A Tale of Two Plays:
Emerging Alberta Resource Plays
Wilrich and Duvernay

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Manager, Engineering
May 27, 2014
Introduction

- **Reserves and Resources Overview**
  - From Prospective Resources to Contingent Resources
- **Wilrich Overview**
  - Development to date
  - Emergence of “production and economic hot spots”
  - Development / Economics improvements
  - Defining Contingent Areas
- **Duvernay Shale Overview**
  - Development to date
  - How are economic hotspots defined here?
  - Development / Economic improvements
  - Defining Contingent Areas
- **Conclusions**
• Remember volumes move *Vertically*  
  – Low estimate contingent resources are a step away from proved reserves, not 3P reserves

• Range of uncertainty should narrow as you move vertically  
  – P10/P90 for reserves should be less than prospective resources

• **The key difference between a prospective resources and contingent resources** is the ability to more accurately predict recoverable volumes based on production or test information.
Drill to De-risk

- Initial pilot wells (hopefully) discover the presence of hydrocarbons
  - Acquire adequate reservoir information for given stage of development
- Initial tests/completions establish productivity
  - Presence of hydrocarbons alone is typically not enough to convert a prospective resource into contingent for regional resource plays
  - Deliverability needs to be known
- Repeated success and commerciality converts resources into reserves
- Drill at optimal density to de-risk play while minimizing capital expense
  - Required distance between the wells depends on the geology
Resource Evaluation Cycle

Estimated PIIP
- Assumed petrophysics cutoffs
- Kerogen density assumptions

Undeveloped Reserve/Resource Assignments
- Assign reserves and resources offsetting performance using volumetrics and analogy

Performance Data
- Initial Rate assumption
- Typecurves (Aarps eqn)
- Terminal Declines

Recovery Factors
- Check performance / decline analysis versus PIIP estimates
- Do these make sense based on produced fluid encountered?
• Marine shale with interbedded fine grained sands
• Targeted zones are sands in repeated cycles
• Though cutoffs from a interpretation standpoint are still in flux (2% to 4%) more prospective zones are readily identified with traditional evaluation techniques
• In general water saturation is irreducible (15-30%)
• Allows for (at the least) qualitative assessment to target best areas first
• Low permeability
• Pressure gradients have been shown to vary across play, with gradients reducing to the East
• Development to date focused on higher pressure areas
• Gas produced is lean(ish)
  – Liquid yields 5-20 bbl/mmcf raw
• Three early development areas have emerged
Spirit River/Wilrich History – Year End 2011

- North – Musrea, Kakwa, Red Rock
- Central – Ansell, Edson, Sundance
- South – Willesden Green, Pembina, Ferrier
Spirit River/Wilrich History – Year End 2012
Total production from Spirit River is over 1.3 BCF/D as of March 31, 2014.
- As of March 31, 2014 over 900 wells were identified as Spirit River/Wilrich.

The majority of the development and production is centered in the three key areas.
Spirit River Production
Can we normalize all this data?

Plot shows differences in production based on year on stream...could industry be finding the best areas as the play evolves?
Can we normalize all this data?

A simple normalization to rate per stage shows otherwise...does that mean we have a typecurve for the whole play?
Wilrich History – Year End 2011
Fun map…but what did the wells do?

On a strict rate basis the production is dropping with additional years of drilling.
Fun map…but what did the wells do?

Normalizing by stage tells the same story…guess Geology is important!
Impact on Contingent Resources

- With deliverability reducing away from identified “hot spot” contingent resources away from well control are limited
- Contingent resources may only extend 1-2 miles away from control
Completion Costs vs. Time for Regions

- **NORTH**
- **CENTRAL**
- **SOUTH**
Lower EURS in the south offset by lower completion and drilling costs
All in D&C from <4MM in South to 6-7 MM in North
Costs suggest three major areas are “commercially interesting”
• Devonian aged shale
• Targeted zones are high quartz, thermally mature shale
• Before cutoffs can be considered have to:
  – Account for thermal maturity
  – Adjust porosity measurements for TOC, which can be calibrated based on radioactivity
  – Still significant reliance on core analysis compared to log analysis
• Water saturation – *undersaturated*!
  – <10% based on core analysis in some areas
  – Impossible to quantify with traditional analysis techniques
• If thickness is all we needed to know it would be easier to find most prospective areas first
• Lower permeability
- Thermal maturity of liquid rich shales is one of the key drivers in estimating reserves.
  
  Thermal Maturity influences:
  - In-situ hydrocarbons
  - Pressure
  - Porosity
  - Recovery Factor

Balance between liquid yield (economic benefit) and energy in the system (reservoir benefit) leads to commercial results.
• Pressure gradients are high, in some cases over 0.8 psi/ft
  – Likely a function of thermal maturity
• Development to date focused on thickest areas, and areas with high condensate/oil gas ratio
• Gas produced is very lean…or very rich, and everything in between
  – Oil/Condensate yields from 0 to >1,000 bbl/mmcf raw
### December 31, 2011 (Horizontals Only)

<table>
<thead>
<tr>
<th>Location</th>
<th>On Prod</th>
<th>MCFD</th>
<th>BBL/D (O+C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kaybob / Simonette</td>
<td>3</td>
<td>2,489</td>
<td>275</td>
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<tr>
<td>Edson</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Willesden Green/ Ferrier</td>
<td>1</td>
<td>1,467</td>
<td>30</td>
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<tr>
<td><strong>TOTAL</strong></td>
<td>4</td>
<td>3,956</td>
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### December 31, 2012

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<tr>
<td>Kaybob / Simonette</td>
<td>17</td>
<td>20,320</td>
<td>1,237</td>
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<td>Edson</td>
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<tr>
<td>Willesden Green/ Ferrier</td>
<td>6</td>
<td>3,885</td>
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<td><strong>TOTAL</strong></td>
<td>23</td>
<td>24,205</td>
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### December 31, 2013

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<td>Willesden Green/ Ferrier</td>
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<td><strong>TOTAL</strong></td>
<td>88</td>
<td>63,022</td>
<td>9,076</td>
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## March 31, 2014

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<td>80</td>
<td>56,486</td>
<td>7,252</td>
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<tr>
<td>Edson</td>
<td>1</td>
<td>1,323</td>
<td>-</td>
</tr>
<tr>
<td>Willesden Green/ Ferrier</td>
<td>19</td>
<td>12,379</td>
<td>813</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>100</strong></td>
<td><strong>70,188</strong></td>
<td><strong>8,065</strong></td>
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### March 31, 2014

#### Production Report

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Duvernay Gas Production
Not really enough wells to tell us anything reliable…
Besides liquid yields impact these numbers right?
Normalizing the data available

- Dealing with a lot less data
- Dealing with constant changes in fluids

Have to get a bit more creative…
Normalizing Fracture Data

- Since fracture design is changing so rapidly, need to do a bit more work
- Operators are still “working out the kinks” on completions – a lot more unsuccessful stages in the early going, so can’t just use every stage…but success rate has rapidly approached 95-100%
What counts as a successful stage?

• Get the pump rate up
  – Frac models show higher rate increases fracture growth away from the well
  – Allows sand to be carried deeper in the reservoir – greater SRV

• Get the proppant in
  – More sand in the reservoir means better connectivity within the SRV
Now we are getting somewhere…normalizing the performance with fracture data and liquid yields we can predict recovery factors – Geology comes through again!
Normalizing Big Data

Limiting the data to only include cased hole wells narrows the bandwidth
Limiting further to Kaybob area and 2012-2013 development the upside potential becomes more pronounced.
Completion Costs vs. Time for Regions

Only ~70 wells with public completion data, so still a lot of potential for continued reduction in completion costs
Lower Gas EURS offset by higher liquids
Kaybob Duvernay now Contingent?

• Can reliably predict recoverable volumes across wide range of liquid yields
• Large areas moved into contingent resource category when recoverable estimates become more accurate/predictable
• Results have tended toward the “commercially interesting” in Kaybob area with liquid yields greater than 75 bbl/mmcf
  ‒ have yet to defined the maximum but return on investment is expected to decrease as oil window is approached
Impact on Contingent Resources

- Areas where normalized results show repeatable results, and liquid yields are also more predictable, larger areas can be classified as contingent resources
  - Halo represent 3-mile radius around well control
• Both the Wilrich and Duvernay cover large areas
• Hotspots for development in the Wilrich are more readily identified with traditional log analysis techniques
• Rapid changes in deliverability over the Wilrich limits extent to which contingent resources can be assigned compared to regional Duvernay
• Economic learnings / savings demonstrating continued commercial development opportunities
One last map… All Duvernay and Spirit River
Thank You

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