

**Application 1409180
Application 1394112
Application 1481725**

Canadian Natural Resources Limited ("Canadian Natural") Opening Statement

Canadian Natural produces both gas and thermally recovered bitumen and, as a consequence, has participated in past regulatory hearings pertaining to gas production associated with McMurray Formation bitumen the results of which have required that some of its gas production be shut-in. Canadian Natural recognizes that in the public interest it is prudent to produce bitumen prior to gas in order to optimize resource recovery. Gas must be shut-in until the bitumen is first recovered or the bitumen may never be recovered. Today, Canadian Natural finds itself applying to have gas wells shut-in due to a threat to Alberta's bitumen resource. In this, and in past regulatory proceedings, Canadian Natural is committed to all stakeholders receiving a fair hearing and to resources being conserved for optimal ultimate recovery. To this end, Canadian Natural has shut-in those of its own gas wells producing from the Clearwater Formation in the Primrose area to protect the recoverability of the bitumen.

Canadian Natural is making application to have this Board shut in 20 gas wells, 2 of which are our own (which we have already shut-in), and 18 of EnCana's gas wells that are currently producing from the Clearwater Formation (Application 1409180). Canadian Natural also opposes EnCana's Application 1394112 for approval to produce gas from the Clearwater Formation through well 100/ 14-31-68-4 W4M.

It follows from the position stated above, that Canadian Natural is supportive of Husky's (Husky Oil Operations Limited) application (Application 1481725) to shut-in ten

additional wells from which EnCana is currently producing gas from the Clearwater Formation.

Figure 6.1 from Canadian Natural's Evidence Submission of July 4, 2006 , now being displayed, shows that the regions of influence negatively impacting bitumen recovery (in pink) from producing the gas pools are already impacting significant volumes of bitumen in current and future development areas. If gas production continues these regions of influence will only grow and the impact to the bitumen will increase.

The evidence submitted by Canadian Natural in this proceeding establishes four tenets that we submit should guide the Board in making the decision to shut-in gas production from the Clearwater Formation from the 18 EnCana wells that are the subject of this proceeding until the Clearwater bitumen has been recovered:

1. gas and bitumen within the Clearwater Formation are in pressure communication;
2. production of gas caps within the Clearwater Formation is removing solution gas from the Clearwater bitumen;
3. active solution gas drive is required for economic Clearwater Formation bitumen recovery schemes; and
4. The 18 EnCana gas wells, which are the subject of this application and are currently producing from the Clearwater Formation, are degassing the Clearwater bitumen, removing solution gas drive and thereby negatively impacting future Clearwater bitumen recovery

The following is a brief summary of the evidence that Canadian Natural submits in support of these tenets:

1) Gas and bitumen within the Clearwater Formation are in pressure communication

- a) Field data from piezometers confirms that gas production has drawn down bitumen pressure by hundreds of kPa's in only months and the magnitude of this pressure decline will increase with time
 - o The updated pressure plot for 10-32-68-4 W4M, found in Appendix F of Canadian Natural's Information Response to Board Staff dated August 15, 2006 and now displayed illustrates rapid pressure transmission through the Clearwater bitumen zone

- b) Pressure communication through the Clearwater bitumen zone implies a mobile water phase
 - o Figure 3.1 of Canadian Natural's, July 4, 2006 Evidence now displayed illustrates this rapid pressure transmission through the Clearwater bitumen zone. In this example, a piezometer instrumented observation well located 80 m laterally from a horizontal CSS well, detects within days the pressure of cycled steam injection into the CSS well (thin blue lines the cycled steam, observation well pressure response in the bold blue line). This is irrefutable evidence of the very effective transmission of pressure through the bitumen-bearing sand of the Blue valley.

- c) There is hydraulic continuity over large regions within the area embodying the gas pools in question
- o Figure 4.3 of Canadian Natural's July 4, 2006 Evidence here displayed illustrates the linear relationship between pressure and depth (m ASL) that indicates hydraulic continuity
- d) The geological nature of the bitumen-producing Clearwater Formation, that contains multiple cross-cutting relationships at varying scales, precludes the isolation of pressure between gas caps and economic bitumen by regionally laterally continuous mud beds acting as seals
- o Figure 2.2 of Canadian Natural's July 4, 2006 Evidence (now displayed) is a composite schematic that we have prepared based on the analysis of core obtained from hundreds of wells with a general density of at least 4 wells per section. Interpretation of this core shows the Clearwater Formation to be comprised of a number of stacked, locally incised paleovalleys which truncate any muddy facies (such as facies assemblages C & D) that might otherwise be laterally extensive enough to act as regional seals to pressure and exsolved gas migration. In addition, core interpretation shows that the depositional environments within the valleys consists of numerous tidal and estuarine channel incisions that further precludes the existence of any effective mud seals within the valleys.

We point out that there appears to be general acceptance of this geological model amongst the industry stakeholders in this regulatory proceeding. For example, the geological model used by EnCana in its

reservoir simulations contains shale barriers in places but not as regionally continuous seals. We draw the Board's attention to Figure E.2 in EnCana's Sept 05, 2006 submission in Application 1409180. Of the detailed distribution of facies, which include interbedded sands and muds, EnCana states that:

“While EnCana believes that such work is extremely important to the design of any thermal project, it is not critical to any of the issues before the Board.”

That quote is found at Page 2 of EnCana's response to Husky's IR in Application 1481725 dated Feb 5, 2007.

Husky states that its:

“regional facies distribution reflects an interpretation of the reservoir as an Incised Valley System...”

This quote is found at pg. 9 of Husky's Reply Evidence dated January 30, 2007.

Husky further states:

“We also concur with the CNRL statement that: the interpretation of valley sediment fill is not critical to the impact of gas production on bitumen recovery....”

This quote is found in Husky's Response to Board Staff IRs dated Oct 03, 2006.

In summary the field data and the geological model confirm tenet 1, that the gas caps are in pressure communication with the bitumen.

2) Production of gas caps within the Clearwater Formation is removing solution gas from the Clearwater bitumen

- a) Gas production from the pools in question exceeds the volume of the OGIP (original gas in place) and the volumetrics are relatively well constrained by the density of wells and seismic
- b) P/Z values from the gas pools in question predict that gas production will exceed the OGIP
- c) Some P/Z trends show curvature over time indicating that there is already pressure support from solution gas
- d) Some piezometers exhibit pressure increases due to bitumen swelling which is consistent with data in the literature now displayed:

- Figure 5 of Batycky et al., 1997 (included in CNRL response to AEUB IR, Aug 15, 2006) illustrates pressure increases (spikes) during production due to bitumen swelling just prior to exsolving gas
- Figure 5.5 (Canadian Natural's Submission of Evidence, July 4, 2006) also illustrates a pressure increase in a bitumen-bearing well due to bitumen swelling and gas exsolution as a result of the nearby Fisher E gas pool being produced

Material balance, decline analysis and volumetrics confirm that solution gas must be evolving from the bitumen beyond the zero edge of the gas cap.

3) Active solution gas drive is required for economic Clearwater Formation bitumen recovery schemes

At this point we must emphasize the importance of solution gas drive in Clearwater bitumen recovery and distinguish such from the recovery of McMurray Formation bitumen. In CSS used to recover Clearwater bitumen, gas is a major drive mechanism whereas in SAGD, used to recover McMurray bitumen, gravity is the critical drive mechanism.

Field observations that support the importance of solution gas drive in CSS include:

- a) Direct observation of bitumen shrinkage as gas comes out of solution. This provides irrefutable evidence of dissolved gas existing in the bitumen and implies that it must exert pressure to “drive” the bitumen during recovery
- Here we display Figure 1.1 of Canadian Natural’s July 4, 2006 Evidence that shows shrinkage of almost 50% in a wellhead sample taken during a late stage production phase of a cycle when gas drive is expected to be dominant.
- b) Stable gas / oil ratios (GOR’s) during CSS production necessitate the ongoing generation of gas as it exsolves from the bitumen being produced. It is a general reservoir engineering principle that whenever produced GOR is greater than the initial solution GOR, it is indicative of solution gas drive as a component of production.
- Here we display Figure 1 of Batycky et al., 1997 that is included in CNRL’s response to an AEUB IR (Aug 15, 2006). This Figure shows a sustained production GOR over a production phase of several months.
 - We now display Figure 6 of Canadian Natural’s Reply Evidence dated January 29, 2007 that also illustrates stable producing GOR plotted against pore volumes of steam injected for two horizontal CSS well pads
- c) Low, long term producing pressures associated with late stage producing phases of individual CSS cycles are maintained by solution gas continuously exsolving. In this respect we will now display the following:

- Figures 1 and 5 of Batycky et al., 1997 (included in CNRL response to AEUB IR, Aug 15, 2006) show the extended nature (months to years) of late production phases
 - Figure 1 of Canadian Natural's July 25, 2006 response to EnCana's IR illustrates the late stage producing phase or "tail" production (extending for 10 months in this example)
 - Figure 3 of Canadian Natural's response to EnCana's IR of Feb 14, 2007 illustrates sustained low pressure support from exsolving gas during CSS production
- d) In cases where bitumen does not contain significant dissolved gas, such as with the McMurray bitumen, CSS performance is much less effective
- This is illustrated in Figure 6 of Canadian Natural's Feb 14, 2007 response to an EnCana IR. Figure 6 shows the lack of effectiveness (cum SOR of ~12) of CSS in McMurray bitumen recovery

In addition to the field evidence described above, the literature (included in CNRL response to AEUB IR, August 15, 2006) contains further support for solution gas drive in the form of laboratory models and simulations:

Batycky et al., 1997 demonstrates from physical models and some simulations that solution gas contributes up to 50% oil recovery.

Denbina et al. 1987 presents simulations that indicate a role of solution gas contributing over 20% of CSS oil recovery.

Frauenfeld et al. 1988 presents results of physical models in which live-oil experiments produced significantly more oil than dead-oil experiments reflecting the importance of gas drive to the performance of thermal recovery processes

- We now display Figures 5 & 6 from that paper which show over 50% decrease in oil recovery with dead-oil compared to that with live-oil

The evidence from field observation, mechanistic physical models, and from previous CSS simulation indicates that an active solution gas drive is a crucial part of CSS bitumen recovery.

4) EnCana's 18 producing gas wells within the Clearwater Formation are degassing the Clearwater bitumen, removing solution gas drive and thereby negatively impacting future Clearwater bitumen recovery

- a) Physical models indicate up to a 50% negative impact of removing solution gas
 - As an example, we display Figure 8 from Batycky et al., 1997 which illustrates the results of 3D physical models showing up to a 50% decrease in recovery from dead-bitumen compared to live-bitumen

- b) The CSS field experiments in the McMurray bitumen at Hangingstone illustrates that where bitumen does not contain significant dissolved gas, CSS performance is much less effective
 - o We display Figure 6 of Canadian Natural's Feb 14, 2007 response to an EnCana IR which shows the lack of effectiveness, with a cum SOR of ~12, of CSS in McMurray bitumen recovery

- c) Properly calibrated simulations suggest a 20 – 45% negative impact on CSS by removing solution gas

Canadian Natural believes that field evidence and other supporting data from physical models and simulations in the literature are so compelling that there is little need to conduct additional simulations and therefore none were included in its original submission of evidence. However, EnCana's submission of a simulation to suggest that there was no impact of gas cap production on bitumen recovery obliged Canadian Natural to explore the validity of EnCana's simulation argument.

EnCana's simulations attempt to illustrate the effect of gas cap production on the performance of bitumen recovery using CSS. Canadian Natural has, however, identified serious flaws in EnCana's simulations which are most effectively shown through a graphical presentation.

EnCana's simulation with no mud barrier (run ED-1 in EnCana's submission to Application 1409180, Sept 5, 2006), that we are now viewing, clearly illustrates very little transmission of pressure from the gas cap through the bitumen zone to the CSS well. Note that there is no colour (i.e. pressure) change in the graphic anywhere close to the CSS wellbore and therefore it is not surprising that there would be no impact on the CSS well performance; an entirely erroneous conclusion based on an inaccurate model.

In real data, we do see a pressure decrease being transmitted through the bitumen-bearing intervals from that occurring within a produced gas cap. In the current display, we see the location of well 10-32-68-4 W4M about 1 km west of the nearest gas pool edge (Figure 5.1 of Canadian Natural's July 4, 2006 Submission of Evidence). The updated pressure plot for 10-32-68-4 W4M, (found in Appendix F of Canadian Natural's Information Response to Board Staff dated August 15, 2006), and now displayed, illustrates a rapid pressure decline due to pressure transmission from the gas pool to the pressure monitoring well in the Clearwater bitumen zone.

EnCana's simulations of the Husky Caribou area are flawed in that gridblock dimensions chosen are not capable of simulating the processes that are critical to determining whether gas production negatively impacts bitumen recovery. The choice of gridblock size severely limits the simulation's ability to model the sharp temperature and pressure gradients that occur near CSS wellbores and influence their performance. This in part explains the unrealistically high predicted SOR's of about 20 as currently displayed in an un-numbered figure on page 4 of EnCana's reply to a Husky IR, January 25, 2007. Actual SOR's are on the order of 3 – 4 and even situations where little to no gas drive is

expected as in the McMurray Formation bitumen, cumulative SOR's of unsuccessful CSS have been on the order of 12.

An additional flaw in EnCana's simulations is an unrealistic premature truncation of CSS oil production in every cycle. Note in Figure 8 (Canadian Natural response to EnCana IR, Feb 14, 2007), now being displayed, that EnCana's simulation (pink line) artificially stops production, whereas more realistic oil production (green line) continues for many more months. By such premature truncation, a major portion of oil production due to the solution drive mechanism is excluded resulting in unrealistic production profiles.

Canadian Natural has demonstrated how the EnCana models have been artificially manipulated. By extending the production phase to include the solution gas drive portion of the cycle, and initializing the models at a depleted solution GOR state, even these models can show that solution gas drive is important to CSS recovery. See Figure 9 of Canadian Natural's response to EnCana IR, Feb 14, 2007, and Figure 10 of Canadian Natural's response to EnCana IR, Feb 14, 2007.

Simulations must be validated by being ground truthed to field evidence. The lack of ground truthing of EnCana's simulation completely invalidates any conclusions drawn from their results and cannot be used to support any further gas production from the wells being considered in this proceeding.

Contrary to EnCana's simulation practice, Canadian Natural's simulation was first matched and calibrated to actual field data (displayed in Figure 9 of Canadian Natural's Reply Evidence, Jan 29, 2007 where simulated oil production matches actual), and then

used to test the sensitivity to changing parameters such as pressure and associated solution GOR's that are known to change and migrate through bitumen-bearing intervals. This is a much more credible approach to using simulations which shows the significant negative impact to bitumen recovery by the removal of solution gas (see Figure 10 of Canadian Natural's Reply Evidence, Jan 29, 2007 where bitumen recovery degrades by 22% because of degassing the bitumen down to an initial solution GOR of 1).

Conclusion

In conclusion, field evidence, literature including physical models and simulations, our own history matched simulations, once ground truthed to field evidence, all point to a negative impact on CSS bitumen recovery as a result of the removal of solution gas through production of the Clearwater gas caps in question. Though these data indicate a negative "technical" impact of 20 – 50%, this loss of efficiency will translate to a 100% effective loss as the technical impact will render the resource uneconomic.

It is therefore imperative that Clearwater gas production from the 18 wells under consideration in this application be shut-in immediately until the Clearwater bitumen has been recovered.