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**GEOLOGICAL SURVEY OF CANADA
OPEN FILE 7658**

**Shallow Drilling and Piezometer Installations
near Killarney, Manitoba for Hydrogeological Investigations
of the Spiritwood Buried Valley Aquifer**

M.J. Hinton and D.R. Sharpe

2014

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Abstract

The Geological Survey of Canada (GSC) is investigating the hydrogeology of the Spiritwood buried valley aquifer in southwestern Manitoba as part of its Groundwater Geosciences Program. This Open File reports on a drilling program conducted in November 2010 in which one shallow and one intermediate depth piezometer were installed within separate boreholes at each of three sites near Killarney, Manitoba to complement existing deep wells monitored by Manitoba Conservation and Water Stewardship (Government of Manitoba, Ministry of CWS). Boreholes were advanced without drilling fluids by the cable tool method and by driving core tubes which allowed for accurate borehole logging and the collection of sample cores at selected depths. This Open File includes the geological logs of the boreholes, the piezometer construction details and the geotechnical data measured on sampled core. Geotechnical analyses included measurement of approximate shear strength using a pocket penetrometer ($n=21$), grain size distribution ($n=8$), gravimetric water content ($n=91$), and wet bulk density ($n=22$) from which dry bulk density ($n=22$) and volumetric water content ($n=22$) were calculated and porosity ($n=22$) estimated.

The drilling program was a collaborative effort between the Agri-Environmental Services Branch (AESB) of Agriculture and Agri-Food Canada (AAFC) and the Geological Survey of Canada of Natural Resources Canada (NRCan).

Table of Contents

Abstract	iii
Table of Contents	iv
List of Figures:	v
List of Tables:	vi
Introduction	1
Study area	1
Previous and current studies	1
Methods	2
Results	4
Site GSC-BH-SW-02 (CWS well G05OA010)	4
Site GSC-BH-SW-03 (CWS well G05OA009)	4
Site GSC-BH-SW-04 (CWS well G05OA008)	5
Additional work and installations	6
Summary	6
Acknowledgments	6
References	7
Figures	9
Tables	30
Appendices	48
Appendix A: Field borehole descriptions	48
Appendix B: Additional photographs	95

List of Figures:

Figure 1. Regional map of the approximate extent of the Spiritwood buried valley.....	9
Figure 2. Satellite image (source Google Earth) of the proposed and actual drill sites.....	10
Figure 3. B-12 cable tool rig and field core logging trailer at site G05OA010 (GSC-BH-SW02), November 2010.....	11
Figure 4. Photographs of piezometer sites.....	12
Figure 5. Borehole log for GSC-BH-SW-02B completed with piezometer GSC-SW-02-p1.....	14
Figure 6. Borehole log for GSC-BH-SW-02A completed with piezometer GSC-SW-02-p2.....	15
Figure 7. Borehole log for GSC-BH-SW-03B completed with piezometer GSC-SW-03-p1.....	16
Figure 8a. Borehole log for GSC-BH-SW-03A completed with piezometer GSC-SW-03-p2, 1 of 2..	17
Figure 8b. Borehole log for GSC-BH-SW-03A completed with piezometer GSC-SW-03-p2, 2 of 2..	18
Figure 9. Borehole log for GSC-BH-SW-04B completed with piezometer GSC-SW-04-p1.....	19
Figure 10. Borehole log for GSC-BH-SW-04A completed with piezometer GSC-SW-04-p2.....	20
Figure 11. Legend for borehole logs in Figures 5-10 (provided by AAFC).....	21
Figure 12. Grain size analysis, borehole GSC-BH-SW-04A, 12.19-12.50 m depth.....	22
Figure 13. Grain size analysis, borehole GSC-BH-SW-04A, 13.40 m depth.....	23
Figure 14. Grain size analysis, borehole GSC-BH-SW-04A, 14.00 m depth.....	24
Figure 15. Grain size analysis, borehole GSC-BH-SW-04A, 14.60 m depth.....	25
Figure 16. Grain size analysis, borehole GSC-BH-SW-03A, 24.00-24.10 m depth.....	26
Figure 17. Grain size analysis, borehole GSC-BH-SW-03A, 24.10-24.30 m depth.....	27
Figure 18. Grain size analysis, borehole GSC-BH-SW-02A, 8.35-8.55 m depth.....	28
Figure 19. Grain size analysis, borehole GSC-BH-SW-02B, 1.00 m depth.....	29

List of Tables:

Table 1. Borehole and piezometer designations and locations	30
Table 2. Piezometer installations	31
Table 3. Borehole log descriptions, GSC-BH-SW-02A	33
Table 4. Borehole log descriptions, GSC-BH-SW-02B	34
Table 5. Borehole log descriptions, GSC-BH-SW-03A	35
Table 6. Borehole log descriptions, GSC-BH-SW-03B	37
Table 7. Borehole log descriptions, GSC-BH-SW-04A	38
Table 8. Borehole log descriptions, GSC-BH-SW-04B	39
Table 9. Geotechnical data, site GSC-BH-SW-02 (G05OA010).	40
Table 10. Geotechnical data, site GSC-BH-SW-03 (G05OA009).	41
Table 11. Geotechnical data, site GSC-BH-SW-04 (G05OA008).	43
Table 12. Borehole log, CWS well, G05OA010 as recorded in the CWS database.....	45
Table 13. Borehole log, CWS well, G05OA009 as recorded in the CWS database.....	46
Table 14. Borehole log, CWS well, G05OA008 as recorded in the CWS database.....	47

Introduction

The Geological Survey of Canada (GSC) is investigating the hydrogeology of the Spiritwood buried valley aquifer in southwestern Manitoba as part of its Groundwater Geosciences Program. The Spiritwood buried valley aquifer is a cross-border aquifer extending from Manitoba, through North Dakota and into South Dakota (Figure 1). This aquifer has been studied extensively in North Dakota but is less known in Manitoba. The Water Resources Branch of Manitoba Natural Resources (currently Water Science and Management Branch of Manitoba Conservation and Water Stewardship, CWS) had previously drilled boreholes in the study area in 1974 and again in 2000-02. Eight monitoring wells drilled along the Spiritwood buried valley aquifer between Margaret, Manitoba, and the international border are currently being monitored by CWS. Most of these monitoring wells are screened at depth in confined units; interpretation of their water level fluctuations is problematic since there are no records of groundwater level response near the ground surface and at intermediate depths. A drilling program was undertaken in November 2010 to install piezometer nests at four sites with active CWS monitoring wells along the Spiritwood buried valley aquifer. One site was not accessible and, at the conclusion of fieldwork, two additional piezometers (one shallow, one intermediate depth) were installed at each of three existing sites. The purpose of this GSC Open File is to present the logs and geotechnical data collected from the six boreholes drilled near Killarney, Manitoba in November 2010.

The drilling program was a collaborative effort between Agriculture and Agri-Food Canada (AAFC) and Natural Resources Canada (NRCan). AAFC provided the drill rig with the field crew and technical support for geotechnical analysis of collected samples and compilation of field logs. NRCan selected the sites, ensured utility clearances before drilling, consulted with drillers to select piezometer installation depths, developed piezometers and installed water level recording dataloggers.

Study area

The study area is located in southwestern Manitoba near the town of Killarney (Figure 2). Four active CWS monitoring well sites were targeted for shallow piezometer installations: G05OA008, G05OA009, G05OA010, and G05OA011, however site G05OA011 was not accessible to the drill rig due to water ponding at the surface in a ditch. AAFC and GSC assigned their own site numbers to the new boreholes and the GSC also assigned new piezometer numbers to the completed piezometers. All borehole and piezometer designations are presented in Table 1 along with their GPS coordinates.

Previous and current studies

The groundwater resources of the Brandon map area were first mapped and summarized by Halstead (1959). By mapping the bedrock topography, he recognized the presence of deep valleys in the bedrock that were subsequently filled with glaciofluvial and glacial sediments. Although he acknowledged the potential of these buried valley aquifers for higher yield wells, there was minimal information available about them. More information existed for the shallower sand and gravel bodies found locally within the till. He observed that the volume of water recovered from these inter-till aquifers varied depending on their thickness, extent and interconnection with other aquifers and the ground surface.

Bedrock topography was subsequently mapped for all southern Manitoba by Klassen et al. (1970). Teller et al. (1976) similarly compiled bedrock topography and sediment thickness for southern Manitoba, whereas Sie and Little (1976) produced several maps and cross-sections of the Brandon

map area for the Groundwater Availability Map Series produced by Manitoba Natural Resources, Water Resources Branch. These maps indicate the presence of a broad buried valley that crosses the international border in a north-south direction just south of Cartwright, Manitoba, and then extends from Cartwright to the northwest towards the Souris River near Margaret.

The province of Manitoba has undertaken test drilling of the Spiritwood aquifer in 1961-62, 1974 and then installed 8 monitoring wells in 2000-02. The results of these drilling programs were never published, although the logs are available within the provincial water well records. In 2009, the province drilled 23 boreholes to specifically target buried valleys to the north and west of the current study area between Margaret and Brandon (Toop, 2010). Test drilling and a short-term pump test were conducted for the development of a groundwater supply for the Town of Killarney (Friesen Drilling Ltd., 2007; W. L. Gibbons & Associates Inc., 2009).

The Spiritwood buried valley aquifer was studied in greater detail in North Dakota where it is a significant water source for irrigation and municipal supply (Randich and Kuzniar, 1984; Shaver, 1984; Shaver and Pusc, 1992). Several cross-sections of mud-rotary holes were drilled at approximately one mile intervals to define the extent of the Spiritwood buried valley aquifer as well as the shallower inter-till aquifers in the area just south of the international boundary (Randich and Kuzniar, 1984).

As part of the GSC's Groundwater Geoscience Program, airborne and ground electromagnetic (Oldenborger, 2010b; Oldenborger, 2010a; Oldenborger et al., 2010; Oldenborger et al., 2011; Oldenborger et al., 2013), seismic reflection (Oldenborger et al., 2011; Oldenborger et al., 2013; Pullan et al., 2013; Pugin et al., 2014) and borehole (Crow et al., 2012a) geophysical surveys were conducted to help define the location, depth and composition of the Spiritwood buried valley aquifer in Manitoba. A borehole was cored to a depth of 97.5 m (320 feet) south of Cartwright, Manitoba, and two piezometers were installed at the site (Crow et al., 2012b).

Methods

All six boreholes were advanced with a B-12 cable tool rig owned and operated by the Agri-Environmental Services Branch (AESB) of AAFC without adding drilling fluids (water or mud; Figure 3 and Appendix B). A 3 $\frac{7}{8}$ " diameter excavator bit was used to drill the initial borehole and bring cuttings to the surface for geological logging. Sediments were described and classified in the field using a modified unified soil classification system (USCS). A pocket penetrometer was used on site to provide estimates of unconfined compressive strength and assist sample descriptions. Intact cores were retrieved for selected intervals in 0.75 m length brass liner tubes driven into the sediment. Cores were sealed and stored for subsequent gravimetric water content and wet bulk density analysis in the laboratory. A core catcher was occasionally used at the base of the tube depending on the nature of the cored sediment. The upper portions of the borehole were usually reamed out using 5 $\frac{5}{8}$ " and sometimes 7 $\frac{7}{8}$ " bits to assist with the advance of a temporary 4" casing to keep the borehole open in sandy sections and allow for installation of piezometers and filter sands. The 4" casing was removed following piezometer installation. Piezometers were completed with 2" nominal PVC pipe (schedule 40 thickness) fitted with 20-slot screens (20/1000" slot width). Filter sand was emplaced adjacent to (and slightly above) screened intervals (Table 2). The borehole annulus was sealed with bentonite and followed by borehole cuttings. Lockable steel casing protectors (5'x6"x6") were installed over each piezometer and extended approximately 0.75 m above ground surface (stick up). Locks on the wells were supplied by CWS and were keyed alike to all the CWS monitoring wells.

Cores were extruded from the tubes at AAFC laboratories in Regina to log the geology and obtain samples for geotechnical analysis. Samples were analyzed for gravimetric moisture content (ASTM Committee D18 on Soil and Rock, 2005), wet bulk density (AAFC internal method, described below), and compressive strength using a pocket penetrometer. Grain size analysis (ASTM Committee D18 on Soil and Rock, 2006; ASTM Committee D18 on Soil and Rock, 2007) was conducted to determine the sand and gravel fractions ($>75\text{ }\mu\text{m}$) of the non-till units. Particles passing through the $75\text{ }\mu\text{m}$ sieve (silt and clay sized particles) are reported in aggregate as “fines”.

Wet bulk density is measured by weighing a wet sample sealed in wax both in air and in water, and includes the following steps (PFRA, no date):

1. The soil sample was coated with paraffin wax.
2. The waxed sample was weighed on a balance.
3. On the same balance, the sample was suspended into a large container of water and weighed while it was submerged in water.
4. The sample density was calculated using the following equation:

$$\rho_{wet} = \frac{m_a \cdot \rho_{water}}{m_a - m_w} \quad (1)$$

where

ρ_{wet} is wet bulk density (g/cm^3),

ρ_{water} is the density of water (g/cm^3), assumed to be $1\text{ g}/\text{cm}^3$,

m_a is the sample weight in air (g), and

m_w is the sample weight in water (g).

From the measured values of gravimetric water content and wet bulk density, both the dry bulk density and volumetric water content were calculated by the following equations:

$$\rho_{dry} = \frac{\rho_{wet}}{(1+w)} \quad (2)$$

$$\theta = \frac{\rho_{wet} \cdot w}{\rho_{water}} \quad (3)$$

where

ρ_{dry} is dry bulk density (g/cm^3),

w is gravimetric water content (g water/g of soil), and

θ is volumetric water content (cm^3/cm^3).

Porosity was also estimated from the following equation by assuming a specific gravity of sediment particles of 2.65:

$$n = \frac{(G_s \cdot \rho_{wet}) - \rho_{dry}}{G_s \cdot \rho_{wet}} \quad (4)$$

where

n = porosity (cm^3/cm^3), and

G_s = specific gravity ($\text{g}/\text{cm}^3 / \text{g}/\text{cm}^3$).

Results

Two boreholes were advanced at each of three sites and a piezometer was constructed in each borehole for a total of six piezometers (Figure 4, Table 1). Piezometer construction is summarized in Table 2. Borehole logs for each borehole are presented graphically in Figures 5 to 10 and tabulated in Tables 3 to 8. The legend for borehole logs is shown in Figure 11. Borehole logs were based both on field observations of sediment samples during drilling and laboratory inspection of extruded cores. Field borehole descriptions are reproduced in Appendix A. Grain size distributions of non-till units are presented in Figures 12 to 19. Geotechnical results are compiled in Tables 9 to 11.

Site GSC-BH-SW-02 (CWS well G05OA010)

The well log for the mud-rotary drilled monitoring well G05OA010 (Table 12) corresponds closely with that obtained from borehole GSC-BH-SW-02A (Figure 6, Table 3). A shallow sand unit was encountered between 0.45 and 1.15 m and was instrumented with piezometer GSC-SW-02-p1 (in borehole GSC-BH-SW-02B) which will provide an effective measurement of the water table depth. The deepest observation of oxidation in borehole GSC-BH-SW-02A was 3.15 m whereas beige till was noted to a depth of 3.7 m (12') for well G05OA010.

Although the borehole log for GSC-BH-SW-02A only indicates one deeper sand unit from 8.00 m to 8.60 m, another thinner sandy seam was encountered at 9.75 m (Appendix A1) and is also recorded in well G05OA010 from 33-34' (10.1-10.4 m). The screen for piezometer GSC-SW-02-p2 straddles this thin sandy seam. Borehole GSC-BH-SW-02A was not extended deeper because there were no other sandy units reported above the deeper aquifer in well G05OA010 (Table 12) and drilling progress was hampered by a cobble at 9.1 m.

Grain size analyses of the shallow (Figure 19) and intermediate (Figure 18) sand units yielded similar size distributions that indicate a predominance of medium sand with 18% and 16% of fines (silt and clay sized sediment), respectively. Geotechnical data show fairly consistent measurements within the till (Table 9). Average values of wet and dry bulk densities ($n=5$) were 2.08 ± 0.06 and $1.78 \pm 0.08 \text{ g}/\text{cm}^3$, respectively. Results showed consistency as the average volumetric water content ($n=5$) was 0.30 ± 0.02 , whereas the average estimated porosity ($n=5$) was 0.33 ± 0.03 . Pocket penetrometer readings indicated a very stiff to hard consistency. The sand at 8.0 to 8.6 m depth had higher gravimetric water contents than the till (Table 9), which suggests that the porosity of the sand is higher than that of the till and/or that the dry bulk density of the sand is lower than that of the till.

Site GSC-BH-SW-03 (CWS well G05OA009)

The well log for the mud-rotary drilled monitoring well G05OA009 (Table 13) indicates a clayey beige till (i.e. oxidized) to a depth of 5.5 m (18') which is comparable to the observed maximum depths of 6.75 m of joint oxidation and the presence of gypsum in borehole GSC-BH-SW-03A (Figure 8, Table 5). The shallow piezometer GSC-SW-03-p1 is completed in a silty seam within the oxidized till of borehole GSC-BH-SW-03B and provides a measurement of the water table depth. The sand seam from 1.4 to 1.5 m depth would not have been suitable for piezometer installation since the water table is below this depth most of the time.

The numerous descriptions of “clay shale” within borehole GSC-BH-SW-03A either as fragments or as “shale” units are testimony to the high proportion of reworked shale within the till (Figure 8, Table 5, Appendix A3). The shale is present throughout much of the thickness of till as the first “clay shale” unit in borehole GSC-BH-SW-03A is recorded at 17.8-18.0 m depth (and at 18.6-19.2 m (61-63') depth in G05OA009) and the depth of the true shale bedrock surface is recorded as 59.7 m (196') in well G05OA009.

A five foot thick “sand and gravel layer” was recorded in well G05OA009 at a depth of 32.0-33.5 m (105-110'). In borehole GSC-BH-SW-03A only a few thin sandy and silty seams were encountered within the till between depths of 22.8 and 33.4 m. Piezometer GSC-SW-03-p2 straddles the lowermost of these thin sandy seams with a filter pack extending from 31.4 to 35.0 m depth.

The greater variability in the till was also observed in the geotechnical properties. Gravimetric water contents exhibited a wide range from 13.0 to 30.8 g of water/100 g of dry soil even below the water table with an average for all measurements of 21.3 ± 4.9 g/100 g. Average values of wet and dry bulk densities ($n=11$) were 1.97 ± 0.11 and 1.64 ± 0.14 g/cm³, respectively, whereas average volumetric water content and porosity were 0.33 ± 0.04 and 0.38 ± 0.05 , respectively. Pocket penetrometer readings had the largest range of the three sites and indicated stiff to hard consistency.

Grain size analyses from the only non-till or clay shale units encountered characterize the sandy and silty seams. The sand seam is predominantly fine sand (75%), has no sediment coarser than medium sand (8%) and has 17% fines (24.0-24.1 m depth, Figure 16). The underlying sandy silt unit has only 1% medium sand, 44% fine sand and is predominantly (55%) fines (24.1-24.3 m depth, Figure 17).

Site GSC-BH-SW-04 (CWS well G05OA008)

The well log for the mud-rotary drilled monitoring well G05OA008 (Table 14) differs significantly with that obtained from borehole GSC-BH-SW-04A (Figure 10, Table 7). Whereas the well log for G05OA008 records brown coarse sand (0-5.5 m, 0-18') and brown coarse gravel (5.5-6.7 m, 18-22'), the description of borehole GSC-BH-SW-04A makes no mention of sand or gravel and simply reports stiff to hard till with oxidized fractures or joints to a depth of 7.90 m. Similarly, the sandy non-till units in borehole GSC-BH-SW-04A (between 12.19 and 14.80 m depth) are offset from the gravel recorded in well G05OA008 (between 18.9 and 19.5 m, 62-64'). As the UTMs on well G05OA008 (Table 14) concur with those for GSC-SW-04-p1 and -p2 (Table 1), even though they were obtained independently, it is concluded that the correct well log for G05OA008 was likely used but that the site geology may have been misinterpreted in the mud-rotary borehole.

Piezometer GSC-SW-04-p1 was completed near the base of the oxidized zone (filter pack from 4.00 to 7.50 m depth), slightly below the water table (2.6-3.8 m deep). The intermediate depth piezometer GSC-SW-04-p2 straddles the sand and gravel units in borehole GSC-BH-SW-04A with a filter pack extending from 11.40-15.10 m depth.

Compared to borehole GSC-BH-SW-03A, the grain size distributions of non-till units in GSC-BH-SW-04A (Figures 12-15) are coarser and slightly less uniform (better graded). In particular, the sample at 13.4 m depth has 42% gravel, 49% sand and 9% silt and clay (fines; Figure 13). The presence of fines even in gravel units suggests that high hydraulic conductivities are unlikely within the inter-till sands and gravels of these boreholes.

Geotechnical data show considerable variability (Table 11). Gravimetric water contents are generally lower than for site GSC-BH-SW-03 with an average value of 16.3 ± 3.8 g/100 g that may reflect the coarser grain size in borehole GSC-BH-SW-04A. Although average values and standard deviations of porosities and volumetric water contents are similar to those for borehole GSC-BH-SW-03A, the estimated porosities (0.37 ± 0.06 , n=6) are consistently higher than the calculated volumetric water contents (0.28 ± 0.04 , n=6) even if only those samples below the water table are considered (n=5). Average values of wet and dry bulk densities (n=5) were 1.96 ± 0.13 and 1.68 ± 0.15 g/cm³, respectively. Pocket penetrometer readings indicated very stiff to hard consistency.

Additional work and installations

The piezometer nests are being used to assess groundwater conditions at these three sites as part of the investigation of the Spiritwood buried valley aquifer. These piezometers have also been developed, bail and slug tested and instrumented to allow for continuous monitoring. The piezometers have also been purged and sampled for groundwater geochemical and isotopic analyses. Soil moisture probes have been installed at sites GSC-BH-SW-02 and GSC-BH-SW-04 to provide data on the timing of infiltrating precipitation in relation to groundwater recharge.

Summary

This report documents geological, geotechnical and piezometer data collected during the drilling of six boreholes at three sites near Killarney, Manitoba. A piezometer was successfully installed in each borehole such that each monitoring site now has a vertical nest of three piezometers, including a shallow piezometer near the water table, an intermediate piezometer that straddles a sandy seam or layer, and a deeper Manitoba CWS monitoring well. As these boreholes were advanced without drilling fluids and cores were retrieved, the geology logs were expected to be more accurate than mud-rotary logger boreholes. The boreholes predominantly intercepted till with occasional gravel and sand or silt seams or thin layers. The depth of oxidation within the till varied from 3.15 m to 7.90 m. Till was mostly stiff to very hard. Geotechnical measurements were most uniform at site GSC-BH-SW-02 and most variable at site GSC-BH-SW-03. These piezometer installations will permit interpretation of the hydraulic relations between the groundwater table and the Spiritwood buried valley aquifer.

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Figures

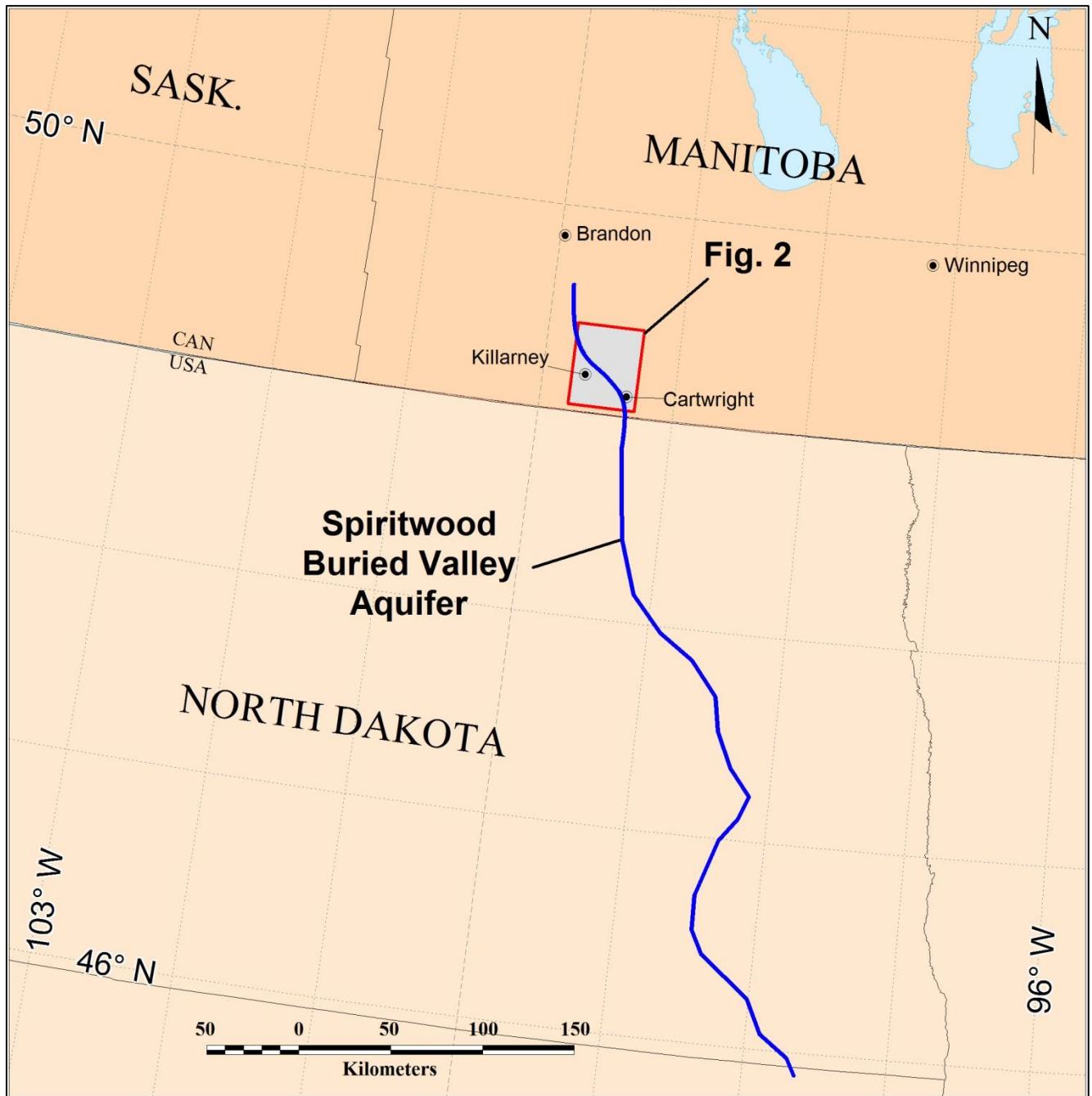


Figure 1. Regional map of the approximate extent of the Spiritwood buried valley.

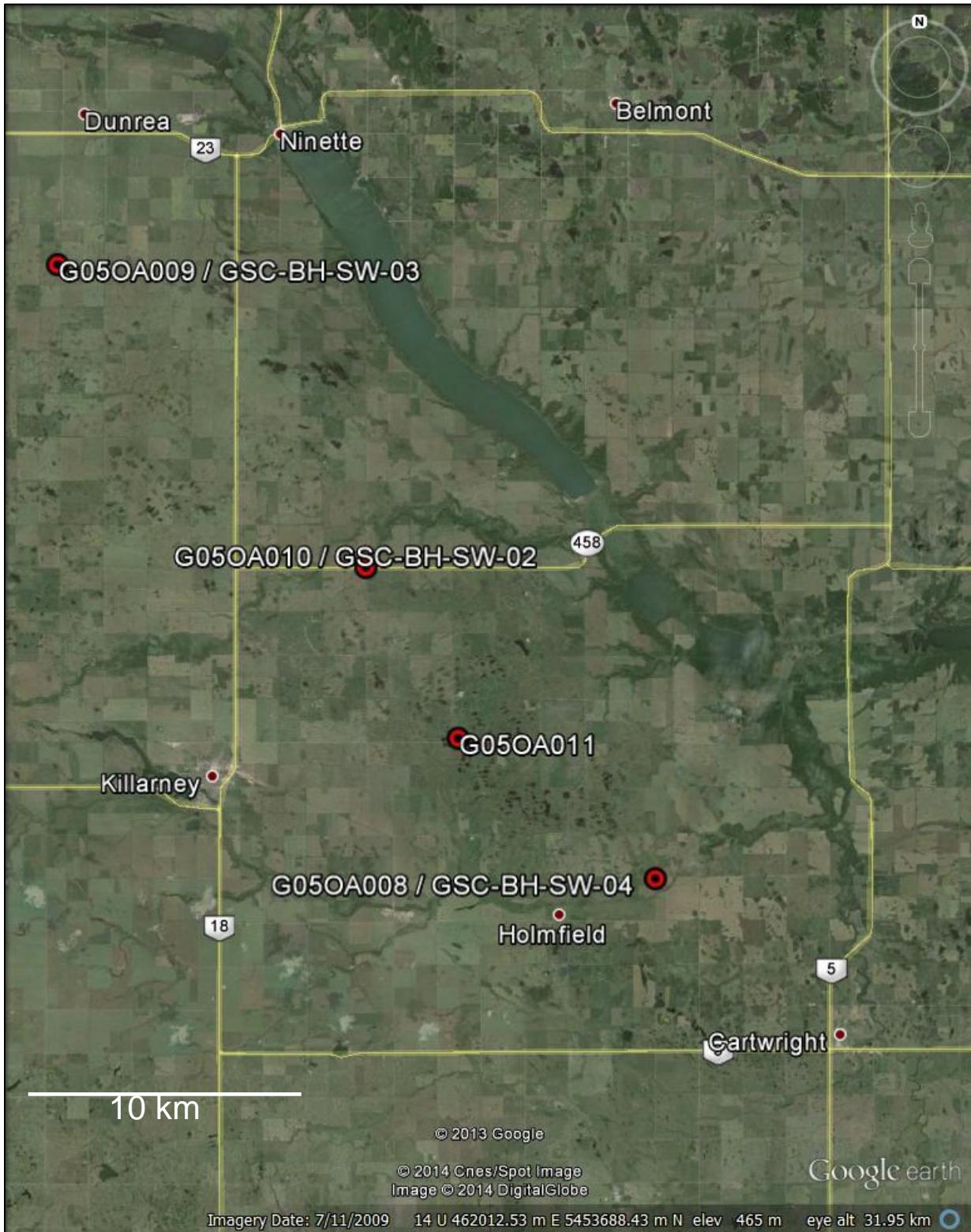


Figure 2. Satellite image (source Google Earth) of the proposed and actual drill sites. First identifiers are the Manitoba Water Stewardship well numbers, second identifiers are the GSC borehole site numbers.



Figure 3. B-12 cable tool rig and field core logging trailer at site G05OA010 (GSC-BH-SW02), November 2010.



Figure 4. Photographs of piezometer sites.

a) GSC-SW-02-p1 (foreground), GSC-SW-02-p2 (middle) and G05OA010 (distant), facing NNW.



b) GSC-SW-03-p1 (left), GSC-SW-03-p2 (middle) and G05OA009 (right), facing NNE.



c) G05OA008 (left), GSC-SW-04-p2 (middle), GSC-SW-04-p1 (right), facing south.

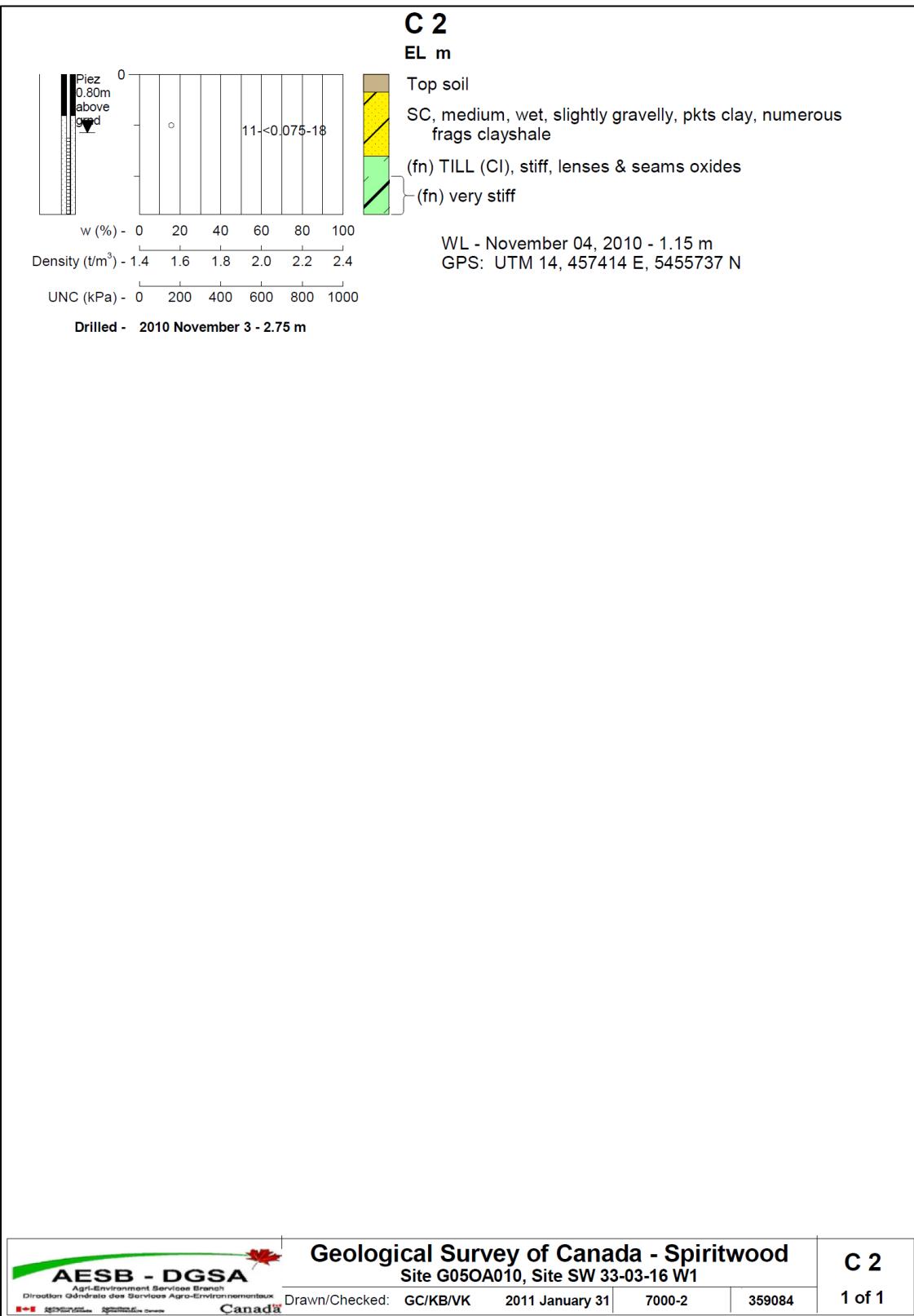


Figure 5. Borehole log for GSC-BH-SW-02B completed with piezometer GSC-SW-02-p1.

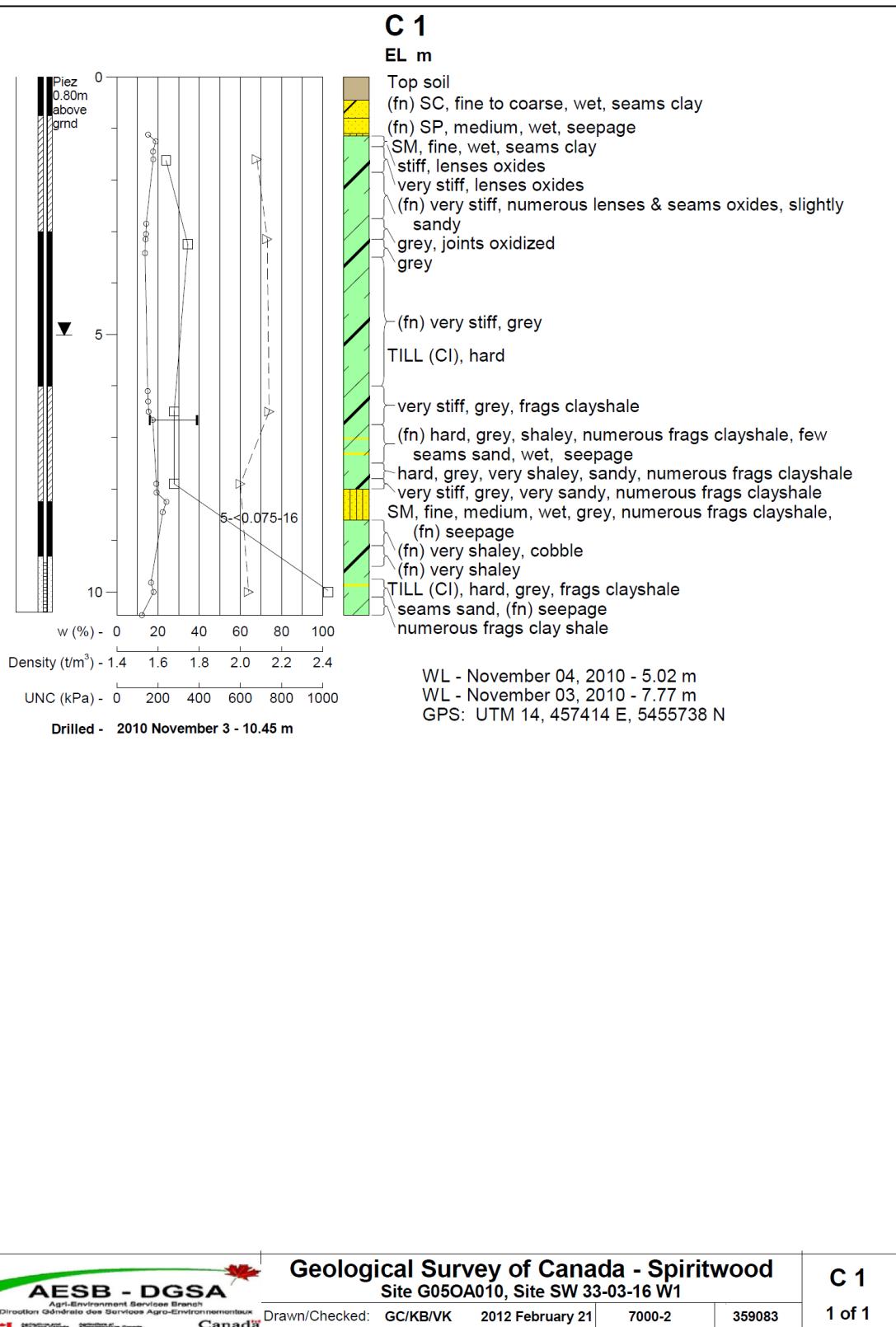


Figure 6. Borehole log for GSC-BH-SW-02A completed with piezometer GSC-SW-02-p2.

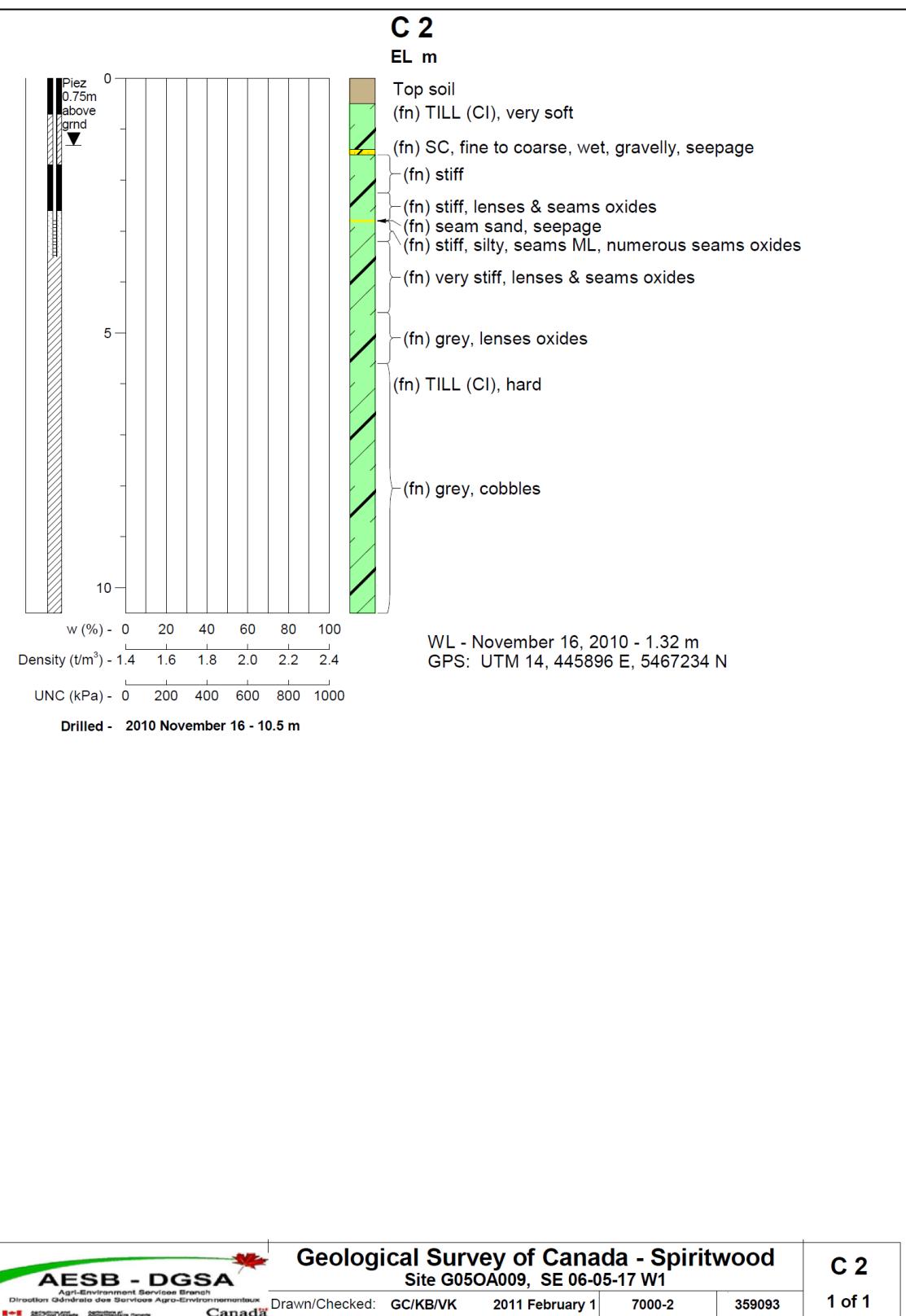


Figure 7. Borehole log for GSC-BH-SW-03B completed with piezometer GSC-SW-03-p1.

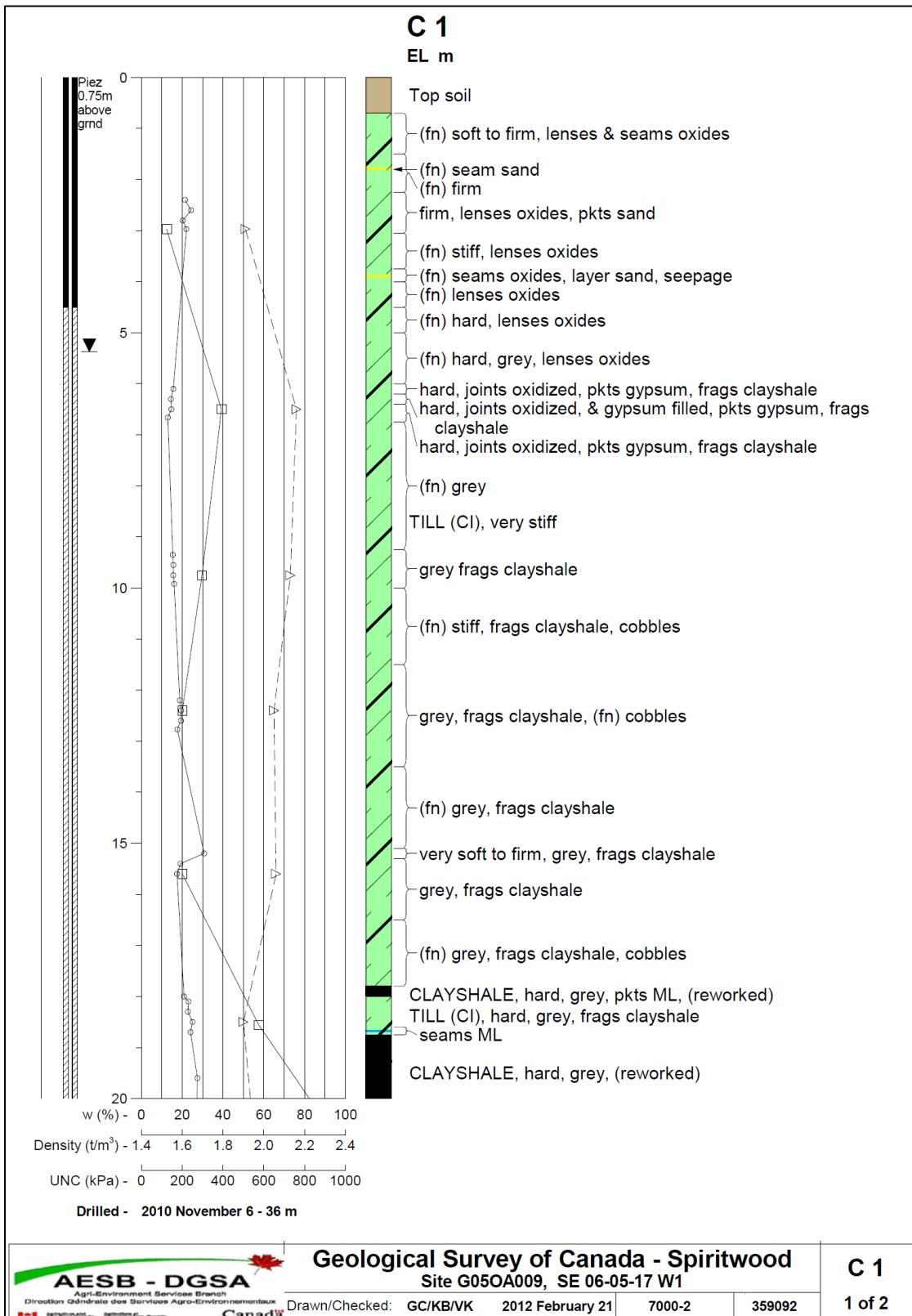


Figure 8a. Borehole log for GSC-BH-SW-03A completed with piezometer GSC-SW-03-p2, 1 of 2.

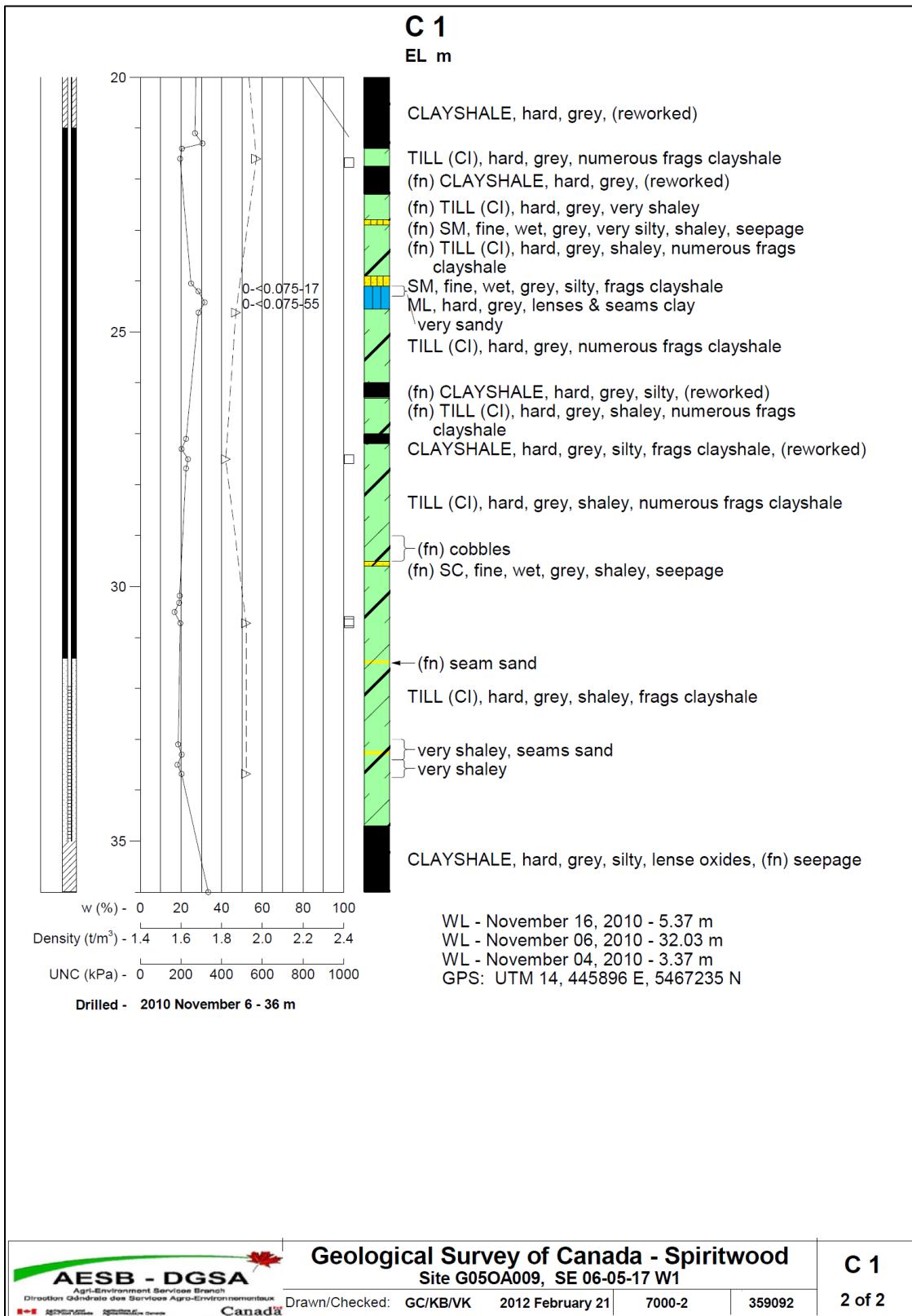


Figure 8b. Borehole log for GSC-BH-SW-03A completed with piezometer GSC-SW-03-p2, 2 of 2.

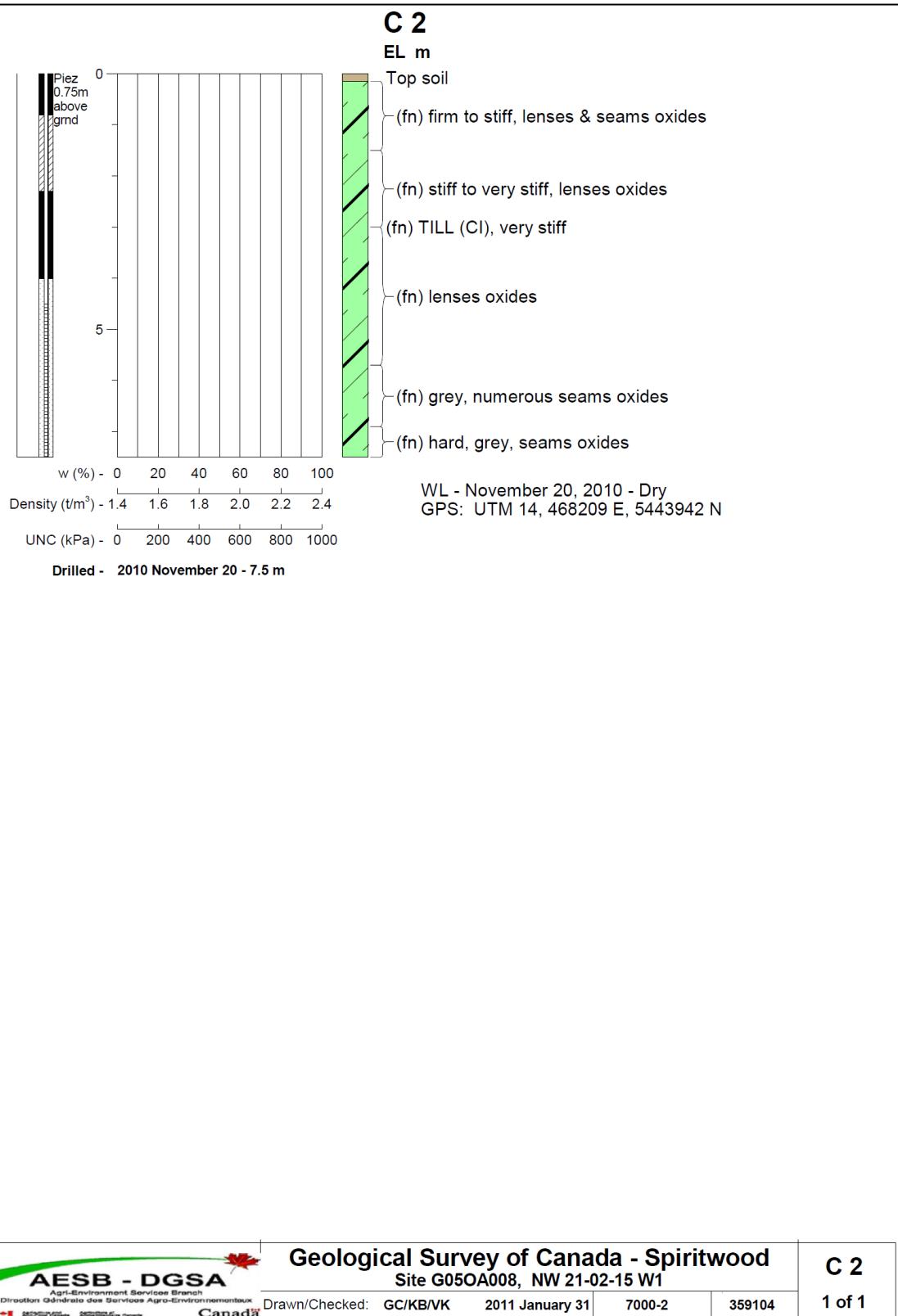


Figure 9. Borehole log for GSC-BH-SW-04B completed with piezometer GSC-SW-04-p1.

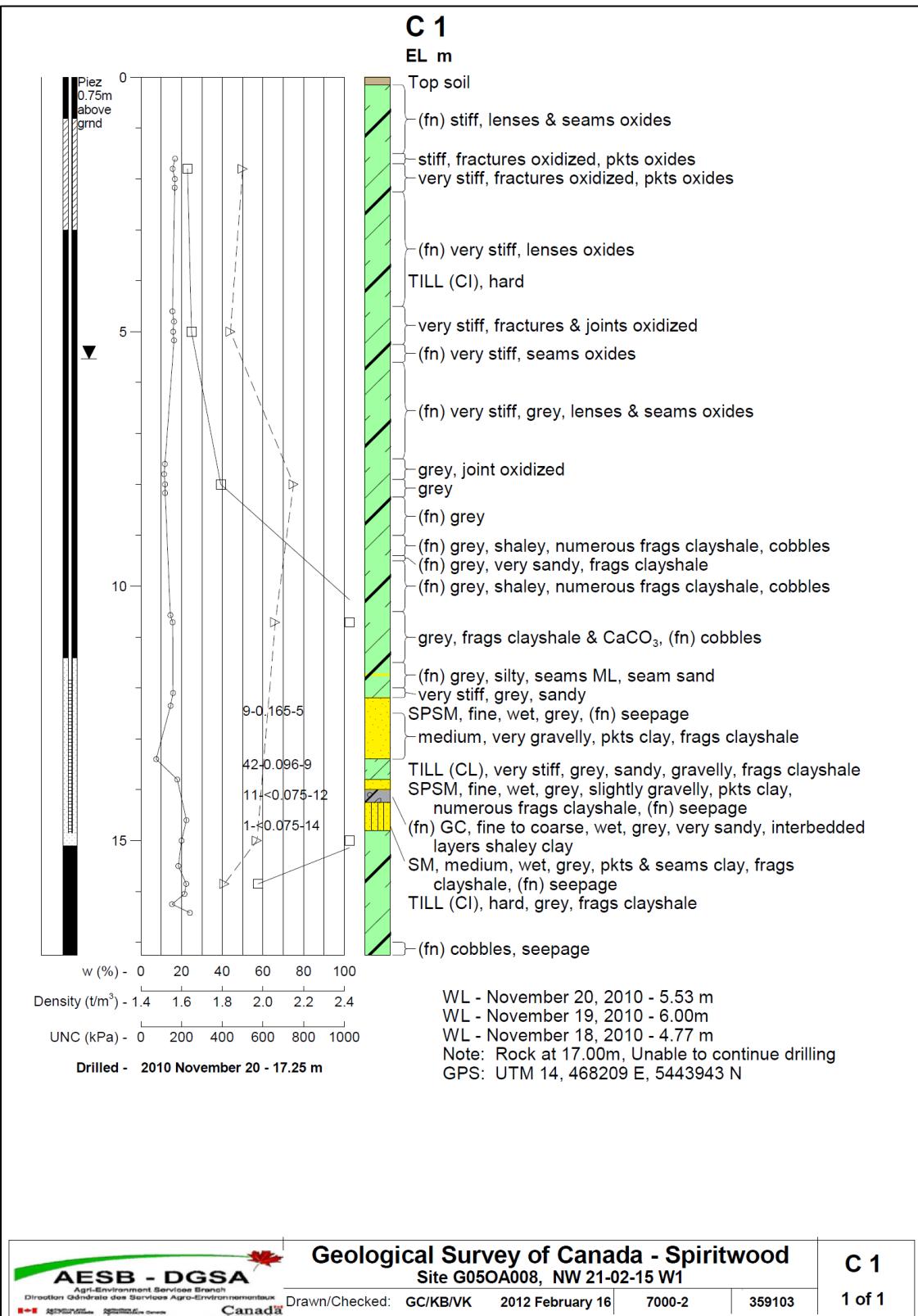


Figure 10. Borehole log for GSC-BH-SW-04A completed with piezometer GSC-SW-04-p2.

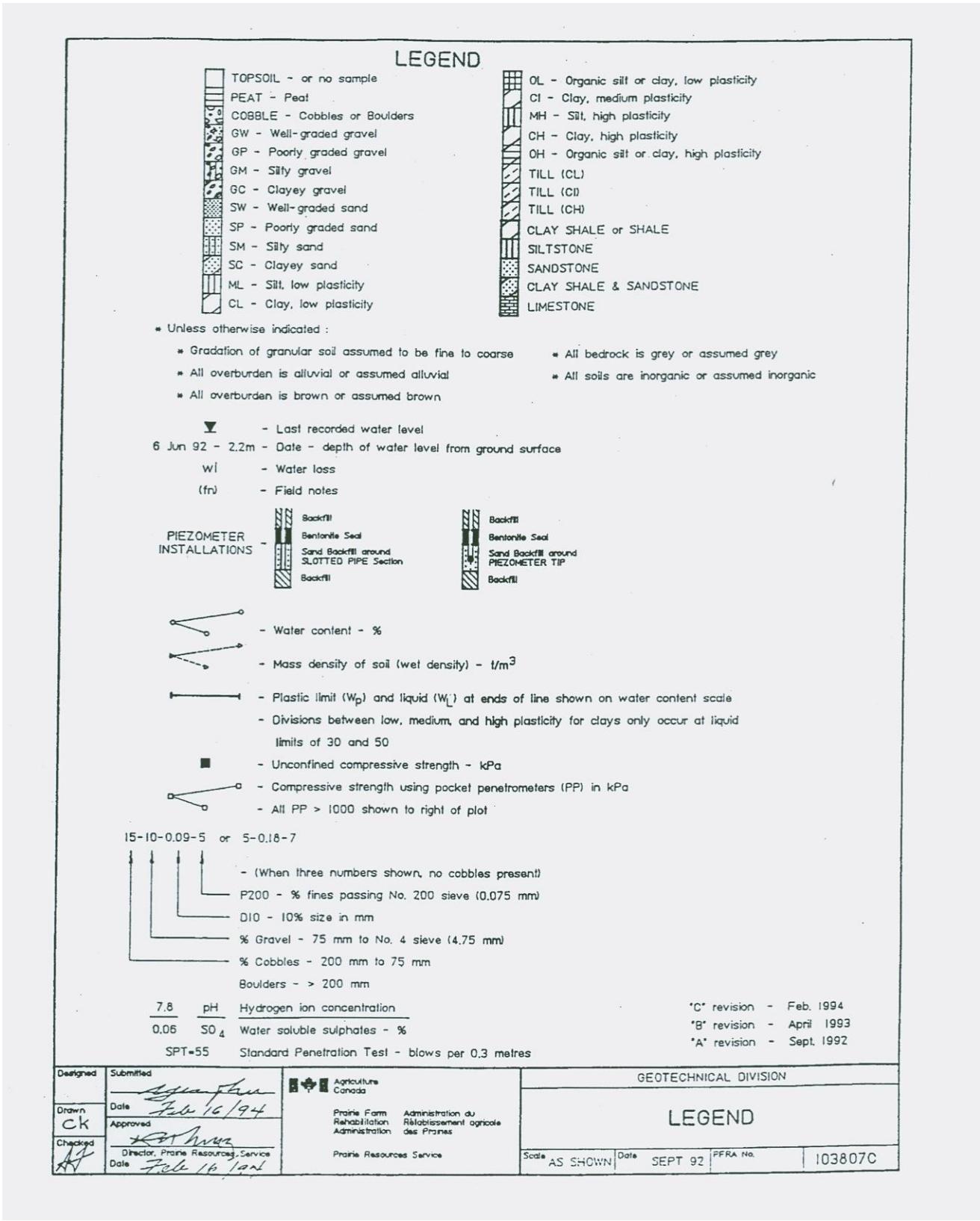


Figure 11. Legend for borehole logs in Figures 5-10 (provided by AAFC).

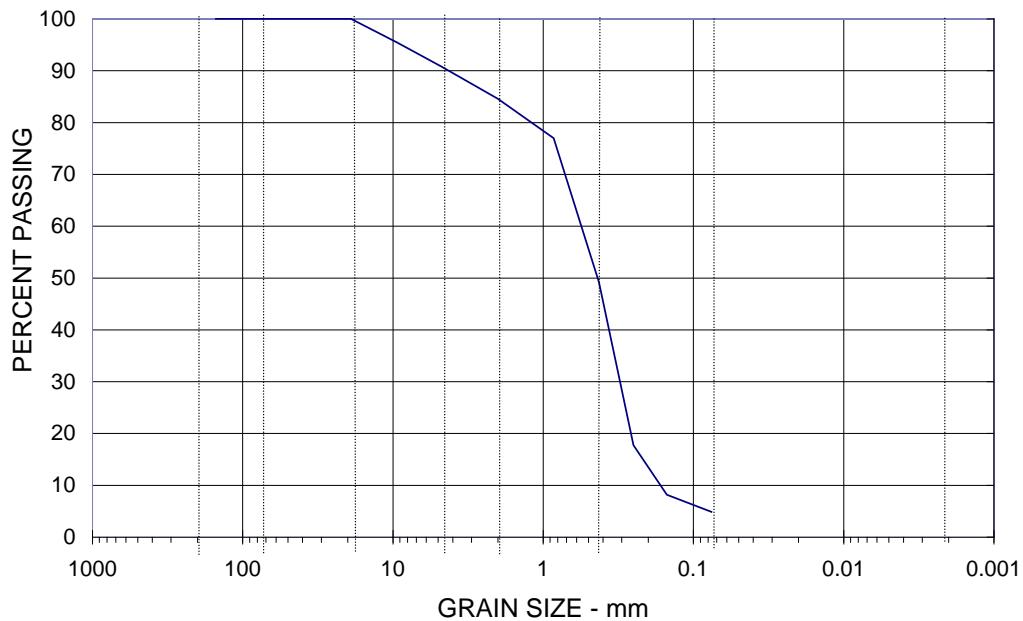
Grain Size Analysis

ASTM D422, D1140, C117, C136

D60=	0.557	D30=	0.308	SPSM, fine, wet, dark grey
D10=	0.165	Cc=	1.028	
Cu=	3.365	D15=	0.216	
		D85=	2.127	

COBBLES	GRAVEL		SAND			FINES
	COARSE	FINE	COARSE	MEDIUM	FINE	
0	0	9	6	36	44	5

COBBLES	GRAVEL		SAND			FINES
	Coarse	Fine	Coarse	Medium	Fine	



 AESB - DGSA Agri-Environment Services Branch Direction Générale des Services Agro-Environnementaux Canada	GSC Spiritwood	C 1
	G05OA008, NW 21-02-15 W1	
	January 24, 2011	Depth: 12.19 - 12.50m 5B

Figure 12. Grain size analysis, borehole GSC-BH-SW-04A, 12.19-12.50 m depth.

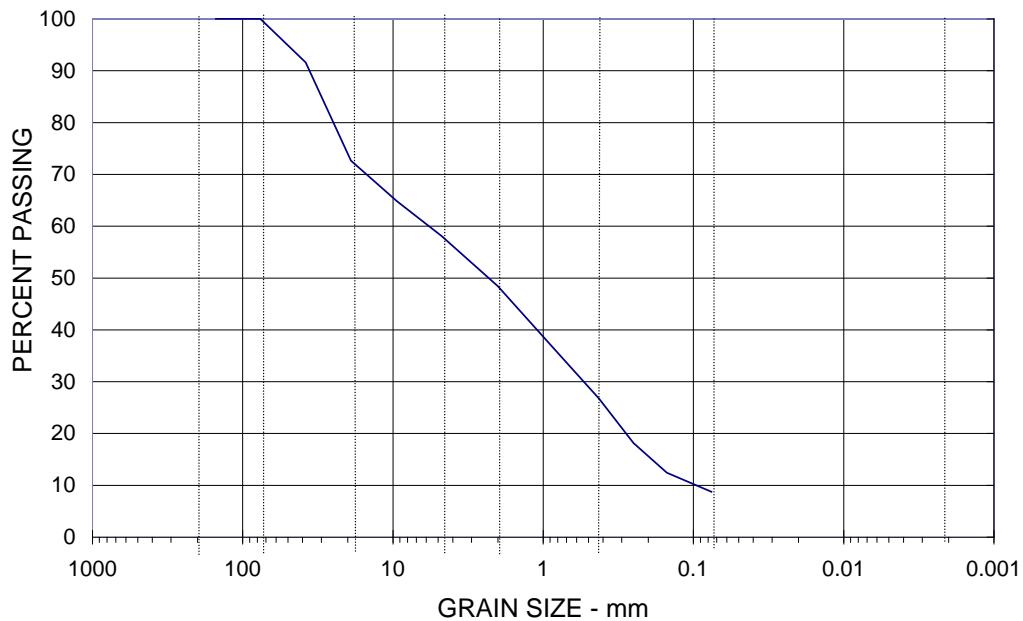
Grain Size Analysis

ASTM D422, D1140, C117, C136

D60=	5.773	D30=	0.536	SPSM, medium, wet, grey, very gravelly,
D10=	0.096	Cc=	0.518	pkts clay, frags Clay Shale
Cu=	60.024	D15=	0.189	
		D85=	29.904	

COBBLES	GRAVEL		SAND			FINES
	COARSE	FINE	COARSE	MEDIUM	FINE	
0	27	15	10	21	18	9

COBBLES	GRAVEL		SAND			FINES
	Coarse	Fine	Coarse	Medium	Fine	



 Agri-Environment Services Branch Direction Générale des Services Agro-Environnementaux Canada	GSC Spiritwood	C 1
	G05OA008, NW 21-02-15 W1	
	January 24, 2011	Depth: 13.40m 6

Figure 13. Grain size analysis, borehole GSC-BH-SW-04A, 13.40 m depth.

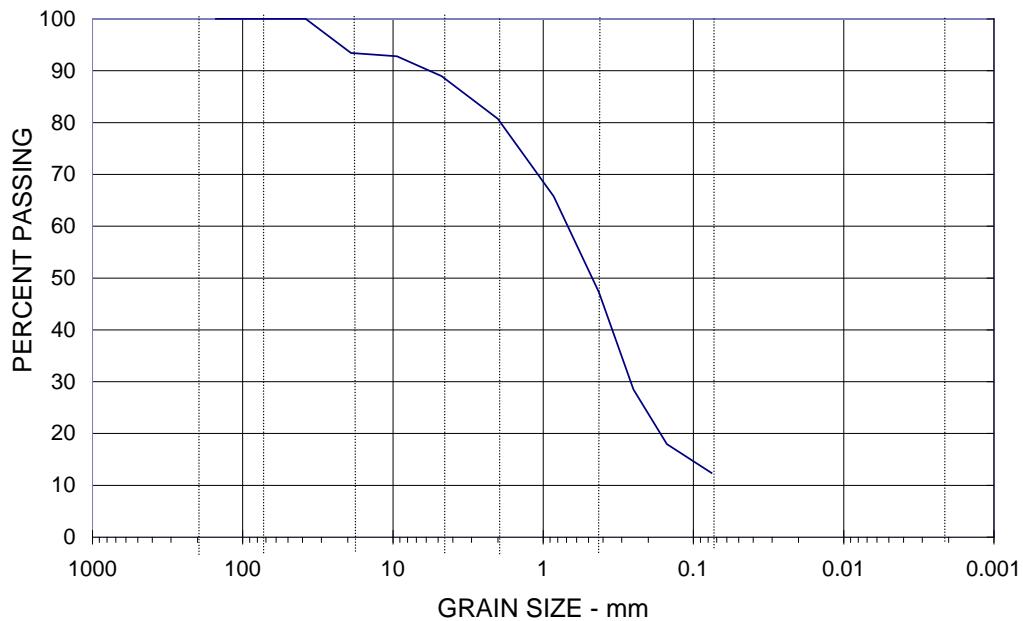
Grain Size Analysis

ASTM D422, D1140, C117, C136

D60=	0.686	D30=	0.261	SPSM, fine, wet, slightly gravelly,
D10=	#N/A	Cc=	#N/A	pkts clay, numerous frags Clay Shale
Cu=	#N/A	D15=	0.105	
		D85=	3.132	

COBBLES	GRAVEL		SAND			FINES
	COARSE	FINE	COARSE	MEDIUM	FINE	
0	7	4	8	34	35	12

COBBLES	GRAVEL		SAND			FINES
	Coarse	Fine	Coarse	Medium	Fine	



 Agri-Environment Services Branch Direction Générale des Services Agro-Environnementaux Canada	GSC Spiritwood	C 1
	G05OA008, NW 21-02-15 W1	
	January 24, 2011	Depth: 14.00m 8

Figure 14. Grain size analysis, borehole GSC-BH-SW-04A, 14.00 m depth.

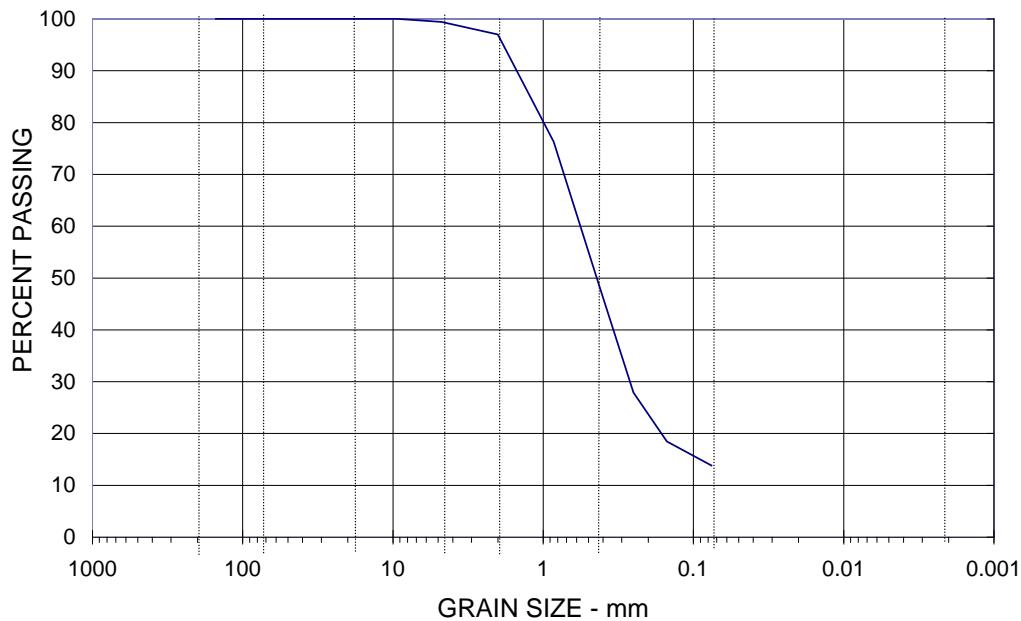
Grain Size Analysis

ASTM D422, D1140, C117, C136

D60=	0.565	D30=	0.264	SM, medium, wet, very dark grey, pkts & seams clay,
D10=	#N/A	Cc=	#N/A	frags Clay Shale
Cu=	#N/A	D15=	0.090	
		D85=	1.219	

COBBLES	GRAVEL		SAND			FINES
	COARSE	FINE	COARSE	MEDIUM	FINE	
0	0	1	2	48	35	14

COBBLES	GRAVEL		SAND			FINES
	Coarse	Fine	Coarse	Medium	Fine	



 <small>Agri-Environment Services Branch Direction Générale des Services Agro-Environnementaux</small>	GSC Spiritwood	C 1
	G05OA008, NW 21-02-15 W1	
	January 24, 2011 Depth: 14.60m	9

Figure 15. Grain size analysis, borehole GSC-BH-SW-04A, 14.60 m depth.

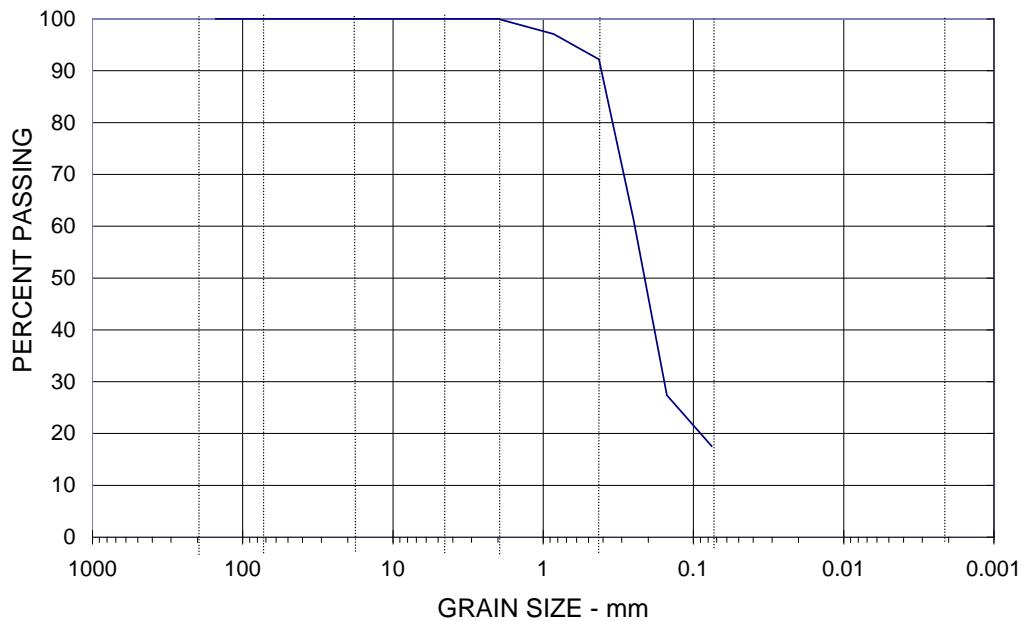
Grain Size Analysis

ASTM D422, D1140, C117, C136

D60=	0.245	D30=	0.156	SM, fine, wet, dark grey, frags Clay Shale,
D10=	#N/A	Cc=	#N/A	slightly silty
Cu=	#N/A	D15=	#N/A	
		D85=	0.376	

COBBLES	GRAVEL		SAND			FINES
	COARSE	FINE	COARSE	MEDIUM	FINE	
0	0	0	0	8	75	17

COBBLES	GRAVEL		SAND			FINES
	Coarse	Fine	Coarse	Medium	Fine	



 Agri-Environment Services Branch Direction Générale des Services Agro-Environnementaux Canada	GSC Spiritwood	C 1
	G050A009, SE 06-05-17 W1	
	January 25, 2001	Depth: 24.00 - 24.10m 10A

Figure 16. Grain size analysis, borehole GSC-BH-SW-03A, 24.00-24.10 m depth.

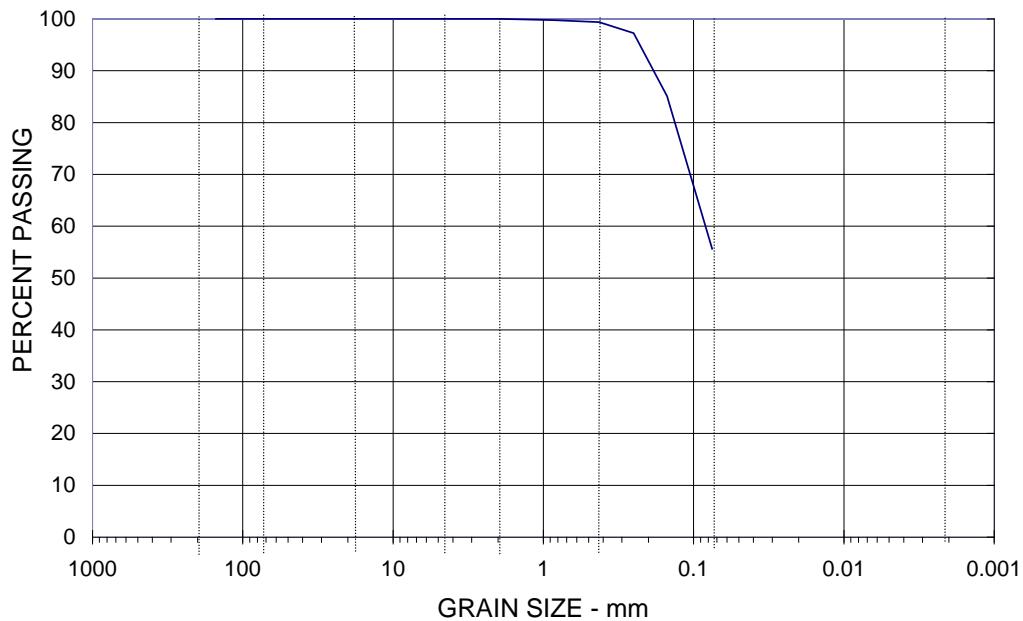
Grain Size Analysis

ASTM D422, D1140, C117, C136

D60=	0.083	D30=	#N/A	ML, hard, very dark grey, very sandy,
D10=	#N/A	Cc=	#N/A	lenses & seams clay
Cu=	#N/A	D15=	#N/A	
		D85=	0.150	

COBBLES	GRAVEL		SAND			FINES
	COARSE	FINE	COARSE	MEDIUM	FINE	
0	0	0	0	1	44	55

COBBLES	GRAVEL		SAND			FINES
	Coarse	Fine	Coarse	Medium	Fine	



 AESB - DGSA Agri-Environment Services Branch Direction Générale des Services Agro-Environnementaux  Canada	GSC Spiritwood	C 1
	G05OA009, SE 06-05-17 W1	
	January 25, 2011	Depth: 24.10 - 24.30m 10B

Figure 17. Grain size analysis, borehole GSC-BH-SW-03A, 24.10-24.30 m depth.

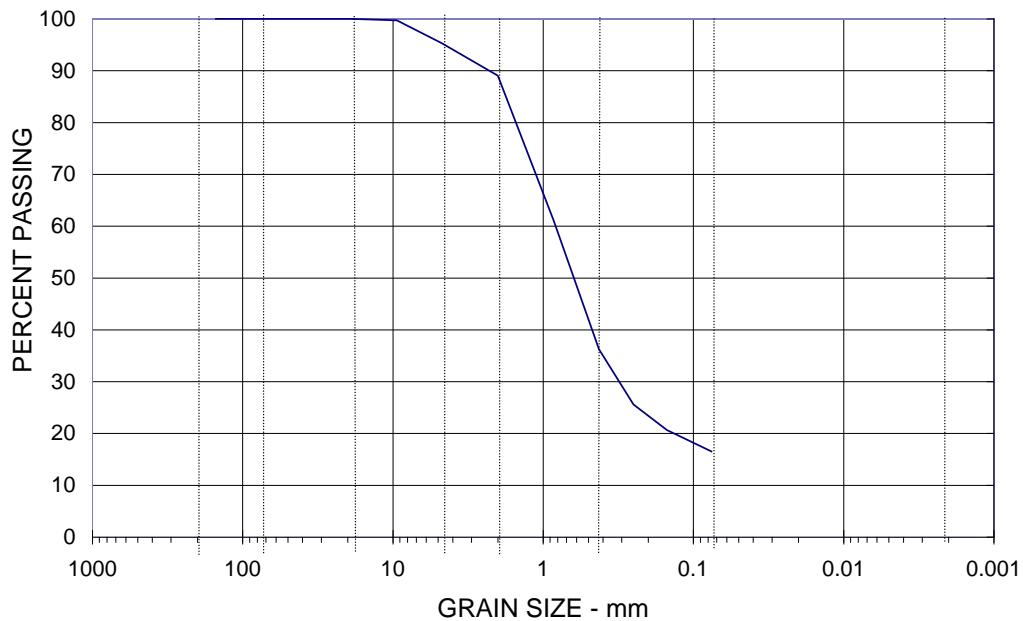
Grain Size Analysis

ASTM D422, D1140, C117, C136

D60=	0.825	D30=	0.311	SM, medium, wet, grey,
D10=	#N/A	Cc=	#N/A	numerous frags clayshale
Cu=	#N/A	D15=	#N/A	
		D85=	1.767	

COBBLES	GRAVEL		SAND			FINES
	COARSE	FINE	COARSE	MEDIUM	FINE	
0	0	5	6	53	20	16

COBBLES	GRAVEL		SAND			FINES
	Coarse	Fine	Coarse	Medium	Fine	



 AESB - DGSA Agri-Environment Services Branch Direction Générale des Services Agro-Environnementaux  Canada	GSC - Spiritwood	C 1
	G05OA010; SW 33-3-16 W1	
	January 26, 2011	Depth: 8.35 - 8.55 m 4D

Figure 18. Grain size analysis, borehole GSC-BH-SW-02A, 8.35-8.55 m depth.

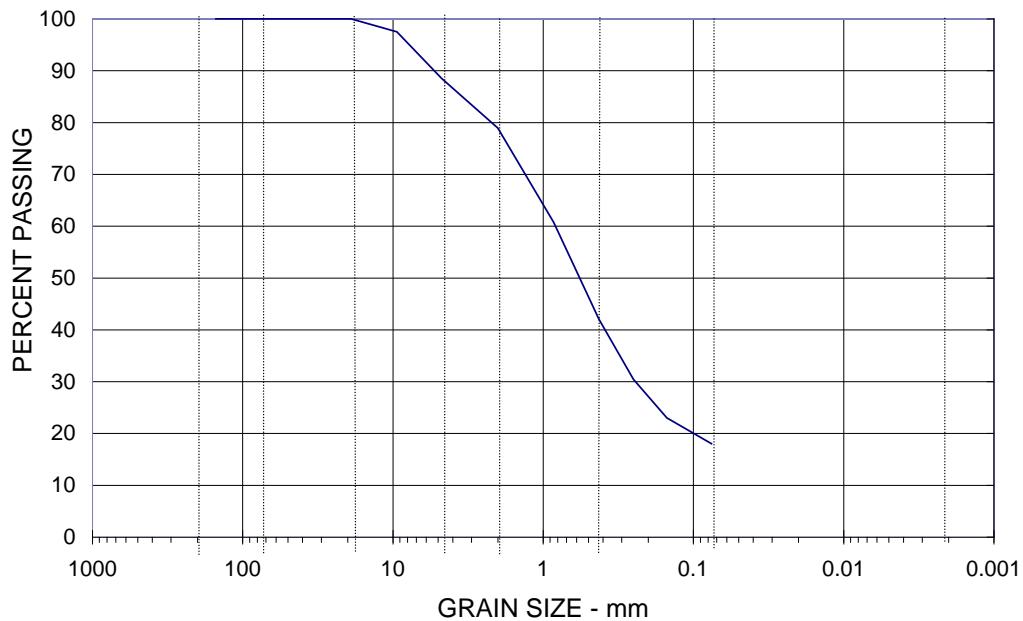
Grain Size Analysis

ASTM D422, D1140, C117, C136

D60=	0.828	D30=	0.243	SC, medium, wet, slightly gravelly,
D10=	#N/A	Cc=	#N/A	pkts clay, numerous frags clayshale
Cu=	#N/A	D15=	#N/A	
		D85=	3.459	

COBBLES	GRAVEL		SAND			FINES
	COARSE	FINE	COARSE	MEDIUM	FINE	
0	0	11	10	37	24	18

COBBLES	GRAVEL		SAND			FINES
	Coarse	Fine	Coarse	Medium	Fine	



 AESB - DGSA Agri-Environment Services Branch Direction Générale des Services Agro-Environnementaux  Canada	GSC - Spiritwood	C 2
	G05OA010; SW 33-3-16 W1	
	January 26, 2011	Depth: 1.00 m 1

Figure 19. Grain size analysis, borehole GSC-BH-SW-02B, 1.00 m depth.

Tables

Table 1. Borehole and piezometer designations and locations.

AAFC borehole ID	Nearby CWS monitoring well ID	GSC borehole ID	GSC piezometer ID	UTM E NAD83, Zone 14	UTM W NAD83, Zone 14	Quarter section
G05OA010 C1	G05OA010	GSC-BH-SW-02A	GSC-SW-02-p2	457414.6	5455734.3	SW33-3-16-W1
G05OA010 C2	G05OA010	GSC-BH-SW-02B	GSC-SW-02-p1	457414.7	5455732.9	SW33-3-16-W1
G05OA009 C1	G05OA009	GSC-BH-SW-03A	GSC-SW-03-p2	445897.5	5467233.2	SE6-5-17-W1
G05OA009 C2	G05OA009	GSC-BH-SW-03B	GSC-SW-03-p1	445895.5	5467232.9	SE6-5-17-W1
G05OA008 C1	G05OA008	GSC-BH-SW-04A	GSC-SW-04-p2	468211.5	5443940.0	NW21-2-15-W1
G05OA008 C2	G05OA008	GSC-BH-SW-04B	GSC-SW-04-p1	468209.8	5443939.9	NW21-2-15-W1

GPS data were collected in October 2011 using a Trimble Pathfinder ProXT GPS receiver with an integrated SBAS (Satellite Based Augmentation Systems) to provide 2 to 5 meter horizontal accuracy.

Table 2. Piezometer installations.

GSC piezometer	Stick up (mags)	Depth to screen top (mbgs)	Depth to screen bottom (mbgs)	Mid-screen depth (mbgs)	Screen length (m)	Total casing depth (mbgs)	Measured depth from measuring point to bottom (m)	Approx. length of pipe at installation (m)
GSC-SW-02-p2	0.771	9.43	10.40	9.92	0.97	10.396	11.167	11.15
GSC-SW-02-p1	0.737	1.25	2.75	2.00	1.50	2.733	3.47	3.50
GSC-SW-03-p2	0.690	31.96	34.95	33.46	2.99	34.967	35.657	35.70
GSC-SW-03-p1	0.690	2.80	3.50	3.15	0.70	3.553	4.243	4.25
GSC-SW-04-p2	0.767	11.85	14.85	13.35	3.00	14.442	15.209	15.60
GSC-SW-04-p1	0.730	4.51	7.50	6.01	2.99	7.437	8.167	8.25

GSC piezometer	Approx. elevation top of casing (masl)	Filter pack material	Depth to top of filter pack (mbgs)	Depth to bottom of filter pack (mbgs)	Type of seal	Top of seal (mbgs)	Bottom of seal (mbgs)
GSC-SW-02-p2	470.461 ^a	sand	9.30	10.45	Hole Plug bentonite 1/4" pellets Hole Plug bentonite chips	8.25 3.00	9.30 6.00
GSC-SW-02-p1	470.427 ^a	sand	0.80	2.75	Native material	0.00	0.80
GSC-SW-03-p2	468.137 ^b	sand	31.40	35.00	Hole Plug bentonite 1/4" pellets and Econo Hole Plug	21.00	31.40
GSC-SW-03-p1	468.137 ^b	sand	2.60	3.50	Hole Plug bentonite chips	1.70	2.60
GSC-SW-04-p2	470.987 ^c	sand	11.40	15.10	Hole Plug bentonite chips	3.00	11.40
GSC-SW-04-p1	470.950 ^c	sand	4.00	7.50	Hole Plug bentonite chips	2.30	4.00

Table 2. Piezometer installations (continued).

GSC piezometer	Piezometer material	Piezometer diameter, nominal (in)	Piezometer inside diameter (cm)	Slot size "/1000	Screen material	Method of drilling	Drilling fluid	Date drilling start	Date completion
GSC-SW-02-p2	PVC, sch 40	2	5.17	20	PVC	B14 cable-tool rig	none	02-Nov-10	03-Nov-10
GSC-SW-02-p1	PVC, sch 40	2	5.17	20	PVC	B14 cable-tool rig	none	03-Nov-10	03-Nov-10
GSC-SW-03-p2	PVC, sch 40	2	5.17	20	PVC	B14 cable-tool rig	none	04-Nov-10	06-Nov-10
GSC-SW-03-p1	PVC, sch 40	2	5.17	20	PVC	B14 cable-tool rig	none	16-Nov-10	16-Nov-10
GSC-SW-04-p2	PVC, sch 40	2	5.17	20	PVC	B14 cable-tool rig	none	17-Nov-10	20-Nov-10
GSC-SW-04-p1	PVC, sch 40	2	5.17	20	PVC	B14 cable-tool rig	none	20-Nov-10	20-Nov-10

^a Not surveyed yet. Approximate elevation obtained by adding casing stick up to the reported ground surface elevation of 469.690 masl of Manitoba CWS well G05OA010.

^b Not surveyed yet. Approximate elevation obtained by adding casing stick up to the reported ground surface elevation of 467.447 masl of Manitoba CWS well G05OA009.

^c Not surveyed yet. Approximate elevation obtained by adding casing stick up to the reported ground surface elevation of 470.220 masl of Manitoba CWS well G05OA008.

Table 3. Borehole log descriptions, GSC-BH-SW-02A.

Top Depth (m)	Bottom Depth (m)	USCS description	Description
0.00	0.45	TOPSOIL	
0.45	0.80	SC	(fn) SC, fine to coarse, wet, seams clay
0.80	1.10	SP	(fn) SP, medium, wet, seepage
1.10	1.15	SM	SM, fine, wet, seams clay
1.15	8.00	TILL (CI)	TILL (CI), hard
1.15	1.35	TILL (CI)	stiff, lenses oxides
1.35	1.85	TILL (CI)	very stiff, lenses oxides
1.85	2.75	TILL (CI)	(fn) very stiff, numerous lenses & seams oxides, slightly sandy
2.75	3.15	TILL (CI)	grey, joints oxidized
3.15	3.50	TILL (CI)	grey
3.50	6.00	TILL (CI)	(fn) very stiff, grey
6.00	6.75	TILL (CI)	very stiff, grey, frags clayshale
6.75	7.50	TILL (CI)	(fn) hard, grey, shaley, numerous frags clayshale, few seams sand, wet, seepage
7.50	7.80	TILL (CI)	hard, grey, very shaley, sandy, numerous frags clayshale
7.80	8.00	TILL (CI)	very stiff, grey, very sandy, numerous frags clayshale
8.00	8.60	SM	SM, fine, medium, wet, grey, numerous frags clayshale, (fn) seepage
8.60	10.45	TILL (CI)	TILL (CI), hard, grey, frags clayshale
8.60	9.10	TILL (CI)	(fn) very shaley, cobble
9.10	9.50	TILL (CI)	(fn) very shaley
9.75	10.10	TILL (CI)	seams sand, (fn) seepage
10.10	10.45	TILL (CI)	numerous frags clay shale

Table 4. Borehole log descriptions, GSC-BH-SW-02B

Top Depth (m)	Bottom Depth (m)	USCS description	Description
0.00	0.35	TOPSOIL	
0.35	1.60	SC	SC, medium, wet, slightly gravelly, pkts clay, numerous frags clayshale
1.60	2.75	TILL (CI)	(fn) TILL (CI), stiff, lenses & seams oxides
2.00	2.75	TILL (CI)	(fn) very stiff

Table 5. Borehole log descriptions, GSC-BH-SW-03A

Top Depth (m)	Bottom Depth (m)	USCS description	Description
0.00	0.70	TOPSOIL	
0.70	17.80	TILL (CI)	TILL (CI), very stiff
0.70	1.50	TILL (CI)	(fn) soft to firm, lenses & seams oxides
1.50	2.25	TILL (CI)	(fn) firm
1.80		TILL (CI)	(fn) seam sand
2.25	3.05	TILL (CI)	firm, lenses oxides, pkts sand
3.05	3.75	TILL (CI)	(fn) stiff, lenses oxides
3.75	4.00	TILL (CI)	(fn) seams oxides, layer sand, seepage
4.00	4.50	TILL (CI)	(fn) lenses oxides
4.50	5.00	TILL (CI)	(fn) hard, lenses oxides
5.00	6.00	TILL (CI)	(fn) hard, grey, lenses oxides
6.00	6.20	TILL (CI)	hard, joints oxidized, pkts gypsum, frags clayshale
6.20	6.40	TILL (CI)	hard, joints oxidized, & gypsum filled, pkts gypsum, frags clayshale
6.40	6.75	TILL (CI)	hard, joints oxidized, pkts gypsum, frags clayshale
6.75	9.25	TILL (CI)	(fn) grey
9.25	10.00	TILL (CI)	grey frags clayshale
10.00	11.50	TILL (CI)	(fn) stiff, frags clayshale, cobbles
11.50	13.50	TILL (CI)	grey, frags clayshale, (fn) cobbles
13.50	15.10	TILL (CI)	(fn) grey, frags clayshale
15.10	15.30	TILL (CI)	very soft to firm, grey, frags clayshale
15.30	16.50	TILL (CI)	grey, frags clayshale
16.50	17.80	TILL (CI)	(fn) grey, frags clayshale, cobbles
17.80	18.00	SHALE	Clay shale, hard, grey, pkts ML, (reworked)
18.00	18.75	TILL (CI)	TILL (CI), hard, grey, frags clayshale
18.60	18.75	TILL (CI)	seams ML
18.75	20.01	SHALE	Clay shale, hard, grey, (reworked)
20.00	21.40	SHALE	Clay shale, hard, grey, (reworked)
21.40	21.75	TILL (CI)	TILL (CI), hard, grey, numerous frags clayshale
21.75	22.30	SHALE	(fn) CLAY SHALE, hard, grey, (reworked)
22.30	22.80	TILL (CI)	(fn) TILL (CI), hard, grey, very shaley
22.80	22.90	SM	(fn) SM, fine, wet, grey, very silty, shaley, seepage
22.90	23.90	TILL (CI)	(fn) TILL (CI), hard, grey, shaley, numerous frags clayshale
23.90	24.10	SM	SM, fine, wet, grey, silty, frags clayshale
24.10	24.55	ML	ML, hard, grey, lenses & seams clay
24.10	24.30	ML	very sandy
24.55	26.00	TILL (CI)	TILL (CI), hard, grey, numerous frags clayshale
26.00	26.30	SHALE	(fn) Clay shale, hard, grey, silty, (reworked)
26.30	27.00	TILL (CI)	(fn) TILL (CI), hard, grey, shaley, numerous frags clayshale
27.00	27.20	SHALE	Clay shale, hard, grey, silty, frags clayshale, (reworked)
27.20	29.50	TILL (CI)	TILL (CI), hard, grey, shaley, numerous frags clayshale
29.00	29.50	TILL (CI)	(fn) cobbles
29.50	29.60	SC	(fn) SC, fine, wet, grey, shaley, seepage

Table 5 (continued). Borehole log descriptions, GSC-BH-SW-03A

Top Depth (m)	Bottom Depth (m)	USCS description	Description
29.60	34.70	TILL (CI)	TILL (CI), hard, grey, shaley, frags clayshale
31.50		TILL (CI)	(fn) seam sand
33.00	33.40	TILL (CI)	very shaley, seams sand
33.40	33.75	TILL (CI)	very shaley
34.70	36.00	SHALE	Clay shale, hard, grey, silty, lense oxides, (fn) seepage

Table 6. Borehole log descriptions, GSC-BH-SW-03B

Top Depth (m)	Bottom Depth (m)	USCS description	Description
0.00	0.50	TOPSOIL	
0.50	1.40	TILL (CI)	(fn) TILL (CI), very soft
1.40	1.50	SC	(fn) SC, fine to coarse, wet, gravelly, seepage
1.50	10.50	TILL (CI)	(fn) TILL (CI), hard
1.50	2.25	TILL (CI)	(fn) stiff
2.25	2.79	TILL (CI)	(fn) stiff, lenses & seams oxides
2.80		TILL (CI)	(fn) seam sand, seepage
2.81	3.20	TILL (CI)	(fn) stiff, silty, seams ML, numerous seams oxides
3.20	4.60	TILL (CI)	(fn) very stiff, lenses & seams oxides
4.60	5.60	TILL (CI)	(fn) grey, lenses oxides
5.60	10.50	TILL (CI)	(fn) grey, cobbles

Table 7. Borehole log descriptions, GSC-BH-SW-04A.

Top Depth (m)	Bottom Depth (m)	USCS description	Description
0.00	0.15	TOPSOIL	
0.15	12.19	TILL (CI)	TILL (CI), hard
0.15	1.50	TILL (CI)	(fn) stiff, lenses & seams oxides
1.50	1.70	TILL (CI)	stiff, fractures oxidized, pkts oxides
1.70	2.25	TILL (CI)	very stiff, fractures oxidized, pkts oxides
2.25	4.50	TILL (CI)	(fn) very stiff, lenses oxides
4.50	5.25	TILL (CI)	very stiff, fractures & joints oxidized
5.25	5.60	TILL (CI)	(fn) very stiff, seams oxides
5.60	7.50	TILL (CI)	(fn) very stiff, grey, lenses & seams oxides
7.50	7.90	TILL (CI)	grey, joint oxidized
7.90	8.25	TILL (CI)	grey
8.25	9.00	TILL (CI)	(fn) grey
9.00	9.40	TILL (CI)	(fn) grey, shaley, numerous frags clayshale, cobbles
9.40	9.50	TILL (CI)	(fn) grey, very sandy, frags clayshale
9.50	10.50	TILL (CI)	(fn) grey, shaley, numerous frags clayshale, cobbles
10.50	11.50	TILL (CI)	grey, frags clayshale & CaCO ₃ , (fn) cobbles
11.50	12.00	TILL (CI)	(fn) grey, silty, seams ML, seam sand
12.00	12.19	TILL (CI)	very stiff, grey, sandy
12.19	13.40	SPSM	SPSM, fine, wet, grey, (fn) seepage
12.50	13.40	SPSM	medium, very gravelly, pkts clay, frags clayshale
13.40	13.80	TILL (CL)	TILL (CL), very stiff, grey, sandy, gravelly, frags clayshale
13.80	14.00	SPSM	SPSM, fine, wet, grey, slightly gravelly, pkts clay, numerous frags clayshale, (fn) seepage
14.00	14.25	GC	(fn) GC, fine to coarse, wet, grey, very sandy, interbedded layers shaley clay
14.25	14.80	SM	SM, medium, wet, grey, pkts & seams clay, frags clayshale, (fn) seepage
14.80	17.25	TILL (CI)	TILL (CI), hard, grey, frags clayshale
17.00	17.25	TILL (CI)	(fn) cobbles, seepage

Table 8. Borehole log descriptions, GSC-BH-SW-04B

Top Depth (m)	Bottom Depth (m)	USCS description	Description
0.00	0.15	TOPSOIL	
0.15	7.50	TILL (CI)	(fn) TILL (CI), very stiff
0.15	1.50	TILL (CI)	(fn) firm to stiff, lenses & seams oxides
1.50	3.00	TILL (CI)	(fn) stiff to very stiff, lenses oxides
3.00	5.70	TILL (CI)	(fn) lenses oxides
5.70	6.90	TILL (CI)	(fn) grey, numerous seams oxides
6.90	7.50	TILL (CI)	(fn) hard, grey, seams oxides

Table 9. Geotechnical data, site GSC-BH-SW-02 (G05OA010).

AAFC borehole ID	Sample	Depth (m)	Measured Gravimetric Water Content (g water /100g dry soil)	Measured Wet Density (g wet soil /cm ³ wet soil)	Measured Pocket Penetrometer (kPa)	Calculated Dry Density (g dry soil /cm ³ wet soil)	Calculated Volumetric water content (cm ³ water /cm ³ wet soil)	Estimated porosity (cm ³ void /cm ³ total volume)
G05OA010 C 1	1A	1.17	15.2					
G05OA010 C 1	1B	1.25	18.9					
G05OA010 C 1	1C	1.45	17.6					
G05OA010 C 1	1D	1.60	17.7	2.08	239	1.77	0.31	0.33
G05OA010 C 1	2A	2.85	14.3					
G05OA010 C 1	2B	3.05	14.2					
G05OA010 C 1	2C	3.25	14.0	2.13	345	1.87	0.26	0.29
G05OA010 C 1	2D	3.42	13.7					
G05OA010 C 1	3A	6.10	15.0					
G05OA010 C 1	3B	6.30	15.2					
G05OA010 C 1	3C	6.50	15.4	2.14	278	1.85	0.29	0.30
G05OA010 C 1	3D	6.66	17.4					
G05OA010 C 1	4A	7.90	19.2	2.00	278	1.68	0.32	0.37
G05OA010 C 1	4B	8.10	19.3					
G05OA010 C 1	4C	8.25	24.1					
G05OA010 C 1	4D	8.45	22.3					
G05OA010 C 1	5A	9.85	16.6					
G05OA010 C 1	5B	10.00	17.9	2.04	1036	1.73	0.31	0.35
G05OA010 C 1	6	10.45	12.2					
G05OA010 C 2	1	1.00	15.7					

Table 10. Geotechnical data, site GSC-BH-SW-03 (G05OA009).

AAFC borehole ID	Sample	Depth (m)	Measured Gravimetric Water Content (g water /100g dry soil)	Measured Wet Density (g wet soil /cm ³ wet soil)	Measured Pocket Penetrometer (kPa)	Calculated Dry Density (g dry soil /cm ³ wet soil)	Calculated Volumetric water content (cm ³ water /cm ³ wet soil)	Estimated porosity (cm ³ void /cm ³ total volume)
G05OA009 C 1	1A	2.40	21.4					
G05OA009 C 1	1B	2.60	24.4					
G05OA009 C 1	1C	2.80	20.3					
G05OA009 C 1	1D	2.97	22.1	1.91	124	1.56	0.35	0.41
G05OA009 C 1	2A	6.10	15.7					
G05OA009 C 1	2B	6.30	14.5					
G05OA009 C 1	2C	6.50	14.7	2.16	393	1.88	0.28	0.29
G05OA009 C 1	2D	6.68	13.0					
G05OA009 C 1	3A	9.35	15.4					
G05OA009 C 1	3B	9.55	15.7					
G05OA009 C 1	3C	9.75	15.6	2.13	297	1.84	0.29	0.30
G05OA009 C 1	3D	9.92	16.1					
G05OA009 C 1	4A	12.20	18.8					
G05OA009 C 1	4B	12.40	19.5	2.05	201	1.72	0.33	0.35
G05OA009 C 1	4C	12.60	19.4					
G05OA009 C 1	4D	12.78	17.7					
G05OA009 C 1	5A	15.20	30.8					
G05OA009 C 1	5B	15.40	19.2					
G05OA009 C 1	5C	15.60	17.5	2.06	201	1.75	0.31	0.34
G05OA009 C 1	6	18.00	20.9					
G05OA009 C 1	7A	18.10	23.1					
G05OA009 C 1	7B	18.30	22.8					
G05OA009 C 1	7C	18.50	25.1	1.90	576	1.52	0.38	0.43

Table 10 (continued). Geotechnical data, site GSC-BH-SW-03 (G05OA009).

AAFC borehole ID	Sample	Depth (m)	Measured Gravimetric Water Content (g water /100g dry soil)	Measured Wet Density (g wet soil /cm ³ wet soil)	Measured Pocket Penetrometer (kPa)	Calculated Dry Density (g dry soil /cm ³ wet soil)	Calculated Volumetric water content (cm ³ water /cm ³ wet soil)	Estimated porosity (cm ³ void /cm ³ total volume)
G05OA009 C 1	7D	18.68	24.1					
G05OA009 C 1	8	19.60	27.5					
G05OA009 C 1	9A	21.10	26.9					
G05OA009 C 1	9B	21.30	30.6					
G05OA009 C 1	9C	21.50	20.5					
G05OA009 C 1	9D	21.68	19.6	1.97	1112	1.65	0.32	0.38
G05OA009 C 1	10A	24.05	25.0					
G05OA009 C 1	10B	24.20	28.5					
G05OA009 C 1	10C	24.42	31.7					
G05OA009 C 1	10D	24.62	28.6	1.87		1.45	0.42	0.45
G05OA009 C 1	11A	27.10	22.5					
G05OA009 C 1	11B	27.30	20.3					
G05OA009 C 1	11C	27.50	23.5	1.82	1036	1.47	0.35	0.44
G05OA009 C 1	11D	27.68	22.5					
G05OA009 C 1	12A	30.17	19.4					
G05OA009 C 1	12B	30.32	19.1					
G05OA009 C 1	12C	30.50	16.8					
G05OA009 C 1	12D	30.67	19.7	1.92	1532	1.60	0.32	0.39
G05OA009 C 1	13A	33.10	18.6					
G05OA009 C 1	13B	33.30	20.4					
G05OA009 C 1	13C	33.50	18.3					
G05OA009 C 1	13D	33.68	20.3	1.92	1492	1.60	0.32	0.40
G05OA009 C 1	14	36.00	33.4					

Table 11. Geotechnical data, site GSC-BH-SW-04 (G05OA008).

AAFC borehole ID	Sample	Depth (m)	Measured Gravimetric Water Content (g water /100g dry soil)	Measured Wet Density (g wet soil /cm ³ wet soil)	Measured Pocket Penetrometer (kPa)	Calculated Dry Density (g dry soil /cm ³ wet soil)	Calculated Volumetric water content (cm ³ water /cm ³ wet soil)	Estimated porosity (cm ³ void /cm ³ total volume)
G050A008 C-1	1A	1.60	16.8					
G050A008 C-1	1B	1.80	15.6	1.90	230	1.64	0.26	0.38
G050A008 C-1	1C	2.00	16.7					
G050A008 C-1	1D	2.17	16.6					
G050A008 C-1	2A	4.60	15.5					
G050A008 C-1	2B	4.80	16.3					
G050A008 C-1	2C	5.00	15.9	1.84	249	1.59	0.25	0.40
G050A008 C-1	2D	5.18	16.3					
G050A008 C-1	3A	7.60	11.8					
G050A008 C-1	3B	7.80	11.4					
G050A008 C-1	3C	8.00	11.9	2.15	393	1.92	0.23	0.27
G050A008 C-1	3D	8.18	11.9					
G050A008 C-1	4A	10.58	14.5					
G050A008 C-1	4B	10.72	15.6	2.06	1148	1.78	0.28	0.33
G050A008 C-1	5A	12.10	15.8					
G050A008 C-1	5B	12.40	14.6					
G050A008 C-1	6	13.40	7.5					
G050A008 C-1	7	13.80	17.9					
G050A008 C-1	9	14.60	22.4					
G050A008 C-1	10	15.00	20.0	1.97	1112	1.64	0.33	0.38
G050A008 C-1	11	15.50	18.4					
G050A008 C-1	12A	15.85	22.3	1.81	576	1.48	0.33	0.44

Table 11 (continued). Geotechnical data, site GSC-BH-SW-04 (G05OA008).

AAFC borehole ID	Sample	Depth (m)	Measured Gravimetric Water Content (g water /100g dry soil)	Measured Wet Density (g wet soil /cm ³ wet soil)	Measured Pocket Penetrometer (kPa)	Calculated Dry Density (g dry soil /cm ³ wet soil)	Calculated Volumetric water content (cm ³ water /cm ³ wet soil)
G050A008 C-1	12B	16.05	21.4				
G050A008 C-1	12C	16.25	15.3				
G050A008 C-1	12D	16.47	24.1				

Table 12. Borehole log, CWS well, G05OA010 as recorded in the CWS database.

Well PID: 116770

LOCATION: SW33-3-16W
 UTMX:457411.7 UTMY:5455641.5 XY Accuracy:1 EXACT [<5M] [GPS]
 UTMZ:469.69 (ground surface elevation) Z Accuracy:1 EXACT <10CM
 Owner: WRB
 Driller: Ralph Edwards & Sons Drilling LTd.
 Well Name: G05OA010 KILCART #11
 Date Completed: 2001 Aug 22
 Well Use: OBSERVATION
 Well Status: ACTIVE Aquifer: SAND AND GRAVEL

REMARKS:

PUMPED WITH AIR, EC=1990

WELL LOG (Imperial units)

From	To(ft.)	Log
0.0	2	TOPSOIL, BLACK
2.0	5	SAND AND GRAVEL, LIMESTONE
5.0	12	TILL, BEIGE, SAND
12.0	26	TILL, GREY, CLAYEY, STONY
26.0	27.5	SAND AND GRAVEL, MAINLY SHALE
27.5	33	TILL, GREY, CLAYEY, STONY
33.0	34	SAND AND GRAVEL, LAYER 50/50 SHALE AND LIMESTONE
34.0	80	TILL, DARK GREY, CLAYEY, STONY
80.0	85	SHALE, BALCK, RUBBLY, LOSING WATER
85.0	124	SAND AND GRAVEL, 80% SHALE & 20% LIMESTONE
124.0	140	SHALE, SOFT, BLACK

WELL CONSTRUCTION

From	To(ft)	Const.Method	Inside Dia.(in)	Outside Dia.(in)	Slot Size(in)	Type	Material
0.0	115.0	CASING	5.0			INSERT	BLACK IRON
115.0	120.0	PERFORATIONS	5.0		0.010	WIRE WOUND	S. S.

Top of Casing: 3.0 ft. above ground

PUMPING TEST

Date : 2001 Aug 23 Pumping 10.0 Imp. gallons/minute

Water level before test : 6.0 ft below ground

Water level at end of test : 35.0 ft below ground

Test duration: 1:00:00

Test Zone: from 115.0 ft to 120.0 ft

Table 13. Borehole log, CWS well, G05OA009 as recorded in the CWS database.

Well PID: 116814

LOCATION: SE6-5-17W

UTMX:445899.6 UTMY:5467232.5 XY Accuracy:1 EXACT [<5M] [GPS]

UTMZ:467.447 (ground surface elevation) Z Accuracy:1 EXACT <10CM

Owner: WRB

Driller: Ralph Edwards & Sons Drilling LTD.

Well Name: G05OA009 KILCART #8

Date Completed: 2001 Jul 25

Well Use: OBSERVATION

Well Status: ACTIVE

Aquifer: SAND AND GRAVEL

REMARKS:

PUMPED WITH AIR, EC=2320

WELL LOG (Imperial units)

From To(ft.) Log

0.0 18 TILL, BEIGE, CLAYEY

18.0 61 TILL, GREY, CLAYEY

61.0 63 SHALE LAYER,BLACK, BRITTLE

63.0 105 TILL, GREY, CLAYEY, SOME STONE

105.0 110 SAND AND GRAVEL LAYER

110.0 150 TILL, GREY, CLAYEY

150.0 175 SAND AND GRAVEL, 50% SHALE, 50% LIMESTONE

175.0 194 SAND AND GRAVEL, VERY COARSE, 1/2 TO 1 INCH DIAMETER

194.0 196 STONE

196.0 200 SHALE, HARD, BLACK

WELL CONSTRUCTION

			Inside	Outside	Slot		
From	To(ft)	Const.Method	Dia.(in)	Dia.(in)	Size(in)	Type	Material
0.0	163.0	CASING	5.0			INSERT	BLACK IRON
163.0	168.0	PERFORATIONS	5.0		0.010	WIRE WOUND	S. S.
Top of Casing:			2.5 ft. above ground				

PUMPING TEST

Date : 2001 Jul 26 Pumping 20.0 Imp. gallons/minute

Water level before test : 23.0 ft below ground

Water level at end of test :

Test duration:

Test Zone: from 163.0 ft to 168.0 ft

Table 14. Borehole log, CWS well, G05OA008 as recorded in the CWS database.

Well PID: 116767

LOCATION: NW21-2-15W

UTMX:468210.4 UTMY:5443941.9 XY Accuracy:1 EXACT [<5M] [GPS]

UTMZ:470.22 (ground surface elevation) Z Accuracy:1 EXACT <10CM

Owner: WRB

Driller: Ralph Edwards & Sons Drilling LTd.

Well Name: G05OA008 KILCART #1

Date Completed: 2001 Sep 05

Well Use: OBSERVATION

Well Status: ACTIVE

Aquifer: SAND AND GRAVEL

REMARKS:

PUMPED WITH AIR, EC=1490

WELL LOG (Imperial units)

From To(ft.) Log

0.0 18 SAND, COARSE, BROWN

18.0 22 GRAVEL, COARSE, BROWN

22.0 62 TILL, GREY, CLAYEY

62.0 64 GRAVEL, SHALE, SOME LIMESTONE

64.0 130 TILL, GREY, CLAYEY

130.0 140 ROCKY TILL, CARBONACEOUS

140.0 180 SAND AND GRAVEL, GREY, SAND, GRAVEL, 80 % SHALE, 20%
LIMESTONE

180.0 198 TILL, GREY, VERY CLAYEY

198.0 200 TILL, GREY

200.0 220 SHALE, HARD, DARK GREY, VERY STIFF

WELL CONSTRUCTION

			Inside	Outside	Slot		
From	To(ft)	Const.Method	Dia.(in)	Dia.(in)	Size(in)	Type	Material
0.0	175.0	CASING	5.0			INSERT	BLACK IRON
175.0	180.0	PERFORATIONS	5.0		0.010	WIRE WOUND	S. S.

Top of Casing:

PUMPING TEST

Date : 2001 Sep 12 Pumping Imp. gallons/minute

Water level before test : 50.0 ft below ground

Water level at end of test :

Test duration:

Test Zone: from 175.0 ft to 180.0 ft

Appendices

Appendix A: Field borehole descriptions.

A1. Field borehole description, GSC-BH-SW-02A, page 1 of 8.

Project <u>G S.C. Spritwood</u> Site <u>G050A010</u>			PFRA TESTHOLE LOG								
Hole No. <u>C-1(SW02A)</u> Elev. <u>m</u> Location <u>SW 33-3-16-W1 GPS coordinate are</u> Drilled by <u>R.D.</u> Date Started <u>Nov 2/2010</u> Logged by <u>D.G.</u> Date Completed <u>Nov 3/2010</u> Water Level Final <u>5.02</u> m Top Pipe <input checked="" type="checkbox"/> Time-Date <u>Nov 4/10 8:45 AM</u> Installation <u>2" P.V.C. Sch 40 pipe piezometer</u> Page <u>1</u> of <u>8</u> General <u>B-14 cable tool rig</u>			LOCATION SKETCH (A) Bit pressure , Revolutions per minute (B) Circulation fluid , Pump pressure, Volume % Loss (C) Drive sample weight , Drop distance , Blow count								
Time	Depths -m		Formation and Water Data		Drill Data and Remarks				Sample Data		
	(Underline sample drive)	Group	Description, Characteristics, Abnormal Conditions, Sample Type		Depth Casing Shoe m	Depth Hole Fluid m	(A) kPa (B) kPa (C) kg	rpm cm ³ /s Drop-m	Length-m	PP kPa	No.
			0-0.45 Topsoil black, organic, stiff Fibers (roots)						3 7/8" Excavator		
			0.45-0.80 SC fine-coarse, brown, wet clay binder, with a few clay seams						3 7/8" Excavator		
			0.80-1.10 SP fine-coarse brown, wet med Predom, water coming into hole								
			1.10-1.85 SP coarse-fine, Brown, wet some gravel Particles to CI + top till, Brown, very stiff lenses of oxidized						Brass liner with catcher	.75 .56 2.3	1

A1. Field borehole description, GSC-BH-SW-02A, page 2 of 8.

Project	G.S.C. - Spiritwood			PFRA TESTHOLE LOG									
Site	G050A010												
Hole No.	C-1 cont'd			Elev.									
Location													
Drilled by				Date Started									
Logged by				Date Completed									
Water Level Final	m	Top Pipe <input checked="" type="checkbox"/>	Top Grd <input type="checkbox"/>	Time-Date									
Installation													
Page	2	of	8										
General													
Time	Depths - m	Formation and Water Data			Drill Data and Remarks						Sample Data		
	(Underline sample drive)	Group	Description, Characteristics, Abnormal Conditions, Sample Type		Depth Casing Shoe m	Depth Hole Fluid m	(A) kPa (B) kPa (C) kg	rpm cm ³ /s Drop-m	% Loss Blows	Length - m	PP kPa	No.	
			Rammed hole out to 1.85m with 5 5/8" Excavator										
			Set 3.36m of 4" casing into hole										
			Drive casing down to 1.85m										
			1.85-2.25 CI+cup Till, Brown, very stiff										
			- 2.75 numerous lenses of oxides, slightly sandy										
			2.25										
			2.75-3.5 CI - cup Till, dark grey, hard										
			few lenses of oxides + shale Particles										
			3.36										
			3.5-4.0 CI + cup Till, dark grey, very stiff, few shale particles										
			3 7/8" Excavator										
			2.20										

Project <u>G.S.C. Spiritwood</u> Site <u>G050A010</u> Hole No. <u>C-1 contd</u> Elev. _____ m Location _____ Drilled by _____ Date Started _____ Logged by _____ Date Completed _____ Water Level Final _____ m Top Pipe <input checked="" type="checkbox"/> Top Grd <input type="checkbox"/> Time-Date _____ Installation _____ Page <u>3</u> of <u>8</u> General _____			PFRA TESTHOLE LOG LOCATION SKETCH (A) Bit pressure , Revolutions per minute (B) Circulation fluid, Pump pressure, Volume % Loss (C) Drive sample weight, Drop distance, Blow count										
Time	Depths - m		Formation and Water Data			Drill Data and Remarks					Sample Data		
	(Underline sample drive)	Group	Description, Characteristics, Abnormal Conditions, Sample Type			Depth Casing Shoe m	Depth Hole Fluid m	(A) kPa (B) kPa (C) kg	rpm cm ³ /s Drop -m	% Loss Blows	Length - m	PP kPa	No.
			4.0-50 CI+wp till, dark grey, very stiff few shale Particles and a few limestone Pebbles+cobbles								3 1/8" Excavator	3.0	
			5.0-60 CI+wp till, dark grey, very stiff few shale Particles and limestone Pebbles, occasional cobble								3 1/8" Excavator	2.75	
			6.0-6.75 CI+wp till, dark grey, very stiff Brasslinch 13 -75.72 2.753 shale Particles, and Pebbles of limestone										
			6.75-7.5 CI-wp till, Dark grey, Hard shaly, numerous shale particles cut sand seam at 7.3 and 7.5, water coming into hole										

A1. Field borehole description, GSC-BH-SW-02A, page 4 of 8.

Project G.S.C. Spiritwood
Site G050A010
Hole No. C-1 cont'd Elev. _____ m
Location _____
Drilled by _____ Date Started _____
Logged by _____ Date Completed _____
Water Level Final _____ m Top Pipe Top Grd Time-Date _____
Installation _____
Page 4 of 8
General _____

PFRA TESTHOLE LOG

LOCATION SKETCH

- (A) Bit pressure, Revolutions per minute
(B) Circulation fluid, Pump pressure, Volume % Loss
(C) Drive sample weight, Drop distance, Blow count

Time	Depths - m		Formation and Water Data			Drill Data and Remarks					Sample Data		
	(Underline sample drive)	Group	Description, Characteristics, Abnormal Conditions, Sample Type	Depth Casing Shoe m	Depth Hole m	(A) kPa	cm ³ /s	% Loss	Length - m	PP kPa	No.		
					Fluid m	(B) kPa	(C) kg	Drop - m	Blows	Drive	Rec.	Test	
			Took water level of hole it is at 6.57m from ground level and is still coming into hole slowly Install 3.10m + 2.90m of 4" casing into hole Total casing is 9.36m Drive casing down to 7.5m										
			7.5-7.8 CT - up till, dark grey, Hard very shaly, crumbly sandy, numerous shale Particles and limestone Pebbles										

Project G. S. C. Spiritwood
 Site B050A010
 Hole No. C-1 cont'd Elev. _____ m
 Location _____
 Drilled by _____ Date Started _____
 Logged by _____ Date Completed _____
 Water Level Final _____ m Top Pipe Top Grd Time-Date _____
 Installation _____
 Page 5 of 8
 General _____

PFRA TESTHOLE LOG

LOCATION SKETCH

- (A) Bit pressure , Revolutions per minute
- (B) Circulation fluid , Pump pressure , Volume % Loss
- (C) Drive sample weight , Drop distance , Blow count

Time	Depths -m		Formation and Water Data		Drill Data and Remarks					Sample Data		
	(Underline sample drive)	Group	Description, Characteristics, Abnormal Conditions, Sample Type		Depth Casing Shoe m	Depth Hole Fluid m	(A) kPa (B) kPa (C) kg	rpm cm ³ /s Drop-m	% Loss	Length -m	PP kPa	No.
			Drive	Rec.								
			7.8-8.55 CT-wpt till, dark grey, hard							.75		
			-8.60 crumbly, very shaly To									
			Brown shale Particles with limestone Pebbles, water bearing water coming into hole									
			8.60									
			8.6-9.1 CT+wpt till, dark grey, hard							3 1/8" Excavator		
			limestone cobble at 9.1m.									
			very shaly							9.1m		
			* end of Day									
			Nov. 3/2010									
			G.W.L 7.77m									
			9.1-9.5 CT-wpt till, dark grey, hard							3 1/8" Excavator		
			crumbly, very shaly numerous									
			shale Particles+chunks+limestone Pebbles									

Project G.S.C. Spiritwood
 Site GOSOA010
 Hole No. C-1 cont'd Elev. _____ m
 Location _____
 Drilled by _____ Date Started _____
 Logged by _____ Date Completed _____
 Water Level Final _____ m Top Pipe Top Grd Time-Date _____
 Installation _____
 Page 6 of 8
 General _____

PFRA TESTHOLE LOG

LOCATION SKETCH

- (A) Bit pressure , Revolutions per minute
 (B) Circulation fluid , Pump pressure , Volume % Loss
 (C) Drive sample weight , Drop distance , Blow count

Time	Depths -m		Formation and Water Data		Drill Data and Remarks					Sample Data		
	(Underline sample drive)	Group	Description, Characteristics, Abnormal Conditions, Sample Type		Depth Casing Shoe m	Depth Hole Fluid m	(A) kPa (B) kPa (C) kg	rpm cm³/s Drop-m	% Loss Blows	Length -m	PP kPa	No.
										Drive	Rec.	Test
			Bailed water out of hole 9.20 <small>(Clay Shale Till)</small>									
			9.5-9.75 CI-cwp till, dark gray, hard crumbly, very shaly numerous shale chunks and limestone Pebbles				3 1/2"	Excavator				
							9.36					
			Tools Binding in hole due to cobble at 9.1m causing casing to go crooked Pulled casing back to 9.0 meters									
			9.75-10.1 Sm fine-coarse, gray, ccs <small>(Clay Shale Till)</small>				Bronchitis	35.35 > 5				
			mostly shale + limestone, to CI-cwp till, gray, hard crumbly, very shaly numerous shale chunks and limestone Pebbles water coming into hole				Note: no blow count tools Binding due to rock above					
							Note: appears to be thin interbedded cut sand layer within the clay shale Till -					

A1. Field borehole description, GSC-BH-SW-02A, page 7 of 8.

Project <u>G.S.C. Spiritwood</u>	PFRA TESTHOLE LOG													
Site <u>B050A010</u>														
Hole No. <u>C-1 cont'd</u>	Elev. _____ m													
Location _____														
Drilled by _____	Date Started _____													
Logged by _____	Date Completed _____													
Water Level Final _____ m	<input checked="" type="checkbox"/> Top Pipe		<input type="checkbox"/> Top Grd Time-Date _____											
Installation _____														
Page <u>2</u> of <u>8</u>														
General _____														
Formation and Water Data Depth - m Description, Characteristics, Abnormal Conditions, Sample Type				Drill Data and Remarks Depth Casing Shoe m Depth Hole m (A) kPa Fluid m (B) kPa cm ³ /s % Loss (C) kg Drop-m Blows							Sample Data Length - m PP kPa Drive Rec. Test			No.
Time	(Underline sample drive)	Group	Description, Characteristics, Abnormal Conditions, Sample Type											
			Clay shale reworked 10.1-10.4m C.I.-up Till, dark grey, hard crumbly, very shaly, numerous shale chunks + limestone Pebbles											
3 1/8" Excavator Bag 6 Bottom of hole, Prepare to install a 2" P.V.C. Plastic Pipe plug into hole. Length of 2" sch 40 slotted pipe is 0.97m. "20 slot size Length of the 2" solid PVC pipe is 10.13 meters Total length of Pipe in hole is 11.15 meters Bottom of the slotted pipe is at 10.40 m below grd. level Top of the slotted pipe is at 9.43 m below grd. level Top of the 2" P.V.C. pipe is 0.75 m above grd. level Backfilled the hole around the slotted pipe with Filter sand, top of sand pack is at 9.30m ~ from grd. level. Then Backfilled the hole with 1/4" Bentonite Pellets and Janned casing at the same time														

Project <u>G. S. C. Spiritwood</u> Site <u>G050A010</u> Hole No. <u>C-1 cont'd</u> Elev. _____ m Location _____ Drilled by _____ Date Started _____ Logged by _____ Date Completed _____ Water Level Final _____ m Top Pipe <input type="checkbox"/> Top Grd <input type="checkbox"/> Time-Date _____ Installation _____ Page <u>8</u> of <u>8</u> General _____	<h3 style="text-align: center;">PFRA TESTHOLE LOG</h3> <h4 style="text-align: center;">LOCATION SKETCH</h4> <p style="text-align: center;">(A) Bit pressure , Revolutions per minute (B) Circulation fluid, Pump pressure, Volume % Loss (C) Drive sample weight , Drop distance , Blow count</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th rowspan="2">Time</th> <th rowspan="2">Depths -m (Underline sample drive)</th> <th colspan="3">Formation and Water Data</th> <th colspan="5">Drill Data and Remarks</th> <th colspan="3">Sample Data</th> </tr> <tr> <th rowspan="2">Group</th> <th rowspan="2">Description, Characteristics, Abnormal Conditions, Sample Type</th> <th>Depth Casing Shoe</th> <th>Depth Hole Fluid</th> <th>(A) kPa (B) kPa (C) kg</th> <th>rpm</th> <th>% Loss</th> <th>Length -m</th> <th>PP kPa</th> <th>No.</th> </tr> <tr> <th>m</th> <th>m</th> <th></th> <th>Drop-m</th> <th>Blows</th> <th>Drive</th> <th>Rec.</th> <th>Test</th> </tr> </thead> <tbody> <tr> <td></td> <td></td> <td colspan="10" style="height: 30px; vertical-align: top;"> <p>Top of Bentonite Pellets is at 8.25 from grd level and casing shoe is at 8.20 meter from grd level.</p> <p>Pulled 6.0 meter of 4" casing out of hole. Bottom of casing shoe is at 3.00 m Below grd level.</p> <p>Hole caved in to 6.0 meter from grd level.</p> <p>Backfilled hole from 6 meter to 3.0m with Bentonite chips Then Pulled all remaining 4" casing out of the hole. Backfilled remainder of the hole to 0.75 m with clay cuttings. Then put a steel Protective Pipe around the 2" PVC pipe. The Protective Pipe is 5x6" x 6" with a locking lid. Top of the Protective Pipe is 0.80m Above grd. level. Pipe is marked and capped end of Hole</p> </td> <td></td> </tr> </tbody> </table>	Time	Depths -m (Underline sample drive)	Formation and Water Data			Drill Data and Remarks					Sample Data			Group	Description, Characteristics, Abnormal Conditions, Sample Type	Depth Casing Shoe	Depth Hole Fluid	(A) kPa (B) kPa (C) kg	rpm	% Loss	Length -m	PP kPa	No.	m	m		Drop-m	Blows	Drive	Rec.	Test			<p>Top of Bentonite Pellets is at 8.25 from grd level and casing shoe is at 8.20 meter from grd level.</p> <p>Pulled 6.0 meter of 4" casing out of hole. Bottom of casing shoe is at 3.00 m Below grd level.</p> <p>Hole caved in to 6.0 meter from grd level.</p> <p>Backfilled hole from 6 meter to 3.0m with Bentonite chips Then Pulled all remaining 4" casing out of the hole. Backfilled remainder of the hole to 0.75 m with clay cuttings. Then put a steel Protective Pipe around the 2" PVC pipe. The Protective Pipe is 5x6" x 6" with a locking lid. Top of the Protective Pipe is 0.80m Above grd. level. Pipe is marked and capped end of Hole</p>										
Time	Depths -m (Underline sample drive)			Formation and Water Data			Drill Data and Remarks					Sample Data																																	
		Group	Description, Characteristics, Abnormal Conditions, Sample Type	Depth Casing Shoe	Depth Hole Fluid	(A) kPa (B) kPa (C) kg	rpm	% Loss	Length -m	PP kPa	No.																																		
m	m				Drop-m	Blows	Drive	Rec.	Test																																				
		<p>Top of Bentonite Pellets is at 8.25 from grd level and casing shoe is at 8.20 meter from grd level.</p> <p>Pulled 6.0 meter of 4" casing out of hole. Bottom of casing shoe is at 3.00 m Below grd level.</p> <p>Hole caved in to 6.0 meter from grd level.</p> <p>Backfilled hole from 6 meter to 3.0m with Bentonite chips Then Pulled all remaining 4" casing out of the hole. Backfilled remainder of the hole to 0.75 m with clay cuttings. Then put a steel Protective Pipe around the 2" PVC pipe. The Protective Pipe is 5x6" x 6" with a locking lid. Top of the Protective Pipe is 0.80m Above grd. level. Pipe is marked and capped end of Hole</p>																																											

Project G.S.C. Spiritwood
 Site C050A010
 Hole No. C-2 (SW02B) Elev. _____ m
 Location SW 33-3-16-W2 and it is 1.5 meters south of hole C-1
 Drilled by RD Date Started Nov 3/2010
 Logged by DG Date Completed Nov 3/2010
 Water Level Final 1.15 m Top Pipe Top Grd Time-Date Nov 4/10
 Installation 2" PVC Sch. 40 Plastic Pipe Piez
 Page 1 of 2
 General _____

PFRA TESTHOLE LOG

		PFRA TESTHOLE LOG
		8:30 AM
		LOCATION SKETCH
(A) Bit pressure , Revolutions per minute		
(B) Circulation fluid , Pump pressure, Volume % Loss		
(C) Drive sample weight , Drop distance , Blow count		

Time	Depths - m	Formation and Water Data			Drill Data and Remarks					Sample Data		
	(Underline sample drive)	Group	Description, Characteristics, Abnormal Conditions, Sample Type	Depth Casing Shoe m	Depth Hole Fluid m	(A) kPa (B) kPa (C) kg	rpm cm³/s Drop -m	% Loss Blows	Length - m	PP kPa	No.	
			0 - 0.35 Top soil Black, organic, stiff fibers (roots)						3 1/8" Excavator			
			0.35 - 1.0 SC fine-coarse, brown, wet slight clay binder						3 1/8" Excavator Bag 1			
			1.0 - 1.6 SC fine-coarse, brown, wet with a few interbedded clay seams				"	"	"	"		
			1.6 - 2.0 CI top till, Brown, stiff lenses + seams of oxidized				"	"	"	"	1.50	
			Reamed hole out to 2.0m with 5 5/8" Excavator									

Project Geological Survey Of Canada Spiritwood							PFRA TESTHOLE LOG											
Site GOS04009			Location CSE6-5-17-W1 GPS coordinates are Easting 144 445896 Norgthing 546 7235															
Hole No. C3(SW03A) Elev. m			Date Started Nov 4/2010															
Drilled by R.D.			Date Completed Nov 6/2010															
Logged by D.G.			Time-Date Nov 16/10															
Water Level Final 5.37 m			Top Pipe Top Grd															
Installation 2" PVC sch.40 Plastic Pipe Prez			Time-Date Nov 16/10															
Page 1 of 18			General B-14 cable Tool rig Plan# 359092															
Time	Depths - m		Formation and Water Data			Drill Data and Remarks				Sample Data								
	(Underline sample drive)	Group	Description, Characteristics, Abnormal Conditions, Sample Type			Depth Casing Shoe m	Depth Hole Fluid m	(A) kPa	rpm	Length - m	PP kPa	No.						
								(B) kPa	cm ³ /s	% Loss	Drive	Rec.						
								(C) kg	Drop - m	Blows								
			0-0.70 Top soil, Black, organic, Firm Fibers (roots)					3 1/2"	"Excavator									
			7.0-15 C.I + up till, Brown, soft to Firm lenset seams of oxides Hole is squeezing					3 1/2"	"Excavator									
			Reamed hole out to 1.5m with 5 5/8" excavator															
			1.5-2.25 C.I + up till, brown, Firm wet sand seam at 1.80m Hole squeezing, seams of oxides					3 1/2"	"Excavator									
			Reamed hole out to 2.0m with 7 7/8" excavator Set 1.69m of 6" casing with Drive shoe into hole Drive casing down to 1.60m															

A3. Field borehole description, GSC-BH-SW-03A, page 2 of 18

Project <u>G.S.C. Spiritwood</u> Site <u>GOSA009</u>				PFRA TESTHOLE LOG								
Hole No. <u>CFB cont'd</u> Elev. _____ m Location <u>C-1</u>												
Drilled by _____ Date Started _____ Logged by _____ Date Completed _____												
Water Level Final _____ m Top Pipe <input checked="" type="checkbox"/> Top Grd <input type="checkbox"/> Time-Date _____												
Installation _____ Page <u>2</u> of <u>18</u>				LOCATION SKETCH (A) Bit pressure, Revolutions per minute (B) Circulation fluid, Pump pressure, Volume % Loss (C) Drive sample weight, Drop distance, Blow count								
Time	Depths - m	Formation and Water Data			Drill Data and Remarks					Sample Data		
	(Underline sample drive)	Group	Description, Characteristics, Abnormal Conditions, Sample Type			Depth Casing Shoe m	Depth Hole Fluid m	(A) kPa (B) kPa (C) kg	rpm cm^3/s Drop - m	% Loss Blows	Length - m Drive	PP kPa Rec.
2-25 To 2.30-3.05	CI top till, brown, soft to CI top till, Brown, stiff with lenses of oxides, trace of water on sampler barrel				Brass liner 8	-75.75	1.52	-75.75	1.52	note water in hole		
<p>Added 1.56m of 6" casing, total casing is 3.25m</p> <p>Driving casing down to 3.0 m</p>												
3.05-3.5	CI top till, Brown, stiff									3 $\frac{1}{2}$ " Excavator		
-3.75	lenses of oxides											
<p>Reamed hole out to 3.5m with 5 $\frac{1}{2}$" Excavator</p>												
3.75-4.0	CI top till, dark gr brown very stiff, seams of sand and thin wet sand layer 3.8-3.9						3 $\frac{1}{2}$ " Excavator			2.25		
							note	water coming in to hole				
									from the next sand layer			

Project	G.S.C. Spiritwood			PFRA TESTHOLE LOG									
Site	GOSOA007												
Hole No.	CZcontd			Elev.	m								
Location	C-1												
Drilled by				Date Started									
Logged by				Date Completed									
Water Level Final	m	Top Pipe	<input checked="" type="checkbox"/>	Time-Date									
Top Grd	<input type="checkbox"/>												
Installation				LOCATION SKETCH									
Page	3 of 18			(A) Bit pressure, Revolutions per minute									
General				(B) Circulation fluid, Pump pressure, Volume % Loss									
(C) Drive sample weight, Drop distance, Blow count													
Time	Depths - m		Formation and Water Data			Drill Data and Remarks					Sample Data		
	(Underline sample drive)	Group	Description, Characteristics, Abnormal Conditions, Sample Type			Depth Casing Shoe m	Depth Hole Fluid m	(A) kPa (B) kPa (C) kg	rpm cm ³ /s Drop - m	% Loss Blows	Length - m	PP kPa	No.
			Static water level in hole after 40 min was: 3.37m from ground level										
			Reamed hole out to 4.0 m with 5 1/2" excavator										
			4.0-4.5 CI + up till, dark gr brown very stiff, lenses+specks of oxides, few shale Particles										
			Added 60m of 6" casing, total casing is 4.25m Drive casing down to 4.25m										
			4.5-5.0 CI - up till, dark gr brown Hard, few lenses+specks of oxides, Pebbly few shale Particles										

A3. Field borehole description, GSC-BH-SW-03A, page 4 of 18

Project	G.S.C. Spiritwood			PFRA TESTHOLE LOG									
Site	GOSA 009												
Hole No.	C-20ntd			Elev.	m								
Location	C1												
Drilled by				Date Started									
Logged by				Date Completed									
Water Level Final	m	Top Pipe	<input checked="" type="checkbox"/>	Time-Date									
Top Grd	<input type="checkbox"/>												
Installation													
Page	4 of 18												
General													
Time	Depths - m	Formation and Water Data			Drill Data and Remarks					Sample Data			No.
	(Underline sample drive)	Group	Description, Characteristics, Abnormal Conditions, Sample Type			Depth Casing Shoe m	Depth Hole Fluid m	(A) kPa (B) kPa (C) kg	rpm cm ³ /s Drop-m	% Loss	Length - m	PP kPa	
	5.0-6.0	CI - up till, grey, hard few oxides + specks of oxides few shale particles, very slight traces of water in a few oxidized joints											
	6.0-6.75	CI - up till, grey, hard few oxides, shale particles few cobbles											
	6.75-8.0	CI - up till, grey, hard to very stiff, few shale particles and cobbles Chimestone											
	Ramed hole out to 8.0m with 5 1/2" Excavator												

Project	G.S.C. Spiritwood													
Site	GOSOA009													
Hole No.	C-2 cont'd													
Location	C-1													
Drilled by	Date Started _____													
Logged by	Date Completed _____													
Water Level Final	m	Top Pipe	<input checked="" type="checkbox"/>	Time-Date										
Installation														
Page 5 of 8														
General														
PFRA TESTHOLE LOG														
LOCATION SKETCH														
(A) Bit pressure , Revolutions per minute (B) Circulation fluid , Pump pressure, Volume % Loss (C) Drive sample weight , Drop distance, Blow count														
Time	Depths -m		Formation and Water Data			Drill Data and Remarks					Sample Data			
	(Underline sample drive)	Group	Description, Characteristics, Abnormal Conditions, Sample Type			Depth Casing Shoe m	Depth Hole Fluid m	(A) kPa (B) kPa (C) kg	rpm cm ³ /s Drop-m	% Loss Blows	Length-m	PP kPa	No.	
8.0-9.25	CIT+cup till, grey, very stiff few shale Particles									3 1/2" Excavator				
9.25-10.	CIT+cup till, grey, stiff few shale Particles. Trace of cut to creeping into hole no visual sand seems noticed									Borebottom 12.75-75 2.53 Note: sample pulled out of line. Cut cation and retrieved sample.				
10m-11.5	CIT+cup till, grey, stiff few shale particles and limestone cobbles									3 1/2" Excavator 2.5				
	Reamed hole out to 11.5m with 5 5/8" Excavator													

A3. Field borehole description, GSC-BH-SW-03A, page 6 of 18

Project	G.S.C. Spiritwood			PFRA TESTHOLE LOG									
Site	COSOA009												
Hole No.	Q-Yeon 1			Elev.	m								
Location	(-)												
Drilled by				Date Started									
Logged by				Date Completed									
Water Level Final	m	Top Pipe	<input checked="" type="checkbox"/>	Time-Date									
Top Grd	<input type="checkbox"/>												
Installation													
Page	6	of	18										
General													
Time	Depths - m		Formation and Water Data			Drill Data and Remarks					Sample Data		
	(Underline sample drive)	Group	Description, Characteristics, Abnormal Conditions, Sample Type			Depth Casing Shoe m	Depth Hole Fluid m	(A) kPa (B) kPa (C) kg	rpm cm ³ /s Drop-m	% Loss Blows	Length - m	PP kPa	No.
11.5-12.1													
12.1-12.85													
12.85-13.5													
13.5-14.6													

11.5-12.1 CT + up till, grey, very stiff
few limestone cobbles

12.1-12.85 CT + up Till, dark grey,
very stiff, few shale particles
and limestone cobbles

12.85-13.5 CT + up till, As above, Cobble at 13.0 meters
Reamed hole out to 13.0 m with 5 1/2" excavator

13.5-14.6 CT + up till, dark grey, very
stiff, few shale particles
and limestone Pebbles

Reamed hole out to 14.6 m with 5 1/2" Excavator

A3. Field borehole description, GSC-BH-SW-03A, page 7 of 18

Project	G.S.C.- Spiritwood			PFRA TESTHOLE LOG									
Site	Q050A009												
Hole No.	Q-3 contd			Elev.									
Location	C-1												
Drilled by				Date Started									
Logged by				Date Completed									
Water Level Final	m	Top Pipe	<input checked="" type="checkbox"/>	Time-Date									
Top Grd	<input type="checkbox"/>												
Installation													
Page	2 of 18												
General													
				LOCATION SKETCH									
				(A) Bit pressure , Revolutions per minute (B) Circulation fluid , Pump pressure, Volume % Loss (C) Drive sample weight , Drop distance , Blow count									
Time	Depths-m (Underline sample drive)	Formation and Water Data			Drill Data and Remarks						Sample Data		
		Group	Description, Characteristics, Abnormal Conditions, Sample Type	Depth Casing Shoe m	Depth Hole Fluid m	(A) kPa (B) kPa (C) kg	rpm cm ³ /s Drop-m	% Loss Blows	Length-m	PP kPa	No.	Drive	Rec.
		14.6-15.1 CT+wp till, dark grey, very stiff few shale particles and limestone Pebbles						3 1/2" Excavator					3.0
		15.1-15.85 CT+wp Till, dark grey, very stiff few shale particles and limestone Pebbles						Brasslinier	18-75-602.65				
		15.85-16.1 CT+wp till, As above						3 1/2" Excavator					
		Ramed hole out to 16.1m with 5 5/8" Excavator											
		16.1-16.5 CT+wp till, grey, very stiff few limestone cobbles + shale Particles											

A3. Field borehole description, GSC-BH-SW-03A, page 8 of 18

Project <u>G.S.C. Spiritwood</u> Site <u>GOSPA009</u> Hole No. <u>Q-2 contd</u> Elev. _____ m Location <u>C1</u> Drilled by _____ Date Started _____ Logged by _____ Date Completed _____ Water Level Final _____ m Top Pipe <input checked="" type="checkbox"/> Top Grd <input type="checkbox"/> Time-Date _____ Installation _____ Page <u>3</u> of <u>18</u> General _____			PFRA TESTHOLE LOG										
LOCATION SKETCH (A) Bit pressure, Revolutions per minute (B) Circulation fluid, Pump pressure, Volume % Loss (C) Drive sample weight, Drop distance, Blow count													
Time	Depths - m		Formation and Water Data			Drill Data and Remarks					Sample Data		
	(Underline sample drive)	Group	Description, Characteristics, Abnormal Conditions, Sample Type			Depth Casing Shoe m	Depth Hole Fluid m	(A) kPa (B) kPa (C) kg	rpm cm ³ /s Drop-m	% Loss Blows	Length - m	PP kPa	No.
			Set 3.27 with shoe + 3.38 + 3.23 + 3.12 + 2.90 + 1.48 = 17.38m of 4" casing into hole, total 4" casing is 17.38m. Drive casing down to 16.5m. end of Day										
			Nov 5/2010 Drill out inside of casing to 16.5m										
			16.5-17.8 CI top till, dark grey, very stiff, cobbles of limestone and shale particles										
			17.8-18 Clay Shale, silty, dark grey with hard few MI lenses										

A3. Field borehole description, GSC-BH-SW-03A, page 9 of 18

Project <u>G.S.C. Spiritwood</u> Site <u>20504069</u> Hole No. <u>C-3 cont'd</u> Elev. _____ m Location <u>C-1</u>					PFRA TESTHOLE LOG							
Drilled by _____ Date Started _____ Logged by _____ Date Completed _____ Water Level Final _____ m Top Pipe <input checked="" type="checkbox"/> Top Grd <input type="checkbox"/> Time-Date _____ Installation _____ Page <u>9</u> of <u>18</u> General _____					LOCATION SKETCH (A) Bit pressure, Revolutions per minute (B) Circulation fluid, Pump pressure, Volume % Loss (C) Drive sample weight, Drop distance, Blow count							
Time	Depths - m		Formation and Water Data		Drill Data and Remarks					Sample Data		
	(Underline sample drive)	Group	Description, Characteristics, Abnormal Conditions, Sample Type		Depth Casing Shoe m	Depth Hole Fluid m	(A) kPa	rpm		Length - m	PP kPa	No.
		<u>18.0-18.75</u> clay shale, silty, Reworked with numerous limestone pebbles, med hard, dark grey							<u>Brasslinex 26</u>	<u>.75.75</u>	> 7	
		<u>18.75-19.6</u> Clay Shale, Reworked, Dark gray, hard silty, numerous, shale bands concretions, ls.										
		<u>Removed 1.43m of casing, Added 3.38m of 4" casing</u> <u>Total casing 19.28m</u> <u>Drive casing down To 190m</u>										

A3. Field borehole description, GSC-BH-SW-03A, page 10 of 18

Project	GSC - Spiritwood			PFRA TESTHOLE LOG									
Site	GOSOA009												
Hole No.	C-3 control			Elev.	m								
Location	C-1												
Drilled by				Date Started									
Logged by				Date Completed									
Water Level Final	m	Top Pipe	<input checked="" type="checkbox"/>	Time	Data								
Top Grd													
Installation													
Page	10 of 18												
General													
Time	Depths - m	Formation and Water Data			Drill Data and Remarks					Sample Data			No.
	(Underline sample drive)	Group	Description, Characteristics, Abnormal Conditions, Sample Type		Depth Casing Shoe m	Depth Hole Fluid m	(A) kPa (B) kPa (C) kg	rpm cm ³ /s Drop - m	% Loss Blows	Length - m	PP kPa		
	19.6-21.0	Clay Shale, Reworked, dark grey Hard, with shalestone concretions crumbly.											
	21.0-21.75	Clay Shale, Reworked, Hard silty, Crumbly, with a few limestone Pebbles @ 21.75m											
		Added 1.48m of casing, total = 20.26m											
		20.5m											
	21.75-22.3	Clay Shale Reworked, dark grey Hard, numerous limestone Pebbles, appears till like											
	22.3-22.8	CI - cup till, dark grey hard very shaly, crumbly, limestone Pebbles											

Project <u>GSC - Spiritwood</u> Site <u>G050A069</u> Hole No. <u>2-B cont'd</u> Elev. _____ m Location <u>C-1</u> Drilled by _____ Date Started _____ Logged by _____ Date Completed _____ Water Level Final _____ m Top Pipe <input checked="" type="checkbox"/> Top Grd <input type="checkbox"/> Time-Date _____ Installation _____ Page <u>11</u> of <u>18</u> General _____				PFRA TESTHOLE LOG LOCATION SKETCH (A) Bit pressure , Revolutions per minute (B) Circulation fluid , Pump pressure, Volume % Loss (C) Drive sample weight , Drop distance, Blow count									
Time	Depths-m		Formation and Water Data			Drill Data and Remarks					Sample Data		
	(Underline sample drive)	Group	Description, Characteristics, Abnormal Conditions, Sample Type			Depth Casing Shoe m	Depth Hole Fluid m	(A) kPa (B) kPa (C) kg	rpm cm ³ /s Drop-m	% Loss Blows	Length-m	PP kPa	No.
			22.8-22.9 Sm fine, grey, wet shaly very silty, very slight trace at water in hole								3 1/8" Excavator		
			22.9-23.0 CI-wpTill, Dark grey, Hard very shaly, crumbly numerous shale chunks								3 1/8" Excavator		
			Removed 1.48m of casing, Added 3.34m, total=22.62 22.6										
			23.0-23.78CI-wpTill, dark grey, As above -23.9m										
			Very slight water seepage coming into hole from the 22.8-22.9 layer Added 1.48m of casing, total=24.10m Drive casing down to 23.75										

Project <u>G.S.C. Spiritwood</u>	Site <u>GOSO A009</u>	PFRA TESTHOLE LOG											
Site No. <u>C-3 contd</u>	Elev. _____ m												
Location <u>C-1</u>													
Drilled by _____	Date Started _____												
Logged by _____	Date Completed _____												
Water Level Final _____ m	Top Pipe <input checked="" type="checkbox"/>	Top Grd <input type="checkbox"/>	Time-Date _____										
Installation _____													
Page <u>12</u> of <u>12</u>													
General _____													
LOCATION SKETCH													
(A) Bit pressure, Revolutions per minute (B) Circulation fluid, Pump pressure, Volume % Loss (C) Drive sample weight, Drop distance, Blow count													
Time	Depths - m		Formation and Water Data			Drill Data and Remarks					Sample Data		
	(Underline sample drive)	Group	Description, Characteristics, Abnormal Conditions, Sample Type			Depth Casing Shoe m	Depth Hole Fluid m	(A) kPa (B) kPa (C) kg	rpm cm ³ /s Drop-m	% Loss Blows	Length - m	PP kPa	No.
			23.9-24.0 Sm fine, silty, dark grey, wet clay binder							3 7/8" Excavator			
							24.0 m						
			24.0-24.75 PSM fine-med, grey, wet shale particles, To CI-up till, dark grey hard							Borestinger	.75-69 > 10		
			very shaly, numerous shale chunks										
			water coming into hole										
			Removed 1.48m of casing, added 3.24m, Total = 25.96m										
			24.75 Bailed cutter out of hole approx 3 gallons										
			24.75-25.95 CI - up till, dark grey										
			hard, very shaly										
			numerous, shale chunks										
			crumbly				25.9						

Project	<u>G.S.C. Spiritwood</u>				PFRA TESTHOLE LOG								
Site	<u>E050A009</u>												
Hole No.	<u>R23 cont'd</u>				Elev.								
Location	<u>C-1</u>												
Drilled by					Date Started								
Logged by					Date Completed								
Water Level Final	m	Top Pipe	<input checked="" type="checkbox"/>	Time-Date									
Top Grd	<input type="checkbox"/>												
Installation					LOCATION SKETCH								
Page	<u>13 of 18</u>				(A) Bit pressure, Revolutions per minute								
General					(B) Circulation fluid, Pump pressure, Volume % Loss								
				(C) Drive sample weight, Drop distance, Blow count									
Time (Underline sample drive)	Depths - m Group	Formation and Water Data			Drill Data and Remarks					Sample Data			No.
		Description, Characteristics, Abnormal Conditions, Sample Type	Depth Casing Shoe m	Depth Hole Fluid m	(A) kPa (B) kPa (C) kg	rpm cm ³ /s Drop - m	% Loss Blows	Length - m	PP kPa	Drive	Rec.	Test	
		26.0-263 CI-clay shale, silty sandy, dark gray hard.											
		26.3-270 CI-wpt till, dark grey, hard very shaly, with numerous shale particles + chunks											
		Added 1.48m of casing, total = 27.34m 27.0m											
		270-2775 CI-wpt till, dark grey, hard very shaly, with limestone cobbles and Numerous shale chunks, crumbly											
		Boreline 50.75.75 > 11											

A3. Field borehole description, GSC-BH-SW-03A, page 14 of 18

Project	G.S.C. Spiritwood			PFRA TESTHOLE LOG									
Site	GOSA009												
Hole No.	R-3 contd			Elev.	m								
Location	C-1												
Drilled by				Date Started									
Logged by				Date Completed									
Water Level Final	m	Top Pipe	<input type="checkbox"/>	Time-Date									
Top Grd	m	Top Grd	<input checked="" type="checkbox"/>										
Installation													
Page	14 of 18												
General													
Time	Depths - m		Formation and Water Data			Drill Data and Remarks				Sample Data			No.
	(Underline sample drive)	Group	Description, Characteristics, Abnormal Conditions, Sample Type			Depth Casing Shoe m	Depth Hole Fluid m	(A) kPa (B) kPa (C) kg	rpm cm ³ /s Drop-m	% Loss Blows	Length - m	PP kPa	
										Drive	Rec.	Test	
22.75-29.0	CT	wptill, dark grey, hard very shaly, limestone cobbles numerous shale particles + chunks crumbly								3 7/8"	Excavator		
29.0-29.5	CT	wptill, dark grey Hard, very shaly, limestone cobbles, numerous shale chunks											
29.5-29.6	SG	fine, dark grey, wet, very shaly, very slight trace of water in the hole								3 7/8"	Excavator		
		Added 1.48m of casing, total casing 30.68m 29.6a											

A3. Field borehole description, GSC-BH-SW-03A, page 15 of 18

Project <u>G.S.C. Spintwood</u> Site <u>GOSO A009</u> Hole No. <u>225 cont'd</u> Elev. _____ m Location <u>C-1</u>				PFRA TESTHOLE LOG LOCATION SKETCH (A) Bit pressure, Revolutions per minute (B) Circulation fluid, Pump pressure, Volume % Loss (C) Drive sample weight, Drop distance, Blow count								
Time	Depths - m	Formation and Water Data			Drill Data and Remarks				Sample Data			
	(Underline sample drive)	Group	Description, Characteristics, Abnormal Conditions, Sample Type	Depth Casing Shoe m	Depth Hole Fluid m	(A) kPa	rpm	(B) kPa	cm ³ /s	% Loss	Length - m	PP kPa
		29.6-30m CI-wp till, dark grey, hard very shaly, shale chunks & limestone cobbles								3 7/8" Excavator		
		30.0m To 30.1-30.85 CI-wp till, dark grey, hard very shaly, with shale chunks, limestone cobbles								Brasshaw 55 75.75 > 12		
										30.5		
		30.85-32.6 CI-wp Till, dark gray, hard slightly sand, shaly, with shale chunks, limestone cobbles thin sand seam, wet, at 31.5m								3 7/8" Excavator		
		Removed 1.48m of casing, Added 3.39, total = 32.59m Drive casing down to 32.2m								Notes: = very slight water seepage into the hole		

A3. Field borehole description, GSC-BH-SW-03A, page 16 of 18

Project	G.S.C. Spiritwood			PFRA TESTHOLE LOG									
Site	GOSO A009												
Hole No.	C3eonPd			Elev.	m								
Location	C-1												
Drilled by				Date Started									
Logged by				Date Completed									
Water Level Final	m	Top Pipe	<input type="checkbox"/>	Time-Date									
Top Grd	<input type="checkbox"/>												
Installation				LOCATION SKETCH									
Page	16	of	18	(A) Bit pressure , Revolutions per minute									
General				(B) Circulation fluid , Pump pressure, Volume % Loss									
(C) Drive sample weight , Drop distance , Blow count													
Time	Depths -m	Formation and Water Data			Drill Data and Remarks						Sample Data		
	(Underline sample drive)	Group	Description, Characteristics, Abnormal Conditions, Sample Type		Depth Casing Shoe m	Depth Hole Fluid m	(A) kPa (B) kPa (C) kg	rpm cm ³ /s Drop -m	% Loss Blows	Length -m	PP kPa	No.	
		Nov. 6/2010											
		STATIC water level in hole is at 32.03m from grd level 32.6-33.0 CI -wp till, dark grey, hard very shaly, with shale Particles + chunks											
		33.0-33.75 CI -wp Till, dark grey, hard very shaly, with shale Particles + chunks											
		33.75-34.7 CI -wp till, As above with a few limestone cobbles											

Project <u>G.S.C. Spiritwood</u> Site <u>GOSO1009</u> Hole No. <u>03 contd</u> Elev. _____ m Location <u>L-1</u> Drilled by _____ Date Started _____ Logged by _____ Date Completed _____ Water Level Final _____ m Top Pipe <input checked="" type="checkbox"/> Top Grd <input type="checkbox"/> Time-Date _____ Installation _____ Page <u>18</u> of <u>18</u> General _____				PFRA TESTHOLE LOG LOCATION SKETCH (A) Bit pressure , Revolutions per minute (B) Circulation fluid , Pump pressure , Volume % Loss (C) Drive sample weight , Drop distance , Blow count									
Time	Depths -m (Underline sample drive)	Formation and Water Data			Drill Data and Remarks					Sample Data			
		Group	Description, Characteristics, Abnormal Conditions, Sample Type	Depth Casing Shoe m	Depth Hole Fluid m	(A) kPa (B) kPa (C) kg	rpm cm ³ /s Drop-m	% Loss Blows	Length -m	PP kPa	No.	Drive	Rec.
		<p>Jammed casing and poured Filter sand into hole at same time</p> <p>Top of the sand Pack is at 31.40 m. from ground level</p> <p>Then Poured 4" Bentonite Pellets into the hole and Jammed</p> <p>Casing out at the same time Top of the Bentonite Pellets</p> <p>is at 30.4 m. from ground level. Pulled all 4"</p> <p>casing out of hole. Then grinded the hole with a</p> <p>steel survey chain. Hole is open to 30.3 meters. Then</p> <p>Poured two bags of Econo-Hole Plug into the hole</p> <p>Top of Hole Plug is at 21.0 meters from ground level</p> <p>Backfilled the remainder of the hole with clay</p> <p>cuttings to 4.50 m from ground level. Then Pulled</p> <p>all 6" casing out of Hole. Backfilled hole to 0.70 m.</p> <p>with clay cuttings and Bentonite chips. Then Installed</p> <p>1.5mx15cmx15cm</p> <p>a 5'x6"x6" Protective steel pipe around the 2" P.V.G</p> <p>Pipe plug. Pipe is capped and Marked. END of Hole</p> <p>A water level will be obtained later</p>											

A4. Field borehole description, GSC-BH-SW-03B, page 1 of 5

Project <u>Geological Survey of Canada Spiritwood</u> Site <u>G050A009</u> Hole No. <u>C-2 (SW038)</u> Elev. _____ m Location <u>SE6-5-17-W1st 1719 1.80m west of Hole C-1 (SW03A)</u> Drilled by <u>R.D.</u> Date Started <u>Nov 16/2010</u> Logged by <u>D.G.</u> Date Completed <u>Nov 16/2010</u> Water Level Final <u>1.32</u> m Top Pipe <input checked="" type="checkbox"/> Time-Date <u>NOV 16 PM</u> Top Grd <input type="checkbox"/> Installation <u>8" PVC Plastic Pipe piping. (sch 40)</u> Page <u>1</u> of <u>5</u> General <u>B-14 cable tool rig Plan # 359093</u>				PFRA TESTHOLE LOG								
LOCATION SKETCH												
(A) Bit pressure, Revolutions per minute (B) Circulation fluid, Pump pressure, Volume % Loss (C) Drive sample weight, Drop distance, Blow count												
Time	Depths - m		Formation and Water Data			Drill Data and Remarks				Sample Data		
	(Underline sample drive)	Group	Description, Characteristics, Abnormal Conditions, Sample Type			Depth Casing Shoe m	Depth Hole Fluid m	(A) kPa (B) kPa (C) kg	rpm cm ³ /s Drop - m	Length - m Blows	PP kPa Drive Rec. Test	No.
	0 - 0.5	Topsoil, Black, organic, stiff fibers (roots)										
	0.5 - 1.40	CI tropy till, Brown, very soft, lacking pebbles										
	1.4 - 1.50	SG fine-coarse, brown, wet gravelly, water seeping into hole										
		Reamed hole out to 1.5m with 7 1/2" excavator										
		Set 1.69m of 6" casing into hole										
		Drive casing down to 1.50m										
	1.5 - 2.25	CI tropy till, Brown, stiff few seams of oxides										

Project	G.S.C. Spiritwood		PFRA TESTHOLE LOG										
Site	GOSA1009												
Hole No.	C-2 cont'd	Elev.											
Location													
Drilled by			Date Started										
Logged by			Date Completed										
Water Level Final	m	Top Pipe <input checked="" type="checkbox"/>	Time-Date										
Top Grd <input type="checkbox"/>													
Installation													
Page 2 of 5													
General													
LOCATION SKETCH													
(A) Bit pressure , Revolutions per minute (B) Circulation fluid , Pump pressure , Volume % Loss (C) Drive sample weight , Drop distance , Blow count													
Time	Depths - m		Formation and Water Data			Drill Data and Remarks					Sample Data		
	(Underline sample drive)	Group	Description, Characteristics, Abnormal Conditions, Sample Type			Depth Casing Shoe m	Depth Hole Fluid m	(A) kPa (B) kPa (C) kg	rpm cm ³ /s Drop - m	% Loss Blows	Length - m	PP kPa	No.
	Added 1.56 m of 6" casing, total = 3.25 m												
	Drive casing down to 3.25												
	2.25-2.8 CT up till, brown, stiff												
	lens + seams of oxid.												
	soft sand seam at 2.8m												
	water coming into hole												
	2.8-3.0 CT up till, brown, stiff												
	- 3.20 silty, with interbedded												
	thin layer + seam at 3.0m wet sandy												
	numerous seams of oxid.												
	Ramed hole out to 3.0m with 5 1/2" excavator												
	Drive casing down to 3.0m												
	3.20-3.70 CT up, till, qbrown, very stiff												
	lenses + seams of oxid.												
	3 1/2" Excavator												

A4. Field borehole description, GSC-BH-SW-03B, page 3 of 5

Project	G.S.C. Spiritwood			PFRA TESTHOLE LOG									
Site	GOSO A009												
Hole No.	C-2 cont'd			Elev.									
Location													
Drilled by				Date Started									
Logged by				Date Completed									
Water Level Final	m	Top Pipe <input checked="" type="checkbox"/>	Top Grd <input type="checkbox"/>	Time-Date									
Installation													
Page	3 of 5												
General													
Time	Depths - m	Formation and Water Data			Drill Data and Remarks					Sample Data			No.
	(Underline sample drive)	Group	Description, Characteristics, Abnormal Conditions, Sample Type		Depth Casing Shoe m	Depth Hole Fluid m	(A) kPa (B) kPa (C) kg	rpm cm ³ /s Drop - m	% Loss Blows	Length - m	PP kPa		
			Added 1.0m of 6" casing, total = 4.25m										
			Drive coming down to 3.70m										
			Bailed water out of Hole										
			3.70-4.60 CI up till, dark gr brown very stiff, lenses seems of oxides										
			Reamed hole out to 4.6m with 5 5/8" Excavator										
			4.60-5.0 CI - up Till, grey, hard - 5.6 lenses of oxides										
			4.20										
			Reamed hole out to 5.0m with 5 5/8" Excavator										

Project <u>G.S.C. Spiritwood</u> Site <u>GOS0A609</u> Hole No. <u>C-2 contd</u> Elev. _____ m Location _____ Drilled by _____ Date Started _____ Logged by _____ Date Completed _____ Water Level Final _____ m Top Pipe <input checked="" type="checkbox"/> Top Grd <input type="checkbox"/> Time-Date _____ Installation _____ Page <u>4</u> of <u>5</u> General _____			PFRA TESTHOLE LOG										
LOCATION SKETCH (A) Bit pressure , Revolutions per minute (B) Circulation fluid , Pump pressure , Volume % Loss (C) Drive sample weight , Drop distance , Blow count													
Time	Depths-m		Formation and Water Data			Drill Data and Remarks					Sample Data		
	(Underline sample drive)	Group	Description, Characteristics, Abnormal Conditions, Sample Type			Depth Casing Shoe m	Depth Hole Fluid m	(A) kPa (B) kPa (C) kg	rpm cm ³ /s Drop -m	% Loss Blows	Length-m	PP kPa	No.
			<u>5.6 - 9.0 CT-clay Till, grey, Hard</u> <u>few cobbles</u>								<u>3 7/8" Excavator</u>		
			<u>9.0 - 10.5 CT-typ Till dark grey, Hard</u> <u>few cobbles, cobble at 10.1</u> <u>and another at 10.5 m.</u>								<u>3 7/8" Excavator</u>		
			<u>Bottom of hole, Prepare hole for a 2" sch40 PVC Plastic pipe piez</u> <u>Backfill hole with clay cuttings and Bentonite chips and tamp</u> <u>it tight into the hole with the rig tool stem.</u>										
			<u>Hole was Backfilled to 4.20 meters from ground level!</u>										
			<u>Pulled casing back to 3.5m. Then backfilled hole with</u> <u>clay cuttings to 3.5m meters from ground level.</u>										
			<u>Then set 2" PVC Plastic Pipe piez in to hole</u> <u>Length of exposed slotted pipe is 0.70 meters #20 slot size</u> <u>length of Just 2" PVC Pipe is 3.65 meters</u>										

Project <u>G.S.C. Spiritwood</u> Site <u>GOSO Area</u> Hole No. <u>C-2 cont'd</u> Elev. _____ m Location _____ Drilled by _____ Date Started _____ Logged by _____ Date Completed _____ Water Level Final _____ m Top Pipe <input checked="" type="checkbox"/> Top Grd <input type="checkbox"/> Time-Date _____ Installation _____ Page <u>5 of 5</u> General _____				PFRA TESTHOLE LOG								
LOCATION SKETCH (A) Bit pressure, Revolutions per minute (B) Circulation fluid, Pump pressure, Volume % Loss (C) Drive sample weight, Drop distance, Blow count												
Time	Depths - m	Formation and Water Data			Drill Data and Remarks					Sample Data		
	(Underline sample drive)	Group	Description, Characteristics, Abnormal Conditions, Sample Type	Depth Casing Shoe m	Depth Hole Fluid m	(A) kPa	rpm	(B) kPa cm ³ /s	% Loss	Length - m	PP kPa	No.
									Drive	Rec.	Test	
		<p>Total length of 2" pipe in hole is 4.25 meters Bottom of slotted pipe is at 3.5 meters from ground level Top of the exposed slot is at 2.8 meters from ground level Top of the 2" pipe pipe is 0.75 meters above grnd level. Then Poured Filter sand down the hole and pulled the 6" casing out at the same time top of sand pack is at 2.6m. 6" casing is at 2.6m too. then Pulled casing back to 1.69m and Backfilled the hole around the Piez. Pipe with Bentonite chips to 1.70m from grnd level. There is 0.9m of Bentonite chip in the hole to form a seal around the P.U.G. Pipe. Pulled all 6" casing out of the hole. Backfilled hole with clay cuttings to 0.70m from grnd level. <small>(1.5m x 15cm x 15cm)</small> Placed a 5'x6"x6" Protective pipe around the 2" Pipe pipe. Pipe is capped and marked. End of Hole. </p>										

Project <u>Geological Survey of Canada Spiritwood</u> Site <u>GOSA A008</u> Hole No. <u>C-1(SW04A)</u> Elev. <u>m</u> Location <u>NW1-2-15-W2 G.P.S. coordinates are Easting 14U 0468209</u> Drilled by <u>R.D.</u> Date Started <u>Nov 18/2010</u> Northing <u>5443943</u> Logged by <u>D.G.</u> Date Completed <u>Nov 20/2010</u> Drill along the north side of the road Water Level Final <u>5.53</u> m Top Pipe <input checked="" type="checkbox"/> Time-Date <u>Nov 20/2010</u> in the R.M. of Tok. Installation <u>2" SCH40 P.V.C. Plastic Pipe piez</u> Page <u>1</u> of <u>11</u> General <u>B-14 cable Tool rig Plan # 359103</u>		PFRA TESTHOLE LOG LOCATION SKETCH (A) Bit pressure , Revolutions per minute (B) Circulation fluid , Pump pressure, Volume % Loss (C) Drive sample weight , Drop distance , Blow count											
Time	Depths-m		Formation and Water Data			Drill Data and Remarks				Sample Data			
	(Underline sample drive)	Group	Description, Characteristics, Abnormal Conditions, Sample Type			Depth Casing Shoe m	Depth Hole Fluid m	(A) kPa (B) kPa (C) kg	rpm cm ³ /s Drop-m	% Loss Blows	Length-m	PP kPa	No.
			<u>0 - 0.15 Top soil, Black organic, stiff</u>										
			<u>0.15- 1.5 CI+wp till, Brown, stiff</u>										
			<u>Lenses & seams of oxides</u>										
			<u>1.5- 2.25 CI+wp till, Brown, stiff to very stiff, lenses of oxides</u>										
			<u>Few organic streaks</u>										
			<u>Reamed Hole out to 2.25m with 5 5/8" excavator</u>										
			<u>2.25- 4.0 CI+wp till, Brown, very stiff</u>										
			<u>Few cobbles, lenses of oxides, and a few organic streaks</u>										

A5. Field borehole description, GSC-BH-SW-04A, page 2 of 11

Project	G.S.C. Spiritwood			PFRA TESTHOLE LOG								
Site	GOSO A008											
Hole No.	C-1 cont'd			Elev.								
Location												
Drilled by				Date Started								
Logged by				Date Completed								
Water Level Final	m	Top Pipe	<input type="checkbox"/>	Time-Date								
Top Grd		Top Grd	<input type="checkbox"/>									
Installation												
Page	2 of 11											
General												
LOCATION SKETCH												
(A) Bit pressure , Revolutions per minute												
(B) Circulation fluid , Pump pressure , Volume % Loss												
(C) Drive sample weight , Drop distance , Blow count												
Time (Underline sample drive)	Depths - m	Formation and Water Data			Drill Data and Remarks					Sample Data		
		Group	Description, Characteristics, Abnormal Conditions, Sample Type	Depth Casing Shoe m	Depth Hole Fluid m	(A) kPa	rpm	(B) kPa	cm ³ /s	% Loss	Length - m	PP kPa
(C) kg	Drop - m			Blows	Drive	Rec.	Test					
		<i>Reamed hole out to 4.0 m with 5 1/2" excavator</i>										
	4.0-4.5	<i>CI+up till, gr. brown, very stiff 3 1/2" Excavator lenses + seams of oxides</i>										
	4.5-5.25	<i>CI+up till, dark gr. brown very stiff, lenses of oxides</i>										<i>Boreholes 19.75.75.3.0.2</i>
	5.25-5.6	<i>CI+up till, dark gr. brown, very stiff 3 1/2" Excavator 3.0 seams of oxides</i>										
	5.6-7.0	<i>CI+up till, grey, very stiff, lenses + seams of oxides</i>										<i>3 1/2" Excavator</i>

Project	<u>G.S.C. Spiritwood</u>			PFRA TESTHOLE LOG								
Site	<u>G050A008</u>											
Hole No.	<u>C-1 east Id</u>			Elev.	m							
Location												
Drilled by				Date Started								
Logged by				Date Completed								
Water Level Final	m	Top Pipe	<input checked="" type="checkbox"/>	Time-Date								
Top Grd												
Installation												
Page <u>3</u> of <u>11</u>												
General												
				(A) Bit pressure , Revolutions per minute								
				(B) Circulation fluid , Pump pressure, Volume % Loss								
				(C) Drive sample weight , Drop distance , Blow count								
Time	Depths - m		Formation and Water Data		Drill Data and Remarks				Sample Data			
	(Underline sample drive)	Group	Description, Characteristics, Abnormal Conditions, Sample Type		Depth Casing Shoe m	Depth Hole Fluid m	(A) kPa (B) kPa (C) kg	rpm cm ³ /s Drop - m	% Loss Blows	Length - m	PP kPa	No.
	Reamed hole out to 7.0 m with 5 5/8" Excavator											
7.0-7.5	CI-wp Tilly grey, very stiff dark 3 7/8" Excavator. seams of oxides										2.5 5.5	
7.5-8.25	CI-wp till, dark grey, Hard numerous seams + lenses of oxides (carbified joints)										Brass liner 26.75.75 > 3	
8.25-9.0	CI-wp till, dark grey, Hard as above, cobble at 9.0m.										3 7/8" Excavator	
	Reamed hole out to 9.0m, with 5 5/8" excavator											

A5. Field borehole description, GSC-BH-SW-04A, page 4 of 11

Project <u>G.S.C. Spiritwood</u> Site <u>GOSOAdd8</u>			PFRA TESTHOLE LOG										
Hole No. <u>C-1c on Pd</u>	Elev. _____ m												
Location _____													
Drilled by _____	Date Started _____												
Logged by _____	Date Completed _____												
Water Level Final _____ m	Top Pipe <input checked="" type="checkbox"/>	Top Grd <input type="checkbox"/>	Time-Date _____										
Installation _____													
Page <u>4</u> of <u>11</u>													
General _____													
LOCATION SKETCH													
(A) Bit pressure , Revolutions per minute (B) Circulation fluid, Pump pressure, Volume % Loss (C) Drive sample weight,Drop distance, Blow count													
Time (Underline sample drive)	Depths -m	Formation and Water Data			Drill Data and Remarks						Sample Data		
		Group	Description, Characteristics, Abnormal Conditions, Sample Type	Depth Casing Shoe m	Depth Hole Fluid m	(A) kPa (B) kPa (C) kg	rpm cm ³ /s Drop-m	% Loss Blows	Length -m		PP kPa	No.	
9.0-9.4	CI-cwp till, dark grey, hard shaly, numerous shale chunks and limestone pebbles & cobbles								3 7/8"	Excavator			
9.4-9.5	CI-cwp till, dark grey, hard very sandy, shale particles						3 7/8"	Excavator					
9.5-9.7	CI-cwp Till, dark grey, Hard shaly, with numerous shale chunks and limestone Pebbles						3 7/8"	excavator					
Ramed hole out to 9.7m with 5 5/8" Excavator To help drill out the cobble at 9.6mtrs													

Project <u>G.S.C. Spiritwood</u> Site <u>G050A008</u> Hole No. <u>C-1 contd</u> Elev. _____ m Location _____ Rilled by _____ Date Started _____ Drilled by _____ Date Completed _____ Water Level Final _____ m Top Pipe <input type="checkbox"/> Top Grd <input checked="" type="checkbox"/> Time-Date _____ Installation _____ Age <u>5</u> of <u>11</u> General _____			PFRA TESTHOLE LOG									
			LOCATION SKETCH (A) Bit pressure, Revolutions per minute (B) Circulation fluid, Pump pressure, Volume % Loss (C) Drive sample weight, Drop distance, Blow count									
Time	Depths - m	Formation and Water Data			Drill Data and Remarks					Sample Data		
	(Underline sample drive)	Group	Description, Characteristics, Abnormal Conditions, Sample Type	Depth Casing Shoe m	Depth Hole Fluid m	(A) kPa	rpm	(B) kPa cm ³ /s	% Loss	Length - m	PP kPa	No.
		9.7-10.5 CI - up till, dark grey hard shale, numerous limestone cobbles and shale particles					37g	" Excavator	>			
		10.5-10.8 CI - up till, dark grey, hard - 11.5 shale particles, and limestone Pebbles + cobbles					30.20	7	4			
		Bottom hit cobble at 10.8m and caused tools to bind										
		Reamed hole out to 10.8m with 5 1/2" excavator										
		11.5-12.0 CI - up till, dark grey, hard silty, with a few, damp sandy with seams, sand seam at 11.8m damp					37g	" Excavator	>			
		Reamed hole out to 11.8m with 5 1/2" excavator										

A5. Field borehole description, GSC-BH-SW-04A, page 7 of 11

Project <u>G.S.C. Spiritwood</u> Site <u>GOSO A008</u>				PFRA TESTHOLE LOG								
hole No. <u>C-1 cont'd</u>	Elev. _____ m											
Location _____												
drilled by _____	Date Started _____											
cored by _____	Date Completed _____											
Water Level Final _____ m	Top Pipe <input checked="" type="checkbox"/> Top Grd <input type="checkbox"/>	Time-Date _____										
Installation _____												
Page <u>7 of 11</u>												
General _____												
LOCATION SKETCH												
(A) Bit pressure, Revolutions per minute (B) Circulation fluid, Pump pressure, Volume % Loss (C) Drive sample weight, Drop distance, Blow count												
Time	Depths - m	Formation and Water Data			Drill Data and Remarks				Sample Data			No.
	(Underline sample drive)	Group	Description, Characteristics, Abnormal Conditions, Sample Type		Depth Casing Shoe m	Depth Hole Fluid m	(A) kPa (B) kPa (C) kg	rpm cm ³ /s Drop-m	% Loss Blows	Length - m	PP kPa	
	GP	12.5-13.4 GM fine-coarse, grey, wet								Sample Barrel	Bag - 6	
		numerous cobbles										
		water coming into hole										
Added 1.43m of casing, Total = 14.49m												
		13.4										
		(CL till gravel)										
	13.4-13.8	GC fine-coarse, grey, wet								Sample Barrel	Bag - 7	
		slightly cemented, with										
		numerous shale particles,										
		clay binder										
		13.8-14.0 S.P.S.M coarse-fine, grey								Sample Barrel	Bag - 8	
		wet, very many cobbles										
		water coming into hole										
		14.0m										

Project	<u>G.S.C. Spiritwood</u>			PFRA TESTHOLE LOG								
Site	<u>C0501008</u>											
Hole No.	<u>C-1 cont'd</u>			Elev.								
Location												
Drilled by				Date Started								
Logged by				Date Completed								
Water Level Final	<u>m</u>	Top Pipe <input checked="" type="checkbox"/>	Time-Date									
Top Grd	<input type="checkbox"/>											
Installation												
Page	<u>9</u> of <u>11</u>											
General												
Time	Depths-m	Formation and Water Data			Drill Data and Remarks					Sample Data		
	(Underline sample drive)	Group	Description, Characteristics, Abnormal Conditions, Sample Type		Depth Casing Shoe m	Depth Hole Fluid m	(A) kPa (B) kPa (C) kg	rpm cm ³ /s Drop-m	% Loss Blows	Length-m	PP kPa	No.
		Removed 1.48m of casing, Added 2.90m, total casing - 15.91										
14.8-15.0		CI - wptill, dark grey, hard 14.60m - shale particles										
15.0												
15.0-15.5		CI - wptill, dark grey, hard - 15.75m numerous shale Particles										
15.5												
15.75-16.5		CI - wptill, dark grey, Hard crumpled, shaly, with numerous shale particles										
16.5-17.0		CT - wptill, As above cobble at 17.0 meters										
		Added 1.48m of casing, Total = 17.39m										

Project <u>G.S.C. - Spintwood</u> Site <u>G0504008</u> Hole No. <u>C-1 cont'd</u> Elev. _____ m Location _____ Rilled by _____ Date Started _____ Bogged by _____ Date Completed _____ Water Level Final _____ m Top Pipe <input type="checkbox"/> Top Grd <input checked="" type="checkbox"/> Time Date _____ Installation _____ Age <u>10</u> of <u>11</u> General _____				PFRA TESTHOLE LOG LOCATION SKETCH (A) Bit pressure , Revolutions per minute (B) Circulation fluid , Pump pressure, Volume % Loss (C) Drive sample weight , Drop distance , Blow count									
me	Depths - m	Formation and Water Data			Drill Data and Remarks					Sample Data			
	(Underline sample drive)	Group	Description, Characteristics, Abnormal Conditions, Sample Type	Depth Casing Shoe m	Depth Hole m	Fluid m	(A) kPa	rpm	(B) kPa	cm ³ /s	% Loss	Length - m	PP kPa
		Slight water seepage into hole 17.0m at 17.0 meters. Put 4" chisel bit on to drill rock 17.0-17.25 Cobbles at 17 and another at 17.25m 4" chisel bit water coming into hole at 17.25 and very small amount of sand											
		Unable to drill Past 17.25m due to the cobbles at 17 and 17.25 meters. Bottom of hole static water level after 35 minutes 6.0m below ground level Pulled 4" casing back to 14.80m from ground level Backfilled hole from 17.25m to 15.1 meter with bentonite chips to seal off the bottom layer Then Poured filter sand into hole Filter sand is from 15.1-14.8m from grd. level. Then installed a 2" PVC-Plastic Pipe going into the hole Sch. 40 wall thickness											

Project <u>G.S.C. Spiritwood</u> Site <u>G050A008</u> Hole No. <u>C-1eastel</u> Elev. _____ m Location _____ Rilled by _____ Date Started _____ Bogged by _____ Date Completed _____ Water Level Final _____ m Top Pipe <input checked="" type="checkbox"/> Top Grd <input type="checkbox"/> Time-Date _____ Installation _____ Age <u>11</u> of <u>11</u> General _____			PFRA TESTHOLE LOG									
LOCATION SKETCH												
(A) Bit pressure , Revolutions per minute (B) Circulation fluid , Pump pressure , Volume % Loss (C) Drive sample weight , Drop distance , Blow count												
me	Depths - m	Formation and Water Data			Drill Data and Remarks					Sample Data		
	(Underline sample drive)	Group	Description , Characteristics , Abnormal Conditions , Sample Type	Depth Casing Shoe m	Depth Hole Fluid m	(A) kPa	rpm	(B) kPa	cm ³ /s	% Loss	Length - m	PP kPa
		Length of exposed slotted 2" pipe is 3.0 m #20 slot size Total length of just 2" Pipe is 12.60 meters Total Pipe in the hole is 15.60 meters Bottom of the slotted pipe is at 14.85 m from ground level Top of the 2" slotted pipe is at 11.85 m from ground level Top of the 2" PVC pipe is 0.75 m above ground level Pulled casing and backfilled hole with filter sand at the same time. tip of sand Pack is at 11.4 m from ground level. Pulled all 4" casing out of hole and backfilled hole to 3.0 m from ground level with bentonite chips (5-50/16 bags of Holes Plug). end of Day										
		Nov. 20/2010 complete Pig installation Backfilled hole with clay cuttings to 0.8 m below ground level (1.5m x 15 x 15) Put a 5x6" x 6" Protective steel Pipe over the 2" PVC Plastic Pipe Pipe is marked and capped. end of Hole										

Project Geological Survey Of Canada Spiritwood				PFRA TESTHOLE LOG								
Site GOSO A008												
Hole No.	C-2(SW04B)	Elev.										
Location	NW21-2-15-W2 Drilled 1.8m west of hole C-1	m			drilled in north ditch of the east-west road							
Drilled by	R.D	Date Started			Nov 20/2010							
Logged by	D.C.	Date Completed			Nov 20/2010							
Water Level Final	Day	m	Top Pipe	<input type="checkbox"/>	Time-Date	Nov 20/2010						
Top Grd			Top Grd	<input checked="" type="checkbox"/>								
Installation	2" sch 40 P.V.C Plastic Pipe piez.											
Page	1	of	3	LOCATION SKETCH								
General	B-14 cable tool rig Plan #359104			(A) Bit pressure , Revolutions per minute								
				(B) Circulation fluid , Pump pressure, Volume % Loss								
				(C) Drive sample weight , Drop distance , Blow count								
Time	Depths - m	Formation and Water Data			Drill Data and Remarks					Sample Data		
	(Underline sample drive)	Group	Description, Characteristics, Abnormal Conditions, Sample Type			Depth Casing Shoe m	Depth Hole Fluid m	(A) kPa (B) kPa (C) kg	RPM cm ³ /s Drop - m	% Loss Blows	Length - m	PP kPa
	0 - 0.15	Topsoil, Black, organic, stiff						3 $\frac{1}{2}$ " Excavator				
	0.15 - 1.5	CT up till, Brown, firm - stiff lenses of oxidized organic streaks						" "	" "		1.25	
	1.5 - 3.0	Reamed hole out to 1.5m with 5 $\frac{1}{2}$ " Excavator CT up till, Brown, stiff to very stiff, lenses of oxidized few organic streaks						3 $\frac{1}{2}$ " Excavator				
	3.0 - 4.7	Reamed hole out to 3.0m with 5 $\frac{1}{2}$ " Excavator CT up Till, Brown, very stiff, lenses speak's of oxidized						3 $\frac{1}{2}$ " Excavator				

A6. Field borehole description, GSC-BH-SW-04B, page 2 of 3

Project	G.S.C. Spiritwood			PFRA TESTHOLE LOG								
Site	60501008											
Hole No.	C-2 cont'd			Elev.								
Location												
Filled by				Date Started								
Bogged by				Date Completed								
Water Level Final	m	Top Pipe	<input checked="" type="checkbox"/>	Time-Date								
Top Grd	m	Top Grd	<input type="checkbox"/>									
Installation												
Age	2	of	3									
General												
LOCATION SKETCH												
(A) Bit pressure , Revolutions per minute (B) Circulation fluid, Pump pressure, Volume % Loss (C) Drive sample weight, Drop distance, Blow count												
Line No.	Depths - m (Underline sample drive)	Formation and Water Data			Drill Data and Remarks					Sample Data		
		Group	Description, Characteristics, Abnormal Conditions, Sample Type	Depth Casing Shoe m	Depth Hole Fluid m	(A) kPa	rpm	(B) kPa	cm ³ /s	% Loss	Length - m	PP kPa
	4.7 - 5.70	CI+wp till, dark gray brown very stiff, lenses of oxides										
	5.7 - 6.0	CI+wp till, brownish gray to grey, very stiff numerous seams of oxides										
		Rammed hole out to 4.5 m with 5 5/8" Excavator										
	6.9 - 7.5	CI+wp till, gray, Hard with seams of oxides a few cobbles										
		Bottom of Hole, Install a 2" PVC Plastic Pipe pigtail hole with a sch 40 wall thickness										

A6. Field borehole description, GSC-BH-SW-04B, page 3 of 3

Project <u>GSC - Spiritwood</u> Site <u>GOSO A008</u>			PFRA TESTHOLE LOG									
Hole No. <u>C-2eonPd</u>	Elev. _____ m											
Location _____												
Drilled by _____	Date Started _____											
Logged by _____	Date Completed _____											
Water Level Final _____ m	Top Pipe <input checked="" type="checkbox"/> Time-Date _____											
Top Grd <input checked="" type="checkbox"/>												
Installation _____												
Page <u>3</u> of <u>3</u>												
General _____												
Time (Underline sample drive)	Depth-m m	Formation and Water Data			Drill Data and Remarks				Sample Data			No.
		Group	Description, Characteristics, Abnormal Conditions, Sample Type	Depth Casing Shoe m	Depth Hole Fluid m	(A) kPa (B) kPa (C) kg	rpm cm ³ /s Drop - m	% Loss Blows	Length - m Drive	PP kPa Rec.	Test	
		<p>Length of 2" slotted pipe is 2.99 m. with #20 slot size</p> <p>Length of just 2" PVC pipe is 5.26 meters</p> <p>Total 2" Pipe in hole is 8.25 meters</p> <p>Bottom of the slotted pipe is at 7.5 m. below ground level</p> <p>Top of the slotted pipe is at 4.5 m. below ground level</p> <p>Then packed Filter sand down hole to form a sand pack around the 2" Pipe. The top of sand pack is at 4.0 m from ground level. Then backfilled the hole with bentonite chips to 2.30 m from ground level.</p> <p>Back filled the remainder of the hole with clay cuttings to 0.80 m from ground level.</p> <p>(1.5m+1.5m=3.0m)</p> <p>Put a 5x6"x6" Protective steel Pipe over the 2" PVC Pipe. Pipe is marked and capped.</p> <p>At this time the water level pipe is dry 0.75 above grd</p> <p>END OF Hole</p>										

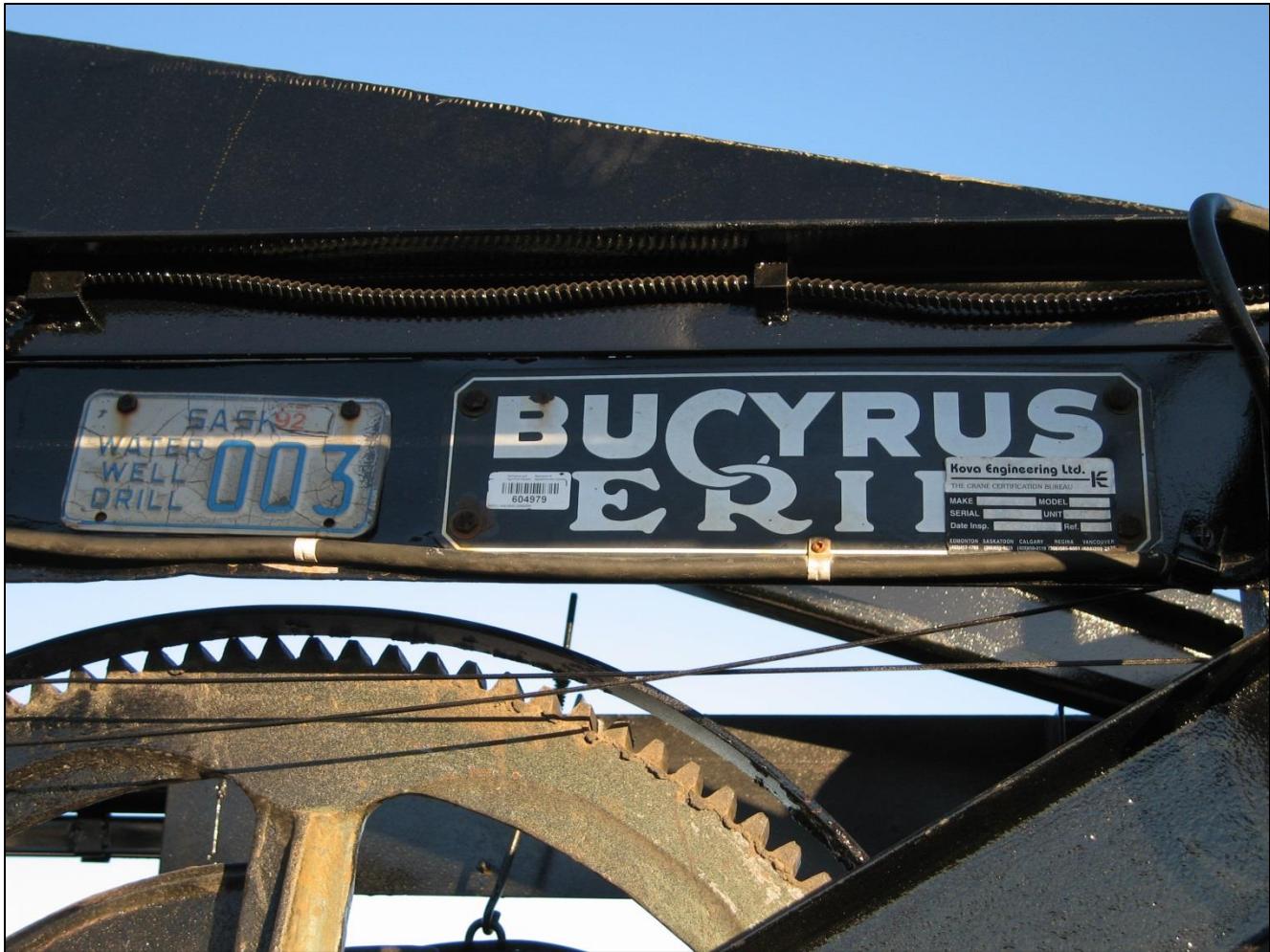
Appendix B: Additional photographs.



Photograph B1. AAFC B-12 drill rig setup with crew.



Photograph B2. AAFC B-12 drill rig at site G05OA010/GSC-BH-SW-02, November 2010, facing east.



Photograph B3. AAFC B-12 drill rig name plate.



Photograph B4. Site G05OA010/GSC-BH-SW-02, October 2011, facing east.



Photograph B5. Site G05OA009/GSC-BH-SW-03, October 2012, facing north.



Photograph B6. Site G05OA009/GSC-BH-SW-03, October 2012, facing east with loading station well in the distance.