REGIONAL BACKGROUND ASSESSMENT OF GROUNDWATER WELLS IN THE GREATER HUDSON HOPE AREA

Submitted to:

OIL & GAS COMMISSION
Fort St. John, BC

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Executive Summary

Coal Bed Methane exploration has been initiated near Hudson's Hope, BC. Concerns by the local residents of Hudson Hope over impacts to water quality and quantity have resulted in the Oil & Gas Commission undertaking a baseline survey of water resources in the Greater Hudson Hope area. Impacts to water have occurred in the U.S.A. (Ministry of Energy and Mines, 2002), though the areas impacted differ from the geology and climate of the study area, there exists a concern in the community that impacts may occur as development proceeds. Rationale was to establish monitoring sites for baseline data on water quality and quantity prior to Coal Bed Methane exploration.

Diversified Technical Services (DTS) was requested to identify suitable sites in the area and gather baseline data on the water. Eight Environmental Monitoring Sites (EMS) were located and sampled for water quality and quantity data during the fall of 2003. Quality analysis was completed for Potability, Dissolved Metals, and Extractable Petroleum Hydrocarbons. Quantity data included static water level measurement, pump tests, and flow measurements on springs and creeks. A review of surficial and bedrock geology was completed to identify the aquifers and guide the location of EMS.

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 (SCEK) for funding this project.

1.0 <u>Introduction</u>

1.1 **Study Area –** Hudson Hope, BC (Figure 1) 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 – April of each year as illustrated in Chart 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. Chart 1 illustrates the typical runoff regime with the highest flows occurring in the month of May.

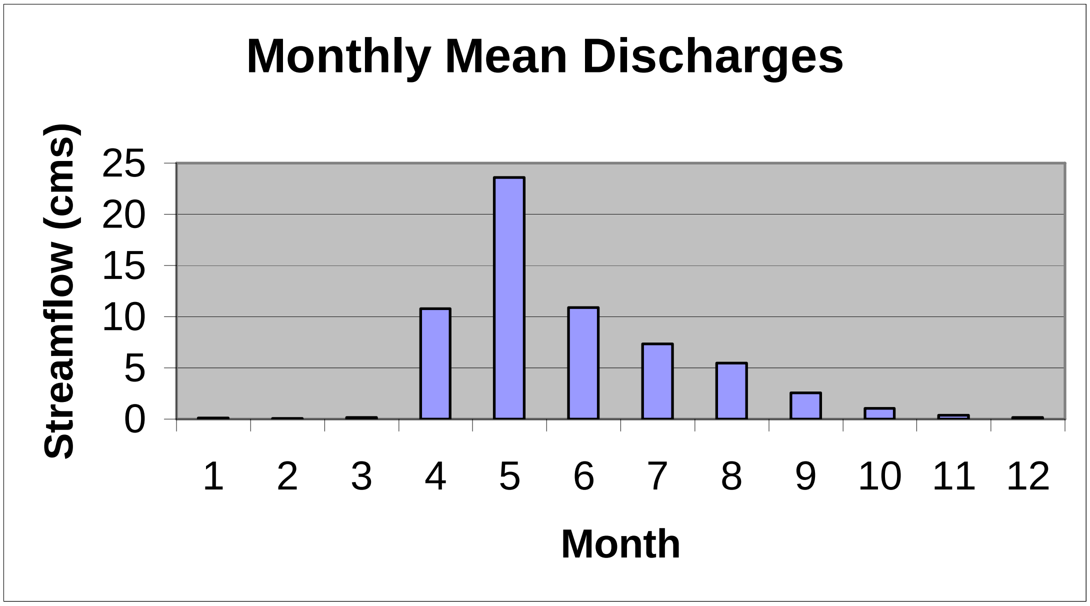

Chart 1. Monthly Mean Discharges. Blueberry River. Water Survey of Canada.

2.3 **Land Uses** – Land uses include agriculture, recreation, hydro–electric, and forestry. Recreation use is high in areas 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 licensing is administered through the *Water Act* in BC, and 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, and 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 shale and sandstone. 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, and 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.

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: 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 an 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

8 sites were sampled (Figures 3 & 4). Analysis of the water quality was completed in the field and through lab analysis; field tests were completed to provide basic water quality parameters in real time. A portable water meter (Hanna Instruments 991301) was used to measure the pH, Temperature, Total Dissolved Solids, and Electrical Conductivity of the water. This allowed the monitoring of the well purging to establish when the parameters had stabilized to collect a representative groundwater sample. 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. Water samples were obtained from the monitoring sites and sent to NorWest Labs in Edmonton for analysis. Routine Water (Potability), Dissolved Metals, and Extractable Petroleum Hydrocarbons tests were also completed. Results of analyses are provided in Table 1.

6.0 Water Quantity Assessment

Yield tests and water level data was compiled on several of the sites for long term groundwater quantity monitoring. A groundwater well yield test involves pumping the water out of the well at a continuous rate and measuring the draw down inside the well. Measurements were taken using a Sphlor water level meter, which indicates the water level by the probe making contact with the water level. This equipment allowed very precise and efficient monitoring of the water level. Flow rate was measured using the stopwatch and pail method; measurements were repeated throughout the testing to ensure constant flow rates. Recharge of the well was measured after a continuous pumping time of 2 hours was completed. Yield on flowing surface waters was determined by using a timed float and cross sectional area method.

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. It was initially thought to use two deep wells, two shallow wells, two surface water bodies, and two springs for the monitoring sites. Surface water bodies (dugouts) were minimal in the area and collected localized surface runoff area. 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. Discussions were held with landowners to outline the program and the activities that would be completed. The majority of people were open to the project.

Site # 1 (Figure 5) 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, and 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 License 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 (Figure 6) 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 (Figure 7) 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 (Figure 8) 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 are 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 (Figure 9) 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 (Figure 10) 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 1) 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 climatic variability over time, plus monitoring any impacts to water.
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.
3. **Water Database** Development of a database to store and analyze water quality / quantity information.
4. **Risk Areas** Hydro Geological Assessment of the area will prove up the potential impacts on the water and further delineate risk areas.

10.0 References

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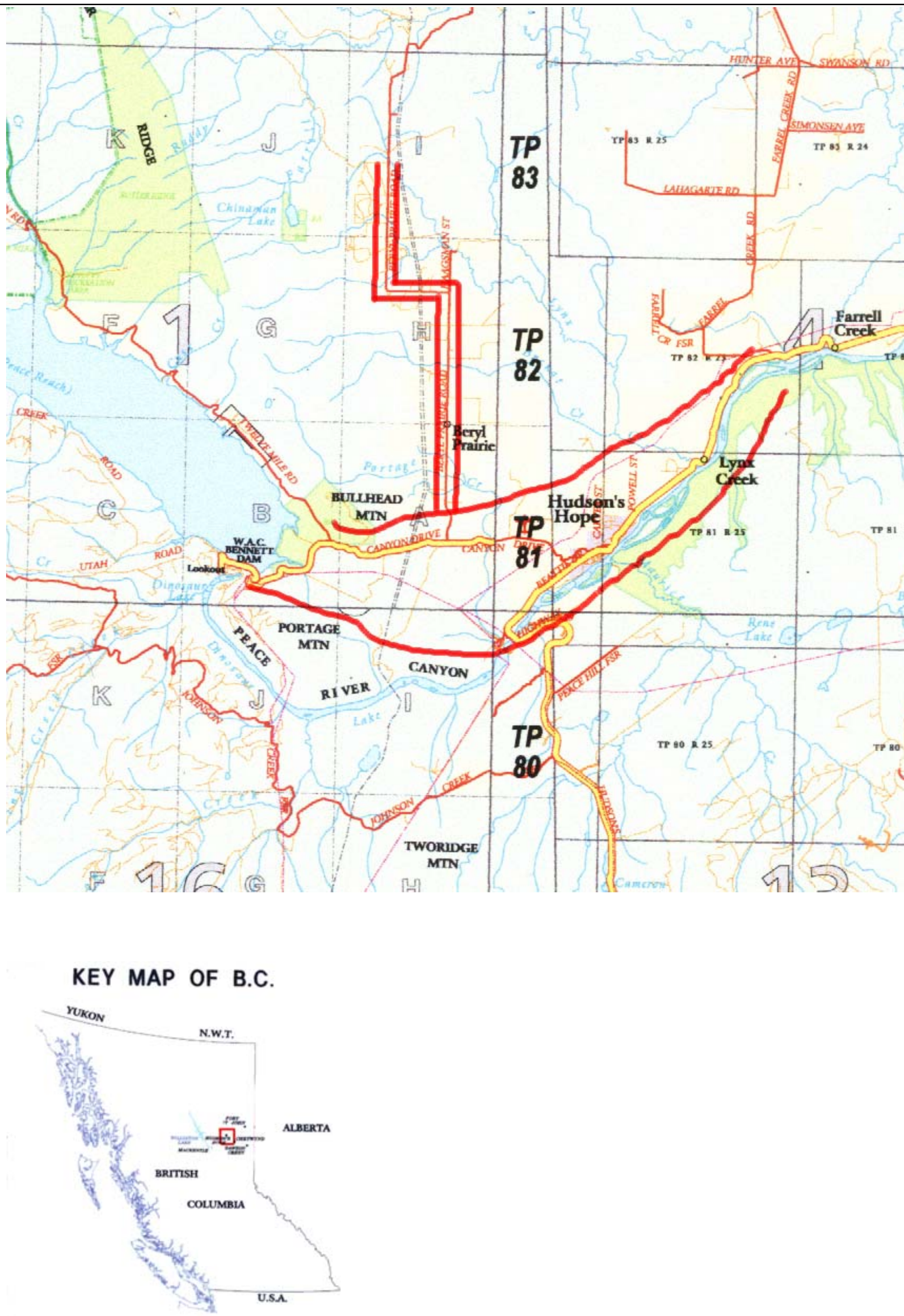
11.0 <u>Figures</u>



Regional Background Assessment of Groundwater
Wells in the Greater Hudson Hope Area

Diversified Technical Services Dawson Creek, BC	Figure 1 Risk Areas Study Area Location

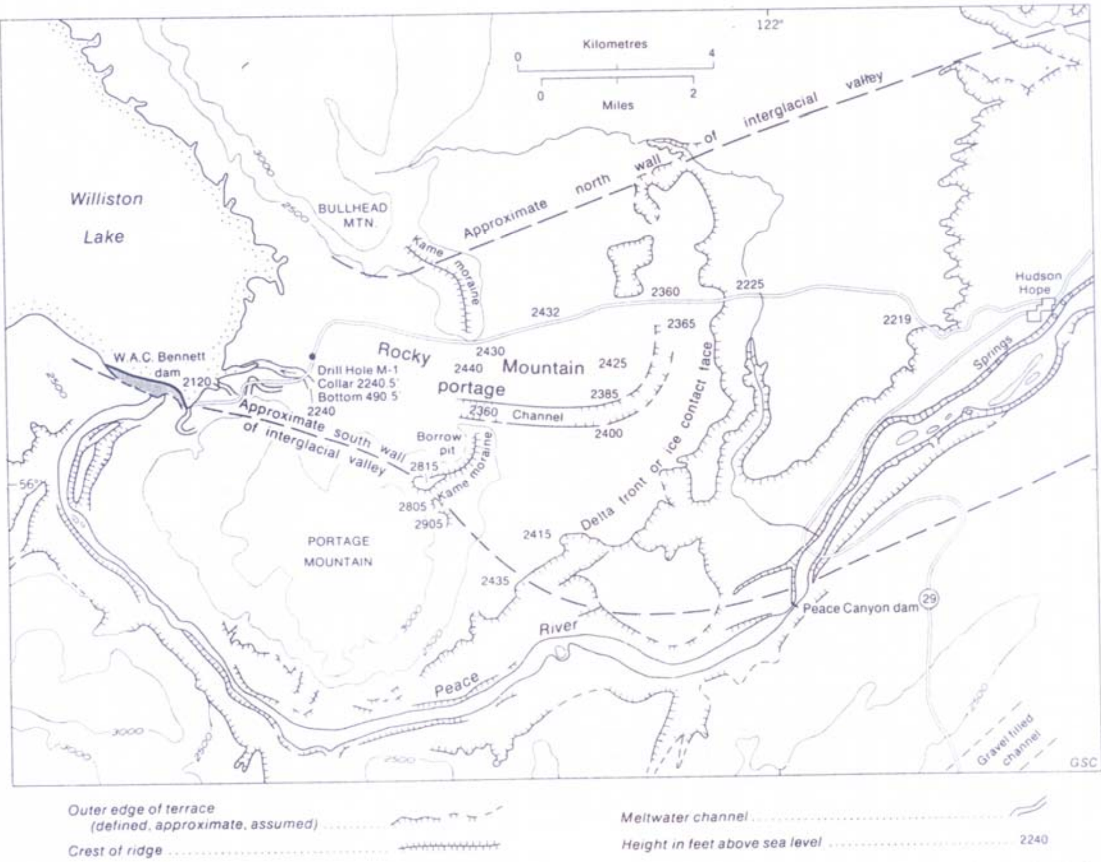


Figure 7. *Peace River Canyon – Hudson Hope area, British Columbia, showing the former (interglacial) Peace River valley, late glacial kame moraine and meltwater channel in the portage, and postglacial trench of Peace River.*

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

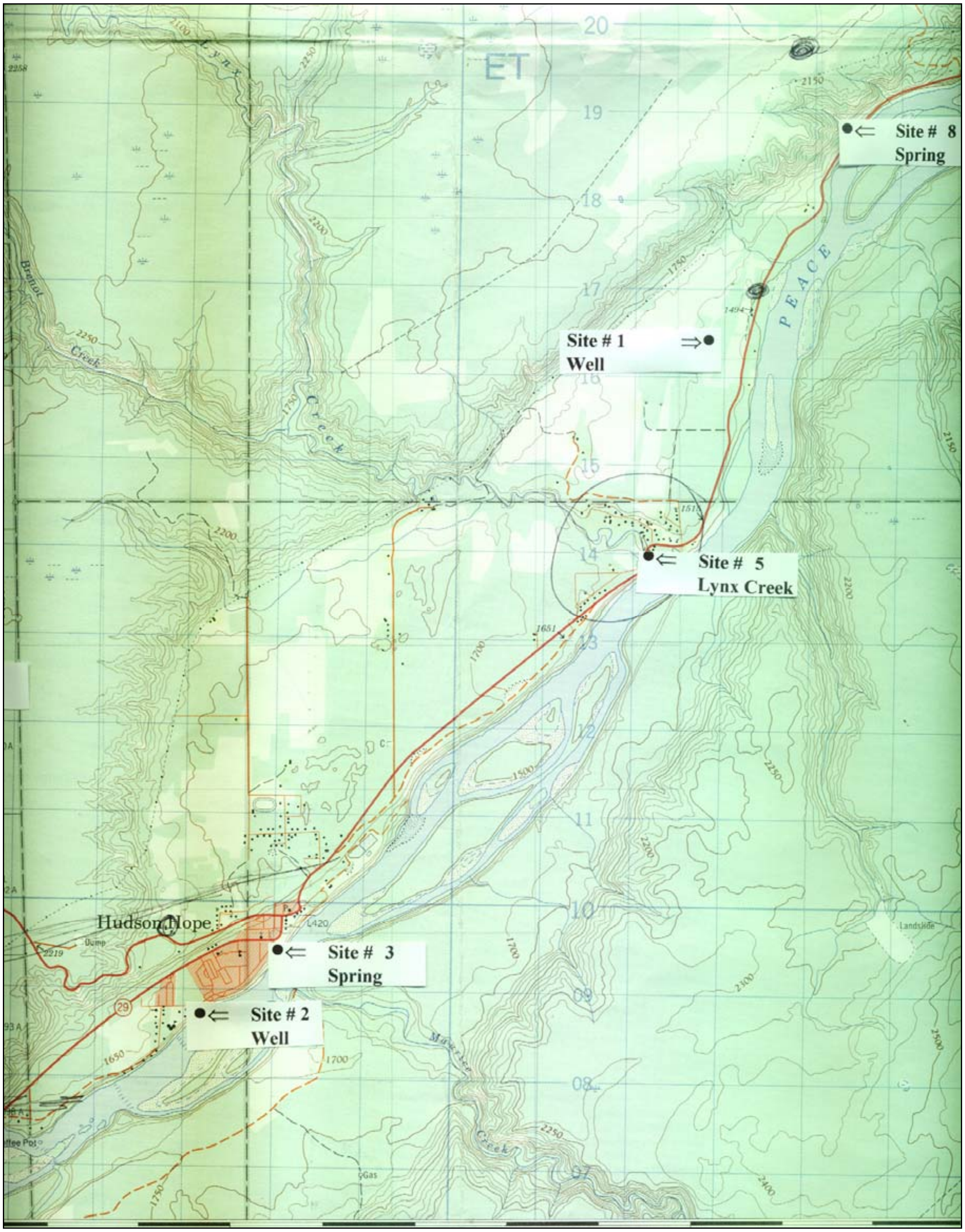


Figure 3 - Sample Site Locations East Map Sheet

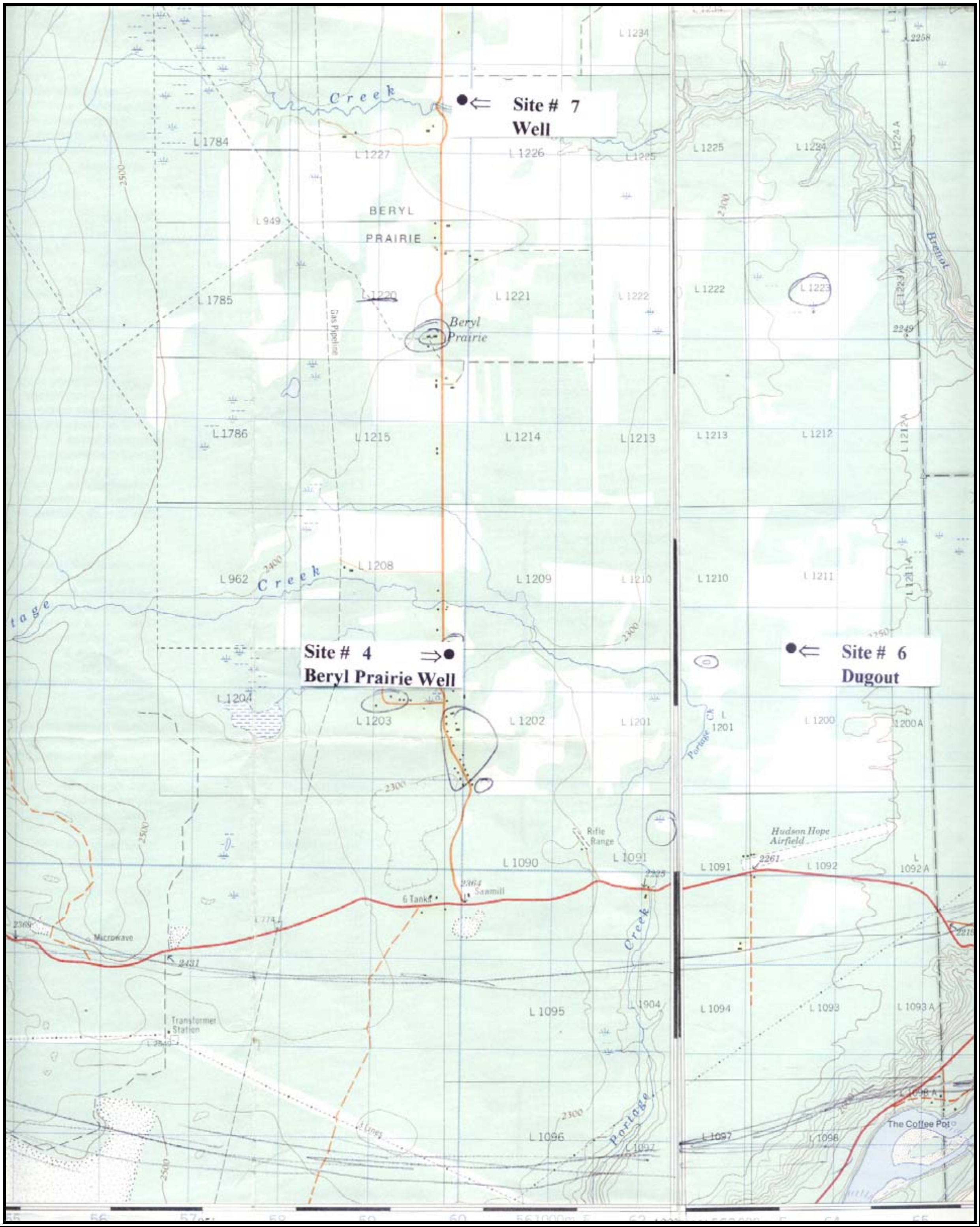


Figure 4. - Sample Site Locations West Map Sheet

Figure 5a.

Figure 5b. Water Quality.


Figure 6. Beryl Prairie Well


Figure 7. Lynx Creek.


Figure 8. Dugout


Figure 9. Well

Figure 10. Spring, tributary crossing Hwy #29

CBM Drilling Operation

Table 1. Hudson's Hope Groundwater Survey, August 2003

					Site # 1	Site # 2	Site # 3	Site # 4	Site # 5	Site # 6		Site # 7	Site # 8
Paramter	**Units**	**CDWGL**	**Guideline Type**	**MDL (Sites 1-6)**	**Well East of Lynx Cr.**	**Well in HH**	**Spring in HH**	**Well, lower Beryl Prairie**	**Lynx Cr.**	**Dugout north of Airfield**	**MDL (Sites 7 & 8)**	**Well, upper Beryl Prairie**	**Spring West of Farrell Cr. Road**
pH		6.5 - 8.5	AO		7.57	7.74	7.83	7.53	8.36	8.13		7.16	8.14
Specific Conductance	µS/cm	No guideline		1	1240	733	1220	675	677	424	1	2690	2200
Total Dissolved Solids	mg/L	≤500	AO	1	819	400	827	409	457	234	1	2110	1830
Hardness-total	mg/L	No guideline			646	384	728	440	417	211		919	976
Calcium	mg/L	No guideline		0.2	154	79.8	147	108	70.8	46.2	0.2	256	174
Magnesium	mg/L	No guideline		0.2	63.7	44.9	87.8	41.3	58.2	23.3	0.2	67.8	131
Iron	mg/L	≤0.3	AO	0.01	<0.01	<0.01	0.02	0.01	0.01	0.03	0.01	<0.05	<0.05
Sodium	mg/L	≤200	AO	0.4	41.6	13.3	8.4	3.1	16.4	3.1	0.4	366	233
Potassium	mg/L	No guideline		0.4	2.7	2	1.7	1.3	2.8	18.4	0.4	3.2	6.7
Chloride	mg/L	≤250	AO	0.5	2	3.4	2	<0.5	1.1	6.9	0.5	15.4	8.4
Sulphate	mg/L	≤500	AO	0.2	396	46.3	397	15.4	113	2.1	0.2	975	1000
Bicarbonate	mg/L	No guideline		5	322	427	374	488	376	273	5	870	544
Fluoride	mg/L	No guideline		0.05	0.36	0.29	0.2	0.19	0.32	0.12	0.05	0.82	0.55
Nitrite	mg/L	No guideline		0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.01	<0.01	<0.01
Nitrate	mg/L	No guideline		0.004	0.148	0.386	0.179	<0.004	<0.004	<0.004	0.02	<0.02	1.54
Dissolved Metals (ICPMS)													
Aluminum	µg/L	No guideline		5.0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	20	<20	<20
Antimony	µg/L	6	MAC	0.2	<0.2	<0.2	<0.2	<0.2	0.2	<0.2	1.0	<1	<1
Arsenic	µg/L	25	MAC	0.2	<0.2	<0.2	<0.2	3.6	1.5	4.7	1.0	1.3	<1
Barium	µg/L	1000.0	MAC	1.0	35	163	20	183	99	377	2.0	6	42
Beryllium	µg/L	No guideline		0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.5	<0.5	<0.5
Bismuth	µg/L	No guideline		0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	2.0	<2	<2
Boron	µg/L	5000.0	MAC	2.0	70	33	32	20	54	23	2.0	844	180
Cadmium	µg/L	5	MAC	0.01	0.02	0.04	0.02	0.01	0.02	0.06	0.05	<0.05	<0.05
Chromium	µg/L	50	MAC	0.5	<0.5	0.5	0.5	2.7	1.9	1.3	2.0	12	<2
Cobalt	µg/L	No guideline		0.1	<0.1	<0.1	<0.1	0.3	0.3	0.2	0.5	<0.5	<0.5
Copper	µg/L	≤1000	AO	1.0	3	1	<1	<1	<1	2	1.0	8	11
Lead	µg/L	10	MAC	0.1	0.7	<0.1	<0.1	<0.1	<0.1	<0.1	0.5	<0.5	<0.5
Lithium	µg/L	No guideline		0.1	76	12	12	17	32	9	0.5	770	239
Manganese	µg/L	≤50	AO	5.0	<5	<5	<5	173	<5	<5	20	130	<20
Mercury (vapour ext, AA)	µg/L	1.0	MAC	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	<0.1
Molybdenum	µg/L	No guideline		1.0	<1	11	5	5	6	16	5.0	<5	<5
Nickel	µg/L	No guideline		0.5	<0.5	<0.5	<0.5	<0.5	<0.5	1.1	2.5	<2.5	<2
Selenium	µg/L	10	MAC	0.2	19.1	2.2	0.6	<0.2	0.9	<0.2	1.0	1	<1
Silver	µg/L	No guideline		0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.5	<0.5	<0.5
Strontium	µg/L	No guideline		1.0	605	625	602	437	470	176	5.0	975	832
Thallium	µg/L	No guideline		0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.2	<0.2	<0.2
Tin	µg/L	No guideline		1.0	<1	<1	<1	<1	<1	<1	5.0	<5	<5
Titanium	µg/L	No guideline		0.5	4.9	0.8	6.7	<0.5	1.3	<0.5	2.0	20	16
Uranium	µg/L	20	MAC	0.5	4.4	2.2	2.5	5.6	3.8	5	2.0	<2	<2
Vanadium	µg/L	No guideline		0.1	<0.1	0.3	0.1	<0.1	0.3	0.2	0.5	0.7	<0.5
Zinc	µg/L	≤5000	AO	1.0	50	21	5	9	9	5	5.0	3.4	8