INTRODUCTION

• Quick overview of Geography
• High level comparison and contrast of East vs. West Basins
• Early lessons from the East Basin
  – Limited entry
  – Thermal maturity and water
• Maturity controls from West that may impact the east
GLJ EXPERIENCE

• GLJ has evaluated significant portions of the Duvernay across all the development areas
• GLJ has also provided technical support on various A&D transactions:
  – Encana / PetroChina
  – Chevron / KUFPEC
  – Vesta / Riverstone
  – Artis / Warburg Pincus
WEST BASIN VS. EAST BASIN DEPOSITION

- Basin filling sediment, offsetting Leduc carbonate buildups.
- West Basin was a more typical shale resource
  - High organic content
  - Quartz dominated; highly brittle
  - Sourced from north
- Rimbey-Leduc trend may have acted as barrier
- East Basin carbonate dominated
QUICK COMPARISON OF WEST VS. EAST BASIN

WEST BASIN
- Full spectrum of thermal maturity
- Quartz-dominated
- **Continuous organic-rich sections**
- Strong organic porosity component
- Proven commercial in the condensate window
- Oil Window results continue to improve with completions
- Development in the oil window comparable to East Basin in Kaybob, lagging in Willesden Green

EAST BASIN
- Primarily Oil Window
- Carbonate-dominated
- **Interbedded organic horizons**
- Much more mixed porosity system
- Proven to be commercially viable
THERMAL MATURITY MAPPING

- Thermal Maturity predicts hydrocarbon types, and can influence HCPV
- Mapping incorporates:
  - Burial depth
  - Source rock analysis
  - Condensate yields from producing wells
  - Other geologic controls…

- Maturity mapping is a key factor in economic viability based on commodities.
- Improvements in well design have increased the size of the economically viable area, but eventually the reservoir sets the limit.
Kaybob has set the pace, but East Basin producing well counts surpassed Willesden Green early in 2018 behind development by Vesta and Artis.
2 early wells (00/05-18-034-24W4 and 00/08-20-033-24W4/0) completed with open hole technology

The results were...less than spectacular compared to Cased well design
Early development in Westerdale showed promise in adding entry point density:
- Blue - ~12 m between perfs
- Green - ~6 m between perfs

But there appears to be a limit to these gains, as early results at tighter density (Red - ~4 m between perfs) are uncertain but have trended backwards.

Do tighter perforations start to trend toward open-hole results and less fracture complexity?
Splitting results from the East Basin by Perforation density...
WESTERDALE RESULTS TREND

• Though not definitive binned results for Westerdale show improved results from NE to SW
• Mineralogy and interbedded hybrid system supporting improved results?
  – Or is it just Higher maturity with depth
  – Or just randomness and small sample size?
Note that despite the growth in sand intensity in the West Basin, to date the East Basin has remained relatively timid in its completions.
PACE SETTING OIL WELLS TO DATE
(*WITH COMPLETION DATA AVAILABLE)

Pace setting wells
00/05-09-065-20W5,
00/07-11-039-28W4,
02/14-06-032-24W4
compared to other Kaybob Results to date
THERMAL MATURITY IS NOT 1:1 WITH DEPTH

- Expected hydrocarbon type follows depth somewhat, but there are other controls which impact thermal maturity
THERMAL MATURITY IS NOT (ALWAYS) 1:1 WITH DEPTH

- Early indications in the East Basin (via GOR and API measurements) suggest a strong correlation with depth
BESIDES API, CAN MATURITY PREDICT WATER?

CAVEAT ALERT - SMALL SAMPLE SIZE

- Measured API’s in the East Basin appear to show a strong correlation with steady state water-oil ratios
• As with the East Basin, the Niobrara shows interbedded organic source rock with carbonate beds
As with the WCSB, development to Northeast is up dip.
Up dip development shows higher water production.
There appears to be a tipping point with Water cuts at which oil production is significantly inhibited.
Peak oil generation occurs at and \( \sim \) Tmax of 435°C
- This roughly correlates to depths as shown in RED

Strictly generating oil may not be sufficient, maturity may need to be far enough into the oil generation to expel sufficient water to attain commercial thresholds
- The location of this threshold can fluctuate with technology, capital and prices
Along with depth – the following are some learnings from the West Basin which have yet to be fully explored in the East Basin
Where underlying structural highs exist, differences in thermal maturity can occur.

In Kaybob:
- over Swan Hills platform highs the Majeau Lake is thin
- Hypothesis is that Majeau Lake is behaving as an thermal insulator
- Therefore, higher thermal maturity (lower CGRs) in regions of thin Majeau Lake
• Example of Majeau Lake thick and Swan Hills Embayment
  – CGRs of ~400 bbl/mmcf offset by ~200 bbl/mmcf
SNOWBIRD TECTONIC ZONE

- Willesden Green Maturity contours influenced by Snowbird Tectonic zone
- Shown at Resourceful wells in T45-46, R03-04W5
  - NW Trajectory consistently lower CGR compared to SE
Activity to date has been weighted toward the condensate window (100-400 bbl/mmcf)...

But recent activity by 1) Raging River (Baytex), 2) Crescent Point, and 3) the JV of Kiwetinohk and Journey will likely result in increased activity in the oil window.
CONCLUSION

• East and West are different to the point of not being analogs
• East basin maturity is strongly correlated to depth
• Maturity could also have an impact on expected water production
  – Denver Basin Niobrara a better analog than the West Basin?
• Maturity controls learned from the West still need to be explored as we gather more data