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International Petroleum Consulting

CRC Mining

CoalBed Concepts Pty Ltd

CoalBed Geoscience

Developments in Inseam Drilling Technology

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Where are we now?

- Developments over past 5 years.
  - Emergence of ‘parallel’ energy business, coal seam gas (CSM).
    - Improved understanding of science of gas production.
    - Business opportunities associated with contiguous resource.
    - New surface based drill operators & options.
    - Competing priorities, coal v. gas resource.
    - Greenhouse reality is changing the economics of coal seam gas.
  - Unprecedented energy boom.
    - Impact upon resources, manpower & equipment.
  - Growth of MRD SIS as a means of draining coal from the surface.
    - Oilfield technology now available.
    - Capable of drilling large, long boreholes and draining far in advance of mine workings. Chance to be proactive, rather than reactive. NPV issues …

Where are we now?

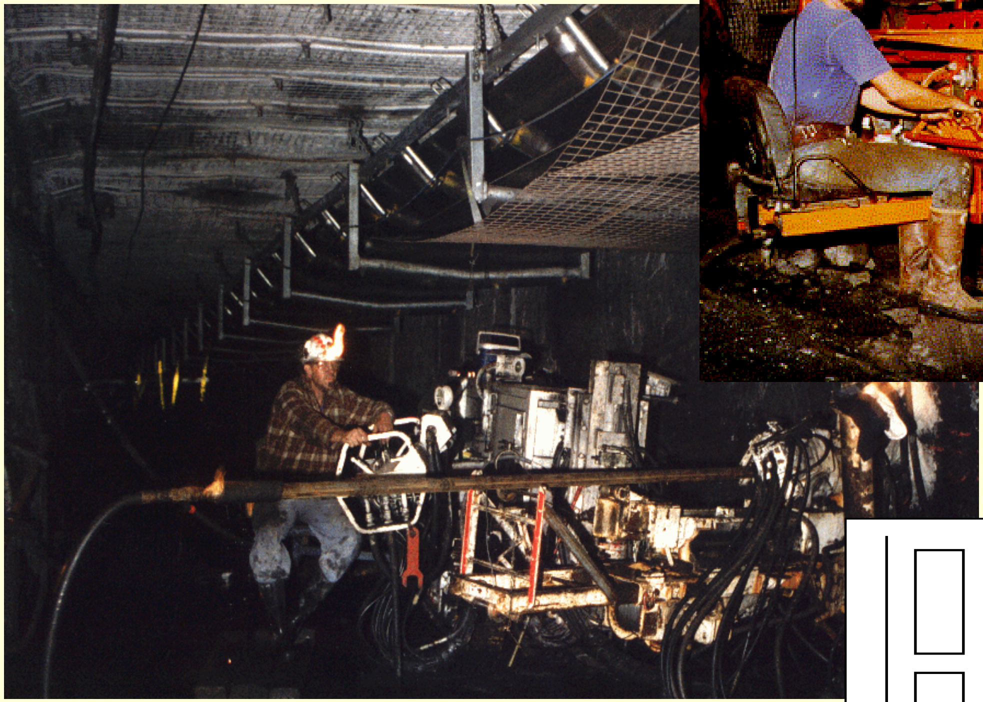
- <u>Developments over past 5 years (continued).</u>
  - Reservoir modeling tools (oilfield derived) readily available.
    - Single well or full field models.
    - Tied to economic assessment tools.
    - Analytical rigour now possible.
    - Accuracy of outputs = quality of inputs, scrutiny of gas information database.
  - Underground drilling? Little change.
    - Operators have passed lost tool risk to the client in inseam drilling operations. No incentive for change.
    - ‘Comfort’ with existing systems. Culture.
    - Consolidation of inseam drilling contract services.
    - <u>*System working – no outburst fatalities in years.*</u>

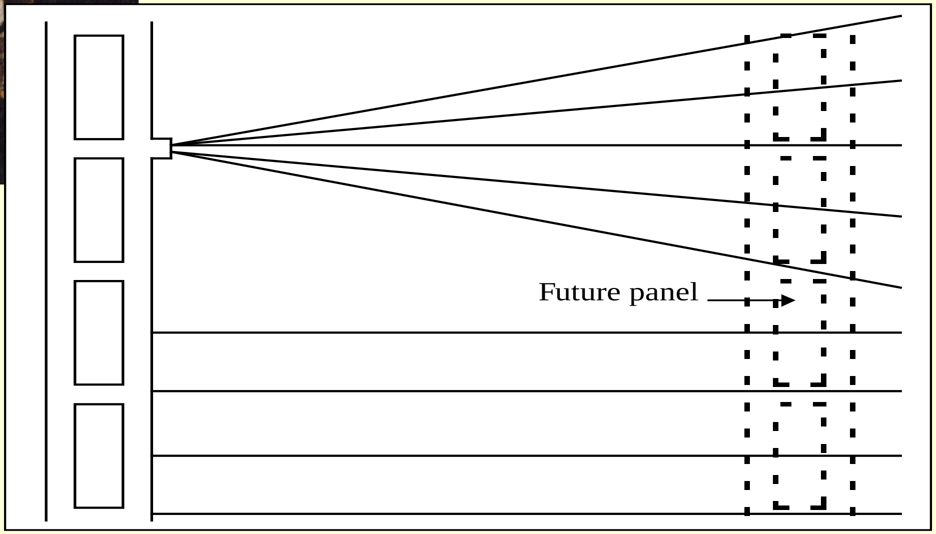
What are the core issues / problems relevant to the future of inseam drainage?

- ‘Soft coal’ – coal that cannot be drilled.
- ‘Tight coal’ – coal that can be drilled but will not drain.
- Variable flows from inseam holes – why do some holes perform and others not?
- Multiple seam drainage.
- Cost. $/ tonne. Too expensive?
- Loss in hole of steering / survey systems (related to above).
- Inadequate geological information gathering, including drill parameters.
- Horizon control.

Time value of money issue… do we drain now or later? Do we drill underground at all?

Inseam Drilling





Typical cost to mine?

$1-$5 per tonne

Why has it been successful to date?

- Smart instruments, routine formula drilling (mechanical, repeatable)
  - Why should we engineer the smarts down the hole, and not up the hole?
- Australian coal is generally hard, & pore pressure low
  - Note: our system works poorly elsewhere
- The pressure differential encourages gas desorption without ‘completion’
  - No ‘bringing the well on line’, i.e. no production science
- The majority of holes are <400m depth, and equipment ‘comfortable’ at this depth (no finesse required)
  - 12t push / pull to drill NQ 400m??? Suggestion of over engineering.
- *Comment: The IS barrier limits the alternatives available*

The downside

- Extremely expensive equipment that may be lost down hole
  - At first sign of trouble ‘boggy ground’ called & hole abandoned
  - Under utilisation of exploration function, not drilled to distance, risk factor
  - No training or emphasis on developing the finesse for long exploration holes
- No objective means of evaluating formation during or after drilling – no geophysics
  - Again, under performance of exploration function
  - Reliance on skill & diligence of operator
- <u>We are stuck with a mature, inflexible system of underground gas drainage</u>, *but we know it works.*

Where to from here?

Main problems:

1. Balance / pressurisation related. ‘Soft coal’, poor drainage performance of holes, lost tools.
2. Cost. Locked into antiquated systems, mature & inflexible.
3. Lack of completion science & analytical rigour.
4. Geological reality – increasing pore pressure with depth, low perm due to stress factors.

What is proposed to address these issues … ???

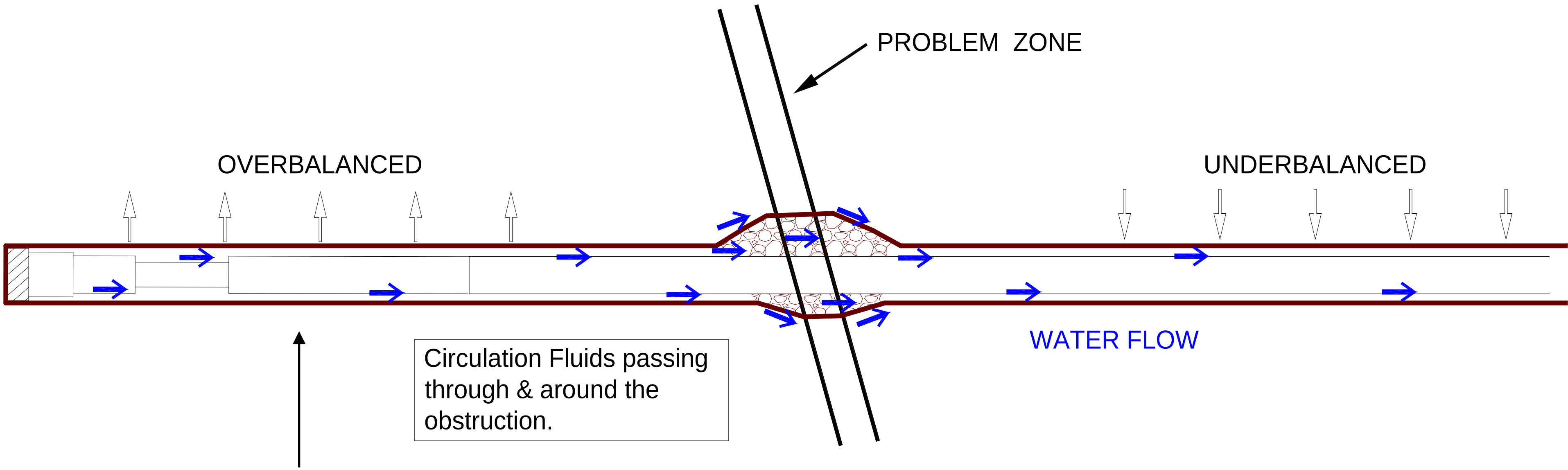
- Balance / pressurisation …cost, geo information … Coiled Tubing Systems, ‘Super Logger’.
- Analytical rigour … reservoir engineering & modeling.
- Multi-seam drainage. Difficult problem, best attacked from whole-field degasification strategy (not from underground).

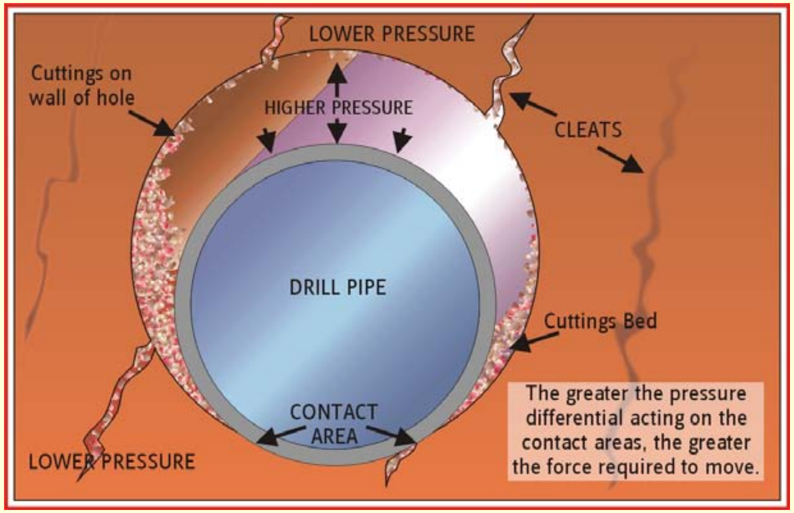
Get drilling out of the pit & degas from the surface?

‘Soft Coal’
The ‘boggy ground’ myth …

- The common excuse for borehole termination
  - All about tectonic history, structure, and pore pressure
  - Fundamentally due to borehole conditioning issues (rapid accumulation of cuttings bed leads to drag)
  - Note: may not be related to geology (but usually is) …
- Cuttings removal & balance control the key
- Balance problems = differential sticking …
- Problem (once diagnosed) may not be at the bit
  - Need to define the problem zone
- May be just reaching lockup condition (not ‘boggy’ at all), due to poor borehole conditioning
- ***Fighting a losing battle with existing technology to deal with this issue.***

Differential sticking in underground inseam drilling



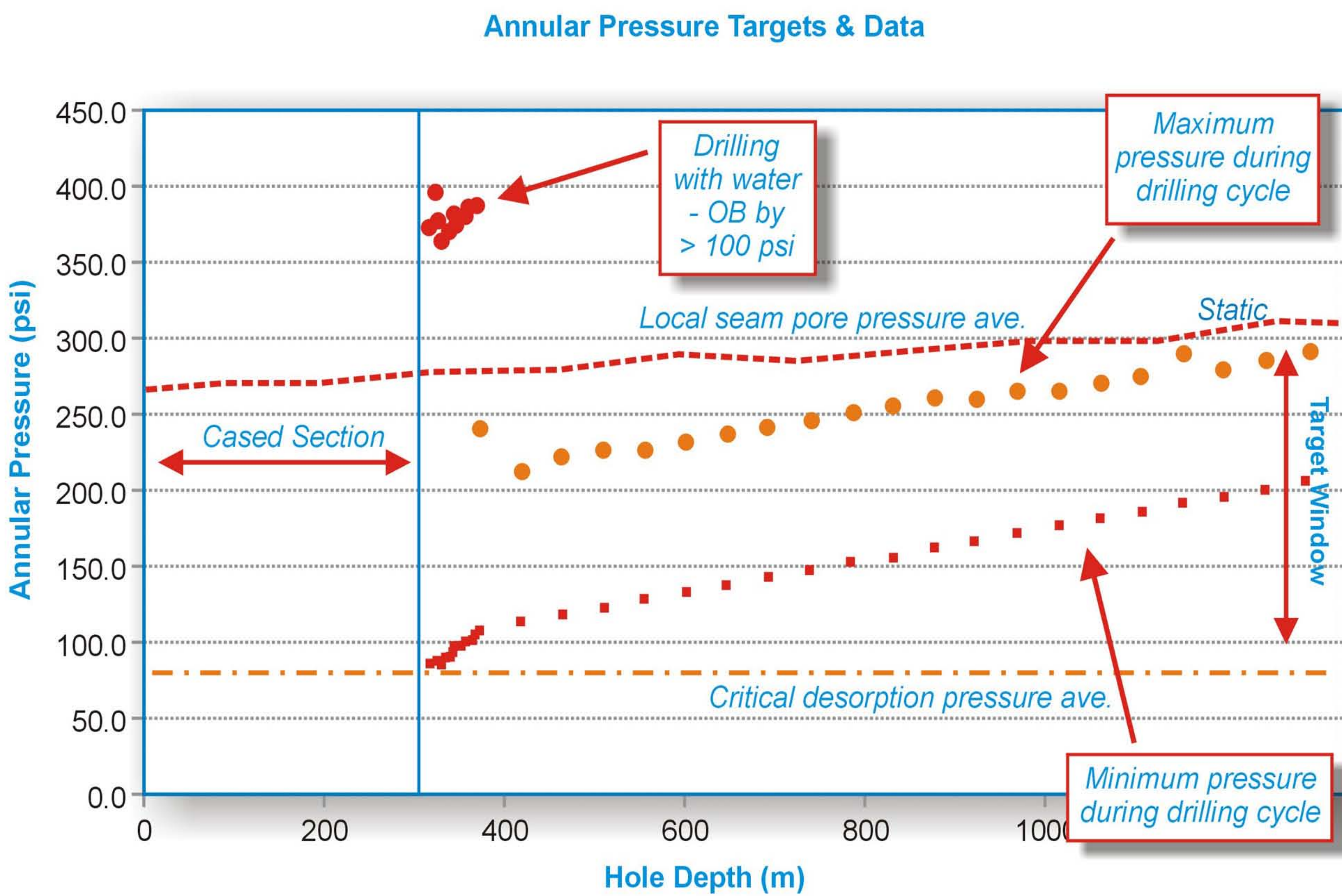


- May be due to a geological structure
- May be due to high pore pressure of coal
- May be due to weak coal
- May be due to inadequate cuttings clearance

'Key holing' makes situation worse

Solving the soft coal problem is a *'Question of Balance'*

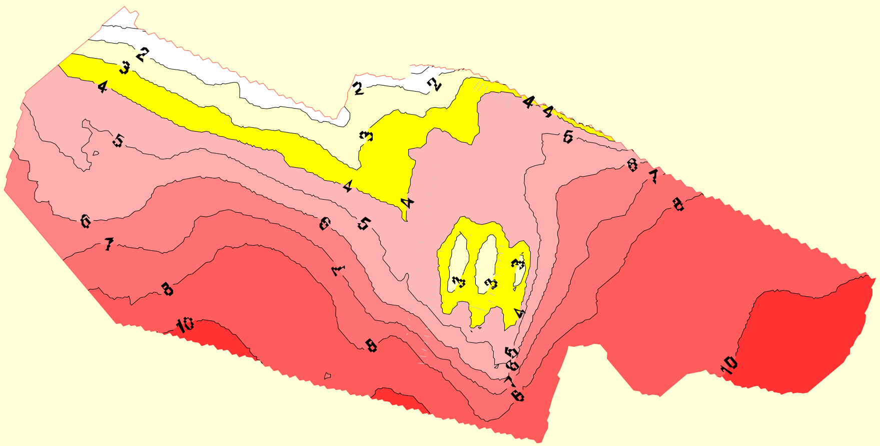
- Inseam underground drilling is <u>underbalanced</u>
  - Borehole drilled at 'near atmospheric' (120kPa) and pore pressure of seam is above 2000kPa
  - Pressure differential encourages desorption – may be very rapid – gas & coal cuttings ejected from formation into borehole
- Success of inseam drilling depends upon stable wall of borehole
  - If not, pressure differentials, diff stick, mechanical jamming (collapse of formation around string)
- Overbalanced state in underground drilling rare – but when it occurs = trouble
- It is theoretically desirable to maintain perfect balance in drilling boreholes

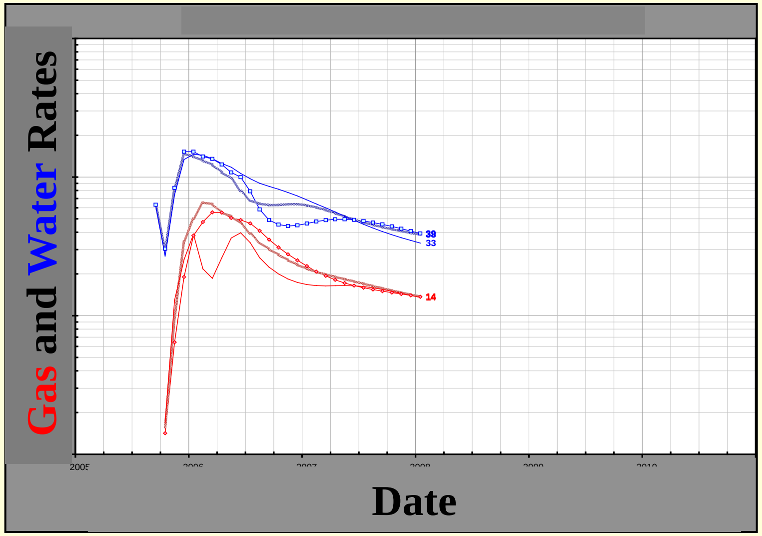


Annular Pressure Targets & Data
Annular Pressure (psi)
450.0
400.0
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
0
200
400
600
800
1000
Hole Depth (m)
Drilling with water - OB by > 100 psi
Maximum pressure during drilling cycle
Local seam pore pressure ave.
Static
Cased Section
Target Window
Critical desorption pressure ave.
Minimum pressure during drilling cycle

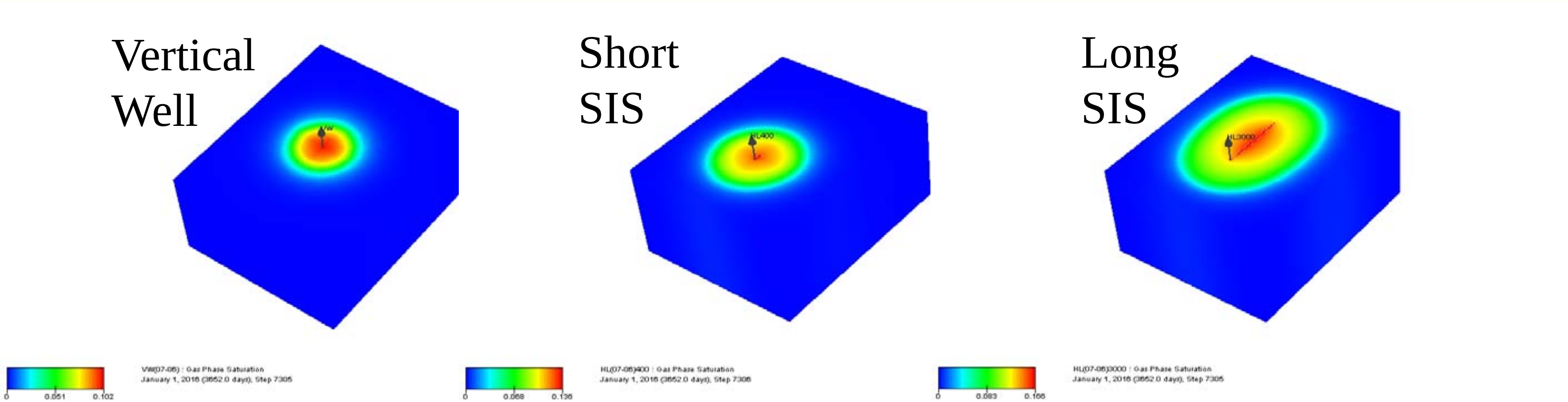
Addressing reservoir engineering & modelling … *analytical rigour*

SIM ID	Individually Test Influence of Fourteen Parameters													
BF000	X		X			X			X		X		X	
BF001	X			X		X			X		X		X	
BF002	X				X	X			X		X		X	
BF003	X		X				X		X		X		X	
BF004	X		X					X	X		X		X	
BF005	X		X			X			X			X	X	
BF006	X		X			X			X		X			X
BF007	X		X			X				X	X		X	
BF008		X	X			X			X		X		X	

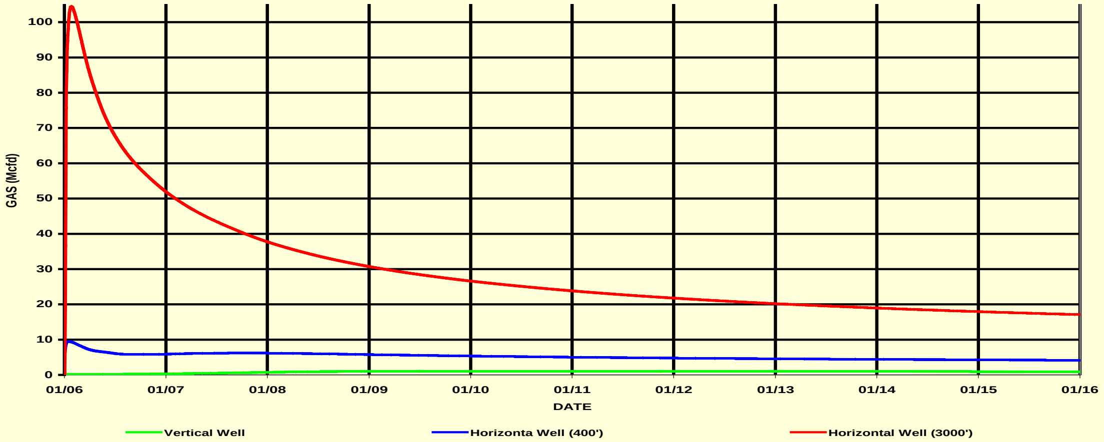




Single-Well Model
Test Different Completion Types



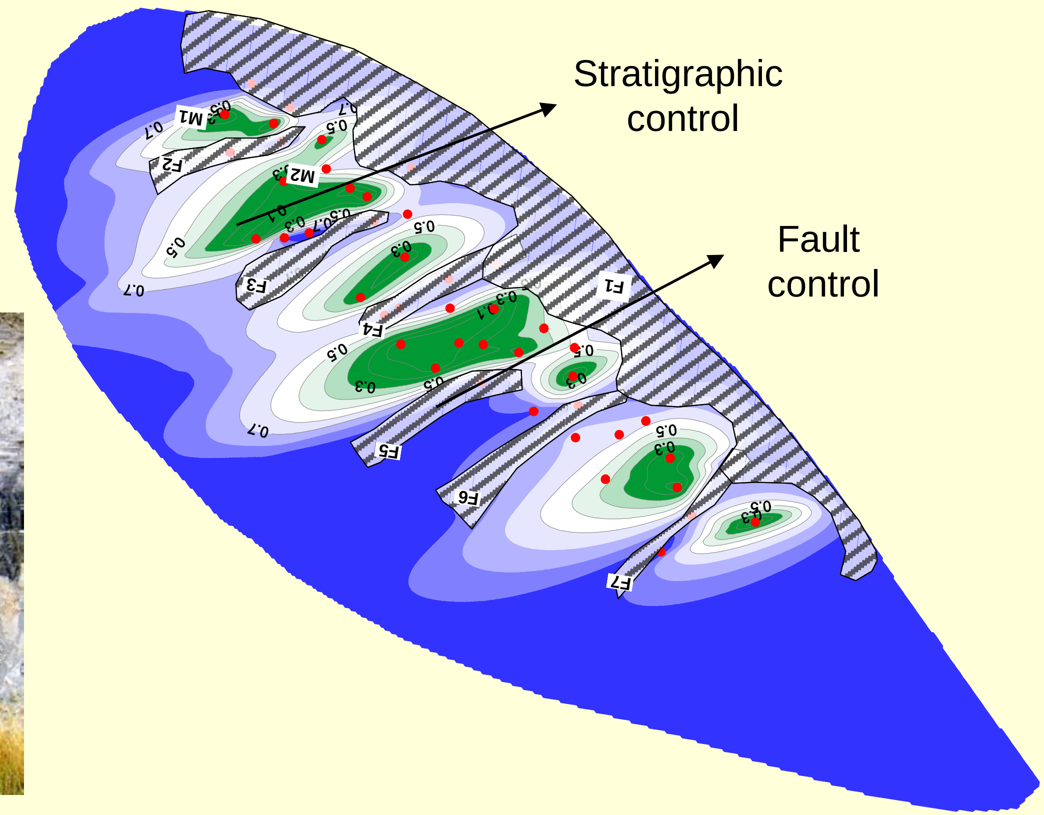
Gas Rate Comparison for Different Well Types



Maybe solution is not underground

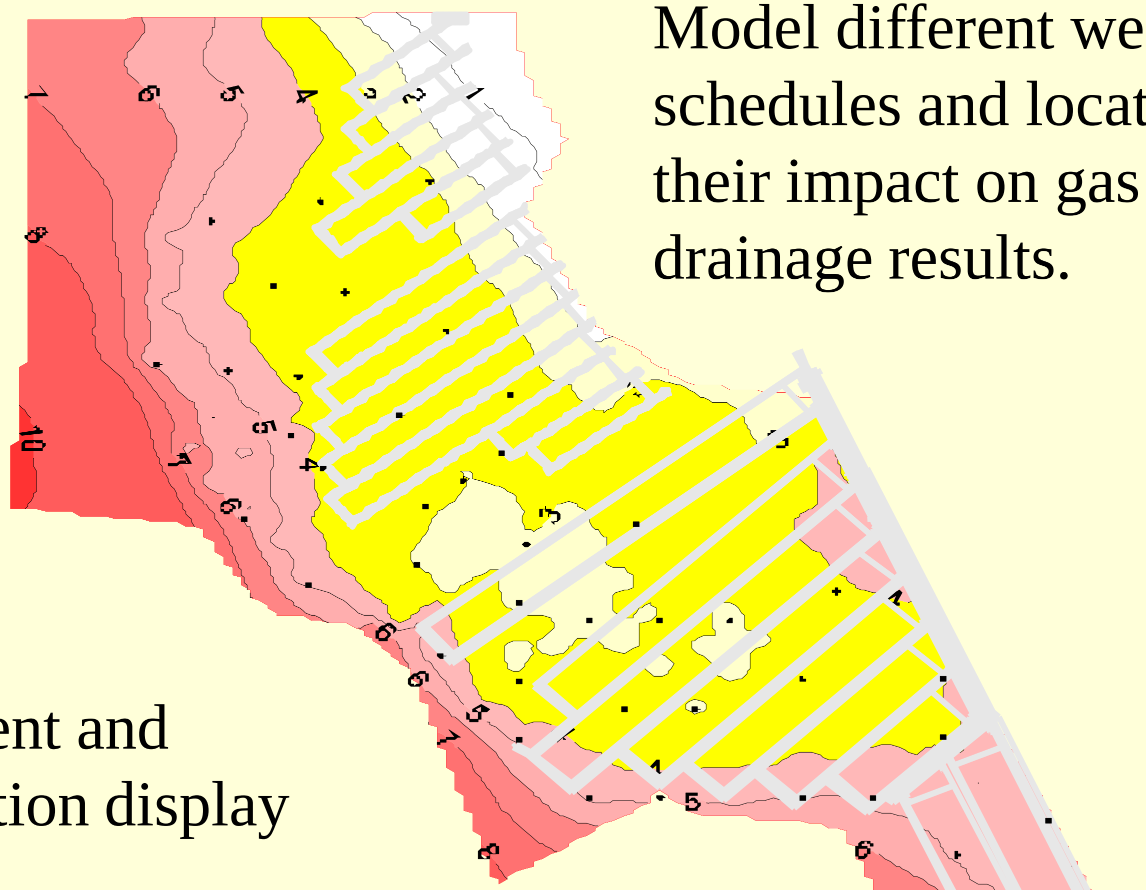
Window Area Models
Include Geologic Flow Features

Models to display and evaluate known flow barriers, baffles and enhanced flow features.



Development Model
Test Different Development Scenarios

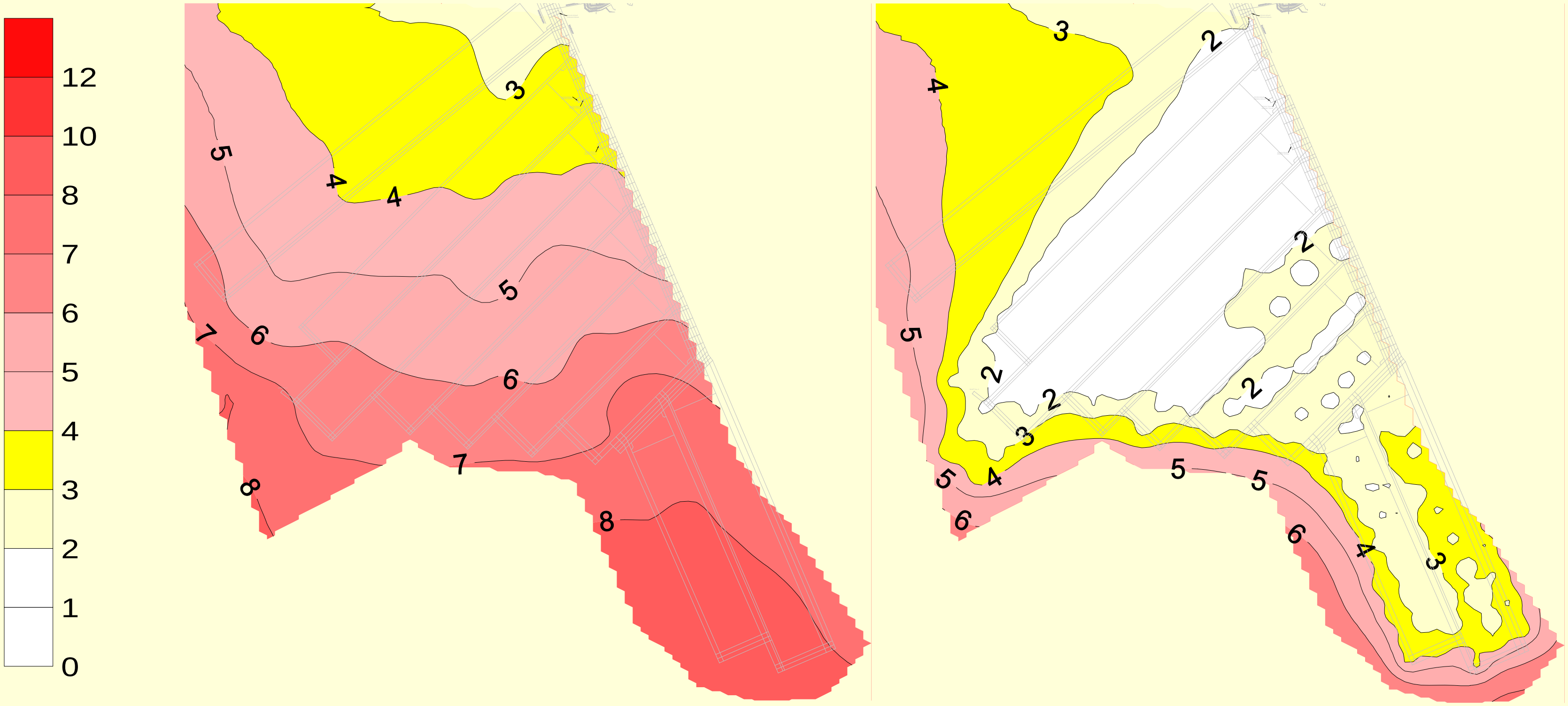
Model different well spacings, schedules and locations to test their impact on gas and water drainage results.



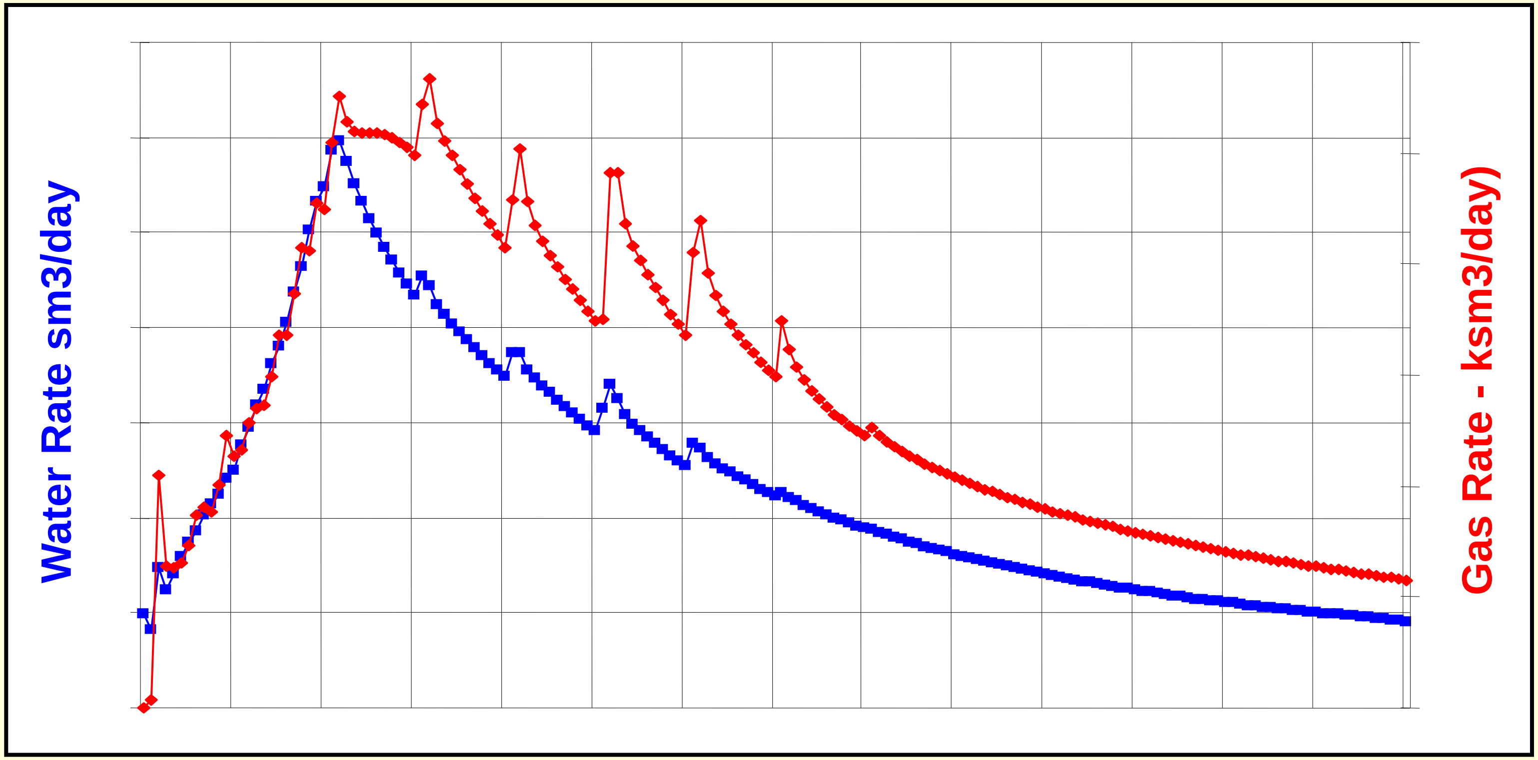
Gas content and
well location display

Development Model
Optimise Well Placement and Timing

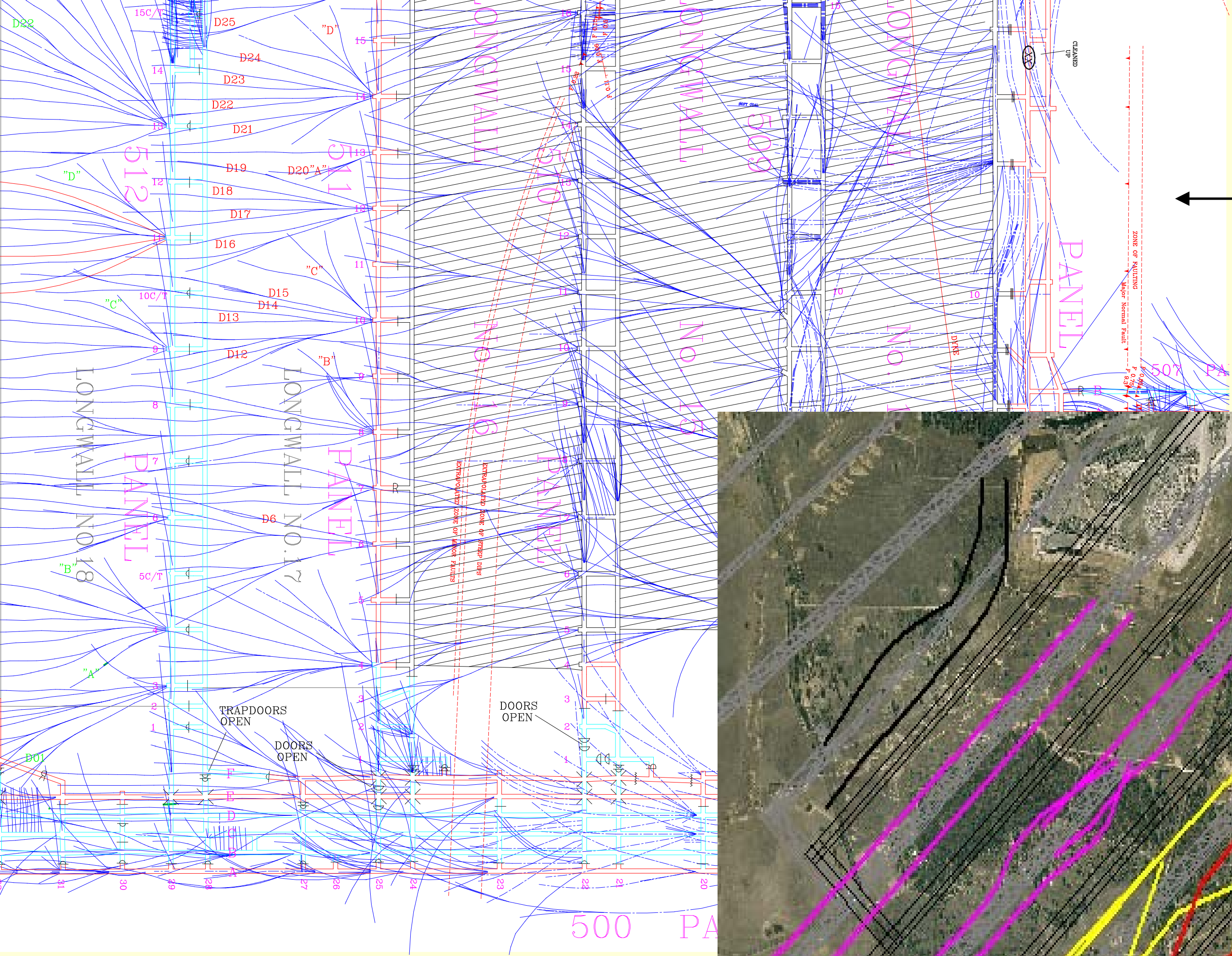
Gas Content before and after Pre-Mining Drainage



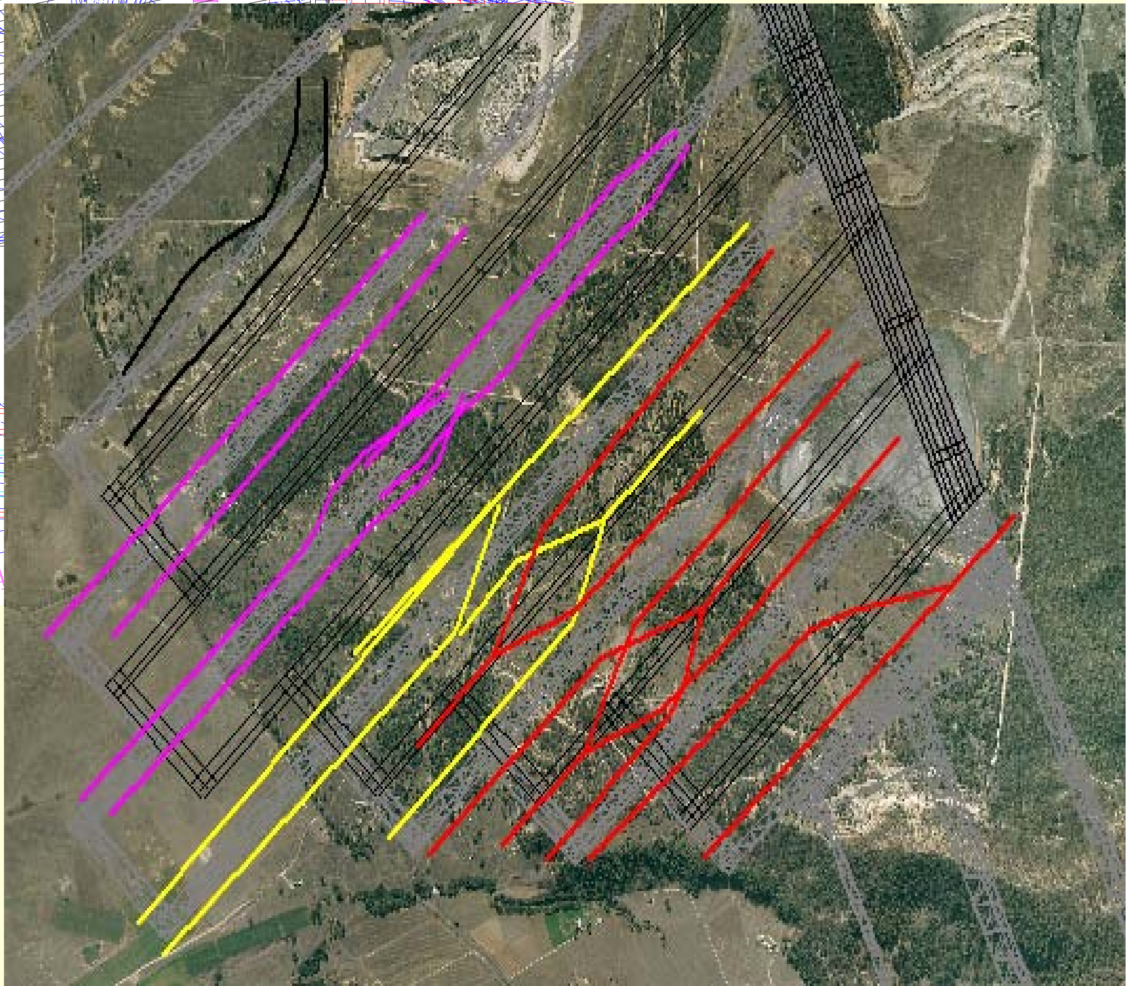
CSM Development Model
Optimize Well Placement and Timing



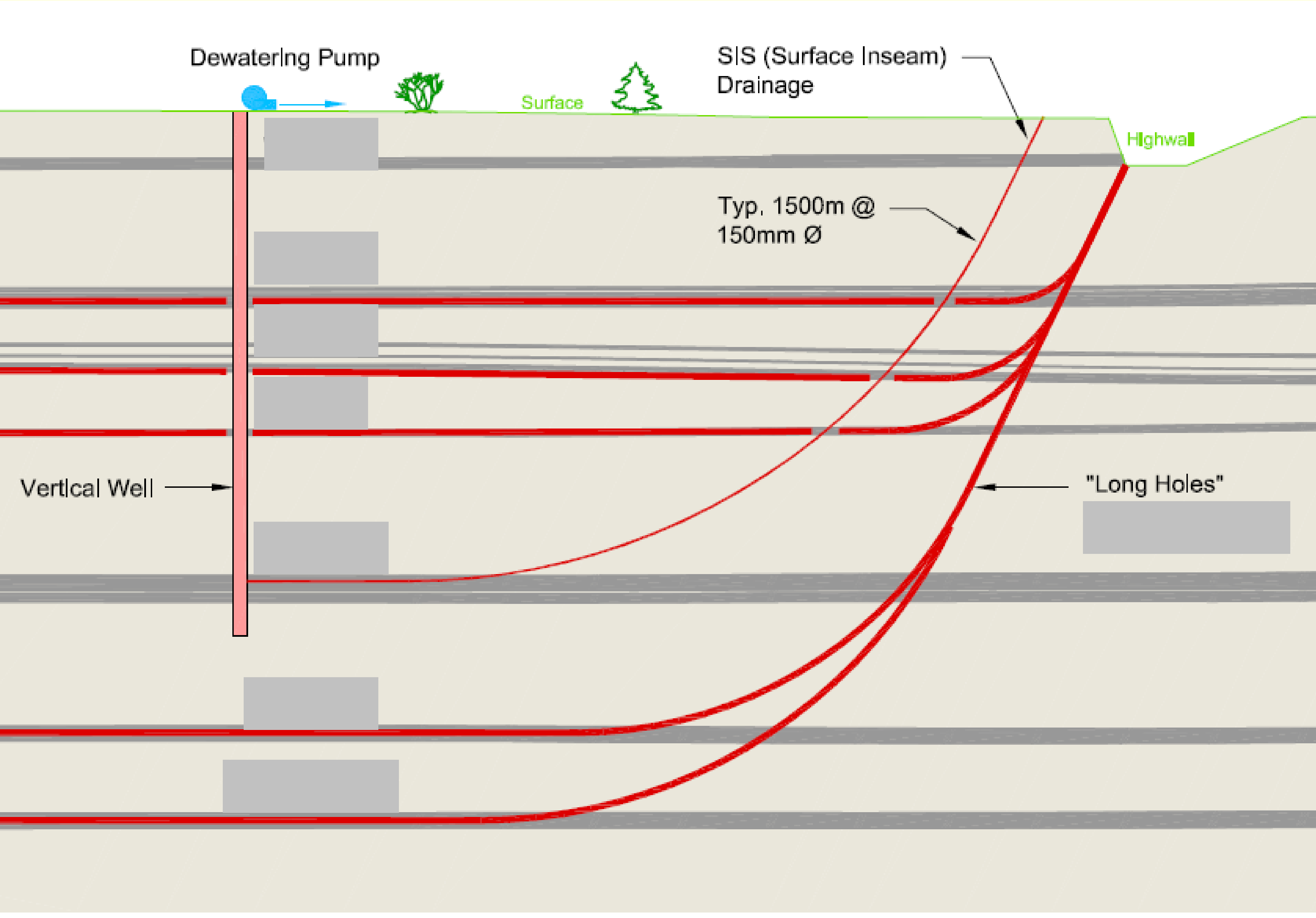
Analytical rigour provides economic benchmarks, assists planning & tests your gas database.



The past …



The future …


Dewatering Pump
Surface
SIS (Surface Inseam)
Drainage
Highwall
Typ. 1500m @
150mm Ø
Vertical Well
"Long Holes"

If underground drilling is necessary … maybe Coiled Tubing?

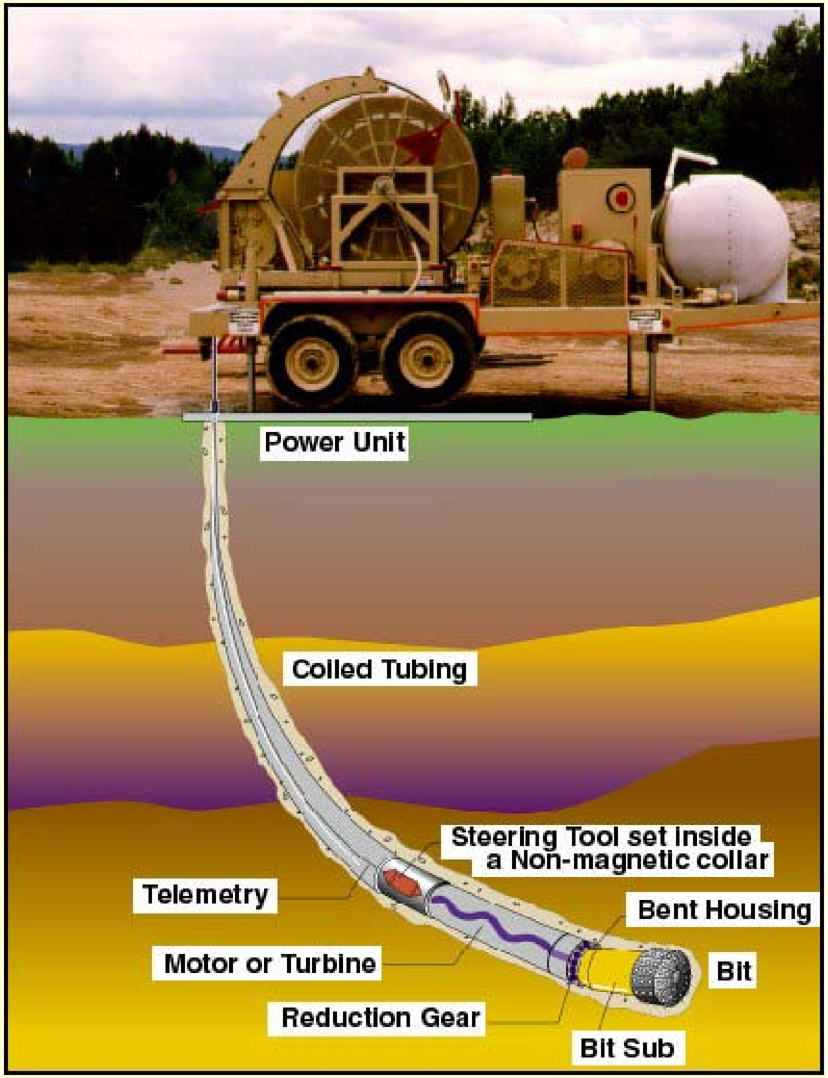
- Continuously milled tubing (usually steel)
- Developed for workovers (re-entries) of oil and gas wells
- Typical tubing diameters 1.5” to 5.5” (38mm to 140mm)
- Practically any length can be supplied

Coiled Tubing *Drilling*

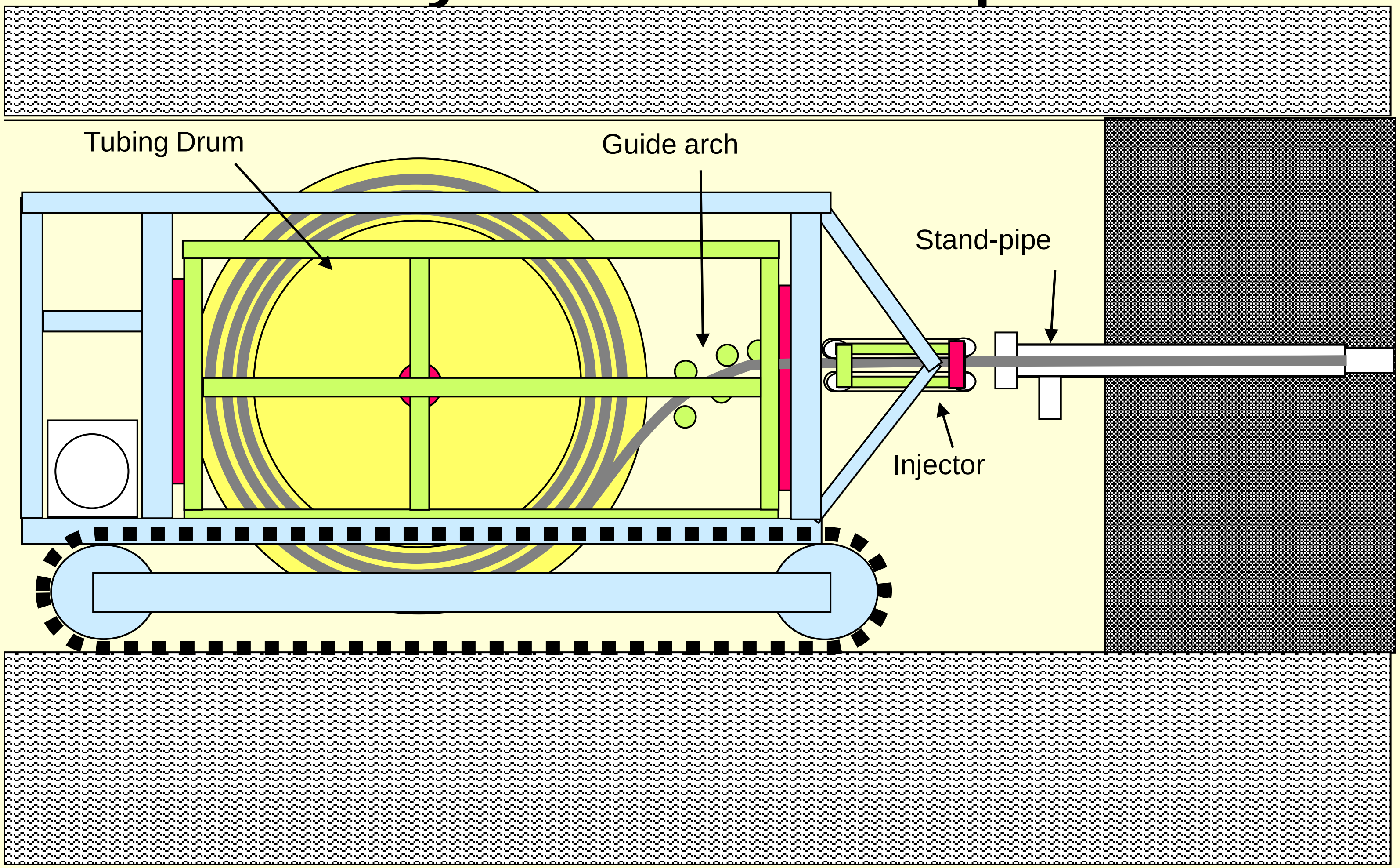
- Developed by the O&G drilling industry in early 1990's
- Benefits of CTD include:
  - Rapid tripping speeds into/out of hole (50+ m/min)
  - Continuous drilling process – no delays due to rod changing
  - More automated / less personnel - no rod handling
  - Safe and efficient pressure control (underbalanced drilling)
  - Smaller footprint and weight
  - Faster rigup / rigdown
  - High speed telemetry (optional by use of wireline)
- Over 3500 CTD wells drilled in 2005 - 2500 of these were for CBM applications (mostly Canada)

Oilfield CT rig

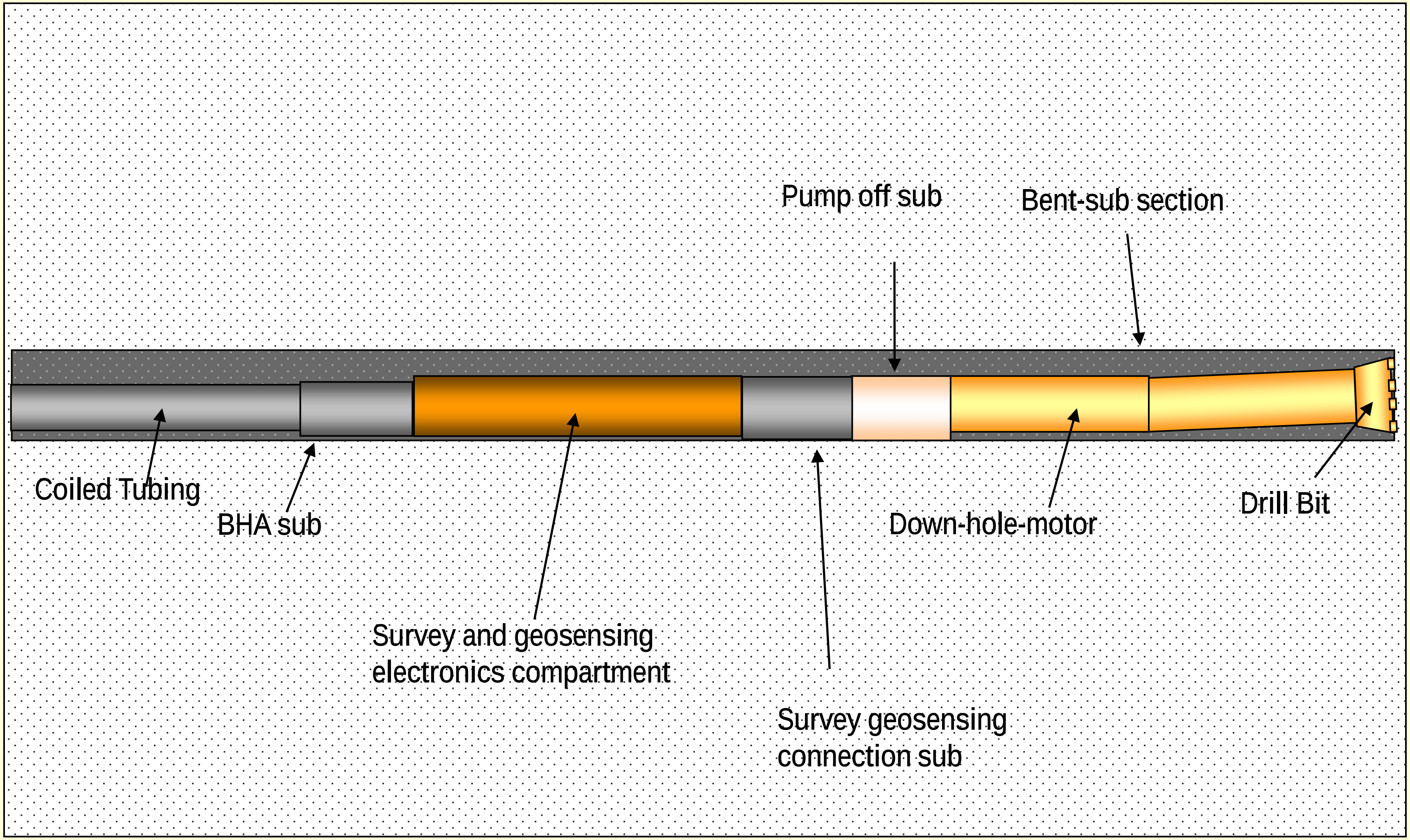
Coiled Tubing Drilling



Underground Coiled Tubing System Concept



Downhole Concept



Conclusions

- More gas drainage options than ever before.
  - Therefore, increased complexity, many different approaches available for gas drainage.
- More analytical rigour available and little excuse to ignore it.
- CTS a possible paradigm shift in inseam drilling technology.
- Be warned. Trouble ahead if systems do not change.
- However, culture a major barrier to implementation of all of above.

Questions?