The Carbon Geostorage Initiative

Probability of Success Assessment and Proof of Concept Well Drilling

Queensland Government

Acknowledgements

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Chris Hindmarsh
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Riza Stibbe-Clout
Ritu Thomas

The CGI team
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Owen Dixon
Mike McKillop
Dave Hodgkinson

Carbon Geostore Management
Carbon Store Australia
Worley Parsons
RLMS
Converge

ACALET
Commonwealth Government

CCS Perspectives

- Climate change – controversy associated with opinion
- Emissions trading schemes and carbon tax
- Existing geostorage and EOR operations
- Economics and financing
- Major projects underway
- Capacity estimates
- Long term impacts, management and accountability

Carbon Geostorage Initiative Stage II

- Field data collection program objectives
  - To collect precompetitive geoscience data
  - To contribute to defining a ‘bankable’ geostorage resource
  - To contribute to an improved understanding of the Great Artesian Basin groundwater system
  - Definition of success

Definitions

Pre-competitive

Precompetitive is traditionally ...

- To improve the assessment of the State's resource endowment.
- To inform the State's governance of the exploitation (by others) of this endowment.
- To promote its exploitation (by others) – typically this means collecting data to a level where commercial entities will take exploration risk.

Traditional concepts are not appropriate for CCS. Updated understanding is that the State does (or participates in) Exploration, Appraisal and Development functions.

- So need to extend beyond promoting commercial exploration (by others) and take consideration that government(s) are likely to be (or at least fund) the first explorers *and* developers

Implying more data and more site specific data and more sensitivities to communities and overlapping rights

Bankability

Traditional concepts relate to attraction of project financing such as:

1. **Technical maturity**. Evidence supporting the assessment of performance to within a level of confidence acceptable to investors.
2. **Economic & commercial maturity**. Evidence that the resource can be developed at a cost (or return) which is required by investors, to a level of confidence acceptable to them.
3. **Licence to develop**. Evidence or indicators to give investors sufficient confidence that development consents are or can be put in place.
   - Environmental Impact Assessment (including aspects of public acceptance)
   - Storage Lease
   - Coordination agreements with overlapping and neighbouring tenement rights holders

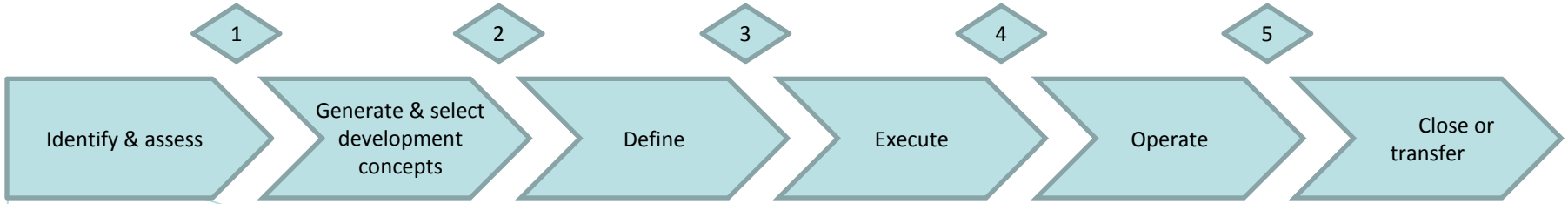
Generalised Project Process

Do we understand what we're starting ?
- Is the *frame* for decision making appropriate and understood?
- Are objectives clear and "success" clear and measureable ?
- Is there meaningful reliable information & analyses ?

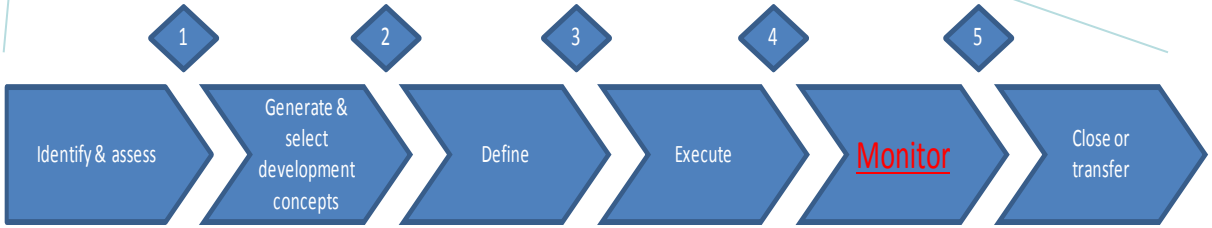
Have a full range of strategies and scenarios been identified ?
- Are there clear alternatives ?
- Are trade-offs and values articulated and understood ?

Is the program optimally selected ?
Is the reasoning logically correct (linking actions to objectives) ?
- Are key risks managed ?
- Is there commitment to action ?

CCS Project

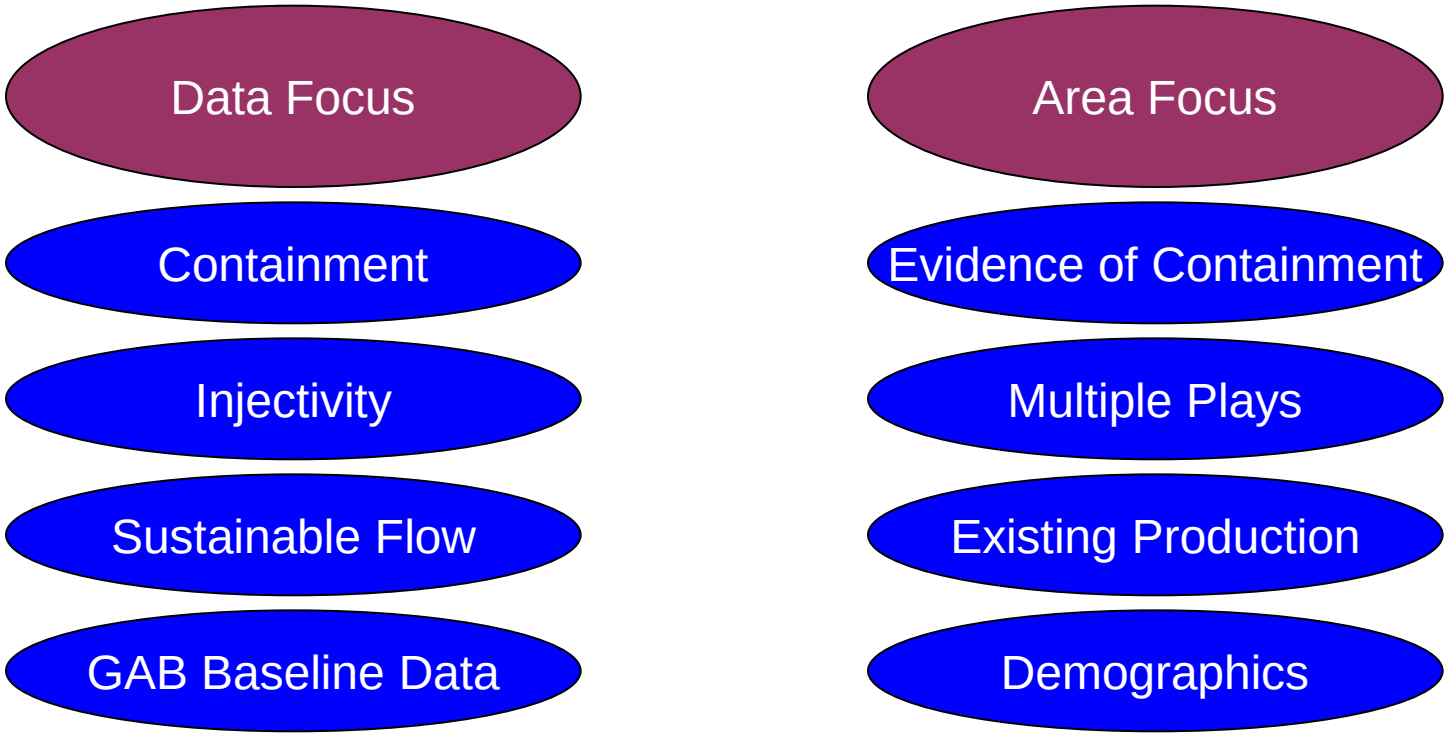


CGI "Project"
Is there an opportunity ?

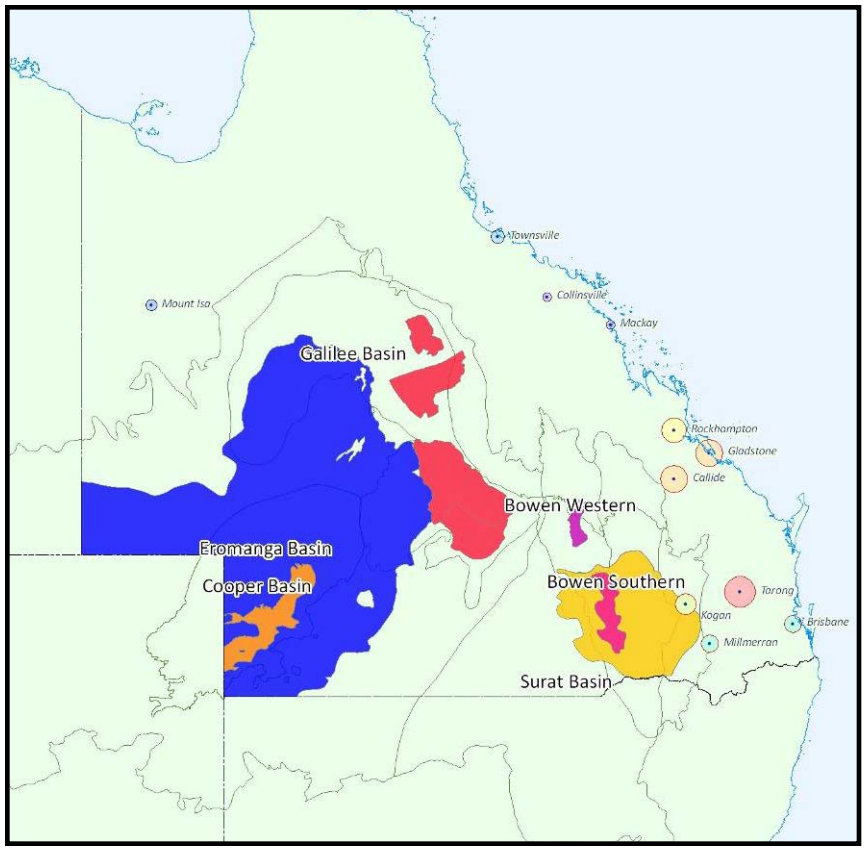


This will be very iterative

Program Implications



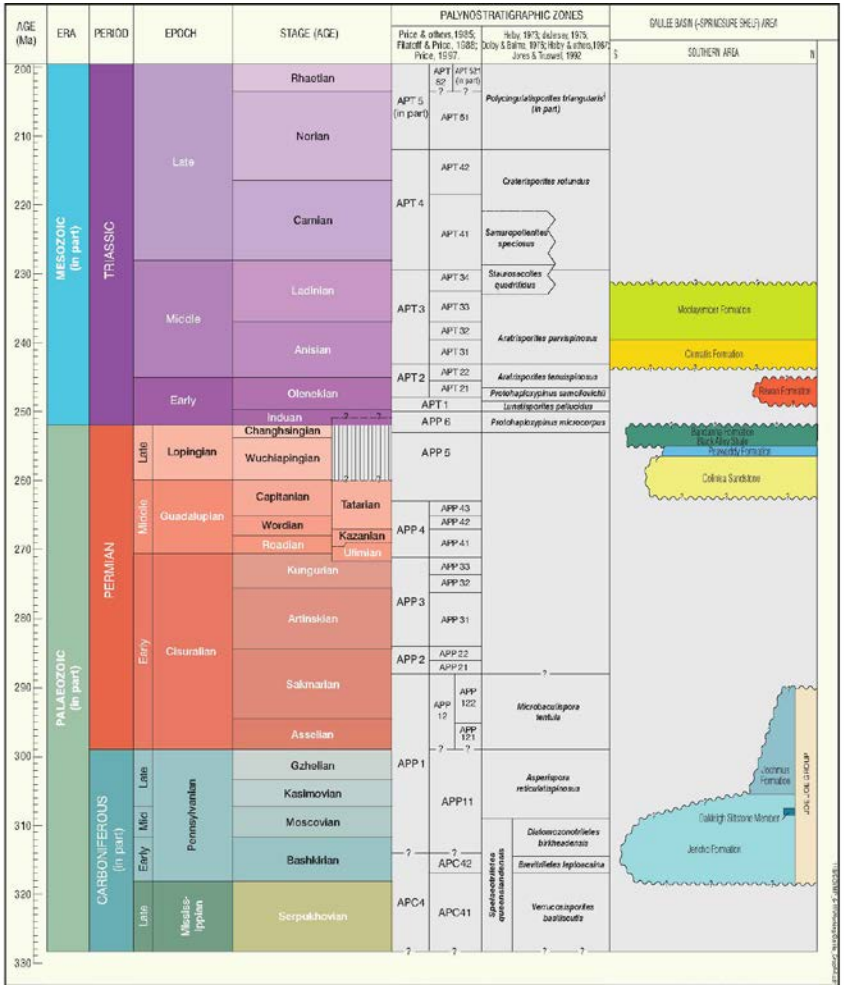
Target Basins



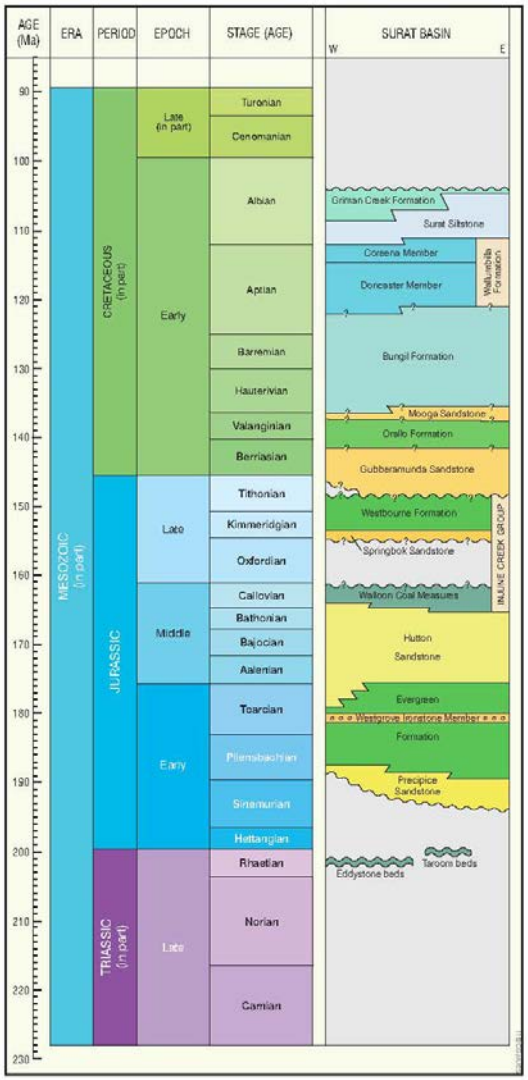
Proposed Drilling Sites

1. southern Galilee Basin
2. central Surat Basin

Geostorage Plays – Galilee Basin



Geostorage Plays – Surat Basin

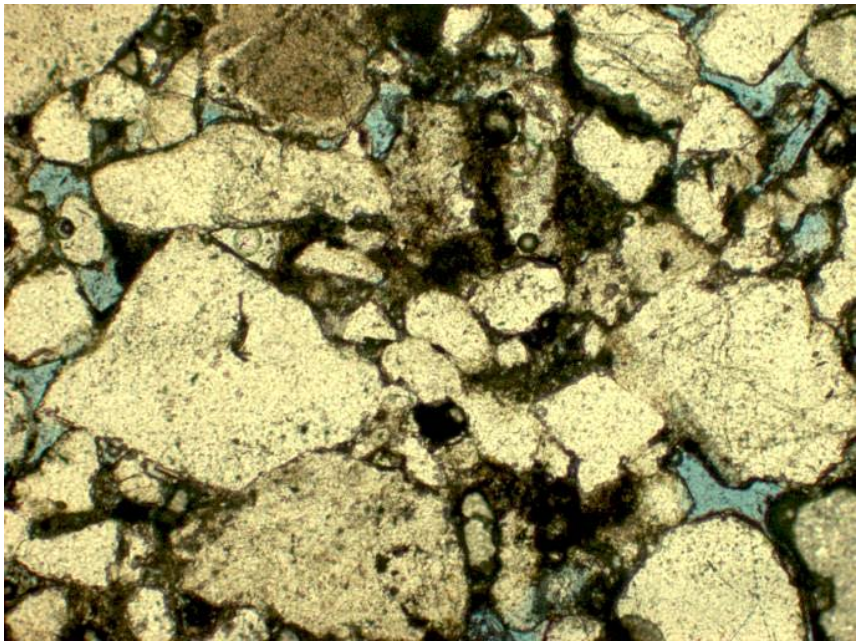


Seal

Reservoir

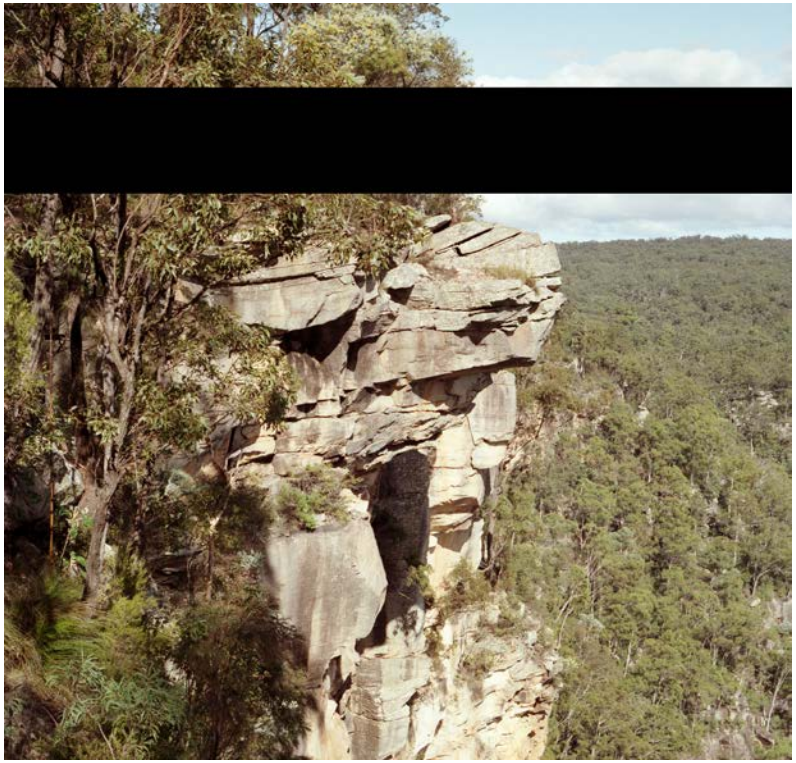
Reservoir Rocks

The Lower Jurassic Precipice Sandstone in the Surat Basin

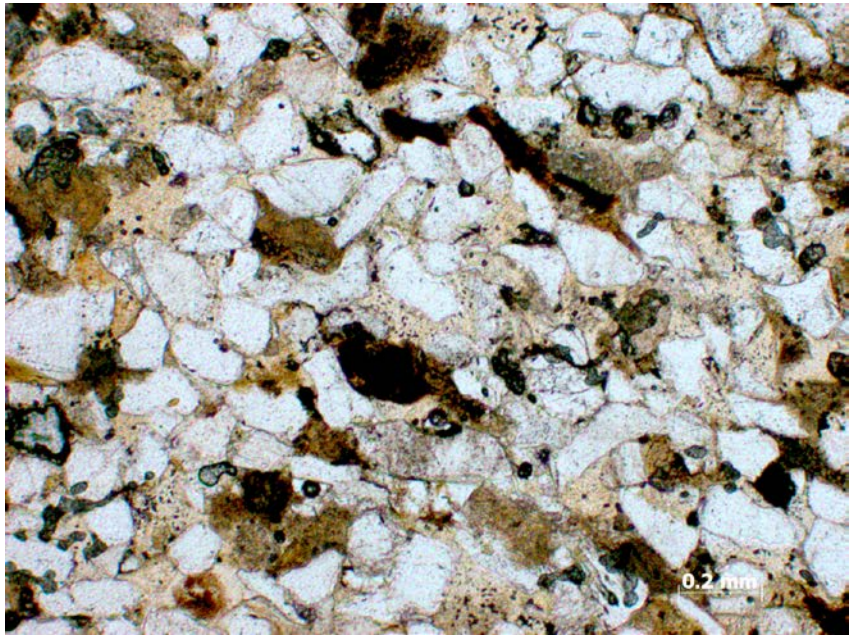


medium-grained, moderately sorted
- 1010 m deep, central Surat Basin
- 85% quartz, 12% clays

Reservoir Rocks



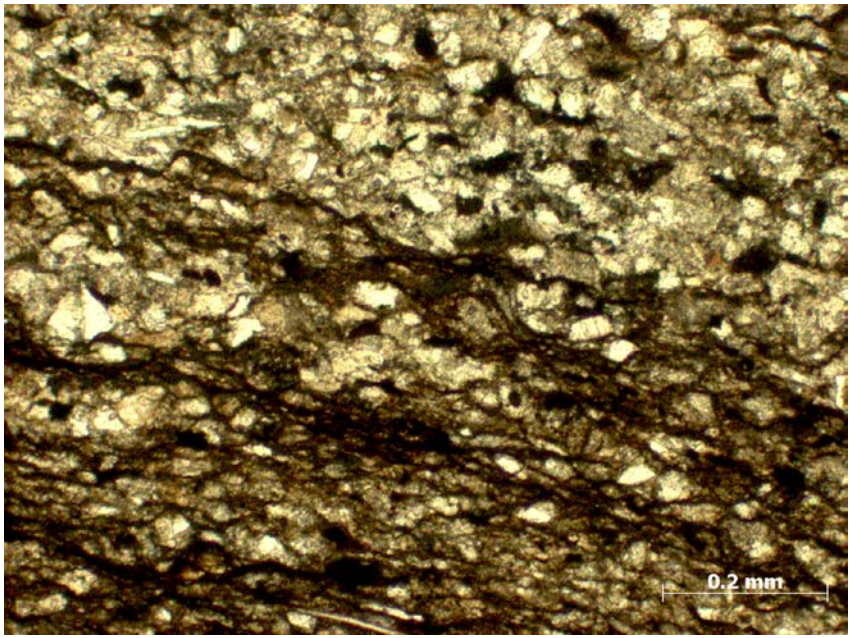
The Middle Triassic Clematis Sandstone in the Galilee Basin



Clematis Sandstone
530 m deep - southern Galilee Basin

Seal Rocks

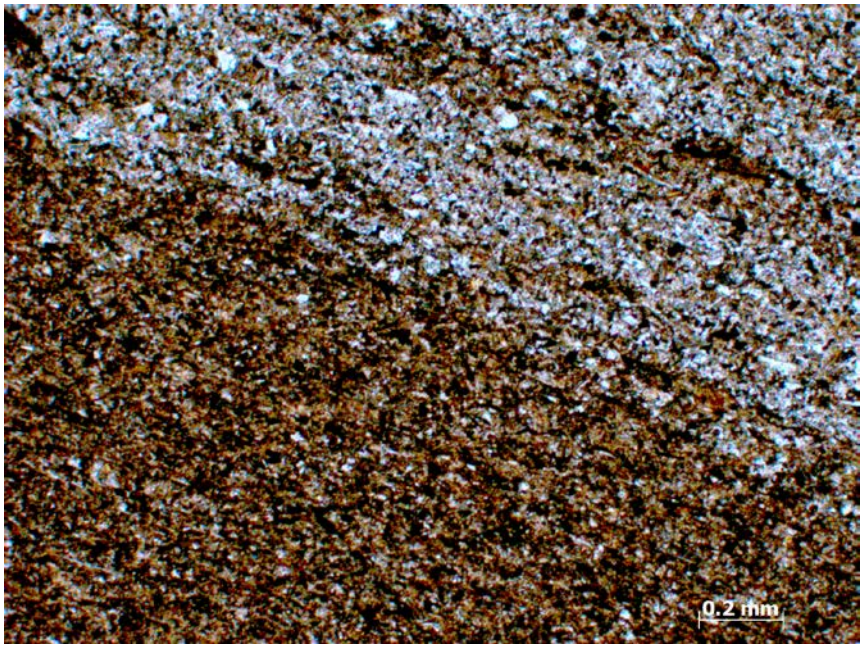
The Lower to Middle Jurassic Evergreen Formation of the Surat Basin



2060 m deep, central Surat Basin
- 61% quartz, 28% clays

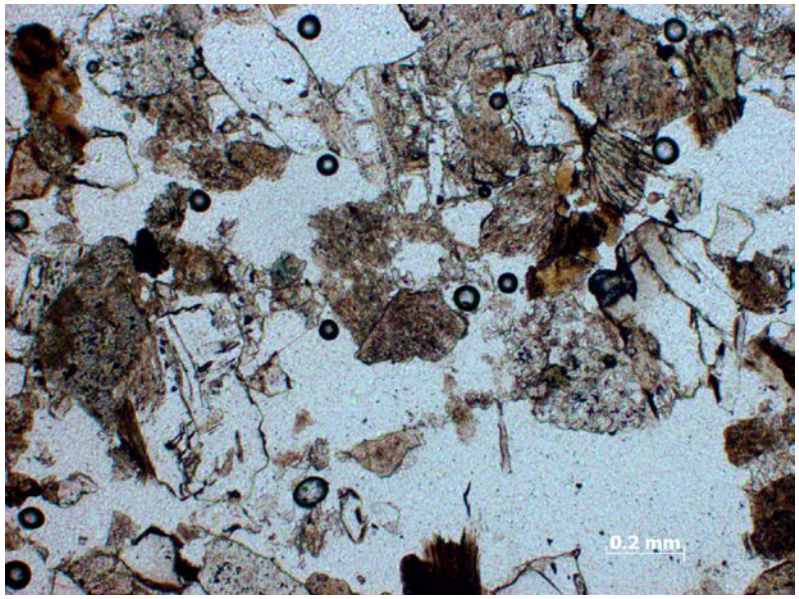
Seal Rocks

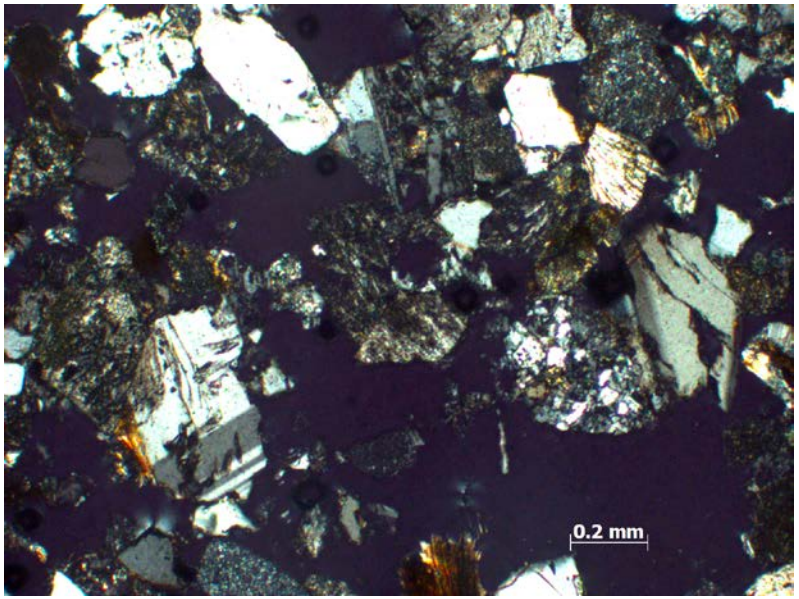
The Upper Middle Triassic Moolayember Formation of the Bowen Basin



Moolayember Formation
250 m deep southern Galilee Basin

Seal Rocks?





Walloon Coal Measures
460 m deep, northern Surat Basin
- 35% quartz, 43% feldspars, 12% clays

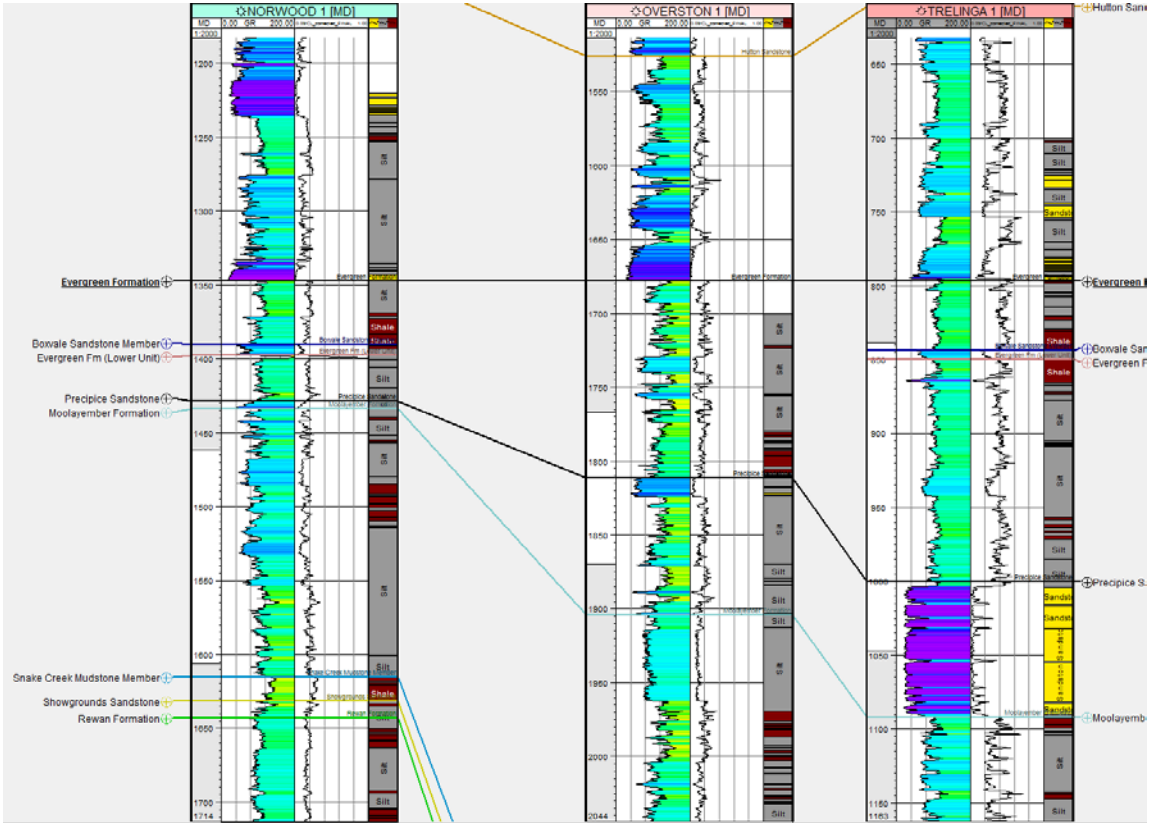
Target Area Selection

Sand fractions estimation for reservoir and seals

- Vshale was estimated using wells with gamma ray logs:

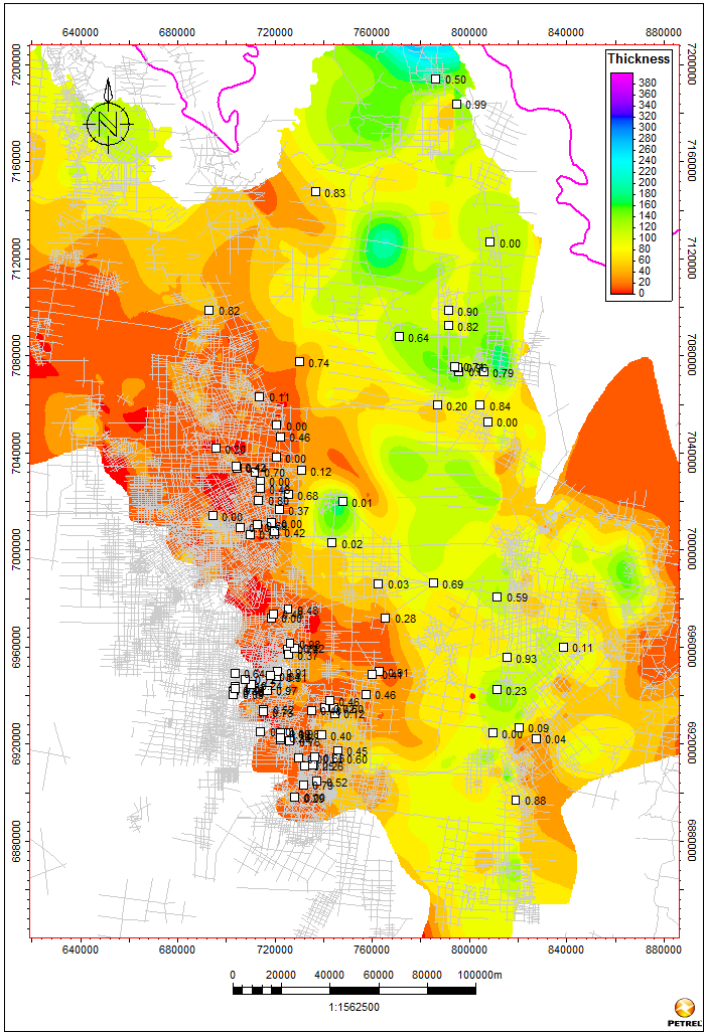
$$Vshale = \frac{(GR - GR_{min})}{(GR_{max} - GR_{min})}$$

- The following Cut off was applied: Sand less than 10% V-clay; Silt between 10% and 35% V-clay, and; clay greater than 35% V-clay.
- Then the fraction of sandy sections refer only to clean Sst less than 10% Shale.

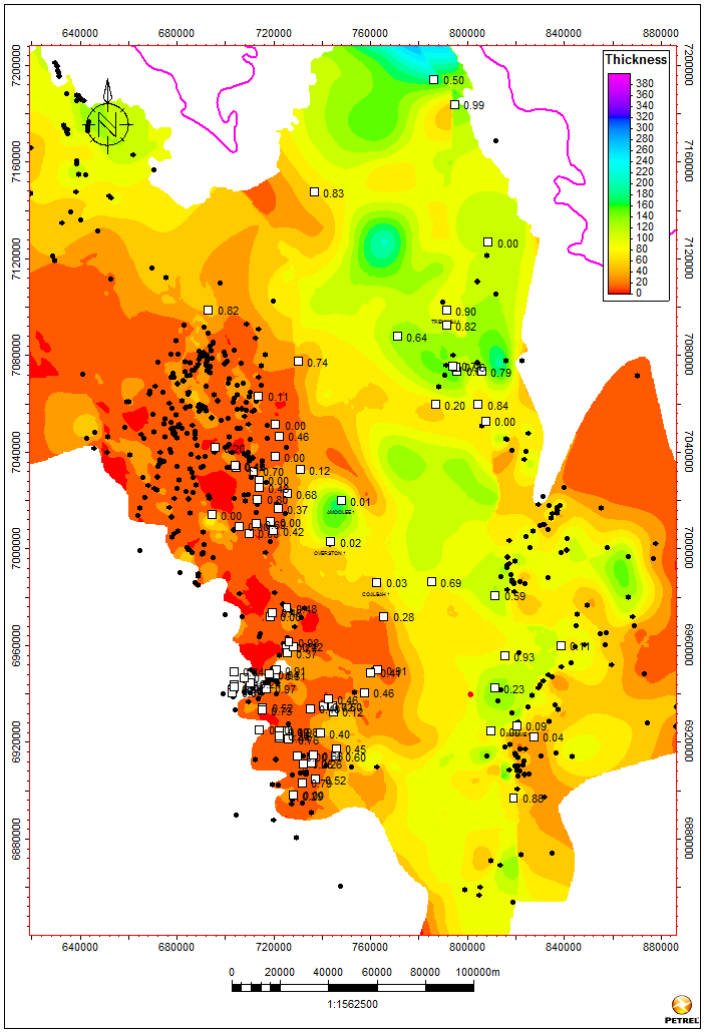


From Left to right: GR, Vshale and Lithology

Data Drivers

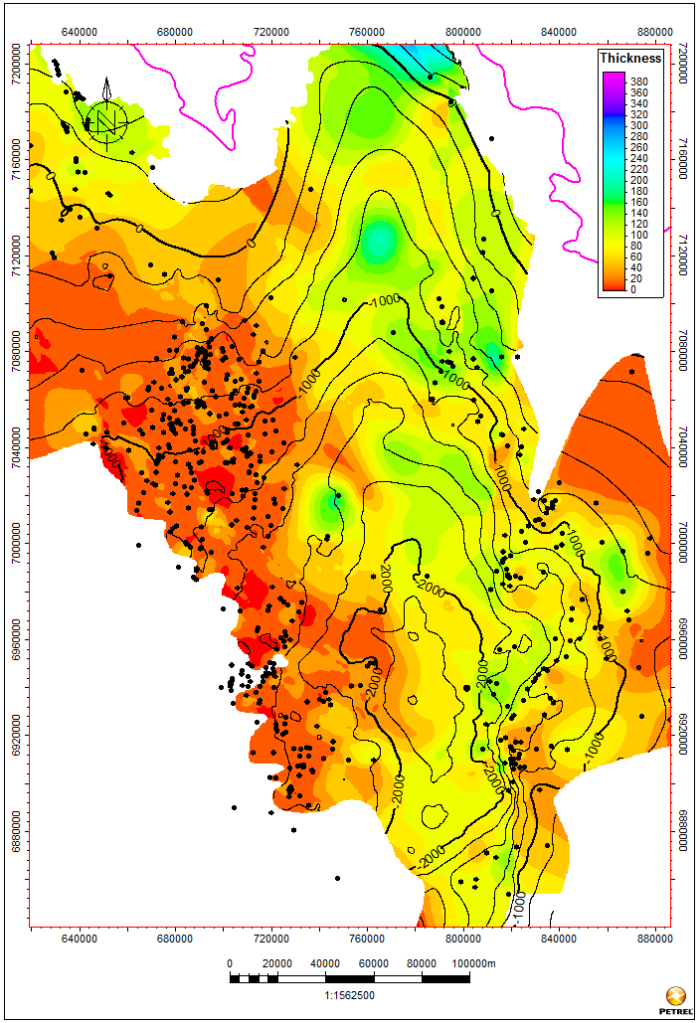


Precipice Sandstone – spatial thickness variation, seismic data and wells used for V-shale calculations

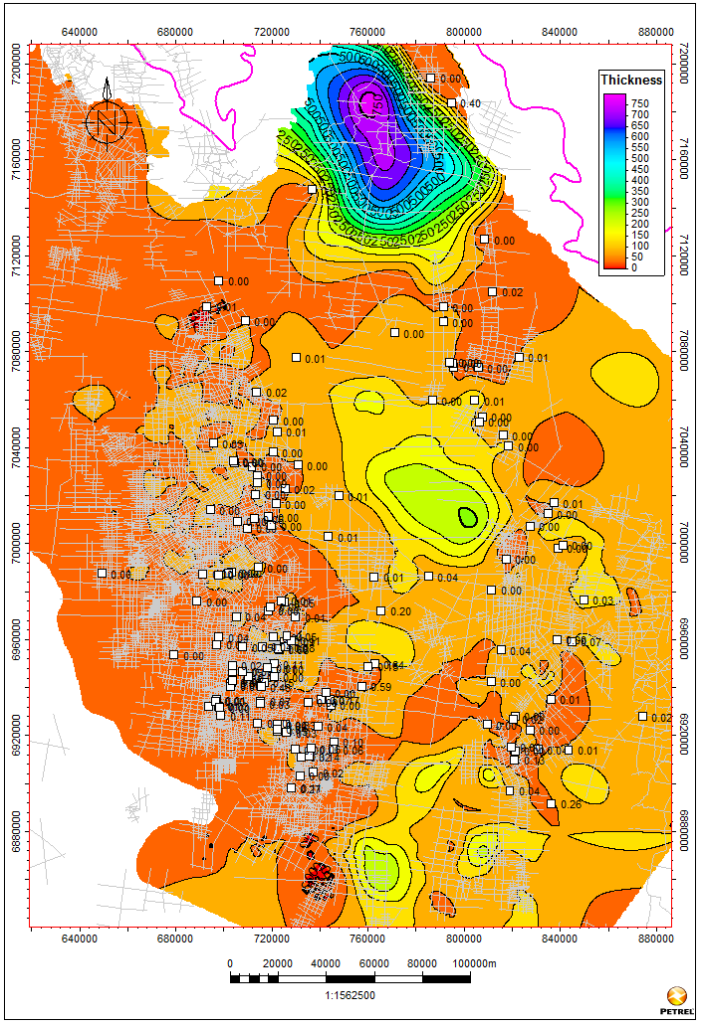


Precipice Sandstone – spatial thickness variation, wells used for V-shale calculations and well intersections (Black dots)

Data Drivers

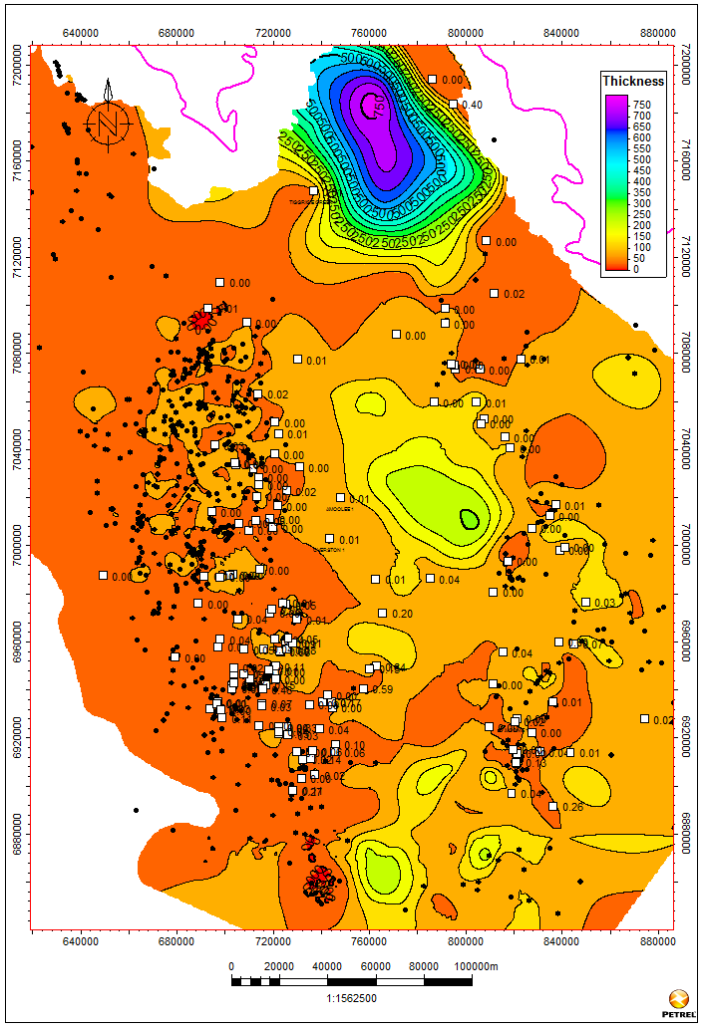


Precipice Sandstone – spatial thickness variation and depth contours

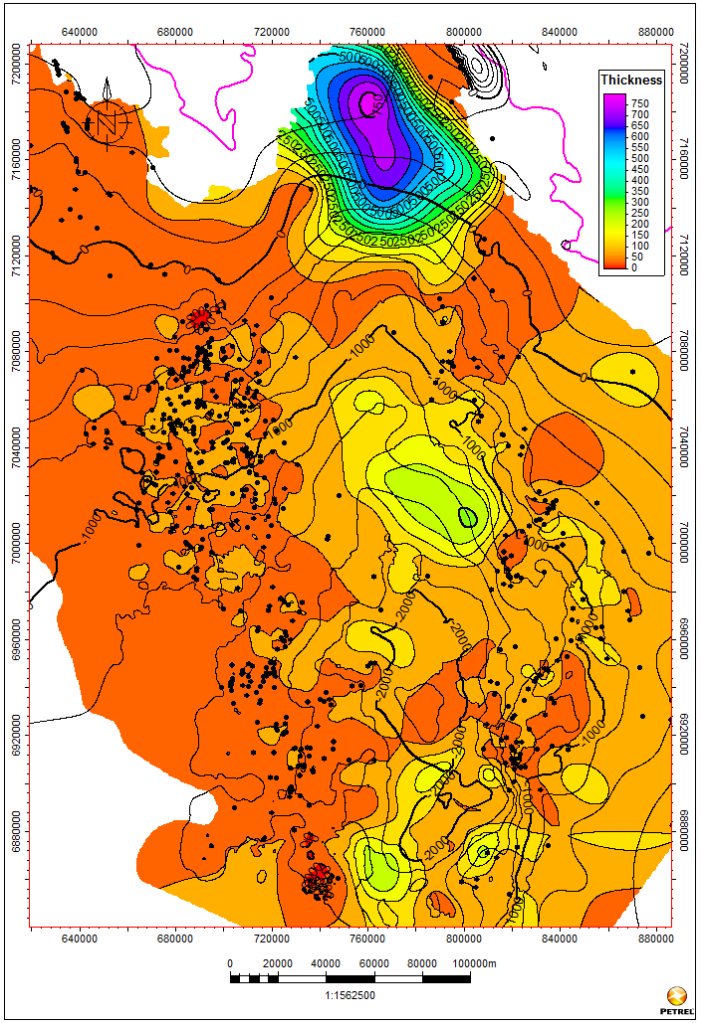


Evergreen Formation – spatial thickness variation, seismic data and wells used for V-shale calculations

Data Drivers

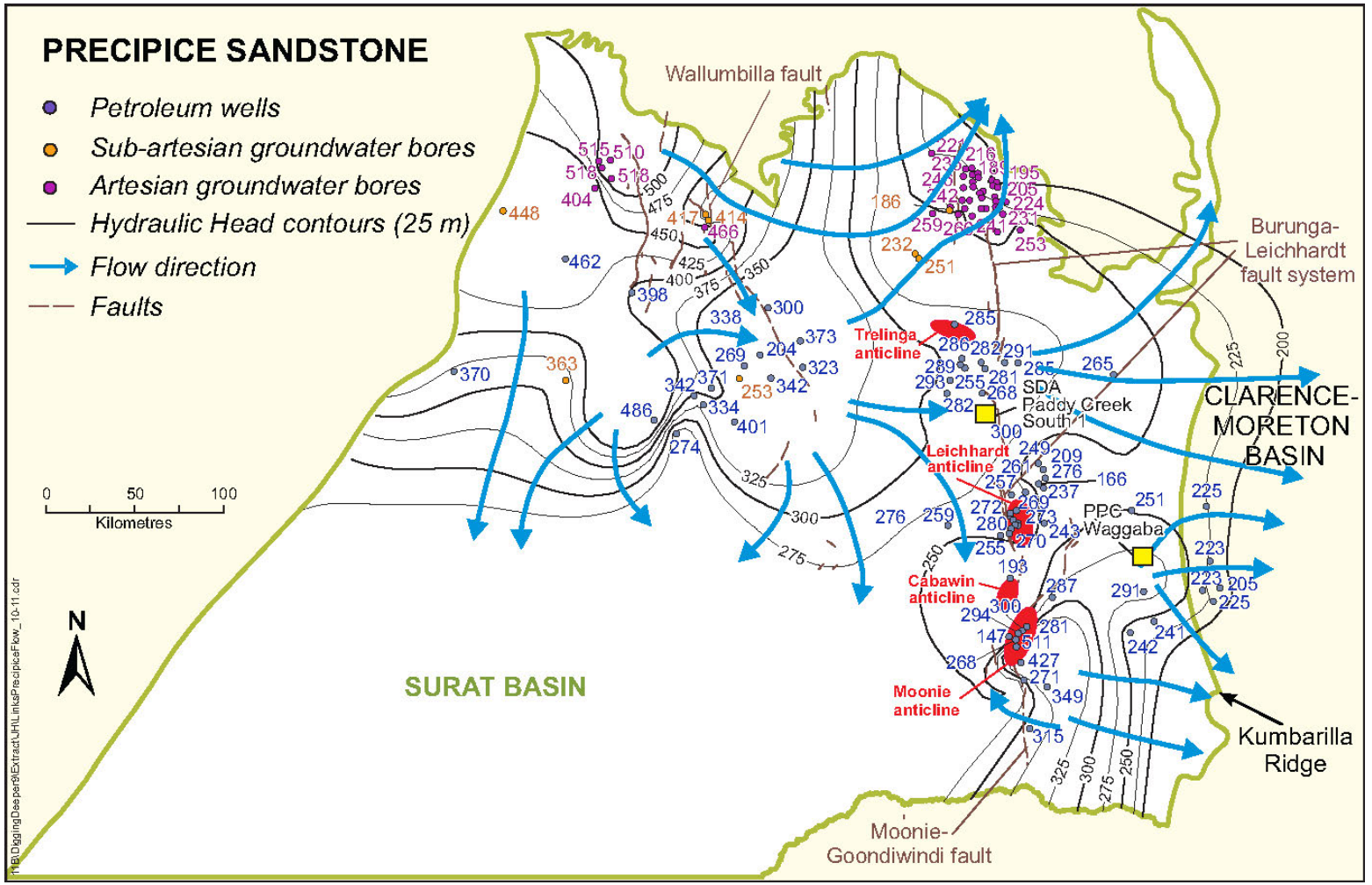


Evergreen Formation – spatial thickness variation, wells used for V-shale calculations and well intersections (Black dots)

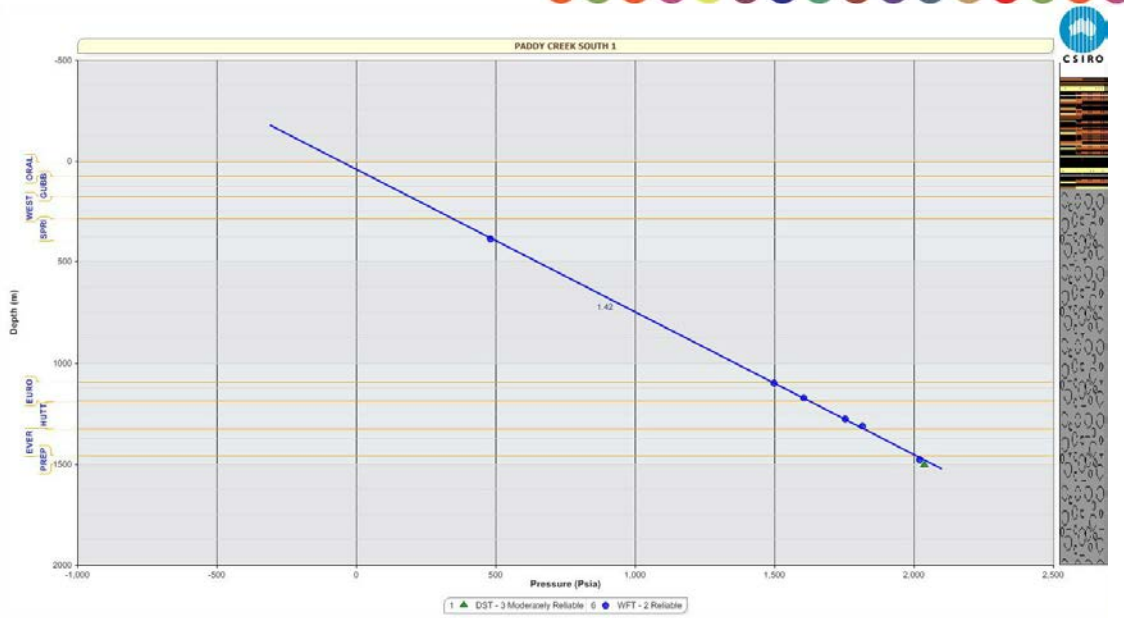


Precipice Sandstone – spatial thickness variation and depth contours

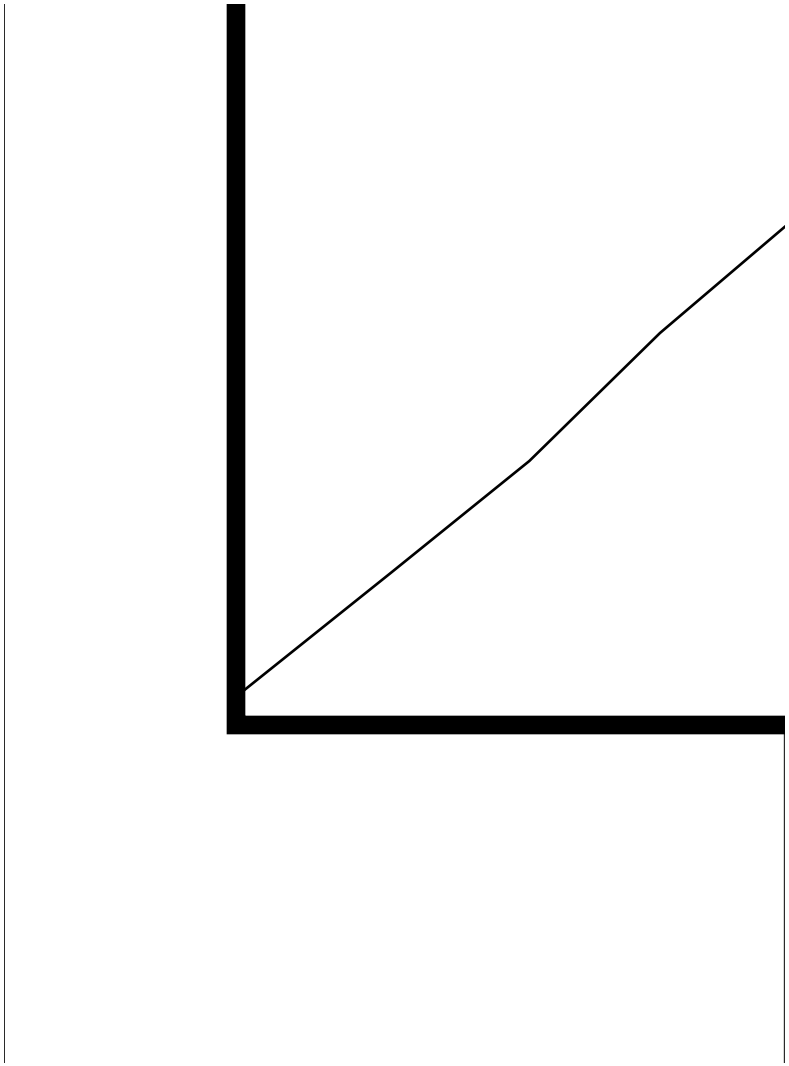
Hydrodynamics



Containment



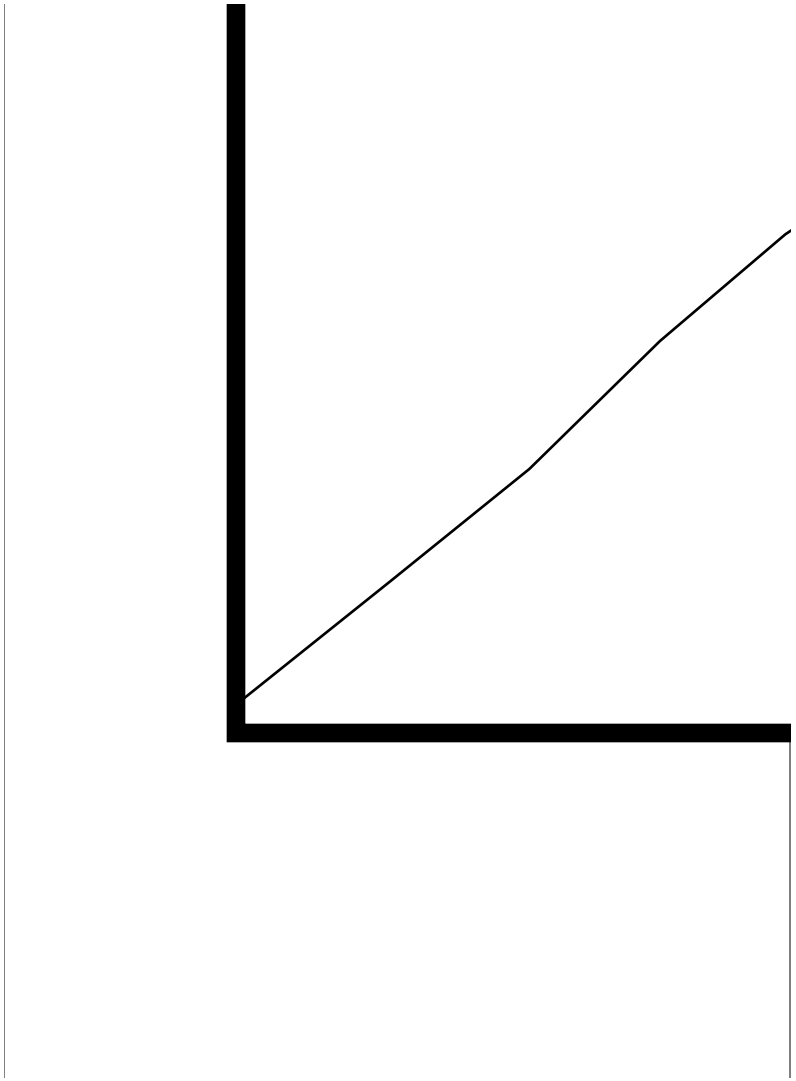
Additional Site Selection Parameters – Surat Basin



Greenhouse gas tenement areas and major drainage systems

Strategic cropping land trigger areas and restricted land

Additional Site Selection Parameters – Surat Basin



Development leases (grants and applications) and coal seam gas wells

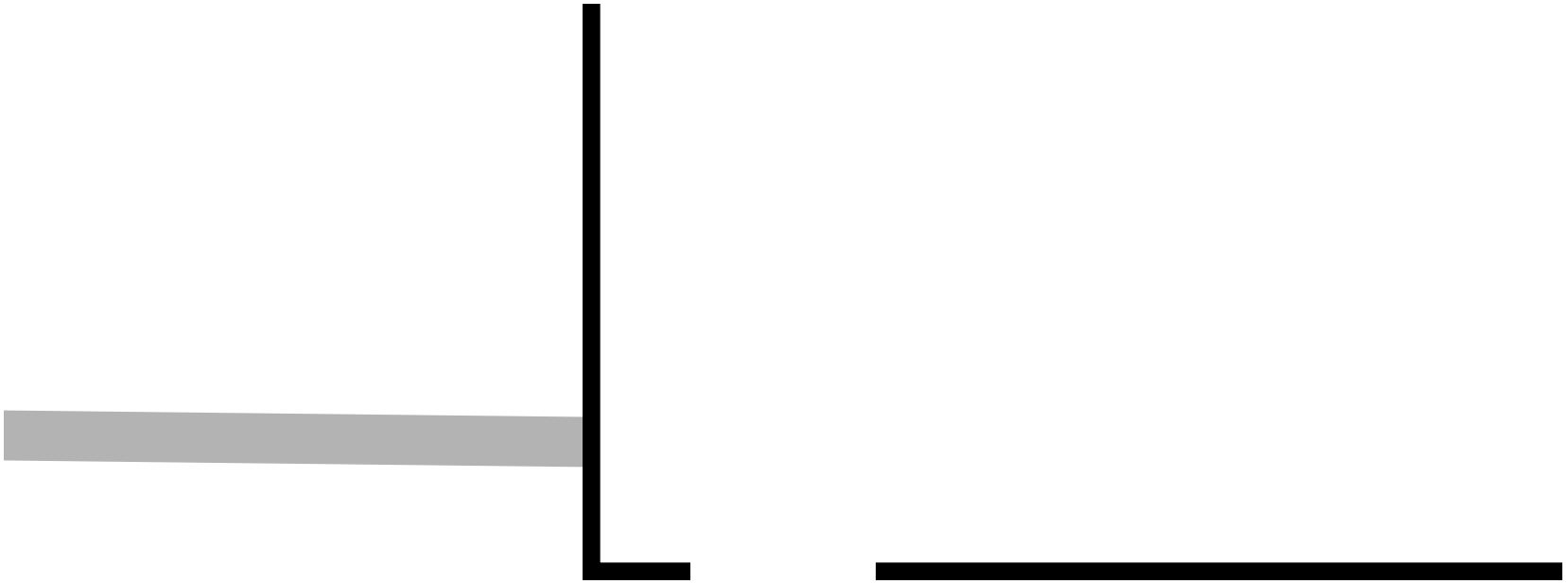
Risk segmentation map

Additional Site Selection Parameters – Galilee Basin

Greenhouse gas tenement areas, major drainage systems and restricted land

Development leases (grants and applications)

Additional Site Selection Parameters – Galilee Basin



Seismic data and well information

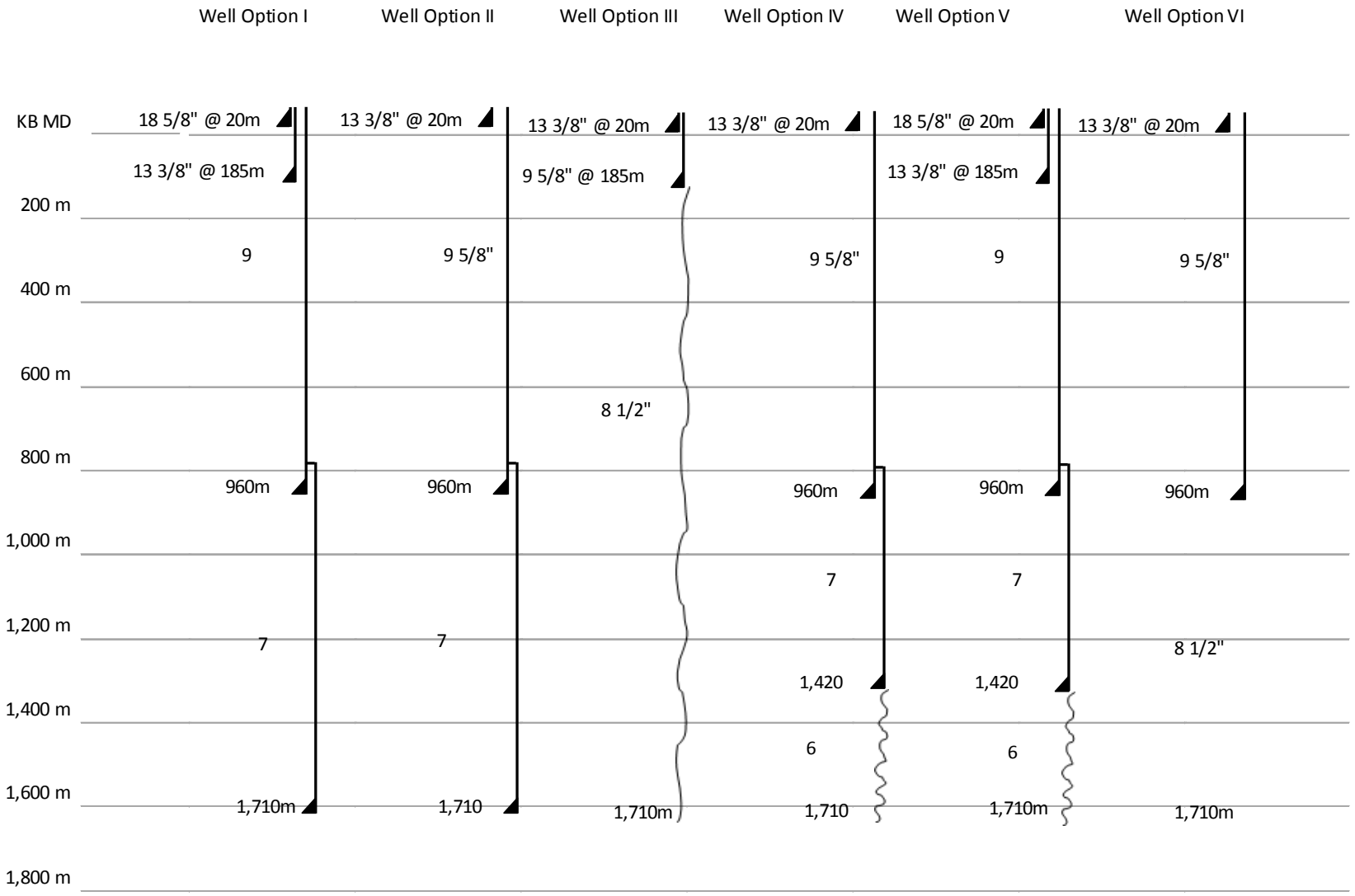
Risk segmentation map

Well Concept Select Parameters

Data requirements for Galilee Well (v. 24 October 2011)

Formation depths below GLE	Classification		Essential data									2nd tranche					3rd tranche				Other ----> (decreasing priority)										
			cement returns					surface logs (incl sonic & dens)																		virgin pressures	formation fluids					
Toolebuc 200m Cadna-Owie 500m Hooray 572m Westbourne 686m Adori 780m Birkhead 840m	Overburden (GAB)	GLE = 363 m (approx) Near Surface																													
		Overburden formations																													
Hutton 970m	Play 2	Hutton	Cement bond	good quality cuttings (no PDC)	core (full section start in Hutton - can be "slim" - advice needed)	virgin pressures	check shots	standard / "supercombo" type logs (to be advised	hole quality (high def calipre)	Long term pressure monitoring	Mud gas smpling incl. (isotopes of carbon)	formation fluid samples (not nec PVT)	fracture gradient	Image logs	Bulk-scale instantaneous injectivity		formation fluid samples (not nec PVT)	Image logs	Bulk-scale instantaneous injectivity			Extended well test (production)		Long term pressure monitoring	Periodic fluid sampling						
Evergreen 1167m		Evergreen																													
Precipice 1236m		Precipice (secondary play)																													
Moolaymber 1280m	Play 1	Moolayamber																													
Clematis 1440m		Clematis (primary play)																				Extended well test (production)		Periodic fldui sampling							
	The first set of design / cost concepts should assume TD at base Clematis.																														
Bandana 1700m Joe-Joe 1900m	Play 3	Permian Play to base Colinlea SST	A second set of design concepts should extend the data requirements to Play 3 and the vase Colinlea sandstone. But should only consider "Essential data" and tranches 2 & 3. Tranche 3 should prioritise bulk-scale instantaneous injectivity in the Colinlea higher than similar tests in the Precipice.																												

Well Concept Select Summary



Preliminary Decision Model at End of Well Concept Select

A. Locations

- A1 Map plays at >800m bGL (and size = big)
- A2 Segment by depth >800 + <1500 (degrade res qual)
- A3 Segment E-W (2 us 1 play)
- A4 Segment N-S (degrading res qual)
- A5 Fill-in data gaps
- A6 Avoid constraints (PL's, PLA's, existing wells, major faults)
- A7 On seismic line (+/- 100m)
- A8 avoid land holder objections (prefer F-hold or Roads to avoid NT)
- A9 avoid (if poss) complex CH + NT
- A10 select (wet weather access if poss)

B. Sequence

- B1 Rig avail. Vs. operate in 2012 (top hole drilling) ?
- B2 "Least complex" access and consents (incl NT & CH)
- B3 drill highest Ps play segment first
- B4 drill highest P90 cost first (to take risk while funds are max)
- B5 drill 2nd basin in 1st phase (remaining funds >P90 well cost?)
- B6 minimise rig move (time + cost)

C. Concept, Function, Data, Contingencies

- C1 Define critical data U/C (voi) by play segment
- C2 Define 2nd + 3rd tranch data (trade offs/cost + risk)
- C3 Define cost (P50+P90) + risk/data set (well concept)
- C4 set limit as P90 (well costs) – (choice must fit iterative test)
- C5 'choose' highest Ps play segment concept/data-set first
- C6 'choose' second basin concept second
- C7 'choose' next highest Ps play-segment concept Next . . . And so on to limit
- C8 form main 'what if' contingencies (overspend)

'choose'
(move + trade offs)

(A) Maximise well count (locations) for critical data
(B) Use remaining cost to fill in tranches of data at highest Ps play segment

E. Geotechnical Studies

- E1 Define main technical uncertainties 1. containment 2. injectivity 3. baselines
- E2 Define data + poss studies predrill + rank
- E3 Define data + poss studies post-drill + rank well by well synthesis
- E5 Define predrill studies needed to prep for post-drill studies (these are firm)
- E6 from highest to lowest rank, do the post-drill studies (maintain cost sum)

Consider 2nd $50 million for the EWT tranches?

Conclusions

- Highest probability of success – Surat Basin
- Cost benefit analysis applied to select optimal well design
- Proof of concept for both basins
  - Containment – decision gate 1
  - Injectibility – decision gate 2
- Requirement for greater understanding of the depositional systems in the target basins – sequence stratigraphic approach