LAURIDSEN WATER WELL COMPLAINT REVIEW

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EXECUTIVE SUMMARY

In November of 2005 Ms. Lauridsen initiated a complaint of increased methane in her well with EnCana. In late November of 2005 Alberta Environment (AENV) initiated correspondence with Ms. Lauridsen to investigate a water well complaint and made arrangements to undertake sampling. The Alberta Research Council (ARC) was contracted by AENV to critically review the scientific and technical data contained in the AENV and Alberta Energy and Utilities (AEUB) Lauridsen water well complaint file. In addition, ARC was asked to do an independent review of all relevant data, including new data that has become available through Directive 35 (Standard Baseline Water-Well Testing for CBM/NGC Operations).

The ARC independent review and evaluation involved the examination of all the data contained in the AENV file and the following additional lines of evidence:

- Review of the local and regional geology and hydrostratigraphy.
- Calculation of hydraulic gradients between the aquifer in the Upper Horseshoe Canyon Formation and the CBM wells.
- A theoretical review of the potential of methane migration along a fracture (potentially induced by well stimulation) between the Horseshoe Canyon aquifer and the CBM well using the observed pressure gradients.
- An estimation of the change in dissolved methane concentrations in the Lauridsen well related to the fluctuations in water level observed in the Lauridsen well.
- A graphical and statistical approach to the evaluation of the major ion, bacteria, gas and isotope chemistry of the Lauridsen well, 145 surrounding water wells from the AENV database and CBM wells in the area.

The Alberta Research Council’s overall conclusion of the evidence from the review of the AENV and AEUB files, along with a new review and evaluation of additional data and concepts, is that energy development projects in the area most likely had no adverse affects on Ms. Lauridsen’s private water supply well.

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1 INTRODUCTION

The Alberta Research Council (ARC) was contracted by Alberta Environment (AENV) to conduct a review of the technical and scientific data on the subject of a complaint placed by landowner Ms. Fiona Lauridsen, located SW-11-027-22 W4M, near Redland, Alberta. The complaint was about Coal Bed Methane (CBM) activities undertaken by EnCana Corporation and her concerns about the presence of increased methane gas in her water well and an associated or simultaneous decrease in water quality. Historically, methane has been observed in water wells in the Rosebud and Redland areas. This is an expected occurrence because most water wells in the area are completed in coal that can contain methane. The complainant suggests that CBM activities in the area have increased the amount of methane in her well. ARC undertook this review to assess whether the evidence suggests that energy resource extraction operations have impacted the water quality on the landowner's property through the migration of methane from the CBM well to the water well. ARC agreed to work under contract to Alberta Environment (AENV) to independently assess the situation and provide conclusions identifying whether or not the AENV investigation suggests groundwater has been impacted by CBM or conventional oil/gas extraction activities in the area.

This report summarizes ARC's independent conclusions based on scientific and technical data surrounding the investigation of the complaint. The review is based primarily on the collected information in AENV's water well complaint file. Available scientific and technical data include groundwater quality data, water well construction characteristics, oil and gas extraction and production activities, and local groundwater gas characteristics. In addition, ARC endeavoured to compile, review and assess supplementary information not included within the complaint file. This supplementary information includes results of an evaluation of CBM Baseline water well testing data in the general area (provided by AENV and WorleyParsons Komex), digital elevation maps and a geological cross section of the area constructed by ARC.

2 REGIONAL GEOLOGIC AND HYDROGEOLOGIC SETTING

2.1 Stratigraphy

The study area is found within the Alberta Basin. A complete review of the geology of the basin is provided in Mossop and Shetsen (1994). A brief overview is given below. The Alberta basin originated in the late Proterozoic by rifting of the North American craton Early sedimentary deposition was dominated by carbonates, evaporates and shale. Uplift of the Rocky Mountains in the early Cretaceous deposited fluvial sandstone and shale into the developing foreland basin. Sea level rises and falls during the middle to late Cretaceous resulted in deposition of marine shale and coal-bearing fluvial sandstone. Peat accumulation provided the source material for the major coal-bearing strata including the Manville, Belly River and Edmonton (including the Horseshoe Canyon Formation). The latter two formations are where the EnCana CBM wells are completed. A period of compression and uplift in the Tertiary led to the deposition of fluvial sandstone, siltstone and shale. Peat accumulation provided the source material for the coals in the Cretaceous/Tertiary Scollard Formation and the Tertiary Paskapoo Formation. Glaciation during the Quaternary eroded the bedrock and deposited unconsolidated sediments on the bedrock. A description of the geology encountered in the area of investigation is as follows:

Belly River Group

The deepest geologic unit penetrated by the EnCana CBM wells is the Belly River Group. The upper part (Oldman Formation) of the Belly River Group consists of sandstones, siltstones and coal (Lethbridge) deposited in a floodplain and lacustrian environment (Beaton et al. 2002).

Bearpaw Formation

A marine transgression deposited fine-grained marine sediments of the Bearpaw Formation directly onto the Belly River Group. These sediments are predominantly shale and siltstone, with some sandstone beds and claystone (Macdonald et al. 1987).

Edmonton Group

The Edmonton group is comprised of four formations, from oldest to youngest: the Horseshoe Canyon Formation, the Whitemud Formation, The Battle Formation and the Scollard Formation. Only the Horseshoe Canyon is present in the study area. The Horseshow Canyon formation consists of shale, siltstone and coal members (Basal, Rockyford, Drumheller, and Weaver), deposited in deltaic and fluvial environments (Beaton et al 2002). In the area, the Horseshoe Canyon Formation is covered by Late Tertiary–Quaternary unconsolidated sediments or till.

2.2 Regional Stress Regime

The stress regime of upper Cretaceous – Tertiary coal-bearing strata in Alberta has a strong correlation to permeability and fracture directions in coal (face cleats). This in turn has a strong control on the direction that “fluids” (both gas and water) tend to migrate in these strata. Rock mechanics theory and field measurements shows that fractures trend in a direction normal to the least compressive stress. Horizontal stress orientations in Alberta have been measured using well breakout analyses (i.e. damage to boreholes caused by stresses acting on the rock) (Bachu and Michael 2002). Based on breakout analysis the most likely azimuth (orientation) of fractures and face cleats in the coal would be about 055°E of N. Three energy wells line up on an approximate 055° azimuth to the Lauridsen well. These well, and others, were investigated in section 3 of this report.

2.3 Hydrostratigraphy and Groundwater Flow and Gradients

Regional flow systems across the Alberta Basin are controlled in part by major recharge areas along the Rocky Mountain front in western Alberta. Regional flow within the basin is northeast towards the basin edge (Hitcheon 1969a,b). Bachu (1999) recognised that flow in the northern part of the basin was driven by topography north-eastward, however, flow in Upper Cretaceous rocks in the south-western part of the basin (including the study area) was directed southwestward, driven by erosional rebound due to stripping of up to 3800m of sediments (Parks, and Tóth 1995; Bachu 1999). Regionally, the Horseshoe Canyon Formation acts as an aquifer above the Bearpaw Formation aquitard. Below the Bearpaw, the upper Belly River Formation acts as an aquifer.

In the Redland area, shallow groundwater flow within the overburden is directed towards the Rosebud River. Regional groundwater flow in the Upper Horseshoe Canyon aquifer (Carbon Thompson and Weaver coals where most domestic wells including the Lauridsen well are completed) is directed to the northeast (Bachu and Michael 2002). Hydraulic conductivities of the rock are expected to be low to intermediate and yields from wells in this area are expected to be 1 to 5 imperial gallons per minute (Borneuf 1972). The Lauridsen well was tested at between 0.7 and 2.4 imperial gallons per minute and had an estimated average hydraulic conductivity of $2x10^{-6}$ m/s as estimated by ARC from the available pumping test data.

In the deeper (below 200 m) Horseshoe Canyon Formation groundwater flow is also directed to the northeast (Bachu and Michael 2002). Permeability data for the coal zones are not well reported in the literature. However, it is expected that permeability of the coal decreases with depth of burial. Unpublished data referred to by Bachu and Michael (2002) indicates permeabilities for deep coals on the order of a few mD which indicates very low primary permeability. Completion data from the EnCana wells in the area suggest that the coals (with the exception of the upper Carbon Thompson and Weaver members of the Horseshoe Canyon) are not water saturated based on pressure measurements and water production data.

Regionally groundwater flow in the Belly River aquifer is directed to the southwest due to erosional uplift (Parks and Tóth 1995; Bachu 1999). Coal permeability is expected to be on the order of a few mD, similar to that in the overlying Horseshoe Canyon coals. Completion data from the EnCana wells in the area show that the coals are not water saturated. The implication of this is that hydrocarbon gases are not expected to be transported from the deep (gas saturated) coals to the shallow (water saturated) coals in a dissolved state.

Large downward vertical gradients between the upper Horseshoe Canyon aquifer (where the Lauridsen well is completed) and the deeper Horseshoe Canyon coals (Drumheller member and below) are expected and were measured (Section 4.4.2) The Horseshoe Canyon and Belly River coal zones are underpressured (or lower) with respect to predicted hydraulic gradients based on elevation differences. These lower pressures have been interpreted to be due to erosional rebound caused by stripping of up to 3800m of sediments (Parks. and Tóth, 1995; Bachu 1999).

3 ENERGY WELL INFORMATION

A map of the energy wells within a minimum 1.5 km radius of the Lauridsen well is shown on Figure 1. A list of gas well information (including the drilling date, loss of circulation, surface casing depth, total depth, cement returns and perforations) was supplied to AENV by EnCana

(Appendix A). More detailed information was gathered on several wells in the area because of their proximity (<800 m) from the Lauridsen well and a specific well of concern identified by Ms. Lauridsen with perforation depths of 125.5 m. A review of the tour reports was provided by Brenda Austin of the AEUB (Table 1). All depths on the table are in mKb. ARC has added the elevation (above seal level) of the upper perforations in the energy well from AEUB and EnCana records. The 4 energy wells in closest proximity (<800 m) to the Lauridsen water well and the specific CBM well (05-14) that had shallow perforations are discussed below. Compositional and/or isotopic data was available for some of these energy wells in the vicinity of the Lauridsen well and is discussed in section 4 of this report.

The closest energy well (320 m ENE) to the Lauridsen well is 00/07-11-27-22W4M/3. This well lines up with expected predominant fracture direction in the area (section 2 above). This well was originally completed in the Basal Belly River Formation, Viking & Manville formations with perforations from 1188.5 to 1191.5, 636 to 639 and 604 to 607 mKb (metres from the Kelly bushing which is usually 3 to 4 metres above ground surface). Conventional gas was produced from the two lower perforations. The lower zones were abandoned with a bridge plug and capped with cement in April 2005 and the well was re-completed in the Horseshoe Canyon Formation with the upper perforation between 175.9 to 177.9 mKb. Well stimulation was done using 100% nitrogen gas. AEUB records show that since 2005 this well produces 0 to 1.3 m^3 of water per month, and to-date has a cumulative water production of less than 4 m^3. This is a relatively small amount of water that is likely coming from the coal and from condensation of water vapour with the gas. No lost circulation was reported for this well and both the surface and production casings had good cement returns. This information does not indicate any apparent drilling and construction issues with this well.

The next closest energy wells are 00/04-11-27-22W4M and 02/04-11-27-22W4M and are both approximately 700 m to the south-west of the Lauridsen well. These wells also line up with expected predominant fracture direction. The 00/04-11-27-22W4M well is completed in the Edmonton, Belly River, Viking and Manville Formations with uppermost perforations from 616.5 to 619.5 mKb in October 1997. Circulation was lost during the drilling of the surface casing between 12 and 31 m due to gravel in the overburden material above the bedrock. This is the sandy gravel that was encountered during the drilling of the GOWN well in the area and also noted on several water well drilling records in the area. Circulation control was regained by adding bentonite and lime to the drilling fluids. The surface casing was cemented with good returns to the surface noted. It is very unlikely that this circulation loss in the overburden could have affected the Lauridsen well which is 700 m to the south west and completed in bedrock at about 60 m. AEUB records show that since 2000 this conventional gas well produces 0 to 8.8 m^3 of water per month, with a cumulative water production of 74 m^3.

The 02/04-11-27-22W4M well is completed in the Edmonton (Horseshoe Canyon) Formation with uppermost perforations from 190.5 to 191.5 mKb and was drilled in January 2004. Well stimulation was done using 100% nitrogen gas. The well had good cement returns on the surface and production casings. There are no apparent drilling and construction issues with this well. Since 2004 this gas well produces 0 to 3.6 m^3 of water per month, with a cumulative water production of 19.5 m^3. The water is likely coming from the coal and from condensation of water in the gas.

EnCana CBM well 00/05-14-027-22 W4M, located about 2 km northwest of the Lauridsen well, was drilled October 13, 2003, perforated February 15, 2004 and nitrogen fractured on March 2, 2004. The top perforation was stimulated with 3,000 m^3 of nitrogen (at standard temperature and pressure) at a rate of 500 m^3/min for six minutes. The top set of perforations in this CBM well (125.5 to 126.4 mKb) was in the Weaver coal zone, the same as many of the local water wells. Given the similar depths of the CBM zones and the water wells, with a horizontal distance of 2 km, additional evaluation of possible effects of fracturing on the water-bearing aquifer is merited. Three possible effects are considered:

i. Change in water quantity (water levels) due to initial pressure increase during fracturing and from production of water from the aquifer.
ii. Change in water quality due to injected nitrogen reacting with the groundwater in the coal zone.
iii. Change in water quality (increased methane) from methane migration from deeper zones into the water-bearing aquifer.

i. The Hydrogeological Consultants Ltd (2005) report calculated an estimated increase in water levels in a well (1.2 km from the 00/05-14-027-22 W4M CBM well) caused by the injection of nitrogen. An increase in water level of 0.02 m would be expected to persist for 640 hours at a distance of 1.2 km. The details of the calculation are not presented in the consultants report, but it appears that they have used an equivalent porous media model to determine the changes. This may not adequately model fracture flow in coal aquifers. If the CBM well continued to produce water from the upper perforation during gas production, a drop in water levels would be expected over time. This drop can be calculated using the water production rate, the aquifer transmissivity and storativity, and the distance from the CBM well. After the CBM well was completed, water was observed (during a video inspection) entering the 125.6 to 126.5 m interval (Hydrogeological Consultants Ltd 2005). The upper perforation of EnCana CBM well 00/05-14-027-22 W4M was unsuccessfully cement squeezed (abandoned) on July 1, 2004. The upper 4 perforations (between 125.5 and 142.4 m) were cement squeezed on July 12, 2004, successfully abandoning the zone. These zones would have been pressure tested to confirm successful abandonment. On October 10 2004 the whole well was abandoned with a cement plug from 17 to 425 m. The current public well ticket for this well states the status as “abandoned gas”. As the connection of the CBM well to the local water-bearing aquifer was eliminated by this cement squeeze, completed in within 4 months of fracturing and with only 4 m^3 of water was reported recovered from the well, no measurable effect on local water well quantity would be expected.

ii. The injected slug of nitrogen from the fracturing 00/05-14-027-22 W4M could potentially affect the water quality of water wells completed in the same aquifer. After fracturing of the 00/05-14-027-22 W4M CBM well, the nitrogen gas pressure was allowed to bleed off and then the well was “flowed” (pumped) for 75 days to produce back the nitrogen. An evaluation of amount of nitrogen removed from the coal zones during this flow was done by Hydrogeological Consultants Ltd (2005). This was based on an unreferenced graph titled “N_2 concentration decline post-stimulation- Strathmore well” that shows nitrogen concentration of produced gas as a function of flow time. The Hydrogeological Consultants Ltd (2005) evaluation concluded that “there is no reason to expect any significant nitrogen remained in the 125.5 to 126.5 metre coal zone when the perforations were closed using a cement squeeze”.

iii. The connection between the upper and lower zones of the 00/05-14-027-22 W4M CBM well, through the shallower and deeper perforations, could potentially lead to the upward migration of methane from a lower zone to the water-bearing aquifer. Water entering the upper perforations of 00/05-14-027-22 W4M would tend to counteract the migration of methane into the water-bearing aquifer. A brief discussion of the physics involved in migration of a methane bubble is presented in section 4.4.5 below and in Appendix D).

A residential water well is located about 1200 m south-west of the 00/05-14-027-22 W4M CBM well. Mr. Sean Kenny complained to EnCana that sediment started to be produced from an old (1950) water well on his property at NE-10-027-22 W4M and a 2000 well at 07-10-027-22 W4M. A new well for the Kenny property (completed September 29, 2004) at NE-10-027-22 W4M also produced sediment which did not significantly improve through well development. A thorough review of Mr. Kenny’s wells is not within the scope of this ARC review. EnCana contracted Hydrogeological Consultants Ltd to investigate these complaints (Hydrogeological Consultants Ltd 2005 and 2006). Remedial work (placement of k-packers and liners) was performed on Mr. Kenny’s wells and the amount of sediment did reduce (Hydrogeological Consultants Ltd 2005 and 2006). Unfortunately, no gas compositional or isotopic analyses were done on the energy well or Mr. Kenny’s well during the time period of the perceived impact to help determine if there was any connection between the water well problems and CBM drilling.

Theoretical evaluations (Hydrogeological Consultants Ltd 2005) of the pressure pulse created by the injection and removal of the nitrogen during flowing of the well (calculated with same method as above) indicate an impact to Mr. Kenny’s wells is unlikely. However, without direct measurement of water levels (pressures) and chemical/isotopic measurements in both the CBM well and the water wells during the event, it is inconclusive as to whether or not Mr. Kenny’s wells were impacted by nitrogen fracturing of 00/05-14-027-22 W4M.

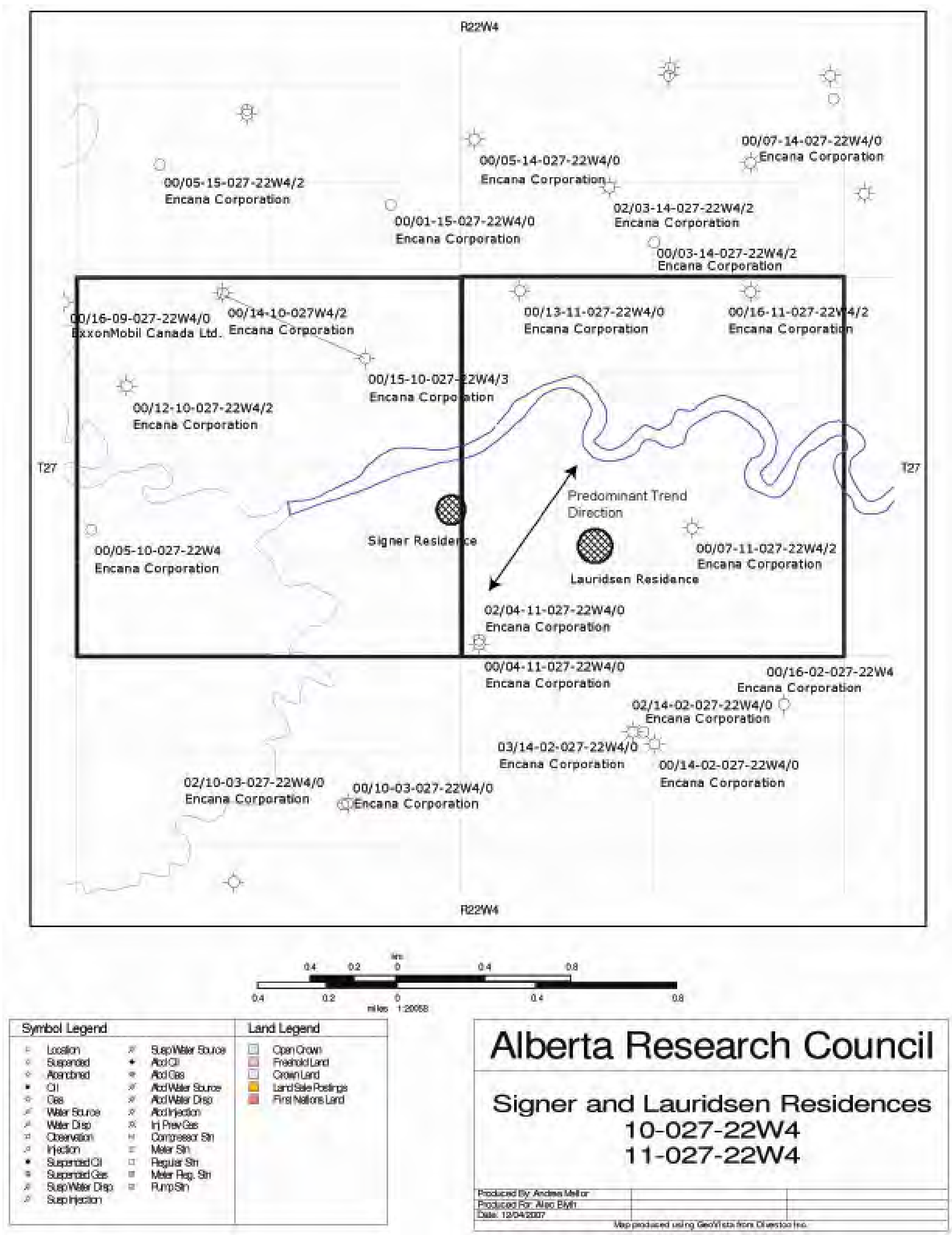

Figure 1 Energy wells in the vicinity of the Lauridsen water well. Energy wells 4-11 and 7-11 line up with the expected fracture direction (arrow on map).

Table 1 AEUB review of wells near the Lauridsen residence.

Well Location	Spud date/FDD/On Production	Surface Casing (m)	Total Depth (m)	Perforation Depths (m) and Dates	Fracture Depths (m) and Dates	Comments
00/14-10-027-22W4 Production history : Perfs 1479 – 1481 & 1476–1478, tested and abandoned. Perfs 1249-1252, on production 19 Jun 01 and perfs 559.5 -603 added July 02, and 461.5 – 464.5 & 451 – 455 added Aug 02. Packer installed at 459 Oct 02 to isolate water production from lower zones. CBM zones added in 07. Less than 1m3/d water production.	05 Mar 01 09 Mar 01 On prod. 19 Jun 01 & 25 Sep 07	182.0	1511.0	1479.0 – 1481.0 / 29 Mar 01 1476.0 – 1478.0 / 29 Mar 01 1249. 0 – 1252.0 / 11 Apr 01 559.5 – 603.0 / 6 Jul 02 461.5 – 464.5 / 28 Aug 02 451.0 – 455.0 / 28 Aug 02 All below on 16 Sep 07 401.4 – 401.9, 395.0 – 395.5 390.8 - 391.3, 349.3 – 349.8 326.0 – 327.0, 320.6 – 321.1 260.8 – 262.8, 259.3 - 259.8 249.9 – 250.4, 245.8 – 246.3 231.0 – 233.0, 229.7 – 230.2 220.7 – 221.2, 216.3 – 216.8 211.5 – 212.0, 210.0 – 211.0	1249.0 – 1252.0 / 1 May 01 559.5 – 603.0 / 2 Aug 02 Perfs between the depths of 210.0 – 401.9 were individually frac'd on 23 Sep 07	Bridge plug capped with cement at 1466.5 to 1474.5 (11 Apr 01) - abandoned lower zone .Also a bridge plug at 459.0 (11 Oct 02) to isolate lower zones. No lost circulation reported. Cement returns on surface and production casing. No wellbore issues evident. Upper perf at 632.90 MASL
00/15-10-027-22W4 (Directionally drilled well. Surface hole in 14-10 and bottom hole in 15-10.) Production history: 718-720 on production 19 Mar 05. CBM perfs on production 25 Sep 07. Water production less than 1m3/d	4 Jun 03 7 Jun 03 On prod. 19 Mar 05 & 25 Sep 07	135.0	1548.0	1498.0 – 1500.0 / 13 Aug 03 1414.0 – 1417.0 / 24 Oct 03 718.0 – 720.0 / 4 Dec 03 Following perfs - 16 Sep 07 740.2 – 741.2, 705.7 – 706.2 555.4 – 555.9, 404.4 – 404.9 399.4 – 400.4, 395.5 – 396.0 353.7 – 354.2, 328.9 – 329.9 232.0 – 323.5, 260.5 – 263.5 259.1 – 259.6, 257.3 – 257.8 239.2 – 239.7, 229.6 – 231.6 228.2 – 229.2, 225.4 – 225.9 219.0 – 219.5, 214.5 – 215.0 208.3 – 210.3	1498.0 – 1500.0/2 Oct 03 1414.0 – 1417.0/15 Nov 03 Perfs from 208.4 – 741.2 frac'd individually on 20 Sep 07	Lower zones abandoned w/ Bridge plugs capped w/ cement @ 1484 – 1492 on 23 Oct 03, and 1404 – 1412 on 5 Dec 03. No losses reported. Cement returns on surface and production casings. No wellbore issues evident. Upper perf at 634.4 MASL

Table 1 Continued.

Well Location	Spud date/FDD/On Production	Surface Casing (m)	Total Depth (m)	Perforation Depths (m) and Dates	Fracture Depths (m) and Dates	Comments
00/04-11-027-22W4	29 Oct 97 30 Oct 97 10 Jun 98	43.0	780.0	669.0 – 672.0 / 17 Nov 97 616.5 – 619 5	669.0 – 672.0 / 24 Nov 97	Lost circulation reported at 12 to 31 metres in overburden due to gravel. Lost circulation material (bentonite and lime) was pumped to regain circulation. Control regained at 43.0 m, and surface casing set. Cement returns on production and surface casings. Upper perf at 218.2 MASL
02/04-11-027-22W4	21 Jan 04 21 Jan 04 19 Nov 04	42.7	504.0	Following perfs on 22 Apr 04 190.5 – 191.5, 192.4 – 193.1 208.7 – 209.7, 212.1 – 214.1 248.1 – 251.1, 302.5 – 303.5 308.4 – 309.4, 332.3 – 333.3 334.9 – 335.9, 372.5 – 373.5	Perfs from 190.5 to 373.5 individually frac'd on 5 Jun 04	No lost circulation reported. Cement returns on surface and production casings. No apparent well bore issues. Upper perf at 644.3 MASL
00/07-11-027-22W4 Production history: Production from lower perfs on 03. Other perfs have not produced to date.	3 Dec 02 8 Dec 02 22 May 03	148.6	1286.0	1188.5 – 1191.5/16 Jan 03 636.0 – 639.0/20 Apr 04 604.0 – 607.0/ 8 Jun 04 Following perfs on 13 Apr 05 342.8 – 343.8, 337.0 – 338.0 299.4 – 300.4, 296.4 – 297.4 272.7 – 273.7, 211.9 – 214.9 188.0 – 189.0, 175.9 – 177.9	1188.5 – 1191.5/11 Feb 03 636.0 – 639.0/24 May 04 604.0 – 607.0/ 26 Jun 04 Perfs from 175.9 to 343.8 frac'd on 2 May 05	Lower zones abandoned with bridge plug capped with cement at 1172 – 1182 on 20 Apr 04, and a bridge plug at1137.3 to 1140.8 on 22 Jun 05. No lost circulation reported. Cement returns on surface and production casings. No apparent well bore issues. Upper perf at 622.6 MASL
00/05-14-027-22W4 Fluid level in well reached 80 mKB during shut-in prior to sampling upper perfs. There was a packer at 172.0 m in hole at the time. 4 m3 water reported recovered from well.	13 Oct 03 13 Oct 03 Not on production	85.0	467.0	Following perfs on 15 Feb 04 418.9 – 419.9, 415.5 – 416.5 374.3 – 375.3, 371.7 – 372.7 358.4 – 359.4, 354.5 – 355.5 347.8 – 348.8, 342.6 – 343.6 284.9 – 286.9, 283.5 – 284.5 259.3 – 260.3, 248.0 – 250.0 244.9 – 245.9, 238.6 – 239.6 234.6 - 235.6, 228.7 – 230.7 222.0 – 223.0, 220.1 0 221.1 186.1 - 187.1, 177.1 – 178.1 141.4 – 142.4, 133.0 – 134.0 131.7 – 132.7, 125.5 – 126.5	Perfs from 125.5 to 419.9 frac'd on 2 Mar 04	Cement squeezed top 4 perfs on 12 Jul 04: 141.4 – 142.4, 133.0 – 134.0 131.7 – 132.7, 125.5 – 126.5 Cement plug from 17.0 to 425.0 m on 10 Oct 04. Cement returns on surface and production casing. Cement top inside surface casing confirmed with log. No apparent wellbore issues. Upper perf at 743.0 MASL

4 LAURIDSEN WATER WELL INFORMATION

4.1 Initiation of Well Complaint

The water well complaint by Ms. Lauridsen was originally made to EnCana about a concern related to methane in her well. In December of 2005 AENV staff initiated the investigative process.

4.2 Well Design, Construction and Maintenance

The water well drilling report for the Lauridsen Water Well, available through the AENV Groundwater Information Centre (GIC) (Well ID # 0123545), is included in Appendix B. This drilling report was mistakenly labelled SE-11-027-22W4 rather than SW-11-027-22W4. The well was constructed (December 14, 1977) by Lin Murray Drilling for the landowner at the time (J. Patterson). The lithology log is not very detailed and coal is not noted in the log. Based on the total depth of this well and surrounding well information, this well is likely completed in coal. The borehole was drilled to total depth (61.0 m) and a 140 mm diameter casing was inserted with torch-cut perforations from 36.6 to 61.0 m. A packer was put on the casing and a cement seal was placed from 15.2 to 30.5 m. The seal did not extend to surface. It is not clear if the existing seal provides adequate protection against contamination of water from ground surface entering the well. The casing extends to surface and an adjacent pit contains the pressure tank & controls, a cistern and a transfer pump. The cistern is used to provide storage because the well provides limited yield.

Notes in the AENV complaint file indicate that the well did not have regular shock chlorination. Total Coliform bacteria were detected in three separate analyses (Nov 2003, August 2004 and September 2006). Total coliforms were too numerous to count (TNTC) in the first two analyses. These bacterial results could indicate a poor well seal. No information on subsequent well maintenance is contained in the file, but the most recent sampling in June 2007 did not detect coliform bacteria. Bacterial analyses (December 2006 and June 2007) indicate that iron related bacteria (IRB) and sulphur reducing bacteria (SRB) are present in the well water. A downhole camera inspection of the well in March 2006 by Gerritsen Drilling Ltd. found holes corroded through the casing in the torch-perforated section. The well was flushed and a PVC well liner was installed inside the existing casing.

4.3 Stratigraphy

No accurate lithology records exist for the Lauridsen well. Several good quality drilling report are available for wells drilled in the next quarter section to the west. A new AENV groundwater observation well network (GOWN) well (installed in March 2007) is approximately 800 m to the northwest also provides detailed lithology information.

A geologic cross section through the Lauridsen well was constructed using lithology information from the Kenny well, the Signer well, a GOWN well and geophysical logs from the EnCana CBM wells 05-14-027-22 W4M, 15-10-027-22 W4M and 07-11-027-22 W4M (Figure 2). The contour interval on this map is 2 m and the colour shading visually denotes elevation.

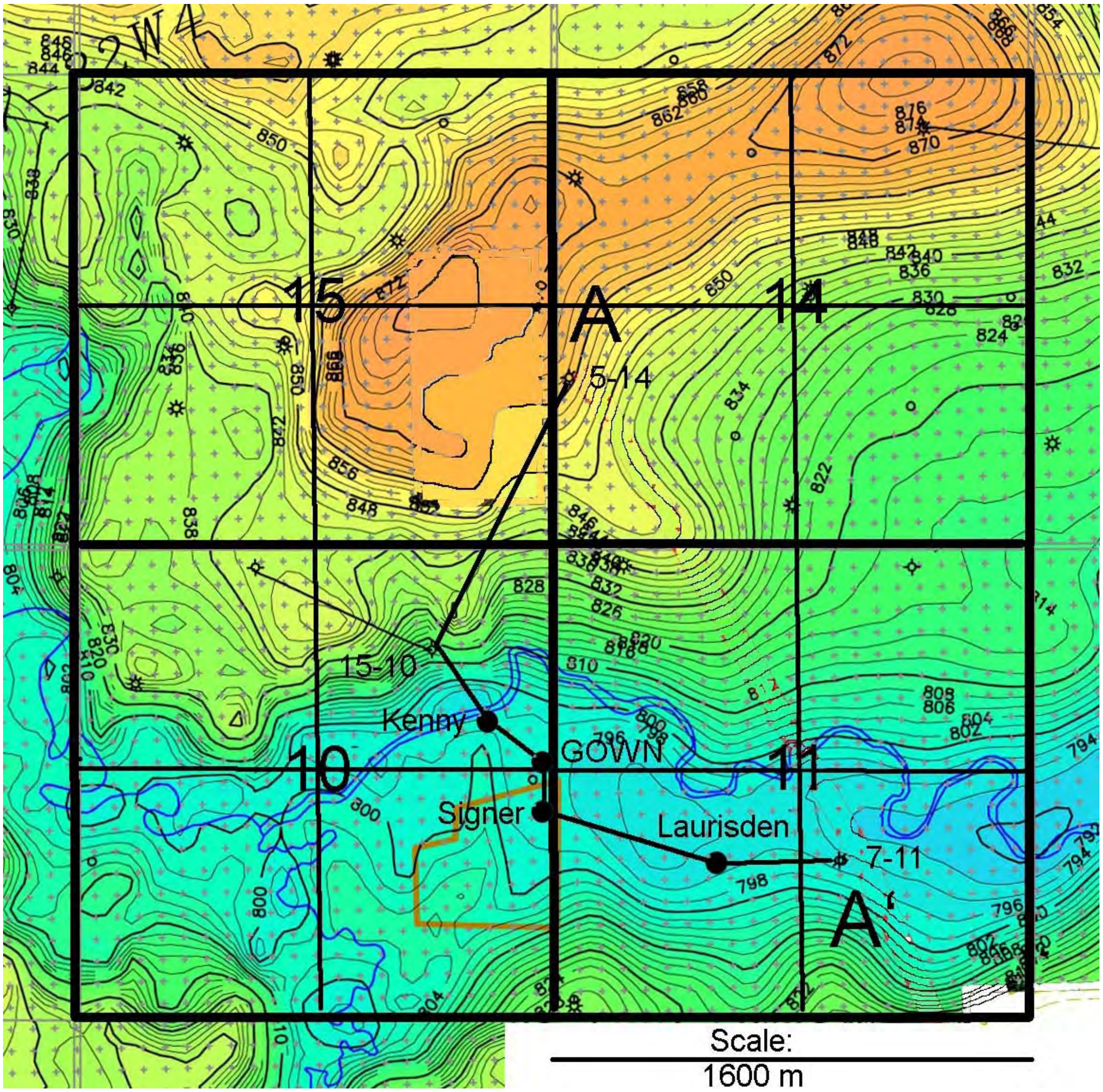

Figure 2 Map showing location of cross-section. DEM image supplied by EnCana.

The cross-section (Figure 3) illustrates that the Lauridsen well is completed in coal zones of the Upper Horseshoe Canyon Formation. The groundwater bearing zone is likely the Weaver coal zone at a depth of about 51m (744 MASL). The EnCana 07-11-027-22W4M CBM well, located 320 m to the east of the Lauridsen well, has production casing perforations starting at 175.9m (619 MASL) which indicates a vertical separation of 125 m) between the water-bearing zone of the Lauridsen well and the upper perforations of the CBM well. A saturated sand and gravely sand layer was encountered in the residential water wells and in the GOWN well at a depth of about 2 to 5 m. This gravely sand layer is a potential pathway for surface water to enter water wells if an adequate seal is not in place in the water wells.

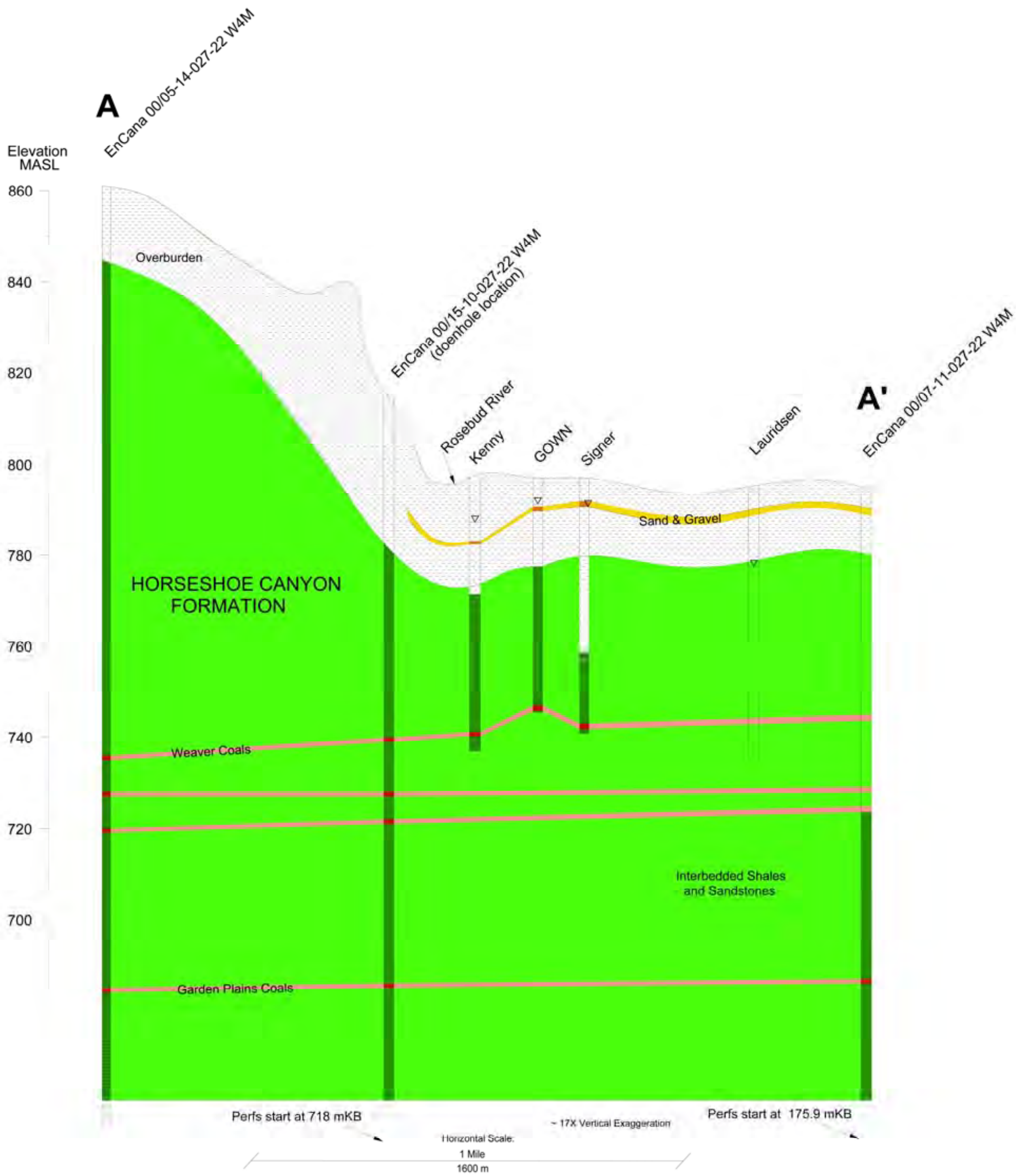

Figure 3 Geologic cross-section.

4.4 Hydrogeology

4.4.1 General Groundwater flow directions

Local and very shallow groundwater flow may be controlled by the unconfined sand and sandy gravel layer encountered at a depth of 2 to 5 m in several nearby water wells. The shallow flow is likely controlled by topography and flow directions are likely from the Lauridsen well site to the Rosebud River to the north (Borneuf 1972). In the Lauridsen well, the deeper confined groundwater flow within the upper Horseshoe Canyon bedrock is part of the regional groundwater flow system flow directed to the northeast (Bachu and Michael 2002).

4.4.2 Vertical Hydraulic Gradient

An estimation was made of the vertical hydraulic gradient between the coal zones of the Lauridsen well and that of nearest EnCana CBM well with pressure data (02/14-02-027-22 W4M about 1 km to the south) using the following:

Depth of coal zone in Lauridsen well = 744 MASL.

Depth of upper coal zone in EnCana CBM well 00/07-11-027-22W4M = 619 MASL.

The head of water in the Lauridsen well = 787 MASL.

A shut-in pressure of 422.9 KPa was measured in the Garden Plains Coal member of EnCana CBM well 02/14-02-027-22W4M (equivalent to 43.2 m of water). Therefore the equivalent head of water in the CBM well = 662.2 MASL assuming density of 1000 kg/m^3 (fresh water).

The vertical gradient is estimated from = $\Delta h/\Delta l$ = (787-662.2)/(744-619) = 1.0. This suggests a large downward vertical gradient. If these coal zones become connected, groundwater would flow down into the CBM well. The rate of flow however, is going to be controlled by the hydraulic conductivity of the flow path. For example, if a fracture connects a CBM well to an overlying aquifer, the amount of groundwater produced could be significant, as determined by the fracture aperture.

4.4.3 Hydraulic Conductivity

Two pumping tests have been performed on the Lauridsen Well. A 120 minute pumping test followed by a 120 minute recovery test was done December 6, 2006 by M&M Drilling limited. A second 81 minute pumping test was performed by AENV on June 5, 2007 as part of a sampling trip. No analysis of this data was found in the AENV file. The aquifer test data was analysed by ARC for this report using AQTESOLV, Version 3.50 Professional, Aquifer Test Design and Analysis Computer Software (1996-2003 HydroSOLVE Inc.). This software provides analytical solutions for evaluating parameters in confined, unconfined, leaky, or fractured aquifer systems, and allows evaluation of the aquifer test data by visual curve matching to select the most appropriate interpretation to represent aquifer conditions at the site.

The Theis (1935) confined aquifer solutions were used to solve the drawdown and recovery portions of the pumping tests. An average apparent transmissivity of 1.2E-4 m^2/min (0.17

m^2/day) was calculated. This value suggests that the aquifer has low to moderate transmissivity. The raw data and graphical solutions are included in Appendix C. No storativity value can be determined because it is not possible to calculate from water level measurements taken in a well that is being pumped. To calculate a storativity, water level measurements must be made in a non-pumping well in a well located a short distance from the pumping well. A storativity value of 0.005 can be estimated for this bedrock aquifer based on values reported in the literature (Freeze and Cherry 1979). The transmissivity and storativity can be used to predict the drawdown in water levels caused by pumping of the Lauridsen well.

4.4.4 Water levels and methane saturation

Static water levels from the Lauridsen water well have been variable (Table 2). The maximum difference in water levels is 2.3 m which corresponds to a pressure difference of 0.22 Atm (3.3 PSI). A drop in pressure is expected to decrease the solubility of methane in the water and cause an increase in the amount of methane coming out of the water. This is similar to the case where pressure is decreased in a carbonated drink (by opening the top) and CO_2 bubbles out of solution. An estimation of the concentration of methane in water (in the Lauridsen Well) at saturation can be done using the head (height) of water above the coal zone and the Henry's Law equilibrium equation:

Head of water above coal zone at the highest static water level = 42.7 m or 4.12 Atm

Head of water above coal zone at the lowest static water level = 40.4 m or 3.90 Atm

Henry's constant for methane = 1.4×10^{-3} Moles/Atm (at 298.15 °K)

A temperature correction needs to be done to the Henry's constant to account for the observed temperature of 285.15 °K (12 °C) in the Lauridsen well:

Henry's constant for methane in water at 12 °C = 1.1×10^{-3} Moles/Atm

Therefore, based on this equation, the concentration of methane in water is calculated to be 4.51×10^{-3} Moles/kg of water at saturation for the highest static water level and 4.27×10^{-3} Moles/kg of water at saturation for the lowest static water level.

This could explain an increase in the amount of methane coming out of the water. However, it does not explain the source of the methane.

Table 2 Static water levels in the Lauridsen well.

Date	Static Water Level (m TOC)
Dec 14, 1977	9.14
Nov 26, 2003	10.6
Aug 13, 2004	9.00
Dec 6, 2006	8.30

4.4.5 Potential for Methane Gas Migration

In order to estimate methane gas migration potential from an active CBM site to an overlying water supply aquifer, an assessment of the forces controlling the methane gas bubble migration is helpful. If an aquifer overlying a CBM zone was connected to the CBM zone through and induced fracture (from well stimulation) methane bubbles would tend to rise in the fracture due to buoyancy forces. Groundwater flow downward in the fracture would tend to counteract the buoyancy force and prevent the bubble from rising. Appendix D provides a discussion on how those forces are determined and presents simplified calculations (personal communication with Dr. J, Jones, PhD., University of Waterloo) that determine what kinds of flow conditions prevent methane gas bubble migration into an overlying water supply.

An example of the application of this approach for the case of an induced fracture connecting a CMB zone with an overlying aquifer (e.g. either in the geological medium or in a casing annulus) provides some estimates of groundwater flow in the fractures (under the observed gradients at the site) were compared to the terminal velocity (maximum velocity the bubble can reach given the density and viscosity of the fluids involved) of methane bubbles. For a 100 μm fracture, the flow velocity in the aperture would stop a methane bubble of 245 μm or less from rising into an overlying aquifer. In coal fracturing operation the intended fracture apertures are in the order of 1000 μm (1 mm) (personal communication with Paul Smolarchuk, Canadian Spirit Energy). The groundwater flow velocity in a 1 mm fracture would stop a bubble of 2.5 mm or less from rising. This kind of assessment suggests that if an induced connection existed between the CBM well and the Lauridsen water well, methane bubbles would not tend to rise in a fracture because of the downward groundwater flow based on the hydraulic gradient estimated for the local area.

4.5 Water and Gas Chemistry

In this section ARC compiles, reviews and assesses water and gas chemistry data from the AENV and AEUB files (Lauridsen well complaint file and energy well data) and additional data from D35 water well testing in the area (collected under AEUB Directive 35). Data from D35 testing was provided by AENV and from EnCana’s consultant (WorleyParsons Komex). The chemistry from one hundred and forty five (145) water well tests from a radius of approximately 10 km from the Lauridsen well have become available from the new AENV database and are compared here with the Lauridsen water well and the CBM wells. Of these new well results, 41 have free gas analyses and/or isotope geochemistry. An analysis of this new chemistry data is organized into major ion chemistry, gas chemistry and isotope geochemistry.

4.5.1 Historical Major Ion and Bacteria Chemistry Prior to Complaint

Three historical water quality analyses are available for the Lauridsen water well prior to the initiation of the complaint (Table 2). Copies of the analyses are included in Appendix E. The January 31, 1983, November 26, 2003 and August 13, 2004 samples (analyzed by ARC

Vegreville, WSH Labs and WSH Labs, respectively) have routine potability analyses with ion balances within 2.5%. This is an acceptable lab QA/QC. It is not possible for ARC to comment on the field QA/QC as this type of information was not available. All three analyses show the Lauridsen well exceeds the aesthetic objectives (set by the Summary Guidelines for Canadian Drinking Water Quality set by Health Canada 2007) for total dissolved solids (TDS), sodium and iron. Sodium levels in the well (about 450 mg/L) exceed the 200 mg/L guideline and may be a concern for people on sodium reduced diets. In addition, the aesthetic objectives for pH is exceeded in the January 31, 1983 analysis, the aesthetic objectives for chloride is exceeded in the January 31, 1983 analysis and the maximum acceptable concentration for fluoride is exceeded in the November 26, 2003 and August 13, 2004 analyses. The maximum acceptable concentration of total coliforms was exceeded in the November 26, 2003 and August 13, 2004 analyses, with concentrations too numerous to count (TNTC). More recent sampling of this well (since December 2006) showed no coliform bacteria.

4.5.2 Major Ions, Metals and Bacterial Chemistry

In addition to the historic water analysis from the Lauridsen well, several new water analyses were performed (Table 3). Analyses were from AENV sampling and WhorlyParsons Komex reports (2006 and 2007). These routine potability analyses have ion balances of 10% (which is an acceptable value) except for the June 5, 2007 analysis which has an ion balance difference of 10.8%. This ion balance is outside of the generally acceptable range. The analyses show the Lauridsen well consistently exceeds the aesthetic objectives for total dissolved solids (TDS) and sodium. As well, the pH is high and the aesthetic objective is often exceeded. The maximum acceptable concentrations for fluoride have sometimes been exceeded. One analysis shows the presence of total coliform bacteria in exceedence of the maximum acceptable concentration. Copies of the analyses are included in Appendix E.

The major ion chemistry of the D35 water wells, the Lauridsen well and the GOWN wells is presented on Figure 4. There is a strong positive correlation of specific water types in the area, namely sodium-bicarbonate ($Na-HCO_3$) and sodium-bicarbonate-chloride ($Na-HCO_3-Cl$) type waters, with the presence of methane in the water (shown in Figure 4). The Lauridsen water well falls into this group. It is reported that in the reducing conditions, found where methane occurs in coalbed zones, it is expected that biochemical reduction of dissolved sulphate occurs, causing precipitation of sulphides, resulting in depleted dissolved sulphate content. Bicarbonate, on the other hand, tends to be enriched as a result of carbonate dissolution by oxygenated recharge water and by sulphate reduction methane production (fermentation). Calcium and magnesium tend to be depleted by inorganic precipitation of calcite due to reduced solubility in the presence of elevated bicarbonate (Van Voast 2003).

The major ion chemistry is presented on Schoeller plots (Figure 5 and 6). Most of the wells with methane have depleted calcium, magnesium and sulphate. Again, these wells show the water wells with methane tends to have sodium-bicarbonate (Na-HCO3) or sodium-bicarbonate-chloride (Na-HCO3-Cl) type waters. The Lauridsen water well falls into this group.

Table 3 Summary of Chemical Analyses for the Lauridsen Water Well

Parameter	Units	Lauridsen Well																										GCDWQ Recommended Limit	
Date	dd/mm/yyyy	31-Jan-83	26-Nov-03	13-Aug-04	5-Jan-06	5-Jan-06	5-Jan-06	5-Jan-06	5-Jan-06	5-Jan-06	5-Jan-06	17-Feb-06	17-Feb-06	17-Feb-06	17-Feb-06	12-Apr-06	12-Apr-06	13-Apr-06	13-Apr-06	8-Sep-06	8-Sep-06	8-Sep-06	6-Dec-06	6-Dec-06	5-Jun-07	5-Jun-07	5-Jun-07	AO	MAC
Time	hh/mm				10:30	11:15	11:25	12:50	13:30	13:30	13:40	9:00	Duplicate	9:30	8:45	11:30	Duplicate			11:05	11:35	13:15	10:50	10:50	13:30	13:30	13:30		
Location			Hydrant	Well	Hydrant	Well	Well	Hot water tank	House Tap		Hot water tank	Well	Well	Well	Well	Well	Well	Before	After	Well	Well	Well	Well	Well	Well	Well	Well		
Laboratory		ARC veg	WSH	WSH	Maxxam	Maxxam	Maxxam	Maxxam	Maxxam	ALS	Maxxam	ALS	ALS	Maxxam	PBR	ALS	ALS	Norwest	Norwest	ALS	ALS	ALS	ALS	U of C	ALS	ARC	U of C		
pH	units	**8.7**	8.01	8.48	---	---	---	---	8.43	8.2	---	8.2	8.2	8.44	---	8.3	8.4	---	---	**8.6**	**8.6**	---	8.5	---	**8.7**	---	---	6.5 - 8.5	---
EC	µS/cm	1926	1843	1554	---	---	---	---	1810	1760	---	1750	1770	1850	---	1810	1860	---	---	1820	1800	---	1830	---	1740	---	---	---	---
TDS-calculated	mg/L	**1126**	**1096**	**1078**	---	---	---	---	**1070**	**1050**	---	**997**	**1010**	**1050**	---	**1000**	**1010**	---	---	**1040**	**1060**	---	**1050**	---	**1090**	---	---	500	---
Total Alk. as CaCO3	mg/L	671	706	714	---	---	---	---	715	730	---	724	732	718	---	683	692	---	---	717	717	---	751	---	662	---	---	---	---
Sodium	mg/L	**455**	**460**	**453**	---	---	---	---	**441**	**424**	---	**393**	**398**	**431**	---	**407**	**407**	---	---	**403**	**432**	---	**403**	---	**517**	---	---	200	---
Potassium	mg/L	0.9	0.6	1.5	---	---	---	---	0.8	0.8	---	0.8	0.9	0.6	---	1.0	1.0	---	---	0.8	0.8	---	1.5	---	0.9	---	---	---	---
Calcium	mg/L	<1	4.6	6.3	---	---	---	---	3.8	3.5	---	3.5	3.6	3.4	---	3.6	3.2	---	---	1.6	1.8	---	1.3	---	<0.5	---	---	---	---
Magnesium	mg/L	<1	<0.1	0.9	---	---	---	---	0.4	0.4	---	0.4	0.4	0.3	---	0.6	0.5	---	---	0.3	0.3	---	0.2	---	<0.1	---	---	---	---
Iron	mg/L	**2.04**	**0.647**	**1.48**	---	---	---	---	0.06	0.02	---	---	---	0.01	---	---	---	---	---	---	---	---	0.05	---	0.17	---	---	0.3	---
Iron (total)	mg/L	---	---	---	---	---	---	---	---	---	---	---	---	---	---	4.87	4.87	---	---	---	---	---	1.79	---	0.321	---	---	---	---
Manganese	mg/L	---	0.010	0.014	---	---	---	---	0.006	<0.01	---	---	---	<0.004	---	---	---	---	---	---	---	---	<0.01	---	0.004	---	---	0.05	---
Manganese (total)	mg/L	---	---	---	---	---	---	---	---	---	---	---	---	---	---	0.029	0.029	---	---	---	---	---	0.02	---	0.004	---	---	---	---
Chloride	mg/L	**260**	200	186	---	---	---	---	186	182	---	162	163	180	---	177	177	---	---	203	195	---	184	---	173	---	---	250	---
Fluoride	mg/L	1.38	**1.7**	**1.58**	---	---	---	---	**1.73**	**1.5**	---	---	---	**1.61**	---	---	---	---	---	---	---	---	1.4	---	---	---	---	---	1.5
Sulphate	mg/L	<5	4	<0.6	---	---	---	---	3.7	3	---	2.5	2.2	3.3	---	1.5	1.3	---	---	<0.5	1.3	---	3.4	---	0.8	---	---	500	---
Carbonate	mg/L	26	0	10	---	---	---	---	10.3	<5	---	<5	<5	14	---	<5	21	---	---	29	29	---	22	---	31	---	---	---	---
Bicarbonate	mg/L	766	861	846	---	---	---	---	852	890	---	883	893	847	---	826	802	---	---	815	815	---	871	---	744	---	---	---	---
NO3 as N	mg/L	---	1.2	<0.2	---	---	---	---	<0.003	<0.05	---	<0.05	<0.05	<0.003	---	<0.05	<0.05	---	---	<0.05	<0.05	---	<0.05	---	<0.05	---	---	---	10
NO2 as N	mg/L	<0.05	<0.3	<0.3	---	---	---	---	<0.003	0.08	---	<0.05	<0.05	<0.003	---	<0.05	<0.05	---	---	<0.05	<0.05	---	<0.05	---	<0.05	---	---	---	1
NO2+NO3 as N	mg/L	<0.05	1.2	<0.2	---	---	---	---	<0.003	0.08	---	<0.05	<0.05	<0.003	---	<0.05	<0.05	---	---	<0.05	<0.05	---	<0.07	---	<0.07	---	---	---	10
Ion Balance %	%	95	102	103	---	---	---	---	98.0	94.4	---	90.7	91.0	97.0	---	96.8	95.1	---	---	87.8	95.3	---	86.8	---	124	---	---	---	---
Bacteria																													
Total Coliforms	cfu/100mL	---	**TNTC**	**TNTC**	---	---	---	---	---	---	---	---	---	---	---	---	---			---	---	---	<1	---	---	---	---	---	0
Total Coliforms	mpn/100mL	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	**1**	---	---	---	<1	---	---	---	0
Escherichia Coli	cfu/100mL	---	0	0	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	<1	---	---	---	---	---	0
Escherichia Coli	mpn/100mL	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---		<1	---	---	---	<1	---	---	---	0
S Reducing Bacteria	cfu/mL	---	---	---	---	---	---	---	---	---	---	---	---	---	<100	---	---	---	---	---	---	---	700000	---	700000	---	---	---	---
S Reducing Bacteria	MPN/mL	---	---	---	---	---	---	---	---	---	---	0.4	0.9	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Iron Related Bacteria	cfu/mL	---	---	---	---	---	---	---	---	---	---	<10	<10	---	10	---	---	---	---	---	---	---	9000	---	2300	---	---	---	---
Dissolved Hydrocarbons																													
Benzene	mg/L	---	---	---	---	---	---	---	<0.0004	<0.0005	---	---	---	---	---	<0.0005	<0.0005	---	---	---	---	---	---	---	---	<0.0001	---	---	0.005
Toluene	mg/L	---	---	---	---	---	---	---	<0.0004	<0.0005	---	---	---	---	---	0.0086	0.0078	---	---	---	---	---	---	---	---	<0.0001	---	0.024	---
EthylBenzene	mg/L	---	---	---	---	---	---	---	<0.0004	<0.0005	---	---	---	---	---	<0.0005	<0.0005	---	---	---	---	---	---	---	---	<0.0001	---	0.0024	---
Xylenes	mg/L	---	---	---	---	---	---	---	<0.0004	<0.0005	---	---	---	---	---	<0.0005	<0.0005	---	---	---	---	---	---	---	---	<0.0001	---	0.3	---
F1(C6-C10) - BTEX	mg/L	---	---	---	---	---	---	---	<0.1	<0.1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	<0.01	---	---	---
F2 (C10-C16)	mg/L	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	<0.05	---	---	---
F3(C16-C34)	mg/L	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	<0.02	---		
F4(C34-C50)	mg/L	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	<0.02	---		
Dissolved Gas Analysis																													
Nitrogen	mg/L	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	12.70	---	---	---
Carbon Dioxide	mg/L	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	<1	<1	---	---	---	---	5.93	---	---	---
Oxygen	mg/L	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	0.53	---	---	---
Methane	µg/L	---	---	---	---	---	---	---	---	---	---	---	---	---	---	42400	35780	42800	66300	39000	45000	<5	---	---	33000	31900	---	---	---
Ethane	µg/L	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	3.21	---	---	---
Propane	µg/L	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	<0.01	---	---	---
n-Butane	µg/L	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	<0.01	---	---	---
i-Butane	µg/L	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	<0.01	---	---	---
δ13C Methane	‰ PDB	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	-62.5		
Free Gas Analysis																													
Nitrogen	ppm	---	---	---	284800	207000	173800	199500	---	---	183300	---	---	---	---	---	---	---	---	---	---	---	110000	---	---	77600	---	---	---
Carbon Dioxide	ppm	---	---	---	3800	3000	2800	11900	---	---	12400	---	---	---	---	---	---	---	---	---	---	---	1600	---	---	1910	---	---	---
Oxygen	ppm	---	---	---	52400	54000	47000	23200	---	---	16000	---	---	---	---	---	---	---	---	---	---	---	17000	---	---	9870	---	---	---
Methane	ppm	---	---	---	659000	736000	776400	765100	---	860000	788100	---	---	---	---	---	---	---	---	---	---	---	880000	---	---	979000	---	---	---
Ethane	ppm	---	---	---	31	40	43	51	---	---	54	---	---	---	---	---	---	---	---	---	---	---	<5	---	---	18.40	---	---	---
Propane	ppm	---	---	---	<1	<1	<1	<1	---	---	<1	---	---	---	---	---	---	---	---	---	---	---	<5	---	---	<0.05	---	---	---
n-Butane	ppm	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	<5	---	---	<0.05	---	---	---
i-Butane	ppm	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	<5	---	---	<0.05	---	---	---
δ13C CO2	‰ PDB	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	-1.0	---	---	1.9	---	---
δ13C Methane	‰ PDB	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	-62.8	---	---	-63.3	---	---
δ13C Ethane	‰ PDB	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	nd	---	---	nd	---	---
δ13C Propane	‰ PDB	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	nd	---	---	nd	---	---
δ13C n-Butane	‰ PDB	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	nd	---	---	nd	---	---
δ13C i-Butane	‰ PDB	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	nd	---	---	nd	---	---

GCDWQ - Health Canada Guidelines for Canadian Drinking Water Quality (2007)
AO - Aesthetic objective
MAC - Maximum acceptable concentration
nd - not detected by gas chromatography so not run for isotopes
--- not analyzed
TNTC - Too numerous to count
Bold font denotes exceedence of GCDWQ limit

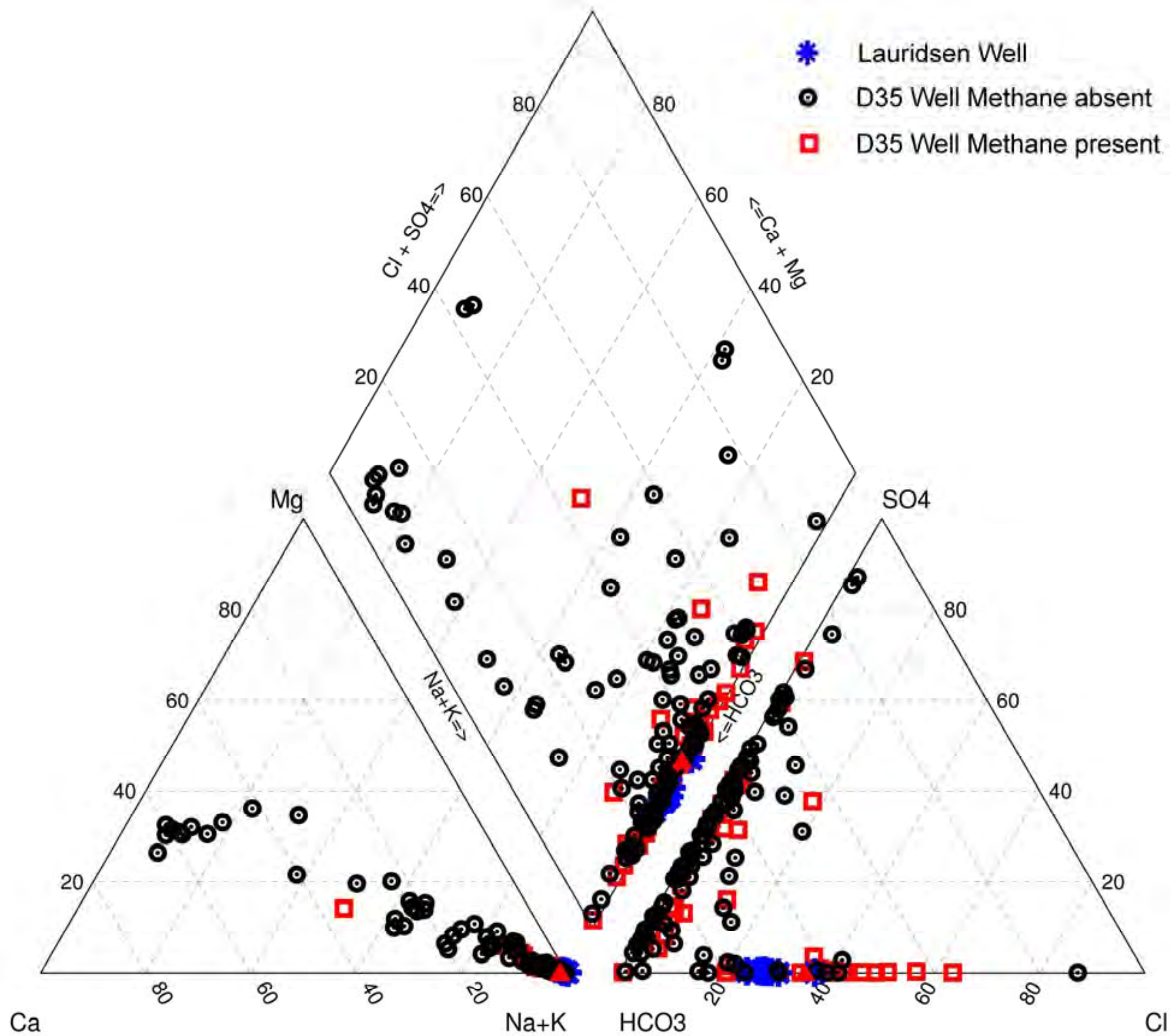

Figure 4. Piper plot of water chemistry from the Lauridsen well, Surrounding D35 water wells and the GOWN wells.

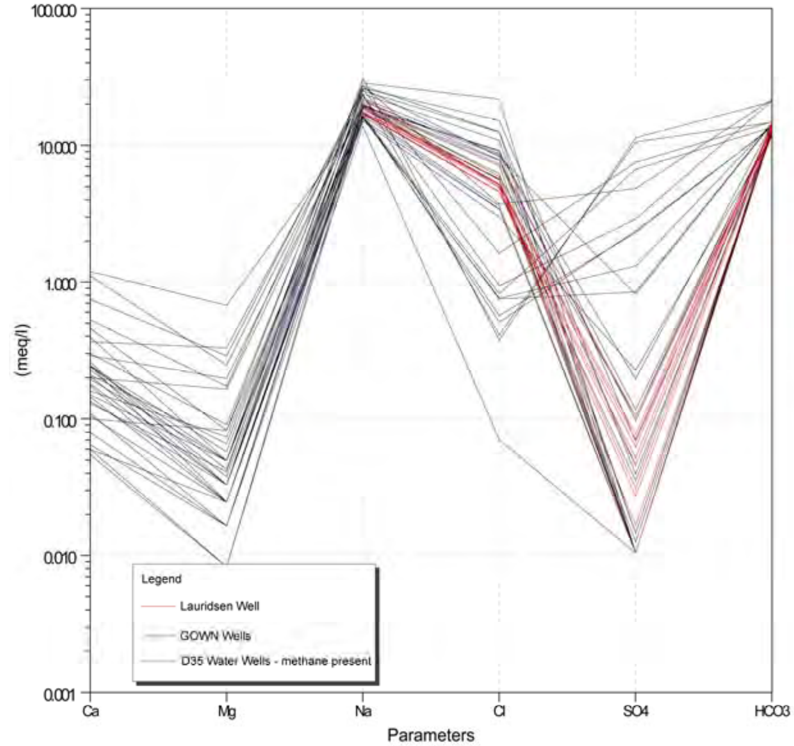

Figure 5 Schoeller plot of water wells with methane present.

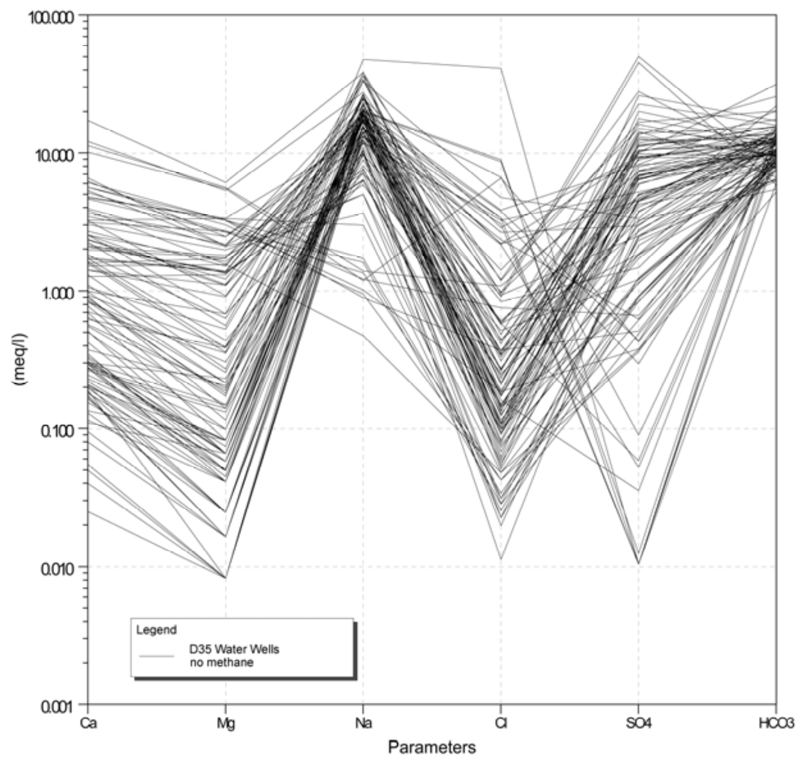

Figure 6 Schoeller plot of water wells with no methane.

4.5.3 Dissolved Organic Chemistry

An analysis for EPA volatile priority pollutants and extractable priority pollutants and CCME hydrocarbons (F1234) are available for the Lauridsen well (Table 3 and Appendix E). All volatile and extractable organic compounds were below the analytical detection limit with the exception of four compounds not expected to be related to CBM activities. These compounds are 2-Methyl-2-Propanol (1 µg/l), an alcohol used as is used as a solvent, and three different phthalates (Bis (2-ethylhexyl) phthalate (1.6 µg/l), Butylbenzylphalate (0.1 µg/l) and Di-n-butylphthalate (0.3 µg/l)) all plasticizers used in PVC plastic (Grant Prill, ARC, personal communication). A likely source for latter compound is new plastic tubing used during sampling. Several BTEX and F1-F4 analyses were done on the Lauridsen well (Table 3). All BETX and F1234 analyses were below detection limit. No Canadian Drinking Water Guideline limits have been exceeded for EPA priority pollutants or CCME hydrocarbons.

Several dissolved methane analyses were available for the Lauridsen well with concentrations ranging from 35,780 to 66,300 µg/l. One high precision (method detection limit = 0.01µg/L) dissolved gas analysis was performed on the Lauridsen well (Table 3) with methane (31,900 µg/l) and a small amount of ethane (3.21 µg/l) detected.

4.5.4 Atmospheric Elements and Hydrocarbon Gas Chemistry

Several free gas analysis are available for the Lauridsen well (Table 3). The samples appear to be free from atmospheric contamination (based on low oxygen and nitrogen values). The gas samples contain 659,000 to 979,000 ppm methane and 18.4 to 54 ppm ethane. C3 and higher gases were below the detection limit (e.g. 0.05 ppm in the June 2007 analysis). In addition to the Lauridsen well, 36 nearby water wells from the D35 database and 3 GOWN wells have gas chemistry. Methane and ethane concentration are similar to those measured in the Lauridsen well. A more rigorous, statistical approach to differentiate gas characteristics is presented at the end of this section.

To address the concern that the nitrogen fracturing could have affected the Lauridsen water well, the nitrogen concentration of the free gas in the Lauridsen well was compared to concentrations in D35 wells, the GOWN wells, several CBM wells and conventional gas wells. The Lauridsen well analyses range from 7.8 to 28.4 % nitrogen. The variability is likely due to the location (well, hydrant, house tap or hot water tank) that the sample was taken from (and possibly to sampling procedure variability between different sampling events or different field personnel. A histogram of the nitrogen gas content from D35 water wells (Figure 7) shows two groups. One group falls in a range of 5 to 30% nitrogen while the other group is greater than 50% nitrogen. The group with greater than 50% nitrogen tends also to have lower methane concentrations and may be indicative of atmospheric contamination in the sample. Nitrogen levels could also be higher due to another factor such as breathing wells (wells that take in air during atmospheric pressure highs and expel air with depleted oxygen content during atmospheric pressure lows) which have been noted in Alberta (Hydrogeological Consultants Ltd

1999), or to aquifer connection to the atmosphere at some distant point from the well (such as an aquifer outcrop on a valley wall). Nitrogen concentrations in energy wells are less than 15%. The Lauridsen well nitrogen analyses fall within the normal range observed for the D35 wells with no air contamination.

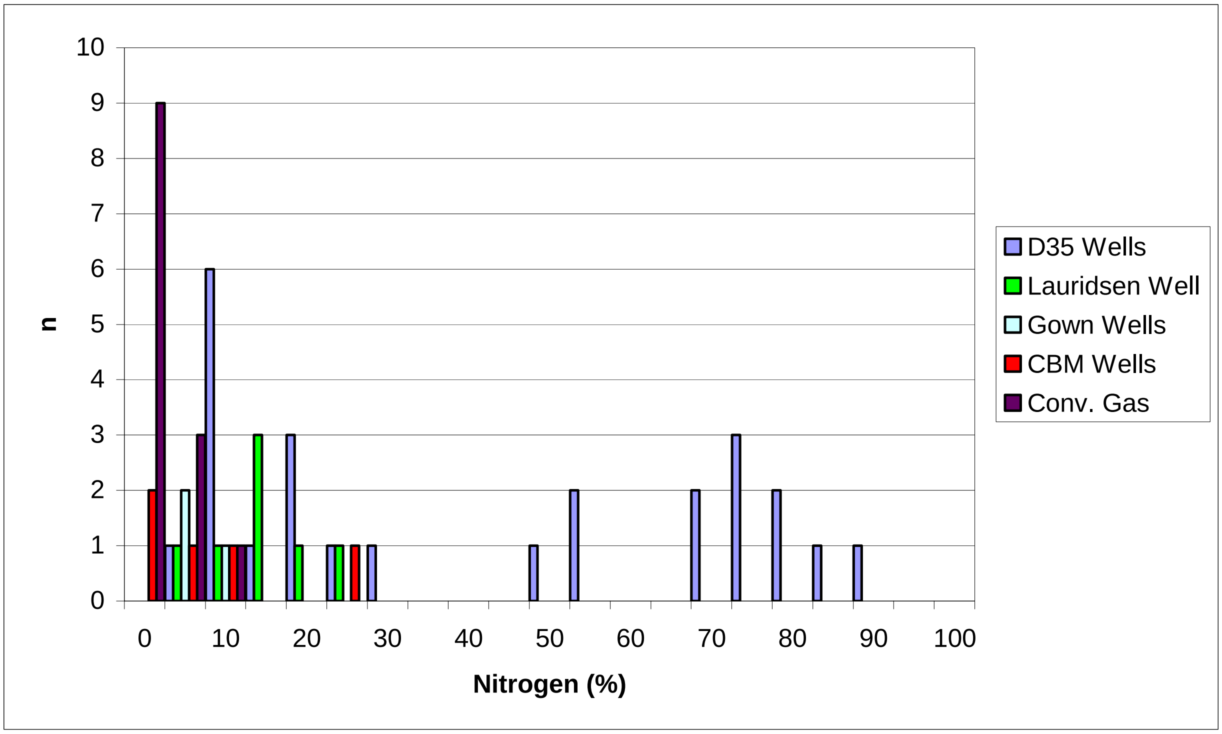

Figure 7 Histogram of nitrogen concentrations in water wells and energy wells.

4.5.5 Stable Carbon Isotope Chemistry on Hydrocarbon Gas

Stable carbon isotopes sometimes can be used to help in the identification of the origin of gas in water wells. Two carbon isotope analyses on hydrocarbon gas were available for the Lauridsen well (Table 3). In addition to the Lauridsen well, 27 nearby water wells from the D35 database and 3 GOWN wells have carbon isotope analyses on hydrocarbon gases and carbon dioxide. Carbon isotope analyses were available for the EnCana CBM wells located in 08-12-027-22 W4M, 03-14-027-22 W4M, 07-13-027-22 W4M, 06-24-027-22 W4M and 14-12-027-22 W4M. Carbon isotope analyses were also available for the EnCana conventional gas wells located in 08-12-027-22 W4M and 14-12-027-22 W4M.

Isotopic results from the Lauridsen well and the GOWN wells in Rosebud and Redland were performed by the Applied Geochemistry group at the University of Calgary using a gas chromatograph coupled to a Finnigan MAT delta plus XL mass spectrometer (3 kV). This analytical setup requires at least 500 ppm methane, 300 ppm ethane and 200 ppm propane in the injected gas to stay in the linear range of the mass spectrometer (Dr. Bernhard Mayer, personal communication). The reported $\delta^{13}C$ values have a precision of +-0.5 per mil for both free and dissolved gases (He headspace equilibration technique). The analytical techniques for gas isotope results the D35 results are not known.

Some of the energy wells tested have questionable quality data. The qualitative QA/QC assessment of the EnCana well data is presented in Table 4. The GC analysis for 02/08-12 and 00/08-12 appears to be representative of CBM and conventional gas respectively, but the isotope values of the methane are not. It appears that the samples may have got mixed up and the CBM gas sample was labelled as the conventional gas sample and vice versa. The sample from 00/03-14 appears contaminated by air, based on the composition being predominantly nitrogen and oxygen, with hydrocarbons below the detection limit. These analyses were not used in the ARC evaluation.

The new deep GOWN (Groundwater Observation Well Network) well in Rosebud, completed in the Drumheller coals, is representative of shallow (140 m) CBM in the area. This well has no water and has flowing gas. Several of the CBM wells are representative of CBM gas compositions. However, deeper CBM well gas carbon isotopes are not well represented in the area due to the problems noted above. Data from CBM wells from Township 45, Ranges 20 and 21 was used to compare the Lauridsen well carbon isotopes to typical deeper CBM well carbon isotopes.

Table 4 Energy (and GOWN) well QA/QC data quality.

Well Name	Type	GC	Isotopes	Data Quality
GOWN Rosebud #1 SW-18-027-21W4M	CBM	Yes	Yes	Acceptable
02/04-44-027-22W4M	CBM	Yes	No	Acceptable
02/08-12-027-22W4M	CBM	Yes	Yes	Isotope results may be from 00/08-12 (lab error?)
00/03-14-027-22W4M	CBM	Yes	Yes	Air contaminated sample
00/05-14-027-22W4M	CBM	Yes	No	Acceptable
00/06-24-027-22W4M	CBM	Yes	No	Acceptable
00/14-10-027-22W4M	Conv.	Yes	No	Acceptable
00/15-10-027-22W4M	Conv.	Yes	No	Acceptable
02/04-11-027-22W4M	Conv.	Yes	No	Acceptable
00/07-11-027-22W4M	Conv.	Yes	No	Acceptable
00/08-12-027-22W4M	Conv.	Yes	Yes	Isotope results may be from 00/08-12 (lab error?)
00/14-12-027-22W4M	Conv.	Yes	Yes	Acceptable
00/07-13-027-22W4M	Conv.	Yes	No	Acceptable

A histogram of the carbon isotope values of methane from the Lauridsen water well, the surrounding D35 water wells, CBM wells and conventional gas is presented in Figure 8. The methane values for the Lauridsen well fall within the general peak for methane values. A statistical analysis of the mean isotopic compositions is presented at the end of this section. From a visual observation of the plot, it is observed that the CBM wells have a less depleted (less negative) methane isotope signature, while the one conventional gas signature is even less depleted. The D35 wells and Lauridsen well have methane isotope signatures that fall within the range of -60 to -80, typical of biogenic methane (Schoell 1980; Whiticar et al. 1986; Rice 1993).

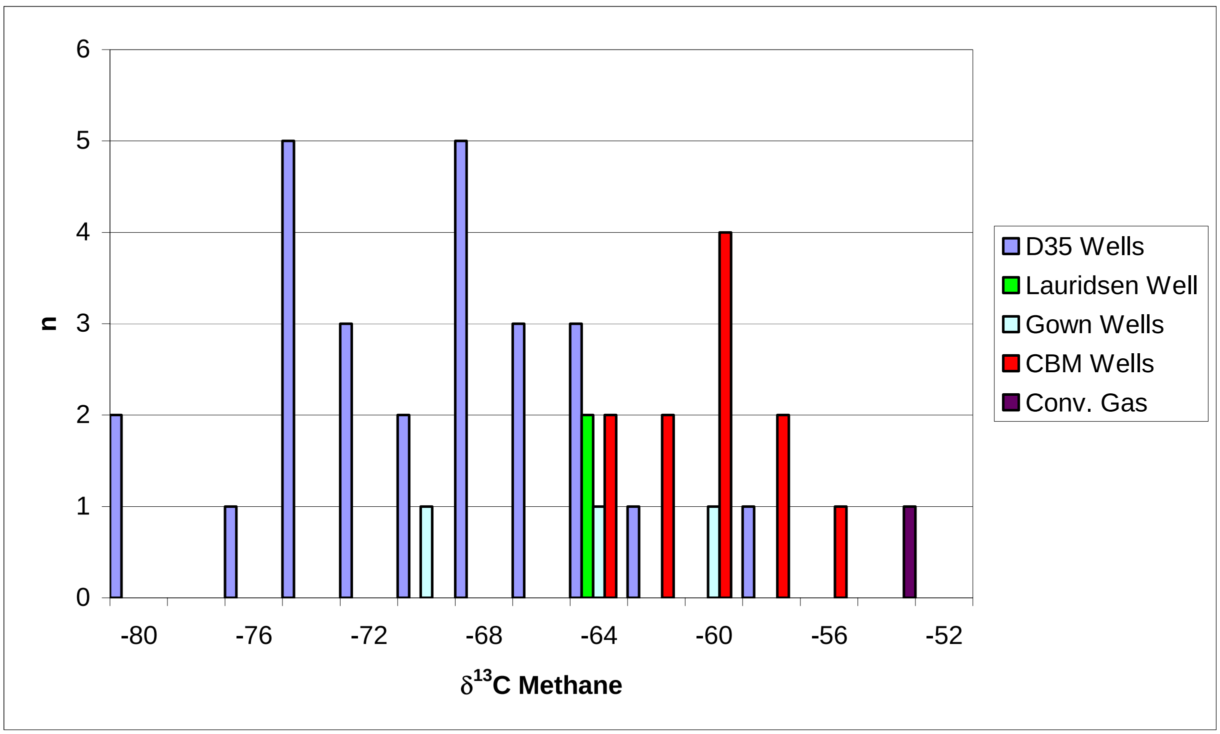

Figure 8 Histogram of the carbon isotope values of methane in all water wells and Energy wells.

A histogram of the carbon isotope values of ethane from the D35 water wells, the GOWN well, CBM wells and conventional gas is presented in Figure 9. The Lauridsen well and two of the GOWN wells do not contain enough ethane to get a meaningful ethane carbon isotope signature (i.e. below the method detection limit) therefore they do not appear on the diagram. The CBM wells have ethane isotope signatures that fall within the general range for the surrounding D35 water wells. The conventional gas well (Viking Formation) has a much less depleted ethane isotope signature.

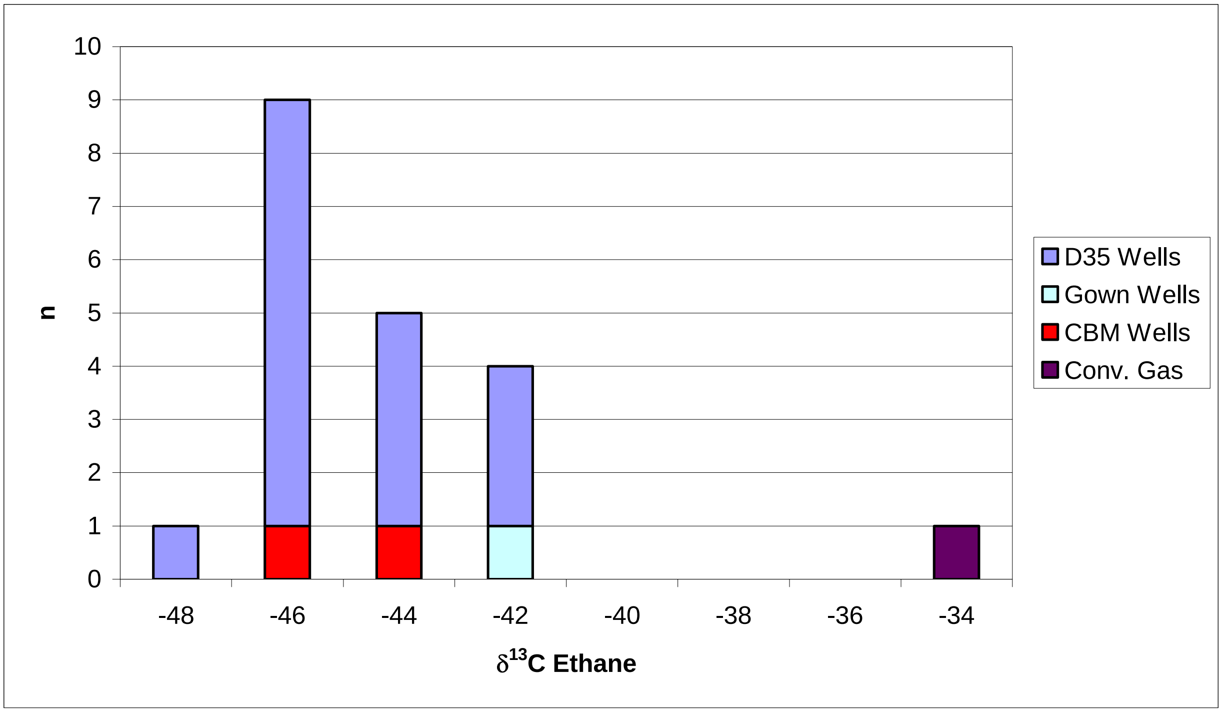

Figure 9 Histogram of the carbon isotope values of ethane in all water wells and energy wells

A plot of the methane concentration versus the methane carbon isotope signature ($\delta^{13}C_{\text{Methane}}$) is presented on Figure 10. Below the line at -60 ‰ typically represents a biogenic (bacterial) origin for methane (Schoell 1980 and 1983; Whiticar et al 1986; Rice 1993). The CBM well has a $\delta^{13}C_{\text{Methane}}$ value that is less enriched than the typical range of -60 to -80 ‰, typical of biogenic methane. This value represents a mixed thermogenic and biogenic origin. The water well data, including the Lauridsen well, all have $\delta^{13}C_{\text{Methane}}$ values that are clearly biogenic.

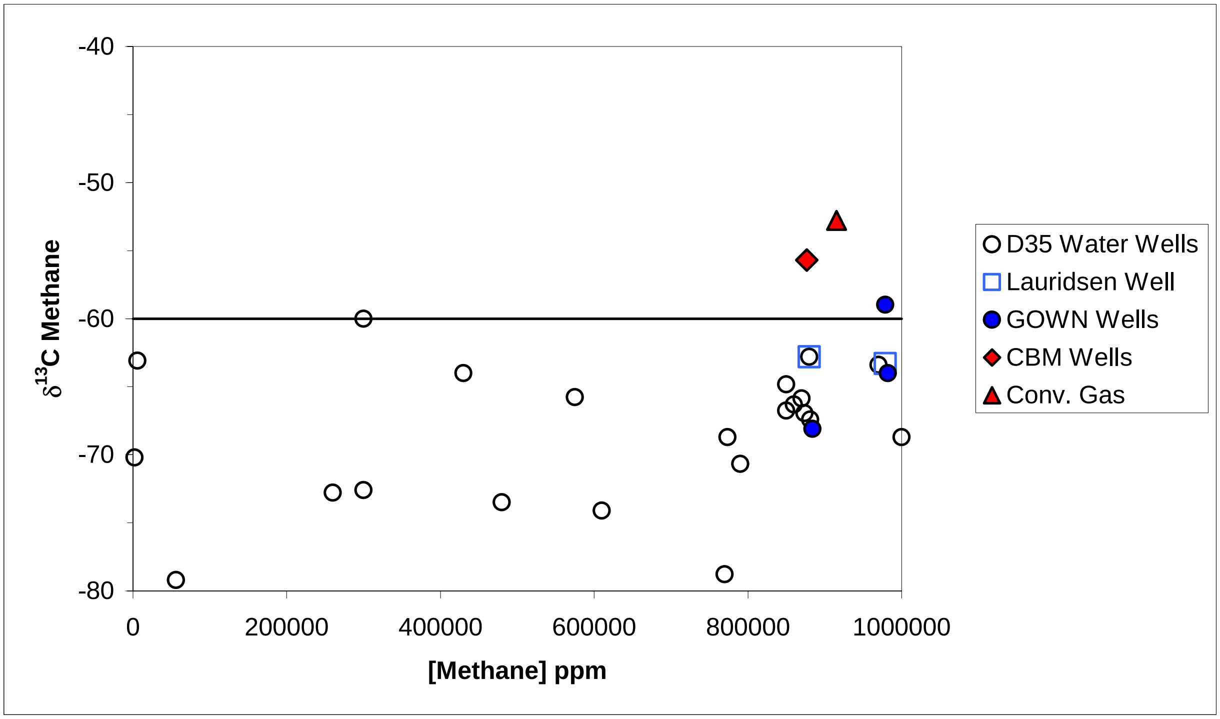

Figure 10 Methane concentration versus $\delta^{13}C$ of methane.

A plot of the ethane concentration versus the ethane carbon isotope signature ($\delta^{13}C_{\text{Ethane}}$) is presented on Figure 11. Most of the water wells have ethane concentrations below the lab detection limit (which was as high as 100 ppm for some analyses). The Lauridsen well has 39.6 ppm ethane (average of 6 analyses), which is below the method detection limit to run carbon isotopic analysis of ethane. Of the D35 wells with detectable ethane, concentrations are several times less than that observed in the CBM wells or the deep GOWN well in Rosebud. The $\delta^{13}C_{\text{Ethane}}$ values of the water wells are within the range of $\delta^{13}C_{\text{Ethane}}$ values observed in the CBM well and the GOWN well. The ethane concentration and isotopic signature of ethane from the conventional gas well is markedly different from the water wells and the CBM wells. A more rigorous statistical approach to mean isotope values is presented at the end of this section.

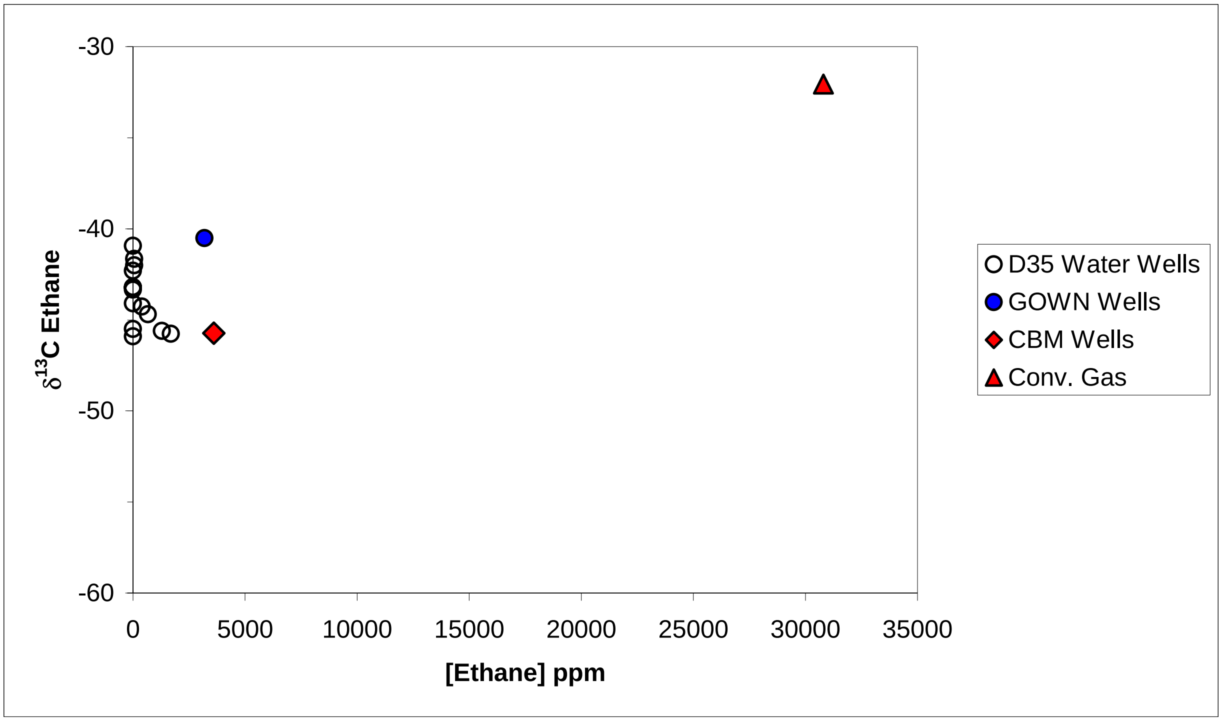

Figure 11 Ethane concentration versus $\delta^{13}C$ of ethane.

A plot of the methane carbon isotope signature ($\delta^{13}C_{\text{Methane}}$) versus the ethane carbon isotope signature ($\delta^{13}C_{\text{Ethane}}$) is presented on Figure 12. The Lauridsen well (and two of the GOWN wells) does not appear on this plot because ethane isotopes were below the method detection limit. The $\delta^{13}C_{\text{Methane}}$ values of the CBM wells, the deep GOWN well and the conventional gas well are less depleted than the water wells. The $\delta^{13}C_{\text{Ethane}}$ values of the CBM wells and the GOWN well are similar to the D35 water wells.

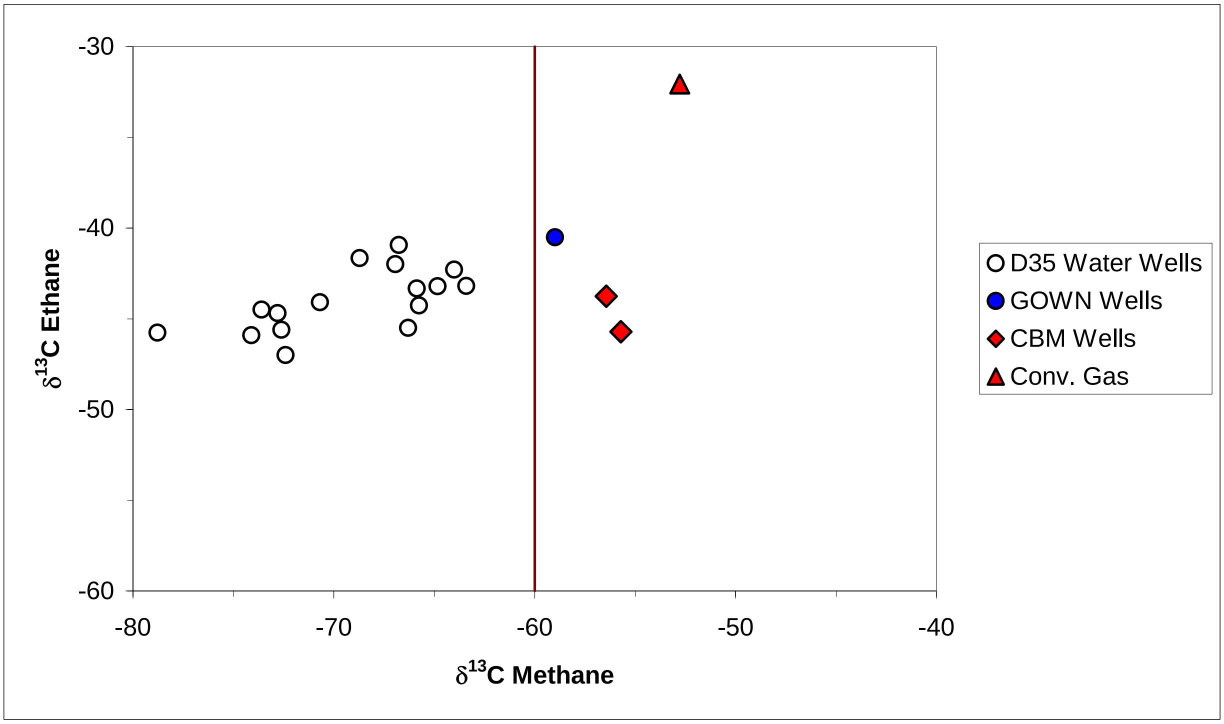

Figure 12 δ^{13}C Methane versus δ^{13}C Ethane.

A plot of the carbon isotopes of coexisting methane and CO_2 from water wells are presented on Figure 13. Lines of equal carbon isotope fractionation (α) between methane and CO_2 are shown. This line represents the isotopic difference between these coexisting pairs of carbon species (methane and carbon dioxide). Data above the α=1.055 line can be indicative of methane origination from the CO_2 reduction pathway while data below this line can be indicative of methane origination from the fermentation pathway (Whiticar et al. 1986). The data indicates that methane from the Lauridsen well and the majority of D35 well originates from the microbial reduction of CO_2 (i.e. biogenic origin).

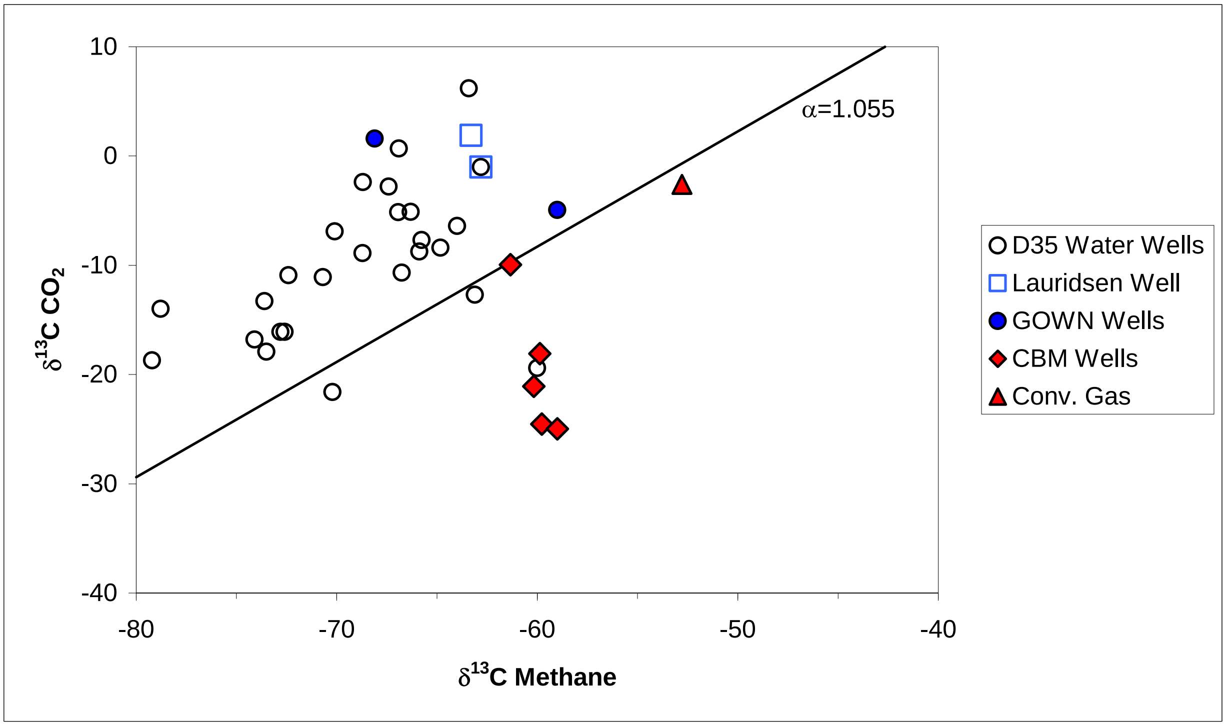

Figure 13 $\delta^{13}C$ Methane versus $\delta^{13}C$ CO_2. The α value is a line of equal fractionation between methane and CO_2.

Both the hydrocarbon gas composition and the isotopic signatures can be modified by mixing between different sources of gases (such as biogenic methane with thermogenic methane). These hypothetical mixing curves can be calculated using the equations of Jenden et al. (1993) shown on Figure 14. The y-axis of this plot is the ratio of methane to all other hydrocarbon gases.

For this investigation three different end member gases were considered to be the most likely sources and to be mixed in varying ratios: the statistical average biogenic gas in the area, a gas with an isotopic signature similar to the Lauridsen well, and typical CBM gas.

The first mixing scenario was the average biogenic gas found in the D35 water well ([Methane=437104 ppm], $\delta^{13}C_{methane}$=-68.7 ‰) mixed with a typical CBM gas ([Methane=876700 ppm], $\delta^{13}C_{methane}$=-55.7 ‰). The second scenario was this same average methane concentration gas with a methane isotopic signature ($\delta^{13}C_{methane}$=-63.5 ‰) chosen so the Lauridsen well would fall on the curve, mixed with the CBM gas. The tick marks on the curves represent mixtures of CBM gas with the gas from water wells, ranging from 0% to 100%

The Lauridsen well mixing curve 2 shows a possible <0.5% mix of the CBM member with a biogenic end-member (chosen to fall though the well). While this is possible, the gas composition and $\delta^{13}C_{methane}$ value of the Lauridsen well is not statistically any different from the average D35 water well (discussed below). A similar plot can be constructed for ethane. This plot is not shown as the Lauridsen well had ethane concentrations below the method detection limit for isotopic analysis.

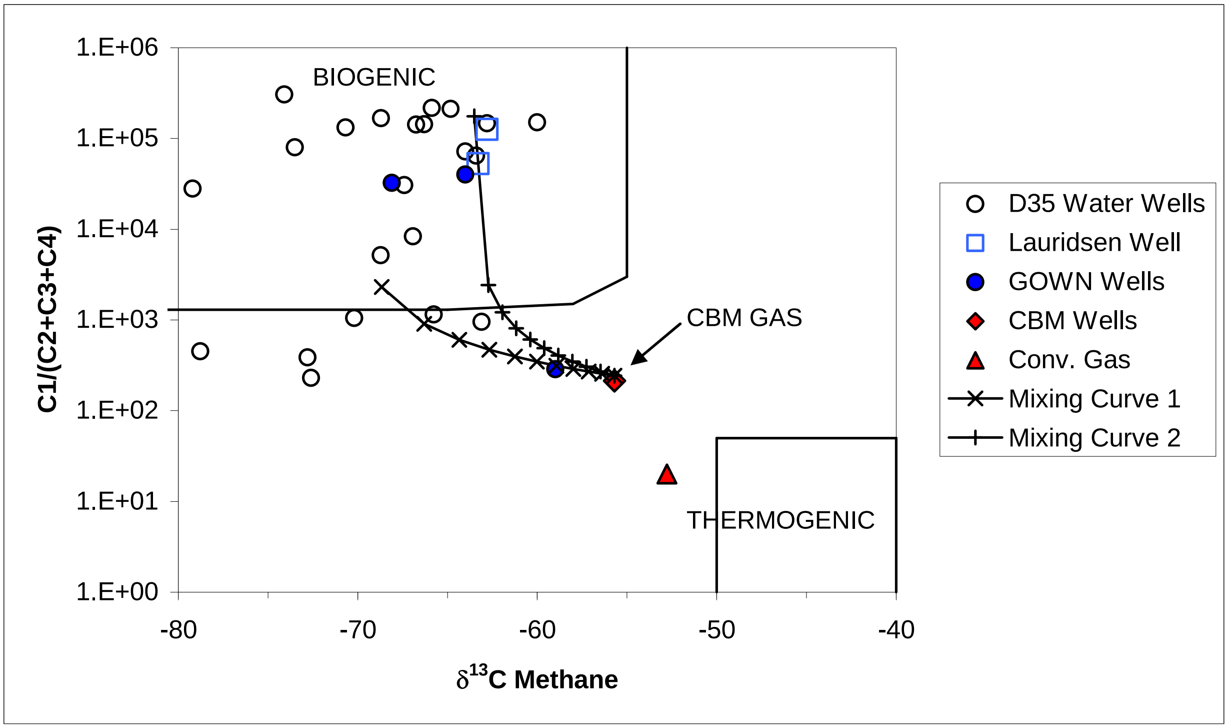

Figure 14 Mixing plot of $\delta^{13}C$ of methane versus the methane/C2+ ratio. Data for the bacterial and thermogenic fields are from Faber and Stahl 1984.

A statistical analysis was performed on gas concentration and gas carbon isotope data. The concentration of methane, ethane and propane along with the carbon isotope values of methane and ethane from water wells containing methane were compared to the Lauridsen water well and the CBM wells (Table 5). Hydrocarbon gases were detected in 36 of 145 (25%) of the wells in the Rosebud and Redland area.

Student T-Tests were used to compare methane concentrations in the Lauridsen well with the surrounding D35 water wells. T-Tests are based on a t-distribution, which is similar to a normal distribution, but is dependent upon the number of samples measured. There is no significant difference between the mean methane concentrations in the Lauridsen well with that of the D35 water well (5% level of significance). This statistically validates the contention that the methane concentrations in the Lauridsen well is the same as that of surrounding D35 water wells

Ethane was detected by gas chromatography in 10 of 145 (7%) wells tested. Ethane carbon isotopes were measured in 16 wells by mass spectrometry, a more sensitive technique. Of these ten wells, the average concentration was 619 ppm as compared to 3798 ppm in the CBM wells. Propane and butane were not detected (by gas chromatography) in any of the water wells as compared to 559 ppm and 351 respectively in the CBM wells. The propane and butane carbon isotopes were measured in two water wells. The method detection limit to run carbon isotopic analysis of methane, ethane and propane are 500, 300 and 200 ppm respectively at the University of Calgary and the University of Waterloo (personal communication with Dr. Bernhard Mayer, University of Calgary and Robert Drimmie, University of Waterloo). The method, and therefore detection limit, used to determine methane, ethane, propane and butane isotopes in the D35 wells is not stated.

Student T-Tests were used to compare mean methane carbon isotope value in the Lauridsen well with the surrounding D35 water wells and the CBM wells. There is no significant difference between the mean methane carbon isotope values in the Lauridsen well with that of the D35 water well (5% level of significance). This statistically validates the observation that the carbon isotope value of the methane in the Lauridsen water well is the same as the methane isotope signature of the surrounding D35 water wells.

There is a statistically significant difference between the mean methane carbon isotope values in the D35 wells with that of the CBM wells (5% level of significance). This statistically validates the observation that the carbon isotope values of the methane in the CBM wells is less depleted than the methane isotope signature of the surrounding water wells.

There is a statistically significant difference between the mean methane carbon isotope values in the Lauridsen well with that of the CBM wells (5% level of significance). This statistically validates the observation that the carbon isotope values of the methane in the CBM wells is less depleted than the methane isotope signature of the Lauridsen well.

Student T-Tests were used to compare mean ethane carbon isotope value in the D35 water wells and the CBM wells. There is no statistically significant difference between the mean ethane carbon isotope values in the D35 wells with that of the CBM wells (5% level of significance). This statistically validates the observation that the carbon isotope values of the ethane in the CBM wells are the same as the ethane isotope signatures of the surrounding water wells. This does not indicate the D35 water wells have been impacted by ethane from CBM wells. The similarity between ethane isotope signatures is expected as both the CBM wells and the D35 water wells are completed in the same formation (but different coal members) in the area. No statistical comparisons can be made with the Lauridsen well because the ethane concentration was below the method detection limit for carbon isotopes.

Table 5. Statistical values and T-Tests of the gas and isotope data.

D35 Water Wells	[Methane] (ppm)	$\delta^{13}C_{Methane}$ (‰)	$\delta^{13}C_{Ethane}$ (‰)
n	37	28	16
Min	440	-79.20	-47.00
Max	1000000	-60.00	-40.94
Mean	554456	-68.63	-44.00
Std.	355263	4.73	1.73

Lauridsen Water Wells	[Methane] (ppm)	$\delta^{13}C_{Methane}$ (‰)	$\delta^{13}C_{Ethane}$ (‰)
n	8	2	0
Min	659000	-63.30	
Max	979000	-62.80	
Mean	805450	-63.05	
Std.	98341	0.35	

CBM Wells	[Methane] (ppm)	$\delta^{13}C_{Methane}$ (‰)	$\delta^{13}C_{Ethane}$ (‰)
n	14	11	3
Min	702700	-63.96	-45.72
Max	979100	-56.44	-40.51
Mean	889200	-60.09	-43.33
Std.	113421	2.04	2.63

T-Test	T-Test	Degees of Freedom	5% level of significance
Mean [Methane] D 35 and Lauriden	-1.966	43	**significant difference**
Mean $\delta^{13}C_{Methane}$ D 35 and Lauridsen	-1.638	28	no significant difference
Mean $\delta^{13}C_{Ethane}$ D 35 and Lauridsen			
Mean [Methane] D 35 and CBM Wells	-3.441	49	**significant difference**
Mean $\delta^{13}C_{Methane}$ D 35 and CBM Wells	-5.738	37	**significant difference**
Mean $\delta^{13}C_{Ethane}$ D 35 and CBM Wells	-0.573	17	no significant difference
Mean [Methane] Lauridsen and CBM Wells	-1.744	20	**significant difference**
Mean $\delta^{13}C_{Methane}$ Lauridsen and CBM Wells	-1.975	11	**significant difference**
Mean $\delta^{13}C_{Ethane}$ Lauridsen and CBM Wells			

5 CONCLUSIONS

The Alberta Research Council's review of the AENV Lauridsen complaint file and AEUB data, and our independent review of additional data and aspects of the complaint, provides the following conclusions:

- The Lauridsen water well is completed in the Upper Horseshoe Canyon Formation as are some of the upper perforations of the CBM wells. Local water wells appear to be predominantly producing water from the Carbon Thompson and Weaver coals of the Horseshoe Canyon Formation.
- In the Rosebud area, the deep GOWN well and CBM drilling and completions records indicate that the coals are not water saturated below the Weaver coal. Under natural conditions, flow between these coal zones is expected to be very limited.
- A local stress analysis indicates the most likely azimuth (orientation) of fractures and face cleats in the coal would be about 055° (Bachu and Michael 2002). Three energy wells line up with the Lauridsen well on this general orientation.
- Energy Wells in the vicinity (within 1.5 km) of the Lauridsen well have no apparent drilling and construction issues that would contribute to methane or degredation of water quality in the Lauridsen well.
- The CBM well 00/05-14-027-22 W4M, located about 2 km northwest of the Lauridsen well, had perforations and fracturing in the same aquifer that the Lauridsen well is completed. The connection between these wells has since been removed (cement squeezed) and it is unlikely that these short-lived perforations had any measurable effects on the Lauridsen well.
- Records in the AENV well complaint file indicate the Lauridsen well is not regularly shock chlorinated. Holes were observed in the casing of the well by a drilling contractor using a well camera. The 30 year old well casing is not in good condition.
- An estimate of downward vertical gradient between the Lauridsen well and the Horseshoe Canyon CBM zones is 1.0. This represents a large downward vertical gradient. If these two zones become connected, water would flow downwards into the CBM well rather than up into the Lauridsen.
- A theoretical evaluation of the potential migration of methane as bubbles from the CBM well to the Lauridsen well (through an induced fracture) suggests that the downward flow of groundwater in the fracture would stop the upward migration of methane bubbles.
- A 2.3 m fluctuation in static water level was observed in the Lauridsen well. The cause of this decrease is unknown but possible causes include groundwater resource extraction by the Lauridsen well or nearby users or from drought. This drop in water level, and corresponding drop in pressure on the coal zone, can be shown to contribute to the increase in amount of methane dissolved in the groundwater at saturation. This effect would be even greater during pumping of this well where the static water level drops by about 24 m.
- The water well major ion chemistry for the Lauridsen wells shows Na-HCO_3-Cl type water. The analyses show the Lauridsen well consistently exceeds the aesthetic

objectives for total dissolved solids (TDS) and sodium. As well, the pH is high and the aesthetic objective is often exceeded. This water chemistry is typical of water wells in the area. The maximum acceptable concentrations for fluoride have sometimes been exceeded. Three analyses shows the presence of total coliform bacteria in exceedence of the maximum acceptable concentration, with two analyses showing numbers too numerous to count.

- For all the D35 wells in the area sodium-bicarbonate (Na-HCO_3) and sodium-bicarbonate-chloride (Na-HCO_3-Cl) type waters are strongly associated with the presence of methane in the water. The Lauridsen water well chemistry is not unique. It, along with many other wells in the area, has Na-HCO_3-Cl type water.
- The methane carbon isotope values for the Lauridsen well fall within the general histogram peak for methane values for all D35 wells in the area. The CBM wells have a less depleted methane isotope signature.
- The ethane carbon isotope values for the CBM wells fall within the general histogram peak for ethane values for all D35 wells in the area.
- The CBM wells have $\delta^{13}C$ methane values that are less depleted than the typical range (-60 to -80 ‰) for biogenic methane. This value represents a mixed thermogenic and biogenic origin.
- The water well data, including the Lauridsen well, all have $\delta^{13}C$ methane values that are clearly biogenic. This means the methane likely formed at a shallow depth.
- The $\delta^{13}C$ ethane values of all the water wells are similar to the values of the CBM wells, but concentrations are lower (indicating a different origin or potential mixing, see next conclusion point).
- The hydrocarbon gas composition and isotopic values are modified by mixing between different sources of gases. For example, a hypothetical mixing of 4% CBM gas with a biogenic end-member could produce results similar to the Lauridsen well. While gas mixing is possible, the gas composition and $\delta^{13}C_{methane}$ value of the Lauridsen well is not statistically any different from the average D35 water well in the area.
- Student T-Tests statistically validate the observation that the carbon isotope value of the methane in the Lauridsen water well is the same as the methane isotope signature of the surrounding D35 water wells.
- Student T-Tests statistically validate the observation that the carbon isotope values of the methane in the CBM wells is different than the methane isotope signature of the surrounding water wells.
- Student T-Tests statistically validate the observation that the carbon isotope value of the ethane in the CBM wells is the same as the ethane isotope signature of the surrounding D35 water wells. This does not indicate the D35 water wells have been impacted by ethane from CBM wells. The similarity between ethane isotope signatures is expected as both the CBM wells and the D35 water wells are completed in the same formation (but different coal members) in the area.

Overall Conclusion

- The Alberta Research Council's overall conclusion of the evidence from the review of the AENV and AEUB files, along with a new review and evaluation of addition data and aspects, is that energy development projects in the area most likely have not adversely affected Ms. Lauridsen's water well.

6 CLOSURE

This report details a thorough review of the AENV well complaint file for Ms. Lauridsen regarding Coal Bed Methane (CBM) and conventional gas activities undertaken by EnCana and the subsequent perceived decrease in water quality of the Lauridsen well.

This work was carried out in accordance with accepted hydrogeological practices.

Respectfully submitted,
Alberta Research Council
Permit to Practice P03619

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Research Hydrogeologist

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APPENDIX A

SUMMARY OF ENERGY WELL DRILLING AND COMPLETION DETAILS

Well info for Alberta Research Council request

20-Apr-2006

all wells within 1600m of Lauridsen and Ernst water wells

Well Head (/00 event sequence)	Spud Date	Rig Release	Lost circulation (Y/N)	Surface Casing Depth (m)	TD (m)	Cement returns (surface casing) (m3)	Cement returns (prod casing) (m3)	Perf Count	Perf date	Perf top (mKb)	Perf bottom (mKb)	Frac Count	Frac Date	Frac Top (mKb)	Frac Bottom (mKb)	Frac fluid
100/07-11-027-22W4/00	07-Dec-02	09-Dec-02	N	144	1287	1.00	7	11	13-Apr-05	342.8	343.8	2	24-May-04	636.0	639.0	NITRIFIED FOAM
									13-Apr-05	299.4	300.4		02-May-05	175.9	343.8	N2
									13-Apr-05	337.0	338.0					
									20-Apr-04	636.0	639.0					
									13-Apr-05	272.7	273.7					
									13-Apr-05	296.4	297.4					
									17-Jan-03	1188.5	1191.5					
									13-Apr-05	211.9	214.9					
									13-Apr-05	175.9	177.9					
									08-Jun-04	604.0	607.0					
									13-Apr-05	188.0	189.0					
100/04-11-027-22W4/00	29-Oct-97	30-Oct-97	N	20	771	0.7	1	2	17-Nov-97	669.0	672.0	1	24-Nov-97	669.0	672.0	N2
									27-Nov-97	616.5	619.5					
102/04-11-027-22W4/00	21-Jan-04	21-Jan-04	N	43	504	0.2	1.1	10	22-Apr-04	302.5	303.5	1	03-Jun-04	190.5	373.5	N2
									22-Apr-04	334.9	335.9					
									22-Apr-04	190.5	191.5					
									22-Apr-04	372.5	373.5					
									22-Apr-04	308.4	309.4					
									22-Apr-04	332.3	333.3					
									22-Apr-04	212.1	214.1					
									22-Apr-04	208.7	209.7					
									22-Apr-04	192.1	193.1					
									22-Apr-04	248.1	251.1					
100/14-02-027-22W4/00	28-Feb-95	03-Mar-95	N	45	756	0.02	2	2		615.0	618.0					
									29-Jul-95	664.0	668.0					
102/14-02-027-22W4/00	07-Oct-03	07-Oct-03	N	43	472	0.2	1.5	13	11-Feb-04	331.1	332.1	1	27-Feb-04	162.9	372.7	N2
									11-Feb-04	306.6	307.6					
									11-Feb-04	302.1	303.1					
									11-Feb-04	214.3	217.3					
									11-Feb-04	211.4	212.4					
									11-Feb-04	333.3	334.3					
									11-Feb-04	200.4	201.4					
									11-Feb-04	193.6	196.6					
									11-Feb-04	254.2	255.2					
									11-Feb-04	371.7	372.7					
									11-Feb-04	162.9	163.9					
									11-Feb-04	190.8	191.8					
									11-Feb-04	247.6	250.6					
103/14-02-027-22W4/00	17-Aug-04	19-Aug-04	N	144	1326	0.8	6	9	17-Feb-05	615.0	618.0					
									17-Feb-05	613.5	614.5					
									26-Feb-05	543.0	544.0					
									25-Oct-04	1226.0	1229.0					
									09-Jan-05	671.5	676.0					
									03-Mar-05	501.0	502.0					
									16-Jan-05	646.0	650.0					
									17-Feb-05	620.0	624.5					
									25-Oct-04	1223.0	1226.0					
100/10-03-027-22W4/00	18-Jun-95	20-Jun-95	N	44	764	0.7	1	2	29-Jul-95	680.0	683.0					
									29-Jul-95	673.0	678.0					
102/10-03-027-22W4/00	19-May-02	20-May-02	N	64	462	0.3	3	13	28-Jun-02	196.2	199.2					
									28-Jun-02	382.3	383.3					
									28-Jun-02	261.7	262.7					
									28-Jun-02	218.8	221.8					
									28-Jun-02	343.1	344.1					
									28-Jun-02	311.4	312.4					
									28-Jun-02	256.2	258.2					
									28-Jun-02	228.3	229.3					
									28-Jun-02	341.0	342.0					
									28-Jun-02	214.2	215.2					
									28-Jun-02	203.1	204.1					
									28-Jun-02	254.2	256.2					
									28-Jun-02	316.8	317.8					
100/16-02-027-22W4/00	14-Aug-04	16-Aug-04	N	143	1326	0	5	15	28-Mar-05	246.3	249.3	1	02-May-05	191.4	377.3	N2
									28-Mar-05	210.1	211.1					
									22-Jan-05	584.5	586.0					
									28-Mar-05	233.0	234.0					
									15-Sep-04	1223.5	1225.5					
									28-Mar-05	308.3	309.3					
									28-Mar-05	376.3	377.3					
									28-Mar-05	334.1	335.1					
									28-Mar-05	372.9	373.9					
									28-Mar-05	191.4	192.4					
									15-Sep-04	1225.5	1228.0					
									28-Mar-05	214.3	216.3					
									28-Mar-05	193.6	196.6					
									28-Mar-05	300.6	301.6					
									28-Mar-05	205.8	206.8					
102/16-02-027-22W4/00			N	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A							
100/06-02-027-22W4/00	18-Aug-89	24-Aug-89	N	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A							
102/06-02-027-22W4/00	27-Oct-03	07-Nov-03	N	150	1331		5	7	26-Apr-04	600.0	601.0					
									26-Feb-04	646.0	650.0					
									26-Feb-04	637.0	638.5					
									19-Feb-04	670.0	671.5					
									13-Jan-04	1221.5	1223.0					
									26-Feb-04	640.0	643.0					
									13-Jan-04	1225.0	1229.0					
103/06-02-027-22W4/00	14-May-05	25-May-05	N	69	754	1	2	16	30-Aug-05	311.1	312.1	1	22-Sep-05	191.5	654.9	N2
									30-Aug-05	213.9	214.4					
									30-Aug-05	377.5	378.0					
									30-Aug-05	217.0	219.0					
									30-Aug-05	654.4	654.9					
									04-Jul-05	498.5	499.5					
									30-Aug-05	389.4	389.9					
									16-Jul-05	235.0	239.0					
									30-Aug-05	248.8	251.8					
									04-Jul-05	500.5	503.5					
									30-Aug-05	306.5	307.0					
									10-Jul-05	256.5	264.0					
									30-Aug-05	196.0	197.0					
									30-Aug-05	197.5	198.5					
									30-Aug-05	191.5	192.0					
									30-Aug-05	227.4	227.9					

Well info for Alberta Research Council request

20-Apr-2006

all wells within 1600m of Lauridsen and Ernst water wells

Well Head (/00 event sequence)	Spud Date	Rig Release	Lost circulation (Y/N)	Surface Casing Depth (m)	TD (m)	Cement returns (surface casing) (m3)	Cement returns (prod casing) (m3)	Perf Count	Perf date	Perf top (mKb)	Perf bottom (mKb)	Frac Count	Frac Date	Frac Top (mKb)	Frac Bottom (mKb)	Frac fluid
100/13-11-027-22W4/00	16-Jun-03	18-Jun-03	N	140	1342	2	1	2	11-Aug-03	682.5	684.0					
									17-Jul-03	1234.0	1236.0					
100/16-11-027-22W4/00	20-May-00	06-Jun-00	N	200	1463	0.5		2	29-Jul-00	1211.0	1214.0					
									15-Jul-00	1431.5	1433.0					
100/15-10-027-22W4/00	04-Jun-03	07-Jun-03	N	135	1548	2	4	3	04-Dec-03	718.0	720.0					
									23-Oct-03	1414.0	1417.0					
									13-Aug-03	1498.0	1500.0					
100/04-12-027-22W4/00	26-Jul-04	30-Jul-04	N	142	1438	0	6	5	17-Feb-05	602.0	603.0					
									29-Oct-04	1314.6	1320.5					
									11-Feb-05	666.0	670.0					
									11-Feb-05	671.0	673.5					
									17-Feb-05	604.0	605.0					
100/06-12-027-22W4/00	20-Jul-98	21-Jul-98	N	#N/A	751	#N/A	4	21	31-Jul-03	186.0	187.0	2	07-Sep-98	565.0	568.0	N2
									15-Sep-98	565.0	568.0		29-Sep-98	565.0	566.0	N2
									31-Jul-03	231.5	234.5					
									31-Jul-03	366.0	368.0					
									31-Jul-03	287.0	288.0					
									31-Jul-03	199.0	202.0					
									31-Jul-03	376.0	377.0					
									31-Jul-03	217.0	218.0					
									31-Jul-03	363.0	364.0					
									31-Jul-03	355.0	356.0					
									31-Jul-03	208.5	209.5					
									31-Jul-03	293.0	295.0					
									31-Jul-03	368.0	370.0					
									31-Jul-03	360.5	361.5					
									31-Jul-03	372.0	373.0					
									30-Aug-98	653.0	657.0					
									31-Jul-03	238.0	239.0					
									31-Jul-03	190.0	192.0					
									31-Jul-03	196.0	197.0					
									31-Jul-03	214.0	215.0					
									31-Jul-03	318.5	321.5					
102/06-12-027-22W4/00	31-Jan-02	04-Feb-02	N	202	1464	1	0.5	3	23-Feb-02	1208.0	1209.0					
									23-Feb-02	1210.0	1211.0					
									12-Feb-02	1398.0	1401.0					
100/08-12-027-22W4/00	07-Dec-02	09-Dec-02	N	132	1294	0.5	8	4	29-May-04	605.0	612.0					
									01-Feb-03	1192.5	1195.0					
									17-Jan-03	1207.5	1209.0					
									03-May-04	617.5	622.5					
102/08-12-027-22W4/00	22-Jan-04	22-Jan-04	N	43	503	0.2	1	14	27-Apr-04	280.2	282.2	1	24-Jun-04	163.0	399.3	N2
									27-Apr-04	204.3	205.3					
									27-Apr-04	163.0	167.0					
									27-Apr-04	186.0	188.0					
									27-Apr-04	194.6	195.6					
									27-Apr-04	305.4	306.4					
									27-Apr-04	344.5	345.5					
									27-Apr-04	350.2	351.2					
									27-Apr-04	307.2	308.2					
									27-Apr-04	181.1	182.1					
									27-Apr-04	169.5	170.5					
									27-Apr-04	398.3	399.3					
									27-Apr-04	217.2	220.2					
									27-Apr-04	176.8	177.8					
100/14-12-027-22W4/00	26-Jun-03	29-Jun-03	N	159	1456	1	3	3	20-Sep-03	1426.0	1428.5					
									11-Nov-03	1205.5	1207.0					
									31-Jul-03	1426.5	1428.0					
100/04-13-027-22W4/00	05-Feb-05	08-Feb-05	N	162	1467	2	6	1	17-Feb-05	1209.0	1212.0					
100/07-13-027-22W4/00	26-Jul-98	27-Jul-98	N	#N/A	744	#N/A	1	1	05-Sep-98	648.0	654.0	1	09-Sep-98	0.0	0.0	N2
102/07-13-027-22W4/00	22-May-02	24-May-02	N	194	1482	0.5	3	2	15-Oct-02	1206.0	1208.0					
									06-Jun-02	1438.0	1442.5					
100/12-13-027-22W4/00	17-Jul-03	20-Jul-03	N	140	1367		4	1	18-Oct-03	1263.0	1265.0					
100/15-13-027-22W4/00	18-Jun-03	21-Jun-03	N	162	1481	2	3	4	20-Sep-03	1216.0	1219.0					
									31-Jul-03	1459.5	1461.0					
									29-Aug-03	1399.5	1402.0					
									29-Aug-03	1404.5	1406.0					
100/03-14-027-22W4/00	06-Jul-05	06-Jul-05	N	66	746	0.5	2	20	27-Feb-06	378.0	379.0	2	14-Aug-05	621.5	645.0	N2
									27-Feb-06	238.8	239.8		02-Mar-06	201.4	657.6	N2
									27-Feb-06	201.4	202.0					
									27-Feb-06	508.7	509.7					
									24-Jul-05	644.0	645.0					
									27-Feb-06	373.1	374.1					
									09-Sep-05	248.5	251.0					
									27-Feb-06	324.3	325.3					
									27-Feb-06	301.9	302.9					
									27-Feb-06	237.6	238.6					
									24-Jul-05	621.5	623.5					
									27-Feb-06	367.9	368.9					
									27-Feb-06	656.6	657.6					
									27-Feb-06	204.5	205.5					
									25-Sep-05	223.0	225.0					
									27-Feb-06	212.6	213.6					
									27-Feb-06	207.5	208.5					
									27-Feb-06	205.7	206.7					
									27-Feb-06	649.9	650.9					
									04-Sep-05	416.0	418.0					
102/03-14-027-22W4/00			N	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A							
100/08-14-027-22W4/00	10-Jun-98	26-Jul-98	N	#N/A	759	#N/A	1	1	05-Sep-98	569.0	572.0					
100/01-24-027-22W4/00	27-Jul-98	28-Jul-98	N	#N/A	762	#N/A	1	1	21-Nov-98	430.0	433.0	1	26-Nov-98	430.0	433.0	N2
100/11-07-027-21W4/00	04-Jun-94	14-Jun-94	N	308	1501	#N/A	#N/A	5	27-Jun-94	1387.5	1389	3	05-Jul-94	1210.0	1212.0	
									15-Jul-94	654	659		10-Jul-94	1210.0	1212.0	
									27-Jun-1994	1388.5	1389		17-Jul-94	654.0	659.0	
									14-Jul-1994	654	659					
									28-Jun-94	1210	1212					
100/07-18-027-21W4/00	16-Aug-1974	25-Aug-1974	N	151	632	#N/A	#N/A	2	18-Jun-97	591.9	594.4					
									05-Sep-1974	591.9	594.4					

APPENDIX B
WATER WELL DRILLING REPORTS

Water Well Drilling Report

Alberta Environment

The data contained in this report is supplied by the Driller. The province disclaims responsibility for its accuracy.

Well I.D.:	0123545
Map Verified:	Map
Date Report Received:	
Measurements:	Imperial

1. Contractor & Well Owner Information

Company Name: LIN MURRAY DRILLING		Drilling Company Approval No.:
Mailing Address:	City or Town:	Postal Code:
WellOwner's Name: PATTERSON, JOE	Well Location Identifier:	
P.O. Box Number: 718	Mailing Address: ROSEBUD	Postal Code:
City:	Province:	Country:

2. Well Location

1/4 or LSD	Sec	Twp	Rge	Westof M
SE SW?	11	027	22	4

Location in Quarter
0 FT from Boundary
0 FT from Boundary

Lot Block Plan

Well Elev: 2625 FT
How Obtain: Estimated

3. Drilling Information

Type of Work: New Well
Reclaimed Well
Date Reclaimed: Materials Used:
Method of Drilling: Rotary
Flowing Well: No Rate: Gallons
Gas Present: No Oil Present: No

Proposed well use: Domestic & Stock
Anticipated Water Requirements/day
0 Gallons

6. Well Yield

Test Date (yyyy/mm/dd): 1977/12/14
Start Time: 11:00 AM
Test Method: Bailer
Non pumping static level: 30 FT
Rate of water removal: 2 Gallons/Min
Depth of pump intake: 0 FT
Water level at end of pumping: FT
Distance from top of casing to ground level: Inches

Depth To water level (feet)
Elapsed Time
Drawdown Minutes:Sec Recovery
Total Drawdown: 0 FT

If water removal was less than 2 hr duration, reason why:

Recommended pumping rate: 4 Gallons/Min
Recommended pump intake: 0 FT
Type Pump Installed
Pump Type:
Pump Model:
H.P.:
Any further pumptest information?

4. Formation Log

Depth from ground level (feet)	Lithology Description
30	Sandy Topsoil
32	Hard Ledges
100	Yellow Clay
160	Gray Clay
200	Gray Shale

5. Well Completion

Date Started(yyyy/mm/dd): 1977/12/12	Date Completed(yyyy/mm/dd): 1977/12/14
Well Depth: 200 FT	Borehole Diameter: 0 Inches
Casing Type:	Liner Type: Steel
Size OD: 0 Inches	Size OD: 5.5 Inches
Wall Thickness: 0 Inches	Wall Thickness: 0.156 Inches
Bottom at: 0 FT	Top: 0 FT Bottom: 200 FT
Perforations from: 120 FT to: 200 FT	Perforations Size: 0.125 Inches x 2 Inches
from: 0 FT to: 0 FT	0 Inches x 0 Inches
from: 0 FT to: 0 FT	0 Inches x 0 Inches
Perforated by: Torch	
Seal: Packer & Cement from: 50 FT	to: 100 FT
Seal: from: 0 FT	to: 0 FT
Seal: from: 0 FT	to: 0 FT
Screen Type: from: 0 FT to: 0 FT	Screen ID: 0 Inches Slot Size: 0 Inches
Screen Type: from: 0 FT to: 0 FT	Screen ID: 0 Inches Slot Size: 0 Inches
Screen Installation Method:	
Fittings Top:	Bottom:
Pack: Grain Size:	Amount:
Geophysical Log Taken: Retained on Files:	
Additional Test and/or Pump Data Chemistries taken By Driller: No Held: 1	Documents Held: 2
Pitless Adapter Type: Drop Pipe Type: Length: FT	Diameter: Inches
Comments:	

7. Contractor Certification

Driller's Name: UNKNOWN DRILLER
Certification No.:
This well was constructed in accordance with the Water Well regulation of the Alberta Environmental Protection & Enhancement Act. All information in this report is true.
Signature Yr Mo Day

APPENDIX C
PUMPING TEST GRAPHICAL SOLUTION

M & M Drilling Co. Ltd.

Box 1, Site 22, RR 2, Strathmore, AB T1P 1K5

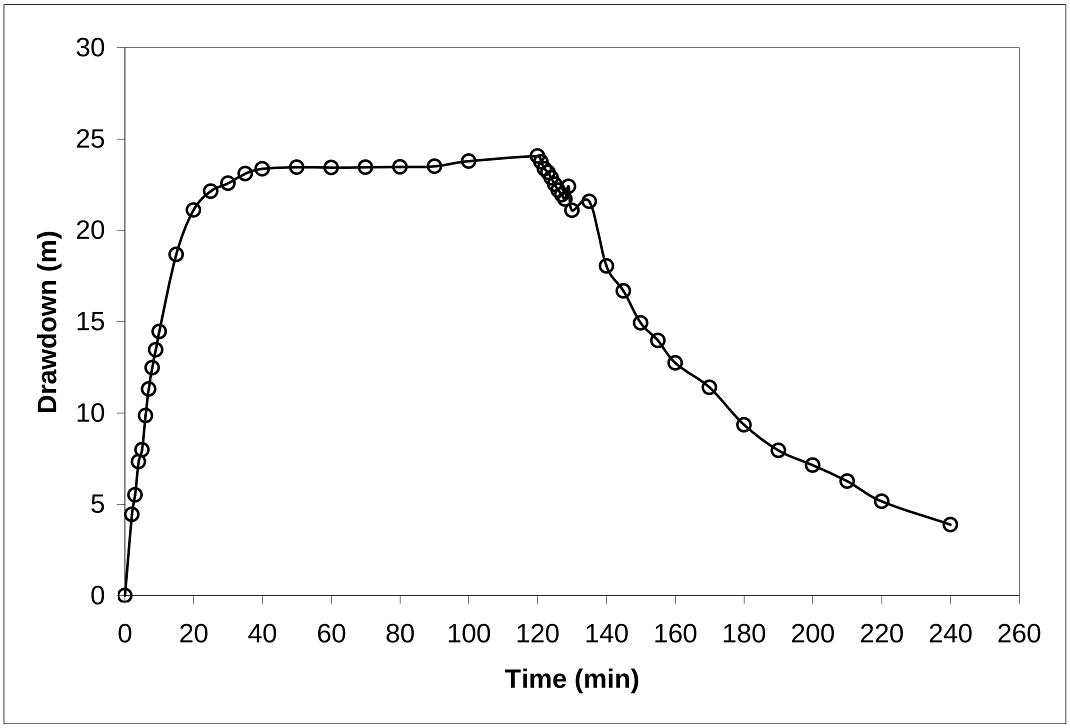
(403) 934-4271 • Fax (403) 934-4865

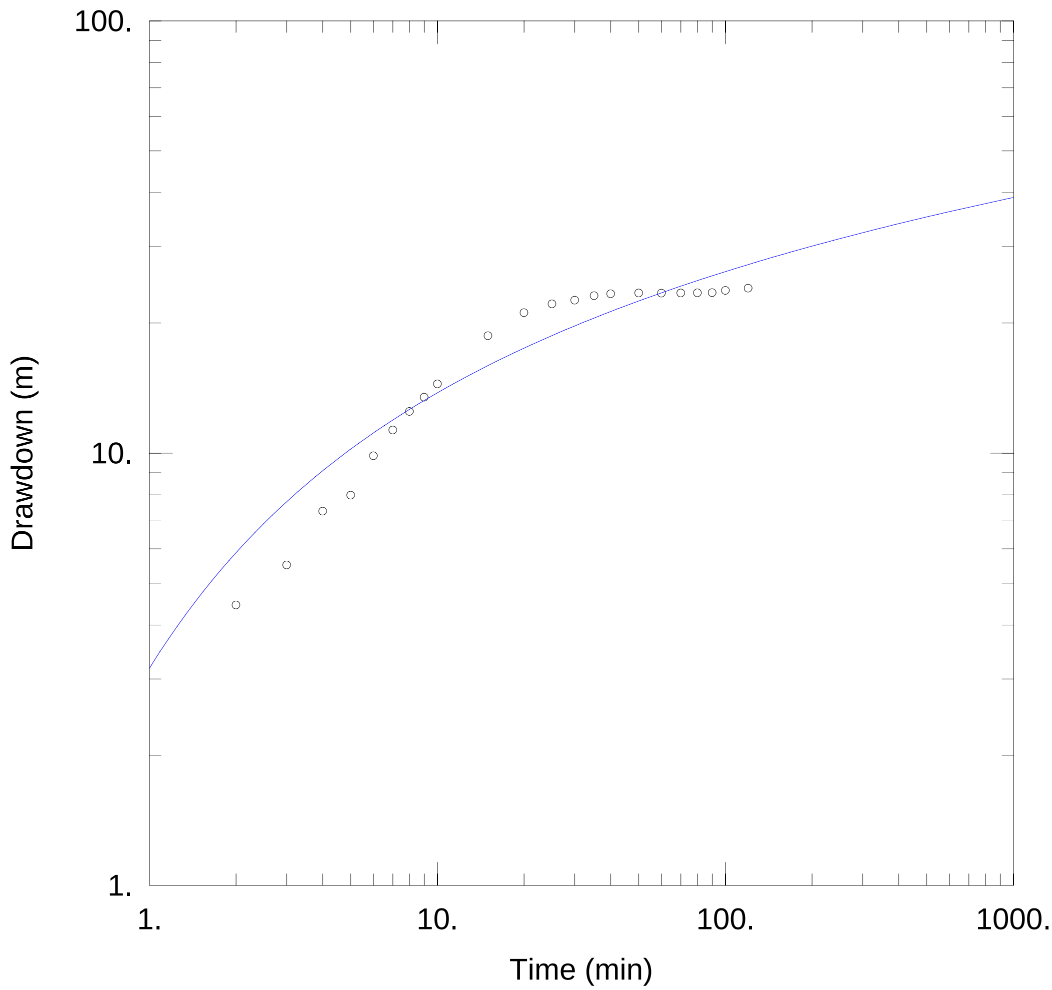
Name:	LAURIDSEN, PETER/FIONA	*Test #:*	1236 - 5793
Addres:	BOX 681	*Date:*	12/6/2006
Location:	ROSEBUD, ALBERTA	*Start Time:*	8:30:00 AM
Post. Code:	T0J 2T0 *Phone:* 403-677-2378	*Static Level:*	8.300M
Tested For:	ENCANA , TYLAR SMITH	*Well Name:*	ECA ECOG WAYNE HUSSA
Water Well Location:	SW-11-27-22-W4	*Land Location:*	05-28-26-21-W4
Well Description:	STOCK WELL	*AFE Number:*	0673357/WHEDC10/20831
Pumping Rate:	2.4 IGM START 1.5 IGM FINISH	*Readings By:*	DAVE

☑ PRE-TEST ☐ POST TEST ☐ REALESTATE

DRAWDOWN READINGS		RECOVERY READINGS	
MINUTES	DEPTH in METERS	MINUTES	DEPTH in METERS
1		1	32.05
2	12.75	2	31.67
3	13.805	3	31.48
4	15.635	4	31.17
5	16.285	5	30.835
6	18.15	6	30.5
7	19.6	7	30.255
8	20.775	8	30.01
9	21.765	9	30.7
10	22.75	10	29.395
15	26.975	15	29.885
20	29.41	20	26.35
25	30.44	25	24.98
30	30.875	30	23.225
35	31.41	35	22.265
40	31.66	40	21.05
50	31.75	50	19.7
60	31.74	60	17.645
70	31.76	70	16.24
80	31.78	80	15.44
90	31.8	90	14.56
100	32.08	100	13.465
120	32.36	120	12.18

June 5, 2007 Lauridsen Well Puming Test
Flow rate variable 2.4 to 1.5 Igal/min, Well diameter 5.5 inches
M&M Drilling





LAURIDSEN WELL

Data Set: O:\hg\PROJECTS\2007-2008\Lauridsen Well Complaint\Lauridsen 06 Pumping Test.aqt
Date: 12/05/07 Time: 16:11:21

PROJECT INFORMATION

Company: Alberta Research Council
Client: Alberta Environment
Project: 87890016
Location: SW-11-027-22 W4M
Test Well: Lauridsen Well
Test Date: December 6, 2006

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
Lauridsen	0	0

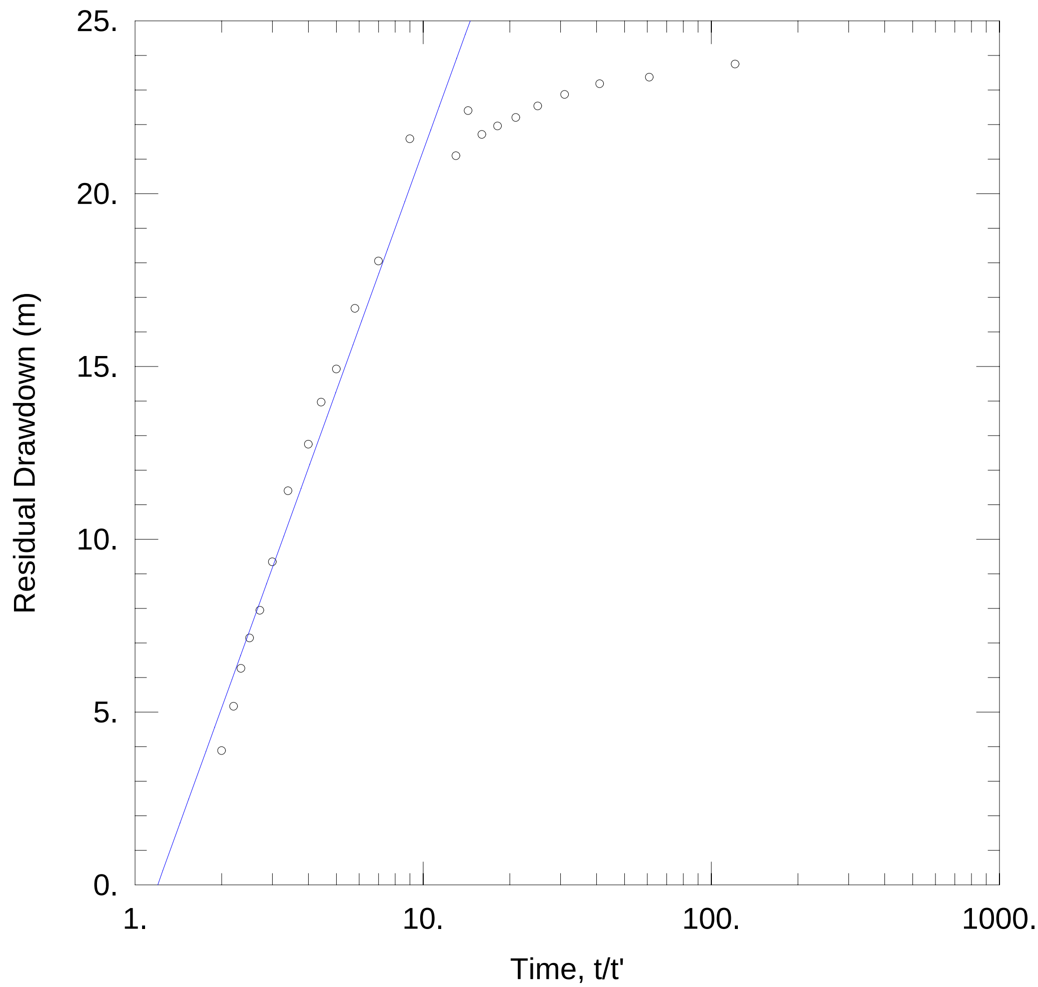
Observation Wells

Well Name	X (m)	Y (m)
○ Lauridsen	0	0

SOLUTION

Aquifer Model: Confined
Solution Method: Theis

T = 0.0001567 m^2/min
S = 0.0003061
Kz/Kr = 1.
b = 0.92 m



LAURIDSEN WELL

Data Set: O:\hg\PROJECTS\2007-2008\Lauridsen Well Complaint\Lauridsen 06 Pumping Test all.aqt
Date: 12/05/07 Time: 16:30:04

PROJECT INFORMATION

Company: Alberta Research Council
Client: Alberta Environment
Project: 87890016
Location: SW-11-027-22 W4M
Test Well: Lauridsen Well
Test Date: December 6, 2006

AQUIFER DATA

Saturated Thickness: 0.92 m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
Lauridsen	0	0

Observation Wells

Well Name	X (m)	Y (m)
○ Lauridsen	0	0

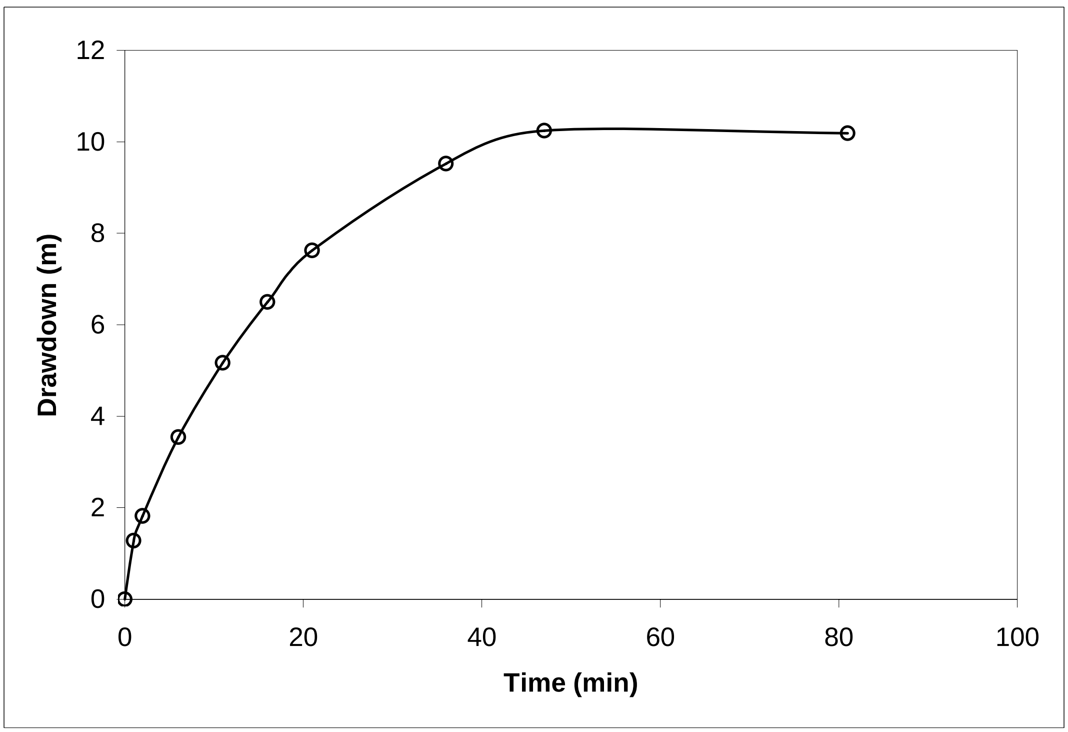
SOLUTION

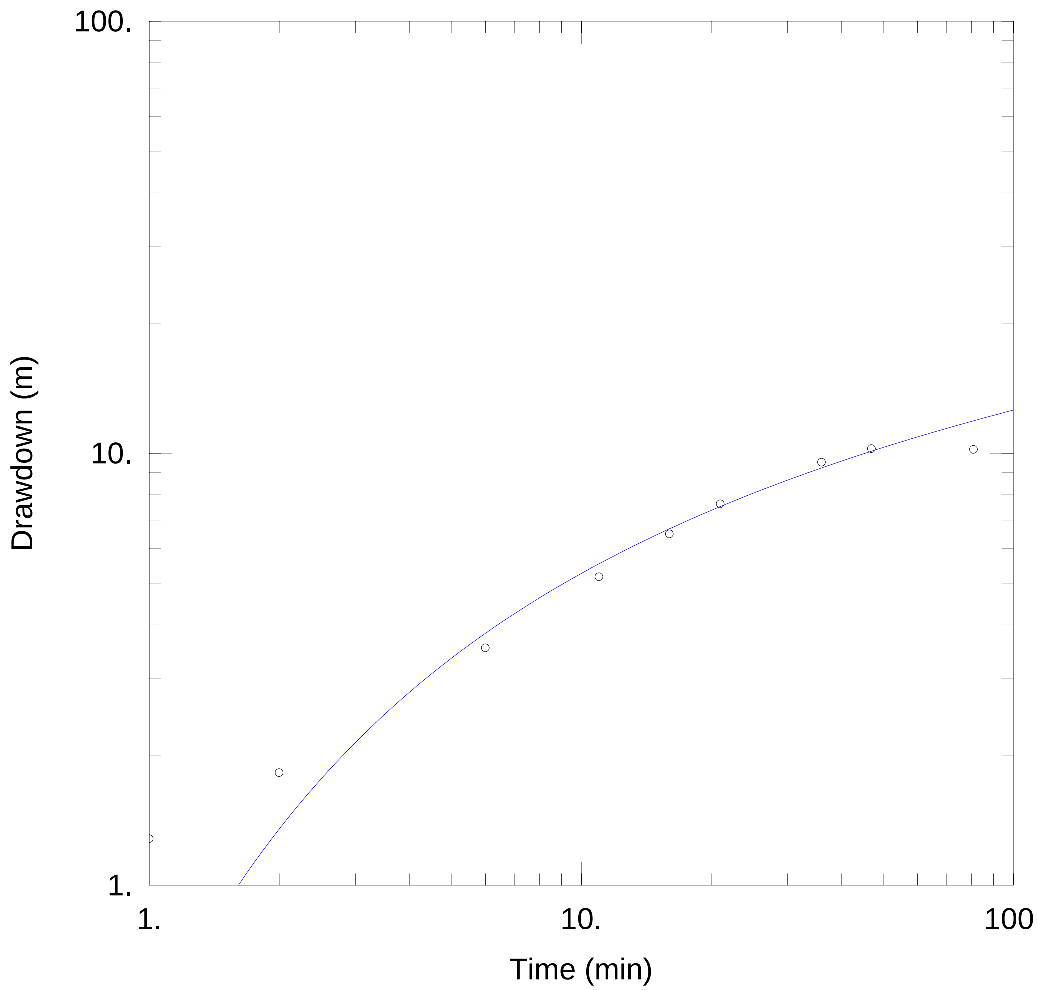
Aquifer Model: Confined Solution Method: Theis (Recovery)

T = 8.668E-5 m^2/min S/S' = 1.199

June 5, 2007 Lauridsen Well Puming Test
Flow rate variable 1.7 to 0.9 USgal/min, Well diameter 5.5 inches
AENV during sampling

Time	Elapsed Time (min)	WL (m)	DD (m)
11:14:00 AM	0	15.2	0
11:15:00 AM	1	16.48	1.28
11:16:00 AM	2	17.02	1.82
11:20:00 AM	6	18.74	3.54
11:25:00 AM	11	20.37	5.17
11:30:00 AM	16	21.7	6.5
11:35:00 AM	21	22.825	7.625
11:50:00 AM	36	24.72	9.52
12:01:00 PM	47	25.44	10.24
12:35:00 PM	81	25.39	10.19





LAURIDSEN WELL

Data Set: O:\hg\PROJECTS\2007-2008\Lauridsen Well Complaint\Lauridsen 07 Pumping Test.aqt
Date: 12/05/07 Time: 16:25:00

PROJECT INFORMATION

Company: Alberta Research Council
Client: Alberta Environment
Project: 87890016
Location: SW-11-027-22 W4M
Test Well: Lauridsen Well
Test Date: June 5, 2007

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
Lauridsen	0	0

Observation Wells

Well Name	X (m)	Y (m)
○ Lauridsen	0	0

SOLUTION

Aquifer Model: Confined
Solution Method: Theis

T = 0.0001453 m^2/min
Kz/Kr = 1.
S = 0.0007677
b = 0.92 m

APPENDIX D

ASSESSMENT OF METHANE GAS MIGRATION POTENTIAL

Assessment of the forces controlling the methane gas bubble migration (personal communication with Dr. Jon Jones, PhD., University of Waterloo).

Buoyancy Force:

Buoyancy is the upward force exerted on an object produced by the surrounding fluid in which it is fully or partially immersed due to the pressure difference of the fluid between the top and the bottom of the object. Buoyancy is the force that gives the wings on airplanes the lift required for them to fly.

The net upward buoyancy force is equal to the magnitude of the weight of the fluid displaced by the object.

In simpler terms: Suppose you put a rubber ball in a beaker of water. One of three things will happen:

1) If the weight of the rubber ball equals the weight of the volume of water it displaces: the ball will remain stationary

2) If the weight of the ball is less than the weight of the volume of water it displaces: the ball will begin to float upwards until it breaks through the water surface and will continue to rise until the weight of the volume of water displaced equals the weight of the rubber ball. This is why ice bergs float. A cubic meter of iceberg weighs less than a cubic meter of ocean water.

3) If the weight of the ball is greater than the weight of the volume of water it displaces: the rubber ball will sink to the bottom of the beaker.

Weight Force (In Terms of Methane Gas and Water):

One cubic meter of methane gas under 1 atmosphere of pressure at 15° C has a mass of ~ 0.68 kg. One meter of water under the same conditions has a mass of ~ 1000 kg. So if we placed a bubble of methane gas in our beaker, it would always float upwards because the mass of the methane is much less than the mass of the water it displaces.

Comparison of Forces:

Looking at the forces acting on the bubble of methane gas:

The net force pulling the methane gas bubble upwards is: Fb - Wm

Where Fb = Buoyant force [MLT-2]

Wm = Weight of the bubble [MLT-2]

We have established that the weight of the methane gas bubble is much less than the buoyant force (which is equal to the weight of the water that the bubble displaces). Therefore, the gas bubble will migrate upwards at some velocity rate.

If the velocity rate at which the methane gas bubble is rising were to be counteracted by water flowing downwards at the same rate of velocity, then the bubble would remain stationary. If the water velocity were increased, the bubble would be pushed downward. Conversely, if the water velocity were decreased, the bubble would again begin to move upward, albeit at a slower rate.

The velocity at which a gas bubble migrates upward in a column of water is a function of the size of the bubble, i.e. the larger the bubble, the larger the upward velocity due to the increase in the net upward buoyant force. Also note that, as the gas bubble migrates upwards, it will be hindered by friction exerted on the bubble due to the viscosity of the fluid it is rising through.

Calculation Results:
Given the velocity that a gas bubble migrates upward in a column of water, it is simply a matter of determining if there is sufficient downward water velocity to counteract the upward migration of the bubble.

Radius of gas bubble (m)	Terminal upward velocity (m/s)
1.0×10^{-6}	2.18×10^{-6}
1.0×10^{-5}	2.18×10^{-4}
1.0×10^{-4}	2.18×10^{-2}
1.0×10^{-3}	2.18×10^{0}

Note: The upward velocities values listed represent theoretical maximum values. There are a number of factors that can affect these values.

The three most likely scenarios for the migration of the gas bubbles in natural systems would be through fractures, porous media and through cylindrical conduits like boreholes. The formulas for calculating the water velocities in these openings can be looked up in any standard hydrogeology textbook. Naturally, the site-specific conditions (and corresponding hydrological parameters) will dictate which particular formula (or formulas) is used.

Partial List of Mitigating Factors Affecting Upward Gas Migration

1. Tortuosity: Except for the case of upward migration through a borehole, the bubble will have to take a circuitous path in its migration upward as it manoeuvres through interconnected pore throats or fracture networks. As a result, the upward migration of the gas will be hindered.

2. Relative Size of the Gas Bubble to Pore Throat, Borehole or Fracture Aperture it is Flowing Through: If the diameter of the bubble is of the same order as the opening it is flowing through, there will be additional frictional forces slowing down the upward migration of the gas. The velocity values listed above assume that these forces are negligible.

3. Gas Entry Pressure: For the case of gas migration through fracture apertures or pore throats that are smaller than the diameter of the gas bubble, sufficient upward buoyant force is required for the bubble to exceed the gas entry pressure. All other factors being constant, a single gas bubble whose initial buoyant force is insufficient to overcome the gas entry pressure will remain trapped. However, the usual case is a large number of gas bubbles migrating simultaneously.

As the gas consolidates at entrapment sites, the buoyant force will increase and eventually upward migration will resume.

4. Bubble Volume as a Function of Pressure: As the gas bubble migrates upward, the column of fluid exerting pressure on the bubble decreases. As a result, the bubble increases in size, thereby generating greater upward velocity due to an increase in the buoyant force. A quantitative expression relating the dynamics between bubble expansion and while moving upward and the accompanying increase in velocity are very difficult to obtain. For the velocities listed, it was assumed that the size of the bubble remains constant. While the first three mitigating factors in this list would tend to decrease the rate of upward gas migration, this factor would increase it.

5. Any geochemical processes that would make the bubble lose mass during migration (and thereby reduce its volume and decrease its upward velocity). However, it is very likely that this factor would be negligible in most instances.

APPENDIX E

CHEMICAL ANALYSES

ALBERTA ENVIRONMENT
CHEMICAL ANALYSIS REPORT

WELL NAME: PATTERSON, J.
LOCATION: LSD SE SEC 11 TWP 027 RG 22 M 4
WELL DEPTH: 200
AQUIFER:
SAMPLING DATE: 1/31/1983 TIME: 0

WELL ID No:0123545
SAMPLE No: 1114
WATER LEVEL: -9
LABORATORY: VG
PRINT DATE: 11/30/2007

FIELD:	**MG/L**	**FIELD:**	**MG/L**
BICARBONATE	-9	CARBONATE	-9
CHLORIDE	-9	CONDUCTIVITY	-9
DISSOLVED OXYGEN	-9	EH	-9
IRON	-9	MANGANESE	-9
PH	-9	SULPHATE	-9
S2	-9	TEMPERATURE°C	-9
TOTAL ALKALINITY	-9	TOTAL HARDNESS	-9

LABORATORY: Analysis Date: 2/16/1983

COD	-9	CONDUCTIVITY	1926
DIC	-9	FLUORIDE	1.38
ION BALANCE	0.95	PH	8.7
SAR	-9	SIO2	8.1
TOTAL ALKALINITY	671	TC	-9
TDS	1126	TN	-9
DOC	-9		
AMMONIUM-N	-9	BICARBONATE	765.7513
CALCIUM	0.998*	CARBONATE	26.001
CHLORIDE	260.36765	MAGNESIUM	1.000768*
NITRATE-N	-9	NITRITE-N	0.0504*
PHOSPHATE	-9	POTASSIUM	0.9085
SODIUM	454.9998	SULPHATE	4.9968*
$NO_2 + NO_3$	0.0144*	TOTAL HARDNESS	7
ALUMINUM	-9	ARSENIC	-9
BARIUM	-9	BERYLIUM	-9
CADMIUM	-9	CHROMIUM	-9
COBALT	-9	COPPER	-9
IRON	2.04	LEAD	-9
MANGANESE	-9	MERCURY	-9
MOLYBDENUM	-9	NICKEL	-9
SELENIUM	-9	STRONTIUM	-9
VANADIUM	-9	ZINC	-9
HYDROCARBONS	-9	PESTICIDES	-9
PHENOLICS	-9	OTHER 3	0

Remarks:
-9 indicates that no analysis was done for this parameter
*Indicates concentrations less than.
Temperature reported in Degree Centigrade. Conductivity reported in microsiemens/cm, pH in pH units. Alkalinity and Hardness expressed as Calcium Carbonate. FE, VA, PB, AL, AG expressed as extractable. FE in field measurements and all remaining metals expressed as total.

EH - Oxidation-Reduction Potential
DIC - Dissolved Inorganic Carbon
DOC - Dissolved Organic Carbon
TDS - Total Dissolved Solids

SAR - Sodium Adsorption Ratio
COD - Chemical Oxygen Demand
TN - Total Particulate Nitrogen
TC - Total Particulate Carbon

NOTE: This data may not be fully checked.
The Province disclaims all responsibility for its accuracy

M & M Drilling Co. Ltd.

Box 1, Site 22, RR 2, Strathmore, AB T1P 1K5

(403) 934-4271 • Fax (403) 934-4865

Name:	LAURIDSEN, PETER	*Test #:*	1236 - 2516
Address:	BOX 681	*Date:*	11/26/2003
Location:	ROSEBUD, ALBERTA	*Start Time:*	10:15 AM
Post. Code:	T0J 2T0 *Phone:* 403-677-2378	*Static Level:*	34' 9 1/2"
Tested For:	ENCANA CORP., T. SMITH	*Well Name:*	ECA-ECOG 102 REDLAND
Well Location/Description:	SW-11-27-22-W4 FARM WELL	*Land Location:*	4-11-27-22-W4
Pumping Rate:	STATIC AND SAMPLES	*AFE Number:*	0316879
GPS	N-51-17-22.0 W-112-59-45.8	*Readings By:*	EINER DAVIDSON

☑ PRE-TEST ☐ POST TEST ☐ REALESTATE

Well Location On Site: APPROX 24' FROM N.W. CORNER OF QUANSET
Pit Type: 5' CULVERT
Pit Condition: TOP OF CULVERT IN POOR CONDITION
Pump Size and Type: JET PUMP
Tank Size and Type: 1600 GALLON CISTERN
Casing Size and Type: 5 3/4" STEEL
Liner Size and Type: N/A
Well Depth: N/A

Water:
- *Appearance* ☐ Clear ☑ Colour SLIGHT YELLOW
- *Odor* ☑ None ☐ Yes
- *Suspended Solids:* ☐ None ☑ Yes FINE PARTICLES

Pumping Procedure:
- *Open Discharge:* ☐ No ☑ Yes
- *Pressure Tank* ☑ No ☐ Yes
- *Pressure Reading* N/A
- *Special Fitting* ☑ None ☐ Yes

Samples Taken:
- ☐ Chemical23:
- ☑ Chemical51:
- ☑ Coliform Bacteri
- ☐ Heavy Metals:
- ☑ TOC
- ☑ H2S:
- ☐ OilAndGrease:
- ☐ *Other Sample*

Lab where samples were tested: ☑ WSH ☐ Other
Measurement Taken From: WELL
Miscellaneous test information: SAMPLES TAKEN FROM HYDRANT.

WSH Labs (1992) LTD.

3851B - 21 Street N.E.
Calgary, Alberta
Canada T2E6T5
Ph: (403) 250-9164
Fax: (403) 291-4597
Website: www.wshlabs.com

M & M Drilling Co. Ltd.	P.O # 3278	Client I.D	Peter Lauridsen Farm Well
Box 1, Site 22, RR# 2	Lab # 41122	Legal	SW-11-27-22-W4
Strathmore, AB T1P 1K5	Ph 934-4271	Date Sampled	11/26/03
Attn Bill Murray	Fax 934-4865	Date Received	11/27/03
		Date Reported	12/4/03

WATER RESULTS

Cations	mg/L	Anions	mg/L	General Parameters	mg/L	
Saturation Index	0.0	Bicarbonates	861	E.C. (μS/cm)	1843	
Calcium	4.6	Bromides	< 0.6	Coliform, Total	TNTC	(CFU/100mL)
Iron	0.647	Carbonates	0	Escherichia Coli (E.Coli)	0	(CFU/100mL)
Magnesium	< 0.1	Chlorides	200	Heterotrophic Plate Count		(MPN/mL)
Manganese	0.010	Fluorides	1.7	Hardness ($CaCO_3$)	12	*SOFT*
Potassium	0.6	Nitrates	1.2	pH	8.01	
Silicon		Nitrites	< 0.3	Sulfides (S)	0.014	
Sodium	460	NO_3+NO_2	1.2	T. Alkalinity ($CaCO_3$)	706	
Ammonium	< 0.1	Phosphates	N/A	T.D.S (Calculated)	1096	
		Sulfates	4	Turbidity (N.T.U)	2.45	
Sum of Cations	20.25			Total Organic Carbon	9.2	
Sum of Anions	19.94			Total Kjeldahl Nitrogen		
Ionic Balance	1.02			Ammonia Nitrogen		
% Difference	0.77			Total Phosphorus		
T.D.S. / E.C. Ratio	0.59			Color (T.C.U)		
SAR	57.77 *(May limit plant growth)*					

Trace Metals Profile

	ug/L		ug/L		ug/L
Phosphorus	129	Cadmium	< 0.8	Barium	109
Thallium	< 5	Nickel	< 2	Lithium	140
Arsenic	< 2	Beryllium	< 0.8	Tin	2
Selenium	6	Thorium	< 5	Molybdenum	5
Chromium	< 0.8	Vanadium	< 0.8	Antimony	< 1
Zinc	27	Bismuth	3	Titanium	< 1
Lead	< 2	Silver	< 0.8	Zirconium	< 1
Copper	3	Aluminum	16	Uranium	
Cobalt	< 0.8	Strontium	69	Mercury	

Silty samples may account for higher iron, manganese and silicon content.
*TDS: Total Dissolved Solids *SAR : Sodium Adsorption Ratio
*TNTC: Too Numerous To Count *< Denotes less than detection limit
The results above are related only to the items analyzed.
Please see the reverse side of this page for the Canadian Drinking Water Quality Guideline

Certified By

M & M Drilling Co. Ltd.

Box 1, Site 22, RR 2, Strathmore, AB T1P 1K5

(403) 934-4271 • Fax (403) 934-4865

Name:	LAURIDSEN, PETER	*Test #:*	**1236 - 3196**
Address:	BOX 681	*Date:*	8/13/2004
Location:	ROSEBUD, ALBERTA	*Start Time:*	8:20 AM
Post. Code:	T0J 2T0 *Phone:* 403-677-2376	*Static Level:*	29' 6 1/2"
Tested For:	ENCANA CORP., K. SCURGEON	*Well Name:*	ECA/ECOG 102 REDLAND
Well Location/Description:	SW-11-27-22-W4 FARM WELL	*Land Location:*	4-11-27-22-4
Pumping Rate:	STATIC AND SAMPLES	*AFE Number:*	0316879
GPS	N-51-17-22.0 W-112-59-45.8	*Readings By:*	D.SAWYER & H.JORDAN

☑ PRE-TEST ☐ POST TEST ☐ REALESTATE

Well Location On Site: 24' N.W. OF QUANSET
Pit Type: 5' CULVERT
Pit Condition: POOR
Pump Size and Type: JET PUMP
Tank Size and Type: 1600 GALLON CISTERN
Casing Size and Type: 5 3/4"
Liner Size and Type: N/A
Well Depth: N/A

Water:
- *Appearance* ☐ Clear ☑ Colour SLIGHTY YELLOW
- *Odor* ☑ None ☐ Yes
- *Suspended Solids:* ☐ None ☑ Yes LITTLE BLACK PARTICLES

Pumping Procedure:
- *Open Discharge:* ☐ No ☑ Yes
- *Pressure Tank* ☑ No ☐ Yes
- *Pressure Reading* N/A
- *Special Fitting* ☑ None ☐ Yes

Samples Taken:
- ☐ Chemical23:
- ☑ Chemical51:
- ☑ Coliform Bacteri
- ☐ Heavy Metals:
- ☑ TOC
- ☑ H2S:
- ☐ OilAndGrease:
- ☐ *Other Sample*

Lab where samples were tested: ☑ WSH ☐ Other
Measurement Taken From: CASING TOP
Miscellaneous test information: SAMPLES TAKEN FROM DIRECT LINE INTO CISTERN.

WSHLabs (1992) LTD.

3851B - 21 Street N.E.
Calgary, Alberta
Canada T2E6T5
Ph: (403) 250-9164
Fax: (403) 291-4597
Website: www.wshlabs.com

M & M Drilling Co. Ltd.
Box 1, Site 22, RR 2
Strathmore, AB T1P 1K5

Phone:	934-4271	Lab Number:	44209
Fax:	934-4865		
Cell:		PO Number:	4121

Attention:	Bill Murray	Date Sampled:	8/13/2004
Client ID:	Peter Lauridsen	Date Received:	8/13/2004
Location:	Farm Well	Date Reported:	8/17/2004
Legal:	SW-11-27-22-W4		

Cations

	mg/L
Calcium	6.3
Iron	1.48
Magnesium	0.9
Manganese	0.014
Potassium	1.5
Sodium	453
Ammonium	<0.1

A..ons

	mg/L
Bicarbonates	846
Bromides	<0.6
Carbonates	10
Chlorides	186
Fluorides	1.58
Nitrates	<0.2
Nitrites	<0.3
$NO_3 + NO_2$	<0.2
Sulfates	<0.6

Sum of Cations	20.12
Sum of Anions	19.52
Ion Balance	1.03
% Difference	1.51
TDS / EC Ratio	0.69
SAR	44.67
Saturation Index	0.6

General Parameters

Electrical Conductivity (µS/cm)	1554
pH (in pH units)	8.48
Hardness (as mg/L $CaCO_3$)	19
Total Alkalinity (as mg/L $CaCO_3$)	714
Calculated TDS (mg/L)	1078

Other Parameters

Total Coliform (CFU/100mL)	TNTC
Escherichia Coliform (CFU/100mL)	0
Heterotrophic Plate Count (MPN/mL)	
Sulfides (S) (mg/L)	0.024
Turbidity (NTU)	2.1
Color (TCU)	
Total Kjeldahl Nitrogen (mg/L)	
Ammonia Nitrogen (mg/L)	
Organic Nitrogen (mg/L)	
Total Phosphorus (mg/L)	
Total Organic Carbon (mg/L)	11.0
Dissolved Organic Carbon (mg/L)	
Trihalomethanes (mg/L)	
Boron (mg/L)	
Silicon (mg/L)	
Phenol (mg/L)	
Cyanide (mg/L)	
Total Suspended Solids (mg/L)	
Total Dissolved Soilds (mg/L)	

**BACTERIA DETECTED
RECOMMEND SHOCK
CHLORINATION**

Trace Metals

	µg/L
Thallium	<5
Thorium	<5
Tin	1
Molybdenum	2
Antimony	1
Titanium	2
Zirconium	1
Phosphorus	52
Arsenic	<2
Selenium	<2
Lead	<2
Bismuth	<2
Nickel	3
Aluminum	20
Chromium	<0.8
Zinc	3
Copper	2
Cadmium	<0.8
Beryllium	<0.8
Cobalt	2
Vanadium	<0.8
Silver	<0.8
Strontium	49
Barium	62
Lithium	64
Uranium	
Mercury	

Certified By: [signature]

..ples may account for higher iron, manganese and silicon concentrations.
The results above are related only to the items analyzed.
Please see the reverse side of this page for the Canadian Drinking Water Quality Guideline.
TDS = Total Dissolved Solids, SAR = Sodium Adsorption Ratio, TNTC = Too Numerous To Count (>200 colonies), < denotes less than detection limit
Analysis methods are based on Standard Methods for the Examination of Water and Wastewater 20th Edition and can be made available upon request.

Maxxam Analytics Inc

CERTIFICATE OF ANALYSIS

Sample Point I.D.	
Client I.D.	
Meter Number	
Laboratory Number	A600525:A28891
Operator Name	KOMEX INTERNATIONAL LIMITED
NTS (BC Survey)	
Well ID	
Well Name	SW-11-27-22 W4M
Name of Sampler	MCLK
Company	KOMEX
Field or Area	
Pool or Zone	
Sample Point	VALHALLA HYDRANT GAS FROM BOTTLE
Container Identity	SYRINGE
Percent Full	
Test Recovery	
Test Type / No. / Multiple Recovery	
Interval 1 / Interval 2 / Interval 3 (From: / To:)	
Elevations (m) KB / GRD	
Sample Gathering Point	
Solution Gas	
Well Fluid Status	
Well Status Mode	
Production Rates: Water m3/d / Oil m3/d / Gas 1000m3/d	
Gauge Pressures kPa: Source / As Received	
Temperature °C: Source	
Temperature °C: As Received	23.0
Well Status Type	
Well Type	
Gas or Condensate Project	
Licence No.	
Date Sampled Start	2006/01/05 10:30
Date Sampled End	
Date Received	2006/01/06
Date Reported	2006/01/10
Date Revision Reported	2006/01/10
Analyst	KD

PARAMETER DESCRIPTION	RESULTS	Units	Method
Dissolved Gas Analysis			
Carbon Monoxide	<0.01	mole%	
Carbon Dioxide	0.38	mole%	
Oxygen	5.24	mole%	
Nitrogen	28.48	mole%	
Hydrogen	<0.01	mole%	
Methane (C1)	65.90	mole%	
Acetylene (C2H2)	<1	ppm (mole)	
Ethylene (C2H4)	<1	ppm (mole)	
Ethane (C2)	31	ppm (mole)	
Propylene (C3H6)	<1	ppm (mole)	

** Information not supplied by client -- data derived from LSD information

Results relate only to items teste

Remarks:

CERTIFICATE OF ANALYSIS

Maxxam Analytics Inc

Sample Point I.D.	
Client I.D.	
Meter Number	
Laboratory Number	A600525:A28893
Operator Name	KOMEX INTERNATIONAL LIMITED
NTS (BC Survey)	
Well ID	
Well Name	SW-11-27-22 W4M
Name of Sampler	MCLK
Company	KOMEX
Field or Area	
Pool or Zone	
Sample Point	#1 VALHALLA WELL BOTTLE SAMPLE
Container Identity	SYRINGE
Percent Full	
Test Recovery	
Test Type / No. / Multiple Recovery	
Interval 1 / Interval 2 / Interval 3 — From: / To:	
Elevations (m) — KB / GRD	
Sample Gathering Point	
Solution Gas	
Well Fluid Status	
Well Status Mode	
Production Rates — Water m3/d / Oil m3/d / Gas 1000m3/d	
Gauge Pressures kPa — Source / As Received	
Temperature °C — Source / As Received	/ 23.0
Well Status Type	
Well Type	
Gas or Condensate Project	
Licence No.	
Date Sampled Start	2006/01/0511:15
Date Sampled End	
Date Received	2006/01/06
Date Reported	2006/01/10
Date Revision Reported	2006/01/10
Analyst	KD

PARAMETER DESCRIPTION	RESULTS	Units	Method
Dissolved Gas Analysis			
Carbon Monoxide	<0.01	mole%	
Carbon Dioxide	0.30	mole%	
Oxygen	5.40	mole%	
Nitrogen	20.70	mole%	
Hydrogen	<0.01	mole%	
Methane (C1)	73.60	mole%	
Acetylene (C2H2)	<1	ppm (mole)	
Ethylene (C2H4)	<1	ppm (mole)	
Ethane (C2)	40	ppm (mole)	
Propylene (C3H6)	<1	ppm (mole)	

** Information not supplied by client -- data derived from LSD information

Results relate only to items teste

Remarks:

CERTIFICATE OF ANALYSIS

Maxxam Analytics Inc

Sample Point I.D.	
Client I.D.	
Meter Number	
Laboratory Number	A600525:A28894
Operator Name	KOMEX INTERNATIONAL LIMITED
NTS (BC Survey)	
Well ID	
Well Name	SW-11-27-22 W4M
Name of Sampler	MCLK
Company	KOMEX
Field or Area	
Pool or Zone	
Sample Point	#2 VALHALLA WELL BOTTLE SAMPLE
Container Identity	SYRINGE
Percent Full	
Test Recovery	
Test Type	
No.	
Multiple Recovery	
Interval 1 / Interval 2 / Interval 3 — From: / To:	
Elevations (m) — KB / GRD	
Sample Gathering Point	
Solution Gas	
Well Fluid Status	
Well Status Mode	
Production Rates — Water m3/d / Oil m3/d / Gas 1000m3/d	
Gauge Pressures kPa — Source / As Received	
Temperature °C — Source	
Temperature °C — As Received	23.0
Well Status Type	
Well Type	
Gas or Condensate Project	
Licence No.	
Date Sampled Start	2006/01/0511:25
Date Sampled End	
Date Received	2006/01/06
Date Reported	2006/01/10
Date Revision Reported	2006/01/10
Analyst	KD

PARAMETER DESCRIPTION	RESULTS	Units	Method
Dissolved Gas Analysis			
Carbon Monoxide	<0.01	mole%	
Carbon Dioxide	0.28	mole%	
Oxygen	4.70	mole%	
Nitrogen	17.38	mole%	
Hydrogen	<0.01	mole%	
Methane (C1)	77.64	mole%	
Acetylene (C2H2)	<1	ppm (mole)	
Ethylene (C2H4)	<1	ppm (mole)	
Ethane (C2)	43	ppm (mole)	
Propylene (C3H6)	<1	ppm (mole)	

** Information not supplied by client -- data derived from LSD information

Results relate only to items teste

Remarks:

Maxxam Analytics Inc

CERTIFICATE OF ANALYSIS

Sample Point I.D.	
Client I.D.	
Meter Number	
Laboratory Number	A600525:A28871
Operator Name	KOMEX INTERNATIONAL LIMITED
NTS (BC Survey)	
Well ID	
Well Name	SW-11-27-22 W4M
Name of Sampler	MCLK
Company	KOMEX
Field or Area	
Pool or Zone	
Sample Point	#1 VALHALLA HOT WATER TANK
Container Identity	tedlarBag
Percent Full	
Test Recovery	
Test Type / No. / Multiple Recovery	
Interval 1 / Interval 2 / Interval 3 — From: / To:	
Elevations (m) — KB / GRD	
Sample Gathering Point	
Solution Gas	
Well Fluid Status	
Well Status Mode	
Production Rates — Water m3/d / Oil m3/d / Gas 1000m3/d	
Gauge Pressures kPa — Source / As Received	
Temperature °C — Source	
Temperature °C — As Received	23.0
Well Status Type	
Well Type	
Gas or Condensate Project	
Licence No.	
Date Sampled Start	2006/01/0512:50
Date Sampled End	
Date Received	2006/01/06
Date Reported	2006/01/10
Date Revision Reported	2006/01/10
Analyst	KD

PARAMETER DESCRIPTION	RESULTS	Units	Method
Dissolved Gas Analysis			
Carbon Monoxide	<0.01	mole%	
Carbon Dioxide	1.19	mole%	
Oxygen	2.32	mole%	
Nitrogen	19.95	mole%	
Hydrogen	0.01	mole%	
Methane (C1)	76.51	mole%	
Acetylene (C2H2)	<1	ppm (mole)	
Ethylene (C2H4)	<1	ppm (mole)	
Ethane (C2)	51	ppm (mole)	
Propylene (C3H6)	<1	ppm (mole)	

** Information not supplied by client -- data derived from LSD information

Results relate only to items teste

Remarks:

Maxxam Analytics Inc

KOMEX INTERNATIONAL LIMITED
Attention: JAMES ARMSTRONG
Client Project #: C63630000
P.O. #:
Site Reference: SW-11-27-22 W4M

Sample Description : VALHALLA HOUSE TAP
Sample Date & Time : 2006/01/05 13:30
Sampled By : KM
Sample Type : Grab
Sample Received Date 2006/01/05
Sample Station Code :

Maxxam Sample Number : A28940
Maxxam Job Number : CA600538
Sample Access :
Sample Matrix : Water
Report Date : 2006/01/11

PARAMETER DESCRIPTION	RESULTS	Units	QA/QC Batch	MDL	RDL	meq/L
Calculated Parameters						
Hardness (CaCO3)	11	mg/L	1008663	0.5	1	
Ion Balance	0.98	N/A	1008665	0.01	0.02	
Misc. Inorganics						
Conductivity	1810	uS/cm	1008323	1	2	
pH	8.43	N/A	1008322	0.01	0.02	
Total Dissolved Solids	1070	mg/L	1008671	10	20	
Anions						
Alkalinity (PP as CaCO3)	8.5	mg/L	1008320	0.5	1	
Alkalinity (Total as CaCO3)	715	mg/L	1008320	0.5	1	
Bicarbonate (HCO3)	852	mg/L	1008320	0.5	1	13.967
Carbonate (CO3)	10.3	mg/L	1008320	0.5	1	0.343
Dissolved Chloride (Cl)	186	mg/L	1009158	0.5	1	5.239
Dissolved Fluoride (F)	1.73	mg/L	1009108	0.05	0.1	
Dissolved Sulphate (SO4)	3.7	mg/L	1009159	0.5	1	0.077
Hydroxide (OH)	<0.5	mg/L	1008320	0.5	1	
Nutrients						
Dissolved Nitrate (N)	<0.003	mg/L	1009252	0.003	0.006	
Dissolved Nitrite (N)	<0.003	mg/L	1009252	0.003	0.006	
Nitrate plus Nitrite (N)	<0.003	mg/L	1008669	0.003	0.006	
Physical Properties						
Turbidity	2.5	NTU	1008430	0.1	0.2	

N/A = Not Applicable
RDL = Reportable Detection Limit
MDL = Method Detection Limit - Calculated on the basis of the instrument detection level, the dilution used, and the weight of the sample.
Results are not corrected for surrogate or moisture values unless otherwise stated.

Maxxam Analytics Inc

KOMEX INTERNATIONAL LIMITED
Attention: JAMES ARMSTRONG
Client Project #: C63630000
P.O. #:
Site Reference: SW-11-27-22 W4M

Sample Description	:	VALHALLA HOUSE TAP	Maxxam Sample Number	:	A28940
Sample Date & Time	:	2006/01/05 13:30	Maxxam Job Number	:	CA600538
Sampled By	:	KM	Sample Access	:	
Sample Type	:	Grab	Sample Matrix	:	Water
Sample Received Date		2006/01/05	Report Date	:	2006/01/11
Sample Station Code	:				

Elements by Atomic Spectroscopy

PARAMETER DESCRIPTION	RESULTS	Units	QA/QC Batch	MDL	RDL	meq/L
Cations						
Dissolved Calcium (Ca)	3.8	mg/L	1008496	0.3	0.6	0.190
Dissolved Magnesium (Mg)	0.4	mg/L	1008496	0.2	0.4	0.033
Dissolved Potassium (K)	0.8	mg/L	1008496	0.3	0.6	0.020
Dissolved Sodium (Na)	441	mg/L	1008496	0.5	1	19.182
Dissolved Iron (Fe)	0.06	mg/L	1008496	0.01	0.02	0.002
Dissolved Manganese (Mn)	(0.006)	mg/L	1008496	0.004	0.008	0.000

RDL = Reportable Detection Limit
MDL = Method Detection Limit - Calculated on the basis of the instrument detection level, the dilution used, and the weight of the sample.
() = Result < RDL and is subject to reduced levels of confidence
Results are not corrected for surrogate or moisture values unless otherwise stated.

Maxxam Analytics Inc

KOMEX INTERNATIONAL LIMITED
Attention: JAMES ARMSTRONG
Client Project #: C63630000
P.O. #:
Site Reference: SW-11-27-22 W4M

Sample Description : VALHALLA HOUSE TAP
Sample Date & Time : 2006/01/05 13:30
Sampled By : KM
Sample Type : Grab
Sample Received Date 2006/01/05
Sample Station Code :

Maxxam Sample Number : A28940
Maxxam Job Number : CA600538
Sample Access :
Sample Matrix : Water
Report Date : 2006/01/11

Volatile Organics by GC-MS

PARAMETER DESCRIPTION	RESULTS	Units	QA/QC Batch	MDL	RDL	meq/L
Volatiles						
Purgeable Benzene	<0.0004	mg/L	1008353	0.0004	0.0008	
Purgeable Toluene	<0.0004	mg/L	1008353	0.0004	0.0008	
Purgeable Ethylbenzene	<0.0004	mg/L	1008353	0.0004	0.0008	
Purgeable Xylenes (Total)	<0.0008	mg/L	1008353	0.0008	0.002	
Purgeable F1 (C06-C10) - BTEX	<0.1	mg/L	1008353	0.1	0.2	

Surrogate Recoveries (%):

D8-TOLUENE (sur.): 100 Control Limits: 88 - 110

RDL = Reportable Detection Limit
MDL = Method Detection Limit - Calculated on the basis of the instrument detection level, the dilution used, and the weight of the sample.
Results are not corrected for surrogate or moisture values unless otherwise stated.

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L353687-1 SW 11 27 22 W4								
Sampled By: NOT PROVIDED on 05-JAN-06 @ 13:30								
Matrix: WATER								
BTEX, F1 (C6-C10) and F2 (>C10-C16)								
F2 (>C10-C16)	<0.05		0.05	mg/L	10-JAN-06	11-JAN-06	DNH	R361973
BTEX and F1 (C6-C10)								
Benzene	<0.0005		0.0005	mg/L	09-JAN-06	08-JAN-06	OOG	R362252
Toluene	<0.0005		0.0005	mg/L	09-JAN-06	08-JAN-06	OOG	R362252
EthylBenzene	<0.0005		0.0005	mg/L	09-JAN-06	08-JAN-06	OOG	R362252
Xylenes	<0.0005		0.0005	mg/L	09-JAN-06	08-JAN-06	OOG	R362252
F1(C6-C10)	<0.1		0.1	mg/L	09-JAN-06	08-JAN-06	OOG	R362252
F1-BTEX	<0.1		0.1	mg/L	09-JAN-06	08-JAN-06	OOG	R362252
Methane, dissolved	48		0.005	mg/L	06-JAN-06	06-JAN-06	RLB	R362012
Routine Water: Major Ions,F,Fe,Mn&Turb.								
Iron (Fe)-Dissolved	0.02		0.01	mg/L		06-JAN-06	HSC	R361832
Chloride (Cl)	182		0.1	mg/L	06-JAN-06	06-JAN-06	WJR	R361694
Fluoride (F)	1.5		0.1	mg/L	06-JAN-06	06-JAN-06	WJR	R361694
Manganese(Mn)-Dissolved	<0.01		0.01	mg/L		06-JAN-06	HSC	R361832
Nitrate+Nitrite-N	0.08		0.05	mg/L	06-JAN-06	06-JAN-06	WJR	R361694
Nitrate-N	<0.05		0.05	mg/L	06-JAN-06	06-JAN-06	WJR	R361694
Nitrite-N	0.08		0.05	mg/L	06-JAN-06	06-JAN-06	WJR	R361694
Sulphate (SO4)	3.0		0.5	mg/L	06-JAN-06	06-JAN-06	WJR	R361694
Turbidity	2.9		0.2	NTU		09-JAN-06	KG	R362184
pH, Conductivity and Total Alkalinity								
pH	8.2		0.1	pH		06-JAN-06	KG	R361784
Conductivity (EC)	1760		3	uS/cm		06-JAN-06	KG	R361784
Bicarbonate (HCO3)	890		5	mg/L		06-JAN-06	KG	R361784
Carbonate (CO3)	<5		5	mg/L		06-JAN-06	KG	R361784
Hydroxide (OH)	<5		5	mg/L		06-JAN-06	KG	R361784
Alkalinity, Total (as CaCO3)	730		5	mg/L		06-JAN-06	KG	R361784
Ion Balance Calculation								
Ion Balance	94.4			%		09-JAN-06		
TDS (Calculated)	1050			mg/L		09-JAN-06		
Hardness (as CaCO3)	10			mg/L		09-JAN-06		
ICP metals for routine water								
Calcium (Ca)	3.5		0.5	mg/L		06-JAN-06	HSC	R361832
Potassium (K)	0.8		0.1	mg/L		06-JAN-06	HSC	R361832
Magnesium (Mg)	0.4		0.1	mg/L		06-JAN-06	HSC	R361832
Sodium (Na)	424		1	mg/L		06-JAN-06	HSC	R361832
L353687-2 AIR BAG								
Sampled By: NOT PROVIDED on 05-JAN-06 @ 13:15								
Matrix: AIR								
Methane	860000		2	ppm		12-JAN-06	CCE	R362424

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

Maxxam Analytics Inc

CERTIFICATE OF ANALYSIS

Sample Point I.D.	
Client I.D.	
Meter Number	
Laboratory Number	A600525:A28872
Operator Name	KOMEX INTERNATIONAL LIMITED
NTS (BC Survey)	
Well ID	
Well Name	SW-11-27-22 W4M
Name of Sampler	MCLK
Company	KOMEX
Field or Area	
Pool or Zone	
Sample Point	#2 VALHALLA HOT WATER TANK
Container Identity	tedlarBag
Percent Full	
Test Recovery	
Test Type / No. / Multiple Recovery	
Interval 1 / Interval 2 / Interval 3 (From: / To:)	
Elevations (m) KB / GRD	
Sample Gathering Point	
Solution Gas	
Well Fluid Status	
Well Status Mode	
Production Rates: Water m3/d / Oil m3/d / Gas 1000m3/d	
Gauge Pressures kPa: Source / As Received	
Temperature °C: Source	
Temperature °C: As Received	23.0
Well Status Type	
Well Type	
Gas or Condensate Project	
Licence No.	
Date Sampled Start	2006/01/0513:40
Date Sampled End	
Date Received	2006/01/06
Date Reported	2006/01/10
Date Revision Reported	2006/01/10
Analyst	KD

PARAMETER DESCRIPTION	RESULTS	Units	Method
Dissolved Gas Analysis			
Carbon Monoxide	<0.01	mole%	
Carbon Dioxide	1.24	mole%	
Oxygen	1.60	mole%	
Nitrogen	18.33	mole%	
Hydrogen	0.02	mole%	
Methane (C1)	78.81	mole%	
Acetylene (C2H2)	<1	ppm (mole)	
Ethylene (C2H4)	<1	ppm (mole)	
Ethane (C2)	54	ppm (mole)	
Propylene (C3H6)	<1	ppm (mole)	

** Information not supplied by client -- data derived from LSD information

Results relate only to items teste

Remarks:

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L364427-1 ROUTINE 1								
Sample By: NOT PROVIDED on 17-FEB-06 @ 09:00								
Matrix: WATER								
Iron Reducing Bacteria	<10		10	CFU/mL		17-FEB-06	BC	R379528
Sulphate Reducing Bacteria	0.4		0.3	MPN/mL		17-FEB-06	BC	R379528
Routine Water Analysis								
Chloride (Cl)	162		0.1	mg/L	17-FEB-06	17-FEB-06	WJR	R373563
Nitrate+Nitrite-N	<0.05		0.05	mg/L	17-FEB-06	17-FEB-06	WJR	R373563
Nitrate-N	<0.05		0.05	mg/L	17-FEB-06	17-FEB-06	WJR	R373563
Nitrite-N	<0.05		0.05	mg/L	17-FEB-06	17-FEB-06	WJR	R373563
Sulphate (SO4)	2.5		0.5	mg/L	17-FEB-06	17-FEB-06	WJR	R373563
pH, Conductivity and Total Alkalinity								
pH	8.2		0.1	pH		17-FEB-06	KG	R373648
Conductivity (EC)	1750		3	uS/cm		17-FEB-06	KG	R373648
Bicarbonate (HCO3)	883		5	mg/L		17-FEB-06	KG	R373648
Carbonate (CO3)	<5		5	mg/L		17-FEB-06	KG	R373648
Hydroxide (OH)	<5		5	mg/L		17-FEB-06	KG	R373648
Alkalinity, Total (as CaCO3)	724		5	mg/L		17-FEB-06	KG	R373648
Ion Balance Calculation								
Ion Balance	90.7			%		21-FEB-06		
TDS (Calculated)	997			mg/L		21-FEB-06		
Hardness (as CaCO3)	10			mg/L		21-FEB-06		
ICP metals for routine water								
Calcium (Ca)	3.5		0.5	mg/L		21-FEB-06	RAZ	R374344
Potassium (K)	0.8		0.1	mg/L		21-FEB-06	RAZ	R374344
Magnesium (Mg)	0.4		0.1	mg/L		21-FEB-06	RAZ	R374344
Sodium (Na)	393		1	mg/L		21-FEB-06	RAZ	R374344
L364427-2 ROUTINE 2								
Sample By: NOT PROVIDED on 17-FEB-06 @ 09:00								
Matrix: WATER								
Iron Reducing Bacteria	<10		10	CFU/mL		17-FEB-06	BC	R379528
Sulphate Reducing Bacteria	0.9		0.3	MPN/mL		17-FEB-06	BC	R379528
Routine Water Analysis								
Chloride (Cl)	163		0.1	mg/L	17-FEB-06	17-FEB-06	WJR	R373563
Nitrate+Nitrite-N	<0.05		0.05	mg/L	17-FEB-06	17-FEB-06	WJR	R373563
Nitrate-N	<0.05		0.05	mg/L	17-FEB-06	17-FEB-06	WJR	R373563
Nitrite-N	<0.05		0.05	mg/L	17-FEB-06	17-FEB-06	WJR	R373563
Sulphate (SO4)	2.2		0.5	mg/L	17-FEB-06	17-FEB-06	WJR	R373563
pH, Conductivity and Total Alkalinity								
pH	8.2		0.1	pH		17-FEB-06	KG	R373648
Conductivity (EC)	1770		3	uS/cm		17-FEB-06	KG	R373648
Bicarbonate (HCO3)	893		5	mg/L		17-FEB-06	KG	R373648
Carbonate (CO3)	<5		5	mg/L		17-FEB-06	KG	R373648
Hydroxide (OH)	<5		5	mg/L		17-FEB-06	KG	R373648
Alkalinity, Total (as CaCO3)	732		5	mg/L		17-FEB-06	KG	R373648
Ion Balance Calculation								
Ion Balance	91.0			%		21-FEB-06		
TDS (Calculated)	1010			mg/L		21-FEB-06		
Hardness (as CaCO3)	11			mg/L		21-FEB-06		
ICP metals for routine water								
Calcium (Ca)	3.6		0.5	mg/L		21-FEB-06	RAZ	R374344
Potassium (K)	0.9		0.1	mg/L		21-FEB-06	RAZ	R374344

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L364427-2 ROUTINE 2								
Sample By: NOT PROVIDED on 17-FEB-06 @ 09:00								
Matrix: WATER								
Routine Water Analysis								
ICP metals for routine water								
Magnesium (Mg)	0.4		0.1	mg/L		21-FEB-06	RAZ	R374344
Sodium (Na)	398		1	mg/L		21-FEB-06	RAZ	R374344

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

Maxxam Analytics Inc

WORLEYPARSONS KOMEX
Attention: KIMBERLEY MCLEISH
Client Project #: C63630000
P.O. #:
Site Reference: VALHALLA FARMS

Sample Description	:	VALHALLA FARMS KITCHEN TAP	Maxxam Sample Number	:	A59022
Sample Date & Time	:	2006/02/17 9:30	Maxxam Job Number	:	CA606517
Sampled By	:	KM	Sample Access	:	
Sample Type	:	Grab	Sample Matrix	:	Water
Sample Received Date		2006/02/17	Report Date	:	2006/02/23
Sample Station Code	:				

PARAMETER DESCRIPTION	RESULTS	Units	QA/QC Batch	MDL	RDL	meq/L
Calculated Parameters						
Hardness (CaCO3)	9.8	mg/L	1050140	0.5	1	
Ion Balance	0.97	N/A	1050141	0.01	0.02	
Total Dissolved Solids	1050	mg/L	1050148	10	20	
Misc. Inorganics						
Conductivity	1850	uS/cm	1051015	1	2	
pH	8.44	N/A	1051014	0.01	0.02	
Anions						
Alkalinity (PP as CaCO3)	11.7	mg/L	1051012	0.5	1	
Alkalinity (Total as CaCO3)	718	mg/L	1051012	0.5	1	
Bicarbonate (HCO3)	847	mg/L	1051012	0.5	1	13.885
Carbonate (CO3)	14.0	mg/L	1051012	0.5	1	0.467
Dissolved Fluoride (F)	1.61	mg/L	1051018	0.05	0.1	
Hydroxide (OH)	<0.5	mg/L	1051012	0.5	1	
Sulphate (SO4)	3.3	mg/L	1052001	0.5	1	0.069
Chloride (Cl)	180	mg/L	1051984	0.5	1	5.070
Nutrients						
Dissolved Nitrate (N)	<0.003	mg/L	1052004	0.003	0.006	
Dissolved Nitrite (N)	<0.003	mg/L	1052004	0.003	0.006	
Nitrate plus Nitrite (N)	<0.003	mg/L	1050145	0.003	0.006	
Physical Properties						
Turbidity	2.6	NTU	1050711	0.1	0.2	

N/A = Not Applicable
RDL = Reportable Detection Limit
MDL = Method Detection Limit - Calculated on the basis of the instrument detection level, the dilution used, and the weight of the sample.
Results are not corrected for surrogate or moisture values unless otherwise stated.

WORLEYPARSONS KOMEX
Attention: KIMBERLEY MCLEISH
Client Project #: C63630000
P.O. #:
Site Reference: VALHALLA FARMS

Sample Description	:	VALHALLA FARMS KITCHEN TAP	Maxxam Sample Number	:	A59022
Sample Date & Time	:	2006/02/17 9:30	Maxxam Job Number	:	CA606517
Sampled By	:	KM	Sample Access	:	
Sample Type	:	Grab	Sample Matrix	:	Water
Sample Received Date		2006/02/17	Report Date	:	2006/02/23
Sample Station Code	:				

Elements by Atomic Spectroscopy

PARAMETER DESCRIPTION	RESULTS	Units	QA/QC Batch	MDL	RDL	meq/L
Cations						
Dissolved Calcium (Ca)	3.4	mg/L	1052771	0.3	0.6	0.170
Dissolved Magnesium (Mg)	(0.3)	mg/L	1052771	0.2	0.4	0.025
Dissolved Potassium (K)	0.6	mg/L	1052771	0.3	0.6	0.015
Dissolved Sodium (Na)	431	mg/L	1052771	0.5	1	18.747
Dissolved Iron (Fe)	(0.01)	mg/L	1052771	0.01	0.02	0.000
Dissolved Manganese (Mn)	<0.004	mg/L	1052771	0.004	0.008	

RDL = Reportable Detection Limit
MDL = Method Detection Limit - Calculated on the basis of the instrument detection level, the dilution used, and the weight of the sample.
() = Result < RDL and is subject to reduced levels of confidence
Results are not corrected for surrogate or moisture values unless otherwise stated.

Metals by ICP, Major cations, Fe and Mn - Matrix spike exceeds acceptance limits for Na, due to matrix interference. Re-analysis yields similar results.

CERTIFICATE OF ANALYSIS

Table 1. Water Samples: Iron Bacteria:

PBR LAB ID	Client Sample ID	CFU / 100ml Iron Bacteria (Protocol # 1203)
06-NW-01	Valhalla Farms Kitchen Tap #1	1.0×10^3
06-NW-02	Valhalla Farms Kitchen Tap #2	2.5×10^3

Note: Microbial count is in Colony Forming Units (CFU).

Table 2. Water Samples: Sulphate Reducing Bacteria

PBR Lab ID	Client Sample ID	CFU / ml Sulphate Reducing Bacteria
06-NW-01	Valhalla Farms Kitchen Tap #1	< 1*
06-NW-02	Valhalla Farms Kitchen Tap #2	< 1*

Note: Microbial count is in Colony Forming Units (CFU).
*** no bacteria was present.***

Jennifer Chiang (Analyst)
DATE: 060306

Reviewed: R Bishnoi
Ram D. Mehta, Ph.D., P.Biol
DATE: 06 03 06

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L379038-3 1								
Sample By: LM on 12-APR-06 @ 11:30								
Matrix: WATER								
Total Metals								
Total Trace Metals								
Silver (Ag)	<0.005		0.005	mg/L		17-APR-06	QLI	R390447
Aluminum (Al)	2.06		0.01	mg/L		17-APR-06	QLI	R390447
Boron (B)	0.32		0.05	mg/L		17-APR-06	QLI	R390447
Barium (Ba)	0.130		0.003	mg/L		17-APR-06	QLI	R390447
Beryllium (Be)	<0.002		0.002	mg/L		17-APR-06	QLI	R390447
Cadmium (Cd)	<0.001		0.001	mg/L		17-APR-06	QLI	R390447
Cobalt (Co)	<0.002		0.002	mg/L		17-APR-06	QLI	R390447
Chromium (Cr)	<0.005		0.005	mg/L		17-APR-06	QLI	R390447
Copper (Cu)	0.003		0.001	mg/L		17-APR-06	QLI	R390447
Molybdenum (Mo)	0.006		0.005	mg/L		17-APR-06	QLI	R390447
Nickel (Ni)	0.002		0.002	mg/L		17-APR-06	QLI	R390447
Lead (Pb)	<0.005		0.005	mg/L		17-APR-06	QLI	R390447
Tin (Sn)	<0.05		0.05	mg/L		17-APR-06	QLI	R390447
Strontium (Sr)	0.103		0.002	mg/L		17-APR-06	QLI	R390447
Titanium (Ti)	0.034		0.001	mg/L		17-APR-06	QLI	R390447
Thallium (Tl)	<0.05		0.05	mg/L		17-APR-06	QLI	R390447
Vanadium (V)	0.003		0.001	mg/L		17-APR-06	QLI	R390447
Zinc (Zn)	0.012		0.001	mg/L		17-APR-06	QLI	R390447
Total Major Metals								
Calcium (Ca)	4.1		0.5	mg/L		19-APR-06	SYF	R390913
Potassium (K)	1.2		0.1	mg/L		19-APR-06	SYF	R390913
Magnesium (Mg)	0.7		0.1	mg/L		19-APR-06	SYF	R390913
Sodium (Na)	420		1	mg/L		19-APR-06	SYF	R390913
Iron (Fe)	4.47		0.005	mg/L		19-APR-06	SYF	R390913
Manganese (Mn)	0.028		0.001	mg/L		19-APR-06	SYF	R390913
Methane, dissolved	42.4		0.005	mg/L		13-APR-06	NOS	R390592
BTEX								
Benzene	<0.0005		0.0005	mg/L	17-APR-06	17-APR-06	KEB	R390502
Toluene	0.0086		0.0005	mg/L	17-APR-06	17-APR-06	KEB	R390502
Ethylbenzene	<0.0005		0.0005	mg/L	17-APR-06	17-APR-06	KEB	R390502
Xylenes	<0.0005		0.0005	mg/L	17-APR-06	17-APR-06	KEB	R390502
Routine Water Analysis								
Chloride (Cl)	177		0.1	mg/L	13-APR-06	13-APR-06	LHH	R390051
Nitrate+Nitrite-N	<0.05		0.05	mg/L	13-APR-06	13-APR-06	LHH	R390051
Nitrate-N	<0.05		0.05	mg/L	13-APR-06	13-APR-06	LHH	R390051
Nitrite-N	<0.05		0.05	mg/L	13-APR-06	13-APR-06	LHH	R390051
Sulphate (SO4)	1.5		0.5	mg/L	13-APR-06	13-APR-06	LHH	R390051
pH, Conductivity and Total Alkalinity								
pH	8.3		0.1	pH		19-APR-06	JF	R390673
Conductivity (EC)	1810		3	uS/cm		19-APR-06	JF	R390673
Bicarbonate (HCO3)	826		5	mg/L		19-APR-06	JF	R390673
Carbonate (CO3)	<5		5	mg/L		19-APR-06	JF	R390673
Hydroxide (OH)	<5		5	mg/L		19-APR-06	JF	R390673
Alkalinity, Total (as CaCO3)	683		5	mg/L		19-APR-06	JF	R390673
Ion Balance Calculation								
Ion Balance	96.8			%		20-APR-06		
TDS (Calculated)	1000			mg/L		20-APR-06		
Hardness (as CaCO3)	11			mg/L		20-APR-06		
ICP metals for routine water								

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L379038-3 1								
Sample By: LM on 12-APR-06 @ 11:30								
Matrix: WATER								
Routine Water Analysis								
ICP metals for routine water								
Calcium (Ca)	3.6		0.5	mg/L		13-APR-06	RAZ	R389500
Potassium (K)	1.0		0.1	mg/L		13-APR-06	RAZ	R389500
Magnesium (Mg)	0.6		0.1	mg/L		13-APR-06	RAZ	R389500
Sodium (Na)	407		1	mg/L		13-APR-06	RAZ	R389500
L379038-4 2								
Sample By: LM on 12-APR-06 @ 11:30								
Matrix: WATER								
Total Metals								
Total Trace Metals								
Silver (Ag)	<0.005		0.005	mg/L		17-APR-06	QLI	R390447
Aluminum (Al)	3.45		0.01	mg/L		17-APR-06	QLI	R390447
Boron (B)	0.32		0.05	mg/L		17-APR-06	QLI	R390447
Barium (Ba)	0.134		0.003	mg/L		17-APR-06	QLI	R390447
Beryllium (Be)	<0.002		0.002	mg/L		17-APR-06	QLI	R390447
Cadmium (Cd)	<0.001		0.001	mg/L		17-APR-06	QLI	R390447
Cobalt (Co)	<0.002		0.002	mg/L		17-APR-06	QLI	R390447
Chromium (Cr)	<0.005		0.005	mg/L		17-APR-06	QLI	R390447
Copper (Cu)	0.009		0.001	mg/L		17-APR-06	QLI	R390447
Molybdenum (Mo)	0.006		0.005	mg/L		17-APR-06	QLI	R390447
Nickel (Ni)	0.002		0.002	mg/L		17-APR-06	QLI	R390447
Lead (Pb)	<0.005		0.005	mg/L		17-APR-06	QLI	R390447
Tin (Sn)	<0.05		0.05	mg/L		17-APR-06	QLI	R390447
Strontium (Sr)	0.118		0.002	mg/L		17-APR-06	QLI	R390447
Titanium (Ti)	0.049		0.001	mg/L		17-APR-06	QLI	R390447
Thallium (Tl)	<0.05		0.05	mg/L		17-APR-06	QLI	R390447
Vanadium (V)	0.004		0.001	mg/L		17-APR-06	QLI	R390447
Zinc (Zn)	0.012		0.001	mg/L		17-APR-06	QLI	R390447
Total Major Metals								
Calcium (Ca)	5.3		0.5	mg/L		19-APR-06	SYF	R390913
Potassium (K)	1.5		0.1	mg/L		19-APR-06	SYF	R390913
Magnesium (Mg)	1.1		0.1	mg/L		19-APR-06	SYF	R390913
Sodium (Na)	426		1	mg/L		19-APR-06	SYF	R390913
Iron (Fe)	4.87		0.005	mg/L		19-APR-06	SYF	R390913
Manganese (Mn)	0.029		0.001	mg/L		19-APR-06	SYF	R390913
Methane, dissolved	35.78		0.005	mg/L		13-APR-06	NOS	R390592
BTEX								
Benzene	<0.0005		0.0005	mg/L	17-APR-06	17-APR-06	KEB	R390502
Toluene	0.0078		0.0005	mg/L	17-APR-06	17-APR-06	KEB	R390502
Ethylbenzene	<0.0005		0.0005	mg/L	17-APR-06	17-APR-06	KEB	R390502
Xylenes	<0.0005		0.0005	mg/L	17-APR-06	17-APR-06	KEB	R390502
Routine Water Analysis								
Chloride (Cl)	177		0.1	mg/L	13-APR-06	13-APR-06	LHH	R390051
Nitrate+Nitrite-N	<0.05		0.05	mg/L	13-APR-06	13-APR-06	LHH	R390051
Nitrate-N	<0.05		0.05	mg/L	13-APR-06	13-APR-06	LHH	R390051
Nitrite-N	<0.05		0.05	mg/L	13-APR-06	13-APR-06	LHH	R390051
Sulphate (SO4)	1.3		0.5	mg/L	13-APR-06	13-APR-06	LHH	R390051
pH, Conductivity and Total Alkalinity								
pH	8.4		0.1	pH		19-APR-06	JF	R390673

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L379038-4 2								
Sample By: LM on 12-APR-06 @ 11:30								
Matrix: WATER								
Routine Water Analysis								
pH, Conductivity and Total Alkalinity								
Conductivity (EC)	1860		3	uS/cm		19-APR-06	JF	R390673
Bicarbonate (HCO3)	802		5	mg/L		19-APR-06	JF	R390673
Carbonate (CO3)	21		5	mg/L		19-APR-06	JF	R390673
Hydroxide (OH)	<5		5	mg/L		19-APR-06	JF	R390673
Alkalinity, Total (as CaCO3)	692		5	mg/L		19-APR-06	JF	R390673
Ion Balance Calculation								
Ion Balance	95.1			%		20-APR-06		
TDS (Calculated)	1010			mg/L		20-APR-06		
Hardness (as CaCO3)	10			mg/L		20-APR-06		
ICP metals for routine water								
Calcium (Ca)	3.2		0.5	mg/L		13-APR-06	RAZ	R389500
Potassium (K)	1.0		0.1	mg/L		13-APR-06	RAZ	R389500
Magnesium (Mg)	0.5		0.1	mg/L		13-APR-06	RAZ	R389500
Sodium (Na)	407		1	mg/L		13-APR-06	RAZ	R389500

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

NORWEST LABS

Norwest Labs
Bay 9, 2712-37 Avenue N.E.
Calgary, AB. T1Y-5L3
Phone: (403) 291-2022
Fax: (403) 291-2021

Analytical Report

Bill to: Fiona Lauridsen
Report to: Fiona Lauridsen
Box 681
Rosebud, AB, Canada
T0J 2T0
Attn: Fiona Lauridsen
Sampled By:
Company:

Project
ID:
Name:
Location:
LSD:
P.O.:
Acct. Code:

NWL Lot ID: 456133
Control Number: E 273480
Date Received: Apr 13, 2006
Date Reported: Apr 24, 2006
Report Number: 842871

		NWL Number	456133-1	456133-2	456133-3	
		Sample Description	SE 29-26-21 W4M	Lauridsen - before	Lauridsen - after	
		Matrix	Water	Water	Water	
Analyte		**Units**	**Results**	**Results**	**Results**	**Detection Limit**
Methane Content of Water						
Methane	Volume Gas / Volume Liquid	mL gas/m³ water	9	65200	101000	5
Methane	Mass / Volume Liquid	mg/L	0.006	42.8	66.3	0.003

Approved by: C. Swyngedouw

Chris Swyngedouw, PhD, PChem
Consulting Scientist

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters		Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L431072-1	CK090806A								
Sampled By:	CK on 08-SEP-06 @ 11:05								
Matrix:	WATER								
	Methane, dissolved	39		0.005	mg/L	08-SEP-06	08-SEP-06	RLB	R441986
L431072-4	CK090806B								
Sampled By:	CK on 08-SEP-06 @ 11:35								
Matrix:	WATER								
	Methane, dissolved	45		0.005	mg/L	08-SEP-06	08-SEP-06	RLB	R441986
L431072-7	CK090806C								
Sampled By:	CK on 08-SEP-06 @ 11:05								
Matrix:	WATER								
	Free CO2	<1		1	mg/L		11-SEP-06	SHT	R440448
L431072-10	CK090806D								
Sampled By:	CK on 08-SEP-06 @ 11:35								
Matrix:	WATER								
	Free CO2	<1		1	mg/L		11-SEP-06	SHT	R440448
L431072-13	CK090806M								
Sampled By:	CK on 08-SEP-06 @ 13:15								
Matrix:	WATER								
	Methane, dissolved	<0.005		0.005	mg/L	08-SEP-06	08-SEP-06	RLB	R441986
L431072-16	9879442								
Sampled By:	CK on 08-SEP-06 @ 11:35								
Matrix:	WATER								
TC and EC by MPN									
	MPN - Total Coliforms	1		1	MPN/100mL		11-SEP-06	RBD	R440205
	MPN - E. coli	<1		1	MPN/100mL		11-SEP-06	RBD	R440205
L431072-17	CK090806 E								
Sampled By:	CK on 08-SEP-06 @ 11:05								
Matrix:	WATER								
Routine Water Analysis									
	Chloride (Cl)	203		0.1	mg/L	11-SEP-06	11-SEP-06	LHH	R440650
ICP metals for routine water									
	Calcium (Ca)	1.6		0.5	mg/L		12-SEP-06	MAT	R441116
	Potassium (K)	0.8		0.1	mg/L		12-SEP-06	MAT	R441116
	Magnesium (Mg)	0.3		0.1	mg/L		12-SEP-06	MAT	R441116
	Sodium (Na)	403		1	mg/L		12-SEP-06	MAT	R441116
Ion Balance Calculation									
	Ion Balance	87.8			%		13-SEP-06		
	TDS (Calculated)	1040			mg/L		13-SEP-06		
	Hardness (as CaCO3)	5			mg/L		13-SEP-06		
	Nitrate+Nitrite-N	<0.05		0.05	mg/L	11-SEP-06	11-SEP-06	LHH	R440650
	Nitrate-N	<0.05		0.05	mg/L	11-SEP-06	11-SEP-06	LHH	R440650
	Nitrite-N	<0.05		0.05	mg/L	11-SEP-06	11-SEP-06	LHH	R440650
	Sulphate (SO4)	<0.5		0.5	mg/L	11-SEP-06	11-SEP-06	LHH	R440650
pH, Conductivity and Total Alkalinity									

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L431072-17 CK090806 E								
Sampled By: CK on 08-SEP-06 @ 11:05								
Matrix: WATER								
Routine Water Analysis								
pH, Conductivity and Total Alkalinity								
pH	8.6		0.1	pH		11-SEP-06	GK	R440254
Conductivity (EC)	1820		3	uS/cm		11-SEP-06	GK	R440254
Bicarbonate (HCO3)	826		5	mg/L		11-SEP-06	GK	R440254
Carbonate (CO3)	25		5	mg/L		11-SEP-06	GK	R440254
Hydroxide (OH)	<5		5	mg/L		11-SEP-06	GK	R440254
Alkalinity, Total (as CaCO3)	718		5	mg/L		11-SEP-06	GK	R440254
L431072-18 CK090806 F								
Sampled By: CK on 08-SEP-06 @ 11:35								
Matrix: WATER								
Routine Water Analysis								
Chloride (Cl)	195		0.1	mg/L	11-SEP-06	11-SEP-06	LHH	R440650
ICP metals for routine water								
Calcium (Ca)	1.8		0.5	mg/L		12-SEP-06	MAT	R441116
Potassium (K)	0.8		0.1	mg/L		12-SEP-06	MAT	R441116
Magnesium (Mg)	0.3		0.1	mg/L		12-SEP-06	MAT	R441116
Sodium (Na)	432		1	mg/L		12-SEP-06	MAT	R441116
Ion Balance Calculation								
Ion Balance	95.3			%		13-SEP-06		
TDS (Calculated)	1060			mg/L		13-SEP-06		
Hardness (as CaCO3)	6			mg/L		13-SEP-06		
Nitrate+Nitrite-N	<0.05		0.05	mg/L	11-SEP-06	11-SEP-06	LHH	R440650
Nitrate-N	<0.05		0.05	mg/L	11-SEP-06	11-SEP-06	LHH	R440650
Nitrite-N	<0.05		0.05	mg/L	11-SEP-06	11-SEP-06	LHH	R440650
Sulphate (SO4)	1.3		0.5	mg/L	11-SEP-06	11-SEP-06	LHH	R440650
pH, Conductivity and Total Alkalinity								
pH	8.6		0.1	pH		11-SEP-06	GK	R440254
Conductivity (EC)	1800		3	uS/cm		11-SEP-06	GK	R440254
Bicarbonate (HCO3)	815		5	mg/L		11-SEP-06	GK	R440254
Carbonate (CO3)	29		5	mg/L		11-SEP-06	GK	R440254
Hydroxide (OH)	<5		5	mg/L		11-SEP-06	GK	R440254
Alkalinity, Total (as CaCO3)	717		5	mg/L		11-SEP-06	GK	R440254

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L460632-1 C64340345								
Sampled By: CLIENT on 06-DEC-06 @ 10:50								
Matrix: WATER								
Coal Bed Methane Suite								
Chloride (Cl)	184		0.1	mg/L		08-DEC-06		R474213
Fluoride (F)	1.4		0.1	mg/L		08-DEC-06		R474213
ICP metals for routine water								
Calcium (Ca)	1.3		0.5	mg/L		13-DEC-06	MAT	R475594
Potassium (K)	1.5		0.1	mg/L		13-DEC-06	MAT	R475594
Magnesium (Mg)	0.2		0.1	mg/L		13-DEC-06	MAT	R475594
Sodium (Na)	403		1	mg/L		13-DEC-06	MAT	R475594
Ion Balance Calculation								
Ion Balance	86.8	RRV		%		13-DEC-06		
TDS (Calculated)	1050			mg/L		13-DEC-06		
Hardness (as CaCO3)	4			mg/L		13-DEC-06		
Iron (Fe)-Dissolved	0.05		0.01	mg/L		13-DEC-06	MAT	R475594
Iron (Fe)-Total	1.79		0.01	mg/L		12-DEC-06		R474950
Iron Bacteria	9000		25	CFU/mL	07-DEC-06	17-DEC-06	DJK	R476725
Manganese(Mn)-Dissolved	<0.01		0.01	mg/L		13-DEC-06	MAT	R475594
Manganese (Mn)-Total	0.02		0.01	mg/L		12-DEC-06		R474950
Nitrate and Nitrite as N	<0.07		0.07	mg/L		11-DEC-06		
Nitrate-N	<0.05		0.05	mg/L		08-DEC-06		R474213
Nitrite-N	<0.05		0.05	mg/L		08-DEC-06		R474213
Sulphate (SO4)	3.4		0.5	mg/L		08-DEC-06		R474213
Sulfur Reducing Bacteria	700000		200	CFU/mL	07-DEC-06	17-DEC-06	DJK	R476721
pH, Conductivity and Total Alkalinity								
pH	8.5		0.1	pH		08-DEC-06	GK	R474466
Conductivity (EC)	1830		3	uS/cm		08-DEC-06	GK	R474466
Bicarbonate (HCO3)	871		5	mg/L		08-DEC-06	GK	R474466
Carbonate (CO3)	22		5	mg/L		08-DEC-06	GK	R474466
Hydroxide (OH)	<5		5	mg/L		08-DEC-06	GK	R474466
Alkalinity, Total (as CaCO3)	751		5	mg/L		08-DEC-06	GK	R474466
Total & Fecal Coliforms								
Total Coliforms	<1		1	CFU/100mL		07-DEC-06	BC	R474505
Fecal Coliforms	<1		1	CFU/100mL		07-DEC-06	BC	R474505

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L460566-1 C64340345								
Sampled By: MEGAN CAWTHORPE on 06-DEC-06 @ 09:38								
Matrix: GAS								
CO2 and C1-C4 hydrocarbons								
C1-C4 GC/FID Vapor Scan								
Methane	880000		5	ppm		11-DEC-06	RSM	R474709
Ethane	<5		5	ppm		11-DEC-06	RSM	R474709
Propane	<5		5	ppm		11-DEC-06	RSM	R474709
Butane	<5		5	ppm		11-DEC-06	RSM	R474709
Carbon Dioxide	1600		10	ppm		12-DEC-06	CVD	R475259
Nitrogen	11		1	%		12-DEC-06	CVD	R475259
Oxygen	1.70		0.1	%		12-DEC-06	CVD	R475259

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ISOTOPE SCIENCE LABORATORY
Dept of Physics and Astronomy
University of Calgary
2500 University Dr. NW, Calgary, Alta.
T2N-1N4

Results
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Fax *: (403) 220 7773*
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Name: Kristina Flage
ALS Laboratory Services
1313 44 Ave NE
Calgary,
Alberta, Canada
T2E 6L5

phone: 1-403-291-9897
fax: 1-403-291-0298
email: kristina.flagel@alsenviro.com

Project:

#	Sample Name	$\delta^{13}C_{CH4}$	$\delta^{13}C_{C2}$	$\delta^{13}C_{CO2}$	$\delta^{13}C_{C3}$	$\delta^{13}C_{iC4}$	$\delta^{13}C_{nC4}$	CH_4 (%)	CO_2 (%)	Comments	
5	C64340345 (Encana)	**-62.8**		**-1.0**				88	0.16		L460535

δ^{13}C-PDB of Hydrocarbon gases (GCC-IRMS)

All results reported in the usual permil notation relative to IAEA stds
IAEA values used to normalize data

	^{13}C
NBS 18	-5.1 ± 0.1
NBS 19	1.95 (b.d.)
Messer CO2 I	-0.29 ± 0.20
Messer CO2 II	-40.13 ± 0.17

Precision and accuracy as 1 sigma of (n=10) lab stds are: 0.5 for δ^{13}C
note: (b.d.) = 'by definitiion'

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L514150-1 RAW WATER LAURIDSEN WELL								
Sampled By: HVDJ on 05-JUN-07 @ 13:30								
Matrix: WATER								
Total Metals								
Total Major Metals								
Calcium (Ca)	3.6		0.5	mg/L		12-JUN-07	SYF	R534402
Potassium (K)	0.8		0.1	mg/L		12-JUN-07	SYF	R534402
Magnesium (Mg)	0.4		0.1	mg/L		12-JUN-07	SYF	R534402
Sodium (Na)	409		1	mg/L		12-JUN-07	SYF	R534402
Iron (Fe)	0.321		0.005	mg/L		12-JUN-07	SYF	R534402
Manganese (Mn)	0.004		0.001	mg/L		12-JUN-07	SYF	R534402
Total Trace Metals								
Silver (Ag)	<0.005	RAMB	0.005	mg/L		12-JUN-07	CVM	R534422
Aluminum (Al)	0.04		0.01	mg/L		12-JUN-07	CVM	R534422
Boron (B)	0.29		0.05	mg/L		12-JUN-07	CVM	R534422
Barium (Ba)	0.117		0.003	mg/L		12-JUN-07	CVM	R534422
Beryllium (Be)	0.008		0.002	mg/L		12-JUN-07	CVM	R534422
Cadmium (Cd)	<0.001		0.001	mg/L		12-JUN-07	CVM	R534422
Cobalt (Co)	<0.002		0.002	mg/L		12-JUN-07	CVM	R534422
Chromium (Cr)	<0.005		0.005	mg/L		12-JUN-07	CVM	R534422
Copper (Cu)	0.001		0.001	mg/L		12-JUN-07	CVM	R534422
Molybdenum (Mo)	0.005		0.005	mg/L		12-JUN-07	CVM	R534422
Nickel (Ni)	<0.002		0.002	mg/L		12-JUN-07	CVM	R534422
Lead (Pb)	<0.005		0.005	mg/L		12-JUN-07	CVM	R534422
Tin (Sn)	<0.05		0.05	mg/L		12-JUN-07	CVM	R534422
Strontium (Sr)	0.085		0.002	mg/L		12-JUN-07	CVM	R534422
Titanium (Ti)	<0.001		0.001	mg/L		12-JUN-07	CVM	R534422
Thallium (Tl)	<0.05		0.05	mg/L		12-JUN-07	CVM	R534422
Vanadium (V)	<0.001		0.001	mg/L		12-JUN-07	CVM	R534422
Zinc (Zn)	0.043		0.001	mg/L		12-JUN-07	CVM	R534422
Iron Bacteria	2300		25	CFU/mL		16-JUN-07	RBD	R536220
Methane, dissolved	33		0.005	mg/L	06-JUN-07	06-JUN-07	CFR	R534029
Sulfur Reducing Bacteria	700000		200	CFU/mL		16-JUN-07	RBD	R536218
TC and EC by MPN								
MPN - Total Coliforms	<1		1	MPN/100mL		07-JUN-07	DJK	R532152
MPN - E. coli	<1		1	MPN/100mL		07-JUN-07	DJK	R532152
Major Ions & Dissolved Metals								
Chloride (Cl)	173		0.1	mg/L		07-JUN-07	LHH	R532717
Dissolved Trace Metals								
Silver (Ag)	<0.005		0.005	mg/L		09-JUN-07	MX	R533071
Aluminum (Al)	<0.01		0.01	mg/L		09-JUN-07	MX	R533071
Boron (B)	0.32		0.05	mg/L		09-JUN-07	MX	R533071
Barium (Ba)	0.121		0.003	mg/L		09-JUN-07	MX	R533071
Beryllium (Be)	<0.001		0.001	mg/L		09-JUN-07	MX	R533071
Cadmium (Cd)	<0.001		0.001	mg/L		09-JUN-07	MX	R533071
Cobalt (Co)	<0.002		0.002	mg/L		09-JUN-07	MX	R533071
Chromium (Cr)	<0.005		0.005	mg/L		07-JUN-07	HAS	R532428
Copper (Cu)	<0.001		0.001	mg/L		09-JUN-07	MX	R533071
Molybdenum (Mo)	0.006		0.005	mg/L		09-JUN-07	MX	R533071
Nickel (Ni)	<0.002		0.002	mg/L		09-JUN-07	MX	R533071
Lead (Pb)	<0.005		0.005	mg/L		09-JUN-07	MX	R533071
Tin (Sn)	<0.05		0.05	mg/L		09-JUN-07	MX	R533071
Strontium (Sr)	0.084		0.005	mg/L		09-JUN-07	MX	R533071
Titanium (Ti)	<0.001		0.001	mg/L		09-JUN-07	MX	R533071

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L514150-1 RAW WATER LAURIDSEN WELL								
Sampled By: HVDJ on 05-JUN-07 @ 13:30								
Matrix: WATER								
Major Ions & Dissolved Metals								
Dissolved Trace Metals								
Thallium (Tl)	<0.05		0.05	mg/L		09-JUN-07	MX	R533071
Vanadium (V)	0.003		0.001	mg/L		09-JUN-07	MX	R533071
Zinc (Zn)	0.005		0.001	mg/L		09-JUN-07	MX	R533071
ICP metals for routine water								
Calcium (Ca)	<0.5		0.5	mg/L		08-JUN-07	JF	R532743
Potassium (K)	0.9		0.1	mg/L		08-JUN-07	JF	R532743
Magnesium (Mg)	<0.1		0.1	mg/L		08-JUN-07	JF	R532743
Sodium (Na)	517		1	mg/L		08-JUN-07	JF	R532743
Ion Balance Calculation								
Ion Balance	124	RRV		%		09-JUN-07		
TDS (Calculated)	1090			mg/L		09-JUN-07		
Hardness (as CaCO3)	<1			mg/L		09-JUN-07		
Iron (Fe)-Dissolved	0.170		0.005	mg/L		07-JUN-07	HAS	R532428
Manganese (Mn)-Dissolved	0.004		0.001	mg/L		07-JUN-07	HAS	R532428
Nitrate and Nitrite as N	<0.07		0.07	mg/L		08-JUN-07		
Nitrate-N	<0.05		0.05	mg/L		07-JUN-07	LHH	R532717
Nitrite-N	<0.05		0.05	mg/L		07-JUN-07	LHH	R532717
Sulphate (SO4)	0.8		0.5	mg/L		07-JUN-07	LHH	R532717
pH, Conductivity and Total Alkalinity								
pH	8.7		0.1	pH		06-JUN-07	MAT	R532396
Conductivity (EC)	1740		3	uS/cm		06-JUN-07	MAT	R532396
Bicarbonate (HCO3)	744		5	mg/L		06-JUN-07	MAT	R532396
Carbonate (CO3)	31		5	mg/L		06-JUN-07	MAT	R532396
Hydroxide (OH)	<5		5	mg/L		06-JUN-07	MAT	R532396
Alkalinity, Total (as CaCO3)	662		5	mg/L		06-JUN-07	MAT	R532396

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters		Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L522178-1	RAW WATER LAURIDSEN WELL								
Sampled By:	CLIENT on 05-JUN-07 @ 13:30								
Matrix:	WATER								
	Methane, dissolved	33		0.005	mg/L	26-JUN-07	26-JUN-07	CFR	R540243

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALBERTA RESEARCH COUNCIL | ORGANICS ANALYSIS DATA SHEET | ARC SAMPLE NUMBER: T07-1622

VOLATILE PRIORITY POLLUTANTS

Contact: Miller
SmpNo : 07MU080999 ProjNo : ABMIWS GrpSmpNo :
StaNo : StaType:
Comment: Laurisden Residence
Matrix : 6
SmpDate: 5-Jun-07 @ 1330 Samplers..ID1 : 195635
EndDate: @ ..ID2 :

METHOD: A102.1
SCAN: VPP

		TimeLines (days) from sample date Max	Actual
Date Received : 8-Jun-07	by: DRC\	-	3 --
Date Extracted: 12-Jun-07	by: SS	7	7 ok
Date Analyzed : 12-Jun-07	by: BJS	7	7 ok

Raw DataFile : V1622

VMV_CODE	COMPOUND NAME	ug/L	flag	MDL	+\-
100651	1,1,1,2-Tetrachloroethane	0.0		.1	.1
95224	1,1,2,2-Tetrachloroethane	0.0		.1	.1
95214	1,1-Dichloroethane	0.0		.1	.1
100645	1,1-Dichloropropylene	0.0		.1	.1
100655	1,2,3-Trichloropropane	0.0		.1	.1
100656	1,2,4-Trimethylbenzene	0.0		.1	.1
100641	1,2-Dibromoethane	0.0		.1	.1
95215	1,2-Dichloroethane	0.0		.1	.1
100657	1,3,5-Trimethylbenzene	0.0		.1	.1
100644	1,3-Dichloropropane	0.0		.1	.1
100643	2,2-Dichloropropane	0.0		.1	.1
100638	2-Chlorotoluene	0.0		.1	.1
95200	Benzene	0.0		.1	.1
95201	Bromodichloromethane	0.0		.1	.1
95203	Bromomethane	0.0		.1	.1
95205	Chlorobenzene	0.0		.1	.1
95208	Chloroform	0.0		.1	.1
95209	Dibromochloromethane	0.0		.1	.1
95221	Ethyl benzene	0.0		.1	.1
100647	Isopropylbenzene	0.0		.1	.1
95222	Methylene chloride	0.0		2.0	.1
95223	Styrene	0.0		.1	.1
95225	Tetrachloroethylene	0.0		.3	.1
100654	Trichloroethylene	0.0		.1	.1
95232	Vinyl chloride	0.0		.5	.1
100642	cis-1,2-Dichloroethylene	0.0		.1	.1
95234	m,p-Xylene	0.0		.1	.1
100650	n-Propylbenzene	0.0		.1	.1
100648	p-Isopropyltoluene	0.0		.1	.1
100636	tert-Butylbenzene	0.0		.1	.1
95220	trans-1,3-Dichloropropylene	0.0		.3	.1
95227	1,1,1-Trichloroethane	0.0		.1	.1
95228	1,1,2-Trichloroethane	0.0		.1	.1
95216	1,1-Dichloroethylene	0.0		.1	.1
100652	1,2,3-Trichlorobenzene	0.0		.1	.1
100653	1,2,4-Trichlorobenzene	0.0		.1	.1
100640	1,2-Dibromo-3-chloropropane	0.0		.3	.1
95211	1,2-Dichlorobenzene	0.0		.1	.1
95218	1,2-Dichloropropane	0.0		.1	.1
95212	1,3-Dichlorobenzene	0.0		.1	.1
95213	1,4-Dichlorobenzene	0.0		.1	.1
95207	2-Chloroethoxyethylene	0.0		.4	.1
100639	4-Chlorotoluene	0.0		.1	.1
100634	Bromobenzene	0.0		.1	.1
95202	Bromoform	0.0		.5	.1
95204	Carbon tetrachloride	0.0		.1	.1
95206	Chloroethane	0.0		.1	.1
106204	Chloromethane	0.0		.5	.1
95210	Dibromomethane	0.0		.1	.1
100646	Hexachlorobutadiene	0.0		.3	.1
102608	MTBE	0.0		.1	.1
100649	Naphthalene	0.0		.1	.1
100397	TRIHALOMETHANES	0.0		.1	.1
95226	Toluene	0.0		.1	.1
95229	Trichlorofluoromethane	0.0		.1	.1
100407	XYLENES	0.0		.1	.1
95219	cis-1,3-Dichloropropylene	0.0		.3	.1
100637	n-Butylbenzene	0.0		.1	.1
95233	o-Xylene	0.0		.1	.1
100635	sec-Butylbenzene	0.0		.1	.1
95217	trans-1,2-Dichloroethylene	0.0		.1	.1

Zero (0) values indicate that the analyte is not DETECTED. MDL - Method Detection Limit

flags B - This analyte is found in the blank as well as the sample. The blank value has been subtracted.
X - Estimated value. The target compound meets the identification criteria, but is less than the MDL.
H - Compound Detected Q - Qualifying ions present but failed the ion ratio limits.
M - This value is calculated by an alternate Raw DataFile.

* - asterik following the value for Actual days taken indicates the prescribed time for that event was exceeded.

** - the Date Sampled is unknown, therefore timeline calculations can not be performed.

Certified For: Yogesh Kumar
BUSINESS UNIT MANAGER
ANALYTICAL CHEMISTRY
ALBERTA RESEARCH COUNCIL
BAG 4000, VEGREVILLE, ALBERTA
T9C 1T4 (780) 632-8455

Date: 15-Jun-07

Contact Person: Grant Prill

mail to: Miller Leslie
Alberta Environment
2nd Floor Deerfoot Square
2938-11st NE
Calgary, Alberta T2E 7L7

VOLATILE PRIORITY POLLUTANTS

Contact: Miller
SmpNo : 07MU080999 ProjNo : ABMIWS GrpSmpNo :
StaNo : StaType:
Comment: Laurisden Residence
Matrix : 6
SmpDate: 5-Jun-07 @ 1330 Samplers..ID1 : 195635
EndDate: @ ..ID2 :

METHOD: A102.1	TimeLines (days) from sample date Max	Actual	
SCAN: VPP			
Date Received : 8-Jun-07 by: DRC\	-	3	--
Date Extracted: 12-Jun-07 by: SS	7	7	ok
Date Analyzed : 12-Jun-07 by: BJS	7	7	ok
Raw DataFile : V1622			

TENTATIVELY IDENTIFIED COMPOUNDS // COMMENTS	ESTIMATED CONCENTRATION ug/L
2-Propanol, 2-Methyl	1.0

Laboratory's comments regarding this sample:

The following items regarding the sample were recorded. A Yes notation indicates a problem with the specified item.

Inappropriate Sample Container - No
Inappropriate Temperature - No
Inappropriate Headspace - No
Broken / Leaking Container - No

This sample was analyzed by GC/MS. An additional GC/FID scan may have been used for screening purposes and to assist with quantitative data analysis.
Estimated concentrations for tentively identified compounds are calculated assuming an equal response to internal standards.
* - asterik following the value for Actual days taken indicates the prescribed time for that event was exceeded.
** - the Date Sampled is unknown, therefore timeline calculations can not be performed.

Certified For: Yogesh Kumar
BUSINESS UNIT MANAGER
ANALYTICAL CHEMISTRY
ALBERTA RESEARCH COUNCIL
BAG 4000, VEGREVILLE, ALBERTA
T9C 1T4 (780) 632-8455

Date: 15-Jun-07
Contact Person: Grant Prill

mail to: Miller Leslie
Alberta Environment
2nd Floor Deerfoot Square
2938-11st NE
Calgary, Alberta T2E 7L7

If there are any questions or concerns regarding this report, please contact the person indicated above.
Please check the mailing information and inform the lab if changes are required.

EXTRACTABLE PRIORITY POLLUTANTS

Contact: Miller
SmpNo : 07MU080999 ProjNo : AEMIWS GrpSmpNo :
StaNo : StaType:
Comment: Laurisden Residence
Matrix : 6
SmpDate: 5-Jun-07 @ 1330 Samplers..ID1 : 195635
EndDate: @ ..ID2 :

METHOD: EC/3 | TimeLines (days)
SCAN: EPP | from sample date

		Max	Actual
Date Received :	8-Jun-07 by: DRC\	-	3 --
Date Extracted:	11-Jun-07 by: drc	7	6 ok
Date Analyzed :	13-Jun-07 by: drc	21	8 ok
Raw DataFile :	E1623		

VMV_CODE	COMPOUND NAME	ug/L	flag	MDL	+\-
100730	1,2,4-Trichlorobenzene	0.0		.1	.1
103632	2,3,4,6-Tetrachlorophenol	0.0		.1	.2
100700	2,4-Dichlorophenol	0.0		.1	.2
100703	2,4-Dinitrophenol	0.0		.1	.2
100733	2,6-Dinitrotoluene	0.0		.1	.1
100699	2-Chlorophenol	0.0		.2	.2
100704	2-Nitrophenol	0.0		.1	.2
100698	4-Chloro-3-methylphenol	0.0		.1	.2
100705	4-Nitrophenol	0.0		.1	.2
100710	Acenaphthylene	0.0		.1	.1
100731	Benzidine	0.0		.2	.2
100716	Benzo(a)pyrene	0.0		.1	.2
100715	Benzo(ghi)perylene	0.0		.2	.1
100739	Bis(2-chloroethoxy)methane	0.0		.1	.1
100741	Bis(2-chloroisopropyl)ether	0.0		.1	.1
100743	Butylbenzylphthalate	.1	H	.1	.1
100744	Di-n-butylphthalate	.3	H	.1	.1
100718	Dibenzo(ah)anthracene	0.0		.5	.1
100746	Dimethyl phthalate	0.0		.1	.1
100720	Fluorene	0.0		.1	.1
100727	Hexachlorobutadiene	0.0		.5	.1
100729	Hexachloroethane	0.0		.5	.1
100749	Isophorone	0.0		.1	.1
100736	N-Nitrosodiphenylamine	0.0		.1	.1
100735	Nitrobenzene	0.0		.1	.1
100723	Phenanthrene	0.0		.1	.1
100724	Pyrene	0.0		.1	.1
100734	1,2-Diphenylhydrazine	0.0		.1	.1
100708	2,4,6-Trichlorophenol	0.0		.1	.2
100701	2,4-Dimethylphenol	0.0		.2	.2
100732	2,4-Dinitrotoluene	0.0		.1	.1
100725	2-Chloronaphthalene	0.0		.1	.1
100702	2-Methyl-4,6-dinitrophenol	0.0		.1	.2
100738	4-Bromophenyl phenyl ether	0.0		.1	.1
100742	4-Chlorophenyl phenyl ether	0.0		.1	.1
100709	Acenaphthene	0.0		.1	.1
100711	Anthracene	0.0		.1	.1
100712	Benzo(a)anthracene	0.0		.1	.1
100713	Benzo(b)fluoranthene	0.0		.1	.1
100714	Benzo(k)fluoranthene	0.0		.1	.1
100740	Bis(2-chloroethyl)ether	0.0		.1	.1
100748	Bis(2-ethylhexyl)phthalate	1.6	H	.1	.4
100717	Chrysene	0.0		.1	.1
100747	Di-n-octyl phthalate	0.0		.1	.1
100745	Diethyl phthalate	0.0		.1	.1
100719	Fluoranthene	0.0		.1	.1
100726	Hexachlorobenzene	0.0		.1	.1
100728	Hexachlorocyclopentadiene	0.0		.1	.1
100721	Indeno(1,2,3-cd)pyrene	0.0		.1	.1
100737	N-Nitroso-di-n-propylamine	0.0		.2	.1
100722	Naphthalene	0.0		.1	.1
100706	Pentachlorophenol	0.0		.1	.2
100707	Phenol	0.0		.1	.2

Zero (0) values indicate that the analyte is not DETECTED. MDL - Method Detection Limit

flags B - This analyte is found in the blank as well as the sample. The blank value has been subtracted.
X - Estimated value. The target compound meets the identification criteria, but is less than the MDL.
H - Compound Detected Q - Qualifying ions present but failed the ion ratio limits.
M - This value is calculated by an alternate Raw DataFile.

* - asterik following the value for Actual days taken indicates the prescribed time for that event was exceeded.
** - the Date Sampled is unknown, therefore timeline calculations can not be performed.

Certified For: Yogesh Kumar
BUSINESS UNIT MANAGER
ANALYTICAL CHEMISTRY
ALBERTA RESEARCH COUNCIL
Date: 13-Jun-07
BAG 4000, VEGREVILLE, ALBERTA
Contact Person: Grant Prill
T9C 1T4 (780) 632-8455

mail to: Miller Leslie
Alberta Environment
2nd Floor Deerfoot Square
2938-11st NE
Calgary, Alberta T2E 7L7

If there are any questions or concerns regarding this report, please contact the person indicated above.
Please check the mailing information and inform the lab if changes are required.

CCME Hydrocarbons in Water

Contact: Miller
SmpNo : 07MU080999 ProjNo : AEMIWS GrpSmpNo :
StaNo : StaType:
Comment: Laurisden Residence
Matrix : 6
SmpDate: 5-Jun-07 @ 1330 Samplers..ID1 : 195635
EndDate: @ ..ID2 :

METHOD: 3319
SCAN: F123W

			TimeLines (days) from sample date Max	Actual
Date Received :	8-Jun-07	by: DRC\	-	3
Date Extracted:	12-Jun-07	by: SS	10	7 ok
Date Analyzed :	12-Jun-07	by: BJS	14	7 ok

Raw DataFile : V1624

DataFile	Analyzed	VMV_CODE	COMPOUND NAME	ug/L	flag	MDL	+\-
V1624	12-Jun-07	106092	F1 Benzene	0.0		.1	
V1624	12-Jun-07	106094	F1 Ethylbenzene	0.0		.1	
V1624	12-Jun-07	106091	F1 Hydrocarbons(C6-C10)-BTEX	0.0		10.0	
V1624	12-Jun-07	106093	F1 Toluene	0.0		.1	
V1624	12-Jun-07	106095	F1 m,p-Xylene	0.0		.1	
V1624	12-Jun-07	106096	F1 o-Xylene	0.0		.1	
E1624	13-Jun-07	106097	F2 Hydrocarbons(C10-C16)	0.0		5.0	
E1624	13-Jun-07	106098	F3 Hydrocarbons(C16-C34)	0.0		20.0	
E1624	13-Jun-07		F4 Hydrocarbons(C34-C50)	0.0		20.0	

Zero (0) values indicate that the analyte is not DETECTED. MDL - Method Detection Limit

flags B - This analyte is found in the blank as well as the sample. The blank value has been subtracted.
X - Estimated value. The target compound meets the identification criteria, but is less than the MDL.
H - Compound Detected Q - Qualifying ions present but failed the ion ratio limits.
M - This value is calculated by an alternate Raw DataFile.

* - asterik following the value for Actual days taken indicates the prescribed time for that event was exceeded.

** - the Date Sampled is unknown, therefore timeline calculations can not be performed.

Certified For: Yogesh Kumar

Date: 15-Jun-07

Contact Person: Grant Prill

BUSINESS UNIT MANAGER
ANALYTICAL CHEMISTRY
ALBERTA RESEARCH COUNCIL
BAG 4000, VEGREVILLE, ALBERTA
T9C 1T4 (780) 632-8455

mail to: Miller Leslie
Alberta Environment
2nd Floor Deerfoot Square
2938-11st NE
Calgary, Alberta T2E 7L7

Client: Miller

Sample No: 07MU080999 Group Sample No: Site Descrip/Comment: Laurisden Residence

Station No: Project No: ABMTWS Canister: 1544

Agency: 202 Samp Type: 1 SampMatrix: 6 Collection: 1 Samp Date: 5-Jun-07 Time: 1330 Samplers ID: 195635

SubGroups	FILE	VMV	NAME	ConcRpt	MDL	ConcRptUnit	InjDate
DG_C1C4							
	W1625	106770	Butane	0.00	.01	ug/L	11-Jun-07
	W1625	106771	Ethane	3.21	.01	ug/L	11-Jun-07
	W1625	106772	Ethylene	0.00	.01	ug/L	11-Jun-07
	W1625	106773	Isobutane	0.00	.01	ug/L	11-Jun-07
	W1625	106774	Methane	31900.00	.01	ug/L	11-Jun-07
	W1625	106775	Propane	0.00	.01	ug/L	11-Jun-07
DG_TCD							
	L1625	106776	Carbon dioxide	5.93	1.00	mg/L	12-Jun-07
	L1625	106777	Nitrogen	12.70	6.00	mg/L	12-Jun-07
	L1625		Oxygen	.53	6.00	mg/L	12-Jun-07
G_C1C4							
	C1625	106778	Butane	0.00	.05	ppmv	11-Jun-07
	C1625	106779	Ethane	18.40	.05	ppmv	11-Jun-07
	C1625	106780	Ethylene	0.00	.05	ppmv	11-Jun-07
	C1625	106781	Isobutane	0.00	.05	ppmv	11-Jun-07
	C1625	106782	Methane	979000.00	.05	ppmv	11-Jun-07
	C1625	106783	Propane	0.00	.05	ppmv	11-Jun-07
G_TCD							
	G1625	106784	Carbon dioxide	1910.00	300.00	ppmv	11-Jun-07
	G1625	106785	Nitrogen	77600.00	1000.00	ppmv	11-Jun-07
	G1625		Oxygen	9870.00	1000.00	ppmv	11-Jun-07

[ARC_Remarks]:

SubGroups

DG_C1C4 and DG_TCD = Disolved Gas in water sample

G_C1C4 and G_TCD - Free Gas from canister

Certified For: Yogesh Kumar, Business Unit Manager
Environmental Monitoring
Alberta Research Council
Vegreville, Alberta
T9C 1T4

By:

Contact Person: Grant Prill
Environmental Monitoring
Alberta Research Council
Vegreville, Alberta T9C 1T4
T9C 1T4
(780) 632-8455

Date: 14-Jun-07

University of Calgary
Carbon Isotope Analyses

		Free Gas				Dissolved Gas		
Sample I.D.	**Field Site**	$\delta^{13}C_{CH4}$ (‰)	$\delta^{13}C_{C2}$ (‰)	$\delta^{13}C_{Co2}$ (‰)	δD_{CH4} (‰)	$\delta^{13}C_{CH4}$ (‰)	$\delta^{13}C_{C2}$ (‰)	$\delta^{13}C_{CO2}$ (‰)
KC62-1	Rosebud #1	-59.0	-40.5	-5.0	-285.0	n.r.	n.r.	n.r.
KC63-1	Jessica	-67.4	n.a.	-2.8	-298.3	-66.3	n.a.	n.a.
KC64-1	Lauridain	-63.3	n.a.	1.9	-291.2	-62.5	n.a.	n.a.
KC65-1	Signer	-66.9	n.a.	0.7	-297.2	-66.3	n.a.	n.a.
KC66-1	Rosebud #2	-64.0	n.d	n.a	n.a.	-63.4	n.d.	n.a.
KC67-1	Rosebud #3	-68.1	n.d.	1.6	n.a.	-69.5	n.d.	n.a.

n.a.	Not Analyzed
n.d.	Not Detected
n.r.	Not Received