GROUNDWATER MONITORING
IN THE GREATER HUDSON HOPE AREA

FINAL REPORT

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OIL & GAS COMMISSION

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Executive Summary

Eight water sources initially were identified and assessed for water quality and quantity during the "Regional Background Assessment Of Groundwater Wells In the Greater Hudson Hope Area, December 2003". These sources were initially assessed during the summer and fall months, an assessment was completed to gather data on the water sources in the winter months. Concerns by the local residents of Hudson Hope over impacts to water quality and quantity resulted in the undertaking of a baseline survey of water resources in the Greater Hudson Hope area.

The sites were monitored for pH, electrical conductivity, temperature and water flow/level. 7 out of the eight had little variation in the field parameters, one site is a surface water body and had a change in conductivity and pH. This change can be attributed to seasonal changes in ice cover and subsequent water quality changes but should be monitored seasonally to confirm this fluctuation.

Acknowledgements

Diversified Technical Services would like to express its appreciation to the individuals who shared their time and knowledge towards formulating the information in this report. In particular, we would like to thank the staff at the OGC and the landowners in the Hudson Hope area who devoted time and knowledge towards this project.

We would like to thank the Science and Community Environmental Knowledge Fund for funding this project.

1.0 Introduction

1.1 **Study Area –** Hudson Hope, BC (Figure 3) is located @ 70 km. west of Fort St. John, BC in the Peace River section of northeastern British Columbia. The area extends from Latitude 56^{o} 01' to 56^{o} 08' North and from Longitude 121^{o} 45' to 122^{o} 05' West on NTS map sheets 94 B1 and 94 A4. The area includes the District of Hudson's Hope, BC.

1.2 **Literature on Similar Impacts** – "Selected Annotated References on Water Handling, Environmental and Land Use Aspects of Coal Bed Methane Development" summarizes various studies and reports that have been prepared on the impacts of CBM development in the United States and Canada. The areas of the report that are pertinent to this study are:

1.) Impacts to groundwater quantity from coal bed dewatering,

2.) Impacts to water quality from produced water disposal processes,

3.) Produced water handling techniques, and

4.) Land based impacts from CBM activities.

2.0 Profile

2.1 **Morphology** – The study area is located on the western edge of the Alberta Plateau in the high plains division of the Great Plains of North America. The area has a continental climate with warm summers and cold winters. Precipitation is about 425 mm annually and comes as 50% snow throughout the months of November – March. The mean annual temperature is @ 3^{o} Celsius with 68 days of frost free time annually.

2.2 **Hydrology** – Permanent streams in the study area consist of the Peace River, Lynx Creek and Farrell Creek, ephemeral streams are Portage Creek and unnamed tributaries of the systems. Natural low flow periods occur during the months of November through April of each year as illustrated in Figure 1. The Peace River has been regulated by the construction of the Bennett dam and has low flows during the months of May – July in the range of 290 m^3/s. The river is monitored for stream discharge at Hudson Hope by Water Survey of Canada. Figure 1 illustrates the typical runoff regime with the highest flows occurring in the month of May.

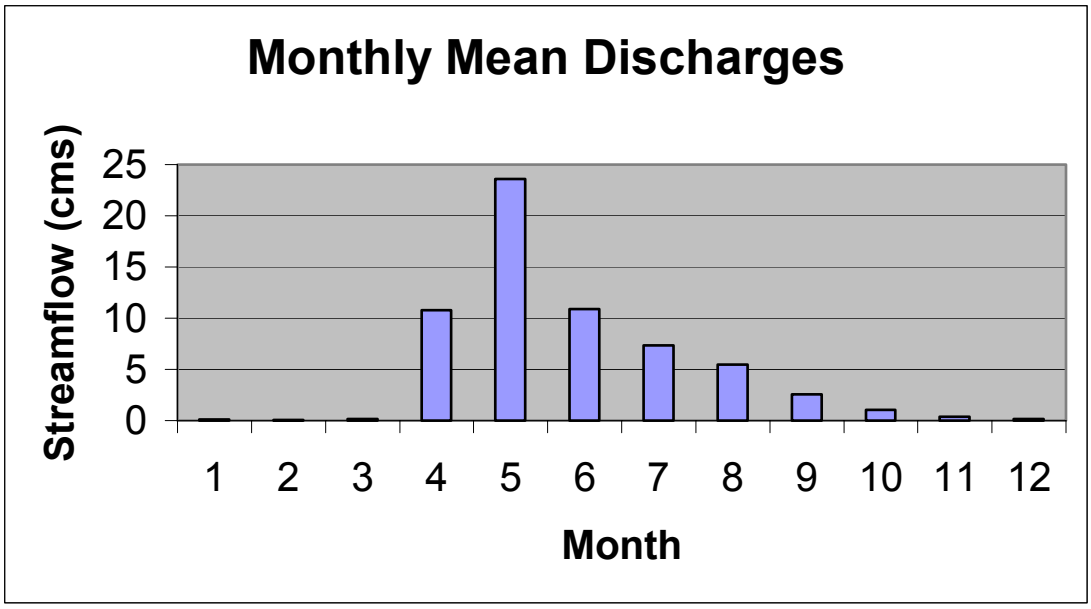


Figure 1. Monthly Mean Discharges. Blueberry River. Water Survey of Canada.

2.3 **Land Uses** – Land uses include agriculture, recreation, hydro–electric and forestry. Recreation use is high in area with tourism, hunting and fishing being the major areas of interest. W.A.C. Bennett dam, Peace Canyon dam, Dinosaur Lake, Williston Lake and the Peace River are major attractions. Agriculture is focused on cattle, forage crops and some grain farming. Forestry is limited in the area but does occur on private and Crown land, White Spruce, Lodge Pole Pine and Trembling Aspen are the species that are harvested. Road infrastructure is quite good with all weather roads being Highway #29, Canyon Drive, Beryl Prairie Road, Farrell Creek road and various access roads. Buildings are mainly domestic structures and ancillary buildings for farms.

2.4 **Water Uses** – Water use is in the study area includes municipal, domestic, hydro-electric power generation and agriculture (stock watering and irrigation). Surface water allocation and licencing is administered through the *Water Act* in BC, groundwater is not regulated at this time. A groundwater database is administered by Ministry of Sustainable Resource Management to store water well drilling logs. Recreation is a major user of the water as the Peace River is a popular boating, fishing and camping destination for locals and tourists.

2.5 **Aquatic Life** - in the Peace River consists of Bull Trout, Mountain Whitefish, Northern Pike, Rainbow Trout, Suckers (Long nose and Large-scale), Spot tail Shiner, Sculpin (Prickly and Spoonhead). Bull trout are listed as endangered and vulnerable, Spot tail shiner is a red listed species, and spoon head Sculpin is rated as a regionally significant species. The Lynx Creek is one of the last streams entering the Peace River downstream of the Peace Canyon Dam, this

dam is an obstruction to upstream travel for fish and has been the focus of many studies by the Provincial Fisheries program. Species in Lynx Creek include most of those present in the Peace River.

2.6 Waste Discharges – A landfill operated by the Peace River Regional District is located within the study area, no research was completed on the history of the landfill. Agriculture activities would expect to see feedlot waste and some minor in crop chemical applications.

3.0 Bedrock and Surficial Geology

The region is underlain by sedimentary rocks which are flat lying and gently dipping to the North East, they consist of Cretaceous shales and sandstones. The plains section consists of undulating and rolling till plain interspersed with glacial lake basins. The main rivers have cut deep post glacial channels as much as 700 feet deep, which in places expose the underlying Upper Cretaceous bedrock. A mantle of unconsolidated debris overlying the bedrock is the result of glaciations which include coarse to medium lacustrine and alluvial deposits. The till in the study area is usually less than 3 meters thick and is buried by sands and gravels laid down by outwash from meltwater streams leaving the ice front. The Peace River (preglacial) was blocked by the Keewatin ice and formed an inland lake called Lake Peace, the shorelines of the lake are located between the elevations of 2750 feet and 2260 feet, beach deposits and lake deposits (gravel, sand, clay and silt) were laid down by wave action and glacial meltwater in the study area.

Mathews has described how the advance and retreat of the glaciers has created the topography and soils that we see today. The study area was occupied by Lake Peace, a large inland lake formed by the melting of the Cordillean and Laurentide ice sheets, with the west shoreline near the study area. Melting of the Cordillean ice into the lake and fluvial outwash from the glacier has created deltaic deposits which are primarily of granular origin. The pre glacial valley is shown on Figure 2 which corresponds to the higher risk area detailed later in the report.

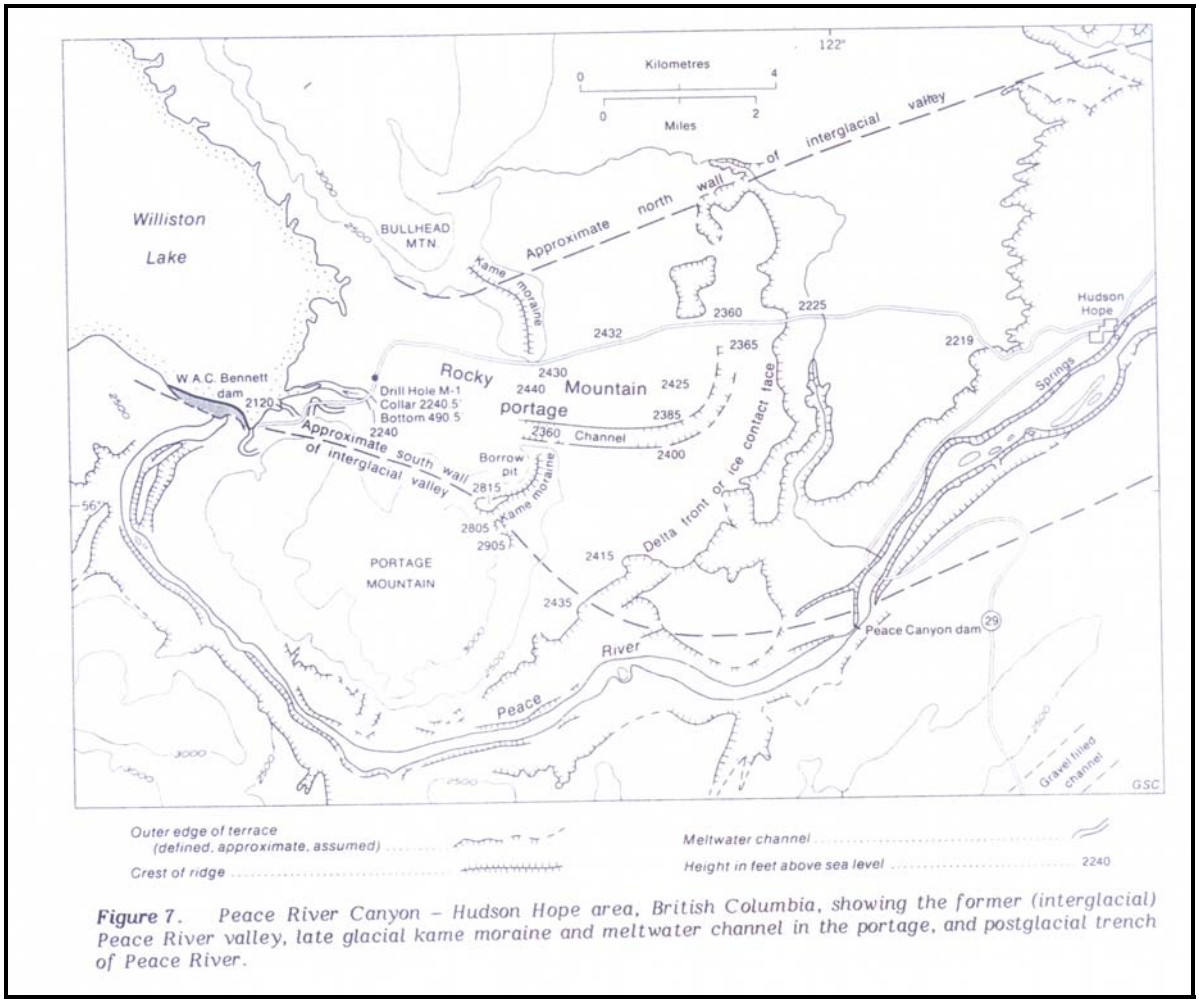


Figure 7. Peace River Canyon – Hudson Hope area, British Columbia, showing the former (interglacial) Peace River valley, late glacial kame moraine and meltwater channel in the portage, and postglacial trench of Peace River.

Figure 2. Geologic Survey of Canada. Bulletin #331, 1980.

4.0 Aquifers

There are three groundwater sources in the area, a shallow aquifer (unconfined) in the unconsolidated sediments laid down during glaciation, a confined aquifer below the impermeable layer (shale or clay) and a bedrock aquifer.

4.1 **Unconfined Aquifer** is a saturated bed of surficial soil that does not have an impermeable layer between the water table and the ground surface. The water table is exposed to the atmosphere through the pore spaces in the overlying soil. Water levels fluctuate with seasons and climatic variability as recharge areas are localized and dependent on precipitation. A majority of the study has this type of aquifer.

4.2 **Confined Aquifer** is a water bearing soil that has a confining layer between the water table and the ground surface. Usually the water is under pressure as the recharge area is located upslope and in unconfined materials. A major feature of the area is the pre-glacial Peace River valley that runs eastward from WAC Bennett dam (between Portage Mtn and Bullhead Mtn.) and rejoins the Peace River Valley at Hudson's Hope. The pre-glacial valley floor (bedrock) is at least 1000 feet below the WAC Bennett dam and 500 feet below the District of Hudson Hope (data derived from test holes conducted by PFRA and BC Hydro). An impermeable clay – silt layer is located between 10 – 60 meters below the District of Hudson Hope (PFRA, 2001) with sands and gravels down to @ 135 meters, bedrock was not encountered in the test hole. This is consistent with Mathews that a deep pre glacial valley exists below the present day river elevation.

4.3 **Springs** occur in the area and are a combination of unconfined and bedrock aquifers daylighting out at incised valleys. The largest spring appear 10 meters below the terrace that the District of Hudson Hope sits on, drilling data from PFRA and BC Hydro show a perched water table with a impermeable clay layer beneath a gravel deposit. Discussions with locals revealed the springs were present prior to the construction of the Bennett dam but flows substantially increased after the filling of the reservoir. It is possible that water is following the preglacial valley from the reservoir and flowing on the clay/silt lacustrine deposit of the glacier. Minor springs were found on the East edge of the area near the Peace River and Farrell Creek road, springs day lighted out on top of the shale bedrock, flows were minor but locals said the springs flowed year round. The third source of springs was reported to be in the Brenot Creek / Lynx Creek incised valley, no investigation was done on to confirm the presence/absence of the springs as there are no users of the springs, Lynx Creek was sampled as this groundwater flow will form a major portion of the winter low flow.

4.4 **Bedrock aquifer** is located generally throughout the study area. The bedrock consists of sandstone on the west side of the area and shale on the eastern edge as shown by mapping, water well logs and bedrock exposures in the area. It is assumed that the bedrock slopes to the northeast as evidenced by local topography and water well records. Coarse granular soils in the beryl Prairie area allow high rates of infiltration from precipitation as the surface is permeable. Brenot Creek and Lynx Creek likely receive their base flow from groundwater recharge.

5.0 Water Quality Assessment

Analysis of the water quality was completed in the field and provided basic water quality parameters in real time. Changes in water quality can become evident with pH, conductivity and temperature. A portable water meter (Hanna Instruments 991301) was used to measure the pH, Temperature, Total Dissolved Solids and Electrical Conductivity of the water. Established practice is to pump out 2-5 well volumes to ensure the water being sampled is from the aquifer and not being affected by the well casing.

6.0 Water Quantity Assessment

Flow measurements on streams and springs plus water level data was compiled on the sites for long term groundwater quantity monitoring. Wells with access were measured with a water level indicator tape.

Yield on flowing surface waters was determined by using a Swoffler flow meter Model 2100. Water depth and velocity was measured at 20 verticals for each measurement site to develop a cross sectional profile of the stream. Velocity measurements were taken at 60% of the depth of each vertical, this depth gives the mean velocity for the vertical. The effective depth was determined as the distance from the bottom of the ice to the river substrate. A Stihl gas powered ice auger was used to drill through the river ice to first locate the active channel and then delineate the extent of the flowing stream.

7.0 Environmental Monitoring Site Locations

The area is geologically complex as there are several surface water, groundwater, topographical and sediment deposits influencing the flow regimes. The sampling sites were located after a review of well water logs, existing reports, topographic map, air photo map review, field inspections and discussions with residents. Soils in the area of Beryl Prairie and the Peace River valley limit the development of dugouts as the soil is very permeable. Lynx Creek was selected for the second surface water sampling site as it drains a majority of the study area and receives groundwater recharge for its base flow. Monitoring sites were selected to monitor the various aquifers present in the area and obtain baseline data for the sites.

Site # 1 is located on the Peace River terrace and consists of a shallow (9 meter deep) well (150mm diameter) situated in gravels and sands. Soils in the area consist of the Branham Unit (BC Soil Survey) which are well drained and rapidly pervious.

Site #2 is located on the terrace and consists of a shallow (10 meter deep) well (1.2 meter diameter) situated in gravels and sands. Soils in the area consist of the Branham Unit (BC Soil Survey) which are well drained and rapidly pervious.

Site # 3 is located on the terrace and consists of a spring which flows out of the Peace River bank. Flows in the spring were measured at 250 gallons / minute and flow year round, several of these springs daylight out of the bank of the Peace

River below the Hudson Hope community. The site is under application for a Water Licence and was developed in 2003. Soils in the area consist of the Branham Unit (BC Soil Survey) which are well drained and rapidly pervious.

Site # 4 is located on the Beryl Prairie road and is the community well for the area and consists of a deep (68 meter deep) well (150mm diameter) situated in gravels and sands. Soils in the area consist of the Beryl – Lynx Unit (BC Soil Survey) which are well drained and moderately pervious.

Site # 5 is sampling the Lynx Creek watershed at the Highway #29 bridge crossing. The area was chose to monitor the watershed which encompasses a large portion of the CBM activity area.

Site # 6 is located on District Lot 1200 and consists of a dugout with a remote watering system to supply 140 head of cattle throughout the winter. Soils in the area consist of the Kenzie Unit and consist of a moss bog peat site which is very poorly drained and slowly pervious. It is thought that the area depends on the adjacent Beryl Lynx soils for groundwater supply as these soils are well drained and moderately pervious. The volume of water required for watering the herd in the winter combined with the dugout volume would require infiltration to sustain the withdrawals.

Site # 7 is located on the North portion of D.L. 1226 lying North of the Brenot Creek and consists of a deep (100 meters deep) well (150mm diameter) situated in gravels, clay layers and sands. Soils in the area consist of the Beryl-Lynx Unit (BC Soil Survey) which are well drained and moderately pervious.

Site # 8 is located on the Highway # 29 and consists of a spring which daylights on the shale a short distance up the creek valley. Reports from the locals say the spring runs year round Soils in the area consist of the Septimus Creek Unit (BC Soil Survey) which are steep and include a variety of bedrock, colluvial, moraine and fluvial materials incised by drainages.

8.0 Risk Areas

Risk areas (Figure #3) were identified to aid in focusing the review and monitoring of sites that require a higher level of protection. Areas were deemed as having a higher risk by using the surficial soils information, location of dwellings and access corridors. Data was compiled and analyzed using maps, reports and databases. Areas identified are to be used as a guide and should not preclude areas outside the study zone. This risk assessment is based on the information reviewed in this report and is not intended as all inclusive but can be used as a guide for higher level review of activities.

a. **Peace River Terrace and Pre Glacial Valley** This area has extensive water use for the area, the District of Hudson Hope and a minimum of 30 homes depend on this source for their water supply. The pre glacial

valley consists of gravels and sands deposited by the melting of the Cordillean glacier into Lake Peace, moraine and fluvial outwash have created a large unconfined aquifer which has a risk of contamination. The Peace River terrace has a large fluvial deposit of gravels and sands which are susceptible to contamination, no impermeable layer exists. Highway #29 and Canyon Drive run through the length of the area and increase the risk from transportation of materials.

b. **Beryl Prairie Road Corridor** This area has an aquifer that flows to the North East on the sedimentary bedrock, gravels and sands are the predominant surficial soil and minimal impermeable clay layers exist. Emphasis is on the 2 km. corridor West of the road and 1 km. East. An estimate of 40 dwellings in the area with a majority having wells developed in the aquifer.

9.0 Recommendations

Future work on the project should include:

1. **CBM Water Monitoring** Environmental Monitoring Sites should have seasonal monitoring of static water level, pH, electrical conductivity and temperature with annual sampling for the full suite of analysis. The baseline data can be a source of information to monitor any impacts to water quality or quantity. Site #6 (dugout) should be monitored this spring for field parameters as the winter measurements were slightly different from the summer data. This variation can be attributed to seasonal fluctuations in water quality but needs to be confirmed.
2. **Landowner Monitoring** Promote the process for the landowners to monitor their water source by providing the tools and training. Education and communication would be the focus.

10.0 References

BC Environment. 1993. Groundwater Resources of British Columbia.

Buchanan, B. et al. 2000. Water Wells That Last For Generations. Prairie Farm Rehabilitation Association, Agriculture and Agri-Food Canada.

Driscoll, F.G. 1986. Groundwater and Wells. Johnson Filtration Systems Ltd.

Lord, T.M.and Green, A.J. 1986. Soils of the Fort St. John – Dawson Creek Area, British Columbia. British Columbia Soil Survey. Agriculture Canada.

Mathews, W.H. 1980. Retreat of the Last Ice Sheets in Northeastern British Columbia and Adjacent Alberta. Geological Survey Bulletin # 331.

McDonald, L.E. and Strosher, M.M. 2002. CBM Produced Water Guideline. Environmental Protection, Water Land and Air Protection.

Minstry of Water, Land and Air Protection. 1992. Framework for a Hydrogeologic Study.
http://wlapwww.gov.bc.ca/wat/gws/gwdocs/gweddocs/framework.html

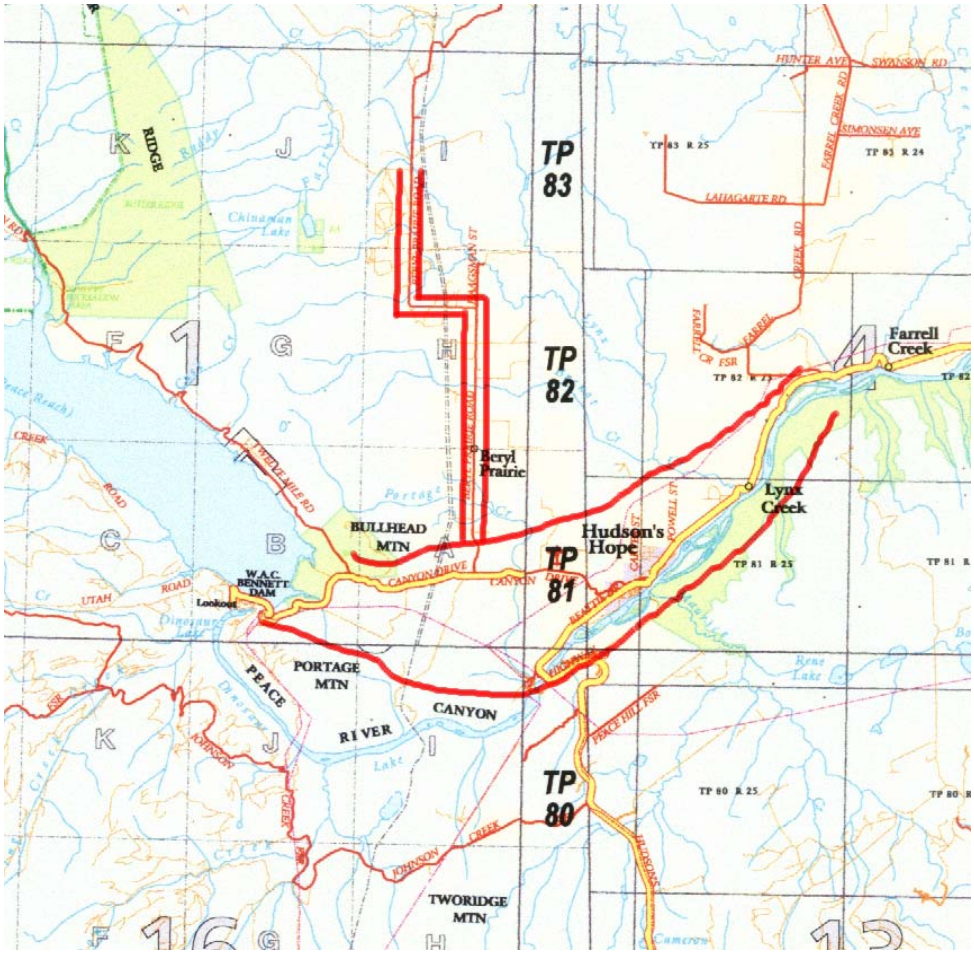
Ministry of Energy and Mines. 2003. Coalbed Methane in British Columbia.
www.gov.bc.ca/em

Ministry of Energy and Mines. 2002. Selected Annotated References On Water Handling, Environmental and Land Use Aspects of Coalbed Methane Development.

Ministry of Environment, Lands and Parks. 1996. Defining the Source Area of Water Supply Springs.

Peterson, H.G. 2003. Water Sampling, Analysis and Interpretation. Safe Drinking Water Foundation (Canada).
http://www.quantumlynx.com/water/vol8no2/story2.html

11.0 Tables and Figures



Monitoring of Groundwater Wells in the Greater Hudson Hope Area

Diversified Technical Services Dawson Creek, BC	Figure 3 Risk Areas Study Area Location

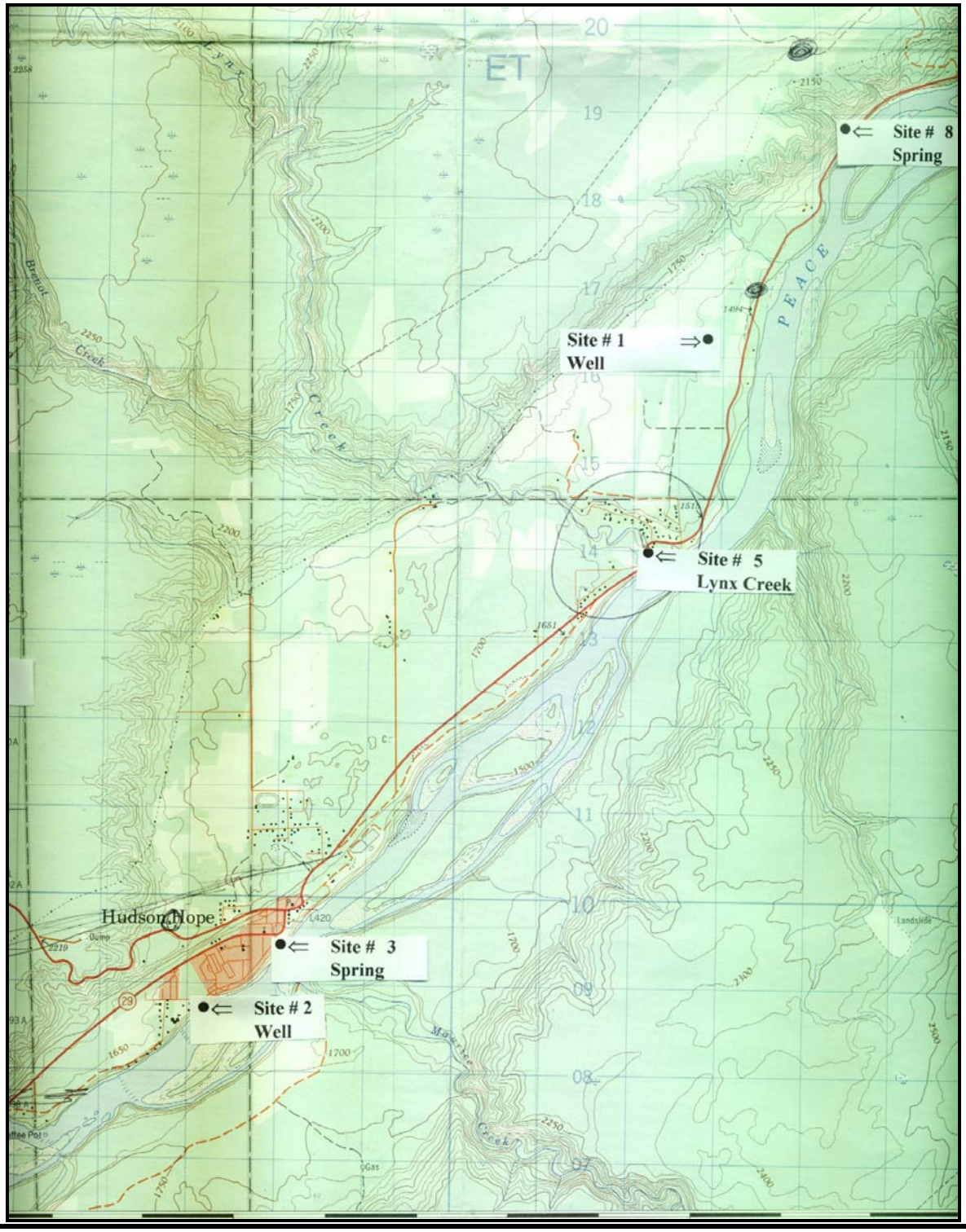


Figure #2 - Sample Site Locations East Map Sheet

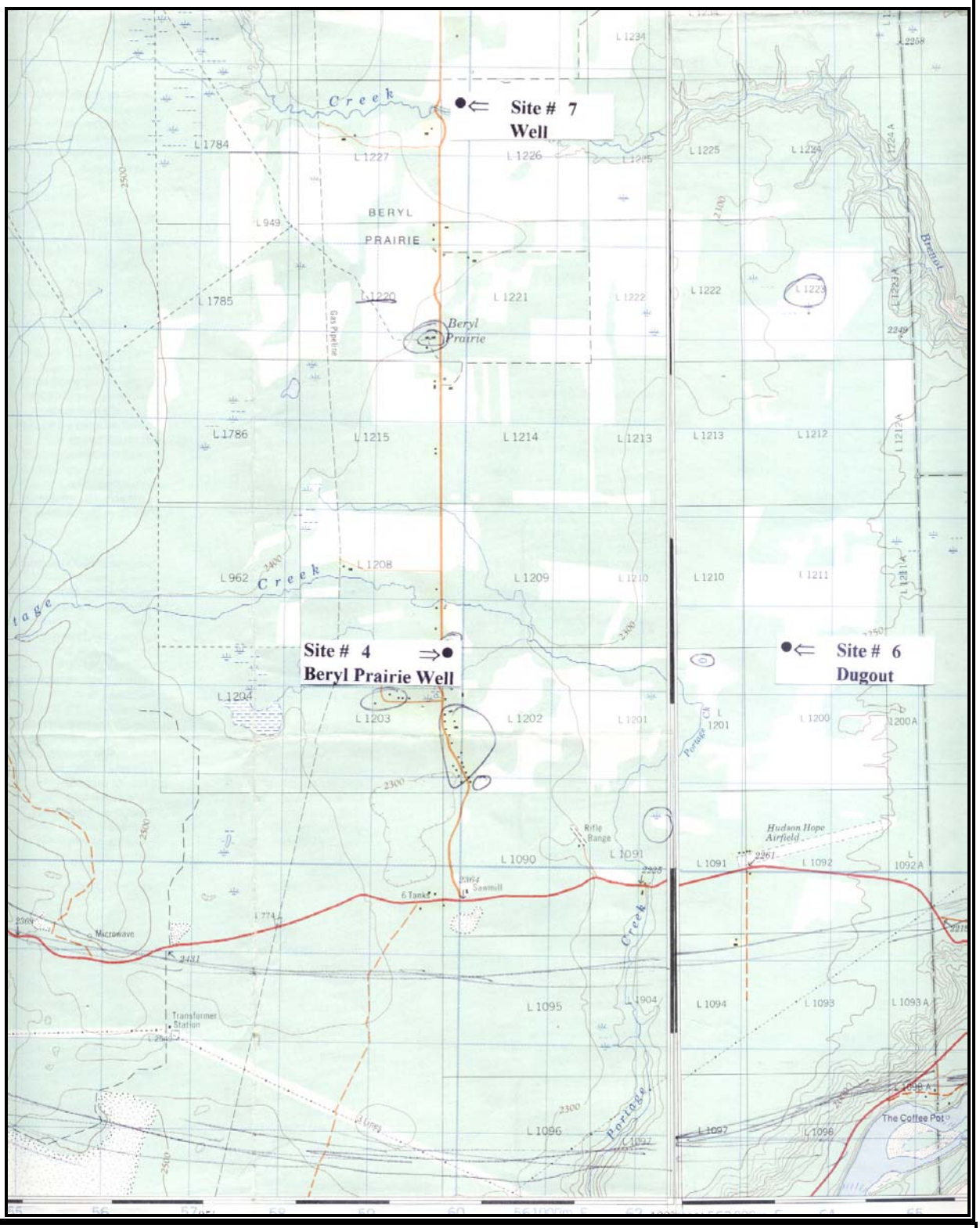


Figure 3. - Sample Site Locations West Map Sheet

Site #1.

Site 1. Water Quality.

Site 4. Beryl Prairie Well

Site 5. Lynx Creek.

Site 6. Dugout

Site 7. Well

Site 8. Spring, tributary crossing Hwy #29

CBM Drilling Operation