

September 30, 2014

7820-4580-32640-02

Peter Cochrane
Leucrotta Exploration Inc.
700, 639 – 5th Avenue SW
Calgary, AB T2P 0M9

Dear Mr. Cochrane:

**RE: PRODUCED WATER DISPOSAL SPECIAL PROJECT APPROVAL
LEUCROTTA SILVERBERRY 06-16-88-20 W6M; WA# 3076
SILVERBERRY FIELD – NORTH PINE “A” POOL**

Oil and Gas Commission staff have reviewed the application, dated July 17th, 2014, requesting approval to dispose of produced water into the Silverberry field North Pine “A” pool via the subject well.

The subject well 06-16-88-20 was drilled in March 1972, completed in the North Pine formation from 1406.9 to 1409.6 mKB, and producing 329.1 e⁶m³ of gas from this single well pool prior to being suspended in May 1994 due to reaching its economic limit. This depleted pool is suitable for the geologic storage of disposal fluids.

Wellbore integrity was examined to verify disposal fluid containment during operation, and following abandonment, with attention to;

1. Potential for groundwater contamination due to surface casing set above probable base of groundwater;
2. Potential for disposal fluid communication with other formations due to lack of cement behind casing in the interval 170 to 949 mKB, and a hole detected in the casing at 868.2 mKB; and
3. Current casing integrity due to corrosion metal losses.

These concerns were communicated to Leucrotta following a pre-application well review, and addressed in detail in the application. Specific approval conditions for monitoring, testing and operational limits will ensure safe and contained disposal into this depleted pool.

Attached please find Order 14-02-009, designating an area in the Silverberry field – North Pine “A” pool as a Special Project under section 75 of the *Oil and Gas Activities Act*, for the operation and use of a storage reservoir for the disposal of produced water and well stimulation flowback fluid. This Order includes a number of detailed operational conditions including: continuous wellhead measurements, a maximum wellhead injection pressure, ultimate reservoir pressure limit, as well as wellbore integrity monitoring and reporting requirements. Disposal wells are subject to regular field inspection and audit. Contravention of a condition of this Order may be subject to enforcement under section 62 of OGAA, or suspension or cancellation of the Order under section 75(2)(b).

Monthly reporting requirement instructions are posted at <http://www.bcogc.ca/node/11152/download>. Additional general information regarding disposal wells is available on the Commission's website at <http://www.bcogc.ca/industry-zone/documentation/Subsurface-Disposal>.

In certain circumstances, disposal well operation may induce seismicity. The Commission advises that disposal well permit holders monitor seismic events in proximity to the well and be prepared to modify operations to mitigate induced seismicity. Permit holders may monitor seismic events through the Natural Resources Canada seismic monitoring network at <http://www.earthquakescanada.nrcan.gc.ca/recent/index-eng.php>

A notice of this application was posted on the OGC website. An objection was received by the Commission regarding the proposed disposal facility servicing this well, concerning suitability for disposal within this area of elevated reservoir pressures. This concern was discussed with the objecting party and has been addressed by the conditions of this approval.

Should you have any questions, please contact Petra Kriescher-Trudgeon at (250) 419-4415 or Ron Stefik at (250) 419-4430.

Sincerely,

A handwritten signature in dark ink, appearing to be 'R. Stefik', is written over a horizontal line.

Ron Stefik, Eng.L.
Supervisor, Reservoir Engineering
Oil and Gas Commission

Attachment

ORDER 14-02-009

1. Under Section 75(1)(d) of the *Oil and Gas Activities Act*, the Oil and Gas Commission (Commission) designates the operation and use of a storage reservoir for the disposal of produced water, including flowback from fracturing operations, into the North Pine A pool – Silverberry field as a special project in the following area:

DLS Twp 88 Rge 20 W6M Section 16 - Lsds 3, 4, 5 and 6.

2. Under section 75(2) of the *Oil and Gas Activities Act*, the special project designation in this Order is subject to the following conditions. The Permit Holder shall:
 - a) Inject produced water, including well flowback completion fluids, only into the well Leucrotta Silverberry 06-16-88-20 W6M; WA# 3076 North Pine "A" pool perforations 1406.9 to 1409.6 mKB.
 - b) Not exceed an injection pressure, measured at the wellhead on the subject well, of 14,600 kPag or the pressure required to fracture the formation, whichever is lesser.
 - c) Inject only through tubing with a packer set as near as is practical above the injection interval.
 - d) Continually measure and record the wellhead casing and tubing pressures.
 - e) Cease injection and notify the Commission immediately if hydraulic isolation is lost in the wellbore or formation.
 - f) Submit the annual packer isolation test report to the Commission within 30 days of the completion of the test.
 - g) Include the disposal operating hours and the maximum injection pressure value on the monthly BC-S18 disposal statement.
 - h) Cease injection upon reaching a maximum formation pressure of 11,580 kPaa.
 - i) Conduct an annual reservoir pressure test on the formation in the subject well, with a shut-in period of sufficient length to provide data for calculation of the reservoir pressure, and submit a report of the test within 60 days of the end of the test.
 - j)
 - i) Perform a casing inspection log to plug back depth on the subject well and submit results to the Commission within 30 days of the completion of logging, at an interval of not more than every 10 years, commencing from the date of initial disposal.
 - ii) Perform an annual hydraulic isolation log on the subject well to plug back depth and submit results to the Commission within 30 days of the completion of logging.
 - k) Not conduct a hydraulic fracture stimulation on any formation in the subject well without prior Commission approval
 - l) Conduct a groundwater monitoring program as detailed in Appendix A.

Advisory Guidance for Order 14-02-009

- I. A production packer must be set above the injection interval and the space between the tubing and casing (including the space between the 3 packers) filled with corrosion inhibiting fluids, as per section 16(2) of the Drilling and Production Regulation.
- II. Annual packer isolation tests are required, as per section 16(3) of the Drilling and Production Regulation.
- III. Injected fluids must be metered, as per section 74 of the Drilling and Production Regulation.
- IV. A monthly disposal statement must be submitted to the Commission not later than the 25th day of the month following the reported month, as per section 75 of the Drilling and Production Regulation.



Ron Stefik, Eng.L.
Supervisor, Reservoir Engineering
Oil and Gas Commission

DATED AT the City of Victoria, in the Province of British Columbia, this 30th day of September 2014.

Order 14-02-009 Appendix A – Groundwater Monitoring Requirements

Leucrotta Silverberry 06-16-88-20 (WA# 3076) Produced Water Disposal

Monitoring Well Locations and Screened Intervals

- One deep and two shallow monitoring wells are required to be installed prior to commencing disposal operations.
- The deep monitoring well shall be screened using a 3 m length screen across the first porous interval containing groundwater below the surface casing (approximately 171 m to 183.6 m depth as indicated by the geophysical log) to allow for a representative groundwater sample from this zone.
- The shallow monitoring wells shall be screened using a 3 m length screen across the water table or at the shallowest porous zone containing groundwater to allow for the collection of a representative groundwater sample from this zone (depth to be determined during drilling).
- The deep monitoring well and one shallow monitoring well shall be installed to the southeast of the well Leucrotta Silverberry 6-16-88-20 WA 3076.
- One shallow monitoring well shall be installed to the northwest of WA 3076.
- All monitoring wells shall be installed within a maximum distance of 50 m from WA 3076, and a minimum distance of 20 m from WA 3076.
- The two monitoring wells on the southeast of the disposal well shall be 3 to 5 m apart.

Requirements for Drilling and Monitoring Well Construction

Drilling and monitoring well construction shall be completed using standard procedures for environmental investigations. Suitable monitoring well design and installation procedures for environmental investigations can be referenced in: *British Columbia Field Sampling Manual for Continuous Monitoring and the Collection of Air, Air-Emission, Water, Wastewater, Soil, Sediment, and Biological Samples (2003)*.

- Monitoring wells shall be drilled, constructed, and abandoned under the supervision of a qualified groundwater professional registered with the Association of Professional Engineers and Geoscientists of BC (APEGBC).
- Monitoring wells shall be drilled, constructed, and abandoned using procedures that mitigate potential impacts to the environment.
- Monitoring wells shall be constructed to allow the collection of representative groundwater samples from the target sampling depth.
- Permit holders shall assess the needs and requirements for blow out prevention prior to drilling and take appropriate measures where applicable.
- If artesian conditions are encountered during drilling, flow shall be adequately controlled.

- Drilling wastes or any water produced shall not be discharged to surface water bodies, cause erosion of land, flooding of neighbouring property, or deposition of sediment into streams.
- Subsurface geological conditions encountered during drilling shall be logged from the ground surface to the total drilling depth, through field observations of samples or drill cuttings, or appropriate geophysical logging, to identify depth intervals of aquifers, porous zones containing groundwater, aquitards, and zones of low permeability.
- Monitoring wells shall be designed and constructed to isolate aquifers and water-bearing zones using appropriately located seals comprised of appropriate sealant.
- The monitoring well riser pipe or casing shall extend at least 0.3 m above the ground surface, if practical.
- The locations and elevations of the top of the riser pipe/casing and the elevation of the ground surface shall be surveyed (elevations relative to geodetic datum, locations in UTM coordinates).
- An effective and permanent surface seal and well cover shall be constructed to prevent contaminants from the surface or shallow subsurface zone from entering the monitoring well or the subsurface, and to protect the monitoring well from damage. Surface seals shall be appropriately placed outside the monitoring well riser pipe or casing, and consist of appropriate sealant, extending from within 0.3 m of the ground surface to a depth of 4.5 m below the ground surface, provided 1 m clearance between the top of the screen is maintained, or 1 m into competent bedrock if bedrock is encountered at depths shallower than 4.5 m.
- Appropriate measures for flood proofing and the prevention of ponded or accumulated water in the vicinity of the monitoring well shall be implemented.
- Monitoring wells shall be registered with the Provincial Wells Database:
http://www.env.gov.bc.ca/wsd/data_searches/wells/
- Upon abandonment, all equipment and materials, including casing, liner, and riser pipe, shall be removed, or if removal is not practical, cut off at least 0.5 m below ground level.
- Upon abandonment, the well/borehole shall be completely filled with appropriate sealant, cement grout, or appropriate backfill materials along its entire length so as to preclude any vertical movement of liquids within the well or in annular space surrounding the outer well casing or between casings, and to seal off water-bearing zones. Materials at the ground surface, up to 0.5 m depth, shall be appropriate for the intended use of the land.
- Well abandonment shall be documented with the well record registered with the Provincial Wells Database.

Groundwater sampling frequency and procedures

Water quality sampling shall be conducted using standard environmental sampling protocols in accordance with the *British Columbia Field Sampling Manual for Continuous Monitoring and the Collection of Air, Air-Emission, Water, Wastewater, Soil, Sediment, and Biological Samples (2003)*, and as follows:

- A minimum of three (3) baseline samples shall be collected at each monitoring well to establish pre-disposal groundwater quality. The samples shall be collected at 48-hour intervals or greater.
- Following the baseline sample collection period, groundwater sampling shall be conducted from each monitoring well on a monthly basis during the first year of operation, and quarterly thereafter, unless approval is obtained from the Commission to vary this sampling schedule.
- Groundwater sampling shall continue on a quarterly basis for a period of one year after disposal well abandonment, unless approval is obtained by the Commission to vary this sampling schedule.
- Groundwater sampling events shall include an appropriate quality assurance/quality control (QA/QC) program including field duplicates and field blanks.
- Groundwater samples shall be collected using standard environmental sampling procedures that ensure that the sample is representative of the aquifer at the zone of sampling and the sample is not cross-contaminated during sampling.
- Samples shall be transferred to appropriate sampling containers and preserved in the field as necessary for each analytical parameter.
- Samples shall be submitted, using appropriate storage and transportation procedures, with appropriate chain of custody documentation, within 48 hours of collection, for analysis at a certified laboratory.

Groundwater analytical parameters

- Baseline groundwater samples shall be analyzed for: physical parameters (which include colour, electrical conductivity, hardness, pH, total dissolved solids, and turbidity), anions and nutrients (which include alkalinity, chloride, fluoride, nitrate, nitrite, sulfate), total and dissolved metals, dissolved gases (C1-C3), benzene, ethylbenzene, toluene, and xylenes (BETX), volatile petroleum hydrocarbons (VPH), polycyclic aromatic hydrocarbons (PAH), and light and heavy extractable petroleum hydrocarbons (LEPH/HEPH).
- If dissolved methane is detected at concentrations greater than 2 mg/L, more detailed isotopic analyses shall be conducted for one representative baseline sample to differentiate between biogenic and thermogenic sources. Methane isotopic sampling shall be conducted using protocols described in: *The Free Gas Sampling Standard Operating Procedure for Baseline Water Well Testing (2009)*, prepared for Alberta Environment and Sustainable Resource Development.

- Monthly groundwater samples shall be analyzed for pH, total dissolved solids, anions and nutrients, cations, total metals, VPH, and LEPH/HEPH.
- Once annually, commencing one year after operation of the disposal well is initiated, groundwater samples shall be analyzed for the same suite of parameters as the baseline samples.
- The groundwater analytical program may be revised over time, with approval of the Commission, based on the analytical results.

Groundwater level monitoring

- Groundwater level monitoring shall be completed under the supervision of a qualified groundwater professional registered with APEGBC.
- Static groundwater levels prior to initiating disposal activities shall be established over the baseline period in each monitoring well.
- Once disposal operations have commenced, groundwater levels in the monitoring wells shall be measured daily using an electronic data logger or by hand measurement.
- The date and time of initiation of disposal operations shall be recorded.

Reporting

- A baseline groundwater report shall be prepared by a qualified groundwater professional registered with APEGBC and submitted in pdf format to the Commission within 30 days of commencing disposal operations at the well. The baseline report shall: provide a description of historical and existing site activities and locations; document monitoring well drilling and monitoring well installation procedures; provide graphical monitoring well diagrams indicating construction details and geological observations; provide monitoring well location and elevation data; provide a map indicating monitoring well locations relative to the disposal well; and document sampling and water level monitoring procedures, dates, times, and results. Analytical results shall be presented in table format and laboratory analytical reports shall be retained on file by the permit holder.
- Once disposal operations have commenced, monitoring data shall be submitted monthly to the Commission within 30 days of the last day of each month. The dates and times of groundwater sampling, analytical results, daily water level measurements, and daily injection volumes shall be reported. Analytical results shall be presented in table format, and original laboratory analytical reports shall be retained on file by the permit holder.