Cumulative Regional Water Demand for Hydraulic Fracturing Operations: A Conceptual Scoping Study

Presented By:
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Operations Engineer, E.I.T.

September 16, 2015
QUALIFYING COMMENTS

*Please contemplate this material from Seven Generations Energy Ltd. ("7G") only in the context of this warning.*

This presentation contains information about 7G and the industry in which 7G operates that may be found to be inaccurate with the passage of time. This includes, forward looking information, which involves various risks, uncertainties and other factors, including, without limitation, information pertaining to: estimates of industry water requirements, demand and consumption; forecasted number of wells and lateral length of wells; estimated amount of frac sand required; estimates regarding water recycling, production and recovery; estimates of fossil water resources; and future conditions, potential outcomes and plans.

This presentation also includes qualitative and quantitative judgments and descriptions of factors used in determining potential outcomes, which by their very nature can, and will likely be found to be, inaccurate with the passage of time. In fact, other evaluators likely would have different predictions and different assessments at this time. We believe that this uncertainty is the essence of using new technologies and/or applying established technologies in new ways or to newly developed resources. 7G continues to test, advance, and incorporate different technologies with the goal of minimizing and balancing cumulative environmental impacts, maximizing resource recovery and providing the best economic returns for our investors. Technologies that 7G believes will accomplish this today will invariably change tomorrow as technology and innovation advance.

7G has drawn information from various sources and taken into consideration the judgment and experience of its own employees and consultants to prepare this presentation. From the myriad of sources of information and evaluation techniques that are available, we have chosen a subset which may or may not have the result of producing estimates and forecasts which all parties would agree are appropriate and/or rigorous, in the circumstances. We, are satisfied that the information contained herein is thorough and accurate; however, time may prove us to be in error.
AGENDA

- Introduction
  - Who is Seven Generations Energy?
  - Development area/region
  - The plan for water sources

- Potential Development Water Needs
  - Smoky/Wapiti sub-watershed
  - Area being assessed & well density range
  - Well design & water requirements per well range
  - Water volume demand for the entire development

- Fresh Water Resources
  - Recycling flowback & produced water
  - Surface water – Smoky river basin
  - Fossil water resources – Basal Belly River

- Comparing Supply & Potential Demand of Water Resources in the Area
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• Comparing Supply & Potential Demand of Water Resources in the Area
WHO IS SEVEN GENERATIONS ENERGY?
WHAT OUR NAME MEANS.....

"In every deliberation, we must consider the impact on the seventh generation... even if it requires having skin as thick as the bark of a pine."

An ecological concept that urges the current generation of humans to live sustainably and work for the benefit of the seventh generation into the future. It originated with the Great Law of the Iroquois - which holds appropriate to think seven generations ahead and decide whether the decisions made today would benefit the seventh generation.
WHO IS SEVEN GENERATIONS ENERGY?

- Independent petroleum company acquiring, developing and optimizing liquids rich tight gas resource plays
- Publicly traded on TSX (VII)
- Single focus area: Kakwa River Project
DEVELOPMENT AREA

www.google.ca/maps/@54.6857442,-118.7133885,9.5z
WHAT’S THE PLAN FOR WATER SOURCES?

• You don’t start with a plan, you start with an idea.
• A plan is something that you develop together with all of the stakeholders.
• This conceptual scoping study is intended to re-frame assumptions around old ideas in the public dialogue around sourcing water for hydraulic fracturing operations.
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SMOKY/WAPITI SUB-WATERSHED

http://www.mightypeacesow.org/subwatersheds.html
AREA BEING ASSESSED

- Grande Prairie
- Wapiti River
- Smoky River
- Partial Smoky River Basin: ~5,000 sections
- Montney Development: ~3,750 sections

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### AREA BEING ASSESSED & WELL DENSITY RANGE

- **Partial Smoky River Basin:**
  - ~5,000 sections
- **Montney Development:**
  - ~3,750 sections

<table>
<thead>
<tr>
<th>Estimates</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sections</td>
<td>1,500</td>
<td>3,750</td>
</tr>
<tr>
<td>Well density [wells/section]</td>
<td>12</td>
<td>20</td>
</tr>
<tr>
<td>Wells (1600m laterals) in area</td>
<td>18,000</td>
<td>75,000</td>
</tr>
<tr>
<td>Hz meters drilled [x 10^6 m]</td>
<td>28.8</td>
<td>120</td>
</tr>
</tbody>
</table>
### WELL DESIGN & WATER REQUIREMENTS PER WELL RANGE

~ 2 – 39 million m³/year of water to develop shaded green area over ~40 year life cycle

<table>
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<tr>
<td>Hz meters drilled [x 10⁶ m]</td>
<td>28.8</td>
<td>120</td>
</tr>
<tr>
<td>Frac sand [t/m]</td>
<td>0.75</td>
<td>3.00</td>
</tr>
<tr>
<td>Sand required* [x 10⁶ t]</td>
<td>21.6</td>
<td>360</td>
</tr>
<tr>
<td>Water for SW frac (6.9m³/t) [x 10⁶ m³]</td>
<td>74.5</td>
<td>1,242</td>
</tr>
<tr>
<td>Water for N₂ frac (1.7m³/t) [x 10⁶ m³]</td>
<td>18.4</td>
<td>306</td>
</tr>
<tr>
<td>Total water [x 10⁶ m³/40 years]</td>
<td>92.9</td>
<td>1,548</td>
</tr>
<tr>
<td>Total water [x 10⁶ m³/year]</td>
<td>2.3</td>
<td>38.7</td>
</tr>
<tr>
<td>Olympic pools (~2500 m³) [/year]</td>
<td>929</td>
<td>15,480</td>
</tr>
</tbody>
</table>

* Assumes the industry uses 50% slickwater (SW) fracs and 50% N₂ foam fracs.

~ 2 – 39 million m³/year of water to develop shaded green area over ~40 year life cycle.

Montney Development

Partial Smoky River Basin
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  - Water volume demand for the entire development

• **Fresh Water Resources**
  - Recycling flowback & produced water
  - Surface water – Smoky river basin
  - Fossil water resources – Basal Belly River

• **Comparing Supply & Potential Demand of Water Resources in the Area**
FRESH WATER RESOURCES

RECYCLING FLOWBACK WATER AND PRODUCED WATER
RECYCLING FLOWBACK WATER & PRODUCED WATER

Considerations:

• Environment
  • Saline water spills are very difficult to clean up
  • Storage
  • Transportation
  • Greenhouse gas emissions
  • Waste stream – only fluid volume reduced, not solid waste

• Safety
  • Potential for naturally occurring radioactive materials (NORMs) and residual hydrocarbons
  • Bacteria – potential for H₂S

• Well performance (impact on reservoir/production)

• Chemicals

• Materials

• Regulations

• And more...
RECYCLING FLOWBACK WATER & PRODUCED WATER

Water recovered post injection over life cycle of a well:

Flowback Water + Produced Water
Water Injected During Frac

= ~40%

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<td>Volume recovered from well [x 10^6 m^3/year]</td>
<td>0.9</td>
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**RECYCLING FLOWBACK WATER & PRODUCED WATER**

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Total Dissolved Solids (TDS) = 100,000 mg/L

**WASTE:**

- 60-90% sent to disposal
- TDS = 200,000 mg/L

**FRESH WATER:** 10-40% re-usable
- TDS = 1,000 mg/L

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<tr>
<th>Estimates</th>
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<th>Max</th>
</tr>
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<tbody>
<tr>
<td>Volume of fresh water ‘recovered’ from well [%]</td>
<td>4</td>
<td>16</td>
</tr>
<tr>
<td>Volume of fresh water ‘recovered’ from well [x 10^6 m^3/year]</td>
<td>0.1</td>
<td>6.2</td>
</tr>
<tr>
<td># of wells produced to recover frac volume for 1 well</td>
<td>25</td>
<td>6.25</td>
</tr>
</tbody>
</table>
SURFACE WATER
SURFACE WATER – SMOKY RIVER BASIN

SURFACE WATER – SMOKY RIVER BASIN

Wapiti at Smoky
~2,698 x 10^6 m^3/yr

Avg Smoky at Peace
- Avg Little Smoky at Smoky
- Avg Simonette at Smoky
- Avg Wapiti at Smoky

Avg Smoky before Wapiti
or
11,000 x 10^6 m^3/yr
- 1,251 x 10^6 m^3/yr
- 865 x 10^6 m^3/yr
- 2,698 x 10^6 m^3/yr

~6,186 x 10^6 m^3/yr

Smoky at Peace
~11,000 x 10^6 m^3/yr

L. Smoky at Smoky
~1,251 x 10^6 m^3/yr

Simonette at Smoky
~865 x 10^6 m^3/yr


www.mightypeacesow.org/surface-quantity.html

wateroffice.ec.gc.ca/index_e.html, 07GE001, Average across 2000-2011

wateroffice.ec.gc.ca/index_e.html, 07GH002, Average across 1971-1986

wateroffice.ec.gc.ca/index_e.html, 07GH001, Average across 2000-2011
SURFACE WATER – SMOKY RIVER BASIN

- Avg Smoky before Wapiti
  - 11,000 x 10^6 m^3/yr
  - 1,251 x 10^6 m^3/yr
  - 865 x 10^6 m^3/yr
  - 2,698 x 10^6 m^3/yr
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- Avg Smoky at Peace
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  ~11,000 x 10^6 m^3/yr

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  ~1,251 x 10^6 m^3/yr

- Simonette at Smoky
  ~865 x 10^6 m^3/yr

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## SURFACE WATER – SMOKY RIVER BASIN

<table>
<thead>
<tr>
<th>Estimates</th>
<th>SUPPLY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Smoky River flow below Wapiti River [x 10^6 m³/year]</td>
<td>6,186</td>
</tr>
<tr>
<td>Average Smoky River flow below Wapiti River [x 10^6 m³/day]</td>
<td>16.9</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Estimated total water demand</th>
<th>DEMAND</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Min</td>
</tr>
<tr>
<td>Total water [x 10^6 m³/year]</td>
<td>2.3</td>
</tr>
<tr>
<td>Total water [days of avg daily Smoky River flow/40 years]</td>
<td>5.5</td>
</tr>
<tr>
<td>Total water [days of avg daily Smoky River flow/year]</td>
<td>0.1</td>
</tr>
<tr>
<td>Total water [mins of avg daily Smoky River flow/day]</td>
<td>0.5</td>
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</table>
FRESH WATER RESOURCES

FOSSIL WATER RESOURCES
FOSSIL WATER RESOURCES

Fossil water:
- Cretaceous age sediments and older
- often > 600 m below ground surface

Possible Options – Belly River & Cardium Formation
- Variable Deliverability
- Large water resources magnitude
- Chemistry compatible with well construction
- Isolated from surficial waters
- Regulatory challenges for stimulation use (due to saline/non-saline classification)
FOSSIL WATER RESOURCES – BASAL BELLY RIVER

http://cnx.org/contents/c9e55045-eb05-4176-ae02-39e0ce01bf51@5/Water-Cycle-and-Fresh-Water-Su
# FOSSIL WATER RESOURCES – BASAL BELLY RIVER

## Estimates

<table>
<thead>
<tr>
<th>Supply Parameter</th>
<th>Supply [x 10^6 m^3/section]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basal Belly River (Bsl BLRV) supply</td>
<td>7.8</td>
</tr>
<tr>
<td>Bsl BLRV recharge</td>
<td>0.05</td>
</tr>
<tr>
<td>Total Wapiti Group (WPTI GRP) supply</td>
<td>184.3</td>
</tr>
</tbody>
</table>

## Demand

<table>
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<th>Demand Parameter</th>
<th>Demand Min</th>
<th>Demand Max</th>
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<td></td>
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<tr>
<td>Total water [x 10^6 m^3/section]</td>
<td>0.06</td>
<td>0.4</td>
</tr>
<tr>
<td>Total water [% of confined (Bsl BLRV) aquifer/section]</td>
<td>No recharge</td>
<td>0.8</td>
</tr>
<tr>
<td>Total water [% of unconfined (WPTI GRP) aquifer/section]</td>
<td>No recharge</td>
<td>0.03</td>
</tr>
<tr>
<td>Total water [% of unconfined (WPTI GRP) aquifer/section]</td>
<td>Recharge</td>
<td>0.1</td>
</tr>
<tr>
<td>Total water [% of unconfined (WPTI GRP) aquifer/section]</td>
<td>Recharge</td>
<td>0.004</td>
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## COMPARING VOLUME OF WATER SUPPLY AND DEMAND

<table>
<thead>
<tr>
<th>Estimates of demand</th>
<th>Min</th>
<th>Max</th>
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<td>Total water [x 10^6 \text{ m}^3/\text{year}]</td>
<td>2.3</td>
<td>38.7</td>
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### RECYCLING

| Volume of fresh water recovered from well \[x 10^6 \text{ m}^3/\text{year}\] | 0.1  | 6.2  |

### SURFACE WATER

| Total water \[\text{days of avg daily Smoky River flow/40 years}\] | 5.5  | 91.4 |
| Total water \[\text{days of avg daily Smoky River flow/\text{year}}\] | 0.1  | 2.3  |
| Total water \[\text{mins of avg daily Smoky River flow/\text{day}}\] | 0.5  | 9    |

### FOSSIL WATER

| Total water \[% of confined (Bsl BLRV) aquifer/section\] | No recharge | 0.8  | 5.3  |
| Total water \[% of unconfined (WPTI GRP) aquifer/section\] | Recharge    | 0.1  | 4.6  |
| Total water \[% of unconfined (WPTI GRP) aquifer/section\] | No recharge | 0.03 | 0.21 |
| Total water \[% of unconfined (WPTI GRP) aquifer/section\] | Recharge    | 0.004| 0.19 |
CONCLUSIONS

Water use and sources for water need to be considered in the context of

- Initial estimates suggest that the gas industry’s potential fresh water needs are probably within the carrying capacity of the fresh water resources of the overlying region.
- Fossil water, particularly Cretaceous Belly River and Cardium zones, add an additional zone worth considering.
- Surface storage and seasonal retention and point of source management are required to assure that water withdrawals are not damaging to the fresh water ecosystems of the region.

Water recycling needs to be considered in the context of

- Effect of recycled water chemistry on stimulated well performance and thereby the number of wells required to optimally drain the land and the rate of gas production achievable.
- The environmental impacts and risks associated with increased handling of saline produced water and concentrated brine or dehydrated solids produced from the recycling processes available.
- Greenhouse gas emissions relative to emissions without water recycling.
- The water disposal capacity of the region.
Acknowledgements:
John Aoun, Pat Carlson, Glen Nevokshonoff, Bob Riopel, Morteza Nobakht, Mike Carlson

Questions and Discussion