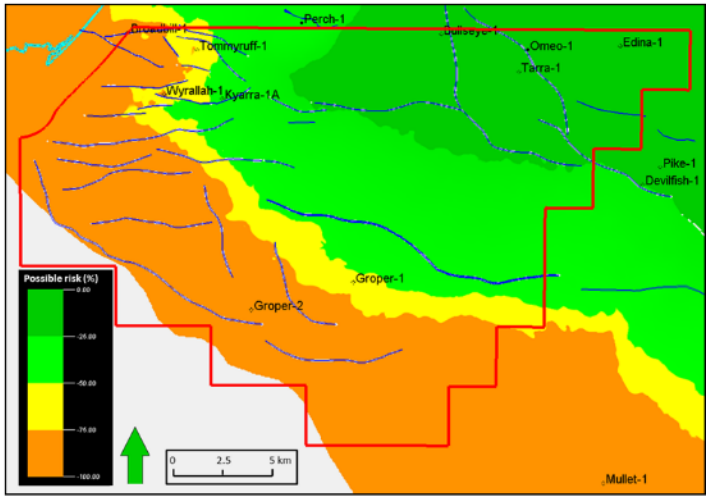
Resource Proximity downgrades deeper basin



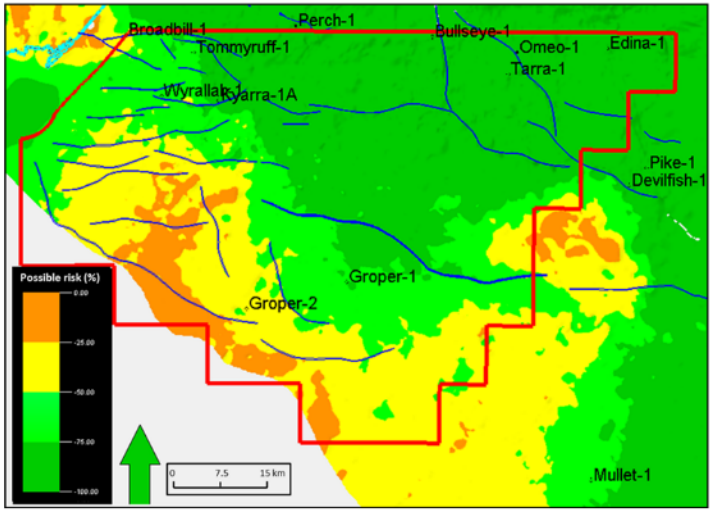


PROSPECTIVE STORAGE SITES INVENTORY- 2011

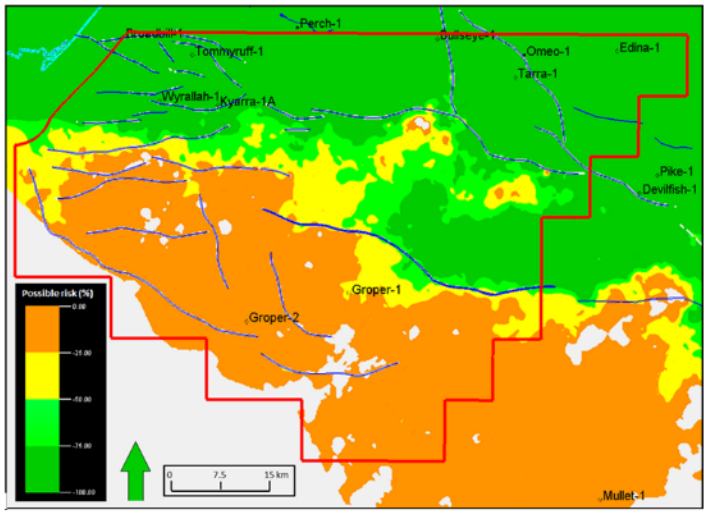
Target Depth



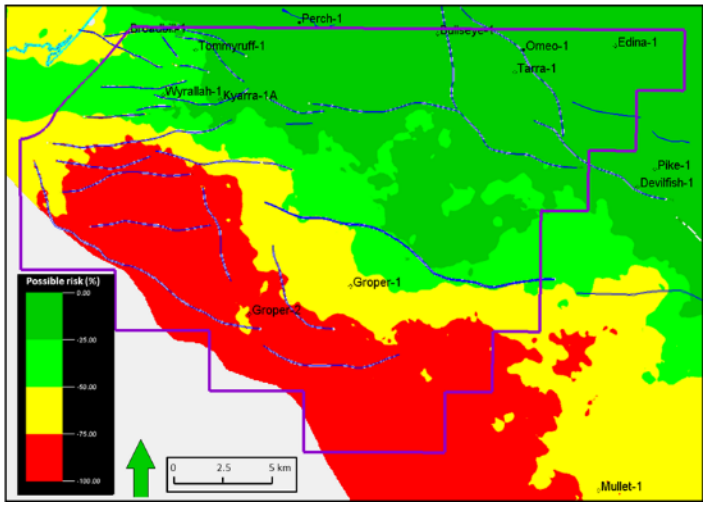
LEF thickness



Reservoir Thickness



CRS Play Fairway



EXAMPLE of Play Fairway Analysis (VIC-GIP-001)

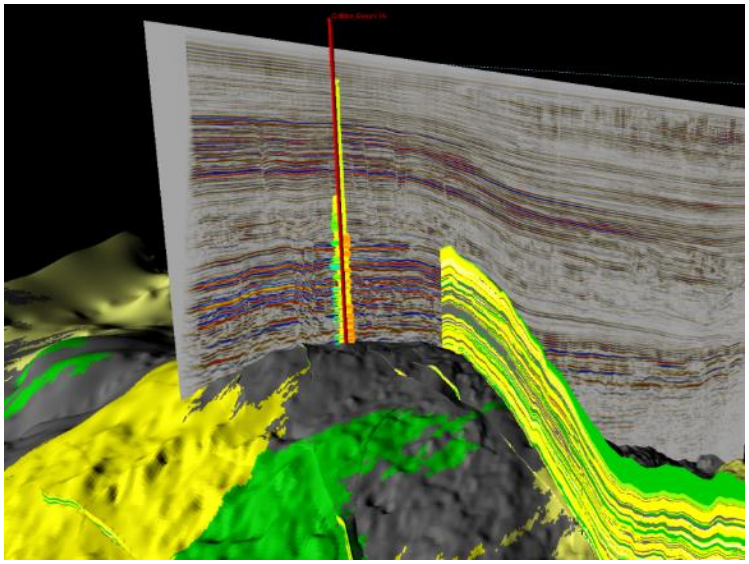
Rankings Summary

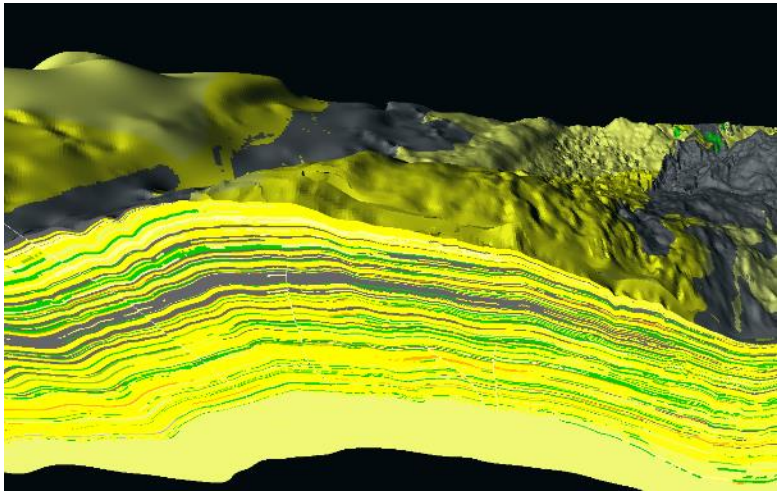
- Multiple ***possible*** sites/traps
- Focus on the best options:-
  - ✓ Capacity
  - ✓ Injectivity
  - ✓ Containment
  - ✓ Monitoring
  - ✓ Permitting
  - ✓ Stakeholder Support
- Avoid existing infrastructure

- Play fairway approach checks multiple sites in one process

Outline

- Background/Historical
- External Reviews
  - International Best Practice- Certification
  - Peer Reviews
- Site Selection Process - Workflow
- Modelling
- Risk Analysis
- Appraisal Plan
- Lessons Learned: Issues & Challenges





1st Generation models:

Models	Site A	Site B	Site C	Site D
Resolution (m)	50 x 50	50 x 50	25 x 25	50 x 50
km x km	44.5 x 27.1	34.3 x 25.7	23.3 x 25.3	31 x 52
Layers	51	71	44	53
Total grid cells	24.7 million	26 million	25 million	31 million
Lake Entrance thickness	124m	268m	102m	136m
Cobia thickness	335m	113m	347m	302m
IntraFmn seals (# layers)	100m (6)	50m (4)	80m (8)	50m (6)
Halibut thick (m)	820m	243m	353m	300m

3rd Generation models – 220 layers
c.80 million cells
PETREL and Eclipse E100 and E300
Oil industry standard software
Good, but not cheap

STATIC MODELLING SUMMARY

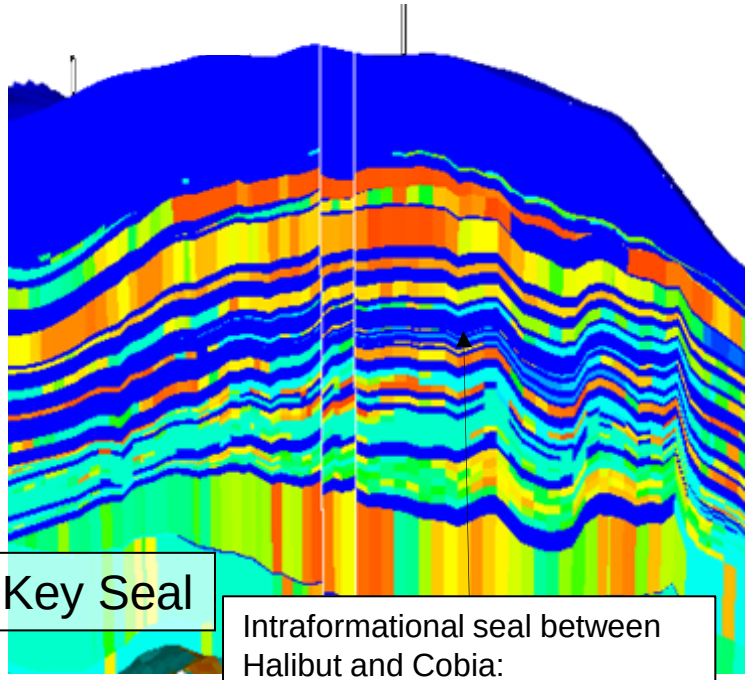
To scale

	Formation	Layer No.	Avg. Permeability X (md)	Avg. effective Porosity (fraction)	Avg. Thickness (m)
	Lakes Entrance	1	0.1	0.05	127
	Green Sand	2-3	21	0.05	9
Cobia	Y-Top Latrobe	4	Nil	Nil	Nil
Cobia	X-Top Latrobe	5	0.01	0.06	13
Cobia	W-Top Latrobe	6	2016	0.26	20
Cobia	V-Top Latrobe	7	0.007	0.05	7.4
Cobia	U-Top Latrobe	8	1035	0.17	23.6
Cobia	T-Top Latrobe	9	0.01	0.05	6.6
Cobia	S-Top Latrobe	10	1392	0.23	41
Cobia	R-Shale	11	0.04	0.03	11
Cobia	Q-Shale	12	1496	0.19	10.3
Cobia	P-Coal,Shale	13	0.65	0.05	17.6
Cobia	O-Sand5	14	615	0.18	17.4
Cobia	N-Coal,Shale	15	0.05	0.05	9.4
Cobia	M-Sand4	16	362	0.15	6.5
Cobia	L-Coal,Shale	17	0.02	0.05	20.3
Cobia	K-Sand3	18	856	0.15	7.2
Cobia	J-Coal,Shale	19	0.1	0.05	10
Cobia	G-Sand2	20	565	0.15	6.6
Cobia	F-Coal,Shale	21	0.2	0.05	13.5
Cobia	E-Sand A1	22	397	0.12	6.5
Cobia	D-Shale1	23	0.01	0.06	4.5
Cobia	C-Sand1	24	1008	0.2	13
Cobia	B-Coal, Shale	25-26	0.05	0.05	17
Halibut	Halibut	27-31	545	0.17	27
Halibut	G	32-39	118	0.13	47.4
Halibut	F	40-44	431	0.19	39
Halibut	E	45	103	0.08	19.2
Halibut	D	46	103	0.08	92
Halibut	C	47	94	0.075	3
Halibut	B	48	309	0.16	68
Halibut	A	49	640	0.17	46

Cobia: 520 / 0.13 / 285

Halibut: 370 / 0.16 / 342

Secondary Seal



Key Seal

Intraformational seal between Halibut and Cobia:
Sand/Coal/Shale sequence:

- 71m gross interval
- 45m nett shale and coal

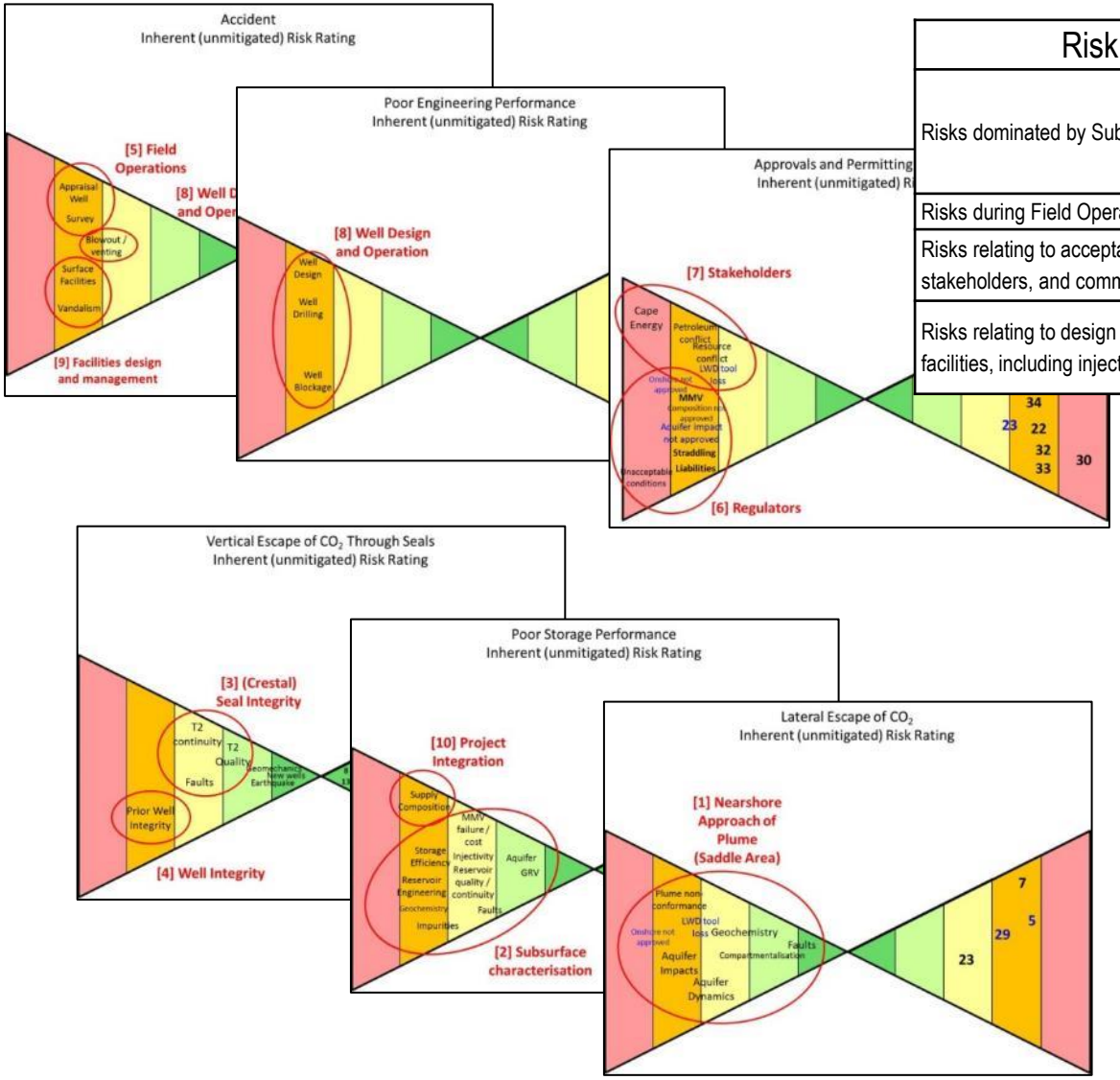
Injection Reservoir

Dynamic model 3.9 million cells (169 x 103 x 222) model.

DYNAMIC MODELLING SUMMARY

Outline

- Background/Historical
- External Reviews
  - International Best Practice- Certification
  - Peer Reviews
- Site Selection Process- Workflow
- Modelling
- Risk Analysis
- Appraisal Plan
- Lessons Learned: Issues & Challenges



Risk Class	Aggregated Risk
Risks dominated by Subsurface Uncertainty	1 Nearshore Approach of Plume
	2 Subsurface Characterisation
	3 (Crestal) Seal Integrity
	4 Legacy Well Integrity
Risks during Field Operations	5 Field Operations
Risks relating to acceptance by regulators, stakeholders, and community	6 Regulators and Legislation
	7 Stakeholders incl. Community
Risks relating to design and operation of new facilities, including injection (and monitoring) wells	8 New Well Design and Operation
	9 Facilities Design and Operation
	10 Project Integration

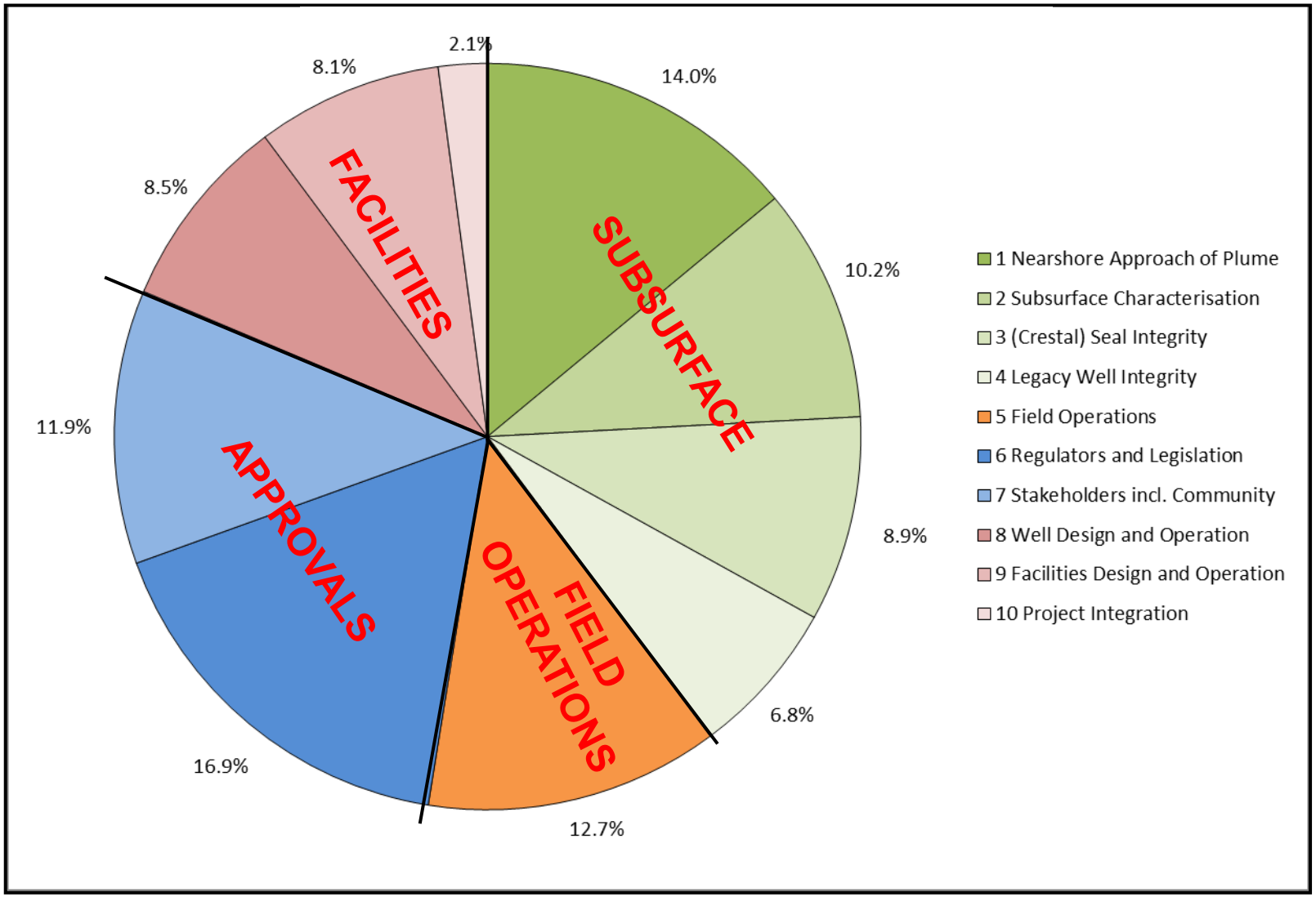
CONSOLIDATED RISK CATEGORIES

- Storage performance
- Vertical Escape
- Lateral Escape
- Engineering performance
- Accident
- Approvals & Permitting

166 FEP's => 42 Storage risks => 10 Aggregated risks => 4 Risk Classes

Risk Register Evolution: Sept-14 Bow-Tie Risking

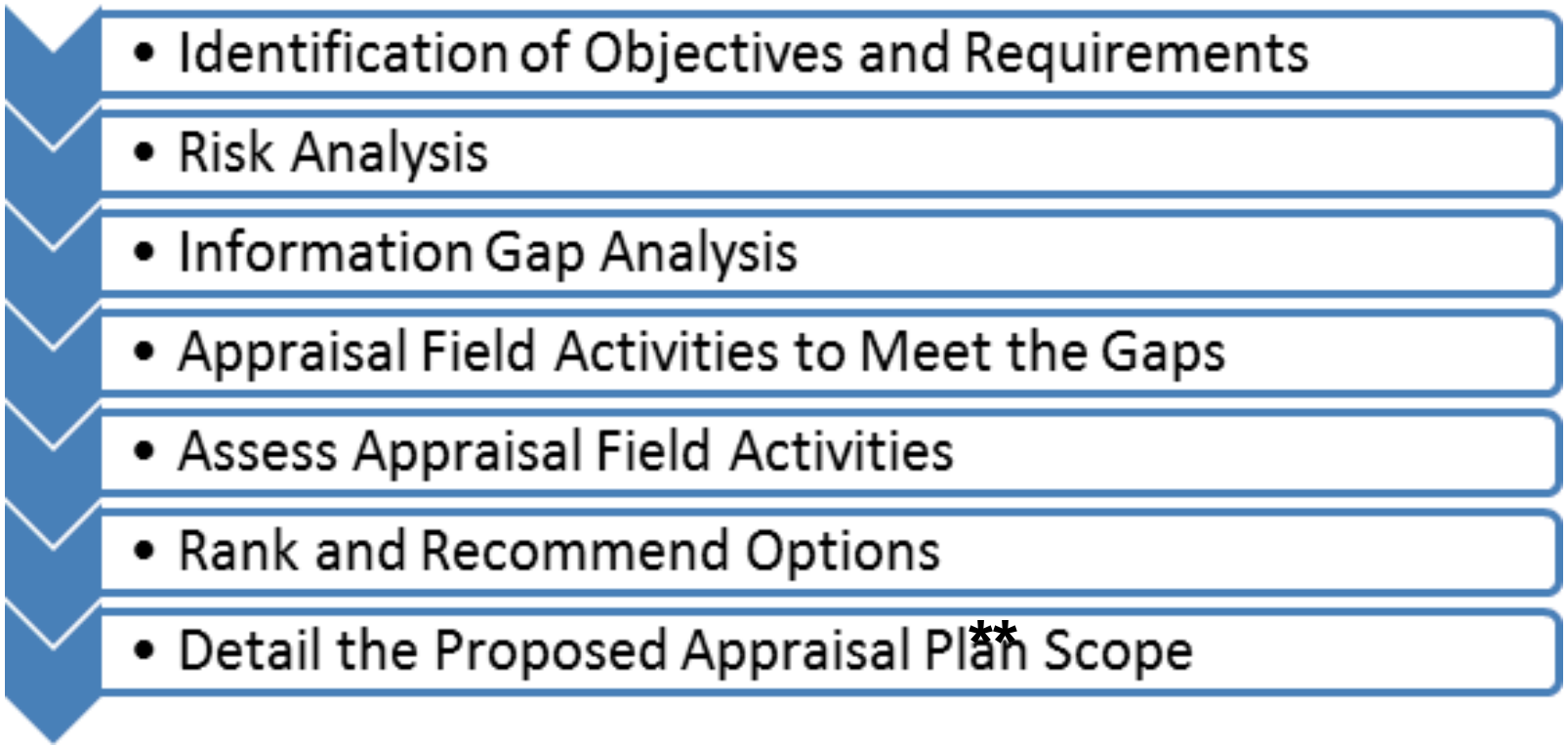
Post-treatment Storage risk (60% of untreated)



Risk Register Evolution: Sept-14 High-level classes

Outline

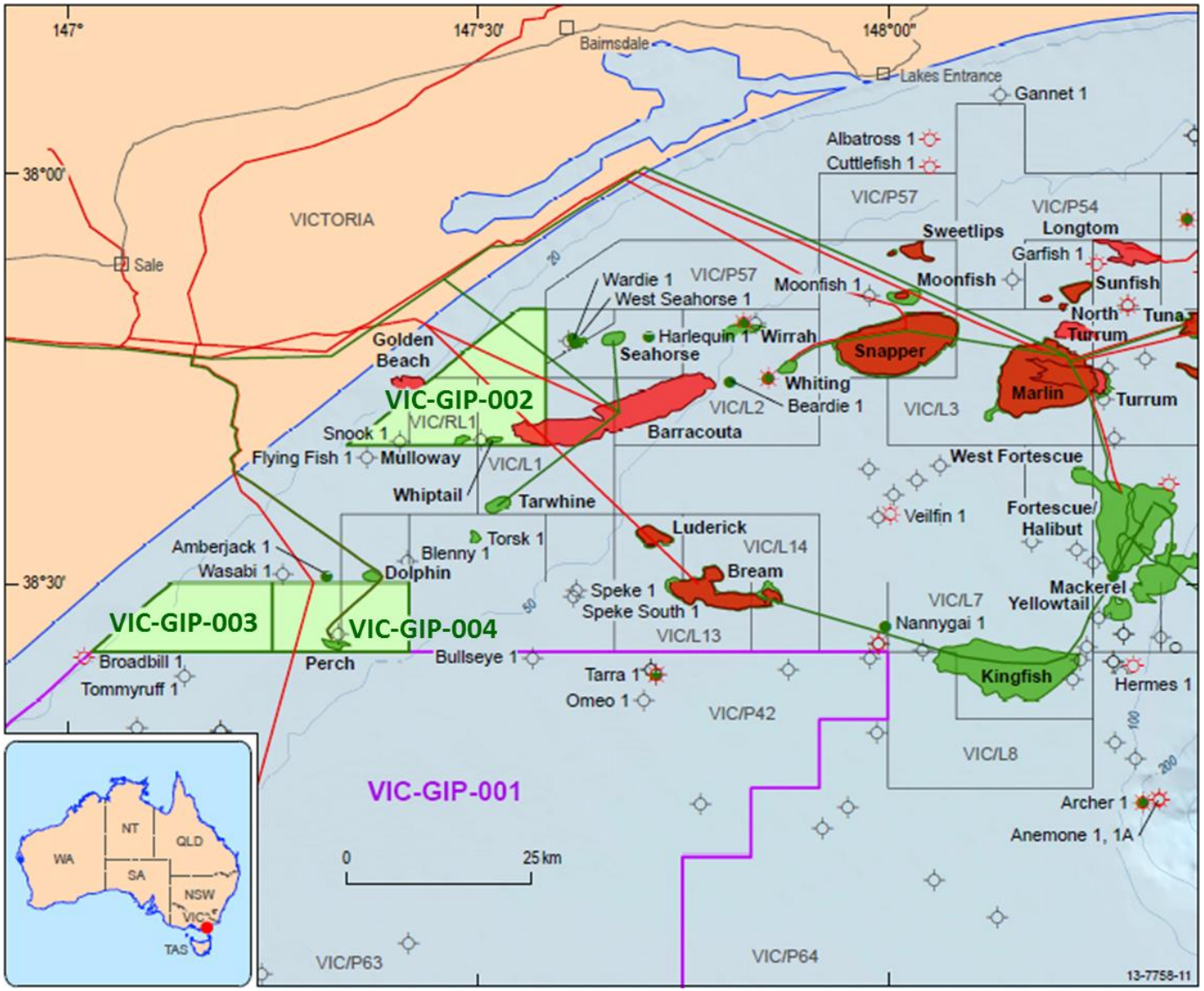
- Background/Historical
- External Reviews
  - International Best Practice- Certification
  - Peer Reviews
- Site Selection Process- Workflow
- Modelling
- Risk Analysis
- Appraisal Plan
- Lessons Learned: Issues & Challenges



** includes Value-for-Money analysis

A multi-year work programme is envisaged to Appraise each site – requiring around $100m of expenditure, so it is important to choose the best site before starting appraisal – see other projects for approaches that were less successful.

APPRAISAL PLAN: Work Flow / Methodology



2014 GHG Acreage Release

Outline

- Background/Historical
- External Reviews
  - International Best Practice- Certification
  - Peer Reviews
- Site Selection Process- Workflow
- Modelling
- Risk Analysis
- Appraisal Plan
- Lessons Learned: Issues & Challenges

Lessons learned

- **Not to be first of a kind… Utilise existing Technology and Methodologies**
- Systematic approach with strong process to support decisions
- DNV-RP-J203 (is first-of-a-kind) but has provided valuable external endorsement
- Advantageous to have fully skilled in-house Geoscience and Engineering team (was also a key finding in ZeroGen Project)
- Data-rich basin plus Play Fairway approach ensures viability of storage sites, but brings other resources into close proximity
- A high level of government involvement is required at this pre-commercial stage of CCS, BUT government procurement process is not ideal for flexibility and speed

Lessons learned

TECHNICAL ISSUES

- **Seal** – “Proving” Containment – can never be ***definitive*** before injection commences
- **Capacity** – uncertainty of Ultimate capacity until end stages
- **Perceptions** of Stakeholder Reactions (Petroleum operator, Regulator, Community)
- Sensitivity of **Environmental** Footprint
- Sensitivity of Interaction with **Aquifer**
- **“Mind Your Language**” Perceived Sensitivities to Jargon frustrates the technical progress
- Beware Scientific Community challenges … speciality inputs, Grandstanding,
- Publication restraints – now becoming more open

The CarbonNet Project

Thank You
- Any questions?

CarbonNet storage site selection Process & certification to DNV-RP-J203:

Dr. Nick Hoffman, CarbonNet Storage Advisor

15th September 2015

State Government Victoria