BC Oil & Gas COMMISSION

September 1, 2017 7820-4580-32640-02

Donald Zinger
Completions Consultant
Leucrotta Exploration Inc.
700-639 5th Avenue SW
Calgary, AB T2P 0M9

Dear Mr. Zinger:

RE: PRODUCED WATER DISPOSAL SPECIAL PROJECT APPROVAL; AMENDMENT #1
LEUCROTTA SILVERBERRY 06-16-88-20 W6M; WA# 3076
SILVERBERRY FIELD – NORTH PINE "A" POOL

The Commission has reviewed groundwater monitoring and sampling results submitted over the period from October 2014 through June 2017 pursuant to requirements outlined in Approval Order 14-02-009, Appendix A. A groundwater monitoring program was included as part of the approval in order to alleviate concerns about casing and cement quality. Monthly groundwater sampling was extended beyond the initial one year period to ensure representative baseline sampling.

Based on a review of the analytical results, and the submitted report entitled "Leucrotta Silverberry 6-16-088-20 W6M Groundwater Monitoring Data Review", dated April 5, 2017, prepared by Waterline Resources Inc., the Commission agrees to a reduction in the groundwater sampling frequency from monthly to quarterly.

The permitted reduction in sampling frequency is based on demonstrated consistency in groundwater chemistry over time throughout disposal operations, and consideration of potential contaminants of concern (PCOCs) as indicated by analysis of a production water sample in April 2016.

Please note that the sampling frequency and required analytical parameters may be amended at any time.

Attached please find **Order 14-02-009 Amendment #1**, 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. This Order contains a number of detailed operational conditions, including a maximum wellhead injection pressure, requirement for continuous tubing and casing pressure monitoring, and an ultimate reservoir pressure limit. Additional general information regarding disposal wells is available on the Commission's website at http://www.bcogc.ca/industry-zone/documentation/Subsurface-Disposal.

Please note the changes from Order 14-02-009, which include a correction of the perforation interval in condition 2a), a re-calculation of maximum reservoir pressure to the corrected top of perfs in condition 2i), alterations to Appendix A to reflect the revised groundwater sampling frequency and analytical parameters, as well as a new condition 2m) requiring annual disposal fluid sampling and analysis to support the groundwater monitoring program. Disposal fluid sampling results should be submitted as a water analysis file via the eSubmission portal. Requirements for eSubmission of gas and fluid analysis can be found in the Well Data Submission Requirements Guide. One PDF and one PAS file are required for submission. The PAS file must be in standard format, meaning that the additional parameters for the disposal fluid analysis are to be included as part of the PDF file.

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In certain circumstances, disposal well operation may induce seismicity of values that require modification of operations to mitigate.

Please note that disposal of fluid with high total dissolved solids content requires adjustment of the wellhead injection pressure to remain below formation fracture pressure, as per order condition 2(b).

Should you have any questions regarding groundwater monitoring requirements, please contact Laurie Welch at (250) 980-6066. For questions regarding the remainder of the Order, please contact Michelle Harding at (250) 419-4493 or Ron Stefik at (250) 419-4430.

Sincerely,

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

Attachment

BC Oil & Gas COMMISSION

ORDER 14-02-009 Amendment #1

1 Under Section 75(1)(d) of the *Oil and Gas Activities Act*, the 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 only into the well Leucrotta Silverberry 6-16-88-20; WA# 3076 – North Pine 'A' pool (disposal perforations 1404.5 – 1407.3 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 electronically.

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) 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.

i) Cease injection upon reaching a maximum formation pressure of 11,560 kPaa, measured at 1405.9 mKB.

j) i) Perform a casing inspection log 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 temperature log on the subject well 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.

m) Once annually, sample the disposal fluid, analyze for the same suite of parameters as groundwater monitoring wells in Appendix A, and submit composition analysis, indicating the disposal well as the sample source.

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

DATED AT the City of Victoria, in the Province of British Columbia, this 1st day of September, 2017.

Advisory Guidance for Order 14-02-009 Amendment #1

I. A production packer must be set above the injection interval and the space between the tubing and casing filled with corrosion and frost inhibiting fluids, as per section 16(2) of the Drilling and Production Regulation.

II. Annual packer isolation tests are required to be submitted, as per section 16(3) of the Drilling and Production Regulation.

III. Injected fluids must be metered and the injection pressure measured at the wellhead, 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.

V. Seismic events must be reported and disposal operations suspended as per section 21.1 of the Drilling and Production Regulation.

Appendix A – Groundwater Monitoring Requirements

Leucrotta Silverberry 6-16-88-20 (WA 3076) Produced Water Disposal

The following groundwater monitoring program is to be conducted on three groundwater monitoring wells, identified as "MW14-01", "MW14-02S", and "MW14-02D", previously installed and sampled as per requirements outlined in Order 14-02-009 Appendix A, issued on September 30, 2014.

Groundwater sampling frequency and procedures

Groundwater 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:

- Groundwater samples shall be collected from each monitoring well on a quarterly basis 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 to 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.
- Records of sampling procedures used shall be retained for review by the Commission upon request.

Groundwater analytical parameters

- Groundwater samples shall be analyzed for parameters consistent with previous analyses at the monitoring wells, including:
    - General Chemistry (pH, total dissolved solids, electrical conductivity, salinity, hardness, turbidity, colour, cations and anions)
    - Total and Dissolved Metals
    - Benzene, Ethylbenzene, Toluene, Xylenes (BETX)
    - Polycyclic Aromatic Hydrocarbons (PAHs)
    - Volatile Hydrocarbons (VHw) (C6 to C10)

  - Volatile Petroleum Hydrocarbons (VPHw) (C6 to CIO - BETX)
  - Extractable Petroleum Hydrocarbons C10-C19 (EPHw10-19)
  - Light and Heavy Extractable Petroleum Hydrocarbons (LEPH/HEPH)
- The groundwater analytical program may be revised over time, as determined by the Commission.

Groundwater level monitoring

- Groundwater levels in the monitoring wells shall be measured daily using an electronic data logger.
- In addition to electronic monitoring of water levels, prior to each sampling event, manual water level measurements shall be collected and recorded to confirm accuracy of the electronic data logger readings. Temporary removal of the data logger may be needed to accommodate the water level probe in the monitoring well, and water levels should be allowed to recover to static levels prior to recording a manual water level measurement.

Reporting

- Groundwater analytical results, daily (electronic) and quarterly (manual) water level measurements, and daily injection volumes, shall be submitted quarterly to the Commission within 30 days of each groundwater sampling event by Email to Hydrogeology@bcogc.ca, or via eSubmission, if available.
- Once annually, sampling procedures and analytical results for the groundwater sample analysis **and disposal fluid analysis** (requirement 2m of Special Project Approval Order 14-02-009, Amendment #1), water level monitoring, and daily injection volume records shall be compiled into a report, prepared by a qualified professional, to be submitted to the Commission by Email to Hydrogeology@bcogc.ca, or via eSubmission, if available. Original laboratory analytical reports shall be appended to the report.