Horn River Basin Water Project Update, Northeastern British Columbia (Parts of NTS 094I, J, O, P)

C.J. Salas, Geoscience BC, Vancouver, BC, salas@geosciencebc.com

D. Murray, Kerr Wood Leidal Associates Ltd., Victoria, BC

C. Davey, Kerr Wood Leidal Associates Ltd., Victoria, BC

Salas, C.J, Murray, D. and Davey, C. (2014): Horn River Basin Water Project update, northeastern British Columbia (parts of NTS 094I, J, O, P); *in* Geoscience BC Summary of Activities 2013, Geoscience BC, Report 2014-1, p. 135–138.

Introduction

Water availability plays a pivotal role in the development of the Horn River Basin; however, the available hydrological and climate information in the basin is very limited. Geoscience BC and the Horn River Basin Producers Group (HRBPG), the Fort Nelson First Nation and the Fort Liard First Nation (Acho Dene Koe) all have a strong commitment to effective water management in the area. In order to meet this commitment, the Horn River Basin Water Project was initiated in 2008 to study the deep, shallow and surface water components. The deep and shallow water components of the study are complete, and work on the surface water aspect of the study is ongoing. The objectives of the study are to 1) understand water quantity in the region, 2) determine water quality, 3) use alternate biomonitoring methodology (benthic sampling) to evaluate environmental health, and 4) build First Nation capacity in water management.

As part of Phase II of the project, a three-year program was started in the late spring of 2011 to study the regional surface water system. This program included the installation of seven hydrometric stations and three climate stations to help provide the baseline water quantity information needed (Figure 1).

This year provided the first full season of environmental information. Information collected from this project is now available from the Geoscience BC website (http://www.geosciencebc.com/s/HornRiverBasin.asp). Water quality sampling was initiated this year with the benthic sampling.

A new important component to the study was initiated this year by the Cold Regions Research Centre (CRRC; B. Quinton and J. Baltzer, Wilfred Laurier University; E. Johnson, BC Ministry of Natural Gas Development; M. Hayashi, University of Calgary). They will examine the water balance in areas of muskeg and discontinuous permafrost along with temporal variations in discontinuous permafrost.

Keywords: *hydrometric station, climate station, Horn River Basin, slickwater, fraccing, stage-discharge curve, SDR, biomonitoring, benthic sampling, snow pillow*

This publication is also available, free of charge, as colour digital files in Adobe Acrobat® PDF format from the Geoscience BC website: http://www.geosciencebc.com/s/DataReleases.asp.

Background

The Horn River Basin covers an area of 11 000 km^2, much of it covered in muskeg, and spans 42 major watersheds in northeastern BC. It also has an estimated mean case of 448 tcf of gas-in-place ultimate potential reserves (BC Ministry of Natural Gas Development and National Energy Board, 2010), making it one of the richest gas basins in North America. Unconventional gas development in the basin is water intensive with an average well using upward of 80 000 m^3 of water (Johnson, 2012) in slickwater completions (i.e., high volume of water with a low concentration of sand and friction reducers). In 2011, 133 wells used 7 million m^3 of water from the basin for oil and gas activities.

The HRBPG recognized the need for a water management plan that would enable sustainable and responsible development of unconventional gas in the Horn River Basin. In late 2008, the HRBPG, along with Geoscience BC, and the BC Ministry of Natural Gas Development, initiated the Horn River Basin Water Project, which would aid in responsible development of the gas resource. Phase II of this project is the Horn River Basin Water Study, part of which is the study of the deep, shallow and surface water components. The deep and shallow groundwater components of the study have been finished, and currently, the research consortium is on the second year of a three-year regional surface water study, managed by Kerr Wood Leidal Associates Ltd. (KWL), which is focusing on collecting data with respect to water quality and quantity. The Fort Nelson and Acho Dene Koe First Nations partners are providing people who are being trained as water monitors.

Additionally, in order to better understand surface-shallow groundwater interaction in areas of muskeg and discontinu-

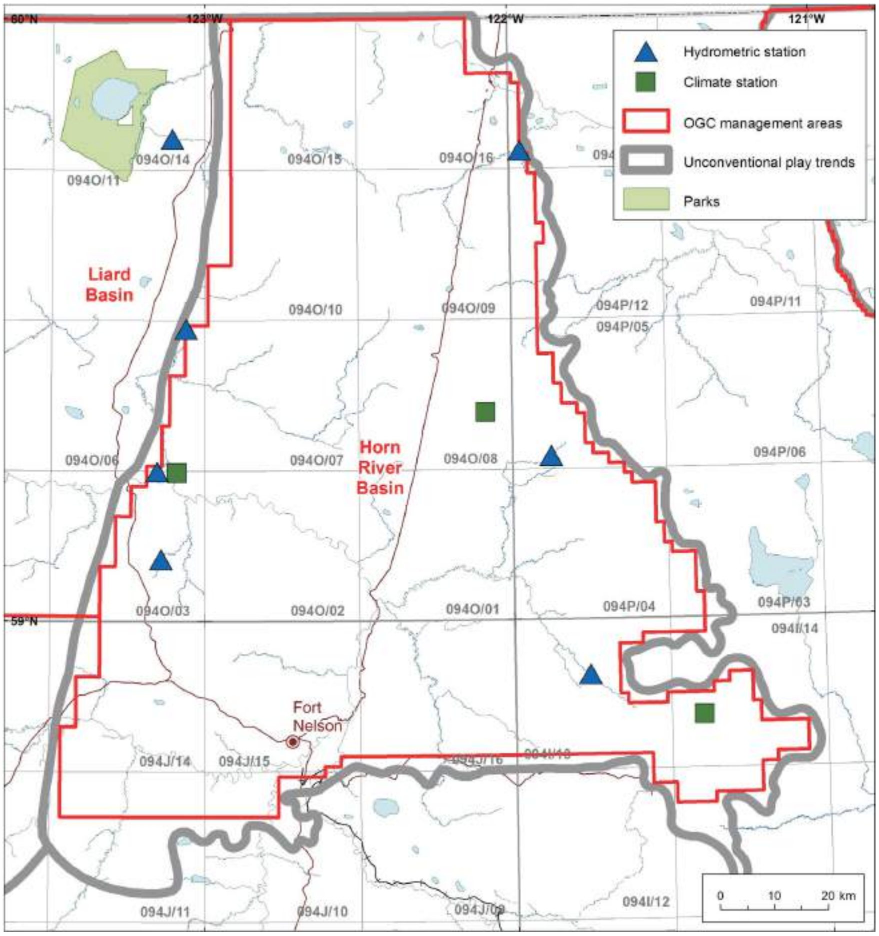

Figure 1. Location of hydrometric and climate stations, Horn River Basin, northeastern British Columbia. Abbreviations: OGC, BC Oil and Gas Commission.

ous permafrost, and to properly understand the water balance in these complex areas, an additional study has been undertaken by CRRC. Research into this subject will not only give a better understanding as to water availability in these regions but also provide important information with respect to temporal variations in the discontinuous permafrost—critical information that is necessary when building infrastructure in these areas.

Objectives of Surface Water Component

The primary objectives of the surface water component of the Horn River Basin Water Study are

1) to collect accurate water flow, water quality and climate data, which will allow the characterization of baseline conditions and provide better accuracy and reliability for water use;
2) to train First Nations representatives in all aspects of water monitoring;
3) to aid and support the sustainable planning and use of water in unconventional gas development; and
4) to provide the necessary data needed for informed decisions by the HRBPG and the BC Oil and Gas Commission.

The objectives of the surface water component of the study are being attained through the installation and monitoring of an environmental monitoring network. The environmental monitoring network comprises 1) hydrometric and climate monitoring, 2) water quality and biological monitoring, and 3) data management and reporting. Although not part of the environmental monitoring network per se, the acquisition of the scientific data necessary for the understanding of the muskeg groundwater-surface water interaction and its impact on the water balance in areas of discontinuous permafrost will be very important in resolving the water balance question.

Hydrometric and Climate Monitoring Program

Seven hydrometric monitoring sites were installed by a field team (supported by First Nation water monitoring trainees; Table 1) and were placed in time to capture the spring freshet of 2012—four of these stations capture real-time data. The data is uploaded (via satellite) every six hours and transmitted to a proprietary website housing a hydrometric program (FlowWorks), which is owned and operated by KWL. This data can be accessed and downloaded through the Geoscience BC website (http://www.geosciencebc.com/s/HornRiverBasin.asp).

The real-time stations consist of a data logger fixed inside an enclosure and placed a few metres from the stream bank above flood level (stage). Stage (depth) data from the streams are collected using pressure transducers encapsulated within metal sleeves inserted into the stream bed/bank. Discharge is not measured directly, thus stage-discharge relationships (SDR) are created by measuring instantaneous discharge at different water levels and relating them to a fixed staff gauge. The pressure transducer measures stage (water level) every 15 minutes. Discharge (flow) is then related to the stage measurements through the SDR developed over time. This SDR is used to convert the stage measurements recorded by the pressure transducer into discharge values for the creation of a hydrograph. The discharge measurements collected under this baseline program generally meet ‘Class A’ hydrometric data standards and are typically given an uncertainty value of ±7%.

Three climate stations were installed shortly after the hydrometric stations in June 2012 (Table 1). All of the climate stations capture real-time data. Each climate station consists of a data logger and transmitter with various sensors, a 5 m tower for the wind sensors, a telemetry antenna and a 3 m diameter snow pillow, which lies adjacent to the station collecting snowpack information (Figure 2). Each climate station collects information on barometric pressure, dew point temperature, precipitation, relative humidity, solar radiation, snow-water equivalent, temperature (minimum and maximum), wind speed and direction.

Water Quality Program

Five watersheds were chosen for the surface water program: Dilly Creek, Kiwigana River, Sahtaneh River, D'Easum Creek and Stanolind Creek. The locations of the water sampling sites correspond to the seven hydrometric station sites. Each standard sampling trip consists of water sample collection for laboratory analyses and recording of field parameters such as temperature, dissolved oxygen, pH, conductivity, salinity, total dissolved solids and turbidity. Analytical parameters for laboratory analyses include general water chemistry, major ions, nitrogen speciation, metals (total and dissolved), volatile organic compounds (benzene, toluene, ethylbenzene, xylene), and extractable petroleum hydrocarbons (EPH). A standard quality assurance–quality control program used trip blanks and field blanks to ensure data quality. All sampling was conducted using nitrile gloves to avoid contamination and samples were shipped to the lab within 72 hours of collection.

Benthic Program

The intent of the benthic biomonitoring program is to use an alternate biomonitoring methodology (benthic sampling) to evaluate environmental health.

A large set of reference site data comprising 30 or more samples from the Horn River region is being developed by Environment Canada. Five benthic biomonitoring sites were selected and sampled in 2011 for the dataset. These were all candidate reference sites. A kick net method was employed to collect the benthic invertebrates at each site. The kick net was placed on the bottom of a creek, and a person kicked up rocks (for three minutes) in front of it so the net captured a large sample of benthic invertebrates floating within the water. The invertebrates were collected in sample bottles, preserved and sent to the lab for analyses. Benthic invertebrates in the samples are being categorized in the lab and reported into the database. In 2012, six sites were selected and sampled, all of which were test sites. Once the set of reference site data is finalized, then individual test sites can be compared against the reference data to determine if the water quality at the test site is impaired.

Initial Program Results

To date, seven open water measurements of discharge have been collected from each hydrometric monitoring site—excluding Dilly Creek, which has six open water measurements of discharge. Generally, BC hydrometric standards recommends a minimum of ten discharge measurements well distributed through the range of flows to develop a rating curve. Therefore, the SDRs developed to date are considered preliminary. However, the manual measurements of discharge collected to date are very well distributed and thus there is a high degree of confidence in the SDRs. A representative SDR and accompanying hydrograph from the Kiwigana River station is shown in Figure 3. It is anticipated that by the end of 2013, ten or more manual readings of discharge will have been collected, enabling the finalization of the SDRs. It should also be noted that the recommended upper limit of applicability for each SDR is a measure of how far the curve can be confidently extrapolated beyond the highest discharge measurement.

Table 1. Name and UTM location for hydrometric and climate stations, Horn River Basin, northeastern British Columbia.

Site	Station type	Easting*	Northing *
D'Easum Creek (real time)	Hydrometric	494095	6629320
Delkpay Creek	Hydrometric	496640	6594093
Dilly Creek (real time)	Hydrometric	558226	6627266
Kiwigana River (real time)	Hydrometric	491233	6567759
Komie Creek	Hydrometric	564187	6570824
Sahtaneh Creek (real time)	Hydrometric	571554	6530452
Stanolind Creek	Hydrometric	491929	6551504
Two Island Lake (real time)	Climate	551981	6578887
Kiwigana River (real time)	Climate	494843	6567568
Sierra (real time)	Climate	592552	6523137

*UTM Zone 10

Figure 2. Photograph of Kiwigana River climate station, northeastern British Columbia. The white object on the ground, to the right of the climate station, is a snow pillow. Photo courtesy of B. Ortman, Peace Country Technical Services Ltd.

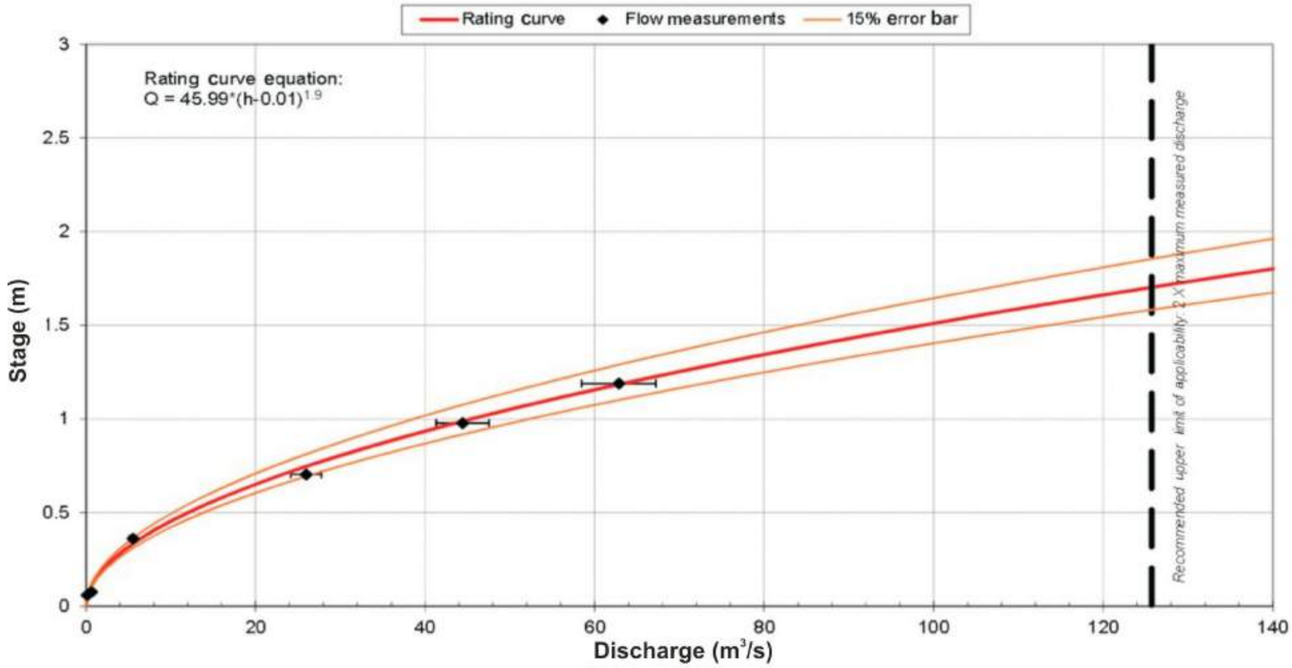

Figure 3. Preliminary stage-discharge curve for hydrometric station on Kiwigana River (northeastern British Columbia) with corresponding hydrograph (produced by Kerr Wood Leidal Associates Ltd.). The stage-discharge curve has been estimated by the method of maximum likelihood. In the rating curve equation, Q is the discharge and h is the gauge height.

Data collected from all the stations show very low base flows after the 2012 freshet. Based on the limited hydrometric data record presented here, the ability to withdraw water from the Horn River Basin streams is greatest, and most predictable, during the spring freshet. The use of real-time stations to monitor stream-flow conditions and the climate variables (precipitation and temperature, in particular) allow better prediction of possible limitations to near-term water withdrawals.

Three official water quality sampling events have been completed, and benthic sampling has also been initiated; however, until a larger dataset is collected comparisons between sites cannot be made.

Data from the climate stations indicate that warmest and coldest recorded temperatures occurred at the Kiwigana station (+33.1 and –37.9°C). Precipitation data collected by the climate stations also corroborates the drought conditions (50–70 mm over the summer months) seen from the hydrometric stations during the summer of 2012. The use of real-time climate stations, which allow monitoring of precipitation events, in conjunction with an enhanced understanding of surface-groundwater interflow may allow for better water-use practices in the future.

Conclusion

As part of the Horn River Basin Water Project, the second year of the three-year study of surface water is being completed. Core to the study has been the installation of seven hydrometric and three climate stations to help determine baseline water quantity. Additionally, water quality is being studied through traditional water chemistry techniques and less traditional biomonitoring programs. A separate study has been initiated this year to increase the understanding of surface-shallow groundwater interaction in areas of muskeg and discontinuous permafrost.

References

BC Ministry of Natural Gas Development and National Energy Board (2010): Ultimate potential for unconventional natural gas in northeastern British Columbia's Horn River Basin; BC Ministry of Natural Gas Development, Oil and Gas Reports 2011-1, 39 p., URL <http://www.empr.gov.bc.ca/OG/Documents/HornRiverEMA_2.pdf> [November 2013].

BC Ministry of Environment (2009): Manual of British Columbia hydrometric standards; prepared for Resources Information Standards Committee, 204 p., URL <http://www.ilmb.gov.bc.ca/risc/pubs/aquatic/hydrometric/man_BC_hydrometric_stand_V1.0.pdf> [November 2013].

Johnson, E. (2012): Water issues associated with hydraulic fracturing in northeast British Columbia; Unconventional Gas Technical Forum, Victoria, April 2–3, 2012, 25 p. (presentation), URL <http://www.empr.gov.bc.ca/OG/oilandgas/petroleumgeology/UnconventionalGas/Documents/E%20Johnson.pdf> [November 2013].