UNCERTAINTY IN UNCONVENTIONAL BASINS

Bill Haskett
Haskett Consulting International
Houston - Vancouver

This presentation is the Thursday Lunch Talk at the SPE Denver Section's Advanced Practices in Unconventional Basins meeting. This talk was selected for a full-conference lunch slot as the tools and techniques of uncertainty management are applicable to all areas and phases of resource exploration and development. Slide decks are (should be) made to support the words being said as opposed to the other way around. In the absence of those words they often fall by the wayside or fail to adequately communicate the intended message. To mitigate this, a discussion of each slide is provided in the notes section. I've tried to write out the key points and explanations in friendly, informal-speak, so have at it. If there are any questions, please contact the author ("me").

Published description of talk:

Uncertainty in Unconventional Basins

Companies spend a time and money trying to reduce uncertainty believing that to be the key to increasing confidence of making the correct decision. Often, this time and capital is wasted. They've spent too much and have taken too long, losing profit and competitive advantage in the process because they have not fully understood the uncertainty present or know how to effectively handle it. We are going to look at ways to identify and deal with uncertainty efficiently and effectively through the

value chain; from play entry, early development, operational efficiency, to infrastructure planning.
Undoubtedly, there are times when uncertainty reduction is important and value creative, but when is enough enough? When does additional learning destroy value? There are tools, including Value of Information, Value of Control, and Value of Learning (VoL, a new approach, helps us with operational efficiency), that help us to understand the materiality of attempting to reduce uncertainty.
As we look at uncertainty potential reduction/resolution, we will approach the effort using four questions that should always be asked:
1/ Is this uncertainty material?
2/ Can we do anything about it?
3/ Is it worth doing anything about it?
4/ What if we are wrong?
Our quest is to be efficient explorers, developers, and producers, but more than that, we also have strategic opportunities in uncertainty identification/handling. Control, positioning, and the creation/preservation of competitive advantage becomes the ultimate reward for understanding and properly handling uncertainty in our unconventional projects.

Narrative:
We will start with a few basic principles on the approach to uncertainty and a few statistical reminders that the root of the uncertainty is the fact that we have well-result collections and not field averages. Then we move on to understanding full project uncertainty and the recognition that, at least initially, we do not need to understand what we have. All we really need is confidence that what we have is greater than what we need to have.

So, uncertainty is recognized, what do we do about it? Not every uncertainty is worth our time and effort to reduce. There are four Primary Uncertainty questions we need to ask. We delve into each of these questions and talk briefly about the tools and techniques to assess and provide sound decision support and uncertainty management. The questions are worth repeating:
1/ Is the uncertainty material?
2/ Can we (or anybody) do anything about it?
3/ Is it worth it for us to do anything about the uncertainty?
4/ What if we are wrong?

We will keep the discussion focused on business decision objectives, process efficiency, and hold everything in a context of competition and competitive advantage.

The latter portion of the presentation centers on the nature of, and tools to handle Risk, particularly asymmetric threat to projects and value. We finish with a reminder that uncertainty management techniques are just as applicable to project management and cost & schedule

Through the talk, we bring in elements from the published articles/papers/presentations, some of which are listed below:

- Case Study: They Hate Us and Can't Be Trusted: Formulating Development Strategy in a Cloud of Suspicion. W.J.Haskett, Decision Analysis Affinity Group annual meeting, 2019.
- Practical Decision Support in Logistics and Project Management, W.J.Haskett, Decision Analysis Affinity Group annual meeting, 2015.
- The Myth of Sweet Spot Exploration, W.J. Haskett, SPE 170960, Oct. 2014
- The Materiality Question, W.J. Haskett, Decision Strategies white paper, March 2012
- Unconventional Type Curves: Useful, or Sirens of Destruction?, W.J. Haskett, SPE-147059, SPE ATCE, Denver, CO, Nov. 2011
- Pitfalls in the Evaluation of Unconventional Resources, W.J. Haskett and P.J. Brown, SPE-135208, SPE ATCE, Florence, Italy, Sept. 2010.
- Pain and Regret, W.J. Haskett, SPE 116773, October 2008
- Evaluation of Unconventional Resource Plays, W.J. Haskett and P.J. Brown, SPE 96879, Oct '05

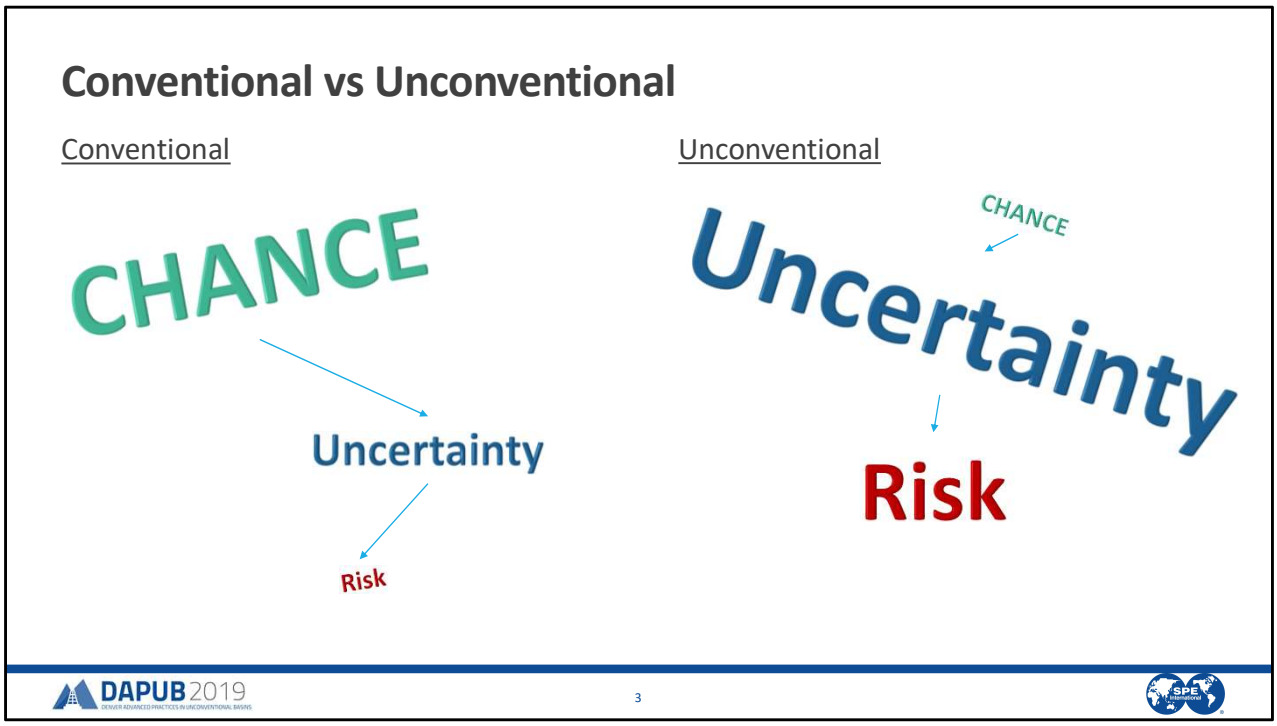
You spend too much and you take too long

Immaterial Precision is Bad

"It is better to be approximately correct than be precisely wrong."

As we work to avoid making poor decisions, we often spend too much time, resource, and capital attempting to nail down uncertainties that are either immaterial to the decision at hand, or that venture far into a land of unwarranted precision. Ultimately, the failure to understand uncertainty and the various methods to recognize, manage, and use it to create competitive advantage leaves companies in tough positions. Companies over-spend and waste time as decision-makers wrestle with uncertainty inappropriately or out of decision context. This is universal. Companies spend too much and take too long.

It may feel good to put a number to a recovery or use it for program planning (e.g. well spacing) and the temptation do be precise is strong. Remember, it is always better to be approximately correct than it is to be precisely wrong.



Unconventional resource exploitation projects have been entered, tested, and operated for more than two decades, however we still have holdovers in thinking from Conventional days.

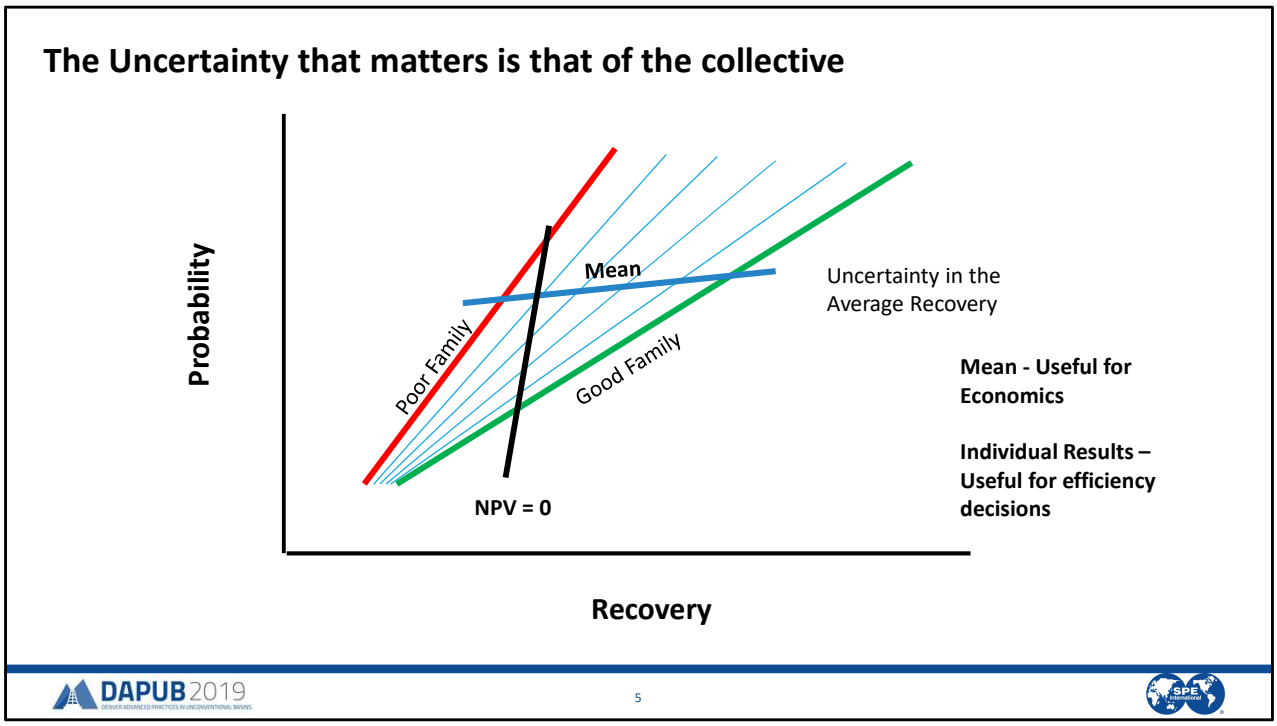
In Conventional resource exploitation we start with a Chance of discovery. When we make a discovery we have pool or field-size estimates for resource/reserves. While they are uncertain, the projects tend to be well bounded and quickly appraised. Chance of commerciality, the probability that we will find at least the minimum economic pool-size (MEPS) is extremely important and we spend substantial time assessing the probability of geologic success as a precursor to it. While financial Risk is always present, the establishment of a pre-drill MEPS guides our decision-making and minimizes project threat (Portfolio threat still exists).

Geologic success probability in Unconventional projects is essentially 100%. Chance is now more business related than anything else… is the recovery material enough and cover a material acreage extent sufficient to sustain a positive operating margin to be worthy of the investment? Our biggest issue is Uncertainty. Our Uncertainty is multi-dimensional. Our quest in Unconventional is to identify the family of wells we have as quickly and as efficiently as we can, or at least determine that the family of wells we are likely to have is better than the family of wells we need to have to go forward with the project.

What is this “family of wells” stuff? We drill individual data points in Unconventional that may or may not give us good indications of what we expect to have after our resource area has been drilled. We have uncertainty in the individual well result. A profitable project will have a good recovery distribution across its wells. A poor project will have a well collection that is, well, poorer. Whatever project we have, we know that there will be a distribution of wells. We hope that distribution is a collection of good wells, but we aren’t sure. Our Uncertainty at the project level is uncertainty of what the *average* well will be. Each point along that average well distribution line represents a family of wells. Our uncertainty has two dimensions. We have a distribution of distributions, and we will talk more about that in a couple slides.

Myth	Reality
"A confident decision is a good decision"	Good decisions bring Confidence, but Confidence that ignores uncertainty is silly.
"To make a good decision I need to know what final result will be."	You will know the final result… someday. Sadly, you have to make the decision today.
"To make a good decision I need to eliminate the possibility of being wrong"	And in doing so you will waste time, capital, and competitive advantage… if it's even possible
"I want a number. Why can't you just give me the number?"	With uncertainty, it is more important to know where your decision changes than it is to number crunch a particular result.

This slide is relatively self explanatory. These are four statements that decision-makers have been known to utter. The reality is somewhat different



When we look at Uncertainty in a potential project, or even within a project to which new technology is being applied, we have uncertain results well-by-well and uncertain average results. This is the two-dimensional uncertainty reality we talked about on Slide 3. We will use an analogy. We will look at the well collections as families of wells and draw comparisons with our own families, individually or collectively.

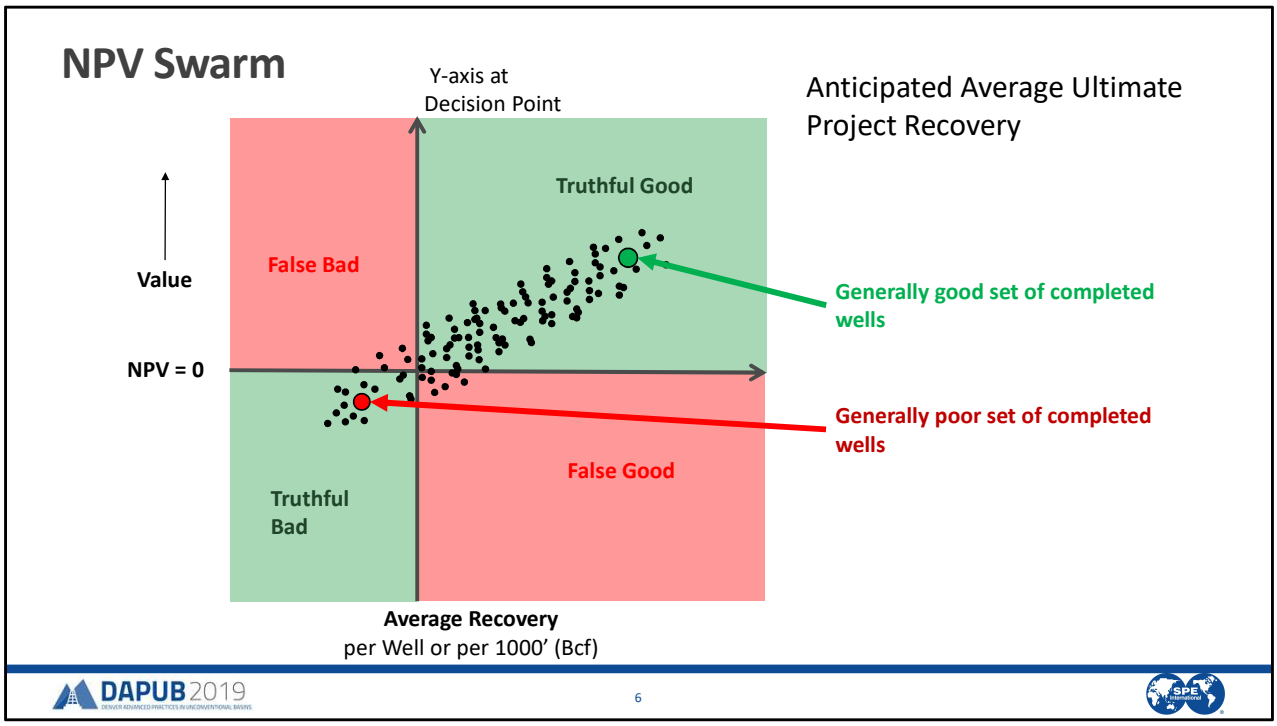
This slide shows an upper bounding well collection (Good Family) and a lower bounding collection (Poor Family). As with our own families, we have a diversity of "goodness" within each of the family members. They average a range of goodness across many possible collections. One thing that we do know from our two decades of drilling is that the individual well collections, no matter what they average, have a track record of being lognormally distributed… which should be expected as the recovery (our meter of goodness) is the product of individual parameters.

The worst person in our families has a closer kinship with the other "worst persons" in other families than they do with the top end individuals of their own families. The same applies to our well collections. A poor well in a good collection can be just as poor as a poor well in a poor collection. The big difference occurs in the mid to top ends.

Some companies, including a couple big ones, look at the uncertainty of the mean across

the potential families in a project. This works well for economics and go/no go decisions for projects and applied technologies. That said, there are benefits for staying at the well-level a little while longer.

Also note on this slide that the NPV=0 line… typically the criteria used to determine go/no go, does not occur at a specific recovery amount. There is an uncertainty as to the break-even (BE) components.



Each of the dots on this chart represent the drilling of the entire project. It is a plot of the average recovery and the value shown by a project having that specific average recovery. This is a stochastic assessment output. Each dot is an iteration or realization of what could be, based on many input uncertainties, technical and cost. The swarm represents the value uncertainty of the project as a function of recovery factor.

So what? Why should we care? Remember that we do not get our "reality" information all at once. We get it well by well. So the question arises, how many wells to we need in order to have confidence that we are making the correct decision? While that depends on how confident you want to be we *can* get some estimate of that if we stay at the well level for a bit (as opposed to jumping to the variability of the average well).

The point at which the middle of the uncertainty swarm crosses the NPV=0 line represents the economics based go/no go decision point, otherwise known as the "critical recovery". Note that there is error (uncertainty) around this point but we can usually get fairly close.

In this example there are few outcomes in the False Good (false positive) and False Bad (false negative) result regions. If we throw a number of wells at this project, we have a reasonable chance at reaching a confident reliable conclusion on whether or not it should be pursued. As we start drilling wells and receiving data on flow rates and expected

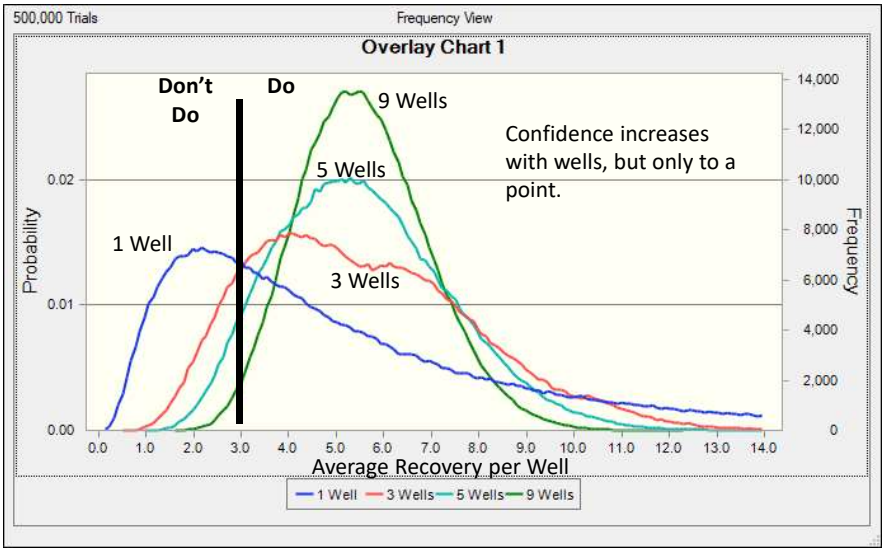
recovery, the more data points we have the better, right? Not right. The swarm shows where we could end up given all of our contributing uncertainties and while the bulk of the outcomes lay on the profitable side of the decision line, we don't know where we will end up. Our reality becomes visible as we drill wells.

We will continue this discussion on the next couple slides but first, a few tips on looking at swarm uncertainty. It can be very useful.

Improve (reduce) cost shuffles the swarm upwards (it moves upwards at the after-tax value of the cost savings)
Extrapolating the swarm trend indicates required recovery (given entire swarm in sub-economic).
Swarm thickness is a function of project factors not assessed through recovery.

Swarm slope is an indication of relative operational priorities. What that means… if the swarm slope is steep, there's usually more money to be made by improving recovery than saving money. If the slope is shallow, prioritizing cost savings and efficiency is the indicated priority. Remember though that the capability to alter those elements will come into play. In our experience while saving money and improving recovery will be beneficial to the project, it pays to understand the priorities. Do you know where the biggest advantage is for your projects? Are they cost or productivity enabled? You need to know.

Confidence When Making the Correct Decision



For the probability distributions shown on this slide a single recovery distribution was created running from 1.5 Bcf at the P90 (10th percentile) to 12 Bcf at the P10 (90th percentile). The distribution was limited at 15 Bcf. Our assessment of the project sets the critical recovery amount at 3 Bcf. How many wells are needed to provide us confidence that our distribution of recoveries averages at least 3 Bcf?

Many companies ask the wrong question at this stage. They want to know how many wells they have to drill in order to validly assess what they will have on average. Remember that that is the number that they have run economics on and people get anchored to numbers. That may be the number on which their bonuses depend, but that is NOT the number on which the decision depends. The decision is to develop or not develop the project. The decision is to use the new technology or not to use it. Calculation of a precise mean is immaterial to the decision at hand. So, how many wells do we need in order to be confident that we are making the correct decision? In our current example, the critical recovery or the "Decision Threshold" is at 3 Bcf. If our wells indicated a 3 Bcf recovery average, we, being risk-neutral, would be indifferent to proceeding with the project. (This isn't precisely true as we have negated the benefit of early withdrawal from the project if things indeed were headed to the poor side. Remember, our decision threshold is currently set based on a project where all wells were always drilled. This doesn't usually happen. We don't pursue full projects that have well after well after well showing sub-economic results.

At least we shouldn't. But for now we can ignore this point).

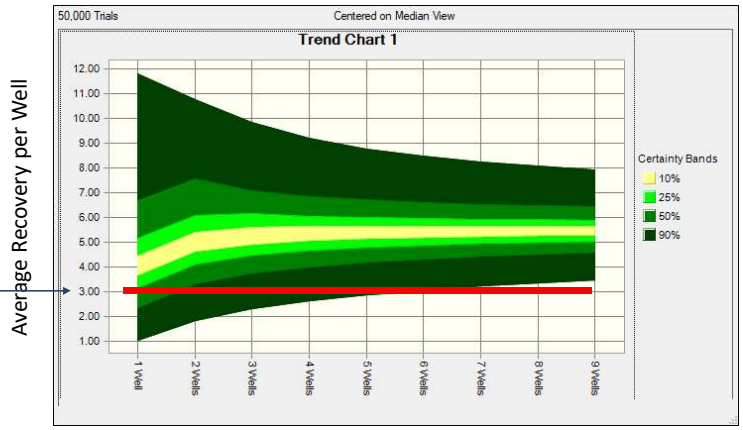
This is a contrived single data set. We know for sure that the average result is above the decision threshold. Yet we see that with insufficient well numbers we have a strong possibility of walking from the project. In this case we are looking at the confidence drilling a low number of wells provides us on the "correct" decision to continue. The first wells we drill teach us the most. Well 1 shows us an average well distribution that is sub-decision threshold about 30% of the time (look at it as an area function). After three wells we are at about a 20% chance of making an incorrect decision after the fifth well we are at about an 8% chance of making an incorrect decision or a 92% confidence that we will make the correct decision. Is 92% good enough? If so, then stop and make the decision. 92% is better confidence than most Unconventional projects will provide after 50 wells let alone 5 (a topic covered on Slide 9). As wee increase the number of wells, the incremental confidence of making the correct decision decreases. At some point the added value of an additional well falls below the cost to drill it. One thing that you should see for sure is that fewer wells may be needed to give confidence that the results are beyond the threshold the number needed to provide relative certainty on the average well.

For the statistics aficionados, you may be curious about the secondary mode in the 3 well case. Well spotted. This is due to the limit that was emplaced on the distribution. The use of limits at the upper ends of distributions brings lognormal in line with what we see in reality but can make low population sample look a bit strange. By-the-way, the bump is also seen in the wider modal region in the 5 well case and possibly explains the dual bump at the top of the 9 well case mode.

Confidence When Making the Correct Decision

Your confidence depends on your decision point.

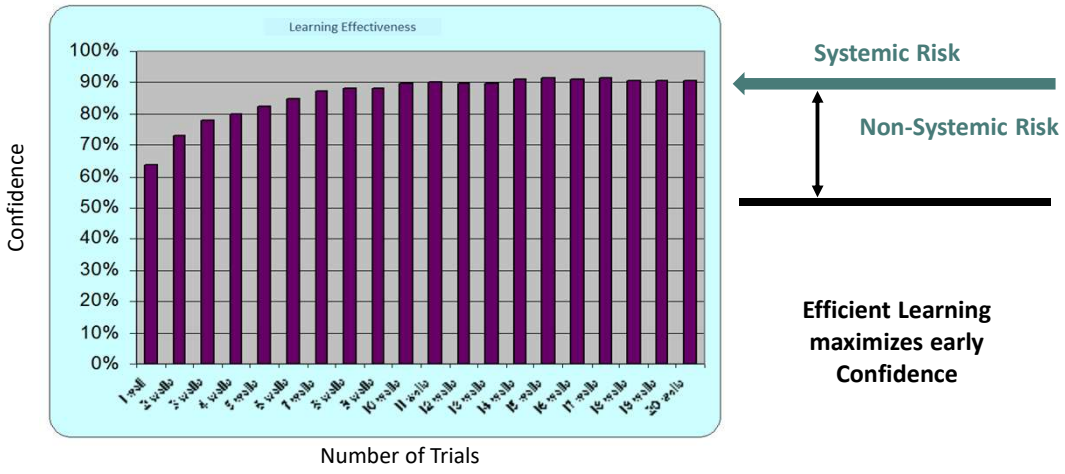
Decision Point



Number of Wells (samples)

This slide shows the same data as the last one, only in a different format. Some people can relate to this format better than the probability density plots shown in the last slide.

Confidence of Making a Reliable Decision



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This chart is from an actual unconventional project assessment. Note that the confidence of making a correct decision improves quickly until it hits a pivot point around Well 8. Don't confuse this with a silly notion that the probability of success changes with increased drilling. Our confidence of making a correct decision increases with new information. Our decision can be either to develop or walk from the project. The probability of success of a project is unchanged. It is, or it isn't.

As we drill wells (or apply new technology to existing wells), we reduce non-systemic risk. This is uncertainty directly related to our parameter (recovery). Testing recovery does not inform us on all project uncertainties, as such there will remain an irreducible amount of uncertainty or risk. 100% confidence is impossible

I am aware that a few companies are very much fans of multi-variate regression. To paraphrase on senior executive at a recent conference… *we use multi-variate regression as we adjust several levers at the same time. Wells are expensive and we can do the assessment after just a few wells*. Well, no they can't. At least they cannot do it to obtain results of any reliable confidence.

The ground is very unlikely to lie to you by showing a higher recovery than is possible. However, as we mess with it in drilling and completion we can inadvertently convince it to

show us less than what is possible. The reliability of our information is asymmetric. If we have initial results indicative of very good production and recovery, the likelihood that we will have a Good Family is high. If we have poor results, it may either be truthfully poor or falsely poor.

Primary Decision Threshold Principle

Knowing what you have is less important than having confidence that what you have is greater then what you need.

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We have been leading up to this statement. I call it the Primary Decision Threshold Principle. The quest for figuring out what you have gets in the way of efficient project decisions. It isn't necessary to understand exactly what you have for most if not all initial project decisions. Recognize what is necessary and makes a material difference. Be decision-focused. Efficiency and profit will follow. This is a foundation principle for decision threshold based modeling, evaluation, and strategy.

Four Primary Uncertainty Questions…

1/ Is this uncertainty material?

2/ Can we do anything about it?

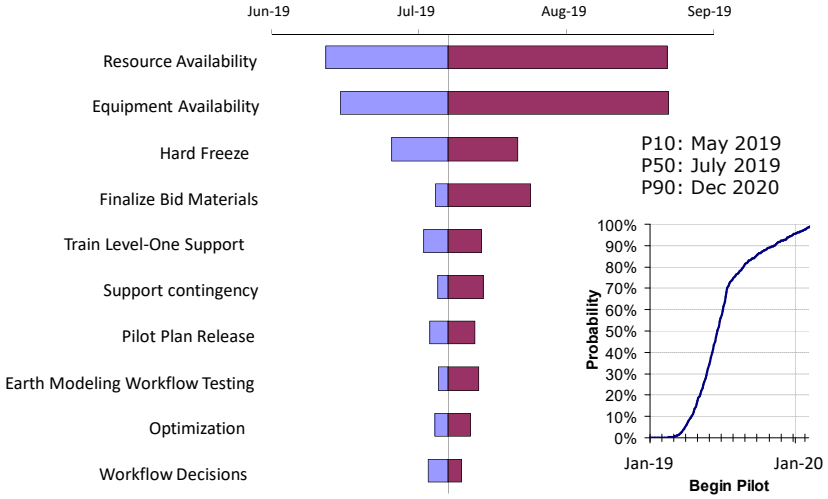
3/ Is it worth doing anything about it? (what would make it worthwhile?)

4/ What if we are wrong?

These four questions should be asked for every uncertainty. If question 1 is answered with a “No”, skip to Q.#4. If Q.#2 is a “No”, once again, skip to Q.#4. If the answer to #3 is “Not worth it”, you need to ask under what conditions would it be or become worthwhile to do something about.

The first three questions are asked to save time, effort, and capital, the only things managers can allocate. Question 4 though is different. It always gets asked. It is there to help you think of and assess the things we often skip over, the things we don’t think can happen until they do. We will return to this question over and over, and we will talk about some tools, techniques, and approaches that you will be able to immediately apply to your projects.

Materiality - Schedule Risk Tornado



But… Materiality is more than just contribution to variance.

It matters more when the uncertainty is in close proximity to a decision.

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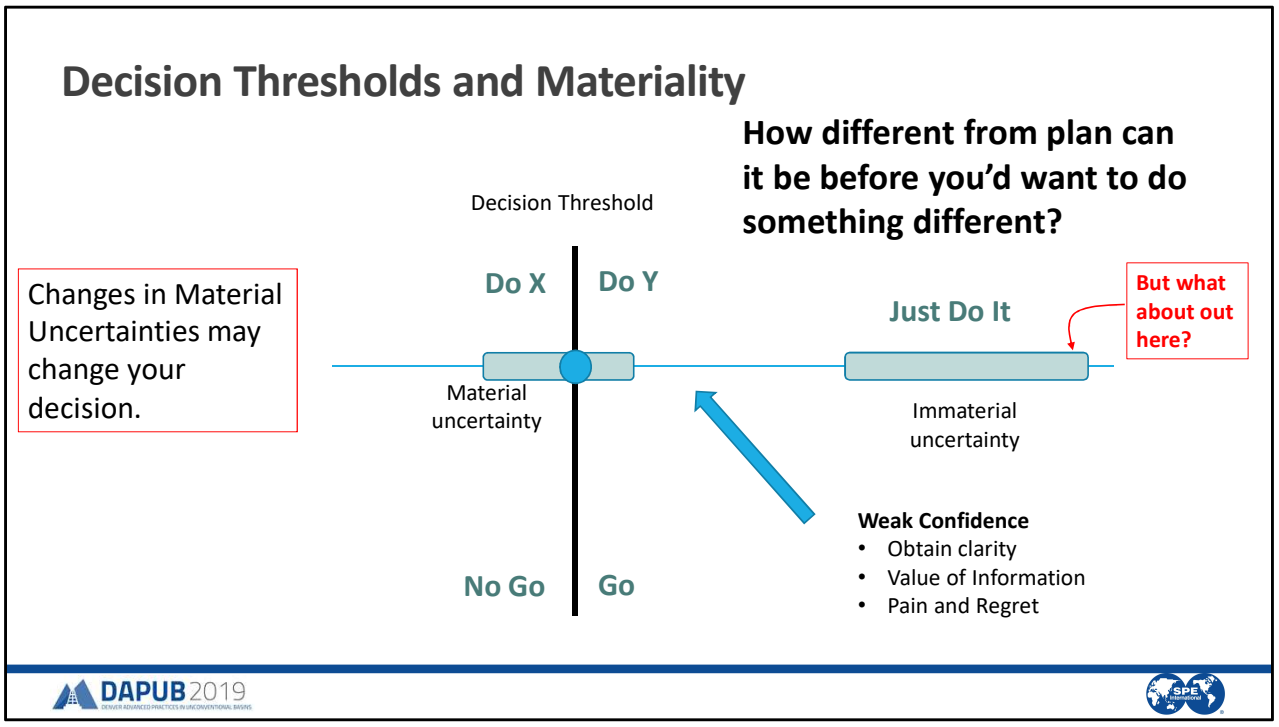
We are starting with materiality. Is an uncertainty material? How do we tell? It has to have two components. The first one we will talk about is the popular notion that material uncertainties are those that make the biggest difference in the value of the project. It is difficult to argue with a decision-maker when they point to a tornado diagram similar to the one shown and talk about one of the bigger uncertainties as “obviously” being material. However, if the uncertainty is not linked to a decision, it is just an outcome modifier and if that is able to be affected, then yes, the uncertainty *may* be material. If the uncertainty affects a material decision, then yes, it is a material uncertainty. For uncertainties to be material they need to make a difference either to value or to a decision… or to the creation or maintenance of Competitive Advantage.

Decision Thresholds and Materiality



Here we see two uncertainty outcome ranges. The range that straddles the decision is material. The uncertainty range far away from the decision point is labelled as "immaterial". Is that always true? Shall we write off that variability, accepting it as it comes, or is there something we could do to anchor in the upper end? At some point the right-side distribution will attract your attention. It should not attract your attention when you are deciding to do X or to do Y. Appropriate timing of investigation and mitigation is important.

(the x-axis is whatever units the uncertainty is measured in)

Indifference Assessment – where do you care?

Indifference is the point at which two possible decision paths are equal to the decision-maker.

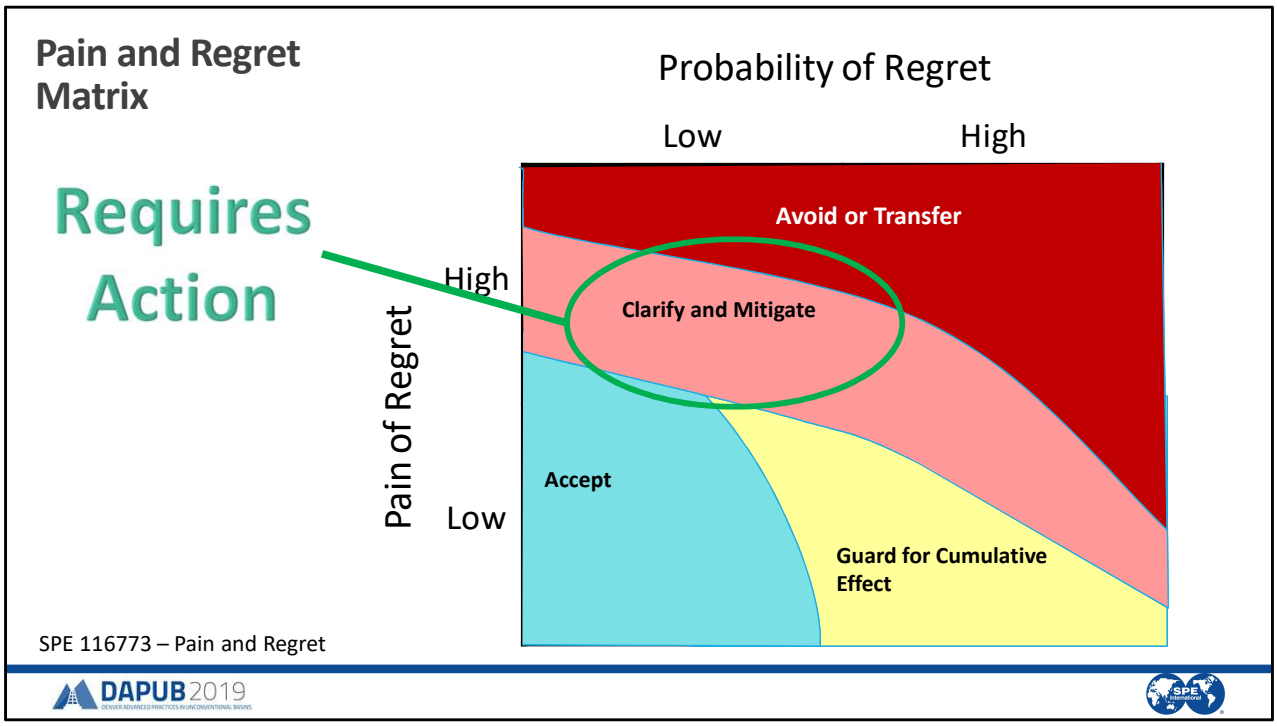
Equality may be in terms of:

- Value
- Competitive Advantage
- Resources used
- Any other Objective

Not the same as a Cost-Benefit analysis

Understanding where the decision points take place across a potential outcome uncertainty improves work efficiency and can provide early confidence within a project.

One of many tools we use in decision management is called an Indifference Assessment. It is a critical part of decision-based project risk management. We want to identify where, across the range of uncertainty, we would change our decision path. It is vital to know where our decisions change inside or outside of uncertainty ranges. This helps decision-makers pay attention to the material decisions. It can also cut through the clutter and illuminates the decisions that really matter. Decisions on go/no go as well as the ones targeted to improve efficiency can be differentiated. (Though I am not deriding the usefulness of efficiency improvement. Uncertainties that change the path we travel are strategic. Efficiency related uncertainties are tactical.)



A second tool is a Pain and Regret Assessment. See my SPE paper on Pain and Regret (listed in the notes for Slide 1) for the reference.

Regret is the occurrence of an undesirable outcome of a Chance or a sub-threshold Uncertainty element. Typically, in connection to an uncertainty, Regret is expressed by the probability of the uncertainty outcome falling below the minimum required amount, or beyond a tolerable amount. All projects have regret potential. Regret is binary. There is regret or there isn't.

Pain is the penalty felt given regret occurs. The penalty can be in project delay, work re-do, value lost, cost increase, and the element companies often miss… Competitive Advantage. Pain does not exist without regret.

Pain and Regret are like Uncertainty and Chance, or Correlation and Dependency. One is a binary probability based item (it happens or it doesn't) and one is a range based item.

The Slide shows the Pain and Regret Matrix and the four main areas within it. If both Pain and Prob. of Regret are low, companies will *typically* accept the risk. Often they simply ignore it as the outcome potential is felt to be immaterial. As we move into higher probabilities of Regret, but still with low Pain, we have to watch out for the cumulative

effect. Many a moose has been driven into a lake by flies. Beware of system fatigue.

At the opposite end of the scale we see high Pain and High Regret probabilities. Typically companies will want to avoid all high-Pain events or situations and will pay a premium to do that. It is often an unnecessary premium. If the high Pain situations cannot be avoided, the standard Risk Management tactic of transfer should be investigated. An example of a high pain event is when a development/pipeline company attempts to do conventional exploration and committed to 10 wells. When the failure of all ten exploration wells coincided with a drop in oil price, the company incurred cashflow problems threatening its existence.

While there might be some negotiation or payment option for the Transfer action, the last area of the chart, “Clarify and Mitigate” will require the most effort/action. Under normal operating circumstances the uncertainties in this category are usually threats and opportunities to avoid threats via the acquisition of new information… think pilot of new technology before implementation, seismic before drilling, part-play assessment prior to an infrastructure decision.

Noseworthy's Doctrine of Competitive Advantage (a quick aside)

If you don't control a material uncertainty or process pinch-point, it is often good to be in the way of those who do.

(But you better be material)

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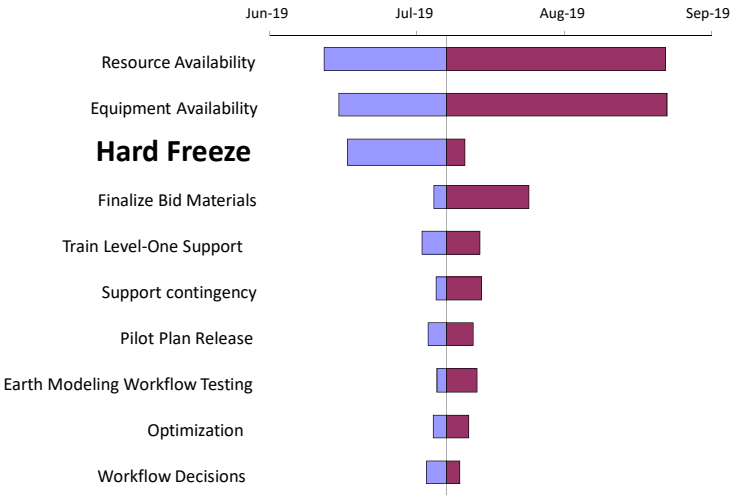
It is impertinent to name a saying after yourself so I named this one after my Newfie Grandfather. Hopefully the slide speaks for itself. The key here is that the creation of stable Competitive Advantage is powerful for a company. It usually takes control of a product pinch-point, scarce resource, or process bottleneck. Sometimes Competitive Advantage comes cheap, sometimes it can cost a lot. You do not want to lose Competitive Advantage if at all avoidable. It reaches to the core of a company's success potential. Yet, no company can be in full control of every aspect. If you find that you do not control an uncertainty, being in the way of those who do control it can be quite profitable.

The squeaky wheel doesn't always get the grease. Sometimes it just gets replaced.

Can We Do Anything About it?



If you can't do anything about it, base your action on the materiality of the downside threat.

- Mitigate Threat,
- Transfer Risk
- Accept Risk

On to Question #2… Can you do anything about it? Before spending time effort and capital on uncertainty reduction, it is good to assess if you can do anything about the material uncertainties in the first place.

If you cannot do anything about a material uncertainty, base your actions on mitigating the downside threat.

In this Tornado plot (the same plot as we showed to discuss materiality), the third item from the top is uncontrollable. You may look at the possibility of moving the schedule activities to place the cold sensitive elements at a warmer time. If this is undoable, then Risk transfer or acceptance are the options.

Value of Information

Spending money and time to increase Value by avoiding downside

The change in Project value given the investigation to get new information about an Uncertainty or Chance element, prior to the commitment decision of the project.

- Pre-drill seismic
- Production testing
- System stability
- Pilot wells

New information has value only if it has the chance of altering a decision.

New information has variable reliability… truth telling for positive and negative outcomes

Editorial – This is an extremely important tool in our effort to make correct decisions efficiently. There are several course providers on this topic, and a leading expert in this is now living in Denver.

Question #3… Is it worth it to try to do something about the uncertainty?

Not all information gained in a project has value. If information simply makes you feel more confident about an action that was not dependent upon the uncertainty, then there would be better things to do with the time/effort/capital. There have been instances where extra wells have been drilled on projects before making an infrastructure decision merely to make a decision-maker happy, even though the extra wells would have no impact on the decision. Usually this situation results from the mixing of personal utility with the utility of the company. The Pain of a wrong decision tends to be felt by individuals more severely than the company.

Information has value only if it has the capability of changing the decision.

Remember that information is not perfect. But, we first determine the value of the information given that it *would* be perfect. If perfect information doesn't pay for itself, less reliable imperfect information certainly won't.

Value of Information techniques have been around for quite a while. We won't go into the tactics here but it can be carried out in several ways… Bayesian revision in trees, Matrix based assessment, and my favorite, Venn diagrams. VoI, taught well, takes a two-three day

workshop. Not that it is difficult to do. It has a lot of power in decision support which is brought out through knowledge and practice.

(There are many sources for help on VoI. Most decision consultants can assist, but I should bring your attention to a Denver resident and author of "Why Can't You Just Give Me The Number", Patrick Leach, who is one of the world experts in it. I have taught courses with Pat on several continents and recommend him. He has recently taken over Michael Walls' numerically oriented decision support course at Colorado School of Mines.)

Value of Control

Spending money and time to get Competitive Advantage

Looks at a specific uncertainty

What is the value of knowing or being able to select the outcome?

Answers the Questions…

How much is it worth to you to remove the uncertainty

Given the probability of successfully controlling the uncertainty, How much capital, time, effort can we assign to control it?

"IWIK"

Editorial - People forget about this approach and as a result often forfeit Competitive Advantage

Value of Control is a tool that many forget about. Competitive Advantage is about control (mostly) and Value of Control fits along side of working to create and maintain it, though it can save you time and money as well.

Value of Control is the assessment of the value gained by reducing a particular uncertainty. You are typically buying the Control by spending a scarce resource. Naturally, the value is higher when we anchor the uncertainty to a particularly favorable location within the possible range.

What is IWIK? It is often the key indicator that a VoC assessment may be needed. It stands for "I wish I knew"… a call for uncertainty reduction, but that uncertainty reduction usually comes at a cost and that would push us to Question 3 and we aren't done with Question 2 yet.

Value of Learning

Spending money and time to be more efficient

VoL = Value of the project After Learning – Value of the Project Before Learning

Cost of Learning must be < Value of Learning

Learning improves Process

Would you learn anyway? Often Learning is merely accelerated by effort.

Immaterial Learning is Learning that comes to late for it to capture value, Learning that is unassociated with process decisions, or fails to make a difference

Editorial – This is new stuff brought about by work in Unconventionals

Value of Learning is the newest tool in the toolbox. I've been developing it over the past couple years. It deals with information that leads to improved process. How much should you spend to learn how to do things better/faster? How do you assess material learning, especially when you would have eventually figured out the "correct" approach as well drilling proceeded?

VoL is important in a process or repetitive activity. For example, we eventually will learn what the optimal well spacing should be. We aren't dumb. We will make adjustments along the way as we carry out development. VoC helps us figure out the penalty for not learning quickly. In well spacing there will be either an over capitalization of the project as we drill too small of a spacing, or lost resource as the well pattern does not efficiently extract all of the product. We have also committed/planned a number of wells so not only are we below optimal value on the wells drilled to date, we are going to be lower on all of the currently unchangeable locations. How long does it take to reorganize the program and is there anything we can do to soften the blow in a cost effective manner? How much should we allocate to figuring out how to do things better?

So What Are You Going Do To Benefit from Uncertainty?

Know where your **Decision** point is. Use threshold decision principles.

What if we are wrong? Understand your Pain and Regret.

Risk is Asymmetrical – Take advantage of that.

Pay attention to Critical Path dangers.

- Method is applicable to process as well as Projects
- Project Risk Management

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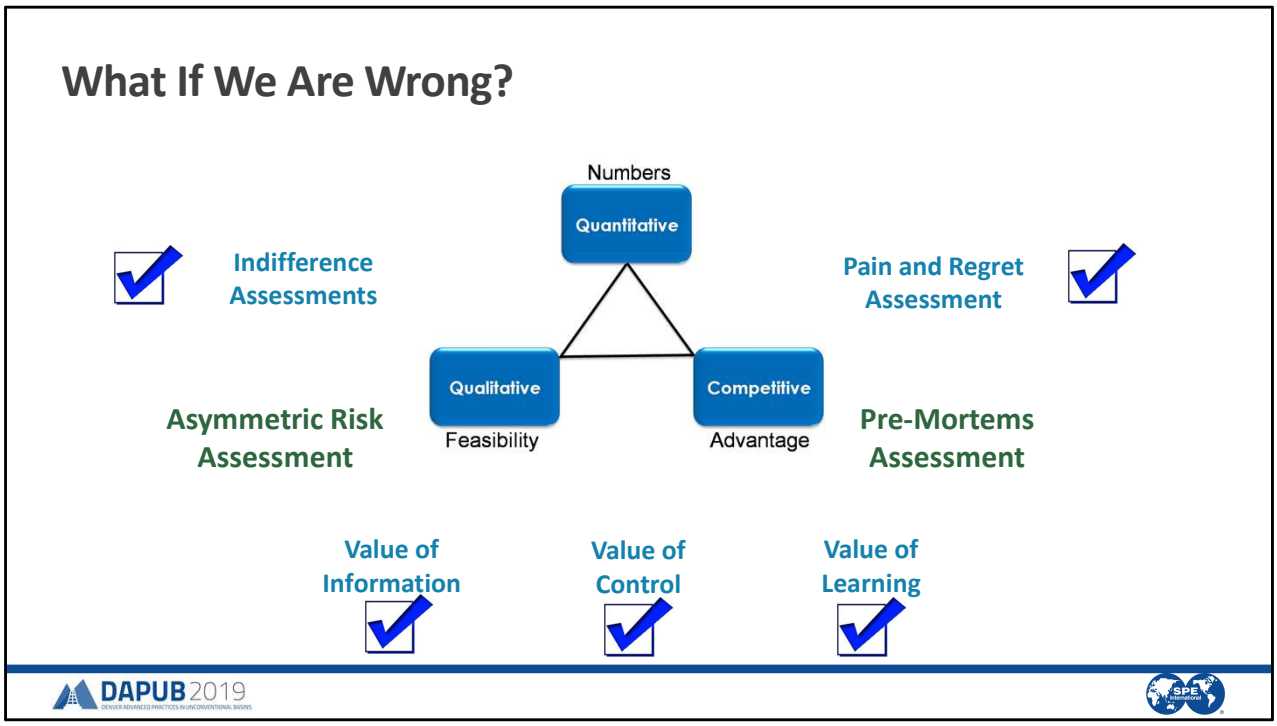
Yes, you certainly can benefit from recognizing and appropriately dealing with Uncertainty.

We have dealt with the first two items. The remainder of the presentation will deal with Question #4… What if we're wrong?

We are about to find out that Risk is Asymmetrical and that provides us opportunities to plan better, operate better, and negotiate better, especially if we recognize the asymmetry and know how to take advantage of it.



Assessments combine Qualitative and Quantitative methods in a context of Competitive Advantage. We have talked about the tools of materiality and the tools of worthiness. Now we look at the tools of Threat. Back when we discussed the questions, it should have become apparent that you *always* ask Question #4 – "What if we are wrong?". It might have the cursory answer "We don't care as we accept all risk of that." which is fine if the party stating that (and the company) is fully informed of the consequences of being wrong.

So how do you go about figuring out what could go wrong with a project when your team believes (strongly) that they are on the right path. Carry out a Pre-Mortem.

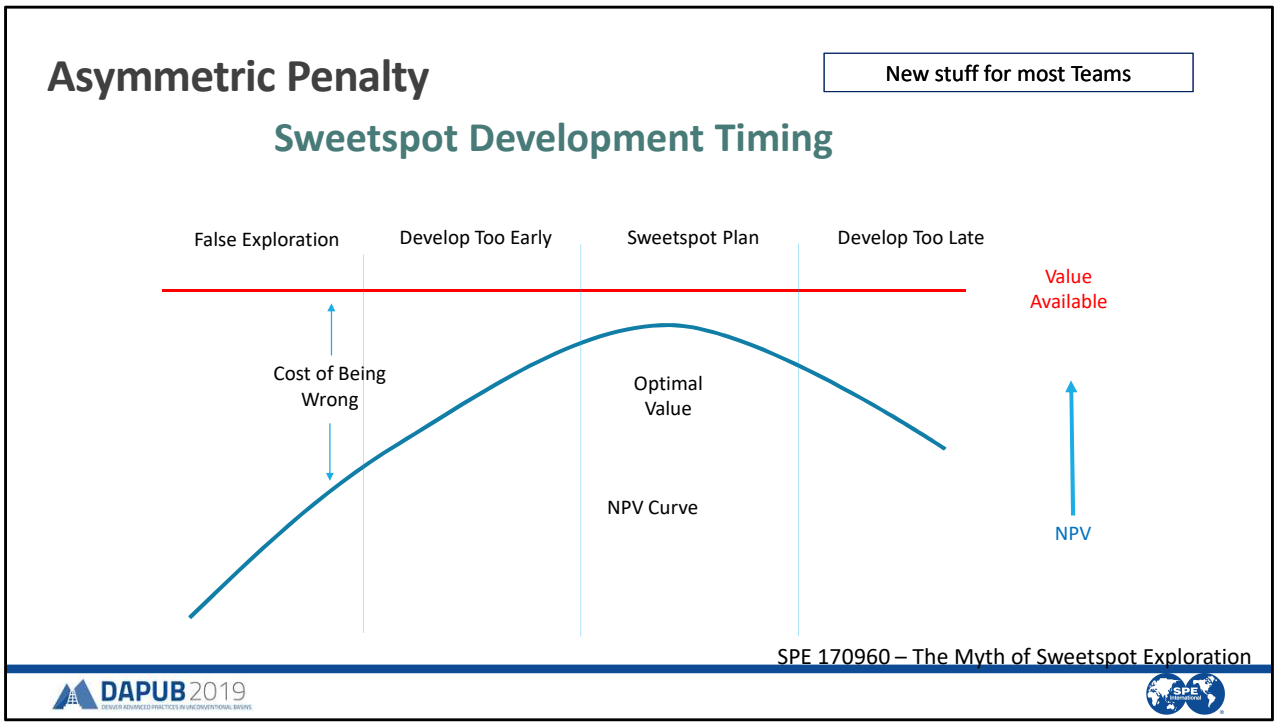
Pre-Mortem

We've all heard of a Post-Mortem. It is what is carried out to find the proximate and related causes of death, typically of a recently living creature, but it can also take place for projects and unfortunate events. One of the tools that looks at central and contributory causes is a "root cause analysis". How do you carry this out on a project that hasn't been done yet? Assume that you are sitting 5, 10, maybe 15 years in the future examining how and why the project failed. This requires people to put themselves into the position where it is a given that the project as failed. Work backward from the potential sources of failure to find the root and contributory causes, sometimes you will find a combination of internal or external events. Look at the threat and uncertainty assessment for that element to see what your

current decision path and risk mitigation program may have missed. Look for ramifications and unintended outcomes of your decisions. Then ask the first three questions again *before* spending time and effort to mitigate the newly found weaknesses. Concentrate on the material uncertainties that can be altered and are worth altering. It is critical to have a good facilitator for a pre-mortem. It avoids significant bias and eradicates most Group Think.

Asymmetric Risk

The penalty for being off in one direction is different from being off in the other for most Regret events. This means that it is possible to pre-plan based on the principles of Risk-minimization. We shall now take a closer look at this.



You can see the differing penalty situations when we look at a development plan for a sweetspot.

Some companies still like to look for and develop sweetspots. A sweetspot is typically defined as the local occurrence of a group of wells that exhibit characteristics typical of the top 25% of the expected well population. There are many dangers of sweetspot development strategies which I have outlines in an SPE paper “The Myth of Sweetspot Exploration” (SPE 170960), however, if the operating company executes a sweetspot development plane at the appropriate time and manner, value of the project can be enhanced.

One of the dangers is jumping to develop a sweetspot too early, committing funds for drilling, completion, and infrastructure before the part-play has been defined or confidence created. The cost of being wrong can be exceptionally high. One north American company spent over a billion dollars chasing sweetspots instead of establishing confidence that the play required. Exploration success happens when material sustained production is seen over a business-sized developable area. Being led astray by early good results can be expensive. Similarly developing early before a coherent infrastructure and egress plan has been decided may strand capital and incur inefficient drilling.

At the other end, it is possible to delay the development past its prime development time. This too causes Pain, but not as mush as the Pain of developing too early. The Risk (potential of financial or competitive loss) is asymmetric.

Let’s take a look at a case study, a real situation where the assessment of asymmetric risk was helpful.

Development Well Placement

We have a development plan that places wells a certain distance apart

But it is a decision fraught with uncertainty

Where is the Risk?

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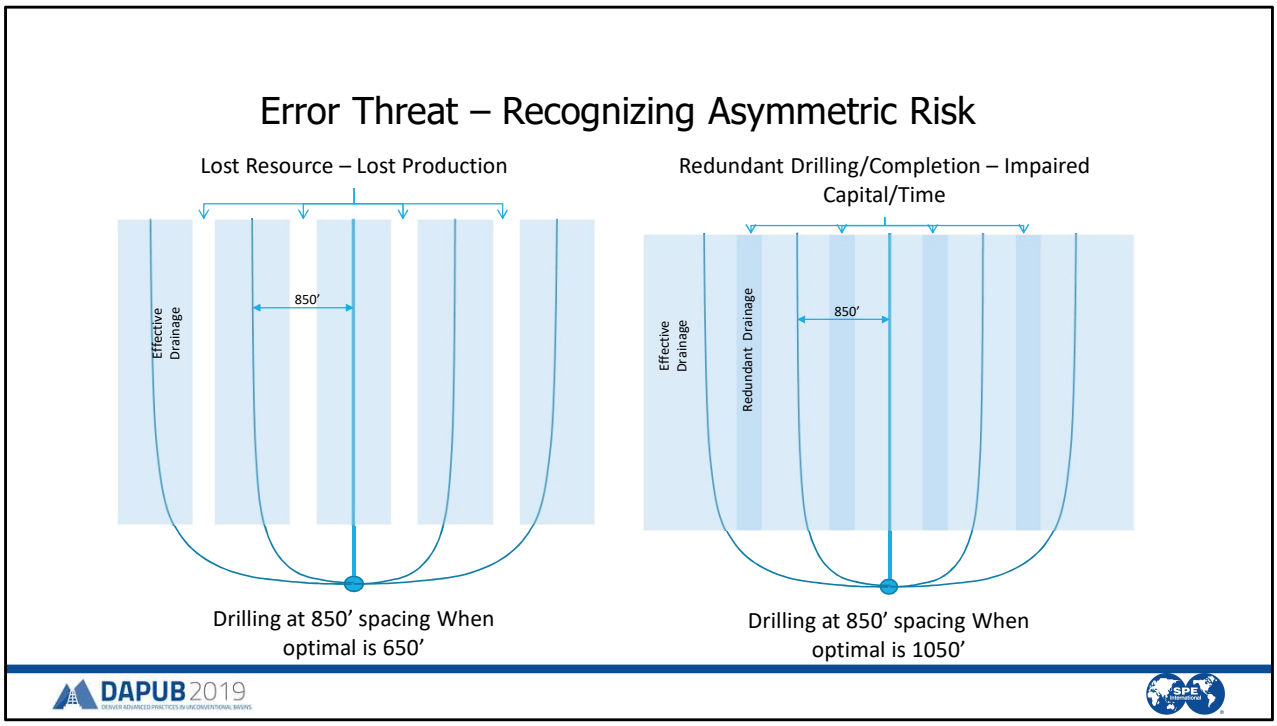
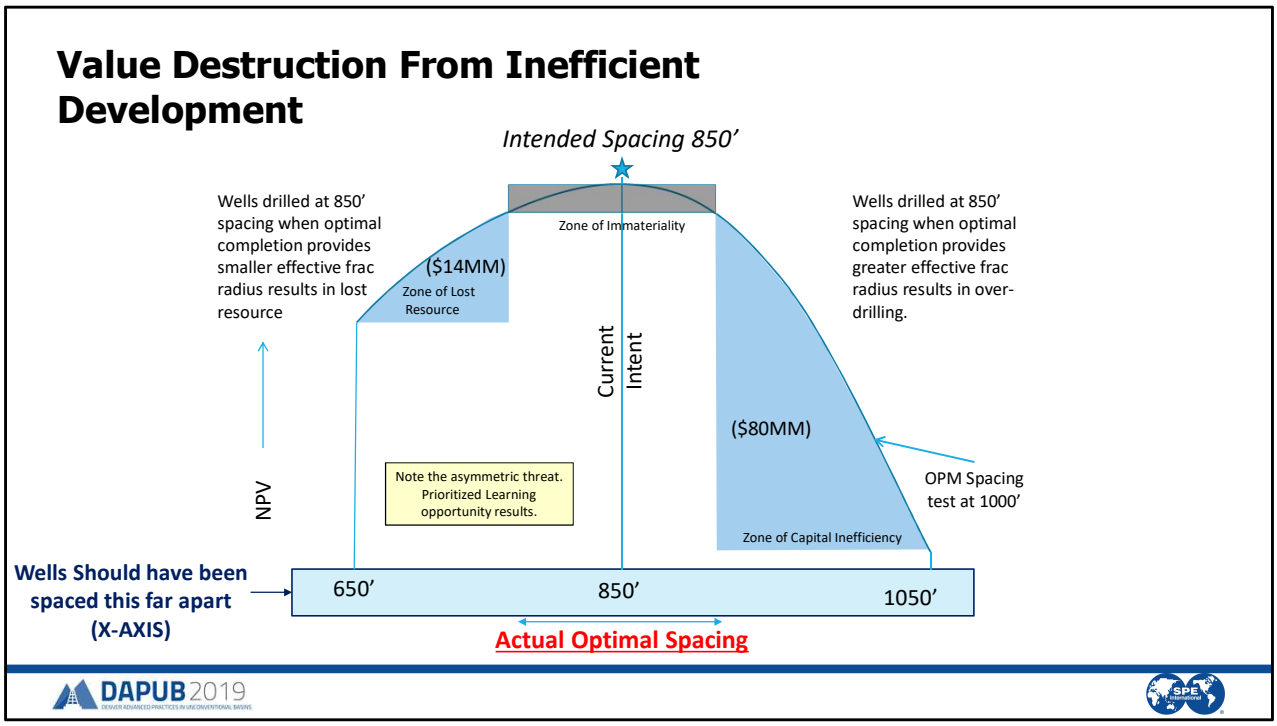
The risk is two sided. The uncertainty we are dealing with is the appropriate or optimal well spacing. The risk is that we will drill too densely thereby over-capitalizing the project area, or we will drill too far apart leaving resource in the ground, unreachable by current technology (and that's always what we have to assess… we cannot make up new magical technologies to justify a decision today).



What is worse, leaving resource in the ground or over-capitalizing?

In the Slide, our plan is to drill similar length parallel wells (keeping it simple) at a spacing of 850’. If we are correct we make a lot of money. If we are wrong we lose or are at least inefficient.

The two situations shown in the Slide are representative of the P10 and P90 drainage area. The value assessment you will see takes into account production acceleration for the redundant drainage case. We are looking at a 30 well adjustment time if we elect to change well spacing for future wells. The project will ultimately have around 140 wells grouped into 6 infrastructure clusters. Pads of 8 to 14 wells will be drilled.



Over-capitalization has a much higher penalty. The plan is to drill at an 850' spacing and if that ends up being the efficient drainage area, the drilling plan will show the peak value. As the actual efficient drainage area of the wells differs from plan, value decreases.

Leaving resource behind, as would result from an actual efficient well spacing of 650' creates a loss of resource produced from the drilled area. The value is $14MM less than the plan valuation.

Over capitalization resulting as we drill 850' spaced wells that are capable of efficiently draining on a 1050' spacing costs $80MM. This is a real case from a real development area.

There is an opportunity in the planning phase to optimize the spacing to minimize potential financial impact. Shifting the planned spacing to the right (larger spacing) cuts out downside risk faster than it is added on the lost resource side.

Now, during discussion and planning of the drilling program, the Client was approached by a local and disadvantaged competitor with an offer to jointly develop the area. They stated that they would be willing to drill their pad first at an agreed spacing. Where would you like the "free" information? Where will it do you the most good to reduce uncertainty and potential pain? The Client requested the competitor to drill at a 1000' spacing. OPM (other

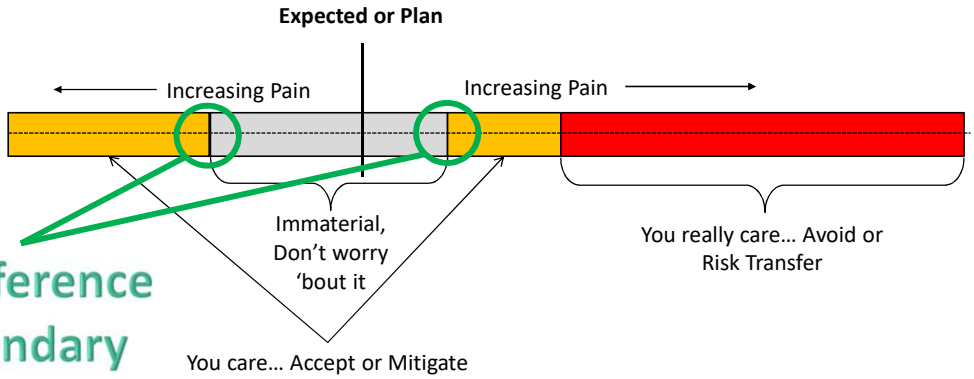
people's money) can be used to advantage if you know how to do it and have a handle on the uncertainty you face.

The last item here I would like to point out is the grey box at the top of the value curve. It is the Zone of Immateriality. It identifies the zone around the plan where any adjustment of the plan would be immaterial, where it either wouldn't make a difference or that the difference it does make would be less than the cost to make the change. The ZoI will also be asymmetrical but no where near as much as the value asymmetry in the resolved uncertainty. You can threat the ZoI as a large range of indifference.

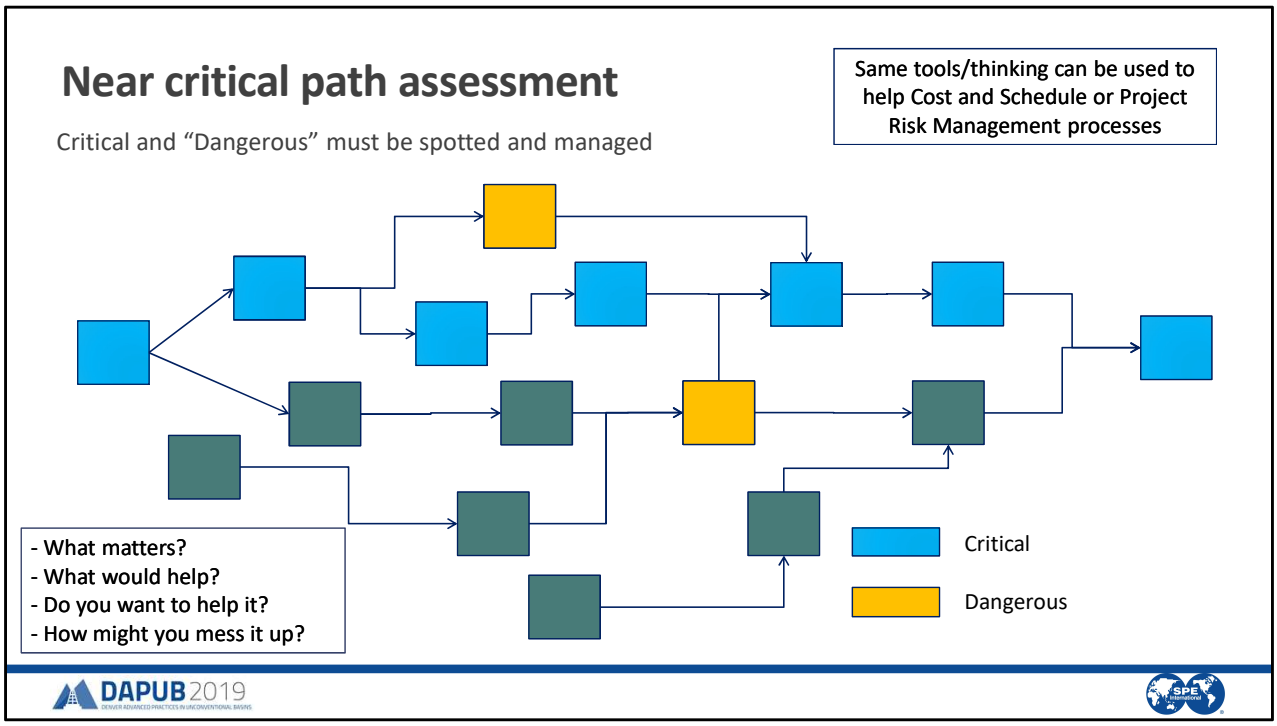
Where Do You Care Across the Outcome Range?

How different from plan can it be before you'd want to do something different?

Immateriality – Where the cost and hassle to change exceeds the benefit of change



Understanding your uncertainty allows you to focus your energy on uncertainties that make a difference. Understanding where your decision points are with respect to the anticipated range of results helps you understand what is important and how to act faster and more efficiently. Identifying the threat allows you to consciously choose to accept, mitigate, or transfer Risk.



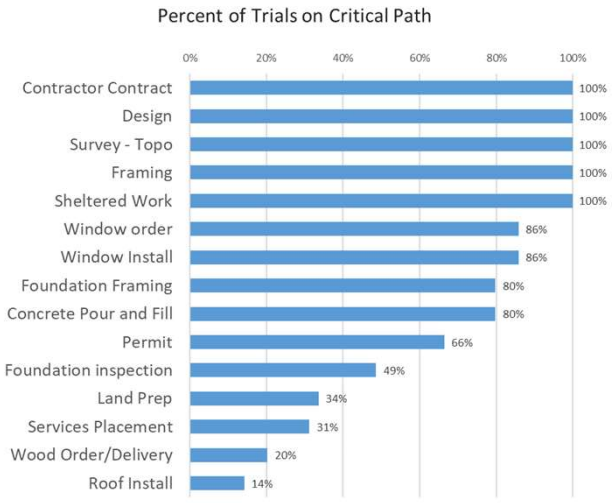
We've talked throughout the presentation about unique or individual uncertainties, but I also want you to know that the same principles of uncertainty management apply to uncertainty chains. The techniques and tools used may differ slightly but the principles and Prime Questions will be the same. An example of a chain uncertainty assessment is shown in the slide. When we look at project management uncertainty, a common way to do so is to create an uncertainty literate cost and schedule model. From the model we can determine the Critical Path within the project or process (note that this can be used to assess any chain of uncertainties, not just cost and schedule). The Critical Path contains the sequence of events or activities that takes the longest. Project Managers manage Critical Paths. It is typical to strive for the particular activity you are managing to move off the Critical Path. If each activity in the PERT Chart (that's what the presentation method is called) has a range associated with it, it is possible to assess the overall outcome of the uncertainty chain stochastically.

This allows you to identify material activities that may be alterable in context or sequence. More than that though, it alerts you to the surprise appearances of "Near Critical Path" items that don't appear on the CP when assessed deterministically but do pose a danger to the project completion when assessed given their potential ranged outcomes. Carry out projects faster by understanding and managing your uncertainty.

Percent of Time on Critical Path

Questions to address

1. What endangers the project?
   - "Stuck" critical path items
   - "Surprise" Critical Path items
2. What penalty does it cause?
3. Can I do anything about it?
4. Is it worth doing anything about it?
5. What if we are wrong?



This is an example of a Critical Path Assessment from a construction project. The same principles and questions apply to unconventional project timelines.

If you forget everything else remember the 4 Questions…

1/ Is the Uncertainty Material

(Does it make a difference and is it associated with a Decision?)

2/ Can you do anything about it?

(Is it controllable by anybody?)

3/ Is it worth doing anything about?

(Do you want to do anything about it?)

4/ What if we are wrong?

(Stop believing you have everything covered and remember… Risk is asymmetric)

As the Slide says, if you forget everything else said and written in this presentation, I want you to remember the four Primary Questions. But yes, in a close second remember the Primary Threshold Decision Principle and Noseworthy's Doctrine (yeah, I know, you've already forgotten them)

I hope you have gotten something out of this presentation, something you can use at work right away, and hopefully you are thinking about how to take advantage of understanding uncertainty in unconventional basins.

UNCERTAINTY IN UNCONVENTIONAL BASINS

Bill Haskett
Haskett Consulting International
Houston – Vancouver
bill@haskettconsults.com
+1.713.526.2410
+1.604.484.5107