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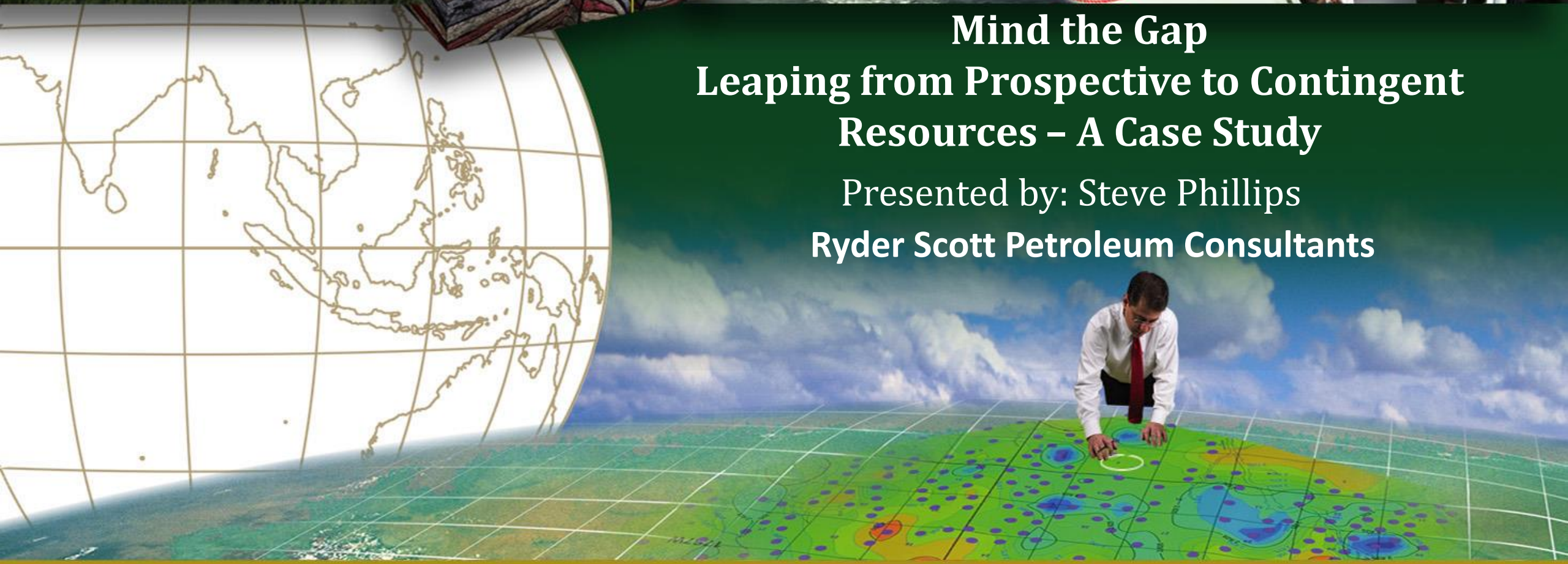
Mind the Gap
Leaping from Prospective to Contingent Resources – A Case Study

Presented by: Steve Phillips

Ryder Scott Petroleum Consultants



INTRODUCTION – TREASURE ISLAND

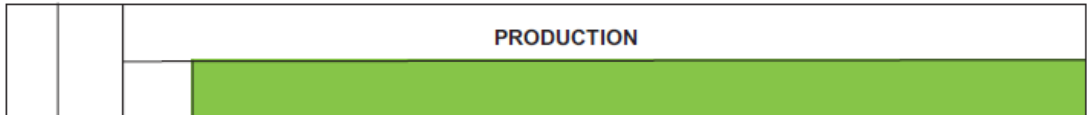
- You have a map of an island somewhere…
- Said to hold one or more buried treasure chests
- Talk in the tavern – maybe up to ten!
- Found another likely island, crew starts digging
- Previous five islands barren – mutiny in the air
- A shovel hits a buried box, excitement spikes
- When opened – a few coins and trinkets
- Disappointing, but you found something!
- How do you keep crew digging, but avoid being hung?

INTRODUCTION – THE DILEMMA OF DISCOVERY

- Maturation of resource volume is vital to any E&P company
- Managing the transition from Prospective Resources to Contingent Resources is an exercise in credibility
- Internal (crew): exploration vs. production departments
- External (ship owners): investors, partners, governments
- The big question – How do you quantify a discovery to avoid:
  - –Over-promising?
  - –Missing opportunity?

DISCOVERY – SIMPLE DEFINITIONS

Nothing here about seismic



2.1.1 Determination of Discovery Status

2.1.1.1 A discovered petroleum accumulation is determined to exist when one or more exploratory wells have established through testing, sampling, and/or logging the existence of a significant quantity of potentially recoverable hydrocarbons and thus have established a known accumulation. In the absence of a flow test or sampling, the discovery determination requires confidence in the presence of hydrocarbons and evidence of producibility, which may be supported by suitable producing analogs (see Section 4.1.1, Analogs). In this context, "significant" implies that there is evidence of a sufficient quantity of petroleum to justify estimating the in-place quantity demonstrated by the well(s) and for evaluating the potential for commercial recovery.

Does not allow for absence of drilling and logging

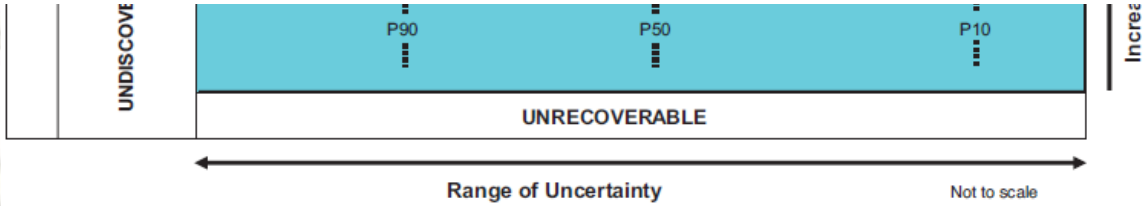
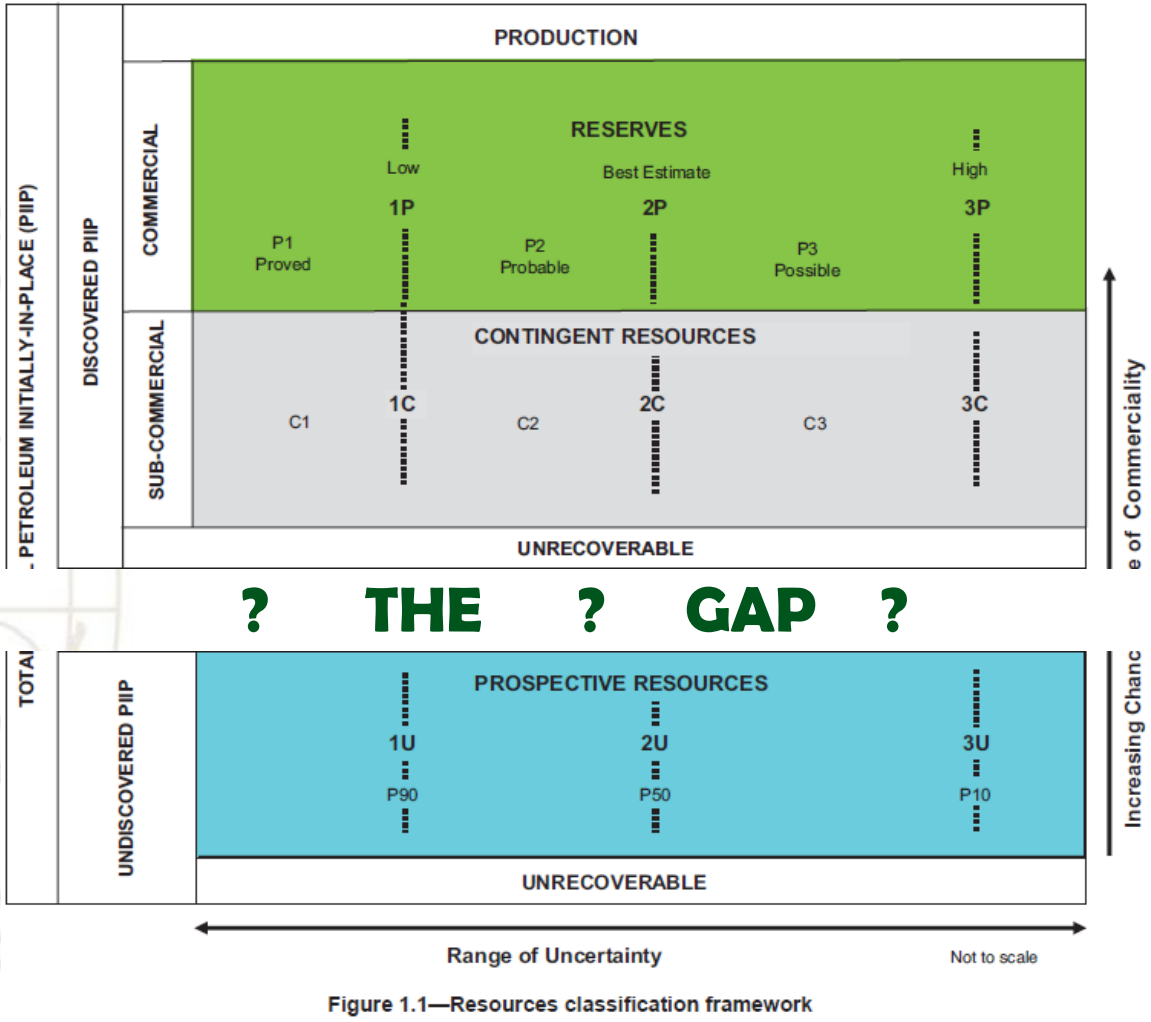


Figure 1.1—Resources classification framework

Source: Petroleum Resources Management System, June, 2018

DISCOVERY – DIFFICULT TO APPLY IN PRACTICE

- Example from real project
- Altered, conceptual sketches, no actual data
- No specific volumes
- Illustrates problems when technical estimates lack definitional framework
- Recommendation for maturing undiscovered volumes



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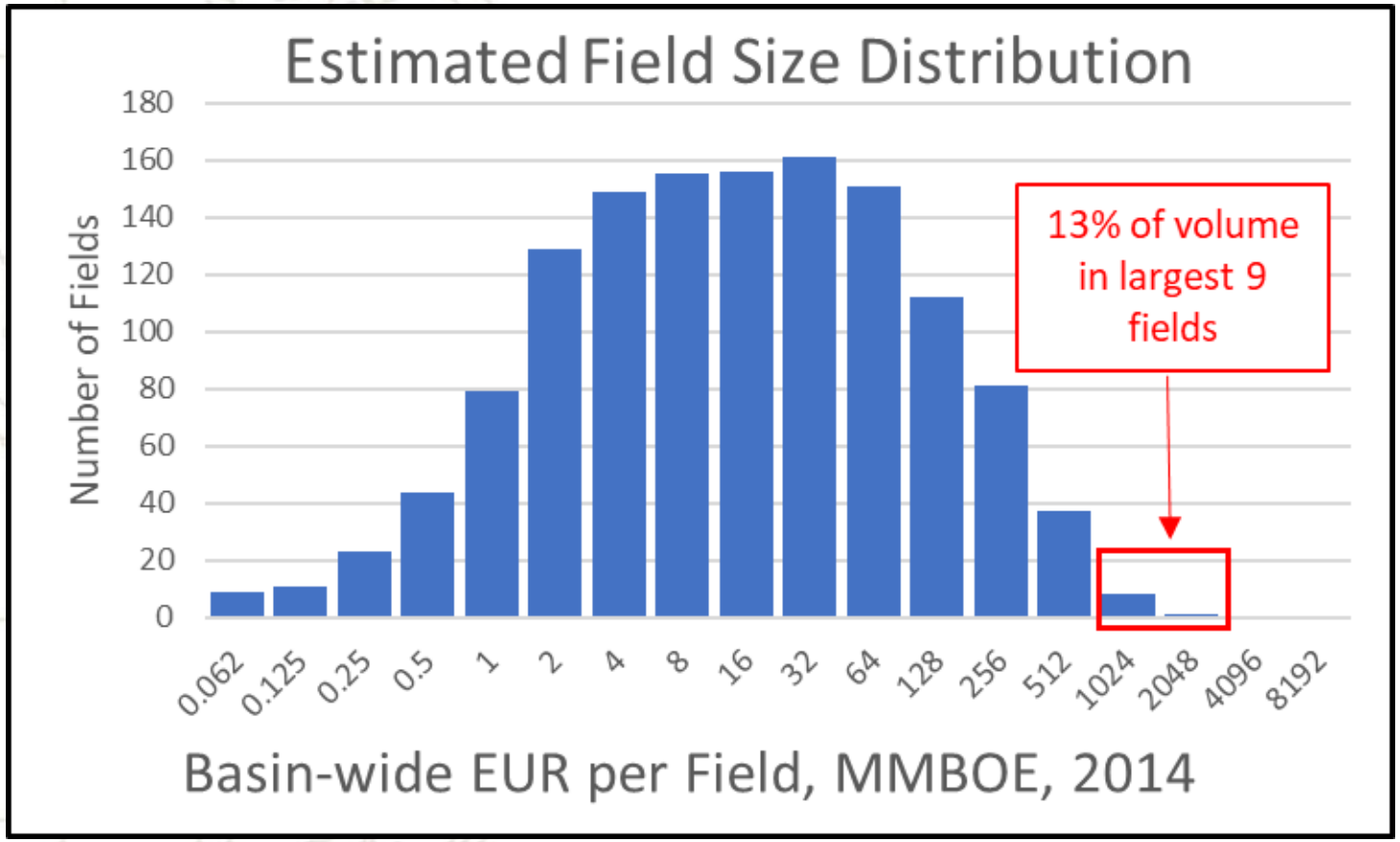
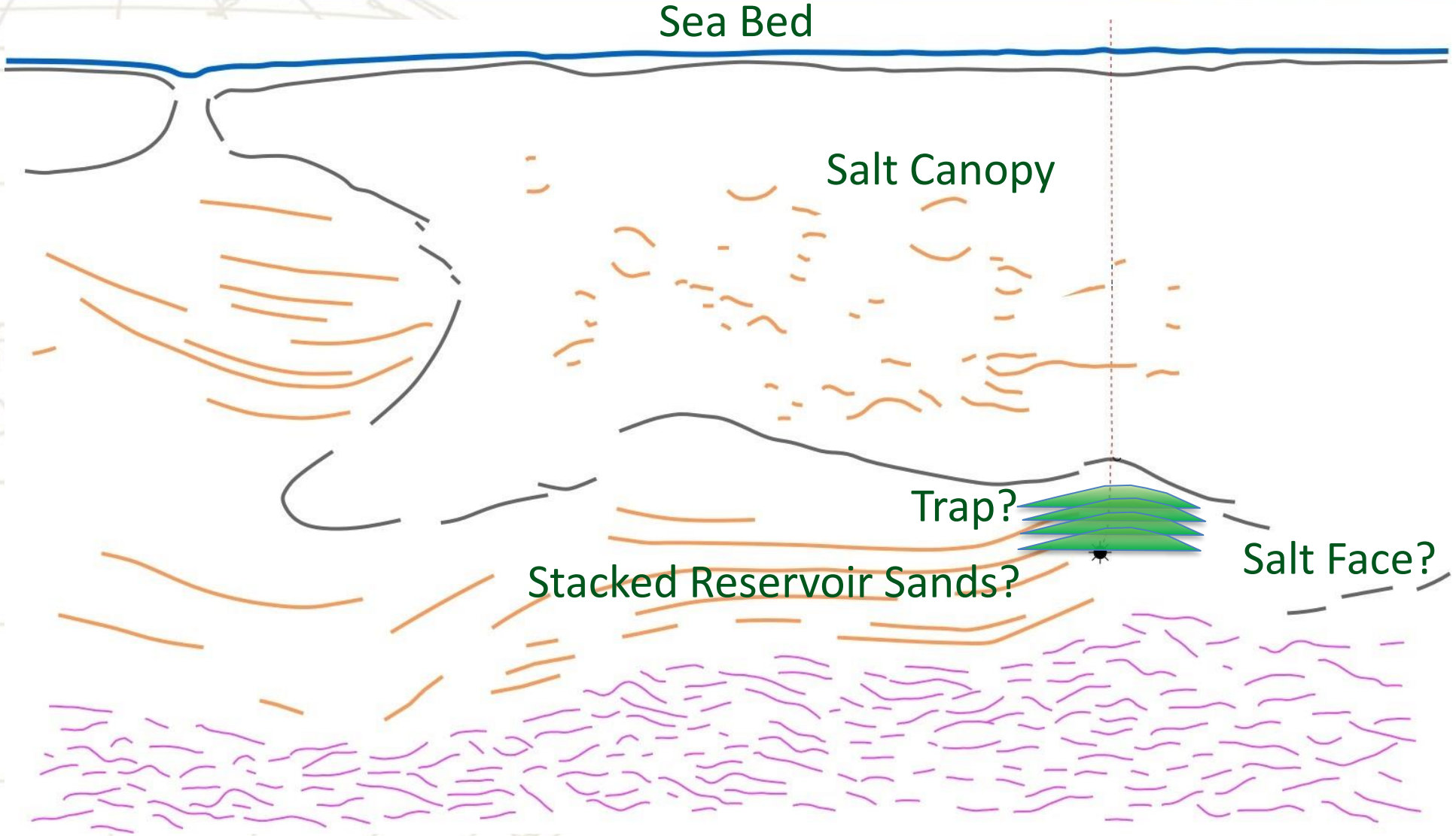
Source: Petroleum Resources Management System, June, 2018

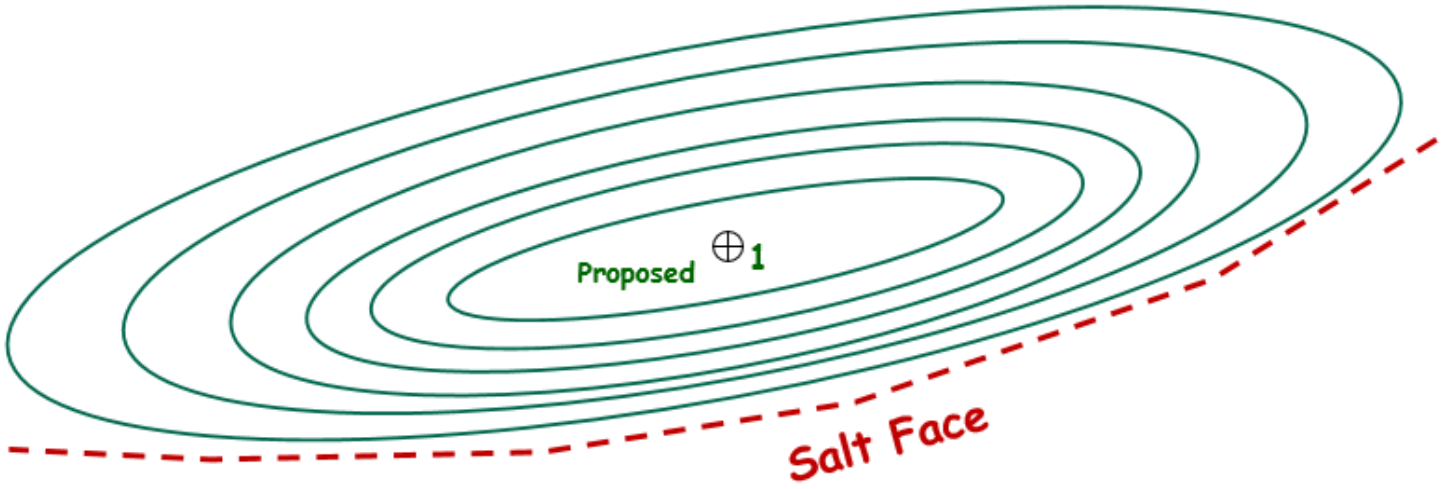
Targeting the high side of known fields



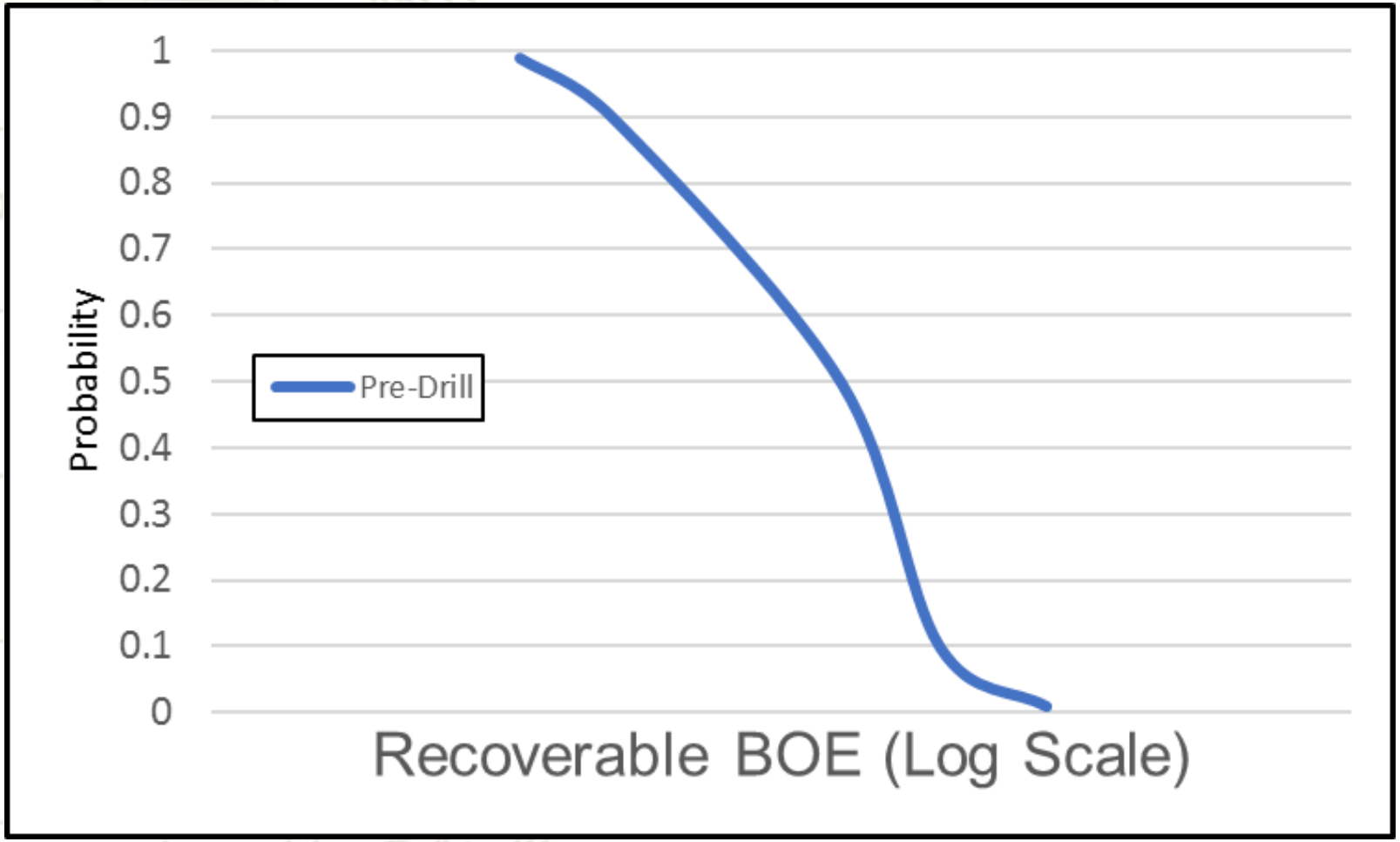
SKETCH OF SEISMIC PROFILE OVER PROSPECT



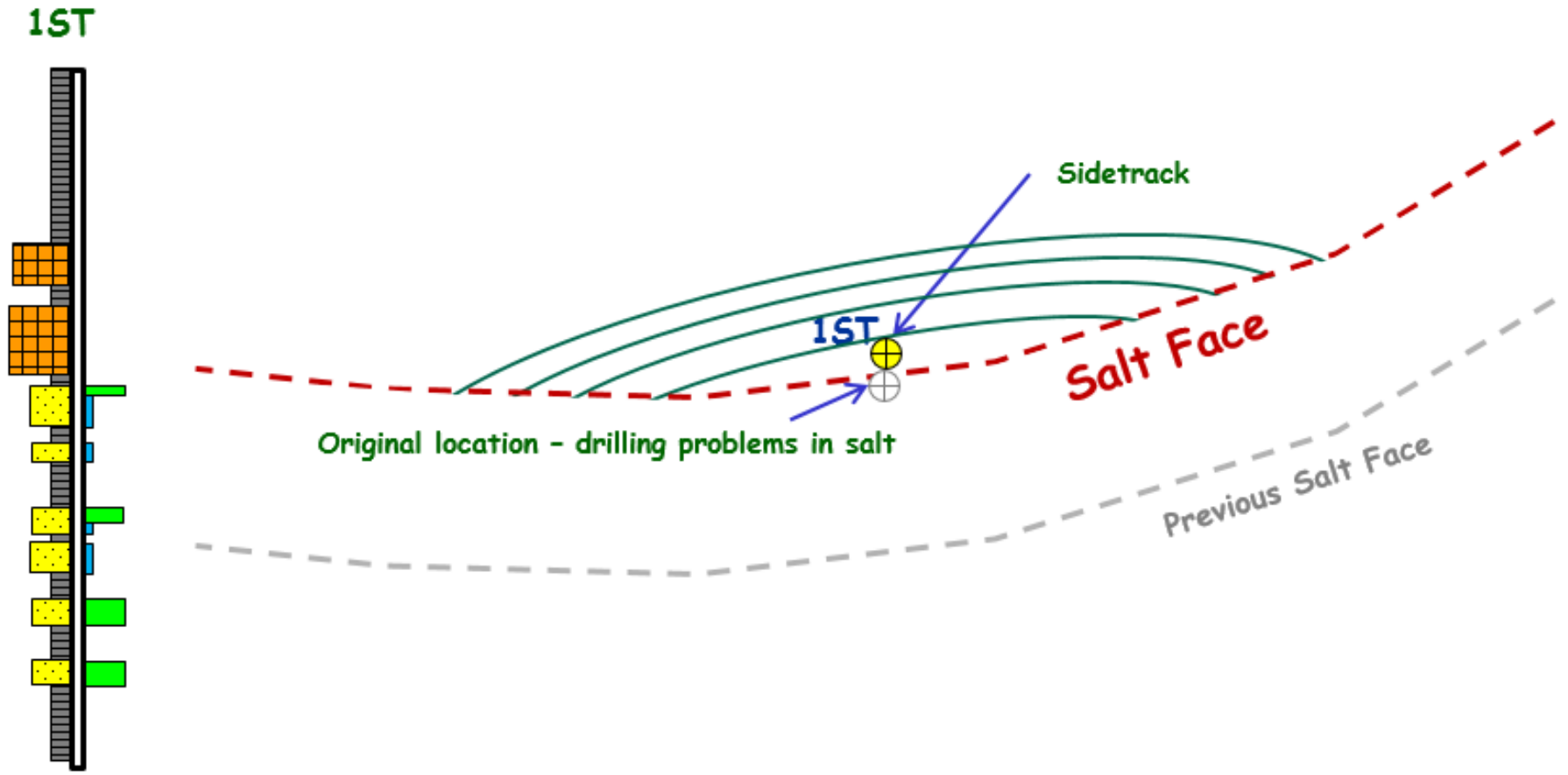
Structure map on anticipated closure



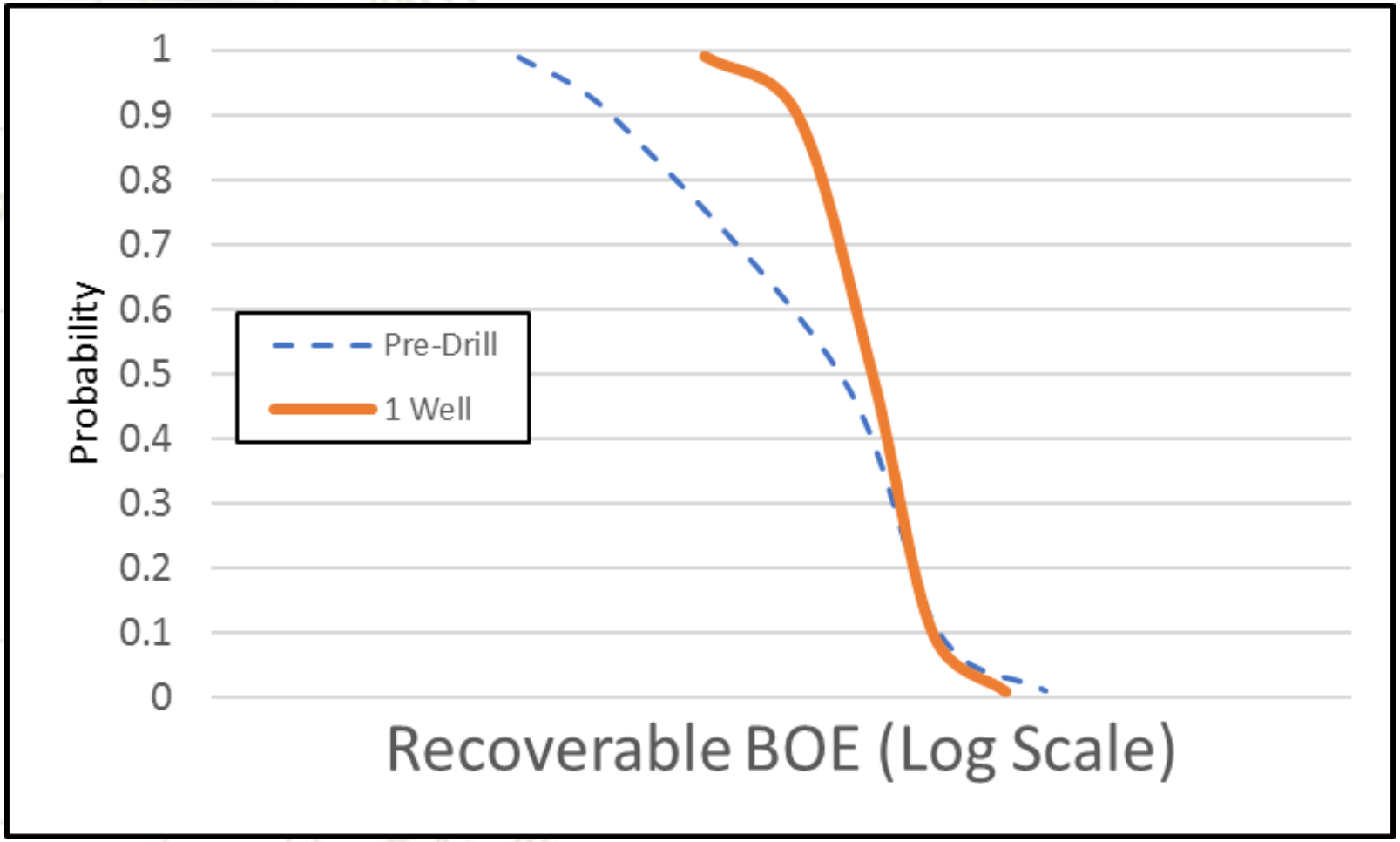
COMPANY PRE-DRILL RESOURCE ESTIMATE



Original borehole hit salt, then sidetracked

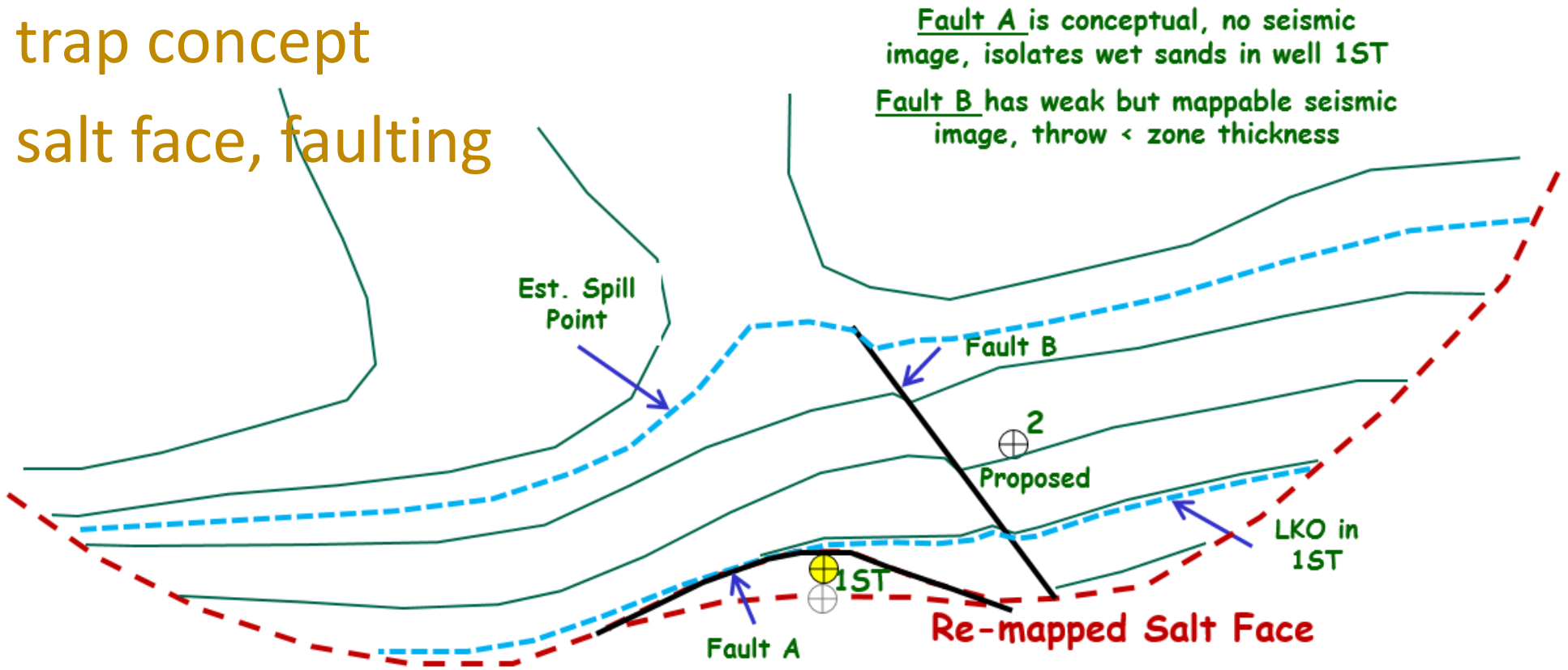


Is increase in low-side justified?



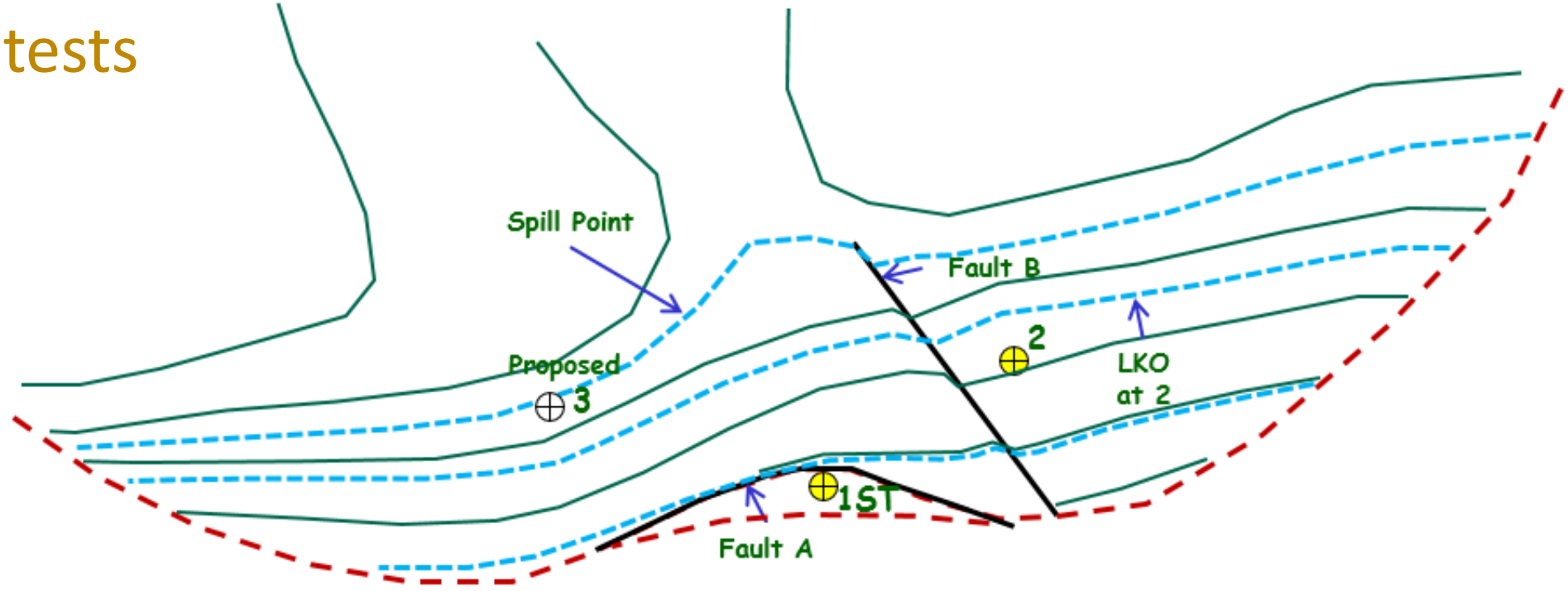
FOUR YEARS LATER….

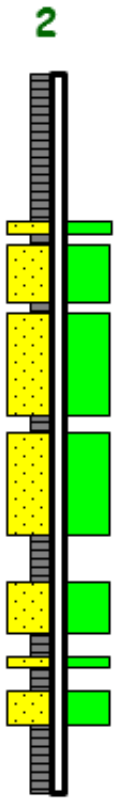
- Seismic reprocessed, remapped
- New trap concept
- New salt face, faulting



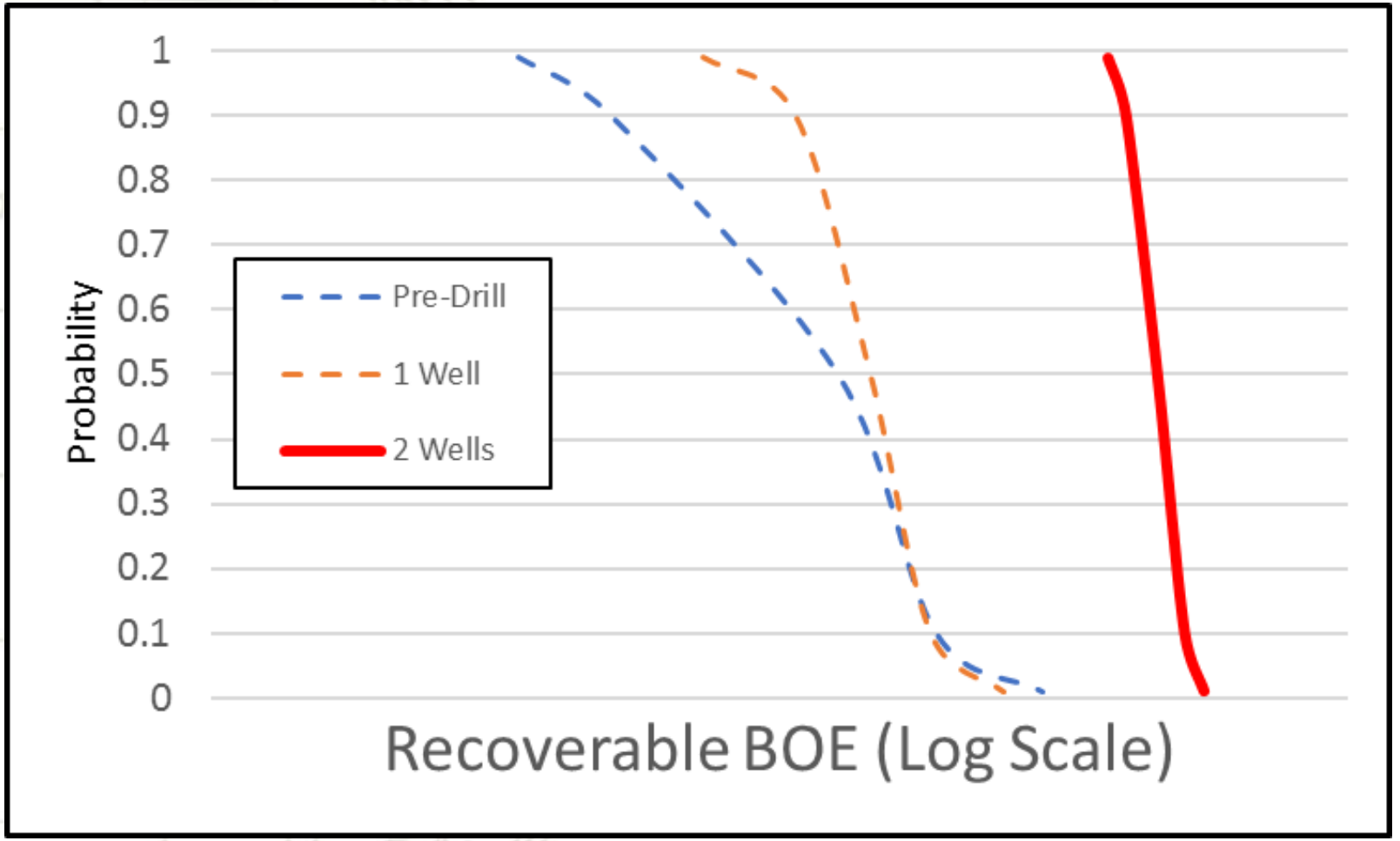
RESULTS OF SECOND WELL - SUCCESS!

- Well 2 finds multiple pay zones, no water, no salt
- New data – logs, cores, pressures, samples, LKO
- No tests

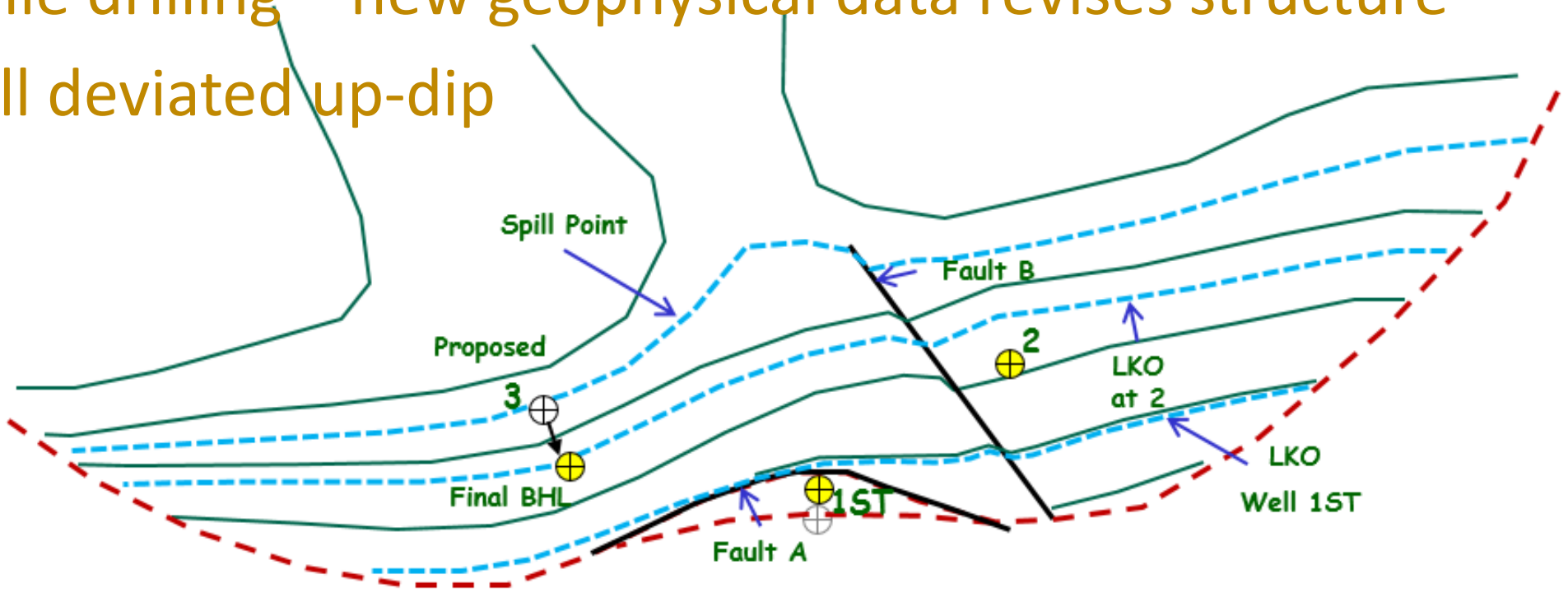




Reasonable basis, but does not anticipate reserves categories

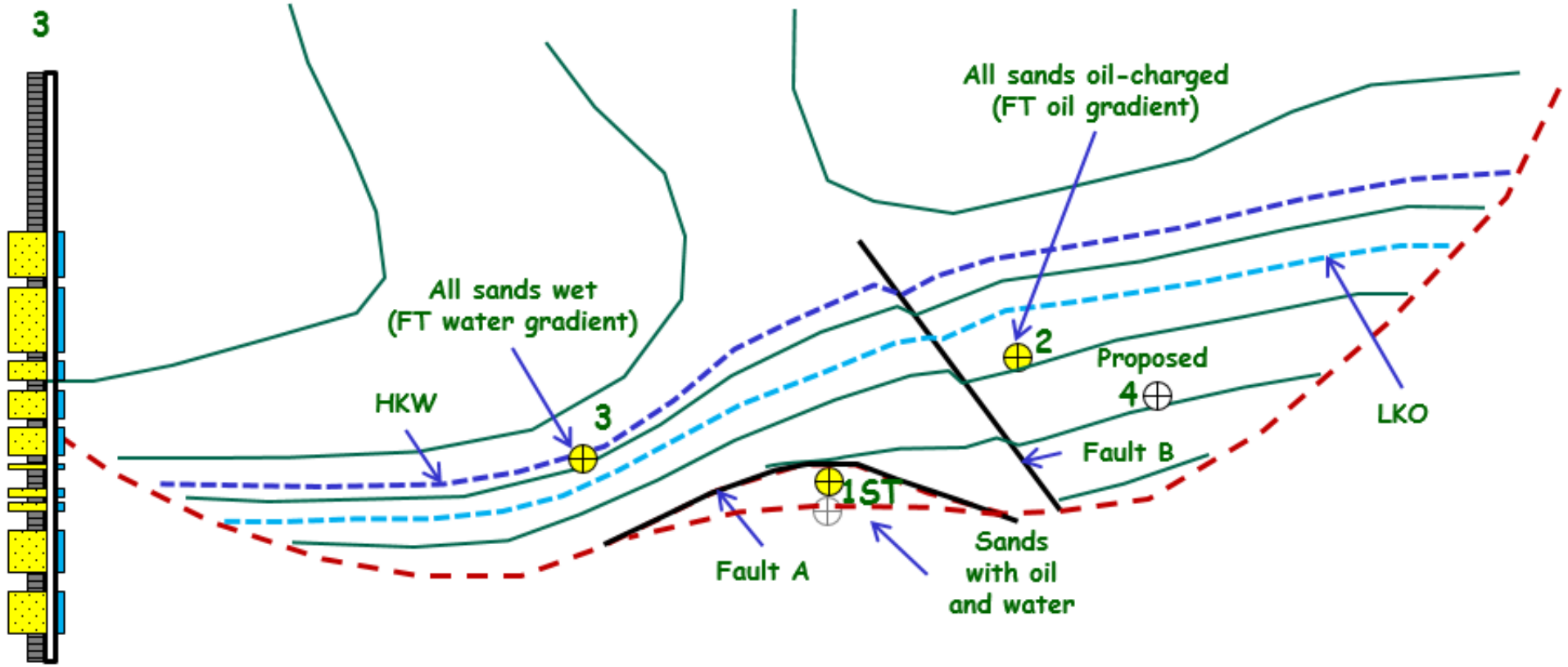


- Well 3 located to target oil-water contact
- While drilling – new geophysical data revises structure
- Well deviated up-dip

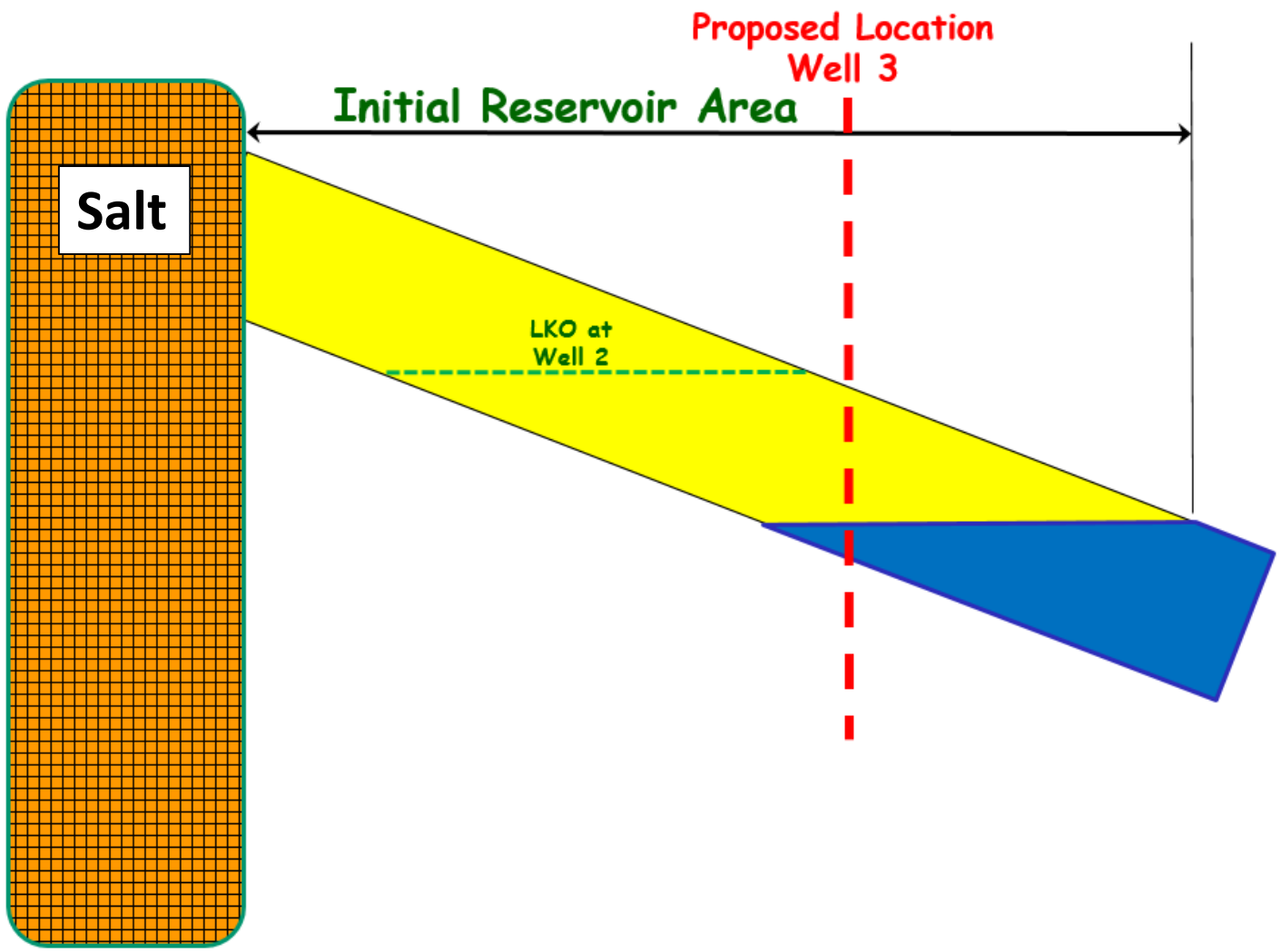


RESULTS OF THIRD WELL – INTERESTING AGAIN

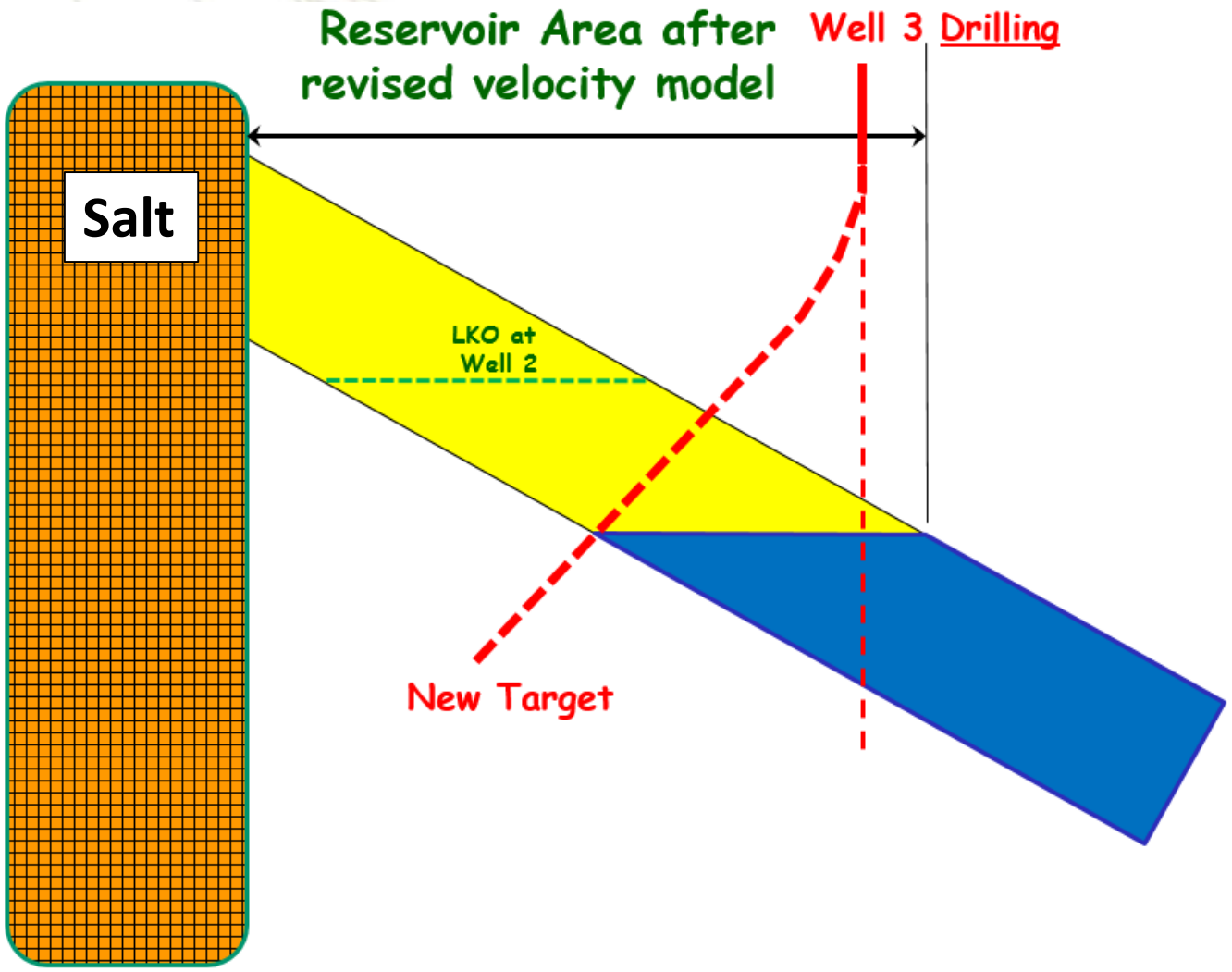
- Well 3 finds sands correlative with Well 2
- All sands wet, highest-known water established



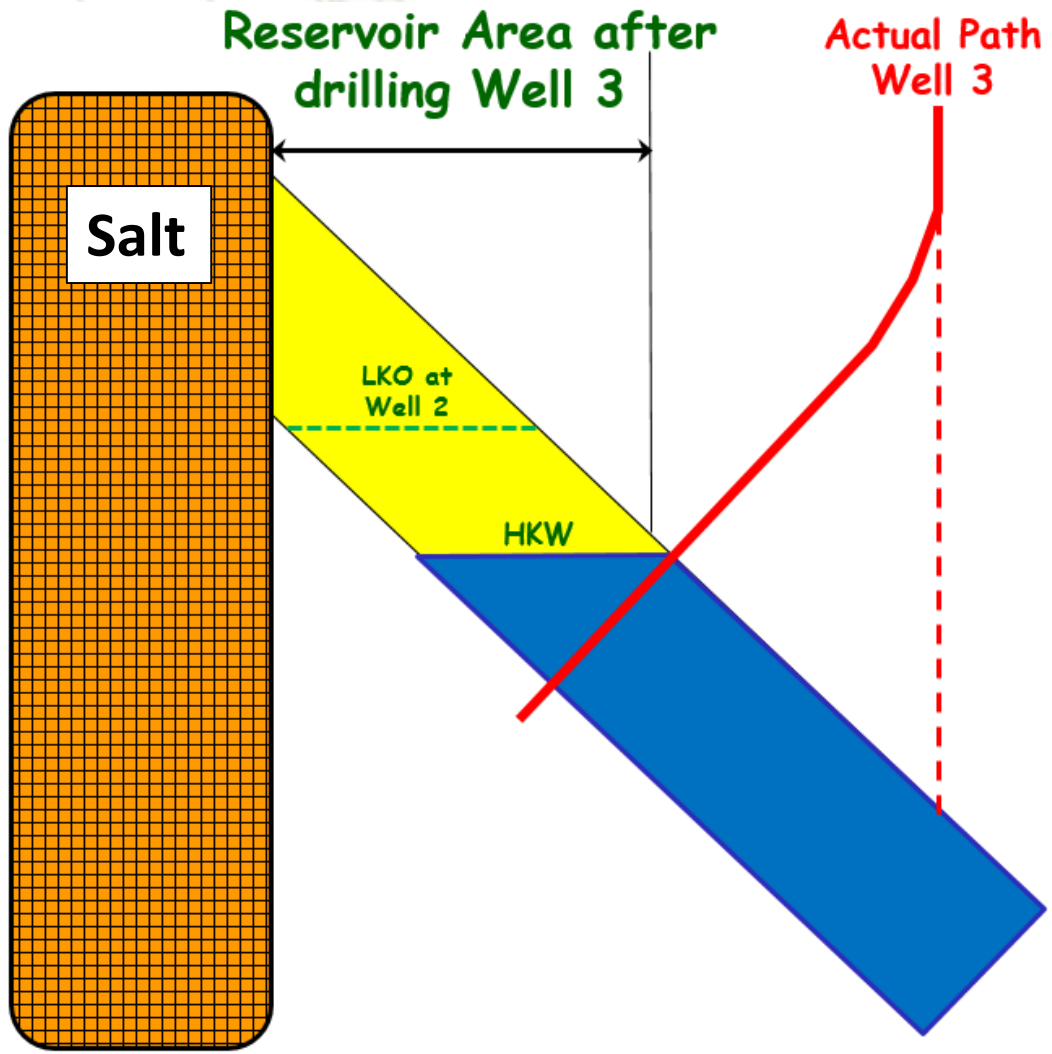
WELL 3 STORY – PART ONE



WELL 3 STORY – PART TWO



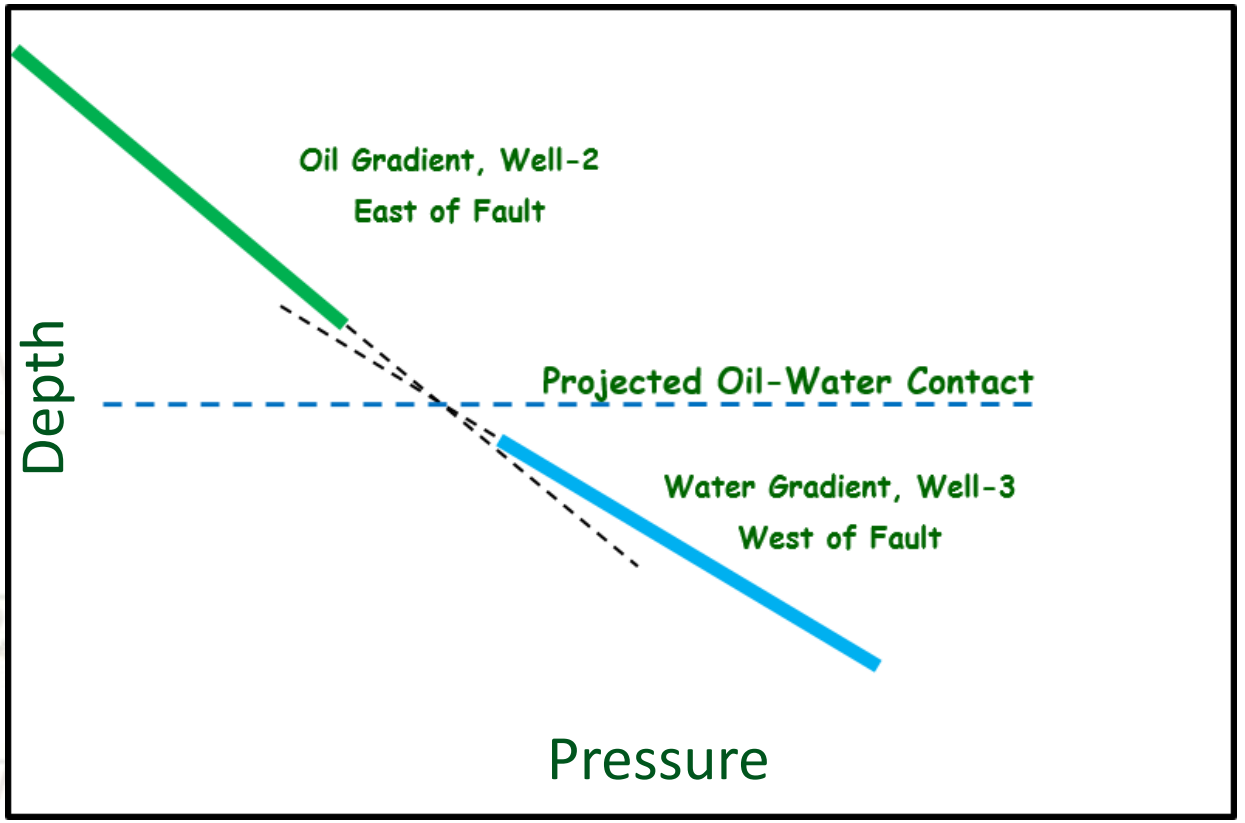
WELL 3 STORY – PART THREE



Moral of the story…. Caution advised when declaring extent of a discovery.

MORE DATA, MORE QUESTIONS

- Oil and water pressure gradients observed on opposite sides of fault
- Does the projected OWC make the Well 3 area discovered?

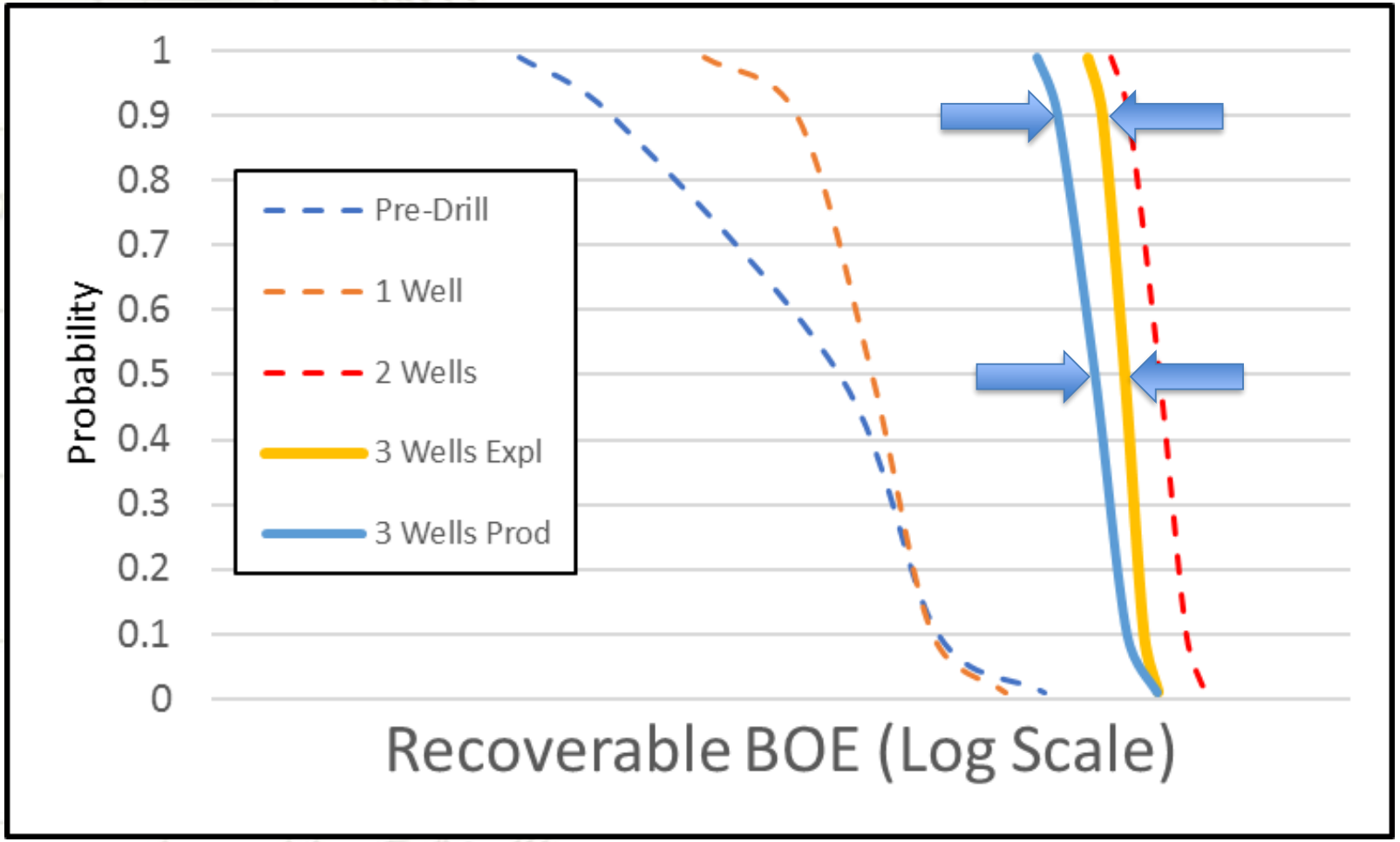


Caution should be exercised in assigning Reserves to adjacent reservoirs isolated by major, potentially sealing faults until this reservoir is penetrated and evaluated as commercially mature and economically productive. Justification for assigning Reserves in such cases should be clearly documented. Reserves should not be assigned to areas that are clearly separated from a known accumulation by non-productive reservoir (i.e., absence of reservoir, structurally low reservoir, or negative test results); such areas may contain Prospective Resources.

PRMS, 2018, Table 3

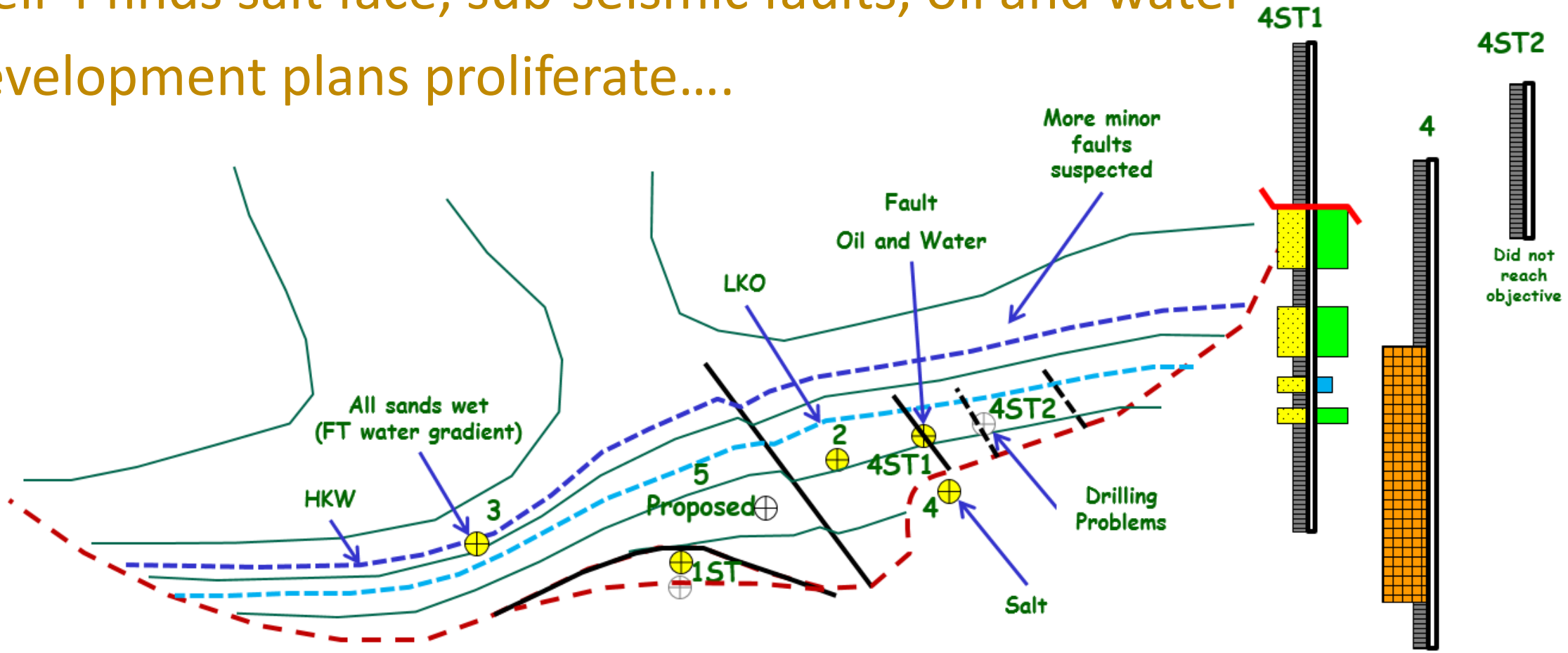
ESTIMATES AFTER THIRD WELL – NOW A "TEAM" EFFORT

Conflicting metrics?

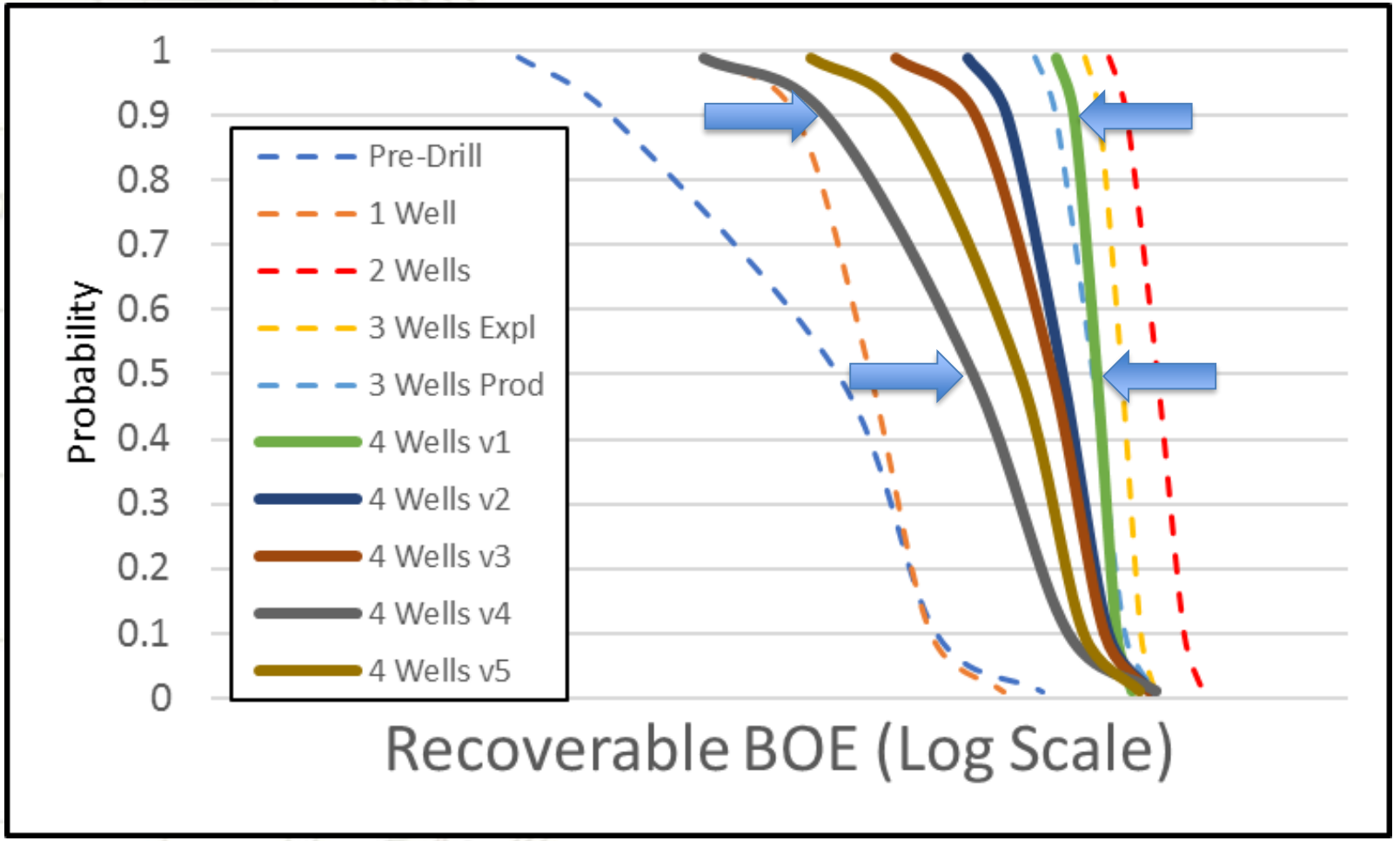


RESULTS OF FOURTH WELL – ENOUGH INTEREST ALREADY!

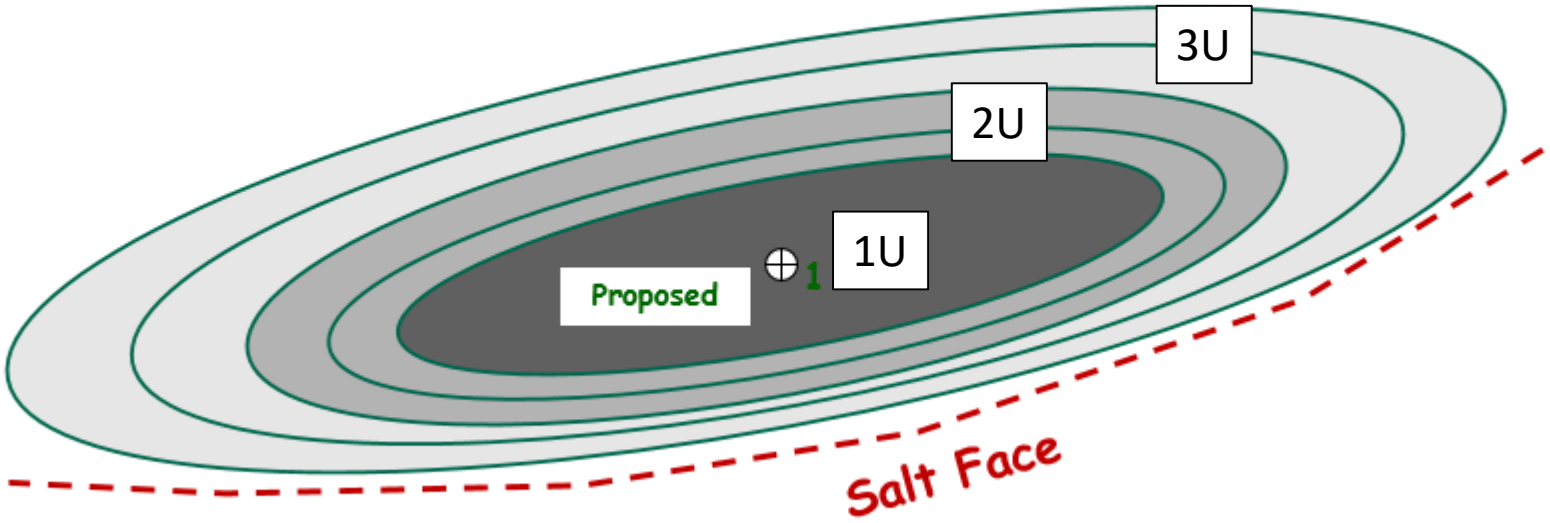
- Well 4 finds salt face, sub-seismic faults, oil and water
- Development plans proliferate….



Good technical work unsupported by definitional framework



Prospective Resources



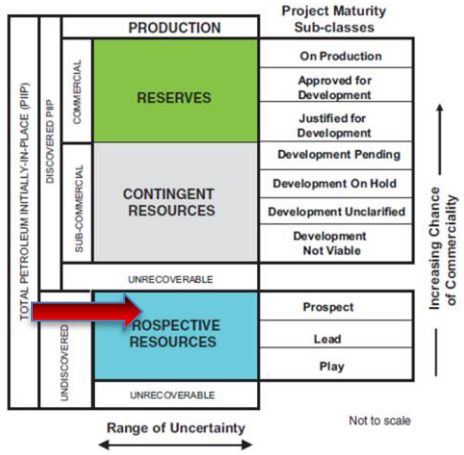
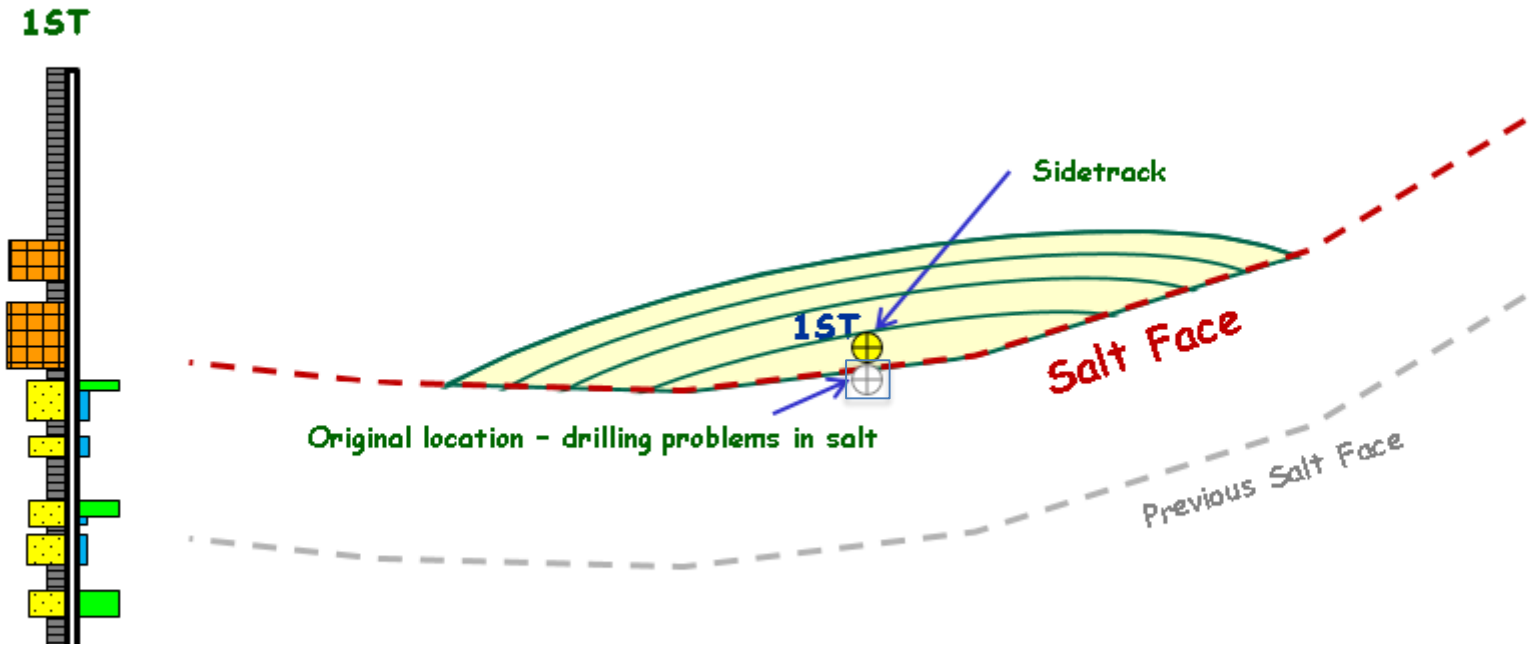


Figure 2.1—Sub-classes based on project maturity

Discovery? Yes, but geological model not valid for future wells



2.1.1.2 Where a discovery has identified recoverable hydrocarbons, but is not considered viable to apply a project with established technology or with technology under development, such quantities may be classified as Discovered Unrecoverable with no Contingent Resources. In future evaluations, as appropriate for petroleum resources management purposes, a portion of these unrecoverable quantities may become recoverable resources as either commercial circumstances change or technological developments occur.

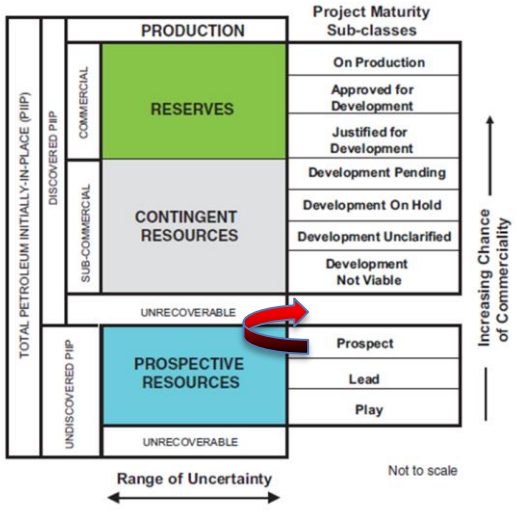


Figure 2.1—Sub-classes based on project maturity

AN UNDER-UTILIZED CLASSIFICATION?

- Discovery of a Petroleum System confirmed (source, reservoir, trap, charge).
- No viable project with established or developing technology or any foreseeable price environment.
- Driven by subsurface reality. More data needed?
- The framework was designed to move petroleum discoveries from prospective to reserves.
- In circumstances where no further development is planned, a path needed to allow these items to exit the framework.
- SPE-PRMS accommodates this with potential to classify as **Discovered Unrecoverable.**

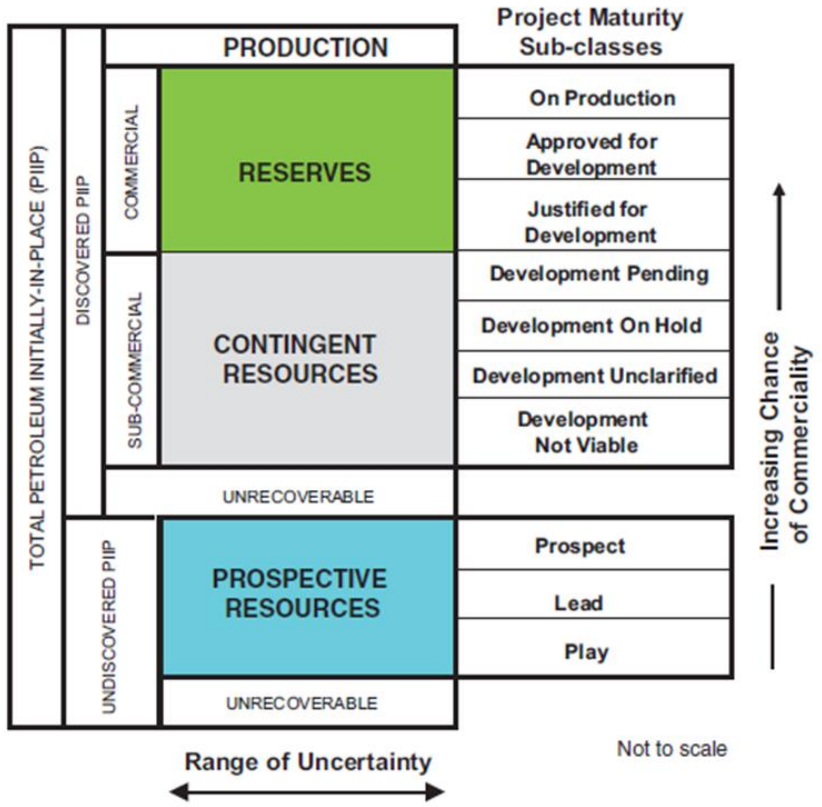
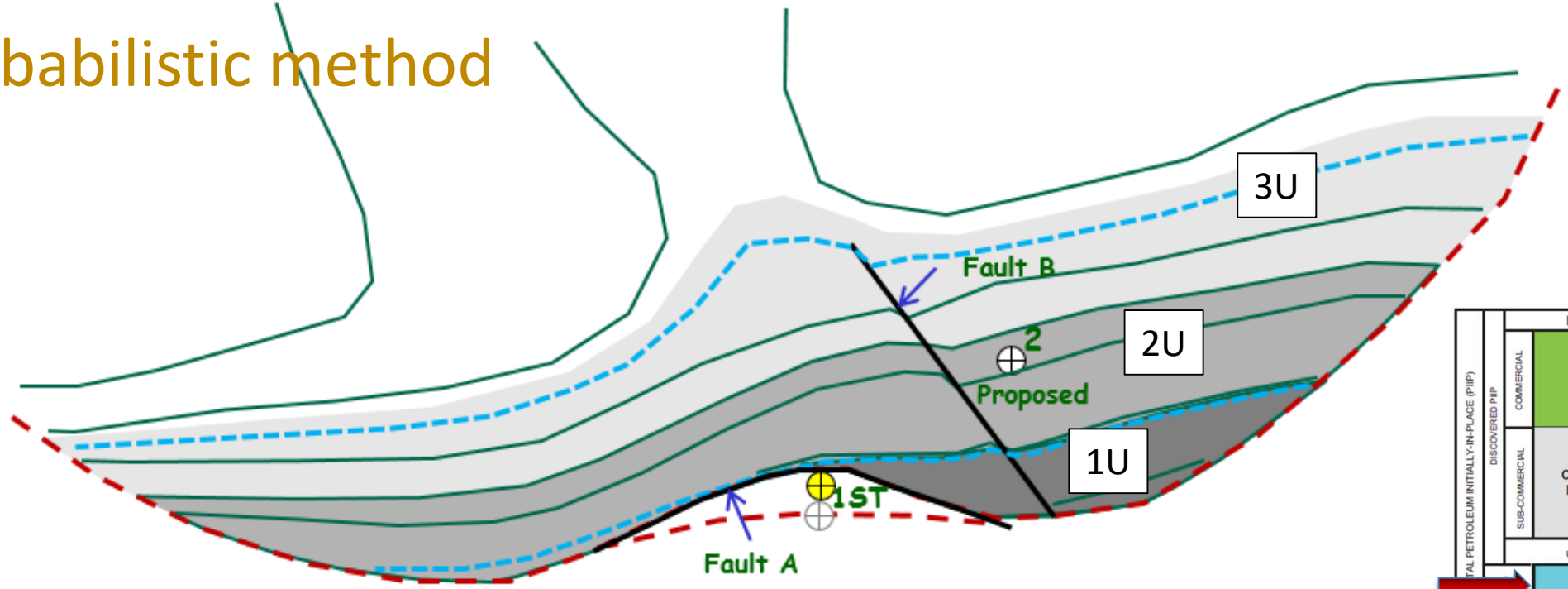


Figure 2.1—Sub-classes based on project maturity

AFTER REMAPPING

- Prospective resources estimated for entire area: 1U, 2U, 3U
- Area penetrated by Well 1 excluded from estimate
- Probabilistic method



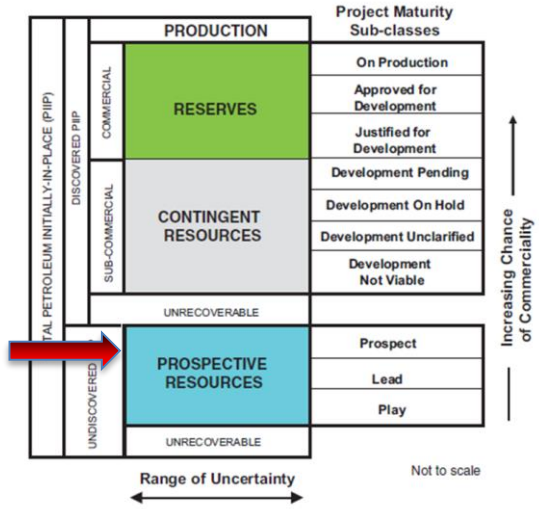
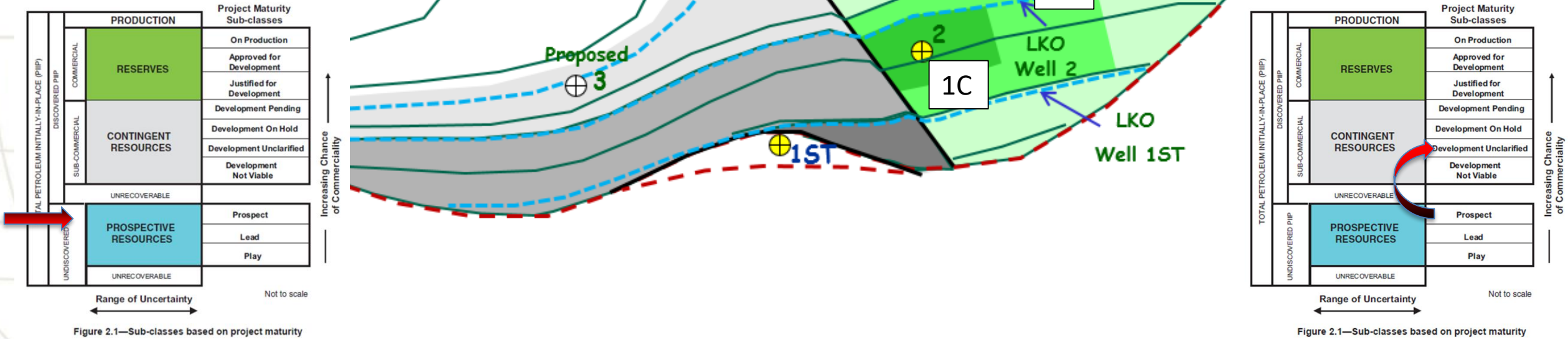


Figure 2.1—Sub-classes based on project maturity

AFTER SECOND WELL

- Area east of fault recommended for Contingent – Unclarified
- Probabilistic, associated with defined physical areas
- Area west of fault has not been discovered – remains Prospective



AFTER THIRD WELL

- Adjustments needed to west side volume range
- No changes to resource classes

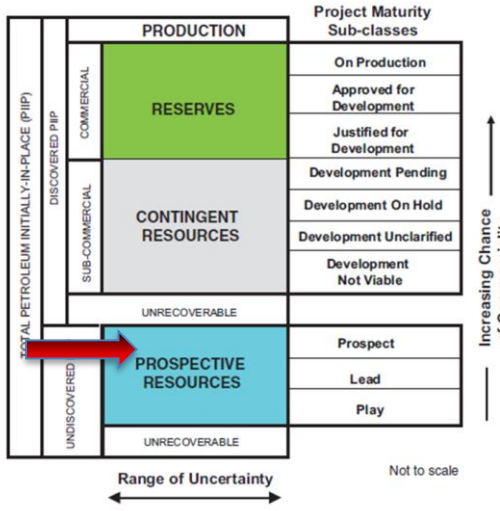
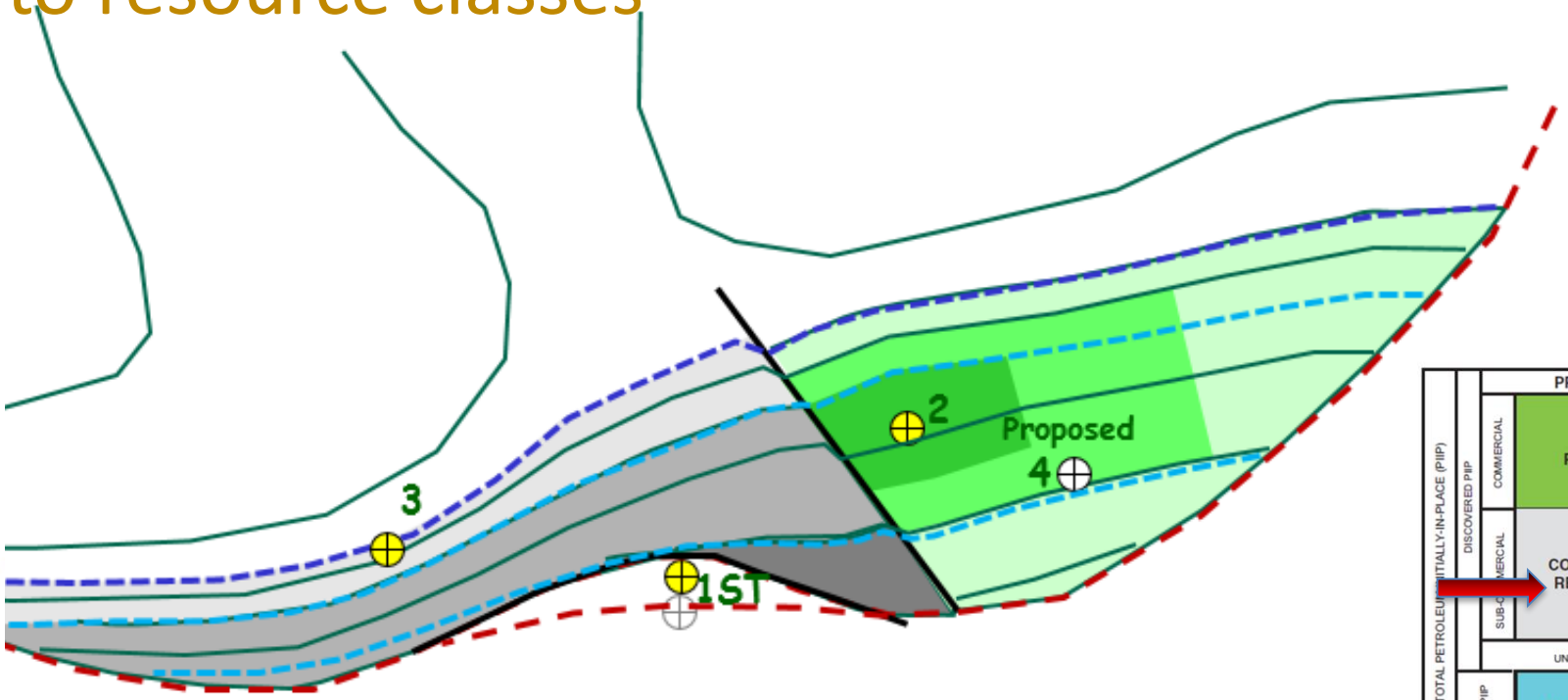


Figure 2.1—Sub-classes based on project maturity



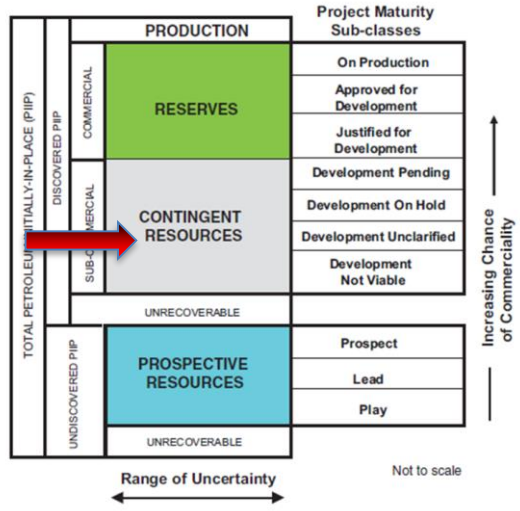
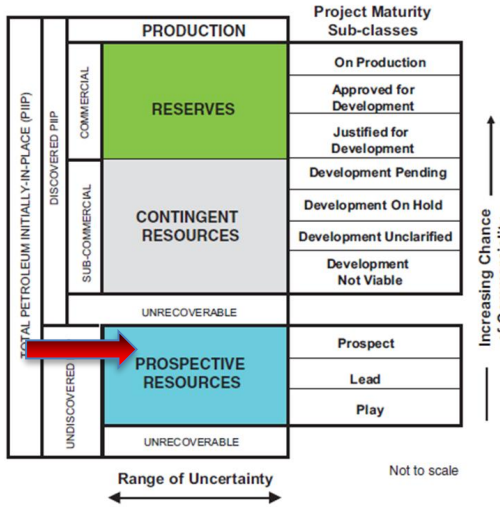


Figure 2.1—Sub-classes based on project maturity

AFTER FOURTH WELL

- Adjustments needed to east side volume range
- Hopefully, little or no change to 1C Contingent Resources



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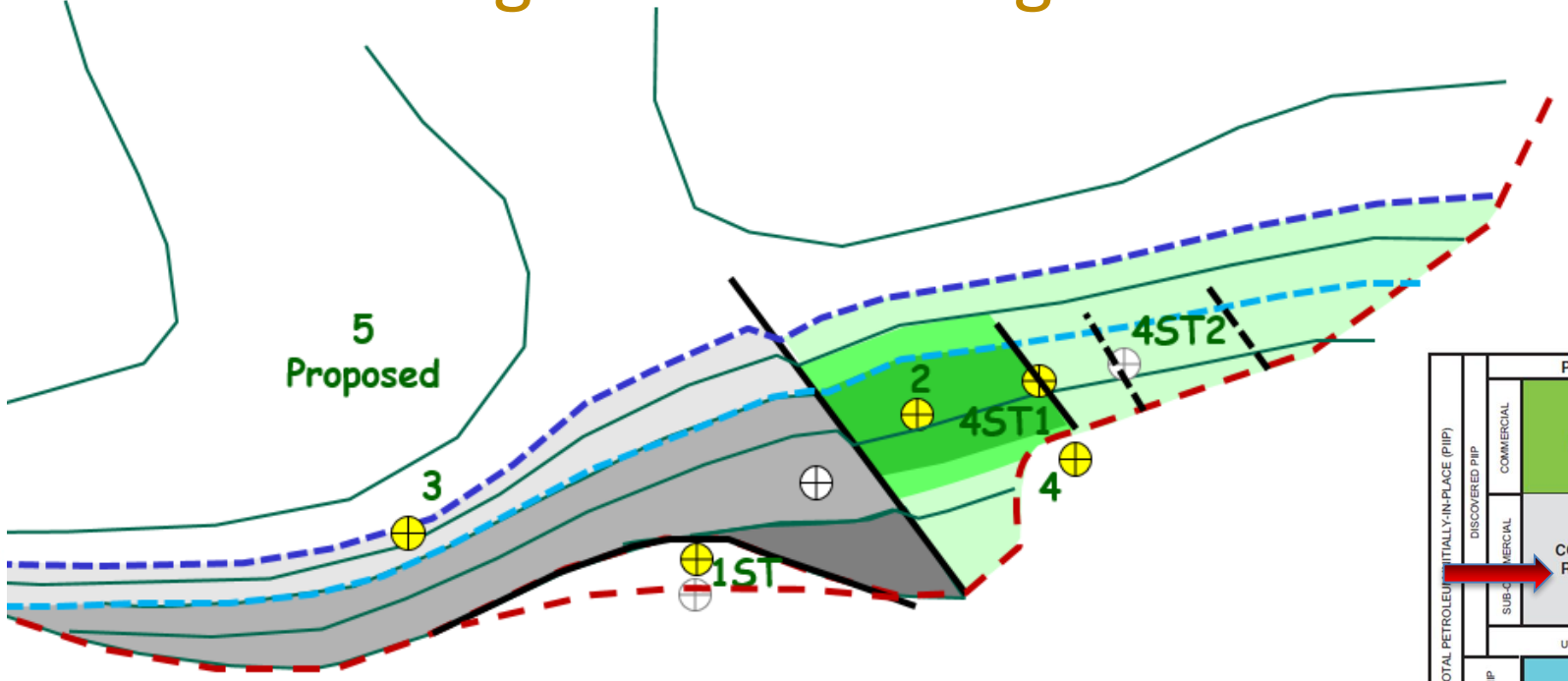


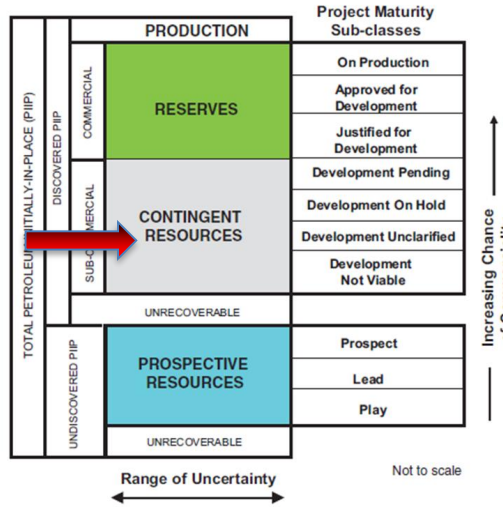
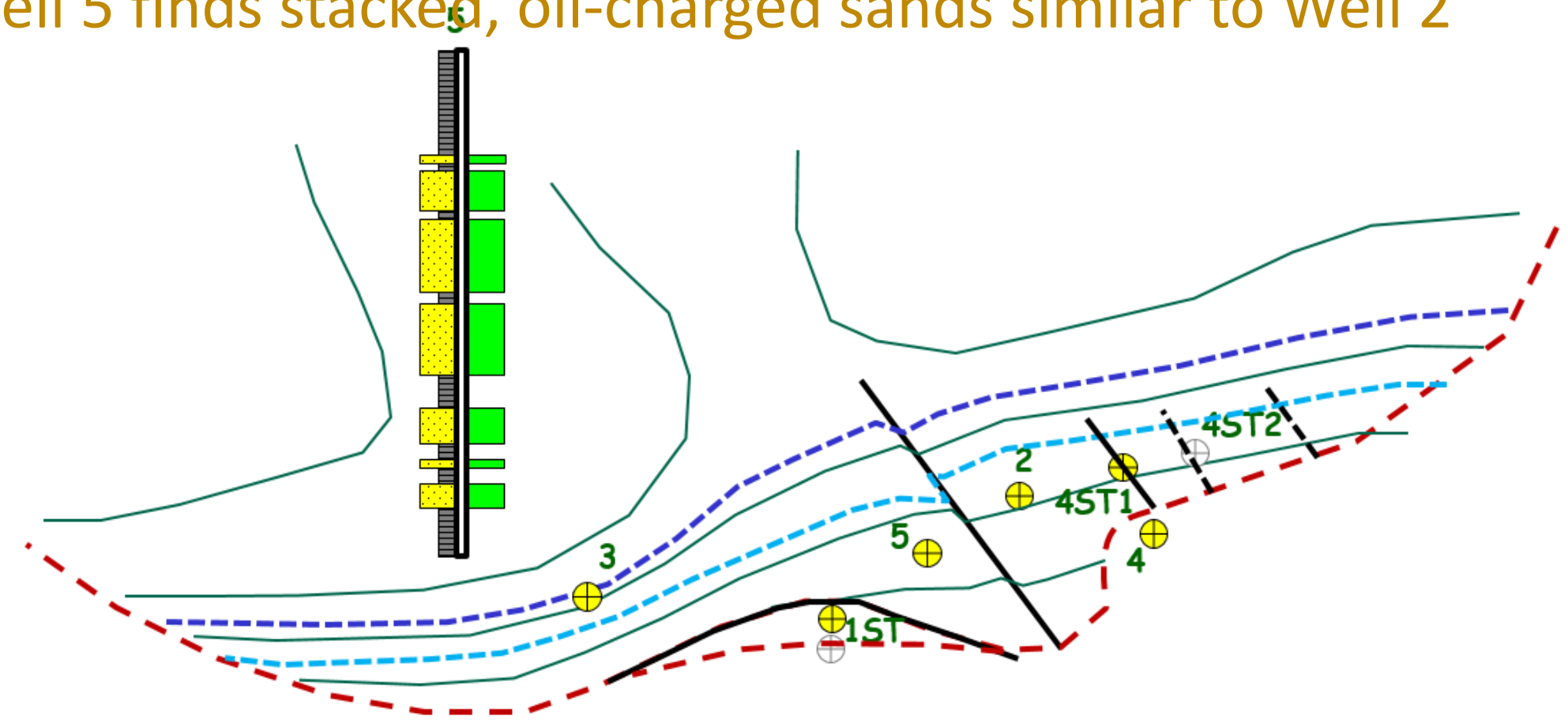


Figure 2.1—Sub-classes based on project maturity

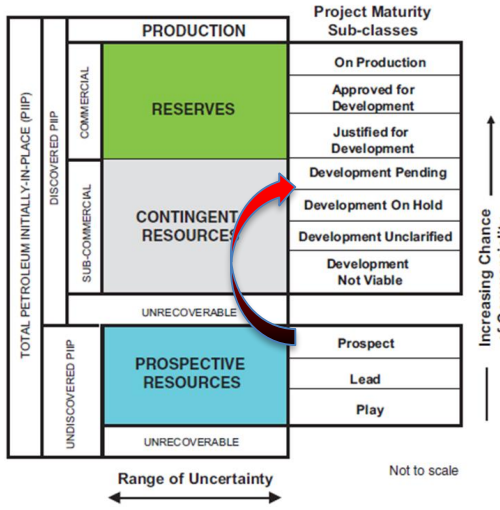
THE FIFTH WELL – SUCCESS AGAIN

- Well 5 finds stacked, oil-charged sands similar to Well 2



DISCOVERY COMPLETE

- Discovery area extended, Maturity Subclasses upgraded



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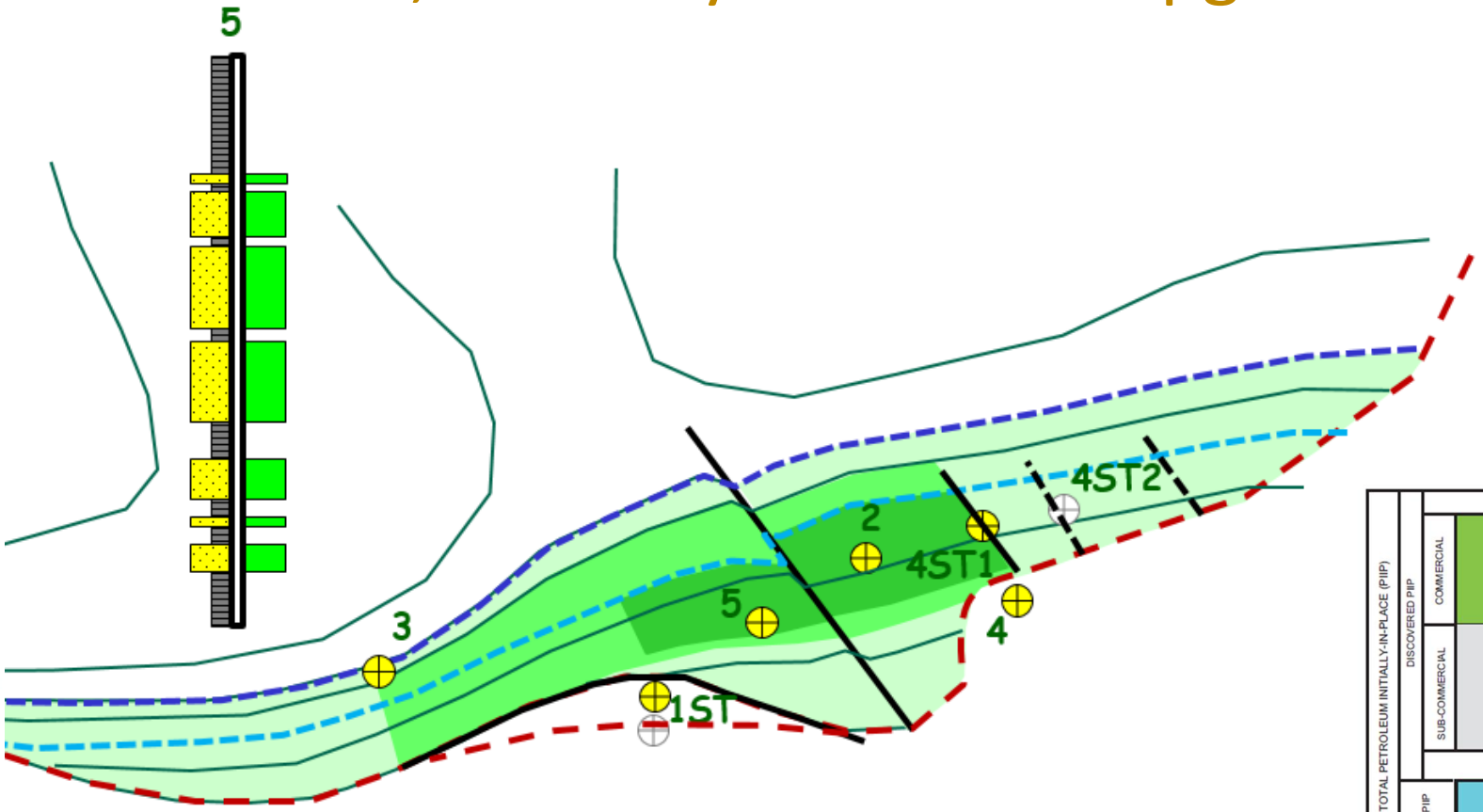


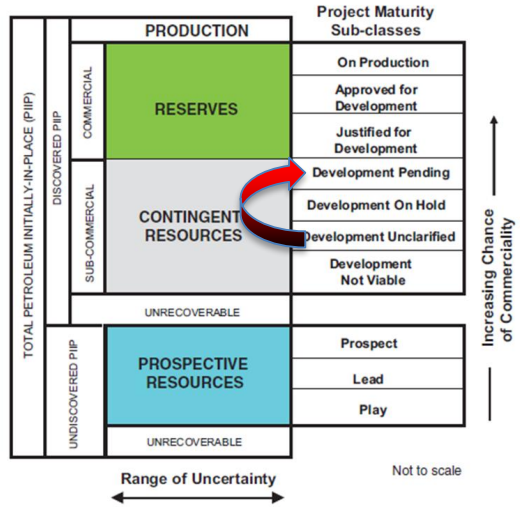
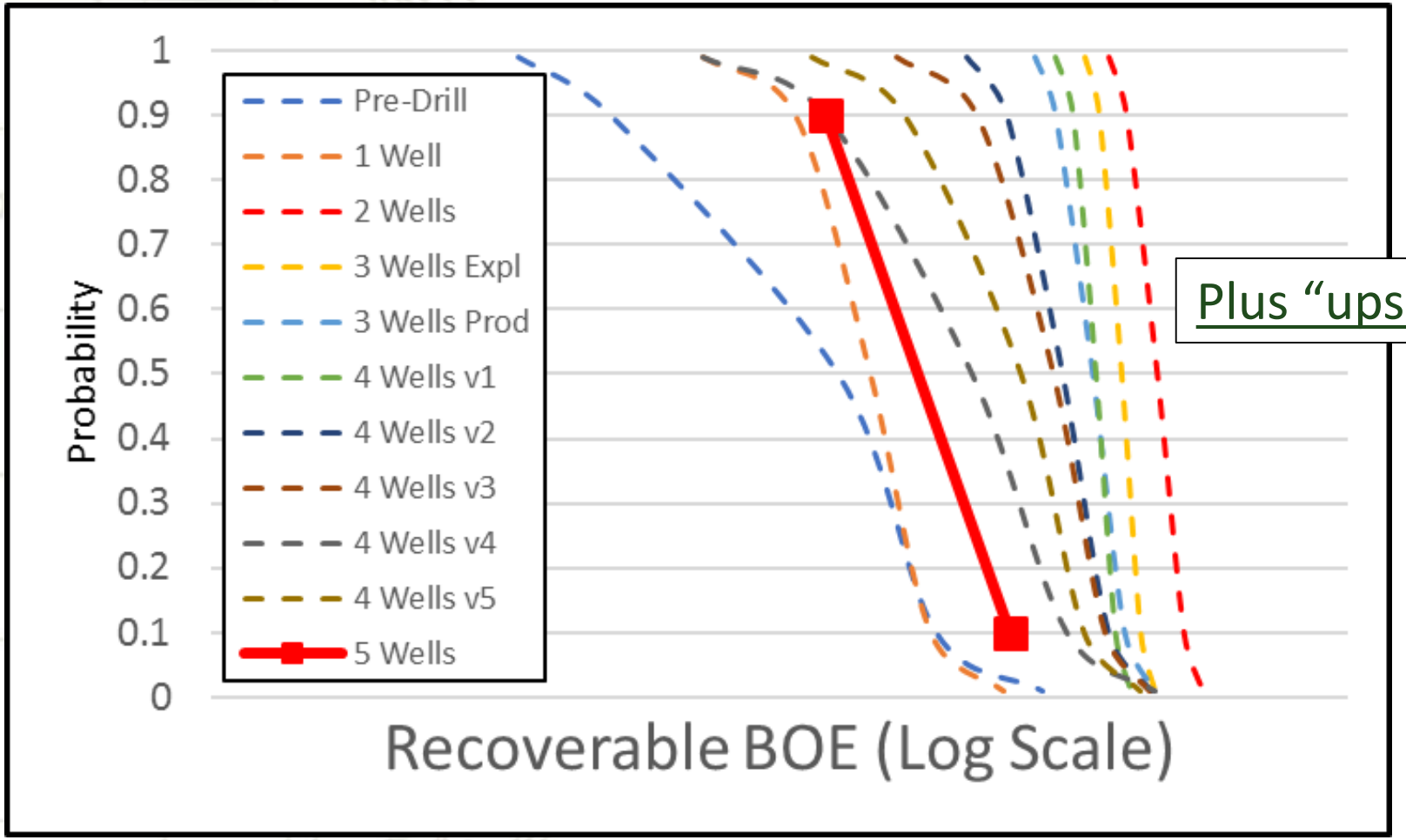


Figure 2.1—Sub-classes based on project maturity

This is a good approach



Plus "upside potential"

UPSIDE POTENTIAL – WHERE DOES IT FIT?

- Very small, unpromising finds best classified as Discovered Unrecoverable
- Potentially large, technically sound, poorly delineated areas should not be pushed into Contingent Resources – AND
- Should not be forgotten
- Transition team needed?

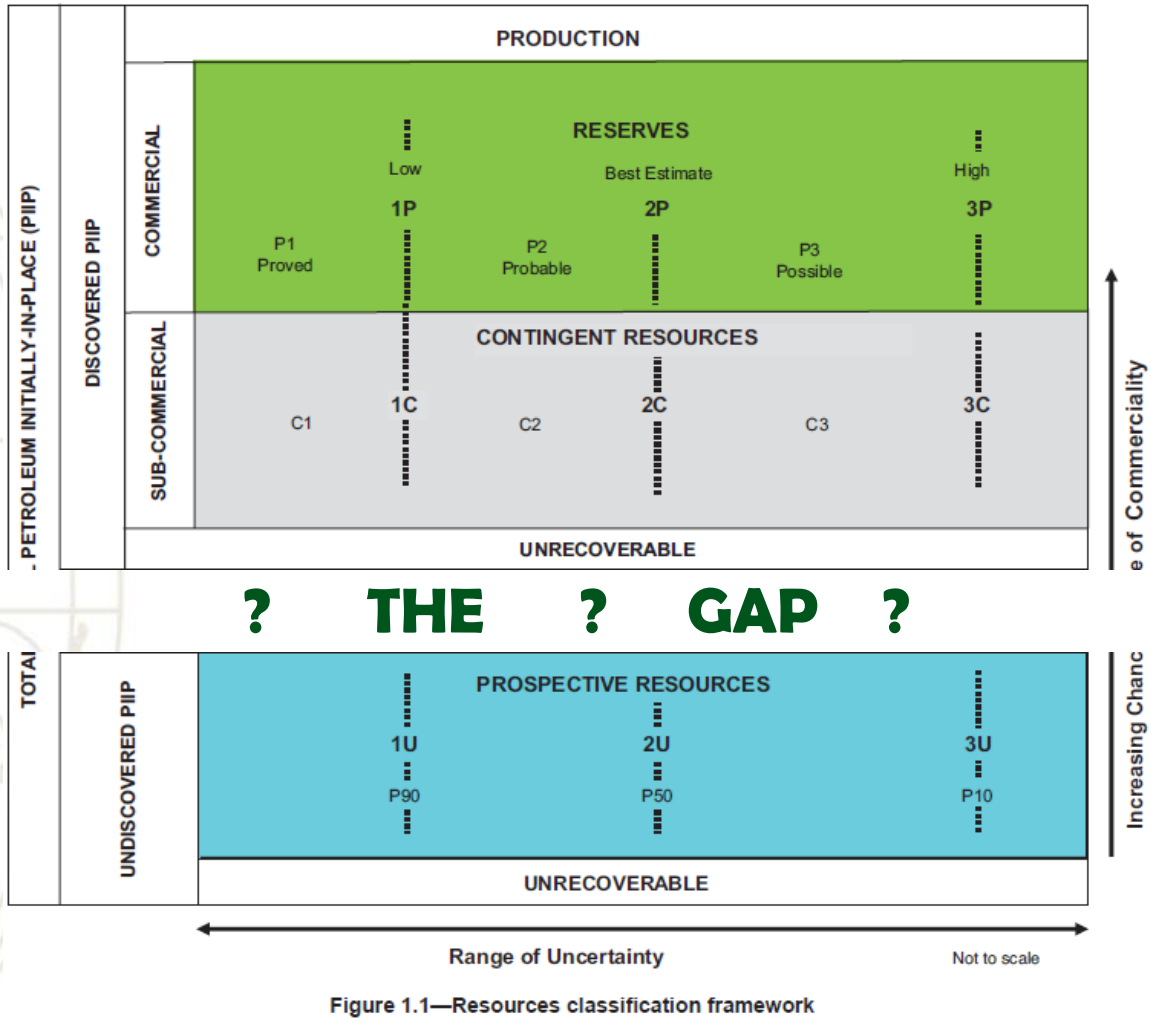


Figure 1.1—Resources classification framework

Source: Petroleum Resources Management System, June, 2018

Strengths and Weaknesses of the Probabilistic Method

STRENGTHS INCLUDE

- The uncertainty range of the result can be derived from basic parameter uncertainty ranges
- Easily lends itself to numerical treatment
- Can be applied throughout the business cycle from exploration to production
- Naturally links in with value-of-information work
- Allows capture of the range of outcomes when insufficient detailed data are available

WEAKNESS INCLUDE:

- Can lead to extensive, complicated, and sometimes ineffective calculation work
- Categories (e.g., P90, P50, P10) may not correspond to specific physical areas or volumes when simple Monte Carlo methods are used.
- The Probability Density Function of basic parameters is not always known and technical judgment has to be applied
- Dependencies between parameters are even more difficult to assess.

Adapted from: Guidelines for Application of the Petroleum Resources Management System, Nov 2011

CONCLUSION

- Any resource estimation method, probabilistic or deterministic, that is not associated with definitions is weaker as a decision-making tool.
- Exploration and production departments commonly have different objectives and metrics. Independent opinions can help.
- A corporate reserves group should be involved from the prospect evaluation stage onward and guide evolution of resource estimations at each step.
- Individual technical workers should be trained in resource estimation concepts and applications.

QUESTIONS