Overview of the Montney Water Project: A New Geoscience BC Initiative in Northeastern British Columbia (NTS 093P, 094A, B)

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Introduction

This paper is an overview of Geoscience BC's Montney Water Project (MWP), which is a collaboration between industry, government, communities and stakeholders to provide a regional overview of water resources in the Montney shale gas play area of northeastern British Columbia. The project outcomes are intended to assist the oil and gas industry in locating and evaluating water sources and waste fluid disposal zones. In addition, results will also be of value to provincial and local governments, communities and other stakeholders. The project objectives are to compile existing data, provide a synopsis of knowledge for all water resources from surface to deep bedrock, and identify data and knowledge gaps for future research and project planning. During the initial phase, a number of hydrological models will be assessed to determine their applicability in the region.

The liberation of natural gas from unconventional tight sandstone and shale plays through hydraulic fracturing (fracing) requires significant quantities of water. This water is used to fracture essentially impermeable reservoir rocks deep below the surface (commonly >1500 m), thereby providing a conduit for the gas to flow from the rock to the wellbore.

In the Montney play region, water for hydraulic fracing is potentially obtained from surface sources (e.g., rivers and lakes), local water providers (e.g., the City of Dawson Creek, private dugouts and groundwater wells of private landowners) and bedrock aquifers. Other users of the water resources include local communities (municipal), landowners and agriculturalists. One of the important water resources that extends across the Montney play is the Kiskatinaw River watershed, which is the water supply for the City of Dawson Creek. Gaining more detailed knowledge of available hydrological data, assessing surface and groundwater interactions, and the overall hydrological cycle in the region is the ultimate goal of the project.

Keywords: *unconventional gas, shale gas, Triassic Montney Formation, tight sandstone and shale, surface water, groundwater, unconsolidated and bedrock aquifers, disposal zones, water wells*

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Montney Play

British Columbia's Montney play is an extensive natural gas resource that underlies over 2 million ha and extends from the BC-Alberta border near the City of Dawson Creek, northwest to Pink Mountain. The area includes the 460 000 ha Regional Heritage Field (Montney "A" gas pool) as defined by the BC Oil and Gas Commission (OGC). Geologically, the reservoir comprises the Triassic Doig phosphate zone (Middle Triassic) in the Groundbirch area (Pine River area) and the Montney Formation (Lower Triassic) in the Swan Lake, Bissette Creek and City of Dawson Creek areas (C. Adams, pers. comm., 2010). The target horizon lies approximately 1200 to over 4400 m below surface, with an average thickness of 300 to 500 m. Petroleum and natural gas tenure dispositions and drilling activity in this area have increased dramatically over the last five years and record land (petroleum and natural gas rights) sales of $1.3 billion occurred in 2008. The Montney play has evolved into a world-class natural gas play and it is estimated to contain an original-gas-in-place of 35 to 250 trillion cubic feet (Tcf) of natural gas (Adams, 2010). The MWP area (Figure 1) includes the Heritage Montney "A" gas pool as defined by the OGC, the pool has an original-gas-in-place estimate of 52.8 Tcf, initial raw gas reserves of 7.5 Tcf and production of 450 mmcf/day (BC Oil and Gas Commission, 2009, 2010). Over 30 companies have drilled wells in the Montney play area since 2003, led by Encana Corporation, Arc Resources Ltd., Shell Canada Limited and Murphy Oil Corporation (C. Adams, pers. comm., 2010).

Physiographic Setting

The MWP area is dominantly within the Alberta Plateau, a flat to gently rolling glaciated feature between 600 and 800 m asl elevation (Holland, 1976). This plateau is deeply incised by the Peace River and its tributaries, the Kiskatinaw, Beatton, Pine (and Murray), Moberly and Halfway rivers (Figure 1).

Drainage over part of the upland surface is poorly organized; there are areas of muskeg and low gradient streams

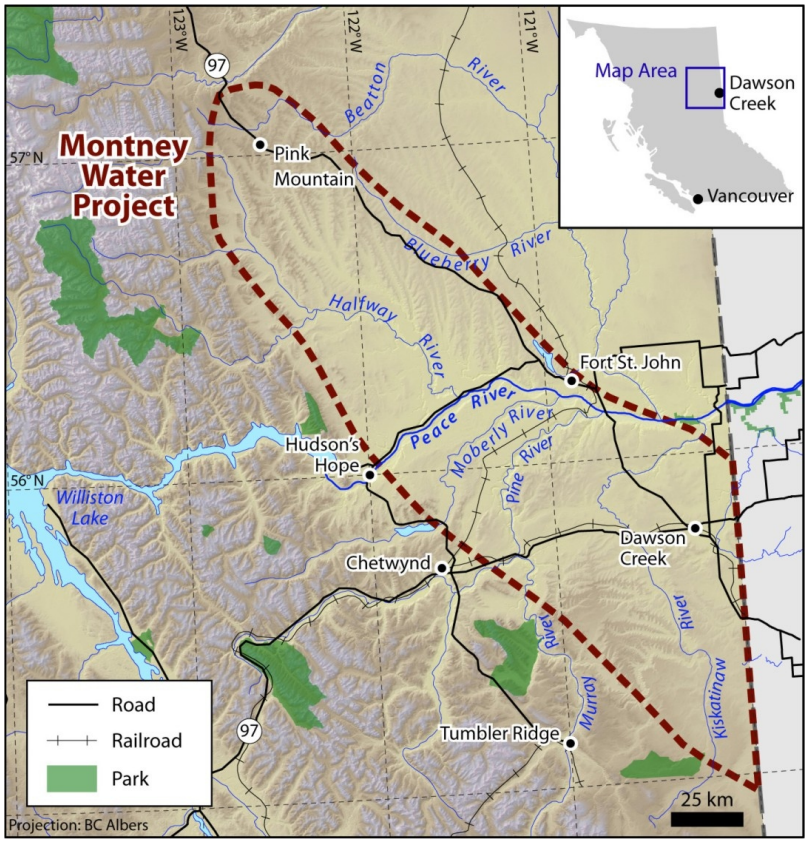

Figure 1. Location of the study area for the Montney Water Project, northeastern British Columbia. Base map information from Canadian digital elevation data (Canadian Council on Geomatics, 2004) and the Atlas of Canada base maps (Natural Resources Canada, 2007). The digital-elevation-model base map was assembled by K. Shimamura.

that meander across the surface before eventually incising to join one of the main streams. North of the Peace River, much of the drainage is controlled by the Halfway and Beatton rivers. These rivers have become entrenched in the soft Fort St. John Group shale below the upland surface (Holland, 1976).

The region was glaciated during the Pleistocene (Mathews, 1978a, b, 1980). As the ice waned, the Laurentide Ice Sheet blocked regional drainage, resulting in the development of a large proglacial lake (glacial Lake Peace), with shorelines identified between 688 and 838 m asl (Mathews, 1980). This large lake is responsible for depositing a blanket of glaciolacustrine sediment across the lake basin, ranging in thickness from a few metres to more than 50 m in some locations. Post-Pleistocene erosion has incised the rivers to their present elevations.

Montney Water Project

The MWP is focused on developing an inventory of the water resources. The project comprises three components: 1) surface water bodies (lakes, stream and rivers); 2) shallow aquifers in unconsolidated sediments (e.g., glaciofluvial deposits) and shallow bedrock (<250 m below surface); and 3) deep bedrock aquifers and disposal zones (>250 m below surface). The MWP was officially announced in October 2010, by Geoscience BC and its partners. The initial phase consists of collecting relevant public information for evaluating water resources at the regional level. The objective of this phase is to compile existing and pertinent data in formats that can be used in GIS-based systems. This is to be completed by the spring of 2011. Progress for components 1 and 2 are discussed below. Progress for component 3 can be found in Hayes et al. (2011).

Project Governance

Geoscience BC developed the MWP through engagement with industry, government, communities and stakeholders. Geoscience BC, through its contractors, acts as the general project manager with elements conducted by consultants and government agencies. The project is guided by a steering committee and a technical advisory group composed of industry and government representatives.

The MWP is being delivered as a co-operative effort between Geoscience BC, exploration companies, contractors, Ministry of Environment, Ministry of Energy, OGC, Ministry of Health Services and Northern Health Authority. Funding support for the initial phase of this project has been provided by the following seven companies: Arc Resources Ltd., ConocoPhillips Canada, Devon Energy Corporation (Canada), Encana Corporation, Progress Energy Resources Corp., Shell Canada Limited and Talisman Energy Inc. These companies are matching funds provided by Geoscience BC and the Science and Community Environmental Knowledge Fund, an industry-sponsored fund that is administered by the OGC. In addition, government organizations are providing significant in-kind support to the project.

Current Status of the Montney Water Project

Surface Water

This component will assess the surface water resource through the collection of a variety of publicly available data, including climate and precipitation data, stream flow, lake volume and related hydrometric information at the watershed level. These datasets vary in their quality and com-

pleteness and each will be ranked in the initial phase of the project. The hydrological analysis is aimed at determining surface water availability, seasonal changes in these volumes and recharge rates on a drainage sub-basin and basin (watershed) level (Figure 2).

Kiskatinaw River Watershed Research Project

The Kiskatinaw River Watershed Research Project is a collaborative research project developed jointly between the City of Dawson Creek, University of Northern British Columbia and Ministry of Environment. The project is receiving some financial support from Geoscience BC and forms an important partner-project within the MWP area. The goal is to obtain sufficient scientific information necessary to successfully manage the watershed and thereby reduce conflict and uncertainty between water users. The Kiskatinaw River watershed (drainage basin) provides community water supply and supports various other values such as timber harvesting, agriculture, oil and gas, wildlife and recreation. The Kiskatinaw watershed's hydrology is currently poorly understood and has proven to be intermittent in terms of water supply.

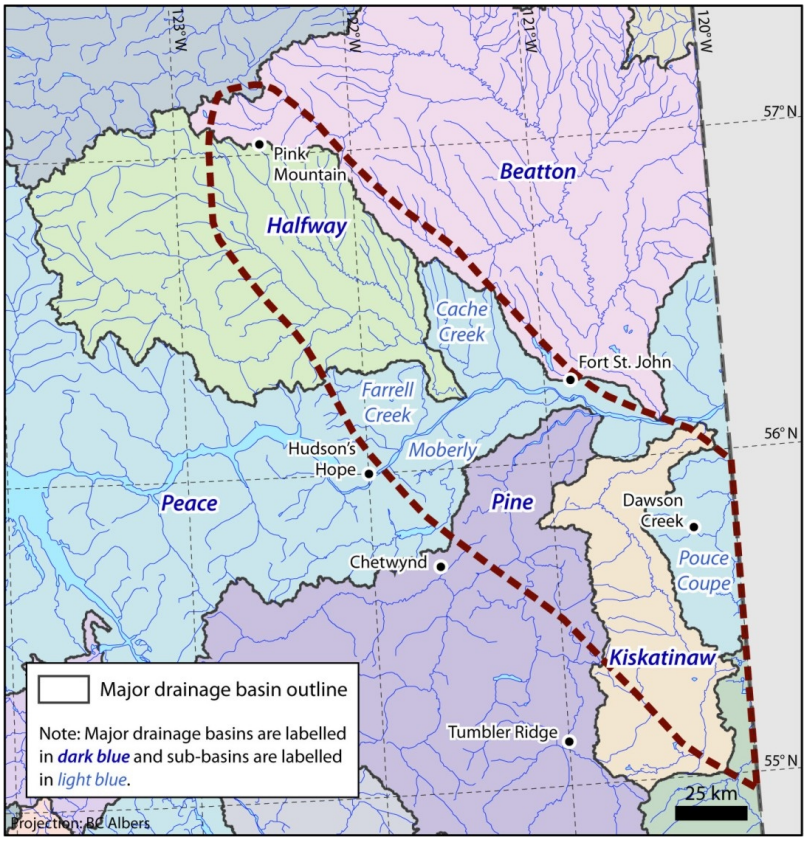

Figure 2. Main drainage basins of the Montney Water Project, northeastern British Columbia: Beatton, Halfway, Peace, Pine and Kiskatinaw. The boundary of the Montney Water Project is represented by the red dashed line.

Two Ph.D. candidates, F. Hirshfield and G. Saha, are conducting the project as part of their dissertations. The project includes six main tasks:

1) investigating the contribution of discharge and sediment levels (sediment yield) from each tributary to the main stem of the Kiskatinaw River;
2) selecting a hydrological model for watershed modelling;
3) examining the impacts of future climate changes on the snowmelt processes and discharge;
4) identifying the impacts of oil and gas activities on discharge in each tributary and main stem;
5) investigating the surface water–ground water (SW-GW) interaction and quantification of groundwater contribution to river flow; and
6) modelling of water quality in the Kiskatinaw River and its tributaries.

For task 1, data logging devices for capturing flow information at various water levels have been installed on selected tributaries of Kiskatinaw River. Measured tributary flow will then be compared to the gauged flow at the Farmington hydrological station to determine specific tributary contributions. Discharge data will be used for hydrological model calibration.

Water in Unconsolidated Sediments and Shallow Bedrock

Most of the Montney play area is covered by unconsolidated sediments comprising glacial, glaciofluvial, glaciolacustrine and fluvial deposits that vary greatly in thickness. These diverse materials include aquifers and aquitards. Provincial and federal government mapping programs have delineated these deposits at various scales within various portions of the Montney play area. In addition, several agencies collect relevant data, including the Ministry of Environment, Environment Canada, Prairie Farm Rehabilitation Administration, Ministry of Energy and OGC.

Since much of the unconsolidated material is of glacial origin, the first priority of this component is to compile existing Quaternary mapping and data in the Montney play area. A summary report describing which deposits hold the best potential for sourcing water in unconsolidated sediments will be produced. From this initial effort, potential future fieldwork or other appropriate studies will be defined. The

majority of this component is being overseen by Ministry of Energy (A. Hickin).

Surficial Geology

A digital compilation of surficial geology maps at 1:250 000 scale (NTS 093P, 094A) and 1:50 000 scale (NTS 093P/09, /10, /15, /16, 094A/01, /02, /07, /08; Figure 3) is being prepared by MAF Geographix (M. Fournier). Approximately 30% of the MWP area is covered by 1:50 000 scale surficial geology mapping. In addition, new mapping has been proposed by the Ministry of Energy in NTS 093P/01 and /08.

Depth to Bedrock

Depth to bedrock information is being collected by Ministry of Energy (A. Hickin) to support models that will delineate paleochannels (buried valleys). These channels are known to contain coarser material and good aquifers locally. The existence of the buried channels has been known for decades (Matthews, 1978a) and they are reported to have higher water yields than other aquifers in the Quaternary section (Cowen, 1998). Recent, unpublished work by E. Janicki (Ministry of Energy) will be incorporated into the depth to bedrock project.

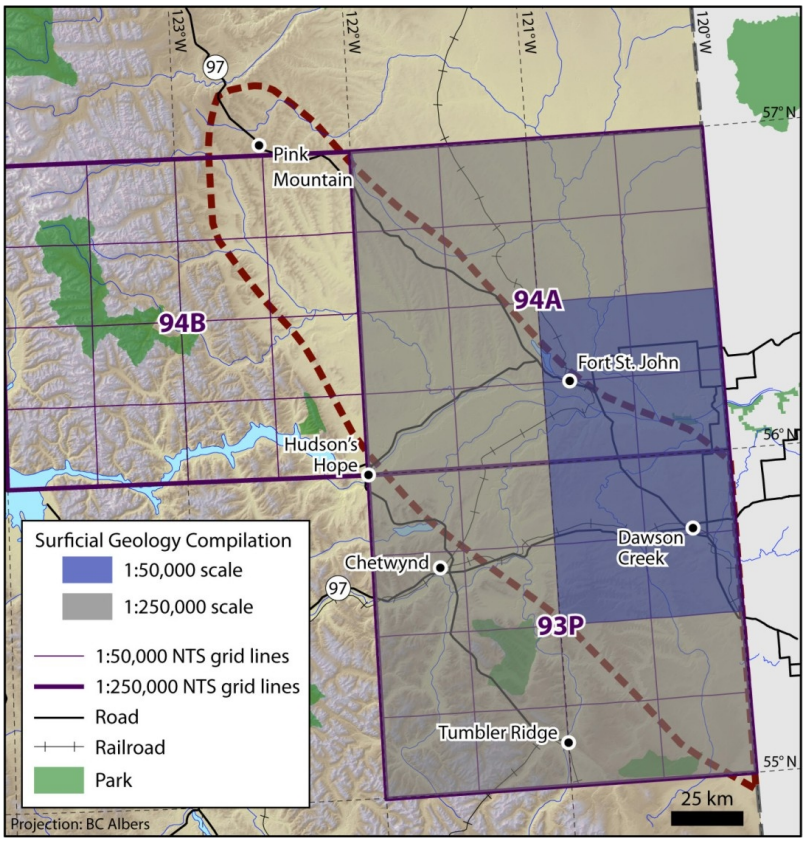

Figure 3. Index of surficial geology digital map compilation underway for the Montney Water Project, northeastern British Columbia.

Domestic and Public Water Wells

An update of the digital database of domestic and public water wells, and the regional shallow aquifers database, will be completed. This part of the project is spearheaded by the Ministry of Environment (M. Wei, L. MacFarlane, K. Ronneseth). It entails inputting previously unrecorded information from water wells into the Ministry's publicly available WELLS database. In addition, wells sourcing "groundwater under the direct influence of surface water" will be identified in select areas.

The Ministry of Environment maintains a WELLS database for the entire province. Data for this database is submitted on a voluntary basis, which results in incomplete coverage across regions. Currently, there are about 500 WELLS records in the MWP area. This is a partial representation of the number of actual wells in the region. Therefore, the Ministry of Environment will solicit new data from various sources and enter this new information into its WELLS system. The new data will then be used to review and refine the knowledge of shallow aquifers.

Aquifer Classification

Geoscience BC has let a contract, with the assistance of the Ministry of Environment, to complete the mapping and classification of aquifers identified during this project and those currently being used as sources of water in the Montney play area. The mapping and classification follows the BC aquifer classification system (Kreye, Ronneseth and Wei, 1994), which maps the known outline of an aquifer and subjectively classifies the aquifer based on the level of use and vulnerability. Aquifer classification mapping was initiated in the Peace River in 2004 with funding from Agriculture Canada (Lowen Hydrogeology Consulting, 2004). Mapping and classification is continuing via Geoscience BC for the remaining priority areas in the Montney play area where well record data are available.

Deep Bedrock Water and Disposal Zones

One of the key focuses of the MWP is assessing the potential for deep bedrock water sources and deep disposal zones in the area. These zones are much deeper than domestic water wells, at depths >250 m below surface. This component of the MWP is being completed by Petrel Robertson Consulting Ltd. and Canadian Discovery Ltd., and is described by Hayes et al. (2011). The deep bedrock work has been di-

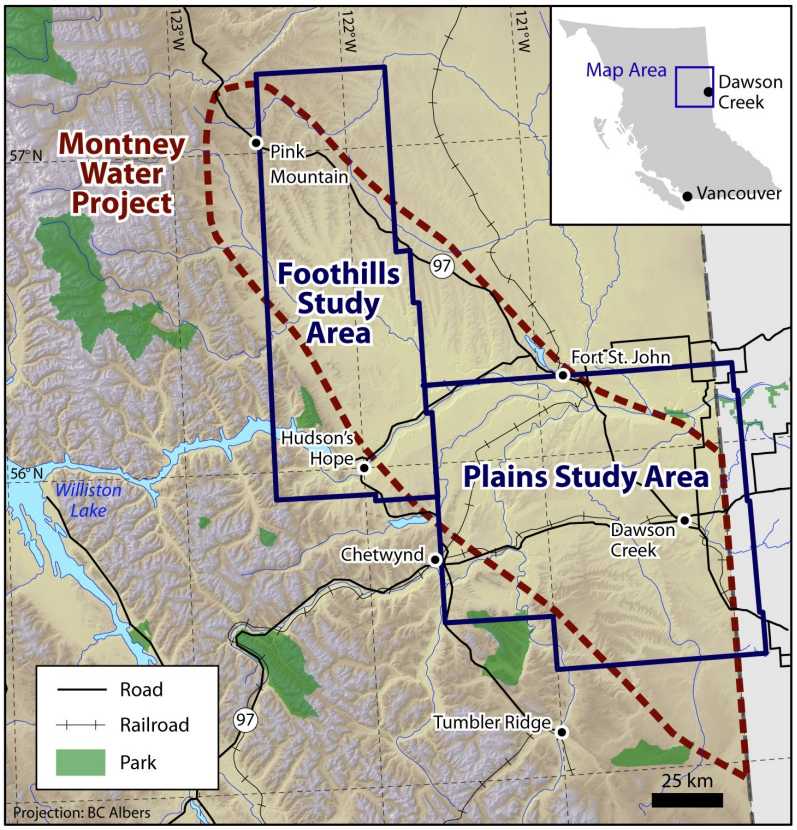

Figure 4. Foothills and Plains deep bedrock and disposal zone study areas (outlined in blue), northeastern British Columbia. See Hayes et al. (2011) for details.

vided into two distinct study areas: Plains study area and Foothills study area, as depicted in Figure 4.

Database Design and Management

The database design and management component is being led by Foundry Spatial Ltd. (B. Kerr) with input from government and industry experts. The initial phase of this component of the project is dedicated to inventory and data collection, with water supply as the primary focus. Information on existing water wells, aquifers, lake bathymetry, bedrock topography/drift thickness, deep regional stratigraphy and other various themes is being collected in order to identify potential water sources.

Currently, hydrological and hydrogeological modelling options are being investigated to define future data requirements. Given the number of stakeholders involved with the project, the wide range of modelling options, and the overlap between individual model requirements, a GIS database containing all available datasets is being developed to allow for quick and easy access to data for future modelling and analysis.

Conclusion

Geoscience BC's MWP is a collaborative project, involving industry, government (local and provincial) and other stakeholders. Results of the initial phase of the project will provide resource developers and managers with a robust inventory of data applicable for the assessment of water sources in the Montney play. This part of the MWP involves the compilation of water-related information in a coherent database offering a single reference location for all existing water information. This data will be fundamental in assessing knowledge gaps that will need to be addressed in future work. These outcomes will inform all parties about the merits and scope for the next phase of the MWP.

Acknowledgments

The Montney Water Project team includes M. Wei, L. MacFarlane, K. Ronneseth (Ministry of Environment), A. Hickin (Ministry of Energy), B. Kerr (Foundry Spatial), G. Russo (Ministry of Health Services), and D. Tamblyn (Northern Health Authority). These experts' ongoing contributions to the project are extremely beneficial and appreciated. In addition, input from the technical advisory group ensures the project remains focused on the region's water resources. P. Caputa, previously with the City of Dawson Creek, provided background material on the Kiskatinaw River Watershed Research Project. The author would like to thank C. Anglin, A. Hickin, F. Ferri and C. Sluggett for their time, comments and improvements to the manuscript. Figures were prepared by F. Ma at Geoscience BC. The digital elevation model used in the figures was prepared by K. Shimamura, Geological Survey of Canada.

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