Q. Provide a document that clearly outlines the retirement costs to take Holyrood out of service 2017 (or beyond)? What is the cost to convert unit(s) to synchronous condenser operation? Are these costs factored into the CPW analysis?

A. Since the Holyrood site will not be retired, and production will not cease until approximately 2020, Nalcor has not undertaken detailed studies of the equipment and facility retirements necessary at Holyrood. Planning for these activities will be undertaken over the coming years in consultation with appropriate regulatory authorities.

The cost to convert the units to synchronous condenser operation is not expected to be a major undertaking – the capital cost of conversion is estimated at $7 million.

The cost of conversion has been included in the CPW analysis. As the funds required to convert the units to synchronous condenser operation are also included in the Labrador Island Transmission Link Island Upgrades budget, the separate cost entry in Strategist is not required. This results in a slight overstatement of the Interconnected Scenario CPW, but this is not material, and will be adjusted in subsequent analyses.

Q. With respect to Exhibit 10 (a), please provide the load balance estimate annually from 2014 to 2067 in a format similar to that provided for years 2010 to 2014.

A. Please see attached *MHI-Nalcor-13a* and *MHI-Nalcor-13b*– Energy Balance and LOLH Results - Island Isolated and Labrador HVdc Link for an annual summary of forecast load versus firm energy capability from 2010 to 2067, as well as the LOLH for each year.

2010 PLF FORECAST
ENERGY BALANCE AND LOLH RESULTS
Isolated Island

DATE: April-10 CASE: ISO - INI 100Q SCENARIO: Expansion

YEAR	FORECAST		FIRM	ENERGY	ADDITIONS and RETIREMENTS				LOLH
		Firm	CAPABILITY	BALANCE	Addition	Retirement	Addition	Retirement	
	MW	GWh	GWh	GWh			GWh	GWh	***2.8***
2010	1,519	7,585	8,953	1,368					0.15
2011	1,538	7,709	8,953	1,244					0.22
2012	1,571	7,849	8,953	1,104					0.41
2013	1,601	8,211	8,953	742					0.84
2014	1,666	8,485	9,030	545	*25 MW Wind (77.2 GWh)*		77.2		2.41
2015	1,683	8,606	9,203	597	*Island Pond (172.3 GWh)*		172.3		2.54
2016	1,695	8,623	9,203	580					1.88
2017	1,704	8,663	9,203	540					2.19
2018	1,714	8,732	9,302	569	*Portland Creek (99 GWh)*		99.0		2.44
2019	1,729	8,803	9,302	499					2.23
2020	1,744	8,869	9,410	540	*Round Pond (108 GWh)*		108.0		2.63
2021	1,757	8,965	9,410	445					2.54
2022	1,776	9,062	10,685	1,623	*170 MW CCCT (1340 GWh)*	Hardwoods CT[1] & CBP Co-Gen	1,340.0	(65.0)	2.76
2023	1,794	9,169	10,685	1,516					1.02
2024	1,813	9,232	11,079	1,847	*50 MW CT(394.2 GWh)*	Stephenville CT[1]	394.2		1.35
2025	1,827	9,290	11,079	1,789					1.89
2026	1,840	9,372	11,079	1,706					2.34
2027	1,856	9,461	11,473	2,012	*50 MW CT(394.2 GWh)*		394.2		2.67
2028	1,872	9,543	11,473	1,930	*2 * 27 MW Windfarms*	2 * 27 MW Windfarms	167.0	(167.0)	1.69
2029	1,888	9,623	11,473	1,850					1.52
2030	1,903	9,701	11,867	2,166	*50 MW CT(394.2 GWh)*		394.2		1.72
2031	1,918	9,779	11,867	2,088					1.69
2032	1,934	9,857	11,867	2,010					2.13
2033	1,949	9,935	12,468	2,533	*2 * 170 MW CCCT (1340 GWh)*	Holyrood 1 & 2	2,680.0	(2,078.8)	2.13
2034	1,964	10,014	12,468	2,455	*25 MW Wind*	*25 MW Wind*	77.2	(77.2)	1.25
2035	1,978	10,084	12,468	2,384					1.33
2036	1,992	10,154	12,891	2,737	*170 MW CCCT (1340 GWh)*	Holyrood 3	1,340.0	(917.1)	1.53
2037	2,006	10,225	12,891	2,666					1.06
2038	2,020	10,295	12,891	2,596					1.34
2039	2,033	10,365	12,891	2,526					1.67
2040	2,046	10,428	12,891	2,463					2.01
2041	2,058	10,491	12,891	2,401					2.46
2042	2,070	10,553	13,285	2,732	*50 MW CT(394.2 GWh)*		394.2		2.65
2043	2,082	10,616	13,285	2,670					1.76
2044	2,095	10,678	13,285	2,607					2.13
2045	2,107	10,741	13,680	2,939			394.2		2.59
2046	2,119	10,803	13,680	2,876	*50 MW CT(394.2 GWh)*				2.79
2047	2,132	10,866	13,680	2,814					1.86
2048	2,144	10,928	13,680	2,751	*2 * 27 MW Windfarms*	2 * 27 MW Windfarms	167.0	(167.0)	2.25
2049	2,156	10,991	13,680	2,689	*50 MW CT(394.2 GWh)*	*50 MW CT*	394.2	(394.2)	2.73
2050	2,167	11,046	15,020	3,974	*170 MW CCCT (1340 GWh)*		1,340.0		2.57
2051	2,178	11,100	15,020	3,919					0.35
2052	2,188	11,155	14,625	3,470	*170 MW CCCT (1340 GWh)*	*50 MW CT & 170 MW CCCT*	1,340.0	(1,734.2)	0.52
2053	2,199	11,210	14,625	3,416					1.06
2054	2,210	11,264	14,625	3,361	*25 MW Wind*	*25 MW Wind*	77.2	(77.2)	1.24
2055	2,220	11,319	14,231	2,912		*50 MW CT*		(394.2)	1.76
2056	2,231	11,374	15,571	4,197	*170 MW CCCT (1340 GWh)*		1,340.0		2.65
2057	2,242	11,429	15,571	4,143					0.43
2058	2,253	11,483	15,571	4,088					0.50
2059	2,263	11,538	15,571	4,033					0.59
2060	2,274	11,593	15,571	3,978					0.70
2061	2,285	11,648	15,571	3,924					0.82
2062	2,296	11,702	15,571	3,869					0.96
2063	2,306	11,757	15,020	3,263	*2 * 50 MW CT(394.2 GWh) 170 MW CCCT*	*2 * 170 MW CCCT*	2,128.4	(2,680.0)	1.45
2064	2,317	11,812	15,414	3,602	*50 MW CT(394.2 GWh)*		394.2		2.69
2065	2,328	11,866	15,414	3,547					1.83
2066	2,339	11,921	15,414	3,493	*170 MW CCCT (1340 GWh)*	*170 MW CCCT*	1,340.0	(1,340.0)	2.13
2067	2,349	11,976	16,360	4,384	*170 MW CCCT (1340 GWh)*	*50 MW CT*	1,340.0	(394.2)	2.05

Note: 1. Currently no firm energy associated with Stephenville and Hardwoods CTs.

2010 PLF FORECAST
ENERGY BALANCE AND LOLH RESULTS
Labrador HVdc Link

DATE: October-10 CASE: DCL - INI 101D-M SCENARIO: Expansion

YEAR	FORECAST		FIRM	ENERGY	ADDITIONS and RETIREMENTS				LOLH
		Firm	CAPABILITY	BALANCE	Addition	Retirement	Addition	Retirement	
	MW	GWh	GWh	GWh			GWh	GWh	***2.8***
2010	1,519	7,585	8,953	1,368					0.15
2011	1,538	7,709	8,953	1,244					0.22
2012	1,571	7,849	8,953	1,104					0.41
2013	1,601	8,211	8,953	742					0.84
2014	1,666	8,485	9,347	862	*50 MW CT(394.2 GWh)*		394.2		2.23
2015	1,683	8,606	9,347	742					1.55
2016	1,695	8,623	9,347	724					1.83
2017	1,704	8,663	15,290	6,627	*DCL (5943 GWh)*		5,943.0		0.11
2018	1,714	8,732	15,290	6,558					0.11
2019	1,729	8,803	15,290	6,487					0.12
2020	1,744	8,869	15,290	6,421					0.12
2021	1,757	8,965	12,294	3,330		Holyrood 1 & 2 & 3		(2,995.9)	0.13
2022	1,776	9,062	12,229	3,167		Hardwoods CT[1] & CBP Co-Gen		(65.0)	0.15
2023	1,794	9,169	12,229	3,061					0.23
2024	1,813	9,232	12,229	2,997		Stephenville CT[1]			0.26
2025	1,827	9,290	12,229	2,939					0.48
2026	1,840	9,372	12,229	2,857					0.53
2027	1,856	9,461	12,229	2,768					0.61
2028	1,872	9,543	12,062	2,520		2 * 27 MW Windfarms		(167.0)	0.72
2029	1,888	9,623	12,062	2,440					1.01
2030	1,903	9,701	12,062	2,361					1.14
2031	1,918	9,779	12,062	2,283					1.61
2032	1,934	9,857	12,062	2,205					1.74
2033	1,949	9,935	12,062	2,127					2.06
2034	1,964	10,014	12,062	2,049					2.33
2035	1,978	10,084	12,062	1,978					2.60
2036	1,992	10,154	12,161	2,007	*Portland Creek (99 GWh)*		99.0		2.66
2037	2,006	10,225	13,501	3,277	*170 MW CCCT (1340 GWh)*		1,340.0		2.20
2038	2,020	10,295	13,501	3,206					0.76
2039	2,033	10,365	13,107	2,742		50 MW CT		(394.2)	0.95
2040	2,046	10,428	13,107	2,679					1.40
2041	2,058	10,491	13,107	2,617					1.60
2042	2,070	10,553	13,107	2,554					1.77
2043	2,082	10,616	13,107	2,491					1.94
2044	2,095	10,678	13,107	2,429					2.06
2045	2,107	10,741	13,107	2,366					2.37
2046	2,119	10,803	13,501	2,698	*50 MW CT(394.2 GWh)*		394.2		2.44
2047	2,132	10,866	13,501	2,636					1.89
2048	2,144	10,928	13,501	2,573					2.02
2049	2,156	10,991	13,501	2,510					2.33
2050	2,167	11,046	13,896	2,850	*50 MW CT(394.2 GWh)*		394.2		2.37
2051	2,178	11,100	13,896	2,795					1.78
2052	2,188	11,155	13,896	2,740					1.90
2053	2,199	11,210	13,896	2,686					2.17
2054	2,210	11,264	14,290	3,025	*50 MW CT(394.2 GWh)*		394.2		2.20
2055	2,220	11,319	14,290	2,970					1.63
2056	2,231	11,374	14,290	2,916					1.75
2057	2,242	11,429	14,290	2,861					2.01
2058	2,253	11,483	14,684	3,201	*50 MW CT(394.2 GWh)*		394.2		2.05
2059	2,263	11,538	14,684	3,146					1.49
2060	2,274	11,593	14,684	3,091					1.63
2061	2,285	11,648	14,684	3,036					1.86
2062	2,296	11,702	14,684	2,982					2.08
2063	2,306	11,757	15,078	3,321	*50 MW CT(394.2 GWh)*		394.2		2.13
2064	2,317	11,812	15,078	3,266					1.52
2065	2,328	11,866	15,078	3,212					1.73
2066	2,339	11,921	15,472	3,551	*50 MW CT(394.2 GWh)*		394.2		1.78
2067	2,349	11,976	14,132	2,156		*170 MW CCCT*		(1,340.0)	2.66

Note: 1. Currently no firm energy associated with Stephenville and Hardwoods CTs.

Q. Please identify the additional costs to provide the extended overload capacity of the HVDC system and describe the financial impact it will have on the CPW analysis.

A. The HVDC capital cost estimate developed for Decision Gate 2 was premised upon extended overload capacity in the converters, while the third spare submarine cable was planned to be used to support peak current flow during a temporary pole failure. Thus all identified hardware requirements were included in the HVDC capital cost and hence the CPW analysis.

Q. With respect to Exhibit 11 and the plant maintenance requirements, please describe the HVDC plant performance criteria that are incorporated into the design requirements.

A. While the specific HVdc plant performance criteria have not been defined in detailed design documents, NL Hydro System Planning has reviewed typical performance and operating performance criteria and are satisfied that current HVdc systems can comply with the required system reliability criteria. The preparation of the functional specification that will be issued to potential suppliers of the HVdc converter stations will be part of the detailed design phase of the project which will be performed by SNC Lavalin as part of the Engineering Procurement and Construction Management contract. The overall reliability of the HVdc system is documented in Exhibit 29, Revision 1 and the HVdc plant will be designed to support that reliability level.

Q. With respect to Exhibit 16, figure 7-3, please provide the justification and details supporting the addition of two 50 MW CTs and the 170 MW CCCT in the generation mix (years 2022, 2024 to 2027)?

A. With respect to Exhibit 16, figure 7-2, additional generation is required in 2022, 2024 and 2027 to avoid violating Hydro's planning criterion for capacity:

Capacity: The Island Interconnected System should have sufficient capacity to satisfy a Loss of Load hours (LOLH) expectation target of not more than 2.8 hours per year.

To avoid violating Hydro's capacity criterion, Strategist selected the addition of two 50 MW CTs and the 170 MW CCCT in the generation mix (years 2022, 2024 to 2027) as part of the least cost portfolio.

The LOLH is increasing (and additional generation required) in this case for two reasons:

(1) Normal load growth
(2) Retirement of the Hardwoods 50 MW CT and the end of the 15 MW Corner Brook Co-gen PPA in 2022 and the retirement of the Stephenville 50 MW CT in 2024.

As well, without the addition of generating capability, the Island's firm energy criterion would be violated in 2027.

Energy: The Island Interconnected System should have sufficient generating capability to supply all of its firm energy requirements with firm system capability.

Please refer to the Energy Balance and LOLH Results sheet in MHI-Nalcor-13 for further background information.

Q. As one unit at Holyrood is already capable of synchronous condenser operation; when are the other two units converted? Please provide a document that outlines the plan and timing for the synchronous condenser conversion at Holyrood.

A. While no specific document has been prepared for the plan and timing of the conversion of the remaining two units to synchronous condensers at Holyrood, it is anticipated that conversion must be completed prior to commissioning the Soldiers Pond converter. It has recently been decided that SNC-L will perform the engineering and procurement activities associated with these conversions and as part of that task a schedule and execution plan will be developed in conjunction with the system planning and operations teams.

Q. With respect to Exhibit 15, please explain how the numbers tie to the CPW results? Why were the 75/25 D/E ratio and respective costs not incorporated in the calculation?

A. The supply of Muskrat Falls energy to Hydro is through a power purchase agreement, and not on a cost of service basis. Exhibit 15 shows the development of the power purchase agreement price to Hydro (which is reflected in the CPW analysis), and the inputs used in Exhibit 15 are those for the developer of Muskrat Falls, not Hydro.

For further information, please refer to response to MHI-Nalcor-35.

Q. With respect to Exhibit 18 (HVDC), have the cost estimates and system configuration been upgraded to the current project definition? The original report had the converters at Gull Island and the transmission line was a different voltage. Please provide definitive design report(s) on the final configurations and costs for the HVDC Labrador Island Transmission System.

A. The cost estimates are based on current project definition and composition of the estimates. Please refer to the response to MHI- Nalcor- 7. There is no definitive design report as this work was done internally however document CE 32 (Exhibit 23) HVdc System – Historical Summary outlines the sequence of events leading to the current project definition.

Q. With respect to Exhibit 19 (Muskrat Falls), has there been any detailed analysis carried out relating to the clay spur and the effectiveness of the sump pump system under impounded conditions (tests, simulations, experience of other dam operators)? Please provide supporting documentation.

A. The conceptual design for stabilization of the north spur was outlined in Appendix C of Exhibit 19. As discussed in the attached technical note, the long term stability of the North Spur will be further addressed during the current detailed design phase. The attached technical note also provides information of the work carried out since 1999 relating to the North Spur and associated well point system.

A site investigation is also planned for 2012 to gather additional geotechnical information relating to the North Spur which will be required to complete the detailed design. The capital cost estimate for Muskrat Falls includes the work identified in the 1999 study relating to the North Spur stabilization.

Further details can be found in the attached technical note (Exhibit 38) and consultant reports (Exhibits 39, 40, and 41).

LOWER CHURCHILL PROJECT

MUSKRAT FALLS NORTH SPUR
1999 TO 2011

Technical Note

Date: 20-July-2011
Rec. No. 202-120142-00014

nalcor
energy
LOWER CHURCHILL PROJECT

1. Purpose

The purpose of this technical note is to summarize the work undertaken at the Muskrat Falls North Spur since 1999.

2. Description

In 1999, a Final Feasibility Study report was completed for the generation facility at Muskrat Falls. This report outlined details of previous investigations, soil stratigraphy and properties, groundwater conditions, hydrogeology, stability analyses and a conceptual design for potential stabilization measures.

In 2007, a field program was carried out to assess the condition of the pumpwell system that had been installed in 1981 in order to prevent continued regression of the slopes of the North Spur due to potential landslide activity. The report on the 2007 program, Assessment of Existing Pumpwell System (MF1260) in July 2008, made several recommendations to extend the life of the existing system and ensure its continued operation for the next 10 years. The recommendations included the cleaning and inspection of the 22 wells to enable an assessment of the condition of the system, and the installation of new piezometers to further assess groundwater conditions in the area of the North Spur.

In 2009, a well inspection program was carried out which included cleaning and condition assessment of all 22 wells, their pumps, intake screens, sensors and risers. The operation of all hardware was checked and defective components were replaced. The report on the 2009 program, Evaluation of Existing Wells, Pumps and Related Infrastructure in the Muskrat Falls Pumpwell System (MF1271) in March 2010, described this program and made several recommendations for well assessment, upgrades and continued monitoring.

Also in 2009, a drilling program was carried out for the installation of 8 new piezometers. A report on this program, Installation of New Piezometers in the Muskrat Falls Pumpwell System (MF1272) in April 2010, described this program and made recommendations for future monitoring, including upgrading the data acquisition system.

In 2010, Nalcor installed new telecommunications equipment for the Muskrat Falls site, to improve the reliability of the pump data that is transmitted from site. In addition, Nalcor continues to monitor the overall performance of the system by collecting water level data from the piezometers and performing required maintenance on the system.

The long term stability of the North Spur will be further addressed during the current detailed design phase of the Lower Churchill Project. The conceptual design outlined in the 1999 Study will be analyzed and further developed based on current information and additional geotechnical information that will be obtained in a site investigation program planned for 2012.

3. Reference Reports

For further details, a one to two page description of each of the following reports is included in the Appendix:

MF1260 - Assessment of Existing Pumpwell System
MF1271 - Evaluation of Existing Wells, Pumps and Related Infrastructure in the Muskrat Falls Pumpwell System
MF1272 - Installation of New Piezometers in the Muskrat Falls Pumpwell System

Appendix

MF1260 – Assessment of Existing Pumpwell System

The purpose of this study was to determine the suitability of the pump well system installed on the north spur at the Muskrat Falls site. The scope of this study included an on-site inspection of the system to determine the present physical condition and operational characteristics.

The final report based on this study was submitted to the NE-LCP group in July 2008.

Major Findings

Information obtained from the inspections was compared to historical data from prior investigations to assess the performance of the pump well system.

The dewatering system has operated continuously since 1981 and there has been no major landslide activity on the spur since. However, the system is currently 27 years old, and some rehabilitation work is required to ensure its continued operation for the next 10 years.

The original piezometers were struck by lightning in 1983. Seven (7) new standpipe piezometers were installed in 1997, but one is out of order.

Three (3) of the pumps (W-1, W-2, and W-22) have been decommissioned, and several of the remaining pumps operate less than 100 minutes per annum, while some wells are very active.

It was noted that the main 600 V AC line exiting the control shelter was divided into four (4) runs of 600 V AC. The 600 V AC cable powers three groups of six (6) motors and one group of four (4) motors in series.

Conclusions and Recommendations

It was recommended that data acquisition and automatic data transformation for all piezometers be installed, along with four (4) new standpipe piezometers, in the narrowest section of the spur.

To maintain and improve the dewatering system, the following recommendations were made:

- The wells should be flushed by a qualified company with experience in well drilling, as one well (W-4) was seen to be discharging silt and fine sand;
- A television camera should be used to inspect the screen and confirm its integrity;
- Pumps should be installed in wells W-1, W-2 and W-22;
- A down-hole test called a Radiation Absorption or Density test should be used to inspect any possible voids behind and within the filter;
- Piezoelectric elevations should be recorded on a more frequent basis;
- All pumps, risers and level sensors should be pulled, inspected, and cleaned. All specifications and details of pumps, motors and sensor positions should be recorded and all sensors and relays tested;
- Seven (7) new wells should be installed in three (3) blocks to replace the existing system and maintain the maximum lowering of the groundwater in the area;
- Consideration should be given to the installation of a flow monitoring device at the collector pipe outlet; the output would be transmitted to Goose Bay with pump function data.

In addition, it was recommended that all electrical components from the control panel be tested to ensure the electrical infrastructure was not deteriorating. Back-up power should be provided in the event of a power outage.

An investigation as to the cause of the problematic data, with a review of all overload relays and sensors, should be completed. The remote terminal unit should undergo self testing. This data would then be compared with the transmitted data to determine whether the errors were caused by the monitoring or the radio transmission components of the system.

Due to the unreliability of the transmission components, it was recommended that the following options for data transmission be explored:

- Satellite technology;
- Fibre optic/communications cable along the existing pole line to HVGB;
- Data Transmission over existing power lines;
- Additional upgrades to VHF system.

It was also recommended that the following activities be carried out to assist with the ongoing dewatering operations:

- Implement procedures for responding to high-level alarms;
- Provide back-up pump and motor capability at facilities in HVGB;
- Clear trails to all piezometers and weirs while installing safety hand lines as appropriate;

- Re-bury the exposed portion of the outfall pipe and re-grade the slope to prevent further erosion;
- Replace and/or repair the outfall heater.

MF1271 – Evaluation of Existing Wells, Pumps and Related Infrastructure in the Muskrat Falls Pump well System

The purpose of this study was to present the findings of the 2009 inspection and cleaning program of the pump well system installed on the north spur at the Muskrat Falls site. The scope of work included removal of pumps, risers, and electrical components from the wells, down hole camera inspections, well cleaning, and component inspection and reinstallation.

The second draft of this report was submitted to the NE-LCP group in January 2010.

Major Findings

The wells in the system were operating satisfactorily and wells screens were generally in good condition, with the exception of wells W-1, W-2, W-15 and W- 18. It was expected that W-15 could be readily repaired at the control panel. Wells W-1, W-2 and W-18 may no longer be viable.

The bottom riser, just above the pump, of most of the wells was covered in silt, iron and Manganese deposits and in some cases was corroded. The bottom riser was replaced in 11 wells.

The valves and piping in the area of the pitless adaptor were frequently in poor condition, in particular in well W-4 and well W-9. The couplings at Well W-3 were also in poor condition and were replaced.

Historically, a 3 mm hole was drilled in the bottom riser of all wells to allow for drainage of excess water and as a means of preventing the pipes from freezing. It was possible that spray water from the hole caused moderate build up of iron staining in the screen and high turbidity levels in the area of the pump intake.

In wells W-3, W-5, W-6, W-7, W-8, W-17, W-18 and W-20, the sensors may be set high in relation to the top of the pump and in wells W-5 and W-6, the low sensor is set higher than the measured water level. With the sensors at the current levels, the pumps would not come on frequently in these wells unless the water level rose significantly. Water levels were monitored in the piezometers prior to and throughout the well inspection program. The water levels did not vary more than 0.3 m to 0.6 m from water levels recorded when the well dewatering system was in full operation.

The electrical components of the system continue to be problematic.

Conclusions and Recommendations

The dewatering system has operated continuously since November 1981 and there has been no further major landslide activity on the spur. The purpose of the installation has, therefore, been fulfilled. Rehabilitation work recommended in previous reports has been completed.

MF1272 – Installation of New Piezometers in the Muskrat Falls Pump well System (2009)

Following a field investigation in November 2007, it was recommended in the July 2008 report that eight (8) new piezometers be drilled at four (4) locations to further assess groundwater conditions in the area of the dewatering system. The purpose of this study was to summarize the piezometer installation program that took place in 2009.

The first draft of this report was submitted to the NE-LCP group in October 2009.

Major Findings

The installation of eight (8) new piezometers was completed at Muskrat Falls. Daily field reports were compiled and have been attached to the report.

A total of five (5) boreholes were drilled at four (4) sites using a skidder-mounted CME-55 drill rig provided by Lantech of Dieppe, NB. Borehole depths ranged between 35.4 m and 58.5 m below existing ground surface. Piezometers were then installed in the completed boreholes.

Monitor well Nos. 2009 P1A and P1B, 2009 P3A and P3B, and 2009 P4A and P4B each comprise of two (2) 25 mm ID nested piezometers, installed at different depths. Monitor well Nos. 2009 P2A and P2B each comprise of a single 50 mm ID piezometer. All screens were installed using a coarse slag material as a filter pack and fill material. They were then isolated, top and bottom, with coated bentonite pellets and, with the exception of 2009 P2A and P2B, were fitted with a geosock material and were grouted to near ground surface using a volclay grout.

Conventional split spoon sampling was carried out in borehole 2009 P2B and at selected locations within the other boreholes to identify more permeable soils for the installation of the screens.

Initial water level readings were obtained from each piezometer, with the exception of 2009 P4A and P4B.

Conclusions and Recommendations

Actual locations of the boreholes were modified due to site constraints. In order for this component of the project to remain on budget, it was decided that two (2) smaller piezometers would be nested within each borehole instead of the original plan to install one (1) piezometer in each borehole.

A falling head test was performed at piezometer P2-A and P2-B by adding approximately 45 litres of water to each piezometer and recording the water level variations until the piezometer water elevation stabilized (approximately 60 to 90 minutes).

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THE Lower Churchill PROJECT

July 2008

MF1260 - Assessment of Existing Pumpwell System

prepared by

HATCH™

in association with

RSW inc.

Statnett

TGS TransGrid Solutions

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Executive Summary

The purpose of this WTO was to determine the suitability of the pumpwell system installed in the north spur at the Muskrat Falls site with a view to a life extension of ten years. The review included an on-site inspection of the system to determine the present physical condition and operational characteristics.

In October 2007, an interim report was submitted which described the findings of a site visit during the period from September 9 to 11, 2007 and outlined the requirements of a field program to be undertaken in the autumn of 2007 to obtain additional information to aid in the assessment of the system.

From November 5 to 8, this field program was carried out to perform tests on pumps and piezometers. The dewatering system was shut down for 5 hours each day on November 7 and 8, and the water level recovery in wells and piezometer water elevation were recorded for half of the system each day. Information obtained from these visits was then compared with historical data from prior investigations to assess the performance of the pumpwell system and to determine the required action to allow the system to operate satisfactorily for the next ten years.

The dewatering system has operated continuously since November 1981 and there has been no further major landslide activity on the spur. The purpose of the installation has, therefore, been fulfilled. However, the system is currently 26 years old, and some rehabilitation work is required to ensure its continued operation for the next 10 years.

Piezometers

The originally installed piezometers were struck by lightning in 1983. The new standpipe piezometers, installed in 1997, are partially functional. Only 7 of the 10 suggested piezometers were installed and one of these (P-C) is out of order. The recommendations for piezometer upgrades can be categorized as follows:

- Installation of 4 new standpipe piezometers in the narrowest section of the spur (Figure 4):
    - One piezometer on the west of W-4
    - Two piezometers on both sides of W-9
    - One piezometer in the location of the previously proposed P-E
- Installation of data acquisition systems and automatic data transformation for all piezometers and selected wells including: W-2, W-4, W-9, W-13, W-19, and W-22. The specifications and a cost estimate for the instrumentation are provided in Appendix D.

Until such time as the system is automatic, recording of the piezometric elevations should be undertaken on a more frequent basis (e.g. monthly). There are few records in some years; in 2003, the piezometer elevations were recorded only two times, in 2005: three times, and in 2006: three times.

Wells

Three of the pumps (W-1, W-2, and W-22) have been decommissioned, and several of the remaining pumps operate less than 100 minutes per annum, while some wells are very active. The continued dependence of the dewatering system on only a few wells, W-4 in the South Block and W-9 and W-10 in Central Block, is not advisable. To maintain and improve the dewatering system at the current level, the following are recommended for immediate implementation (less than four months) and in the very near future (less than twelve months):

- The wells have been in continuous operation for 26 years, and based on an inspection of one well (W-4) in the November 2007 site visit which was seen to be discharging silt and fine sand (and the data of the 1994-1996 site activities) there is a need to repeat the flushing of the wells similar to the activities in 1996. Such flushing should be undertaken by a qualified company with experience in well drilling (immediate).
- It would be also appropriate to consider the use of a television camera to inspect the screen and confirm its integrity. The use of a down-hole test called a γ-γ Test (Radiation Absorption or Density test) is also recommended to allow the inspection of possible voids behind and within the filter given the volume of fines which have passed through both since 1981 (immediate).
- Pumps should be installed in wells W-1, W-2, and W-22 (immediate).
- Until the installation of an automatic data acquisition system, the well water elevations and piezometers readings should be recorded and interpreted manually by plotting the phreatic surfaces in different sections of the spur (immediate).
- All pumps, risers and level sensors should be pulled, inspected and cleaned. All specifications and details of pumps, motors and sensor positions should be recorded and all sensors and relays tested (immediate).
- In order to achieve and maintain maximum lowering of the groundwater in the area, seven new wells should be installed in the very near future in three blocks to replace the existing system:
    - In the Southern Block, 2 wells, close to W-4 and place W-4 into a backup mode
    - In the Central Block, 3 wells, close to W-9, W-10, and W-11 and place W-9, W-10, and W-11 into a backup mode
    - In the Northern Block, 2 wells, close to W-18 and W-20 and place W-19 and W-20 into backup mode
- Consideration should be given to the installation of a flow monitoring device at the collector pipe outlet, the output from which could be transmitted to Goose Bay with pump function data (very near future).

Electrical Supply

From the SNC-Lavalin construction report, it was noted that the main 600 V AC line exiting the control shelter was divided into four runs of 600 V AC. The 600 V AC cable runs powered three groups of 6 motors and one group of 4 motors in series. The grouping of motors was not identified. Little is known about the power cables feeding the pumps. It is recommended that all electrical components from the control panel outward be tested to ensure the electrical infrastructure is not deteriorating.

Back-up power should also be provided in the event of a power outage. (While the WTO indicated a generator was on site for this purpose, this is not the case.)

Data Monitoring and Transfer

The data collected by Hydro for the pumps appears unreliable due to ON/ON and OFF/OFF sequences. The ON/OFF data originates from the pump level relay and is processed at the MF Control Shelter before being transmitted by VHF radio to Hydro's offices.

Hydro should investigate the cause of the troublesome data with a review of all overload relays and sensors. The remote terminal unit should undergo self testing. To ensure the data being collected is meaningful, a computer should be installed at the shelter to collect the data before transmission. This data would then be compared with the transmitted data to determine whether the errors are caused by the monitoring or the radio transmission components of the system. It is understood that the transmission components have been upgraded in recent years, and if it is concluded that they are still at fault, the following options for data transmission should then be explored:

- Satellite technology.
- Fibre optic/communications cable along the existing pole line to Goose Bay.
- Data transmission over existing power lines.
- Additional upgrades to VHF system.

General Recommendations

It is recommended that the following activities be carried out to assist with the ongoing dewatering operation:

- Implement procedures for responding to high-level alarms.
- Provide back-up pump and motor capability at site or at Hydro's facilities in Goose Bay.
- Clear trails to all piezometers (1997 and original standpipes) and weirs, and install safety hand lines as appropriate.
- Re-bury the exposed portion of the outfall pipe and re-grade the slope to prevent further erosion. Repair and/or replace the outfall heater.

1. Introduction

Newfoundland and Labrador Hydro (Hydro) is pursuing engineering studies with respect to the development of the hydroelectric potential of the Lower Churchill River at Gull Island and Muskrat Falls. These sites are located downstream 225 km and 285 km respectively from the Upper Churchill hydroelectric facility that was developed in the late 1960s. The total potential capacity at the two sites is approximately 2800 megawatts (MW), the Gull Island site being the larger. In addition to the development of these sites, the overall concept includes various potential transmission arrangements involving combinations of ac and dc lines of various capacities.

Early studies in the late 1970s concluded that the land spur which reaches from the north bank of the Churchill river at Muskrat Falls to the large rock knoll closer to the south bank could be incorporated with a natural embankment dam at this location. In this context the natural spur constituted a considerable capital asset, if it could be maintained. Natural mass wasting processes, however, were quickly eroding the spur but it was determined that these could be arrested with the installation of a pump well system. Such a system was installed in 1981.

The purpose of this WTO was to determine the suitability of the pumpwell system installed in the north spur at the Muskrat Falls site with a view to a life extension of ten years. The review included an on-site inspection of the system to determine the present physical condition and operational characteristics.

In October 2007, an interim report was submitted which described the findings of a site visit during the period from September 9 to 11, 2007 and outlined the requirements of a field program to be undertaken in the autumn of 2007 to obtain additional information to aid in the assessment of the system.

From November 5 to 8, this field program was carried out to perform tests on pumps and piezometers. The dewatering system was shut down for 5 hours each day on November 7 and 8, and the water level recovery in wells and piezometers water elevation were recorded for half of the system each day.

This document presents the findings of the assessment of the system from both field visits and makes recommendations for continued operation.

2. Historical and Geological Background

2.1 Site Characteristics

The site of Muskrat Falls on the lower Churchill River, located about 30 km upstream from Happy Valley/Goose Bay in Labrador (as shown in Figure 1) , has been recognized as a potential hydro electric development for several decades. At this site, the Churchill River has a drop of about 15 m from el 18 m at the upstream side to el 3 m at the downstream side. Past studies contemplated raising the head to about 40 m.

The prominent features of the site include a rock knoll rising to almost 150 m in elevation. The rock knoll is connected to the left bank by a spur of land about 1 km long, which forms a natural barrier forcing the diversion of the Churchill River into a channel carved out south of the rock knoll. The spur rises to elevation 60 m and has a minimum width of 150 m at the south side, in the upstream - downstream direction.

2.2 Geology and Sediments

The Muskrat Falls site is underlain at a maximum depth of about 270 m by crystalline metamorphic rocks composed of granitic gneiss of Precambrian age, with some dark mafic bands and occasional irregular pegmatite stringers. In addition to the rock knoll which rises sharply from the buried valley floor, several exposures are found on the right bank of the river.

The Churchill River valley is preglacial in origin, and was formed largely by river action prior to the Pleistocene epoch. Subsequent widening and reshaping of the valley occurred during the Wisconsin glaciation period, about 13 000 years ago. An estimated thickness of 60 m of a deposit of sand, gravel and boulders filled the lower part of the reshaped bedrock valley during the course of glaciation. As the glacier retreated, the sea level rose and caused submergence of the valley by an estuary extending up to Gull Island. This inundation of the valley by the rising sea resulted in the deposition of marine and estuarine sediments in an environment of saline and brackish water.

Isostatic rise of the land relative to the sea then caused a gradual recession of the estuary and resulted in the deposition of a layer of fine sand, over marine clay sediments.

The sediments in the spur consist of four units.

a) Upper Sand (el 60 to 45 m) covering the terrain and consisting of uniform fine to medium sand approximately 10 to 15 m thick.

b) Stratified Drift (el 50 to -10 m) consisting of a marine clay deposit generally underlain with a varying thickness of sandy materials. The sandy components dominate the southern 250 m long section of the spur against the rock knoll and constitutes an aquifer. The thickness of the upper clay increases toward the north.

   It is noted that primarily these two units in (a) and (b) are engaged in the failure activity of the downstream face of the spur.

c) Lower Marine Clay (el -10 to -60 m) is a stratified impervious silty clay deposit.

d) Lower Aquifer (el -70 to -210 m) composed of pervious sand and gravel, and occupying the lower part of the buried valley.

Gullies and creeks exist along both the upstream and downstream slopes of the spur. The most prominent gully is found in the area of the three lakes in the north side of the spur. Numerous creeks and a small stream were found originating as springs at the sand and clay contact.

Hydrogeologically, there are two aquifers. The water level in the Lower Aquifer is at el +5 m which is considerably higher than the surface of the overlying marine clay unit suggesting confined characteristics. However, it is the hydrogeologic behavior of the upper aquifer which has a dominant effect on bank stability. Recharge into this unit is from the northwest, through the upper sand unit and hydraulic connections in the stratified drift. Along the dewatering system alignment, the water level was originally at about el 30 m at the south side of the spur rising to el 47 m about half way and dropping to about 15 m at the north end.

2.3 Bank Instability and Groundwater Control Facilities

The banks of the Churchill River between Gull Island and Goose Bay are scarred by numerous landslides, some of which involve large quantities of overburden. Figure 2 shows an aerial site photo taken in 1988. A common characteristic of these slides, including those located inland, is that they are adjacent to a watercourse. In some instances where the failed mass has been transported by the erosive influence of water, as is the case on the downstream face of the spur, the scars left behind are rather steep. The destructive effect of erosion is most evident in the riverbed immediately downstream from the rapids. Erosion here is extensive and is caused by eddy currents emerging below the falls. Soundings indicate the presence of a local depression in the riverbed of the order of 70 m below river level adjacent to the rock knoll.

Instability has affected the slopes of the spur, particularly the downstream slope, as well as the left bank of the river downstream from the spur. In 1978, a major landslide occurred on the south end of the spur resulting in the loss of a considerable portion of land in the downstream perimeter. Minor failures were further experienced in 1980-81. High piezometric water levels and steep hydraulic gradients in the sediments above river level and tailwater rapid drawdown effects due to the collapse of the downstream ice-dam, have been the major causes contributing to instability.

In order to protect the remaining spur from further instability, a continuously pumped dewatering system was installed along the downstream shoulder of the spur in 1981. At the time of their installation, the system was considered to be "a temporary stabilization measure . . . and not a total defense against mass wasting", Acres (1994). The dewatering system was anticipated to lower the groundwater level in the spur from about el 30 m to at least el 15 m and preferably as low as el 3.5 m.

22 wells were installed in a line spaced at 30 m with an average depth of 63 m close to the edge of the downstream slope of the spur. The drilling diameter was 300 mm with a screen and PVC riser pipe having an internal diameter of 150 mm. All the pumps are connected to a 300 mm diameter collector pipe, with 75 mm of insulation, finally discharging to an existing stream through an exposed portion close to the outfall location. Two level limit switches were installed in each well above the electric submersible pump. The pumps originally were Berkeley model 4BL-2L with a 1.5 hp motor and 60 L/m capacity, but many pumps and/or motors have been subsequently replaced. The records of this equipment replacement are incomplete. On/off sequences of pumps are transmitted over VHF radio to

the Goose Bay office, over the 138-kV power line to Churchill Falls, and then via satellite to St. John's where the data is entered into the Hydro data base. A 25-kV power supply, tapped from the 138kV power line from Churchill Falls to Goose Bay, supplies the pumps. A full reporting of the construction and initial assessment of the system is presented in Report No 11.99.18, dated March 1982, by SNC-Lavalin Newfoundland.

To monitor the groundwater regime, 17 piezometers (vibrating wire) were installed in 1981 but all were lost in 1983 due to a power surge from a lightning strike on the power line. Figure 3 graphically depicts the location of the wells and the former group of piezometers (P-1 to P-17). The system began pumping in November 1981 and has continued essentially uninterrupted. After the power spike in 1983, the site recordings were decreased to pump function, i.e., pumping duration and the number of pumping cycle initiations during a 24-hr period.

In a report by Acres international (Report No. P10932, 1994), it was recommended that the wells be cleaned. Following this report, the wells were inspected, cleaned, and flushed in 1996. The detail of this operation is presented in Acres Report No. P11759.01, 1997. Also, seven manually monitored standpipe piezometers (A (2 tips), B (2 tips), C, D (2 tips), F (2 tips), G, J (2 tips)) were installed in 1997 and have been read subsequently. Report No. P11759.02, dated February 1998, presents the installation report of the piezometers. The recorded piezometers data for the last 10 years are plotted in Section 4.2.

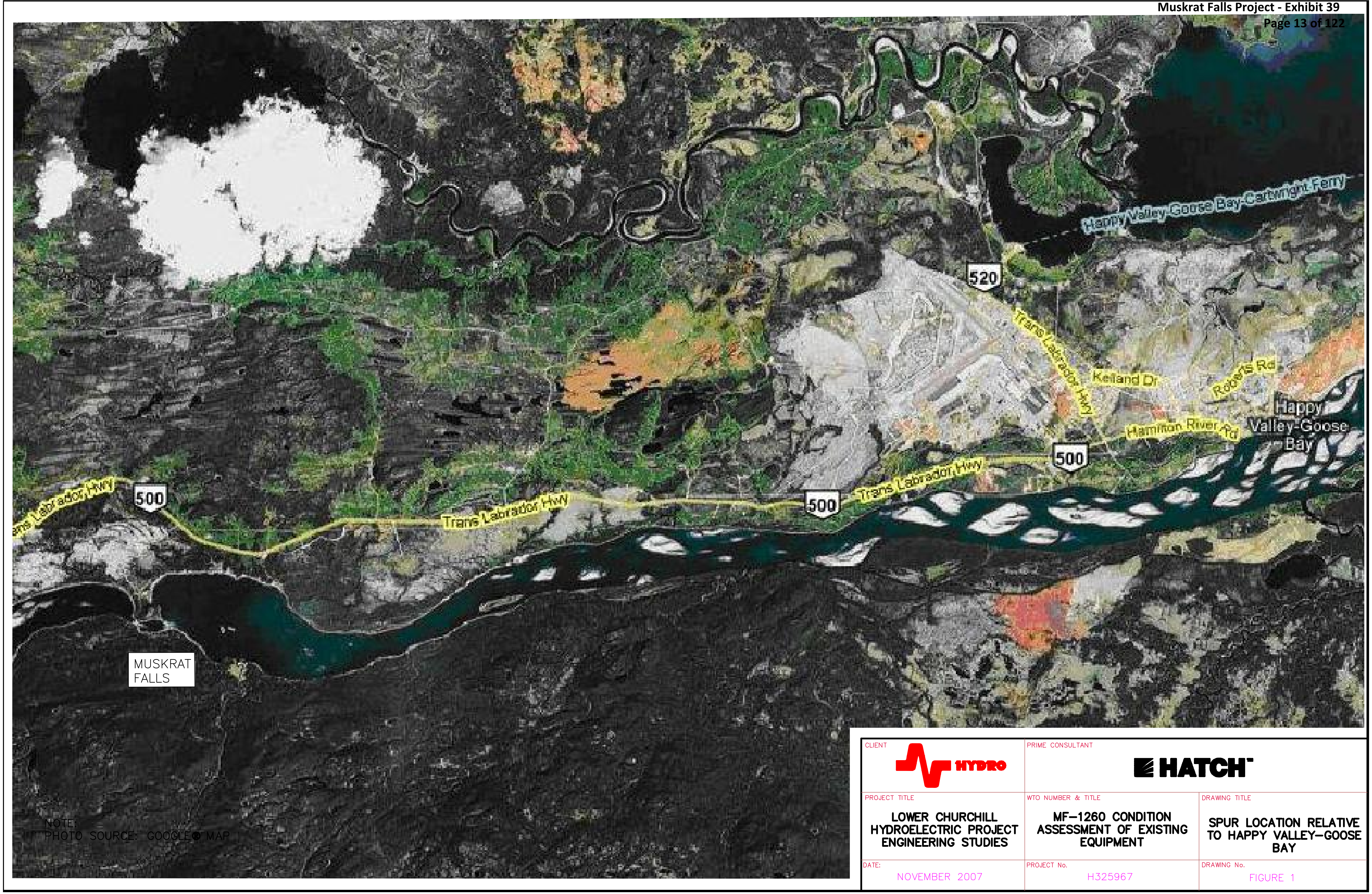
In 1997, 12 standpipe piezometers were installed in 7 boreholes and these continue to be monitored. Subsequent records of operation of the well system have recorded pump functions only, namely pumping duration and the number of pump cycle initiations per day.

Hydro staff carried out formal maintenance inspections in 1994, 1995 and in 1997 at which times and variously, some or all the pumps were retrieved, cleaned and reinstalled or replaced as necessary. The Hydro Goose Bay office retains records of such maintenance activities in varying degrees of detail.

2.4 Background Reports

Reports of previous site assessments are available as follows:

- SNC-Lavalin, "Muskrat Falls Dewatering System, Construction Report Operation and Maintenance Information", (1982);
- SNC-Lavalin, "Muskrat Falls Dewatering System, Engineering Assessment", (1982);
- Acres International, "Muskrat Falls Development", (1978);
- Acres International, "Muskrat Falls, Review of Dewatering System", (1994);
- Acres International, "Dewatering System Assessment and Rehabilitation", (1997); and
- Acres International, "Standpipe Piezometer installation Program Report", (1997 and 1998).



NOTE:
PHOTO SOURCE: GOOGLE® MAP

CLIENT: HYDRO

PRIME CONSULTANT: HATCH

PROJECT TITLE: LOWER CHURCHILL HYDROELECTRIC PROJECT ENGINEERING STUDIES

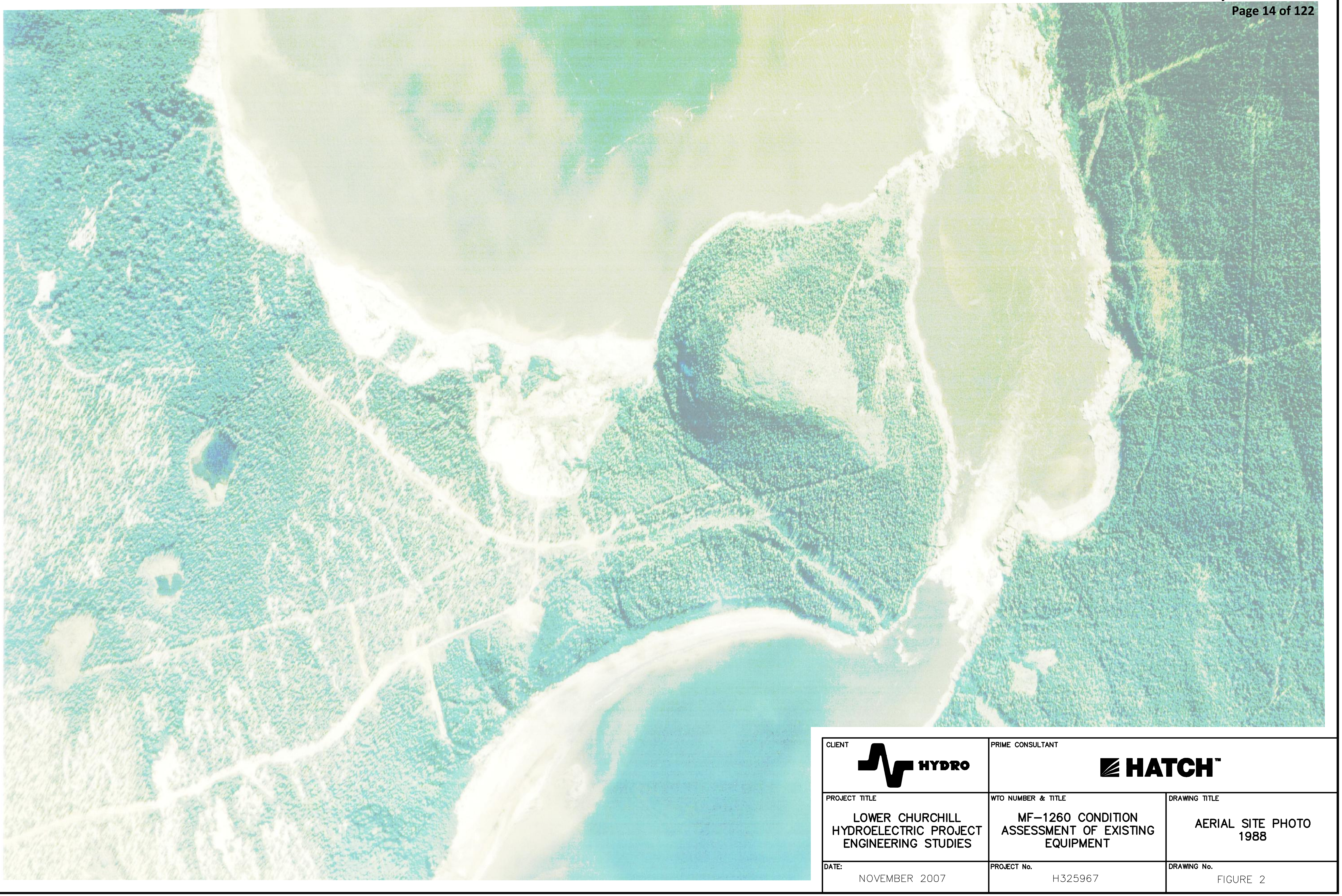
WTO NUMBER & TITLE: MF-1260 CONDITION ASSESSMENT OF EXISTING EQUIPMENT

DRAWING TITLE: SPUR LOCATION RELATIVE TO HAPPY VALLEY-GOOSE BAY

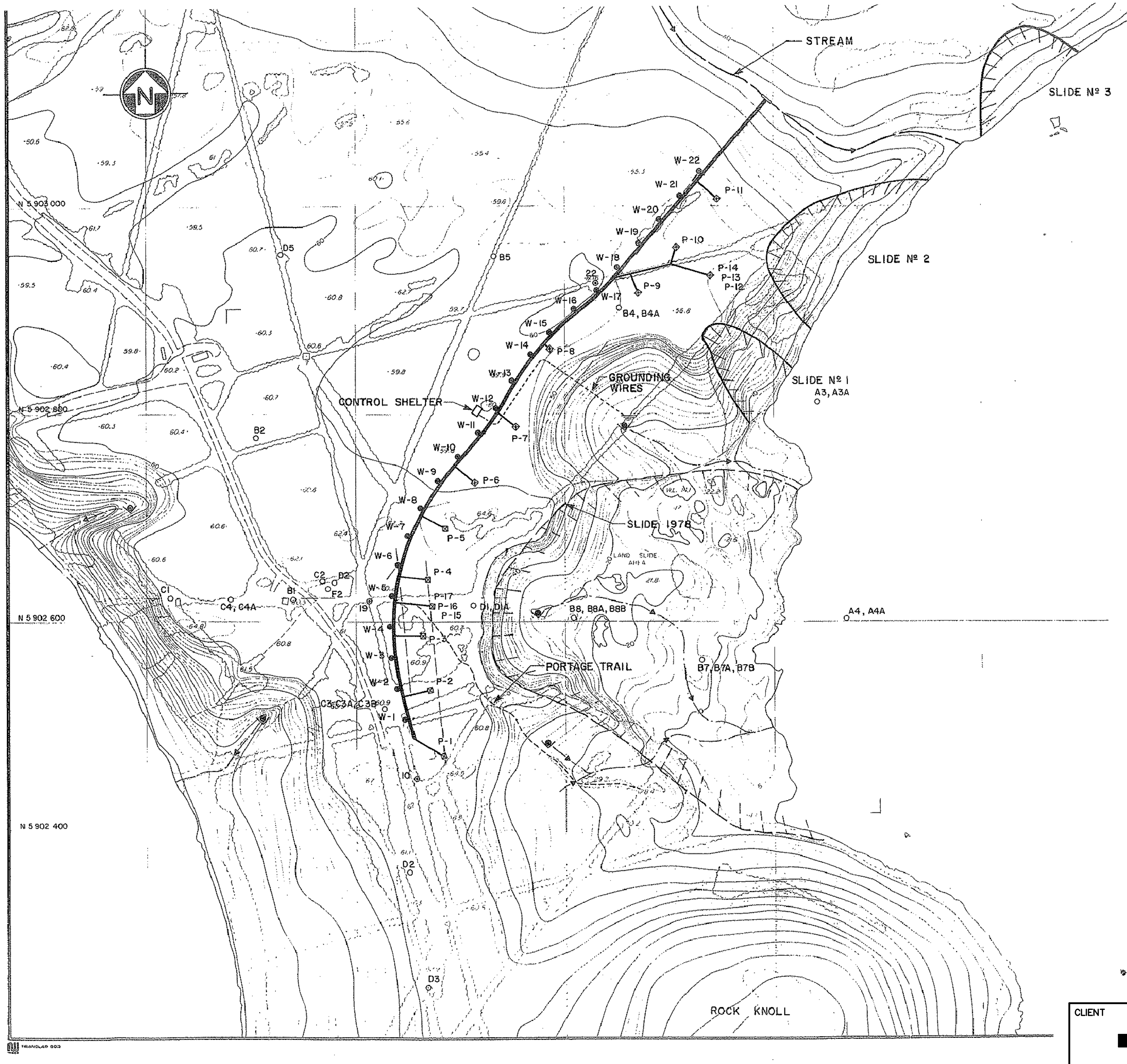
DATE: NOVEMBER 2007

PROJECT No. H325967

DRAWING No. FIGURE 1



CLIENT HYDRO	PRIME CONSULTANT HATCH™	
PROJECT TITLE LOWER CHURCHILL HYDROELECTRIC PROJECT ENGINEERING STUDIES	WTO NUMBER & TITLE MF-1260 CONDITION ASSESSMENT OF EXISTING EQUIPMENT	DRAWING TITLE AERIAL SITE PHOTO 1988
DATE: NOVEMBER 2007	PROJECT No. H325967	DRAWING No. FIGURE 2



LEGEND

- ○ BOREHOLE (1979)
- W-1 PUMPING WELL (1981)
- P-1 PIEZOMETER (1981)
- 22 SURVEY STATION
- TRENCH FOR COLLECTOR PIPE AND CABLES
- SPRING
- RECENT LANDSLIDES (1980-1981)
- LANDSLIDE (1978)

WELLS

	N	E
W1	5902 506.5	648 246.8
W2	5902 535.8	648 239.7
W3	5902 565.3	648 234.3
W4	5902 595.2	648 232.7
W5	5902 625.1	648 234.6
W6	5902 654.5	648 240.3
W7	5902 683.1	648 249.4
W8	5902 710.3	648 262.0
W9	5902 735.4	648 277.8
W10	5902 759.2	648 296.5
W11	5902 782.1	648 315.9
W12	5902 806.1	648 333.3
W13	5902 831.9	648 349.1
W14	5902 857.8	648 367.2
W15	5902 879.5	648 385.8
W16	5902 901.9	648 408.5
W17	5902 918.6	648 431.0
W18	5902 942.4	648 451.6
W19	5902 965.3	648 471.0
W20	5902 988.2	648 490.3
W21	5903 011.1	648 509.7
W22	5903 034.0	648 529.1

PIEZOMETERS

	N	E
P1	5902 471.0	648 283.8
P2	5902 533.2	648 271.2
P3	5902 587.1	648 264.1
P4	5902 639.5	648 269.3
P5	5902 688.3	648 285.5
P6	5902 732.9	648 313.5
P7	5902 788.7	648 352.3
P8	5902 862.5	648 384.0
P9	5902 916.1	648 468.6
P10	5902 961.9	648 507.4
P11	5903 007.7	648 546.2
P12	5902 932.2	648 542.2
P13	5902 933.1	648 541.1
P14	5902 934.1	648 539.8
P15	5902 616.7	648 274.9
P16	5902 616.8	648 273.8
P17	5902 616.9	648 272.2

NOTE

FOR SECTIONS SEE PLATE 2

CLIENT HYDRO	PRIME CONSULTANT HATCH™	
PROJECT TITLE LOWER CHURCHILL HYDROELECTRIC PROJECT ENGINEERING STUDIES	WTO NUMBER & TITLE MF-1260 CONDITION ASSESSMENT OF EXISTING EQUIPMENT	DRAWING TITLE WELL AND PIEZOMETER LOCATION PLAN
DATE: NOVEMBER 2007	PROJECT No. H325967	DRAWING No. FIGURE 3

3. Site Visit Observations

Two site visits were performed for this assessment during September and November 2007. The first site inspection was carried out on September 10 and 11 by Hatch and Hydro representatives. The inspection included a tour of the well installations, the discharge point, the control building, slide area crest, the upstream toe area, and the piezometer locations. On September 10, a helicopter was used for aerial investigation of the spur and the downstream toe as well as to assist in a surface inspection of a portion of downstream toe.

After the first site visit, it was recommended that a second site visit be carried out to perform water level recovery tests on blocks of wells. Accordingly, the second site visit was made from November 5 to 8 by representatives of Hatch, Hydro and a local subcontractor, Minuskat Limited. The details of the tests and the related findings are presented in Section 3.2.

3.1 Site Observations – First Visit (September, 2007)

In order to methodically describe the site visit observations, the observations are divided into three sections: general pump operation, geotechnical, and electrical.

3.1.1 General Pump Operation

- During the first site visit, it was observed that 19 submersible electric pumps were on automatic level control.
- Two pumps in Well 1 (W-1) and Well 2 (W-2), close to the narrowest spur section, were decommissioned prior to the 1996 Acres report.
- One pump in W-22 has been recently pulled out as it was found to be malfunctioning.
- The backup generator, as described in the WTO, does not exist.
- Hydro acknowledges anomalies in the data collection of on/off sequencing of the pumps.

3.1.2 Geotechnical Observations

Wells:

- During the site visit, the existing pump in W-4 was removed and a new pump was installed by Hydro. The replacement started about 10 am (September 11) and the system returned back to operation around 1 pm.
- Silt and fine sand were produced from W4 (observed in discharged water, the pump riser, and the pump) which may have intensified after 4 months of operation with a weaker pump (0.5 hp pump instead of 1.5 hp).
- The discharge from W4 has been reduced significantly as a result of a weaker pump.
- Silt and fine sand were also produced in Wells 9 and 10.

Piezometers:

- Two piezometers, P-B and P-D, each with 2 tips, were read before system shutdown and all of the piezometers were read after the system restoration.
- Generally, the static water levels in the piezometers, before and after system shutdown, were consistent with the water levels read in the past 10 years.
- The water levels in the piezometers changed during interruption of the pumping operation (i.e. for the replacement of the pump in W-4) – the lower piezometer B, which was originally dry, showed a water level after 2.5 hours of the pumping shutdown – this piezometer is close to W-4 which has the most active pump.
- Piezometer C (P-C) has been out of order since March 2007 (riser pipe blockage) and has previously shown little response since installation.
- Three weirs which were recommended in 1997 were not seen – Hydro staff reported that they are accessible only with difficulty.
- Some of the piezometers from the original investigation program (A, B, and C series shown in Figure 3), which were accessible before in 1994 (Acres report), are no longer read or accessible.

Spur Slopes:

- Ongoing erosion and sloughing and active springs exist at the downstream toe of the spur.
- The upstream toe was also inspected and no significant erosion was observed.
- Access to the discharge point of the well system was difficult as the area was very overgrown.

Well W4 Condition:
Acres (1994) reported that W-4 is responsible for up to 85% of the total dewatering activity. During the first site visit, it was noted that the pump motor installed in W-4 for several months prior to the visit had a capacity of 0.5 hp. During the site visit, this motor was replaced with a 1.5 hp unit. Shortly after replacement of this pump and system restoration, the pump in W-3 went offline, while on the first day, in addition to the pump in W-4 being in operation, the pump in W-3 was also continuously operational. It is important to mention that after system restoration, W-4 also did not operate continuously. This is taken to mean that W-3, or other wells in the vicinity, can not act as a sufficient substitute for W-4 due to either high transmissivity in W-4 or low transmissivity in other adjacent wells, unless sufficient pump capacity exists in all pumps.

3.1.3 Electrical Observations

- The telephone operating via the Hawk 2 VHF radio had heavy static and was unable to transmit a call.
- W-10 relay underwent approximately 10 minutes of continuous switching between operating and high level alarms after power returned to the control panel (subsequent to system shutdown during W-4 replacement).

- Multiple pumps are fed from a single power cable. A similar arrangement exists for the control cables.
- Five sensors were identified at W-4 suggesting that a replacement was installed and the broken sensor was not removed.
- Electrical cables were exposed along the outfall pipe. It is assumed these are the heat trace cables at the outfall, as installed during initial construction.
- The pump function in W-3 was not fully understood as the pump operation signal was on prior to the system shutdown (for the replacement of pump in W-4); however, it did not return to pumping after 2.5 hours, when the pumping system returned on.

3.2 Site Observations – Second Visit (November 2007): Recovery Test

The main purposes of this site visit were:

- Understanding the phreatic surface (piezometric surface) in the spur at different sections.
- Defining the correlation between the variations in well water level and the piezometers.
- Measuring the water level recovery in the wells and piezometers after the system shutdown.

In the last 26 years, the performance of the wells has been recorded, both on/off occurrences and on-time minutes. However, as several occurrences of on/on and off/off sequences were observed in the recordings, the current situation of the wells could not be judged by these statistical data. As a result, water level recovery tests were recommended to define the activity of the wells. This would clarify whether any blockage has occurred in the filters or screens of the wells and would confirm the necessity for any remedial action.

3.2.1 Original Block Test Plan

Initially, it was intended to divide the wells into three main blocks as shown in Figure 4. These test blocks were to consist of the following wells and piezometers:

a) Block 1 (Southern Block): Wells 1 to 8 and piezometers P-A, and P-B

b) Block 2 (Central Block): Wells 9 to 15 and piezometer P-D

c) Block 3 (Northern Block): Wells 16 to 22 and piezometers P-F, P-G, and P-J

It was originally intended to shut down the pumps of each block in turn over the three days while all other pumps were running and record the variation of water levels in the block wells, the block piezometers, and the wells in the vicinity. However, the system providing power to the sensors could not be isolated in blocks. For safety reasons, no dip meter could be introduced into the wells while this system was energised. A change was therefore made to the initial plan from block tests to entire system shutdown and block readings on each of two days.

3.2.2 Modified Block Test Plan

In the modified plan, the system was divided into two main blocks: Block 1 and Block 2, as shown in Figure 5:

a) Modified Block 1: W-1 to W-12 and piezometers P-A, P-B, P-D

b) Modified Block 2: W-13 to W-22 and piezometers P-F (2 tips), P-G, P-J (2 tips)

The whole system was shut down and water level variations in each of the modified block wells and piezometers were recorded each day. Each block contained up to 16 reading stations which consisted of both wells and piezometers. To read the levels, every person was assigned 2 reading stations: one primary and one secondary reading point. The primary station was read from initiation at the below noted time intervals for 5 hours (300 min), while the readings at secondary stations were started 15 minutes after the system shutdown. As a result, the proposed time intervals for recording the water level for the two groups stations were:

- Primary station readings after (min): 0, 0.5, 1, 2, 5, 10, 20, 30, 45, 60, 120, 180, 240, 300; and
- Secondary station readings after (min): 15, 25, 35, 50, 65, 125, 185, 245, 305; (or as closely as possible).

Baseline readings were taken on November 6 prior to knowledge of the above noted safety issue. However, zero time readings in the wells were not permitted during the block test plan due to these safety issues.

Primary and secondary reading stations are listed as follows:

- Primary: W-2, W-4, W-6, W-8, W-9, W-10, W-12, W-14, W-16, W-18, W-19, W-20, W-21, P-A1, P-B1, P-D1.
- Secondary: W-1, W-3, W-5, W-7, W-9, W-11, W-12, W-13, W-15, W-17, W-19, W-21, W-22, P-F1, P-F2, P-G, P-J1, P-J2.

3.2.2.1 *Baseline Testing – Day 1 (November 6, 2007)*

Measuring the Water Levels:

On day 1, prior to system shutdown, the following activities were undertaken:

- Personnel were trained to access and read the piezometers and wells.
- Wells and piezometers were unlocked and made accessible.
- Water levels in the wells and piezometers were read and recorded; these are presented in Table 1.

Outlet Discharge Measurement and Water Quality:

On November 6, before system shutdown, the water discharge rate at the outlet was measured by Hydro. The discharge was 22.8 L/min.

The water was noted to be clear with no visible silt.

Piezometer Conditions:

The water elevation in piezometers P-D1 and P-G were somewhat higher than the elevations in the other piezometers.

Table 1
Wells and Piezometer Water Elevations – November 6, 2007

Well	Pumping Water Elevation (m) *	Piezometer	Piezometer Water Elevation (m)
W-1	14.36	P-A1	9.91
W-2	12.22	P-A2	See note C
W-3	8.14	P-B1	8.32
W-4	See note A	P-B2	See note D
W-5	8.28	P-C	See note C
W-6	11.06	P-D1	23.19
W-7	11.96	P-D2	See note D
W-8	9.73	P-F1	12.51
W-9	24.04	P-F2	12.29
W-10	26.72	P-G	18.04
W-11	19.8	P-J1	10.07
W-12	See note B	P-J2	11.23
W-13	5.79		
W-14	14.97		
W-15	9.25		
W-16	9.26		
W-17	10.3		
W-18	17.53		
W-19	8.81		
W-20	12.26		
W-21	See note B		
W-22	29.58		

Notes:

* – Water levels obtained prior to safety advisory

A – Due to large water influx the reading was not reliable

B – The well cap was not accessible

C – Blocked, or dry piezometers

D – The elevations derived from these piezometers readings do not match the spur water table and/or adjacent piezometers level

3.2.2.2 Block Test 1 – Day 2 (November 7, 2007)

The pumping system was turned off at 9:30 am on November 7, 2007 by Hydro personnel and the water level rise in the wells and piezometers located in modified block-1 was recorded. The primary and secondary reading stations were set as follows:

- Primary stations: W-2, W-4, W-6, W-8, W-10, P-A1, P-B1, P-D1.
- Secondary stations: W-1, W-3, W-5, W-7, W-9, W-11, W-12.

Water elevations in W-9 were not read as one level meter probe became jammed inside the well. Recorded elevations in W-4 were not reliable because of continuous water influx.

The variations in water elevation for each well or piezometer are plotted versus time in either logarithmic and linear scales and are presented in Appendix C. The pumping system went back into operation after five hours of shutdown.

Piezometer Drawdown Measurements

After system restoration at about 2:00 PM, the drawdown of piezometers was recorded for two hours. It was originally intended to measure the well drawdown also; however, this was cancelled due to safety issues associated with measuring while sensors are energized. One level reading was performed early next morning. It was noted that the drawdowns in the piezometer levels were limited (less than 1-2 cm) so this procedure was cancelled for the modified block 2. The results of the drawdown test are presented with the recovery test results in Appendix C (only for piezometers P-A1, P-B1, and P-D1).

Outlet Discharge Measurement

After the pumping restoration, the water discharge rate at the collector pipe outlet was measured by known volume container by Hydro twice over a 5-minute interval. The discharges were 57 L/min and 42.6 L/min, respectively.

Discharge Water Quality

It was observed that the discharged water was extremely cloudy and included twigs. As several pumps were in the on-situation after the system restoration, it could not be concluded which wells were producing the observed silty water. Further investigation is necessary, either by video inspection or single-well water discharge measurement, to indicate the wells that are responsible for the silty discharge.

Acres (1997) refers to the large buildup of sediment in some wells mostly about 5 to 20 m in thickness. Also, it was reported that the bottom of several sections of most riser pipes were coated with clay and silt. After a further ten years, the same phenomenon is likely to have occurred.

Pump Activities after System Restoration

After system restoration, which occurred after more than 5 hours of pumping shutdown, 13 out of the 19 pumps were in the on-situation. It took only 5 minutes to observe that only 5 pumps remained active and after 8 minutes, this reduced to three pumps. The sequence, which was almost repeated on the second day after the test, was recorded in the control room as follows:

0 min: Wells, 4, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 19, 21

1 min: Wells, 4, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 19, 21

2 min: Wells, 4, 9, 10, 12, 13, 15, 16, 17

5 min: Wells, 4[*], 10, 12, 15, 19

8 min: Wells, 4, 10, 19

10 min: Wells, 4, 9, 10

20 min: Wells, 4, 10

[*] W-4 went off at min 6 and returned back into an on-situation shortly, again off at min 12.5 and returned on at min 14.

3.2.2.3 Block Test 2 – Day 3 (November 8, 2007)

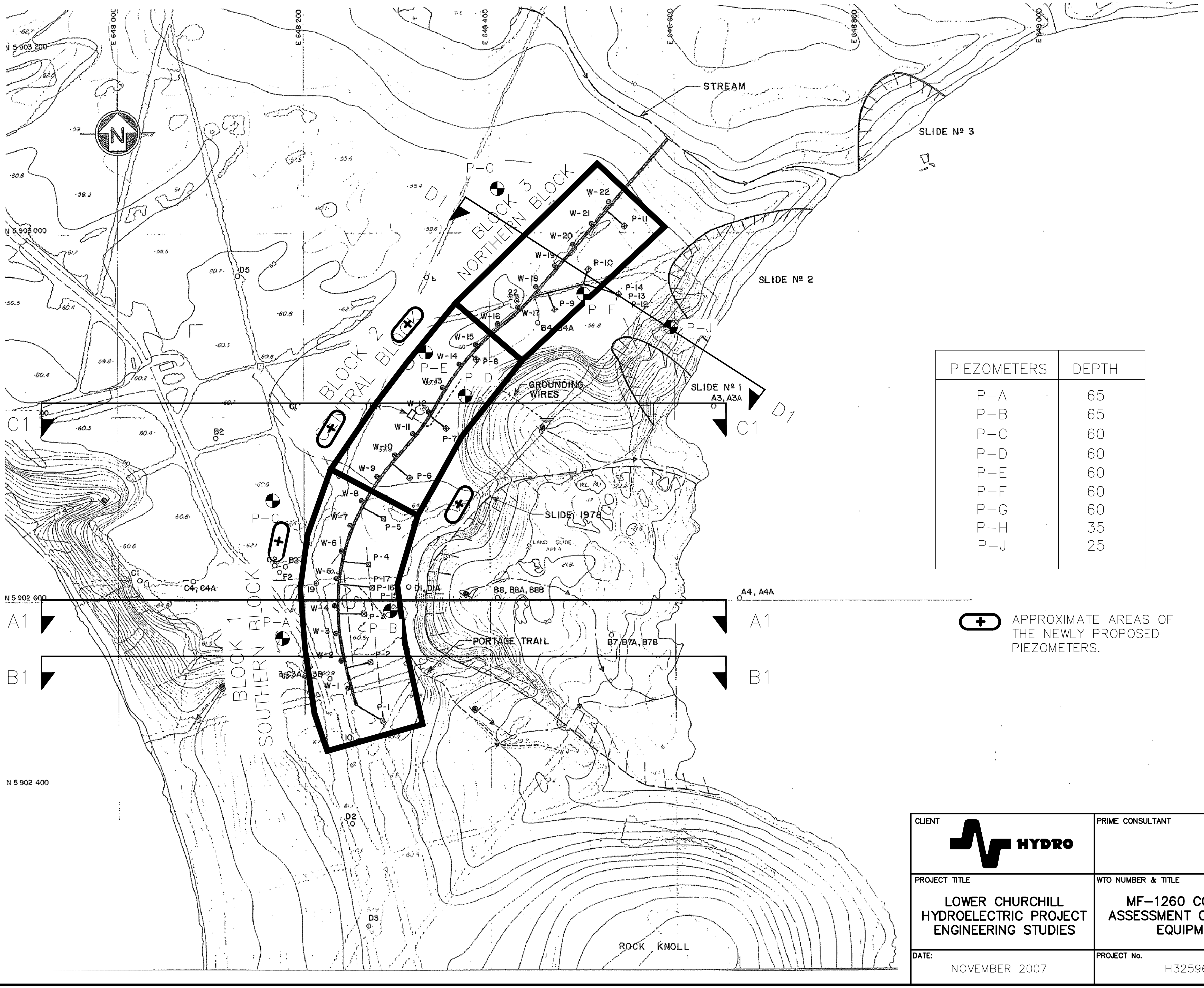
On Day 3, the elevations in the wells and piezometers in modified Block-2 were read after the pumping system was turned off. Also, the water levels in W-4 and W-9 were recorded, as they could not be monitored the first day. On the third day, the primary and secondary reading stations were set as follows:

- Primary stations: W-4, W-9, W-12, W-14, W-16, W-18, W-19, W-20, W-21.
- Secondary stations: W-13, W-15, W-17, W-19, W-21, W-22, P-F1, P-F2, P-G, P-J1, P-J2.

It was noticed that the water elevation in W-4 could be recorded consistently after minute 18; however, the reading in W-9 was very difficult because of the high inflow.

Piezometers Slow Recovery Rate

The piezometer readings in P-F, P-G, and P-J indicate that the water levels had already risen as a result of the first day shutdown and had not recovered to the undisturbed situation. The information gathered from these piezometers is plotted and presented in Appendix B; however, little variation was noted on the last day.



LEGEND

- ○ BOREHOLE (1979)
- W-1 ⊚ PUMPING WELL (1981)
- P-1 ⊠ PIEZOMETER (1981)
- 22 ⊙ SURVEY STATION
- ▬ TRENCH FOR COLLECTOR PIPE AND CABLES
- ◈ SPRING
- RECENT LANDSLIDES (1980-1981)
- LANDSLIDE (1978)

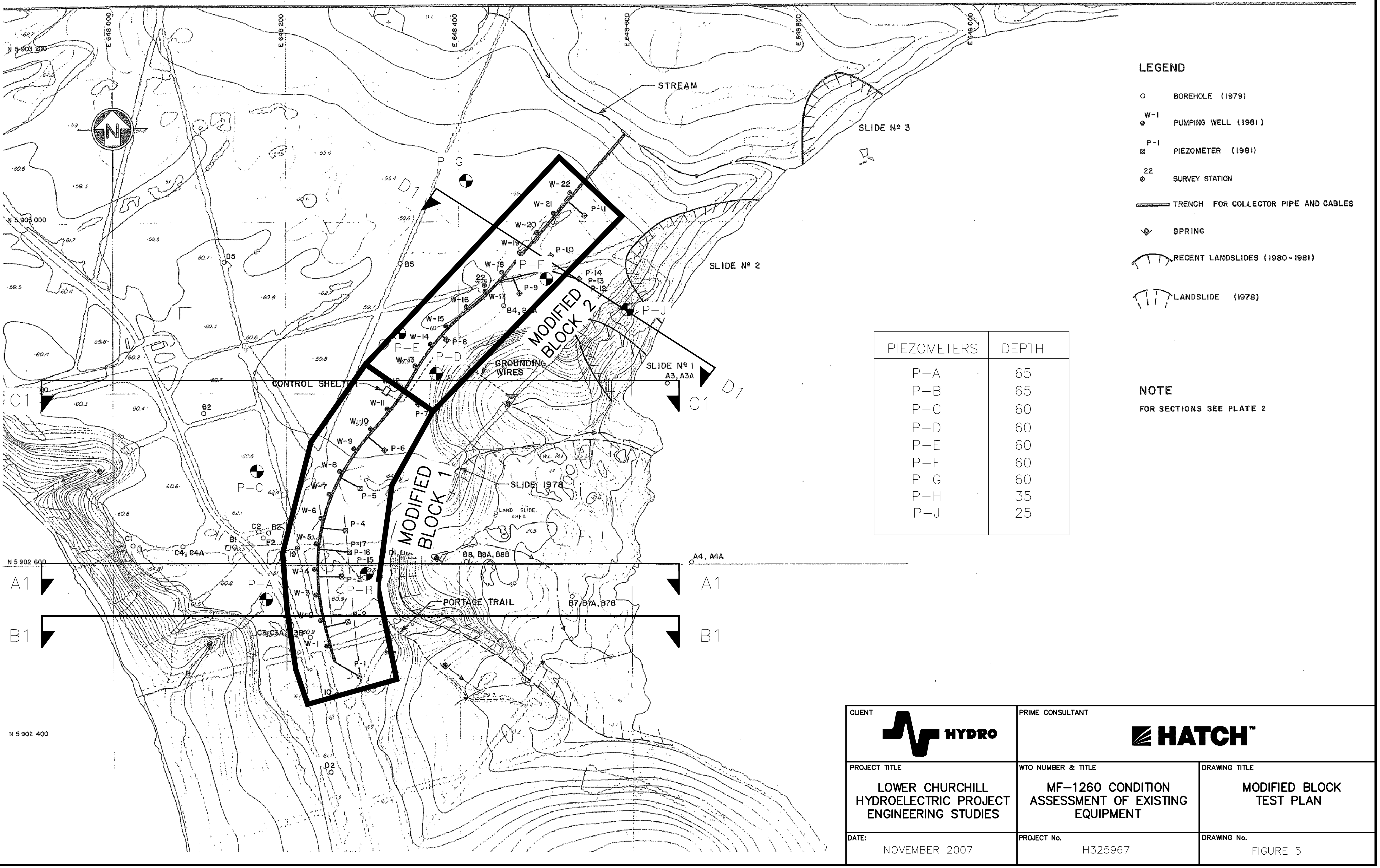
PIEZOMETERS	DEPTH
P-A	65
P-B	65
P-C	60
P-D	60
P-E	60
P-F	60
P-G	60
P-H	35
P-J	25

NOTE

FOR SECTIONS SEE PLATE 2

⊕ APPROXIMATE AREAS OF THE NEWLY PROPOSED PIEZOMETERS.

CLIENT HYDRO	PRIME CONSULTANT HATCH	
PROJECT TITLE LOWER CHURCHILL HYDROELECTRIC PROJECT ENGINEERING STUDIES	WTO NUMBER & TITLE MF-1260 CONDITION ASSESSMENT OF EXISTING EQUIPMENT	DRAWING TITLE ORIGINAL BLOCK TEST PLAN
DATE: NOVEMBER 2007	PROJECT No. H325967	DRAWING No. FIGURE 4



PIEZOMETERS	DEPTH
P–A	65
P–B	65
P–C	60
P–D	60
P–E	60
P–F	60
P–G	60
P–H	35
P–J	25

NOTE

FOR SECTIONS SEE PLATE 2

CLIENT	HYDRO
PRIME CONSULTANT	HATCH™
PROJECT TITLE	LOWER CHURCHILL HYDROELECTRIC PROJECT ENGINEERING STUDIES
WTO NUMBER & TITLE	MF–1260 CONDITION ASSESSMENT OF EXISTING EQUIPMENT
DRAWING TITLE	MODIFIED BLOCK TEST PLAN
DATE:	NOVEMBER 2007
PROJECT No.	H325967
DRAWING No.	FIGURE 5

4. Groundwater Assessment

In order to assess the pumping system performance, it is necessary to compare the present water table in the spur with the water levels before pump installation and after water drawdown equilibrium. Fortunately the original water table is well documented in a number of reports using several piezometers originally installed in the spur either during early investigation or during system construction. However, most of these piezometers have been destroyed, either struck by lightning (p- series originally recommended by SNC-Lavalin) or lost in vegetation (A- , B- , and C- series installed during early investigation), and defining the current water table is limited to either using the 8 existing standpipe piezometers or the water table inside the wells. The water tables inside the wells are also variable due to pumping; however, they are limited by the high and low elevations of wells sensors. The recovery tests performed during the second site visit were very significant in tracking the water levels and in checking whether the well pumps are performing adequately.

In the following sections, it is intended to compare the current spur water table with the historical values. In addition, some plots describing the variation of the piezometer water elevations, installed and monitored since 1997, are presented. These curves define whether or not there is a significant change in water table in the spur in the last 10 years.

Finally, some other factors which can potentially affect the water table in the spur are discussed.

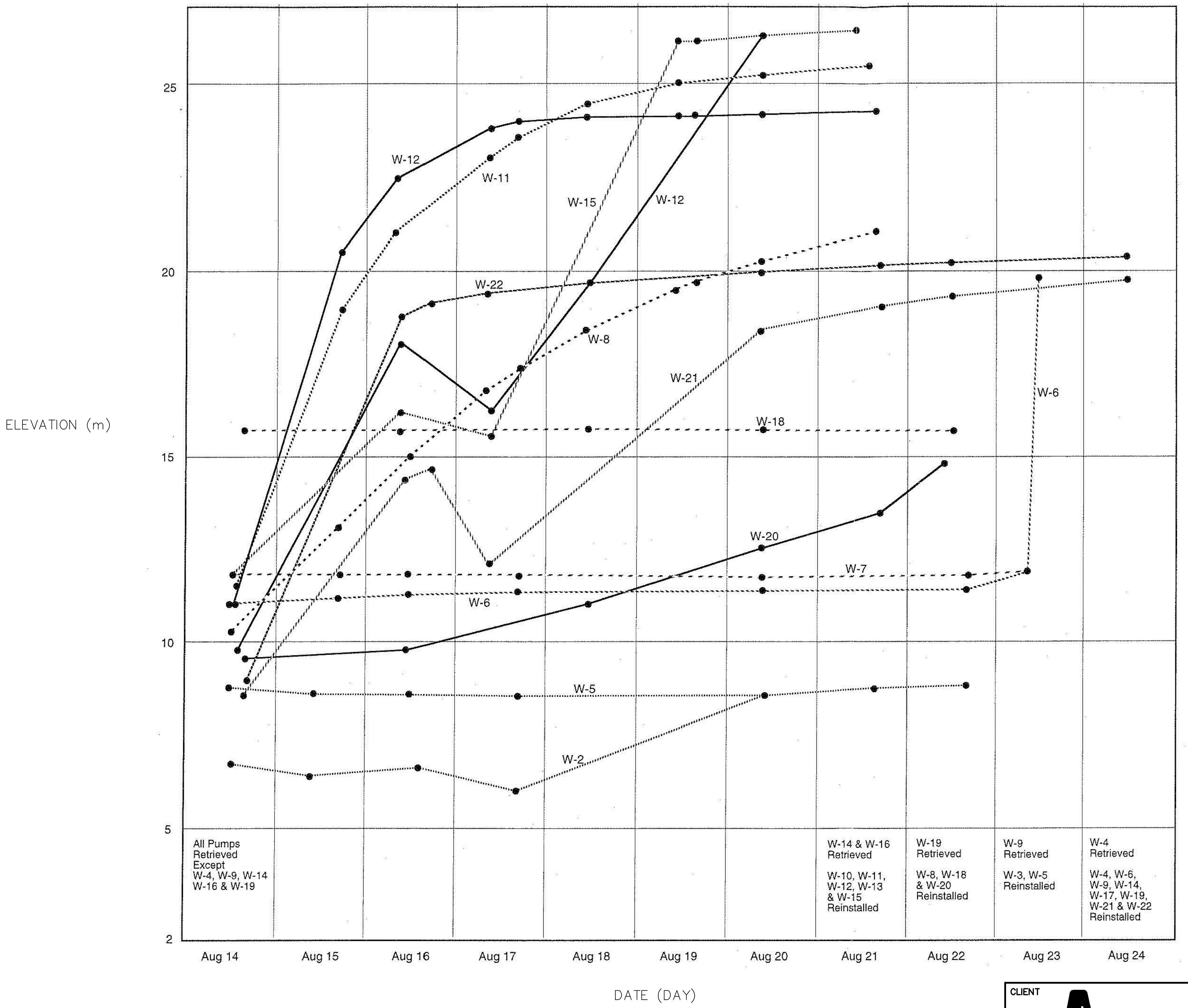
4.1 Historical Data

Groundwater assessments were performed after the installation of the pumping system. These assessments were carried out by SNC-Lavalin in 1982 and were used as the initial water levels for this study.

In August, 1996, a series of recovery tests was made by Acres on the pumps for 11 days to study the groundwater regime in the stratified drift unit (between el -10 and 50) and its response to pumping. In that recovery test, all pumps, other than W-4, W-9, W-14, W-16, and W-19, were retrieved and cleaned over a period of 7 days and the water recoveries were recorded accordingly. Since W-4, W-9, W-14, W-16, and W-19 are the most active, they were retrieved and cleaned in one day. Figure 6 describes the variation of the water elevations and the sequence of pumps after reinstallation/retrieval. In addition, Table 2 provides a summary of the characteristics and water level measurements in the wells. This table contains the water elevations in the wells in 1994 and 1995 in addition to the results of the recovery test during the 11 days. It should be mentioned that the pumps in W-4 and W-9 which are the most active wells were not left out of the well overnight.

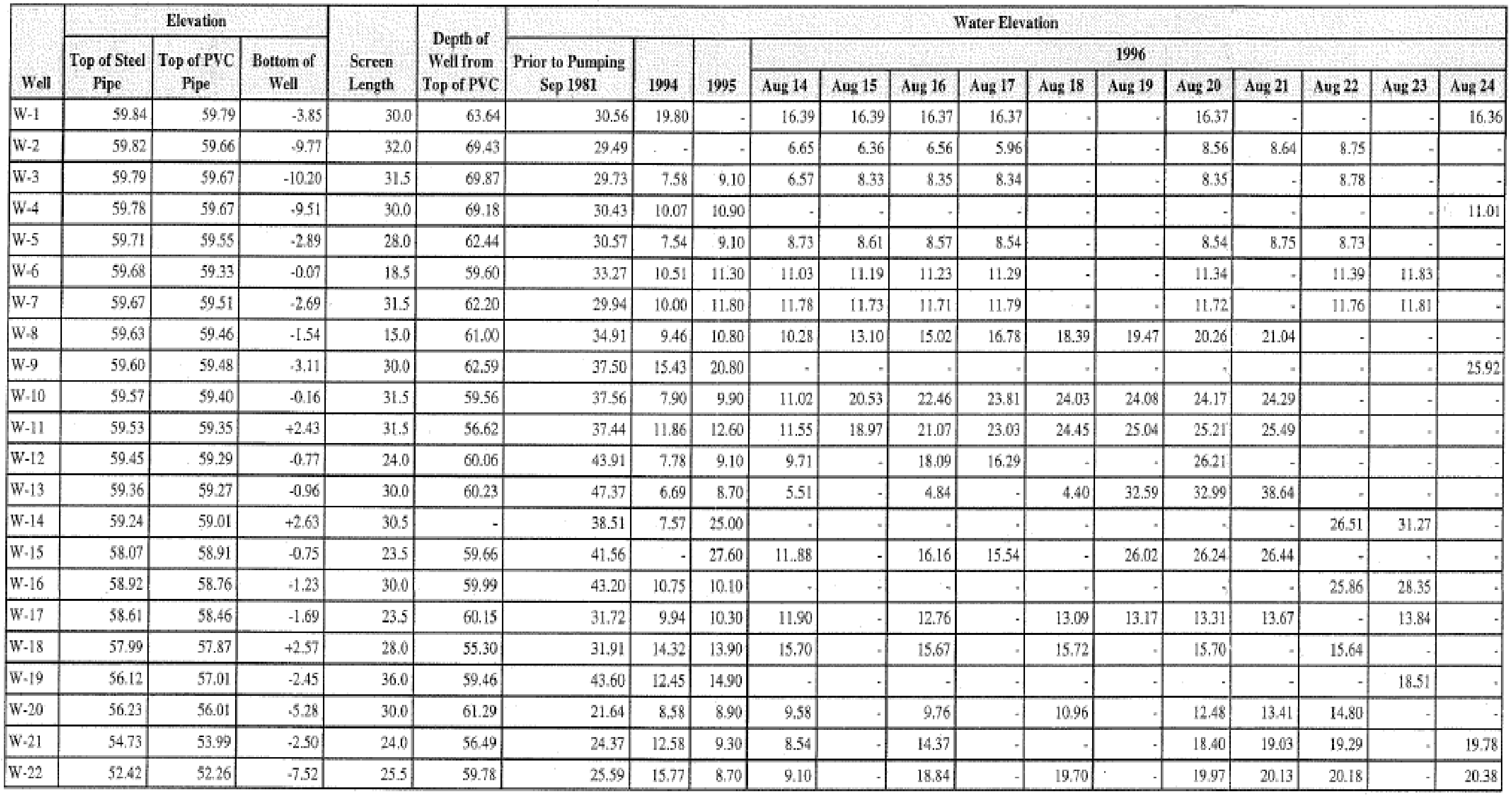
During the 1996 recovery test, the wells could be divided into three major zones: Southern (W-1 to W-7), Central (W-8 to W-17), and Northern (W-18 to W-22). The major observations of the recovery test can be stated as:

- The sand component of about 50 percent is significant in the downstream south side of the spur near the rock knoll, and decreases in the northerly direction. In other words, the downstream south side contains more pervious sediments and offers better opportunities for dewatering than the northern part.



CLIENT	PRIME CONSULTANT	
HYDRO	HATCH™	
PROJECT TITLE LOWER CHURCHILL HYDROELECTRIC PROJECT ENGINEERING STUDIES	WTO NUMBER & TITLE MF–1260 CONDITION ASSESSMENT OF EXISTING EQUIPMENT	DRAWING TITLE RECOVERY IN SELECTED WELLS , PERFORMED BY ACRES – 1996.
DATE: NOVEMBER 2007	PROJECT No. H325967	DRAWING No. FIGURE 6

Table 2
Summary of Characteristics and Water Level Measurements in Wells in Acres Report – 1996



	Elevation					Water Elevation													
									1996										
Well	Top of Steel Pipe	Top of PVC Pipe	Bottom of Well	Screen Length	Depth of Well from Top of PVC	Prior to Pumping Sep 1981	1994	1995	Aug 14	Aug 15	Aug 16	Aug 17	Aug 18	Aug 19	Aug 20	Aug 21	Aug 22	Aug 23	Aug 24
W-1	59.84	59.79	-3.85	30.0	63.64	30.56	19.80	-	16.39	16.39	16.37	16.37	-	-	16.37	-	-	-	16.36
W-2	59.82	59.66	-9.77	32.0	69.43	29.49	-	-	6.65	6.36	6.56	5.96	-	-	8.56	8.64	8.75	-	-
W-3	59.79	59.67	-10.20	31.5	69.87	29.73	7.58	9.10	6.57	8.33	8.35	8.34	-	-	8.35	-	8.78	-	-
W-4	59.78	59.67	-9.51	30.0	69.18	30.43	10.07	10.90	-	-	-	-	-	-	-	-	-	-	11.01
W-5	59.71	59.55	-2.89	28.0	62.44	30.57	7.54	9.10	8.73	8.61	8.57	8.54	-	-	8.54	8.75	8.73	-	-
W-6	59.68	59.33	-0.07	18.5	59.60	33.27	10.51	11.30	11.03	11.19	11.23	11.29	-	-	11.34	-	11.39	11.83	-
W-7	59.67	59.51	-2.69	31.5	62.20	29.94	10.00	11.80	11.78	11.73	11.71	11.79	-	-	11.72	-	11.76	11.81	-
W-8	59.63	59.46	-1.54	15.0	61.00	34.91	9.46	10.80	10.28	13.10	15.02	16.78	18.39	19.47	20.26	21.04	-	-	-
W-9	59.60	59.48	-3.11	30.0	62.59	37.50	15.43	20.80	-	-	-	-	-	-	-	-	-	-	25.92
W-10	59.57	59.40	-0.16	31.5	59.56	37.56	7.90	9.90	11.02	20.53	22.46	23.81	24.03	24.08	24.17	24.29	-	-	-
W-11	59.53	59.35	+2.43	31.5	56.62	37.44	11.86	12.60	11.55	18.97	21.07	23.03	24.45	25.04	25.21	25.49	-	-	-
W-12	59.45	59.29	-0.77	24.0	60.06	43.91	7.78	9.10	9.71	-	18.09	16.29	-	-	26.21	-	-	-	-
W-13	59.36	59.27	-0.96	30.0	60.23	47.37	6.69	8.70	5.51	-	4.84	-	4.40	32.59	32.99	38.64	-	-	-
W-14	59.24	59.01	+2.63	30.5	-	38.51	7.57	25.00	-	-	-	-	-	-	-	-	26.51	31.27	-
W-15	58.07	58.91	-0.75	23.5	59.66	41.56	-	27.60	11..88	-	16.16	15.54	-	26.02	26.24	26.44	-	-	-
W-16	58.92	58.76	-1.23	30.0	59.99	43.20	10.75	10.10	-	-	-	-	-	-	-	-	25.86	28.35	-
W-17	58.61	58.46	-1.69	23.5	60.15	31.72	9.94	10.30	11.90	-	12.76	-	13.09	13.17	13.31	13.67	-	13.84	-
W-18	57.99	57.87	+2.57	28.0	55.30	31.91	14.32	13.90	15.70	-	15.67	-	15.72	-	15.70	-	15.64	-	-
W-19	56.12	57.01	-2.45	36.0	59.46	43.60	12.45	14.90	-	-	-	-	-	-	-	-	-	18.51	-
W-20	56.23	56.01	-5.28	30.0	61.29	21.64	8.58	8.90	9.58	-	9.76	-	10.96	-	12.48	13.41	14.80	-	-
W-21	54.73	53.99	-2.50	24.0	56.49	24.37	12.58	9.30	8.54	-	14.37	-	-	-	18.40	19.03	19.29	-	19.78
W-22	52.42	52.26	-7.52	25.5	59.78	25.59	15.77	8.70	9.10	-	18.84	-	19.70	-	19.97	20.13	20.18	-	20.38

- The recharge feeding the aquifer contained in the unit is mostly from upland on the left bank and the groundwater flow is from the northwest. Infiltration occurs in the upper sand unit or cap, and through discontinuities or hydraulic windows in the upper low permeability clay member into the lower and more pervious sand layers hosting the aquifer. The clay furnishes a confining effect, but the sand layers are interconnected to a degree which permits groundwater flow through the interconnections.
- In addition to the recharge from the northwest, the Churchill River upstream at el 18 has an influence on the spur and the groundwater in the rock knoll to a minor degree. The natural groundwater level before pumping was at el 30 m on the south side of the dewatering system and rises to el 47 m near W-13 and decreases to el 24 m on the north towards the existing stream. The piezometric water level at specific points in the formation, approximately along the line of the wells, is generally between el 20 and 30 m.
- The summary of various properties in Table 3 confirms the presence of good drainage at the south side by virtue of greater sand content and higher conductivity compared to central and northern zones. The wells in this southern zone produced the highest yield and least recovery.
- The most significant conclusion from the standpoint of spur stabilization is related to lowering of the water table as a result of the operation of the dewatering system. The greatest drawdown in the spur, in general, is generated in the southern zone where the hydraulic conductivity is highest and the least is in the northern zone where the hydraulic conductivity is lowest.
- The narrowest width of spur, 150 m, from upstream to downstream occurs at the south side. A significant segment of the land mass was lost in a 1978 landslide and the dewatering system is presently about 80 m from the scarp. There are two springs in the slide scarp which were estimated to emerge at about the same elevations as prepumping. Slide debris still occupies a major portion of shoreline with driftwood piled up high. The accumulation of slide debris provides a buffer between the shore and the toe of slope. Growth of vegetation suggests a measure of stability.
- The central section is more than 300 m away from the bay upstream. However, in the area of wells W-11 to W-16 near the control shelter, the downstream slope of the spur is steep and only about 40 m away from the scarp. Moreover, landslides No. 1 and No. 2 mapped in the early 1980s, Figure 3, appear to have become one scarp probably caused by toe erosion. Inspection during the 1996 rehabilitation work indicated that toe erosion was in progress. Also a spring was found on the downstream slope of W-13 probably due to high piezometric levels in the vicinity.
- The northern section of the spur in the area of W-18 to W-22 is wide and the slide scarp on the downstream is about 80 to 90 m from the line of wells. The ravine located north of W-22 is overgrown and the slope is in the order of 1.5H:1V. No sign of instability was noted in the ravine.

Table 3
Summary of Hydrogeological Observations in Acres Report – 1996

Observations	Southern Zone	Central Zone	Northern Zone
Pump Wells in Zone	**W-1 to W-7**	**W-8 to W-17**	**W-18 to W-22**
Proportion of pervious sand and sandy silt layers in stratified drift unit to el 10 m	55%	20% except for Wells W-9 and W-14 which are similar to southern zone.	5%
Relative bulk hydraulic connectivity (m/s)	1 x 10^{-5}	1 x 10^{-7} to 1 x 10^{-8}	1 x 10^{-8}
Groundwater lowering in 2 years after start of pumping (m)	High of about 15	Low < 5.5	Very low < 0.5
Daily operation of pumps	Long, due to steady inflow from pervious layers; pump in W-4 operates 19 hours	Short, generally 1 hour; pumps W-9 and W-14 work longer due to greater pervious thickness	Short, maximum of 1 hour; pumps operate daily
Recovery in water level after 10 days of pumps shut down in 1996	Very small < 2 m	High, about 35 m in Well W-13 equivalent to prepumping level -Steady state reached in about a week	Moderate to about 10 m as in Wells W-21 and W-22 to el 20, equivalent to invert of nearby stream from Kettle Lakes
Filling of well casing using 2000 gal of water for flushing	Difficult, unable to cause sediments in Wells W-3, W-4, W-5, and W-7 to rise above top of casing	Easy in all wells except W-9	Easy in all wells
Benefit of continued pumping in groundwater lowering	High	Moderate	Negligible

4.2 Piezometer Water Levels

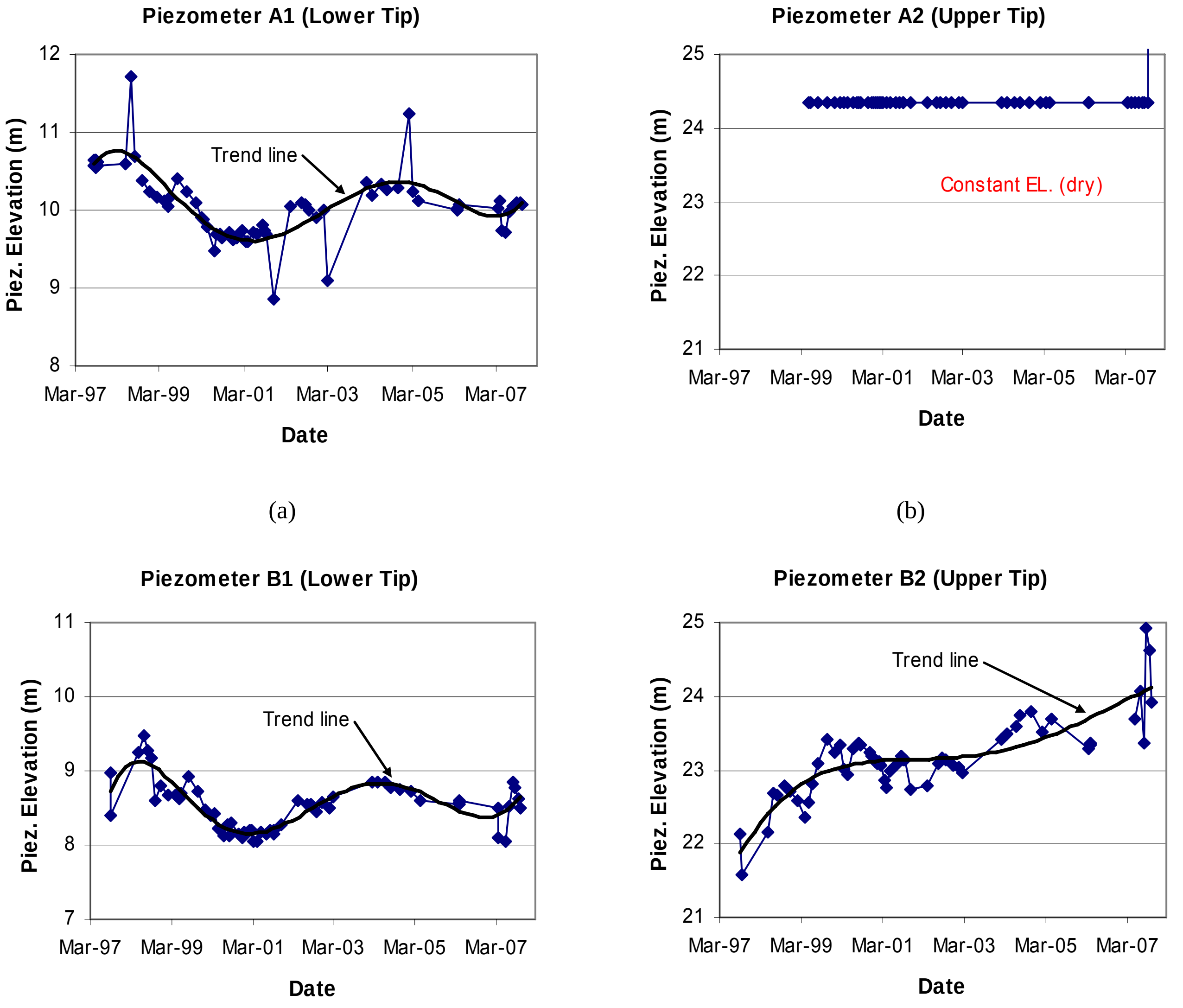
All the piezometers installed prior to 1996 are either lost in vegetation or considered inactive over the last 10 years. As noted earlier, 6 active piezometers (some with two tips) were located during the site visits: piezometers P-A to P-J. For the purpose of this report, the data has been used whenever it can be substantiated by other indications in neighboring installations, the wells water table, or by other observations.

Figures 7 to 10 plot the variation of piezometer water elevation for the last 10 years. Out of 12 observed tips, the readings of four tips are not consistent with the other installations or historic data. These are: P-A2, P-B2, P-C, and P-D2. In the piezometers which have two tips, the suffixes 1 and 2 refer to lower and higher tips, respectively.

In this section, observations regarding level variations in the piezometers are provided as follows:

- The trends of variation for the levels of piezometers P-A1 and P-B1 are very similar. Geometrically, the distance between the two piezometers is about 100 m; however, they can be considered in one cross sectional plane (perpendicular to the pump line).
- Piezometer P-A1 shows the water level 1.5 m higher than P-B1, which is to be expected, as the location of P-A is in the middle of the spur while P-B is closer to downstream.
- P-A2, which is located at the el 24.35, is dry which was also observed during the September 2007 first site visit.
- P-B2 shows an increasing trend of variation. P-B1 shows a virtually stable condition 15 m lower than P-B2 which suggests a separate and distinct groundwater regime in the areas monitored by the tips. P-B2 shows a unique trend within the spur by constantly increasing over the period 1992 to 2007. All other piezometers show a cyclical or constant trend.
- P-C shows an almost constant head; however, there are some reported spikes, which were also noticed in the 2007 visit (it may be that the piezometer riser pipe is damaged). The piezometer should be flushed and tested.
- P-D1 shows the lowest elevation in 2001 equal to el 21.6 m, which occurred at time when P-A1 and P-B1 experienced their lowest piezometric head. This elevation increased to el 23.8 m in April 2006. The recent readings show the elevation at about el 23 m.
- P-D2 shows an approximately constant value of about 31 m. This value is significantly higher than the value expressed by the lower tip and, similar to the case of P-B2, may show a perched water table in a separate and distinct groundwater regime. A dry condition has occasionally been reported for this piezometer tip.
- P-F1 showed a constant value close to 12 m after installation until 2005. From this time, the water level has increased gradually to a maximum of el 12.80 m, a 0.8 m increase. This value stabilized in 2007 at around 12.70 m.
- P-F2 used to be a dry piezometer. From March 2007, this piezometer indicated that the water level increased about 1.0 m, to a maximum of el 13.17 m in August 2007.
- In P-F, the two tips show the same elevation.
- P-G shows the minimum water elevation in 2004 to be around el 16 m. This value increased to el 19 m in March 2007 which is equivalent to a 3 m increase. At the day of the site visit, the piezometer water elevation decreased to about 18 m. Further readings are important for this piezometer.
- P-J1 shows an approximately constant level of el 10 m. In March 2007, this tip showed the highest elevation of el 10.3.
- P-J2, which is the higher tip, was dry from 2000 to March 2005. From April 2006, the piezometer showed an increase in water elevation of about 0.9 m. In March 2007, this value was equal to el 11.70 m and in September 2007, it was el 11.54 m. In August 2007, the water level was reported as el 14.95 m, which may not be correct and was eliminated from the figure.

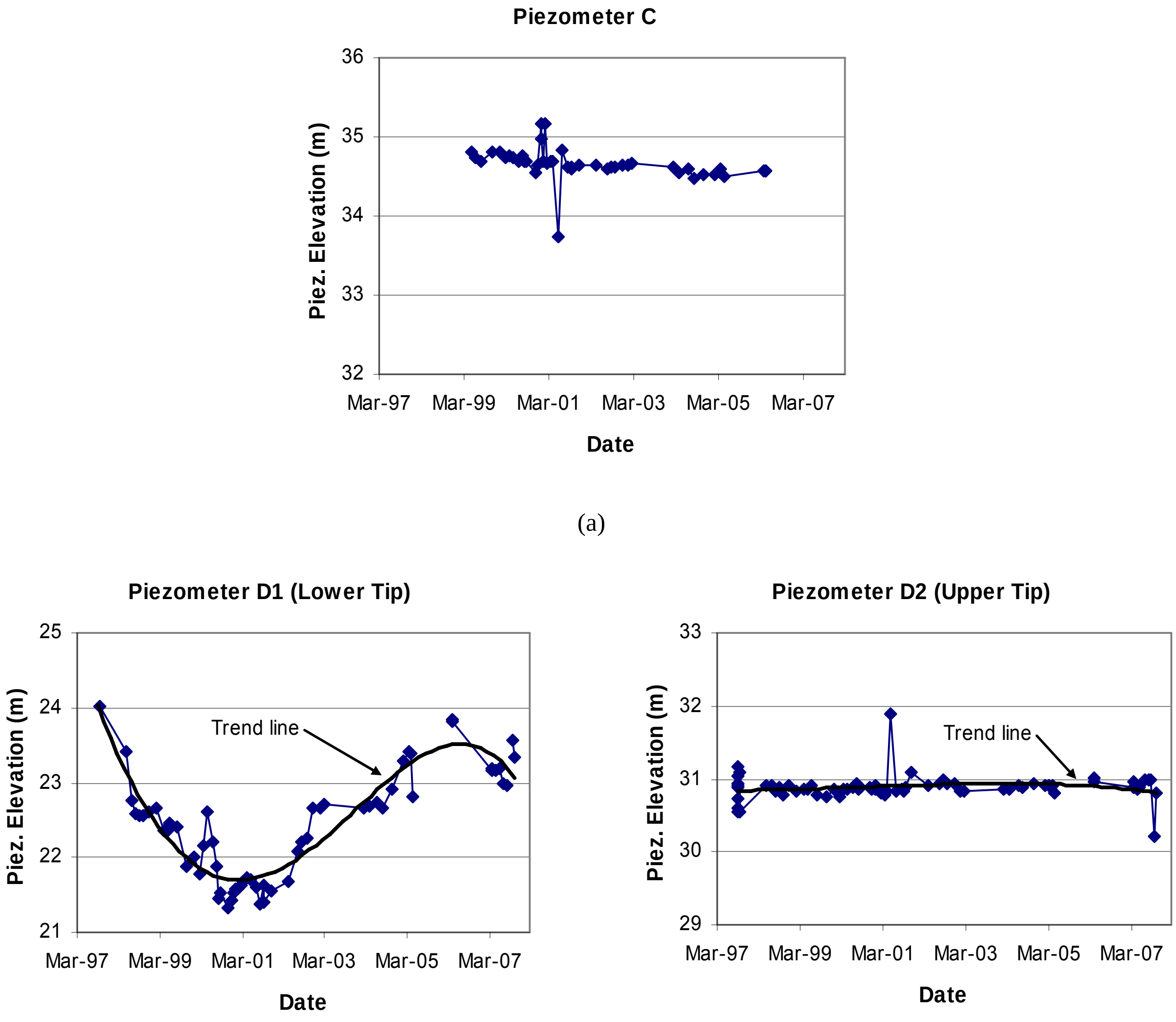
- Similar to the two tips of P-F, the two piezometer tips (P-J1 and P-J2) show approximately the same value or a slightly downward gradient.



(a) (b)

(c) (d)

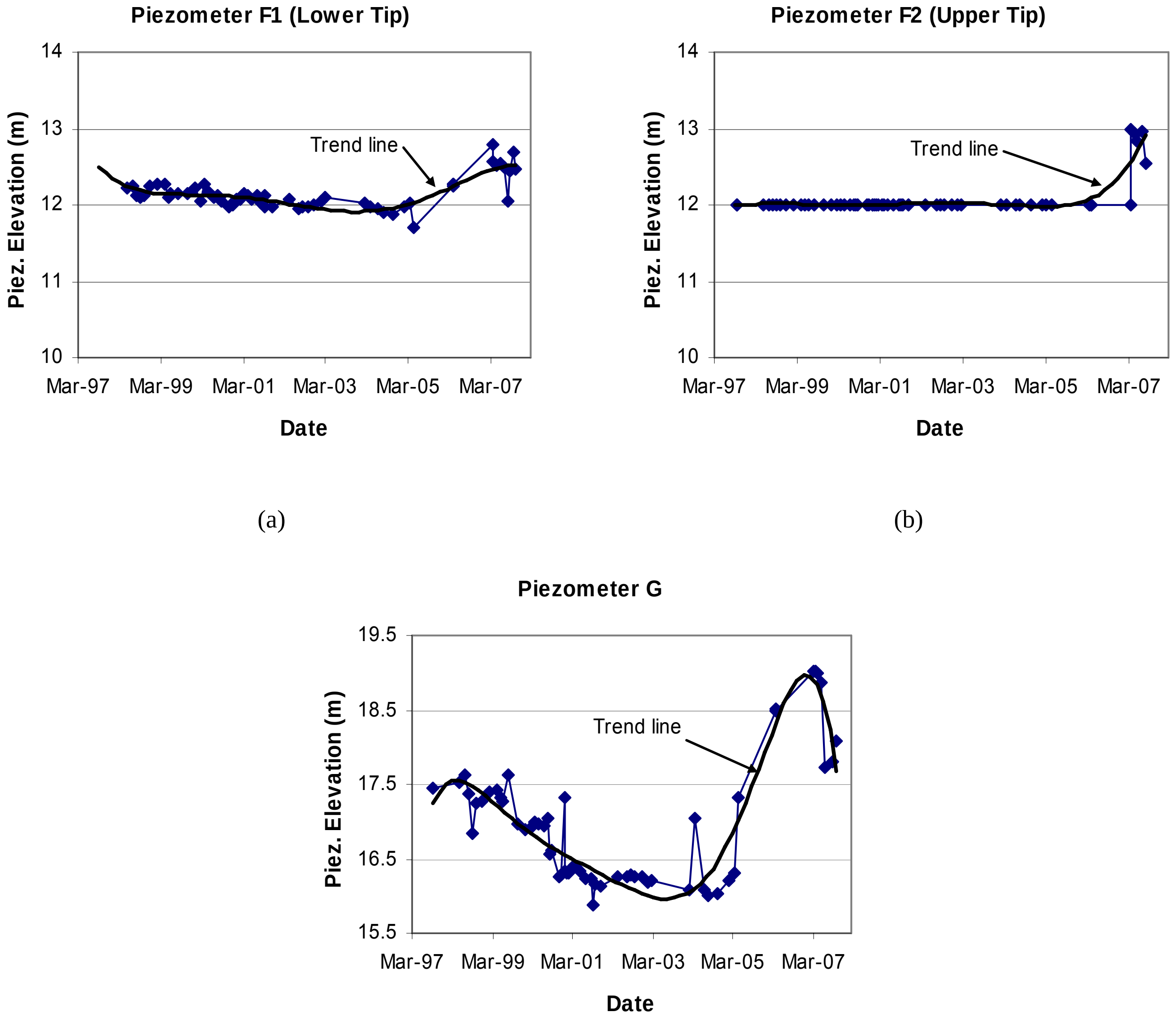
Figure 7 - Piezometer water level variations from 1997 to 2007: (a) P-A1 lower tip, (b) P-A2 upper tip, (c) P-B1 lower tip, (d) P-B2 upper tip



(a)

(b) (c)

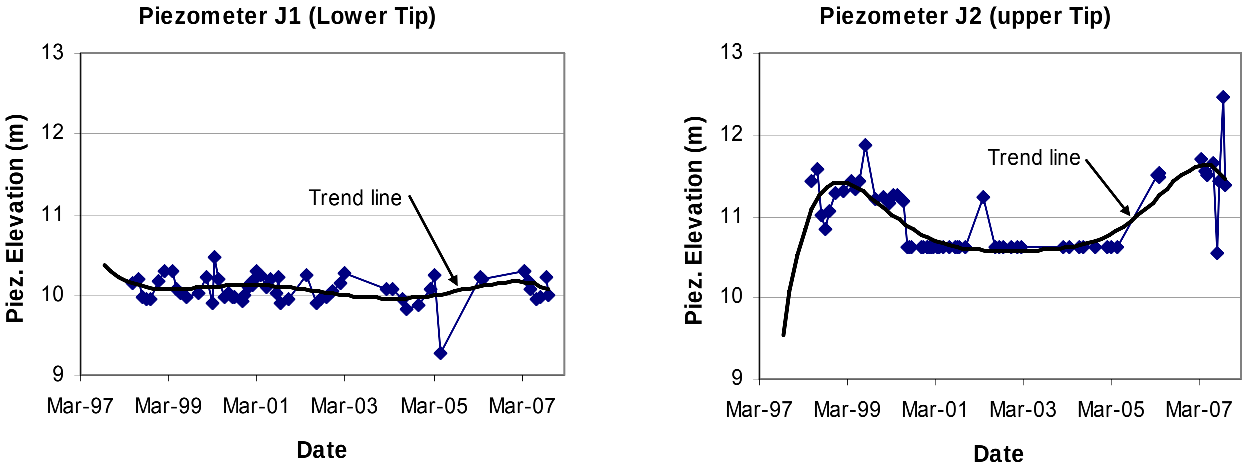
Figure 8 - Piezometer water level variations from 1997 to 2007: (a) P-C, (b) P-D1 upper tip, (c) P-D2 lower tip



(a)

(b)

Figure 9 - Piezometer water level variations from 1997 to 2007: (a) P-F1 lower tip, (b) P-F2 upper tip, (c) P-G



(a) (b)

Figure 10 - Piezometer water level variation from 1997 to 2007: (a) P-J1 lower tip, (b) P-J2 upper tip

General Comments about Piezometer Group Behaviour

Block – 1 (Southern Block):

Piezometers A and B, which are located at the narrowest width of the spur, show a similar trend. According to these piezometers, the general performance of the dewatering system close to these piezometers has not varied in the last 10 years. However, the piezometers P-A1 and P-B1 show an increasing trend in early 2007, as in early 2003, and should be evaluated to confirm cyclical trend or establish a new regime.

Block – 2 (Central Block):

In the middle section of the spur, which is represented only by P-D, the water level in the lower tip has increased about 1.5-2 m since 2001. This indicates that the pumping system efficiency in this section may have deteriorated since 2001 compared with the years from 1997-2001. W-9 to W15 are the wells which are close to P-D.

Block – 3 (Northern Block):

P-G, P-F, and P-J can be considered to be located in one cross section. The water levels in all three piezometers have increased since 2005. P-G shows the highest increase equal to 2.5 m and the two other piezometers show an increase of about 1-1.5 m. These values demonstrate that the situation in this area has changed dramatically in the last three years and the performance of the pumps W-17 to W-22 should be checked against the early performances, accordingly.

4.3 Well Water Elevations

Table 4 provides the well water levels observed during the Nov. 2007 site visits in addition to some reported values prior to and after pumping system initiation. These elevations are taken from Acres Dewatering System Assessment and Rehabilitation report of 1997.

There is not enough data regarding the wells water elevations in the previous reports, however, there is some information about the wells water elevations reported by Acres (1997). Comparing the collected data from the 2007 elevation observations to the record from 1994 to 1996, it can be concluded that most of the wells have an elevation close to their stabilized elevation with a few exceptions:

- Water elevation in W-2 has increased about 6 m, primarily due to pump decommissioning.
- The block of W-9, W-10, and W-11 has significantly higher elevations compared to their values in the period of 1994 to 1996. These high elevations are also confirmed by piezometer elevations in the vicinity.
- Wells W-18, W-20, W-21, and W-22 are experiencing a higher water elevation in comparison to the similar values in 1994 to1996. W-22 is experiencing a significantly higher water level due to pump decommissioning; however, the other wells also show an increase of between 2 and 5 m. Unfortunately there is no data prior to 1994, neither in wells nor in the piezometers.

Table 4
Well Water Elevations – Old and New Data

Well	Prior to Pumping Sep 1981	1994 See note C	1995 See note C	Recovery Test Aug 1996	Prior to Recovery Test Nov 2007	Lowest Observed Level in Nov 2007	Highest Observed Level in Nov 2007
W-1	30.56	19.8	-	16.39	14.36	14.36	14.37
W-2	29.49	-	-	6.65	12.22	12.22	12.28
W-3	29.73	7.58	9.10	6.57	8.14	8.14	8.65
W-4	30.43	10.07	10.90	11.01	See note A	9.44	11.19
W-5	30.57	7.54	9.10	8.73	8.28	8.28	8.62
W-6	33.27	10.51	11.30	11.03	11.06	11.02	11.06
W-7	29.94	10.00	11.80	11.78	11.96	11.96	12.11
W-8	34.91	9.46	10.80	10.28	9.73	9.73	11.70
W-9	37.50	15.43	20.80	25.92	24.04	24.04 [a]	25.38 [a]
W-10	37.56	7.90	9.90	11.02	26.72	26.72	26.44
W-11	37.44	11.86	12.60	11.55	19.8	19.8	21.17
W-12	43.91	7.78	9.10	9.71	See note B	9.54	12.92
W-13	47.37	6.69	8.70	5.51	5.79	5.79	11.90
W-14	38.51	7.57	25.00	26.51	14.97	14.97	18.84
W-15	41.56	-	27.60	11.88	9.25	9.25	21.01
W-16	43.20	10.75	10.10	25.86	9.26	9.26	19.78
W-17	31.72	9.94	10.30	11.90	10.3	10.30	13.12
W-18	31.91	14.32	13.90	15.70	17.53	17.51	17.53
W-19	43.60	12.45	14.90	18.51	8.81	8.81	16.68
W-20	21.64	8.58	8.90	9.58	12.26	11.95	12.22
W-21	24.37	12.58	9.30	8.54	See note B	14.33	15.91
W-22	25.59	15.77	8.70	9.10	29.58	29.58	29.64

Notes: A – Due to water influx the readings should be considered with caution
B – The wells cap were inaccessible
C – Typical random values for comparative reasons

4.4 Hydrogeological Sections

An examination of the last 10 years of piezometer data and the recent recovery tests is essential before any commentary can be made with respect to the hydrogeological performance of the spur under the influence of the dewatering system. In order to understand this performance, three additional cross sections, Figures 11 to 14, have been provided in this report each representing one segment of the spur (Figure 11 is an update of previous reports). The cross sections are chosen in such a way that they cover all the piezometers and one typical well in each section including: W-2, W-4, W-12, and W-19. Section locations are illustrated in Figure 4.

Although there is insufficient piezometric data for Sections B1-B1 and C1-C1, to illustrate trends, the data points on the sections provide an apparent comparison between the current water table and the original phreatic surface.

4.4.1 Section A1-A1

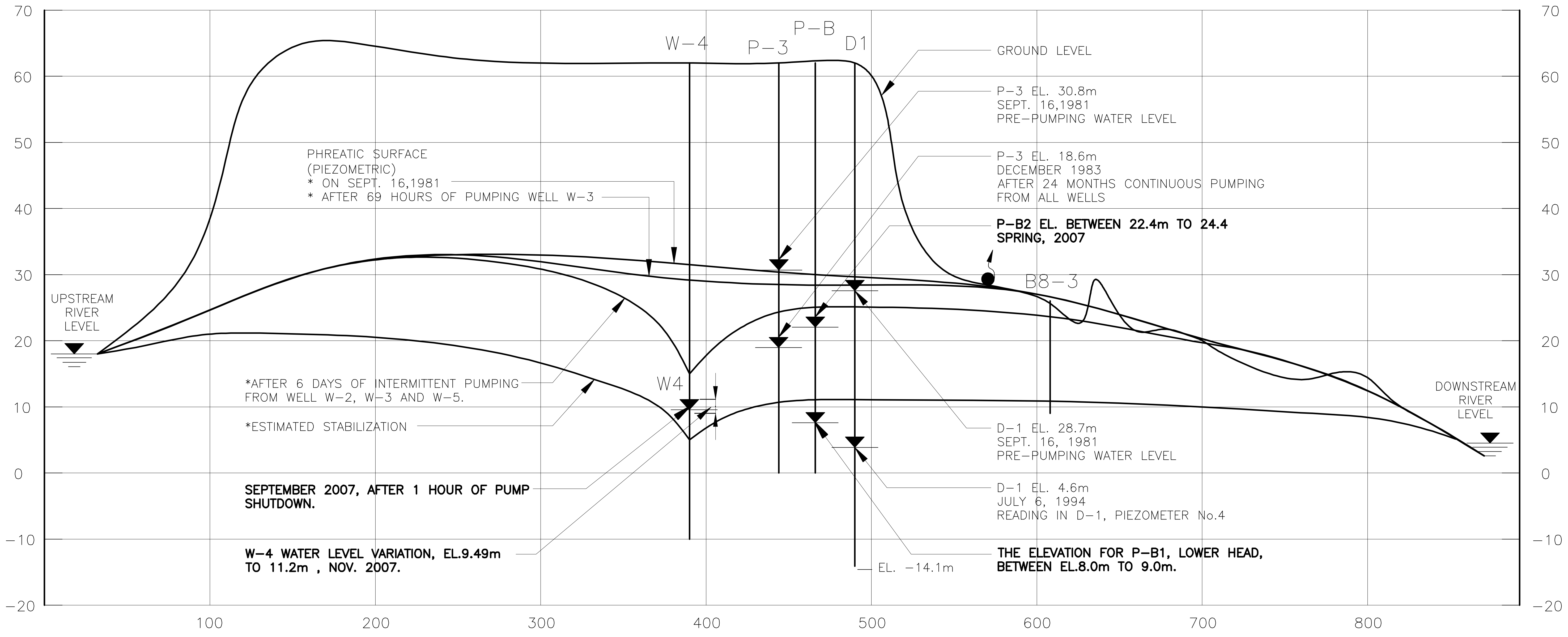
This section, Figure 11, is important because it is close to the narrowest section of the spur, there is a lot of information from other sources, and W-4, which is the most active pump, is located on the section. In the report by Acres International (1994), W-4 is noted to be responsible for 85% of the total dewatering of the system.

Currently, the water levels from P-B1 and W-4 indicate that the water table inside the spur is close to the estimated stabilized water table. P-B2 however, is showing an increasing piezometric level, possibly a perched water table. To confidently draw the current piezometric surface at this cross section, it is necessary to install additional piezometers in the spur, specifically close to the location of the old piezometers, C2, F2, or D2, to the west of W-4 (indicated in Figure 3).

4.4.2 Section B1-B1

This section , Figure 12, is also close to the narrow part of the spur. The original phreatic surface is plotted based on the information provided from SNC-Lavalin report: “Muskrat Falls Dewatering System – Engineering Assessment ”, Plate-4. The piezometric line resulted from 69 hours of pumping. Drawdown data points by Pumps 2,3,4, and 5 were also derived from the report.

The water table in the piezometer P2, read in Dec 1983 (original piezometric surface), indicates that the water table had dropped to el 10 m from el 26 m. In Aug 1996, the water level in W-2 was recorded by Acres to be el 8.75 m which is the lowest derived head in this section. This is shown in Figure 12. The two readings in Sept in P-A1 and Nov 2007 in W-2 indicate that the water tables are about el 10.1 and el 12.2 m, respectively. During the recovery test, the water elevation increased in W-2 by only 0.04 m, which is less than the level rise in the adjacent piezometers. This suggests that W-2 may be damaged as suggested by the removal of the pump several years ago. A well video inspection may reveal any problems.



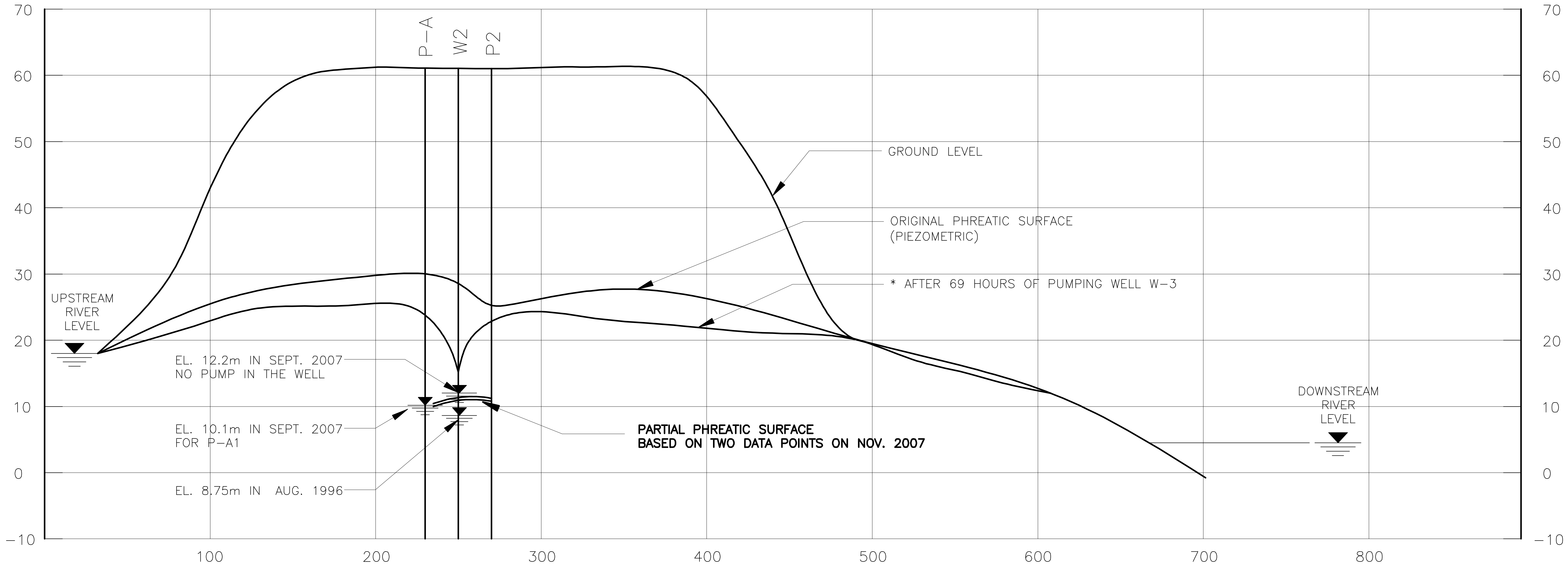
SECTION A1–A1

NOTE:

DRAWING THE CURRENT PHREATIC SURFACE NOT PRACTICAL WITH ONLY TWO DATA POINTS.

ORIGINAL DRAWING FROM ACRES (1994)

CLIENT HYDRO	PRIME CONSULTANT HATCH™	
PROJECT TITLE LOWER CHURCHILL HYDROELECTRIC PROJECT ENGINEERING STUDIES	WTO NUMBER & TITLE MF–1260 CONDITION ASSESSMENT OF EXISTING EQUIPMENT	DRAWING TITLE MUSKRAT FALLS HYDROGEOLOGIC SECTIONS SECTION A1–A1
DATE: NOVEMBER 2007	PROJECT No. H325967	DRAWING No. FIGURE 11



SECTION B1–B1

NOTE:
DRAWING THE CURRENT PHREATIC SURFACE
IS NOT PRACTICAL WITH ONLY TWO DATA
POINTS.

CLIENT HYDRO	PRIME CONSULTANT HATCH™	
PROJECT TITLE LOWER CHURCHILL HYDROELECTRIC PROJECT ENGINEERING STUDIES	WTO NUMBER & TITLE MF–1260 CONDITION ASSESSMENT OF EXISTING EQUIPMENT	DRAWING TITLE MUSKRAT FALLS HYDROGEOLOGIC SECTIONS SECTION B1–B1
DATE: NOVEMBER 2007	PROJECT No. H325967	DRAWING No. FIGURE 12

The water table in W-1 is equal to el 14.3 m, 2.1 m higher than W-2 and about 6.0 m higher than W-4. These indicate that the water tables in W-1 and W-2 are significantly higher than W-3 and W-4, indicating that the water table increases towards the south of the spur. Pumping from W-1 and W-2 will decrease these water tables.

4.4.3 Section C1-C1

This cross section passes through W-12 and P-D and former piezometer, P-7, illustrated in Figure 13. Similar to Section B1-B1, the original water table is plotted on this section based on the SNC-Lavalin report. The reported values for P7 show that the water level decreased from el 22.8 to el 16.7 in Dec 1983. However, the original levels of P7 are not consistent with those derived from the phreatic surface for the intermediate aquifer.

Acres reported the W-12 water elevation equal to el 9.1 m in May 1995. This was also read during the recovery test and varied from el 9.5 m to el 13.9 m after five hours of system shutdown.

The upper tip of P-D (P-D2) shows the water level equal to el 30.9 m for this piezometer, which is again even higher than the initial phreatic surface. In this respect, the dewatering system has not influenced this area, and may reflect a local condition.

The lower tip, P-D1, showed a level of el 23.2 m on Nov 6, 2007. This value is significantly higher than the water tables in the wells in the vicinity: W-12, W-13, W-14, W-15. On the other hand , the water elevation in Wells W-9, W-10 and W-11 (from el 19.8 m to el 26.72 m, from Table 4) are more consistent with the value in P-D1 lower tip. These indicate that P-D1 is representing the actual water elevations in the spur close to wells W9 to W-11.

4.4.4 Section D1-D1

There are three piezometers and one well located in this cross section, as shown in Figure 14, which allow a precise illustration of the current stabilized phreatic surface. However, as discussed in Section 4.2, the piezometric surface has risen significantly since 2005.

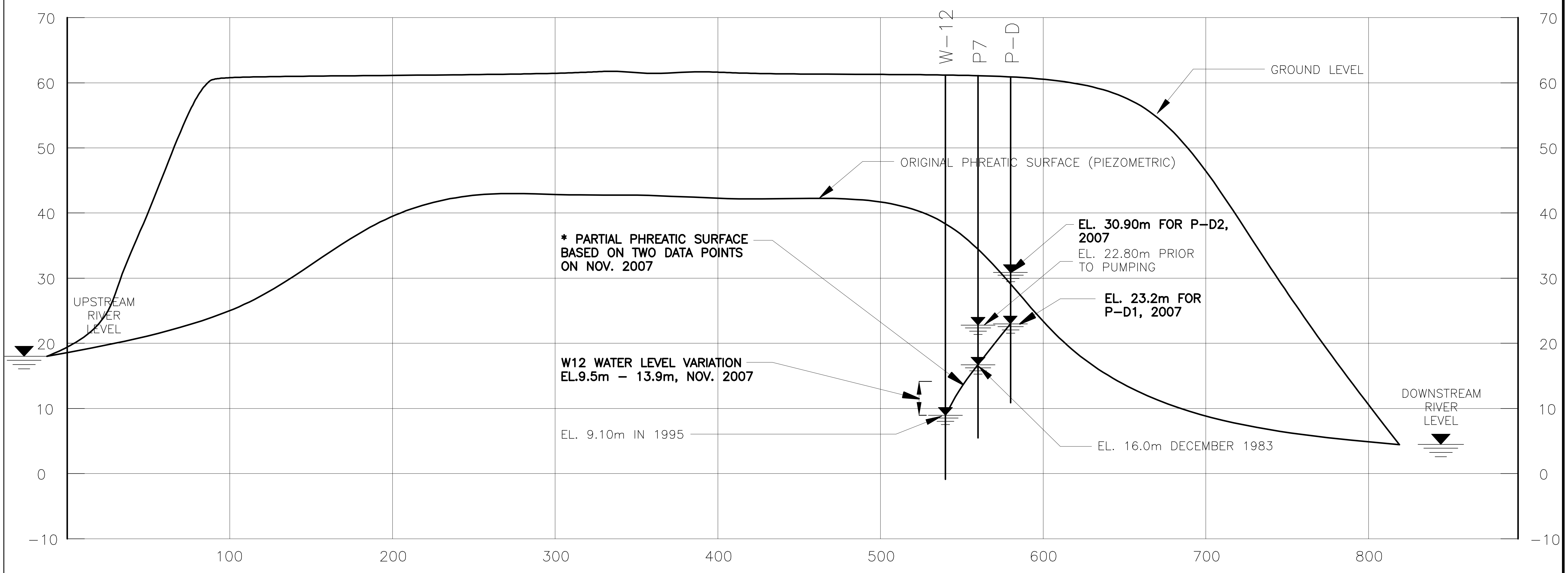
The old piezometer P-10 showed an elevation equal to el 11.39 m in September 1981, prior to pumping, which is significantly lower than the original phreatic surface, around el. 35.0 m and is likely not correct.

The water table in W-19 was at el 40 m, before the system initiation in 1981, and in 1995 Acres showed this value to be at el 14.9 m. The current recovery test indicates that the water table in the well increased from el 8.8 m to el 16.7 m after 5 hours of system shutdown. This confirms that the well is highly active.

The piezometers P-G, P-F, and P-J show the piezometric elevations in Nov 2007 to be el 18.0 m, el 12.3 m , and el 10.1 m, respectfully. These values are consistent with each other and define the water table in this cross section. This cross section can be considered as indicative of the block number 3.

4.5 Precipitation, Temperature, and Upstream River Water Level

In this section, the potential interrelationship between piezometric elevations and precipitation, temperature and/or upstream/downstream river water elevations is addressed. As the only continuous water table information in the spur is derived from standpipe piezometers which were installed in 1997, the focus is on the statistical data after 1997.

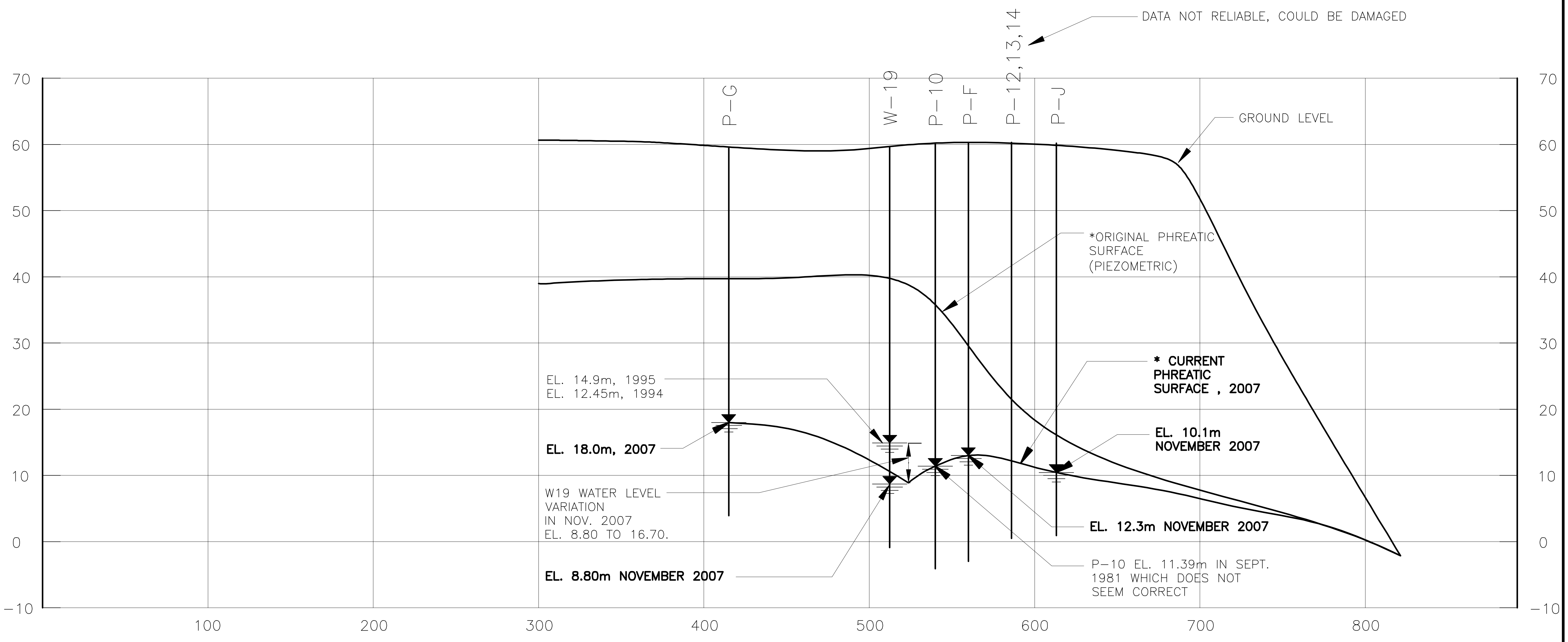


SECTION C1−C1

NOTE:

1. DRAWING THE CURRENT PHREATIC SURFACE IS NOT PRACTICAL WITH ONLY TWO DATA POINTS.
2. ELEVATION IN P−D IS SIGNIFICANTLY HIGH.

CLIENT	PRIME CONSULTANT	
HYDRO	HATCH™	
PROJECT TITLE LOWER CHURCHILL HYDROELECTRIC PROJECT ENGINEERING STUDIES	WTO NUMBER & TITLE MF−1260 CONDITION ASSESSMENT OF EXISTING EQUIPMENT	DRAWING TITLE MUSKRAT FALLS HYDROGEOLOGIC SECTIONS SECTION C1−C1
DATE: NOVEMBER 2007	PROJECT No. H325967	DRAWING No. FIGURE 13



SECTION D1-D1

CLIENT
HYDRO

PRIME CONSULTANT
HATCH™

PROJECT TITLE
LOWER CHURCHILL
HYDROELECTRIC PROJECT
ENGINEERING STUDIES

WTO NUMBER & TITLE
MF-1260 CONDITION
ASSESSMENT OF EXISTING
EQUIPMENT

DRAWING TITLE
MUSKRAT FALLS
HYDROGEOLOGIC SECTIONS
SECTION D1-D1

DATE:
NOVEMBER 2007

PROJECT No.
H325967

DRAWING No.
FIGURE 14

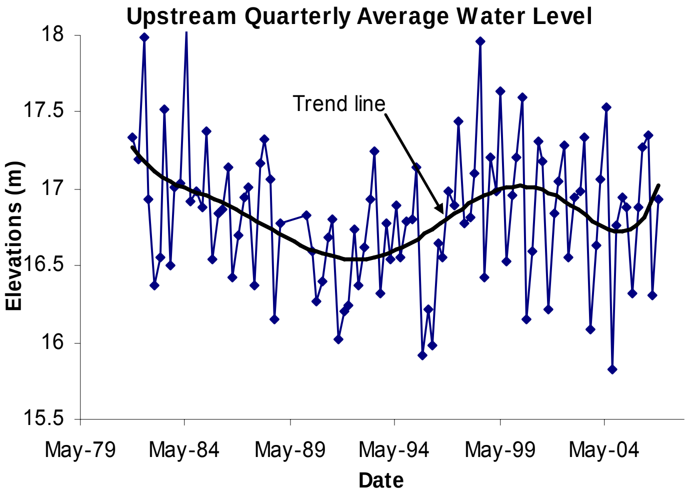
As the piezometric elevations have not been recorded monthly until recently, only quarterly or annual comparisons are provided.

4.5.1 River Water Levels

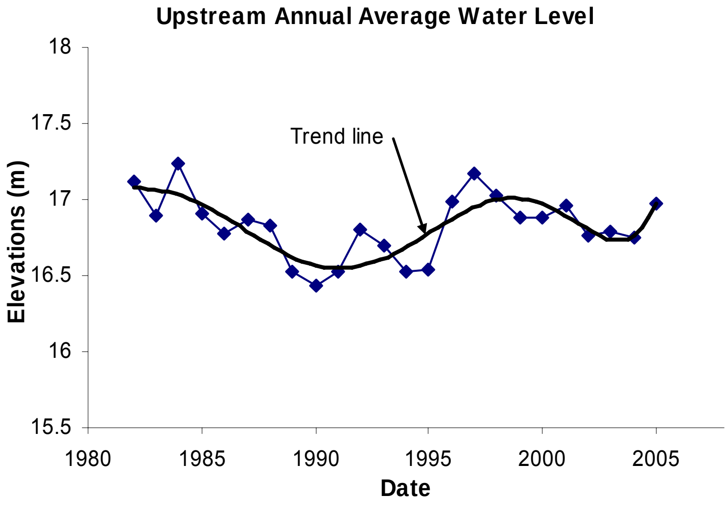
Only upstream river water elevations have been recorded in the last ten years, and information regarding downstream river water level is limited to a few years between 1980 and 1990. Figure 15 shows the variation of upstream water level based on quarterly and annual average values (Water Survey of Canada 03OE001).

The local low values for upstream river water elevation occurred in 1991 and 2004. The range of variation in the elevations for quarterly average data is between el 15.8 and el 18.0 m and for annual values are between el 16.5 and el 17.3 m. The highest quarterly average upstream water level for the last 10 years occurred in June 1998 at el 18.0 m, while the lowest is reported for September 2004 at el 15.8 m.

Comparing the variation of the upstream water levels (showing highest in 1999 and lowest in 2003) with the variation of piezometers P-A , P-B, and P-D, Figures 7 and 8 (which have their lowest elevation in 2001 and the highest value in 2004/5) , it can be concluded that there is no clear correlation between upstream river water level variation and the piezometric elevations.



(a)



(b)

Figure 15 - Upstream average water level: (a) quarterly average from 1980 to 2007, (b) annual average from 1980 to 2007 (W.S.C. Gauge 03OE001)

4.5.2 Precipitation and Temperature

Figure 16 depicts total annual precipitation, total rain, and total snow for the last 10 years at the Goose Bay meteorological station (climate station ID: 8501900). As it can be seen, the highest level of precipitation occurred in 1999, while the lowest level was in 2005. However, it can be observed that the overall trend is one of generally decreasing total precipitation.

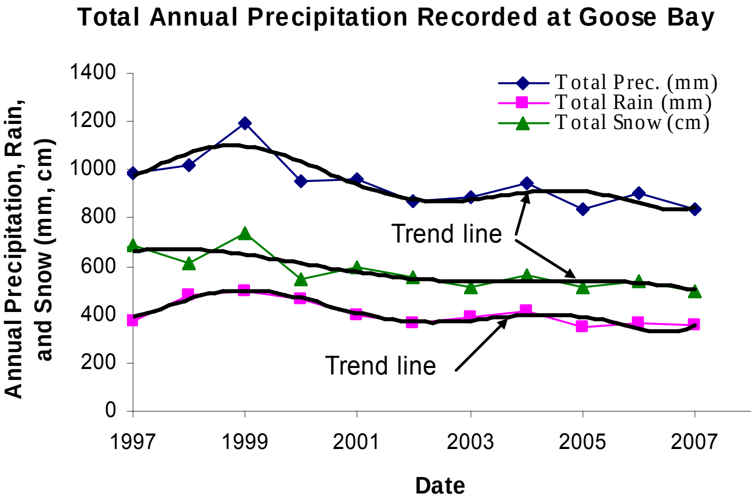


Figure 16 - Total Annual Precipitation, Rain and Snow at Goose Bay from 1997 to 2007 (from Goose Bay Meteorological Station 8501900)

This is contrary to the observed piezometric water level variations for P-A1 and P-B1, since for these piezometers, the local peaks occurred in 2005, which shows the lowest precipitation observed for the period of 1997-2006. Furthermore, the total annual precipitation can not explain the recent rises, since 2005, in the piezometric water tables as were observed in the piezometers located in northern block, including: P-F, P-G, and P-J.

Figure 17 shows the variation of mean annual temperature at Goose Bay (climate station ID: 8501900). This figure shows that the highest mean temperature occurred in 2006 followed by 1999. In these years, the spur area would have naturally experienced the fastest melting season in comparison with other years. No other correlation is apparent.

It is believed therefore that the groundwater level regimes in the south and middle segments of the spur should be controlled by both the river flows from upstream to downstream and by regional precipitation infiltration, while the north segment of the spur should be affected primarily by precipitation runoff from the north bank.

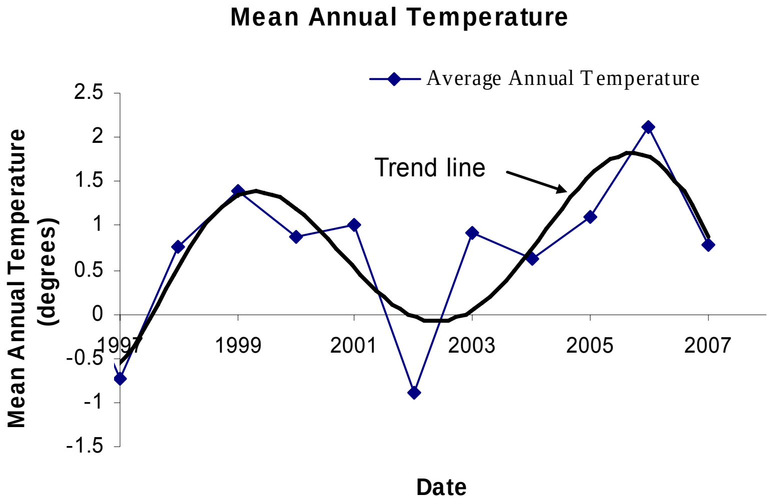


Figure 17 - Mean Annual Temperature at Goose Bay from 1997 to 2007 (from Goose Bay Meteorological Station 8501900)

4.6 Historical Data on Pump Operation

In order to investigate the performance of the pumping system in the recent years (the last four years), the on-time periods of selected pumps and/or blocks are compared with the on-time values of some randomly selected earlier years. For the following discussion, it should be noted that in some months, there was a problem in the data transmission system so those data are absent from the figures. For instance, in Figure 18, the on-time for pump No. 4, for the duration of July to Aug 2007, is recorded equal to zero, which is very unlikely. It is believed that all the data interpretations related to the on-time should be accompanied with some other data like piezometer and well water elevations. However, discounting the information while there is no better substitute is not justified. Nevertheless, these figures may reveal some valuable data which might otherwise have been recently available with an accurate data recording and transmission system.

Figure 18 demonstrates the total monthly on-time for pump no.4 for the last four years (2004 to 2007) as well as a randomly chosen year, 2001, for comparison purposes. This figure shows that the data are usually well recorded for the first six months of each year. The pump experienced its most active year of the four in 2006; however, the values are significantly lower than in 2001. The pump P-4 in well W-4 was changed in September 2007, and the recorded values show that there is a significant decrease in the on-time Oct and Nov 2007 when compared with Oct and Nov 2004 to 2006. The relatively high on-time throughout 2006 suggests that the pump was not performing satisfactorily during this year, as the well water inflow to the well could not be evacuated fast enough. As a result, pump on-time data might be a useful tool for the purpose of system maintenance. The decreased on-time values in the recent years in comparison to 2001 suggest that P-4 has become less active which should be considered carefully.

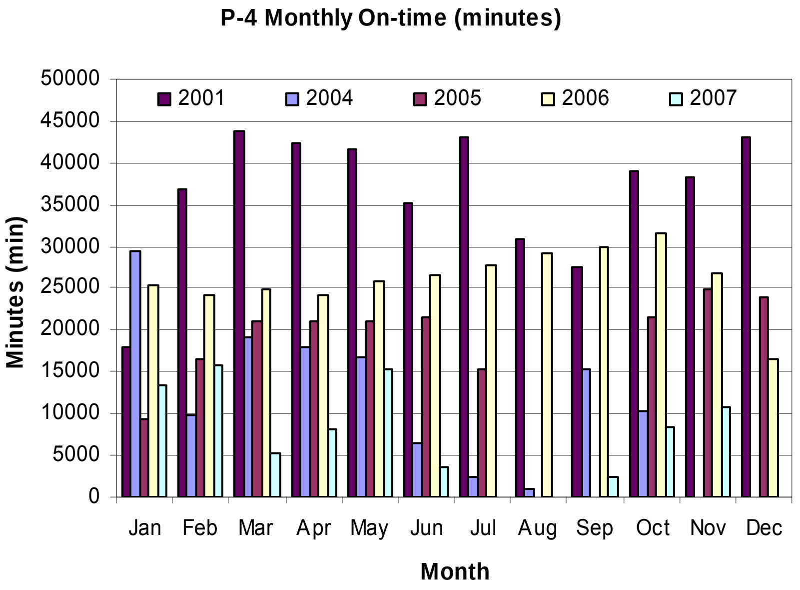


Figure 18 - Monthly on-time for pump no. 4 (P-4)

Figure 19 plots the activity of pump no.9 for the years of 2004 to 2007 and also 2001. This shows that the pump on-time is significantly lower than that of pump no.4. The activities in the recent years have not changed meaningfully from 2001.

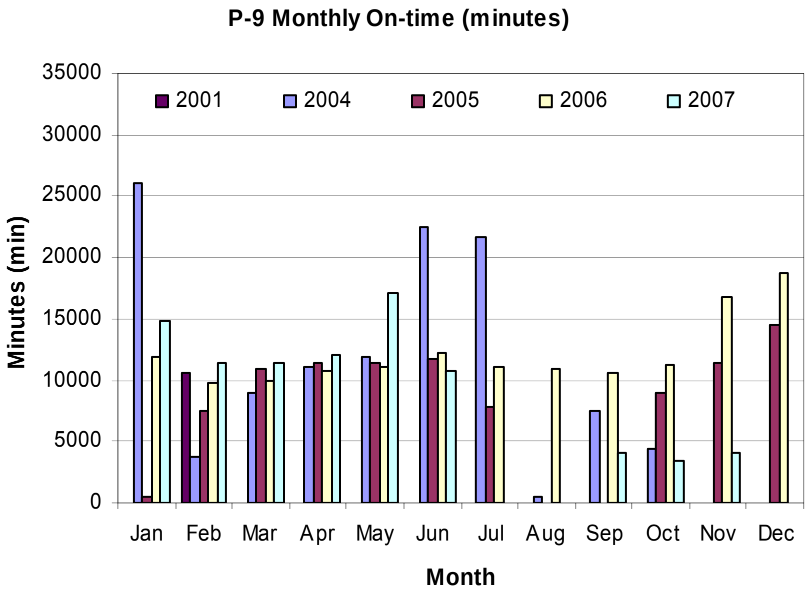


Figure 19 - Monthly on-time for pump no. 9 (P-9)

Figure 20 shows the on-time for pump no. 19. This figure suggests that the pump is generally inactive for years after 2005. This pump is located in the northern block where the water table level has significantly increased in the years after 2005.

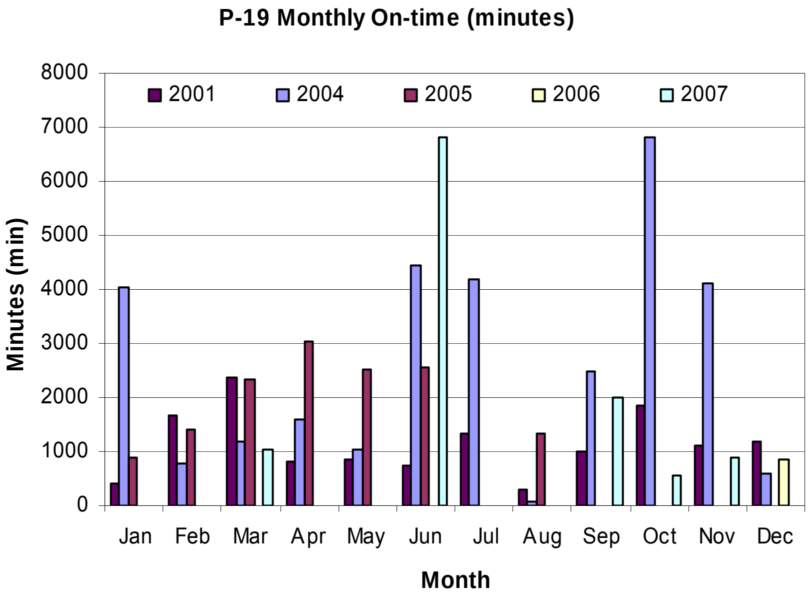


Figure 20 - Monthly on-time for pump no. 19 (P-19)

Figure 21 depicts the total monthly on-time for the block 1 (Southern Block). The block experienced its most active time during year 2006, as a result of high pump no.4 activity; however, the on-time values are much less than the year of 2001.

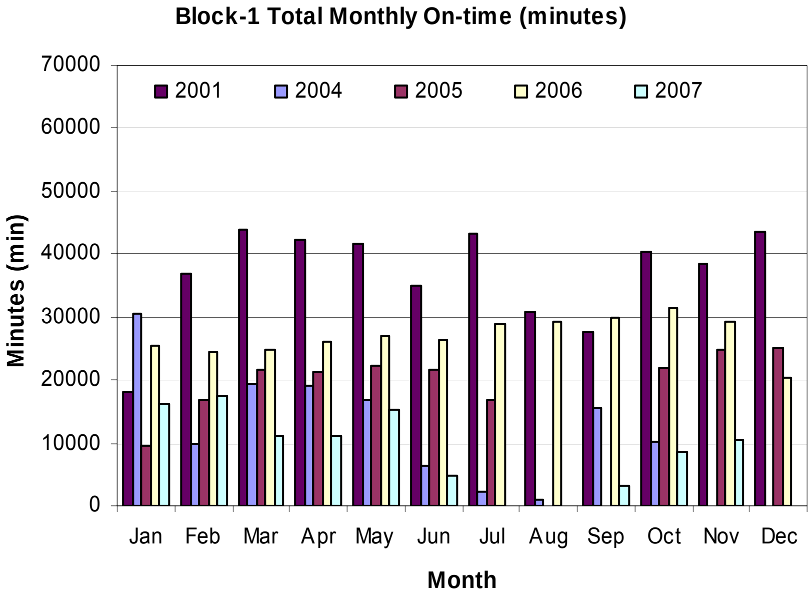


Figure 21 - Total monthly on-time for Block-1 (Southern Block)

Figure 22 also shows that Block-2 (Central Block) had its most active month in November 2006.

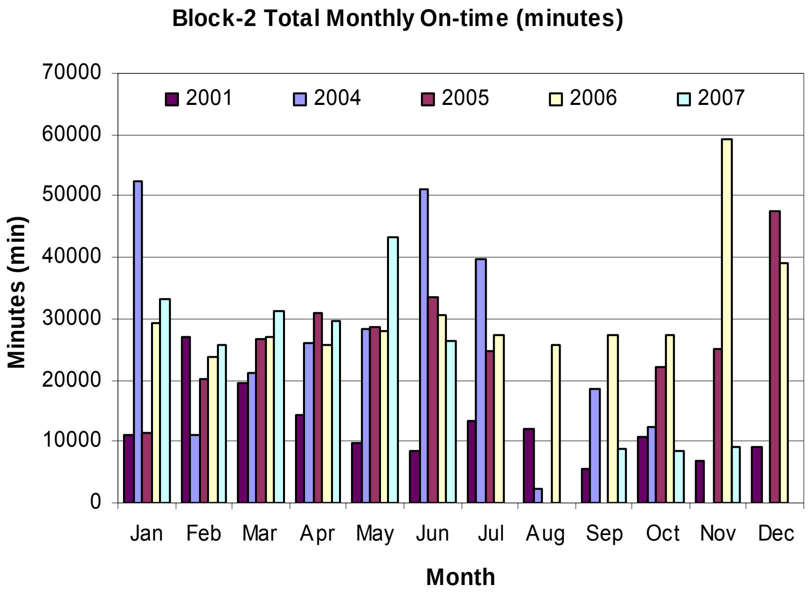


Figure 22 - Total monthly on-time for Block-2 (Central Block)

Figure 23 confirms that Block-3 (Northern Block) is generally much less active than the other two blocks. The two monthly on-time values, Jan 2004 and Nov 2006, are significantly higher than the other years. This might be the result of inconsistent recordings of some on-time activities.

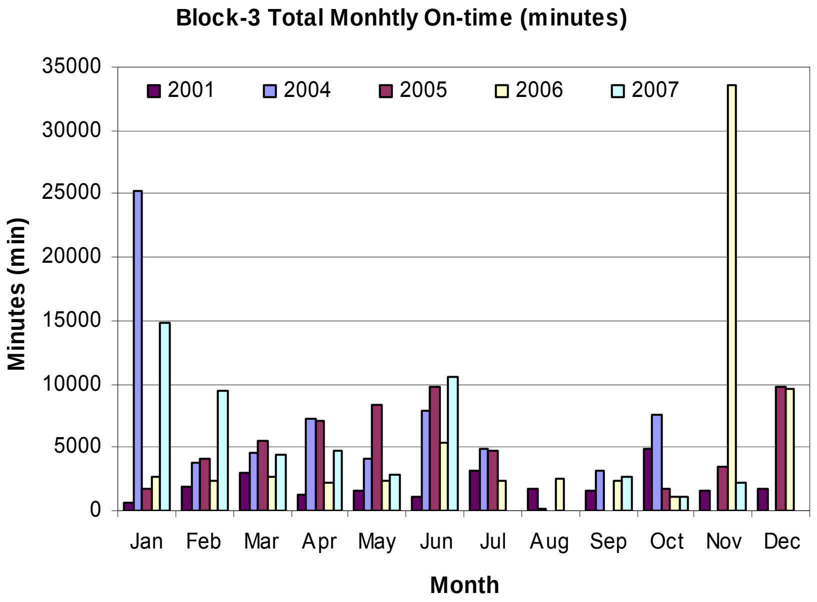


Figure 23 - Total monthly on-time for Block-3 (Northern Block)

Figure 24 shows the average monthly on-time for different blocks for the last four years. This figure shows that Block-2 (Central Block) is the most active block in the recent years followed by Block-1. While the on-time of Block-3 has been almost constant over the years, the other two blocks experienced the most active years in 2006 (other than 2001).

All this suggests that the average on-time minutes could be used as a useful source of system control, in future monitoring, but only when considered in conjunction with the well discharge and well efficiency information. In this case, well efficiency is taken to describe the ability of the screen and filter to pass water without significant head loss. Currently no information is available on either discharge or efficiency.

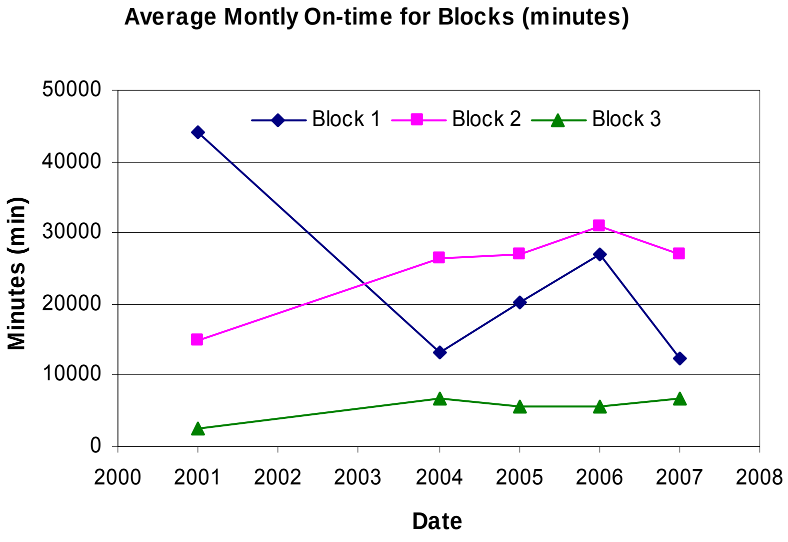


Figure 24 - Average monthly on-time for different blocks

4.7 Recovery Test Results

Appendix C provides the results of the recovery test for the 8 piezometer tips and the 22 wells. The details of the test procedures are described in Section 3.3.

On the first day, after the system restoration, the readings in the piezometers continued. However, as the water rise in the piezometers was less than 1-2 cm, these observations were not repeated on the second day.

4.7.1 Piezometers Recovery Observations

On the first day of the recovery test, P-A experienced the highest increase equal to 15 cm after 5 hours of system shutdown. P-B had 11 cm of rise in water level and P-D experienced about 5 cm rise.

Recovery prediction for piezometers

Shutdown of the pumps might be caused by an unpredictable event such as a problem in power transmission, or well clogging as a result of screen collapse, and so on. In this event, water levels will rise, and the rate of rise is important in the planning of repairs and rehabilitation.

To improve the predictive capability, the experimental results (the recovery test) have been compared with some approximate calculations. The results of the calculations are summarized in Table 5, and the details are presented in Appendix B.

Table 5
Piezometer Water Level Changes - after Appendices B and C – November 6, 2007

Piezometer	Calculation Method	Elapsed Time	Water Level Rise in P-A1 (m)	Water Level Rise in P-B1 (m)
Water Level Rise	Approximate Calc. Appendix B	2 hours = 120 min	0.09	
Water Level Rise	Approximate Calc. Appendix B	5 hours = 300 min	0.11	
Water Level Rise	Approximate Calc. Appendix B	7 days = 10080 min	0.17	
Max Water Level Rise	Recovery Test Appendices B and C	7 days = 10080 min	0.37	0.42
Min Water Level Rise	Recovery Test Appendices B and C	7 days = 10080 min	0.29	0.30

4.7.2 *Well Recovery Observations*

After observing the results of recovery test on the wells, the wells have been categorized into three major groups: highly active, active, and inactive wells. Monitoring the water level rises in the highly active wells was extremely difficult. Some wells (W-4 and W-12) were monitored for a second time on the second day of the site visit; however, it was not practical to reach an ideal and consistent trend of water level variation. The readings of some wells are not reliable but they can be designated as an active well.

The categorization of highly active and active is subjective based on both the on-time for the pump in the well, and the rate of water level rise during the recovery test.

Inactive Wells (passive wells)

W-1, W-2, W-6, W-18, and W-22 were observed to be inactive. The pumps of W-1, W-2, and W-22 at the time of site visit have been decommissioned and removed. W-6 and W-18 are off most of the time; however, some activity is logged during some months. W-22 used to be an active well as in Acres (1997) report. It is anticipated that W-2 and W-22 could contribute usefully in the dewatering of the spur if a pump was installed.

Highly Active Wells

W-4, W-9, W-10, W-12, W-19 can be considered highly active. Unfortunately, the results of recovery test for W-9 and W-10 can not be considered satisfactory. (A level meter was trapped inside the W-9 for the first day and results of the second day are not satisfactory. For W-10, the observed virtually constant water levels during the test contradict the reported high frequency of pumping starts. Hence, either the pumping on-time information is incorrect or the water levels were not read correctly).

Active Wells

The other 12 wells were active and responsive during the recovery test, including: W-3, W-5, W-7, W-8, W-11, W-13, W-14, W-15, W-16, W-17, W-20, and W-21. The active wells experienced some variations in their water level, suggesting that they are passing through an active aquifer and the well, filter, and/or riser pipe are in a satisfactory condition.

For the wells close to W-4 in Block-1, the results of the recovery test suggest that if W-4 fails for any reason, these wells cannot perform as its backup. This is because W-4 appears to be a significantly more active, productive, and efficient well than its neighbor; when considering that while the water level variations for W-3, W-5, and W-7 were limited to 0.41, 0.34, and 0.15m, the water level variation in W-4 (from Min 18 to 300) was 1.75 m. The first site visit observations, noted in Section 3.2.1, also confirm this suggestion.

4.8 Pressure Relief Wells – Comments on Potential Service Life

A description of the Muskrat Falls system is presented in Section 2. It is to be noted that no record of the materials used in the well screens was found, only that the riser pipes are polyvinyl chloride (PVC). Similarly, no record is available indicating the slot size or well screen opening. Figure 25 shows a typical pump and well as-built detail as provided by SNC-Lavalin (1982).

Commercially available well screens and riser pipes are available in a variety of materials such as black iron, galvanized iron, stainless steel, brass, bronze, fiberglass, and PVC. The performance of the well materials over time depends on several factors including:

- strength;
- resistance to damage by servicing operations;
- resistance to attack by chemical constituents in the groundwater; and
- maximum depth of well installation.

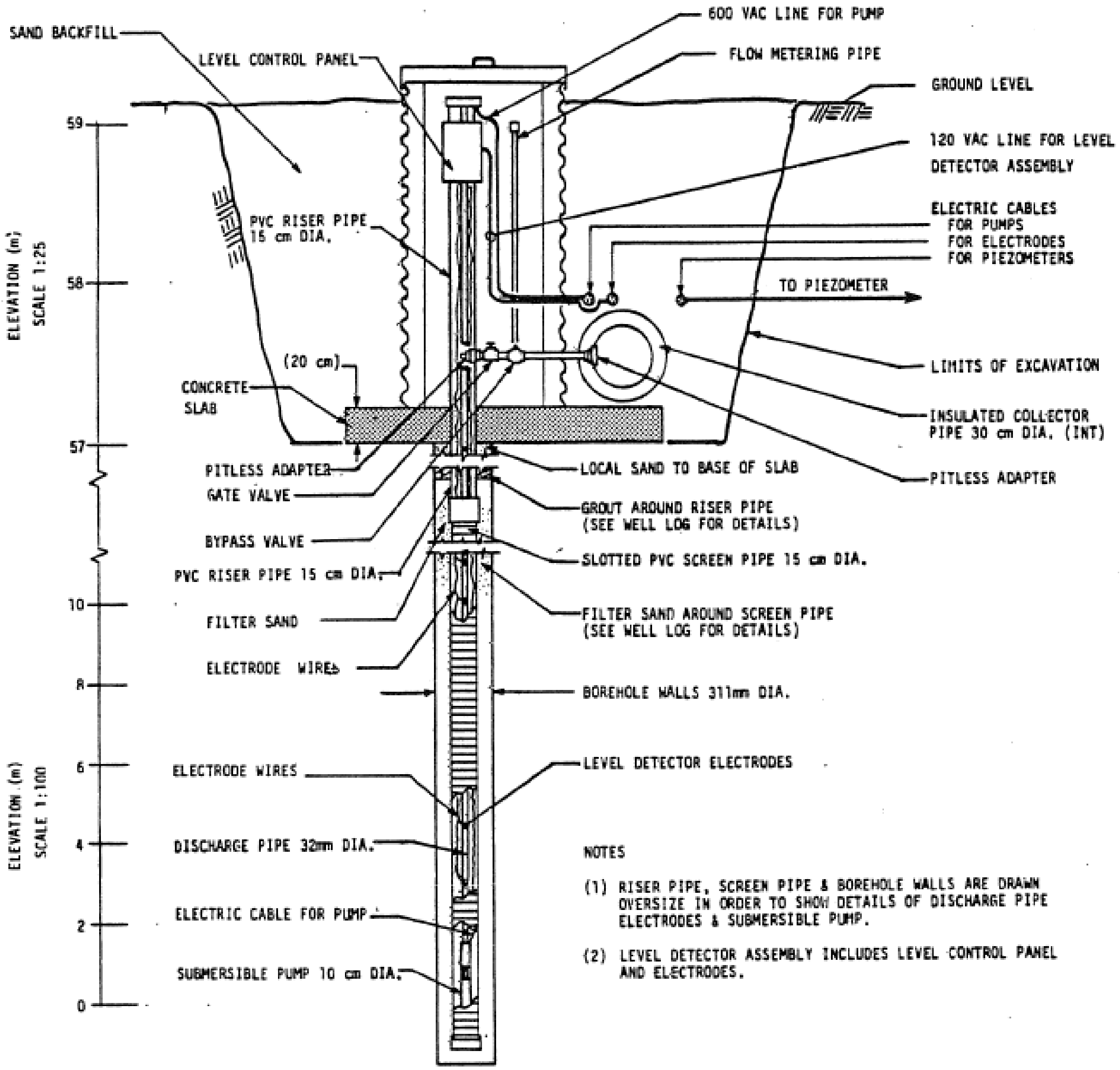


Figure 25 – Typical pump and well as-built detail provided by SNC-Lavalin (1982)

4.8.1 Screen Materials

Stainless steel is a very stable material in most environments; however it is relatively expensive. Type 304 stainless steel has excellent corrosion resistance, whereas Type 403 stainless steel has moderate corrosion resistance. Low-carbon steel for use in a wire-wrapped screen may be economical; however it has no corrosion resistance. Brass and bronze are extremely expensive for this use and may not be completely stable in acidic environments. Fiberglass may have some limited use: however, it has not been used in a wide range of environments. PVC appears to be very stable and easy to install; however it is a relatively weak material and can be easily damaged. The combination of ferrous and nonferrous metals such as a brass screen and a steel riser pipe may induce electrolysis and result in deterioration of materials.

4.8.2 Selection of Materials

Generally, pressure relief wells are designed and installed to protect the foundation of structures. As such, the selection of materials should be based on costs and performance over the life of the structure that is being protected. The choice of a well screen for long-term installation will depend on three factors including:

- water quality;
- potential presence of iron bacteria; and
- strength requirements.

A water quality test will provide information on the type of groundwater and whether it is corrosive and/or encrusting. Enlargement of screen openings due to corrosion or abrasion due to suspended fines in groundwater can cause progressive movement of fines into the well. Therefore it is important to ensure that a well screen be fabricated from corrosion-resistant material for installation in corrosive groundwater environments, and similarly if encrusting groundwater is expected, then future treatments may include acidification. If iron bacteria are expected to be present then selection of material should consider repeated chemical treatments. Strength of material needs to be considered for deeper installations, as does maximum compression and tensile forces during installation and potential physical treatments during development and maintenance activities.

A properly designed and installed filter should be considered for long-term performance of a pressure relief well. In order to prevent infiltration of foundation sands and silts into the filter, the filter gradation should meet the stability requirement that the 15 percent size of the filter should not be greater than 5 times the 85 percent size of the foundation materials. Special blends of hard durable particles may be required to maintain long-term performance of permanent relief wells.

Proper development of pressure relief wells, which may include surging and air lifting and pumping, is also necessary to further develop the zone around the well filter. Accumulation of silt in the well may indicate a breakthrough of silt materials in the well filter and as a result, an ineffective filter.

4.8.3 General Performance of PVC Pressure Relief Well Systems

PVC and stainless steel appear to be the most common materials used in the construction of pressure relief well systems. While PVC is generally less costly than stainless steel, other factors should be considered in the selection of the material. Stainless steel and PVC systems have been successfully used for many years and should be expected to last in compatible environments for at least 50 years. The longevity of pressure relief systems may be more dependent on the installation method rather than the type of materials used. In addition to the above-noted chemical concerns associated with various materials, the depth of installation, type of host materials and pressures may also be of concern. The use of PVC materials in coarse alluvial materials at depths greater than 40 m is generally not recommended due to the potential deformation of the pipe and/or screen. At Muskrat Falls, the new wells will be 60 m or deeper. Specific procedures need to be used for the installation of PVC systems such as considering the heat of hydration of cement grouts and the use of chemicals which may degrade PVC materials. For some installations, the use of a stainless steel screen and a PVC riser pipe has been used to combine the best features of both materials.

Pressure relief wells that have been constructed as a temporary measure may not have an installed filter, which may result in the gradual migration of fines into the well. In some cases this type of well can be rehabilitated by redevelopment of the well, surging, etc. Therefore, prior to installation the expected longevity of the wells should be considered in the design.

Our experience with a number of pressure relief systems is that there appears to be more concern associated with the installation of PVC systems; however, this may be due to installation issues rather than material issues and the expected longevity of the system. Some of these systems were designed for a 20-25 year performance life and have been in place in excess of 25 years without any rehabilitation measures.

5. Summary and Conclusions - Current Groundwater Regime

In this section, the results of the assessment of the current groundwater regime within the spur are summarized:

- Dividing the spur groundwater regime into three zones or blocks was suggested by Acres (1997): namely southern, central, and northern zones. Historical observations show that these zones are influenced by different water sources and the areas impacted by the dewatering system are different. The greatest drawdown is generated in the southern zone while the lowest drawdown was found in the northern zone.
- The groundwater levels in some wells in the central zone (Block-2), wells W-9 to W-11, are significantly higher than their historical values. These current groundwater elevations are also higher than other wells in the vicinity. The nearby piezometer, P-D, also shows the groundwater at a high elevation which confirms the high water elevation in the block. Recently, the piezometric level in P-D has risen about 2 m in comparison with its lowest value recorded in 2001.
- The piezometers in the northern block indicate that the piezometric elevation in this block has recently increased about 1 to 2.5 m. This increasing trend started in 2005 and most of the piezometric levels have followed this trend.
- Hydrogeological sections show that the water table has decreased from the natural groundwater elevation under the influence of the dewatering system. The groundwater depression in Section C1-C1, located in the central block, is less tangible. In order to gain a complete understanding of the water table in these sections and to be able to monitor the spur piezometric elevation, it is necessary to install additional piezometers.
- The evaluation of precipitation, temperature, and upstream river water level indicates that the recent increases in piezometric levels are independent of natural causes, specifically precipitation, and upstream river water level. Acres (1997) also indicated that the northern block is mainly influenced by groundwater flow from the north valley slope rather than the flow from upstream.
- Considering all the uncertainties in the dewatering system data recording and transmission as mentioned in Section 4.6, historical pump operation data indicates that the pumps in the northern block are generally inactive (Figure 24). The average monthly on-time of the northern block is significantly lower than the other two blocks. This observation is to be compared within an observed rise in groundwater levels in piezometers within this block. Despite the increase in the on-time hours in recent years in comparison to 2001, it is clear that pumping in the north block is inefficient.
- The recovery test and predictive calculations indicate that the effect of a short term system shutdown/interruption on the piezometric elevations is not significant. Nevertheless, the current piezometric elevation especially in the southern block should be maintained. Conversely, a long time is needed to draw down the water table, should level rises occur.
- It is necessary to investigate the reason for decommissioning of pumps in W-2 and W-22 as these wells were reported to be active in Acres (1997) report. It is recommended to reactivate these wells, in addition to W-1.

- The observed fine sand, clay, and twigs in the system discharge water, after total shut down, and the fine sand, silt, and clay witnessed specifically in W-4 suggest that filters and/or screens of several wells and collector pipes are not functioning properly. This is a major concern and indicative of continuing system inefficiency and potential well collapse.

6. Final Comments and Recommendations

The dewatering system has operated continuously since November 1981 and there has been no further major landslide activity on the spur. The purpose of the installation has, therefore, been fulfilled. However, the system is currently 26 years old, and some rehabilitation work is required to ensure its continued operation for the next 10 years.

6.1 Wells

Three of the pumps have been decommissioned; several of the remaining pumps appear relatively inactive while some pumps are very active. The continued dependence of the dewatering system, which is now 26 years old, on primarily one well, W-4, and on several wells which have been discharging fines through the screen and the filter for many years, is not advisable. As a result of the fines discharge, the existence of cavities beyond the screens cannot be discounted, the collapse of which could damage or destroy one or more wells. To maintain and improve the dewatering system beyond its current level and therefore ensure its continued operation for an additional 10 year period, it is recommended to carry out the following steps:

6.1.1 Well Cleaning and Detailed System Evaluation

- All pumps, risers, and level sensors should be pulled, inspected, and cleaned. All specifications and details of pumps, motors and sensor positions should be recorded and all sensors and relays tested.
- The wells have been in continuous operation for 26 years, and based on an inspection of one well (W-4) during the September 2007 site visit (and the data of the 1994-1996 site activities) there is a need to repeat the flushing of the wells similar to the activities in 1996. Such flushing should be undertaken by a qualified specialist company with experience in well drilling, installation and maintenance.
- It would be also appropriate to consider the use of a television camera to inspect the screen and confirm its integrity. To clarify water in the well and allow better visibility, it may be necessary to use a flocculent agent (Calgon e.g.). The use of a down-hole γ-γ Test (Reactive Absorption or Density Test) is also recommended to allow the detection and an assessment of the extent of possible voids beyond and within the filter given the volume of fines which have passed through the filter and screen since 1981. The γ-γ Test is a standard well logging technique.
- A detailed evaluation should be prepared of the condition of each current well installation and the surrounding ground and conclusions drawn with respect to its individual status and its status within the system as a whole.

6.1.2 New Well and Piezometer Installations

- It is Hatch’s current judgement, given the data presently available, that to ensure a satisfactory performance of the dewatering system for the next 10 years and to maintain the physical asset of the Muskrat Falls ridge as a whole, 6 or 7 new stainless steel wells need to be installed together with 4 or 5 new double standpipe piezometers, as mentioned previously (each standpipe in a separate hole). The construction of the wells is estimated to approximately cost $930,000 plus engineering and management fees, as described in Appendix E. There is a mobilization and demobilization cost for both the construction of piezometers and wells which is approximately $90,000, hence the total cost will be in excess of $1 million.

- The above mentioned evaluation and the progressive installation and testing of new wells will indicate the exact number and location of the new wells. After testing the new wells to ensure that they are able to achieve the groundwater levels close to the historical low levels, it may be recommended that the original wells are placed into a backup mode for one or two years whereupon they may be decommissioned. This will increase the reliability of the system and will limit the risk of not reaching the target pumping levels in the new wells. The new wells should be distributed among the three blocks close to the most active wells, as follows:
    - In the Southern Block, 2 wells, close to W-4 and place W-4 into a backup mode
    - In the Central Block, 3 wells, close to W-9, W-10, and W-11 and place W-9, W-10, and W-11 into a backup mode
    - In the Northern Block, 2 wells, close to W-19 and W-20 and place W-19 and W-20 into backup mode

6.1.3 Other Recommendations

- Pumps should be installed in wells W-1, W-2, and W-22
- Until the installation of an automatic data acquisition system, the well water elevations and piezometers readings should be recorded and interpreted manually.
- Consideration should be given to the installation of a flow monitoring device at the collector pipe outlet, the output from which could be transmitted to Goose Bay with pump function data.

6.2 Piezometers

The originally installed piezometers were struck by lightning in 1983. The new standpipe piezometers, installed in 1997, are partially functional. Only 7 of the 10 suggested piezometers were installed and one of these (P-C) is believed to be out of order. The recommendations for piezometer upgrades can be categorized into three groups:

- In order to develop a more complete understanding of the phreatic surface and to assist in the creation of hydrogeological cross sections, such as those presented in Section 4.4, and in other sections to be developed in the future, it is suggested to install 4 new double standpipe piezometers. It is estimated that this will cost in the order of $120,000 plus engineering and management fees (Details are provided in Appendix E). The locations of the new piezometers are suggested as follows as shown in Figure 4:
    - One piezometer to the west of W-4 (Section A1-A1)
    - Two piezometers on each side of W-9 (project to Section C1-C1)
    - One piezometer in the location of the previously proposed piezometer P-E (project to Section C1-C1)
- Installation of data acquisition systems and automatic data transmission for all piezometers and several wells converted to standpipe piezometers (W-2, W-4, W-9, W-13, W-19, and W-22)

representing the performance of each well block. The specifications and a cost estimate for the Data Acquisition System and instrumentation are provided in Appendix D.

- Until such time as the system is automatic, recording of the piezometric elevations should continue to be undertaken on a frequent basis (monthly), similar to the readings performed in recent months. It is also suggested to perform well elevation reading a few times every year, taking into account all safety issues. There are few records in some years; (i.e. in 2003, the piezometer elevations were recorded only two times; in 2005, three times; and in 2006, three times).

6.3 Electrical Supply

From the SNC-Lavalin construction report, it was noted that the main 600 V AC line exiting the control shelter was divided into four runs of 600 V AC. The 600 V AC cable runs powered three groups of 6 motors and one group of 4 motors in series. The grouping of motors was not identified. Little is known about the power cables feeding the pumps. It is recommended that all electrical components from the control panel outward be tested to ensure the electrical infrastructure is not deteriorating.

Back-up power should also be provided in the event of a power outage (while the WTO indicated a generator was on site for this purpose, this is not the case).

6.4 Data Monitoring and Transfer

The data collected by Hydro for the pumps appears unreliable due to ON/ON and OFF/OFF sequences. The ON/OFF data originates from the pump level relay and is processed at the MF Control Shelter before being transmitted by VHF radio to Hydro's offices.

Hydro should investigate the cause of the troublesome data with a review of all overload relays and sensors. The remote terminal unit should undergo self testing. To ensure the data being collected is meaningful, a computer should be installed at the shelter to collect the data before transmission. This data would then be compared with the transmitted data to determine whether the errors are caused by the monitoring or the radio transmission components of the system. It is understood that the transmission components have been upgraded in recent years, and if it is concluded that they are still at fault, the following options for data transmission should then be explored:

- Satellite technology.
- Fibre optic/communications cable along the existing pole line to Goose Bay.
- Data transmission over existing power lines.
- Additional upgrades to VHF system.

6.5 General Recommendations

It is recommended that the following activities be carried out to assist with the ongoing dewatering operation.

- Implement procedures for responding to high-level alarms.
- Provide back-up pump and motor capability at site or at Hydro's facilities in Goose Bay.

- Clear trails to all piezometers (1997 and original standpipes), and weirs and install safety hand lines as appropriate.
- Re-bury the exposed portion of the inclined collector pipe and re-grade the slope to prevent further erosion and potential damage. Repair and/or replace the outfall heater and insulation as specified in the original designs. Clear the area of outfall culvert and reinstate the entrance way to the discharge point and provide devices to ensure safe access.

Appendix A

Site Visits Photographs

Downstream slope (Site Visit -1)

Downstream slope (Site Visit -1)

Erosion at downstream slope toe (Site Visit -1)

Pull-out of the pump in W4 (Site Visit -1)

Silt and fines in W4 riser pipe (Site Visit -1)

Cloudy water from W4, after pump replacement (2.5 hours of system shutdown) (Site Visit -1)

Common pump operation before the replacement of pump at W4 (Site Visit -1)

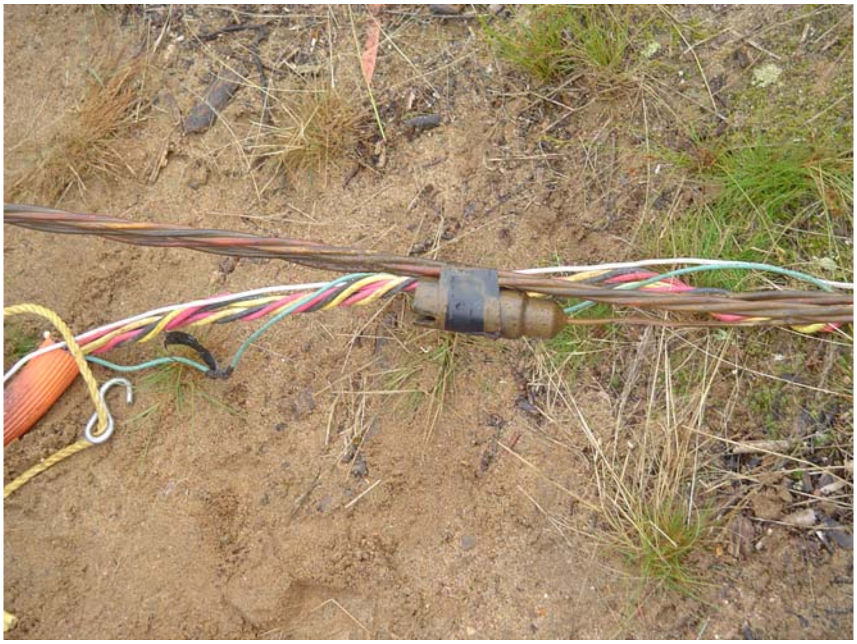
Control panel after system restoration (Site Visit -1)

Decommissioned pumps (Site Visit -1)

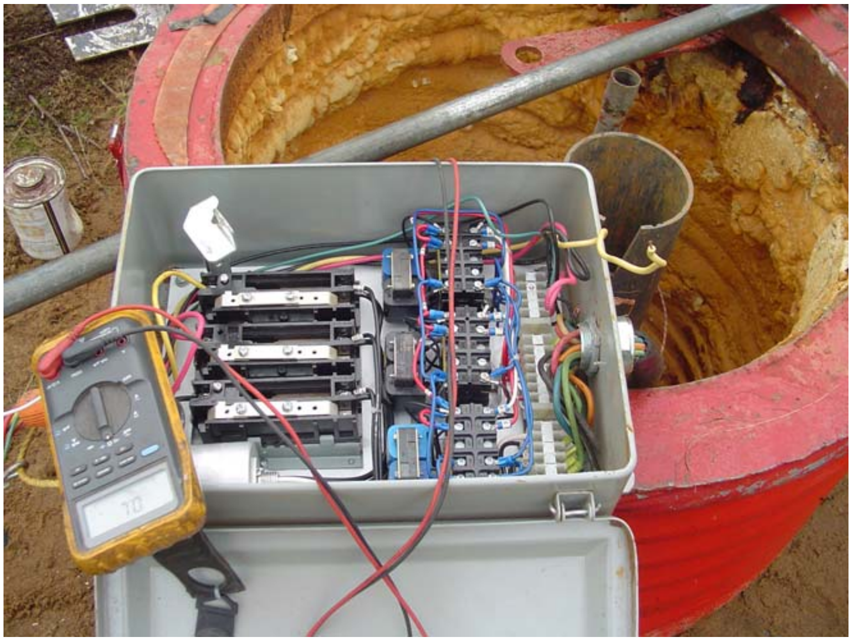
Discharge water from outfall pipe (Site Visit -1)

Shelter room at water outfall (Site Visit -1)

25kV Power to Control Shelter (Site Visit -1)



Level Electrode removed from W4 (Site Visit -1)



Electrical Junction Box in W4 (Site Visit -1)

Water quality at outlet – Cloudy with silt and twigs (Site Visit -2)

Recovery test (Site Visit -2)

Appendix B

Recovery Prediction for Piezometers

Recovery prediction for piezometers:

In this Appendix, the experimental results from the recovery test are compared with some approximate calculations. The main purpose of these calculations is to predict the water table rises in the piezometers P-A and P-B, which are 60 m away from W-4, should any interruption occur in pumping in W-4. The graphical data, using the results of the recovery test, is also used for the prediction of water table rises.

2 hours (120 min) prediction

P-A and P-B are close to W-4, which is the most active well, about 60 m away. A rough calculation predicts a rise of about 9.3 cm in those piezometers after 2 hours of the pump shutdown. It should be mentioned that these calculations are based on available information like the annual on-time for pump in well W-4 which could be approximate. The accuracy of these calculations should be controlled with in-site observations like the performed recovery tests. The calculations and some assumptions used in this Appendix is based on Groundwater and Wells by F.G. Driscoll (1986 - second edition). The main assumptions and calculations are as follows:

Water discharge rate: q_4 = ~ 2.5 (gallon per bucket)*4.55 (L/bucket)/12 (s) = 0.95 L/s

Total on-time for W-4 (2006) = 44409 min

Average on-time/day = 44409 (min) /365 (day) =122 min/day

Average daily discharge = Q = 60 (s/min)*122 (min/day)*.95 (L/s)/1000 (m^3/L) = 6.95 m^3/day

Observation distance from well r = 60 m, Depth of aquifer = 35 m

$K = 1 \times 10^{-5}$ m/s (compatible with Acres (1994))

Coefficient of transmissivity $T = 1 \times 10^{-5} \times 35 \times 86400 = 30.24$ m^2/day (assuming aquifer height equal to 35 m)

Coefficient of storage, S (confined) = 10^{-5} (Driscoll, 1986)

t = 120 min = 1/12 day

$u = r^2S/4Tt$ (Driscoll, Eq. 9.5a) = $3.6x10^{-3} \rightarrow W(u) = 5.1$ (Driscoll, Appendix 9.E)

Drawdown (here drawback), $S = 1/4\pi \times Q/T\ W(u) = 9.3$ cm (Driscoll, Eq. 9.5)

(This formula is normally used for drawdowns resulting from pumping activities; however, in this section it is utilized for water level increase due to pumping shut down).

5 hours (300 min) prediction

In this case, the above calculation can be repeated assuming that the pumping terminates after 7 days, equal to 300 minutes:

t = 300 min = 7 days

$u = r^2S/4Tt = 1.4x10^{-3} \rightarrow W(u) = 6.0$

Drawdown (here drawback), $S = 1/4\pi \times Q/T\ W(u) = 11.0$ cm

7 days (10080 min) prediction

Repeating the above and assuming that the pumping terminates after 7 days (10800 minutes):

t = 10800 min = 7 days

u = $r^2S/4Tt = 4.3\text{x}10^{-5} \rightarrow W(u) = 9.5$

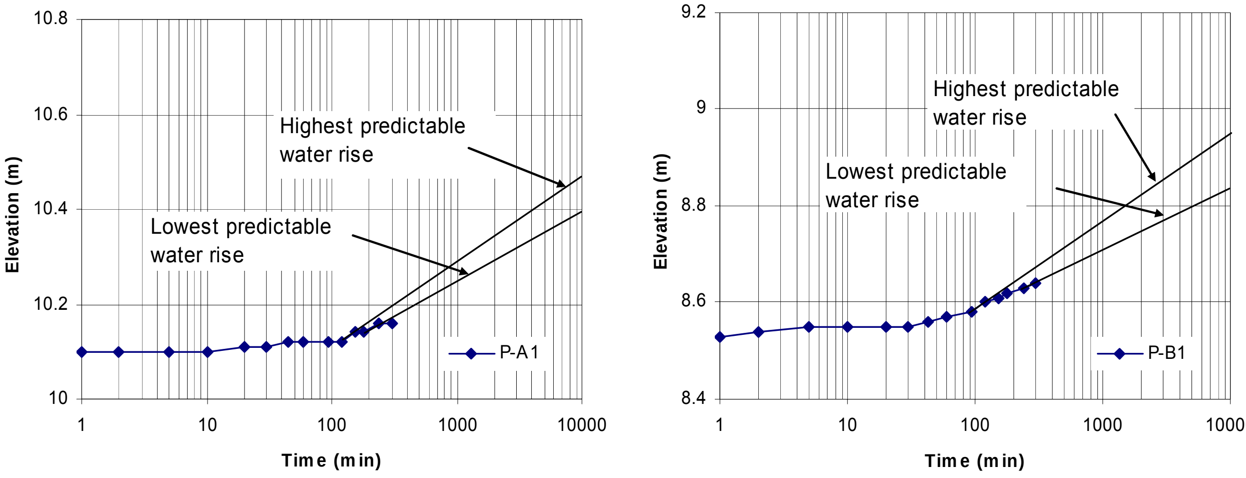
Drawdown (here drawback), S = 1/4π x Q/T W(u) = 17.4 cm

Graphical estimate for 7 days system shutdown

Here, it is intended to predict the water rise in piezometers P-A1 and P-B1 using the recovery test results and graphical methods. Figures B1-(a) and B1-(b) show the results of recovery test on piezometers elevation rise versus time for 5 hours (300 min), on a semi-logarithmic scale. Assuming that the level rise in the piezometers is linear versus time in logarithmic scale, the level variation after 7 days (10080 min) can be predicted as:

P-A1: between 0.29 and 0.37 cm

P-B1: between 0.30 and 0.42 cm



(a) (b)

Figure B1 - Water level rise in piezometers using graphical method (a) P-A1 (lower tip), (b) P-B1 (lower tip)

It can noticed that the level rise derived from the graphical method is considerably higher than the calculation method, about 1.6 to 2.4 times the graphical method. This is because in the graphical method, it is assumed that the rate of variation in logarithmic scale stays constant; however, as the water rises, hydraulic gradient decreases accordingly. It is recommended to consider the experimental results as conservative values as the experiments were performed for only 5 hours, which may not be considered long enough for a 7-day prediction.

Results of recovery test on piezometer elevations on second day of recovery test

The reading of three piezometers: P-F (2 tips), P-G, and P-J (2 tips), were left for the second day of the recovery test. The water level in most of these piezometers increased during the first day shutdown period, and unfortunately were not read gradually in the first day. It was noticed that the water level increased in these piezometers to some extent in the first day and did not return to its original level after about 19 hours of pumping. Table B1 shows the level variations for the three piezometers and the 5 tips.

Table B1
Variations in Piezometer Water Elevations – November 7 and 8, 2007[†]

Piezometer	Distance from Pumping Line (m)	Original Water Elevation (m)	Water Elevation after the end of the First Day Recovery Test (m)	Water Elevation after the Second Day Recovery Test Relative to the First Day (m)
P-F1	40	12.51	12.62 (+ 0.11 m)	12.61 (- 0.01 m) [a]
P-F2	40	12.29	12.58 (+ 0.19 m)	12.46 (-0.12 m)
P-G	90	18.04	18.08 (+ 0.04 m)	18.05 (- 0.03 m)
P-J1	125	10.07	10.08 (+ 0.01 m)	10.08 (- 0.00 m)
P-J2	125	11.23	11.31 (+ 0.08 m)	11.33 (+0.02 m)

[†] P-A1, P-B1, and P-D were not read during the second day of the northern block of wells

[a] The negative level increase during the second day of recovery test is negligible and is due to the probe successive wetting in a 9 mm tube.

P-J is about 125 m away from the wells line and experienced the lowest water table variation among all piezometers. P-F2 had the highest rise in water level among all piezometers; however, the magnitude is similar to P-A rise, 0.15 m, or P-B, 0.11 m. Considering that P-F2 is much closer to the pumping lines, this higher value is understandable. These results suggest that the piezometer variation curve in semi-logarithmic scale would be similar to Figure B1.

Appendix C

Recovery Test Results for Wells and Piezometers

C1 – Nov 7 Readings

C2 – Nov 8 Readings

C1 – Nov 7 Readings

Newfoundland and Labrador Hydro - Muskrat Falls

MF 1260 - Condition Assessment of Existing Equipment
Block Recovery Test

Well or Piez. #	P-A1	**Date:**	Nov. 7th 2007	**Case El.:**	61.81
Read By:	P. BroomField	**Temperature:**	-5 to +5		
Block No:	1	**Weather Condition:**	Rainy with snow periods		

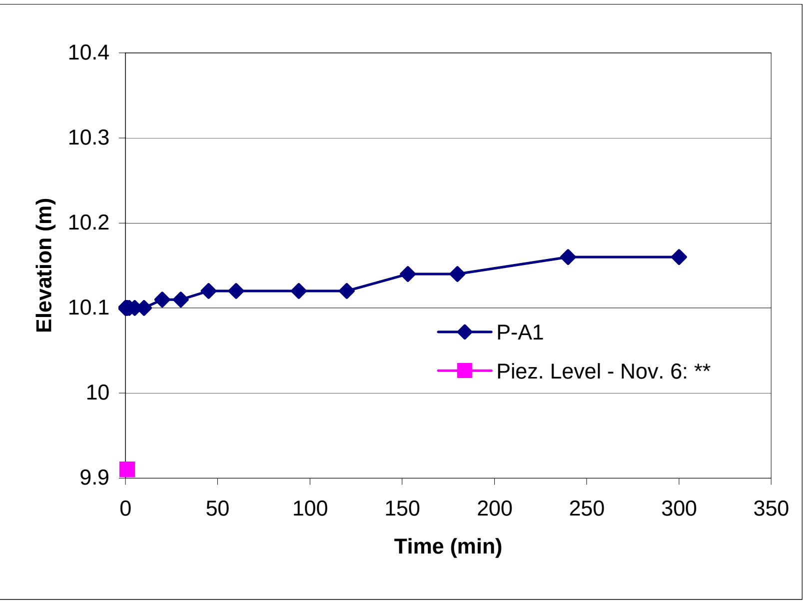
Shutdown Phase

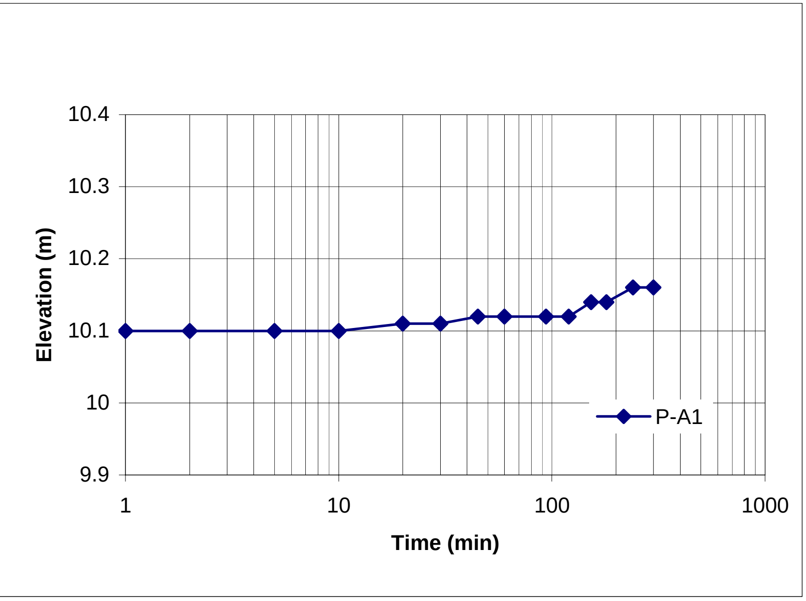
Start Time:

Elapsed Time (Min)	P-A1	
	Reading (m)*	Elevation (m)
Piez. Level - Nov. 6: **		
0	51.9	9.91
Nov 7, Recovery test:		
0	51.71	10.1
0.5	51.71	10.1
1	51.71	10.1
2	51.71	10.1
5	51.71	10.1
10	51.71	10.1
20	51.7	10.11
30	51.7	10.11
45	51.69	10.12
60	51.69	10.12
94	51.69	10.12
120	51.69	10.12
153	51.67	10.14
180	51.67	10.14
240	51.65	10.16
300	51.65	10.16

* Relative to the top of casing

** The source of difference in the elevations at the two days is unknown. May be as a result of a different reference point at the first day.





Newfoundland and Labrador Hydro - Muskrat Falls

MF 1260 - Condition Assessment of Existing Equipment

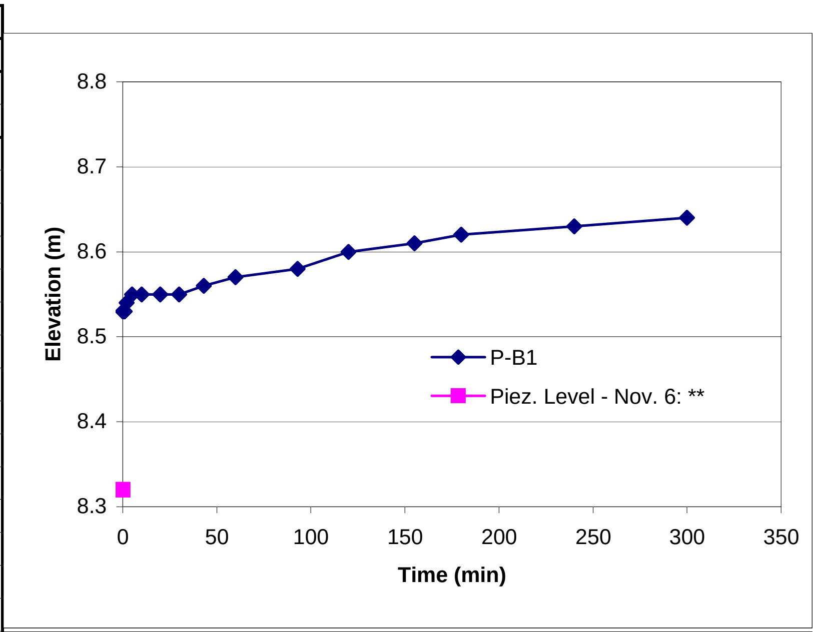
Block Recovery Test

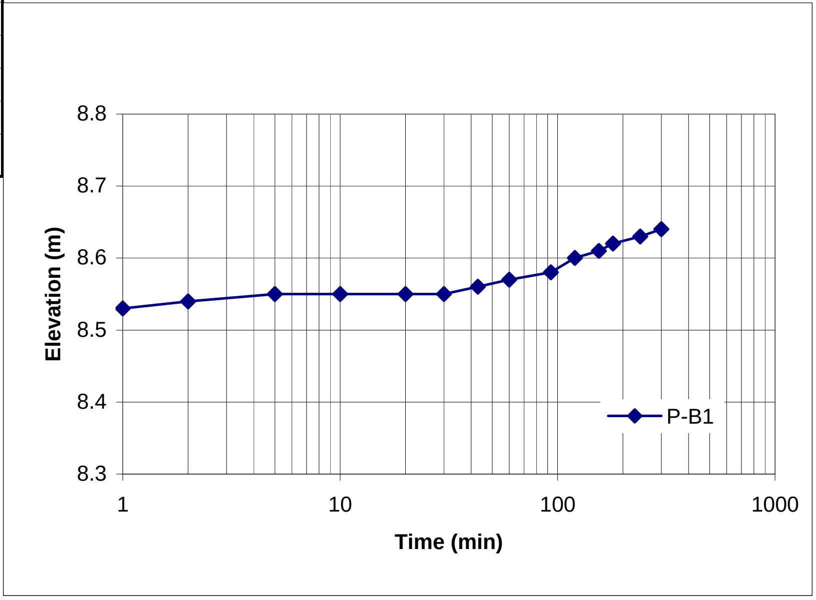
Well or Piez. #	P-B1	**Date:**	Nov. 7th 2007	**Case El.:**	60.22
Read By:	P. Ashayer	**Temperature:**	-5 to +5		
Block No:	1	**Weather Condition:**	Rainy with snow periods		

Shutdown Phase

Start Time:

Elapsed Time (Min)	P-B1	
	Reading (m)*	Elevation (m)
Piez. Level - Nov. 6: **		
0	51.9	8.32
Nov 7, Recovery test:		
0	51.69	8.53
0.5	51.69	8.53
1	51.69	8.53
2	51.68	8.54
5	51.67	8.55
10	51.67	8.55
20	51.67	8.55
30	51.67	8.55
43	51.66	8.56
60	51.65	8.57
93	51.64	8.58
120	51.62	8.6
155	51.61	8.61
180	51.6	8.62
240	51.59	8.63
300	51.58	8.64





* Relative to the top of casing

** The source of difference in the elevations at the two days is unknown. May be as a result of a different reference point at the first day.

Newfoundland and Labrador Hydro - Muskrat Falls

MF 1260 - Condition Assessment of Existing Equipment
Block Recovery Test

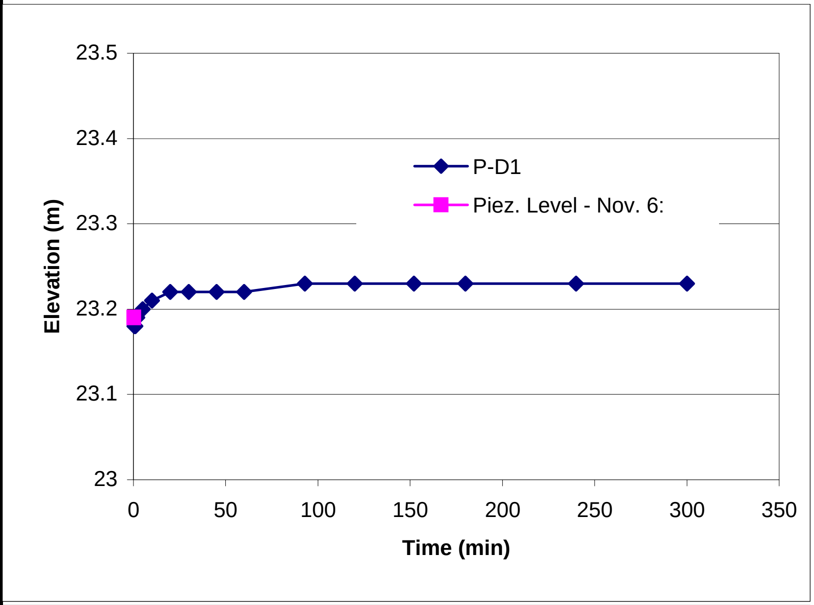
Well or Piez. #	P-D1	**Date:**	Nov. 7th 2007	**Case El.:**	59.7
Read By:	D. O'Driscoll	**Temperature:**	-5 to +5		
Block No:	1	**Weather Condition:**	Rainy with snow periods		

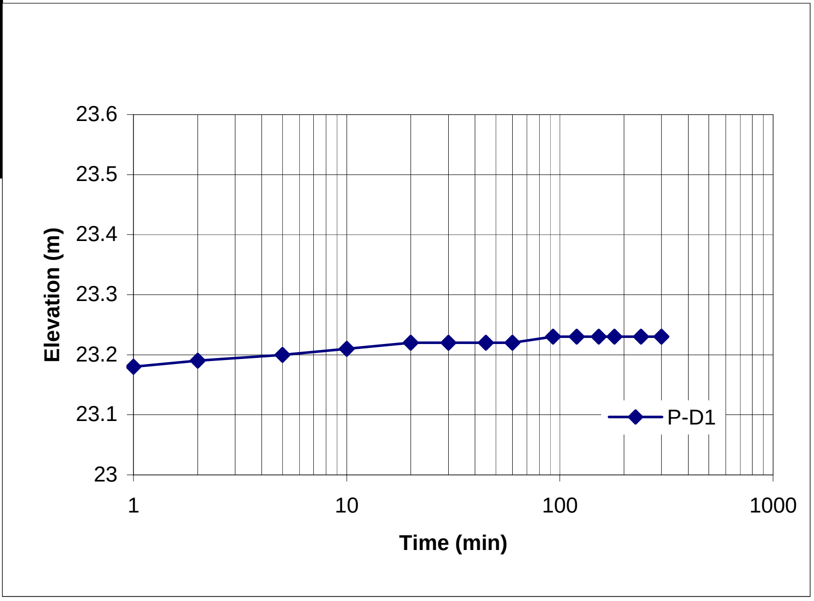
Shutdown Phase

Start Time:

Elapsed Time (Min)	P-D1	
	Reading (m)*	Elevation (m)
Piez. Level - Nov. 6:		
0	36.51	23.19
Nov 7, Recovery test:		
0		
0.5	36.52	23.18
1	36.52	23.18
2	36.51	23.19
5	36.5	23.2
10	36.49	23.21
20	36.48	23.22
30	36.48	23.22
45	36.48	23.22
60	36.48	23.22
93	36.47	23.23
120	36.47	23.23
152	36.47	23.23
180	36.47	23.23
240	36.47	23.23
300	36.47	23.23

* Relative to the top of casing





Newfoundland and Labrador Hydro - Muskrat Falls

MF 1260 - Condition Assessment of Existing Equipment
Block Recovery Test

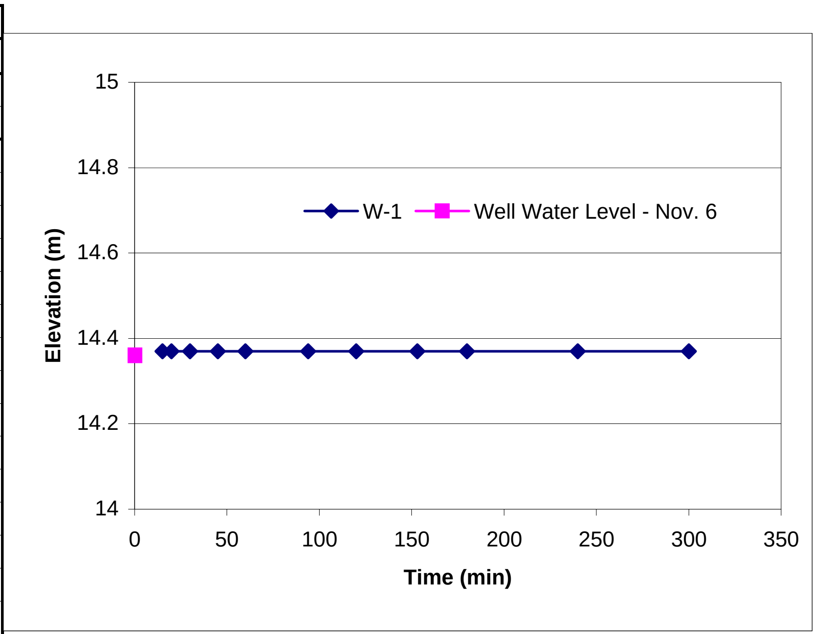
Well or Piez. #	W-1 **Date:**	Nov. 7th 2007 **Case El.:**	57.79
Read By:	P. BroomField **Temperature:**	-5 to +5	
Block No:	1 **Weather Condition:**	Rainy with snow periods	

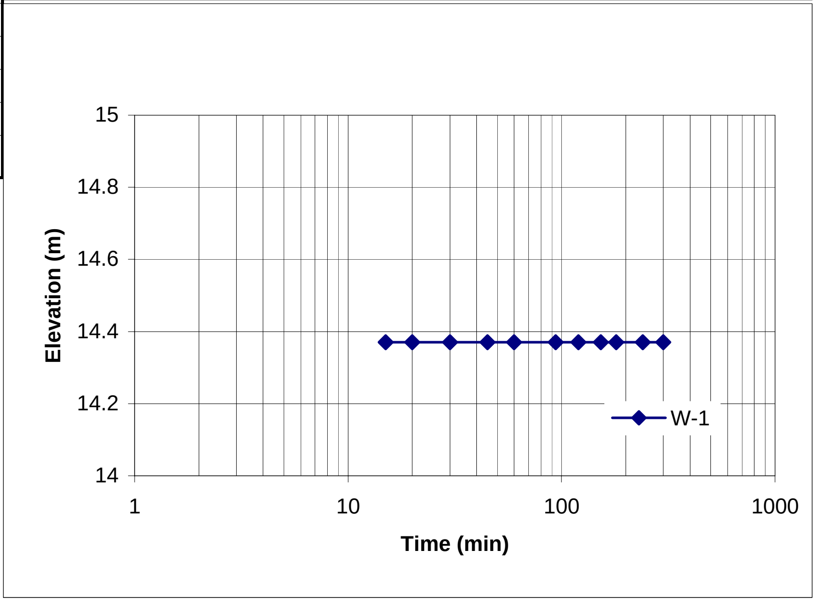
Shutdown Phase

Start Time:

Elapsed Time (Min)	W-1	
	Reading (m)*	Elevation (m)
Well Water Level - Nov. 6		
0	43.43	14.36
Nov 7, Recovery test:		
0		
0.5		
1		
2		
5		
15	43.42	14.37
20	43.42	14.37
30	43.42	14.37
45	43.42	14.37
60	43.42	14.37
94	43.42	14.37
120	43.42	14.37
153	43.42	14.37
180	43.42	14.37
240	43.42	14.37
300	43.42	14.37

* Relative to the top of casing





Newfoundland and Labrador Hydro - Muskrat Falls

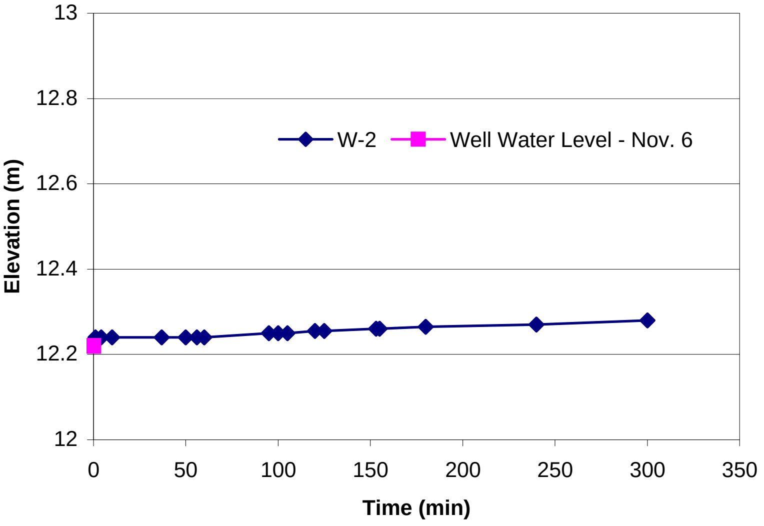
MF 1260 - Condition Assessment of Existing Equipment
Block Recovery Test

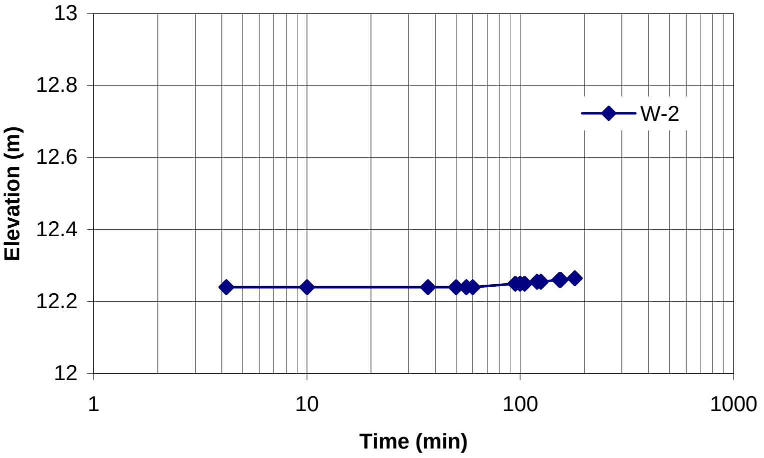
Well or Piez. #	W-2	**Date:**	Nov. 7th 2007	**Case El.:**	59.66
Read By:	J. Mitchell	**Temperature:**	-5 to +5		
Block No:	1	**Weather Condition:**	Rainy with snow periods		

Shutdown Phase

Start Time:

Elapsed Time (Min)	W-2	
	Reading (m)*	Elevation (m)
Well Water Level - Nov. 6		
0	47.44	12.22
Nov 7, Recovery test:		
0		
1	47.42	12.24
4.2	47.42	12.24
10	47.42	12.24
37	47.42	12.24
50	47.42	12.24
56	47.42	12.24
60	47.42	12.24
95	47.41	12.25
100	47.41	12.25
105	47.41	12.25
120	47.405	12.255
125	47.405	12.255
153	47.4	12.26
155	47.4	12.26
180	47.395	12.265
240	47.39	12.27
300	47.38	12.28





* Relative to the top of casing

Newfoundland and Labrador Hydro - Muskrat Falls

MF 1260 - Condition Assessment of Existing Equipment
Block Recovery Test

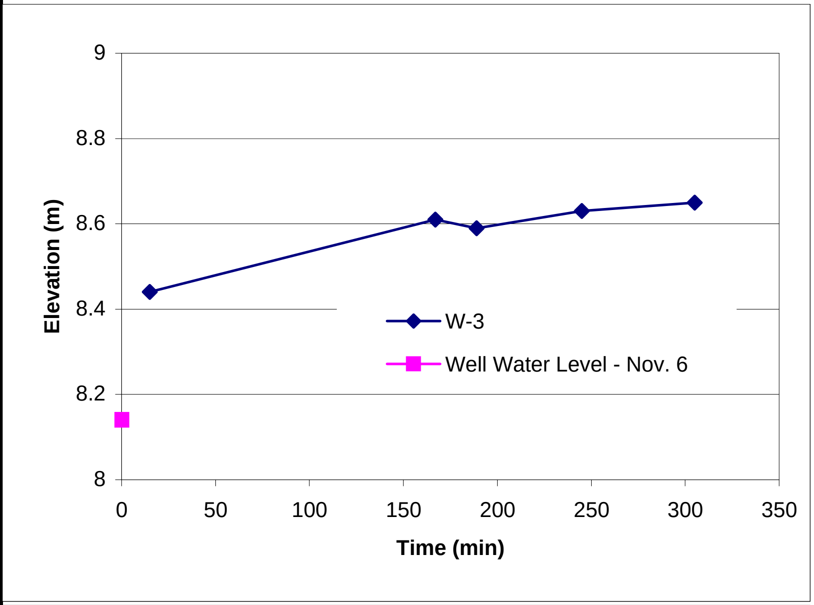
Well or Piez. #	W-3	**Date:**	Nov. 7th 2007	**Case El.:**	59.67
Read By:	J. Mitchell	**Temperature:**	-5 to +5		
Block No:	1	**Weather Condition:**	Rainy with snow periods		

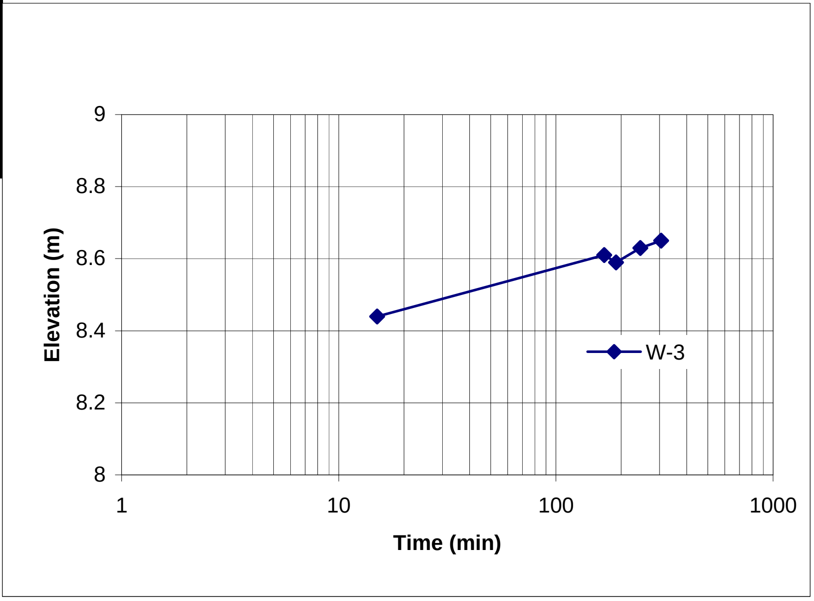
Shutdown Phase

Start Time:

Elapsed Time (Min)	W-3	
	Reading (m)*	Elevation (m)
Well Water Level - Nov. 6		
0	51.53	8.14
Nov 7, Recovery test:		
0		
15	51.23	8.44
167	51.06	8.61
189	51.08	8.59
245	51.04	8.63
305	51.02	8.65

* Relative to the top of casing





Newfoundland and Labrador Hydro - Muskrat Falls

MF 1260 - Condition Assessment of Existing Equipment
Block Recovery Test

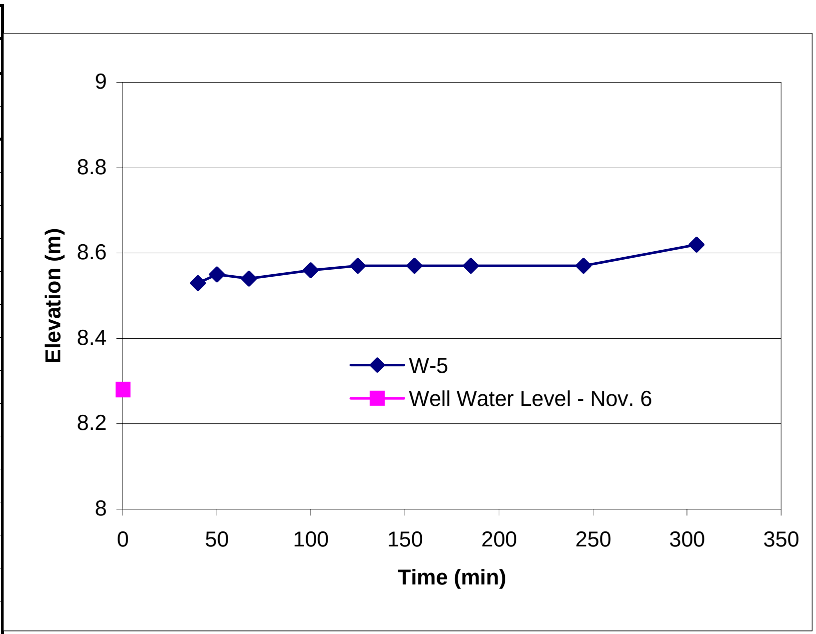
Well or Piez. #	W-5	**Date:**	Nov. 7th 2007	**Case El.:**	59.55
Read By:	N. Jette	**Temperature:**	-5 to +5		
Block No:	1	**Weather Condition:**	Rainy with snow periods		

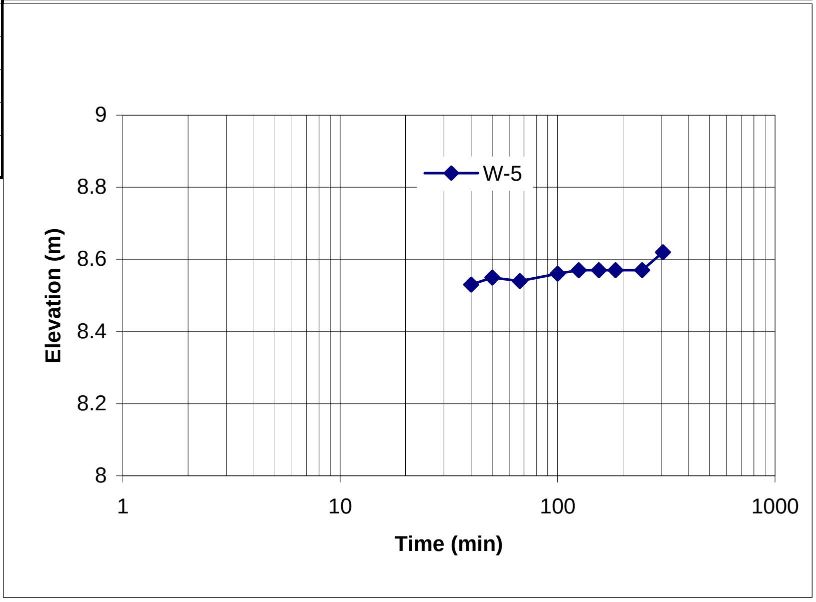
Shutdown Phase

Start Time:

Elapsed Time (Min)	W-5	
	Reading (m)*	Elevation (m)
Well Water Level - Nov. 6		
0	51.27	8.28
Nov 7, Recovery test:		
40	51.02	8.53
50	51	8.55
67	51.01	8.54
100	50.99	8.56
125	50.98	8.57
155	50.98	8.57
185	50.98	8.57
245	50.98	8.57
305	50.93	8.62

* Relative to the top of casing





Newfoundland and Labrador Hydro - Muskrat Falls

MF 1260 - Condition Assessment of Existing Equipment
Block Recovery Test

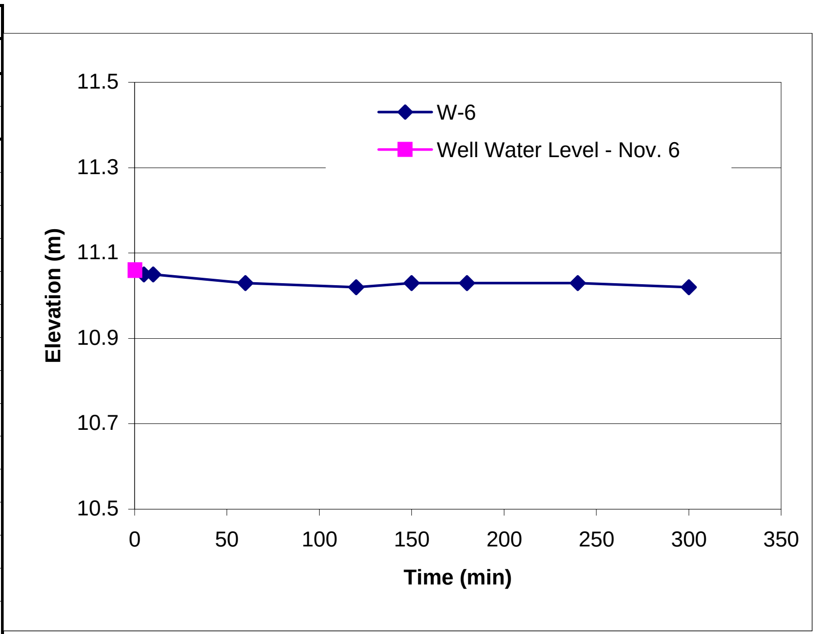
Well or Piez. #	W-6	**Date:**	Nov. 7th 2007	**Case El.:**	59.53
Read By:	L. Rich	**Temperature:**	-5 to +5		
Block No:	1	**Weather Condition:**	Rainy with snow periods		

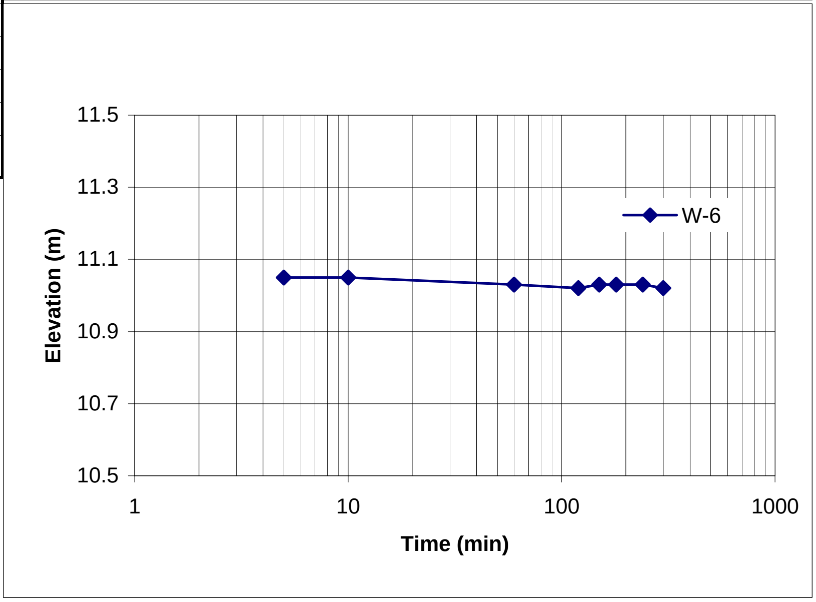
Shutdown Phase

Start Time:

Elapsed Time (Min)	W-6	
	Reading (m)*	Elevation (m)
Well Water Level - Nov. 6		
0	48.47	11.06
Nov 7, Recovery test:		
0		
5	48.48	11.05
10	48.48	11.05
60	48.5	11.03
120	48.51	11.02
150	48.5	11.03
180	48.5	11.03
240	48.5	11.03
300	48.51	11.02

* Relative to the top of casing





Newfoundland and Labrador Hydro - Muskrat Falls

MF 1260 - Condition Assessment of Existing Equipment
Block Recovery Test

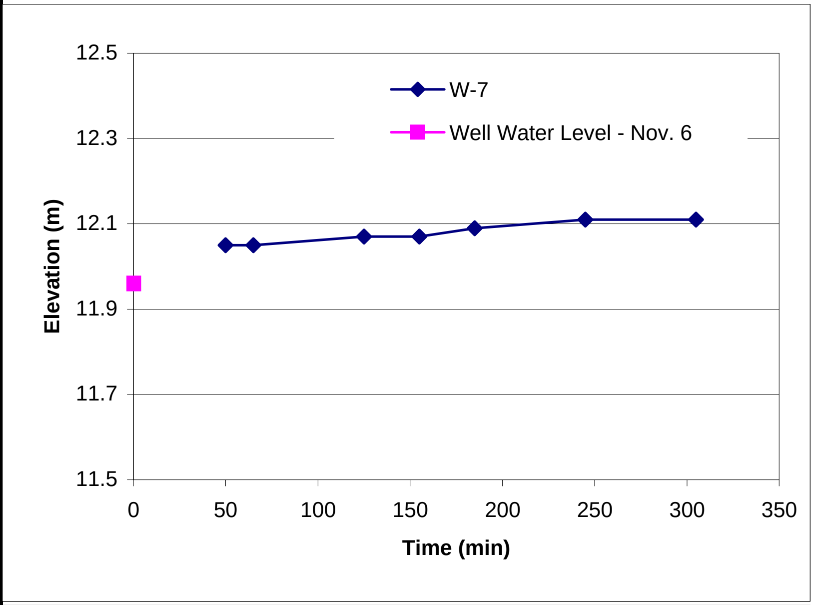
Well or Piez. #	W-7	**Date:**	Nov. 7th 2007 **Case El.:**	59.51
Read By:	L. Rich	**Temperature:**	-5 to +5	
Block No:	1	**Weather Condition:**	Rainy with snow periods	

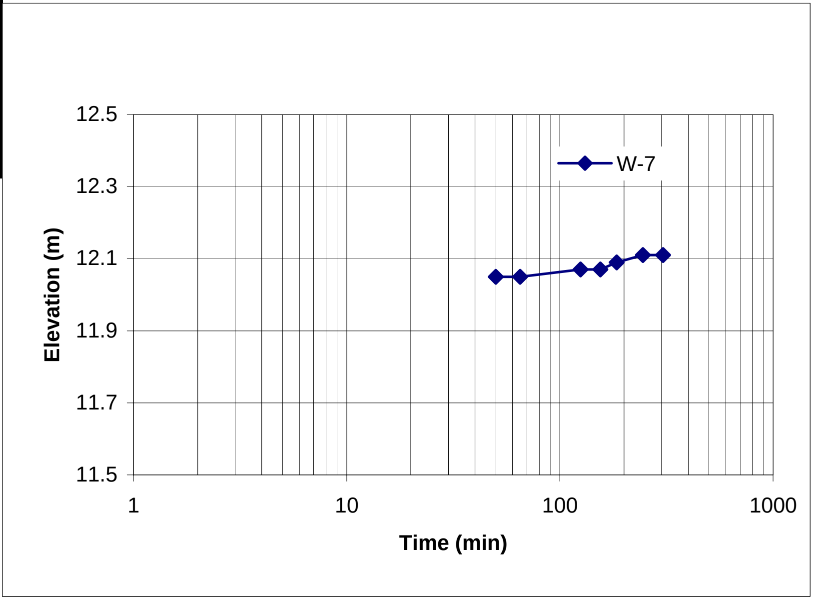
Shutdown Phase

Start Time:

Elapsed Time (Min)	W-7	
	Reading (m)*	Elevation (m)
Well Water Level - Nov. 6		
0	47.55	11.96
Nov 7, Recovery test:		
0		
50	47.46	12.05
65	47.46	12.05
125	47.44	12.07
155	47.44	12.07
185	47.42	12.09
245	47.4	12.11
305	47.4	12.11

* Relative to the top of casing





Newfoundland and Labrador Hydro - Muskrat Falls

MF 1260 - Condition Assessment of Existing Equipment
Block Recovery Test

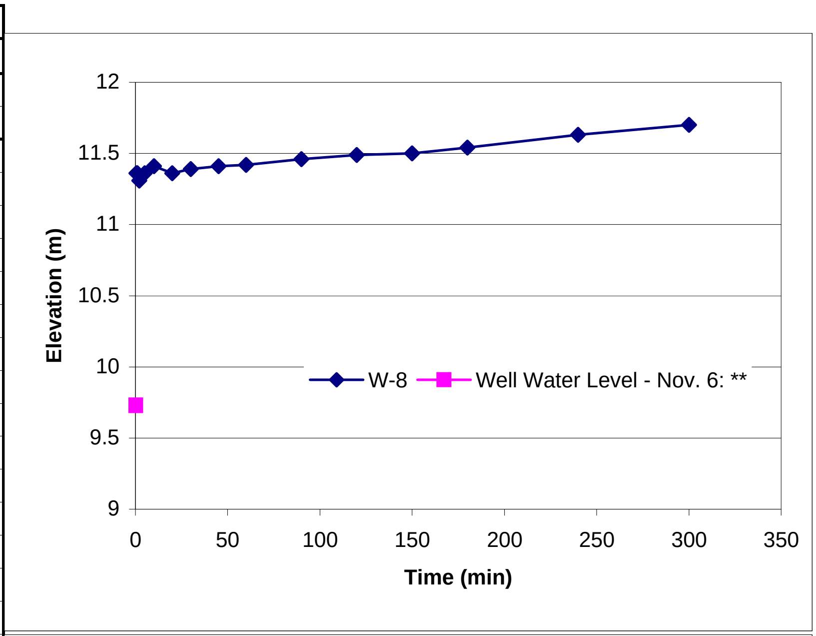
Well or Piez. #	W-8	**Date:**	Nov. 7th 2007	**Case El.:**	59.46
Read By:	B. Crowe	**Temperature:**	-5 to +5		
Block No:	1	**Weather Condition:**	Rainy with snow periods		

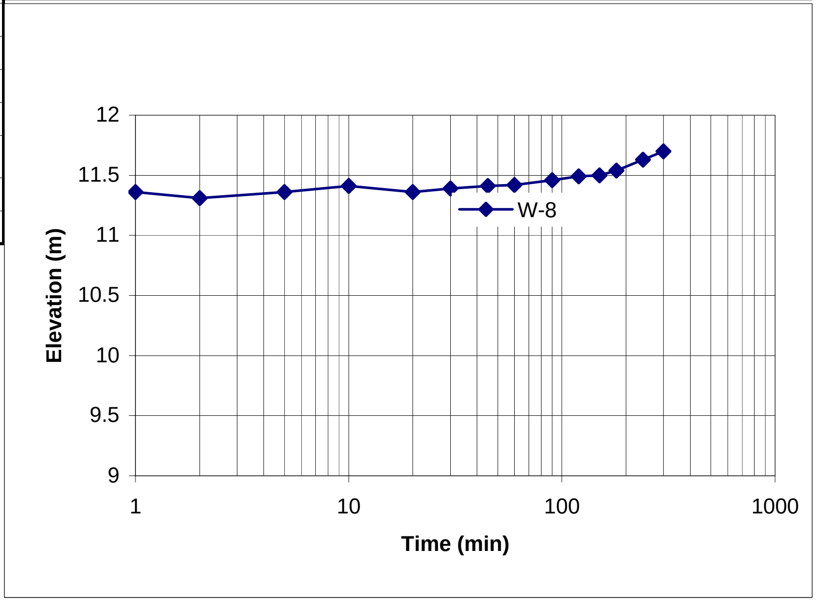
Shutdown Phase

Start Time:

Elapsed Time (Min)	W-8	
	Reading (m)*	Elevation (m)
Well Water Level - Nov. 6: **		
0	49.73	9.73
Nov 7, Recovery test:		
0		
0.5	48.1	11.36
1	48.1	11.36
2	48.15	11.31
5	48.1	11.36
10	48.05	11.41
20	48.1	11.36
30	48.07	11.39
45	48.05	11.41
60	48.04	11.42
90	48	11.46
120	47.97	11.49
150	47.96	11.5
180	47.92	11.54
240	47.83	11.63
300	47.76	11.7

* Relative to the top of casing
** Variation in elevations is due to high variations in well water level.





Newfoundland and Labrador Hydro - Muskrat Falls

MF 1260 - Condition Assessment of Existing Equipment
Block Recovery Test

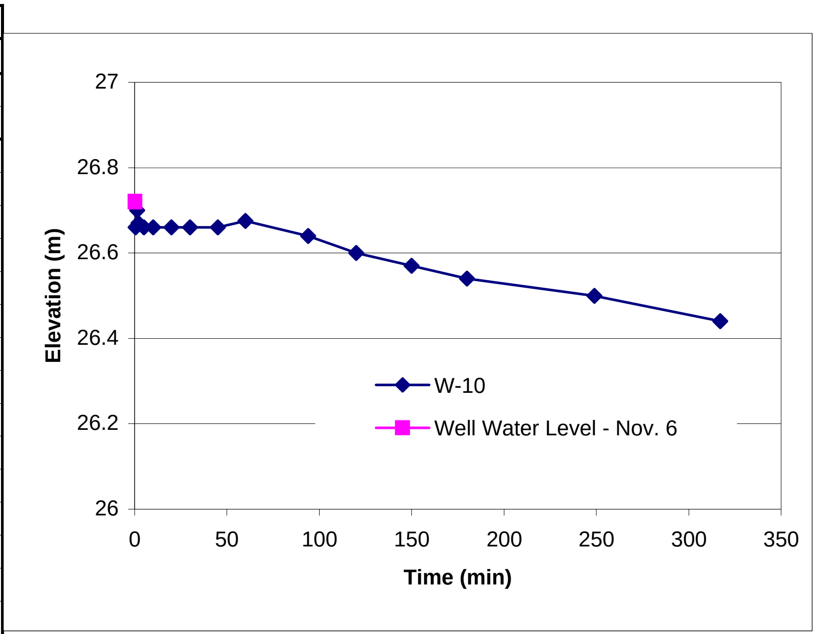
Well or Piez. #	W-10	**Date:**	Nov. 7th 2007	**Case El.:**	59.4
Read By:	L. Evans	**Temperature:**	-5 to +5		
Block No:	1	**Weather Condition:**	Rainy with snow periods		

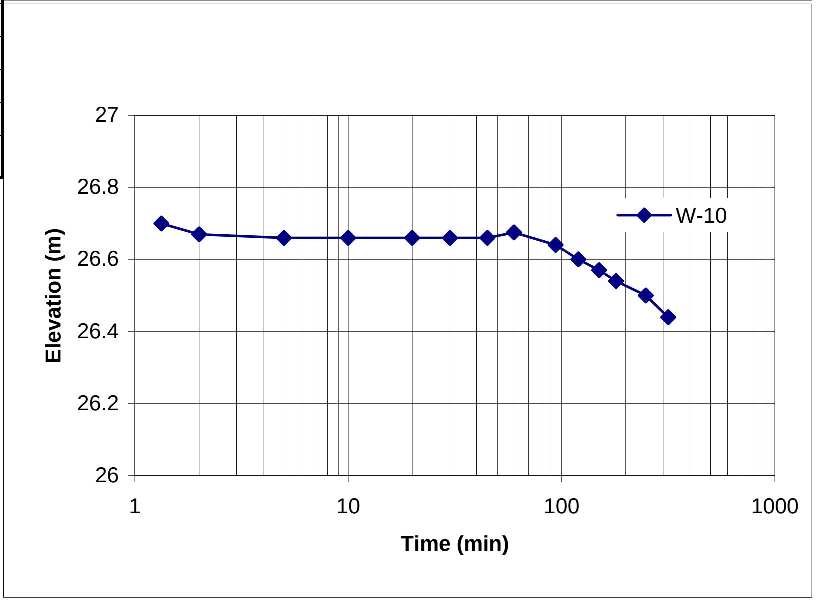
Shutdown Phase

Start Time:

Elapsed Time (Min)	W-10	
	Reading (m)*	Elevation (m)
Well Water Level - Nov. 6		
0	32.68	26.72
Nov 7, Recovery test:		
0		
0.5	32.74	26.66
1.33	32.7	26.7
2	32.73	26.67
5	32.74	26.66
10	32.74	26.66
20	32.74	26.66
30	32.74	26.66
45	32.74	26.66
60	32.725	26.675
94	32.76	26.64
120	32.8	26.6
150	32.83	26.57
180	32.86	26.54
249	32.9	26.5
317	32.96	26.44

* Relative to the top of casing





Newfoundland and Labrador Hydro - Muskrat Falls

MF 1260 - Condition Assessment of Existing Equipment
Block Recovery Test

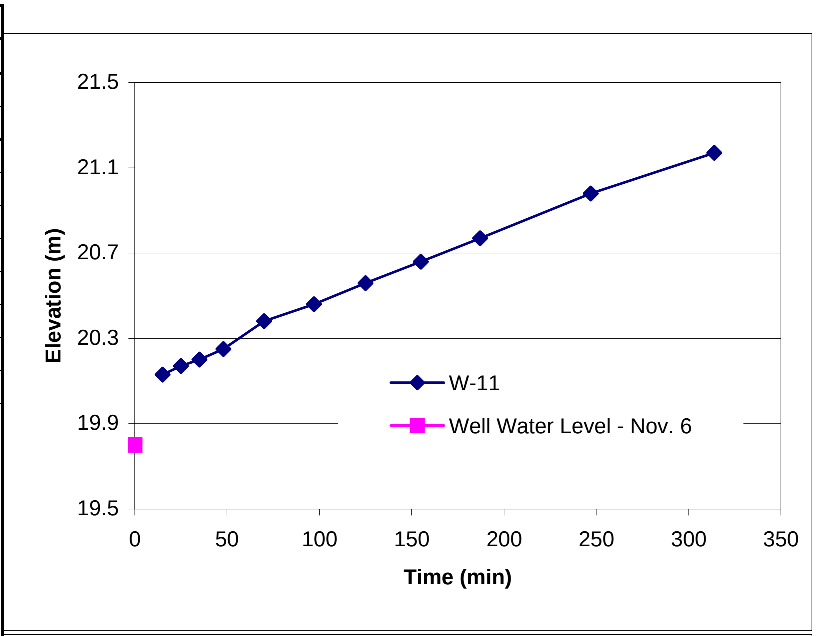
Well or Piez. #	W-11	**Date:**	Nov. 7th 2007	**Case El.:**	59.35
Read By:	L. Evans	**Temperature:**	-5 to +5		
Block No:	1	**Weather Condition:**	Rainy with snow periods		

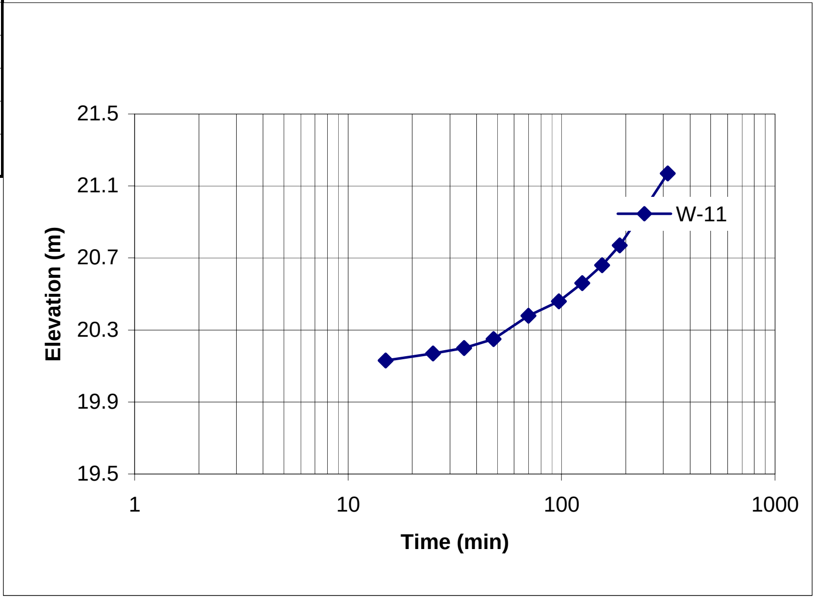
Shutdown Phase

Start Time:

Elapsed Time (Min)	W-11	
	Reading (m)*	Elevation (m)
Well Water Level - Nov. 6		
0	39.55	19.8
Nov 7, Recovery test:		
0		
0.5		
1.33		
2		
5		
15	39.22	20.13
25	39.18	20.17
35	39.15	20.2
48	39.1	20.25
70	38.97	20.38
97	38.89	20.46
125	38.79	20.56
155	38.69	20.66
187	38.58	20.77
247	38.37	20.98
314	38.18	21.17

* Relative to the top of casing





Newfoundland and Labrador Hydro - Muskrat Falls

MF 1260 - Condition Assessment of Existing Equipment
Block Recovery Test

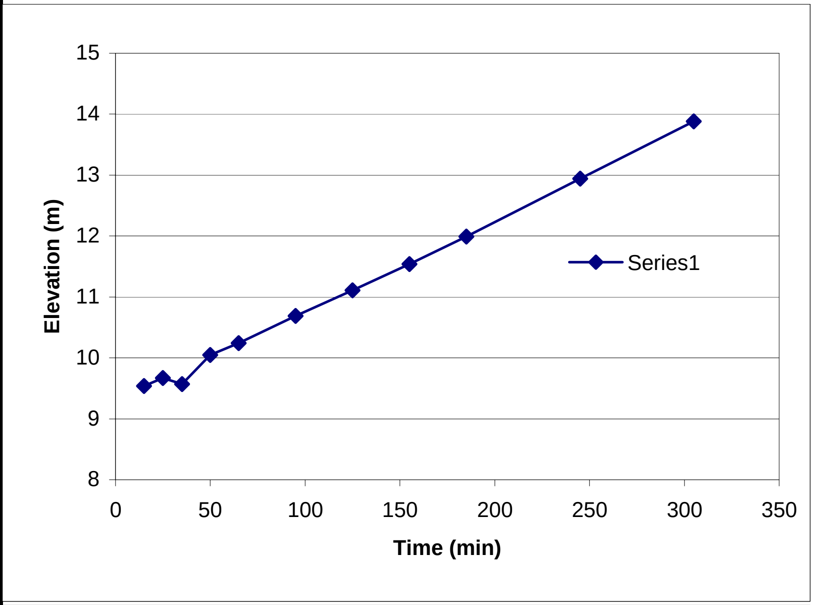
Well or Piez. #	W-12 (Reading-1) **Date:**	Nov. 7th 2007 **Case El.:**	59.29
Read By:	L. Rich **Temperature:**	-5 to +5	
Block No:	1 **Weather Condition:**	Rainy with snow periods	

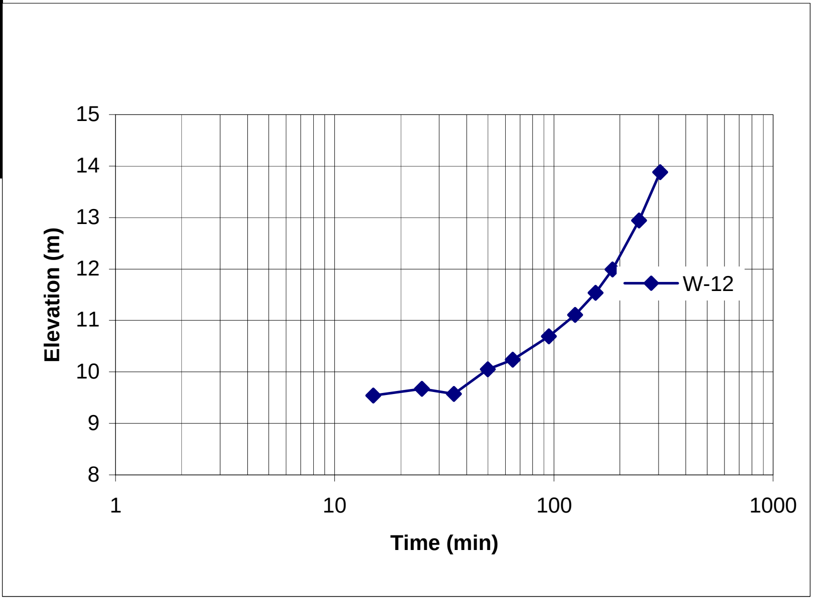
Shutdown Phase

Start Time:

Elapsed Time (Min)	W-12	
	Reading (m)*	Elevation (m)
Well Water Level - Nov. 6		
0		
Nov 7, Recovery test:		
0	-	
0.5		
1		
2		
5		
15	49.75	9.54
25	49.62	9.67
35	49.72	9.57
50	49.24	10.05
65	49.05	10.24
95	48.6	10.69
125	48.18	11.11
155	47.75	11.54
185	47.3	11.99
245	46.35	12.94
305	45.41	13.88

* Relative to the top of casing





C2 – Nov 8 Readings

Newfoundland and Labrador Hydro - Muskrat Falls

MF 1260 - Condition Assessment of Existing Equipment
Block Recovery Test

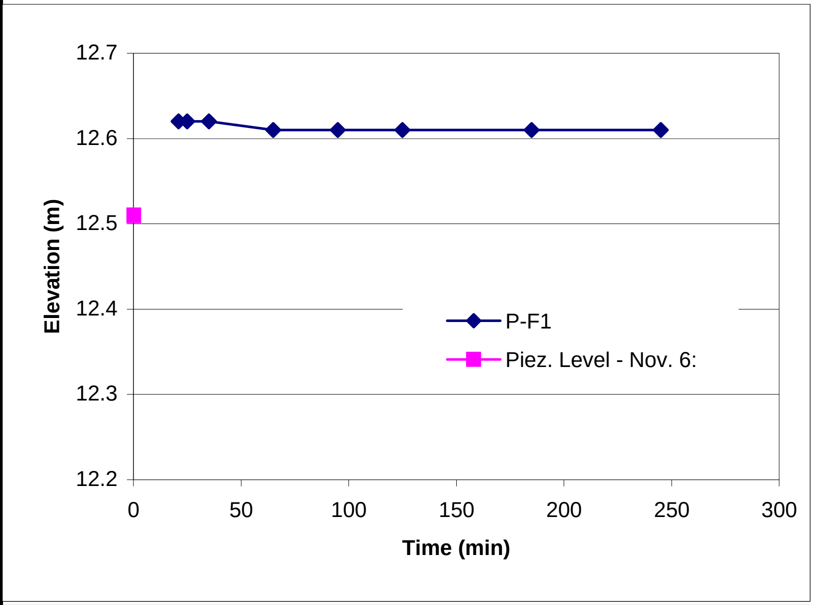
Well or Piez. #	P-F1	**Date:**	Nov. 8th 2007	**Case El.:**	56.38
Read By:	D. O'Driscoll	**Temperature:**	-3 to +1		
Block No:	1	**Weather Condition:**	Cloudy		

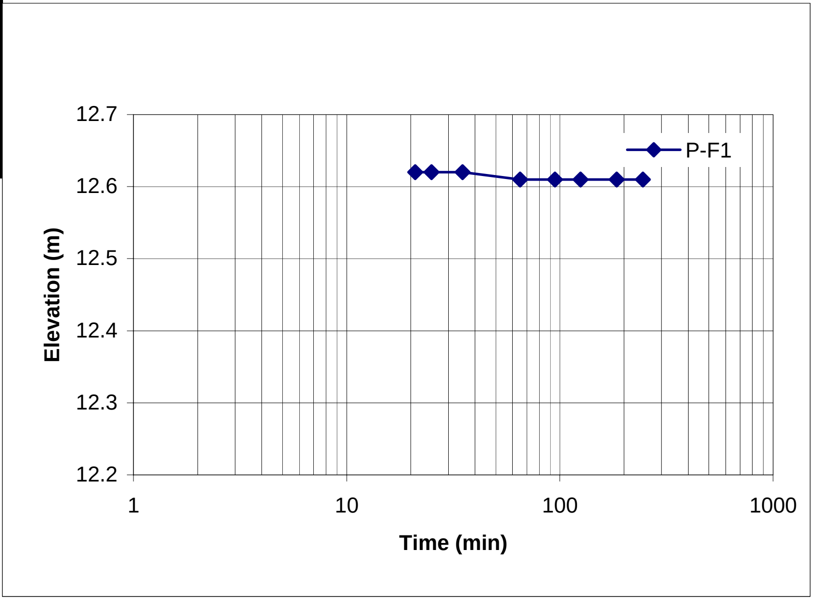
Shutdown Phase

Start Time:

Elapsed Time (Min)	P-F1	
	Reading (m)*	Elevation (m)
Piez. Level - Nov. 6:		
0	43.87	12.51
Nov 8, Recovery test:		
0		
0.5		
1		
2		
5		
15		
21	43.76	12.62
25	43.76	12.62
35	43.76	12.62
65	43.77	12.61
95	43.77	12.61
125	43.77	12.61
185	43.77	12.61
245	43.77	12.61

* Relative to the top of casing





Newfoundland and Labrador Hydro - Muskrat Falls

MF 1260 - Condition Assessment of Existing Equipment
Block Recovery Test

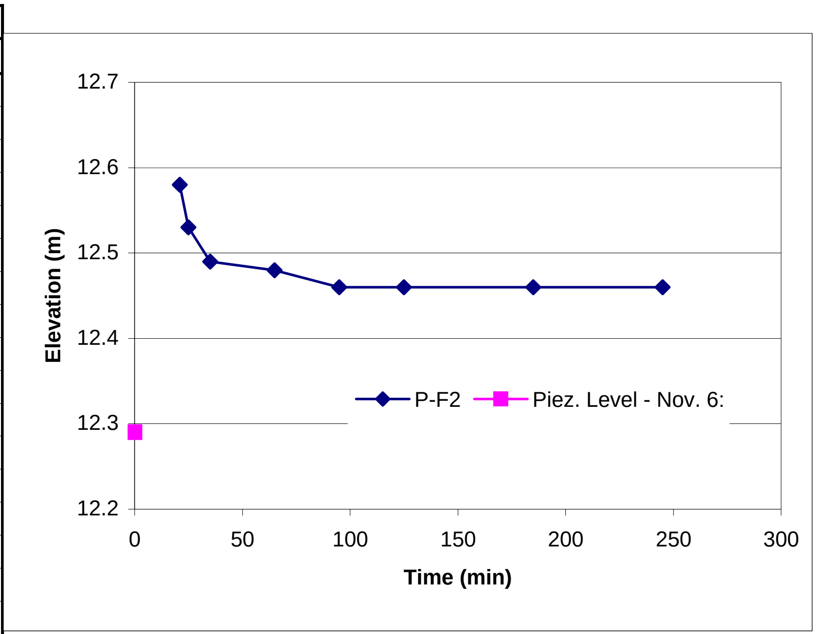
Well or Piez. #	P-F2	**Date:**	Nov. 8th 2007	**Case El.:**	56.38
Read By:	D. O'Driscoll	**Temperature:**	-3 to +1		
Block No:	1	**Weather Condition:**	Cloudy		

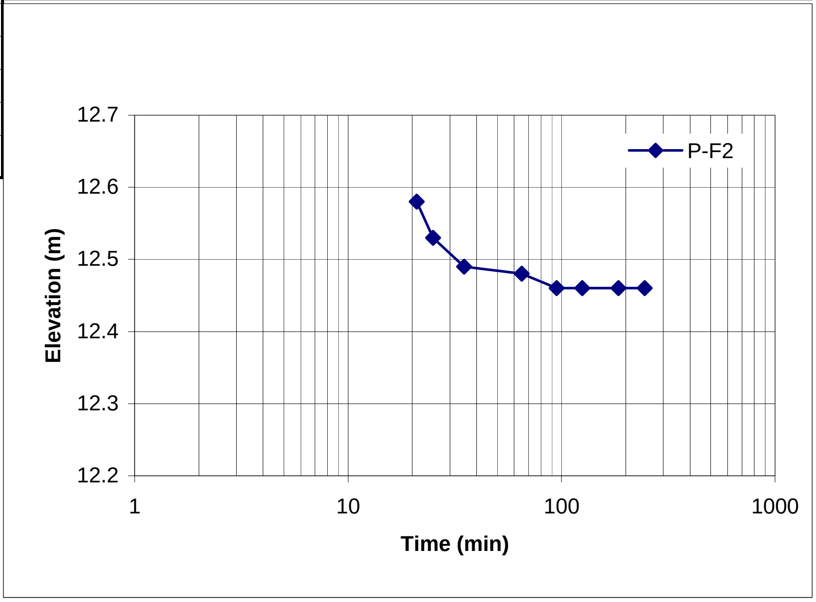
Shutdown Phase

Start Time:

Elapsed Time (Min)	P-F2	
	Reading (m)*	Elevation (m)
Piez. Level - Nov. 6:		
0	44.09	12.29
Nov 8, Recovery test:		
0		
0.5		
1		
2		
5		
15		
21	43.8	12.58
25	43.85	12.53
35	43.89	12.49
65	43.9	12.48
95	43.92	12.46
125	43.92	12.46
185	43.92	12.46
245	43.92	12.46

* Relative to the top of casing





Newfoundland and Labrador Hydro - Muskrat Falls

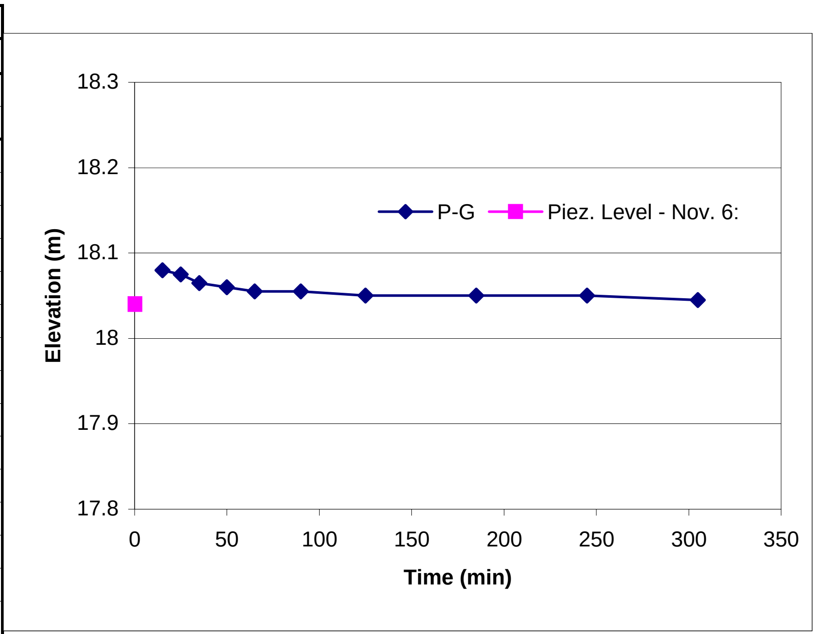
MF 1260 - Condition Assessment of Existing Equipment
Block Recovery Test

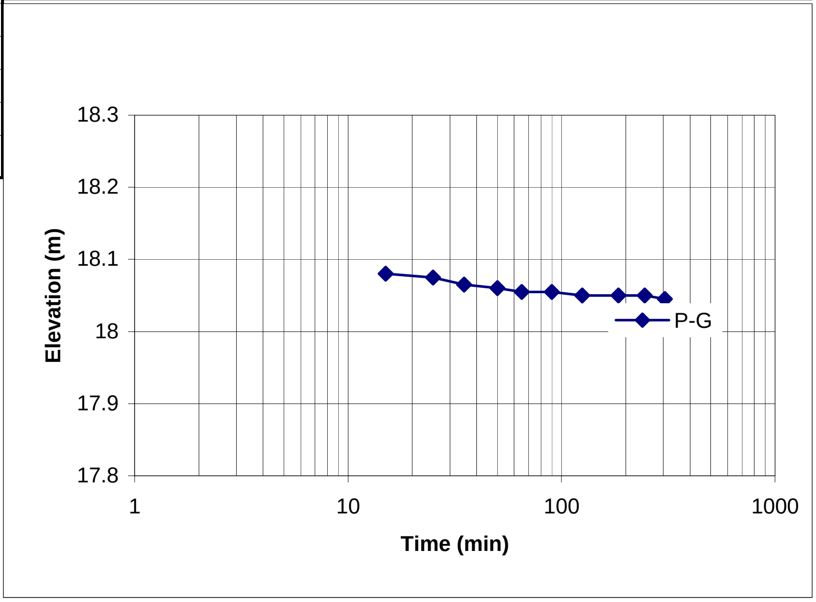
Well or Piez. #	P-G	**Date:**	Nov. 8th 2007	**Case El.:**	55.35
Read By:	P. BroomField	**Temperature:**	-3 to +1		
Block No:	1	**Weather Condition:**	Cloudy		

Shutdown Phase

Start Time:

Elapsed Time (Min)	P-G	
	Reading (m)*	Elevation (m)
Piez. Level - Nov. 6:		
0	37.31	18.04
Nov 8, Recovery test:		
0		
0.5		
1		
2		
5		
15	37.27	18.08
25	37.275	18.075
35	37.285	18.065
50	37.29	18.06
65	37.295	18.055
90	37.295	18.055
125	37.3	18.05
185	37.3	18.05
245	37.3	18.05
305	37.305	18.045





* Relative to the top of casing

Newfoundland and Labrador Hydro - Muskrat Falls

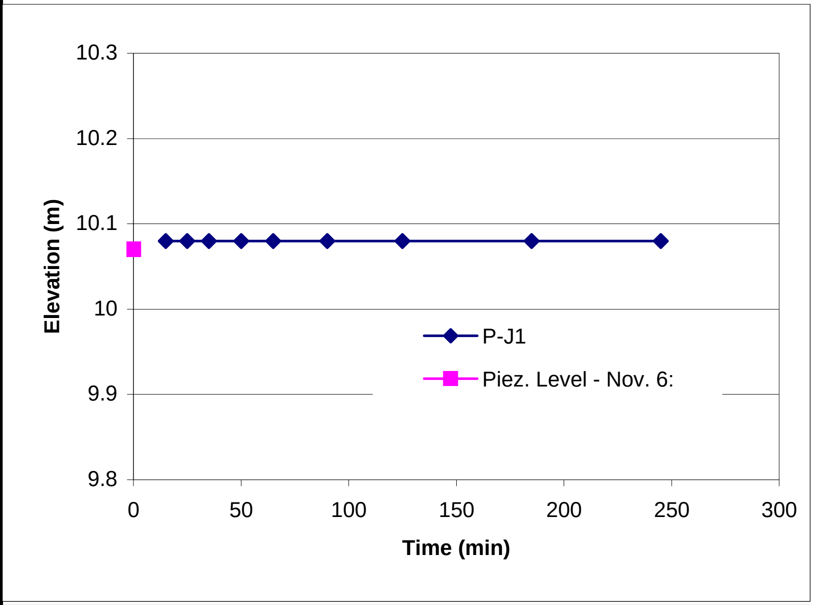
MF 1260 - Condition Assessment of Existing Equipment
Block Recovery Test

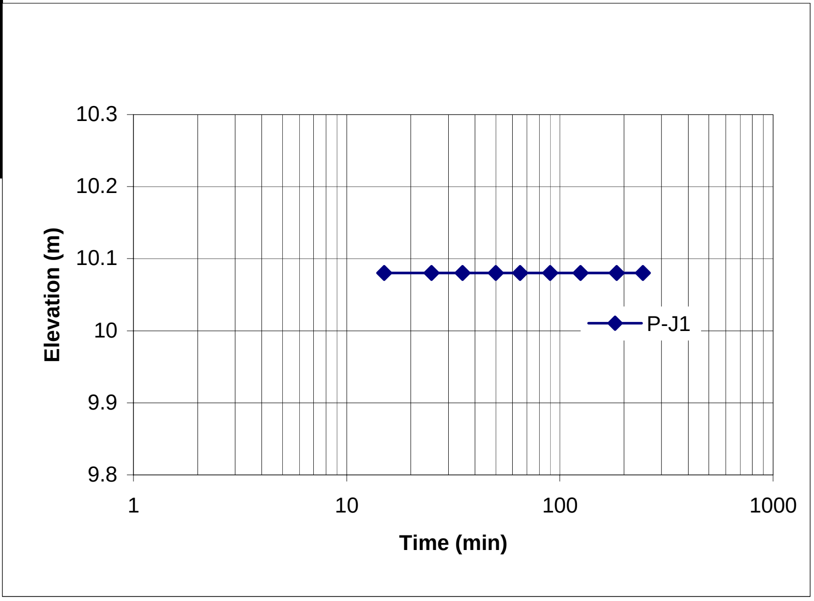
Well or Piez. #	P-J1	**Date:**	Nov. 8th 2007	**Case El.:**	54.36
Read By:	P. Ashayer	**Temperature:**	-3 to +1		
Block No:	1	**Weather Condition:**	Cloudy		

Shutdown Phase

Start Time:

Elapsed Time (Min)	P-J1	
	Reading (m)*	Elevation (m)
Piez. Level - Nov. 6:		
0	44.29	10.07
Nov 8, Recovery test:		
0		
0.5		
1		
2		
5		
15	44.28	10.08
25	44.29	10.08
35	44.28	10.08
50	44.28	10.08
65	44.28	10.08
90	44.28	10.08
125	44.28	10.08
185	44.28	10.08
245	44.28	10.08





* Relative to the top of casing

Newfoundland and Labrador Hydro - Muskrat Falls

MF 1260 - Condition Assessment of Existing Equipment
Block Recovery Test

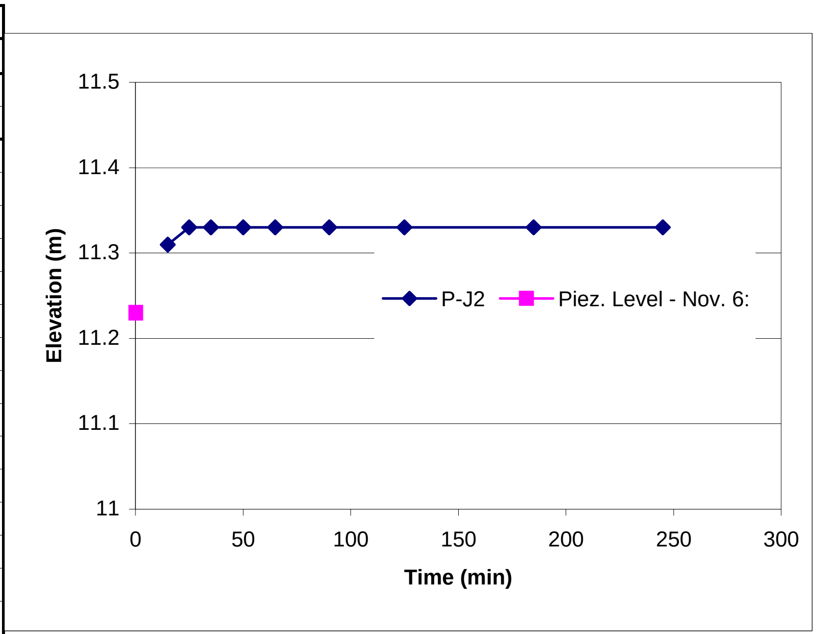
Well or Piez. #	P-J2	**Date:**	Nov. 8th 2007	**Case El.:**	54.36
Read By:	P. Ashayer	**Temperature:**	-3 to +1		
Block No:	1	**Weather Condition:**	Cloudy		

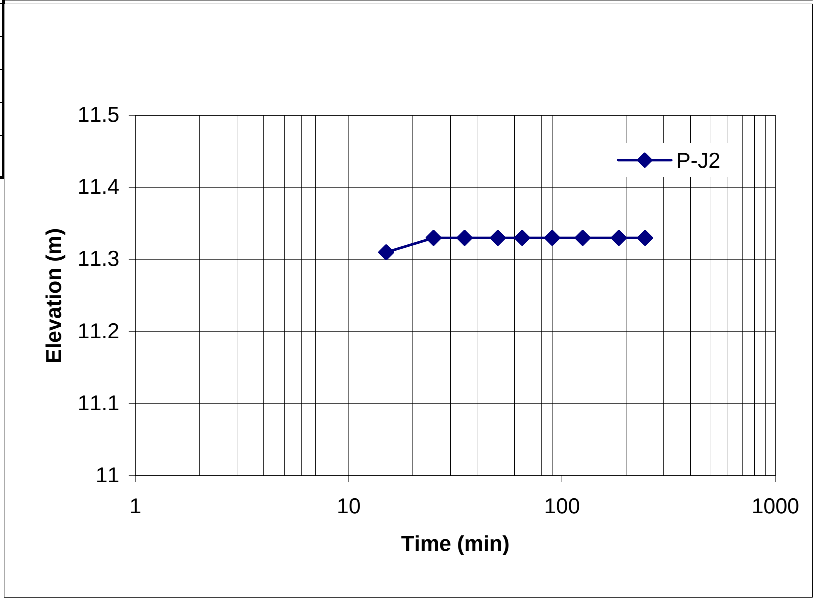
Shutdown Phase

Start Time:

Elapsed Time (Min)	P-J2	
	Reading (m)*	Elevation (m)
Piez. Level - Nov. 6:		
0	43.13	11.23
Nov 8, Recovery test:		
0		
0.5		
1		
2		
5		
15	43.05	11.31
25	43.03	11.33
35	43.03	11.33
50	43.03	11.33
65	43.03	11.33
90	43.03	11.33
125	43.03	11.33
185	43.03	11.33
245	43.03	11.33

* Relative to the top of casing





Newfoundland and Labrador Hydro - Muskrat Falls

MF 1260 - Condition Assessment of Existing Equipment
Block Recovery Test

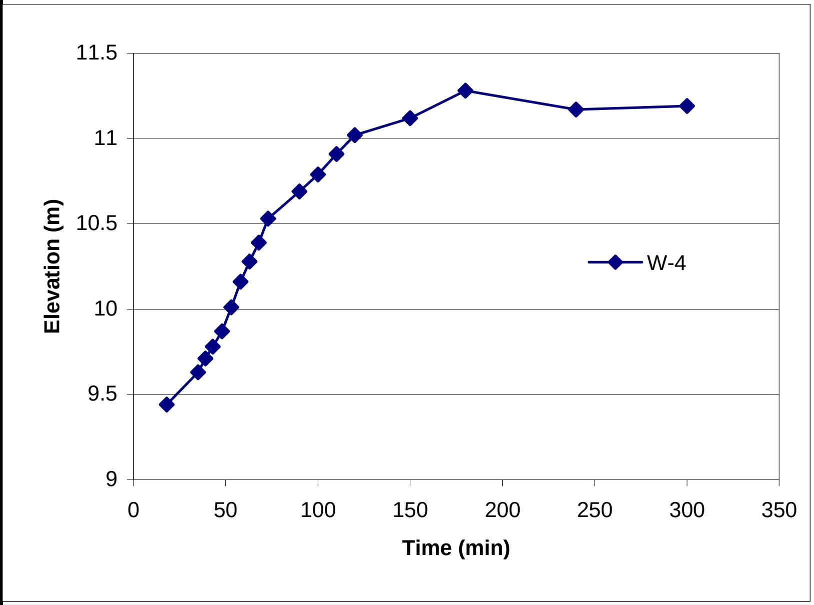
Well or Piez. #	W-4	**Date:**	Nov. 8th 2007	**Case El.:**	59.67
Read By:	N. Jette	**Temperature:**	-3 to +1		
Block No:	1	**Weather Condition:**	Cloudy		

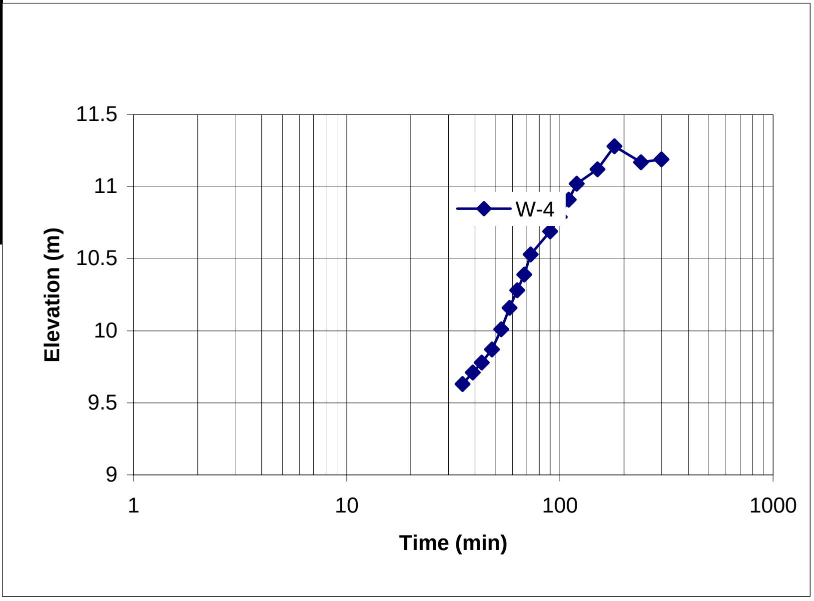
Shutdown Phase

Start Time:

Elapsed Time (Min)	W-4	
	Reading (m)*	Elevation (m)
Well Water Level - Nov. 6		
0		
Nov 8, Recovery test:		
0		
18	50.23	9.44
35	50.04	9.63
39	49.96	9.71
43	49.89	9.78
48	49.8	9.87
53	49.66	10.01
58	49.51	10.16
63	49.39	10.28
68	49.28	10.39
73	49.14	10.53
90	48.98	10.69
100	48.88	10.79
110	48.76	10.91
120	48.65	11.02
150	48.55	11.12
180	48.39	11.28
240	48.5	11.17
300	48.48	11.19

* Relative to the top of casing





Newfoundland and Labrador Hydro - Muskrat Falls

MF 1260 - Condition Assessment of Existing Equipment
Block Recovery Test

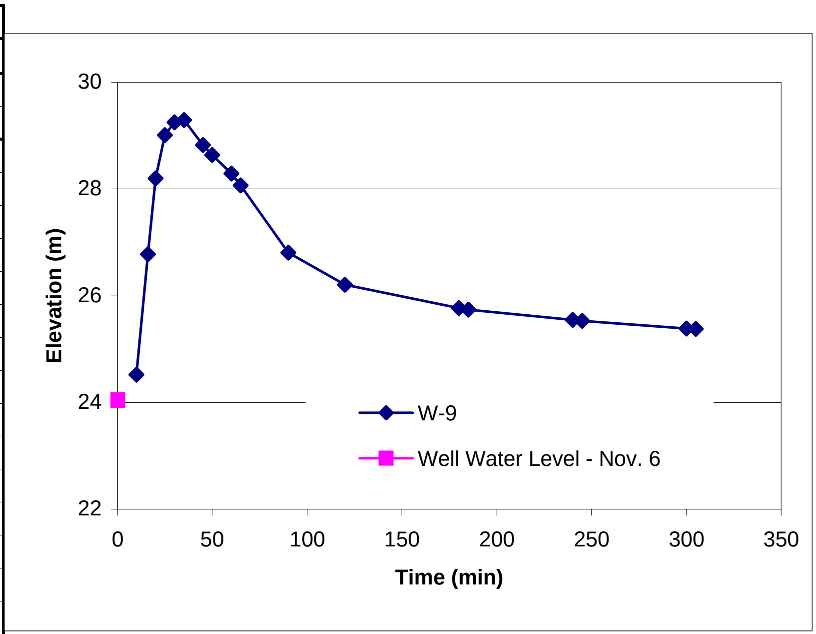
Well or Piez. #	W-9	**Date:**	Nov. 8th 2007	**Case El.:**	59.48
Read By:	B. Crowe	**Temperature:**	-3 to +1		
Block No:	1	**Weather Condition:**	Cloudy		

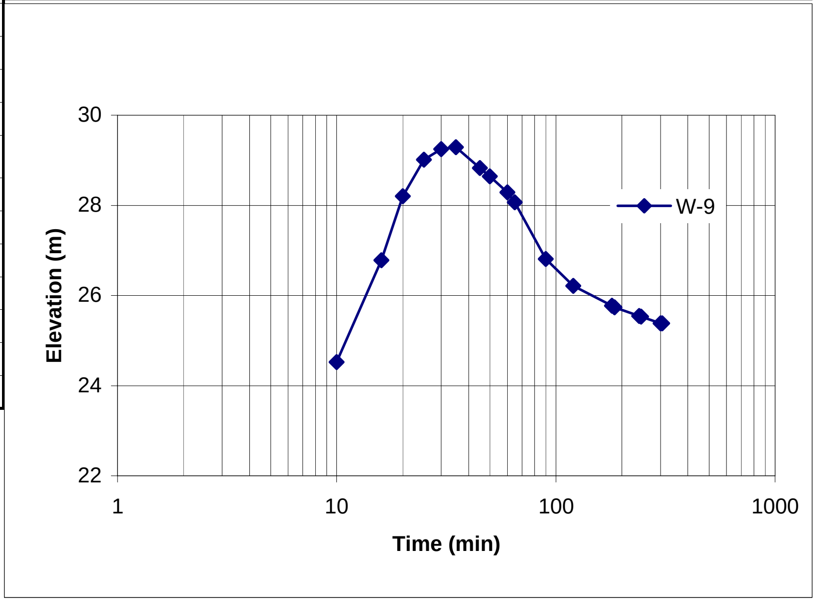
Shutdown Phase

Start Time:

Elapsed Time (Min)	W-9	
	Reading (m)*	Elevation (m)
Well Water Level - Nov. 6		
0	35.44	24.04
Nov 8, Recovery test:		
0		
0.5		
1		
2		
5		
10	34.96	24.52
16	32.7	26.78
20	31.28	28.2
25	30.47	29.01
30	30.23	29.25
35	30.19	29.29
45	30.655	28.825
50	30.84	28.64
60	31.19	28.29
65	31.41	28.07
90	32.67	26.81
120	33.27	26.21
180	33.71	25.77
185	33.74	25.74
240	33.935	25.545
245	33.95	25.53
300	34.095	25.385
305	34.1	25.38

* Relative to the top of casing





Newfoundland and Labrador Hydro - Muskrat Falls

MF 1260 - Condition Assessment of Existing Equipment
Block Recovery Test

Well or Piez. #	W-12 (reading 2)*	**Date:**	Nov. 8th 2007	**Case El.:**	59.29
Read By:	L. Rich	**Temperature:**	-3 to +1		
Block No:	1	**Weather Condition:**	Cloudy		

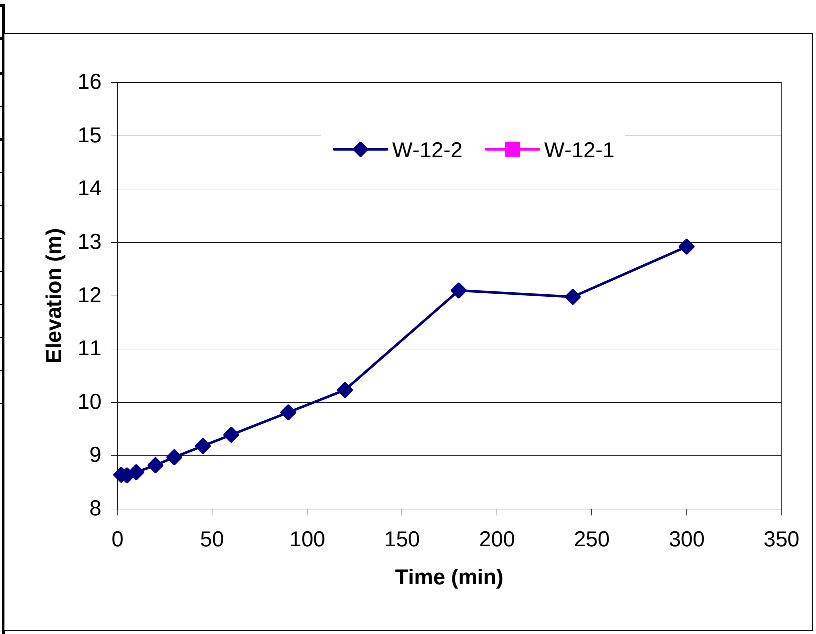
* Test repeated on the second day of the site visit as a primary station.

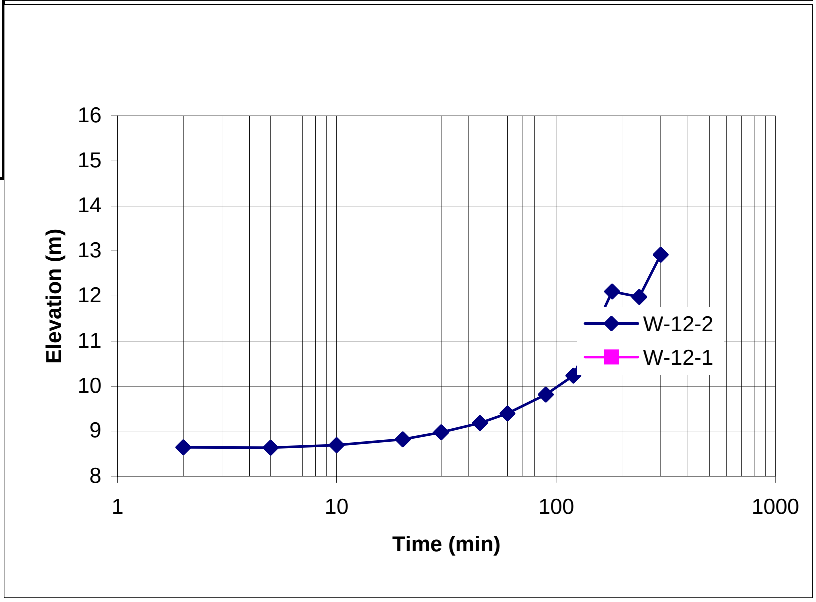
Shutdown Phase

Start Time:

Elapsed Time (Min)	W-12	
	Reading (m)*	Elevation (m)
Well Water Level - Nov. 6		
0		
Nov 7, Recovery test:		
0	-	
0.5	53.7	
1	53.7	
2	50.65	8.64
5	50.66	8.63
10	50.6	8.69
20	50.47	8.82
30	50.32	8.97
45	50.11	9.18
60	49.9	9.39
90	49.48	9.81
120	49.06	10.23
180	47.19	12.1
240	47.31	11.98
300	46.37	12.92

* Relative to the top of casing





Newfoundland and Labrador Hydro - Muskrat Falls

MF 1260 - Condition Assessment of Existing Equipment
Block Recovery Test

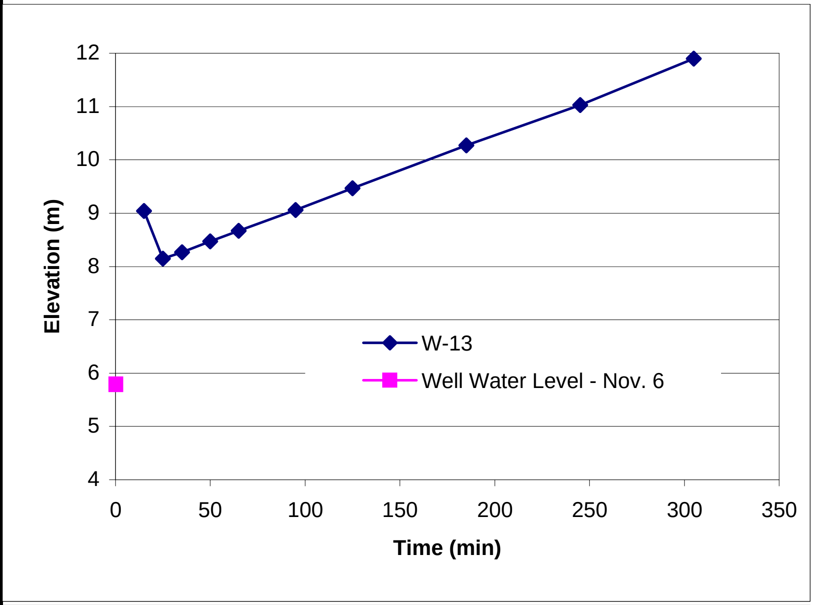
Well or Piez. #	W-13	**Date:**	Nov. 8th 2007	**Case El.:**	57.27
Read By:	L. Rich	**Temperature:**	-3 to +1		
Block No:	2	**Weather Condition:**	Cloudy		

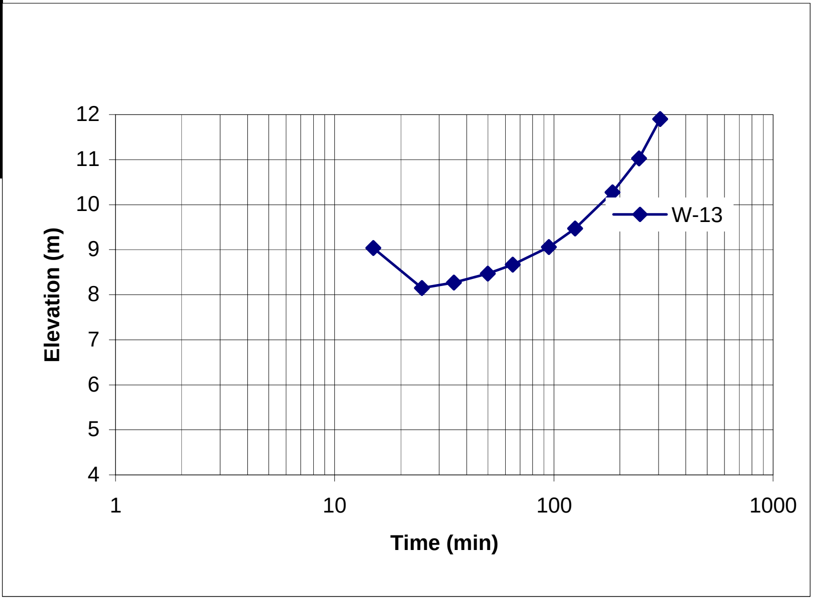
Shutdown Phase

Start Time:

Elapsed Time (Min)	W-13	
	Reading (m)*	Elevation (m)
Well Water Level - Nov. 6		
0	51.48	5.79
Nov 8, Recovery test:		
0		
0.5		
1		
2		
5		
15	48.23	9.04
25	49.12	8.15
35	49	8.27
50	48.8	8.47
65	48.6	8.67
95	48.21	9.06
125	47.8	9.47
185	47	10.27
245	46.24	11.03
305	45.37	11.9

* Relative to the top of casing





Newfoundland and Labrador Hydro - Muskrat Falls

MF 1260 - Condition Assessment of Existing Equipment
Block Recovery Test

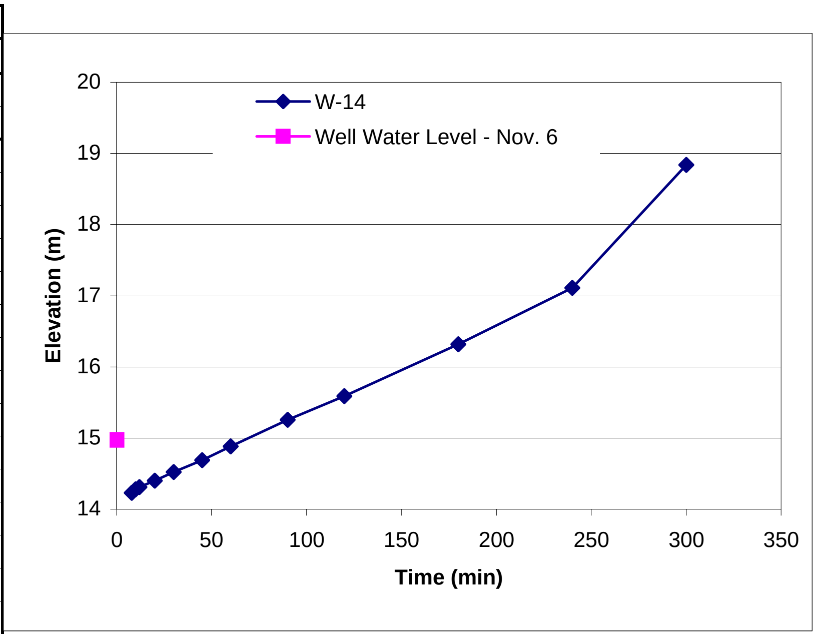
Well or Piez. #	W-14	**Date:**	Nov. 8th 2007	**Case El.:**	59.01
Read By:	J. Mitchell	**Temperature:**	-3 to +1		
Block No:	2	**Weather Condition:**	Cloudy		

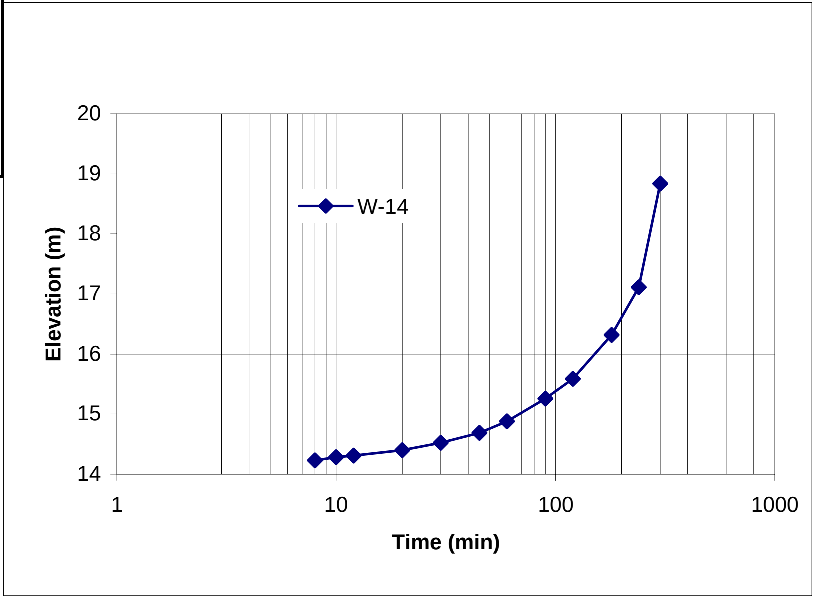
Shutdown Phase

Start Time:

Elapsed Time (Min)	W-14	
	Reading (m)*	Elevation (m)
Well Water Level - Nov. 6		
0	44.04	14.97
Nov 8, Recovery test:		
0		
0.5		
1		
2		
8	44.78	14.23
10	44.73	14.28
12	44.7	14.31
20	44.61	14.4
30	44.49	14.52
45	44.32	14.69
60	44.13	14.88
90	43.755	15.255
120	43.42	15.59
180	42.69	16.32
240	41.9	17.11
300	40.17	18.84

* Relative to the top of casing





Newfoundland and Labrador Hydro - Muskrat Falls

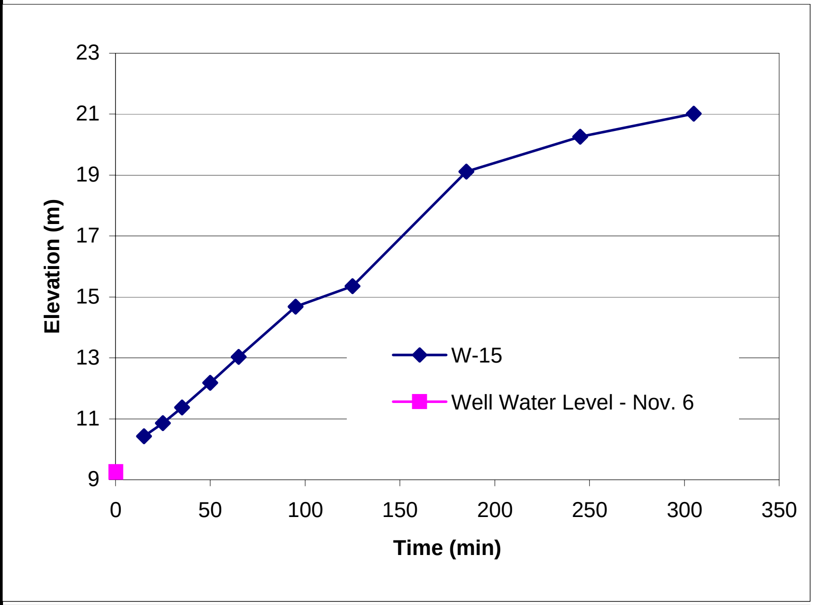
MF 1260 - Condition Assessment of Existing Equipment
Block Recovery Test

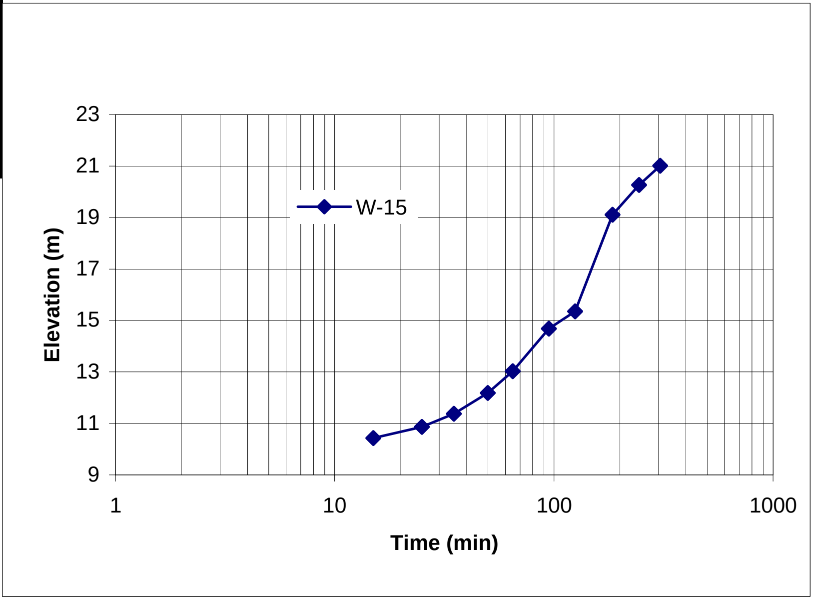
Well or Piez. #	W-15	**Date:**	Nov. 8th 2007	**Case El.:**	58.91
Read By:	J. Mitchell	**Temperature:**	-3 to +1		
Block No:	2	**Weather Condition:**	Cloudy		

Shutdown Phase

Start Time:

Elapsed Time (Min)	W-15	
	Reading (m)*	Elevation (m)
Well Water Level - Nov. 6		
0	49.66	9.25
Nov 8, Recovery test:		
0		
0.5		
1		
2		
8		
10		
15	48.48	10.43
25	48.05	10.86
35	47.54	11.37
50	46.73	12.18
65	45.88	13.03
95	44.23	14.68
125	43.56	15.35
185	39.8	19.11
245	38.65	20.26
305	37.9	21.01





* Relative to the top of casing

Newfoundland and Labrador Hydro - Muskrat Falls

MF 1260 - Condition Assessment of Existing Equipment
Block Recovery Test

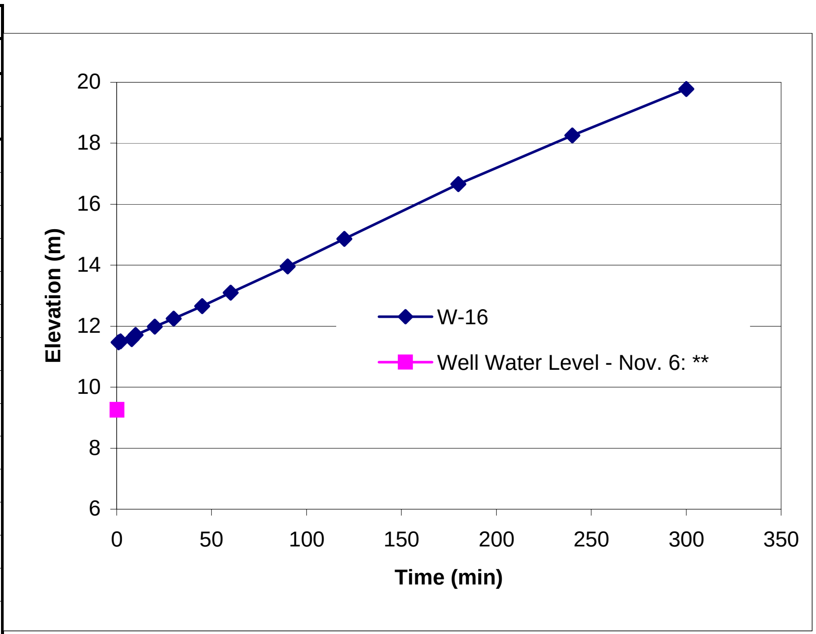
Well or Piez. #	W-16	**Date:**	Nov. 8th 2007	**Case El.:**	58.76
Read By:	B. Crowe	**Temperature:**	-3 to +1		
Block No:	2	**Weather Condition:**	Cloudy		

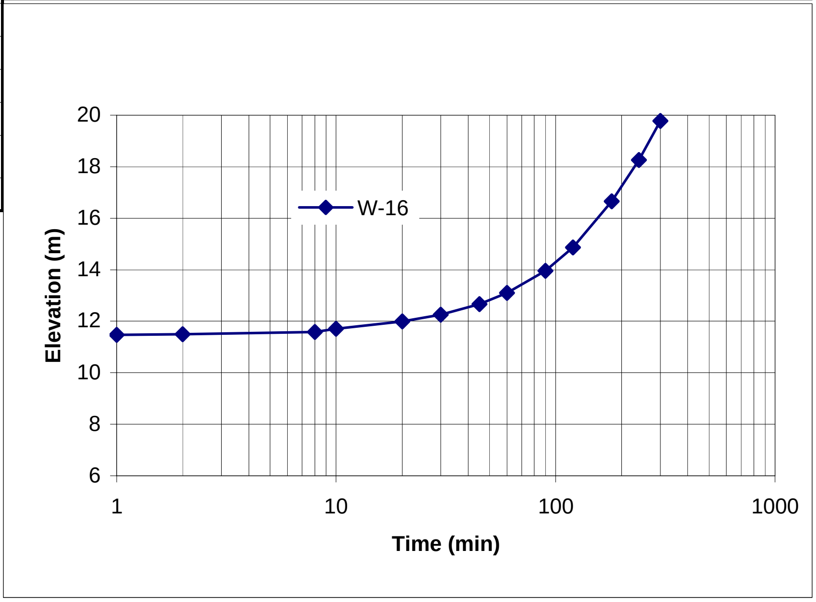
Shutdown Phase

Start Time:

Elapsed Time (Min)	W-16	
	Reading (m)*	Elevation (m)
Well Water Level - Nov. 6: **		
0	49.5	9.26
Nov 8, Recovery test:		
0		
0.5		
1	47.29	11.47
2	47.26	11.5
8	47.18	11.58
10	47.05	11.71
20	46.77	11.99
30	46.51	12.25
45	46.1	12.66
60	45.66	13.1
90	44.8	13.96
120	43.9	14.86
180	42.1	16.66
240	40.5	18.26
300	38.98	19.78

* Relative to the top of casing
** Variation in elevations is due to high variations in well water level.





Newfoundland and Labrador Hydro - Muskrat Falls

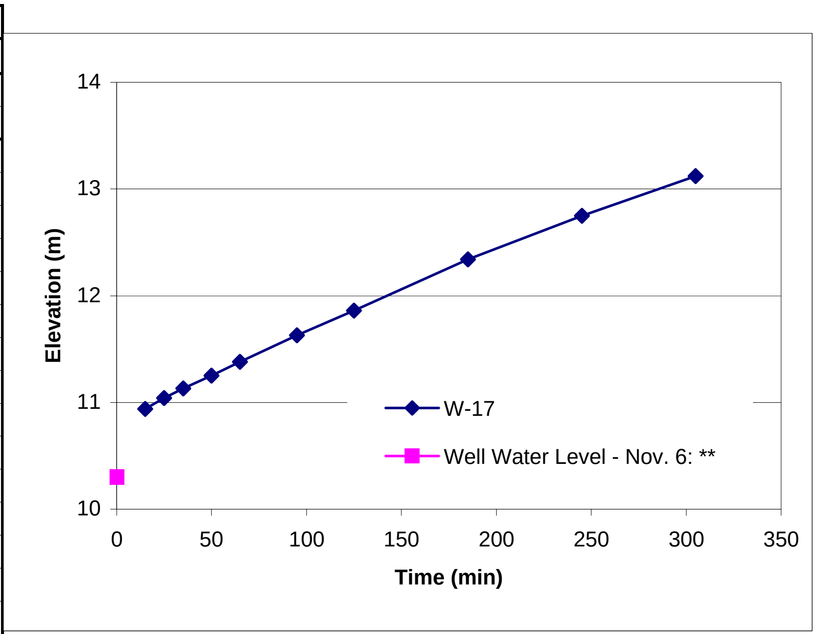
MF 1260 - Condition Assessment of Existing Equipment
Block Recovery Test

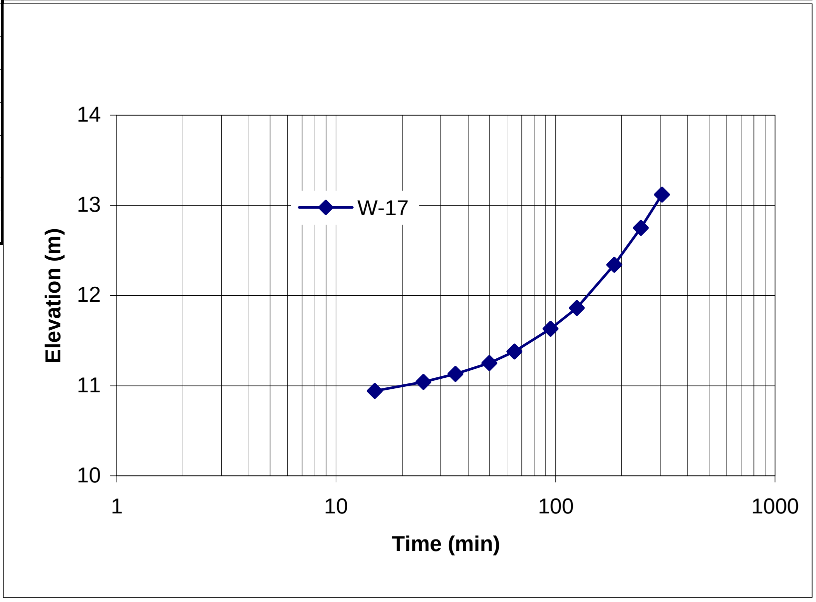
Well or Piez. #	W-17	**Date:**	Nov. 8th 2007	**Case El.:**	58.76
Read By:	B. Crowe	**Temperature:**	-3 to +1		
Block No:	2	**Weather Condition:**	Cloudy		

Shutdown Phase

Start Time:

Elapsed Time (Min)	W-17	
	Reading (m)*	Elevation (m)
Well Water Level - Nov. 6: **		
0	48.46	10.3
Nov 8, Recovery test:		
0		
0.5		
1		
2		
8		
15	47.82	10.94
25	47.72	11.04
35	47.63	11.13
50	47.51	11.25
65	47.38	11.38
95	47.13	11.63
125	46.9	11.86
185	46.42	12.34
245	46.01	12.75
305	45.64	13.12





* Relative to the top of casing
** Variation in elevations is due to high variations in well water level.

Newfoundland and Labrador Hydro - Muskrat Falls

MF 1260 - Condition Assessment of Existing Equipment
Block Recovery Test

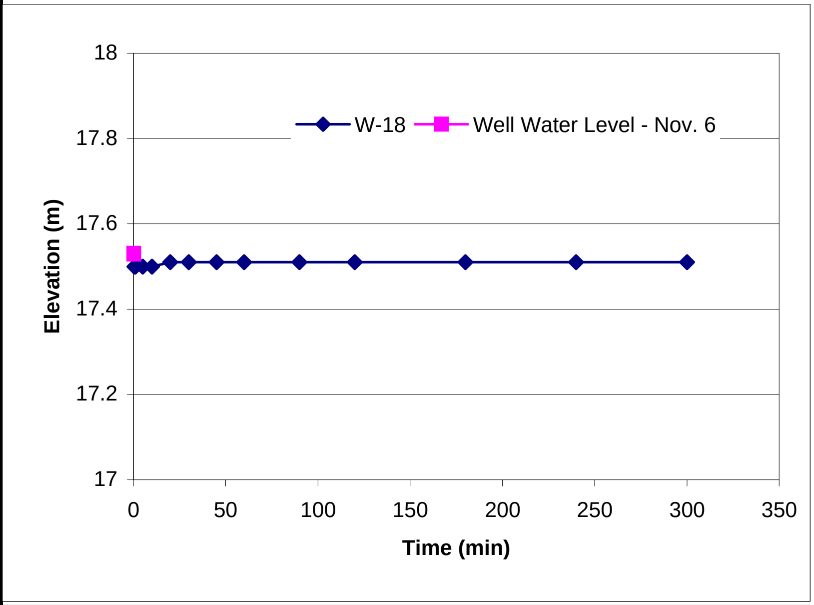
Well or Piez. #	W-18	**Date:**	Nov. 8th 2007	**Case El.:**	57.87
Read By:	P. Ashayer	**Temperature:**	-3 to +1		
Block No:	2	**Weather Condition:**	Cloudy		

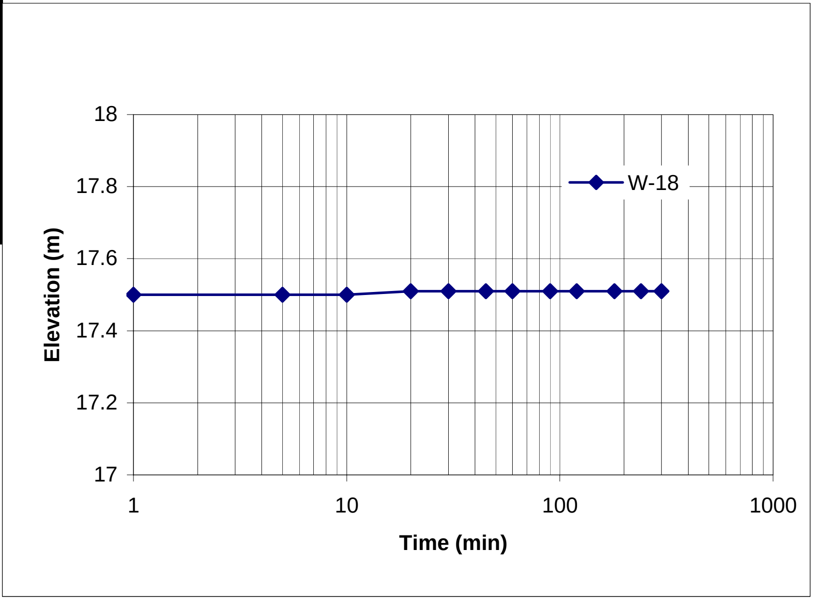
Shutdown Phase

Start Time:

Elapsed Time (Min)	W-18	
	Reading (m)*	Elevation (m)
Well Water Level - Nov. 6		
0	40.34	17.53
Nov 8, Recovery test:		
0		
0.5	40.37	17.5
1	40.37	17.5
5	40.37	17.5
10	40.37	17.5
20	40.36	17.51
30	40.36	17.51
45	40.36	17.51
60	40.36	17.51
90	40.36	17.51
120	40.36	17.51
180	40.36	17.51
240	40.36	17.51
300	40.36	17.51

* Relative to the top of casing





Newfoundland and Labrador Hydro - Muskrat Falls

MF 1260 - Condition Assessment of Existing Equipment
Block Recovery Test

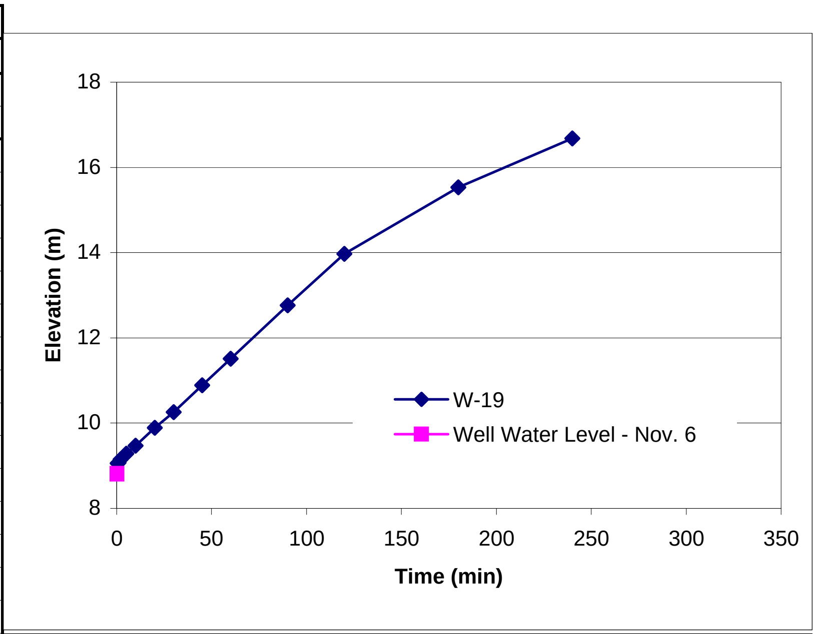
Well or Piez. #	W-19	**Date:**	Nov. 8th 2007	**Case El.:**	57.01
Read By:	D. O'Driscoll	**Temperature:**	-3 to +1		
Block No:	2	**Weather Condition:**	Cloudy		

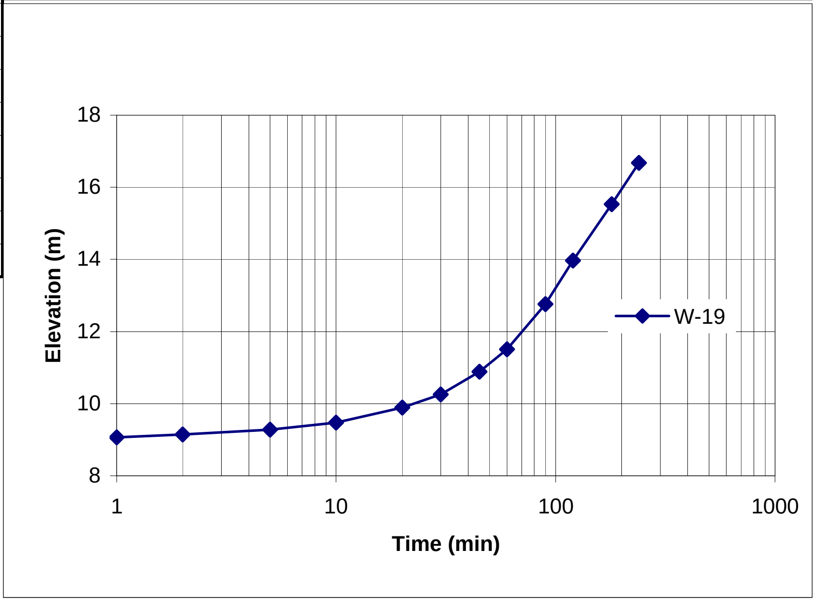
Shutdown Phase

Start Time:

Elapsed Time (Min)	W-19	
	Reading (m)*	Elevation (m)
Well Water Level - Nov. 6		
0	48.2	8.81
Nov 8, Recovery test:		
0		
0.5	47.95	9.06
1	47.94	9.07
2	47.86	9.15
5	47.73	9.28
10	47.54	9.47
20	47.12	9.89
30	46.75	10.26
45	46.12	10.89
60	45.5	11.51
90	44.25	12.76
120	43.04	13.97
180	41.48	15.53
240	40.33	16.68
300		

* Relative to the top of casing





Newfoundland and Labrador Hydro - Muskrat Falls

MF 1260 - Condition Assessment of Existing Equipment
Block Recovery Test

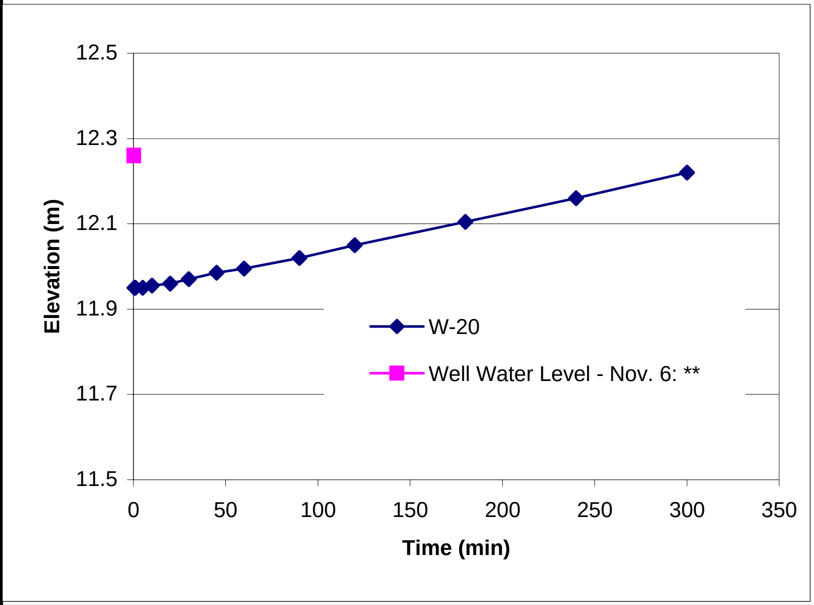
Well or Piez. #	W-20	**Date:**	Nov. 8th 2007	**Case El.:**	56.01
Read By:	P. BroomField	**Temperature:**	-3 to +1		
Block No:	2	**Weather Condition:**	Cloudy		

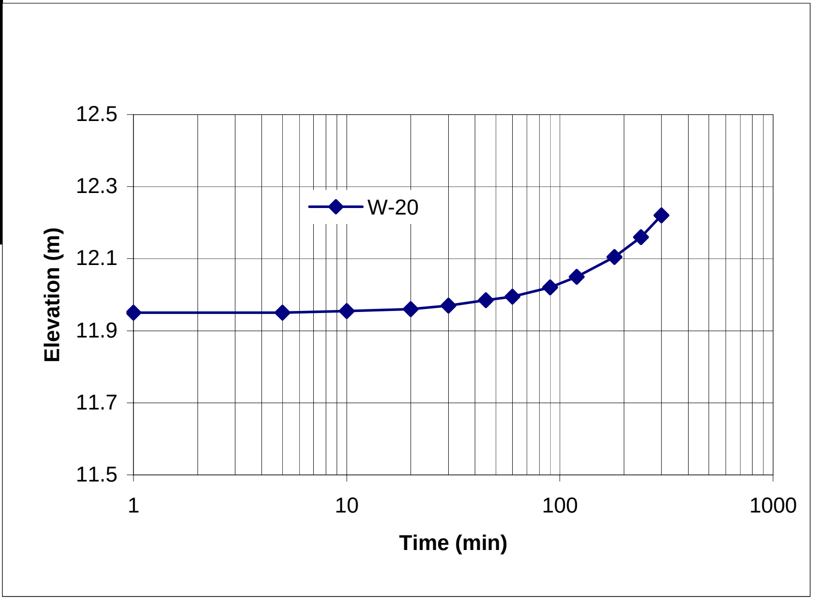
Shutdown Phase

Start Time:

Elapsed Time (Min)	W-20	
	Reading (m)*	Elevation (m)
Well Water Level - Nov. 6: **		
0	43.75	12.26
Nov 8, Recovery test:		
0		
0.5	44.06	11.95
1	44.06	11.95
5	44.06	11.95
10	44.055	11.955
20	44.05	11.96
30	44.04	11.97
45	44.025	11.985
60	44.015	11.995
90	43.99	12.02
120	43.96	12.05
180	43.905	12.105
240	43.85	12.16
300	43.79	12.22

* Relative to the top of casing
** Variation in elevations is due to high variations in well water level.





Newfoundland and Labrador Hydro - Muskrat Falls

MF 1260 - Condition Assessment of Existing Equipment
Block Recovery Test

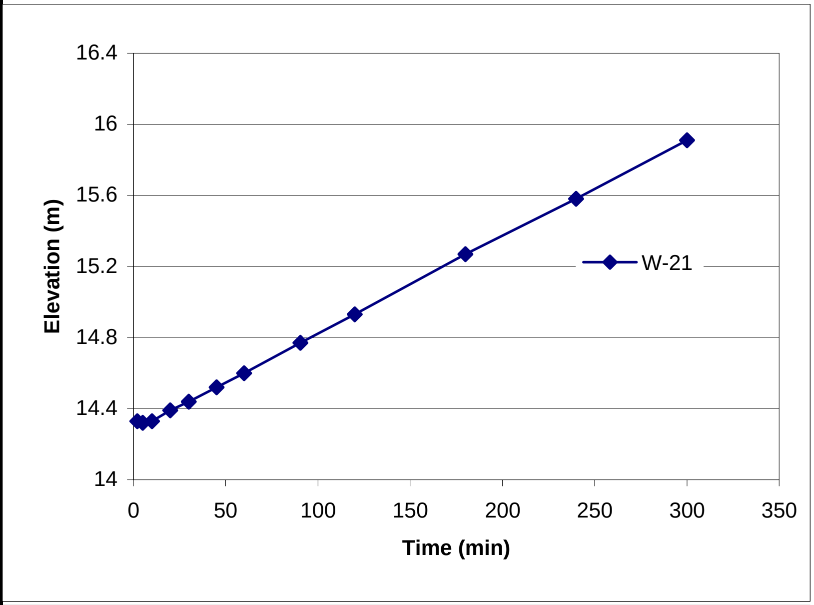
Well or Piez. #	W-21	**Date:**	Nov. 8th 2007	**Case El.:**	59.99
Read By:	L. Evans	**Temperature:**	-3 to +1		
Block No:	2	**Weather Condition:**	Cloudy		

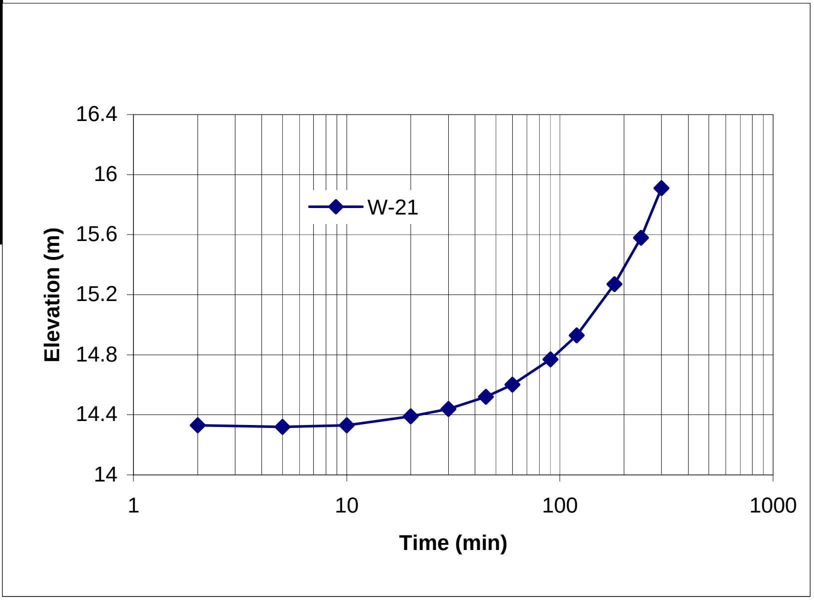
Shutdown Phase

Start Time:

Elapsed Time (Min)	W-21	
	Reading (m)*	Elevation (m)
Well Water Level - Nov. 6		
0		
Nov 8, Recovery test:		
0	-	
0.5		
2	45.66	14.33
5	45.67	14.32
10	45.66	14.33
20	45.6	14.39
30	45.55	14.44
45	45.47	14.52
60	45.39	14.6
90.5	45.22	14.77
120	45.06	14.93
180	44.72	15.27
240	44.41	15.58
300	44.08	15.91

* Relative to the top of casing





Newfoundland and Labrador Hydro - Muskrat Falls

MF 1260 - Condition Assessment of Existing Equipment
Block Recovery Test

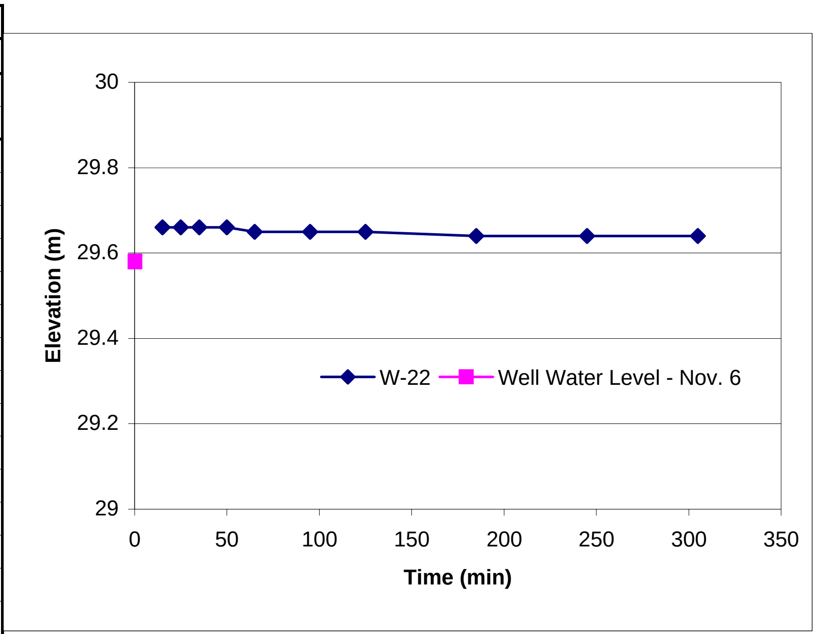
Well or Piez. #	W-22	**Date:**	Nov. 8th 2007	**Case El.:**	59.99
Read By:	L. Evans	**Temperature:**	-3 to +1		
Block No:	2	**Weather Condition:**	Cloudy		

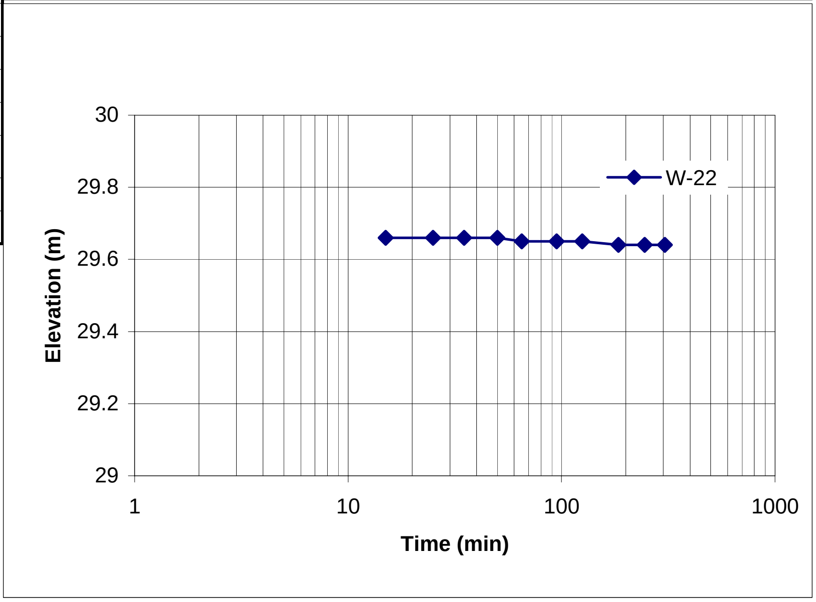
Shutdown Phase

Start Time:

Elapsed Time (Min)	W-22	
	Reading (m)*	Elevation (m)
Well Water Level - Nov. 6		
0	30.41	29.58
Nov 8, Recovery test:		
0		
0.5		
2		
5		
15	30.33	29.66
25	30.33	29.66
35	30.33	29.66
50	30.33	29.66
65	30.34	29.65
95	30.34	29.65
125	30.34	29.65
185	30.35	29.64
245	30.35	29.64
305	30.35	29.64

* Relative to the top of casing





Appendix D

Cost Estimate for Data Acquisition System

Price Estimate for Data Acquisition System

Two budgetary estimates are provided for the Data Acquisition System as follows:

Option A: all sensors to be wired to data logger in the control room. The total cost for this option is $28,295.

Option B: sensors in the NE and Southern regions to communicate remotely using a transceiver with the central data logger in the control room. The cost for this option would be $29,320.

The catalogue of each item used in the above options is attached and also they are listed in Table D1 for both the options A and B. It should be mentioned that in both cases a miniature vibrating wire piezometer should be installed in each piezometer's pvc pipe. This piezometer acts as a sensor and reads and transfers the water head. In both cases the data logger is to be interfaced through cell modem to the internet. Also power is available in the control room only.

It is recommended for option B an additional allowance of $7,200 may be added for professional services.

Table D1
Descriptions for the suggested Items for Options A and B of Data Acquisition System

Part Specifications	Part #	Items Quantity for Option A	Items Quantity for Option B
MINIATOR VIBRATING WIRE PIEZOMETER 0.35 MPa, 17.5 mm DIA	VW2100-0.35-M	13 ea	13 ea
CABLE 4 CONDUCTOR x 22 AWG	EL380004	4000 m	375 m
LIGHTNING PROTECTOR 4 WIRES w/GND WIRE	ELLP	13 ea	10 ea
FLEXDAQ LOGGER 800 TO MONITOR 13 VW PIEZOMETERS C/W MODEM INTERFACE TO INTERNET	ELGL1300	1	0
FLEXDAQ LOGGER 800 TO MONITOR 13 VW PIEZOMETERS C/W MODEM INTERFACE TO INTERNET	ELGL 1300 CONTROL RM	0	1 ea
FLEXDAQ LOGGER 800 & FLEXI-MUX - FOR 6 PIEZOMETERS (NE zone)C/W MODEM INTERFACE TO INTERNET	ELGL 1300 NE ZONE	0	1 ea
FLEXDAQ LOGGER 800 & FLEXI-MUX - FOR 4 PIEZOMETERS (NE zone)C/W MODEM INTERFACE TO INTERNET	ELGL 1300 S ZONE	0	1 ea

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VICTOR CHAN

EST. SHIP DATE	SHIP VIA	F.O.B.	TERMS	ORDER NUMBER
	TBA	Our Dock	Advance pmt.	Q010162

ORDER DATE	P.O. NUMBER	SALESPERSON
20-Dec-07		Al Hunter

L#	PART NUMBER	DESCRIPTION	QTY.	U/M	UNIT PRICE	TOTAL
		CHURCHILL FALLS DAM PROJECT *BUDGETARY ESTIMATE FOR A SYSTEM* *TO MONITOR 11 BOREHOLES CONTAINING 13 PIEZOMETERS (4x DAILY)* *OPTION A: ALL SENSORS TO BE WIRED TO DATA LOGGER IN THE CONTROL ROOM.* *OPTION B: SENSORS IN THE NE AND SOUTHERN REGIONS TO COMMUNICATE REMOTELY USING A TRANSCEIVER WITH THE CENTRAL DATA LOGGER IN THE CONTROL ROOM.* *IN BOTH CASES THE DATA LOGGER IS TO BE INTERFACED THROUGH CELL MODEM TO THE INTERNET. ALSO POWER IS AVAILABLE IN THE CONTROL ROOM ONLY.* *.* *OPTION A*				
	VW2100-0.35	VIBRATING WIRE PIEZOMETER 0.35 MPa, 19 mm DIA	0.00	ea	472.00	
	VW2100-0.35-MM	MICRO MINIATURE VIBRATING WIRE PIEZOMETER, 11mm DIA., 0.35 MPa	0.00	ea	795.00	
	VW2100-0.35-M	MINIATURE VIBRATING WIRE PIEZOMETER, 17.5mm DIA., 0.35 MPa *Cable lengths: TO BE CONFIRMED, 19MM ID PVC MUST BE CLEAN*	13.00	ea	550.00	7,150.00
	EL380004	CABLE, 4 CONDUCTOR x 22 AWG, OSD, RED POLYURETHANE JACKET 0.250" DIA. *ESTIMATED QUANTITY OF CABLE FOR WIRING ALL PIEZOMETERS TO THE CONTROL ROOM DATA LOGGER*	4,000.00	m	2.60	10,400.00
	ELLP4500	LIGHTNING PROTECTION 4 WIRES w/GND WIRE	13.00	ea	290.00	3,770.00
	ELGL1300	FLEXDAQ LOGGER 800 TO MONITOR 13 VW PIEZOMETERS C/W MODEM INTERFACE TO INTERNET *Includes: AVW1 VW interface, PS100 Battery unit, AC Power DIN mount, RST Flexi-Mux 2042, LoggerNet Software, SC32B Interface RS-232, Surge for antenna, Raven Antenna, Raven CDMA IP Cell, Raven Mounting Bracket, Cable glands, and Enclosure .* *Note: All FLEXDAQ loggers are pre-programmed and ready to run.* *.* *OPTION B*	1.00	ea	6,975.00	6,975.00
	VW2100-0.35-M	MINIATURE VIBRATING WIRE PIEZOMETER, 17.5mm DIA., 0.35 MPa *Cable Lengths: TO BE CONFIRMED, 19MM ID PVC MUST BE CLEAN*	13.00	ea	630.00	8,190.00
	EL380004	CABLE, 4 CONDUCTOR x 22 AWG, OSD, RED POLYURETHANE JACKET 0.250" DIA. *ESTIMATED QUANTITY OF CABLE FOR WIRING THE PIEZOMETERS IN THREE SEPERATE ZONES: NORTHEAST, SOUTH , and CONTROL ROOM*	375.00	m	2.60	975.00
	ELLP4500		10.00	ea	290.00	2,900.00

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	TBA	Our Dock	Advance pmt.	Q010162

ORDER DATE	P.O. NUMBER	SALESPERSON
20-Dec-07		Al Hunter

L#	PART NUMBER	DESCRIPTION	QTY.	U/M	UNIT PRICE	TOTAL
		LIGHTNING PROTECTION 4 WIRES w/GND WIRE				
	ELGL1300 CONTROL RM	FLEXDAQ LOGGER 800 TO MONITOR 13 VW PIEZOMETERS C/W MODEM INTERFACE TO INTERNET *AND TRANSCEIVER SYSTEM TO REMOTELY INTERFACE WITH FLEXIMUXES IN NORTHEAST AND SOUTH ZONES* *Includes: AVW1 VW interface, PS100 Battery unit, AC Power DIN mount, RST Flexi-Mux 2042, LoggerNet Software, SC32B Interface RS-232, Surge for antenna, Raven Antenna, Raven CDMA IP Cell, Raven Mounting Bracket, RF401 spread spectrum, 14162 RF401 mounting kit, Antenna whip Omni-directional, Cable glands, and Enclosure .*	1.00	ea	6,615.00	6,615.00
	ELGL1300 NE ZONE	FLEXDAQ LOGGER 800 & FLEXI-MUX - FOR 6 PIEZOMETERS (NE zone) C/W *LOCAL TRANSCEIVER SYSTEM TO COMMUNICATE WITH THE CONTROL ROOM DATA LOGGER* *Includes: AVW1 VW interface, PS100 Battery unit, RST Flexi-Mux 2042, SC32B Interface RS-232, RF401 spread spectrum, 14162 RF401 mounting kit, Antenna whip Omni-directional, 22 Watt Solar Panel, 22 Watt Pole mounting bracket, Cable glands, and Enclosure.*	1.00	ea	5,500.00	5,500.00
	ELGL1300 S ZONE	FLEXDAQ LOGGER 800 & FLEXI-MUX - FOR 4 PIEZOMETERS (S zone) C/W *LOCAL TRANSCEIVER SYSTEM TO COMMUNICATE WITH THE CONTROL ROOM DATA LOGGER* *Includes: AVW1 VW interface, PS100 Battery unit, RST Flexi-Mux 2042, SC32B Interface RS-232, RF401 spread spectrum, 14162 RF401 mounting kit, Antenna whip Omni-directional, 22 Watt Solar Panel, 22 Watt Pole mounting bracket, Cable glands, and Enclosure .*	1.00	ea	5,140.00	5,140.00
		Note: All FLEXDAQ loggers are pre-programmed and ready to run. . *ON SITE SYSTEM COMISSIONING- Optional*				
	PSDLABOUR	PROFESSIONAL SERVICES LABOUR - DAY RATE 10 HR - estimate 2 to 3 days on site *SITE VISIT LABOUR IS CHARGED PORTAL TO PORTAL. ALL OTHER ASSOCIATED EXPENSES ARE CHARGED WITH RECEIPTS AND A 10% PROCESSING CHARGE.* .	6.00	dy	1,200.00	7,200.00
	VW2106	VIBRATING WIRE PORTABLE READOUT- Optional *w/ USB CABLE AND SOFTWARE/MANUAL CD* . *GEOVIEWER- Optional*	1.00	ea	1,985.00	1,985.00
	ELGL5000	GEOVIEWER STANDARD LOGGER SOFTWARE w/ USB KEY	1.00	ea	1,380.00	1,380.00
	PSLABOUR	PROFESSIONAL SERVICES LABOUR *ESTIMATED COST TO COMMISSION GEOVIEWER*	6.00	hr	105.00	630.00

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EST. SHIP DATE	SHIP VIA	F.O.B.	TERMS	ORDER NUMBER
	TBA	Our Dock	Advance pmt.	Q010162

ORDER DATE	P.O. NUMBER	SALESPERSON
20-Dec-07		Al Hunter

L#	PART NUMBER	DESCRIPTION	QTY.	U/M	UNIT PRICE	TOTAL

INITIAL ESTIMATE FOR BUDGETARY PURPOSES
Validity of quote: 60 DAYS
Estimated delivery: to be confirmed.
Subject to RST Instruments Sales Terms and Conditions
(http://www.rstinstruments.com/standard_terms.html).

	NET AMOUNT	68,810.00
	G.S.T.	4,128.60
CDN DOLLARS	**TOTAL DUE**	72,938.60

VIBRATING WIRE PIEZOMETERS

The RST Vibrating Wire Piezometer provides excellent long-term accuracy, stability of readings and reliability under demanding geotechnical conditions. Vibrating Wire Piezometers are the electrical piezometers of choice as the frequency output of VW devices is immune to external electrical noise, and able to tolerate wet wiring common in geotechnical applications.

The vibrating wire piezometer senses pressure by means of a metal diaphragm attached to a vibrating wire element. When pressure is applied to the diaphragm, its deflection is sensed by the vibrating wire element – i.e. the tension in the wire is reduced, and the resonant frequency of the vibrating wire is changed as a result. The vibrating wire is induced to vibrate, and then the resonant frequency is measured via an electromagnetic coil circuit. The resulting frequency is precisely related to the pressure.

The frequency signal is exceptionally immune from cable effects, including length (to several kilometers), splicing, resistance, noise pickup, and moisture. The vibrating wire coil circuit contains no semiconductor devices and has built-in ionized gas discharge device protection against transient damage. As a result, the vibrating wire piezometer provides excellent reliability in typical geotechnical situations – i.e. long outdoor cables buried in saturated soil.

The piezometer is equipped with a standard sintered stainless steel porous filter to prevent soil particles from contacting the diaphragm. A thermistor is built into the piezometer body to permit temperature measurement and temperature compensation of the piezometer. Standard construction is all stainless steel. RST vibrating wire piezometers are shipped with extremely tough polyurethane-jacketed foil-shielded cable for maximum endurance in field conditions.

FEATURES

- Field proven reliability and accuracy.
- Will tolerate wet wiring common in geotechncial applications.
- Immune from external electrical noise.
- Signal transmission of several kilometers.
- Cable lengths may be changed without affecting the calibration.
- High accuracy, IE a low pressure vented model will measure water level changes as small as 0.05 mm (0.02 in.).
- Thermistor for temperature measurement is standard.
- Negligible displacement of pore water during the measurement process.
- Hermetically sealed, stainless steel construction.
- Heavy case to minimize reading errors caused by overburden pressure.
- Data logger compatible.
- Integral lightning protection.

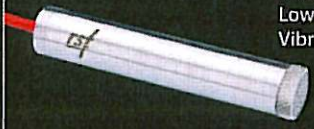
FUNCTIONS

- Assessing performance and investigating stability of earth fill dams and embankments.
- Slope stability investigations.
- Monitoring water levels in wells & standpipes.
- Monitoring pressures behind retaining walls and diaphragm walls.
- Monitoring pore pressures during fill or excavation.
- Monitoring pore pressure in land reclamation applications.

VW2100 Standard Vibrating Wire Piezometer

VW2100-HD: Heavy Duty Vibrating Wire Piezometer

VW2100-DP: Drive Point Vibrating Wire Piezometer



VW2100-L:
Low Pressure Unvented
Vibrating Wire Piezometer

VW2100-MM:
Micro-Miniature
Vibrating Wire Piezometer

Specifications may change without notice. ELB0003D

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The RST Instruments Management System is certified to ISO 9001:2000

OPERATING PRINCIPLE

Vibrating Wire Piezometers contain a high tensile steel wire with a fixed anchor at one end and are attached to a diaphragm at the other end. The wire is electrically plucked, with the resonant frequency of vibration proportional to the tension in the wire. This frequency induces an alternating current in a coil, which is detected by the readout unit and can then be converted to a pressure.

ELECTRICAL CABLE

PART	DESCRIPTION
EL380004	Two twisted pairs cable with polyurethane jacket.

Other types of cables, depending on site conditions and atmospheric reference requirements, are available upon request. These include Vented, FEP, PVC, Polyurethane, and Armored varieties.

VIBRATING WIRE PIEZO SPECIFICATIONS

DESCRIPTION	SPECIFICATIONS
Over range	2 X F.S.
Resolution	0.025% F.S. minimum
Accuracy	0.1% F.S.
Operating Temperature	-20 to 80°C (-4 to 176°F)
Diaphragm Displacement	<0.001 cc at F.S.
Thermal Zero Shift	<0.05% F.S./°C
Materials	Hermetically sealed stainless steel housing
Thermistor Matching	±0.5°C
Thermistor Resolution	0.1°C
Thermistor Accuracy	0.5°C
Filter	50 micron sintered filter. (High air entry alumina filter 1, 3, 5 Bar available)

VIBRATING WIRE PIEZO OPTIONS (Specify when ordering)

Heavy-duty bodies for embankment use.

Push-in drive points for soft soils

High air entry ceramic filters to exclude air

Low range and vented piezometers

Titanium construction for use with corrosive fluids

Multi-point/mixed type sensor strings

Kevlar™* reinforced cable

ANCILLARY EQUIPMENT (Specify when ordering)

VW2106 Vibrating Wire Readout

Dataloggers

Terminal stations

Electrical cable

Cable splice kits

Installation geotextile and socks

Increased lightning protection

ORDERING INFORMATION

PART	DESCRIPTION	PRESSURE RANGE	DIMENSION
VW2100	Standard model for general applications.	0.35, 0.7, 1.0, 2.0, 3.0, 5.0, 7.5 MPa	19 mm Ø X 133 mm 0.75 in. Ø X 5.23 in.
VW2100-HD	Heavy duty piezometer for direct burial in fills and large dam embankments.	0.07, 0.175, 0.35, 0.7, 1.0, 2.0 3.0, 5.0, 7.5 MPa	38.1 mm Ø X 203 mm 1.5 in. Ø X 8.0 in.
VW2100-HHP	High pressure transducer with NPT port.	5.0, 7.5, 10, 25, 50, 75, 100 MPa	25.4 x 143 mm 1 in. Ø X 5.63 in.
VW2100-DP	Drive point model with CPT adapter.	0.07, 0.175, 0.35, 0.7, 1.0, 2.0, 3.0, 5.0, 7.5 MPa	33 mm Ø X 432 mm 1.31 in. Ø X 17 in.
VW2100-L	Low Pressure, unvented.	70, 175 kPa	25 mm Ø X 133 mm 1 in. Ø X 5.23 in.
VW2100-LV	Low Pressure vented.	70, 175 kPa	25 mm Ø X 133 mm 1 in. Ø X 5.23 in.
VW2100-M	Miniature version – 17.5 mm diameter.	0.35, 0.7, 1.0, 2.0, 3.0, 5.0, 7.5 MPa	17.5 mm Ø X 133 mm 0.68 in. Ø X 5.23 in.
VW2100-MM	Micro-miniature version – 11.1 mm diameter.	0.35, 0.7 MPa	11.1 mm Ø X 165 mm 0.43 in. Ø X 6.5 in.

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VW2106 VIBRATING WIRE READOUT

The portable VW2106 Vibrating Wire Readout reads, displays, and logs both vibrating wire sensors and thermistors. Vibrating wire load cells can be read without any additional accessories.

Unprecedented accuracy, flexible memory options and ease of use make the VW2106 invaluable for projects requiring vibrating wire sensor monitoring. Maximum download time is only 15 seconds.

Complementing its high level of accuracy, the VW2106 is also designed for maximum efficiency with the user in mind. In addition to the simple power requirements of only 3 "AA" batteries, the VW2106 comes well-equipped with standard features such as a large graphics display with backlight, a built-in multiplexer, "no-tools" vibrating wire transducer inputs (eliminating the need for alligator clips), and a convenient on-board speaker for sensor diagnostics.

FEATURES

- Durable, compact design for excellent portability and field use.
- Large graphics display with a convenient backlight.
- Readings in raw or engineering units.
- Built-in multiplexer for load cells up to 6 vibrating wire gauges.
- "No-tools" vibrating wire transducer inputs eliminates the need for alligator clips.
- Field-replaceable "AA" alkaline batteries eliminate the need for a large, bulky 12 V battery and a charger.
- On-board speaker for sensor diagnostics.
- Stores up to 254 instrument locations per route, each with a text label, calibration constants, previous data, and up to 11,400 time/date stamped data points.
- Data transfer to a host computer via USB in a compatible file format for Microsoft Excel® and other spreadsheets. User friendly host software for Microsoft Windows® included.

FUNCTIONS

Reads, displays, and logs both vibrating wire sensors and thermistors.

SPECIFICATIONS

Vibrating Wire Readout Excitation Range	400 Hz to 6000 Hz, 5 V Square Wave
Vibrating Wire Readout Resolution	0.01 µs
Vibrating Wire Readout Timebase Accuracy	±50 ppm
Supported Temperature Readout Sensors	NTC3000 (standard), NTC2252, NTC10K, RTD
Temperature Readout Accuracy	±0.1°C
Temperature Readout Range	-50°C to 80°C
Display	Graphic 128 x 64 pixels large character display
Display Backlight	High efficiency LCD with auto off
Max Instrument Locations	254
Memory Capacity	11,400 custom labelled points
Location Identification String	Up to 20 characters
Download Speed	15 seconds (full memory)
Battery	3 "AA" alkaline
Battery Indicator	On-screen, low battery indicator
Operating Temperature	-20°C to 60°C
Dimensions	W 22 cm x D 19 cm x H 9.5 cm (8.75 x 7.5 x 3.75in.)
Weight	1.1 kg (2.4 lbs)

ORDERING INFORMATION

Part Number	VW2106

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The RST Instruments Management System is certified to ISO 9001:2000

QMI REGISTERED

GEOVIEWER SOFTWARE

Designed to simplify data interpretation, the GeoViewer Software allows the user to retrieve data from loggers in near-real time and graphically process the information.

The XY coordinates and displacement data for each reference pin is calculated and displayed in a variety of different charts and graphs, displayed graphically, or presented as a 3D image. Deformation may be animated, time sliced, or rotated as required. An original image may be superimposed with post deformation data to show displacement with time. GeoViewer will automatically collect and process the data to update the screen in near-real time. Alarm functions with user programmable rate/magnitude thresholds are provided. The program format allows data to be imported into outside software programs for further analysis, or will export JPEG images to the internet. Windows™ 95, 98, 2000, NT™ and XP™ operating systems are supported.

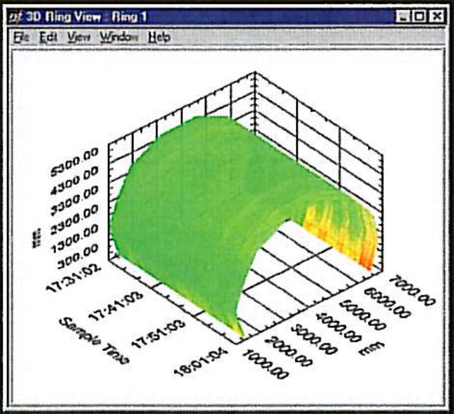
The RST GeoViewer program is custom written in both English and the user's language for each site-specific application. Free demonstration software is available on CD. Please contact RST for details.

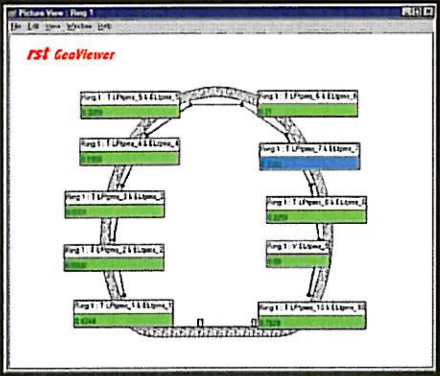
FEATURES

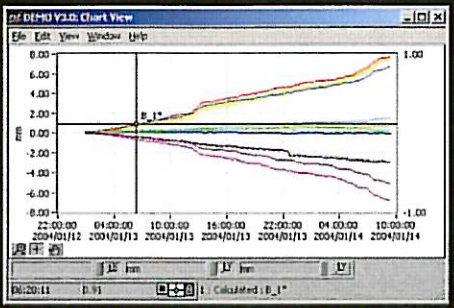
- Near-real time data logger retrieval.
- Graphical representation of data in a variety of forms.
- Software written in both English and customized to the user's specified language.
- Superimposition of original images over post deformation data.
- Automated collection and processing of data updating in near-real time.
- Multiple alarm functions with user programmable rate/magnitude thresholds provisions.
- Cross platform data export abilities to Windows™ 95, 98, 2000, NT™ and XP™ operating systems.
- Export on-screen data representation as JPEG image for internet and e-mail use.

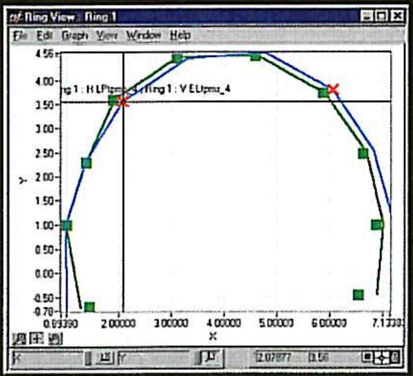
FUNCTIONS

- Assess settlement effects on various civil structures.
- Correlate data obtained from various monitoring instrumentation used on the same specific project.









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The RST Instruments Management System is certified to ISO 9001:2000

designed to your exact specifications

flexDAQ
DATALOGGERS

READY TO RUN
pre-assembled
pre-wired
pre-tested
pre-programmed

CR1000 DATA LOGGER

The CR1000 Datalogger is part of the flexDAQ Datalogger Series. It is a multi-channel data logger designed for reliable, remote monitoring under demanding geotechnical conditions. It provides sensor measurement, timekeeping, data reduction, data/program storage and control functions. Data values are are stored in tables with a time stamp and record number. The CR1000 is capable of monitoring all types of sensors including vibrating wire, servo-accelerometer, linear potentiometer, strain gauge, thermistor, electrolevel, etc.

The standard CR1000 datalogger includes 2 Mbytes of memory for data and program storage. Data and programs are stored either in a nonvolatile Flash memory or RAM. A lithium battery backs up the RAM and real-time clock. The CR1000 also suspends execution when primary power (BPALK, PS100) drops below 9.6 V, reducing the possibility of inaccurate measurements. The CR1000 can be augmented with peripherals to form a data acquisition system; many CR1000 systems can be networked to form a local or regional monitoring network.

Battery-backed SRAM memory, and clock, ensure that data, programs, and accurate time is maintained while the CR1000 is disconnected from its main power source.

Multiplexers, such as the RST Flexi-Mux, can increase the number of sensors that can be measured by the CR1000 by sequentially connecting each sensor to the datalogger. Several multiplexers can be controlled by a single CR1000.

FEATURES

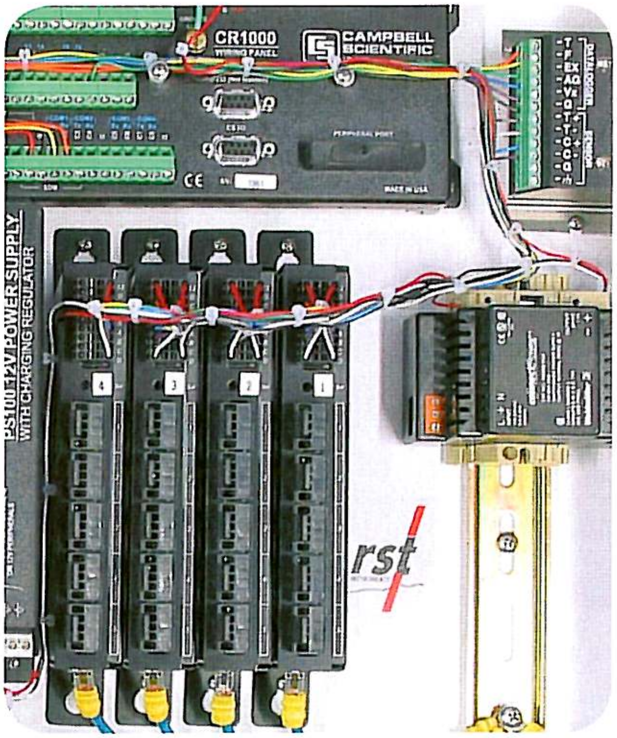
- 2 Mbytes standard memory; 4 Mbytes optional memory.
- Program execution rate of up to 100Hz.
- CS I/O and RS-232 serial ports.
- 13-bit analog to digital conversions.
- 16-bit H8S Hitachi Microcontroller with 32-bit internal CPU architecture.
- Temperature compensated real-time clock.
- Background system calibration for accurate measurements over time and temperature changes.
- Data values stored in tables with a time stamp and record number.
- Battery-backed SRAM memory, and clock, ensure that data, programs, and accurate time is maintained while the CR1000 is disconnected from its main power source.

FUNCTIONS

- Remote datalogging of various types of geotechnical instrumentation used in dams, tunnels, bridges, mines, and natural slopes.
- Alarm triggering when movement reaches a preset critical rate or levels reach a present value.
- Real time data logging and analysis.

ORDERING INFORMATION

Part Number	CR1000



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COMMUNICATION PROTOCOLS

The CR1000 supports three comunication protocols: traditional, PAKBUS®, and Modbus. The traditional communication protocol is connection-based.

The PAKBUS® communication protocol improves upon traditional communications for datalogger networks. PAKBUS® networks have the distributed routing intelligence to continually evaluate links. Continually evaluating links optimizes delivery times and, in case of delivery failure, allows automatic switch over to a configured backup route.

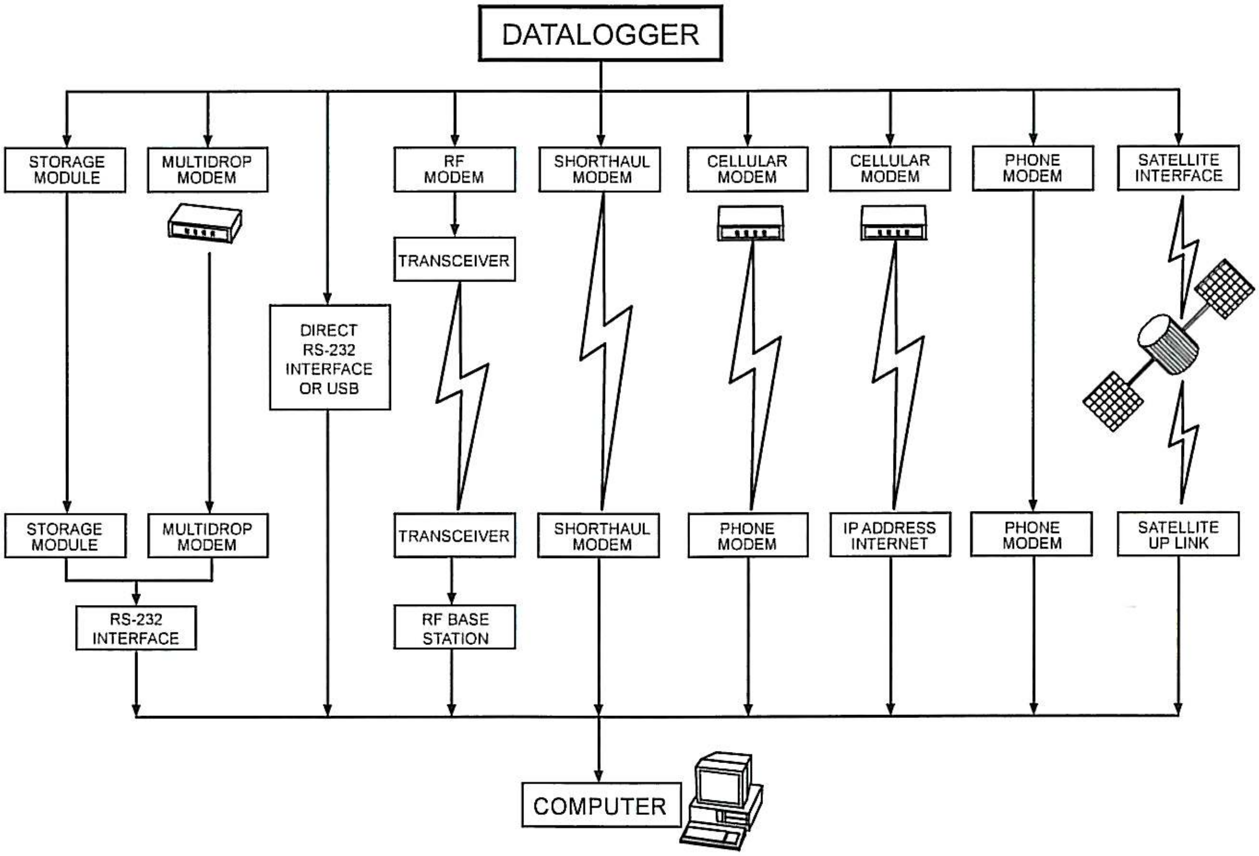
The Modbus protocol allows the CR1000 to work with "off the shelf" Modbus software packages.

COMMUNICATIONS

Compatible telecommunication options include ethernet, phone modems (land-line and cellular), radios, short haul modems, GOES satellite transmitters, and multidrop modems. Real-time and historical data can be displayed on-site using a PDA (requires PConnect 3.1), the CR1000KD keboard/display, or a PC.

The PC connects to the CR1000 via an RS-232 cable, or if optional isolation is required, via the CS I/O port and SC32B interface. Users can transport programs/data to a PC via CompactFlash® cards. The CFM100 module is used to store the programs/data on the card; a SanDisk® ImageMate® card reader is used to download the programs/data to the PC.

DIAGRAM OF POSSIBLE COMMUNICATION METHODS



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Appendix E

Cost Estimate for Construction of the Proposed Wells and Piezometers

Price Estimate for the Construction of the Proposed Wells and Piezometers

In this appendix, a budgetary estimate is provided for the installation of the proposed wells and piezometers. This estimate is based on the following three activities:

- Mobilization
- Construction of seven wells with 12″ in diameter and 200′ in depth
- Construction of eight new piezometers, four to the depth of 200′ and four to the depth of 115′

It should be mentioned that almost half of this estimate is related to the drilling and casing of the wells. This is mainly due to the size of drilling and the installation of filter sand pack.

The approximate estimate for the above activities is as follows:

- Mobilization: $90,750
- Well construction: $931,770
- Piezometer Construction: $116,741

The details of the estimate and the proposed designs are in the next two pages.

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MUSKRAT FALLS, LABRADOR, NEWFOUNDLAND

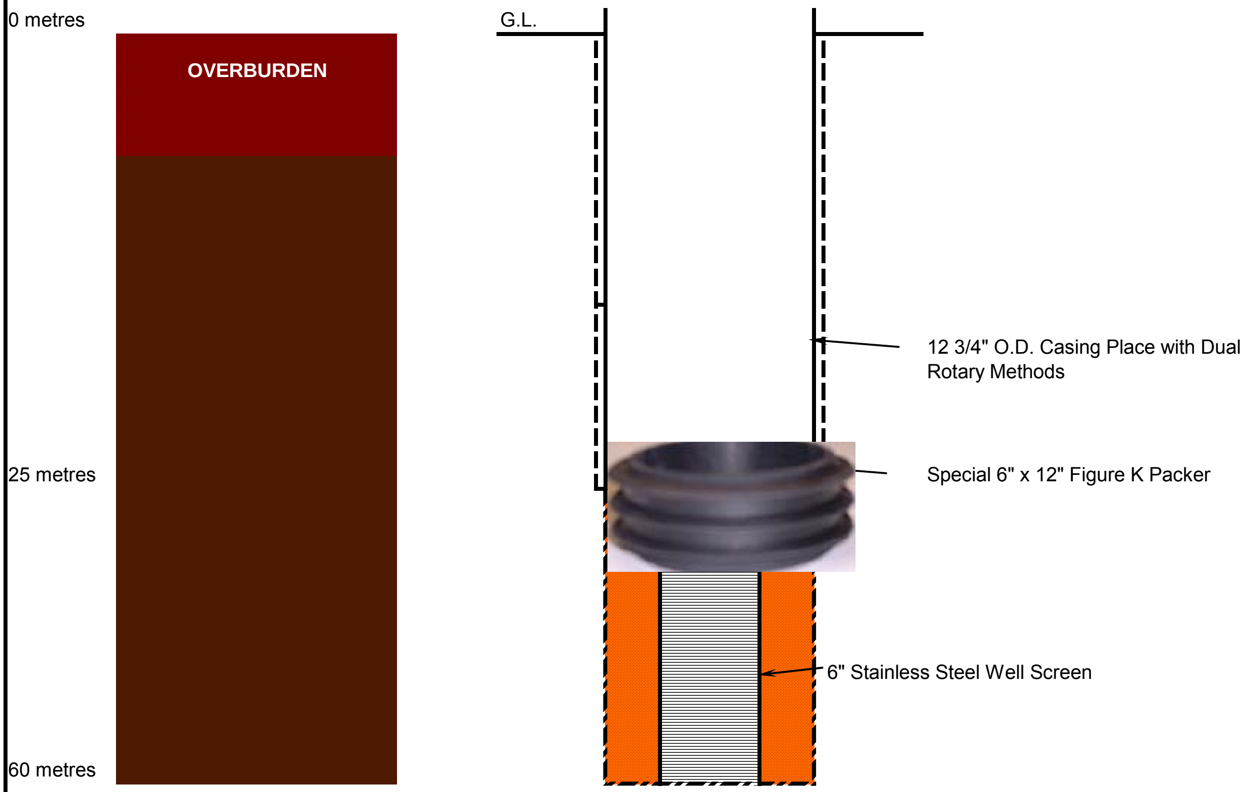
FOR: HATCH
Attention: Mr. Warren Hoyle

ITEM NO.	DESCRIPTION	UNIT	EST. QUANTITY	UNIT COST	ITEM COST
A1	Mobilization and demobilization of drilling equipment, tooling and supplies, room & board	L.S.	1	$90,750.00	**$90,750.00**
	CONSTRUCTION OF SEVEN (7) - 12 INCH PRODUCTION WELLS TO 200 FEET EACH				
B1	Drill in 12 3/4" O.D. casing to approximately 200 feet per well	Foot	1400	$375.00	$525,000.00
B2	Supply 12 3/4" Casing	Foot	700	$75.00	$52,500.00
B3	Supply 6" Pipe Size Stainless steel well screens - based on 115 feet per well	Foot	805	$245.00	$197,225.00
B4	Supply 6" screen lead pipe - based on 10 feet per well	Foot	70	$15.00	$1,050.00
B5	Supply 6" x 12" centralizers for well screen	Each	21	$145.00	$3,045.00
B6	Supply filter pack sand - 2000 lb bags	Bag	62	$700.00	$43,400.00
B7	Supply special figure K packer	Each	7	$1,900.00	$13,300.00
B8	Other work for drill rig and crew and well development, etc.	Hour	175	$550.00	$96,250.00
				TOTAL	**$931,770.00**
	CONSTRUCTION OF EIGHT NEW PIEZOMETERS - FOUR TO 200 FEET AND FOUR TO 115 FEET				
C1	Drilling of 6" borehole utilizing Dual Rotary drilling and sampling methods	Foot	1260	$65.00	$81,900.00
C2	Supply 2" PVC Sch. 40 Riser Pipe - 10 ft lengths	Foot	900	$4.25	$3,825.00
C3	Supply 2" PVC Sch. 40 Slotted Screen - 10 foot lengths	Foot	400	$5.35	$2,140.00
C4	Supply threaded end caps and Slip-on caps	Set	8	$22.00	$176.00
C5	Supply Graded Sand filter pack material - 50 lb bags	Bag	240	$14.00	$3,360.00
C6	Supply Holeplug grout - 50 lb bags	Bag	16	$25.00	$400.00
C7	Supply Quik Grout Bentonite - 50 lb bags	Bag	50	$30.00	$1,500.00
C8	Supply 4" x 5' Casing Protectors	Foot	8	$180.00	$1,440.00
C9	Other work for drill rig and crew and well development, etc.	Hour	40	$550.00	$22,000.00
				TOTAL	**$116,741.00**
				TTOTAL	**$1,139,261.00**

Conceptual Design of 12 3/4" O.D. Dewatering Well

Dewatering Well Replacement
Muskrat Falls Power Facility
Labrador, Newfoundland

HATCH



Drawn by: Bill Davidson

Date February 12, 2008

Note Not To Scale

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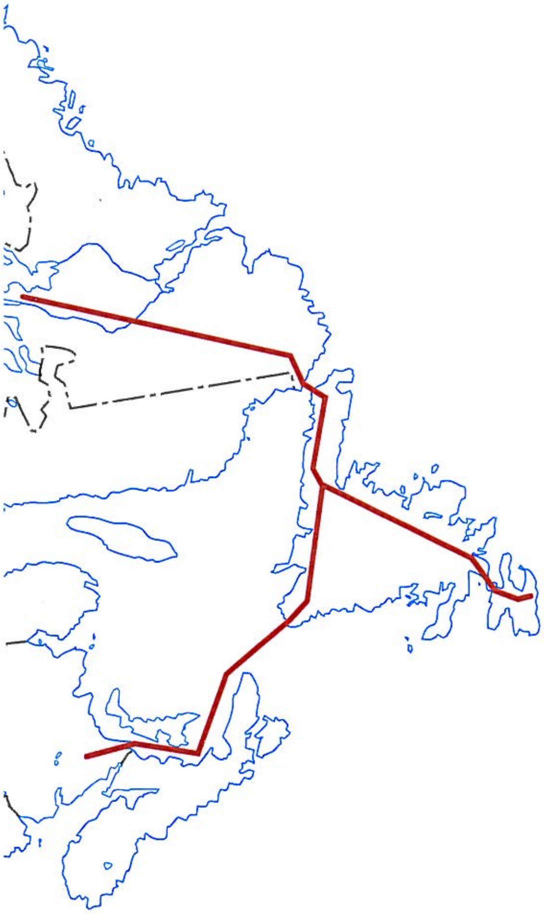
energy



THE Lower Churchill PROJECT

March 2010

MF1271 - Evaluation of Existing Wells, Pumps and Related Infrastructure in the Muskrat Falls Pumpwell System

prepared by

HATCH™

nalcor energy

THE Lower Churchill PROJECT

March 2010

MF1271 - Evaluation of Existing Wells, Pumps and Related Infrastructure in the Muskrat Falls Pumpwell System

ROBERT WOOLGAR
March 22/10

PROVINCE OF NEWFOUNDLAND AND LABRADOR
PEG Newfoundland and Labrador
PERMIT HOLDER
This Permit Allows
HATCH LTD.
To practice Professional Engineering in Newfoundland and Labrador.
Permit No. as issued by PEG D0090
which is valid for the year 2010

prepared by

HATCH™

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Executive Summary

Nalcor Energy - Lower Churchill Project (NE-LCP) is pursuing engineering studies with respect to the development of the hydroelectric potential of the Lower Churchill River at Gull Island and Muskrat Falls. At Muskrat Falls there is a large rock knoll and an overburden spur to the north that could be incorporated with a natural embankment dam. However, natural mass wasting processes were quickly eroding the spur and it was determined through engineering studies in the 1970's that the mass wasting could be arrested with the installation of a pumpwell system. The pumpwell system was installed in 1981. In 1997, Hatch installed 12 piezometers in 7 boreholes to monitor the groundwater levels in the area of the dewatering system and, in 1998, Hatch completed an inspection of the pumpwell system and conducted a well cleaning program.

The well system is currently 28 years old and was installed initially as a temporary measure. A 2008 Hatch report included several recommendations to extend the life of the system and ensure its continued operation for the next 10 years. The recommendations included the cleaning and inspection of 22 wells in the dewatering system and the installation of 8 new piezometers at 4 locations to further assess groundwater conditions in the area of the dewatering system. This document presents the findings of the 2009 well inspection and well cleaning program.

Section 1 of this report includes an introduction, scope of work and description of the well inspection team. A scope of work was developed prior to mobilization to the site and approved by NE-LCP; some of the tasks were modified slightly due to field conditions or following discussion between NE-LCP, Hatch and the well contractor. The historical and geological background and site characteristics are described in Section 2.

Section 3 describes the well inspection and cleaning program that commenced on August 27 and was completed on September 7, 2009. Photographs found in Appendix A document the well inspection and cleaning procedure. Flow rate testing was conducted prior to the start of the well inspection program and after completion of the program. The next task was the system shutdown and removal of pumps and infrastructure. Approximately 3 wells were completed at a time and every effort was made to return the wells to service as quickly as possible.

A downhole camera inspection was completed for every well in order to assess the condition of the PVC casing and stainless steel well screen and make note of any potential cracks or staining. The inspection was completed both prior to and after cleaning. Following the initial downhole camera inspection, the pumps, hardware and infrastructure was inspected, making note of corrosion and wear and replacing components as required. The wells were then cleaned which involved the addition of an HCL acid solution to dissolve encrustation in the casing and on the well screen, the use of a well bore brush and additional water to clean the casing and screen, and a sand pump to remove any sediments in the bottom of the well.

Once all cleaning operations had been finished and a post cleaning camera inspection completed, the pump, riser sections and associated wiring were returned to the well, reconnected and the well re-energized. Observations were made of the operation of wells that had been returned to service and the overall operation of the system. Observation continued until the NE-NLH electrician was confident that the system was working properly.

Section 4 describes the overall findings of the well inspection program. In general, the screens of the wells were in good condition; exceptions are described in Section 4.3, Well Specific Comments.

Based on results of the well inspection program, it has been concluded that the wells in the system are operating satisfactorily and wells screens are generally in good condition, with the exception of wells W-1, W-2, W-15 and W-18. It is expected that W-15 can be readily repaired at the control panel. Wells W-1, W-2 and W-18 may no longer be viable. Therefore, a malfunction of one or more wells could potentially put a significant strain on the system and result in a rise in groundwater levels in the spur.

To ensure a satisfactory performance of the dewatering system for the next 10 years and to maintain the physical asset of the Muskrat Falls ridge as a whole, it is recommended that 6 to 7 new stainless steel wells be installed. The installation would include a replacement of wells W-2 and W-18 (and possibly well W-1) and installation of 3 to 4 additional wells to replace the high yielding wells. Recommendations are detailed in Section 5 of this report.

1. Introduction

Nalcor Energy - Lower Churchill Project (NE-LCP) is pursuing engineering studies with respect to the development of the hydroelectric potential of the Lower Churchill River at Gull Island and Muskrat Falls. These sites are located downstream 225 km and 285 km respectively from the Upper Churchill hydroelectric facility that was developed in the late 1960s. The total potential capacity at the two sites is approximately 3000 megawatts (MW); the Gull Island site being the larger.

Early studies in the late 1970s concluded that a natural embankment dam could be constructed in the area of Muskrat Falls. The land spur which reaches from the north bank of the Churchill River at Muskrat Falls to the large rock knoll closer to the south bank could be incorporated into the embankment dam. In this context, the natural spur constituted a considerable capital asset, if it could be maintained. Natural mass wasting processes, however, were quickly eroding the spur; it was determined that these could be arrested with the installation of a pumpwell system. Such a system was installed in 1981.

A field program was undertaken in 2007 (under Work Task Order MF1260) to assess the performance of the pumpwell system. The purpose of the field program was to assess the existing condition of the system, compare with historical records and determine the required action to allow the system to operate efficiently for the next ten years. In July 2008, a report was submitted which described the findings of a preliminary site visit during the period from September 9 to 11, 2007, and a description of the field program conducted in the autumn of 2007. The field program, carried out on November 5 to 8, 2007, included testing of the wells, pumps and piezometers. The dewatering system was shut down for 5 hours each day on November 7 and 8, and the water level recovery in wells and piezometers were recorded for half of the system each day.

The well system is currently 28 years old and was installed initially as a temporary measure. The 2008 (MF1260) report included several recommendations to extend the life of the system and ensure its continued operation for the next 10 years. The recommendations included the cleaning and inspection of 22 wells in the dewatering system, in an attempt to assess the condition of the system.

This document presents the findings of the well inspection program. The scope of work is described in more detail in the following Section.

1.1 Scope of Work

A scope of work was developed prior to mobilization to the site and approved by NE-LCP. It should be noted that some of the tasks were modified slightly due to field conditions. Any changes from the proposed scope of work are summarized below and discussed in more detail in the appropriate subsection in Section 3 - Well Inspection Field Program.

Following is a description of the scope of work:

- A mobile boom truck, pumps, compressor, ancillary equipment, tooling and personnel were mobilized to the Muskrat Falls site.
- NE-LCP provided some of the equipment related to the project including several pumps, a supply of sensors and approximately 10 riser pipes.
- Water level readings were collected in wells and piezometers before any site activity. The collected data was compared with the historical values presented in the 2008 report. The water discharge rate and quality was to be recorded at the collector pipe outlet. However, it was decided that due to safety concerns and difficult access, the outlet would not be assessed and instead water yields and quality were recorded for each individual well.
- The operation of each of the wells was individually disabled in a sequence, to minimize impact on the operation of the well field pumping network. System shutdown was completed by NE-NLH under Work Protection Code. Operations were planned such that highly active wells (W-4, W-9, W-10, W-16 and W-19) could be re-installed in the same day. The NE-NLH electrician helped to determine the active wells.
- Removed the risers, pump, wiring and sensors from the well.
- Removed any scaling, rust or other debris from the pump, pump intake screen, sensors and risers. Recorded all hardware specifications including, but not limited to, manufacturer, model number, serial number and power input requirements. Photos were taken of all equipment. The operation of all hardware was tested and checked and improperly functioning components were replaced.
- A downhole video camera was lowered into the well to visually assess the condition and integrity of the well casing and screen. In the event the water in the well was cloudy, a flocculent was injected to improve visibility. There was some field testing to assess whether the use of the flocculent was effective at improving visibility. Approximately halfway through the program, the use of the flocculent was discontinued due to lack of evidence of its effectiveness.
- While hardware inspection was proceeding, it was proposed to gently redevelop the well by injecting water in a stepwise progression from a low pressure, low volume compressed air to progressively higher pressure and air volume, as deemed necessary, and thereby remove any debris or sediments that were impeding the optimum functionality of the screen. Based on the visual assessment, it would be determined if continuing with the redevelopment task was appropriate for each well. This technique was carried out at well W-3 and there was insufficient head to lift the injected water to the ground surface. It was decided at that time that this type of cleaning method was not suitable for the well system due to deep water levels and concern about damaging the well screen.
- An acid solution was added to each well and allowed to stand for a period of about one to two hours. A wellbore ‘brush’ was used to brush the casing and wellscreen and remove any debris or encrustation in the well.
- As an alternative to air injection, a sand pump was lowered to the bottom of the well and sediment at the bottom of the well was drawn into the sand pump under suction and removed form the well. Removal of sediment could potentially increase the yield from the well.

- A downhole video camera inspection was repeated to visually assess the condition and integrity of the well casing and screen and to compare the well condition before and after the cleaning procedure.
- Upon completion of successful inspection, testing and data recording of the pump and all related downhole well hardware, together with successful completion of downhole work, the pump, riser pipe, electrical cable, sensors and relays were re-installed in each well. Damaged equipment was replaced from the cache of supplies provided by Nalcor.
- After completion of inspection and cleaning, the well was reconnected to the well field power supply. When the pumps and related electrical components were re-energized, observations were made as to the operation and function of the well.
- Flow/discharge tests were conducted on the wells following completion of all the well inspection and cleaning.
- It was proposed that water levels be collected in the piezometers twice a day, before and after daily activities. Due to time constraints, piezometer water elevations were collected once a day, graphs were prepared and the water table recovery in the spur was compared with Figures 7 to 10 of the MF1260 report.

All of these tasks were executed under the direct supervision of Hatch.

1.2 The Well Inspection Team

The well inspection program was completed by a team of specialists which included:

- A Hatch Site Supervisor who oversaw and was responsible for the completion of the program.
- A water well drilling contractor, pump/electrical contractor and three helpers (P. Sullivan & Sons Ltd).
- An electrician from Nalcor Energy – Newfoundland and Labrador Hydro (NE-NLH), Happy Valley-Goose Bay (HVGB) office.
- A team of two helpers that worked with NE-NLH from the HVGB office.

The water well drilling contractor worked with the boom truck to pull the pumps, risers and electrical works and completed the downhole camera inspections. The pump and electrical contractor completed the inspection, documentation and cleaning of all pumps and infrastructure with the aid of the three helpers. NE-NLH has historically looked after the electrical components of the site and taken water levels in the piezometers on a monthly basis. The NE-NLH electrician provided guidance on the electrical components and protocol for the Work Protection Code and the helpers were involved mainly in the pulling and reinstallation of the pumps and the monitoring of water levels in the piezometers. The Hatch Site Supervisor oversaw the program and ensured that the scope of work was completed.

The following sections outline the details of the well inspection program at Muskrat Falls. Section 2 provides background on the history and geology of the site, Section 3 provides details of the field program, Section 4 summarizes the findings of the program and Section 5 provides conclusions and recommendations.

Photographs, inspection logs and figures are included in Appendix A, B & C, respectively.

2. Historical and Geological Background

2.1 Site Characteristics

The site of Muskrat Falls (Figure 1, Appendix C) on the Lower Churchill River, located about 30 km upstream from HVGB in Labrador, has been recognized as a potential hydroelectric development for several decades. At this site, the Churchill River has a drop of about 15 m from el 18 m at the upstream side to el 3 m at the downstream side. Past studies contemplated raising the head to about 40 m.

The prominent features of the site include a rock knoll rising to almost 150 m in elevation. The rock knoll is connected to the left bank by a spur of land about 1 km long, which forms a natural barrier forcing the diversion of the Churchill River into a channel carved out south of the rock knoll. The spur rises to elevation 60 m and has a minimum width of 150 m at the south side, in the upstream - downstream direction.

2.2 Geology and Sediments

The Muskrat Falls site is underlain at a maximum depth of about 270 m by crystalline metamorphic rocks composed of granitic gneiss of Precambrian age, with some dark mafic bands and occasional irregular pegmatite stringers. In addition to the rock knoll which rises sharply from the buried valley floor, several exposures are found on the right bank of the river.

The Churchill River valley is preglacial in origin, and was formed largely by river action prior to the Pleistocene epoch. Subsequent widening and reshaping of the valley occurred during the Wisconsin glaciation period, about 13,000 years ago. An estimated thickness of 60 m of a deposit of sand, gravel and boulders filled the lower part of the reshaped bedrock valley during the course of glaciation. As the glacier retreated, the sea level rose and caused submergence of the valley by an estuary extending up to Gull Island. This inundation of the valley by the rising sea resulted in the deposition of marine and estuarine sediments in an environment of saline and brackish water.

Isostatic rise of the land relative to the sea then caused a gradual recession of the estuary and resulted in the deposition of a layer of fine sand, over marine clay sediments.

The sediments in the spur consist of four units.

a) Upper Sand (el 60 to 45 m) covering the terrain and consisting of uniform fine to medium sand approximately 10 to 15 m thick.

b) Stratified Drift (el 50 to -10 m) consisting of a marine clay deposit generally underlain with a varying thickness of sandy materials. The sandy components dominate the southern 250 m long section of the spur against the rock knoll and constitute an aquifer. The thickness of the upper clay increases toward the north.

It is noted that primarily these two units in (a) and (b) are engaged in the failure activity of the downstream face of the spur.

c) Lower Marine Clay (el -10 to -60 m) is a stratified impervious silty clay deposit.

d) Lower Aquifer (el -70 to -210 m) composed of pervious sand and gravel, and occupying the lower part of the buried valley.

Gullies and creeks exist along both the upstream and downstream slopes of the spur. The most prominent gully is found in the area of the three lakes in the north side of the spur. Numerous creeks and a small stream were found originating as springs at the sand and clay contact.

Hydrogeologically, there are two aquifers. The water level in the Lower Aquifer is at el +5 m which is considerably higher than the surface of the overlying marine clay unit suggesting confined characteristics. However, it is the hydrogeologic behaviour of the upper aquifer which has a dominant effect on bank stability. Recharge into this unit is from the northwest, through the upper sand unit and hydraulic connections in the stratified drift. Along the dewatering system alignment, the water level was originally at about el 30 m at the south side of the spur rising to el 47 m about half way and dropping to about 15 m at the north end.

2.3 Bank Instability and Groundwater Control Facilities

The banks of the Churchill River between Gull Island and Goose Bay are scarred by numerous landslides, some of which involve large quantities of overburden. Instability has affected the slopes of the spur, particularly the downstream slope, as well as the left bank of the river downstream from the spur. In 1978, a major landslide occurred on the south end of the spur resulting in the loss of a considerable portion of land in the downstream perimeter. Minor failures were further experienced in 1980-81. High piezometric water levels and steep hydraulic gradients in the sediments above river level and tailwater rapid drawdown effects due to the collapse of the downstream annual ice-dam have been the major causes contributing to instability.

In order to protect the remaining spur from further instability, a continuously pumped dewatering system was installed along the downstream shoulder of the spur in 1981. At the time of their installation, the system was considered to be “a temporary stabilization measure . . . and not a total defence against mass wasting” (Acres, 1994). The dewatering system was anticipated to lower the groundwater level in the spur from about el 30 m to at least el 15 m and preferably as low as el 3.5 m.

22 wells were installed in a line spaced at 30 m with an average depth of 63 m close to the edge of the downstream slope of the spur. The drilling diameter was 300 mm with stainless steel screen and PVC riser pipe having an internal diameter of 150 mm. All the pumps are connected to a 300 mm diameter collector pipe, with 75 mm of insulation, finally discharging to an existing stream through an exposed portion close to the outfall location (SNC-Lavalin, 1982).

To monitor the groundwater regime, 17 piezometers (vibrating wire) were installed in 1981 but all were lost in 1984 due to a power surge from a lightning strike on the power line. In 1997, 12 standpipe piezometers were installed in 7 boreholes and these continue to be monitored. Subsequent records of operation of the well system have recorded pump functions only, namely pumping duration and the number of pump cycle initiations per day.

NE-NLH and Acres International staff carried out formal maintenance inspections in 1994, 1995 and in 1997 at which times some or all the pumps were retrieved, cleaned and reinstalled or replaced as necessary (Acres International, 1997). The NE-NLH HVGB office retains records of such maintenance activities in varying degrees of detail.

In 2007, Hatch conducted a site visit and testing of the pumpwell system with the objective of assessing the system condition and making recommendations for a life extension of 10 years. Selected recommendations from the 2008 report are the basis for the work program described in this report.

2.4 Background Reports

Reports of previous site assessments are available as follows:

- SNC-Lavalin, "Muskrat Falls Dewatering System, Construction Report Operation and Maintenance Information", (1982).
- SNC-Lavalin, "Muskrat Falls Dewatering System, Engineering Assessment", (1982).
- Acres International, "Muskrat Falls Development", (1978).
- Acres International, "Muskrat Falls, Review of Dewatering System", (1994).
- Acres International, "Dewatering System Assessment and Rehabilitation", (1997).
- Acres International, "Standpipe Piezometer Installation Program Report", (1997 and 1998).
- Hatch Ltd, "The Lower Churchill Project, MF 1260 – Assessment of Existing Pumpwell System", (2008).

3. Well Inspection Field Program

The well inspection program commenced on August 27 and was completed on September 7, 2009. Figure 1 in Appendix C shows the location and configuration of the well system.

Work progressed concurrently on approximately 3 wells at a time; every effort was made to return the wells to service as quickly as possible. In most cases, wells were returned to service within 24 hours. For wells that are known to be high yielding, such as wells W-4, W-9, W-10, W-16 and W-19, tasks were completed such that these wells could be returned to service the same day. The tasks are described in more detail in the following sections. Photographs were taken to document the procedure and the equipment encountered at each well. Appendix A includes photographs of the general procedure.

3.1 Monitoring of Piezometer Water Levels

The monitoring of piezometer water levels involved:

- Recording of water levels in piezometers P-A1, P-A2, P-B1, P-B2, P-C, P-D1, P-D2, P-F1, P-F2, P-G and P-J1, P-J2 from August 22 to September 8, 2009 on a daily basis. Due to the number of tasks involved in this program, it was not possible to record water levels twice daily. Although P-A-2 and P-F2 have recently been dry, they were monitored daily in case of a change of condition due to shutdown of the dewatering system. Likewise, P-C has recently been out of service but was monitored daily in case of changes in condition.
- Water levels recorded from August 22 to August 26 reflect water levels under normal well system operation (prior to any pump shutdown). Water levels taken from August 27 to September 7 were taken during the daytime and reflect a full shutdown condition in which the power to the system was turned off and all the pumps in the system were shutdown.
- Measurements were taken from the top of the outer metal casing of the piezometer. This is standard practice at the site.

It should be noted that, during the day, generally from about 8 am to 6 pm, the power was locked out to the whole system and all pumps were shut off. This represents a full shutdown condition. After work was completed for the day, the power to the system was re-energized and most wells were returned to service. There were generally a few wells each evening for which the cleaning procedure had not been completed; these wells were manually shut off at the control panel. This overnight condition when a few wells were not in operation is referred to as partial shutdown.

Figure 2 in Appendix C shows the water level elevations in the piezometers from January 2009 to September 8, 2009. The readings from August 27 to September 7 were taken during the full shutdown condition. The pumps were shut off completely through the work day for approximately 10 hours and then turned back on for the overnight period.

Figures 3, 4 and 5 show the water levels in each individual piezometer just prior to and during the well inspection program. In general, the water levels recovered by approximately 0.3 m to 0.6 m during the full shutdown with the exception of P-D-2, where the water level rose about 1.0 m (Figure 4 (c)).

3.2 Flow Rate Testing

Flow rate testing was conducted prior to the start of the well inspection program and after completion of the program; testing consisted of the following:

- Testing of the flow rate and pump capacity at each wellhead, prior to the commencement of the inspection and cleaning program. The pre-inspection testing was conducted on August 27, 2009. A flow test was conducted on each well using a gate valve/discharge pipe and an 11.4 litre pail (2.5 imperial gallons). The flow rate was calculated by recording the amount of time to fill the pail. Reserve pressure was recorded using a gate valve and gauge attached to the riser pipe. Observations were also made of the clarity of the water. This information was used to assess the general capacity of the pump and its general working condition.
- A post inspection flow rate test on September 7, 2009, using the same method of flow calculation as previously.
- During the post inspection testing, pH values were also collected for each well to ensure the acid used in the cleaning procedure had been sufficiently flushed out. Where low values of pH were noted, pumps were switched on manually from the control centre to flush out any residual acid.

Table 3-1 shows the flow rates calculated for each well and the observations made of water clarity both before and after the inspection program. Reserve pressures were noted only at the commencement of the inspection program. It should be noted that the valve was wide open during the test and that the discharge rate calculations are approximate.

Table 3-1 - Well Flow Tests

	27-Aug-09			7-Sep-09		
Well	**Rate (Lpm)***	**Water Clarity**	**Reserve Pressure (kg/cm^2)**	**Rate (Lpm)***	**Water Clarity**	**pH**
W-1	No pump	N/A	N/A	No pump	N/A	N/A
W-2	No pump	N/A	N/A	No pump	N/A	N/A
W-3	57	Fair, orange	6.30	46	Good	7.9
W-4	31	Good	4.90	31	Good	8
W-5	68	Fair	6.30	68	Good	7
W-6	68	Fair	5.25	68	Fair	3.9
W-7	52	Good	4.90	55	Good	4.1
W-8	46	Good	4.90	46	Good	3
W-9	46	Fair, silty	6.86	46	Good	6.7
W-10	46	Fair to good	6.30	41	Fair to good	7
W-11	50	Fair, silty	6.86	57	Fair	7.9
W-12	23	Fair to good	2.80	46	Good	7.3
W-13	52	Fair to good	4.20	36	Good	7.3
W-14	57	Very silty, poor	6.86	48	Good	7.4
W-15	Not working	N/A	0	Not working**	N/A	7.8
W-16	46	Fair	2.10	46	Good	7.8

	27-Aug-09			**7-Sep-09**		
Well	**Rate (Lpm)***	**Water Clarity**	**Reserve Pressure (kg/cm^2)**	**Rate (Lpm)***	**Water Clarity**	**pH**
W-17	17	Fair	1.54	28	Good, yellow	4.6
W-18	No Flow	N/A	0	Not tested**	N/A	N/A
W-19	17	Fair to good	0	17	Good	5.3
W-20	27	Poor, silty	0	23	Fair, some silt	8.1
W-21	46	Poor, silty	5.81	68	Fair, some silt	8.3
W-22	46	Poor, silty	5.88	46	Fair	8.7

*Lpm = Litres per minute, approximate

**Well W-15 – problem at the control panel, Well W-18 – possible screen and formation collapse.

The calculated flow rate is approximate, based on relatively crude measurements of the time in seconds for the flow to fill an 11.4 litre pail. Where the flow rates observed post inspection were lower than those noted prior to the well inspection, it was likely due to the imprecise method of measurement. In general, it was observed that the flow rates both prior to and following the inspection program were the same or improved.

3.3 System Shutdown and Removal of Pump Infrastructure

Prior to removal of the pump infrastructure from each well, a lockout permit was completed by the NE-NLH electrician. The permit was checked by the supervisor from NE-NLH or by personnel from NE-LCP. The power was shut down for all the pumps and controls in the system at one switch and the switch was locked and tagged. All of the personnel involved in the work were included on the permit and were required to sign off the permit if leaving the site.

Following lockout, the pump infrastructure was removed, involving the following tasks:

- Removal of the well cover, testing with a conductance meter to verify there was not any current to the wiring in the well.
- Removal of the riser sections, pump and wiring from the well, riser sections laid down in order of removal from the well by the NE-NLH helpers; at the same time, the NE-NLH electrician supervised the removal of the wiring.

3.4 Downhole Camera Inspection

A downhole camera inspection was completed for every well prior to cleaning in order to assess the condition of the PVC casing and stainless steel well screen and make note of any potential cracks or staining. The inspection involved the following tasks:

- Aluminum sulphate was added to the well water a minimum of 30 minutes prior to the inspection to aid in settling of sediments and to improve the visibility under water. It was found, in general, that the use of the flocculant did not improve the visibility to any great extent and the use of the flocculant was therefore discontinued about halfway through the program.

- Prior to the inspection, the 'As Built' well installation logs and previous down hole camera inspection logs (1997) were reviewed to be aware of conditions and potential problems.
- A descriptive log was completed for each inspection including comments on the condition of the stainless steel screen. Note was also made whether flocculant was used prior to inspection.
- The camera inspection was recorded as a digital video.

The logs of the inspections are found in Appendix B.

3.5 Inspection of Pumps, Hardware and Infrastructure

The inspection of the pumps and hardware involved the following:

- Measurements of the depth of the well, the depth to water level and the depth to the top of the pump.
- Measurements of the depth to the sensors: i) low-low, ii) low, iii) high and iv) high-high sensors. The high sensor activates the pump and the low sensor activates the shut off of the pump. The high-high and low-low sensors are for emergency warning.
- An assessment of the general condition of the pump and whether replacement was necessary. The model number and make of pump was recorded for each system.
- Cleaning and testing of the pump and risers. The pump body was cleaned, the screen was removed and the intake cleaned. All piping was wiped down and checked for cracks or corrosion and riser sections in poor condition were replaced. The threading of riser sections were cleaned and rethreaded as necessary and couplings resealed.
- Checking for corrosion or poor condition of the sensors. A visual inspection of the sensors was completed and sensors in poor condition were replaced. A functional test of the sensors was also completed at the wellhead before reinstallation. This involved passing a small amount of current through the sensor to confirm the sensor was functioning; any malfunctioning sensors were replaced.
- Inspection of the pitless adaptor and replacement of the o ring as required.

The process was documented and photographs taken of the equipment for each well. Table 3-3, Pump and Sensor Details, records the measurements of each well system (depth, water level, depth to each sensor, model number of pump). Figure 6 is a profile of the well system, based on measurements taken and included in Table 3-3.

3.6 Well Cleaning

After completion of the pre-cleaning camera inspection, the following procedure was followed for the cleaning of each well:

- Approximately 11L of a HCL acid solution was added to the well. The solution was left in the well for a standing time of approximately two hours. The purpose of the acid was to dissolve encrustation in the casing and on the well screen. The NE-NLH electrician raised concern that the acid solution could damage the sensors. The pump/electrical contractor called suppliers and was assured there should be no damage to sensors from the addition of acid to the well. However, to minimize risk, it was decided on September 4, 2009 to discontinue the use of the acid.

- The screen and casing were cleaned using a well bore brush and additional water. The screen and casing were cleaned for approximately 30 minutes.
- A sand pump (see Photograph 9, Appendix A) was lowered to the bottom of the well and sediment was drawn into the sand pump under suction. The sand pump was pulled to the surface and the liquid/sediment placed in a pail for observation. The sand pump was used until the water returned was sediment free.

Air injection was used at well W-3 and it was found that there was not enough head in the well to raise the water out of the well. After discussions with the contractor, it was decided that the sand pump did a good job at removing sediments in the well and was the least intrusive method (least chance of damage to the screen and formation) of well cleaning. Air injection was not used at any other well.

Table 3-2, Details of the Well Cleaning, summarizes the type of material removed, the approximate quantity removed and the duration of the cleaning procedure for each well.

Table 3-2 - Details of the Well Cleaning

Well	Acid Added?	Cleaned?	Cleaning Duration (min)	Volume Sediment & Water (L) Removed	Description of Sediment Removed from Well	Notes
W-1	Yes	Yes	45	22	Silty clay	–
W-2	No	No	N/A	N/A	N/A	Obstruction noted during camera inspection
W-3	Yes	Yes	45	18	Silty clay	–
W-4	No	Yes	90	44	Medium sand, fine black sediments & silty clay	–
W-5	Yes	Yes	45	11	Silty clay	–
W-6	Yes	Yes	60	30	Silty clay	–
W-7	Yes	Yes	60	22	Silty clay	–
W-8	Yes	Yes	60	22	Silty clay	–
W-9	Yes	Yes	75	30	Silty clay	–
W-10	No	Yes	75	44	Silty clay	–

Well	Acid Added?	Cleaned?	Cleaning Duration (min)	Volume Sediment & Water (L) Removed	Description of Sediment Removed from Well	Notes
W-11	Yes	Yes	45	18	Silty clay	--
W-12	Yes	Yes	45	30	Silty clay	--
W-13	Yes	Yes	45	22	Silty clay	--
W-14	Yes	Yes	60	32	Silty clay	--
W-15	Yes	Yes	60	22	Silty clay	--
W-16	Yes	Yes	75	32	Silty clay	--
W-17	Yes	Yes	45	22	Relatively clear silty solution	Old pump lodged at bottom; could not get to bottom
W-18	Yes	Yes	60	30	Mixture of medium sand & silty clay	--
W-19	Yes	Yes	60	22	Silty clay	–
W-20	No	Yes	45	30	Heavy silty clay sludge and silty clay	--
W-21	No	Yes	60	32	Heavy silty clay sludge and silty clay	--
W-22	No	Yes	60	30	Heavy silty clay sludge and silty clay	--

* Cleaning included use of the wellbore brush and the sand pump

3.7 Post-Cleaning Downhole Camera Inspection

Following cleaning, a second camera inspection was conducted to assess the effectiveness of the cleaning program. The same procedure was used as described in Section 3.4 Pre-cleaning Downhole Camera Inspection. The log of the pre-cleaning inspection was reviewed as the post-cleaning inspection proceeded to be aware of problems encountered and to note where previous staining had been observed.

The logs of the post-cleaning inspections are found in Appendix B.

3.8 Reinstallation of Well Components and Re-energizing of System

Once all cleaning operations had been finished and a post cleaning camera inspection completed, the pump, riser sections and associated wiring were returned to the well and reconnected. A lockout surrender permit was completed to document the end of the lockout and the re-energizing of the system. The switch was unlocked and released and the system was re-energized. Observations were made of the operation of wells that had been returned to service and the overall operation of the system. Observation continued until the NE-NLH electrician was confident that the system was working properly. Further testing and repairs were required in a number of wells (wells W-6, W-9, W-12 and W-15) following the initial return to service; this is described in Table 4-1.

Table 3-3 - Pump and Sensor Details

					Depth of Sensors				Elevation of Sensors					Current Pump Information			
Well No.	Elevation Top PVC	As Built Depth	Sounded Depth	Depth to W L	Low Low	Low	High	High High	Low Low	Low	High	High High	Elevation of WL	Elevation top of Pump	Depth to top of Pump	Pump Details	Pump Motor Details
W-1	59.79	63.40	64.30	44.30	*												
W-2	59.66	60.00		48.50	*												
W-3	59.67	71.00	69.90	51.93	55.04	53.02	48.02	46.98	4.63	6.65	11.65	12.69	7.74	3.21	56.46	Berkeley - original pump	Franklin 1.5 HP
W-4	59.67	70.00	66.45	50.42	54.92	52.86	49.71	47.83	4.75	6.81	9.96	11.84	9.25	3.31	56.36	Berkeley L15P4FMGS-03	Franklin 1.5 HP
W-5	59.55	62.40	62.92	51.80	52.86	50.83	45.75	44.84	6.69	8.72	13.80	14.71	7.75	4.10	55.45	Berkeley - original pump	Franklin 1.5 HP
W-6	59.33	60.00	60.20	52.60	52.45	50.47	45.52	45.01	6.88	8.86	13.81	14.32	6.73	3.88	55.45	Berkeley SL0P4FP-05	Franklin 1.5 HP
W-7	59.51	63.00	62.64	47.37	50.88	48.85	43.77	42.78	8.63	10.66	15.74	16.73	12.14	4.16	55.35	Berkeley SL20P4TS-26	Franklin 1.5 HP
W-8	59.46	61.00	60.35	47.30	52.48	50.45	45.37	44.43	6.98	9.01	14.09	15.03	12.16	4.24	55.22	Berkeley 4BL21-21861G86	Franklin 1.5 HP
W-9	59.48	62.00	54.13	32.95	46.74	44.73	39.65	38.05	12.74	14.75	19.83	21.43	26.53	10.68	48.80	Berkeley L15P4FMGS-03	Franklin 1.5 HP
W-10	59.40	59.00	58.93	43.46	53.31	51.43	46.35	45.39	6.09	7.97	13.05	14.01	15.94	3.65	55.75	Berkeley L15P4FMGS-03	Franklin 1.5 HP
W-11	59.35	57.00	57.61	37.26	43.90	41.85	36.85	35.55	15.45	17.50	22.50	23.80	22.09	13.14	46.21	Berkeley L15P4FMGS-03	Franklin 1.5 HP
W-12	59.29	61.00	61.52	47.45	53.59	51.56	46.58	45.46	5.70	7.73	12.71	13.83	11.84	3.97	55.32	Berkeley L15P4FMGS-03 New	Franklin 1.5 HP
W-13	59.27	59.00	60.10	26.82	53.77	51.79	46.81	45.79	5.50	7.48	12.46	13.48	32.45	4.13	55.14	Berkeley L15P4FMGS-03 New	Franklin 1.5 HP
W-14	59.01	61.50	57.00	26.87	54.03	52.05	46.95	46.34	4.98	6.96	12.06	12.67	32.14	0.41	58.60	Berkeley L15P4FMGS-03	Franklin 1.5 HP
W-15	58.91	61.50	59.74	30.30	52.91	50.88	45.90	44.88	6.00	8.03	13.01	14.03	28.61	3.87	55.04	Berkeley L15P4FMGS-03 New	Franklin 1.5 HP
W-16	58.76	61.00	59.74	47.42	51.59	49.56	44.53	42.55	7.17	9.20	14.23	16.21	11.34	3.72	55.04	Berkeley L15P4FMGS-03	Franklin 1.5 HP
W-17	58.46	60.00	59.44	46.71	48.52	46.49	41.41	40.11	9.94	11.97	17.05	18.35	11.75	5.85	52.61	Berkeley S10P4C02S-03 New	Franklin 1.5 HP
W-18	57.87	60.00	50.29	38.41	37.06	35.00	29.97	29.13	20.81	22.87	27.90	28.74	19.46	8.62	49.25	Berkeley S10P4C02J-04	Franklin 0.5 HP
W-19	57.01	59.50	57.30	36.27	51.49	49.38	44.40	43.69	5.52	7.63	12.61	13.32	20.74	2.88	54.13	Berkeley S10P4C02S-04	Franklin 0.5 HP
W-20	56.01	64.00	58.83	44.50	47.93	45.93	40.85	39.86	8.08	10.08	15.16	16.15	11.51	2.90	53.11	Berkeley S10P4C02S-03	Franklin 1.5 HP
W-21	53.99	56.50	54.76	39.45	48.80	46.59	41.56	40.57	5.19	7.40	12.43	13.42	14.54	3.21	50.78	Berkeley 15P4F02MGS-03	Franklin 1.5 HP
W-22	52.26	60.00	58.52	38.61	47.02	44.79	39.84	38.85	5.24	7.47	12.42	13.41	13.65	3.01	49.25	Berkeley 15P4F02MGS-03	Franklin 1.5 HP

All measurements in metres

All measurement are taken from the top of the pvc casing of the well

Depth to W L (water level) was taken on the day the well was dismantled and cleaned, at least one hour after system shutdown

* No infrastructure (risers, pump, sensors or wiring) is installed in W-1 and W-2

4. Findings of the Well Inspection Program

4.1 Summary of Findings

The following table, Table 4-1 Results of Well Inspection, summarizes the observations made at each well during the assessment and includes a record of any equipment that was replaced. Details recorded during the camera inspections can be found in Appendix B.

Table 4-1 - Results of Well Inspection

Well	General Observations	Equipment Replacement
W-1	-No pump -Top of screen at a depth of 28.1 m -Areas of heavy black and iron staining (see logs)	
W-2	-No pump -Top of screen at a depth of 37.3 m – 43.6 m and 52.0 m – 69.4 m (note: there was a screen section, followed by PVC, then another screened section) -Heavy black encrustation 37.3 m - 39.0 m, possibly broken -Obstruction at 52.7 m	
W-3	-Heavy corrosion and iron precipitate on the bottom riser -Pump covered in iron and manganese precipitate -Pump cleaned; pump in reasonably good shape -All sensors in good condition, observed that high and high-high sensors do not show evidence of being in water	-Bottom riser replaced
W-4	-Bottom riser and pump covered with silt deposits and iron and manganese precipitate -Noted 5 sensors instead of 4, one had been replaced and the non-functioning one not removed -Pitless adaptor and valve rusted, poor condition -No acid added prior to cleaning -Fine black sediment noted at bottom of casing, removed a greater quantity of sediment than most other wells	-Bottom riser replaced -High–high sensor replaced
W-5	-Bottom riser and pump covered with iron and manganese precipitate -All sensors in good condition, observed that high and high-high sensors do not show evidence of being in water	-Bottom riser replaced
W-6	-Heavy corrosion and iron precipitate on the bottom riser -Pump covered in iron and manganese precipitate. -Pump cleaned; pump in good shape -Sensors inspected, all in good condition -Could not reinstall the pump due to possible obstruction in casing. Camera inspection showed the casing is not plumb, some of the risers are not plumb. Pump was reinstalled with care to the non plumb condition. -O ring at the pitless adaptor was leaking when the post inspection flow tests were conducted; replacement corrected the problem	-Bottom riser replaced -Replaced the O ring

Well	General Observations	Equipment Replacement
W-7	-Bottom riser and pump covered with minor precipitate -Sensors inspected, all in good condition -Pump inspected and in good condition	
W-8	-Bottom riser and pump covered with iron and manganese precipitate -Significant sediment around the pump intake -Pump cleaned, in good condition -Sensors inspected, high sensor not operational, other 3 in good condition	-High sensor replaced
W-9	-Bottom riser and pump covered with iron and manganese deposits -Pitless adaptor rusted, needs replacement -When taking out the pump, NE-NLH personnel noted the pipe was very wet near the ground surface and there was water cascading down casing -When completing the camera inspection, water was noted coming in at the pitless adaptor -Sensors inspected, high-high sensor not operational, other 3 in good condition -Pump was jiving when reinstalled, had to be shut off overnight -Based on the camera inspection and observed water cascading down the casing, it was concluded there is a possible break in the central manifold, with drainage of water back into the well -Replaced the o ring at the pitless adaptor and put the well back in service	-High-high sensor replaced -O ring replaced at pitless adaptor
W-10	-Heavy corrosion and iron precipitate on the bottom riser -Sensors inspected, high-high sensor in poor condition, all others in good condition -Pump inspected and in good condition	-High-high sensor replaced -Bottom riser replaced
W-11	-Bottom riser and pump covered with minor precipitate -Sensors inspected, all 4 sensors were in poor condition -Pitless adaptor was leaking, screen in good condition -Pump inspected and in good condition	-All 4 sensors replaced -O ring at pitless adaptor was replaced
W-12	-Bottom riser and pump covered with iron and manganese precipitate, riser pipe is possibly corroded, poor condition -Pump visually assessed and in poor condition -Sensors inspected, in fair condition -Pump installation jived when reinstalled, possible pump rotation problem, pump turned off overnight -Removed pump and wiring and replaced all sensors and put back into service	-Pump replaced -Bottom riser replaced -All 4 sensors replaced because the pump was “jiving” when originally returned to service.
W-13	-Heavy corrosion and iron precipitate on the bottom riser -Sensors inspected, in fair condition -Pump visually assessed and in poor condition	-Bottom riser replaced -Pump replaced -Low-low sensor replaced.

Well	General Observations	Equipment Replacement
W-14	-Bottom riser and pump covered with iron and manganese precipitate -Sensors inspected, high and high-high sensors are not operational -Pump was inspected and the assessment showed that the bushing needed to be replaced -The pitless adaptor was leaking, pump turned off overnight -The next morning retested, found low-low sensor not functioning	-Bottom riser replaced -High and high-high sensors replaced -Minor repairs to pump, replacement of bushing -O ring at pitless adapter replaced -low-low sensor replaced and wiring repaired
W-15	-This well had not been operational at the start up of the program -Bottom riser and pump covered with iron and manganese precipitate. Bottom riser was cleaned and re-installed -Because the well was not operational and based on pump inspection, decided to replace the pump -Sensors were inspected, cleaned. Sensors were tested at the well head and found that high-high sensor and a section of wiring needed to be replaced -New pump not operational when put back into service [note that pump is awaiting electrical maintenance at the control panel (to be done by NE-NLH)] -Testing at the wellhead and at the control panel showed there was a malfunction at the control panel that predated the inspection program	-Pump replaced -High-high sensor replaced, wiring mended
W-16	-Bottom riser and pump covered with iron and manganese precipitate -Sensors inspected, in fair condition -Pump visually assessed and in good condition	-Bottom riser replaced
W-17	-Pump is a 0.5 HP model -Pump visually assessed and decided to replace -Sensors were inspected, cleaned	-Pump replaced
W-18	-When removing the pump and risers, it was found that the bottom 2 risers and the pump were filled with silica sand (note that this is likely from filter pack around well screen) -The normal cleaning procedure was completed for the well -The camera inspection showed a possible tear in the screen and possible collapse -Pump is a 0.5 HP model, adequate for the yield from the well -Due to the poor condition of the well, it was decided to not reinstall the pump	
W-19	-Heavy iron/manganese staining on the bottom 3 risers -Pump is a 0.5 HP model, adequate for the yield from the well, pump not replaced -Pump visually assessed and in good condition -Sensors were inspected, cleaned	-Bottom riser replaced
W-20	-Bottom riser and pump covered with iron and manganese precipitate -Pump visually assessed and in good condition -Sensors were inspected, cleaned	

Well	General Observations	Equipment Replacement
W-21	-Heavy corrosion on the bottom riser -Sensors inspected, low-low sensor in poor condition, all others in fair condition -Pump visually assessed and in good condition	-Bottom riser replaced -Low-low sensor replaced
W-22	-Bottom riser and pump covered with iron and manganese precipitate -Pump visually assessed and in good condition -Sensors were inspected, cleaned	

4.2 General Comments

Following are some general comments related to the inspection program:

- Water levels were monitored in the piezometers prior to and throughout the well inspection program. The water levels did not vary more than approximately 0.3 m to 0.6 m from water levels recorded when the well dewatering system was in full operation. One exception was P-D-2, where the water level rose approximately 1.0 m during shutdown.
- The bottom riser, just above the pump, of most wells was covered in silt, iron and manganese deposits and in some cases was corroded. The bottom riser was replaced in 11 wells.
- In general it was noted that the condition of the screens in most wells was good. Exceptions are noted in Section 4.3.
- It was observed that the valves and piping in the area of the pitless adaptor are frequently in poor condition. Rusting and poor condition were observed in particular in well W-4 and well W-9. Due to the age of the system, replacement of the valves at all the wells is recommended.
- Initially, it was intended to replace all couplings at each well in order to minimize the risk of breakage of the coupling during infrastructure removal. W-3 was the first well inspected and all the couplings were replaced with the above intention in mind. The couplings at W-3 were in good condition and it was decided that at subsequent wells, only worn couplings would be replaced.
- During the downhole camera inspections, cloudy water conditions occurred frequently, making assessment difficult. However, in most cases, the water was sufficiently clear in one of either the pre-cleaning or post-cleaning inspections to make an assessment possible. Unfortunately, poor visibility conditions were noted in both inspections in well W-8. However, all other testing and inspection showed that well W-8 is generally in good condition.
- It was proposed initially to install safety hand lines at each well. However, based on discussions of previous experiences of the drilling contractor and Nalcor, it was decided not to install safety hand lines.
- As discussed in the July 2008 report, the electrical components of the system continue to be problematic. The contractors made recommendations for improvements to the electrical system. These are discussed in Section 4.3.
- Historically, a 3 mm hole has been drilled in the bottom riser of all wells to allow for drainage of excess water and a means of preventing the pipes from freezing. However, it is possible that

spraying of water from the hole has caused moderate build up of iron staining in the screen and high turbidity levels in the area of the pump intake. The contractors indicated that a device could be designed and installed that would act as a shield and prevent/reduce the spraying of water in the screen.

- Based on discussions with NE-NLH personnel on site, it is our understanding that each well system operates as follows:
  - The water level rises to the high sensor and the pump turns on.
  - The water level is lowered by the pump and when the water level reaches the low sensor, the pump shuts off.
  - The high-high and low-low sensors are emergency warning sensors.
- In wells W-3, W-5, W-6 and W-17, the sensors may not be set at optimal levels based on measurements taken and shown in Table 3-3. For example, in well W-6, the low-low sensor is set higher than the measured water level and in wells W-5 and W-17, the low sensor is set higher than the measured water level. Also, Table 4-1 indicates that for well W-3, the high-high and high sensor do not show evidence of being in water, suggesting that the water level in the well does not rise to the level of the high sensor and therefore the pump does not come on. With the sensors at the current levels in W-3, W-5, W-6 and W-17, the pumps may not come on frequently unless the water level rises significantly. Water levels shown in Table 3-3 were taken on the day the well was dismantled and cleaned, generally a minimum of one hour after system shutdown and water levels could rise more than the recorded level in Table 3-3.

4.3 Well Specific Comments

Well W-1

- Well W-1 is no longer connected to the dewatering system. All electrical wiring and pumps have been removed.
- A pre- and post-cleaning camera inspection was conducted on W-1. The camera inspections showed that the well screen in well W-1 was in satisfactory condition although heavy iron and black staining was noted at several depths (see log for W-1 Appendix B). The well was fully cleaned using an acid solution followed by brushing and removal of debris using the sand pump. It may be possible to install a pump in this well. It is recommended that a short pump test be conducted on this well to assess the potential for long term pumping. The test was not conducted during the field program due to insufficient supplies (risers, lack of connection to the existing system).

Well W-2

- Well W-2 is no longer connected to the dewatering system. All electrical wiring and pumps have been removed.
- A pre-cleaning camera inspection was completed for W-2 and a large rock/obstruction was noted in the screen at depth. The inspection showed that W-2 is likely not a viable well. The water level in

the well was 48.5 m below the top of casing, the obstruction was observed at 52.7 m and there is insufficient head in which to install a pump. Due to poor well condition, further work and cleaning was not completed.

Well W-9

- When the pump was being removed from W-9, personnel noted that the risers were wet from approximately 3 m to the pump. It was possible to hear water cascading down the casing from a near surface depth.
- When conducting the camera inspection, it was observed that water was cascading into the casing through the pitless adaptor at a substantial rate of flow. The contractor suspected that there is a break in the pipe leading from the casing to the header or is coming from the header and, consequently, water is leaking back into W-9.
- Water leakage could cause potential freezing in the upcoming winter season.

Well W-15

- After extensive testing at the wellhead and the control panel, it was evident that the malfunction at W-15 was related to a problem at the control panel. NE-NLH personnel on site at the completion of the program indicated repairs will be made and it is expected W-15 will then be fully operational.

Well W-17

- An old pump was observed in the bottom of W-17, at a depth of 59.3 m below top of casing. The pump does not seem to be an impediment to the operation of the functioning pump in the well.
- There is an unidentified PVC standpipe located near W-17; its purpose and original installation date are unknown by NE-LCP. NE-LCP requested that the standpipe beside W-17 be inspected with the downhole camera. It was found the standpipe was blocked with branches and debris at a depth of 24.5 m and a well screen was not observed.

Well W-18

- When the pump for W-18 was removed, it was noted that the bottom 2 risers were filled with silica sand and the pump was also filled with silica sand. A possible tear in the screen was observed at 45.2 m depth during the camera inspection. Due to the possible tear or formation collapse, the pump was not reinstalled in W-18.

5. Conclusions and Recommendations

The dewatering system has operated continuously since November 1981 and there has been no further major landslide activity on the spur. The purpose of the installation has, therefore, been fulfilled. Some of the rehabilitation work recommended in the July 2008 report has been completed and this will aid in the operation of the system over the next 10 years.

Based on the findings of the well inspection program, the wells in the system are operating satisfactorily and wells screens are generally in good condition, with the exception of wells W-1, W-2, W-15 and W-18. It is expected that W-15 can be readily repaired at the control panel. Wells W-1, W-2 and W-18 may no longer be viable. Therefore, a malfunction of one or more additional wells could potentially put a significant strain on the system and result in a rise in groundwater levels in the spur.

The following recommendations were discussed by Hatch and the well contractor at the site:

- Excavation in the area of well W-9 to assess the source of water entering W-9. A breakage or leak is possible in the horizontal line leading to the collector pipe from W-9 or the central collector pipe. This task requires immediate attention to prevent freezing.
- Replacement of valves, horizontal piping from the pitless adaptor to the collector pipe and pitless adaptor in all wells.
- Implement a maintenance record sheet that documents any maintenance that is completed at the site. This would ensure better record keeping for the system.
- Make electrical repairs at the control panel related to well W-15 and return W-15 to service.
- Installation of a flow monitoring device at each wellhead and at the collector pipe outlet with data transfer to the Goose Bay operation centre. Installation of a flow monitoring device at each well would allow a baseline assessment of the yields from the wells and facilitate record keeping. Changes in yield or lack of flow would alert personnel to technical problems at a specific well that required attention.
- Consideration of replacement of the existing sensors with pressure transducers.
- Further assessment of the location of the four sensors in each well to ensure appropriate water levels are maintained. Adjustment to the locations of sensors if required. The assessment would involve review of historical water levels and operation records, historical and recent monthly precipitation data, review of the well system design drawings and possible discussions with a pump contractor.

A follow up field program is recommended to implement the remaining recommendations from the July 2008 report. These recommendations include:

- Continue the manual recording of water elevations in the piezometers and commence taking water elevations in wells until the installation of an automatic data acquisition system.

- Consideration of a geophysical survey of some of the wells to assess voids around the screen (still to be confirmed by Hatch). This information would be helpful in further definition of the wells that require replacement.
- To ensure a satisfactory performance of the dewatering system for the next 10 years and to maintain the physical asset of the Muskrat Falls ridge as a whole, 6 to 7 new stainless steel wells need to be installed. This would include:
    - Replacement of wells W-2 and W-18 (and possibly well W-1).
    - Installation of 3 to 4 wells to replace the high yielding wells. The existing high yielding wells would be used for back-up. The new wells would include a well in the southern block in the area of W-4; 1 to 2 wells in the central block in the area of wells W-9 and W-10; and a well in the northern block in the area of W-21.
    - These new wells may require installation of additional infrastructure (i.e. new electrical control panel, discharge pipe).
    - If the well replacement program is completed as described above, a geophysical survey would not be necessary.

Appendix A

Photographs

Photograph 1: A flow test was conducted at each well prior to inspection and cleaning.

Photograph 2: The risers, wiring and pump were removed from each well.

Photograph 3: The risers and pump were laid down on the ground for inspection.

Photograph 4: The risers were inspected for corrosion and replaced as required.

Photograph 5: The pump was inspected, the screen removed and all cleaned.

Photograph 6: The four sensors at each well installation were inspected, tested and cleaned. If sensors were in poor condition or malfunctioning, they were replaced.

Photograph 7: A downhole camera inspection was completed before and after cleaning and logs made of the observations. The inspections were recorded as digital videos.

Photograph 8: An acid solution was added to the well and allowed to stand for 2 hours. Then a wellbore brush was used to clean the casing and screen.

Photograph 9: A sand pump was placed down into the well, water and sediments were suctioned into the sand pump. The sand pump was brought to the surface and the sediments collected in a pail for examination.

Appendix B

Inspection Logs

Camera Inspection Report

Project 325967
Well W-1 Before Flushing
Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)
Top of PVC Well Casing	0.0	59.79
As-built bottom of well	63.4	-3.61

Inspector: A.Mills
Started: Sept. 3/09 1:01 pm
Finished: Sept. 3/09 1:20pm
DVD No.:
Note: No flocculant added

Depth (m)	**Description**	**Depth – DVD Cross Reference** **Depth (m)**
0.0	**Top of Casing**	0.0
1.6	Pitless adaptor	1.6
3.4	Coupling – minor glue stains at 3.4 to 3.5	3.4
9.4	Coupling - minor glue stains at 9.4 to 9.5	9.4
15.7	Coupling – minor glue stains at 15.7 to 15.8	15.7
21.8	Coupling – heavy iron staining visible at the coupling No crack visible at 25.0	21.8
28.1	**Top of well screen**	28.1
	Moderate to heavy black staining from 31.1 to 33.2	
31.3	Screen weld/joint – heavy black staining from 31.3 to 34.4	31.3
37.3	Screen weld/joint – heavy iron staining from 37.1 to 40.2	37.3
40.4	Screen weld/joint – Brown burn at joint	40.4
	Heavy iron and black staining from 43.2 to 44.2	
44.3	**Water level** Good clarity below water. Heavy black staining at 46.4, just above the joint	44.3
46.6	Screen weld/joint	46.6
49.6	Screen weld/joint	49.6
49.8	Screen weld/joint	49.8
	Moderate iron staining from 46.6 to 49.6. Minor black encrustation at welds and good condition otherwise to 55.7. Moderate iron staining at 55.7	
63.4	**End of Inspection**	63.4

HATCH™	Camera Inspection Report	**Project** 325967 **Well W-1 After Flushing** Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	Inspector: A.Mills Started: Sept. 6/09 9:25 am Finished: Sept. 6/09 9:40 am DVD No.: Note: No flocculant added
Top of PVC Well Casing	0.0	59.79	
As-built bottom of well	63.4	-3.61	

Depth (m)	**Description**	**Depth – DVD Cross Reference** **Depth (m)**
0.0	**Top of Casing**	0.0
1.6	Pitless adaptor	1.6
3.4	Coupling – minor glue stains at 3.4 to 3.5	3.4
9.4	Coupling - minor glue stains at 9.4 to 9.5	9.4
15.7	Coupling	15.7
21.8	Coupling	21.8
28.1	**Top of well screen** Minor black staining at casing/screen joint	28.1
31.3	Screen weld/joint – minor black staining at joint	31.3
34.5	Screen weld/joint	34.5
37.3	Screen weld/joint	37.3
	Minor iron staining at 37.1 becoming heavy at 40.8	
40.4	Screen weld/joint – Brown burn at joint	40.4
	Heavy iron and black staining from 42.2 to 44.2	
44.3	**Water level** Very cloudy below the water level, poor visibility from 44.3 to bottom	44.3
58.1	Very cloudy, black particulate floating in water	58.1
59.1	**End of Inspection**	59.1

Camera Inspection Report

Project 325967
Well W-2 **Before Flushing**
Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	
			Inspector: A.Mills
Top of PVC Well Casing	0.0	59.66	Started: Sept. 3/09 1:35 pm Finished: Sept. 3/09 1:48pm
As-built bottom of well	69.0	-9.34	DVD No.: Note: No flocculant added

Depth (m)	**Description**	**Depth – DVD Cross Reference Depth (m)**
0.0	**Top of Casing**	0.0
1.4	Pitless adaptor	1.4
6.3	Coupling – minor glue stains at 6.3 to 6.4	6.3
12.5	Coupling - moderate white staining and debris on casing noted from 12.2 to 12.5	12.5
17.5	Coupling – minor glue/sealant stains at 17.4 to 17.5	17.5
18.6	Coupling Heavy staining with glue and sealant from 18.6 to 24.0	18.6
24.8	Coupling Cloudy, poor visibility	24.8
31.1	Coupling	31.1
37.3	**Top of well screen** Very poor condition, heavy black encrustation to 39.0, possibly broken	37.3
39.0	Screen weld/joint – moderate black staining at the weld	39.0
40.5	Screen weld/joint	40.5
43.6	End of screen, start of pvc casing	43.6
44.2	Coupling – heavy iron staining from 45.0 to 45.7	44.2
47.0	Coupling	47.0
48.5	**Water level** Water in the pvc casing, very cloudy and dark.	48.5
52.0	**Top of well screen** Screen is blocked at 52.7 with a rock and debris	52.0
52.7	**End of Inspection**	52.7
	No post cleaning camera inspection completed	

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Camera Inspection Report

Project 325967
Well W-3 **Before Flushing**
Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	
			Inspector: A.Mills
			Started: Aug. 28/09 4:35 pm
Top of PVC Well Casing	0.0	59.67	Finished:Aug. 28/09 5:00 pm
As-built bottom of well	71.0	-11.33	DVD No.:
			Note: Flocculant added

Depth (m)	**Description**	**Depth – DVD Cross Reference** **Depth (m)**
0.0	**Top of Casing**	0.0
1.5	Pitless adaptor	1.5
3.1	Coupling	3.1
6.9	Coupling	6.9
9.2	Coupling Generally good condition from 2.0 to 12.5. Minor vertical iron stains from 7.8 to 8.5 and 13.0 to 15.0	9.2
15.1	Coupling Minor iron staining from 18.0 to 19.0 and 20.0 to 22.3	15.1
21.6	Coupling	21.6
27.9	Coupling	27.9
39.9	**Top of well screen** Moderate iron staining from 36.9 to 38.6	39.9
38.6	Screen weld/joint	38.6
42.9	Screen weld/joint – moderate black staining from 41.3 to 41.6	42.9
46.2	Screen weld/joint – Brown burn at joint	46.2
49.3	Screen weld/joint	49.3
52.4	**Water level** Cloudy immediately below water, clearing with depth	52.4
54.8	5 cm segment of wire noted at 54.8, no break observed	54.8
55.0	Water very cloudy	55.0
55.0	**End of Inspection**	55.0

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Camera Inspection Report

Project 325967
Well W-3 **After Flushing**
Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	
			Inspector: A.Mills
			Started: Aug. 29/09 3:3 pm
Top of PVC Well Casing	0.0	59.67	Finished:Aug. 29/09 4:00 pm
As-built bottom of well	71.0	-11.33	DVD No.:
			Note: Flocculant added

Depth (m)	**Description**	**Depth – DVD Cross Reference Depth (m)**
0.0	**Top of Casing**	0.0
1.5	Pitless adaptor	1.5
3.1	Coupling	3.1
6.9	Coupling	6.9
9.2	Coupling - generally good condition	9.2
15.2	Coupling	15.2
21.3	Coupling	21.3
27.5	Coupling	27.5
33.6	Coupling	33.6
39.9	**Top of well screen** Screen in very good condition, no staining	39.9
42.9	Screen weld/joint Black encrustation from 45.8 to 45.9	42.9
46.2	Screen weld/joint	46.2
49.3	Screen weld/joint	49.3
52.4	Screen weld/joint 25% black encrustation from 52.0 to 52.3	52.4
52.4	**Water level** - water very clear 5 cm segment of wire noted at 54.8, screen not coming apart	52.4
55.2	Screen weld/joint	55.2
58.6	**End of Inspection**	58.6

Camera Inspection Report

Project 325967
Well W-4 **Before Flushing**
Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	
Top of PVC Well Casing	0.0	59.67	Inspector: A.Mills Started: Sept. 5/09 8:56 am Finished: Sept. 5/09 9:15 am DVD No.: Note: No flocculant added
As-built bottom of well	70.0	-10.33	

Depth (m)	**Description**	**Depth – DVD Cross Reference Depth (m)**
0.0	**Top of Casing**	0.0
1.4	A hole cut in casing approximately 7.5 x 3.75 cm	1.4
1.5	Pitless adaptor	1.5
2.1	Coupling Minor vertical iron staining at 2.0 and a small area at 6.6	2.1
8.5	Coupling - minor black staining at the coupling	8.5
14.7	Coupling Generally good condition, minor iron stain at 17.7	14.7
20.9	Coupling	20.9
27.1	Coupling – minor iron stain at 30.2	27.1
33.2	Coupling Glue staining, sealant, grass and possibly wire clump noted at 38.2	33.2
39.6	**Top of well screen** Very heavy black encrustation at 39.6 to 41.6, moderate black staining to 48.5	39.6
42.7	Water infiltration into the top of the screen, cascading down screen. Calcium/white encrustation noted at 45.3	42.7
45.8	Screen weld/joint - Infiltration of water and cascading down screen. Minor iron staining at 46.2 and minor black staining below 45.8	45.8
48.8	Screen weld/joint – moderate black staining from 41.3 to 41.6	48.8
50.2	**Water level** Very cloudy below water, becoming clearer at 51.4	50.2
55.0	Screen weld/joint Screen is in good condition below the water. Black particles in suspension at 59.5. Water becoming very cloudy at 63.0	55.0
69.9	**End of Inspection**	69.9

HATCH	Camera Inspection Report	**Project** 325967 **Well W-4** **After Flushing** Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	Inspector: A.Mills Started: Sept. 5/09 11:51 am Finished:Sept. 5/09 12:05pm DVD No.: Note: No flocculant added
Top of PVC Well Casing	0.0	59.67	
As-built bottom of well	70.0	-10.33	

Depth (m)	**Description**	**Depth – DVD Cross Reference**
		Depth (m)
0.0	**Top of Casing**	0.0
1.4	A hole cut in casing approximately 7.5 x 3.75 cm	1.4
1.5	Pitless adaptor	1.5
2.1	Coupling	2.1
8.5	Coupling	8.5
14.7	Coupling	14.7
20.6	Fine, wet, black sediment on casing – may be residual from sand pump	20.6
20.9	Coupling	20.9
27.1	Coupling	27.1
33.2	Coupling Fine, wet, black sediment on casing – may be residual from sand pump	33.2
39.6	**Top of well screen** Heavy black encrustation at 39.6 to 41.6, not blocked	39.6
42.0	Water infiltration into the top of the screen, cascading down screen.	42.0
42.2	**Water level** – water remains fairly clear, screen in good condition below water	42.2
47.9	Screen weld/joint	47.9
52.7	Water very cloudy	52.7
58.4	Screen weld/joint Screen is in good condition below the water. Black particles in suspension at 59.5 and very cloudy to bottom	58.4
69.1	**Bottom - End of Inspection**	69.1

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Camera Inspection Report

Project 325967
Well W-5 **Before Flushing**
Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	
			Inspector: A.Mills Started: Aug.29/09 2:45 pm
Top of PVC Well Casing	0.0	59.55	Finished:Aug.29/09 3:15 pm
As-built bottom of well	62.4	-2.89	DVD No.: Note: Flocculant added

Depth (m)	**Description**	**Depth – DVD Cross Reference** **Depth (m)**
0.0	**Top of Casing**	0.0
1.4	Pitless adaptor	1.4
4.5	Coupling	4.5
10.7	Coupling - heavy glue/sealant staining from 10.7 to 11.8	10.7
16.7	Coupling – minor glue/sealant staining from 16.7 to 18.9	16.7
22.8	Coupling – heavy glue/sealant staining from 22.8 to 24.8	22.8
29.2	Coupling	29.2
35.5	**Top of well screen** Good condition	35.5
37.4	Screen weld/joint Moderate black staining at the weld, minor black encrustation from 40.2 to 40.4	37.4
40.4	Screen weld/joint Iron staining at weld, minor loose debris at 41.5, moderate black encrustation at 42.1	40.4
44.7	Screen weld/joint	44.7
47.9	Screen weld/joint Minor black encrustation at 46.6 to 47.9 and 49.5 to 50.9	47.9
51.0	Screen weld/joint	51.0
52.2	Screen weld/joint	52.2
52.2	**Water level** - water cloudy below water level	52.2
54.0	Screen weld/joint	54.0
57.2	Screen weld/joint – moderate iron encrustation from 60.1 to 60.6 and at 61.9	57.2
62.0	**End of Inspection**	62.0

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Camera Inspection Report

Project	325967
Well W-5	**After Flushing**
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Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	
Top of PVC Well Casing	0.0	59.55	Inspector: A.Mills Started: Aug.30/09 10:30 am Finished:Aug.30/09 10:55am
As-built bottom of well	62.4	-2.89	DVD No.: Note: Flocculant added

Depth (m)	**Description**	**Depth – DVD Cross Reference Depth (m)**
0.0	**Top of Casing**	0.0
1.4	Pitless adaptor	1.4
4.5	Coupling	4.5
10.7	Coupling - heavy glue/sealant staining from 10.7 to 11.8	10.7
16.7	Coupling – minor glue/sealant staining from 16.7 to 18.9	16.7
22.8	Coupling – heavy glue/sealant staining from 22.8 to 24.8	22.8
29.2	Coupling	29.2
35.5	**Top of well screen** Good condition	35.5
37.4	Screen weld/joint Moderate black staining at the weld, minor black encrustation from 40.2 to 40.4	37.4
40.4	Screen weld/joint Iron staining at weld, minor loose debris at 41.5, moderate black encrustation at 42.1	40.4
44.7	Screen weld/joint	44.7
47.9	Screen weld/joint Minor black encrustation at 46.6 to 47.9 and 49.5 to 50.9	47.9
51.0	Screen weld/joint	51.0
52.2	Screen weld/joint	52.2
52.4	**Water level** Water cloudy below water level, could not see any major areas of encrustation or wear. Very cloudy at 59.0	52.4
59.1	**End of Inspection**	59.1

Camera Inspection Report

Project 325967
Well W-6 Before Flushing
Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	Inspector: A.Mills Started: Aug.30/09 9:30 am Finished:Aug.30/09 10:00am DVD No.: Note: Flocculant added
Top of PVC Well Casing	0.0	59.53	
As-built bottom of well	60.0	-0.47	

Depth (m)	**Description**	**Depth – DVD Cross Reference**
		Depth (m)
0.0	Top of Casing	0.0
1.5	Pitless adaptor	1.5
3.6	Coupling - minor glue/sealant staining	3.6
9.7	Coupling - minor glue/sealant staining	9.7
10.5	Coupling – minor glue/sealant staining	10.5
15.9	Coupling –minor iron staining at coupling	15.9
22.1	Coupling	22.1
28.3	Coupling	28.3
34.4	**Top of well screen** Generally good condition	34.4
37.6	Screen weld/joint - minor iron staining at the weld	37.6
40.7	Screen weld/joint	40.7
43.7	Screen weld/joint	43.7
46.9	Screen weld/joint	46.9
49.9	Screen weld/joint	49.9
52.4	**Water level** – water cloudy below water level	52.4
60.0	**End of Inspection**	60.0
	Note: Well not plumb	

HATCH™	Camera Inspection Report	**Project** 325967 **Well W-6** **After Flushing** Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	Inspector: A.Mills Started: Aug.30/09 3:45 pm Finished:Aug.30/09 4:15 pm DVD No.: Note: No Flocculant added
Top of PVC Well Casing	0.0	59.53	
As-built bottom of well	60.0	-0.47	

Depth (m)	**Description**	**Depth – DVD Cross Reference**
		Depth (m)
0.0	**Top of Casing**	0.0
1.5	Pitless adaptor	1.5
3.6	Coupling - minor glue/sealant staining	3.6
9.7	Coupling - minor glue/sealant staining	9.7
10.5	Coupling – minor glue/sealant staining	10.5
15.9	Coupling –minor iron staining at coupling	15.9
22.1	Coupling	22.1
28.3	Coupling	28.3
34.4	**Top of well screen** Generally good condition. Minor black staining at join with casing	34.4
37.6	Screen weld/joint - minor iron staining at the weld	37.6
40.7	Screen weld/joint	40.7
43.7	Screen weld/joint Minor black staining at 44.5 to 46.8	43.7
46.9	Screen weld/joint	46.9
49.9	Screen weld/joint	49.9
50.6	**Water level** – water cloudy below water level, iron encrustation noted at 55.0, water becoming clear at 58.6, screen in good condition	50.6
60.0	**End of Inspection**	60.0

HATCH™	**Camera Inspection Report**	**Project** **Well W-7** Sheet 1	325967 **Before Flushing** of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	Inspector: A.Mills Started: Aug.30/09 12:25 pm Finished:Aug.30/09 12:44pm DVD No.: Note: Flocculant added
Top of PVC Well Casing	0.0	59.51	
As-built bottom of well	63.0	-3.49	

Depth (m)	**Description**	**Depth – DVD Cross Reference** **Depth (m)**
0.0	**Top of Casing**	0.0
1.2	Coupling	1.2
1.4	Pitless adaptor	1.4
4.1	Coupling	4.1
7.3	Coupling Minor black, iron and glue/sealant staining at coupling	7.3
9.6	Coupling – minor glue/sealant staining	9.6
13.5	Coupling –minor iron staining at coupling	13.5
19.8	Coupling	19.8
21.9	Coupling	21.9
26.0	Coupling – black scrape on the casing, likely from pump removal	26.0
32.2	**Top of well screen** Generally good condition, minor black encrustation at the well screen/casing join	32.2
38.4	Screen weld/joint - minor black staining at the weld	38.4
41.3	Screen weld/joint	41.3
41.5	Screen weld/joint- minor iron staining between 41.3 and 41.5	41.5
44.6	Screen weld/joint	44.6
47.6	Screen weld/joint - brown burn/tarnish at the weld	47.6
48.1	**Water level** – water very turbid to 60.0	48.1
60.0	**End of Inspection**	60.0

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Camera Inspection Report

Project 325967
Well W-7 **After Flushing**
Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)
Top of PVC Well Casing	0.0	59.51
As-built bottom of well	63.0	-3.49

Inspector: A.Mills
Started: Aug.31/09 8:42 am
Finished:Aug.31/09 9:10 am
DVD No.:
Note: Flocculant added

Depth (m)	**Description**	**Depth – DVD Cross Reference** **Depth (m)**
0.0	**Top of Casing**	0.0
1.2	Coupling	1.2
1.4	Pitless adaptor	1.4
4.1	Coupling	4.1
7.3	Coupling Minor black, iron and glue/sealant staining at coupling	7.3
9.6	Coupling – minor glue/sealant staining	9.6
13.5	Coupling –minor iron staining at coupling	13.5
19.8	Coupling	19.8
21.9	Coupling	21.9
26.0	Coupling – black scrape on the casing, likely from pump removal	26.0
32.2	**Top of well screen** Generally good condition, minor black encrustation at the well screen/casing join	32.2
38.4	Screen weld/joint - minor black staining at the weld	38.4
41.3	Screen weld/joint	41.3
41.5	Screen weld/joint- minor iron staining between 41.3 and 41.5	41.5
44.6	Screen weld/joint	44.6
47.6	Screen weld/joint - brown burn/tarnish at the weld	47.6
48.1	**Water level** – water clear, no staining or encrustation noted	48.1
50.8	Screen weld/joint	50.8
54.0	Screen weld/joint Water becoming cloudy at 55.8, minor black encrustation at 56.8	54.0
57.2	Screen weld/joint	57.2
60.0	**End of Inspection**	60.0

Camera Inspection Report

Project 325967
Well W-8 Before Flushing
Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	
			Inspector: A.Mills Started: Aug.30/09 1:25 pm
Top of PVC Well Casing	0.0	59.46	Finished:Aug.30/09 1:48 pm
As-built bottom of well	61.0	-1.54	DVD No.:
			Note: Flocculant added

Depth (m)	**Description**	**Depth – DVD Cross Reference** **Depth (m)**
0.0	**Top of Casing**	0.0
0.1	Coupling – large rust stains from 0.8 to 0.9	0.1
1.5	Pitless adaptor	1.5
3.1	Coupling	3.1
7.8	Coupling	7.8
9.4	Coupling – minor glue/sealant staining	9.4
14.6	Coupling	14.6
15.7	Coupling Minor iron staining from 16.8 to 17.0	15.7
21.8	Coupling	21.8
27.8	Coupling Minor iron staining from 28.2 to 28.3	27.8
30.7	Coupling	30.7
34.1	Coupling Minor black encrustation from 34.1 to 34.2, white debris at 38.1	34.1
40.2	Coupling	40.2
46.2	**Top of well screen** At screen/casing join, moderate black encrustation, iron staining at 48.3	46.2
49.1	Screen weld/joint - minor iron staining at the weld	49.1
49.1	**Water level** Water very turbid, poor visibility to 54.4	52.4
54.4	**End of Inspection**	54.4

Camera Inspection Report

Project	325967
Well W-8	**After Flushing**
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Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	
			Inspector: A.Mills
			Started: Aug.31/09 9:30 am
Top of PVC Well Casing	0.0	59.46	Finished:Aug.31/09 9:45 am
As-built bottom of well	61.0	-1.54	DVD No.:
			Note: No flocculant added

Depth (m)	**Description**	**Depth – DVD Cross Reference** **Depth (m)**
0.0	**Top of Casing**	0.0
0.1	Coupling	0.1
1.5	Pitless adaptor – minor iron staining and glue residue from 1.8 to 2.0	1.5
3.1	Coupling	3.1
7.8	Coupling	7.8
9.4	Coupling – minor glue/sealant staining	9.4
14.6	Coupling	14.6
15.7	Coupling	15.7
21.8	Coupling	21.8
27.8	Coupling	27.8
30.7	Coupling	30.7
34.1	Coupling	34.1
40.2	Coupling	40.2
43.1	**Water level –** water very cloudy	43.1
46.2	**Top of well screen (assumed)** could not see because water cloudy	46.2
60.0	Bottom of well	60.0
60.0	**End of Inspection**	60.0

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		Well W-9	**Before Flushing**
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Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	Inspector: A.Mills Started: Sept. 2/09 9:40 am Finished:Sept.2/09 10:00 am DVD No.: Note: No flocculant added
Top of PVC Well Casing	0.0	59.48	
As-built bottom of well	62.0	-2.52	

Depth (m)	**Description**	**Depth – DVD Cross Reference**
		Depth (m)
0.0	**Top of Casing**	0.0
0.1	Coupling – minor rust stains at coupling	0.1
1.4	Pitless adaptor – fair to poor condition, rust evident	1.4
1.8	Coupling	1.8
2.1	Coupling - minor iron staining at 5.8	2.1
8.2	Coupling – minor glue/sealant staining	8.2
14.5	Coupling Heavy iron staining at 17.5, minor iron stain at 19.6	14.5
20.7	Coupling – iron stain at coupling	20.7
26.8	Coupling	26.8
33.0	**Top of well screen** Condition of screen generally good. Minor black encrustation at 33.7	33.0
34.4	**Water level** Water clear, good visibility, screen is in good condition	34.4
35.9	Screen weld/joint Minor black encrustation at 36.2 and minor iron staining at 40.0 to 40.3	35.9
41.0	Screen weld/joint – water very cloudy below 41.0	41.0
44.0	Screen weld/joint – black particulate suspended in water	44.0
45.5	Screen weld/joint	45.5
49.7	Screen weld/joint Water becoming very cloudy at 49.0. High silt content in water at 53.5	49.7
57.0	**End of Inspection**	57.0

Camera Inspection Report

Project 325967
Well W-9 **After Flushing**
Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	
			Inspector: A.Mills
			Started: Sept. 2/09 2:10 pm
Top of PVC Well Casing	0.0	59.48	Finished:Sept.2/09 2:30 pm
As-built bottom of well	62.0	-2.52	DVD No.:
			Note: No flocculant added

Depth (m)	**Description**	**Depth – DVD Cross Reference** **Depth (m)**
0.0	**Top of Casing**	0.0
0.1	Coupling – minor rust stains at coupling	0.1
1.4	Pitless adaptor – fair to poor condition, rust evident	1.4
1.8	Coupling	1.8
2.1	Coupling - minor iron staining at the coupling	2.1
8.2	Coupling Minor iron staining at 12.3 to 12.4	8.2
14.5	Coupling	14.5
20.7	Coupling – iron stain at coupling	20.7
26.8	Coupling	26.8
33.0	**Top of well screen** Condition of screen generally good. Minor iron encrustation at 32.9 to 33.3	33.0
34.0	**Water level** Water clear, good visibility, screen is in good condition. Water becoming very cloudy at 37.7	34.4
42.1	Screen weld/joint	42.1
45.4	Screen weld/joint	45.4
51.6	Possible Screen weld/joint Water becoming grey to dark grey in colour.	51.6
53.7	Possible Screen weld/joint	53.7
58.7	High silt content in water, soft bottom	58.7
58.7	**End of Inspection**	58.7
	End of Inspection	

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Camera Inspection Report

Project 325967
Well W-10 **Before Flushing**
Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	
			Inspector: A.Mills
			Started: Sept.6/09 8:57 am
Top of PVC Well Casing	0.0	59.40	Finished: Sept 6/09 9:18 am
As-built bottom of well	59.0	0.40	DVD No.:
			Note: No flocculant added

Depth (m)	**Description**	**Depth – DVD Cross Reference** **Depth (m)**
0.0	**Top of Casing**	0.0
0.3	Coupling	0.3
1.5	Pitless adaptor Minor iron staining from 1.5 to 2.7. Heavy staining at 2.5	1.5
4.9	Coupling - iron staining at the coupling	4.9
11.2	Coupling	11.2
17.5	Coupling Minor iron staining at 18.8, 20.2 and 20.5	17.5
23.7	Coupling minor iron stain at coupling	23.7
29.7	**Top of well screen** Orange staining just below top of screen, 1 vertical black streak, otherwise very good condition	29.7
32.9	Screen weld/joint – orange/tarnish at weld	32.9
36.0	Screen weld/joint - minor black encrustation just below weld	36.0
39.0	Screen weld/joint – black/brown tarnish at weld	39.0
44.3	**Water level** – water very cloudy	44.3
45.2	Screen weld/joint Water becoming clearer at 47.0, iron stain at 45.0	45.2
48.1	Screen weld/joint Screen overall looks in good condition	48.1
51.4	Screen weld/joint – brown tarnishing at the weld	51.4
56.0	Water very cloudy, black particulate suspended in water	56.0
59.1	Bottom – black sediments	59.1
59.1	**End of Inspection**	59.1

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Camera Inspection Report

Project 325967
Well W-10 **After Flushing**
Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	
			Inspector: A.Mills
			Started: Sept.6/09 11:47 am
Top of PVC Well Casing	0.0	59.40	Finished:Sept 6/09 12:10 pm
As-built bottom of well	59.0	0.40	DVD No.:
			Note: No flocculant added

Depth (m)	**Description**	**Depth – DVD Cross Reference**
		Depth (m)
0.0	**Top of Casing**	0.0
0.3	Coupling	0.3
1.5	Pitless adaptor Minor iron staining just below pitless adaptor	1.5
4.9	Coupling	4.9
11.2	Coupling	11.2
17.5	Coupling	17.5
23.7	Coupling	23.7
29.7	**Top of well screen** Good condition	29.7
32.9	Screen weld/joint – orange/tarnish at weld	32.9
36.0	Screen weld/joint – black/brown tarnish at weld, otherwise good condition	36.0
39.0	Screen weld/joint – black/brown tarnish at weld	39.0
41.7	Screen weld/joint – black/brown tarnish at weld	41.7
44.2	**Water level** – water very turbid, water did not clear, cloudy to 59.0	44.2
59.0	**End of Inspection**	59.0

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Camera Inspection Report

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Well W-11 **Before Flushing**
Sheet 1 of 2

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)
Top of PVC Well Casing	0.0	59.35
As-built bottom of well	57.0	2.35

Inspector: A.Mills
Started: Sept. 1/09 2:43 pm
Finished:Sept.1/09 3:05 pm
DVD No.:
Note: Flocculant added

Depth (m)	**Description**	**Depth – DVD Cross Reference** **Depth (m)**
0.0	**Top of Casing**	0.0
0.2	Coupling	0.2
1.4	Pitless adaptor	1.4
1.9	Coupling Heavy iron staining from 2.3 to 3.3, a minor iron stain at 3.9, may be due to leakage from pitless adaptor	1.9
7.5	Coupling	7.5
8.1	Coupling Moderate iron staining from 8.1 to 11.8	8.1
13.7	Coupling	13.7
14.2	Coupling Heavy iron staining from 14.2 to 16.5	14.2
20.9	Coupling Heavy iron staining from 23.7 to 25.9	20.9
26.4	Coupling Minor iron staining from 28.2 to 28.3	26.4
26.8	**Top of well screen** Moderate black encrustation at screen/casing join, heavy iron staining at 29.3 to 29.5	26.8
29.6	Screen weld/joint	29.6
32.2	Screen weld/joint Moderate black encrustation and iron staining at 34.9 to 35.1	32.2
35.3	Screen weld/joint	35.3
38.1	Screen weld/joint	38.1
38.2	**Water level** Water very turbid, water clearing with depth	38.2
38.9	Screen weld/joint	38.9

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Camera Inspection Report

Project 325967
Well W-11 **Before Flushing**
Sheet 1 of 2

44.9	Screen weld/joint	44.9
46.9	Screen weld/joint	46.9
52.7	Screen weld/joint	52.7
53.3	Screen weld/joint	53.3
56.3	Screen weld/joint Overall condition of screen is excellent throughout	56.3
57.3	Water becoming dark grey/black	57.3
60.0	**End of Inspection**	60.0

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Camera Inspection Report

Project 325967
Well W-11 **After Flushing**
Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	
			Inspector: A.Mills Started: Sept. 2/09 11:25 am
Top of PVC Well Casing	0.0	59.35	Finished:Sept.2/09 11:40 am
As-built bottom of well	57.0	2.35	DVD No.:
			Note: No flocculant added

Depth (m)	**Description**	**Depth – DVD Cross Reference Depth (m)**
0.0	**Top of Casing**	0.0
0.2	Coupling	0.2
1.4	Pitless adaptor	1.4
1.9	Coupling Minor iron staining at 3.9 to 4.1	1.9
7.5	Coupling	7.5
8.1	Coupling	8.1
13.7	Coupling	13.7
14.2	Coupling Moderate iron staining from 15.3 to 15.5	14.2
20.9	Coupling	20.9
26.4	Coupling	26.4
26.8	**Top of well screen** Minor black encrustation at screen/casing join, heavy iron staining at 29.2	26.8
29.6	Screen weld/joint	29.6
32.2	Screen weld/joint Moderate black encrustation and iron staining at 34.9	32.2
35.1	Screen weld/joint	35.1
36.4	**Water level** Water very turbid, poor visibility	36.4
41.0	Possible black encrustation	41.0
54.2	Water cloudy, becoming yellow in colour, dark grey at 55.5	54.2
58.0	Black sediments	58.0
58.0	**End of Inspection**	58.0

Camera Inspection Report

Project	325967
Well W-12	**Before Flushing**
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Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	Inspector: A.Mills Started: Aug. 31/09 10:43am Finished:Aug.31/09 11:00am DVD No.: Note: No flocculant added
Top of PVC Well Casing	0.0	59.29	
As-built bottom of well	61.0	-1.71	

Depth (m)	Description	Depth – DVD Cross Reference Depth (m)
0.0	**Top of Casing**	0.0
0.2	Coupling	0.2
0.6	Coupling	0.6
1.5	Pitless adaptor Moderate Iron staining from 3.0 to 5.9	1.5
6.7	Coupling	6.7
12.8	Coupling Moderate iron staining from 12.8 to 14.5. Possible horizontal crack in casing at 14.6, wet	12.8
18.9	Coupling Moderate iron staining from 18.9 to 25.0	18.9
25.0	Coupling – Black/brown small area of staining at 28.1	25.0
31.2	**Top of well screen** Moderate black encrustation at screen/casing join	31.2
34.3	Screen weld/joint – Black and brown staining above the weld	34.3
37.3	Screen weld/joint Minor black encrustation at the weld	37.3
40.4	Screen weld/joint Moderate black encrustation at the weld	40.4
43.4	Screen weld/joint Minor black encrustation at the weld	43.4
46.3	Screen weld/joint	46.3
48.4	**Water level** Water turbid, water clearing with depth. Heavy iron encrustation at 52.4, 54.4 and 58.4. Water becoming cloudy at 57.5	48.4
60.0	**End of Inspection**	60.0

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		Well W-12	**After Flushing**
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Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	Inspector: A.Mills Started: Sept. 1/09 8:00 am Finished: Sept.1/09 8:30 am DVD No.: Note: Flocculant added
Top of PVC Well Casing	0.0	59.29	
As-built bottom of well	61.0	-1.71	

Depth (m)	**Description**	**Depth – DVD Cross Reference** **Depth (m)**
0.0	**Top of Casing**	0.0
0.2	Coupling	0.2
0.6	Coupling	0.6
1.5	Pitless adaptor	1.5
6.7	Coupling	6.7
12.8	Coupling No crack in casing observed at 14.6	12.8
18.9	Coupling	18.9
25.0	Coupling	25.0
31.2	**Top of well screen** Minor black encrustation at 33.7	31.2
31.7	**Water level**	31.7
37.3	Screen weld/joint Moderate black encrustation at the weld	37.3
40.4	Screen weld/joint Good condition, minor iron encrustation at 41.9	40.4
43.4	Screen weld/joint Minor black encrustation at the weld, good condition	43.4
46.3	Screen weld/joint	46.3
46.7	Water turbid at 46.7, possible iron encrustation at 54.4 and 58.0	46.7
60.0	**End of Inspection**	60.0
	Note: Due to turbid water, it was decided to stop the inspection and complete the inspection below the water level the next morning. The well was not pumped overnight. The following water levels were observed in the well: Aug. 31/09 43.7 m below top of casing Sept. 1/09 31.7 m below top of casing	

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Camera Inspection Report

Project 325967
Well W-13 **Before Flushing**
Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	
			Inspector: A.Mills
			Started: Aug.31/09 11:30 am
Top of PVC Well Casing	0.0	59.27	Finished:Aug.31/09 11:50am
As-built bottom of well	59.0	0.27	DVD No.:
			No flocculant added

Depth (m)	**Description**	**Depth – DVD Cross Reference** **Depth (m)**
0.0	**Top of Casing**	0.0
0.1	Coupling	0.1
1.5	Pitless adaptor	1.5
6.1	Coupling	6.1
12.2	Coupling	12.2
18.5	Coupling – white patch of sealant noted at 20.4	18.5
24.6	Coupling minor iron stain at coupling	24.6
27.0	**Water level** – water very cloudy	27.0
36.9	**Possible Top of well screen –** water still very cloudy, difficult to make observations. Water cloudy to 60.0	36.9
53.6	Possible black encrustation	53.6
55.6	Possible black encrustation	55.6
58.1	Possible iron encrustation	58.1
60.0	**End of Inspection**	60.0
	Note: It was observed that the casing is not plumb	

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Camera Inspection Report

Project 325967
Well W-13 **After Flushing**
Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	
Top of PVC Well Casing	0.0	59.27	Inspector: A.Mills Started: Sept. 1/09 8:46 am Finished: Sept.1/09 9:16 am DVD No.: Note: Flocculant added 17 hrs ago
As-built bottom of well	59.0	0.27	

Depth (m)	**Description**	**Depth – DVD Cross Reference Depth (m)**
0.0	**Top of Casing**	0.0
0.1	Coupling	0.1
1.5	Pitless adaptor	1.5
6.1	Coupling	6.1
12.2	Coupling	12.2
18.5	Coupling	18.5
24.6	Coupling	24.6
27.2	**Water level** – water very cloudy	27.2
30.8	**Top of well screen** No major encrustation observed. Water clearing at 33.0	30.8
34.2	Screen weld/joint	34.2
37.2	Screen weld/joint Good condition generally. Minor black encrustation at 40. to 40.4	37.2
43.4	Screen weld/joint	43.4
46.5	Screen weld/joint Minor brown encrustation at 47.6 and 50.0	46.5
53.5	Screen weld/joint	53.5
56.8	Screen weld/joint	56.8
59.8	Screen weld/joint	59.8
60.0	**End of Inspection**	60.0
	Comments: Screen generally in good condition throughout	

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Camera Inspection Report

Project 325967
Well W-14 **Before Flushing**
Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	
			Inspector: A.Mills
			Started: Aug.31/09 4:37 pm
Top of PVC Well Casing	0.0	59.01	Finished:Aug.31/09 5:00 pm
As-built bottom of well	61.5	-2.49	DVD No.:
			Note: No flocculant added

Depth (m)	Description	Depth – DVD Cross Reference Depth (m)
0.0	**Top of Casing**	0.0
1.3	Pitless adaptor	1.3
3.4	Coupling - good condition	3.4
11.8	Coupling Minor iron staining at 13.2 to 13.3 and a vertical iron stain at 15.0	11.8
18.0	Coupling Vertical and horizontal black encrustation at 20.6	18.0
24.2	Coupling	24.2
26.9	**Water level** – water very cloudy	26.9
30.6	**Top of well screen** Water very cloudy	30.6
36.2	Screen weld/joint	36.2
52.3	Possible iron staining – water very cloudy	52.3
59.5	**End of Inspection**	59.5

Camera Inspection Report

Project 325967
Well W-14 **After Flushing**
Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	Inspector: A.Mills Started: Sept. 1/09 0:00am Finished:Sept.1/09 0:00am DVD No.: Note: No flocculant added
Top of PVC Well Casing	0.0	59.01	
As-built bottom of well	61.5	-2.49	

Depth (m)	Description	Depth – DVD Cross Reference Depth (m)
0.0	**Top of Casing**	0.0
1.3	Pitless adaptor - iron staining, possible leakage at pitless adaptor	1.3
3.4	Coupling	3.4
5.7	Coupling	5.7
11.8	Coupling	11.8
18.0	Coupling	18.0
24.2	Coupling	24.2
25.6	**Water level** – water very cloudy	25.6
30.6	**Top of well screen** Water very cloudy to 40.5, then clearing	30.6
47.2	Screen weld/joint	47.2
54.6	Iron encrustation at 54.6, water dark grey at 56.9 to 60.2	54.6
60.2	**End of Inspection**	60.2

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Camera Inspection Report

Project 325967
Well W-15 **Before Flushing**
Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	Inspector: A.Mills Started: Sept. 1/09 10:18 am Finished:Sept.1/09 10:40 am DVD No.: Note: No flocculant added
Top of PVC Well Casing	0.0	58.91	
As-built bottom of well	61.5	-2.59	

Depth (m)	**Description**	**Depth – DVD Cross Reference** **Depth (m)**
0.0	**Top of Casing**	0.0
1.4	Pitless adaptor Very minor iron staining at 4.1	1.4
5.9	Coupling	5.9
12.0	Coupling	12.0
18.1	Coupling	18.1
24.4	Coupling	24.4
30.5	**Top of well screen**	30.5
30.6	**Water level** Water clear, good visibility, screen is in good condition, reduced visibility at 33.4	30.6
33.9	Screen weld/joint	33.9
36.5	Screen weld/joint	36.5
39.3	Screen weld/joint Water clear, screen generally in good condition	39.3
45.6	Screen weld/joint Minor iron encrustation at 48.5	45.6
53.9	Screen weld/joint Minor black encrustation at 54.2, becoming very cloudy at 55.1	53.9
59.9	Black sediments, bottom	59.9
59.9	**End of Inspection**	59.9

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		Well W-15	**After Flushing**
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Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	Inspector: A. Mills Started: Sept. 4/09 3:05 pm Finished:Sept.4/09 3:25 pm DVD No.: Note: No flocculant added
Top of PVC Well Casing	0.0	58.91	
As-built bottom of well	61.5	-2.59	

Depth (m)	Description	Depth – DVD Cross Reference Depth (m)
0.0	**Top of Casing**	0.0
1.4	Pitless adaptor Minor iron staining at 2.5	1.4
5.9	Coupling	5.9
12.0	Coupling	12.0
18.1	Coupling	18.1
24.4	Coupling	24.4
30.5	**Top of well screen** Minor iron staining and black encrustation just below the top of screen	30.5
31.0	**Water level** Water cloudy to 31.8 then clearing	31.0
33.9	Screen weld/joint	33.9
35.5	Screen weld/joint - minor black encrustation noted at 35.4 and at weld, good condition below	35.5
39.3	Screen weld/joint Water very clear – screen in good condition	39.3
42.7	Screen weld/joint Water clear, screen generally in good condition	42.7
45.6	Screen weld/joint Minor iron encrustation at 48.5, poor visibility at 50.1	45.6
53.9	Screen weld/joint Minor iron encrustation at 55.1	53.9
60.0	Black sediments, bottom	60.0
60.0	**End of Inspection**	60.0

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Camera Inspection Report

Project 325967
Well W-16 **Before Flushing**
Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)
Top of PVC Well Casing	0.0	58.76
As-built bottom of well	61.0	-2.24

Inspector: A.Mills
Started: Sept. 1/09 9:38 am
Finished:Sept.1/09 10:00 am
DVD No.:
Note: No flocculant added

Depth (m)	**Description**	**Depth – DVD Cross Reference**
		Depth (m)
0.0	**Top of Casing**	0.0
0.9	Coupling	0.9
1.4	Pitless adaptor Moderate iron staining at 3.8	1.4
4.8	Coupling Minor iron staining at 5.6 to 6.0	4.8
11.0	Coupling - minor rust on the coupling Vertical streaks of black staining at 14.8	11.0
17.1	Coupling – minor glue/sealant staining	17.1
23.3	Coupling	23.3
28.0	Coupling	28.0
29.6	**Top of well screen** Condition of screen generally good. Minor black encrustation at 31.1.	29.6
32.8	Screen weld/joint Large area of heavy black encrustation at 33.2, possible hole, minor black encrustation at 34.2, minor iron staining at 35.6	32.8
35.8	Screen weld/joint	35.8
38.9	Screen weld/joint	38.9
42.2	Screen weld/joint – burn/tarnish at weld and moderate black encrustation at 43.8	42.2
45.1	Screen weld/joint	45.1
46.2	**Water level** Water clear, good visibility, minor iron stain at joint, water becoming cloudy at 48.8, cloudy to 60.0	46.2
60.0	Black sediments, bottom	60.0
60.0	**End of Inspection**	60.0
	Note: Hole is not plumb	

Camera Inspection Report

Project 325967
Well W-16 **After Flushing**
Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	Inspector: A.Mills
			Started: Sept. 1/09 2:00 pm
Top of PVC Well Casing	0.0	58.76	Finished:Sept.1/09 2:18 pm
As-built bottom of well	61.0	-2.24	DVD No.:
			Note: No flocculant added

Depth (m)	**Description**	**Depth – DVD Cross Reference Depth (m)**
0.0	**Top of Casing**	0.0
0.9	Coupling	0.9
1.4	Pitless adaptor	1.4
4.8	Coupling Minor iron staining at 6.0 to 6.6	4.8
11.0	Coupling	11.0
17.1	Coupling – minor glue/sealant staining	17.1
23.3	Coupling - minor iron staining at 26.3	23.3
28.0	Coupling	28.0
29.6	**Top of well screen** Condition of screen generally good. Moderate black encrustation vertical streaks from 29.6 to 31.0.	29.6
32.8	Screen weld/joint Large area of heavy black encrustation at 33.2, not a hole, clean below 33.3	32.8
35.8	Screen weld/joint	35.8
37.9	**Water level** Water cloudy below water level	37.9
54.7	Screen weld/joint	54.7
57.0	Screen weld/joint	57.0
58.8	Water dark grey, possible sediments	58.8
60.2	Black sediments, bottom	60.2
60.2	**End of Inspection**	60.2

HATCH	Camera Inspection Report	**Project** 325967 **Well W-17 Before Flushing** Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	Inspector: A.Mills
			Started: Sept. 2/09 2:40 pm
Top of PVC Well Casing	0.0	58.46	Finished:Sept.2/09 3:00 pm
As-built bottom of well	60.0	-1.54	DVD No.:
			Note: No flocculant added

Depth (m)	**Description**	**Depth – DVD Cross Reference** **Depth (m)**
0.0	**Top of Casing**	0.0
1.5	Pitless adaptor Orange discolouration on casing at 3.4	1.5
5.5	Coupling	5.5
11.5	Coupling – minor glue/sealant staining	11.5
17.8	Coupling Small white patches of glue/sealant at 20.6	17.8
23.9	Coupling	23.9
30.2	**Top of well screen** Heavy black encrustation from 30.2 to 31.5	30.2
33.1	Screen weld/joint Minor black encrustation at the weld, heavy black encrustation from 33.3 to 34.0	33.1
36.3	Screen weld/joint	36.3
39.4	Screen weld/joint	39.4
42.6	Screen weld/joint – burn/tarnish at weld and minor black encrustation at 45.0	42.6
45.7	Screen weld/joint	45.7
47.2	**Water level** Water clear, screen is in good condition	47.2
48.7	Screen weld/joint	48.7
52.0	Screen weld/joint – minor dark grey discolouration on screen	52.0
59.3	Screen weld/joint – old pump observed, could not go any deeper	59.3
59.3	**End of Inspection**	59.3

HATCH™

Camera Inspection Report

Project 325967
Well W-17 **After Flushing**
Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	
			Inspector: A.Mills
			Started: Sept. 3/09 2:15 pm
Top of PVC Well Casing	0.0	58.46	Finished:Sept.3/09 2:35 pm
As-built bottom of well	60.0	-1.54	DVD No.:
			Note: No flocculant added

Depth (m)	Description	Depth – DVD Cross Reference Depth (m)
0.0	**Top of Casing**	0.0
1.5	Pitless adaptor	1.5
5.5	Coupling	5.5
11.5	Coupling – minor glue/sealant staining	11.5
17.8	Coupling – minor glue staining to 18.6	17.8
23.9	Coupling	23.9
30.2	**Top of well screen** Heavy black encrustation from 30.2 to 33.0	30.2
33.1	Screen weld/joint Minor black encrustation at the weld	33.1
36.3	Screen weld/joint	36.3
39.4	Screen weld/joint - burn/tarnish at weld	39.4
42.6	Screen weld/joint – burn/tarnish at weld and minor black encrustation at 45.0	42.6
45.7	Screen weld/joint	45.7
47.1	**Water level** Water cloudy, pump ID tag floating on surface, very cloudy to bottom	47.1
59.3	Screen weld/joint – old pump and wiring observed, could not go any deeper	59.3
59.3	**End of Inspection**	59.3

HATCH

Camera Inspection Report

Project 325967
Standpipe by Well W-17
Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	Inspector: A. Mills Started: Sept. 3/09 2:41 pm Finished:Sept.3/09 2:51 pm
Top of PVC Well Casing			Tape No.:
As-built bottom of well			Tape Index:
Sounded bottom of well before flushing			Note: No flocculant added
Sounded bottom of well after flushing			

Depth (m)	**Description**	**Depth – DVD Cross Reference Depth (m)**
0.0	**Top of Casing**	0.0
0.7	Coupling	0.7
5.9	Coupling	5.9
12.0	Coupling	12.0
18.4	Coupling	18.4
24.5	Coupling – metal rod, wood and debris tightly packed	24.5
25.5	**End of Inspection**	24.5

HATCH™	**Camera Inspection Report**	**Project** 325967 **Well W-18** **Before Flushing** Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	Inspector: A.Mills Started: Sept. 3/09 3:45 pm
Top of PVC Well Casing	0.0	57.87	Finished:Sept.3/09 4:05 pm
As-built bottom of well	60.0	-2.13	DVD No.:
			Note: No flocculant added

Depth (m)	**Description**	**Depth – DVD Cross Reference** **Depth (m)**
0.0	**Top of Casing**	0.0
1.2	Coupling - minor rust on coupling	1.2
1.4	Pitless adaptor	1.4
6.0	Coupling	6.0
12.1	Coupling Minor iron staining from 12.8 to 13.4 and at moderate staining at 14.8	12.1
18.3	Coupling Small white patches of glue/sealant at 20.6	18.3
24.4	Coupling – minor iron stain at 28.2	24.4
29.3	**Top of well screen** Heavy black encrustation from 29.3 to 30.0. Very good condition below 30.0	23.9
32.4	Screen weld/joint	32.4
35.4	Screen weld/joint Moderate to heavy black encrustation from 35.4 to 38.6	35.4
38.6	**Water level** Water very cloudy, difficult to assess because of visibility	38.6
41.9	Screen weld/joint	41.9
48.5	Possible screen weld/joint - water cloudy	48.5
51.4	Black sediments, on bottom, possible collapse at 51.4	51.4
51.4	**End of Inspection**	51.4

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Camera Inspection Report

Project 325967
Well W-18 **After Flushing**
Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	
			Inspector: A. Mills Started: Sept. 4/09 12:40 pm
Top of PVC Well Casing	0.0	57.87	Finished:Sept.4/09 1:00 pm
As-built bottom of well	60.0	-2.13	DVD No.:
			Note: No flocculant or acid added

Depth (m)	**Description**	**Depth – DVD Cross Reference** **Depth (m)**
0.0	**Top of Casing**	0.0
1.2	Coupling - minor rust on coupling	1.2
1.4	Pitless adaptor	1.4
6.0	Coupling	6.0
12.1	Coupling Minor iron staining from 12.8 to 13.4 and at moderate staining at 14.8	12.1
18.3	Coupling Small white patches of glue/sealant at 20.6	18.3
24.4	Coupling – minor iron stain at 28.2	24.4
29.3	**Top of well screen** Heavy black encrustation from 29.3 to 32.0.	29.3
32.4	Screen weld/joint	32.4
35.4	Screen weld/joint Moderate to heavy black encrustation from 35.4 to 38.6	35.4
38.6	**Water level** Water very cloudy, difficult to assess because of visibility	38.6
41.9	Screen weld/joint – possible tear in screen at 45.2, water becoming clearer at 47.6	41.9
48.5	Screen weld/joint - water becoming cloudy at 50.0	48.5
51.0	Black sediments, on bottom, water very cloudy	51.0
51.0	**End of Inspection**	51.0

HATCH™	**Camera Inspection Report**	**Project** **Well W-19** Sheet 1	325967 **Before Flushing** of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	Inspector: A.Mills Started: Sept. 3/09 4:11 pm
Top of PVC Well Casing	0.0	57.01	Finished:Sept.3/09 4:30 pm
As-built bottom of well	59.5	-2.54	DVD No.:
			Note: No flocculant added

Depth (m)	**Description**	**Depth – DVD Cross Reference Depth (m)**
0.0	**Top of Casing**	0.0
1.2	Coupling	1.2
1.4	Pitless adaptor - iron staining at 1.7, possible leak at pitless adaptor	1.4
5.8	Coupling - minor rust on coupling, black horizontal line/stain at 6.4, iron staining at 7.2; possible crack at 8.0, not wet	5.8
12.0	Coupling	12.0
18.2	Coupling Heavy glue/sealant stains at 18.2, minor iron staining from 20.0 to 21.0	18.2
24.3	**Top of well screen**	24.3
27.4	Screen weld/joint Moderate black encrustation above the weld, from 27.1 to 27.4	27.4
30.2	Screen weld/joint – heavy black staining at the weld	30.2
33.7	Screen weld/joint – heavy black staining from 33.1 to 33.7 and just above water level at 36.2	33.7
36.4	**Water level** Water cloudy, clearing with depth. Screen in good condition from 41.8 to 47.2	36.4
49.1	Heavy iron encrustation from 49.1 to 51.0. Water becoming cloudy at 52.2., then clearing. Screen in good condition at 55.3	49.1
57.5	Water is black, high silt content	57.5
57.5	**End of Inspection**	57.5

HATCH™	Camera Inspection Report	**Project** 325967 **Well W-19 After Flushing** Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	Inspector: A.Mills Started: Sept. 4/09 12:02 pm Finished:Sept.4/09 12:24 pm DVD No.: Note: No flocculant or acid added
Top of PVC Well Casing	0.0	57.01	
As-built bottom of well	59.5	-2.54	

Depth (m)	**Description**	**Depth – DVD Cross Reference Depth (m)**
0.0	**Top of Casing**	0.0
1.2	Coupling	1.2
1.4	Pitless adaptor - iron staining at 1.7, possible leak in pitless adaptor	1.4
5.8	Coupling - minor rust on coupling, black horizontal line/stain at 6.4, iron staining at 7.2; possible crack at 8.0, not wet	5.8
12.0	Coupling	12.0
18.2	Coupling Heavy glue/sealant stains at 18.2, minor iron staining from 20.0 to 21.0	18.2
24.3	**Top of well screen**	24.3
27.4	Screen weld/joint Moderate black encrustation above the weld, from 27.1 to 27.4	27.4
30.2	Screen weld/joint – heavy black staining at the weld	30.2
33.7	Screen weld/joint – minor black staining from 33.1 to 33.7 and just above water level at 36.2	33.7
36.4	**Water level** Water clear, screen is in good condition from 36.4 to 47.2. Possible heavy calcium encrustation at 49.3. Water becoming black at 58.0.	36.4
59.0	**End of Inspection**	59.0

Camera Inspection Report

Project 325967
Well W-20 **Before Flushing**
Sheet 1 of 2

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	Inspector: A.Mills
Top of PVC Well Casing	0.0	56.01	Started: Sept. 4/09 10:42am Finished:Sept.4/09 11:03am
As-built bottom of well	64.0	-7.99	DVD No.: Note: No flocculant added

Depth (m)	**Description**	**Depth – DVD Cross Reference**
		Depth (m)
0.0	**Top of Casing**	0.0
0.4	Coupling	0.4
0.7	Coupling	0.7
0.9	Coupling	0.9
1.1	Coupling	1.1
1.6	Pitless adaptor Moderate iron staining at 6.1	1.6
7.0	Coupling Moderate to heavy iron staining at 8.6 to 11.7, possible leak in pitless adaptor	7.0
13.3	Coupling - moderate black staining at the coupling	13.3
19.4	Coupling	19.4
25.6	Coupling – heavy iron staining at 28.1	25.6
31.8	**Top of well screen** Moderate black encrustation at screen/casing join, heavy iron staining from 34.6 to 34.8	31.8
35.0	Screen weld/joint Heavy iron and black encrustation at 37.4 to 41.0	35.0
41.2	Screen weld/joint Minor black encrustation at the weld	41.2
42.0	Screen weld/joint Heavy iron staining at 42.6, heavy black encrustation from 43.9 to 44.0	42.0
44.8	**Water level** Water turbid, water clearing with depth.	44.8
50.6	Screen weld/joint – heavy iron staining at 55.6, water cloudy	50.6
56.0	Screen weld/joint	56.0

HATCH™	**Camera Inspection Report**	**Project** 325967 **Well W-20 Before Flushing** Sheet 1 of 2
59.9	Water black, bottom	59.9
59.9	**End of Inspection**	59.9

HATCH	**Camera Inspection Report**	**Project** **Well W-20** Sheet 1	325967 **After Flushing** of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	Inspector: A.Mills Started: Sept. 4/09 2:45am Finished:Sept.4/09 3:05am DVD No.: Note: No flocculant or acid added
Top of PVC Well Casing	0.0	56.01	
As-built bottom of well	64.0	-7.99	

Depth (m)	**Description**	**Depth – DVD Cross Reference**
		Depth (m)
0.0	**Top of Casing**	0.0
0.4	Coupling	0.4
0.7	Coupling	0.7
0.9	Coupling	0.9
1.1	Coupling	1.1
1.6	Pitless adaptor Moderate iron staining at 6.1	1.6
7.0	Coupling	7.0
13.3	Coupling	13.3
19.4	Coupling	19.4
25.6	Coupling	25.6
31.8	**Top of well screen** Minor black encrustation at 33.3	31.8
35.0	Screen weld/joint Heavy iron and black encrustation at weld and at 37.8	35.0
41.2	Screen weld/joint	41.2
44.9	**Water level** Water turbid, remaining cloudy to 60.0	44.9
55.9	Possible screen weld/joint – water cloudy	55.9
56.9	Water yellow in colour	56.9
59.0	Water black	59.0
60.0	**End of Inspection**	60.0

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Camera Inspection Report

Project 325967
Well W-21 **Before Flushing**
Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	
			Inspector: A.Mills
			Started: Sept.5/09 12:55 pm
Top of PVC Well Casing	0.0	53.99	Finished: Sept 5/09 1:15 pm
As-built bottom of well	56.5	-2.51	DVD No.:
			Note: No flocculant added

Depth (m)	**Description**	**Depth – DVD Cross Reference** **Depth (m)**
0.0	**Top of Casing**	0.0
0.3	Coupling	0.3
0.7	Coupling	0.7
1.5	Pitless adaptor	1.5
7.4	Coupling - glue staining at 9.9 and 10.5	7.4
13.7	Coupling	13.7
19.8	Coupling	19.8
25.9	Coupling	25.9
27.4	Coupling	27.4
32.2	Coupling	32.2
33.9	**Top of well screen** – screen is in good condition	33.9
36.1	Screen weld/joint – orange/tarnish at weld	36.1
39.0	Screen weld/joint - heavy black staining at the weld	39.0
39.2	**Water level** Water cloudy to 54.5. Large heavy iron stain at 42.3	39.2
44.9	Screen weld/joint	44.9
45.6	Screen weld/joint Black sediments in suspension at 51.0	45.6
55.1	Black sediments, soft bottom	55.1
55.1	**End of Inspection**	55.1

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Camera Inspection Report

Project 325967
Well W-21 **After Flushing**
Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)
Top of PVC Well Casing	0.0	53.99
As-built bottom of well	56.5	-2.51

Inspector: A.Mills
Started: Sept.5/09 3:00 pm
Finished: Sept 5/09 3:20 pm
DVD No.:
Note: No flocculant or acid added

Depth (m)	**Description**	**Depth – DVD Cross Reference** **Depth (m)**
0.0	**Top of Casing**	0.0
0.3	Coupling	0.3
0.7	Coupling	0.7
1.5	Pitless adaptor	1.5
7.4	Coupling - glue staining at 9.9 and 10.5	7.4
13.7	Coupling	13.7
19.8	Coupling	19.8
25.9	Coupling	25.9
27.4	Coupling	27.4
32.2	Coupling	32.2
33.9	**Top of well screen** – screen is in good condition	33.9
36.1	Screen weld/joint – orange/tarnish at weld	36.1
39.0	Screen weld/joint	39.0
39.5	**Water level** Water cloudy to bottom	39.5
44.9	Screen weld/joint	44.9
45.6	Screen weld/joint Black sediments in suspension at 51.0	45.6
55.0	Black sediments, soft bottom	55.0
55.0	**End of Inspection**	55.0

HATCH	Camera Inspection Report	**Project** 325967 **Well W-22 Before Flushing** Sheet 1 of 1

Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	Inspector: A.Mills Started: Sept. 5/09 1:20 pm Finished:Sept.5/09 1:40 pm DVD No.: Note: Flocculant added
Top of PVC Well Casing	0.0	52.26	
As-built bottom of well	60.0	-7.74	

Depth (m)	**Description**	**Depth – DVD Cross Reference** **Depth (m)**
0.0	**Top of Casing**	0.0
1.4	Pitless adaptor	1.4
5.1	Coupling – glue staining at 6.5	5.1
11.2	Coupling	11.2
17.3	Coupling	17.3
23.6	Coupling	23.6
29.8	Coupling	29.8
35.9	**Top of well screen** Screen in good condition, minor iron staining at 38.1	35.9
39.3	**Water level** Water turbid, clearing at 42.8	39.3
40.7	Possible screen weld/joint – screen in good condition at 42.8	40.7
45.5	Screen weld/joint	45.5
49.9	Screen weld/joint	49.9
50.2	Screen weld/joint	50.2
54.7	Screen weld/joint	54.7
59.1	Water becoming dark grey/black, soft bottom	59.1
59.1	**End of Inspection**	59.1

HATCH™

Camera Inspection Report

Project 325967
Well W-22 **After Flushing**
Sheet 1 of 1

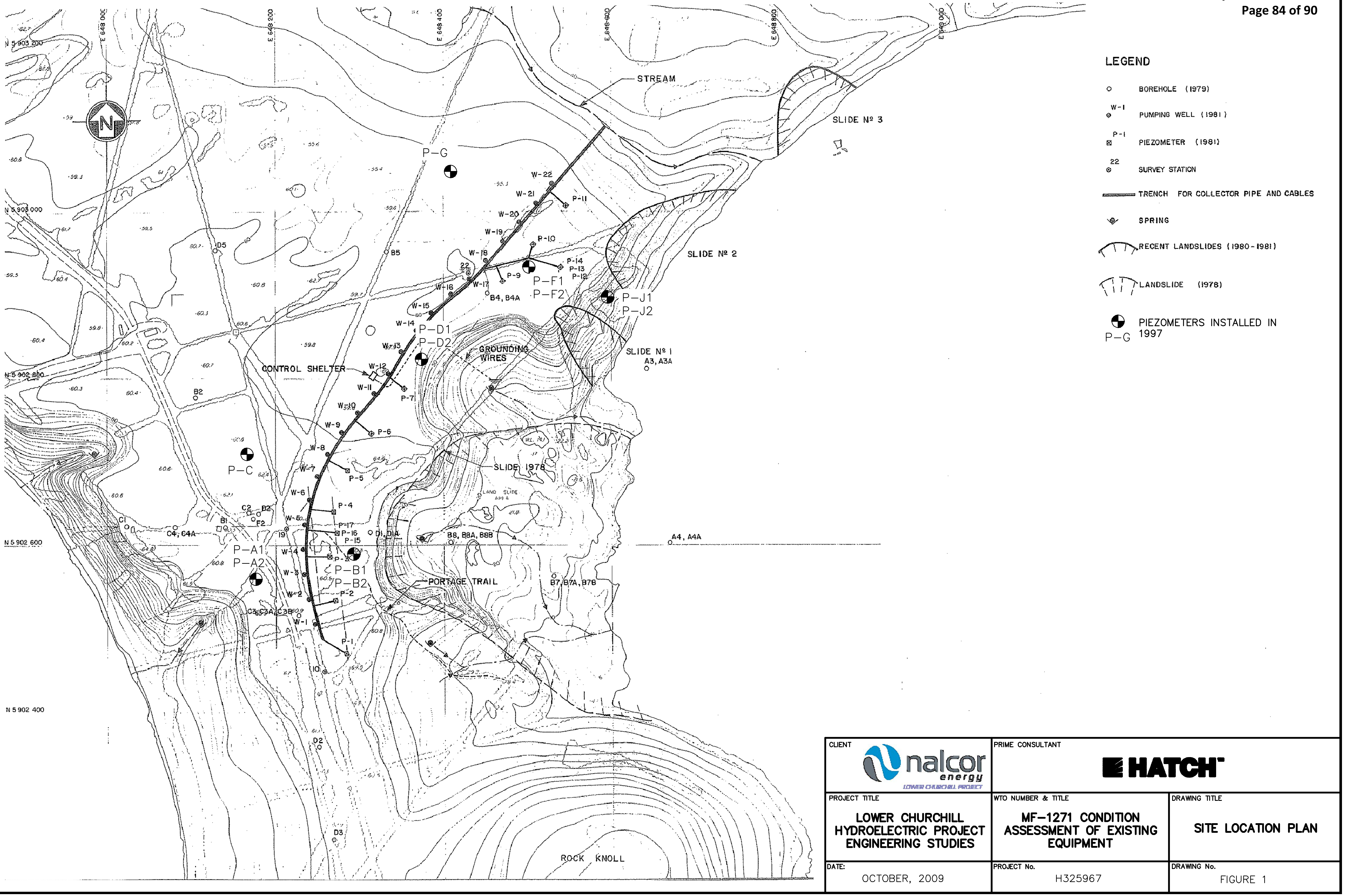
Nalcor
Inspection of Dewatering System
Muskrat Falls Hydro Site

	Depth (m)	Elevation (m)	Inspector: A.Mills Started: Sept. 5/09 3:30 pm
Top of PVC Well Casing	0.0	52.26	Finished:Sept.5/09 3:50 pm
As-built bottom of well	60.0	-7.74	DVD No.:
			Note: Flocculant added

Depth (m)	**Description**	**Depth – DVD Cross Reference** **Depth (m)**
0.0	**Top of Casing**	0.0
1.4	Pitless adaptor	1.4
5.1	Coupling – glue staining at 6.5	5.1
11.2	Coupling	11.2
17.3	Coupling	17.3
23.6	Coupling	23.6
29.8	Coupling	29.8
35.9	**Top of well screen** Screen in good condition, minor iron staining at 38.1	35.9
38.8	**Water level** Water turbid, no clearing to the bottom	38.8
40.7	Possible screen weld/joint	40.7
49.6	Possible screen weld/joint	49.6
54.8	Water becoming yellow at 54.8, dark grey/black at 56.6	54.8
57.7	Water black	57.7
57.7	**End of Inspection**	57.7

Appendix C

Figures



CLIENT

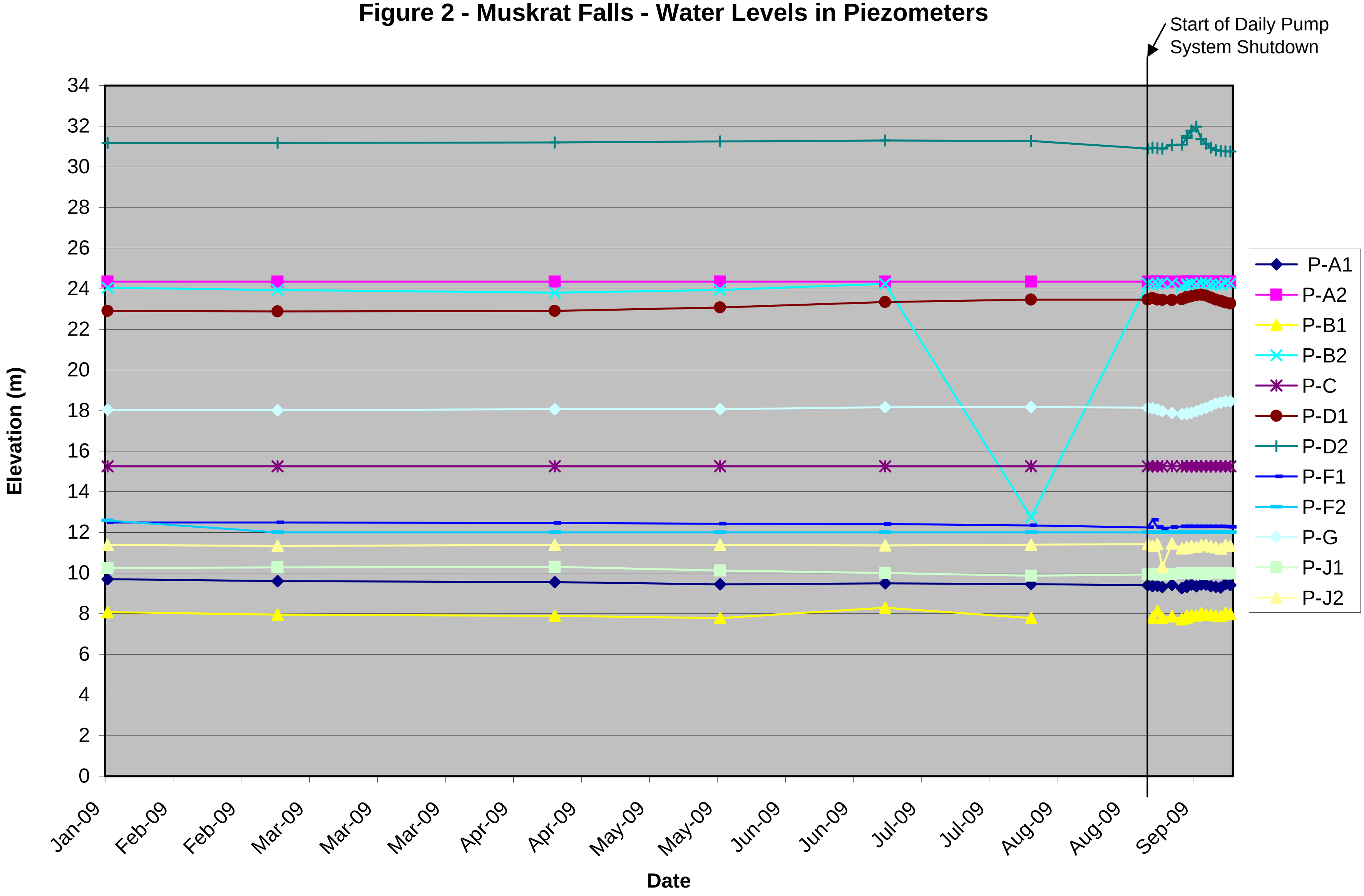
nalcor energy
LOWER CHURCHILL PROJECT

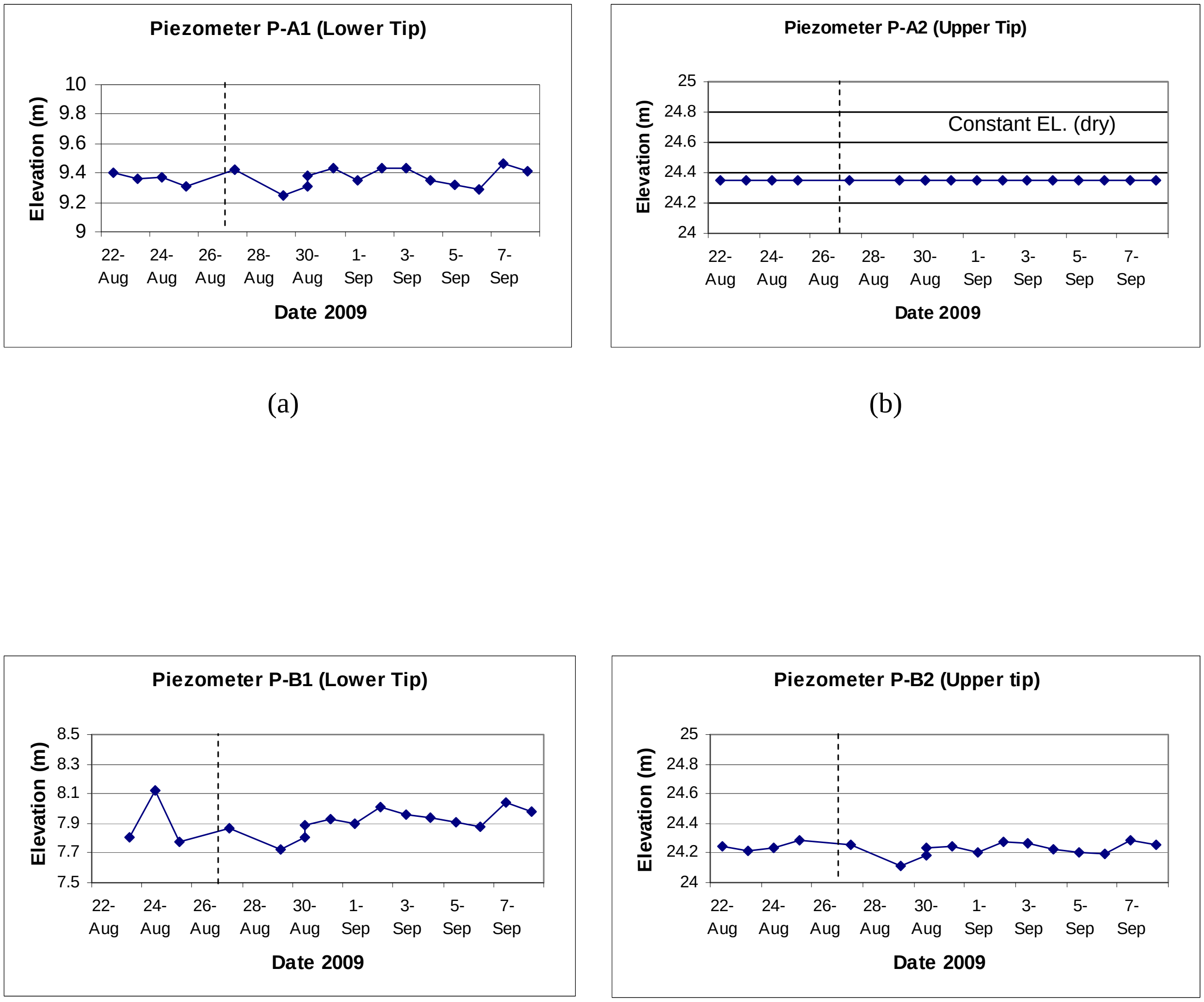
PRIME CONSULTANT

HATCH

PROJECT TITLE	WTO NUMBER & TITLE	DRAWING TITLE
LOWER CHURCHILL HYDROELECTRIC PROJECT ENGINEERING STUDIES	MF-1271 CONDITION ASSESSMENT OF EXISTING EQUIPMENT	SITE LOCATION PLAN
DATE: OCTOBER, 2009	PROJECT No. H325967	DRAWING No. FIGURE 1

Figure 2 - Muskrat Falls - Water Levels in Piezometers



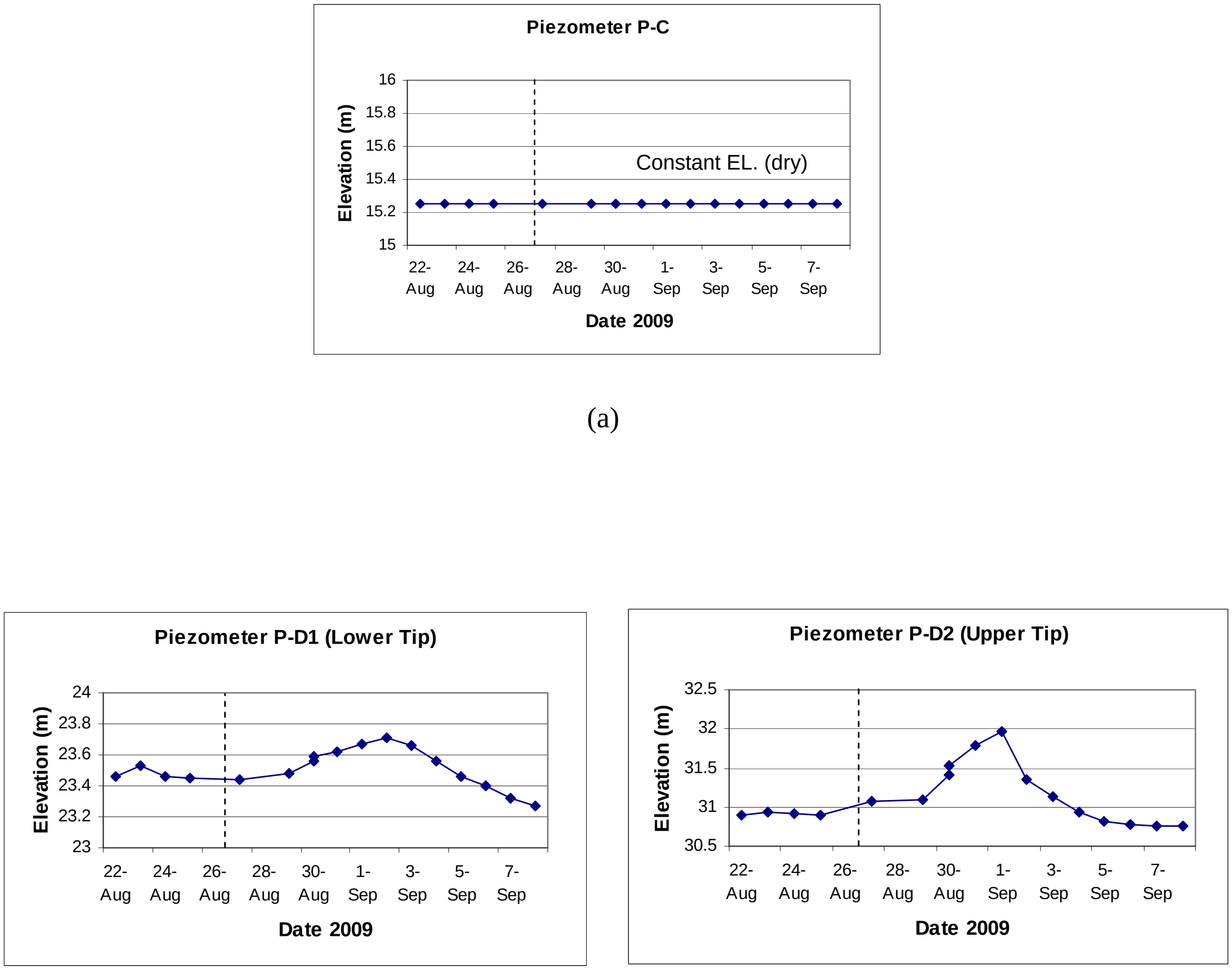


(a) (b)

(c) (d)

Figure 3 – Piezometer water level variations prior to and during the well inspection program:

(a) P-A1 lower tip, (b) P-A2 upper tip, (c) P-B1 lower tip and (d) P-B2 upper tip. Note: Daily shutdown of pump system commenced on August 27, 2009, shown as vertical dashed line.



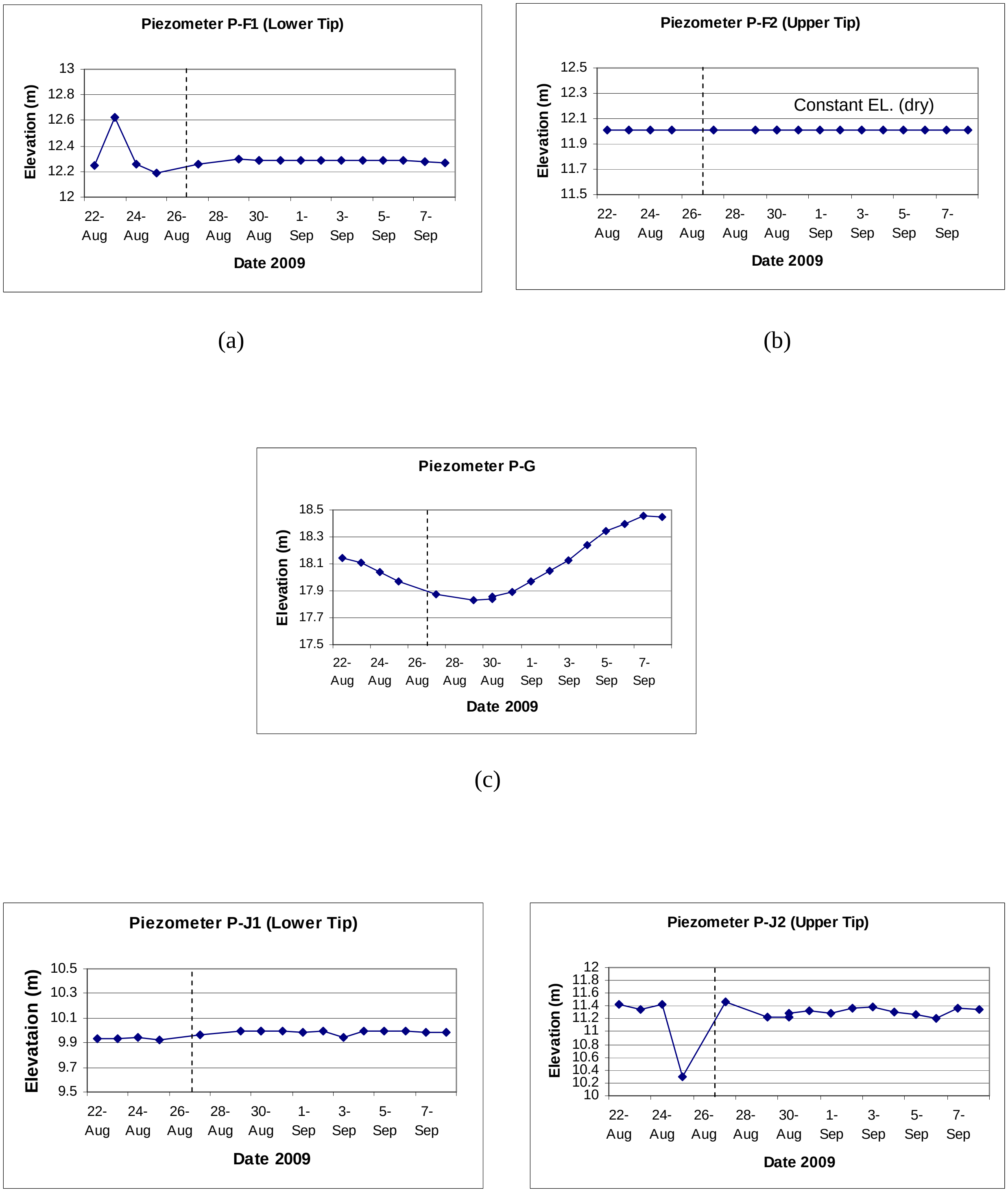
(a)

(b)

(c)

Figure 4 – Piezometer water level variations prior to and during the well inspection program:

(a) P-C, (b) P-D1 lower tip, (c) P-D2 upper tip. Note: Daily shutdown of pump system commenced on August 27, 2009, shown as vertical dashed line.



(a) (b)

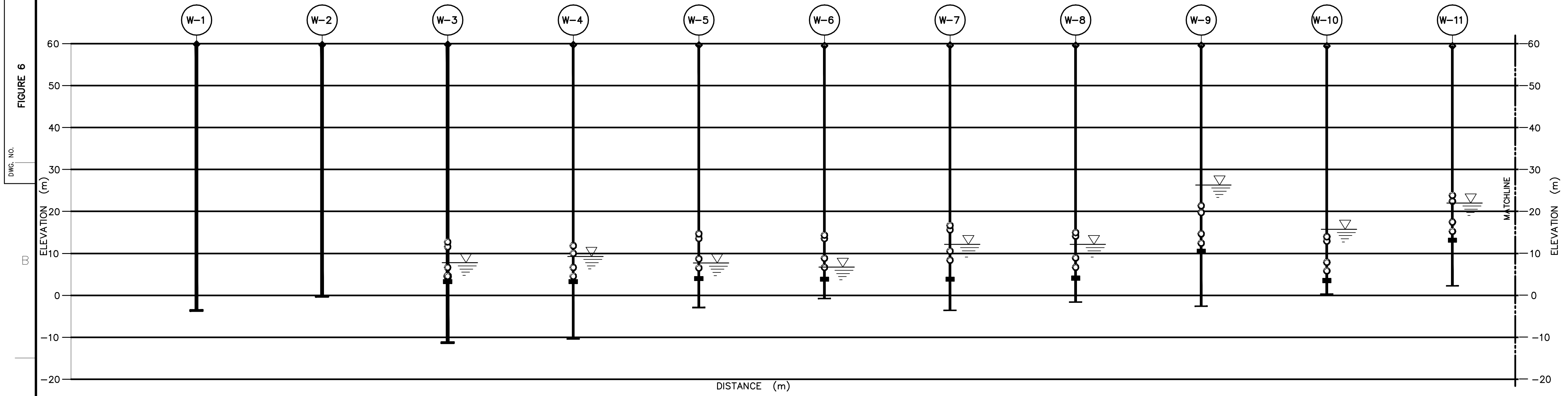
(c)

(d) (e)

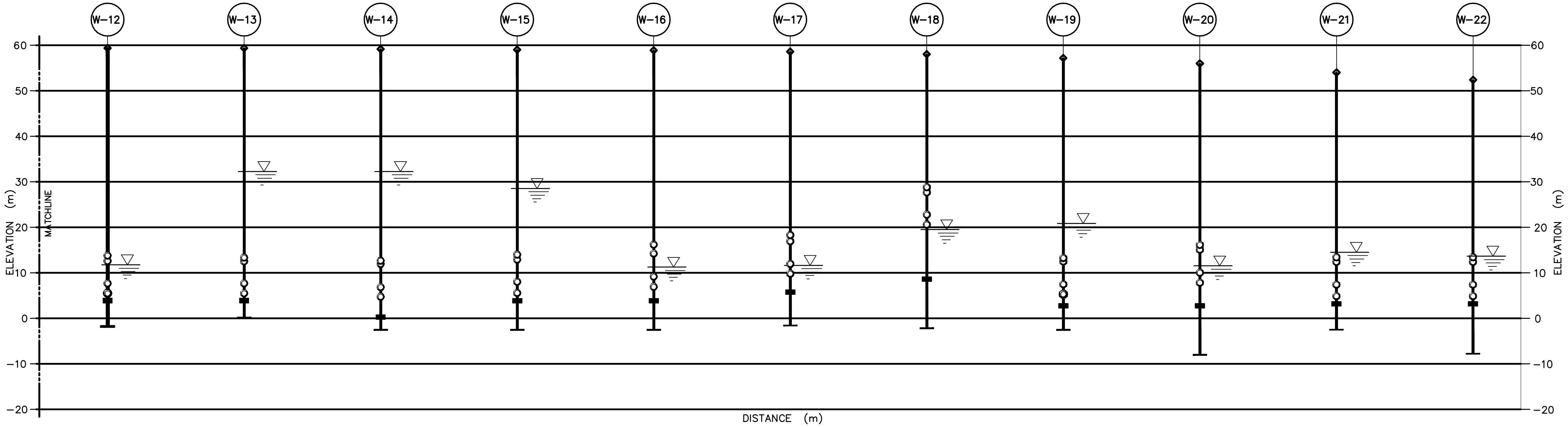
Figure 5 – Piezometer water level variations prior to and during the well inspection program:

(a) P-F1 lower tip, (b) P-F2 upper tip, (c) P-G , (d) P-J1 lower tip, (e) P-J2 upper tip. Note: Daily shutdown of pump system commenced on August 27, 2009, shown as vertical dashed line.

FIGURE 6



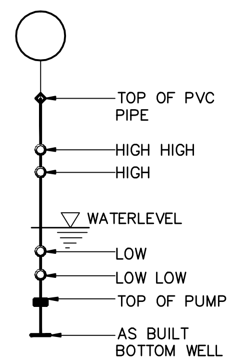
PROFILE OF PUMPWELL SYSTEM



PROFILE OF PUMPWELL SYSTEM

NOTE:

PUMP AND WELL DETAIL MEASURED DURING MUSKRAT FALLS WELL INSPECTION PROGRAM AUG. 27 – SEP 7, 2009.



TYPICAL WELL DETAIL

DRAWING NO.	DRAWING TITLE

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE

REVISIONS

REV.	ISSUE FOR	AUTH. BY	DATE

ISSUE AUTHORIZATION

HATCH

NALCOR ENERGY

LOWER CHURCHILL HYDROELECTRIC PROJECT

MF–1271 CONDITION ASSESSMENT OF EXISTING EQUIPMENT

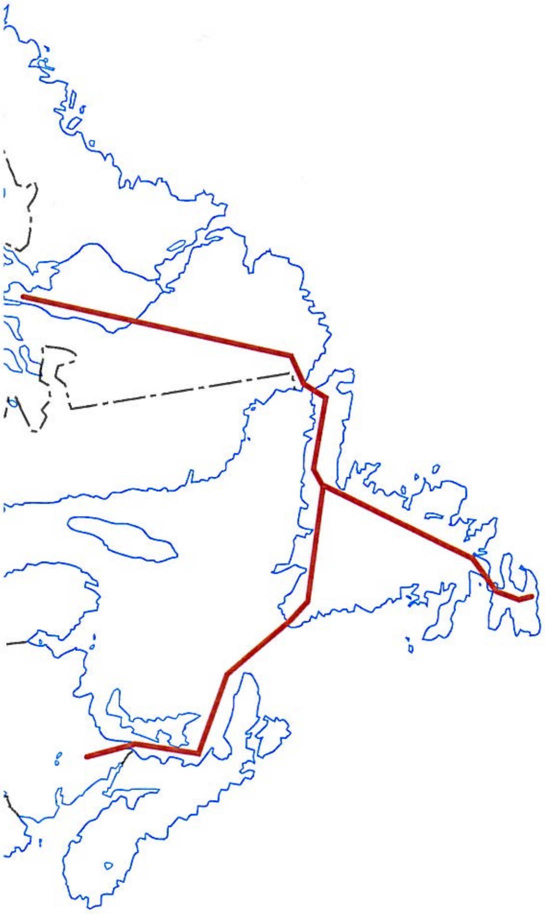
WELL SYSTEM PROFILE

DESIGNED BY
DRAWN BY
DATE
DATE
CHECKED BY
DISCIP. ENGR.
DATE
DATE
PROJ. DES. COORD.
PROJ. ENGR.
DATE
DATE
PROJ. MGR.
PROJECT NUMBER 325967
DATE
SCALE
DRAWING NO. FIGURE 6
REVISION A

CIVIL ELECTRICAL MECHANICAL GEOTECHNICAL HYDROTECHNICAL ARCHITECTURAL OTHER

Dec 09 , 2009 , 2:56pm Login name: kett1004
Drawing Name: C:\Documents and Settings\kett1004\Desktop\325967_FIGURE_6.dwg

nalcor energy



THE Lower Churchill PROJECT

April 2010

MF1272 - Installation of New Piezometers in the Muskrat Falls Pumpwell System

prepared by

HATCH™

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energy

THE Lower Churchill PROJECT

April 2010

MF1272 - Installation of New Piezometers in the Muskrat Falls Pumpwell System

REGISTERED PROFESSIONAL ENGINEER
NEWFOUNDLAND & LABRADOR
ROBERT WOOLGAR
SIGNATURE
May 27, 2010
DATE

PROVINCE OF NEWFOUNDLAND AND LABRADOR
PEG Newfoundland and Labrador
PERMIT HOLDER
This Permit Allows
HATCH LTD.
To practice Professional Engineering
in Newfoundland and Labrador.
Permit No. as issued by PEG D0090
which is valid for the year 2010

prepared by

HATCH™

Table of Contents

Executive Summary

Nalcor Energy - Lower Churchill Project (NE-LCP) is pursuing engineering studies with respect to the development of the hydroelectric potential of the Lower Churchill River at Gull Island and Muskrat Falls. At Muskrat Falls there is a large rock knoll and an overburden spur to the north that could be incorporated with a natural embankment dam. However, natural mass wasting processes were quickly eroding the spur and it was determined through engineering studies in the 1970's that the mass wasting could be arrested with the installation of a pump well system. The pump well system was installed in 1981. In 1997, Hatch installed 12 piezometers in 7 boreholes to monitor the groundwater levels in the area of the dewatering system.

The well system is currently 28 years old and was completed initially as a temporary measure. A 2008 Hatch report included several recommendations to extend the life of the system and ensure its continued operation for the next 10 years. The recommendations included the cleaning and inspection of 22 wells in the dewatering system and the installation of 8 new piezometers to be drilled at 4 locations to further assess groundwater conditions in the area of the dewatering system. This document presents the results of the 2009 piezometer installation program.

The historical and geological background and site characteristics are described in Section 1 followed by the scope of work in Section 2. A scope of work was developed prior to mobilization to the site and approved by NE-LCP. It should be noted that some of the tasks were modified slightly due to field conditions. Any changes from the proposed scope of work are summarized in Section 2 and discussed in more detail in Section 4 Drilling Field Program.

The piezometer drilling team consisted of a Hatch site supervisor, an engineering geologist from Jacques Whitford Stantec Limited, sub contracted by Hatch, that supervised the piezometer field program and a soils drilling contractor and helper from Lantech Drilling Services Inc. that completed the drilling and installation of the piezometers.

The Borehole Drilling Program commenced on August 19 and was completed on September 10, 2009. The locations of the boreholes are shown in Drawing 1054326-GE-01, found in Appendix A, Attachment C. All boreholes were advanced using a CME 75 truck mounted drill rig. A total of 5 boreholes were drilled and 8 piezometers were installed in the 5 boreholes. The specific details of the drilling are described in Section 4 and the piezometer construction details are shown in the borehole logs found in Appendix A, Attachment B. Soil samples were collected from the boreholes and grain size analyzes completed on the samples.

Water levels were collected in the piezometers, with the exception of P4A and P4B, on September 9, 2009 and Parrott Surveying surveyed the horizontal position and elevation for each borehole location. . Falling head tests were performed at two of the piezometers to assess the hydraulic conductivity (permeability) of the water bearing formation.

1. Historical and Geological Background

1.1 Site Characteristics

The site of Muskrat Falls on the Lower Churchill River, located about 30 km upstream from Happy Valley-Goose Bay in Labrador, has been recognized as a potential hydroelectric development for several decades. At this site, the Churchill River has a drop of about 15 m from el 18 m at the upstream side to el 3 m at the downstream side. Past studies contemplated raising the head to about 40 m.

The prominent features of the site include a rock knoll rising to almost 150 m in elevation. The rock knoll is connected to the left bank by a spur of land about 1 km long, which forms a natural barrier forcing the diversion of the Churchill River into a channel carved out south of the rock knoll. The spur rises to elevation 60 m and has a minimum width of 150 m on the south end, in the upstream - downstream direction.

1.2 Geology and Sediments

The Muskrat Falls site is underlain at a maximum depth of about 270 m by crystalline metamorphic rocks composed of granitic gneiss of Precambrian age, with some dark mafic bands and occasional irregular pegmatite stringers. In addition to the rock knoll which rises sharply from the buried valley floor, several exposures are found on the right bank of the river.

The Churchill River valley is preglacial in origin, and was formed largely by river action prior to the Pleistocene epoch. Subsequent widening and reshaping of the valley occurred during the Wisconsin glaciation period, about 13,000 years ago. An estimated thickness of 60 m of a deposit of sand, gravel and boulders filled the lower part of the reshaped bedrock valley during the course of glaciation. As the glacier retreated, the sea level rose and caused submergence of the valley by an estuary extending up to Gull Island. This inundation of the valley by the rising sea resulted in the deposition of marine and estuarine sediments in an environment of saline and brackish water.

Isostatic rise of the land relative to the sea then caused a gradual recession of the estuary and resulted in the deposition of a layer of fine sand, over marine clay sediments.

The sediments in the spur consist of four units.

a) Upper Sand (el 60 to 45 m) covering the terrain and consisting of uniform fine to medium sand approximately 10 to 15 m thick.

b) Stratified Drift (el 50 to -10 m) consisting of an upper marine clay deposit generally underlain with a varying thickness of sandy materials The sandy components dominate the southern 250 m long section of the spur against the rock knoll and constitutes an aquifer. The thickness of the upper clay increases toward the north.

It is noted that primarily these two units in (a) and (b) are engaged in the failure activity of the downstream face of the spur.

c) Lower Marine Clay (el -10 to -60 m) is a stratified impervious silty clay deposit.

d) Lower Aquifer (el -70 to -210 m) composed of pervious sand and gravel, and occupying the lower part of the buried valley.

Gullies and creeks exist along both the upstream and downstream slopes of the spur. The most prominent gully is found in the area of the three lakes at the north end of the spur. Numerous creeks and a small stream were found originating as springs at the sand and clay contact.

Hydrogeologically, there are two aquifers. The water level in the Lower Aquifer is at el +5 m which is considerably higher than the surface of the overlying marine clay unit suggesting confined characteristics. However, it is the hydrogeologic behaviour of the upper aquifer which has a dominant effect on bank stability. Recharge into this unit is from the northwest, through the upper sand unit and hydraulic connections in the stratified drift. Along the dewatering system alignment, the water level was originally at about el 30 m at the south side of the spur rising to el 47 m about half way and dropping to about 15 m at the north end.

1.3 Bank Instability and Groundwater Control Facilities

The banks of the Churchill River between Gull Island and Goose Bay are scarred by numerous landslides, some of which involve large quantities of overburden. Instability has affected the slopes of the spur, particularly the downstream slope, as well as the left bank of the river downstream from the spur. In 1978, a major landslide occurred on the south end of the spur resulting in the loss of a considerable portion of land in the downstream perimeter. Minor failures were further experienced in 1980-81. High piezometric water levels and steep hydraulic gradients in the sediments above river level and tailwater rapid drawdown effects due to the collapse of the downstream annual ice-dam have been the major causes contributing to instability.

In order to protect the remaining spur from further instability, a continuously pumped dewatering system was installed along the downstream shoulder of the spur in 1981. At the time of its installation, the system was considered to be “a temporary stabilization measure . . . and not a total defence against mass wasting” (Acres, 1994). The dewatering system was anticipated to lower the groundwater level in the spur from about el 30 m to at least el 15 m and preferably as low as el 3.5 m.

22 wells were installed in a line close to the edge of the downstream slope of the spur. The wells are spaced at 30 m with an average depth of 63 m. The drilling diameter was 300 mm with stainless steel screen and PVC riser pipe having an internal diameter of 150 mm. All the pumps are connected to a 300 mm diameter buried collector pipe, with 75 mm of insulation, finally discharging to an existing stream through an exposed corrugated steel pipe (SNC-Lavalin, 1982).

To monitor the groundwater regime, 17 piezometers (vibrating wire) were installed in 1981 but all were lost in 1984 due to a power surge from a lightning strike on the power line. In 1997, 12 standpipe piezometers were installed in 7 boreholes and these continue to be monitored. Subsequent records of operation of the well system have recorded pump functions only, namely pumping duration and the number of pump cycle initiations per day.

Nalcor Energy – Newfoundland and Labrador Hydro (NE-NLH) and Acres International staff carried out formal maintenance inspections in 1994, 1995 and in 1997 at which times some or all the pumps were retrieved, cleaned and reinstalled or replaced as necessary (Acres International, 1997). The NE-NLH Goose Bay office retains records of such maintenance activities in varying degrees of detail.

In 2007, Hatch conducted a site visit and testing of the pump well system with the objective of assessing the system conditions and making recommendations for a life extension of 10 years. Selected recommendations from the 2008 report are the basis for the work program described in this report.

1.4 Background Reports

Reports of previous site assessments are available as follows:

- SNC-Lavalin, "Muskrat Falls Dewatering System, Construction Report Operation and Maintenance Information", (1982).
- SNC-Lavalin, "Muskrat Falls Dewatering System, Engineering Assessment", (1982).
- Acres International, "Muskrat Falls Development", (1978).
- Acres International, "Muskrat Falls, Review of Dewatering System", (1994).
- Acres International, "Dewatering System Assessment and Rehabilitation", (1997).
- Acres International, "Standpipe Piezometer Installation Program Report", (1997 and 1998).
- Hatch Ltd, "The Lower Churchill Project, MF 1260 – Assessment of Existing Pumpwell System", (2008).

2. Scope of Work

A scope of work was developed prior to mobilization to the site and approved by NE-LCP. It should be noted that some of the tasks were modified slightly due to field conditions. Any changes from the proposed scope of work are summarized below and discussed in more detail in the appropriate subsection in Section 4: Drilling Field Program.

Following is a description of the scope of work:

- A geotechnical drill rig, ancillary equipment/tooling and personnel were mobilized to the Muskrat Falls site.
- A path was cleared to each drill site location by NE-NLH labourers using chainsaws.
- It was proposed to secure a suitable water supply from the Churchill River with adequate pumps to provide water for the drilling operation. However, a field inspection indicated that it would be more effective to draw water from the pond located at the north end of the property. A pump was set up at the pond location and hoses were laid from the pond to each drilling location.
- Drilling commenced at P2B using 4 ¼″ hollow stem augers, with the intention of converting to HW/NW casing washboring when the limit of augering was reached. However, difficult drilling conditions were encountered at P2B (heaving sands), which resulted in the borehole being abandoned at approximately 15 m depth. P2B was restarted approximately 2 m from the original location using HW casing.
- Conventional split spoon disturbed sampling was completed of unconsolidated soils with Standard Penetration Tests (SPT) at regular intervals in borehole P2B. In subsequent boreholes, testing was completed at selected locations to identify more permeable soils in with to install the piezometer screens. Samples collected by split spoon were inspected, logged and taken back to the laboratory for further testing and analysis.
- 50 mm diameter standpipe piezometers were installed at P2A and P2B. However, due to the difficult soil conditions encountered, the drilling at these locations took longer than expected. In order to complete the program within budget, the remaining borehole locations (P1, P3 and P4) were drilled only with HW/NW casing washboring, limited sampling was completed with particular attention to the anticipated zone of screen installation, and a nested installation was completed with two 25 mm piezometer pipes: one at an upper and one at a lower depth within the same drill hole. New drilling supplies had to be ordered and delivered to facilitate the change in method.
- A drilling additive fluid was used as required at each borehole to keep the hole open.
- Upon completion of drilling/sampling, each borehole was flushed of drill cuttings and supplementary drilling fluids, using clean, clear water.
- The boreholes were logged at the site by the drilling sub-contractor and engineering geologist. The proposed depth of boreholes was 40 m and 60 m. The precise depth of the borehole was determined based on the proposed depth defined by Hatch, previous boreholes in the area, and field conditions encountered. It was found that the formation encountered at a depth of 60 m (designated depth) in P2B was a dry clay, unsuitable for piezometer installation. The lower

piezometer was therefore installed in a water bearing zone at a depth of less than 60 m. The depths of boreholes are discussed in more detail in Section 4.

Following is a description of the monitoring well installation procedure:

- It was proposed that 150 mm of #40 silica sand be placed at the bottom of each borehole. A comparable material called course silag was used instead at the bottom of the borehole and as a filter pack material. The filter pack was placed around the screen and extended to about 600 mm above the screen.
- It was proposed to install a Casagrande-Type piezometer tip to the top of the sand base. However, based on experience and availability, the drilling contractor supplied PVC slotted screen. A 50 mm diameter No. 20 slot screen was installed at P2A and P2B and 25 mm diameter No. 10 slot screens were installed at P1, P3 and P4. A geosock was placed around the screen for piezometers P1, P3, and P4 as an added means of preventing fines from seeping into the piezometer. The geosock and No.10 slot screens were delivered with the new supplies that arrived at the site and were not available for installation at P2A and P2B.
- Coated 3/8″ bentonite pellets were placed to a minimum of 600 mm above the top of the silag sand. The bentonite pellets were left for a short period of time to hydrate before proceeding further with the installation.
- It was proposed to place a cement/bentonite powder grout mixture in each borehole from the top of the bentonite seal to the ground surface. However, the drilling contractor did not have a supply of grout when they first arrived at the site. Therefore, for the installation of 2009 P2A and 2009 P2B, the bentonite pellets were used instead of the grout mixture. Bentonite pellets are commonly used in this type of installation and work equally well as grout.
- For subsequent boreholes, P1, P3 and P4, a tremie tube was used to place a cement/bentonite powder grout mixture called Volclay in each borehole from the top of the bentonite seal to ground surface. The NW/HW drill casing was removed from the borehole in 100 cm to 150 cm increments as the borehole annulus was grouted. Grout volumes and application pressures were monitored during the grouting procedure.
- A steel protective casing fitted with a lockable cap was installed and excess materials were removed from the site.
- It was recommended that falling head tests be performed at each borehole to assess the permeability of the water bearing formation. This test involves adding a measured quantity of water to the piezometer and measuring the water level in the piezometer at specified times until the water level has returned to static or has stabilized. Due to time constraints, falling head tests were conducted only at two piezometer installations: P2A and P2B. The results of the tests are described in Section 4.2.
- The locations of the installed boreholes were surveyed (horizontally and vertically).

3. The Piezometer Drilling Program Team

The piezometer drilling program was completed by a team of specialists which included:

- A Hatch site supervisor that oversaw the completion of the program.
- An engineering geologist from Jacques Whitford Stantec Limited, sub contracted by Hatch, that supervised the piezometer field program, determined the piezometer locations in the field based on locations provided by Hatch, completed detailed logs and directed the piezometer installations.
- A soils drilling contractor and helper from Lantech Drilling Services Inc. that completed the drilling and installation of the piezometers, at the direction of the sub contractor.

4. The Drilling Field Program

The Borehole Drilling Program commenced on August 19 and was completed on September 10, 2009. The Piezometer locations were determined at the site on August 20, 2009.

A safety orientation was conducted at the Nalcor Energy - Lower Churchill Project (NE-LCP) office the morning of August 21, 2009. All personnel involved in the well inspection and piezometer installation field programs took part in the presentation and training and work commenced on site on the afternoon of August 21.

Securing the water supply for the drilling operations was one of the first tasks of the program and involved: clearing of brush from the pond to the general site area, completing minor excavations of the slope to the pond, mobilizing a suitable pump to the pond area and laying of hoses from the pump up to the drill site. While the water supply work was being completed, the drilling contractor unloaded equipment and set up at the first location.

All boreholes were advanced using a CME 75 truck mounted drill rig. A total of 8 piezometers in 5 boreholes were installed; the depths of each monitoring well and depth of water bearing zones are summarized in Table 4.1 and specific details of the drilling are described in the following subsections. The piezometer construction details are shown in the borehole logs found in Appendix A, Attachment B.

Parrott Surveying mobilized to the site on September 4, 2009. The locations of all boreholes were surveyed and the horizontal co-ordinates and elevation collected for each location and included in Table 4.1. The drilling operation was finished at the site on September 9, 2009 and the drilling contractor and all other personnel left the site on September 10, 2009.

Water levels were collected in the piezometers, with the exception of P4A and P4B, on September 9, 2009 and are shown in Table 4.1. The water levels were not collected in P4A and P4B as the piezometers were only completed on September 9 and water levels had not stabilized in the installations. Instructions were left for NE-NLH personnel to take water levels at a later date. Falling head testing was conducted on P2A and P2B on September 9, 2009 and is described in Section 4.2.

Daily summary sheets of the drilling and photographs are also found in Appendix A, Attachments D and E, respectively.

4.1 Piezometer Installation Details

4.1.1 Borehole P1

Borehole P1 is located approximately 20 m west of Piezometer P-C which was installed in 1997 (Drawing 1054326-GE-01, Appendix A, Attachment C). Piezometer P-C has recently become clogged or has collapsed and it is dry. The purpose of Borehole P1 is to replace Piezometer P-C.

Drilling of the borehole and installation of two standpipes was completed between August 31 and September 2, 2009. HW/NW casing and wash boring was used to advance the borehole and SPT measurements and split spoon samples were taken at the anticipated zone of screen installation or at zones where changes in formation were noted. This borehole is located in close proximity to P-C. The bottom of a P-C was installed at a depth of 45.45 m (in sand), below which a stiff clay was encountered to 59.67 m. Based on the findings in P-C and the conditions encountered in this drilling program, P1 was advanced to a total depth of 42.7 m and the deep piezometer was installed in fine sand.

The bottom of the piezometer tip for P1B (the lower piezometer) was installed at a depth of 42.58 m and the monitoring zone was installed from a depth of 39.53 m to 42.52 m. The bottom of the piezometer tip for P1A (the upper piezometer) was installed at a depth of 25.02 m and the monitoring zone was installed from a depth of 21.92 m to 24.97 m.

A 25 mm diameter, 3 m long, No. 10 slot PVC screen and silag filter pack was installed in both P1B and P1A. A geosock was placed over each screen to prevent the intake of fines. A bentonite pellet seal was placed above the screen of each installation and Volclay grout was placed above the upper seal to surface.

4.1.2 Boreholes P2A and P2B

These were the first boreholes completed for the program - drilling of two boreholes and installation of two standpipes was completed between August 22 and August 29, 2009. P2A and P2B are located approximately 80 m and 75 m north-west of W-11 respectively.

P2B was augered to a depth of 15 m. At this depth, sandy material had pushed up into the augers and there was the possibility that the augers would become stuck. The augers were pulled (with some loss of augers) and the borehole was abandoned at approximately 15 m depth; P2B was relocated approximately 2 m from the original location and HW/NW casing and wash boring was used to advance the borehole the rest of the depth.

As discussed in Section 2, Scope of Work, new supplies were ordered as a result of the difficult drilling conditions at P2B. However, it would take approximately 2 to 3 days for the new supplies to arrive and therefore P2B and P2A were completed with the supplies that were available. P2B was advanced to a total depth of 58.5 m, the designated depth for a deep piezometer. However, the formation at the bottom depth was a dry clay that was not suitable for piezometer installation. Based on the samples collected and driller's experience, it was decided to install the bottom tip of the piezometer at a depth of 47.95 m and the monitoring zone was installed from a depth of 44.85 m to 47.90 m, in a wet zone of silty clay.

A 50 mm diameter, 3 m long, No. 20 slot PVC screen and silag filter pack was installed, approximately 1.0 m of bentonite pellets were placed above the screen and silag was placed above the bentonite to a depth of about 13.7 m. A second bentonite seal was placed from 12.2 m to 13.7 m depth. Native sand was placed above the bentonite to the ground surface.

The drilling contractor then moved the rig approximately 10 m south-west of PB2 and advanced the shallow borehole (P2A) using HW/NW casing and wash boring. A compact fine sand was encountered from 29.0 m to 35.4 m and, therefore, the piezometer tip for P2A was installed at a depth of 33.53 m and the monitoring zone was installed from a depth of 30.43 m to 33.48 m in the fine sand.

A 50 mm diameter, 3 m long, No. 20 slot PVC screen with silag filter pack was installed, approximately 0.3 m of bentonite pellets were placed from 29.4 m to 29.7 m depth and silag was placed to 13.2 m depth. A second 1.5 m bentonite seal was placed above the silag, followed by native sand to the ground surface.

4.1.3 Borehole P3

Borehole P3 is located approximately 75 m east of W-9.

Drilling of the borehole and installation of two standpipes was completed between September 3 and September 6, 2009. The borehole was advanced to a total depth of 40.93 m. The total depth and the depth of the lower piezometer, although not as deep as the proposed depth of 60 m, was based on field conditions encountered in P1, P2 and P-C (1997).

HW/NW casing and wash boring was used to advance the borehole and SPT measurements and split spoon samples were taken at the anticipated zone of screen installation or at zones where changes in formation were noted.

The bottom of the piezometer tip for P3B (the lower piezometer) was installed at a depth of 40.63 m and the monitoring zone was installed from a depth of 37.58 m to 40.48 m in a 0.5 m zone of wet, medium sand and zones of silty clay. The bottom of the piezometer tip for P3A (the upper piezometer) was installed at a depth of 23.17 m and the monitoring zone was installed from a depth of 20.07 m to 23.12 m in a 0.3 m zone of fine sand and silty clay.

A 25 mm diameter, 3 m long, No. 10 slot PVC screen and silag filter pack was installed in both P3B and P3A. A bentonite pellet seal was placed above the lower screen from a depth of approximately 35.4 m to 36.6 m, 23.2 m to 23.8 m depth and 18.8 m to 19.4 m depth. Volclay grout was placed from 18.8 m depth to ground surface. Silag was placed between each of the seals and as a filter pack around the screen. A geosock was placed over each screen to prevent the intake of fines.

4.1.4 Borehole P4

Borehole P4 is located approximately 75 m west of W-16.

Drilling of the borehole and installation of two standpipes was completed between September 6 and September 9, 2009. The borehole was advanced to a total depth of 46.0 m. The total depth of the piezometer, although not as deep as the proposed depth of 60 m, was based on field conditions encountered in P1, P2 and P-C (1997).

HW/NW casing and wash boring was used to advance the borehole and SPT measurements and split spoon samples were taken at the anticipated zone of screen installation or at zones where changes in formation were noted.

The bottom of the piezometer tip for P4B (the lower piezometer) was installed at a depth of 44.07 m and the monitoring zone was installed from a depth of 40.97 m to 44.02 m in a zone of wet, silty sand. The bottom of the piezometer tip for P4A (the upper piezometer) was installed at a depth of 29.11 m and the monitoring zone was installed from a depth of 25.40 m to 29.06 m in a zone of silty clay with interbeds of medium grained sand.

A 25 mm diameter, 3 m long, No. 10 slot PVC screen and silag filter pack was installed in P4B and a 25 mm diameter, 3.7 m long, No. 10 slot PVC screen with silag filter pack was installed in P4A. The longer screen for P4A provides a greater surface area for infiltration/seepage of groundwater through the silty clay formation.

A bentonite pellet seal was placed above the bottom screen from a depth of approximately 38.5 m to 40.3 m, at 29.2 m to 30.7 m depth and 23.5 to 24.9 m depth. Volclay grout was placed from 23.5 m depth to ground surface. Silag was placed between each of the seals and as a filter pack around the screen. A geosock was placed over each screen to prevent the intake of fines.

4.2 Falling Head Test

A falling head test was performed at piezometer P2A and P2B on September 9, 2009. A static water level was measured in the piezometer and then approximately 40 litres of water was added to the piezometer. The water levels in the piezometers, following addition of water, were recorded for approximately 60 to 90 minutes. The equation below was used to calculate K_c, the hydraulic conductivity of the aquifer formation (after Hvorslev).

$$k_C = \frac{d^2 \cdot \ln\left[\frac{m \cdot L}{D} + \sqrt{1 + \left(\frac{mL}{D}\right)^2}\right]}{8 \cdot L \cdot (t_2 - t_1)} \ln\frac{H_1}{H_2}$$

Where:

D = Diameter, Screen Intake cm

d = Diameter, Standpipe cm

L = Length of Screen Intake cm

H_c = Constant Piezometric Head cm

m = Transformation Ratio, assumed equals 1

H_1 = Piezometric Head for t = t_1 cm

H_2 = Piezometric Head for t = t_2 cm

q = Flow of Water cm^3/sec

t = Time sec

r = Radius of Screen Intake cm

The calculated hydraulic conductivity of P2A is 2.793 $^{-05}$ cm/s which represents a silty sand. The calculated hydraulic conductivity of P2B is 2.150 $^{-06}$ cm/s which represents a clayey silt to silty clay. These results are consistent with the descriptions of the water bearing formations found in the borehole logs.

Table 5.1
Nalcor Energy - Muskrat Falls
2009 Piezometer Installation
Details of Piezometer Installations

Piezometer Number	Northing	Easting	Ground Surface Elevation (m)	Top of Bedrock (m)	End of Hole (m)	Elevation of Top of Protective Casing (m)	Bottom of Piezometer Tip (m)	Top of Monitoring Zone (m)	Bottom of Monitoring Zone (m)	Water Level Sept. 9/09
2009 P1A	5902903.1	648228.9	(61.01)	N/E	42.7 (18.31)	(61.84)	25.02 (35.99)	21.92 (39.09)	24.97 (36.04)	15.89 (45.95)
2009 P1B							42.58 (18.43)	39.53 (21.59)	42.52 (18.49)	26.08 (35.76)
2009 P2A	5903029.9	648290.9	(59.39)	N/E	35.37 (24.02)	(60.33)	33.53 (25.86)	30.43 (28.96)	33.48 (25.91)	17.86 (42.47)
2009 P2B	5903032.8	648296	(59.45)	N/E	58.50 (0.95)	(60.27)	47.95 (11.50)	44.85 (14.60)	47.90 (11.55)	24.63 (35.64)
2009 P3A	5902950.1	648369.8	(58.39)	N/E	40.93 (17.46)	(59.21)	23.17 (35.22)	20.07 (38.32)	23.12 (35.27)	14.88 (44.33)
2009 P3B							40.63 (17.76)	37.58 (20.81)	40.48 (17.91)	23.96 (35.25)
2009 P4A	5903119.9	648378.9	(54.26)	N/E	46.0 (8.26)	(55.02)	29.11 (25.15)	25.40 (28.86)	29.06 (25.20)	N/A
2009 P4B							44.07 (10.19)	40.97 (13.29)	44.02 (10.24)	N/A

N/E - Not Encountered N/A Not Available
x,y,z coordinates provided by Neil Parrott Surveys Ltd.
( ) - indicates elevations in meters

5. Conclusions and Recommendations

Eight new piezometers were successfully installed at the Muskrat Falls site and initial water levels have been collected. The piezometer locations have been surveyed horizontally and vertically and the locations were cleared of any drilling debris. Locks were placed on the protective casings at each location and the keys were given to NE-NLH personnel. The locations of the new piezometer have been reviewed with NE-NLH personnel so that water levels can be collected at the new piezometers as part of their monthly program of water level measurements at the site.

Recommendations with respect to the new and 1997 piezometers include:

- Installation of a data acquisition system and automatic data transmission for all piezometers. This proposed system was outlined in the Hatch Ltd. report "The Lower Churchill Project, MF 1260 – Assessment of Existing Pumpwell System", (2008) and the specifications and a cost estimate was provided in Appendix D of that report.
- Once 6 to 7 new wells have been drilled and installed as outlined in the recommendations of the report: "Lower Churchill Project, MF 1271 – Evaluation of Existing Wells, Pumps and Related Infrastructure in the Muskrat Falls Pumpwell System", (2010), then existing wells W-2, W-4, W-9, W-10, W-15 and W-21 would be used for back-up pumping. It is recommended that standpipes be installed inside these wells, permitting collection of water level elevations and providing additional information about the performance of the system. Connection of these wells to the data acquisition system is also recommended.
- Until such time as the system is automatic, recording of the piezometric elevations should continue to be undertaken on a frequent basis (monthly). It is recommended that the eight new piezometers be incorporated into the NE-NLH monthly program of water level measurements at the Muskrat Falls site.

Appendix A

Monitoring Well Installations – Muskrat Falls, Labrador

Report Completed by Jacques Whitford Stantec Limited, September 30, 2009

Jacques Whitford Stantec Limited
607 Torbay Road
St. John's, NL A1A 4Y6
Tel: (709) 576-1458
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Stantec

September 30, 2009
File: 1054326

Hatch Limited
Bally Rou Place, Suite E200
280 Torbay Road
St. John's, NL A1A 3W8

Attention: Mr. Paul Curran, P.Eng.

Dear Mr. Curran:

Re: Monitor Well Installations – Muskrat Falls, Labrador

Further to your authorization to proceed, Jacques Whitford Stantec Limited (JWSL) has completed the installation of eight (8) new piezometers at the Muskrat Falls site, some 30 km west of Goose Bay, Labrador. The program was carried out between August 19 and September 9, 2009, in general accordance with the Terms of Reference for this component of the work. Daily field reports were compiled and are appended to this report.

At predetermined locations, a total of five boreholes were drilled at four sites in NW size using a skidder-mounted CME-75 drill rig provided by Lantech of Dieppe, NB. Borehole depths ranged from between 35.4 m and 58.5 m below existing ground surface. Piezometers were installed in the completed boreholes as further outlined below. The Piezometer Location Plan, 1054326-GE-01, is appended to this report.

Approximate borehole locations were initially provided on a drawing by Hatch Limited. Actual locations were modified in the field due to site constraints. In order for this component of the project to remain on budget, it was decided to nest smaller piezometers within each borehole and reduce sampling intervals to a minimum. Coordinates, including northings, eastings and ground surface elevations were provided by Neil Parrott Surveys Limited of Goose Bay, NL under contract to JWSL. These coordinates are provided on the Borehole Records included with this report.

Conventional split spoon soil sampling was carried out in detail in borehole 2009 P2B and at selected locations within the other boreholes to identify more permeable soils in which to install the piezometer screens. All soil samples were visually assessed in the field and returned to our St.John's office for more detailed examination. Selected samples were submitted to our laboratory for more comprehensive testing and classification. The results of the laboratory testing are included within this report and are presented on the Borehole Records.

Initial water level readings were obtained from each piezometer, with the exception of 2009 P4 A&B, on September 9, 2009. Stabilized water levels for 2009 P4 A&B were to be gathered by Nalcor at a later date. All readings were taken from the top of the protective casings as requested by Nalcor and are recorded on the Borehole Records. The Borehole Record Water Level column indicator is located at the corresponding actual depth/elevation below ground surface. The results of these readings are provided within each Borehole Record.

Monitor well Nos. 2009 P1 A&B, 2009 P3 A&B and 2009 P4 A&B, each comprise two 25 mm ID nested piezometers installed at different depths. Monitor well Nos. 2009 P2A and 2009 P2B, each comprise a single 50 mm ID piezometer. All piezometer screens were installed using coarse silag material as a filter pack and fill material, were isolated top and bottom with coated bentonite pellets and except for 2009 P2A and 2009 P2B, were fitted with a geosock material and were grouted to near ground surface using a Volclay grout mixture. Each installation was fitted with a cemented in above-ground steel protector, aluminum access cap and keyed-alike lock. Within each cap, each of the piezometers was identified 'A' or 'B', where applicable.

A selection of site photographs illustrating the work carried out is appended.

We trust this report meets your present requirements. Should any additional information be required, please do not hesitate to contact our office at your convenience.

Sincerely,

JACQUES WHITFORD STANTEC LIMITED

Lorne Boone

Lorne Boone, M.Eng., P.Eng., P.Geo.
Senior Associate

Attachments:	Attachment A	Symbols and Terms used on Borehole and Monitor Well Records
	Attachment B	Borehole Records
	Attachment C	Figures 1 and 2: Gradation Curves Figure 3: Stratigraphic Section New Piezometer Location Plan No. 1054326-GE-01
	Attachment D	Daily Field Reports
	Attachment E	Site Photos

ATTACHMENT A

Symbols and Terms used on Borehole and Monitor Well Records

SYMBOLS AND TERMS USED ON BOREHOLE AND TEST PIT RECORDS

SOIL DESCRIPTION

Terminology describing common soil genesis:

Topsoil	- mixture of soil and humus capable of supporting vegetative growth
Peat	- mixture of visible and invisible fragments of decayed organic matter
Till	- unstratified glacial deposit which may range from clay to boulders
Fill	- material below the surface identified as placed by humans (excluding buried services)

Terminology describing soil structure:

Desiccated	- having visible signs of weathering by oxidization of clay minerals, shrinkage cracks, etc.
Fissured	- having cracks, and hence a blocky structure
Varved	- composed of regular alternating layers of silt and clay
Stratified	- composed of alternating successions of different soil types, e.g. silt and sand
Layer	- > 75 mm in thickness
Seam	- 2 mm to 75 mm in thickness
Parting	- < 2 mm in thickness

Terminology describing soil types:
The classification of soil types are made on the basis of grain size and plasticity in accordance with the Unified Soil Classification System (USCS) (ASTM D 2487 or D 2488). The classification excludes particles larger than 76 mm (3 inches). The USCS provides a group symbol (e.g. SM) and group name (e.g. silty sand) for identification.

Terminology describing cobbles, boulders, and non-matrix materials (organic matter or debris):
Terminology describing materials outside the USCS, (e.g. particles larger than 76 mm, visible organic matter, construction debris) is based upon the proportion of these materials present:

Trace, or occasional	Less than 10%
Some	10-20%
Frequent	> 20%

Terminology describing compactness of cohesionless soils:
The standard terminology to describe cohesionless soils includes compactness (formerly "relative density"), as determined by the Standard Penetration Test N-Value (also known as N-Index). A relationship between compactness condition and N-Value is shown in the following table.

Compactness Condition	SPT N-Value
Very Loose	<4
Loose	4-10
Compact	10-30
Dense	30-50
Very Dense	>50

Terminology describing consistency of cohesive soils:
The standard terminology to describe cohesive soils includes the consistency, which is based on undrained shear strength as measured by *in situ* vane tests, penetrometer tests, or unconfined compression tests.

Consistency	Undrained Shear Strength	
	kips/sq.ft.	kPa
Very Soft	<0.25	<12.5
Soft	0.25 - 0.5	12.5 - 25
Firm	0.5 - 1.0	25 - 50
Stiff	1.0 - 2.0	50 – 100
Very Stiff	2.0 - 4.0	100 - 200
Hard	>4.0	>200

ROCK DESCRIPTION

Terminology describing rock quality:

RQD	Rock Mass Quality
0-25	*Very Poor Quality - Very Severely Fractured, Crushed*
25-50	*Poor Quality- Severely Fractured, Shattered or Very Blocky*
50-75	*Fair Quality - Fractured, Blocky*
75-90	*Good Quality - Moderately Jointed, Sound*
90-100	*Excellent Quality - Intact, Very Sound*

Rock quality classification is based on a modified core recovery percentage (RQD) in which all pieces of sound core over 100 mm long are counted as recovery. The smaller pieces are considered to be due to close shearing, jointing, faulting, or weathering in the rock mass and are not counted. RQD was originally intended to be done on N-size core; however, it can be used on different core sizes if the bulk of the fractures caused by drilling stresses are easily distinguishable from *in situ* fractures. The terminology describing rock mass quality based on RQD is subjective and is underlain by the presumption that sound strong rock is of higher engineering value than fractured weak rock.

Terminology describing rock mass:

Spacing (mm)	Joint Classification	Bedding, Laminations, Bands
> 6000	*Extremely Wide*	-
2000-6000	*Very Wide*	*Very Thick*
600-2000	*Wide*	*Thick*
200-600	*Moderate*	*Medium*
60-200	*Close*	*Thin*
20-60	*Very Close*	*Very Thin*
<20	*Extremely Close*	*Laminated*
<6	-	*Thinly Laminated*

Terminology describing rock strength:

Strength Classification	Grade	Unconfined Compressive Strength (MPa)
Extremely Weak	R0	< 1
Very Weak	R1	1 – 5
Weak	R2	5 – 25
Medium Strong	R3	25 – 50
Strong	R4	50 – 100
Very Strong	R5	100 – 250
Extremely Strong	R6	> 250

Terminology describing rock weathering:

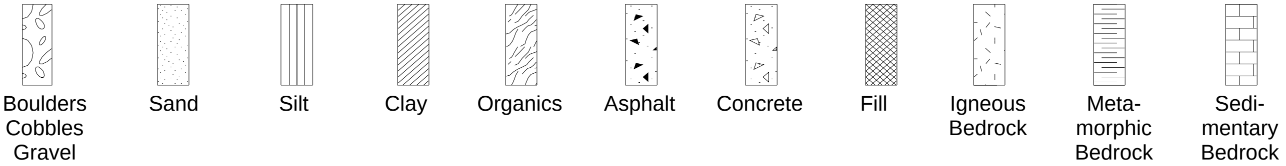
Term	Symbol	Description
Fresh	W1	No visible signs of rock weathering. Slight discolouration along major discontinuities
Slightly Weathered	W2	Discoloration indicates weathering of rock on discontinuity surfaces. All the rock material may be discoloured.
Moderately Weathered	W3	Less than half the rock is decomposed and/or disintegrated into soil.
Highly Weathered	W4	More than half the rock is decomposed and/or disintegrated into soil.
Completely Weathered	W5	All the rock material is decomposed and/or disintegrated into soil. The original mass structure is still largely intact.

Solid Core Recovery (SCR):
Solid core recovery is defined as the cumulative length of all solid (at full diameter) core in the core barrel divided by the length drilled and is recorded as a percentage on a per run basis.

Fracture Index (FI):
Fracture Index is defined as the number of naturally occurring fractures occurring per 0.3 m length of core. The Fracture Index is reported as a simple count of fractures. For > 25 fractures / 0.3 m length, the Fracture Index is reported as >25.

STRATA PLOT

Strata plots symbolize the soil or bedrock description. They are combinations of the following basic symbols. The dimensions within the strata symbols are not indicative of the particle size, layer thickness, etc.



SAMPLE TYPE

SS	Split spoon sample (obtained by performing the Standard Penetration Test)
ST	Shelby tube or thin wall tube
DP	Direct-Push sample (small diameter tube sampler hydraulically advanced)
PS	Piston sample
BS	Bulk sample
WS	Wash sample
HQ, NQ, BQ, etc.	Rock core samples obtained with the use of standard size diamond coring bits.

WATER LEVEL MEASUREMENT

▼	measured in standpipe, piezometer, or well
▽	inferred

RECOVERY

For soil samples, the recovery is recorded as the length of the soil sample recovered. For rock core, recovery (or total core recovery - TCR) is defined as the total cumulative length of all core recovered in the core barrel divided by the length drilled and is recorded as a percentage on a per run basis.

N-VALUE

Numbers in this column are the field results of the Standard Penetration Test: the number of blows of a 140 pound (64 kg) hammer falling 30 inches (760 mm), required to drive a 2 inch (50.8 mm) O.D. split spoon sampler one foot (305 mm) into the soil. For split spoon samples where insufficient penetration was achieved and N-values cannot be presented, the number of blows are reported over sampler penetration in millimetres (e.g. 50/75). Some design methods make use of N value corrected for various factors such as overburden pressure, energy ratio, borehole diameter, etc. No corrections have been applied to the N-values presented on the log.

DYNAMIC CONE PENETRATION TEST (DCPT)

Dynamic cone penetration tests are performed using a standard 60 degree apex cone connected to A size drill rods with the same standard fall height and weight as the Standard Penetration Test. The DCPT value is the number of blows of the hammer required to drive the cone one foot (305 mm) into the soil. The DCPT is used as a probe to assess soil variability.

OTHER TESTS

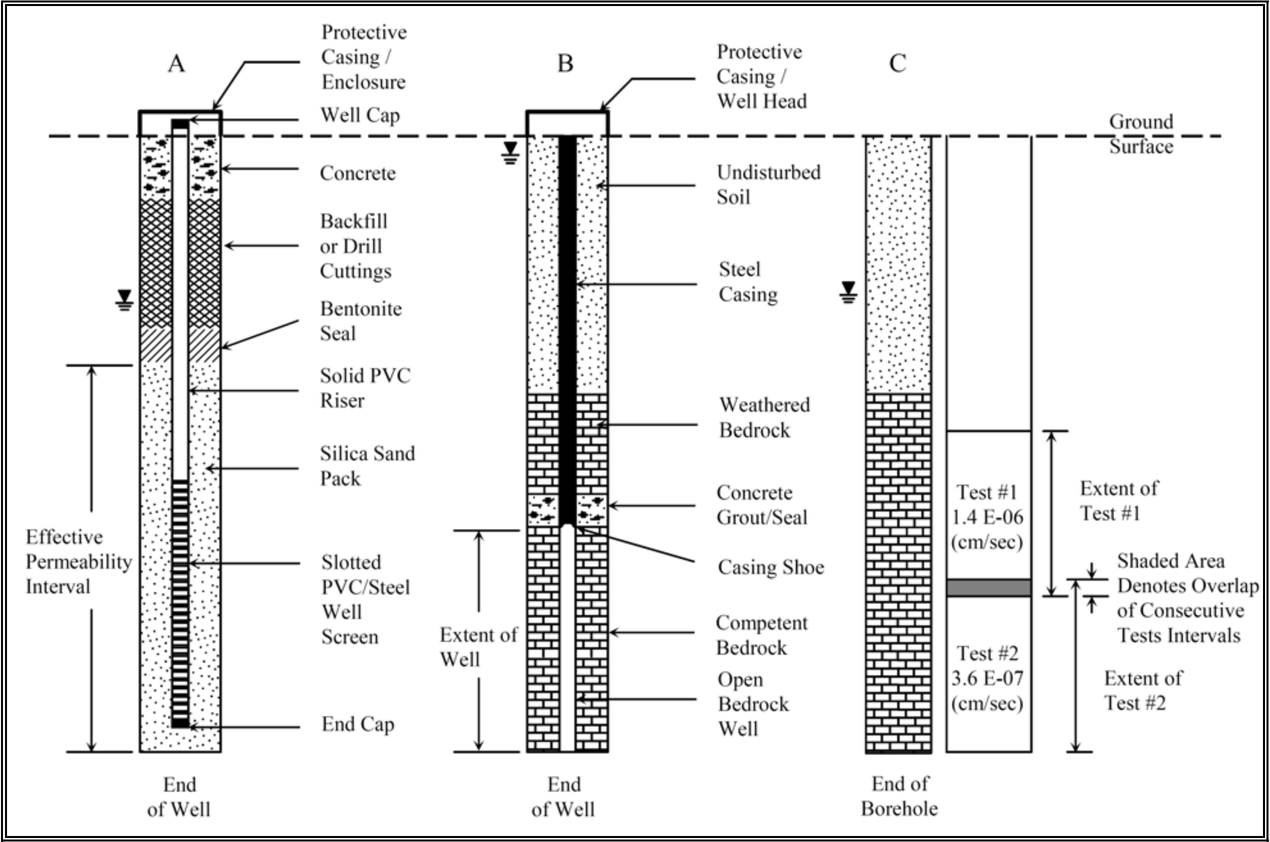
S	Sieve analysis
H	Hydrometer analysis
k	Laboratory permeability
γ	Unit weight
G_s	Specific gravity of soil particles
CD	Consolidated drained triaxial
CU	Consolidated undrained triaxial with pore pressure measurements
UU	Unconsolidated undrained triaxial
DS	Direct Shear
C	Consolidation
Q_u	Unconfined compression
I_p	Point Load Index (I_p on Borehole Record equals $I_p(50)$ in which the index is corrected to a reference diameter of 50 mm)

⊤↓	Single packer permeability test; test interval from depth shown to bottom of borehole
⌶	Double packer permeability test; test interval as indicated
○↓	Falling head permeability test using casing
▽↓	Falling head permeability test using well point or piezometer

SYMBOLS AND TERMS USED ON MONITOR WELL, WATER WELL AND ENVIRONMENTAL RECORDS

Well Construction and Permeability Testing

Basic symbols used in typical monitor or water well and piezometer construction are shown below. The well construction symbols or materials shown below may be combined or altered to suit a particular application. The diagram shows: A) a typical piezometer or monitor well in overburden; B) a typical water well in bedrock; C) borehole permeability test results in bedrock.



Apparent Moisture Content

Terminology used to describe apparent moisture content at the time of borehole drilling or test pit excavation.

Symbol	Description
D	Dry – containing little or no moisture
M	Moist – containing some moisture without having ‘free’ moisture
S	Saturated – ‘free’ moisture can drain from material

Terminology Describing Contamination

Symbol	Description
PID	Photo Ionization Detector (readings in ppm)
TPH	Total Petroleum Hydrocarbon concentration (readings in ppm based on mass)
ppm	Parts Per Million (measurement of concentration, mg/kg or mg/L)
nd	Not Detected – below limit of quantification (LOQ)

Apparent Hydrocarbon Odour

Terminology used to describe apparent hydrocarbon odour at the time of borehole drilling or test pit excavation.

Value	Description
0	No apparent odour
1	Slight odour
2	Moderate odour
3	Strong odour

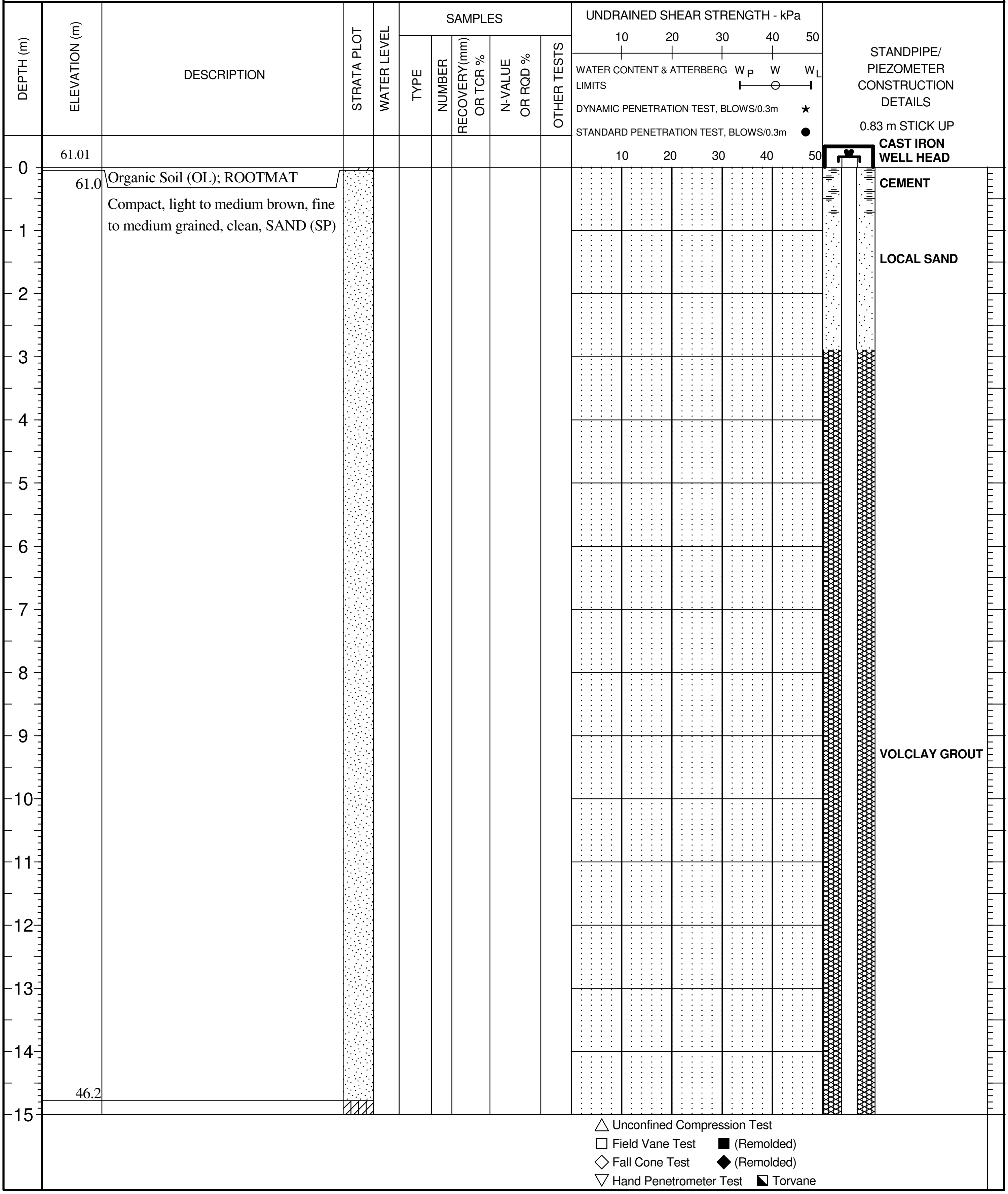
ATTACHMENT B

Borehole Records

Stantec

BOREHOLE RECORD

BOREHOLE No. 2009 P1 A&B
PAGE 1 of 3
CLIENT Hatch Ltd.
PROJECT New Piezometer Installations
LOCATION Muskrat Falls, Labrador
DATES (mm-dd-yy): BORING 8-31-09 to 9-2-09
N 5902903.07 m E 648228.87 m
WATER LEVEL 15.89 m 26.08 m
PROJECT No. 1054326
DRILLING METHOD Wash Boring
SIZE NW
DATUM Geodetic



Stantec

BOREHOLE RECORD

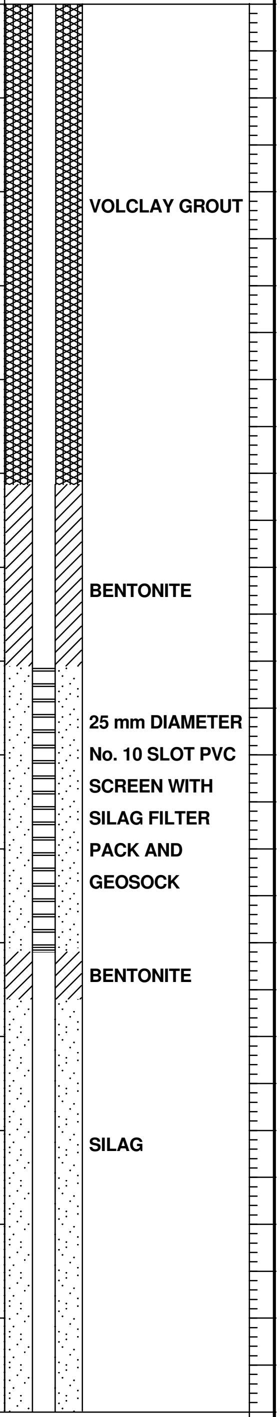
BOREHOLE No. 2009 P1 A&B
PAGE 2 of 3
CLIENT Hatch Ltd.
PROJECT No. 1054326
PROJECT New Piezometer Installations
DRILLING METHOD Wash Boring
LOCATION Muskrat Falls, Labrador
N 5902903.07 m E 648228.87 m
SIZE NW
DATES (mm-dd-yy): BORING 8-31-09 to 9-2-09
WATER LEVEL 15.89 m 26.08 m
DATUM Geodetic

DEPTH (m)	ELEVATION (m)	DESCRIPTION	WATER LEVEL
		Continued from Previous Page	
15		Soft to firm, medium grey, silty CLAY (CL-ML) interbedded with thin layers of fine grained silty sand	
15.89		-P1 A water level at 15.89 m depth below top of casing on September 9, 2009	▼
24	37.0	Soft, medium to dark grey, wet, silty CLAY (CL-ML)	
26.08		-P1 B water level at 26.08 m depth below top of casing on September 9, 2009	▼
30			

SAMPLES: TYPE, NUMBER, RECOVERY(mm) OR TCR %, N-VALUE OR RQD %, OTHER TESTS

UNDRAINED SHEAR STRENGTH - kPa: 10 20 30 40 50
WATER CONTENT & ATTERBERG LIMITS W_P W W_L
DYNAMIC PENETRATION TEST, BLOWS/0.3m ★
STANDARD PENETRATION TEST, BLOWS/0.3m ●
10 20 30 40 50

STANDPIPE/ PIEZOMETER CONSTRUCTION DETAILS



△ Unconfined Compression Test
☐ Field Vane Test ■ (Remolded)
◇ Fall Cone Test ◆ (Remolded)
▽ Hand Penetrometer Test ◪ Torvane

Stantec

BOREHOLE RECORD

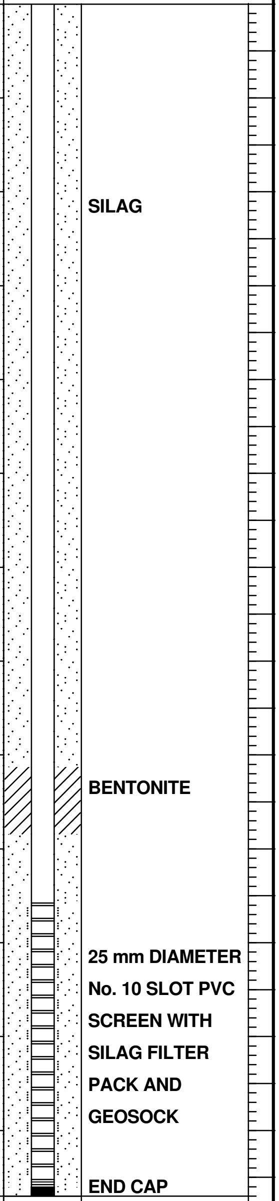
BOREHOLE No. 2009 P1 A&B
PAGE 3 of 3
CLIENT Hatch Ltd.
PROJECT New Piezometer Installations
LOCATION Muskrat Falls, Labrador
DATES (mm-dd-yy): BORING 8-31-09 to 9-2-09
N 5902903.07 m E 648228.87 m
WATER LEVEL 15.89 m 26.08 m
PROJECT No. 1054326
DRILLING METHOD Wash Boring
SIZE NW
DATUM Geodetic

Continued from Previous Page

DEPTH (m)	ELEVATION (m)	DESCRIPTION	SAMPLES TYPE	NUMBER	RECOVERY(mm) OR TCR %	N-VALUE OR RQD %	OTHER TESTS
42	19.1 18.7	Compact, wet, medium grey, fine SAND (SP)	SS	1	405	4	S
	18.3	Soft, wet, medium grey, silty CLAY (CL-ML)					
		End of Borehole					

UNDRAINED SHEAR STRENGTH - kPa: 10 20 30 40 50
WATER CONTENT & ATTERBERG LIMITS W_P W W_L
DYNAMIC PENETRATION TEST, BLOWS/0.3m ★
STANDARD PENETRATION TEST, BLOWS/0.3m ●

STANDPIPE/ PIEZOMETER CONSTRUCTION DETAILS



△ Unconfined Compression Test
☐ Field Vane Test ■ (Remolded)
◇ Fall Cone Test ◆ (Remolded)
▽ Hand Penetrometer Test ◪ Torvane

Stantec

BOREHOLE RECORD

BOREHOLE No. 2009 P2A
PAGE 1 of 3

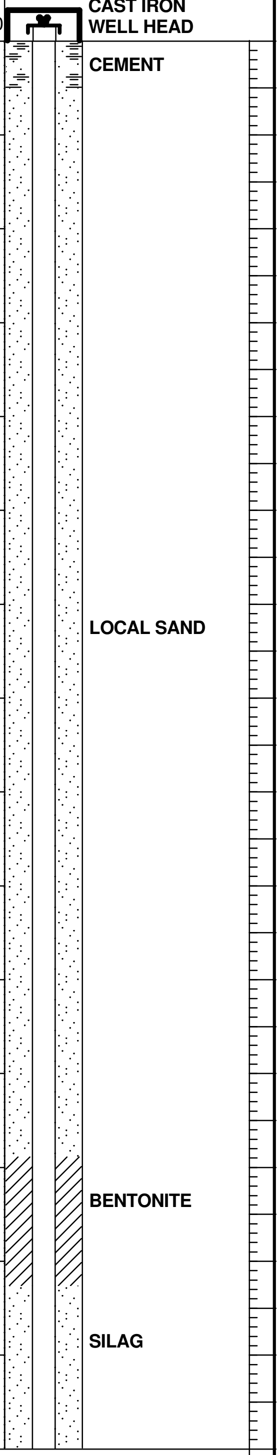
CLIENT Hatch Ltd.
PROJECT New Piezometer Installations
LOCATION Muskrat Falls, Labrador
DATES (mm-dd-yy): BORING 8-28-09 to 8-30-09
N 5903029.95 m E 648290.94 m
WATER LEVEL 17.86 m
PROJECT No. 1054326
DRILLING METHOD Wash Boring
SIZE NW
DATUM Geodetic

DEPTH (m)	ELEVATION (m)	DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES: TYPE	NUMBER	RECOVERY(mm) OR TCR %	N-VALUE OR RQD %	OTHER TESTS
0	59.39								
	59.3	Organic Soil (OL): ROOTMAT							
		Loose to compact, light brown to grey, fine SAND (SP)							
12	47.2	Soft, medium grey, silty CLAY (CL-ML)							
15									

UNDRAINED SHEAR STRENGTH - kPa: 10 20 30 40 50
WATER CONTENT & ATTERBERG LIMITS W_P W W_L
DYNAMIC PENETRATION TEST, BLOWS/0.3m ★
STANDARD PENETRATION TEST, BLOWS/0.3m ●
10 20 30 40 50

STANDPIPE/ PIEZOMETER CONSTRUCTION DETAILS

0.94 m STICK UP



△ Unconfined Compression Test
☐ Field Vane Test ■ (Remolded)
◇ Fall Cone Test ◆ (Remolded)
▽ Hand Penetrometer Test ◪ Torvane

Stantec

BOREHOLE RECORD

BOREHOLE No. 2009 P2A
PAGE 2 of 3
CLIENT **Hatch Ltd.**
PROJECT No. **1054326**
PROJECT **New Piezometer Installations**
DRILLING METHOD **Wash Boring**
LOCATION **Muskrat Falls, Labrador**
N **5903029.95 m** E **648290.94 m**
SIZE **NW**
DATES (mm-dd-yy): BORING **8-28-09 to 8-30-09**
WATER LEVEL **17.86 m**
DATUM **Geodetic**

DEPTH (m)	ELEVATION (m)	DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY(mm) OR TCR %	SAMPLES N-VALUE OR RQD %	SAMPLES OTHER TESTS	UNDRAINED SHEAR STRENGTH - kPa	STANDPIPE/ PIEZOMETER CONSTRUCTION DETAILS
		Continued from Previous Page									
15											
16											
17		-P2 A water level at 17.86 m depth below top of casing on September 9, 2009									
18				▼							
19											
20											
21	38.1										
		Loose to compact, medium grey, fine SAND (SP)									SILAG
22											
23											
24											
25											
26											
27											
28											
29	30.4	Compact, medium grey, fine SAND (SP)									BENTONITE
30											

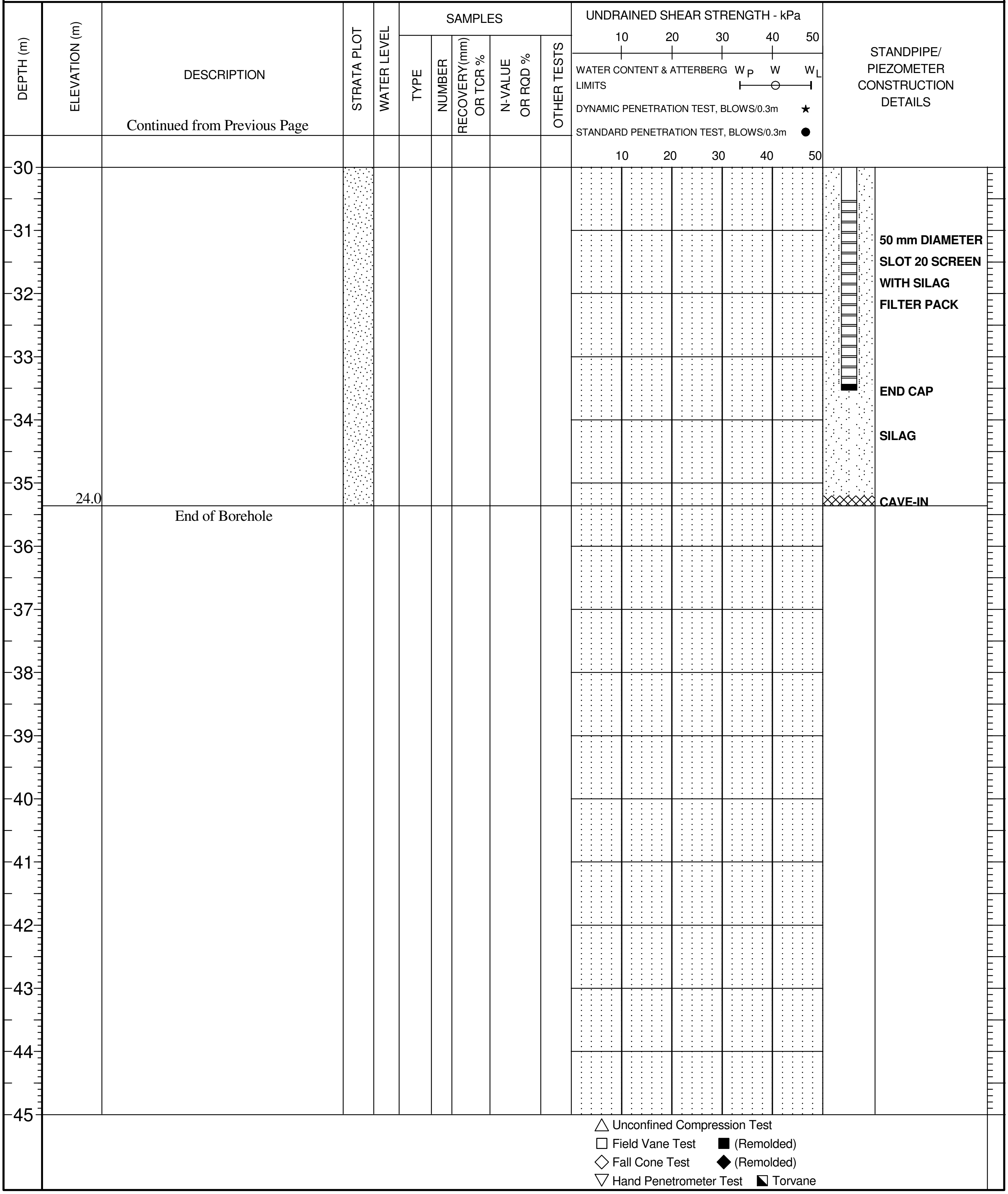
UNDRAINED SHEAR STRENGTH - kPa: 10 20 30 40 50
WATER CONTENT & ATTERBERG LIMITS W_P W W_L
DYNAMIC PENETRATION TEST, BLOWS/0.3m ★
STANDARD PENETRATION TEST, BLOWS/0.3m ●
10 20 30 40 50

△ Unconfined Compression Test
☐ Field Vane Test ■ (Remolded)
◇ Fall Cone Test ◆ (Remolded)
▽ Hand Penetrometer Test ◪ Torvane

Stantec

BOREHOLE RECORD

BOREHOLE No. 2009 P2A
PAGE 3 of 3
CLIENT Hatch Ltd.
PROJECT No. 1054326
PROJECT New Piezometer Installations
DRILLING METHOD Wash Boring
LOCATION Muskrat Falls, Labrador
N 5903029.95 m E 648290.94 m
SIZE NW
DATES (mm-dd-yy): BORING 8-28-09 to 8-30-09
WATER LEVEL 17.86 m
DATUM Geodetic



Continued from Previous Page

24.0

End of Borehole

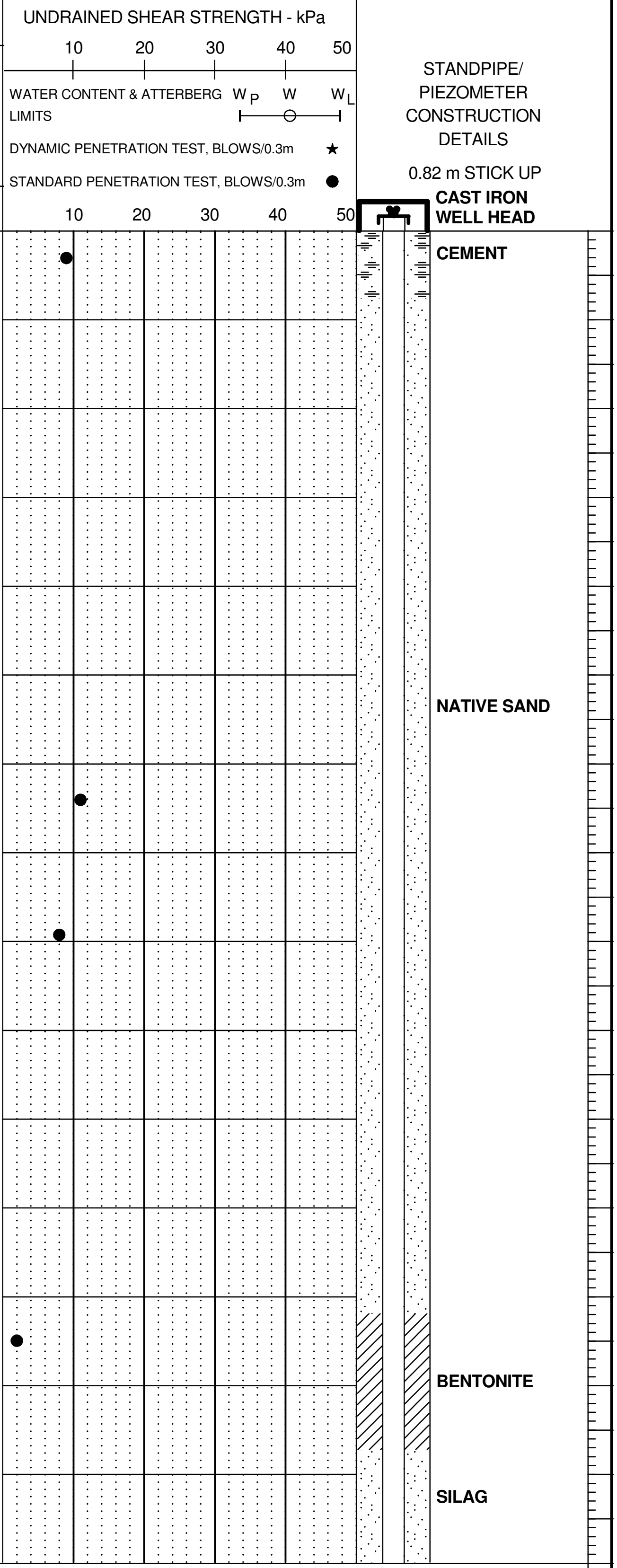
Stantec

BOREHOLE RECORD

BOREHOLE No. 2009 P2B
PAGE 1 of 4

CLIENT Hatch Ltd.
PROJECT New Piezometer Installations
LOCATION Muskrat Falls, Labrador
DATES (mm-dd-yy): BORING 8-22-09 to 8-27-09
N 5903032.79 m E 648296.03 m
WATER LEVEL 24.63 m
PROJECT No. 1054326
DRILLING METHOD Wash Boring
SIZE NW
DATUM Geodetic

DEPTH (m)	ELEVATION (m)	DESCRIPTION	TYPE	NUMBER	RECOVERY(mm) OR TCR %	N-VALUE OR RQD %	OTHER TESTS
0	59.45	Organic Soil (OL): ROOTMAT	SS	1	405	9	
	59.4	Loose to compact, light brown to grey, fine SAND (SP); trace to some organics					
			SS	2	430	11	
			SS	3	535	8	
	47.2	Soft, medium grey, silty CLAY (CL-ML)	SS	4	560	2	



△ Unconfined Compression Test
☐ Field Vane Test ■ (Remolded)
◇ Fall Cone Test ◆ (Remolded)
▽ Hand Penetrometer Test ◪ Torvane

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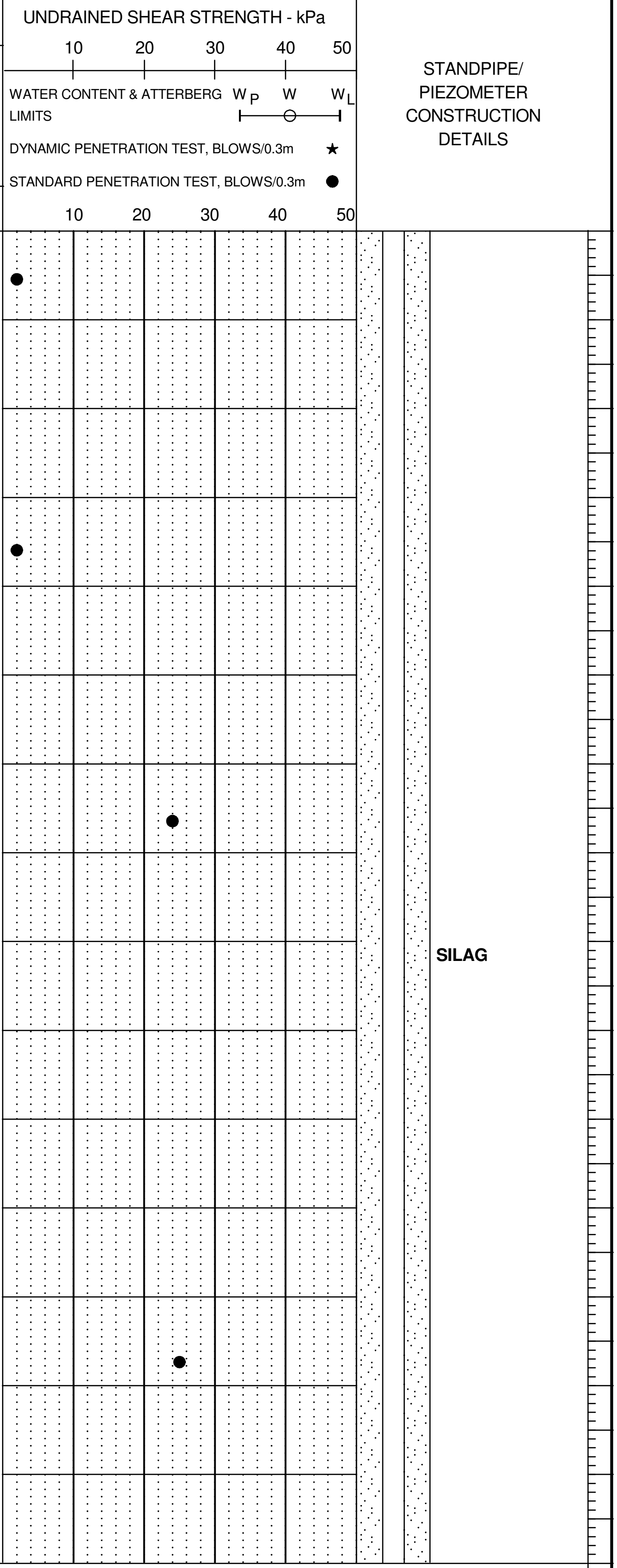
BOREHOLE RECORD

BOREHOLE No. 2009 P2B
PAGE 2 of 4
CLIENT Hatch Ltd.
PROJECT No. 1054326
PROJECT New Piezometer Installations
DRILLING METHOD Wash Boring
LOCATION Muskrat Falls, Labrador
N 5903032.79 m E 648296.03 m
SIZE NW
DATES (mm-dd-yy): BORING 8-22-09 to 8-27-09
WATER LEVEL 24.63 m
DATUM Geodetic

DEPTH (m)	ELEVATION (m)	DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	NUMBER	RECOVERY(mm) OR TCR %	N-VALUE OR RQD %	OTHER TESTS
		Continued from Previous Page							
15.5					SS	5	610	2	
18.6					SS	6	125	2	
21.3	38.1	Loose to compact, medium grey, fine SAND (SP)							
21.6					SS	7	355	24	
24.6		-P2B water level at 24.63 m depth below top of casing on September 9, 2009		▼					
27.7					SS	8	280	25	



△ Unconfined Compression Test
☐ Field Vane Test ■ (Remolded)
◇ Fall Cone Test ◆ (Remolded)
▽ Hand Penetrometer Test ◪ Torvane

Stantec

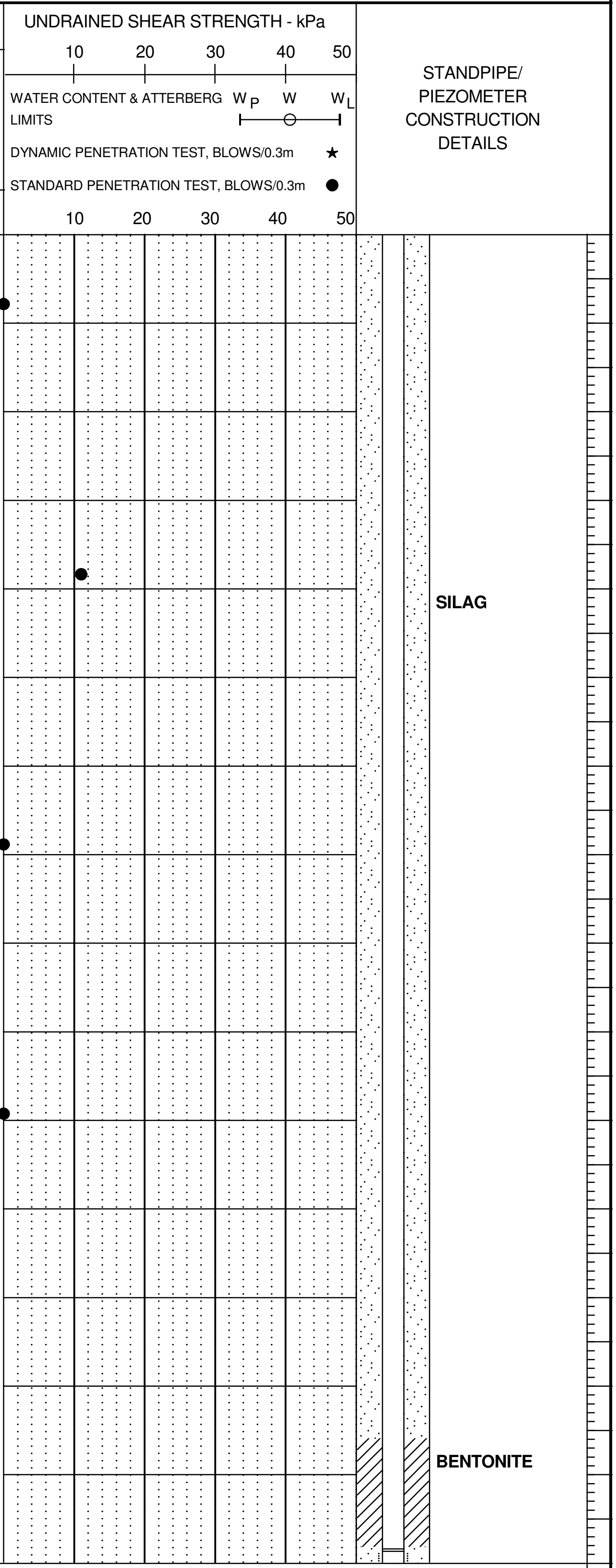
BOREHOLE RECORD

BOREHOLE No. 2009 P2B
PAGE 3 of 4

CLIENT Hatch Ltd.
PROJECT New Piezometer Installations
LOCATION Muskrat Falls, Labrador N 5903032.79 m E 648296.03 m
DATES (mm-dd-yy): BORING 8-22-09 to 8-27-09
WATER LEVEL 24.63 m
PROJECT No. 1054326
DRILLING METHOD Wash Boring
SIZE NW
DATUM Geodetic

Continued from Previous Page

DEPTH (m)	ELEVATION (m)	DESCRIPTION	TYPE	NUMBER	RECOVERY(mm) OR TCR %	N-VALUE OR RQD %	OTHER TESTS
30	29.0						
	28.9	Very loose, medium grey, sandy silt and clay	SS	9	610	0	
31	28.4	Soft, medium grey, clayey SILT					
		Compact, wet, medium grey fine SAND (SP)					
34			SS	10	280	11	
36	22.9	Stiff, medium grey, silty CLAY (CL-ML)					
37			SS	11	280	0	
40			SS	12	430	0	
45							

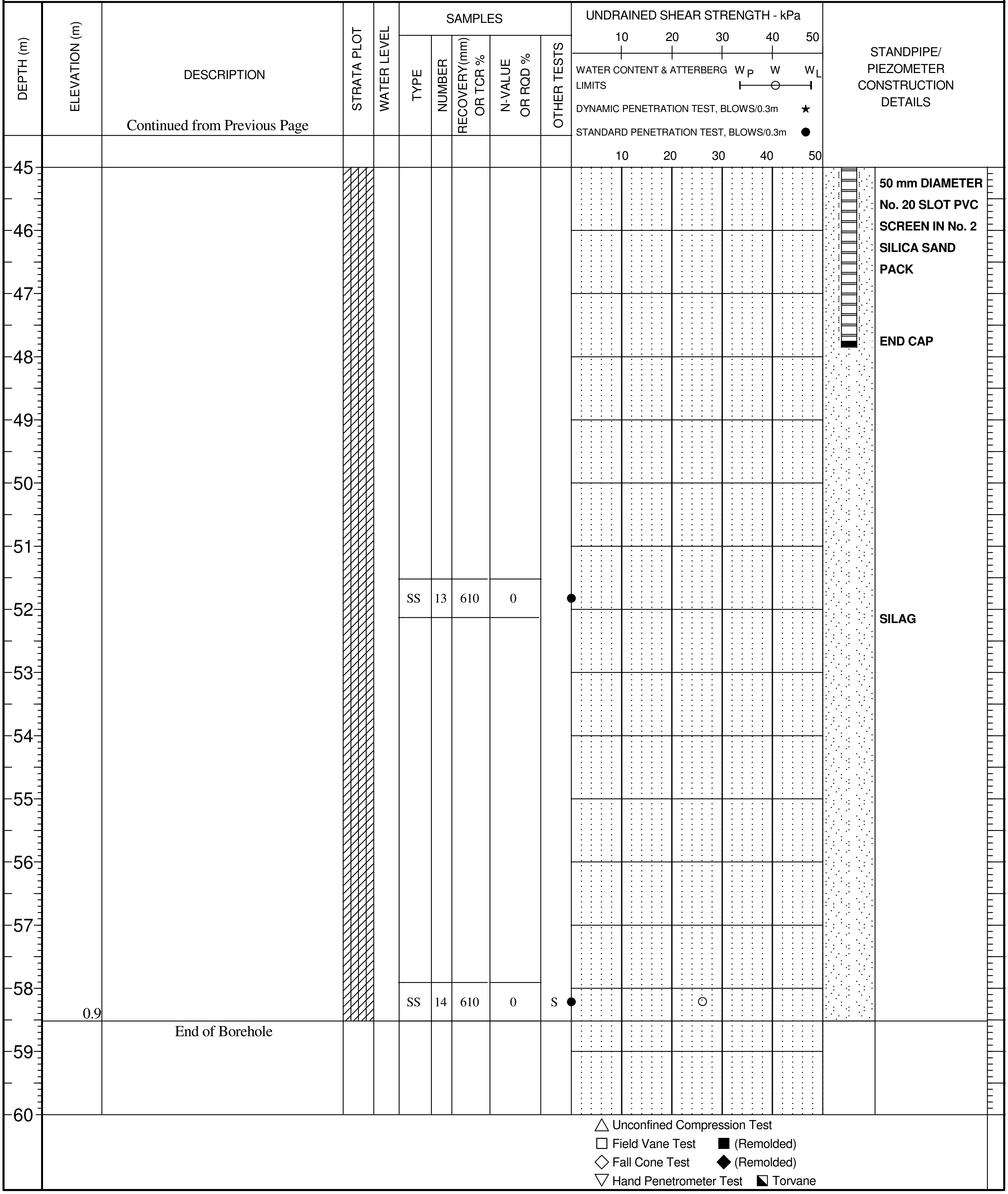


△ Unconfined Compression Test
☐ Field Vane Test ■ (Remolded)
◇ Fall Cone Test ◆ (Remolded)
▽ Hand Penetrometer Test ◪ Torvane

Stantec

BOREHOLE RECORD

BOREHOLE No. 2009 P2B
PAGE 4 of 4
CLIENT Hatch Ltd.
PROJECT New Piezometer Installations
LOCATION Muskrat Falls, Labrador
N 5903032.79 m E 648296.03 m
DATES (mm-dd-yy): BORING 8-22-09 to 8-27-09
WATER LEVEL 24.63 m
PROJECT No. 1054326
DRILLING METHOD Wash Boring
SIZE NW
DATUM Geodetic



ELEVATION (m)	DESCRIPTION	STRATA PLOT	WATER LEVEL	TYPE	NUMBER	RECOVERY(mm) OR TCR %	N-VALUE OR RQD %	OTHER TESTS
	Continued from Previous Page							
				SS	13	610	0	
				SS	14	610	0	S
0.9	End of Borehole							

50 mm DIAMETER No. 20 SLOT PVC SCREEN IN No. 2 SILICA SAND PACK

END CAP

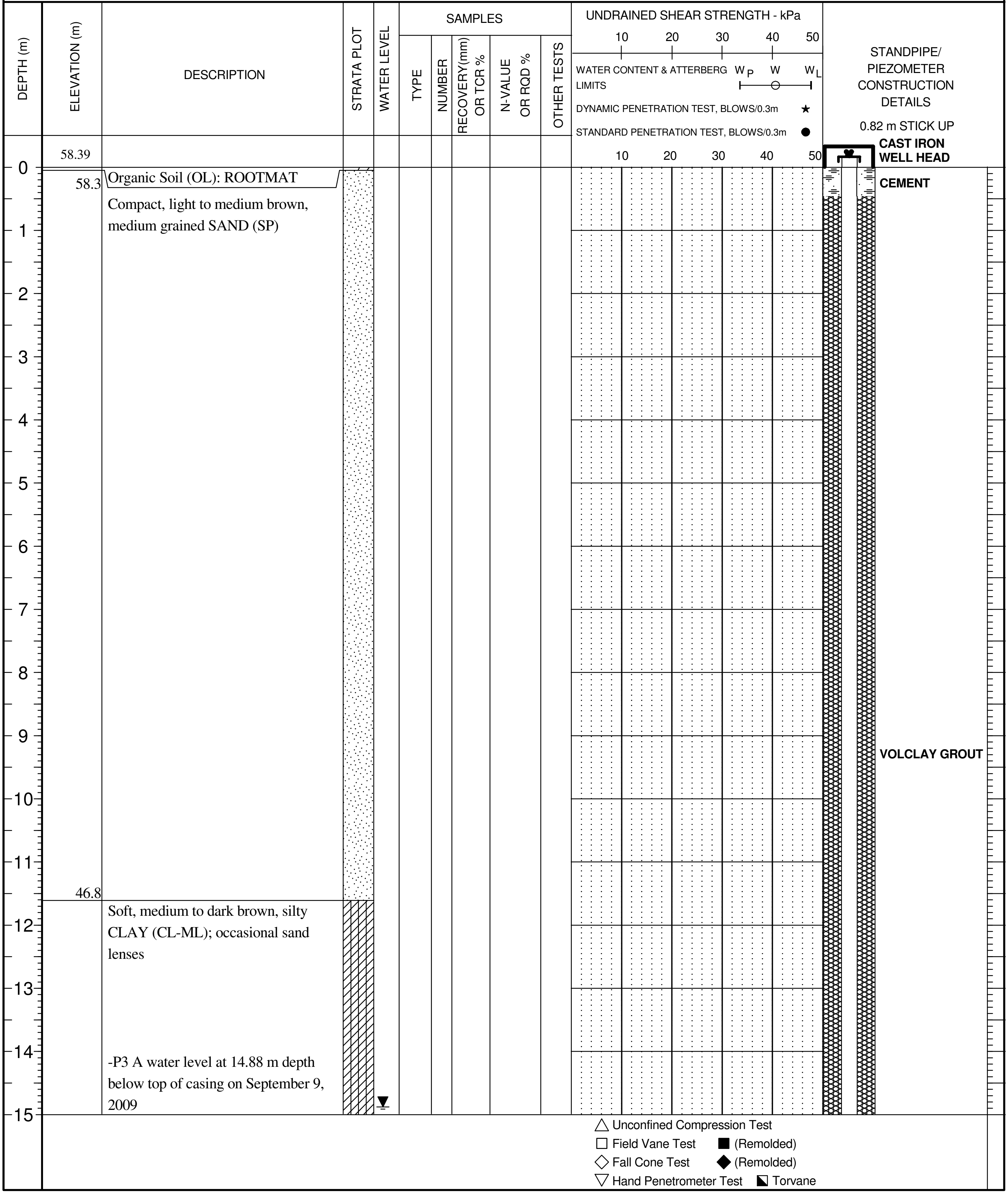
SILAG

△ Unconfined Compression Test
☐ Field Vane Test ■ (Remolded)
◇ Fall Cone Test ◆ (Remolded)
▽ Hand Penetrometer Test ◪ Torvane

Stantec

BOREHOLE RECORD

BOREHOLE No. 2009 P3 A&B
PAGE 1 of 3
CLIENT Hatch Ltd.
PROJECT New Piezometer Installations
LOCATION Muskrat Falls, Labrador
DATES (mm-dd-yy): BORING 9-3-09 to 9-6-09
N 5902950.06 m E 648369.79 m
WATER LEVEL 14.88 m 23.96 m
PROJECT No. 1054326
DRILLING METHOD Wash Boring
SIZE NW
DATUM Geodetic



58.3 Organic Soil (OL): ROOTMAT

Compact, light to medium brown, medium grained SAND (SP)

46.8 Soft, medium to dark brown, silty CLAY (CL-ML); occasional sand lenses

-P3 A water level at 14.88 m depth below top of casing on September 9, 2009

Stantec

BOREHOLE RECORD

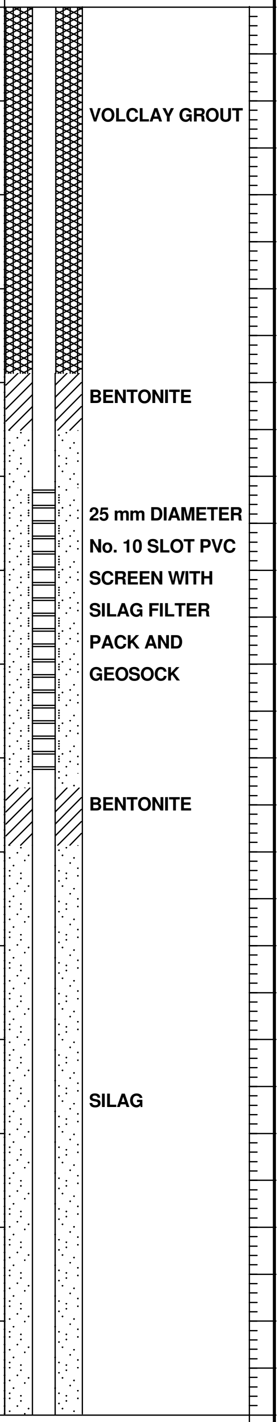
BOREHOLE No. 2009 P3 A&B
PAGE 2 of 3

CLIENT Hatch Ltd.
PROJECT New Piezometer Installations
LOCATION Muskrat Falls, Labrador
N 5902950.06 m E 648369.79 m
DATES (mm-dd-yy): BORING 9-3-09 to 9-6-09
WATER LEVEL 14.88 m 23.96 m
PROJECT No. 1054326
DRILLING METHOD Wash Boring
SIZE NW
DATUM Geodetic

DEPTH (m)	ELEVATION (m)	DESCRIPTION	TYPE	NUMBER	RECOVERY(mm) OR TCR %	N-VALUE OR RQD %	OTHER TESTS
		Continued from Previous Page					
18.3	40.1	Soft, medium to dark grey, silty CLAY (CL-ML)					
22.0	36.4	Compact, medium grey, fine SAND (SP)					
22.3	36.1	Soft, wet, medium to dark grey, silty CLAY (CL-ML) -P3 B water level at 23.96 m depth below top of casing on September 9, 2009	SS	1	610		S

UNDRAINED SHEAR STRENGTH - kPa: 10 20 30 40 50
WATER CONTENT & ATTERBERG LIMITS W_P W W_L
DYNAMIC PENETRATION TEST, BLOWS/0.3m ★
STANDARD PENETRATION TEST, BLOWS/0.3m ●

STANDPIPE/ PIEZOMETER CONSTRUCTION DETAILS



△ Unconfined Compression Test
☐ Field Vane Test ■ (Remolded)
◇ Fall Cone Test ◆ (Remolded)
▽ Hand Penetrometer Test ◩ Torvane

Stantec

BOREHOLE RECORD

BOREHOLE No. 2009 P3 A&B
PAGE 3 of 3

CLIENT **Hatch Ltd.**
PROJECT **New Piezometer Installations**
LOCATION **Muskrat Falls, Labrador**
DATES (mm-dd-yy): BORING **9-3-09** to **9-6-09**
N **5902950.06 m** E **648369.79 m**
WATER LEVEL **14.88 m 23.96 m**
PROJECT No. **1054326**
DRILLING METHOD **Wash Boring**
SIZE **NW**
DATUM **Geodetic**

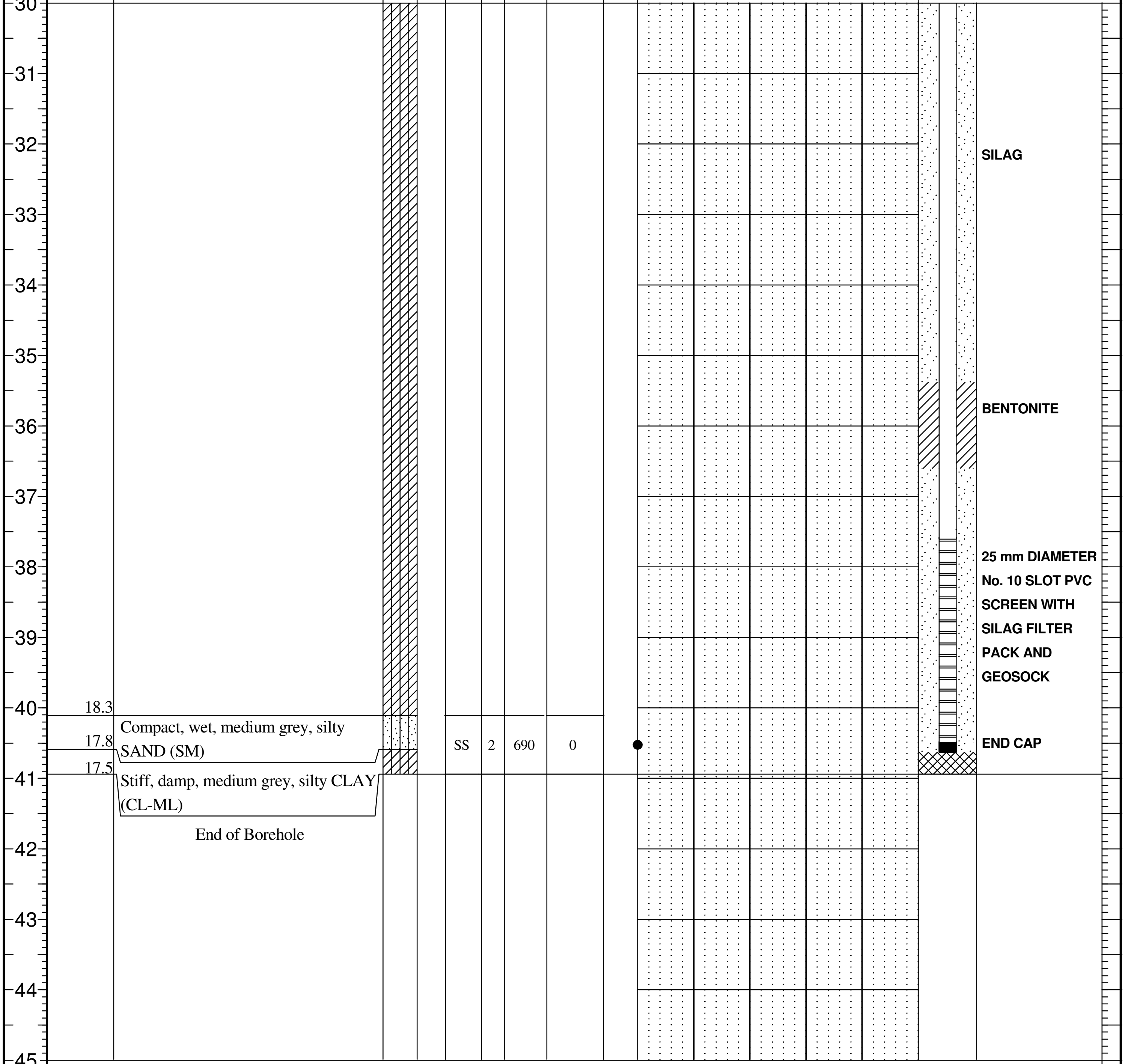
DEPTH (m)	ELEVATION (m)	DESCRIPTION	TYPE	NUMBER	RECOVERY(mm) OR TCR %	N-VALUE OR RQD %	OTHER TESTS
		Continued from Previous Page					
40	18.3	Compact, wet, medium grey, silty SAND (SM)	SS	2	690	0	
	17.8						
41	17.5	Stiff, damp, medium grey, silty CLAY (CL-ML)					
		End of Borehole					

UNDRAINED SHEAR STRENGTH - kPa: 10 20 30 40 50

WATER CONTENT & ATTERBERG LIMITS W_P W W_L

DYNAMIC PENETRATION TEST, BLOWS/0.3m ★

STANDARD PENETRATION TEST, BLOWS/0.3m ●



△ Unconfined Compression Test
☐ Field Vane Test ■ (Remolded)
◇ Fall Cone Test ◆ (Remolded)
▽ Hand Penetrometer Test ◪ Torvane

Stantec

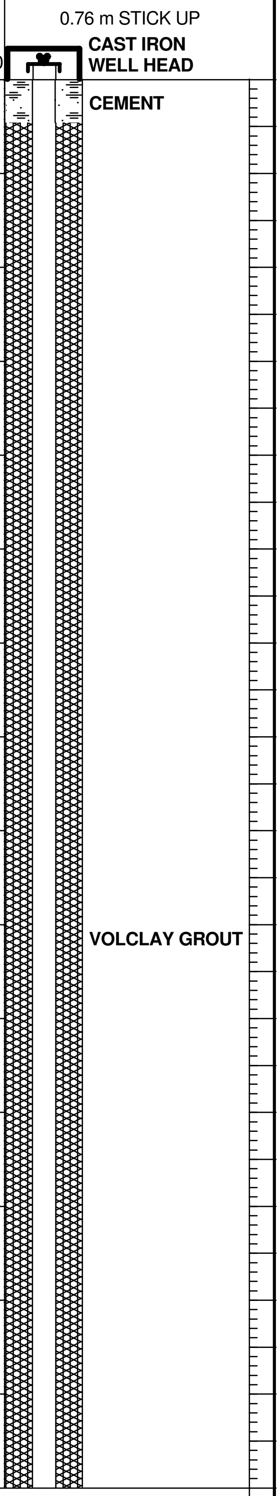
BOREHOLE RECORD

BOREHOLE No. 2009 P4 A&B
PAGE 1 of 4
CLIENT Hatch Ltd.
PROJECT No. 1054326
PROJECT New Piezometer Installations
DRILLING METHOD Wash Boring
LOCATION Muskrat Falls, Labrador
N 5903120 m E 648378.89 m
SIZE NW
DATES (mm-dd-yy): BORING 9-7-09 to 9-9-09
WATER LEVEL N/A
DATUM Geodetic

DEPTH (m)	ELEVATION (m)	DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES: TYPE	SAMPLES: NUMBER	SAMPLES: RECOVERY(mm) OR TCR %	SAMPLES: N-VALUE OR RQD %	SAMPLES: OTHER TESTS
	54.26								
0	54.2	Organic Soil (OL): ROOTMAT							
		Compact, medium brown then grey, medium grained SAND (SP)							
	39.6	Soft, medium to dark grey, silty							
15									

UNDRAINED SHEAR STRENGTH - kPa
10 20 30 40 50
WATER CONTENT & ATTERBERG LIMITS W_P W W_L
DYNAMIC PENETRATION TEST, BLOWS/0.3m ★
STANDARD PENETRATION TEST, BLOWS/0.3m ●
10 20 30 40 50

STANDPIPE/ PIEZOMETER CONSTRUCTION DETAILS



△ Unconfined Compression Test
☐ Field Vane Test ■ (Remolded)
◇ Fall Cone Test ◆ (Remolded)
▽ Hand Penetrometer Test ◪ Torvane

Stantec

BOREHOLE RECORD

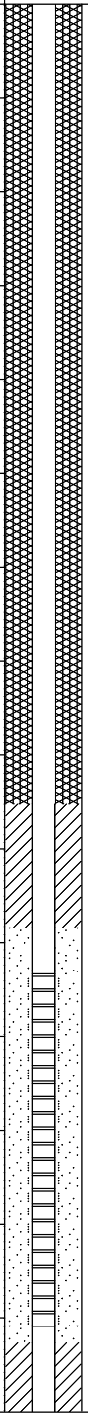
BOREHOLE No. 2009 P4 A&B
PAGE 2 of 4
CLIENT Hatch Ltd.
PROJECT New Piezometer Installations
LOCATION Muskrat Falls, Labrador N 5903120 m E 648378.89 m
DATES (mm-dd-yy): BORING 9-7-09 to 9-9-09 WATER LEVEL N/A
PROJECT No. 1054326
DRILLING METHOD Wash Boring
SIZE NW
DATUM Geodetic

UNDRAINED SHEAR STRENGTH - kPa: 10 20 30 40 50
WATER CONTENT & ATTERBERG LIMITS W_P W W_L
DYNAMIC PENETRATION TEST, BLOWS/0.3m ★
STANDARD PENETRATION TEST, BLOWS/0.3m ●
10 20 30 40 50

Continued from Previous Page

DEPTH (m)	ELEVATION (m)	DESCRIPTION	TYPE	NUMBER	RECOVERY(mm) OR TCR %	N-VALUE OR RQD %	OTHER TESTS
15		CLAY (CL-ML)					
20.7	33.5	Dense, light to medium grey, fine SAND (SP)	SS	1	610	39	
21.6	32.6	Soft, medium grey, silty CLAY (CL-ML)					
23.8	30.4	Interbedded, soft, medium to dark grey, silty CLAY (CL-ML) with compact to dense, medium grey, fine to medium grained SAND (SP)					
29.7	24.5						
30							

STANDPIPE/ PIEZOMETER CONSTRUCTION DETAILS



VOLCLAY GROUT

BENTONITE

25 mm DIAMETER No. 10 SLOT PVC SCREEN WITH SILAG FILTER PACK AND GEOSOCK

BENTONITE

△ Unconfined Compression Test
☐ Field Vane Test ■ (Remolded)
◇ Fall Cone Test ◆ (Remolded)
▽ Hand Penetrometer Test ◪ Torvane

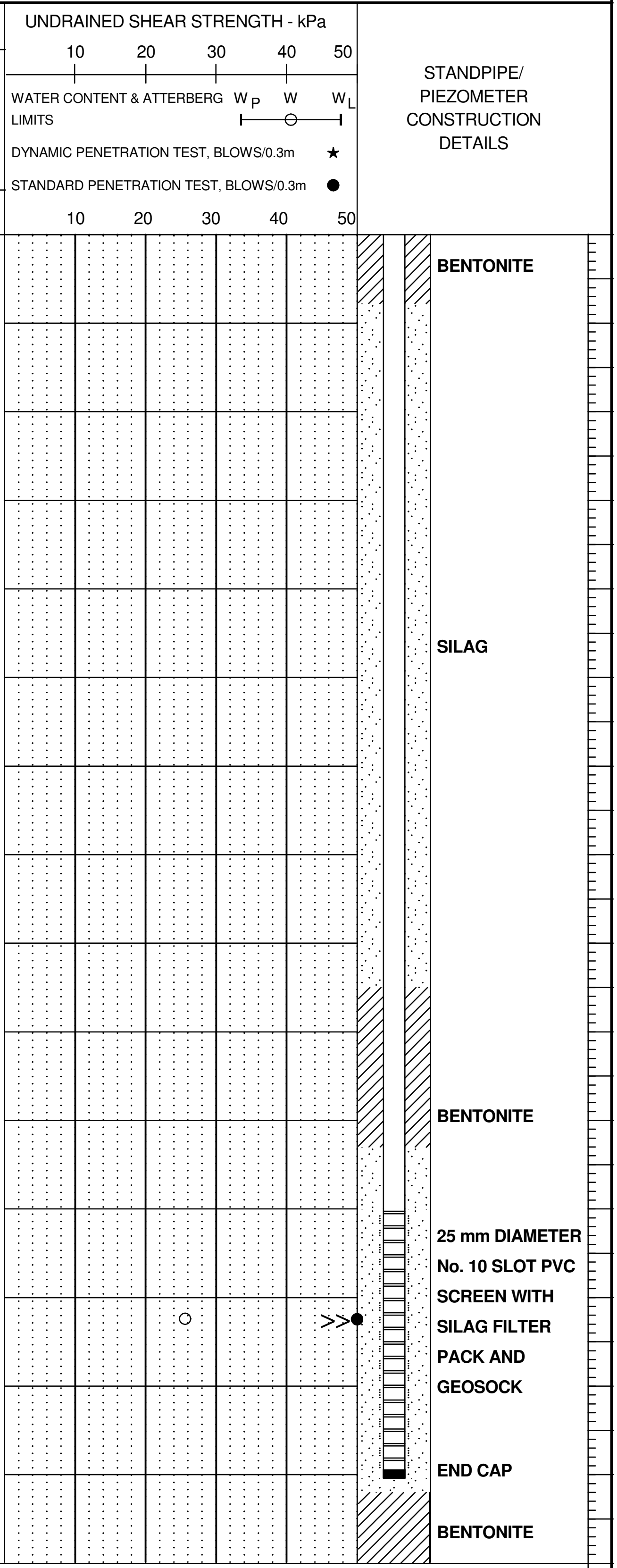
Stantec

BOREHOLE RECORD

BOREHOLE No. 2009 P4 A&B
PAGE 3 of 4

CLIENT Hatch Ltd.
PROJECT New Piezometer Installations
LOCATION Muskrat Falls, Labrador
DATES (mm-dd-yy): BORING 9-7-09 to 9-9-09
N 5903120 m E 648378.89 m
WATER LEVEL N/A
PROJECT No. 1054326
DRILLING METHOD Wash Boring
SIZE NW
DATUM Geodetic

DEPTH (m)	ELEVATION (m)	DESCRIPTION	TYPE	NUMBER	RECOVERY(mm) OR TCR %	N-VALUE OR RQD %	OTHER TESTS
		Continued from Previous Page					
30		Soft, medium to dark grey, silty CLAY (CL-ML)					
	15.1	Compact to dense, medium grey, fine to medium grained silty SAND (SM)					
			SS	2	330	57	S
	9.8	Firm to stiff, medium to dark grey,					
45							



△ Unconfined Compression Test
☐ Field Vane Test ■ (Remolded)
◇ Fall Cone Test ◆ (Remolded)
▽ Hand Penetrometer Test ◪ Torvane

Stantec

BOREHOLE RECORD

BOREHOLE No. 2009 P4 A&B
PAGE 4 of 4
CLIENT Hatch Ltd.
PROJECT New Piezometer Installations
LOCATION Muskrat Falls, Labrador
DATES (mm-dd-yy): BORING 9-7-09 to 9-9-09
PROJECT No. 1054326
DRILLING METHOD Wash Boring
N 5903120 m E 648378.89 m
SIZE NW
WATER LEVEL N/A
DATUM Geodetic

DEPTH (m)	ELEVATION (m)	DESCRIPTION Continued from Previous Page	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY(mm) OR TCR %	SAMPLES N-VALUE OR RQD %	OTHER TESTS	UNDRAINED SHEAR STRENGTH - kPa (10 20 30 40 50); WATER CONTENT & ATTERBERG LIMITS W_P W W_L; DYNAMIC PENETRATION TEST, BLOWS/0.3m ★; STANDARD PENETRATION TEST, BLOWS/0.3m ● (10 20 30 40 50)	STANDPIPE/ PIEZOMETER CONSTRUCTION DETAILS
45		silty CLAY (CL-ML)	▨								▨ BENTONITE
			▨		SS	3	610	1		●	▩ CAVE-IN
46	8.2	End of Borehole									
47											
48											
49											
50											
51											
52											
53											
54											
55											
56											
57											
58											
59											
60											

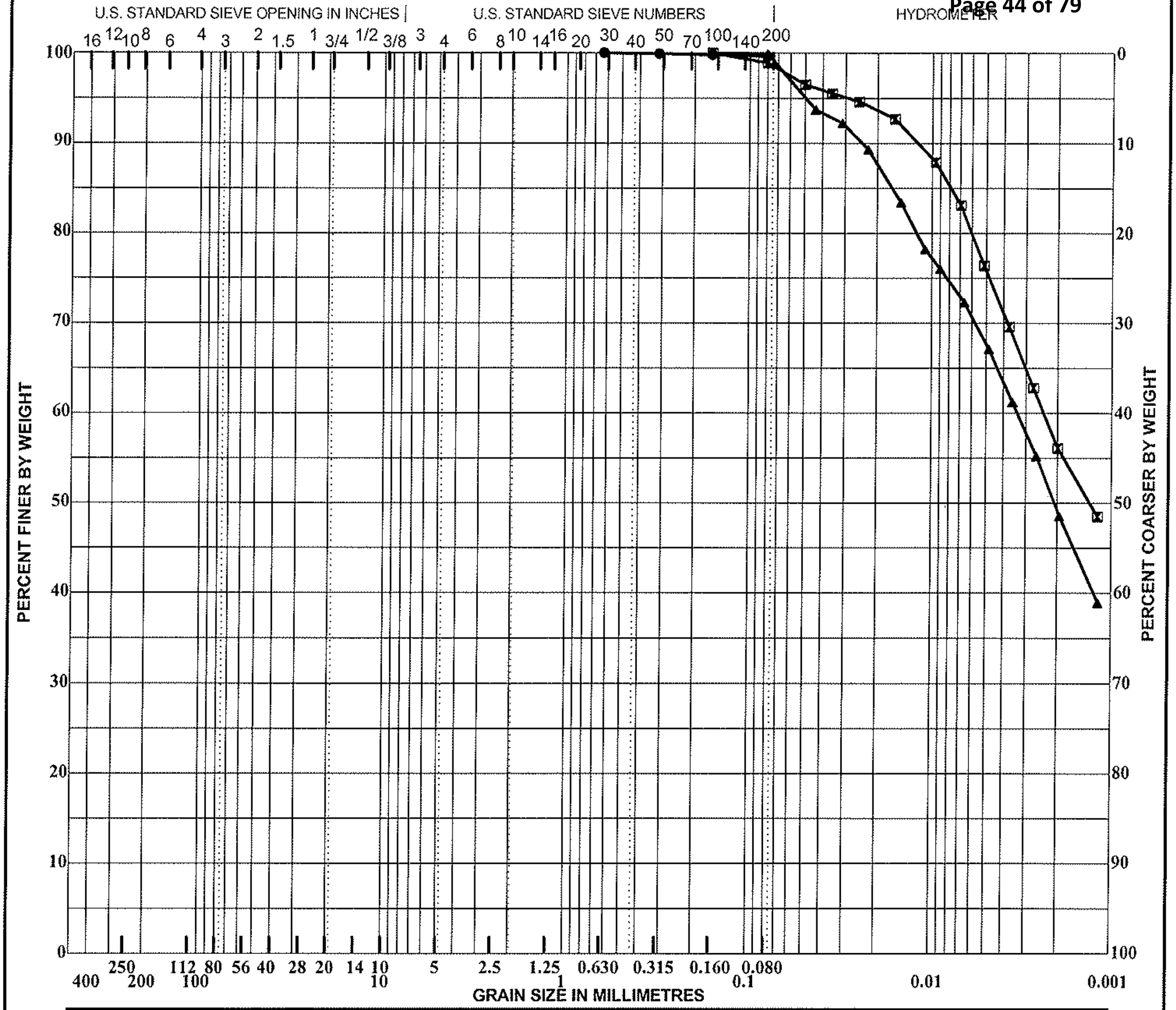
△ Unconfined Compression Test
☐ Field Vane Test ■ (Remolded)
◇ Fall Cone Test ◆ (Remolded)
▽ Hand Penetrometer Test ◪ Torvane

ATTACHMENT C

Figures 1 and 2: Gradation Curves

Figure 3: Stratigraphic Section

New Piezometer Location Plan No. 1054326-GE-01



COBBLE	GRAVEL		SAND			SILT and CLAY
	coarse	fine	coarse	medium	fine	

	Sample	Depth (m)	Description	W%	W_L	W_P	I_P
●	2009 P1 A&B SS1	42.26	Silty CLAY (CL-ML)	29.1			
☒	P2B	58.21	Silty CLAY (CL-ML)	26.1			
▲	2009 P3 A&B SS1	23.13	Silty CLAY (CL-ML)	31.4			

	Sample	Depth (m)	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	2009 P1 A&B SS1	42.26	0.63				0.0	0.4	99.6	
☒	P2B	58.21	0.16	0.00			0.0	1.1	42.7	56.2
▲	2009 P3 A&B SS1	23.13	0.16	0.00			0.0	0.1	50.7	49.2

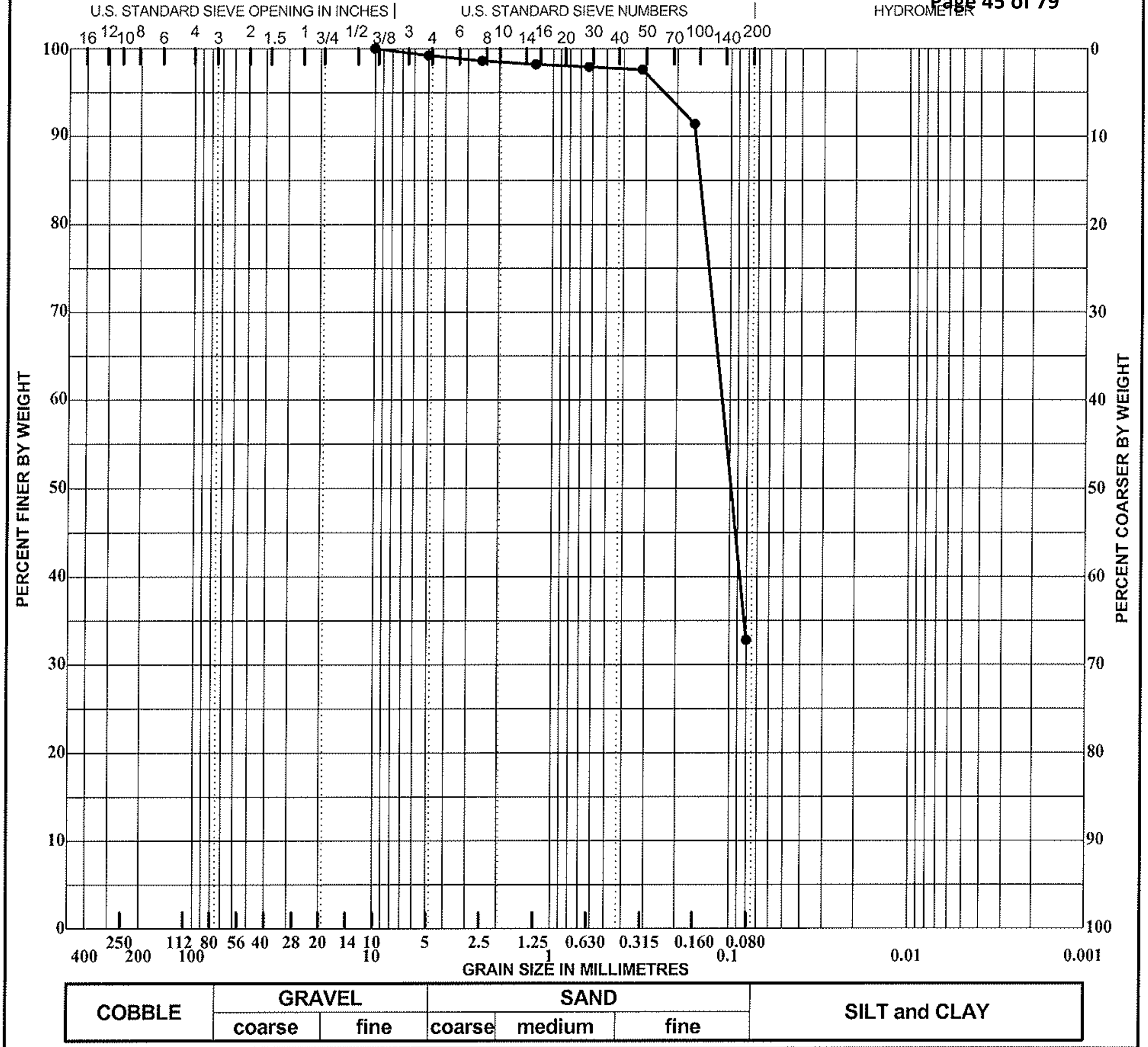
REMARKS:

Stantec

Client: **Hatch Ltd.**
Project: **New Piezometer Installations**
Project No.: **1054326**
Location: **Muskrat Falls, Labrador**

FIGURE 1

GRADATION CURVES



	Sample	Depth (m)	Description	W%	W_L	W_P	I_P
●	2009 P4 A&B SS2	42.24	Silty SAND with gravel (SM)	25.6			

	Sample	Depth (m)	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	2009 P4 A&B SS2	42.24	10.00	0.11			0.8	66.4	32.8	

REMARKS:

Stantec

Client: **Hatch Ltd.**

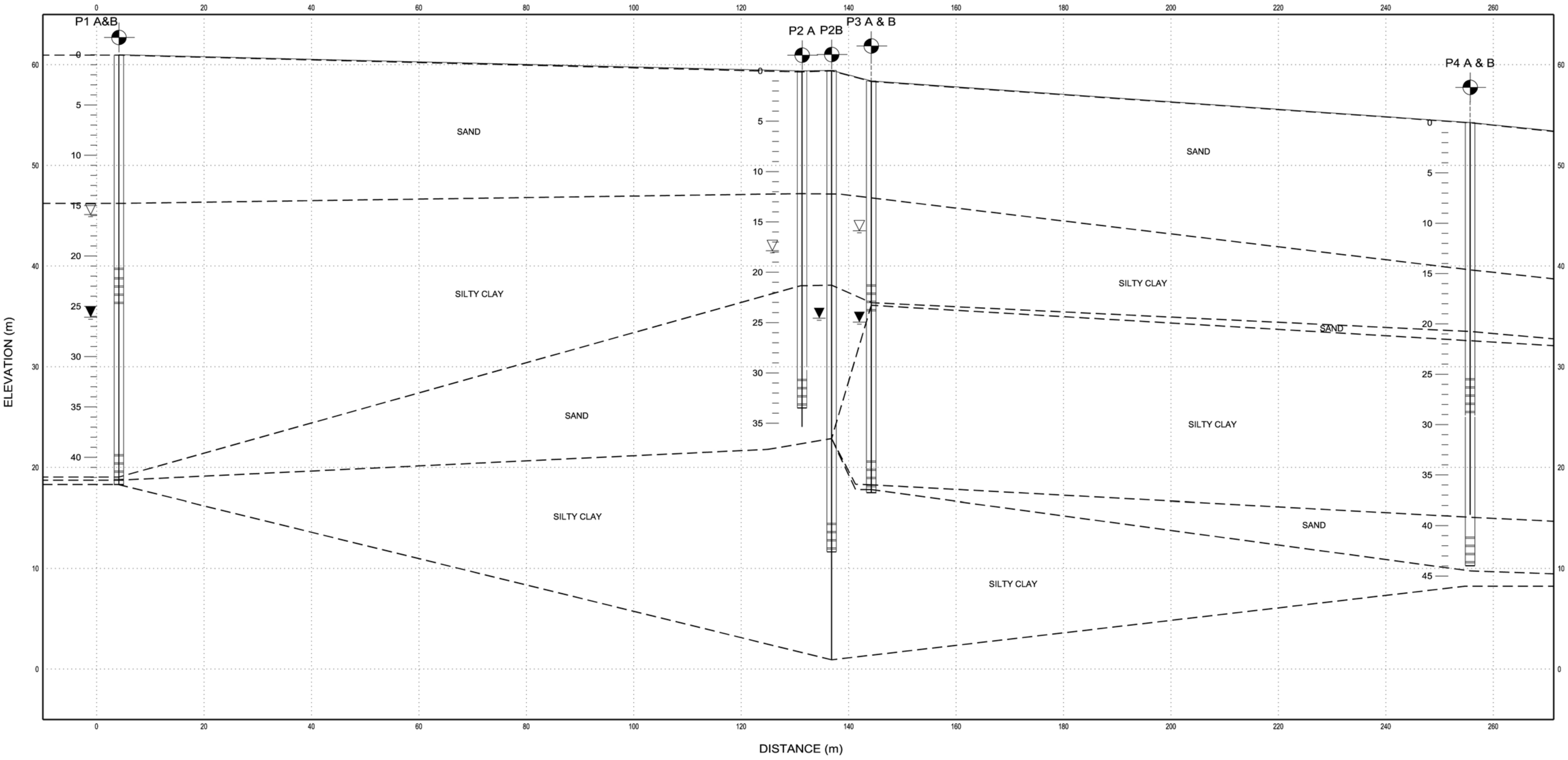
Project: **New Piezometer Installations**

Project No.: **1054326**

Location: **Muskrat Falls, Labrador**

FIGURE
2

GRADATION CURVES



LEGEND:

▽ - DENOTES WATER DEPTH/ELEVATION IN "A" PIEZOMETERS

▼ - DENOTES WATER DEPTH/ELEVATION IN "B" PIEZOMETERS

- NO WATER LEVEL DATA AVAILABLE FOR P4 A & B

NUMBER	ELEVATION (m) TOP OF CSG	DEPTH (m)
2009 P1 A&B	61.01	42.70
2009 P2A	59.39	35.36
2009 P2B	59.45	58.52
2009 P3 A&B	58.39	40.94
2009 P4 A&B	54.26	46.02

REMARKS:
1. INTERPRETATION OF SOIL HORIZONS ARE ESTIMATED BASED ON BOREHOLES 2009 P1 A&B, 2009 P2 A, 2009 P2 B, 2009 P3 A&B AND 2009 P4 A7B.
2. DO NOT SCALE FROM DRAWING.
3. © STANTEC CONSULTING LTD, 2009.

CLIENT: Hatch Ltd.

JOB: 2009 New Piezometer Installations

JOB No: 1054326

LOCATION: Muskrat Falls, Labrador

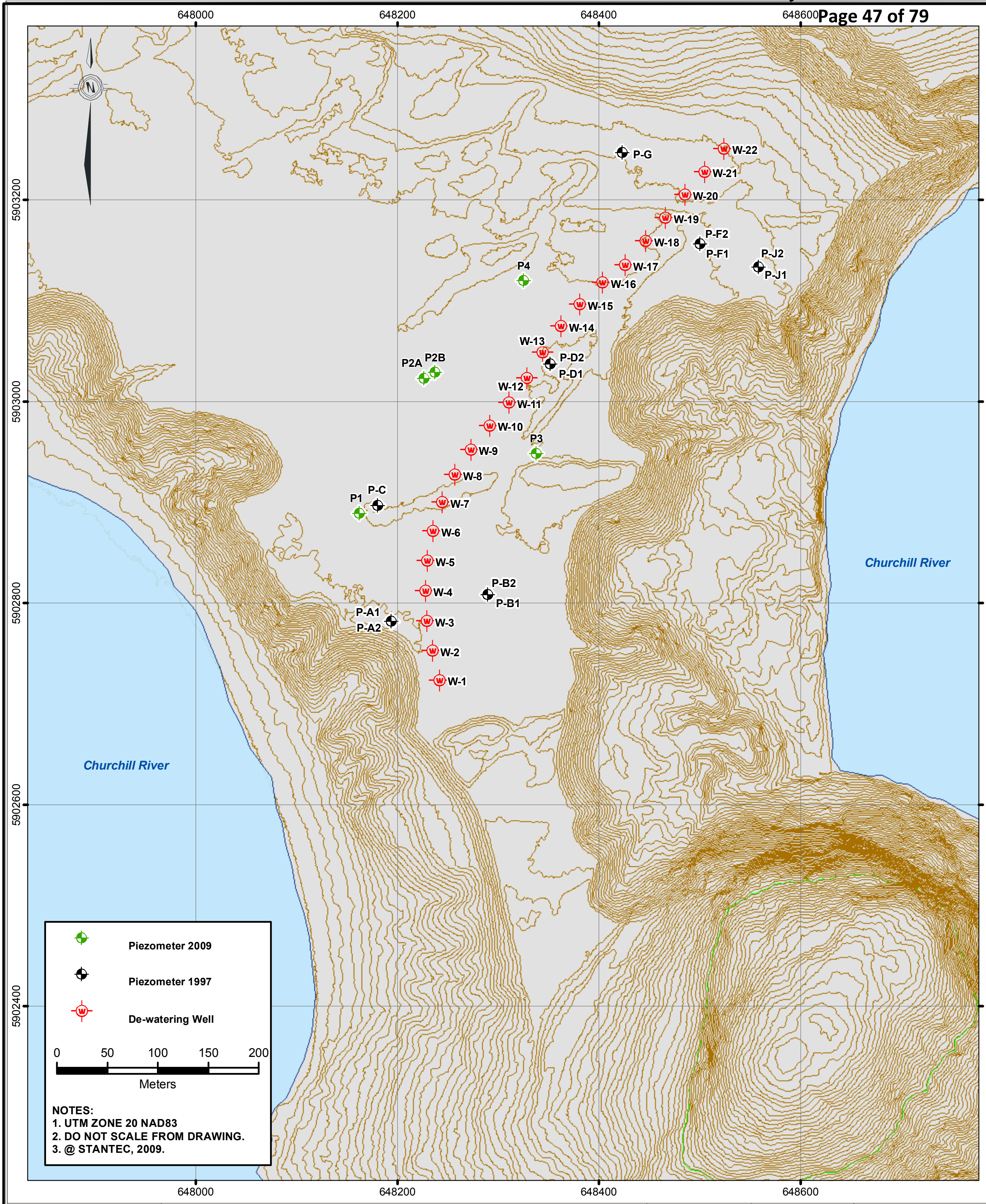
SCALE: VERTICAL 1:400
HORIZONTAL 1:750

DATE: DEC. 3, 2009

FIGURE
3
STRATIGRAPHIC
SECTION

CAD FILE: 1054326-SECTION1.DWG
DRAWN BY: S.N.
EDITED BY:
CHECKED BY:

Stantec



NOTES:
1. UTM ZONE 20 NAD83
2. DO NOT SCALE FROM DRAWING.
3. @ STANTEC, 2009.

CLIENT:
HATCH LTD.

PROJECT TITLE:
NEW PIEZOMETER INSTALLATIONS (2009)

DRAWING TITLE:
NEW PIEZOMETER LOCATION PLAN

SCALE: 1:5,000
DATE: DEC. 11, 2009
DRAWN BY: EM
CHECKED BY:
EDITED BY: EM
REV. No. 0
DRAWING No.: 1054326-GE-01
MAP FILE: 1054326-GE-SITEPLAN.MXD

Stantec

DD/MM/YEAR

ATTACHMENT D

Daily Field Reports

DAILY FIELD REPORT

Stantec
607 Torbay Road
St. John's, NL A1A 4Y6
Tel: 709-576-1458 Fax: 709-576-2125

Project Name: **Geotechnical Investigation – Construction of New Boreholes with Piezometer Installations**	**Date: 19 August 2009** **Project No.: 1054326**
Work Location: Muskrat Falls, Labrador	**Field Geologist: Terry Snelgrove**
Client: Nalcor Energy c/o Hatch Mott MacDonald	**Sheet 1 of 1**

Remarks:

1000h: depart Wabush for Goose Bay

1215h: arrive Goose Bay. Check into Hotel North. Go to Stantec office to check emails and make copies.

1700h: meet with Terry O'Rielly (Nalcor) and Steve Sproull (Hatch) to discuss project.

1900h: return to room to do emails and prepare for the day tomorrow.

Stassinu Stantec Limited Partnership

DAILY FIELD REPORT

Project Name: **Geotechnical Investigation – Construction of Boreholes with Monitor Well Installations**	**Date: 20 Aug 2009** **Project No.: 1054326**
Work Location: Muskrat Falls, LABRADOR	**Supervisor: Terry Snelgrove**
Client: Nalcor Energy c/o Hatch Mott MacDonald	**Sheet 1 of 1**

Borehole Summary

Monitor Well No.	Location NAD 83 Zone 19		Overburden (m)		Bedrock (m)		Depth (m)
	Northing (m)	Easting (m)	Today	To Date	Today	To Date	

Sample/Testing Summary

Monitor Well No.	Type	Nos.	Borehole No.	Type	Nos.

Time Summary

Crew	Drilling	Moving	Testing	Standby	Breakdown	Total
T.Snelgrove				12.0		12.0

Remarks (All times in Eastern Time Zone): Wx: sun/cloud, +18C

0700h – meet Nalcor & Hatch people for breakfast.

0930h – go to site with Hatch people. Layout BH locations. Determine effort for brushcutting.

1130h – lunch with all hands.

1330h – go to safety supply place to get additional equipment with Hatch people.

1430h – return to site to further assess BH locations and get GPS cords.

1600h – meeting at Nalcor office to review each role & responsibilities.

1730h – meet for dinner.

1900h – talk with driller. He just arrived GB. Will meet at safety orientation meeting in AM at Nalcor office.

Stassinu Stantec
Limited Partnership

DAILY FIELD REPORT

Project Name: **Geotechnical Investigation – Construction of Boreholes with Monitor Well Installations**	**Date: 21 August 2009** **Project No.: 1054326**
Work Location: Muskrat Falls, LABRADOR	**Supervisor: Terry Snelgrove**
Client: Nalcor Energy c/o Hatch Mott MacDonald	**Sheet 1 of 1**

Borehole Summary

Monitor Well No.	Location NAD 83 Zone 20		Overburden (m)		Bedrock (m)		Depth (m)
	Northing (m)	Easting (m)	Today	To Date	Today	To Date	

Sample/Testing Summary

Monitor Well No.	Type	Nos.	Borehole No.	Type	Nos.

Time Summary

Crew	Drilling	Moving	Testing	Standby	Breakdown	Total

Remarks (All times in Eastern Time Zone): Wx-Overcast, no wind, +19C

0700h – Meet personnel for breakfast.

0800h – Begin Safety and Env. orientation at Nalcor’s office.

1300h – Finish orientation. Have lunch.

1430h – Head out to site with all personnel involved. Meet with Hickey’s to arrange for excavator in AM. Flag BH location for tree-cutters. Offload drill. No wind today. Flies are quite bad.

1730h – Depart site for Goose Bay.

1830h – Have dinner with personnel.

Stassinu Stantec
Limited Partnership

DAILY FIELD REPORT

Project Name: **Geotechnical Investigation – Construction of Boreholes with Monitor Well Installations**	**Date: 22 August 2009** **Project No.: 1054326**
Work Location: Muskrat Falls, LABRADOR	**Supervisor: Terry Snelgrove**
Client: Nalcor Energy c/o Hatch Mott MacDonald	**Sheet 1 of 1**

Borehole Summary

Monitor Well No.	Location NAD 83 Zone 20		Overburden (m)		Bedrock (m)		Depth (m)
	Northing (m)	Easting (m)	Today	To Date	Today	To Date	
2009 P2B	5903032	0648301	12.8	12.8	0	0	12.8

Sample/Testing Summary

Monitor Well No.	Type	Nos.	Borehole No.	Type	Nos.
2009 P2B	SS	1 thru 4			

Time Summary

Crew	Drilling	Moving	Testing	Standby	Breakdown	Total
Lantech	2.5	7.0	1.0	0.0	0.5	11.0

Remarks (All times in Eastern Time Zone): Wx: AM rain,then sun +18C

0730h – Arrive at site; conduct toolbox meeting; linecutters clear trail to first setup and clear trail to pond for water supply.

1030h – Hickey arrives with excavator. Brushcutters and drill crew work on getting pump and hoses laid out to water supply. Drillers use rig to transport tooling to first setup. Terry (Nalcor) and Steve (Hatch) evaluate linecutters and drillers for safety performance of duties. Linecutters go to Goose Bay to get additional safety equipment, etc. Drillers pass the test. Mark and flag all BH setups and show Don (Nalcor) for clearing.

1430h – Start turning augers. Auger and sample to 12.8m. Augering is easy.

1830h – Sand piping up augers. Need water in the AM. Finish for the day. Check W/L in BH @ 11.8m bgs.

1850h – Depart Site for G. Bay.

1930 – 2130h – working dinner with client.

Stassinu Stantec
Limited Partnership

DAILY FIELD REPORT

Project Name: **Geotechnical Investigation – Construction of Boreholes with Monitor Well Installations**	**Date: 23 August 2009** **Project No.: 1054326**
Work Location: Muskrat Falls, LABRADOR	**Supervisor: Terry Snelgrove**
Client: Nalcor Energy c/o Hatch Mott MacDonald	**Sheet 1 of 1**

Borehole Summary

Monitor Well No.	Location NAD 83 Zone 20		Overburden (m)		Bedrock (m)		Depth (m)
	Northing (m)	Easting (m)	Today	To Date	Today	To Date	
2009 P2B	5903035	0648295	18.9	18.9	-	-	18.9

Sample/Testing Summary

Monitor Well No.	Type	Nos.	Borehole No.	Type	Nos.
2009 PB2	SS	5, 6			

Time Summary

Crew	Drilling	Moving	Testing	Standby	Breakdown	Total
Lantech	9.0	0.5	2.0	0.0	0.0	11.5

Remarks (All times in Eastern Time Zone): Wx-Sunny, lite winds +20C

0730h – arrive at Site. Conduct toolbox safety meeting; drilers go to finish water pump/waterline setup; run augers to 15.2m. Center plug jambed in augers with 1m of silt/clay on top of plug. Had to pull all augers out. Lost 2X10' AW rods and 4 ¼" center plug down borehole.

1330h – Move rig 2m and restart hole with HW casing. Run casing down to 15.2m before continuing to sample. Went to fuel up water supply pump at pond. (450m away).

1500h – Both Julia and Steve go to airport for departure.

1715h – HW casing at 15.2m. start SS5. Split spoon sank 18" into formation with weight of hammer only. Recovered silty clay to clayey silt.

1815h – HW casing at 18.3m. SS6 – split spoon again sank 14" under hammer weight. Recovered same sort of material. (Blows= 0/0/2/2/)

1830h – Secure rig for the nite. Fuel-up and shut down water pump at pond.

1845h – Depart site for Goose Bay.

1930h – Dinner with Anne (Hatch), Terry and Bob White (Nalcor).

Stassinu Stantec
Limited Partnership

DAILY FIELD REPORT

Project Name: **Geotechnical Investigation – Construction of Boreholes with Monitor Well Installations**	**Date: 24 August 2009** **Project No.: 1054326**
Work Location: Muskrat Falls, LABRADOR	**Supervisor: Terry Snelgrove**
Client: Nalcor Energy c/o Hatch Mott MacDonald	**Sheet 1 of**

Borehole Summary

Monitor Well No.	Location NAD 83 Zone 20		Overburden (m)		Bedrock (m)		Depth (m)
	Northing (m)	Easting (m)	Today	To Date	Today	To Date	
2009 P2B	5903035	0648295	15.2	34.1	0	0	34.1

Sample/Testing Summary

Monitor Well No.	Type	Nos.	Borehole No.	Type	Nos.
2009 P2B	SS	7 - 11			

Time Summary

Crew	Drilling	Moving	Testing	Standby	Breakdown	Total
Lantech	8.0		2.5			10.5

Remarks (All times in Eastern Time Zone): Wx-Sunny, breezy, +19C

0730h – Arrive on Site. Conduct toolbox meeting. Driller go fuel-up and start pump.

0800h – Start drilling.Get 5 SS samples today. Anne and Terry O. go to G.Bay to look at boom truck.

1230h – Terry S. go to G.Bay for buckets and stuff.

1445h – Terry S. back on site.

1810h – Depart site for G.Bay.

1900h – Dinner with client.

Stassinu Stantec
Limited Partnership

DAILY FIELD REPORT

Project Name: **Geotechnical Investigation – Construction of Boreholes with Monitor Well Installations**	**Date: 25 August 2009** **Project No.: 1054326**
Work Location: Muskrat Falls, LABRADOR	**Supervisor: Terry Snelgrove**
Client: Nalcor Energy c/o Hatch Mott MacDonald	**Sheet _1_____ of __________**

Borehole Summary

Monitor Well No.	Location NAD 83 Zone 20		Overburden (m)		Bedrock (m)		Depth (m)
	Northing (m)	Easting (m)	Today	To Date	Today	To Date	
2009 P2B	5903035	0648295	18.3	52.4	0	0	52.4

Sample/Testing Summary

Monitor Well No.	Type	Nos.	Borehole No.	Type	Nos.
2009 P2B	SS	12 - 14			

Time Summary

Crew	Drilling	Moving	Testing	Standby	Breakdown	Total
Lantech	8.5	0	3.0	0	0	11.5

Remarks (All times in Eastern Time Zone): Wx Sun, cloud +13C

0730h – Arrive on Site. Conduct toolbox meeting. Review Emerg. Evac. Plan. Saw 2 wolves near site.

0815h – Driller go to startup water pump.

0830h – Start drilling HW

1100h – Terry S. go to get supplies and lunch

1300h – Terry S. back on site. It was discussed with LCB and client and decided to stop sampling until we get to bottom. Therefore, drilled 50 feet in about 4 hrs. Will further discuss tomorrow about installing two 1" wells in each HW borehole to save time.

1820h – Driller at 170'. Clean out BH (9') and take split spoon. Still into firm clays. Will decide tomorrow about well install.

1900h – Depart site for Goose Bay.

2000h – Dinner with client.

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DAILY FIELD REPORT

Project Name: **Geotechnical Investigation – Construction of Boreholes with Monitor Well Installations**	**Date: 26 August 2009** **Project No.: 1054326**
Work Location: Muskrat Falls, LABRADOR	**Supervisor: Terry Snelgrove**
Client: Nalcor Energy c/o Hatch Mott MacDonald	**Sheet 1 of**

Borehole Summary

Monitor Well No.	**Location NAD 83 Zone 20**		**Overburden (m)**		**Bedrock (m)**		**Depth (m)**
	Northing (m)	**Easting (m)**	**Today**	**To Date**	**Today**	**To Date**	
2009 P2B	5903035	0648295	6.1	58.6	0	0	58.6

Sample/Testing Summary

Monitor Well No.	**Type**	**Nos.**	**Borehole No.**	**Type**	**Nos.**
2009 P2B	SS	15			

Time Summary

Crew	**Drilling**	**Moving**	**Testing**	**Standby**	**Breakdown**	**Total**
Lantech	6.0		4.5	0	0	10.5

Remarks (All times in Eastern Time Zone):   Wx: Rain all day, +11C

0730h – Arrive Site. Conduct toolbox meeting. Arriving to Site today are 2 electricians (Nalcor), 3 envir. Auditors (Nalcor), Sterling Kean and Alex (P.Sullivan). Anne M. orient these guys.

0915h – Instruct driller to run HW casing to 190’ (58m). Clean out 11.5’ of soil inside casing. Take final split spoon. Prepare to start well installation. Discuss with personnel about where to install screen and why. Since we are in a stiff, damp clay at this depth, decided to install bottom of screen at 157’

1530h – Start installing coarse sand (sillag) at bottom of hole

1745h – Sillag at 157’. Secure site for the night. Will complete installation tomorrow AM.

1810h – Depart Site for Goose Bay

1915h – Dinner with crew.

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DAILY FIELD REPORT

Project Name: **Geotechnical Investigation – Construction of Boreholes with Monitor Well Installations**	**Date: 27 August 2009** **Project No.: 1054326**
Work Location: Muskrat Falls, LABRADOR	**Supervisor: Terry Snelgrove**
Client: Nalcor Energy c/o Hatch Mott MacDonald	**Sheet 1 of**

Borehole Summary

Monitor Well No.	Location NAD 83 Zone 20		Overburden (m)		Bedrock (m)		Depth (m)
	Northing (m)	Easting (m)	Today	To Date	Today	To Date	
2009 P2B	5903035	0648295	0	58.6	0	0	58.6

Sample/Testing Summary

Monitor Well No.	Type	Nos.	Borehole No.	Type	Nos.

Time Summary

Crew	Drilling	Moving	Testing	Standby	Breakdown	Total
Lantech	0	0	10.5			10.5

Remarks (All times in Eastern Time Zone): Wx-Rain all day +8C

0730h – Arrive Site. Conduct Toolbox meeting.

0810h – Driller startup wter pump and carry out drill rig pre-op check.

0830h – Confirmed order with Lantech for 1” well supplies. He will also ship via truck, Volclay grout and all equipment required to pump grout into boreholes. Scheduled to arrive G.Bay Sunday.

0900h – Begin to install monitor well.

1120h – Peter Sullivan and Julia Hiscock arrive on Site.

1150h – Decided to rent a construction trailer and have it delivered to the Site (confirmed by Nalcor).

1650h – Monitor well completely installed. Perfect installation confirmed by driller.Pull HW casing out of BH.

1715h – Construction trailer arrives. Set it up next to compound. Electricians will wire it up tomorrow.

1815h – Secure rig and Site for the day. Turn off water pump. Ready to move to P2A setup in the AM.

1830h – Depart Site for G. Bay.

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DAILY FIELD REPORT

Project Name: **Geotechnical Investigation – Construction of Boreholes with Monitor Well Installations**	**Date: 28 August 2009** **Project No.: 1054326**
Work Location: Muskrat Falls, LABRADOR	**Supervisor: Terry Snelgrove**
Client: Nalcor Energy c/o Hatch Mott MacDonald	**Sheet 1 of __________**

Borehole Summary

Monitor Well No.	Location NAD 83 Zone 20		Overburden (m)		Bedrock (m)		Depth (m)
	Northing (m)	Easting (m)	Today	To Date	Today	To Date	
2009 P2A	5903029	0648291	35.1	35.1	0	0	35.1

Sample/Testing Summary

Monitor Well No.	Type	Nos.	Borehole No.	Type	Nos.

Time Summary

Crew	Drilling	Moving	Testing	Standby	Breakdown	Total
Lantech	11.0					11.0

Remarks (All times in Eastern Time Zone): Wx-Showers then cloudy +11C

0730h – Arrive on Site. Conduct toolbox meeting. All new arrivals are oriented until 1245h. Small crew in AM

0745h – Driller goes to start pump and do pre-op on drill rig.

0815h – Backfill BH with native sand. Install steel protector and cap on 2009 P2B with cement.

1025h – Rig moved onto new setup for BH 2009 P2A. Start running HW casing. No sampling to be done.

1755h – HW casing at 115’ (35.1m). Used lots of drilling mud and ran casing slowly. Easy drilling

1850h – Secure Site for the day. Depart Site for Goose Bay.

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DAILY FIELD REPORT

Project Name: **Geotechnical Investigation – Construction of Boreholes with Monitor Well Installations**	**Date: 29 August 2009** **Project No.: 1054326**
Work Location: Muskrat Falls, LABRADOR	**Supervisor: Terry Snelgrove**
Client: Nalcor Energy c/o Hatch Mott MacDonald	**Sheet 1 of ____**

Borehole Summary

Monitor Well No.	Location NAD 83 Zone 20		Overburden (m)		Bedrock (m)		Depth (m)
	Northing (m)	Easting (m)	Today	To Date	Today	To Date	
2009 P2A	5903029	0648291		35.1			35.1

Sample/Testing Summary

Monitor Well No.	Type	Nos.	Borehole No.	Type	Nos.

Time Summary

Crew	Drilling	Moving	Testing	Standby	Breakdown	Total
Lantech	8.5			3.0 go to GB to get well supplies		11.5

Remarks (All times in Eastern Time Zone): Wx-Sun, cloud +16C

0730h – Arrive on Site. Conduct toolbox meeting.

0800h – Driller go to start pump and do drill rig pre-op check.

0850h – Driller secured casing last evening. When he disconnected casing from drill head, it fell into the BH about 7’ (3’ bgs). He was able to see and retrieve it. This implies the soils at ~115’ depth are more than likely the soft, wet silty clays we confirmed in the adjacent BH with sampling. Unable to sample.

1100h – Flush drilling mud and soils from inside casing as well as mud on BH wall for 40mins.Prepare to install monitor well.

1300h – Driller had to go to G. Bay to pickup 1” well supplies, grout, grouting materials and equipment and mud

1600h – Driller back from G.Bay with supplies. Complete well installation on 2009 P2A.

1800h – Well installed, casing out of hole. Perfect well installation. Driller drain waterline and pump due to pending frost tonite.

1900h – Depart Site for G. Bay.

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DAILY FIELD REPORT

Project Name: **Geotechnical Investigation – Construction of Boreholes with Monitor Well Installations**	**Date: 30 August 2009** **Project No.: 1054326**
Work Location: Muskrat Falls, LABRADOR	**Supervisor: Terry Snelgrove**
Client: Nalcor Energy c/o Hatch Mott MacDonald	**Sheet _1_____ of __________**

Borehole Summary

Monitor Well No.	Location NAD 83 Zone 20		Overburden (m)		Bedrock (m)		Depth (m)
	Northing (m)	Easting (m)	Today	To Date	Today	To Date	

Sample/Testing Summary

Monitor Well No.	Type	Nos.	Borehole No.	Type	Nos.

Time Summary

Crew	Drilling	Moving	Testing	Standby	Breakdown	Total
Lantech				Driller Sick		

Remarks (All times in Eastern Time Zone): Wx. Sun/cloud +14C

0730h – Arrive on Site. Conduct toolbox meeting. John Mallick replaces Mary-Anne Aylward as bear monitor. He was monitor during the 2007-08 Gull Island field work. Hatch/Nalcor okay with that. Driller sick today !!

0815h – Install rope and flagging tape to keep the public out of work area.

0840h – Organize new office trailer with supplies from G.Bay office. Go to G.Bay and pick up coffee perk and related supplies. Meet with Bob White of Nalcor.

1145h – Get new GPS coordinates for BH locations. Locations were moved slightly to permit easier setups.

Instruct brushcutters to clear path to site from Well road to facilitate access by drillers to move supplies

2000h – Dinner with the group and Bob Barnes.

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DAILY FIELD REPORT

Project Name: **Geotechnical Investigation – Construction of Boreholes with Monitor Well Installations**	**Date: 31 August 2009** **Project No.: 1054326**
Work Location: Muskrat Falls, LABRADOR	**Supervisor: Terry Snelgrove**
Client: Nalcor Energy c/o Hatch Mott MacDonald	**Sheet 1 of**

Borehole Summary

Monitor Well No.	Location NAD 83 Zone 20		Overburden (m)		Bedrock (m)		Depth (m)
	Northing (m)	Easting (m)	Today	To Date	Today	To Date	
2009 P1 A&B	5902908	0648228	11.9	11.9	0	0	11.9

Sample/Testing Summary

Monitor Well No.	Type	Nos.	Borehole No.	Type	Nos.

Time Summary

Crew	Drilling	Moving	Testing	Standby	Breakdown	Total
Lantech		6.0				

Remarks (All times in Eastern Time Zone): Wx-Showers, no wind, +13C

0730h – Arrive on Site. Conduct toolbox meeting. Bob Barnes on Site for a few hours today to review program and progress. He is exceptionally pleased with safety and progress to date. Driller is back to work today.

0820h – Driller removes last piece of casing from BH 2009 P2B. Begins to move off this setup and move all tooling, extend waterline, etc. Moving to setup 2009 P1. Discuss procedures with Bob Barnes. He is satisfied.

1255h – Go to G. Bay to pickup water and 3 pails of Lantech's drilling mud for the afternoon.

1405h – Back from G.Bay. Driller completed the setup. Connect all waterline hoses together and start pump.

1435h – Drilling HW casing begins on BH# 2009 P1.

1520h – Lost all mud returns at 18' depth. Casing becomes tight in BH. Driller mixes heavier mud and at 22.5' depth re-establishes complete returns which contain an abundance of fine to med grained brown sand grains.

1725h – HW casing at 39' depth. Driller pump heavy mud in hole for the nite. Secure rig; shut down pump.

1810h – Depart Site for G. Bay.

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DAILY FIELD REPORT

Project Name: **Geotechnical Investigation – Construction of Boreholes with Monitor Well Installations**	**Date: 1 September 2009** **Project No.: 1054326**
Work Location: Muskrat Falls, LABRADOR	**Supervisor: Terry Snelgrove**
Client: Nalcor Energy c/o Hatch Mott MacDonald	**Sheet 1 of __________**

Borehole Summary

Monitor Well No.	Location NAD 83 Zone 20		Overburden (m)		Bedrock (m)		Depth (m)
	Northing (m)	Easting (m)	Today	To Date	Today	To Date	
2009 P1 A&B	5902908	0648228	30.7	42.6	0	0	42.6

Sample/Testing Summary

Monitor Well No.	Type	Nos.	Borehole No.	Type	Nos.
2009 P1 A&B	SS	1			

Time Summary

Crew	Drilling	Moving	Testing	Standby	Breakdown	Total
Lantech	9.0		2.5			11.5

Remarks (All times in Eastern Time Zone): Wx-Sun,cloud, +16C

0730h – Arrive on Site. Conduct toolbox meeting.

0800h – Driller go to start water pump; do drill rig pre-op check.

0840h – Resume running HW casing. Encounter softer soils at 48.5’ (14.8m) depth. From 14.8m to 21.3m, generally in softer, med to dark grey soils (silty clay?), with occasional thin layers of denser, light to med brown fine to med sands.

1125h – Encounter consistently softer soils at 79.5’. Driller to watch for brief expected change to sand material at a depth of 130’ to 150’.

1520h – Driller confident he is still in soft clay material at 135’ depth.

1540h – Driller noticed increase in head pressure. Clean out 13.7’ of material inside casing. Prep for SS.

1720h – Take SS 137.7’-139’7’.

1750h – Secure drill rig for the nite. Shut off water pump.

1815h – Depart Site for G. Bay.

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DAILY FIELD REPORT

Project Name: **Geotechnical Investigation – Construction of Boreholes with Monitor Well Installations**	**Date: 2 September 2009**
	Project No.: 1054326
Work Location: Muskrat Falls, LABRADOR	**Supervisor: Terry Snelgrove**
Client: Nalcor Energy c/o Hatch Mott MacDonald	**Sheet 1 of ____**

Borehole Summary

Monitor Well No.	Location NAD 83 Zone 20		Overburden (m)		Bedrock (m)		Depth (m)
	Northing (m)	Easting (m)	Today	To Date	Today	To Date	
2009 P1 A&B	5902908	0648228	0.3	42.7	0	0	42.7

Sample/Testing Summary

Monitor Well No.	Type	Nos.	Borehole No.	Type	Nos.

Time Summary

Crew	Drilling	Moving	Testing	Standby	Breakdown	Total
Lantech	7.5		3.0			10.5

Remarks (All times in Eastern Time Zone): Wx- Cloudy,

0730h – Arrive on Site. Conduct toolbox meeting.

0810h – Driller go to start pump. Do drill rig pre-op check.

0850h – Start rig and run HW casing to 42.7m. Check depth, flush BH of all cuttings and drill mud.

1110h – Begin to install deep 1” monitor well (slot 10 screen with geosock).

1420h – Grout batch mixing complete. Install tremie line and begin to grout.

1455h – Driller says he can’t tag top of grout with tape. Therefore, decided to use silag up to bottom of upper well. This will be the procedure for other two locations.

1650h – LCB to order keyed-alike padlocks and give to Perry T. on Friday to get to G. Bay. Driller clening grout from casing and tremie line; flushing system. Will complete install with silag.

1710h – Driller has all HW casing out of P1. Flush all pipes, hoses, tank and pump of grout.

1825h – Driller shut down water pump and secure site for the nite. Depart for G. Bay.

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DAILY FIELD REPORT

Project Name: **Geotechnical Investigation – Construction of Boreholes with Monitor Well Installations**	**Date: 3 September 2009** **Project No.: 1054326**
Work Location: Muskrat Falls, LABRADOR	**Supervisor: Terry Snelgrove**
Client: Nalcor Energy c/o Hatch Mott MacDonald	**Sheet _1_____ of __________**

Borehole Summary

Monitor Well No.	Location NAD 83 Zone 20		Overburden (m)		Bedrock (m)		Depth (m)
	Northing (m)	Easting (m)	Today	To Date	Today	To Date	
2009 P3 A&B	5902952	0648371	21.4	21.4	0	0	21.4

Sample/Testing Summary

Monitor Well No.	Type	Nos.	Borehole No.	Type	Nos.
2009 P3 A&B	SS				

Time Summary

Crew	Drilling	Moving	Testing	Standby	Breakdown	Total
Lantech	7.5	3.0				10.5

Remarks (All times in Eastern Time Zone): Wx-Sun, cloud, +18C

0730h – Arrive on Site. Conduct toolbox meeting.

0815h – Driller go to start water pump. Do pre-op rig check.

0850h – Driller begins to move from P1 setup to P3 setup.

1145h – All tooling and rig now on P3 setup. Begin to run HW casing.

1320h – Call Neil Parrott. He will have a crew here in the AM to survey-in new BH locations.

1500h – HW casing at 42’ Encountered soft, med. Brown silty material at 38.1’.Full mud returns.

1645h – HW casing at 60’. Soft, med to dark grey, silty clay with interbedded fine sand layers.

1725h – HW casing at 70’. Soft, med. to dark grey, silty clay. Full mud returns.

1755h – Secure site for the nite. Shut down water pump. Depart site for G. Bay.

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DAILY FIELD REPORT

Project Name: **Geotechnical Investigation – Construction of Boreholes with Monitor Well Installations**	**Date: 4 September 2009** **Project No.: 1054326**
Work Location: Muskrat Falls, LABRADOR	**Supervisor: Terry Snelgrove**
Client: Nalcor Energy c/o Hatch Mott MacDonald	**Sheet 1 of**

Borehole Summary

Monitor Well No.	Location NAD 83 Zone 20		Overburden (m)		Bedrock (m)		Depth (m)
	Northing (m)	Easting (m)	Today	To Date	Today	To Date	
2009 P3 A&B	5902952	0648371	18.2	39.6	0	0	39.6

Sample/Testing Summary

Monitor Well No.	Type	Nos.	Borehole No.	Type	Nos.
2009 P1 A&B	SS	1			

Time Summary

Crew	Drilling	Moving	Testing	Standby	Breakdown	Total
Lantech	9.5					9.5

Remarks (All times in Eastern Time Zone): Wx-Sun,cloud, PM showers, +16C

0730h – Arrive Site. Conduct toolbox meeting. Driller go to start water pump.

0845h – Drilling resumes on P1. Encountered sand at 72.3'. Clean out and take SS1

0850h – Called LCB and asked him to contact Clyde MacLean at Water Resources and check on water use permit or approval from his superior, the Director of the department.

0955h – Driller stung by wasp. Complaining of burning sensation. Observe for a while. Slowly improving.

1140h – Call from Denise at Neil Parrott Surveys. Survey crew should be here after lunch to survey BHs.

1330h – Drilling HW casing continuing. Now at 105' depth.

1450h – Parrot's surveyors arrive. Conduct brief version of toolbox safety meeting. Survey in x,y,z on all well locations. Report to be provided next week.

1525h – Surveying complete. Surveyors depart site. ** Total time the surveyors are away from their office is ~ 3hrs.**

1640h – HW casing at 130'. Driller pumps heavy mud into BH for the night. Shutdown water pump

1700h – Driller departs site for G. Bay.

1755h – Secure site for the night and depart for G>Bay.

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DAILY FIELD REPORT

Project Name: **Geotechnical Investigation – Construction of Boreholes with Monitor Well Installations**	**Date: 5 September 2009** **Project No.: 1054326**
Work Location: Muskrat Falls, LABRADOR	**Supervisor: Terry Snelgrove**
Client: Nalcor Energy c/o Hatch Mott MacDonald	**Sheet 1 of __________**

Borehole Summary

Monitor Well No.	Location NAD 83 Zone 20		Overburden (m)		Bedrock (m)		Depth (m)
	Northing (m)	Easting (m)	Today	To Date	Today	To Date	
2009 P3 A&B	5902952	0648371	1.2	40.8	0	0	40.8

Sample/Testing Summary

Monitor Well No.	Type	Nos.	Borehole No.	Type	Nos.
2009 P3 A&B	SS	2A, 2B			

Time Summary

Crew	Drilling	Moving	Testing	Standby	Breakdown	Total
Lantech	6.5		1.0			7.5

Remarks (All times in Eastern Time Zone): Wx-Sunny, cool AM,

0730h – Arrive on Site. Conduct toolbox meeting. Driller go to start water pump. Noticed the third hose from the pump was split open. Make repairs.

0900h – Driller install protective casing at 2009 P1 location.

0940h – Resume running HW casing at P3. Casing tight with no mud returns for 40mins.

1035h – Driller thinks he has hit sand at 131.5’. Stop and clean out 4.8’ soils inside casing in prep for SS.

1140h – Take SS2 at 133’. Sand layer from 131.6’ to 133.0’. Run HW to 134’

1410h – Driller does not get back more than 10% of drill mud returns. Weight up mud in hole until tomorrow. Too late in the day to begin installation of wells.

1540h – Bob White (Nalcor) and three other guys show up for a site visit.

1545h – Driller go to shut off water pump and drain all hoses (may be frost tonite).

1620h – Secure site for the nite and depart for G. Bay

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DAILY FIELD REPORT

Project Name: **Geotechnical Investigation – Construction of Boreholes with Monitor Well Installations**	**Date: 6 September 2009** **Project No.: 1054326**
Work Location: Muskrat Falls, LABRADOR	**Supervisor: Terry Snelgrove**
Client: Nalcor Energy c/o Hatch Mott MacDonald	**Sheet 1 of**

Borehole Summary

Monitor Well No.	Location NAD 83 Zone 20		Overburden (m)		Bedrock (m)		Depth (m)
	Northing (m)	Easting (m)	Today	To Date	Today	To Date	
2009 P3 A&B	5902952	0648371		40.8	0	0	40.8

Sample/Testing Summary

Monitor Well No.	Type	Nos.	Borehole No.	Type	Nos.

Time Summary

Crew	Drilling	Moving	Testing	Standby	Breakdown	Total
Lantech		2.0	8.5			10.5

Remarks (All times in Eastern Time Zone): Wx-Sun, cloud +15C

0730h – Arrive on Site. Conduct toolbox meeting. Take group photos. Two bears (one injured) observed about 1km from site and fresh wolf tracks.

0800h – Driller startup water pump and connect all waterline hoses. Do drill rig pre-op check.Take water level readings on new wells.

0840h – Driller ready to begin BH flush on P3 for well install.

0905h – Flushing complete. HW casing is freely moving. Drop in lower well and install silag and bentonite.

1025h – Lower well installed. Place silag up to next bentonite seal.

1145h – Drop in upper well. Place silag and upper bentonite seal.

1240h – Prepare to mix and place grout from 62’ to 2’.

1440h – Grouting completed. Prepare to clean grouting equipment. Then teardown from site P3 and move equipment and drill rig to setup P4.

1800h – All equipment and drill moved to P4 setup. Shut down water pump and secure site for the nite. Depart Site for G. Bay.

DAILY FIELD REPORT

Project Name: **Geotechnical Investigation – Construction of Boreholes with Monitor Well Installations**	**Date: 7 September 2009** **Project No.: 1054326**
Work Location: Muskrat Falls, LABRADOR	**Supervisor: Terry Snelgrove**
Client: Nalcor Energy c/o Hatch Mott MacDonald	**Sheet 1 of**

Borehole Summary

Monitor Well No.	Location NAD 83 Zone 20		Overburden (m)		Bedrock (m)		Depth (m)
	Northing (m)	Easting (m)	Today	To Date	Today	To Date	
2009 P4 A&B	5903123	0648378	33.1	33.1			33.1

Sample/Testing Summary

Monitor Well No.	Type	Nos.	Borehole No.	Type	Nos.
2009 P4 A&B	SS	1A&1B			

Time Summary

Crew	Drilling	Moving	Testing	Standby	Breakdown	Total
Lantech	9.0		1.5			10.5

Remarks (All times in Eastern Time Zone): Wx-Sun, Cloud, +16C

0730h – Arrive on Site. Conduct toolbox safety meeting. P.Sullivan crew demobing from Site today.

0805h – Driller go to start water pump and do rig pre-op check.

0830h – Take WL readings on new wells.

0840h – Driller begins drilling on P4.

1030h – HW casing at 25’.

1210h – Driller reports he went from the compact, medium grained sand to a soft, med grey silty clay at 48’

1335h – Driller reports he went from the silty clay to a sand at 68.1. Stop drilling, clean out ~6’ material up inside casing. Take SS1 from 68’ to 70’. Recovered first 6”of wet, silty clay and the last 18” of dry, fine sand.

1450h – Resume drilling HW casing.

1525h – Driller reports he went from fine sand to soft, silty clay at 71.1’. Then he encountered the dense sand again at 78.3’. Continue drilling to find the next stratigraphic change.

1700h – HW casing at 98.5’. Interbedded fine sand and silty clay.

1740h – HW casing at 108.5’. Mix heavy mud for the nite. Shut down pump and secure for the nite.

1810h – Depart Site for G. Bay.

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DAILY FIELD REPORT

Project Name: **Geotechnical Investigation – Construction of Boreholes with Monitor Well Installations**	**Date: 8 September 2009**
	Project No.: 1054326
Work Location: Muskrat Falls, LABRADOR	**Supervisor: Terry Snelgrove**
Client: Nalcor Energy c/o Hatch Mott MacDonald	**Sheet _1______ of __________**

Borehole Summary

Monitor Well No.	Location NAD 83 Zone 20		Overburden (m)		Bedrock (m)		Depth (m)
	Northing (m)	Easting (m)	Today	To Date	Today	To Date	
2009 P4 A&B	5903123	0648378	12.9	46.0	0	0	46.0

Sample/Testing Summary

Monitor Well No.	Type	Nos.	Borehole No.	Type	Nos.
2009 P4 A&B	SS	2, 3			

Time Summary

Crew	Drilling	Moving	Testing	Standby	Breakdown	Total
Lantech	7.5		2.0			9.5

Remarks (All times in Eastern Time Zone): Wx – Sunny, +12C

0730h – Arrive Site. Conduct toolbox safety meeting. All hands go to look at water pump setup at pond. Driller do drill rig pre-op check.

0820h – Driller resumes running HW casing in P4.

0900h – Take WL readings on new wells with Nalcor guys.

1005h – HW casing at 128.5’. Driller reports he is still in a soft clay.When he connects the next piece of casing, he observes that the water pressure is increasing slightly and the casing is binding slightly.

1145h – running HW casing from 133.5’ to 138.5’ takes 3 tubs of drilling mud. Stop drilling. Clean out 4.8’ of material inside casing in preparation for a SS sample.

1240h – Take SS2 sample from 137.7’ to 139.7’. recovered saturated fine sand with silt.

1350h – HW casing at 140’. Still in sand. Water blocking occ.

1420h – Encounter clay at 146’. Run casing to 149’, clean out casing and take SS from 149’ – 151’. Sample is firm to stiff, dry to damp, med to dark grey silty clay.

1555h – Driller pump heavy mud in BH, drain waterline and shut down pump for the nite.

1615h – Take water level readings in new wells.

1700h – Depart Site for G. Bay.

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DAILY FIELD REPORT

Project Name: **Geotechnical Investigation – Construction of Boreholes with Monitor Well Installations**	**Date: 9 September 209** **Project No.: 1054326**
Work Location: Muskrat Falls, LABRADOR	**Supervisor: Terry Snelgrove**
Client: Nalcor Energy c/o Hatch Mott MacDonald	**Sheet _1_____ of __________**

Borehole Summary

Monitor Well No.	Location NAD 83 Zone 20		Overburden (m)		Bedrock (m)		Depth (m)
	Northing (m)	Easting (m)	Today	To Date	Today	To Date	
2009 P4 A&B	5903123	0648378	0	46.0	0	0	46.0

Sample/Testing Summary

Monitor Well No.	Type	Nos.	Borehole No.	Type	Nos.

Time Summary

Crew	Drilling	Moving	Testing	Standby	Breakdown	Total
Lantech			10.5			10.5

Remarks (All times in Eastern Time Zone): Wx – Sun, cloud, +12C

0730h – Arrive at Site. Conduct toolbox safety meeting. Trailer to be removed from site today. Concern over the poor condition of the tow bar and wheel/axle on the trailer.

0800h – Driller go to connect water hoses and start up water pump. Driller do rig safety pre-op check.

0840h – Driller start to circulate clean water into HW casing and BH to flush out drilling fluids in preparation of well installations.

0925h – Start to install lower monitor well in P4 (P4B).

1130h – Lower well installed with silag around screen and upper bentonite seal in place. Place silag up to bottom portion of upper installation. Place bentonite seal. Install 12' for upper well, then bentonite.

1250h – Mix 150 gal. grout and tremie it down BH.

1405h – Begin pumping grout down BH.

1640h – Borehole grouting complete. Driller wash grout from hoses and equipment.

1650h – Begin to drain and coil up water lines. Shut down water pump and secure site for the nite.

1800h – Depart Site fir G. Bay.

ATTACHMENT E

Site Photos

Photo 1 Water Supply Pump

Photo 2 Drill Rig Move to P4 Setup

Photo 3 Sample 2009 P4 SS1B

Photo 4 2009 P4 Sample SS3

Photo 5 Well Install P4 (B)

Photo 6 Well Install P4 (A)

Photo 7 Mixing Grout 2009 P3

Photo 8 Grouting 2009 P3

Photo 9 Grouting 2009 P3

Photo 10 Grouting 2009 P4

Photo 11 Completed 2009 P2A

Photo 12 2009 P4 (A & B)

Photo 13 Group Picture