ALBERTA ENIRONMENT STANDARD FOR BASELINE WATER WELL TESTING FOR CBM OPERATIONS

SCIENCE REVIEW PANEL
FINAL REPORT

Alberta Environment

BASELINE WATER WELL TESTING (BWWT) FOR CBM OPERATIONS

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1.0 BACKGROUND

The *Baseline Water Well Testing Program* was initiated by Alberta Environment (AENV) as a consequence of the *Coalbed Methane/Natural Gas in Coal Final Report* prepared by the CBM/NGC Multi-Stakeholder Advisory Committee (MAC) in January 2006 (available at www.energy.gov.ab.ca/245.asp). Specifically the first two items in Recommendation 3.3.6 of the Final Report stated that "AENV and ERCB should develop a water well testing program, as follows":

- CBM/NGC operators should be required to offer baseline testing (as described in Recommendation 3.3.5) of all nearby water wells within a specified distance of a proposed CBM/NGC well to be completed above the Base of Groundwater Protection. No consensus was reached on an appropriate distance or depth of completion.
- The information from the baseline testing should be filed by operators in an open, public registry to enhance understanding of Alberta's groundwater system.

The related points in Recommendation 3.3.5 state that "AENV and the Energy Resources Conservation Board (ERCB) should work with stakeholders, including the environmental service industry, to develop standard procedures and reporting requirements for the sampling, analysis and monitoring of both saline and non-saline water quality and quantity for CBM/NGC wells and potentially affected non-saline water wells. Quality assurance and quality control measures should be developed, as well as a range of tests, depending on the type of water being tested, including:

- Testing for a variety of metals and other impurities, as well as total dissolved solids.
- Testing for the presence of gas in water wells. The presence or lack of gas should be included on the water analysis report or file".

The ERCB's Directive 035 "*Baseline Water Well Testing Requirement for Coalbed Methane Wells Completed Above the Base of Groundwater Protection*" (available at www.ercb.ca/docs/Documents/directives/Directive035.pdf) made baseline water well testing mandatory for companies initiating CBM development above the base of groundwater protection after May 1, 2006.

Alberta Environment's "*Standard for Baseline Water-Well Testing for Coalbed Methane/Natural Gas in Coal Operations*" became effective on May 1, 2006. Gas sampling requirements for the Standard were clarified in June 2006, and a revised electronic template for submitting the results of water well testing was made available in February, 2007. The Standard and related documents are available at www.waterforlife.gov.ab.ca/coal/index.html.

A Science Review Panel was struck to evaluate the Baseline Water Well Testing Program with the goal of ensuring that the Standard was effectively obtaining consistent baseline data on groundwater to ensure the protection of groundwater resources and the environment. The Panel's mandate was to:

- Review collected baseline water well data, research relating to baseline testing, feedback from industry and landowners, and information on baseline testing from other jurisdictions (e.g. Colorado) to evaluate the effectiveness of the Standard.
- Identify information gaps.

- Review the progress and provide recommendations on any enhancements to the Standard or in the manner in which baseline data is collected, stored, and evaluated.

The Panel submitted an interim report to AENV on July 31, 2007. AENV provided a detailed response to the interim report on March 11, 2008 and gave a database demonstration on May 30, 2008. The Panel met on seven different occasions in addition to email and telephone conversations to conduct its task. A review of baseline testing in other jurisdictions was not conducted. This report constitutes the final report of this Panel.

2.0 BRIEF UPDATE ON BASELINE WATER WELL TESTING PROGRAM

As of December 2007, the Baseline Water Well Testing (BWWT) Program database included 4349 entries from water wells located predominantly between Calgary and Edmonton. This region is already heavily drilled for conventional oil and gas wells. The region also has some CBM wells that were completed before the initiation of the BWWT Program on May 1, 2006. Considering this pre-existing resource extraction activity, BWWT samples are not necessarily 'true baseline', or pristine, samples of un-impacted groundwater. In reality the BWWT samples may represent groundwater that has been impacted by previous petroleum exploration and development activities, early CBM activities, and/or other anthropogenic impacts.

Although the 4349 BWWT samples were collected in all seasons by different agencies, and were analysed by different labs, it is worthwhile to broadly summarize the data here. Water quality data were available for about 4181 of the BWWT entries in December 2007. Of these entries, gas compositional data were submitted for 704 (or 17%) of the entries. Of the 704 gas compositional analyses submitted, 671 had detectable methane, 143 had detectable ethane, and 5 had detectable propane. Also, 140 of 4181 well waters had quantitatively reported *E. coli* or fecal coliform, and an additional 240 of the 4181 well waters had detectable *E. coli* or fecal coliform (in the latter case, only presence or absence were reported).

Overall the Panel is pleased that AENV has successfully initiated the Baseline Water Well Testing Program. The major AENV contribution to this effort has been data collation and input into an appropriate database. This database is now substantially up-to-date, and the database contents and structure appear to be suitable for scientific investigation, public distribution, and use by regulators. Although this report recommends some further refinements to the gas sampling Standard and database management, on the whole, the Panel is satisfied with the progress to date.

3.0 RECOMMENDATIONS

1. ***The ERCB and AENV need to develop an audit process to ensure all tests committed to in the D035 process are conducted and the results submitted to AENV.*** This recommendation was included in the interim report, and is re-emphasized here because a cursory audit of isotopic analyses conducted by one of the university labs showed that 13 of 37 samples analysed did not appear in the BWWT database. This is thus an

important issue. The need for an audit process, and the perception by the public of regulatory rigour, is self-evident.

2. ***The ERCB must develop a complementary or sister database containing the composition and isotopic composition of produced gases, gases in co-produced waters, and surface casing vent flows.*** This would permit direct comparison of water well gases to CBM well gases, allowing regulators to be proactive, rather than reactive, to well complaints. These samples could be collected inexpensively during drilling (e.g., by degassing canistered coal chips recovered while drilling), and/or from vent gases.

   The Panel understands that the ERCB requires that at least one "Control Well" be drilled in each township that is subject to CBM exploration or development. Thus, the Panel recommends that such samples must be collected from every "Control Well" drilled. The samples must be in sufficient vertical detail as to quantify the compositional and isotopic characteristics of gas from each major coal seam within that township (e.g. Carbon Thompson, Weaver, Garden Plains, Drumheller, etc).

   The Panel is also of the opinion that there is merit to requiring that CBM companies also submit periodic compositional and isotopic data for gases producing wells (possibly including mixed wells). Existing wells should have isolated samples taken if the company involved sets packers across a section for any reason. If not, co-mingled sampling would be better than none, particularly if a spinner log is also done.

3. ***A consistent approach to free gas sampling is needed.*** There is a clear discrepancy in the fraction of wells sampled that produce free gas between different environmental consulting firms conducing the BWWTs. For instance, as of December 2007, the firm that conducted the largest number of BWWTs (979 tests) found free gas in 24% of the wells sampled. Other firms report even higher fractions. In contrast, the firm that conducted the second largest number (892 tests) of BWWTs found free gas in only 2% of wells sampled. (Note that AENV has notified the latter firm about this observation, and the matter is being dealt with). The Panel notes that many of the samples were collected in overlapping geographic areas and therefore such a large difference in the fraction of wells producing free gas is unlikely to be due to chance. This suggests that the type of gas separator/sampler and/or pressure settings used by different consultants may have a significant effect on whether or not free gas is observed and subsequently analyzed.

   The Panel would prefer to not prescribe a particular sampling technique. However, the Panel strongly recommends that AENV invite consultants to collaboratively develop a standard gas sampling technique that consistently yields representative gas samples from water wells. AENV should facilitate this process by having consultants demonstrate the ability of different sample collection methods to capture representative free gas samples.

4. ***In the absence of observed free gas, no characterization of dissolved gases is recommended.*** The Panel believes widespread dissolved gas sampling is an unnecessary procedure and expense at this point. Although there may be dissolved methane and other gases present in well waters, the primary concern of landowners is the presence or absence of free gas in their water wells. If free gas occurs in a well that did not yield

free gas in the initial BWWT, the Panel recognizes that there would be no information about prior dissolved gas concentrations or isotopic composition available for comparison.

5. ***Data quality assurance and quality control measures (QA/QC) need to be incorporated into the field sample collection procedure to ensure a robust database.*** The Panel recommends that each energy company conducting baseline water well testing should ensure that a reasonable fraction (10% is usual) of wells sampled should have field duplicate, blanks, and/or spike samples with blind submission to the analytical laboratories for each type of analysis for which samples are submitted (e.g. water and gas analyses and isotopic composition). The responsibility for reviewing the QA/QC data should be clearly assigned (i.e. either to the industry or the regulators) and reporting required. Tests that fail to meet QA/QC criteria should be re-sampled in accordance with appropriate due diligence.

   QA/QC is explicitly recommended in Section 3.35 of the 2006 Multi-Stakeholder Advisory Council report, and currently not being conducted. Appropriate QA/QC is a particular issue with isotopic compositions in samples with low concentrations of gases (see below), and is compounded by the free gas sampling issues described above. One simple cross-check for free gas analyses is to ensure that there is not significant oxygen in free gases collected from groundwater with low field-measured dissolved oxygen (as is typical in Alberta groundwater).

6. ***The database should include carbon isotopic compositions of samples with low (e.g. less than 500 ppm of methane, or less than 150 ppm of ethane) concentrations. These data should be flagged, and refer to a footnote that the isotopic values are not precise at low concentrations unless gases are sampled carefully in duplicate, and stored and handled with a 'research level' of care.*** Given the decreasing isotopic precision with decreasing concentration, there is some concern that the isotopic composition could be incorrectly interpreted as thermogenic gas. Experience in the lab shows that in most cases the errors introduced by poor sample handling and/or container integrity lead to bias the isotopic data towards ^{13}C enrichment (e.g. increasing $\delta^{13}C$ values), most notably in methane as well as the other homologues. The Panel does not recommend editing the data out of the database in the interest of transparency, but wants database users to be appropriately informed.

7. ***The accuracy and precision of gas sample concentration analyses conducted to date need to be assessed.*** The gas concentrations currently being measured at commercial labs may be using instrumentation designed to measure the heating value of gases for the oil and gas industry, not trace levels of C1 to C4 gases. The Panel suspects that the accuracy and precision of some reported measurements are questionable for the BWWT purposes. The environmental laboratory industry should be subjected to a controlled inter-laboratory 'ring test' to evaluate the QA/QC of gas compositions.

8. ***Appropriate gas sample collection containers should be used and duplicate samples taken.*** Acceptable free gas sample container types could include electro-polished stainless steel air sampling canisters (most ideal) or FlexFoil grab bags or tedlar bags

(Hirsche and Mayer, 2007). Ideally duplicate gas samples should be collected since occasional leaks are readily identifiable due to atmospheric contamination.

9. ***Gas analyses should***:

   a. ***Be reported in consistent units*** *(e.g. ppm, or milligrams of gas per litre of water).* Since the environmental consulting industry is not particularly familiar with gas analyses and concentrations, a fact sheet should be created to clarify conversion between different reporting units.

   b. ***Have specified maximum detection limits, which should be noted in the reporting.*** The maximum detection limits for most hydrocarbons, including methane, should be 10 ppm.

   c. ***Have concentrations reported "as sampled" and not "air corrected".***

10. ***The inclusion of argon in the gas analyte list should be considered.*** Argon is a useful gas for understanding groundwater flow systems and gas-related geochemistry. Depending on the separation and detection methods being conducted, it may be relatively simple to report Ar concentrations. This possibility should be evaluated.

11. ***The Panel does not see any reason to include further analytes (e.g. metals or additional hydrocarbons (e.g. BTEX, F1/F2)) in the BWWT Standard.*** They do not directly address the issue of CBM impacts on well water quality.

12. ***Pathogen indicators should continue to be included in the BWWT and E. coli should be used exclusively as a pathogen indicator.*** This recommendation is consistent with an increasing number of agencies, including major municipalities supplying water, and the Provincial Lab (where pathogen indicator analyses for rural residents are conducted). The rational for moving towards *E. coli* rather than total or fecal coliform as pathogen indicators is that many total, and some fecal, coliform can have non-fecal sources, making their presence in water misleading.

    The rational for including *E. coli* in the Standard even though it is unlikely to be directly related to CBM activities is that *E. coli* tends to be common in poorly maintained or poorly constructed water wells, which may be related to well functioning and water quality.

13. ***The current requirement that domestic wells within a 600 m radius of a proposed or new CBM well (or the nearest well within 800 m if no wells exist within 600 m) should be maintained.*** Although the 600m distance is somewhat arbitrary, there is no compelling reason to make the radius smaller or larger based on our current scientific understanding of the issues.

14. ***The type of work conducted during Baseline Water Well Testing is specific to, and should be supervised exclusively by, Professional Geologists or Professional Engineers from APEGGA.*** The Panel recognizes that there are some groundwater-related activities conducted by professionals regulated by other agencies (e.g., those permitted under Joint Practice Standard in Completion of Reclamation and Remediation Work in Alberta (Sept 2007)). However, sampling and pump testing of water wells is

typically more specialized than reclamation and remediation, and should be conducted by APEGGA members with appropriate training.

15. ***The requirement for a water well pumping test should be maintained.*** The Panel recognizes that pumping tests are expensive, but recommends that they continue to be required. The Panel notes that the wells should be pumped significantly prior to water sampling and the collection of free gas. Even limited pumping test data are better than none in terms of understanding future changes in well condition and/or production. Two hours of pumping, followed by appropriate of sufficient recovery data (i.e. recovery of 90% of drawdown), is appropriate.

16. ***The BWWT reporting template should include a***:

    a. checkbox to verify that the landowners were notified of any health or safety concerns, or that they declined a test;

    b. required unique identification that links the water well to the associated ERCB license application and energy wells (see item 1 above) included to ensure effective audits can be conducted;

    c. calculated ion charge balance (i.e., without estimating any ion concentrations by difference). The BWWT laboratory reports should be rejected when ion balances are poor (larger than ±10%), the source(s) of error evaluated, and the BWWT sampling conducted again.

4.0 THE PATH FORWARD: ISSUES RAISED BY THE PANEL THAT ARE NOT WITHIN ORIGNAL SCOPE

1. ***The utility of hydrogen isotope ratios of methane in groundwater, and produced gases, gases in co-produced (or formation) waters, and surface casing vent flows to discriminate between different sources and processes (e.g. methane oxidation from CO_2 reduction or from fermentation processes) should be evaluated.*** Preliminary data suggesting that such measurements are useful should be carefully considered. One must note however, that hydrogen isotope analyses of water itself must also be conducted to benefit from the hydrogen isotope analyses of the methane. The Panel notes that Alberta isotope labs are not currently set up to process significant numbers of hydrogen isotope ratio analyses on methane samples, but they are available out-of-province.

2. ***The extent of seasonal and temporal variability of free gas concentrations and isotopic compositions in both deep and shallow domestic wells should be characterized, including the relationship between free gas production in a water well, the volume of groundwater pumped, groundwater levels, etc.*** If seasonal and/or temporal variations are significant, the utility of the database may be questioned. The Panel strongly recommends that the seasonal and temporal variability of concentrations and isotope compositions of free gas in water wells must be investigated.

3. ***As a complement to the Baseline Water Well Testing, at least a limited subset of AENV's Groundwater Observation Well Network (as opposed to domestic wells)***

should also be sampled and monitored for the seasonal and temporal variability of groundwater gas concentrations and isotopic compositions. Domestic wells have long screens and are typically subjected to regular pumping and thus continued local degassing. Unless groundwater monitoring wells are used, it may be difficult to sort out natural processes affecting groundwater gas compositions from the effects of regular water well pumping.

When sampling monitoring wells for gas concentrations, total dissolved gas pressures should be measured during monitoring. Total dissolved gas pressure is directly related to in situ gas concentration. Preliminary data from the Rosebud, Alberta area suggest groundwater gas concentrations are being underestimated by a factor of three when TDGP is not measured (Roy et al., 2008). Although TDGP cannot be easily measured on water wells, it should be considered in groundwater monitoring well sampling programs. TDGP probes are commercially available from a number of suppliers. There may also be an opportunity to evaluate some other groundwater gas sampling devices for monitoring wells.

3.0 LITERATURE CITED

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