Deep Aquifer Characterization in Support of Montney Gas Development, Northeastern British Columbia (Parts of NTS 093, 094): Progress Report

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Introduction

The Triassic Montney Formation in northeastern British Columbia is one of North America's newest and hottest gas plays (Figure 1). Ten years ago, the deep Montney Formation was regarded as a thick body of nonprospective siltstones and shales. Today, however, horizontal well technology and multiple hydraulic fracture (frac) stimulations have unlocked huge potential for gas production. Low development risk, large reserves and high flow rates make the Montney play of northeastern BC one of the most economic gas resource plays on the continent.

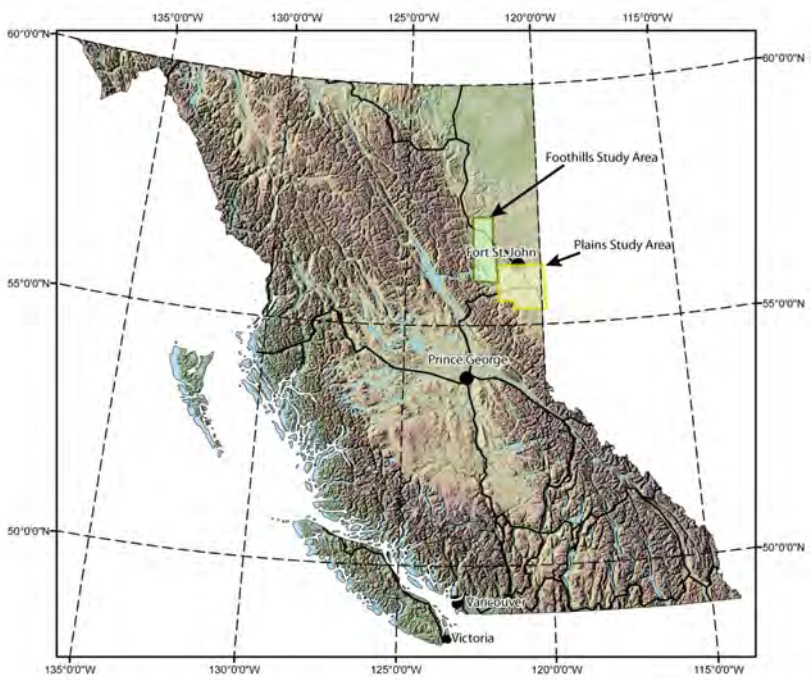

Figure 1. Locations of the Montney gas play areas, in the Peace River plains (Plains study area) and adjacent Foothills (Foothills study area) of northeastern British Columbia.

Since 2005, hundreds of horizontal wells have been drilled into the Montney Formation, and current production exceeds 500 mmcf/day (14 e^6m^3/day)—or approximately 3% of Canada's daily total. A variety of completion and frac techniques have been used to stimulate Montney reservoirs, and experimentation continues to optimize treatments according to local burial depth and rock composition. All of these treatments require large quantities of water—hundreds to thousands of cubic metres per wellbore—and safe disposal must be ensured for substantial volumes of contaminated produced water. Deep subsurface aquifers, carrying nonpotable water and lying far below the water table and domestic water wells, are ideal sources and sinks for the water volumes required. Shallower aquifers, such as buried valley fills associated with Quaternary glaciation and drainage, are also targets. Surface waters may serve as water sources, but produced water cannot be disposed of at surface.

In 2008, members of the Horn River Basin Producers Group asked Geoscience BC to investigate deep subsurface aquifers as sources of frac water and subsequent disposal

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sites for the produced water, to support the emerging Devonian shale gas play in the Horn River Basin (Hayes, 2010). In 2009, a group of producing companies approached Geoscience BC to undertake a similar assessment of potential water sources and sinks in the Montney play area. In response, Geoscience BC assembled a project team to address deep subsurface, shallow subsurface and surface water distribution. Petrel Robertson Consulting Ltd. (PRCL) and Canadian Discovery Ltd. have been commissioned to undertake and report upon the technical assessment of deep subsurface aquifers, and this report summarizes their work to fall 2010.

Regional Setting

Montney Formation strata subcrop along the western flank of the Western Canada Sedimentary Basin, and strata equivalent to the Montney Formation (Toad and Grayling formations) crop out near the eastern edge of the adjacent Rocky Mountains (Figure 2). In the Deep Basin, immediately east of the Foothills, the Montney Formation consists primarily of siltstones deposited in distal shelf settings (Davies et al., 1997). Although pervasively gas-saturated, Montney Formation siltstones exhibit porosities of <10%

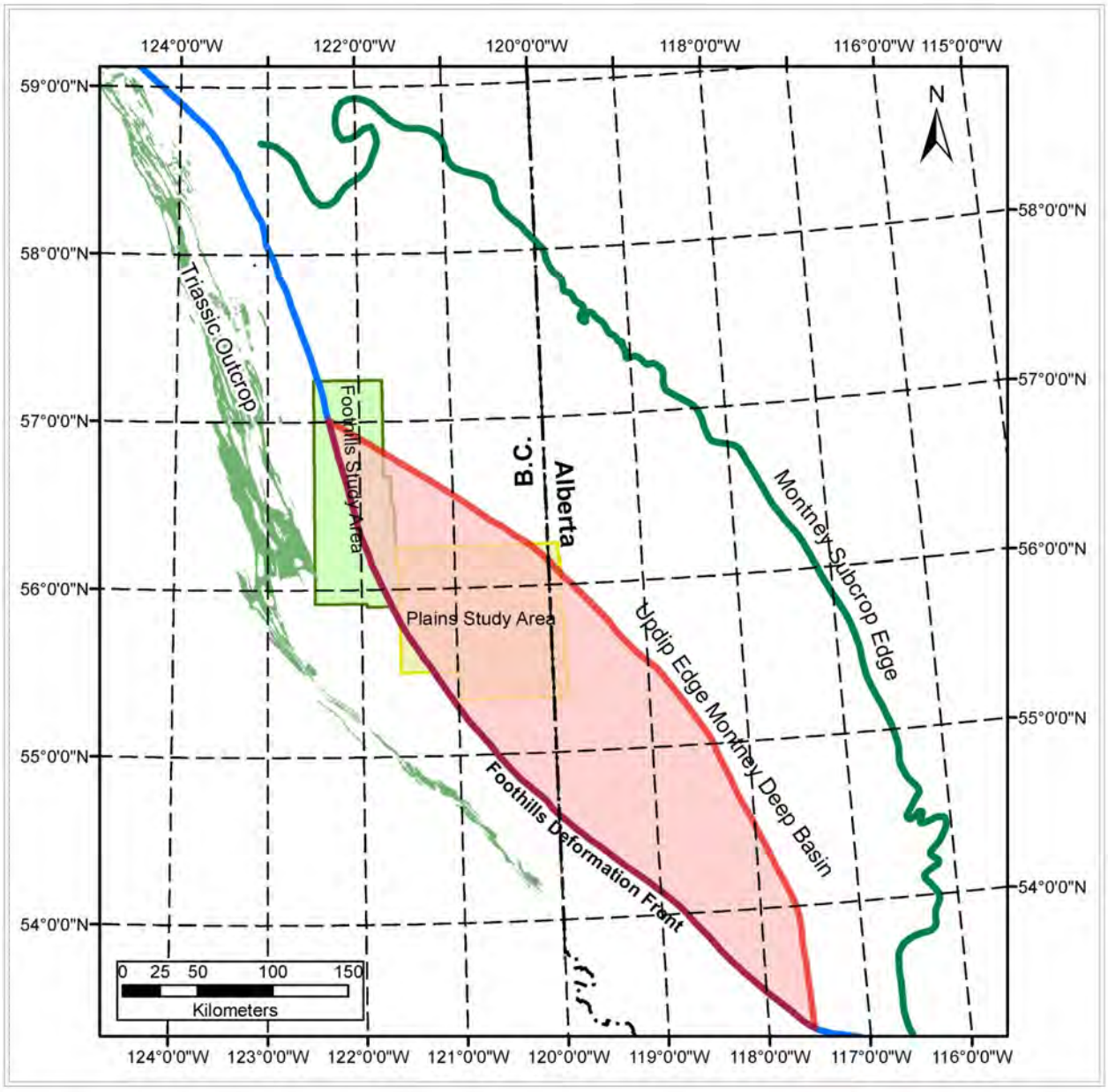

Figure 2. Locations of the Montney Formation subcrop in the Western Canada Sedimentary Basin, the Montney Deep Basin (red-shaded area) and Triassic outcrops (Toad and Grayling formations) in the adjacent Rocky Mountains.

and very low permeabilities and thus are considered 'tight gas' reservoirs.

Systematic development of Montney tight gas began in 2003 in the Dawson Field near Dawson Creek, with the drilling of numerous closely spaced vertical gas wells. In 2005, the first horizontal well was drilled into the play, and the gas rates obtained sparked a massive land rush and subsequently horizontal drilling in several areas across the BC Peace River plains (encompassed in the Plains study area; Figure 3). As play activity progressed, some operators experimented with horizontal wells in thicker, more shaly Montney Formation strata in the outer Foothills. Today, Montney tight gas drilling extends northwestward in the Foothills to near Pink Mountain (outlined by the Foothills study area; Figure 3). The Montney tight gas fairway includes several cities and towns, and extensive areas of agricultural, forestry and other human development—meaning that water resources are in high demand by other users.

The top of the Montney Formation ranges from 2000 to almost 3000 m deep across the play fairway. Several deep subsurface aquifers occur above the Montney Formation, and there is considerable well control with which to map these units because of extensive, multizone gas and oil development. While some aquifer potential exists in deeper

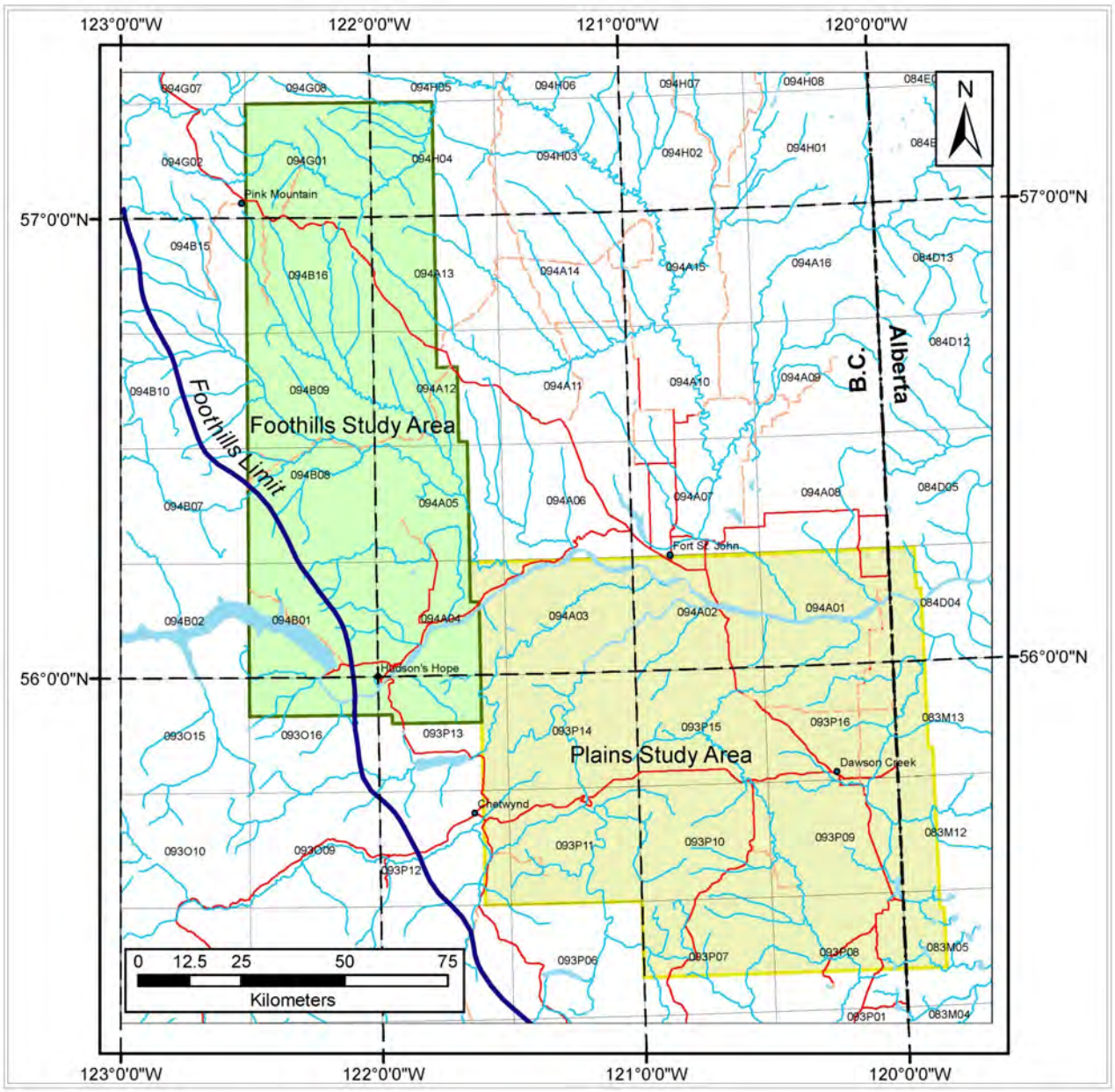

Figure 3. Locations of the Plains and Foothills study areas for Montney tight gas drilling, northeastern British Columbia.

strata, porosities and permeabilities tend to be poorer, and deep-well control is lacking in most areas.

Methodology

Several deep subsurface aquifers overlying the Montney Formation can be identified throughout the Plains and Foothills study areas (Figure 4). Aquifers lying below the Montney Formation were not considered for the Plains study area, as well control is too poor for reasonable characterization. In the Foothills study area, however, the Debolt Formation carbonates immediately underlying the Toad and Grayling formations (stratigraphic equivalents to the Montney Formation) were also included, as they are substantial hydrocarbon reservoirs and thus viable aquifer targets.

Stratigraphic mapping and reservoir characterization were supported by interpretation of well logs, cores, sample cuttings logs (from wellsites) and well test data. The Plains study area stratigraphic database comprises data from approximately 1100 wells distributed relatively evenly across the map sheet (Figure 5). Some very old wells with poor log suites and some closely spaced development wells were excluded. In the Foothills study area, approximately 900 wells were used; note that many of these were drilled along tight northwest anticlinal trends (Figure 6).

To establish a stratigraphic framework, eight regional cross-sections were constructed for the Plains study area and nine regional cross-sections for the Foothills study area (Figures 5, 6). Observations from cores and sample cuttings logs, as well as correlations from the literature and previous studies, were incorporated in the cross-sections.

Logs from each well were tied to the cross-section grid to interpret stratigraphic tops. All full-diameter cores were assigned to the correct stratigraphic unit, and core analysis data (porosity/permeability) were tabulated by formation. Numerous core descriptions from PRCL files and the literature were used for reservoir characterization, and several new cores, primarily in the Baldonnel and Debolt formations, were logged at the BC Ministry of Energy core storage facility in the community of Charlie Lake. As this report is being written, first-cut stratigraphic mapping is being undertaken, based on the stratigraphic work described above. Reservoir characterization work will continue with mapping of the net porous reservoir and the porosity-thickness for each aquifer interval.

Regional hydrostratigraphy and flow characteristics are being examined as stratigraphic work progresses. Existing deep-water source and disposal wells are being catalogued. Test data, including drillstem tests and production/injectivity tests, are being analyzed selectively, assigning results to the appropriate aquifer unit. Results will

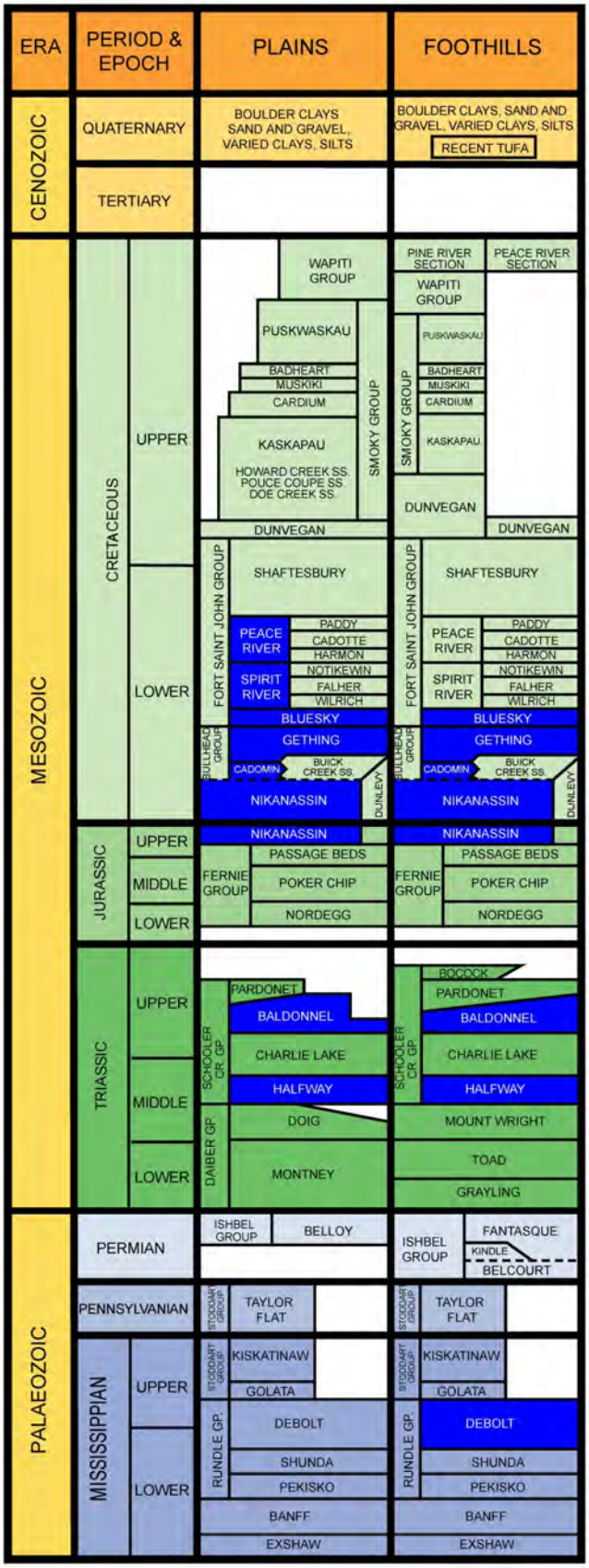

Figure 4. Stratigraphic columns for Peace River plains and adjacent Foothills, southern region of northeastern British Columbia. Potential aquifers are highlighted in dark blue.

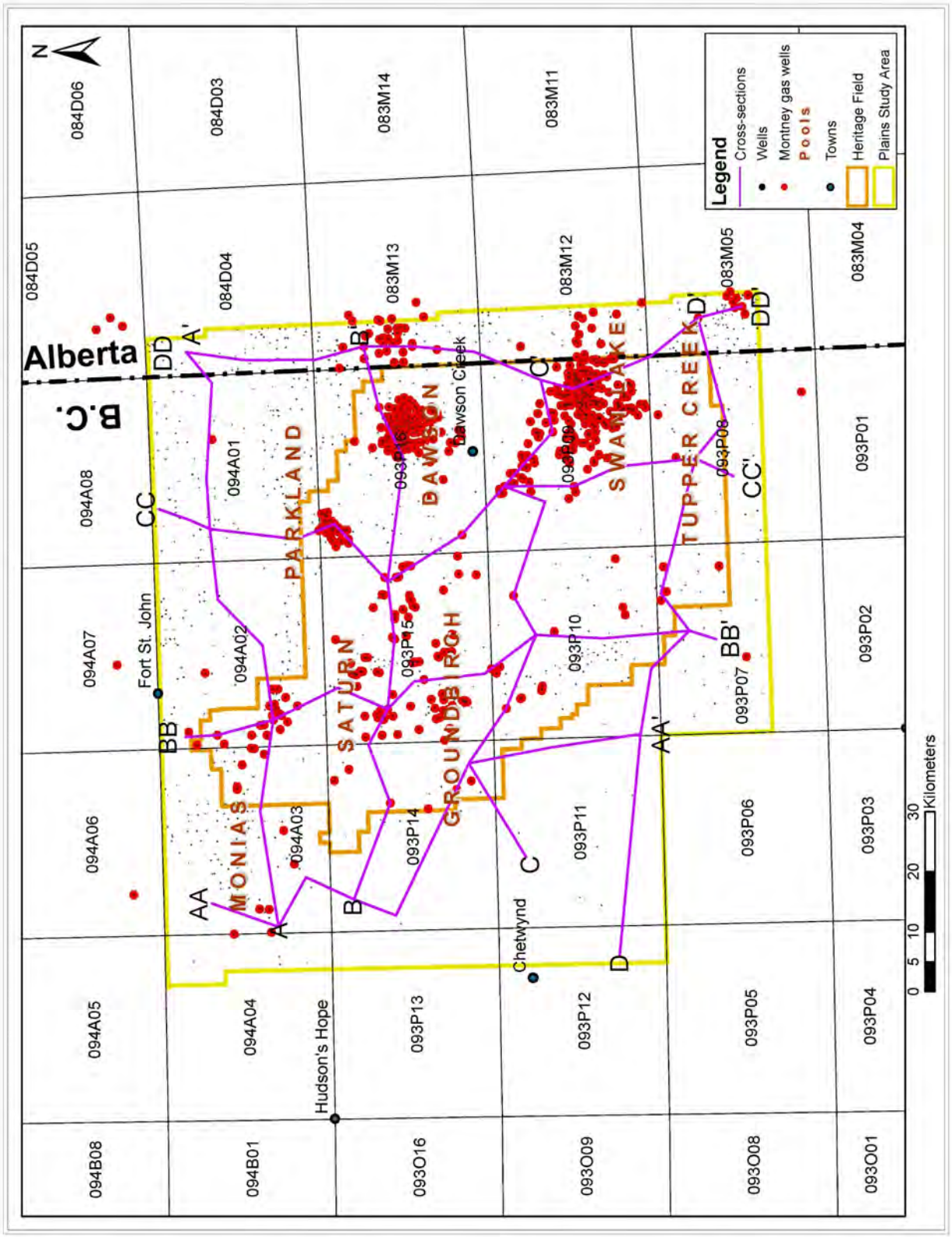

Figure 5. Well base map for Plains study area, northeastern British Columbia, highlighting well control and regional cross-sections.

be combined with the stratigraphic mapping to produce a regional characterization of each aquifer unit.

Preliminary Results

Project completion is scheduled for early 2011, at which time results will be released to working group members and integrated with results from surface and shallow subsurface investigations. Full public release will be scheduled in 2011. A few general observations can be made at this point:

Deep Basin (pervasive gas saturation) hydrodynamic regimes can be defined for most aquifer units. Within the Deep Basin, there is no potential for water production and modest permeabilities will restrict water disposal potential.

Shallow Cretaceous aquifers, particularly the Cardium and Dunvegan formations, crop out in central to northern parts of the Plains study area, and are not present to the north.

Well control and hydrocarbon production in the Foothills study area is strongly focused along northwest anticlinal trends. A key issue will be to determine whether reservoir permeability arises in part from structurally associated fracturing. In many areas, there may be insufficient well control between the sharply defined structural trends to accurately characterize aquifer potential between producing pools.

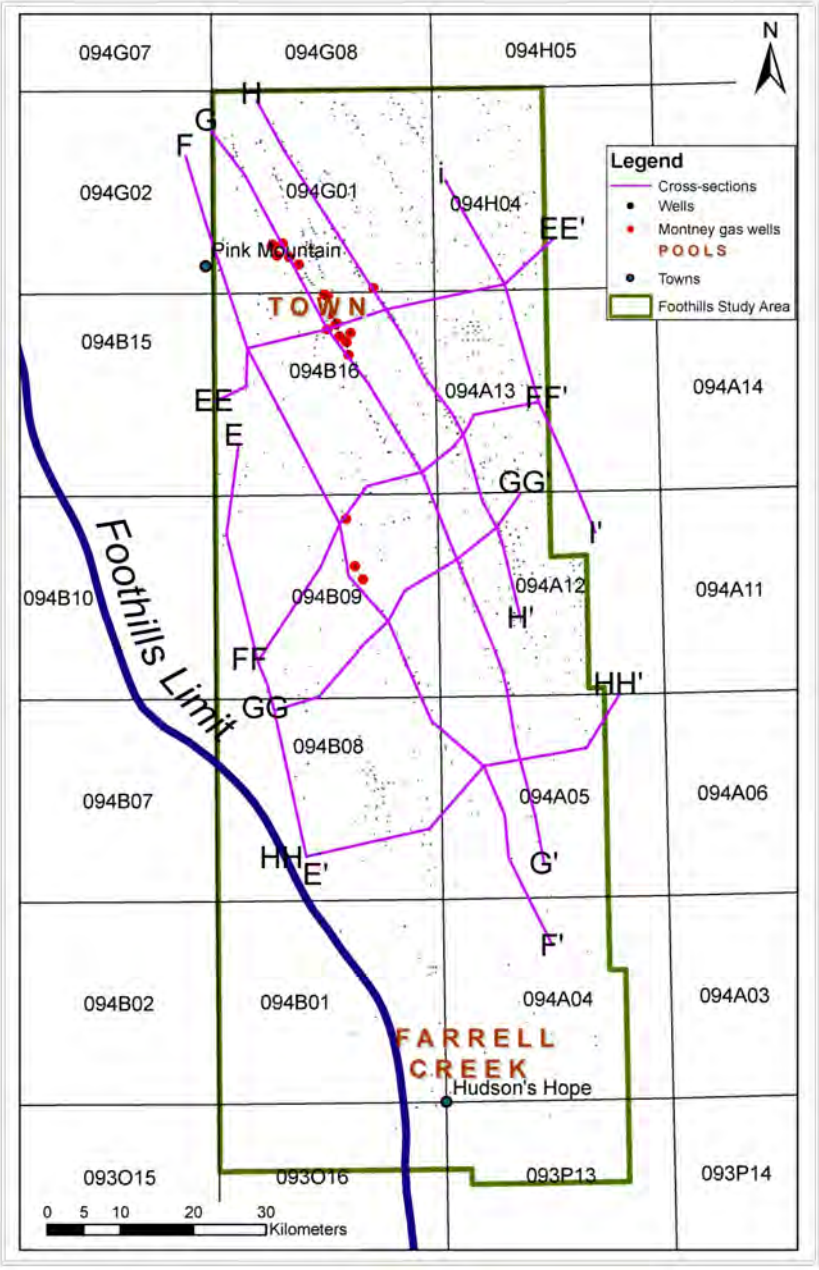

Figure 6. Well base map for Foothills study area, northeastern British Columbia, highlighting well control and regional cross-sections.

References

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