

Alberta

ISBN: 978-0-7785-8122-2 (Printed version) ISBN: 978-0-7785-8123-9 (Online version)

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Rosebud and Redland Monitoring Well Installation Report

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April 12, 2007

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1 INTRODUCTION

The Alberta Environment (AENV) Groundwater Observation Well Network (GOWN) is a network of groundwater wells that monitor groundwater levels in aquifers across Alberta. Within the network some wells are also monitored for a variety of groundwater quality parameters. The network, starting with three wells in 1957, has grown to over 200 wells for better provincial coverage. Regional AENV staff maintain the wells, download data, take manual readings and archive the data into AENV's GOWN database. The AENV Groundwater Information Centre checks the data and maintains the GOWN database.

The Alberta Research Council (ARC) was contracted by AENV to supervise the drilling and installation of three new wells for the GOWN network. This report details the site selection, drilling and well installation data for these monitoring wells.

2 MONITORING WELL LOCATIONS

Monitoring well locations were determined by several regional and local factors including:

- Expand the GOWN network into areas that were not covered;
- Monitoring wells at one site were to be in a nest (at different completion depths) to be representative of hydrogeologic conditions at the local (shallow well) and intermediate (deeper well) scales;
- Monitoring well at the second site was to be representative of hydrogeological conditions at the local scale;
- Monitoring wells were to be located in order to minimize impact from nearby pumping wells (domestic or industrial water supply wells);
- Monitoring well sites needed to be accessible to the drilling rig and the AENV sampling trailer at all times of the year; and
- Wells were to be located in the valley to minimize drilling footage.

Two monitoring wells (nest) were installed in the town of Rosebud, Alberta, Wheatland County, in the SW-18-27-21-W4M (Figure 1) on County owned land. The deeper well (Rosebud #1) was located at N 51.18095°, W 112.56919° at a surface elevation of 793 m. The shallower well (Rosebud #2) was located at N 51.18092°, W 112.56922° at a surface elevation of 793 m. The wells were completed in the Horseshoe Canyon Formation of the Late Cretaceous Edmonton Group (Borneuf, 1972; Hydrogeological Consultants Ltd., 2003). A site survey plan is presented in Figure 2.

One monitoring well was installed in the town of Redland, Alberta, Wheatland County, in 9-10-27-22-W4M (Figure 1). The well (Redland #1) was located at N 51.292437°, W 113.005688° at a surface elevation of 800.6 m. The wells were completed in the Horseshoe Canyon Formation of the Late Cretaceous Edmonton Group (Borneuf, 1972; Hydrogeological Consultants Ltd., 2003). A site survey plan is presented in Figure 3.

3 MONITORING WELL INSTALLATIONS

The monitoring wells were installed by Gerritsen Drilling Limited of Rockyford Alberta using an Ingersoll Rand TH60 drilling rig (Figure 4). The drilling fluids used included bentonite mud and air in the overburden, and foam and air in the bedrock. Specific details of the drilling operation and the completion details for each well are presented below.

3.1 Rosebud Well #1

Drilling of Rosebud Monitoring Well #1 commenced on March 8, 2007. A test hole was advanced to 18.9 m (62') with a 152 mm (6") tricone drill bit using air to remove cuttings. Cuttings were continuously monitored and logged. Loose sand from the upper section of the hole was noted falling into the hole. The hole was reamed with a 200 mm (7%) bit and a temporary 152 mm (6") plastic well casing was set. The hole was then advanced to the final depth of 141.4 m (464') using a 130 mm (5%) bit. Cuttings were lifted by air. Cuttings were continuously monitored and logged. A detailed lithological description and well completion details are presented Appendix A.

The temporary plastic casing was pulled and bentonite chips were smeared around the borehole (using the bit and stabilizer) to control the loose sand at 14 to 16 feet. The bentonite chips were unsuccessful at controlling the sands so the hole was reamed with a 219 mm ($8\frac{5}{8}$ ") bit and 8.23 m (27') of 219 mm ($8\frac{5}{8}$ ") steel conductor pipe was inserted to control the sand. The hole was then reamed with a 200 mm ($7\frac{7}{8}$ ") bit to a depth of 137.77 m (452') using air and foam to lift the cuttings. A downhole camera revealed that sand continued to wash down the hole from behind the conductor pipe. An additional 2.59 m (8.5") of 219 mm ($8\frac{5}{8}$ ") steel conductor pipe was welded on and pushed into the ground. This was successful at controlling the sand.

A 141 mm (5.56") steel casing with threaded joints was grouted into the ground by pushing bentonite grout down the centre of the casing and getting grout returns up the annulus to the surface. The casing was then driven a short distance into the bedrock to make a good grouted and driven seal. A 114 mm (4.5") OD schedule 40 PVC liner with environmental threads and orings, along with 12 evenly spaced K-packers were simultaneously lowered and grouted into place (Figure 4) from above the surface to 141.42 m (464'). The lower end of the liner had a 2.74 m (9') section of 20 slot machined screen. Calcium hypochlorite was used on the threaded joints for disinfection. A schematic diagram of the well completion is presented in Appendix A.

Following completion, the well was Gamma Ray logged by ENZeeTech Inc of Calgary, Alberta. A copy of the gamma log is included in Appendix B.

The well had a casing stick-up of 0.64 m and a total depth of 141.12 m. The well was dry in the completed coal zone and methane gas was present. A compression cap with sampling valve and pressure gauge was fitted to the well and a locking mechanism restricts access to the well.

3.2 Rosebud Well #2

Drilling of Rosebud Monitoring Well #2 commenced on March 22, 2007. A test hole was advanced to 18.9 m (62') with a 200 mm (7%") tricone drill bit using bentonite mud to remove cuttings. A temporary 152 mm (6") plastic well casing was set. The hole was then advanced to the final depth of 55.47 m (182') using a 130 mm (5%") bit. Cuttings were lifted with air. Cuttings

were continuously monitored and logged. A detailed lithological description and well completion details are presented Appendix A.

The temporary plastic casing was pulled and the hole was then reamed with a 200 mm (71/8") bit to a depth of 53.34 m (175') using bentonite mud to lift the cuttings. A 168 mm (65/8") steel casing with welded joints was grouted into the ground by pushing bentonite grout down the centre of the casing and getting grout returns up the annulus to the surface. The casing was then driven a short distance into the bedrock to make a good grouted and driven seal. A 125 mm (4.94") OD schedule 40 PVC liner with threaded joints, along with 3 evenly spaced K-packers were simultaneously lowered and grouted into place from above the surface to 55.47 m (182'). The lower end of the liner had a 2.74 m (9') section of 20 slot machined screen. Calcium hypochlorite was used on the threaded joints for disinfection. A schematic diagram of the well completion is presented in Appendix A. The well was developed with air until the water produced was clear. The apparent well yield was approximately 0.5 Imperial gallons per minute (IGPM).

Following completion, the well was Gamma Ray logged by ENZeeTech Inc of Calgary, Alberta. A copy of the gamma log is included in Appendix B.

The well had a casing stick-up of 0.59 m and a total depth of 55.34 m. The apparent static water level in the well was 13.11 m below ground surface. The well was fitted with a locking cap. The well was shock chlorinated at the completion of the project.

3.3 Redland Well

Drilling of Redland Monitoring Well #1 commenced on March 26, 2007. A test hole was advanced to 22.1 m (72.5') with a 200 mm ($7\frac{1}{8}$ ") tricone drill bit using bentonite mud to remove cuttings. A temporary 152 mm (6") plastic well casing was set. The hole was then advanced to the final depth of 51.51 m (169') using a 130 mm ($5\frac{1}{8}$ ") bit. Cuttings were lifted with air. Cuttings were continuously monitored and logged. A detailed lithological description and well completion details are presented Appendix A.

The temporary plastic casing was pulled and the hole was then reamed with a 200 mm (7%) bit to a depth of 50.29 m (165) using bentonite mud to lift the cuttings. A 168 mm (6%) steel casing with welded joints was grouted into the ground by pushing bentonite grout down the centre of the casing and getting grout returns up the annulus to the surface. The casing was then driven a short distance into the bedrock to make a good grouted and driven seal. A 125 mm (4.94") OD schedule 40 PVC liner with threaded joints, along with 4 evenly spaced K-packers was simultaneously lowered and grouted into place from above the surface to 51.51 m (169'). The lower end of the liner had a 2.74 m (9') section of 20 slot machined screen. Calcium hypochlorite was used on the threaded joints for disinfection. A schematic diagram of the well completion is presented in Appendix A. The well was developed with air until the water produced was clear. The apparent well yield was approximately 1 IGPM.

Following completion, the well was Gamma Ray logged by ENZeeTech Inc of Calgary, Alberta. A copy of the gamma log is included in Appendix B.

The well had a casing stick-up of 0.60 m and a total depth of 51.44 m. The apparent static water level in the well was 4.76 m below ground surface. The well was fitted with a locking cap. The well was shock chlorinated at the completion of the project.

4 CONCLUSIONS AND RECCOMMENDATIONS

The following key points are summarized for the drilling programs in Rosebud and Redland.

- Exploration drilling in Rosebud encountered an apparently saturated silty sand and sand from about 2 to 5 m.
- Exploration drilling in Rosebud encountered several water bearing coal zones above 55 m. The main water bearing coal zone was encountered from 54.25 to 55.17 m. The well completed in this zone (Rosebud Well #2) yielding approximately 0.5 IGPM. This is consistent with the depth and yield of most local water wells (Alberta Environment Provincial Water Well Data Base, 2004).
- In Rosebud no water was encountered from below about 55 m to the maximum depth drilled (about 141 m). No water was encountered in the screened interval of Rosebud Well #1 but methane gas was encountered.
- Exploration drilling in Redland encountered a fine gravel from about 6.4 to 7.3 m.
- Exploration drilling in Redland encountered a minor water bearing sandstone at approximately 48 m. The main water bearing coal zone was encountered from 50.59 to 51.21 m. The well completed in this zone (Redland Well #1) yielded approximately 1 IGPM. This is consistent with the depth and yield of most local water wells (Alberta Environment Provincial Water Well Data Base 2004).

Based on the drilling and testing program at Rosebud and Redland, the following recommendations are made.

- These monitoring wells should be equipped with an automatic water level monitoring device (such as an In-Situ MiniTROLL) to monitor impacts of stresses on the regional aquifer system by water withdrawals or drought.
- Prior to geochemical sampling of Rosebud Well #2 and Redland Well #1, the wells should undergo a pumping test to determine aquifer hydraulic properties. This will also remove residual chlorine resulting from the shock chlorination of the wells.
- Rosebud Well #1 gas should be sampled and analysed for composition (GC analysis) and carbon and hydrogen isotopes.
- The Rosebud Well #1 will need to be licensed by the Alberta Energy and Utilities Board (AEUB). This process has been initiated by AENV.

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

Respectfully submitted,

Alberta Research Council



Alexander Blyth, Ph.D., P.Geol. Research Hydrogeologist

5 REFERENCES

Alberta Environment Provincial Water Well Data Base (2004).

- Borneuf, D., 1972. Hydrology of the Drumheller Area, Alberta. Alberta Research Council Report 72-1.
- Hydrogeological Consultants Ltd., 2003. Wheatland County Part of the South Saskatchewan Basin, Tp 021 to 028, R 17 to 26, W4M. PFRA Regional Groundwater Assessment Report.

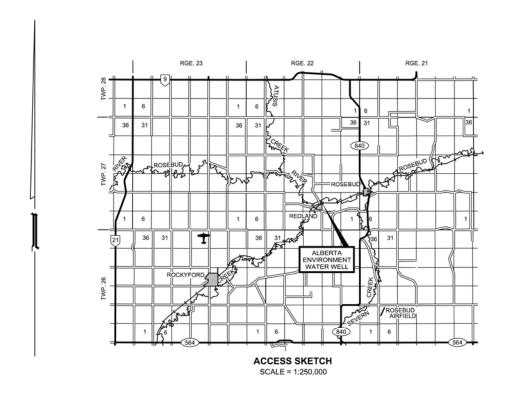


Figure 1. General site location map.

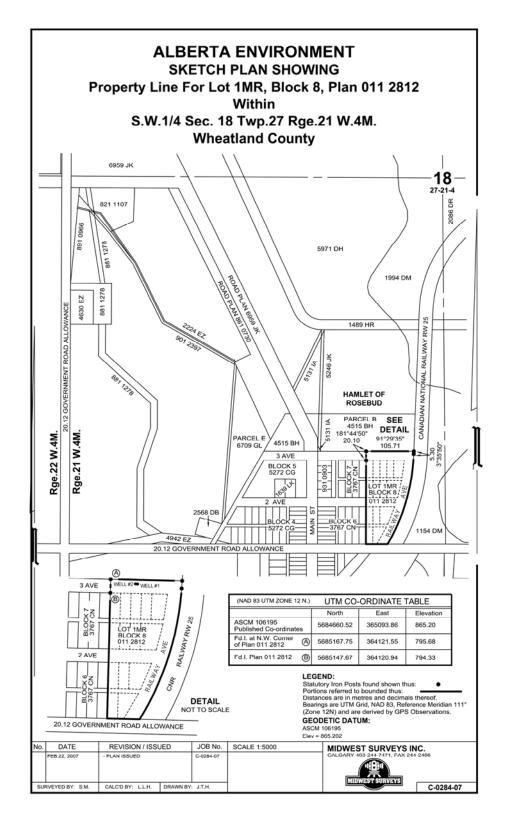


Figure 2. Detailed map of Rosebud area.

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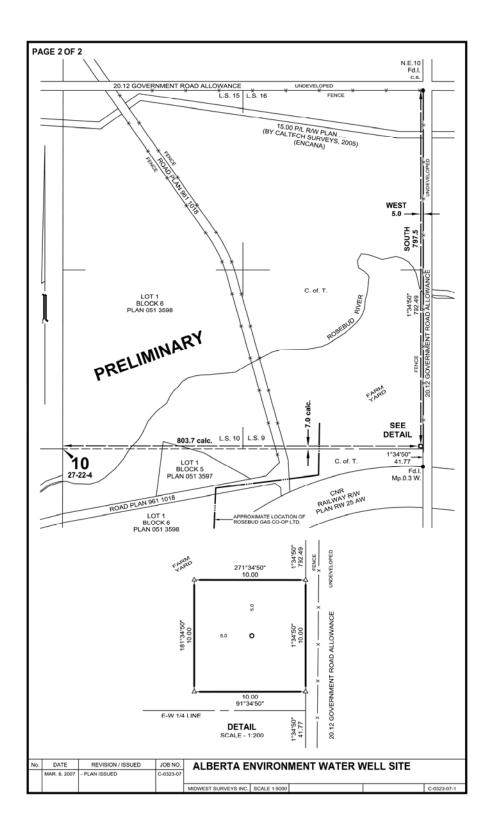


Figure 3. Detailed map of Redland area.



Ingersoll-Rand TH60 Drilling Rig

Tricone bit and Stabilizer



Wildon M15 Diaphragm Grout Pump

Installing and Grouting Liner



K-Packer on Casing Liner

Figure 4. Photographs

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Ingersoll-Rand TH60 Drilling Rig

Tricone bit and Stabilizer



Wildon M15 Diaphragm Grout Pump

Installing and Grouting Liner



K-Packer on Casing Liner

Figure 4. Photographs

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Appendix A Lithological Description and Well Completion Details



Rosehud Well #1 SW-18-27-21 W4

N 51.18095°, W 112.5619, 793 m

```
Depth from
                     Lithology Description
Ground (feet)
                     Clayey Silt, med. brown
                     Silty Clay, med. brown
Clayey Silt, med. brown
             3
    3
           6.5
                     Sandy Silt It brown
                     Silty Sand, It. brown, occasional pebble
  6.5
                    Sand, medium, occasional pebble, poorly sorted, subrounded Clayey Silt, sand from above mixed with returns
   14
16
            32
                     Silty Clay, med. grey
  32
62
66
80
82
97
99
                     Siltstone, med. grey, highly weathered, soft
            66
            80
                     Siltstone, med. grey
                     Sandstone, lt. Grey, fine grained
            82
                     Siltstone, med. grey
                     Sandstone, It. grey, soft. Water ~0.5 IGPM
Shale, black, silty in places
           99
112
 112
117
120
124
132
133
           117
                     Sandstone, lt. grey, soft, fine grained
                     Siltstone, med. grey
           120
           124
                     Sandstone, lt. grey, hard, fine grained
                     Shale, black, occasional It brown surfaces
           132
           133
145
                     COAL (Weaver coal). Water ~1 IGPM
                     Shale, black
 145
147
           147
148
                     Sandstone, It. Grey, fine grained
                     COAL (Weaver coal), Water minor
 148
                     Shale, med. brown, silty
           155
                    Sandstone, It. grey, hard, fine grained
COAL (Weaver coal). Water minor
 155
158
        158
159.5
159.5
                    Siltstone, med. grey
Sandstone, lt. grey, fine grained
 165
           167
  167
           170
                     Shale, black
 170
178
                     Sandstone, It. grey, hard, fine grained
           178
           181
                      COAL (Weaver coal). Water ~1.5 IGPM
 181
190
           190
                     Shale black
                     Sandstone, It. grey, fine grained
           193
 193
209
                    Shale, black, occasional It brown, hard siliceous layers Sandstone, It. grey, fine grained
           209
           216
 216
235
236
258
263
310
311
                     Shale, black. Bentonitic clay layer at 219'
                     Sandstone, It. grey, very hard, siliceous, fine grained
           236
           258
                     Shale, black
                     Sandstone, It. grey, hard, fine grained
           263
           310
                     Siltstone, med. grey. Minor coal at 278'
          311
314
                     COAL (Garden Plains)
                     Shale, black
 314
317
           317
                    Sandstone, It. grey, fine grained
Shale, black, minor siliceous layer, minor coal at 326'
           328
 328
329
330
333
334
                     Sandstone, It. grey, hard, fine grained
                     Shale, black
           330
           333
                     Sandstone, grey, hard, fine grained
          334
335
                     Shale, black
                     Sandstone, grey, hard, fine grained
 335
337
          337
339
                     Siltstone, med. grey
Sandstone, It. grey, fine grained. Siliceous layer at 338'
 339
342
343
354
357
358
359
           342
                     Shale, black
                     COAL (Garden Plains)
           343
          354
357
                     Shale, black. Sandy at 351'
                    Sandstone, lt. grey, hard, fine grained COAL (Garden Plains)
           358
           359
                     Sandstone, It. grey, fine grained Siltstone, med. grey
           368
 368
370
           370
                     Sandstone, It. grey, fine grained, silty
           372
                     Siltstone, med. grey
 372
           373
                     Sandstone, It. grey, fine grained
                     Siltstone, med. grey. Siliceous layer at 374'
 373
        374.5
374.5
                     Shale, black. Siliceous layer at 395
 400
           406
                     Sandstone, lt. grey, hard, fine grained Siltstone, med. grey
 406
           407
                     Sandstone, It. grey, hard, fine grained
Siltstone, med. grey. Sandy from 424-425"
 407
409
           409
           425
 425
432
          432
434
                     Shale, black
COAL (Garden Plains coal)
 434
437
                     Siltstone, med. grey
Sandstone, It. grey, fine grained. Siliceous layer at 439' and 442'
           437
           443
 443
454
           454
                     Siltstone, med. grey
           460
                     COAL (Garden Plains)
 460
           461
                     Siltstone, med. grey
                     COAL (Garden Plains), shaley lenses
 461
           463
 463
           464
                     Siltstone, med. grey
```

Completion Details

Borehole diameter 7 7/8" from surface to 450 ' (137.16 m) Borehole diameter 5 15/16" from 450-464' (137.16 to 141.42 m)

Steel conductor pipe 8 5/8" from surface to 35.5' (10.82 m)
Steel Casing diameter 5 9/16" (ID), threaded joints, from -2.1 - 452' (-0.64m to 137.77 m)

Liner diameter 4.5" (OD), environmental threads with o-rings, from -2.1 to 464' (-0.64 to 141.42 m)

Screened section of liner, 20 slot machined

Bentonite grout from surface to 452' (137.77 m) outside steel casing Bentonite grout from surface to 452' (137.77 m) between steel casing and liner

12 evenly spaced K-Packers

Completed Well Measurements Depth of well 464.97' (141.76 m) to Top of Casing

Casing Stick up 2.10' (0.64 m)

Total depth of well 463' (141.12 m) below ground surface

Static Water Level - no water, 54 PSI pressure

End of hole

Rose	ebud Drilling		Rosebud	/Redlan	d				BOREHOLE:			Rosebud Well 1		
INST	ALLED BY: Alberta Res								SITE:			8789009		
DRIL	L TYPE: Air Rotary			North: 51	.181		We	st: 112.569)	ELEV <i>A</i>	TION:	2	601.706 (ftasl)	
FILL	TYPE: Slough	Bentonite		Grout	Bac	kfill		Sand	Pelton	nite	Open Hole		Unknown	
SAM	PLE TYPE:	Shelby Tube		No Recovery	Spl	it Spoon	Ħ	Disturbed	Dyna	mic Cone	Core		Grab Sample	
D					•••								E	
e p		~~~ ~~~	~		-					WE	LL		l e	
t h	LITHOLO	GIC DESC	CRI	PTION	1				INS	TALI	LATION		v	
(ft)]			Casing diam. Borehole diam			(ftasl)	
- 1.0	Clayey Silt												= 2602.0 = 2603.0	
-2.0 -3.0	76:14 61				<i>-</i>								- 2604.0 - 2605.0	
-4.0 -5.0					J								2606.0 2607.0	
$ \begin{array}{r} 2.0 \\ -3.0 \\ -4.0 \\ -5.0 \\ -6.0 \\ -7.0 \\ -8.0 \\ \end{array} $	Clayey Silt				[/] r								2608.0 - 2609.0	
-8.0 -9.0	Sandy Silt												2610.0 2611.0	
_ 10 0	Silty Sand - Occasiona	ıl pebble											2612.0 2613.0	
- 11.0 - 12.0 - 13.0 - 14.0 - 15.0 - 16.0													- 2614.0 - 2615.0	
- 14.0 - 15.0	Sand Madium again	ional makkla ma	 										2616.0	
- 16.0 - 17.0	Sand - Medium, occas sorted, subrounded	ionai peoble, po	oriy		ſ								2617.0 - 2618.0	
-18.0	Clayey Silt - Sand from	n above mixed w	vith										2619.0 2620.0	
-20.0	returns	ii above iiixed v	VILII										- 2621.0 - 2622.0	
- 19.0 - 20.0 - 21.0 - 22.0 - 23.0 - 24.0													2623.0 - 2624.0	
-24.0													2625.0 - 2626.0	
-25.0 -26.0 -27.0													2627.0 2628.0	
-28.0													2629.0 - 2630.0	
-27.0 -28.0 -29.0 -31.0													2631.0 2632.0	
- 32.0	G.17 GI												2633.0 - 2634.0	
- 33.0 - 34.0 - 35.0	Silty Clay												2635.0 - 2636.0	
-36.0 -37.0													2637.0 2638.0	
- 38.0 - 39.0 - 40.0													- 2639.0 - 2640.0	
-40.0 -41.0													2641.0 - 2642.0	
-42.0 -43.0													2643.0 2644.0	
-44.0 -45.0													2645.0 - 2646.0	
- 46.0 - 47.0													2647.0 2648.0	
-48.0													2649.0 - 2650.0	
- 49.0 - 50.0													2651.0 - 2652.0	
- 51.0 - 52.0 - 53.0 - 54.0 - 55.0 - 56.0 - 57.0 - 58.0 - 59.0 - 60.0													2653.0 - 2654.0	
- 54.0 - 55.0													2655.0 - 2656.0	
- 56.0 - 57.0													2657.0 - 2658.0	
-58.0													2659.0 - 2660.0	
-60.0 -61.0													2661.0 - 2662.0	
-62.0													2663.0 - 2664.0	
- 63.0 - 64.0 - 65.0	Siltstone - Highly wea	thered, soft											2665.0 2666.0	
-66.0													2667.0 - 2668.0	
- 67.0 - 68.0 - 69.0	Siltstone												2669.0 - 2670.0	
- 70.0 - 71.0													2671.0 - 2672.0	
- 70.0 - 71.0 - 72.0 - 73.0													2673.0 - 2674.0	
- /4 ()													2675.0 - 2676.0	
- 75.0 - 76.0 - 77.0 - 78.0 - 79.0													2677.0 - 2678.0	
- 77.0 - 78.0													2679.0 - 2680.0	
- 80.0													2681.0 - 2682.0	
-81.0 -82.0	Sandstone - Fine grain	ed											2683.0 2684.0	
- 83.0 - 84.0	Siltstone												2685.0 - 2686.0	
	Alberta Research Cour	ncil			L	OGGEI	O BY	: Alec Bly	/th	COMP	LETION DE	PTH:	464.00 (ft)	
			Date 1	printed: 12-Apr-20	07 T	YPE: G	as N	Ionitoring	Well		COMPLE	ΓED:		

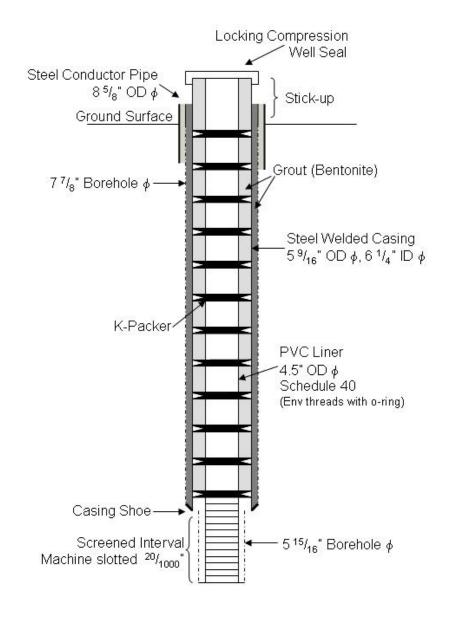
INSTALLED BY: Alberta Research Council SITE: 87	20000		
	8789009		
DRILL TYPE: Air Rotary North: 51.181 West: 112.569 ELEVATION: 2601.706	(ftasl)		
FILL TYPE: Slough Bentonite Grout Backfill Sand Peltonite Open Hole Unknown			
SAMPLE TYPE: Shelby Tube No Recovery Split Spoon Disturbed Dynamic Cone Grab Samp	le		
D	Е		
· WELL	l e		
LITHOLOGIC DESCRIPTION INSTALLATION	v		
Casing diam. = 0.464 ft (ft) Borehole diam. = 0.654 ft	(ftasl)		
- 86.0	- 2687.0 - 2688.0		
$-87.0 \\ -88.0$	- 2689.0 - 2690.0		
$-89.0 \\ -90.0$	2691.0 2692.0		
- 91.0 - 92.0	- 2693.0 - 2694.0		
-02.01	2695.0 - 2696.0		
94.0 95.0 96.0 97.0 98.0 99.0 Sandstone - Soft, water ~0.5 IGPM	- 2697.0 - 2698.0		
- 97.0 - 98.0 Sandstone - Soft, water ~0.5 IGPM	- 2699.0 - 2700.0		
- 99.0 Shala Silty in places	2701 - 2702		
$\begin{bmatrix} -100 \\ -101 \end{bmatrix}$ Shale - Silty in places	- 2703 - 2704		
$egin{array}{c c} -103 & & & & & & & & & & & & & & & & & & &$	2705 - 2706		
$egin{array}{c c} -105 \\ -106 \\ \hline \end{array}$	2707 - 2708		
-107 -108	2709 - 2710		
$egin{array}{c c} -109 & & & & & & & & & & & & & & & & & & &$	- 2711 - 2712		
- 111 - 112	2713 2714		
$\begin{bmatrix} -113 \\ -114 \end{bmatrix}$ Sandstone - Soft, fine grained	- 2715 - 2716		
- 115 - 116	2717 - 2718		
- 117 - 118 Siltstone	- 2719 - 2720		
- 119 Shistone	- 2721 - 2722		
103 104 105 105 106 107 107 108 109 109 100 101	2723 2724		
$\begin{bmatrix} -123 \\ -124 \end{bmatrix}$	- 2725 - 2726		
$\begin{bmatrix} -125 \\ -126 \end{bmatrix}$ Shale - Occasional light brown surfaces	- 2727 - 2728		
$-\frac{127}{128}$	2729 2730		
$-\frac{129}{130}$	- 2731 - 2732		
$\begin{bmatrix} -131 \\ -132 \end{bmatrix}$	2733 - 2734		
- 134 Coar - WEAVER COAE, water -1 101 M	2735 2736		
$\begin{bmatrix} -135 \\ -136 \end{bmatrix}$ Shale	- 2737 - 2738		
$\begin{bmatrix} -137 \\ -138 \end{bmatrix}$	- 2739 - 2740		
$\begin{bmatrix} -139 \\ -140 \end{bmatrix}$	2741 2742		
$-141 \mid -142 \mid$	- 2743 - 2744		
$egin{array}{c c} -143 & & & & \\ -144 & & & & & \\ \hline \end{array}$	2745 2746		
145 - 146 Sandstone - Fine grained	- 2747 - 2748		
148 Coal - WEAVER COAL, water minor	- 2749 - 2750		
149 (com white state of the sta	2751 2752		
- 151 Shale - Shty - 152	- 2753 - 2754		
- 153 - 154	- 2755 - 2756		
155 Sandstone - Hard, fine grained	- 2757 - 2758		
158	- 2759 - 2760		
- 159 Coal - WEAVER COAL, water minor	- 2761 - 2762		
- 161 - 162 - 163 - 164 - 165	2763 2764		
- 164 - 165	- 2765 - 2766		
- 100 Candetona Fina grained	2767 - 2768		
- 167 - 168 - 169 - 169 - 169 - 169	2769 2770 2771		
LOCCED DV. Also Divide COMDI ETION DEDTIL 464	00 (ft)		
Alberta Research Council Date printed: 12-Apr-2007 Date printed: 12-Apr-2007 TYPE: Gas Monitoring Well COMPLETION DEPTH: 404 COMPLETION DEPTH: 404	50 (II)		

Ros	ebud Dril	lling		/Redland					BOREHOLE:			Rosebud Well 1		
INST	ΓALLED	BY: Alberta Res						SITE:			8789009			
DRI	LL TYPE	E: Air Rotary			North: 51	.181	V	Vest: 112.	.569		ELEV	ATION:	2	2601.706 (ftasl)
FILI	TYPE:	Slough	Bentonite		Grout	Backf	ill	Sand	E E	Peltoni	te	Open Hole		Unknown
SAN	IPLE TY	PE:	Shelby Tube	1	No Recovery	Split :	Spoon	Disturbe	ed 🔲 l	Dynam	nic Cone	Core		Grab Sample
D e p t h	I	LITHOLO	GIC DESC	CRI	PTION	1			I	C	Casing diam.	LATION		E 1 e v
- 171 - 172 - 173 - 174 - 175 - 176 - 177 - 178	Sandsto	one - Hard, fine	grained											2712 2773 2774 2775 2776 2777 2778 2778 2779
- 179 - 180	Coal -	WEAVER COA	L, water ~1.5 IC	GPM										- 2780 - 2781 - 2782
- 181 - 182 - 183 - 184 - 185 - 186 - 187 - 188 - 189	Shale													- 2783 - 2784 - 2785 - 2786 - 2787 - 2788 - 2788 - 2789 - 2790 - 2791
- 191 - 192	Sandsto	one - Fine grain	ed											- 2792 - 2793 - 2794
193 194 195 196 197 198 199 200 201 202 203 204 205 206 207		Ocassional ligh is layers	t brown, hard											= 2795 = 2797 = 2797 = 2798 = 2798 = 2800 = 2801 = 2803 = 2803 = 2804 = 2805 = 2806 = 2807 = 2807 = 2808
- 208 - 209 - 210 - 211 - 212 - 213 - 214 - 215 - 216	Sandsto	one - Fine grain	ed											2810 2811 2812 2813 2814 2815 2816 2817
171 172 173 174 175 176 177 178 179 180 181 181 182 181 181 182 181 181 182 181 183 184 185 186 187 188 189 190 191 195 196 197 198 199 190 201 202 203 204 205 206 207 208 209 210 212 213 214 215 216 217 218 219 210 210 201 202 203 204 207 208 209 200 201 201 202 203 204 207 208 209 200 201 202 203 204 205 207 218 219 210 210 210 208 209 200	Shale -	Bentonitic clay	layer at 219'											= 2818 = 2820 = 2821 = 2822 = 2823 = 2824 = 2825 = 2825 = 2827 = 2828 = 2831 = 2831 = 2832 = 2834 = 2834
- 235 - 236 - 237 - 238 - 239 - 240 - 241 - 242 - 243 - 244 - 245 - 246 - 247 - 248 - 249 - 250 - 251	Sandsto grained Shale	one - Very hard,	siliceous, fine											2837 2838 2839 2840 2841 2841 2843 2844 2844 2845 2846 2847 2848 2849 2849 2850 2851 2852
- 252 - 253 - 254														2854 - 2855 - 2856
	Alber	ta Research Coun	cil			LC	GGED I	BY: Alec	Blyth		COMP	LETION DE	РТН	
				Date p	orinted: 12-Apr-20	TYPE: Gas Monitoring Well COMPLETED:							:	

Rose	bud Drilling		Rosebud	/Redlar	ıd			BOREH	OLE:	Rosebud Well 1		
INST	ALLED BY: Alberta Res								SITE:	8789009		
DRIL	L TYPE: Air Rotary			North: 51	.181		We	st: 112.569)	ELEVATION:		2601.706 (ftasl)
FILL	TYPE: Slough	Bentonite	\square	Grout	Bac	kfill		Sand	Peltor	nite	Open Hole	Unknown
SAM	PLE TYPE:	Shelby Tube		No Recovery	₩ Spl	it Spoon		Disturbed	Dyna	mic Cone	Core	Grab Sample
D										*****		E l
e p	LITHOLO	CIC DEC	TDI	DTION	т					WEI		e
t h	LITHOLO	GIC DESC	.KI	PHON	١					ATION	v	
(ft)										Casing diam. = Borehole diam.		(ftasl)
- 256 - 257												2857 2858
- 256 - 257 - 258 - 259 - 260	G 1 . II 1 C											- 2859 - 2860
- 260 - 261	Sandstone - Hard, fine	grained										- 2861 - 2862
- 261 - 262 - 263												- 2863 - 2864
- 264 - 265	Siltstone - Minor coal a	at 278'										2865 - 2866 - 2867
- 266 - 267												2868 - 2869
- 268 - 269												2870 2871
- 270 - 271												- 2872 - 2873
- 272 - 273												2874 - 2875
- 274 - 275												- 2876 - 2877
- 276 - 277												- 2878 - 2879
- 278 - 279												- 2880 - 2881
- 280 - 281												2882 2883
- 282 - 283												2884 - 2885
- 268 - 269 - 270 - 271 - 272 - 273 - 274 - 275 - 276 - 277 - 278 - 279 - 280 - 281 - 282 - 283 - 284 - 285 - 286												2886 2887
- 286 - 287 - 288												2888 2889
– 289 I												- 2890 - 2891
- 290 - 291 - 202												- 2892 - 2893
- 292 - 293 - 204												- 2894 - 2895
- 294 - 295 - 296												2896 - 2897
- 297 - 298												2898 2899
- 299 - 300												2900 - 2901 - 2902
- 301 - 302												2902 - 2903 - 2904
- 303												2905 - 2906
- 305 - 306												2907 - 2908
- 307 - 308												2909 - 2910
- 304 - 305 - 306 - 307 - 308 - 309 - 310 - 311 - 312												2911 2912
- 311 - 312	Coal - GARDEN PLAI	NS			/							- 2913 - 2914
- 313 - 314 - 315 - 316 - 317	Shale											- 2915 - 2916
- 315 - 316	Sandstone - Fine grains	ed										2917 2918
- 317 - 318 - 319	Shale - Minor siliceous	layer, minor										- 2919 - 2920
- 320	coal at 326'	•										- 2921 - 2922
- 322 - 323												- 2923 - 2924
- 324 - 325												- 2925 - 2926
- 326 - 327												- 2927 - 2928
- 328 - 329	Sandstone - Hard, fine	arained										2929 2930 2931
- 321 - 322 - 323 - 324 - 325 - 326 - 327 - 328 - 329 - 330 - 331 - 333 - 333 - 333 - 333 - 333		granicu			/							2931 2932 2933
- 332 - 333	Shale	omoins d										2934 - 2935
- 334 - 335	Sandstone - Hard, fine		/							2936 - 2937		
- 337	Shale									- 2938 - 2939		
- 338 - 339	Sandstone - Hard, fine	grained										2940 - 2941
	Siltstone Alberta Research Counc		I	OGGE	D BY	Y: Alec Bly	rth	COMPL	ETION DEP			
	moera research Coull	Date	printed: 12-Apr-20				1onitoring		COMPLETED:			

Rose	ebud Drilling		Rosebud	/Redla	nd			BOREF	HOLE:	Rosebud Well 1			
INST	ALLED BY: Alberta Rese								SITE:		8789009		
DRIL	L TYPE: Air Rotary			North: 51	.181		We	est: 112.569		ELEVA	TION:	260	1.706 (ftasl)
FILL	TYPE: Slough	Bentonite	\square	Grout	Ва			Sand	Pelton		Open Hole	Uni	known
SAM	PLE TYPE:	Shelby Tube		No Recovery	∭ SĮ	olit Spoon		Disturbed	Dyna:	mic Cone	Core	Gra	ab Sample
D										XX/Ici	T T		E I
e p	LITHOLO	GIC DESC	RI	PTION	J				INIC	WE			e v
t h	Limolo	GIC DESC	/1 11	11101	•					Casing diam.	ATION = 0.464 ft		
(ft)										Borehole diam			(ftasl)
- 341 - 342													2943 2944
- 343 - 344	Coal - GARDEN PLAI	NS				Л							- 2945 - 2946
- 344 - 345 - 346 - 347	Shale - Sandy at 351'												2947 2948
- 347 - 348 - 340													2949 2950
- 350 - 351													- 2951 - 2952
- 352 - 353													2953 - 2954
- 348 - 349 - 350 - 351 - 352 - 353 - 354 - 355 - 356	Sandstone - Hard, fine	arainad											2955 2956 2957
- 357	Saliustolle - Haru, fille	granieu											2957 - 2958 - 2959
- 358 - 359	Coal - GARDEN PLAI	NS				\int_{Γ}							2960 - 2961
- 360 - 361	Sandstone - Fine graine	ed											- 2962 - 2963
- 362 - 363 - 364	Siltstone												- 2964 - 2965
- 365													- 2966 - 2967
- 366 - 367 - 368													2968 2969
- 369 - 370 - 371	Sandstone - Fine grain	ed, silty											- 2970 - 2971
- 371 - 372	Siltstone												2972 - 2973 - 2974
- 372 - 373 - 374 - 375 - 376	Sandstone - Fine graine	ed				Г							2975 2976
- 375 - 376	Siltstone - Siliceous lay	ver at 374'											2977 2978
- 377 - 378 - 379 - 380	Shale - Siliceous layer a												- 2979 - 2980
- 379 - 380													2981 - 2982
- 381 - 382 - 383													- 2983 - 2984
- 383 - 384 - 385													- 2985 - 2986
- 386 - 387													2987 2988
- 388 - 389													- 2989 - 2990
- 390 - 391													2991 - 2992 - 2993
- 392 - 393													2993 - 2994 - 2995
- 394 - 395													2996 2997
- 396 - 397													- 2998 - 2999
- 398 - 399													- 3000 - 3001
- 400 - 401	Sandstone - Hard, fine	grained											- 3002 - 3003
- 402 - 403 - 404													- 3004 - 3005
- 405													3006 - 3007
- 406 - 407 - 408	\Siltstone												- 3008 - 3009
- 409 - 410	Sandstone - Hard, fine	grained				/							- 3010 - 3011 - 3012
- 411 - 412	Siltstone - Sandy from												3012 - 3013 - 3014
-413 -414	·												- 3015 - 3016
- 415 - 416													- 3017 - 3018
- 415 - 416 - 417 - 418													- 3019 - 3020
- 419 - 420													- 3021 - 3022
- 421 - 422 - 423												- 3023 - 3024	
- 423 - 424					<u></u>								3025 3026
	Alberta Research Counc			LOGGE	D B	Y: Alec Bly	/th	COMPI	LETION DEI	TH:	464.00 (ft)		
		Date	printed: 12-Apr-20	007	TYPE: C	Gas N	Monitoring	Well		COMPLET	ED:		

Rose	bud Drill	ing	/Redlan	d				BORE	HOLE:	Ro	osebud Well 1			
INST	ALLED I	BY: Alberta Rese							SITE:			8789009		
DRII	L TYPE:	Air Rotary			North: 51	.181		We	st: 112.569)	ELEV	ATION:	26	601.706 (ftasl)
FILL	TYPE:	Slough	Bentonite		Grout	Bac	kfill		Sand	Peltor	nite	Open Hole	U	nknown
	PLE TYP	 E:	Shelby Tube	1	No Recovery	Spli	t Spoon		Disturbed	Dyna Dyna	mic Cone	Core	G	rab Sample
D e p t h (ft)		ITHOLO(GIC DESC	CRI	PTION	Ŋ					WE TAL Casing diam Borehole diam	LATION 1. = 0.464 ft		E 1 e v (ftasl) = 3027 = 3028
- 427 - 428 - 430 - 431 - 431 - 432 - 433 - 433 - 434 - 435 - 436 - 437 - 448 - 449 - 441 - 442 - 442 - 443 - 444 - 445 - 446 - 447 - 450 - 450 - 451 - 452 - 453 - 454 - 454 - 454 - 454 - 458 - 458	Siltstone Siltstone Sandstone													30.28 3030 3031 3031 3033 3034 3035 3036 3037 3038 3039 3040 3040 3042 3043
- 443 - 444 - 445 - 446 - 447 - 448 - 449 - 450 - 451 - 452 - 453 - 454 - 455 - 456	Siltstone Coal - G	ARDEN PLAI	NS											3045 3046 3047 3048 3049 3051 3051 3052 3053 3054 3055 3055 3055 3055
- 456 - 457 - 458 - 459 - 460 - 461 - 462 - 463 - 464 - 465	\Siltstone)		20										= 3058 = 3059 = 3060 = 3061 = 3062 = 3063 = 3064 = 3065
		END C Oth W	NS, shaley lense DF HOLE AT 40 alor wells in nest ell status: Activ	64.0 f	t		OGGEI) BY	γ· Alec Blv	<i>r</i> th	СОМІ	PI ETION DE	отн.	3066 3067 3068 3069 3070 3071 3071 3072 3073 3073 3074 3075 3077 3077 3077 3077 3077 3080 3081 3081 3081 3082 3085 3086 3088 3088 3089 3090 3091 3091 3094 3095 3096 3097 3096 3097 3096 3097 3097 3098 3099 31101 31101 31101 31101 31101 31101
	Alberta	Research Counc	eil	Date p	orinted: 12-Apr-20				Y: Alec Bly Monitoring		COMF	COMPLET		464.00 (ft)



Schematic Completion Diagram for Rosebud Monitoring Well #1 (not to scale)

Rosebud Well #2

SW-18-27-21 W4 N 51.18092°, W 112.56922, 793 m

Depth		Lithology Description
Ground		01 0114
0	2	Clayey Silt, med. brown
2	3	Silty Clay, med. brown
3	5	Clayey Silt, med. brown
5	6.5	Sandy Silt, It. brown
6.5	14	Silty Sand, lt. brown, occasional pebble
14	15	Sand, medium to coarse grained, poorly sorted, subrounded
15	17	Silty Sand, It brown, some clay
17	20	Clayey Silt, It. grey, some sand
20	26	Silty Clay, It. grey, with occasional pebble
26	28	Clayey Silt, It. Grey
28	51	Silty Clay, It. grey, with occasional pebble
51	61	Silty Clay, bluish grey
61	67	Siltstone, med. brown, highly weathered, soft
67	83	Siltstone, med. grey
83	86	Sandstone, It. grey, fine grained
86	90	Siltstone, med. grey
90	96	Shale, black
96	99	Siltstone, med. grey
99	99.5	COAL (Carbon Thompson), shaley. Water ~ 0.25 IGPM
99.5	103	Shale, black
103	104	Siltstone, med. grey
104	112	Shale, black
112	118	Sandstone, It. grey, fine grained
118	120	Siltstone, med. grey
120	127	Sandstone, It. grey, fine grained
127	129	Siltstone, med. grey
129	130	Shale, black
130	131.0	Siltstone, med. grey
131.0	132.5	COAL (Weaver). Water ~ 0.5 IGPM
132.5	142	Shale, black
142	145	Sandstone, It. grey, fine grained
145	145.5	Shale, brown
145.5	146	COAL (Weaver). Water minor
146	146.5	Shale, bentonitic
146.5	153	Shale, black
153	161	Sandstone, It. grey, fine grained
161	172	Shale, black
172	176	Sandstone, It. grey, fine grained
176	178	Shale, black
178	181	COAL (Weaver). Water ~0.75 IGPM
181	182	Shale, black
End of Hole		

Completion Details

Borehole diameter 7 7/8" from surface to 175 ' (53.34 m) Borehole diameter 5 15/16" from 175-182' (53.34 to 55.47 m)

Steel Casing diameter 6 5/8" (OD), 6 1/4" (ID), welded joints, from -1.94 - 175' (-0.59m to 53.34 m) Liner diameter 4.94" (OD), 4.5" (ID), threaded, from -1.94 - 182' (-0.59m to 55.47 m) Screened section of liner, 20 slot machined, 173-182' (52.73 to 55.47 m)

Bentonite grout from surface to 175' (53.34 m) outside steel casing Bentonite grout from surface to 173' (52.73 m) between steel casing and liner

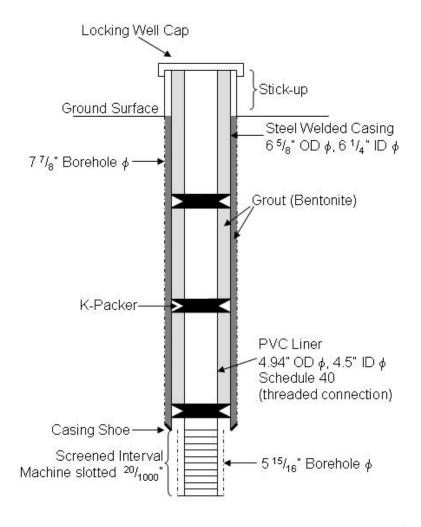
K-Packers at 60, 120 and 172'

Completed Well Measurements
Depth of well 183.45' (55.92 m) to Top of Casing
Casing Stick up 1.94' (0.59 m)
Total depth of well 181.51' (55.34 m) below ground surface
Static Water Level 13.11 m (below ground surface)

Rose	ebud Drilling	Rosebud	/Redlan	d				BOR	EHOLE:	Rosebud Well 2			
INST	CALLED BY: Alberta Rese								SITE	:	8789009		
DRII	LL TYPE: Air Rotary			North: 51	.181		We	est: 112.569)	ELE	VATION:	2601	.706 (ftasl)
	TYPE: Slough	Bentonite		Grout	Bac	kfill		Sand	Peltor	nite	Open Hole	Unkn	iown
	IPLE TYPE:	Shelby Tube	1	No Recovery			Ē	Disturbed	Dyna Dyna	mic Con	Core	Grab	Sample
D					<u>~~~</u> 1				٠ اللـــا				Е
e p			~~~	DELON	.					\mathbf{W}	ELL		l e
t h	LITHOLO	GIC DESC	CRI	PTION	1				INS	TAI	LATION	•	v
(ft)									I		nm. = 0.552 ft iam. = 0.654 ft		(ftasl)
- 1.0	Clayey Silt - medium b	rown											2602.0 2603.0
-2.0 -3.0	Silty Clay - medium bro												2604.0
-4.0 -5.0					'								- 2605.0 - 2606.0
-6.0	Clayey Silt - medium b												- 2607.0 - 2608.0
- 7.0 - 8.0	Sandy Silt - light brown												- 2609.0 - 2610.0
- 9.0 - 10.0	Silty Sand - light brown pebble	n, occasional											- 2611.0
-11.0	1 *												- 2612.0 - 2613.0
- 12.0 - 13.0 - 14.0													2614.0 - 2615.0
- 14.0 - 15.0	Sand - medium to coars	se grained noor	 ·lv										2616.0 2617.0
- 16.0 - 17.0	sorted, subrounded				i i_								2618.0
-18.0	Silty Sand - light brown												2619.0 2620.0
- 19.0 - 20.0 - 21.0					- — — — ⁻								2621.0 - 2622.0
-220	C:14-, C1 1:-1-4				/								2623.0 2624.0
-23.0 -24.0 -25.0 -26.0	pebble	with occasional											2625.0
-25.0													2626.0 2627.0
-27.0	Clayed Silt - light gray												2628.0 2629.0
- 28.0 - 29.0 - 30.0	Silty Clay - light gray,	with occasional											2630.0 2631.0
- 30.0 - 31.0	pebble	with occasional											2632.0
-32.0													- 2633.0 - 2634.0
- 32.0 - 33.0 - 34.0													- 2635.0 - 2636.0
-35.0 -36.0													- 2637.0 - 2638.0
-37.0 -38.0													- 2639.0
-39.0													- 2640.0 - 2641.0
- 40.0 - 41.0													2642.0 2643.0
-42.0 -43.0						\bigvee							- 2644.0 - 2645.0
- 44.0 - 45.0													2646.0
-46.0													2647.0 2648.0
- 47.0 - 48.0													2649.0 2650.0
- 49.0 - 50.0													2651.0 2652.0
- 51.0 - 52.0	City Class bloods by												2653.0
- 52.0 - 53.0 - 54.0	Silty Clay - blueish gra	У											2654.0 - 2655.0
-55.0													2656.0 - 2657.0
- 56.0 - 57.0													- 2658.0 - 2659.0
- 58.0 - 59.0													- 2660.0
-60.0								K-Packer					- 2661.0 - 2662.0
-61.0 -62.0	Siltstone - medium bro	wn, highly						1x-1 ackel					- 2663.0 - 2664.0
- 63.0 - 64.0	weathered, soft	,											- 2665.0
-65.0													- 2666.0 - 2667.0
- 66.0 - 67.0													- 2668.0 - 2669.0
- 68.0 - 69.0	Siltstone - medium gray	У											2670.0 2671.0
- 70.0 - 71.0													2672.0
-72.0													2673.0 2674.0
- 73.0 - 74.0													2675.0 2676.0
	Alberta Research Counc				L	OGGE	D B	Y: Alec Bly	rth	COM	IPLETION DE	PTH:	183.45 (ft)
	Alucita Research Coulic	J11	Date	itd- 12 Av - 20				ndwater Mo			COMPLE		- (9)

Rosebud Drilling	Rosebud/	Redland			BOREHOLE:			Rosebud Well 2			
INSTALLED BY: Alberta Research Council					SITE:			8789009			
DRILL TYPE: Air Rotary	North: 51.	.181	We	est: 112.569)	ELEVATION:		2601.706 (ftasl)			
FILL TYPE: Slough Bentonite	Grout	Backfill		Sand	Peltor	nite	Open Hole	Πū	nknown		
SAMPLE TYPE: Shelby Tube	No Recovery	Split Spoon		Disturbed	Dyna	mic Cone	Core		Grab Sample		
D									E 1		
P LITHOLOGIC DESCRI	DTION	r				WE			e		
LITHOLOGIC DESCRI	PHON					NSTALLATION Casing diam. = 0.552 ft					
(ft)						Casing diam Borehole diar			(ftasl)		
- 76.0 - 77.0									2677.0 2678.0		
- 77.0 - 78.0									2679.0 - 2680.0		
- 79.0 - 80.0									- 2681.0 - 2682.0		
- 81.0 - 82.0									- 2683.0		
- 81.0 - 82.0 - 83.0 - 84.0 Sandstone - light gray, fine grained									- 2684.0 - 2685.0		
-85.0									- 2686.0 - 2687.0		
- 86.0 - 87.0 - 88.0 Siltstone - medium gray									- 2688.0 - 2689.0		
- 89 0									- 2690.0 - 2691.0		
90.0 -91.0 -92.0 Shale - black									2692.0		
92.0 92.0									2693.0 2694.0		
- 93.0 - 94.0									2695.0 2696.0		
95.0 - 96.0									2697.0 2698.0		
97.0 98.0 Siltstone - medium gray									2699.0 2700.0		
- 99.0		Г							2701		
- 101 - 102 - 102 ~0.25 IGPM	71								2702 2703		
- 103 - 104 Shale - black									2704 2705		
- 104 - 105 Siltstone - medium gray									2706 2707		
- 105 - 106 - 107 - 108 - 109 - 110 - 111 - 112									2708 - 2709		
- 108 - 109									- 2710 - 2711		
110 111									- 2712 - 2713		
-112									- 2714		
- 113 - 114 - 115 Sandstone - light gray, fine grained									- 2715 - 2716		
-116									2717 2718		
- 117 - 118									- 2719 - 2720		
119 Siltstone - medium gray				IZ D. 1					- 2721 - 2722		
- 121 Sandstone - light gray, fine grained				K-Packer					2723 2724		
_ 123									2725		
- 125 - 126									2726 2727		
120									2728 2729		
- 124 - 125 - 126 - 127 - 127 - 128 - 129 - 129 - Siltstone - medium gray									2730 2731		
- 130 Shale - black									- 2732 - 2733		
- 132 Siltstone - medium gray									- 2734 - 2735		
134 Coal - WEAVER, water ~0.5 IGPM									- 2736		
– 136 Shale - black									- 2737 - 2738		
- 137 - 138									- 2739 - 2740		
- 139 - 140									- 2741 - 2742		
- 139 - 140 - 141 - 142 - 143 - 143 - Sandstone - light gray, fine grained									- 2743 - 2744		
- 143 - 144 Sandstone - light gray, fine grained								- 2745			
- 145								2746 2747			
Shale - brown									2748 2749		
- 148 Coal - WEAVER, water minor									2750 2751		
Shale - bentonitie Shale - bentonitie		LOGGE	ED B	Y: Alec Bly	/th	COMF	LETION DE	PTH:	183.45 (ft)		
	orinted: 12-Apr-200			ndwater Mo			COMPLET		()		

Rose	ling	/Redlan	d				BOREHOLE:			Rosebud Well 2						
INST	ISTALLED BY: Alberta Research Council										SITE:			8789009		
DRIL	L TYPE	: Air Rotary			North: 51	.181		We	st: 112.569)	ELEV	ATION:	2	2601.706 (ftasl)		
FILL	TYPE:	Slough	Bentonite		Grout	Bac	kfill		Sand	Pelton	nite [Open Hole		Unknown		
SAM	PLE TY	PE:	Shelby Tube	1	No Recovery	Spl	it Spoon		Disturbed	Dyna	mic Cone	Core		Grab Sample		
D e p t h	L	ITHOLO	GIC DESC	CRI	PTION						TAL:	ELL LATION n. = 0.552 ft m. = 0.654 ft		E 1 e v (ftasl) == 2752		
- 151 - 152 - 153 - 154 - 155 - 156 - 157 - 158 - 159 - 160 - 161	Sandsto	one - light gray,	fine grained											2753 2754 2755 2755 2757 2758 2759 2760 2760 2761 2762		
- 160 - 161 - 162 - 163 - 164 - 165 - 166 - 167 - 168 - 169 - 170 - 171 - 172 - 173 - 174 - 175 - 176 - 177 - 178 - 180 - 181 - 183 - 184	Shale -	black												- 2763 - 2764 - 2766 - 2766 - 2767 - 2768 - 2770 - 2771 - 2772 - 2772 - 2773		
- 173 174 175	Sandsto	one - light gray,	fine grained						K-Packer					2775 2776 2777		
- 177 - 178	Shale -	black												2778 - 2779		
178 179 180 181	Coal - V	WEAVER, wate	er ~0.75 IGPM											2780 - 2781 - 2782		
- 182 - 183	Shale -	black												- 2783 - 2784		
- 184 - 185 - 186 - 187			F HOLE AT 18 Tell status: Activ		ft									2785 - 2786 - 2787 - 2788		
														- 2789 - 2791 - 2792 - 2793 - 2794 - 2795 - 2796 - 2797 - 2797 - 2799 - 2800 - 2801 - 2804 - 2804 - 2805 - 2806 - 2807 - 2808 - 2807 - 2808 - 2808 - 2809 - 2811 - 2812 - 2814 - 2815 - 2816 - 2818 - 2818		
- 219 - 220 - 221 - 222 - 223 - 224														- 2820 - 2821 - 2822 - 2823 - 2824 - 2825 - 2826		
Alberta Research Council) B	Y: Alec Bly	rth	COMI	PLETION DE	PTH	: 183.45 (ft)		
		Count	·	Date 1	orinted: 12-Apr-20		TYPE: Groundwater Monitoring Well COMPLETED:									



Schematic Completion Diagram for Rosebud Monitoring Well #2 (not to scale)

Redland 9-10-27-22 W4

N 51.292437°, W 113.005688, 800.6 m

Depth from		Lithology Description
Groun	d (feet)	
0	1	Silty Loam Top Soil, drk. brown
1	9	Clayey Silt, med. brown
9	21	Clayey Silt, med. brown, some pebbles
21	24	Gravel, fine, poorly sorted, subrounded
24	35	Silty Clay, med. grey, occasional pebble
35	40	Silty Sandy Clay, med. grey, occasional pebble
40	43	Silty Clay, med. grey, bits of coal
43	48	Clay, bluish grey, hard
48	49	Coal, loose (not bedrock)
49	50	Clay, brown
50	64	Clay, bluish grey, hard
64	68	Siltstone, med. grey, highly weathered, soft
68	76	Siltstone, med. grey
76	80	Sandstone, It. grey, fine grained
80	84	Shale, black
84	84.5	Sandstone, It. brown, siliceous
84.5	90	Shale, black
90	96	Sandstone, It. grey, fine grained
96	97	Shale, black
97	100	Sandstone, lt. grey, fine grained
100	107	Shale, black
107	108	Sandstone, It. grey, fine grained
108	109	Shale, black
109		Sandstone, It. grey, fine grained
110	116.0	Shale, black
116.0	118	Sandstone, It. grey, fine grained
118		Shale, black
143	143.5	Sandstone, It. grey, fine grained
143.5	145	Shale, black
	145.5	Sandstone, It. grey, fine grained
145.5	158	Shale, black, hard siliceous layers at 155' and 158'
158		Sandstone, It. grey, fine grained. Water ~0.25 IGPM
160		Shale, black
166		COAL (Weaver coal). Water ~1.25 IGPM
168	169	Shale, black
End of	hole	

Completion Details

Borehole diameter 7 7/8" from surface to 165 ' (50.29 m) Borehole diameter 5 15/16" from 165-169' (50.92 to 51.51 m)

Steel Casing diameter 6 5/8" (OD), 6 1/4" (ID), welded joints, from -1.97 - 165' (-0.60m to 50.29 m) Liner diameter 4.94" (OD), 4.5" (ID), threaded, from -1.97 - 169' (-0.60m to 51.51 m) Screened section of liner, 20 slot machined, 160-169' (48.77 to 51.51 m)

Bentonite grout from surface to 165' (50.29 m) outside steel casing Bentonite grout from surface to 160' (50.29 m) between steel casing and liner

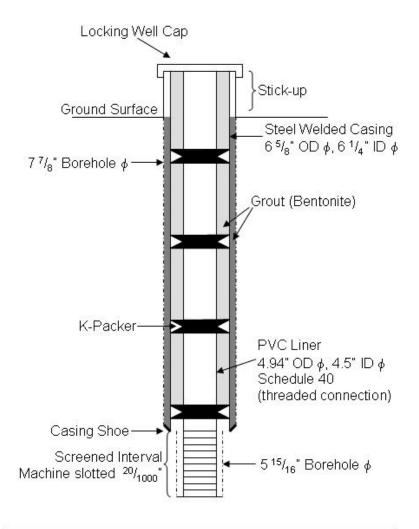
K-Packers at 40, 80, 120 and 160'

Completed Well Measurements
Depth of well 170.69' (52.04 m) to Top of Casing
Casing Stick up 1.97' (0.60 m)
Total depth of well 168.7' (51.44 m) below ground surface
Static Water Level 4.76 m (below ground surface)

Rose	ebud Drill	ing	Rosebud	/Redlai	nd			BORE	HOLE:		Redland Well			
INST	CALLED 1	BY: Alberta Res							SITE:			8789009		
DRII	L TYPE:	Air Rotary	North: 51	.292		We	st: 113.005	1	ELEV <i>A</i>	ATION:	2	626.640 (ftasl)		
FILL	TYPE:	Slough	Bentonite		Grout	Ва	ckfill		Sand	Peltor	nite	Open Hole	ı III i	Unknown
	PLE TYP	PE:	Shelby Tube	1	No Recovery	₩ Sp	lit Spoon	$\overline{\exists}$	Disturbed		mic Cone	Core		Grab Sample
D						<u> </u>	1				<u> </u>			E
e											WE	LL		1 e
p t	L	ITHOLO	GIC DESC	CRI	PTION	1				INS	TALI	LATION		v
h]			Casing diam. Borehole diam			(A D
(ft) - 1.0	- C.1/ I	T. C.1	1 1 1								Sofenoie diam	. = 0.034 II		(ftasl) - 2627.0
-2.0		am Top Soil - o												- 2628.0 - 2629.0
-3.0 -4.0 -5.0	Clayey	Silt - medium b	rown											- 2630.0 - 2631.0
-5.0														- 2632.0
- 6.0 - 7.0 - 8.0 - 9.0														2633.0 2634.0
- 8.0 - 9.0														2635.0 2636.0
- 10.0 - 11.0	Clayey	Silt - medium b	rown, some peb	bles										2637.0 2638.0
- 12.0 - 13.0														2639.0
-14.0														2640.0 2641.0
- 15.0 - 16.0							\leq							2642.0 2643.0
- 17.0 - 18.0														2644.0
100														2645.0 2646.0
-20.0														2647.0 2648.0
-22.0 -23.0	Gravel -	fine, poorly so	rted, subrounde	d										- 2649.0 - 2650.0
-19.0 -20.0 -21.0 -22.0 -23.0 -24.0 -25.0	Silty Cl	ay - medium gr	av oggasional											- 2651.0
-26.0 -27.0	pebble	ay - medium gr	ay, occasionai											- 2652.0 - 2653.0
-27.0 -28.0 -29.0	Process													- 2654.0 - 2655.0
-30.0														- 2656.0 - 2657.0
-31.0														2658.0
- 31.0 - 32.0 - 33.0 - 34.0 - 35.0														2659.0 2660.0
-34.0 -35.0														- 2661.0 - 2662.0
- 36.0 - 37.0	Silty Sa	ndy Clay - med	ium gray,											2663.0
- 38.0 - 39.0	occassio	onal pebble												2664.0 2665.0
-40.0									K-Packer					2666.0 2667.0
- 41.0 - 42.0	Silty Cl	ay - medium gr	•						IX-1 acker					2668.0 2669.0
- 43.0 - 44.0	Clay b	lueish gray, har												2670.0
- 45.0 - 46.0	Clay - 0	iueisii gray, iiai	ıu											2671.0 2672.0
-47.0														2673.0 - 2674.0
- 48.0 - 49.0	Coal - le	oose (not bedro	ck)				- -							- 2675.0 - 2676.0
-50.0	η'		•											- 2677.0
- 51.0 - 52.0 - 53.0	Clay b	lueish gray, har	-d											- 2678.0 - 2679.0
-54.0	Clay - 0	nucisii gray, nai	ıu											- 2680.0 - 2681.0
- 55.0 - 56.0														- 2682.0 - 2683.0
- 57.0 - 58.0														- 2684.0
-59.0														2685.0 - 2686.0
- 60.0 - 61.0														2687.0 2688.0
- 62.0 - 63.0														2689.0 2690.0
- 64.0 - 65.0	C:16-4-	a madi	hiably											2691.0
-66.0	weather	e - medium gray ed. soft	y, nigniy											2692.0 2693.0
- 67.0 - 68.0														2694.0 2695.0
- 69.0 - 70.0	Siltston	e - medium gra	y											2696.0
-71.0														2697.0 2698.0
- 72.0 - 73.0														2699.0 - 2700.0
- 74.0											1			- 2701.0
	Albert	a Research Counc	cil				LOGGE	D BY	: Alec Bly	th	COMP	LETION DE	PTH:	170.69 (ft)
				Date p	printed: 12-Apr-20	07	ГҮРЕ: С	3rour	ndwater Mo	onitoring V	Well	COMPLE	TED:	

Rose	bud Drill	ing	Rosebud/Redland							EHOL	Redland Well				
INSTALLED BY: Alberta Research Council										SITE:		8789009			
DRII	L TYPE:	Air Rotary	North: 51.292 We				st: 113.005	5	ELEV	ATIC	N:	2626.640 (ftasl)			
FILL	TYPE:	Slough	Bentonite		Grout	Bac	kfill		Sand	Peltor	nite	Op	en Hole	П	Unknown
	PLE TYP		Shelby Tube	1	No Recovery	Spl		Ħ	Disturbed	Dyna Dyna	mic Cone	Co	ore	$\overline{\Box}$	Grab Sample
D e p t h		ITHOLOG	GIC DESC	CRI								n. = 0.55			E l e v (ftasl)
- 76.0 - 77.0 - 78.0 - 79.0 - 80.0 - 81.0 - 82.0 - 83.0 - 84.0	Sandston Shale - b	ne - light gray, fi	ine grained						K-Packer		overlose du				- 2702.0 - 2703.0 - 2704.0 - 2706.0 - 2707.0 - 2708.0 - 2708.0 - 2709.0 - 2709.0 - 2709.0
- 85.0 - 86.0 - 87.0 - 88.0 - 89.0 - 90.0 - 91.0 - 92.0 - 93.0 - 94.0	Shale - b	ne - light brown, black ne - light gray, fi													- 2711.0 - 2712.0 - 2713.0 - 2714.0 - 2715.0 - 2716.0 - 2717.0 - 2719.0 - 2720.0 - 2720.0 - 2721.0
95.0 96.0 97.0 98.0 99.0 100 101 102 103 104 105 106 107 108 109	\Shale - \text{Sandston} Shale - \text{\text{Bandston}}	ne - light gray, fi	ine grained												- 2722.0 - 2723.0 - 2724.0 - 2725.0 - 2726 - 2727 - 2728 - 2729 - 2730 - 2731
- 106 - 107 - 108 - 109 - 110 - 111 - 112 - 113 - 114 - 115	Shale - b	ne - light gray, fi													- 2733 - 2734 - 2735 - 2736 - 2737 - 2738 - 2739 - 2740 - 2741
	Shale - b	ne - light gray, fi	ine grained						K-Packer						= 2742 = 2743 = 2744 = 2745 = 2746 = 2747 = 2749 = 2750 = 2751 = 2752 = 2753 = 2753 = 2754 = 2756 = 2757 = 2760 = 2761 = 2762 = 2763 = 2764 = 2765 = 2767 = 2768 = 2768 = 2776 = 2776 = 2777 = 2778
		Mack, hard silice k k§ e'arch Counci				I	OGGEI) BY	: Alec Bly	/th_	COM	PLET	ION DEP	ТН	
				Date p	orinted: 12-Apr-20	07 T	YPE: C	rour	ndwater Mo	onitoring V	Well	C	OMPLET	ED:	

Rosebud Drilling Rosebud/Red						/Redlan	d				BOR	EHOLE:		Redland Well
INSTALLED BY: Alberta Research Council												:	8789009	
DRILL TYPE: Air Rotary North: 51.292								We	st: 113.005		ELE	VATION:		2626.640 (ftasl)
FILL '	TYPE: 🖇	Slough	Bentonite		Grout	Bac	kfill		Sand	Pelton	iite	Open Hole	Ш	Unknown
SAMI	PLE TYPE	 E:	Shelby Tube		No Recovery	Spli	t Spoon		Disturbed	Dyna	mic Con	Core		Grab Sample
D e p t h	LI	THOLO	GIC DESC	CRI							TAI Casing dia	ELL LATIO um. = 0.552 ft iam. = 0.654 ft	N	E 1 e v (ftasl)
- 151 - 152 - 153 - 154 - 155 - 156 - 157 - 158 - 159 - 160 - 161 - 162 - 163 - 164 - 165 - 166 - 167 - 177 - 178 - 179 - 170 - 171 - 172 - 173 - 174 - 175 - 177 - 178 - 177 - 178 - 179 - 180 - 181 - 182 - 183 - 184 - 185 - 188 - 189 - 190 - 191 - 192 - 193 - 194 - 195 - 196 - 197 - 200 - 201 - 201 - 202 - 203 - 204 - 205 - 206 - 207 - 208 - 209 - 210 - 211 - 212 - 213 - 214 - 215 - 216 - 217 - 218 - 219 - 220 - 220 - 221 - 221 - 221 - 221 - 221 - 221 - 221 - 222 - 223 - 224 - 225 - 226 - 227 - 228 - 229 - 220 - 221 - 221 - 221 - 221 - 221 - 222 - 223 - 224 - 225 - 226 - 227 - 228 - 229 - 220 - 221 - 221 - 221 - 221 - 221 - 222 - 223 - 224 - 225 - 226 - 227 - 228 - 229 - 220 - 221 - 221 - 221 - 221 - 222 - 223 - 224 - 225 - 226 - 227 - 228 - 229 - 220 - 221 - 221 - 221 - 222 - 223 - 224 - 225 - 226 - 227 - 228 - 229 - 220 - 221 - 221 - 221 - 221 - 222 - 223 - 221 - 221 - 222 - 223 - 224 - 225 - 226 - 227 - 228 - 229 - 220 - 221 - 221 - 222 - 223 - 224 - 225 - 226 - 227 - 228 - 229 - 220 - 220 - 220 - 221 - 221 - 222 - 223 - 226 - 227 - 228 - 229 - 220 -	\water at ~	EAVER, Wat ack END O	fine grained, er ~1.25 IGPM OF HOLE AT 17 /ell status: Activ		ft				K-Packer	E	3orehole d	am. = 0.654 ft		- 2777 - 2778 - 2778 - 2779 - 2780 - 2781 - 2782 - 2783 - 2784 - 2785 - 2786 - 2787 - 2788 - 2786 - 2787 - 2788 - 2789 - 2790 - 2791 - 2792 - 2793 - 2794 - 2795 - 2796 - 2797 - 2798 - 2799 - 2800 - 2801 - 2802 - 2803 - 2804 - 2805 - 2806 - 2807 - 2808 - 2809 - 2811 - 2812 - 2813 - 2814 - 2815 - 2816 - 2817 - 2818 - 2819 - 2822 - 2823 - 2824 - 2822 - 2823 - 2824 - 2822 - 2823 - 2833 - 2834 - 2834 - 2835 - 2836 - 2837 - 2838 - 2839 - 2839 - 2830 - 2831 - 2814 - 2815 - 2816 - 2817 - 2818 - 2818 - 2819 - 2820 - 2821 - 2822 - 2823 - 2823 - 2824 - 2825 - 2826 - 2827 - 2828 - 2829 - 2830 - 2831 - 2834 - 2835 - 2836 - 2837 - 2838 - 2839 - 2840 - 2841 - 2844
- 221 - 222 - 223 - 224														- 2848 - 2849 - 2850 - 2851
	Alberta	Research Coun	cil			L	OGGEI) B	: Alec Bly	th	COM	IPLETION D	EPTH	I: 170.69 (ft)
				Date	printed: 12-Apr-20	07 T	YPE: G	rour	ndwater Mo	nitoring V	Vell	COMPL	ETED):

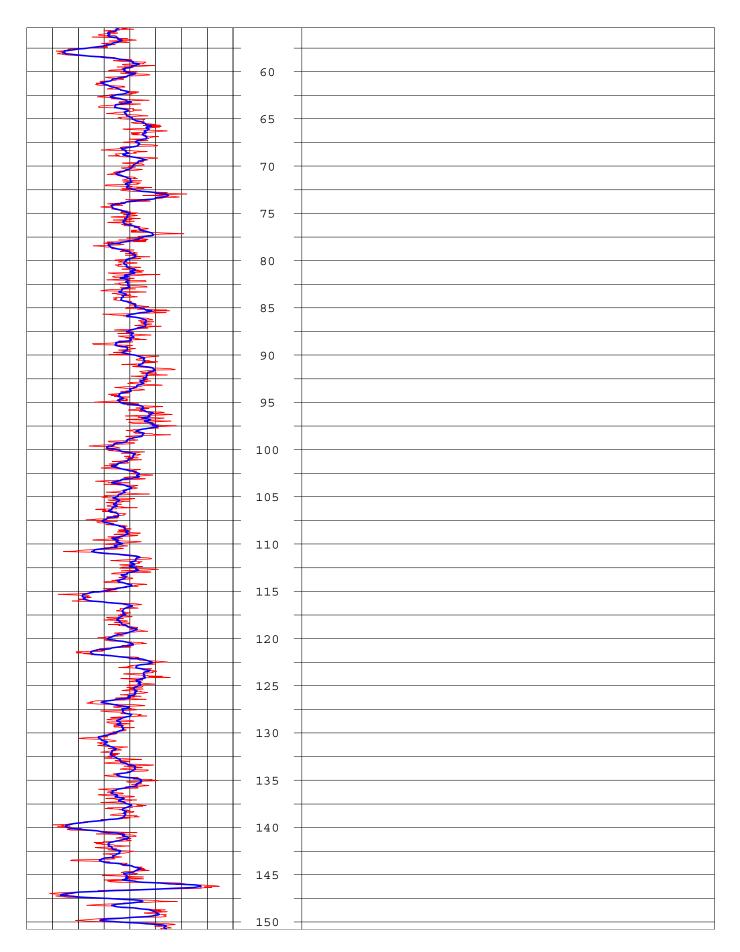


Schematic Completion Diagram for Redland Monitoring Well (not to scale)

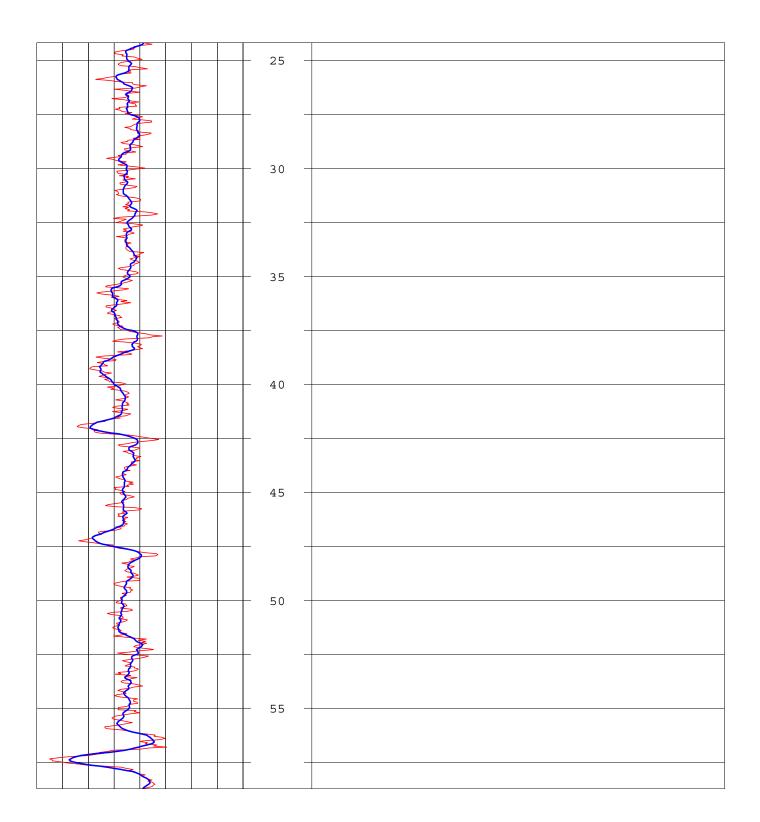
Appendix B E-Log



		COMP	ANY: EN	ZeeTech Ir	nc.
		Locatio	n: Ros	sebud, All	berta
Well	Rosebi	ud-1			OTHER SERVICES
Date	March 2	28, 2007	BH Fluid	H2O	LSD - SW-18-27-21 W4M Elev 795.68
Casin		Steel/P			Lat 51.30158927 Long 112.94917373
File N		Rosebu	d-1 up.WCL		
	n Driller		ı		
Depth	n Logger	Mount	Sopris MG	X II	
Logge		Robert	Kyle		
Witne	SS:		empsey, C.	Гесh.	
0 0	aw *.rd Data - (Depth 60 1m:400m		
	Average (10 p	ts) - Gamma	—		
0	cps	1	60 0 -		
			-		
			5 -		
			10 -		
			15		
		+			
	3		20 -		
			25 -		
		+	-		
			30 -		
			35		
			+ -		
			40		
		+	4.5		
			45		
			50 -		
			-		
ı I I		1 1 1	55 -		



		COMPAN	IY: EN	ZeeTech Ir	nc.
		Location:	Ros	ebud, All	berta
Well	Rosebu	ıd-2			OTHER SERVICES
Date	March 2	8, 2007 B	H Fluid	H2O	LSD - SW-18-27-21 W4M Elev 795.68
Casin		Steel/PV0			Lat 51.30158927 Long 112.94917373
File N	<u> </u>	Rosebud-2	up.WCL		
Depth	Driller				
	Logger	Mount Sc	pris MG	(II	
	ed by:	Robert Ky			
Witne	SS: aw *.rd Data - G	Cliff demp	DSEY, C. I	ech.	
	cps	160	1m:175m		
moving	Average (10 pt	s) - Gamma 160			
7	7		- 0 -		
8	A AMARIAN STATE OF THE STATE OF				
	A		- 5 -		
	The state of the s				
	A Park		- 10 -		
	A PANA		- 15 -		
			- 20 -		



		COM	PAN	IY: EN	ZeeTech Ir	nc.
		Loca	tion:	Red	lland, Alb	perta
Well	Redlan	d 1				OTHER SERVICES
Date	March 2	28, 200	7 B	H Fluid	H2O	LSD - 09-10-27-22 W4M Elev 800.6
Casin		Steel	_			Lat 51.292437 Long 113.005688
File N	<u> </u>	Redla	nd-1	up.WCL		
	Driller			•		
	Logger	Mour	nt So	pris MG	(II	
	ed by:	Robe				
Witne R	SS: aw *.rd File - G		Dem	OSEY, C.T	ecn.	
) Moving	cps Average (10 pt	c) Comm	160	1m:200m		
iviovirig	cps	is) - Gaillill	160			
				- 0 -		
	-			- 5 -		
-				- 10 -		
K				- 15 -		
				- 20 -		
				- 25 -		

