# APPENDIX A

# NSE TERMS OF REFERENCE FOR FOCUS REPORT

# TERMS OF REFERENCE

# FOR THE PREPARATION OF A

# FOCUS REPORT

**CGC Inc.- Fundy Gypsum**

**Miller’s Creek Mine Extension**
**Miller’s Creek, Hants County, Nova Scotia**

**NOVA SCOTIA ENVIRONMENT**

April 11, 2008

## Introduction

The Miller's Creek Mine Extension Project, proposed by CGC Inc. - Fundy Gypsum (the Proponent), was registered for environmental assessment (EA) as a Class 1 Undertaking pursuant to Part IV of the Environment Act on February 21, 2008.

On March 17, 2008, following a review of information submitted by the Proponent, government agencies and the public, the Minister of Nova Scotia Environment and Labour decided that, to better understand the potential for adverse effects or significant environmental effects, a focus report is required. In accordance with section 13(1)(c) of the EA Regulations, the Minister directed the Proponent to provide a Focus Report to examine potential impacts of the proposed Miller's Creek Mine Extension on surface water; groundwater; species-at-risk; wetlands; and, fish and fish habitat.

The Proponent is required to submit the Focus Report within one year of receipt of this Terms of Reference. Upon submission of the Focus Report by the Proponent, NS Environment (NSE) has 12 days to publish a notice in the newspaper, advising the public where the Focus Report can be accessed for review and comment. A 30 day public review period of the Focus Report follows.

At the conclusion of the 30 day public review, NSE has 25 days to review public, government comments, and provide a Report and Recommendations to the Minister.

The Minister of Environment will have the following decision options, following the review of the focus report:
(S. 18) (a) i. the undertaking is approved subject to specified terms and conditions and any other approvals required by statute or regulation;
ii. an environmental-assessment report is required; or
iii. the undertaking is rejected.

The following requirements are presented to the Proponent for response in the form of a Focus Report.

## 1.0 PROJECT DESCRIPTION

Provide a description of the Miller's Creek Mine Extension Project including the following:

- the project location;
- the project boundaries clearly delineated on a map;
- air photos and satellite imagery of the proposed project in relation to the existing Miller Creek mine; and
- any assumptions which underlie the details of the project design, including impact avoidance opportunities.

## 2.0 OTHER METHODS FOR CARRYING OUT THE UNDERTAKING

Describe other methods/alternatives for carrying out the undertaking, including alternative mine layouts. Provide plans and maps showing alternative mine layouts that have been considered.

## 3.0 ADDITIONAL INFORMATION

### 3.1 Groundwater

Provide the following information:

- the approximate locations of off-site wells within 3 km of the proposed pit;
- identify the number of wells located within various radial distances of the proposed pit (e.g., radii of 500 m, 1,000m, 1,500 m, etc.);
- provide a cross-section of the proposed pit showing the existing water table and predicted water table after pit development;

Construct a numerical groundwater model for the proposed pit and surrounding area. Calibrate the model based on existing conditions and discuss how closely the model reproduces the groundwater drawdown at the existing pit. Use the calibrated model to predict potential impacts to groundwater, as discussed in further detail below. The modelling effort must be documented using industry standards (e.g., ASTM, Anderson and Woessner, 1992), which shall include, but not be limited to, a description of the conceptual model, grid design, boundary conditions, model input data and calibration results. The digital model files shall be submitted to NSE with the modelling documentation.

Using the above referenced groundwater model, provide quantitative estimates of the potential groundwater impacts, including but not limited to:

- the predicted groundwater flow rate to the proposed pit;
- the predicted extent of the groundwater cone of depression caused by the proposed pit dewatering operations. The predicted cone of depression shall be presented on a figure, which will include the predicted 1 m drawdown contour;
- identify the number and location of water wells lying within the predicted cone of depression;
- predict the extent of potential salt water intrusion effects and identify which drilled wells may be potentially affected by salt water intrusion;
- predict the amount of baseflow reduction at nearby surface water courses and wetlands (expressed as percent reduction in baseflow).
- predict the amount of drawdown in any proposed “conservation areas” and determine what effect the drawdown may have on habitats in these areas; and
- predict the time it will take for groundwater levels to rebound to pre-pit conditions once dewatering has stopped (i.e., how long will it take to fill the pit with water after mining is complete?).

Provide information on mitigative measures that could be implemented to prevent water well problems at off-site water wells. Note that the modification or replacement of impacted wells, or the provision of alternative water supplies, should be viewed as measures of last resort.

### 3.2 Surface Water

The principle of avoidance of watercourses and wetlands has been acknowledged but does not seem to have been applied. The headwaters of 6 watercourses and 12 wetlands are planned to be within the proposed mine footprint. Provide options for mine development such that water resources will be avoided and protected with vegetated buffers.

Provide information to support predictions and the extent of surface water impacts from this proposed project, and overall conclusions. Also provide proposed monitoring plans to confirm surface water predictions.

Of the 19 watercourses identified in the project area Shaw Brook appears to be the most significant in terms of having continuous annual flows, higher flow rates, and identified water use (agricultural) in the lower reaches. It is also shown in the report to be the watercourse with the greatest percentage of the watershed disturbed by the proposed mine footprint (about 53%), and 1 of 5 streams having headwaters located directly in the footprint. Provide detailed and well defined protection plans as well as monitoring plans to ensure the continued use of this water resource.

Depict items mentioned in text of the EA registration document on maps These items should include:
- the pond in Highfield (page 62) which fire dept uses as a water supply,
- Alison Pond location (page.63),
- Bailey’s Quarry location.

Assess the potential for impacts from the proposed project on the ponds and demonstrate how they will be protected.

Provide maps showing property boundaries in relation to the project to enable the selection of monitoring stations and for the assessment of potential down stream effects from the proposed project.

Provide specifics of methods and protocols used in sampling/measuring surface water for quality and quantity, including outlining QA/QC methods and sample preservation measures. Provide this information to allow an assessment of the quality of the data collected.

Provide an assessment and supporting rationale regarding cumulative effects to the multiple streams and wetlands within the project area resulting from the proposed project and related to effects (over time or space) from multiple undertakings or activities in the area that could impact water resources.

Baseline stream flow monitoring frequency may not be sufficient to capture seasonal variations including peak flows and low flows. Text in the EA registration document indicates monitoring on a monthly basis (page 81) while Table B1, Appendix B indicates a frequency of 7 times per year between Dec 2005 and Dec 2006. This data indicates the highest flows on the June sampling date, which is not the time of year when peak flows are normally expected. Since pre- and post- development comparisons would be based on such baseline data, more frequent, reliable data must be provided. This applies to baseline water quality data as well, where baseline conditions must be better defined.

Interpretation of baseline ambient water quality in streams must use appropriate CCME water quality guidelines as opposed to effluent limits established under pit and quarry guidelines for settling pond discharges ( eg. TSS limits proposed) and include suitable graphed and tabulated data.

Provide details of follow-up monitoring plans for water quality and quantity to confirm EA predictions and for assessing the need for improved mitigation measures.

Groundwater / surface water interaction is noted in the EA registration document as an important consideration in assessing mining projects. This would seem particularly important in the context of karst topography. Provide an assessment with supporting rationale as to how long it would take for the series of lakes proposed in reclamation plans to be filled with water and be capable of producing the water supply to down-stream users as proposed. The suggested time line to achieve full reclamation (up to 50 years) would suggest that controlled release of stormwater would be ongoing for an extended period prior to final reclamation and the existence of the proposed lakes.

Provide details of a stormwater management plan which would support the contention that a “ continued water supply to the downstream reaches of impacted catchments” could be ensured (page 88, Summary in the EA Registration Document). Provide this information to confirm that this supply could be ensured over the long-term with water use(s) protected.

Stormwater management structures eg. settling ponds are proposed to be designed to “typical design standards” . Provide information regarding their design and operation to demonstrate that both increased peak and reduced minimum flows due to climate change will be addressed.

Relevant existing approvals are typically provided in EA registration documents for reference.

Provide a map showing final project development complete with structures e.g. settling ponds, drainage patterns, watercourses, wetlands, and proposed monitoring stations.

Provide contingency plans to address possible spills and accidental upsets to ensure protection of water resources.

### 3.3 Species-at-risk

The diversity of species-at-risk and those of conservation concern (including vascular plants and lichens) within the area proposed for development by CGC-Fundy Gypsum is especially rich, as identified by the extensive surveys completed by the Proponent. One Endangered plant listed under the Nova Scotia *Endangered Species Act* (Ram's-head Lady Slipper), and six others listed under the Nova Scotia General Status of Wild Species including two RED listed species (Round Leaved Hepatica and Eastern Leatherwood) and four YELLOW listed species(Canada Buffalo-Berry, Thimbleweed, Yellow Lady Slipper and Black Ash) all occur within the proposed development footprint. Six species of rare lichens are also found within the proposed development area. At least three species of vascular plants not currently listed under the *Endangered Species Act* are strong candidates for legal listing and either have formal status assessments already underway (e.g. Black Ash) or impending (e.g. Round-leaved Hepatica).

A conservation area is proposed by the Proponent that includes setting aside approximately 40 ha of mineable land which is host to an important assemblage of provincially and locally important plant species**.** No evidence is provided, however, to show how the ecological integrity of the conservation area will be maintained. In addition, species-at-risk would be lost with the current layout of extraction areas. A plan that illustrates a clear mechanism for protection must be provided.

Provide a map showing the location of species-at-risk, wetlands/watercourses, and the proposed conservation area relative to the mine footprint layout.

Provide an assessment of the ecological significance of the Proponent's lands on the Avon Peninsula, within the provincial context.

Provide the results of additional study to determine the required extent of the conservation area in order to protect species-at-risk and their habitat. The size of the conservation area shall be formally agreed upon with NSE and DNR, Wildlife Division.

Specifically, provide information on plans for (1) species-at-risk/habitat conservation with long-term requirements for evidence based scientific research and monitoring, (2) operations management, and (3) reclamation to ensure significant habitats and species-at-risk (including RED and YELLOW listed species) are protected in perpetuity. The geographic focus of all three planning documents should be the eastern region of the proposed development area including wetland #12 and all company lands to the east.

(1) The species-at-risk habitat/conservation planning shall contain detailed description(s) of the physical environment where rare organisms are located including a study design that incorporates an array of test wells for long-term hydrological monitoring. Habitat/conservation planning should be defined on a ten-year time line with standardized annual counts/surveys of individual plants/lichens. Close collaboration with established botanists from universities is recommended to clearly define limitations of the current knowledge surrounding the resilience, population ecology and life history of rare vascular plants and lichens in the plan.

In addition, investigate the potential for private land conservation by consulting with local landowners to determine if the conservation area can be expanded to include neighboring properties.

(2) Operations management planning should provide a clear, concise, phased schedule of proposed extraction activities on the company lands surrounding those lands where rare species, or those at risk are found. Proposed extraction time lines need clear geographic reference in space and time with maps to clarify an acceptable approach that will enable completion of scientific research requirements identified and contained in habitat/conservation planning.

(3) Reclamation planning must address knowledge deficiencies and uncertainties surrounding proposed practices to buffer impacts on species-at-risk and their habitats. Specifically, address appropriate distance/widths (amount of undisturbed habitat) and necessary reparation(s) to maintain effective, functional habitat and the time phase in the project’s operational development. Reclamation planning should provide details and an experimental framework to evaluate effectiveness of reclamation practices to repatriate native vegetation.

### 3.4 Wetlands

All alterations to wetlands are significant, and proponents must apply the mitigative sequence to activities which may impact wetlands. The first step in this sequence is avoidance of wetlands, followed by minimization of unavoidable impacts, and then compensation.

The Proponent has identified 16 wetlands within the project area, and 12 will be fully or partially lost with mining. Impacts to wetlands 10 and 12 can be avoided with slight changes to the southern boundary of the pit. Several wetlands (2, 3, 4, 15, 16) will be lost or impacted by the placement of the stockpiles on the east side of the project area. These impacts can be avoided if the footprints of the stockpiles are reduced, such as by moving overburden west across Ferry Road to the Bailey Quarry, which will be undergoing reclamation. An analysis of wetland avoidance options is particularly relevant for the largest wetland (#1). Alterations made to the pit location to avoid impacts to endangered species or species of conservation concern are not sufficient justification to alter a wetland, as species *and* their habitats are both of importance.

Given the proximity of more than 40 endangered Ram's-Head Lady Slipper plants to wetland #12, and the high potential for adverse effects resulting from changes to topography, vegetation and hydrology, DNR recommends that wetland #12 be fully captured within the conservation area and additional modelling using on-site data be undertaken to assess mitigation options to ensure plant survival.

Undertake a quantitative assessment of the proposed project's impacts to surface and groundwater inputs to streams and wetlands, identify mitigative options to maintain natural annual and interannual hydroperiods for streams and wetlands, and provide monitoring protocols to assess the efficacy of the mitigative options in a manner acceptable to NSE and DNR.

Apply the mitigative sequence for wetland conservation to each wetland identified within the project area.

Provide a thorough analysis of avoidance options and associated impacts to ecosystems and project viability for review and acceptance by NSE and DNR.

### 3.5 Fish and Fish Habitat

The following information shall be collected and presented in a manner that is acceptable to Fisheries and Oceans Canada and NSE:

All streams that may be affected by the project must be assessed, at multiple points, for fish and fish habitat by qualified aquatic scientists. Ponds that may be affected must also be assessed;

Assessment of aquatic habitat must include identification of physical units (ie, riffles, pools, and runs), in-stream cover, substrate composition, stream depth and width, overhead cover and water colouration;

The presence of fish of each stream must be noted;

Provide a map showing assessment points and GPS coordinates.

### 3.6 Reclamation Plan

Provide a detailed site reclamation plan, as this will significantly influence long term survival and function of species and systems in this unusual habitat type (refer to 3.3 Species-at-risk, (3) Reclamation planning).

## 4.0 FOCUS REPORT SUMMARY AND CONCLUSIONS

This section of the Focus Report shall summarize the overall findings and conclusions of the study.

# APPENDIX B GROUNDWATER

## (B.1) CONCEPTUAL SITE MODEL REPORT
## (B.2) GROUNDWATER MODELING REPORT

# (B.1) CONCEPTUAL SITE MODEL REPORT

## TABLE OF CONTENTS

Page

## LIST OF FIGURES
(Following Text)

## LIST OF TABLES
(Following Text)

## LIST OF APPENDIX
(Following Text)

# 1.0 INTRODUCTION

## 1.1 BACKGROUND AND PURPOSE

CGC Inc.-Windsor Plant is seeking to secure the required approvals for the operation and reclamation of a surface gypsum mine at Miller Creek on the Avondale Peninsula area of Hants County, Nova Scotia (Figure B1.2-1 depicts the general site location). The site is known as the Miller's Creek Mine Extension area (Mine Extension). Environmental baseline work was completed at the site between Spring 2005 and Fall 2007 and this data was used to develop an Environmental Assessment Registration Document (EARD) that was submitted to the Province of Nova Scotia for Environmental Assessment (EA) review. The Province determined that additional information was required and therefore issued a Terms of Reference (TOR) for a Focus Report in April 2008. CGC undertook to gather the required additional information and complete the assessment of this information. The TOR (contained in Appendix A of the Focus Report) identified several groundwater related items to be completed. This Conceptual Site Model (CSM) Report contains information that helps to satisfy the TOR for the Focus Report. The CSM Report has been prepared as well to provide a single source for the hydrogeological and geological information used in the development of the Numeric Model for the Site.

## 1.2 REPORT ORGANIZATION

This report is organized in 3 sections. Section 1.0 provides an overview of the Mine Extension and purpose of the report. Section 2.0 provides a description of the investigative activities completed prior to and as part of the data collection phase of the Miller's Creek Mine Extension Project. Section 3.0 describes the geology and hydrogeology of the Avondale Peninsula and specifically in the area of the Mine Extension.

# 2.0 INVESTIGATIVE ACTIVITIES

## 2.1 INTRODUCTION

Data collection activities were as follows:

- water well record compilation;
- monitoring well installation;
- piezometer and surface water station installations;
- step drawdown pumping tests; and
- single well response tests.

## 2.2 WATER WELL RECORD COMPILATION

The objective of water well record data compilation was to define the site geology and hydrogeology for model input. Nova Scotia Environment's *NS Well Log Database: 2008 Edition* was used to compile water well records for the Avondale Peninsula. Well records obtained from the database were matched to their respective civic addresses and to unique CRA identifiers. A total of 40 logs obtained from the Nova Scotia Well Log Database were matched to civic addresses in the survey area. Water level, fracture, and/or geological details were obtained from the logs wherever present. Additional well or water level data for 89 wells were obtained from domestic well surveys conducted for CGC Windsor by Jacques Whitford Environment Ltd. (JWEL) and CRA in 1992 and 2006/07, respectively.

Once the preliminary hydrogeological model was constructed, CRA conducted additional domestic well surveys to gather additional bedrock well information and address some issues related to variable water level elevations. In March and April 2009, CRA collected GPS coordinates at 28 water wells located in the project area. Water level measurements were recorded whenever possible. The number of wells surveyed in 2009 was governed by the consent and availability of the property owners.

Domestic water well data collected are included in Table B1.2-1. There are multiple entries for some wells that reflect the data collected from various information sources, namely the *NS Well Log Database: 2008* and the three domestic well surveys. The domestic well records that were retained for model input are highlighted. Well locations are depicted with their CRA IDs on Figure B1.2-1.

## 2.3 MONITORING WELL INSTALLATION

The locations of monitoring wells installed in the vicinity of the proposed mine extension are shown on Figure B1.2-2. Table B1.2-2 provides a summary of the monitoring well completion details. Stratigraphic logs for these wells are provided in Appendix A.

Logan Drilling Inc (Logan Drilling) of Stewiacke N.S. installed monitoring wells at five locations around the perimeter of the proposed mine extension in 2006 on behalf of CGC. At each location, two monitoring wells were nested in a pair with one well completed in the overburden and one well completed in the bedrock.

The initial stage of the mine extension is planned immediately west of the existing mine in the vicinity of MW-5. Logan Drilling installed test extraction wells MW-6 and MW-7 at the locations shown on Figure B1.2-2 in March and April 2009. These test extraction wells were installed in order to determine aquifer characteristics in the area of the initial extension. Both wells were drilled to a total depth of approximately 54 metres below ground surface (m bgs), which corresponds roughly to the final depth of the proposed mine extension. MW-6 and MW-7 were completed as open hole bedrock wells.

Monitoring wells OB-1, OB-2 and OB-3 were installed adjacent to monitoring well MW-6 in April 2009. OB-1 was completed in the overburden. OB-2 and OB-3 are completed in the shallow and intermediate bedrock, respectively. CRA observed fractures in the core recovered from MW-6 and designed OB-1 and OB-3 to monitor any groundwater in these fracture zones.

MW-6 and MW-7 were developed by a combination of overpumping and backwashing for approximately 3 hours each.

## 2.4 PIEZOMETER AND SURFACE WATER MONITORING STATIONS

As part of the data collection specifically for the Focus Report, a series of piezometers and surface water monitoring stations were installed within and around the proposed project site. The purpose of these installations was to assess the effect of a 72-hour pumping test on shallow groundwater aquifers, springs, and surface water bodies.

Monitoring stations were selected by reviewing project area maps and conducting site reconnaissance visits. From late February to early April 2009, a total of eight surface water monitoring stations and eleven piezometers were installed on the project site. Pressure transducers were installed at every location to record water levels and monitor temperature. At most monitoring stations, three transducers were installed: one in the streambed, one in the bank, and one in the stream itself. A description of all the equipment installed is included in Table B1.2-2. Monitoring locations are depicted in Figure B1.2-2. Barometric loggers were also installed on-site to facilitate barometric compensation of the water level logger data.

A 72-hour pumping test was not conducted at the site since the yield observed during the step-drawdown pumping test was minimal. Therefore, the piezometers and surface water monitoring stations could not be used to simulate the effect of mine dewatering on shallow groundwater aquifers, springs, and surface water bodies. The instrumentation installed does however provide valuable information in regards to seasonal variations in water table and surface water levels.

In addition to transducer data, periodic manual water level measurements were taken at the various monitoring stations. The average water level at each monitoring station was used in the hydrogeological model. These data are included in Table B1.2-3.

## 2.5 STEP-DRAWDOWN PUMPING TEST

Step drawdown pumping tests were completed at test extraction wells MW-6 and MW-7 following completion of well development. The purpose of the step drawdown pumping tests was to determine the sustainable well yield of each test extraction well.

Logan Drilling and CRA completed a step drawdown pumping test at MW-6 on April 28, 2009. The test consisted of pumping MW-6 at rates of 2 and 3 Igpm (Imperial gallons per minute) in three successive stages. The 2 Igpm step lasted one hour but the water level in MW-6 dropped to the pump intake (46 m btoc) in approximately 15 minutes during the 3 Igpm step. The pump was then shut off and the water level in the well was allowed to recover. Water levels were also measured at nearby monitoring wells OB-1, OB-2 and OB-3 during the drawdown and recovery phases of the MW-6 step drawdown pumping test.

The step drawdown pumping test at MW-7 was completed on April 29, 2009 at rates of 2, 3, and 4 Igpm in three successive stages. The 2 Igpm and 3 Igpm steps lasted one hour, however, the water level in MW-7 dropped to the pump intake (46 m btoc) approximately 10 minutes after the start of the 4 gpm test. The pump was then shut off and the water level in the well was allowed to recover. Water levels were also measured at nearby monitoring wells MW-5S and MW-5D during the drawdown and recovery phases of the MW-7 step drawdown pumping test.

CRA performed step tests at bedrock well MW-6 and MW-7 on April 28, 2009 and April 29, 2009, respectively. The results of the step test at MW-6 are summarized in Figure B1.2-3, which illustrates that this well could not sustain a pumping rate of 2 gallons per minute (gpm). Figure B1.2-4 presents the results of the step test at MW-7, which shows that a pumping rate of 4 gpm could not be sustained, while pumping at rates of 2 to 3 gpm also resulted in continuing drawdown in MW-7.

During these step tests continuous monitoring data was also recorded at nearby monitoring wells OB-1, OB-2 and OB-3, which have well screen bottom elevations of 35.6, 25.1 and 18.9 meters above mean sea level (m AMSL). These are significantly shallower than the test wells MW-6 and MW-7, which have screen bottom elevations of -9 and -16.2 m AMSL, respectively. The recorded groundwater levels at these observation locations during and after the step tests are presented in Figure B1.2-5. Monitoring well OB-1 showed little response to either the MW-6 or the MW-7 step test and similarly little response was observed at monitoring wells OB-2 and OB-3 during the MW-7 step test. However, drawdown was observed at monitoring wells OB-2 and OB-3 both during and after the MW-6 step test. The MW-6 step test indicates that the upper portion of the bedrock in the area of OB-2 and OB-3 is hydraulically connected with the deeper bedrock zone in the MW-6 area. The ongoing drawdown that was observed at these locations after the MW-6 step test was completed could be the result of drainage via fractures between the upper bedrock zone and the lower bedrock zone, which continued until equilibrium (full recovery) was achieved

## 2.6 SINGLE WELL RESPONSE TESTS

CRA completed single well response tests at all of the monitoring wells and piezometers in April and May 2009. The results of the single well response tests provide an estimate of hydraulic conductivity in the immediate vicinity of the well being tested.

Typically the single well response tests were completed by first measuring the static water level in the well and then inserting a "slug" of known volume into the well. The displacement of the depth to the static water level was measured and the rate of recovery was measured as the water level in the well returned to the static level. This is called a "falling head test". Once recovery was complete CRA completed "rising head tests" by removing the slug and repeating the procedure as the water level in the well rose back to the static level. In a few cases, bail down recovery tests were conducted in lieu of slug tests. No tests were completed at wells MW-1S and MW-2D as these are historically dry.

CRA used an electronic water level tape to measure the water levels in the wells during the response tests. If recovery took more than a few hours, a pressure transducer was installed in the monitoring well to record the water levels in the well. Pressure transducers were used to log recovery data for all the single well response tests conducted on piezometers installations.

Due to slow recovery in observation well OB-3, transducer data were used in the analysis to complement the manual measurements recorded during the rising head single well response test. Similarly, transducer data were used to analyze the rising head test conducted at monitoring well MW-2S, which also had very slow recovery. Transducer data were used to analyze the single well response tests conducted on the piezometers.

AQTESOLV Version 4.0 Pro was used to analyze the well response tests. Hydraulic conductivity values were generated using the Bouwer-Rice (1976) and Hvorslev (1951) solutions.

# 3.0 GEOLOGY AND HYDROGEOLOGY

## 3.1 GEOLOGY

### Overburden Geology

Regionally, there are a wide variety of unconsolidated units on the bedrock and these vary widely in size of deposit and quality. Most of the material consists of mixed silt and clay with pebbles and cobbles of basalt, granite and occasionally gypsum. However, there are well sorted sand deposits along the east branch of the Avon River where it descends from the highlands, south of the area. There are less well sorted sand and gravel deposits along the St. Croix, Herbert, and Kennetcook Rivers.

In the Mudbank and Retreat Quarries, east of Windsor and just north of Highway 14, red uniform clay beds overlie a sand layer with wood fragments overlying the gypsum. In the Bailey Quarry, near Mantua, unconsolidated sands with occasional large wood fragments and occasional kaolinite clay within the gypsum have been dated as Cretaceous by Falcon-Lang et al. (2006). This is overlain by cobble filled mud. On the west end of the Bailey Quarry, there was a river channel filled with gravel and sand that had flowed north to south and had eroded down to the gypsum before the channel was filled. A mastodon tusk was found in a fossil sink hole below 36 metres of overburden, about 350 metres to the east of this paleoriver channel.

Tidal marshlands along the upper part of the Avon River are dyked and undyked. Sediment is deposited on the marshes during the upper half of the high tide when the turbid water floods into an area. The highland areas have abundant cobbles and boulders within the unconsolidated sediments.

Unconsolidated tidal flat sediments occur along the river courses. The unconsolidated sediment consists of tidal river deposits along the flat areas along the dykes. Along the northern end of the Shaw Valley, there are small sand and gravel deposits. Fletcher (2004) identified a gravel filled channel above the limestone gypsum strata on the shore just north of Newport Landing.

Monitoring well nests were installed at seven locations around the perimeter of the mine extension. The thickness of the overburden at these locations varied from 4.4 m (MW-1) to 15.0 m (MW-2). Most of the overburden at these locations consists of clay. The clay units have various proportions of silt and sand and is described as sandy clay or silty clay, accordingly. Gravel is also occasionally present in the clay.

The overburden sequence consists entirely of clay at most locations, however, 2.4 m of silty sand overlies the clay at MW-3 and 4.7 m of silty sand and sandy silt overlies the clay at MW-4.

The unconsolidated sediment is composed of clay, silt and cobbles. The thickest deposit occurs and is 44 m thick. A map of the overburden thickness, based on the information collected during monitoring well installations and domestic well records, is provided on Figure B1.3-1.

### Bedrock Geology

In the lowlands, the youngest bedrock is the Late Carboniferous Scotch Village Formation. It occurs mainly north of the Kennetcook River and extends from the Avon River on the West to beyond the Kennetcook River on the east and North toward Walton. The sandstones are up to 300 metres thick (Moore et al. 2000). Highly folded and faulted marine sedimentary rocks lie below the Scotch Village Formation. These include the rocks of the Windsor Group. The Windsor Group in turn overlies the Horton Group sandstones and shales which were derived from the slates, hornfels, and granites of the surrounding highlands.

The bedrock below the unconsolidated surface material is shown on a Nova Scotia Department of Natural Resources Map 86-2 (Moore et al. 1986) as the Windsor Group and Canso Group. The Windsor Group consists of interbedded limestones, siltstones, anhydrite, salt and gypsum. Most of the limestones are less than 10 metres thick. The massive anhydrite at the base of the Windsor group is estimated to be 200 to 400 metres thick. The following thicknesses are based on (Moore et al. 2000): The Miller Creek Formation is approximately 72 metres thick at the type section; the Wentworth Formation above it is approximately 45 metres thick; and the Murphy Road formation above it is approximately 185 metres thick. The general trend of the strata is in an east-west to east-northeast to west-northwest direction. There are abundant folds and faults in the strata. The faults have many orientations shown on the map (Moore et al. 1986). The oldest bed identified on this map is the Fisher Limestone member of the Miller Creek Formation in the Visean Series of the Carboniferous System. The youngest strata in the area are in the Canso Group, which consists of siltstones and gypsum and by definition does not contain a marine limestone bed.

The oil well Avondale #2 located at N4987830 E5529443 NS MTM 3 ATS77 (1979), close to the Avon River, intersected at the most only 19 m of the MacDonald Road Formation (MacDonald 2003). Locally, this stratigraphic interval is referred to as the Miller Creek and Wentworth Station Formations. The oil well also intersected the salt zone of the Stewiacke Formation at 199 m bgs.

Excluding household water wells, the area has been explored and sampled with 153 diamond drilled test holes.

The footprint of the Mine Extension project is underlain by the Miller Creek Formation, the Wentworth Station Formation, the Pesaquid Lake Formation and the Murphy Road Formation. All of the siltstone, limestone and gypsum beds of the Miller Creek formation are present. From oldest to youngest, they are the Basal Siltstone with an occasional massive fossiliferous bioherm, the Union Corner Dolostone, the McCulloch Dolostone, the Fisher Siltstone, the Fisher Limestone, the Mantua Limestone, the Belmont Siltstone, the Belmont Limestone, the Chambers Siltstone capped with a dolostone, the Big Red Siltstone, a green siltstone, the Marker Bed Limestone, and the Sanford Limestone. These units are interbedded with gypsum and anhydrite. The stratigraphic thickness is approximately 72 metres and comprises approximately 70% evaporite, 13% siltstone and 17% carbonate in the type section according to Moore et al. (2000).

The Wentworth Formation in the area consists of siltstones, limestones and sulphates. The non-sulphates from oldest to youngest are the St. Croix Siltstone capped with a limestone, the Phillips Limestone, the Dimock Siltstone and Limestone, and the North 60 Limestone. According to Moore et al. (2000), the thickness of the formation is approximately 45 metres in the type section and it consists of 61% evaporite, 29% siltstone and 10% carbonate.

In the outlined proposed extraction area, the rock consists of +/- 72% evaporites, +/- 13% carbonates, and +/- 15% siltstones.

Above the described Wentworth Station Formation there are additional limestones, siltstones and minor sulphates. One of the members is a light beige oolitic limestone, which is 6 or more metres thick, and may have been referred to as the Miller Creek Oolite with a thick siltstone below it. There is also a thinner brown oolitic limestone in this stratigraphic section. All of these units probably occur within the Pesaquid Formation (Moore et al. 2000).

Other thick massive limestones and siltstones were intersected north and south of the deposit. These were not identified but belong to the Murphy Road Formation. No sodium chloride layers were found (Stewiacke Formation) but they may exist at depth in the White Quarry Formation.

The composition of the bedrock based on information obtained during the installation of monitoring wells MW1 through MW7 is as follows:

| Location | Depth Interval (m bgs) | Description (rock types(s) |
|---|---|---|
| MW1D | 14.5 – 33.3 | limestone |
| MW2D | 14.9 – 44.3 | limestone |
| MW3D | 6.3 – 34.3 | limestone |
| MW4D | 6.4 – 36.5 | limestone |
| MW5D | 8.2 – 37.6 | limestone |
| MW6 | 11.0 – 31.2 | grey and brown siltstone |
| | 31.2 – 54.0 | interbedded siltstone, limestone and gypsum |
| MW7 | 10.5 – 14.0 | brown siltstone |
| | 14.0 – 34.7 | interbedded siltstone, limestone and gypsum |
| | 34.7 – 42.0 | brown sandstone with siltstone interbeds |
| | 42.0 – 48.5 | predominately gypsum |
| | 48.5 – 53.7 | interbedded gypsum, siltstone, limestone and sandstone |

The mine extension footprint is located on an eroded anticlinorium domal structure that has its main axis east-west. In the structure, the siltstones, limestones, gypsum and anhydrite have undergone intense plastic deformation. The limestones are generally stretched and pulled apart. The thicker siltstones frequently form the fold axis of tight folds. The wave length of the antiforms is generally 200 to 400 metres apart. Although the fold axes occur in a general east-west direction, they can occur in all directions of the three dimensions.

There is faulting in the rock. It is generally identified when non-stratigraphic mudstones occur in the drill core or is known when stratigraphic intervals are missing. The more obvious faults occur near the base of the Murphy Road Formation and above the White Quarry Formation. The White Quarry

Formation was not found during CGC's core drilling programs in this area, but it is assumed that it lies at 200 to 300 metres depth. A map showing the location of folds and faults identified on the Avondale Peninsula is provided on Figure B.2.1 in the Groundwater Model Report (Appendix B.2).

Logan Drilling collected core samples of the bedrock during the installation of monitoring wells MW-6 and MW-7. CRA measured the Rock Quality Designation (RQD) of the core samples. RQD is calculated by measuring the combined length of all core pieces greater than 10 centimeters in length and converting this to a percentage of the entire core length. At MW-7 the RQD in the upper 5 m of bedrock is poor ranging from 25% to 60% but it improves with depth and RDQ increases to between 90% and 100% from approximately 20 m bgs to the end of the core hole at 54 m bgs. There is a similar trend in improved rock quality with depth at MW-6, but it is not as well defined.

Figure B1.3-2 provides the elevation of the bedrock surface based on the information collected during monitoring well installations and domestic well records. The bedrock surface is irregular and the elevation of the top of bedrock ranges form 7.9 m below MSL to 68.9 m above MSL.

## 3.2 HYDROGEOLOGY

### Overburden

Due to its high clay content the overburden on the Avondale Peninsula generally acts as a low-permeability cover for the underlying bedrock. Any groundwater in this clayey overburden probably acts as limited but persistent leaking recharge to groundwater in the bedrock aquifer.

The surficial material over the areas consists of primarily clay, silt and mud with scattered cobbles and some limited near surface sandy areas. Based on the overburden identified in drilled boreholes and the available water well records in the area, the thickness ranges from 1 to 20 m.

The depth to water in the overburden is variable and ranges from 0.2 m below top of riser at MW-5S to 4.1 m below top of riser at MW-2S. Overburden monitoring well MW-1S is dry.

Single well response test results are provided in Table B1.3-1. The single well response test results in the Site monitoring wells completed in the overburden indicate hydraulic conductivity values that range from 4.2 X $10^{-8}$ cm/s to 2.1 X $10^{-4}$ cm/s.

Most overburden wells in the area are constructed from large diameter (approximately 1 m) concrete pipes installed vertically with an excavator or back hoe. These "dug" wells in the overburden typically have a very low well yield due to the high clay content of the overburden. The "dug" water wells generally behave more as a water storage "tank" to collect/hold surface water. Some have drainage specifically designed to direct surface water towards or even directly into the well. In the summer months some wells are recharged by the owners who have bulk water delivered and placed into their wells.

### Bedrock

Groundwater generally flows from areas of high elevation to areas of low elevation in a radial pattern on the Avondale Peninsula. A map of bedrock groundwater elevation contours is provided on Figure B1.3-2 of the Groundwater Model report. Groundwater occurs primarily in bedrock, and discharges primarily to the surrounding rivers. Groundwater discharges to certain streams, such as the Shaw Brook, have been observed. Bedrock groundwater eventually flows to the rivers surrounding the Avondale Peninsula.

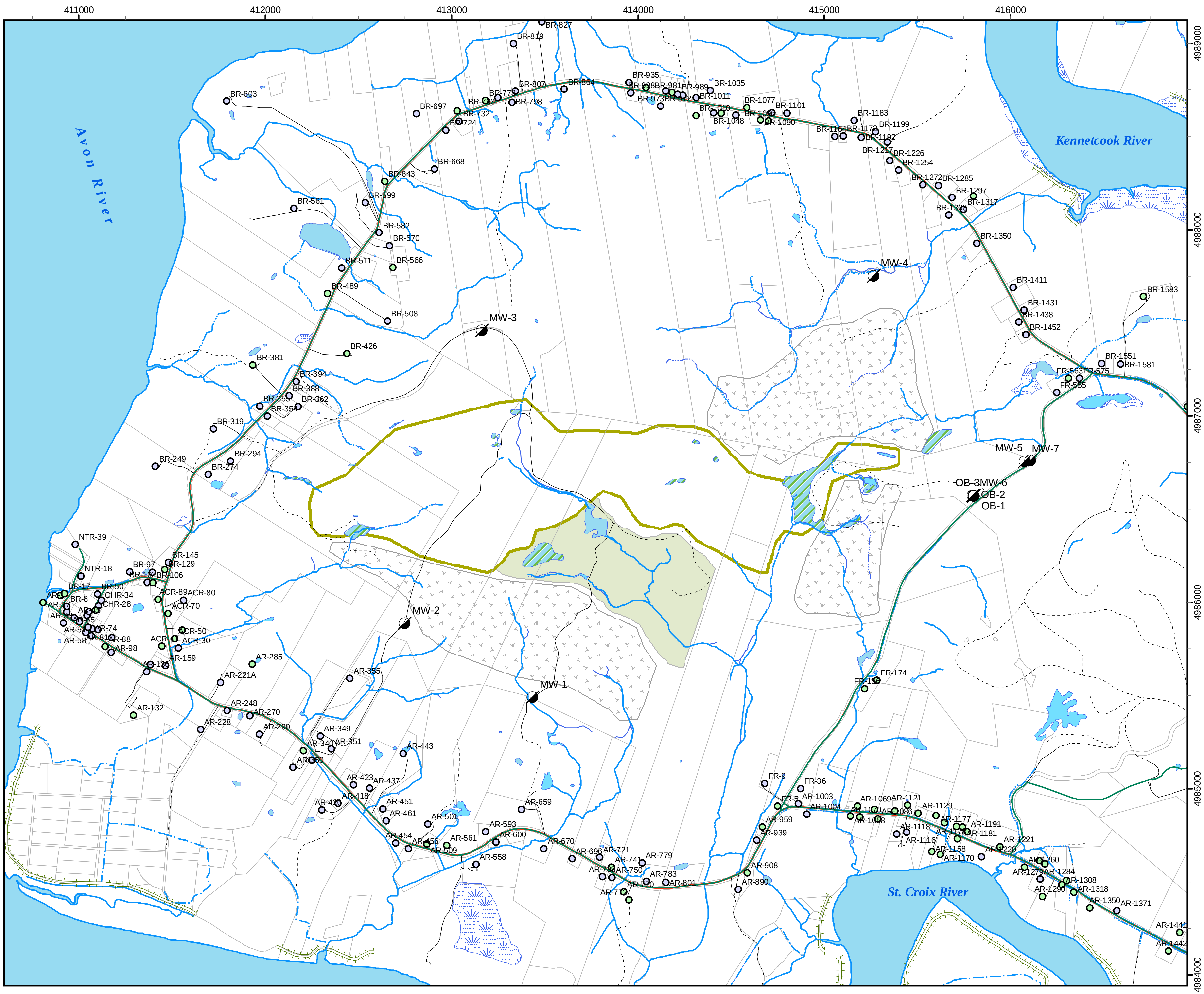
The depth to water in the bedrock is variable and ranges from artesian conditions at MW5D and MW-7 to 13.9 m below top of riser at MW-1D. Bedrock monitoring well MW-2D is dry.

The horizontal hydraulic gradient in the bedrock varies beneath the Avondale Peninsula. The steepest horizontal hydraulic gradient of 0.03 is northwest of monitoring well MW-3D. The shallowest horizontal hydraulic gradient of approximately 0.01 is present beneath the south-west portion of the Avondale Peninsula.

The vertical hydraulic gradient based on groundwater elevation measurements collected at the monitoring well pairs completed in the overburden and bedrock are provided in Table B1.3-2. The magnitude and direction of the vertical hydraulic gradient between the bedrock and the overburden is variable. For example there is a consistent upward gradient that ranges from 0.002 to 0.025 between the bedrock and the overburden at MW-4D and MW-4S. At monitoring well pair MW-3D and MW-3S the vertical gradient varies between -0.03 (downward) and 0.014 (upward).

The bedrock aquifer ranges from low hydraulic conductivity to high depending on the degree of fracture and presence of solution channels. The single well response test results in the Site monitoring wells indicate hydraulic conductivity values that range from $2.5 \times 10^{-6}$ cm/s to $1.3 \times 10^{-4}$ cm/s with a geometric mean of $2.9 \times 10^{-5}$ cm/s. The RQD measurements at MW-6 and MW-7 indicate the bedrock is not highly fractured at these locations and are consistent with the low well yield at these wells.

The observed horizontal hydraulic gradients are generally consistent with the relatively low hydraulic conductivity values discussed above. All other things being equal, the horizontal hydraulic gradient is inversely proportional to the hydraulic conductivity. This infers that there is a higher hydraulic conductivity in the southwest portion of the Avondale Peninsula, where the horizontal hydraulic gradient is lowest. The available reported well yields in the bedrock water wells along Avondale Road were relatively high ranging from 5 Igpm to 20 Igpm. Comparatively lower well yields are reported in the domestic bedrock wells north of this area. For example, step-pumping tests at MW-6 and MW-7, demonstrated a very low yield of less than 2 imperial gallons per minute (Igpm).



**LEGEND:**

Monitoring wells

**Approximate Well Locations**

○ Well Record or Domestic Survey

● No Well Record

Roads

Property

Proposed Extraction Area

Proposed Stockpiles

Proposed Conservation Area

**SOURCE:**

Nova Scotia Topographic Database
Civic Adddress Database
SNS&MR - NS Geomatics Centre

0 100 200 400 600 800
Metres

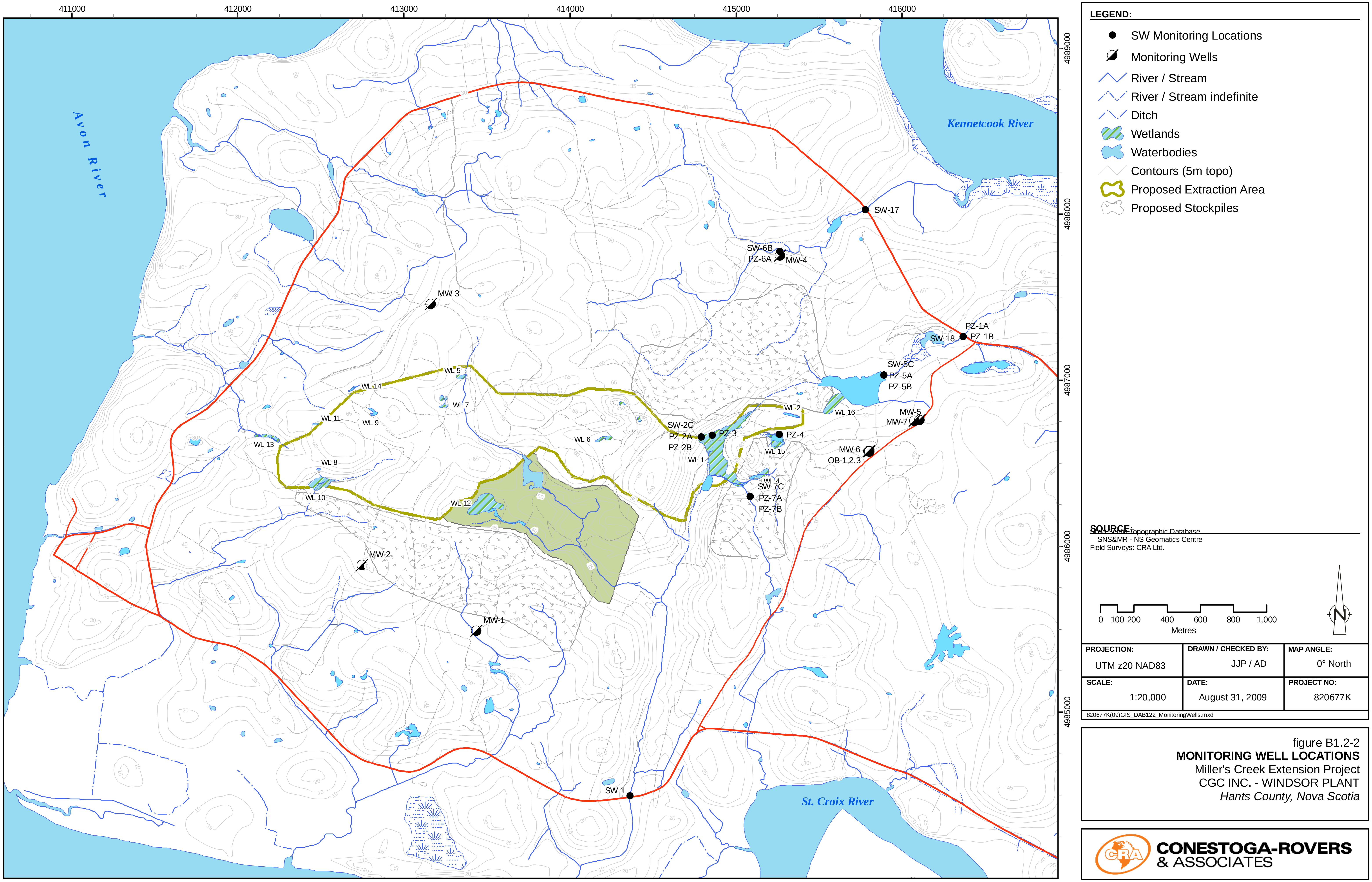
N

| PROJECTION: | DRAWN / CHECKED BY: | MAP ANGLE: |
|---|---|---|
| UTM z20 NAD83 | JJP / | 0° North |
| SCALE: | DATE: | PROJECT NO: |
| 1:20,000 | August 31, 2009 | 820677K |

820677K(09)GIS_DAB121_DomesticWells.mxd

figure B1.2-1
**DOMESTIC WELL LOCATIONS**
Miller's Creek Extension Project
CGC INC.- WINDSOR PLANT
*Hants County, Nova Scotia*

**CONESTOGA-ROVERS & ASSOCIATES**



SOURCE:
Nova Scotia Topographic Database
SNS&MR - NS Geomatics Centre
Field Surveys: CRA Ltd.

| PROJECTION: | DRAWN / CHECKED BY: | MAP ANGLE: |
|---|---|---|
| UTM z20 NAD83 | JJP / AD | 0° North |
| **SCALE:** | **DATE:** | **PROJECT NO:** |
| 1:20,000 | August 31, 2009 | 820677K |

820677K(09)GIS_DAB122_MonitoringWells.mxd

figure B1.2-2

**MONITORING WELL LOCATIONS**

Miller's Creek Extension Project
CGC INC. - WINDSOR PLANT
*Hants County, Nova Scotia*

**CONESTOGA-ROVERS & ASSOCIATES**

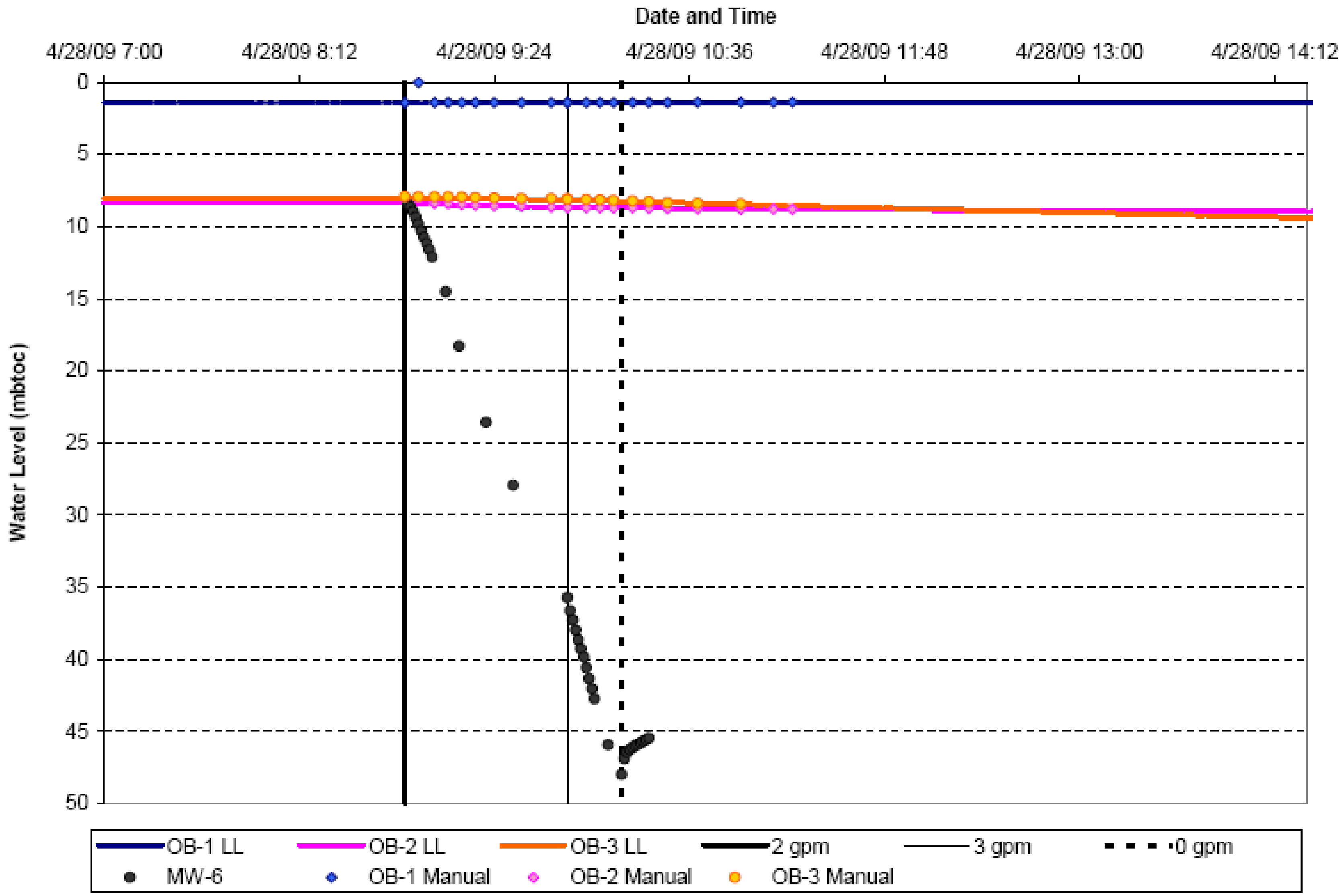


figure B1.2-3

**STEP TEST CHART MW-6**

Miller's Creek Extension Project

CGC Inc. - Windsor Plant

*Hants County, Nova Scotia*

820677K(09) GIS-DAB123 MW6 Step.mxd

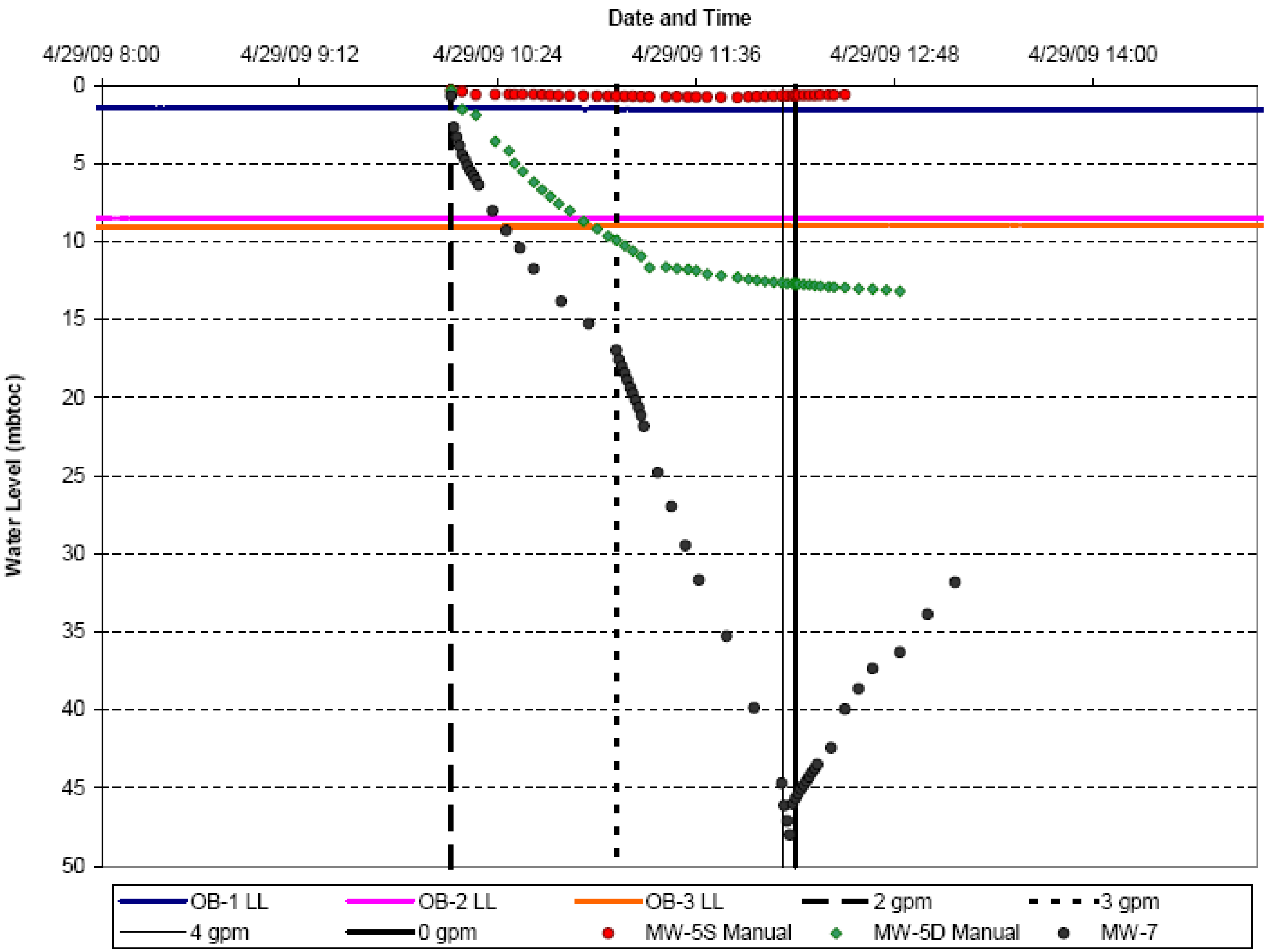


figure B1.2-4

**STEP TEST CHART MW-7**

Miller's Creek Extension Project
CGC Inc. - Windsor Plant
*Hants County, Nova Scotia*

820677K(09) GIS-DAB124 MW7 Step.mxd

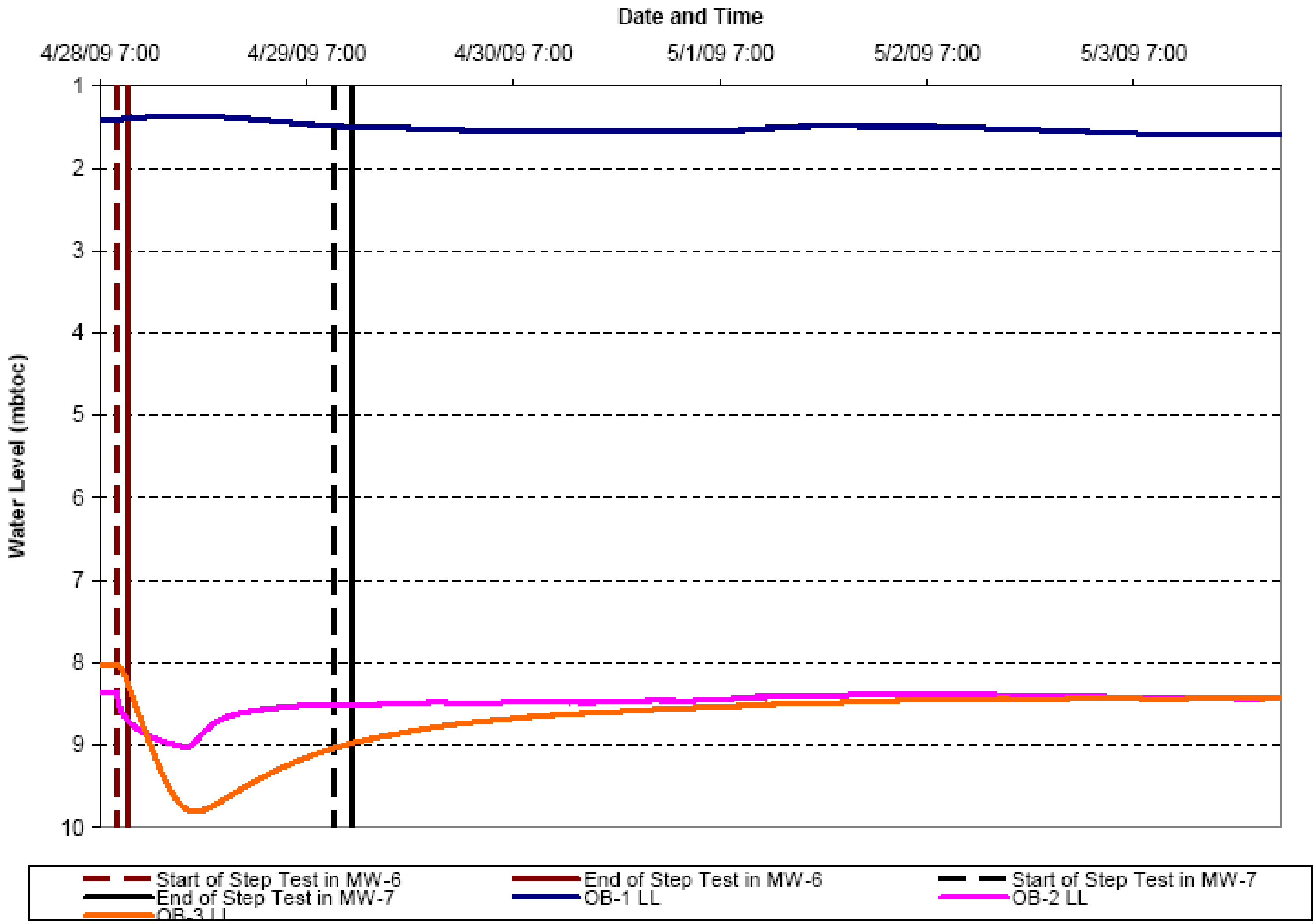


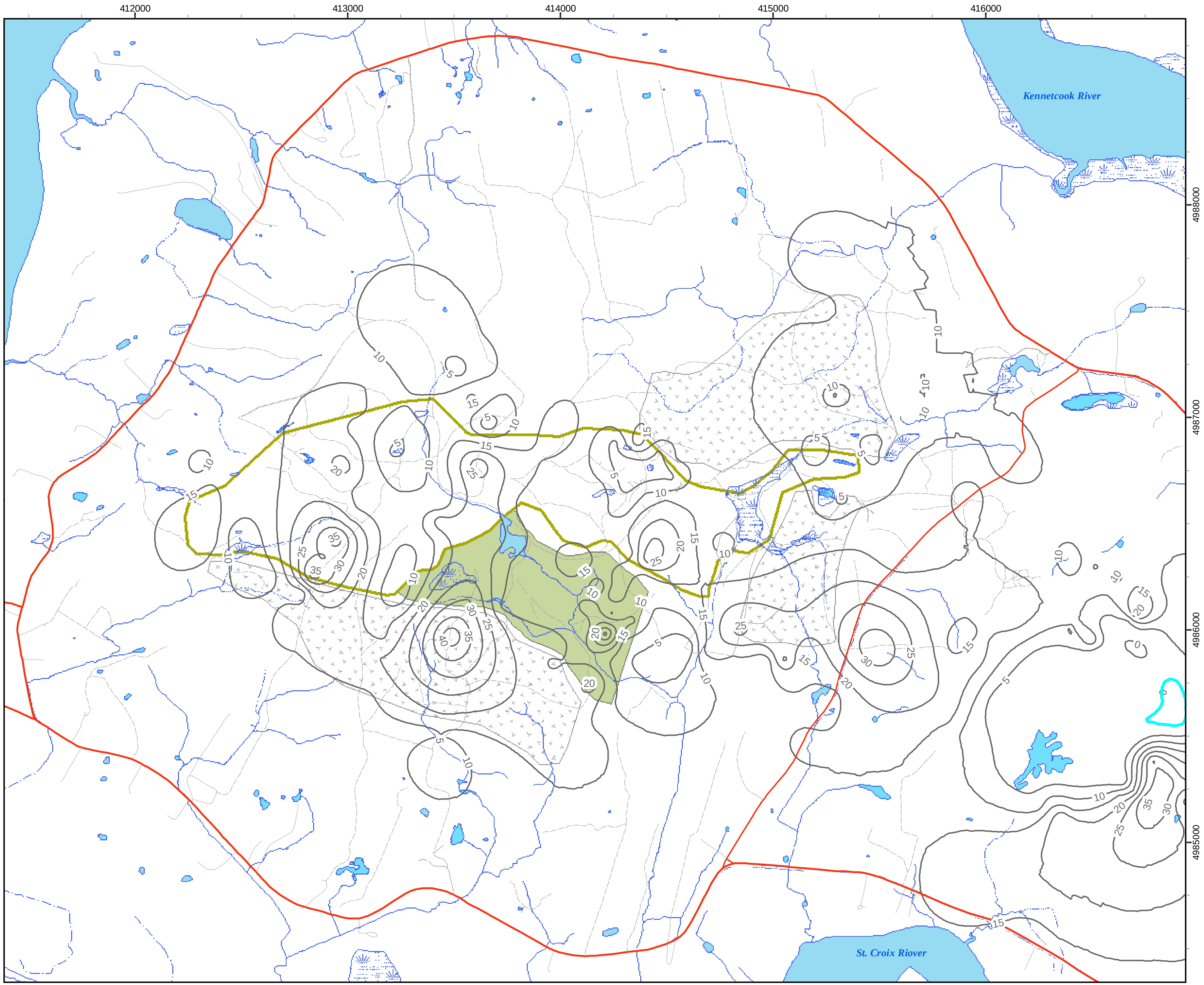
figure B1.2-5

**STEP TEST CHART OB WELLS**

Miller's Creek Extension Project

CGC Inc. - Windsor Plant

*Hants County, Nova Scotia*



**LEGEND:**

- ╱╲ Overburden Thickness (m)
- ▢ Proposed Extraction Area
- ▨ Proposed Stockpiles
- 🟩 Proposed Conservation Area

**SOURCE:**

Nova Scotia Topographic Database
SNS&MR - NS Geomatics Centre
Field Surveys: CRA Ltd.

0 100 200 400 600 800 1,000
Metres

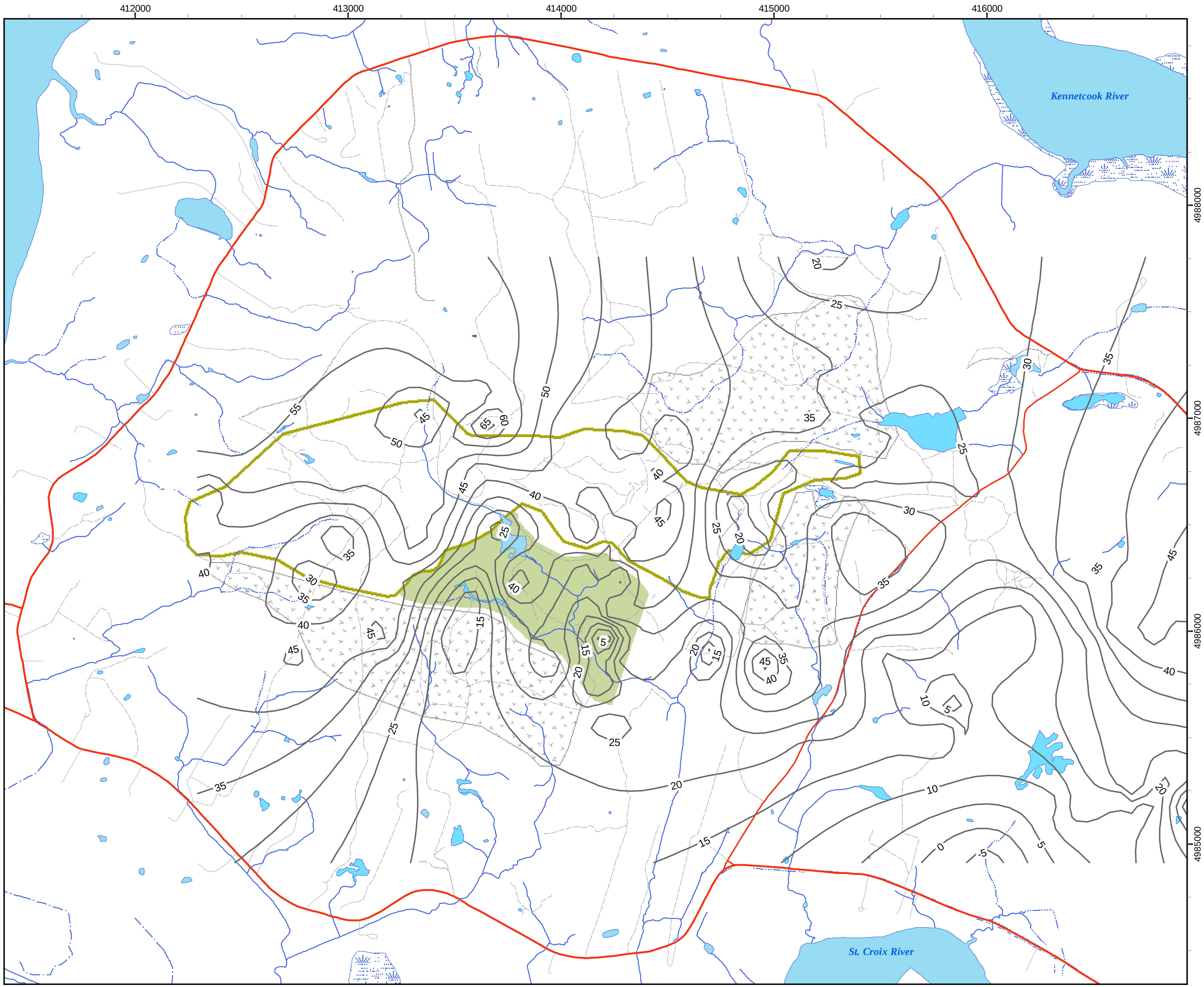
N

| PROJECTION: | DRAWN / CHECKED BY: | MAP ANGLE: |
|---|---|---|
| UTM z20 NAD83 | JJP / AD | 0° North |
| **SCALE:** | **DATE:** | **PROJECT NO:** |
| 1:17,500 | August 31, 2009 | 820677K |

820677K(09)GIS_DAB131_OverburdenThickness.mxd

figure B1.3-1
**OVERBURDEN THICKNESS**
Miller's Creek Extension Project
CGC INC. - WINDSOR PLANT
*Hants County, Nova Scotia*

**CONESTOGA-ROVERS**
& ASSOCIATES



**LEGEND:**

╱╲ Top of Bedrock Elevation (m)

▢ Proposed Extraction Area

▨ Proposed Stockpiles

🟩 Proposed Conservation Area

**SOURCE:**

Nova Scotia Topographic Database
SNS&MR - NS Geomatics Centre
Field Surveys: CRA Ltd.

0 100 200 400 600 800 1,000
Metres

N

| PROJECTION: | DRAWN / CHECKED BY: | MAP ANGLE: |
|---|---|---|
| UTM z20 NAD83 | JJP / AD | 0° North |
| **SCALE:** | **DATE:** | **PROJECT NO:** |
| 1:17,500 | August 31, 2009 | 820677K |

820677K(09)GIS_DAB132_BedrockSurface.mxd

figure B1.3-2

**BEDROCK SURFACE ELEVATION**

Miller's Creek Extension Project
CGC INC. - WINDSOR PLANT
*Hants County, Nova Scotia*

**CONESTOGA-ROVERS & ASSOCIATES**

# Table B1.2-1
# Domestic Well Survey Resutls

| CRA_ID | DATE | PID | UTM_N | UTM_E | WL (m btoc) | Stick Up (m ags) | WL (m bgs) | WELL_TYPE | Survey Info | NS_WELL_LOG_ID | Water Bearing Fractures (mbgs) | | | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ACR-80 | 9/12/2006 | 45170768 | 4986010 | 411563 | 2.34 | 0 | 2.34 | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| AR-1003 | 10/2/1992 | 45199015 | 4984919 | 414863 | 3.05 | 0 | 3.05 | Dug | JWL - 1992 Domestic Well Survey | - | - | - | - | |
| AR-1004 | 2005 | 45171873 | 4984861 | 414907 | - | - | - | Drilled | NS Well Log Database - 2008 Ed. | 050754 | 61.0 | 71.6 | - | |
| AR-1004A | 4/10/2009 | 45171873 | 4984817 | 414915 | 19.8 | 0 | 19.80 | Drilled | CRA - 2009 Domestic Well Survey | - | - | - | - | |
| AR-1004B | 4/10/2009 | 45171873 | 4984803 | 414875 | 19.6 | 0 | 19.60 | Drilled | CRA - 2009 Domestic Well Survey | - | - | - | - | |
| AR-1070 | 10/2/1992 | 45171923 | 4984848 | 415192 | 3.66 | 0 | 3.66 | Dug | JWL - 1992 Domestic Well Survey | - | - | - | - | |
| AR-1116 | 4/10/2009 | 45337409 | 4984750 | 415410 | - | - | - | Drilled | CRA - 2009 Domestic Well Survey | - | - | - | - | |
| AR-1116 | 2006 | 45337409 | 4984765 | 415444 | - | - | 22.9 | Drilled | NS Well Log Database - 2008 Ed. | 061762 | 42.4 | 44.2 | 47.2 | |
| AR-1118 | 2004 | 45339660 | 4984756 | 415390 | - | - | - | Drilled | NS Well Log Database - 2008 Ed. | 040260 | 45.7 | 59.4 | - | |
| AR-1178 | 9/30/1992 | 45183043 | 4984729 | 415716 | 1.83 | 0 | 1.83 | Dug | JWL - 1992 Domestic Well Survey | - | - | - | - | |
| AR-1181 | 9/30/1992 | 45183068 | 4984794 | 415745 | 0.91 | 0 | 0.91 | Dug | JWL - 1992 Domestic Well Survey | - | - | - | - | |
| AR-1220 | 4/10/2009 | 45172764 | 4984657 | 415843 | - | - | - | Drilled | CRA - 2009 Domestic Well Survey | - | - | - | - | |
| AR-1220 | 2006 | 45172764 | 4984635 | 415845 | - | - | - | Drilled | NS Well Log Database - 2008 Ed. | 060026 | 25.9 | 36.6 | - | |
| AR-1284 | 2001 | 45183142 | 4984515 | 416160 | - | - | 12.2 | Drilled | NS Well Log Database - 2008 Ed. | 010124 | 32.0 | 33.5 | - | |
| AR-135A | 11/4/2006 | 45171311 | 4985666 | 411385 | 1.67 | 0 | 1.67 | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| AR-135B | 11/4/2006 | 45171311 | 4985666 | 411385 | 14.94 | unknown | unknown | Drilled | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| AR-135B | 3/26/2009 | 45171311 | 4985665 | 411381 | 10.11 | 0.47 | 9.64 | Drilled | CRA - 2009 Domestic Well Survey | - | - | - | - | |
| AR-1371 | 4/10/2009 | 45183258 | 4984361.29 | 416572.833 | - | - | - | Drilled | CRA - 2009 Domestic Well Survey | - | - | - | - | |
| AR-1371 | 2004 | 45183258 | 4984344 | 416571 | - | - | - | Drilled | NS Well Log Database - 2008 Ed. | 040251 | - | - | - | |
| AR-1442 | 2004 | 45248044 | 4984127 | 416848 | - | - | - | Drilled | NS Well Log Database - 2008 Ed. | 040250 | 51.2 | 59.4 | - | |
| AR-221A | 10/16/2006 | 45338761 | 4985570 | 411761 | 14.02 | 0 | 14.02 | Drilled | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| AR-221A | 2004 | 45338761 | 4985570 | 411761 | - | - | - | Drilled | NS Well Log Database - 2008 Ed. | 041001 | 33.5 | 39.6 | - | |
| AR-221B | 4/17/2007 | 45338761 | 4985570 | 411761 | 14.33 | 0 | 14.33 | Drilled | CRA - 2007 Domestic Well Survey | - | - | - | - | |
| AR-221B | 2006 | 45338761 | 4985570 | 411761 | - | - | - | Drilled | NS Well Log Database - 2008 Ed. | 061753 | 49.7 | 51.5 | - | |
| AR-221C | 4/17/2007 | 45338761 | 4985570 | 411761 | 19.20 | 0 | 19.20 | Drilled | CRA - 2007 Domestic Well Survey | - | - | - | - | |
| AR-221C | 2007 | 45338761 | 4985570 | 411761 | - | - | - | Drilled | NS Well Log Database - 2008 Ed. | 070067 | 66.4 | 71.6 | - | |
| AR-228 | 10/4/2006 | 45171360 | 4985318 | 411655 | 3.65 | 0 | 3.65 | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| AR-228 | 3/25/2009 | 45171360 | 4985317 | 411667 | 1.3 | 0.65 | 0.65 | Dug | CRA - 2009 Domestic Well Survey | - | - | - | - | |
| AR-290 | 9/14/2006 | 45171402 | 4985291 | 411970 | 15.47 | 1.829 | 13.64 | Drilled | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| AR-290 | 3/26/2009 | 45171402 | 4985284 | 411967 | 14.6 | 0.38 | 14.22 | Drilled | CRA - 2009 Domestic Well Survey | - | - | - | - | |
| AR-290 | 2002 | 45171402 | 4985291 | 411970 | - | - | - | Drilled | NS Well Log Database - 2008 Ed. | 020760 | 35.7 | 47.2 | - | |
| AR-349 | 9/19/2006 | 45171428 | 4985281 | 412296 | 3.59 | 0.8 | 2.79 | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| AR-349 | 3/25/2009 | 45171428 | 4985276 | 412289 | 1.3 | 0.73 | 0.57 | Dug | CRA - 2009 Domestic Well Survey | - | - | - | - | Frozen at this depth. |
| AR-350 | 9/14/2006 | 45333085 | 4985113 | 412151 | - | - | - | Drilled | CRA - 2006 Domestic Well Survey | - | - | - | - | Survey was incorrectly completed. SW runs into well and must be pumped out before GW level can be measured. Ignore this well. |
| AR-351 | 10/17/2006 | 45171428 | 4985213 | 412356 | 1.27 | unknown | unknown | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| AR-351 | 3/25/2009 | 45171428 | 4985194 | 411382 | 1.6 | 0 | 1.60 | Dug | CRA - 2009 Domestic Well Survey | - | - | - | - | Well hasn't been used in 2 years. |
| AR-37A | 9/5/2006 | 45170974 | 4985946 | 410936 | 2.08 | 0.4 | 1.68 | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| AR-37B | 9/5/2006 | 45170974 | 4985946 | 410936 | 1.54 | 0 | 1.54 | Drilled | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| AR-418 | 9/7/2006 | 45171469 | 4984920 | 412392 | - | - | - | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| AR-420 | 9/7/2006 | 45194628 | 4984885 | 412304 | - | - | - | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| AR-443A | 9/22/2006 | 45217551 | 4985187 | 412742 | 1.89 | 0.8 | 1.09 | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| AR-443B | 9/22/2006 | 45217551 | 4985187 | 412742 | 2.66 | 0.83 | 1.83 | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| AR-45 | 9/5/2006 | 45171006 | 4985917 | 410977 | 3.21 | 0.075 | 3.13 | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| AR-451 | 9/19/2006 | 45217072 | 4984890 | 412631 | 3.06 | unknown | unknown | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| AR-451 | 3/25/2009 | 45217072 | ***4984887*** | ***412619*** | 1.73 | 0.63 | 1.10 | Dug | CRA - 2009 Domestic Well Survey | - | - | - | - | |

### Table B1.2-1
### Domestic Well Survey Resutls

| CRA_ID | DATE | PID | UTM_N | UTM_E | WL (m btoc) | Stick Up (m ags) | WL (m bgs) | WELL_TYPE | Survey Info | NS_WELL_LOG_ID | Water Bearing Fractures (mbgs) | | | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AR-454 | 10/17/2006 | 45270360 | 4984708 | 412700 | 3.06 | 0 | 3.06 | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| AR-461A | 9/15/2006 | 45156676 | 4984826 | 412650 | 3.73 | 0.6 | 3.13 | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| AR-461B | 9/15/2006 | 45156676 | 4984826 | 412650 | 3.25 | 0.6 | 2.65 | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| AR-558 | 4/12/2009 | 45171568 | 4984595 | 413111 | - | - | - | Drilled | CRA - 2009 Domestic Well Survey | - | - | - | - | |
| AR-558 | 2000 | 45171568 | 4984592 | 413133 | - | - | - | Drilled | NS Well Log Database - 2008 Ed. | 001498 | 18.3 | 24.4 | - | |
| AR-58 | 9/14/2006 | 45171170 | 4985837 | 411036 | 2.47 | 0 | 2.47 | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| AR-593 | 9/19/2006 | 45200102 | 4984768 | 413184 | 13.88 | 0.61 | 13.27 | Drilled | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| AR-593 | 4/12/2009 | 45200102 | 4984783 | 413177 | 13.5 | 0 | 13.50 | Drilled | CRA - 2009 Domestic Well Survey | - | - | - | - | |
| AR-593 | 1994 | 45200102 | 4984768 | 413184 | - | - | 9.1 | Drilled | NS Well Log Database - 2008 Ed. | 942118 | - | - | - | |
| AR-600 | 4/12/2009 | 45171576 | 4984720 | 413256 | - | - | - | Dug | CRA - 2009 Domestic Well Survey | - | - | - | - | |
| AR-600 | 2002 | 45171576 | 4984711 | 413239 | - | - | - | Drilled | NS Well Log Database - 2008 Ed. | 020761 | 21.6 | 24.4 | - | |
| AR-659 | 4/10/2009 | 45171592 | 4984908 | 413436 | - | - | - | Drilled | CRA - 2009 Domestic Well Survey | - | - | - | - | |
| AR-659 | 2000 | 45171592 | 4984888 | 413375 | - | - | - | Drilled | NS Well Log Database - 2008 Ed. | 001497 | 24.4 | 36.6 | - | |
| AR-696 | 9/19/2006 | 45290764 | 4984624 | 413649 | 2.82 | 0.65 | 2.17 | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| AR-696 | 3/25/2009 | 45290764 | 4984636 | 413651 | 2.05 | 0.4 | 1.65 | | CRA - 2009 Domestic Well Survey | - | - | - | - | Well hasn't been used in 2 years. |
| AR-721A | 9/7/2006 | 45067170 | 4984630 | 413795 | 4.32 | 0 | 4.32 | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| AR-721B | 1980 | 45067170 | 4984630 | 413795 | - | - | - | Drilled | NS Well Log Database - 2008 Ed. | 802180 | 42.7 | 48.8 | - | |
| AR-750 | 4/12/2009 | 45171683 | 4984537 | 413855 | 5.95 | 0 | 5.95 | Drilled | CRA - 2009 Domestic Well Survey | - | - | - | - | |
| AR-750 | 2007 | 45171683 | 4984523 | 413863 | - | - | - | Drilled | NS Well Log Database - 2008 Ed. | 070763 | 19.8 | 41.1 | - | |
| AR-779 | 10/17/2006 | 45171733 | 4984600 | 414023 | 1.72 | unknown | unknown | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| AR-779 | 3/25/2009 | 45171733 | 4984601 | 414035 | 2.9 | 0.85 | 2.05 | Dug | CRA - 2009 Domestic Well Survey | - | - | - | - | |
| AR-801A | 9/22/2006 | 45171758 | 4984497 | 414150 | 3.87 | 0 | 3.87 | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| AR-801B | 9/22/2006 | 45171758 | 4984497 | 414150 | 3.82 | 0.5 | 3.32 | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| AR-801C | 2003 | 45171758 | 4984497 | 414150 | - | - | - | Drilled | NS Well Log Database - 2008 Ed. | 030853 | 30.5 | 115.8 | - | |
| AR-81 | 10/13/2006 | 45171097 | 4985854 | 411103 | 24.34 | 0.6 | 23.74 | Drilled | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| AR-81 | 3/26/2009 | 45171097 | ***4985876*** | ***411118*** | 23.14 | 0.44 | 22.70 | Drilled | CRA - 2009 Domestic Well Survey | - | - | - | - | |
| AR-81 | 1994 | 45171097 | 4985854 | 411103 | - | - | - | Drilled | NS Well Log Database - 2008 Ed. | 943193 | 36.0 | - | - | |
| AR-88A | 1988 | 45171253 | 4985761 | 411141 | - | - | - | Drilled | NS Well Log Database - 2008 Ed. | 880521 | 42.7 | 48.8 | - | |
| AR-88B | 1988 | 45171253 | 4985761 | 411141 | - | - | - | Drilled | NS Well Log Database - 2008 Ed. | 880526 | 91.4 | 121.9 | - | |
| AR-89 | 9/12/2006 | 45171238 | 4985811 | 411176 | - | - | - | Drilled | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| BR-1001 | 9/22/2006 | 45170255 | 4988719 | 414241 | 2.19 | 0 | 2.19 | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| BR-102 | 10/11/2006 | 45171014 | 4986108 | 411367 | 1.70 | unknown | unknown | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| BR-1048 | 9/6/2006 | 45170214 | 4988625 | 414409 | 2.16 | 0.2 | 1.96 | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| BR-1068A | 9/22/2006 | 45170164 | 4988613 | 414526 | 3.22 | 0.5 | 2.72 | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| BR-1068B | 9/22/2006 | 45170164 | 4988613 | 414526 | 4.24 | 0.2 | 4.04 | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| BR-1068C | 9/22/2006 | 45170164 | 4988613 | 414526 | 2.47 | 0.2 | 2.27 | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| BR-1068D | 9/22/2006 | 45170164 | 4988613 | 414526 | 0.29 | 0 | 0.29 | Spring | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| BR-107 | 9/7/2006 | 45170859 | 4986159 | 411395 | - | - | - | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| BR-1101 | 9/19/2006 | 45170149 | 4988626 | 414720 | 1.90 | 0.77 | 1.13 | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| BR-1109 | 10/4/2006 | 45170123 | 4988625 | 414801 | - | - | - | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| BR-1183 | 9/17/2006 | 45170131 | 4988587 | 415161 | 2.51 | 0.05 | 2.46 | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| BR-1183 | 1994 | 45170131 | 4988587 | 415161 | - | - | 2.1 | Dug | NS Well Log Database - 2008 Ed. | 942966 | - | - | - | |
| BR-1192A | 9/7/2006 | 45170099 | 4988494 | 415201 | 2.43 | 0.6 | 1.83 | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| BR-1192B | 9/7/2006 | 45170099 | 4988494 | 415201 | 3.50 | 0.67 | 2.83 | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| BR-1192B | 1996 | 45170099 | 4988494 | 415201 | - | - | 1.8 | Dug | NS Well Log Database - 2008 Ed. | 962084 | - | - | - | |
| BR-1199 | 9/19/2006 | 45170081 | 4988524 | 415276 | 3.49 | 0.75 | 2.74 | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| BR-1199 | 1999 | 45170081 | 4988524 | 415276 | - | - | 4.6 | Dug | NS Well Log Database - 2008 Ed. | 993207 | - | - | - | |

## Table B1.2-1
## Domestic Well Survey Resutls

| CRA_ID | DATE | PID | UTM_N | UTM_E | WL (m btoc) | Stick Up (m ags) | WL (m bgs) | WELL_TYPE | Survey Info | NS_WELL_LOG_ID | Water Bearing Fractures (mbgs) | | | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BR-1217 | 9/12/2006 | 45170065 | 4988469 | 415341 | 4.53 | unknown | unknown | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| BR-1226 | 3/25/2009 | 45170057 | ***4988404*** | ***415345*** | 0.5 | 0.86 | -0.36 | Dug | CRA - 2009 Domestic Well Survey | - | - | - | - | |
| BR-1226A | 9/14/2006 | 45170057 | 4988369 | 415353 | - | - | - | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| BR-1226B | 1996 | 45170057 | 4988369 | 415353 | - | - | 2.4 | Dug | NS Well Log Database - 2008 Ed. | 962085 | - | - | - | |
| BR-1272A | 9/6/2006 | 45169992 | 4988240 | 415529 | 2.15 | unknown | unknown | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| BR-1272B | 9/6/2006 | 45169992 | 4988240 | 415529 | 2.28 | 0.11 | 2.17 | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| BR-1297 | 9/12/2006 | 45169968 | 4988171 | 415688 | 1.98 | 0.5 | 1.48 | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | Two wells feeding into each other according to field notes. |
| BR-1308A | 9/6/2006 | 45169869 | 4988078 | 415669 | 1.49 | unknown | unknown | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| BR-1308B | 9/6/2006 | 45169869 | 4988078 | 415669 | 2.63 | unknown | unknown | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| BR-1411 | 3/25/2009 | 45196169 | ***4987682*** | ***415999*** | 1.5 | 0.58 | 0.92 | Dug | CRA - 2009 Domestic Well Survey | - | - | - | - | |
| BR-1411 | 1993 | 45196169 | 4987689 | 416015 | - | - | 1.8 | Dug | NS Well Log Database - 2008 Ed. | 932163 | - | - | - | |
| BR-1431 | 9/13/2006 | 45169901 | 4987569 | 416075 | 1.95 | unknown | unknown | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| BR-1452 | 10/30/2006 | 45169927 | 4987434 | 416085 | 2.72 | 0.6 | 2.12 | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| BR-1452 | 3/25/2009 | 45169927 | ***4987444*** | ***416088*** | 1.7 | 0.7 | 1.00 | Dug | CRA - 2009 Domestic Well Survey | - | - | - | - | |
| BR-1581 | 9/12/2006 | 45169836 | 4987278 | 416593 | 2.05 | 0.5 | 1.55 | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| BR-249 | 9/26/2006 | 45189040 | 4986729 | 411412 | 4.96 | 0.6 | 4.36 | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| BR-249 | 3/25/2009 | 45189040 | 4986723 | 411386 | 1.5 | 0.53 | 0.97 | Dug | CRA - 2009 Domestic Well Survey | - | - | - | - | |
| BR-274 | 10/4/2006 | 45189248 | 4986687 | 411694 | 2.20 | 0.3 | 1.90 | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| BR-319A | 9/13/2006 | 45170701 | 4986930 | 411722 | 1.68 | unknown | unknown | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| BR-319B | 9/13/2006 | 45170701 | 4986930 | 411722 | 2.37 | unknown | unknown | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| BR-354 | 10/13/2006 | 45170669 | 4986998 | 412012 | 2.63 | 0.4 | 2.23 | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| BR-355 | 9/26/2006 | 45170685 | 4987051 | 411971 | - | - | - | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| BR-362 | 10/13/2006 | 45170610 | 4987050 | 412177 | 3.58 | 0.15 | 3.43 | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| BR-388 | 9/5/2006 | 45293966 | 4987108 | 412130 | - | - | - | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| BR-388 | 1974 | 45293966 | 4987108 | 412130 | - | - | - | Dug | NS Well Log Database - 2008 Ed. | 742172 | - | - | - | |
| BR-394 | 9/5/2006 | 45170602 | 4987183 | 412167 | 2.40 | 0.3 | 2.10 | Dug, spring also runs to well | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| BR-508 | 2004 | 45170552 | 4987508 | 412657 | - | - | 2.7 | Dug | NS Well Log Database - 2008 Ed. | 041563 | 2.7 | 3.7 | - | |
| BR-561 | 9/6/2006 | 45170529 | 4988114 | 412155 | 16.00 | 1.83 | 14.17 | Drilled | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| BR-561 | 4/12/2009 | 45170529 | 4988107 | 412163 | 10.7 | 0 | 10.70 | Drilled | CRA - 2009 Domestic Well Survey | - | - | - | - | |
| BR-561 | 1986 | 45170529 | 4988114 | 412155 | - | - | 13.7 | Drilled | NS Well Log Database - 2008 Ed. | 861549 | 48.8 | - | - | |
| BR-570 | 10/4/2006 | 45170495 | 4987912 | 412668 | 3.50 | 0.7 | 2.80 | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| BR-668A | 9/19/2006 | 45170420 | 4988325 | 412909 | 4.38 | 1.6 | 2.78 | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| BR-668B | 9/19/2006 | 45170420 | 4988325 | 412909 | 1.60 | 0.5 | 1.10 | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| BR-697 | 2004 | 45172335 | 4988622 | 412812 | - | - | - | Drilled | NS Well Log Database - 2008 Ed. | 040274 | 13.7 | 45.7 | 61.0 | |
| BR-724 | 10/10/2006 | 45170396 | 4988533 | 412971 | 1.47 | unknown | unknown | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| BR-724 | 3/25/2009 | 45170396 | 4988470 | 412932 | 0.65 | 0 | 0.65 | Dug | CRA - 2009 Domestic Well Survey | - | - | - | - | |
| BR-732A | 1981 | 45162047 | 4988581 | 413042 | - | - | - | Drilled | NS Well Log Database - 2008 Ed. | 812116 | - | - | - | |
| BR-732B | 10/30/2006 | 45162047 | 4988581 | 413042 | 2.16 | 0.8 | 1.36 | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| BR-798 | 9/6/2006 | 45170362 | 4988681 | 413326 | 0.82 | 0.5 | 0.32 | Spring | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| BR-864 | 10/3/2006 | 45170362 | 4988681 | 413326 | 2.38 | unknown | unknown | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| BR-935 | 9/6/2006 | 45170289 | 4988790 | 413952 | 2.20 | 0.1 | 2.10 | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| BR-938 | 9/6/2006 | 45170297 | 4988733 | 413964 | 2.05 | 0.4 | 1.65 | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| BR-972 | 10/11/2006 | 45170271 | 4988662 | 414124 | 1.86 | 0.3 | 1.56 | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| BR-973 | 11/4/2006 | 45006228 | 4988744 | 414151 | 1.01 | 0.7 | 0.31 | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| BR-989 | 9/19/2006 | 45170263 | 4988725 | 414216 | 1.87 | 0.1 | 1.77 | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |

# Table B1.2-1
# Domestic Well Survey Resutls

| CRA_ID | DATE | PID | UTM_N | UTM_E | WL (m btoc) | Stick Up (m ags) | WL (m bgs) | WELL_TYPE | Survey Info | NS_WELL_LOG_ID | Water Bearing Fractures (mbgs) | | | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CGCA | 1956 | - | 4984633 | 415992 | - | - | 3.7 | Drilled | NS Well Log Database - 2008 Ed. | 560068 | - | - | - | |
| CGCB | 1957 | - | 4984633 | 415992 | - | - | - | Drilled | NS Well Log Database - 2008 Ed. | 570061 | - | - | - | |
| CHR-11 | 10/10/2006 | 45171063 | 4985928 | 411046 | 1.96 | 0.2 | 1.76 | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| CHR-17 | 10/30/2006 | 45171089 | 4985948 | 411056 | 1.82 | unknown | unknown | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| CHR-28 | 1974 | 45171121 | 4985981 | 411107 | - | - | - | Drilled | NS Well Log Database - 2008 Ed. | 742160 | - | - | - | |
| CHR-50 | 2007 | 45171147 | 4986022 | 411081 | - | - | - | Drilled | NS Well Log Database - 2008 Ed. | 070762 | 36.6 | 48.8 | - | |
| FR-36 | 9/12/2006 | 45171857 | 4985000 | 414874 | 22.08 | unknown | unknown | Drilled | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| FR-36 | 3/25/2009 | 45171857 | 4985018 | 414886 | 25 | 0.33 | 24.67 | Drilled | CRA - 2009 Domestic Well Survey | - | - | - | - | |
| FR-36 | 1994 | 45171857 | 4985000 | 414874 | - | - | - | Drilled | NS Well Log Database - 2008 Ed. | 942094 | 54.9 | 63.1 | - | |
| FR-36 | 1994 | 45171857 | 4985000 | 414874 | - | - | 24.4 | Drilled | NS Well Log Database - 2008 Ed. | 942119 | - | - | - | |
| FR-555 | 9/6/2006 | 45287521 | 4987125 | 416249 | 3.80 | unknown | unknown | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| FR-555 | 3/25/2009 | 45287521 | ***4987124*** | ***416232*** | 3.2 | 0.93 | 2.27 | Dug | CRA - 2009 Domestic Well Survey | - | - | - | - | |
| FR-575 | 10/13/2006 | 45169844 | 4987201 | 416371 | 1.36 | 0.3 | 1.06 | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| FR-9 | 10/11/2006 | 45205903 | 4985026 | 414683 | 1.60 | 0.15 | 1.45 | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| NTR-18 | 9/7/2006 | 45170933 | 4986139 | 411011 | 11.88 | unknown | unknown | Drilled | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| NTR-18 | 2003 | 45170933 | 4986139 | 411011 | - | - | - | Drilled | NS Well Log Database - 2008 Ed. | 030889 | 24.4 | 32.0 | - | |
| NTR-39 | 10/30/2006 | 45170958 | 4986311 | 410980 | 1.65 | 0.4 | 1.25 | Dug | CRA - 2006 Domestic Well Survey | - | - | - | - | |
| NTR-39 | 3/25/2009 | 45170958 | 4986291 | 411007 | 1 | 0.45 | 0.55 | Spring | CRA - 2009 Domestic Well Survey | - | - | - | - | Owner mentioned that water was from spring. |
| NTR-39 | 1985 | 45170958 | 4986311 | 410980 | - | - | - | Dug | NS Well Log Database - 2008 Ed. | 852052 | - | - | - | |
| W Walker | 1980 | - | 4984894 | 414771 | - | - | - | Drilled | NS Well Log Database - 2008 Ed. | 742174 | 1.2 | - | - | |

**Notes:**

During the CRA - 2009 Domestic Well Survey, UTM data were recorded using TopCon GMS-2 with BR-1 Coast Guard Beacon, which was set to log values within ±1.00 m horizontal accuracy. UTM data in bold were recorded using Garmin GPSmap 60CSx. Garmin GPS Position accuracy: <10 meters, typical. Garmin GPS accuracy at each location was not recorded in the field book but CRA personnel waited until it stabilized to a minimum of ±10m before recording the position.

🟨 Target well used to calibrate the GW model.

m btoc - metres below top of casing
m ags - metres above ground surface
m bgs - metres below ground surface

# Table B1.2-2
## Monitoring Well Completion Details

| Name | Type | Serial Number | Location Description | Easting (Updated with GIS locations) | Northing (Updated with GIS locations) | Estimated GS from Topo Using Surfer (mAMSL) | Stick Up (mags) | Reference Elevation, TOC (masl) | Well Depth (m bTOC) | Well Depth (mbgs) | Screen Interval From (mbgs) | Screen Interval To (mbgs) | Screen Length (m) | Installation Date | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BL1 | barologger | 1017837 | Installed in MW-1 | 413427 | 4985488 | 22.000 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | 2006 | |
| BL2 | barologger | 1039042 | Installed in PZ-1A | 416367 | 4987266 | 22.000 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | Feb-09 | |
| BL3 | barologger | 1039009 | Installed in OB-1 | 415804 | 4986572 | 44.651 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | Apr-09 | |
| MW-1D | levelogger | 1018539 | - | 413436 | 4985491 | 22.000 | 0.5 | 22.50 | 33.796 | 33.296 | 27.2 | 33.296 | 6.096 | 2006 | |
| MW-1S | n/a | n/a | - | 413436 | 4985491 | 22.000 | 0.55 | 22.55 | 5.730 | 5.180 | 2.33 | 5.18 | 2.85 | 2006 | Dry |
| MW-2D | n/a | n/a | - | 412749 | 4985887 | 61.091 | 0.71 | 61.80 | 45.010 | 44.300 | 35.156 | 44.3 | 9.144 | 2006 | Dry |
| MW-2S | levelogger | 1018490 | - | 412749 | 4985887 | 61.091 | 0.8 | 61.89 | 15.940 | 15.140 | 9.044 | 15.14 | 6.096 | 2006 | |
| MW-3D | levelogger | 1018542 | - | 413163 | 4987458 | 57.886 | 0.82 | 58.71 | 35.120 | 34.300 | 25.16 | 34.3 | 9.14 | 2006 | |
| MW-3S | levelogger | 1018504 | - | 413163 | 4987458 | 57.886 | 0.86 | 58.75 | 7.160 | 6.300 | 1.73 | 6.3 | 4.57 | 2006 | |
| MW-4D | levelogger | 1018548 | - | 415265 | 4987752 | 19.533 | 0.74 | 20.27 | 37.240 | 36.500 | 27.3 | 36.5 | 9.2 | 2006 | |
| MW-4S | levelogger | 1018510 | - | 415265 | 4987752 | 19.533 | 0.6 | 20.13 | 6.900 | 6.300 | 1.73 | 6.3 | 4.57 | 2006 | |
| MW-5S | levelogger | 1039188 | - | 416106 | 4986760 | 37.312 | 0.63 | 37.94 | 10.470 | 9.840 | 3.74 | 9.84 | 6.1 | 2006 | Installed new logger - old one not working properly |
| MW-5D | n/a | n/a | - | 416106 | 4986760 | 37.312 | 0.675 | 37.99 | 38.275 | 37.600 | 31.505 | 37.6 | 6.095 | 2006 | Artesian |
| MW-6 | n/a | n/a | - | 415797 | 4986575 | 44.592 | 0.22 | 44.81 | 54.220 | 54.000 | 12.556 | 54 | 41.444 | Apr-09 | Not Instrumented - Open hole, no screen |
| MW-7 | n/a | n/a | - | 416076 | 4986757 | 36.197 | 0.18 | 36.38 | 53.880 | 53.700 | 12.558 | 53.7 | 41.142 | Apr-09 | Artesian - Open hole, no screen |
| OB-1 | levelogger | 1039148 | - | 415804 | 4986572 | 44.651 | 0.61 | 45.26 | 10.055 | 9.445 | 3.045 | 9.445 | 6.4 | Apr-09 | MW-6 observation well |
| OB-2 | levelogger | 1039204 | - | 415803 | 4986573 | 44.638 | 0.61 | 45.25 | 20.525 | 19.915 | 12.195 | 19.915 | 7.72 | Apr-09 | MW-6 observation well |
| OB-3 | levelogger | 1039111 | - | 415802 | 4986574 | 44.609 | 0.66 | 45.27 | 26.775 | 26.115 | 23.055 | 26.115 | 3.06 | Apr-09 | MW-6 observation well |
| PZ-1A | levelogger | 1039055 | Stream bank, just upstream of Belmont Road | 416367 | 4987266 | 22.000 | 0.365 | 22.37 | 1.365 | 1.000 | 0.240 | 1.000 | 0.76 | Feb-09 | |
| PZ-1B | levelogger | 1039064 | Streambed, just upstream of Belmont Road | 416367 | 4987266 | 22.000 | 0.72 | 22.72 | 1.975 | 1.255 | 0.495 | 1.255 | 0.76 | Feb-09 | |
| PZ-2A | levelogger | 1038528 | Wetland #1 water hole bed, in the vicinity of a spring | 414789 | 4986660 | 31.985 | 0.28 | 32.27 | 2.200 | 1.920 | 1.160 | 1.920 | 0.76 | Feb-09 | |
| PZ-2B | levelogger | 1039046 | Wetland #1 water hole bank, in the vicinity of a spring | 414789 | 4986660 | 31.985 | 0.515 | 32.50 | 2.195 | 1.680 | 0.920 | 1.680 | 0.76 | Feb-09 | |
| PZ-3 | levelogger | 1039065 | Wetland #1 spring bed | 414857 | 4986672 | 29.558 | 0.67 | 30.23 | 1.550 | 0.880 | 0.120 | 0.88 | 0.76 | Feb-09 | |
| PZ-4 | levelogger | 1038560 | Beaver pond bed | 415259 | 4986675 | 29.780 | 0.945 | 30.72 | 2.195 | 1.250 | 0.490 | 1.250 | 0.76 | Feb-09 | LL in cm instead of m (could not change in the field) |
| PZ-5A | levelogger | 1038562 | Stream bank, just downstream of large beaver pond | 415903 | 4987017 | 26.000 | 1.215 | 27.22 | 2.130 | 0.915 | 0.155 | 0.915 | 0.76 | Mar-09 | |
| PZ-5B | levelogger | 1038531 | Streambed, just downstream of large beaver pond | 415903 | 4987017 | 26.000 | 0.745 | 26.75 | 2.210 | 1.465 | 0.705 | 1.465 | 0.76 | Mar-09 | |
| PZ-6A | levelogger | 1039079 | Fish Brook stream bank, in the vicinity of MW-4 | 415261 | 4987778 | 18.000 | 0.42 | 18.42 | 1.560 | 1.140 | 0.380 | 1.140 | 0.76 | Mar-09 | |
| PZ-7A | levelogger | 1039353 | Bed of tributary located south of wetland #1 | 415084 | 4986304 | 30.196 | 0.339 | 30.54 | 1.173 | 0.834 | 0.273 | 0.834 | 0.56 | Mar-09 | *ANGLE OF 0.741 RAD AT TOP - ALL VALUES WERE CORRECTED FOR ANGLE |
| PZ-7B | levelogger | 1039351 | Bank of tributary located south of wetland #1 | 415084 | 4986304 | 30.196 | 0.35 | 30.55 | 1.555 | 1.205 | 0.445 | 1.205 | 0.76 | Mar-09 | |
| SW-1 | levelogger | 1018512 | Shaw Brook, upstream of bridge | 414361 | 4984500 | 8.000 | 0.997 | 9.00 | 0.997 | 0.000 | n/a | n/a | n/a | May-08 | |
| SW-17 | levelogger | 1039140 | Fish Brook, under Belmont Road bridge | 415778 | 4988030 | 10.000 | 1.05 | 11.05 | 1.050 | 0.000 | n/a | n/a | n/a | Apr-09 | |
| SW-18 | levelogger | 1038523 | Stream, just upstream of Belmont Road | 416367 | 4987266 | 22.000 | 0.175 | 22.18 | 0.685 | | n/a | n/a | n/a | Feb-09 | |
| SW-2C | levelogger | 1038542 | Wetland #1 water hole, in the vicinity of a spring | 414789 | 4986660 | 31.985 | 0.106 | 32.09 | 0.730 | 0.624 | n/a | n/a | n/a | Feb-09 | |
| SW-5C | levelogger | 1038547 | Stream, just downstream of large beaver pond | 415903 | 4987017 | 26.000 | 0.745 | 26.75 | 1.000 | 0.255 | n/a | n/a | n/a | Mar-09 | |
| SW-6B | levelogger | 1039095 | Fish Brook, in the vicinity of MW-4 | 415261 | 4987778 | 18.000 | 0.77 | 18.77 | 1.515 | 0.745 | n/a | n/a | n/a | Mar-09 | *ANGLE OF 0.182 RAD AT TOP - ALL VALUES WERE CORRECTED FOR ANGLE |
| SW-7C | levelogger | 1039360 | Tributary located south of wetland #1 | 415084 | 4986304 | 30.196 | 0.472 | 30.67 | 0.734 | 0.262 | n/a | n/a | n/a | Mar-09 | *ANGLE OF 0.741 RAD AT TOP - ALL VALUES WERE CORRECTED FOR ANGLE |

Notes:
mAMSL - metres above mean sea level
TOC - top of casing
mbgs - metres below ground surface

## Table B1.2-3
## Groundwater Elevation Data

| Location | Date | Time | Water Level Depth (m asl) | Historical Reference Elevation (m asl) | Water Level Elevation (m asl) |
|---|---|---|---|---|---|
| MW-1D | 12-Jul-06 | - - | 13.88 | 22.5 | 8.62 |
| MW-1D | 13-Mar-07 | - - | 12.315 | 22.5 | 10.185 |
| MW-1D | 12-Mar-09 | 12:00 | 10.665 | 22.5 | 11.835 |
| MW-1D | 24-Apr-09 | 11:30 | 9.928 | 22.5 | 12.572 |
| MW-2S | 01-Aug-06 | - - | 3.57 | 61.891 | 58.321 |
| MW-2S | 30-Oct-06 | - - | 3.52 | 61.891 | 58.371 |
| MW-2S | 12-Mar-07 | - - | 3.785 | 61.891 | 58.106 |
| MW-2S | 10-Jul-08 | - - | 4.105 | 61.891 | 57.786 |
| MW-2S | 12-Mar-09 | 13:00 | 3.855 | 61.891 | 58.036 |
| MW-2S | 07-May-09 | 14:00 | 3.659 | 61.891 | 58.232 |
| MW-2S | 15-May-09 | 11:29 | 3.5 | 61.891 | 58.391 |
| MW-3D | 12-Jul-06 | - - | 1.63 | 58.706 | 57.076 |
| MW-3D | 01-Aug-06 | - - | 1.72 | 58.706 | 56.986 |
| MW-3D | 30-Oct-06 | - - | 2.28 | 58.706 | 56.426 |
| MW-3D | 10-Jul-08 | - - | 2.199 | 58.706 | 56.507 |
| MW-3D | 12-Mar-09 | 14:10 | 1.535 | 58.706 | 57.171 |
| MW-3D | 07-May-09 | 11:30 | 1.789 | 58.706 | 56.917 |
| MW-3S | 12-Jul-06 | - - | 2.02 | 58.746 | 56.726 |
| MW-3S | 01-Aug-06 | - - | 1.61 | 58.746 | 57.136 |
| MW-3S | 30-Oct-06 | - - | 1.79 | 58.746 | 56.956 |
| MW-3S | 10-Jul-08 | - - | 2.243 | 58.746 | 56.503 |
| MW-3S | 12-Mar-09 | 14:10 | 0.945 | 58.746 | 57.801 |
| MW-3S | 07-May-09 | 12:07 | 1.061 | 58.746 | 57.685 |
| MW-4D | 01-Aug-06 | - - | 1.67 | 20.273 | 18.603 |
| MW-4D | 12-Mar-07 | - - | 2.545 | 20.273 | 17.728 |
| MW-4D | 10-Jul-08 | - - | 2.42 | 20.273 | 17.853 |
| MW-4D | 12-Mar-09 | 10:00 | 0.96 | 20.273 | 19.313 |
| MW-4D | 04-May-09 | 13:31 | 1.913 | 20.273 | 18.36 |
| MW-4S | 01-Aug-06 | - - | 2.23 | 20.133 | 17.903 |
| MW-4S | 12-Mar-07 | - - | 2.517 | 20.133 | 17.616 |
| MW-4S | 10-Jul-08 | - - | 2.465 | 20.133 | 17.668 |
| MW-4S | 12-Mar-09 | 10:00 | 0.867 | 20.133 | 19.266 |
| MW-4S | 04-May-09 | 12:31 | 1.565 | 20.133 | 18.568 |
| MW-5D | 29-Apr-09 | 10:07 | 0.328 | 37.987 | 37.659 |
| MW-5D | 07-May-09 | 9:01 | 0.05 | 37.987 | 37.937 |
| MW-5S | 02-Aug-06 | - - | 0.2 | 37.942 | 37.742 |
| MW-5S | 08-Jun-07 | - - | 0.24 | 37.942 | 37.702 |
| MW-5S | 10-Jul-08 | - - | 0.315 | 37.942 | 37.627 |
| MW-5S | 12-Mar-09 | 9:15 | 0.45 | 37.942 | 37.492 |
| MW-5S | 29-Apr-09 | 10:07 | 0.346 | 37.942 | 37.596 |
| MW-5S | 04-May-09 | 10:36 | 0.501 | 37.942 | 37.441 |
| MW-5S | 07-May-09 | 8:58 | 0.407 | 37.942 | 37.535 |
| MW-6 | 28-Apr-09 | 8:51 | 7.166 | 44.812 | 37.646 |
| OB-1 | 23-Apr-09 | 11:22 | 1.208 | 45.261 | 44.053 |
| OB-1 | 28-Apr-09 | 7:45 | 1.411 | 45.261 | 43.85 |
| OB-1 | 07-May-09 | 9:10 | 1.556 | 45.261 | 43.705 |
| OB-1 | 15-May-09 | 9:57 | 1.545 | 45.261 | 43.716 |
| OB-2 | 23-Apr-09 | 13:53 | 8.273 | 45.248 | 36.975 |
| OB-2 | 28-Apr-09 | 7:45 | 8.382 | 45.248 | 36.866 |
| OB-2 | 07-May-09 | 9:20 | 8.498 | 45.248 | 36.75 |

## Table B1.2-3
## Groundwater Elevation Data

| Location | Date | Time | Water Level Depth (m asl) | Historical Reference Elevation (m asl) | Water Level Elevation (m asl) |
|---|---|---|---|---|---|
| OB-2 | 15-May-09 | 9:53 | 8.565 | 45.248 | 36.683 |
| OB-3 | 24-Apr-09 | 9:06 | 7.777 | 45.269 | 37.492 |
| OB-3 | 28-Apr-09 | 7:45 | 7.932 | 45.269 | 37.337 |
| OB-3 | 07-May-09 | 9:23 | 8.319 | 45.269 | 36.95 |
| OB-3 | 15-May-09 | 9:55 | 8.325 | 45.269 | 36.944 |
| PZ-1A | 17-Mar-09 | 14:45 | 0.518 | 22.365 | 21.847 |
| PZ-1A | 25-Mar-09 | 14:30 | 0.57 | 22.365 | 21.795 |
| PZ-1A | 15-May-09 | 7:52 | 0.52 | 22.365 | 21.845 |
| PZ-1B | 17-Mar-09 | 14:45 | 1.01 | 22.72 | 21.71 |
| PZ-1B | 25-Mar-09 | 14:30 | 1 | 22.72 | 21.72 |
| PZ-1B | 15-May-09 | 7:47 | 1.015 | 22.72 | 21.705 |
| PZ-2A | 17-Mar-09 | 12:40 | 0.45 | 32.265 | 31.815 |
| PZ-2A | 26-Mar-09 | 9:30 | 0.61 | 32.265 | 31.655 |
| PZ-2A | 22-May-09 | 9:10 | 0.51 | 32.265 | 31.755 |
| PZ-2B | 17-Mar-09 | 12:40 | 0.77 | 32.5 | 31.73 |
| PZ-2B | 26-Mar-09 | 10:30 | 0.78 | 32.5 | 31.72 |
| PZ-2B | 22-May-09 | 9:10 | 0.695 | 32.5 | 31.805 |
| PZ-3 | 17-Mar-09 | 13:30 | 0.67 | 30.228 | 29.558 |
| PZ-3 | 26-Mar-09 | 10:45 | 0.75 | 30.228 | 29.478 |
| PZ-3 | 22-May-09 | 10:00 | 0.68 | 30.228 | 29.548 |
| PZ-4 | 17-Mar-09 | 14:30 | 0.946 | 30.725 | 29.779 |
| PZ-4 | 26-Mar-09 | 9:30 | 0.97 | 30.725 | 29.755 |
| PZ-4 | 22-May-09 | 8:27 | 0.995 | 30.725 | 29.73 |
| PZ-5A | 25-Mar-09 | 15:20 | 1.34 | 27.215 | 25.875 |
| PZ-5A | 15-May-09 | 9:18 | 1.395 | 27.215 | 25.82 |
| PZ-5B | 25-Mar-09 | 15:20 | 0.83 | 26.745 | 25.915 |
| PZ-5B | 15-May-09 | 9:15 | 0.855 | 26.745 | 25.89 |
| PZ-6A | 26-Mar-09 | 14:45 | 0.79 | 18.42 | 17.63 |
| PZ-6A | 22-May-09 | 14:17 | 0.78 | 18.42 | 17.64 |
| PZ-7A | 26-Mar-09 | 11:00 | 0.465 | 30.536 | 30.071 |
| PZ-7A | 22-May-09 | 11:10 | 0.494 | 30.536 | 30.041 |
| PZ-7B | 26-Mar-09 | 11:00 | 0.4 | 30.546 | 30.146 |
| PZ-7B | 22-May-09 | 11:10 | 0.445 | 30.546 | 30.101 |
| SW-1 | 29-May-08 | 9:38 | 0.333 | 8.997 | 8.664 |
| SW-1 | 04-Jul-08 | 8:20 | 0.399 | 8.997 | 8.598 |
| SW-1 | 23-Jul-08 | 8:20 | 0.387 | 8.997 | 8.61 |
| SW-1 | 14-Aug-08 | 8:33 | 0.367 | 8.997 | 8.63 |
| SW-1 | 16-Sep-08 | 9:15 | 0.347 | 8.997 | 8.65 |
| SW-1 | 09-Mar-09 | 14:48 | 0.231 | 8.997 | 8.766 |
| SW-1 | 09-Apr-09 | 13:00 | 0.187 | 8.997 | 8.81 |
| SW-1 | 21-May-09 | 9:16 | 0.317 | 8.997 | 8.68 |
| SW-17 | 29-May-08 | 13:25 | 0.655 | 11.05 | 10.395 |
| SW-17 | 04-Jul-08 | 12:25 | 0.722 | 11.05 | 10.328 |
| SW-17 | 23-Jul-08 | 10:50 | 0.707 | 11.05 | 10.343 |
| SW-17 | 14-Aug-08 | 11:45 | 0.655 | 11.05 | 10.395 |
| SW-17 | 16-Sep-08 | 12:00 | 0.655 | 11.05 | 10.395 |
| SW-17 | 09-Mar-09 | 14:35 | 0.59 | 11.05 | 10.46 |
| SW-17 | 09-Apr-09 | 9:30 | 0.599 | 11.05 | 10.451 |
| SW-17 | 21-May-09 | 12:34 | 0.6 | 11.05 | 10.45 |
| SW-18 | 25-Mar-09 | 14:30 | 0.47 | 22.175 | 21.705 |

## Table B1.2-3
## Groundwater Elevation Data

| Location | Date | Time | Water Level Depth (m asl) | Historical Reference Elevation (m asl) | Water Level Elevation (m asl) |
|---|---|---|---|---|---|
| SW-18 | 15-May-09 | 7:50 | 0.53 | 22.175 | 21.645 |
| SW-2C | 27-Feb-09 | 14:40 | 0.305 | 32.091 | 31.786 |
| SW-2C | 22-May-09 | 9:10 | 0.3 | 32.091 | 31.791 |
| SW-5C | 06-Mar-09 | 10:00 | 0.77 | 26.745 | 25.975 |
| SW-5C | 25-Mar-09 | 15:20 | 0.79 | 26.745 | 25.955 |
| SW-5C | 15-May-09 | 9:17 | 0.86 | 26.745 | 25.885 |
| SW-6B | 26-Mar-09 | 14:45 | 1.21 | 18.77 | 17.56 |
| SW-6B | 22-May-09 | 14:32 | 1.19 | 18.77 | 17.58 |
| SW-7C | 22-May-09 | 11:10 | 0.653 | 30.669 | 30.016 |

# Table B1.3-1
# Single Well Response Test Results

| Well Name | Corrected Hydraulic Conductivity (cm/s) | | | | |
|---|---|---|---|---|---|
| | Falling Head | | Rising Head | | |
| | Hvorslev | Bouwer-Rice | Hvorslev | Bouwer-Rice | Geometric Mean |
| Overburden | | | | | |
| MW-1S | DRY | | | | |
| MW-2S | Rising Head Test Only | | 5.5E-08 | 4.2E-08 | 4.8E-08 |
| MW-3S | 1.0E-04 | 8.1E-05 | 1.5E-04 | 9.8E-05 | 1.1E-04 |
| MW-4S | 8.4E-05 | 5.2E-05 | 1.1E-04 | 8.4E-05 | 8.1E-05 |
| MW-5S | 8.4E-05 | 3.9E-05 | 2.1E-04 | 9.1E-05 | 8.9E-05 |
| OB-1 | 1.9E-06 | 1.3E-06 | 1.5E-06 | 1.0E-06 | 1.4E-06 |
| Bedrock | | | | | |
| MW-1D | Rising Head Test Only | | 1.4E-05 | 1.1E-05 | 1.2E-05 |
| MW-2D | DRY | | | | |
| MW-3D | 9.5E-05 | 9.5E-05 | 1.8E-04 | 1.7E-04 | 1.3E-04 |
| MW-5D | Rising Head Test Only | | 7.1E-05 | 6.9E-05 | 7.0E-05 |
| OB-2 | 8.6E-05 | 6.1E-05 | 9.0E-05 | 6.4E-05 | 7.4E-05 |
| OB-3 | 3.0E-06 | 2.7E-06 | 2.4E-06 | 2.1E-06 | 2.5E-06 |

## Table B1.3-2
## Vertical Hydraulic Gradients

| Location | 7/12/2006 | 8/1/2006 | 10/30/2006 | 3/12/2007 | 7/10/2008 | 3/12/2009 |
|---|---|---|---|---|---|---|
| MW-3D vs. MW-3S | 0.014 | -0.006 | -0.021 |  | 0.0001 | -0.024 |
| MW-4D vs. MW-4S |  | 0.025 |  | 0.004 | 0.007 | 0.002 |
| MW-5D vs. MW-5S |  |  |  |  |  |  |
| OB-1 vs. OB-2 |  |  |  |  |  |  |
| MW-6 vs OB-3 |  |  |  |  |  |  |

| Location | 4/23/2009 | 4/28/2009 | 4/29/2009 | 5/4/2009 | 5/7/2009 | 5/15/2009 | AVERAGE |
|---|---|---|---|---|---|---|---|
| MW-3D vs. MW-3S |  |  |  |  | -0.030 |  | -0.011 |
| MW-4D vs. MW-4S |  |  |  | -0.007 |  |  | 0.006 |
| MW-5D vs. MW-5S |  |  | 0.002 |  | 0.014 |  | 0.008 |
| OB-1 vs. OB-2 | -0.722 | -0.712 |  |  | -0.709 | -0.717 | -0.715 |
| MW-6 vs OB-3 |  | 0.036 |  |  |  |  | 0.036 |

**Notes:**

negative is downward vertical gradient
positive is an upward vertical gradient

# APPENDIX A

# MONITORING WELL LOGS

**Client:** *Fundy Gypsum Company*
**Project No:** *820677-K*
**Civic Address:** *Undeveloped land*
**City & Province:** *Miller's Creek Extention*
**PID Number:** *45280369*
**UTM Easting:** *413438.738*
**UTM Northing:** *4985495.497*
**Date Started:** *June 22, 2006*
**Date Finished:** *June 22, 2006*

**Drilling Contractor:** *Logan Drilling*
**Drill Type:** *CME*
**Drill Method:** *Hollow Stem Auger*
**Logged By:** *Sherman Jackson*
**TOC Elevation:** *0*
**GL Elevation:** *20.73 m*
**Final Depth:** *5.2 m*
**Depth to Water Strike:** *Dry*
**Depth to Bedrock** *4.4*

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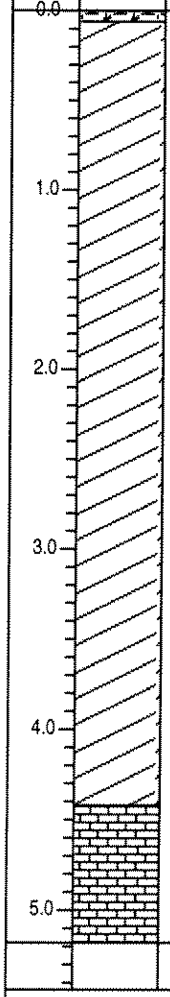
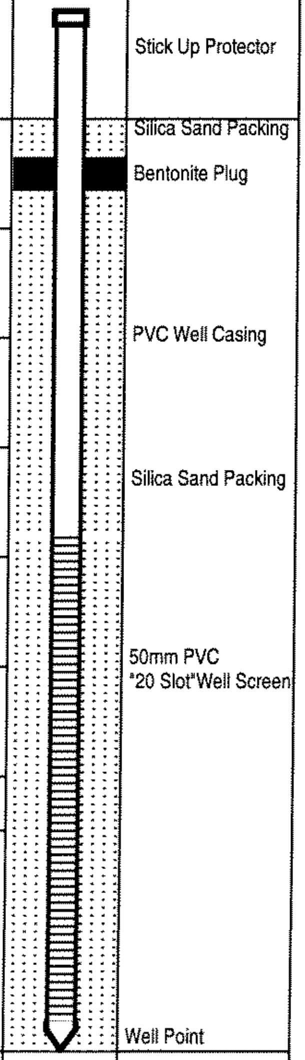
# Monitor Well: MW1 S

**Page:** *1 of 1*

| Depth (m) | Lithology | USCS Classification | Description | Elevation (mamsl) | Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Headspace (ppm/% LEL) | Analysis | Well Construction | Well Details |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | Stick Up Protector |
| 0.0 | | | | 0.0 | | | | | | | | Silica Sand Packing |
| | | | Surface Organics<br>Hard Clay Till | | 1 | SS | 2, 4 | NA | NA | NA | | Bentonite Plug |
| 1.0 | | | | | 2 | SS | 4.5, 4.5 | NA | NA | NA | | |
| | | | | | 3 | SS | 8.5, 14 | NA | NA | NA | | PVC Well Casing |
| 2.0 | | | | | 4 | SS | 7.5, 15 | NA | NA | NA | | Silica Sand Packing |
| | | | | | 5 | SS | 17.5, 23 | NA | NA | NA | | |
| 3.0 | | | | | 6 | SS | 6, 8 | NA | NA | NA | | 50mm PVC "20 Slot"Well Screen |
| | | | | | 7 | SS | Refusal | NA | NA | NA | | |
| 4.0 | | | Weathered Limestone | | | | | | | | | |
| 5.0 | | | | | | | | | | | | Well Point |





**Client:** *Fundy Gypsum Company*
**Project No:** *820677-K*
**Civic Address:** *Undeveloped land*
**City & Province:** *Miller's Creek Extention*
**PID Number:** *45280369*
**UTM Easting:** *413438.756*
**UTM Northing:** *4985496.496*
**Date Started:** *June 22, 2006*
**Date Finished:** *June 23, 2006*

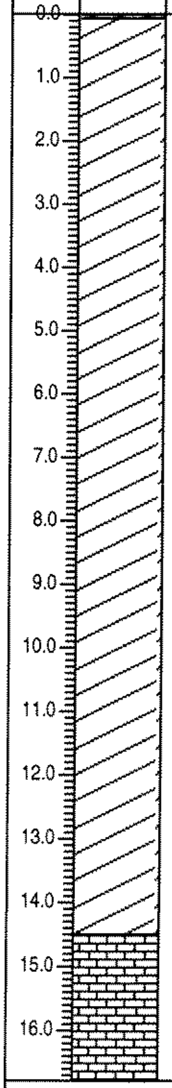
**Drilling Contractor:** *Logan Drilling*
**Drill Type:** *CME*
**Drill Method:** *Hollow Stem Auger*
**Logged By:** *Sherman Jackson*
**TOC Elevation:** *0*
**GL Elevation:** *20.73 M*
**Final Depth:** *33.3 m*
**Depth to Water Strike:** *13.88 m*
**Depth to Bedrock** *4.2*

CONESTOGA-ROVERS & ASSOCIATES

## Monitor Well: MW1 D

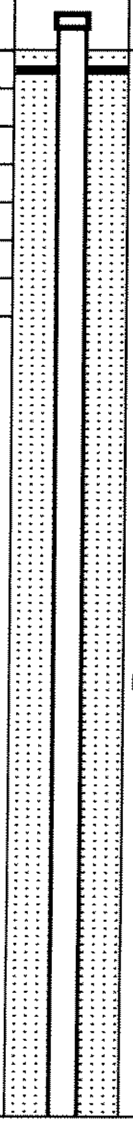
**Page:** *1 of 2*

**Depth (m)** | **Lithology** | **USCS Classification**



| Description | Elevation (mamsl) | Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Headspace (ppm/% LEL) | Analysis |
|---|---|---|---|---|---|---|---|
|  | 0.0 |  |  |  |  |  |  |
| Surface Organics |  | 1 | SS | 2, 4 | NA | NA | NA |
| Hard Clay Till |  | 2 | SS | 4.5,4.5 | NA | NA | NA |
|  |  | 3 | SS | 8.5, 14 | NA | NA | NA |
|  |  | 4 | SS | 7.5, 15 | NA | NA | NA |
|  |  | 5 | SS | 17.5, 23 | NA | NA | NA |
|  |  | 6 | SS | 6, 8 | NA | NA | NA |
|  |  | 7 | SS | Refusal | NA | NA | NA |
| Weathered Limestone |  |  |  |  |  |  |  |

**Well Construction** | **Well Details**



**Client:** *Fundy Gypsum Company*

**Project No:** *820677-K*

**Civic Address:** *Undeveloped land*

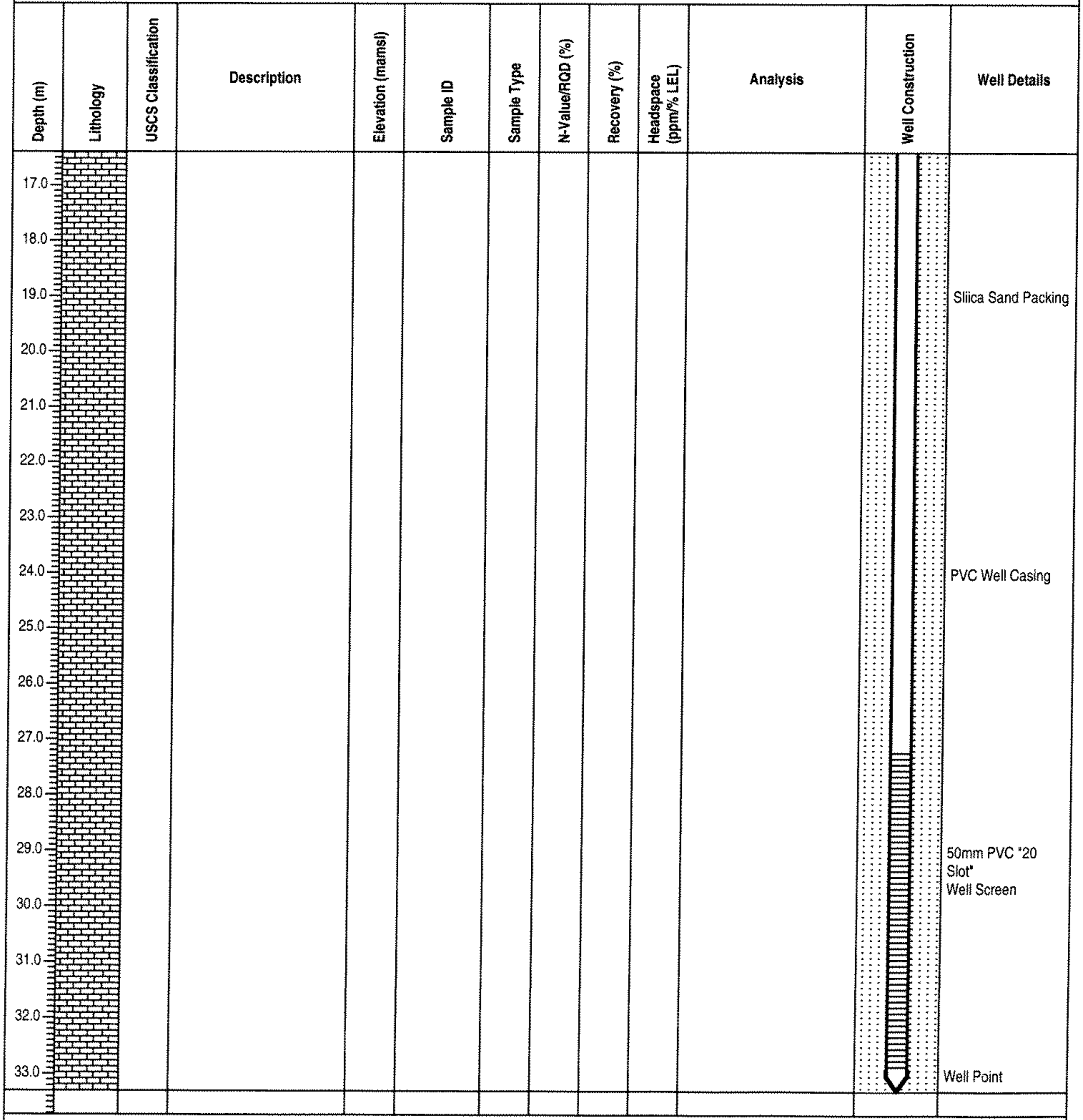
**City & Province:** *Miller's Creek Extention*

**Monitor Well:** *MW1 D*

**Page:** *2 of 2*

**CONESTOGA-ROVERS & ASSOCIATES**

## Monitor Well: MW1 D



**Client:** *Fundy Gypsum Company*
**Project No:** *820677-H*
**Civic Address:** *Undeveloped land*
**City & Province:** *Miler's Creek extention*
**PID Number:**
**UTM Easting:** *412752.118*
**UTM Northing:** *4985892.197*
**Date Started:** *June 30, 2006*
**Date Finished:** *June 30, 2006*

**Drilling Contractor:** *Logan Drilling*
**Drill Type:** *CME*
**Drill Method:** *Hollow Stem Auger*
**Logged By:** *Sherman Jackson*
**TOC Elevation:** *0*
**GL Elevation:** *61.4 m*
**Final Depth:** *15.5 m*
**Depth to Water Strike:**
**Depth to Bedrock** *14.94 m*

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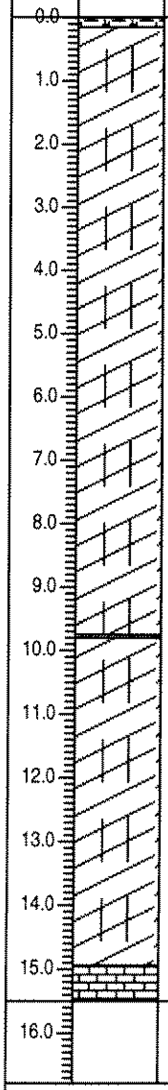
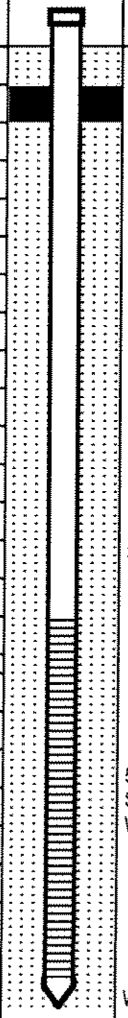
# Monitor Well: MW2 S

**Page:** *1 of 1*





| Depth (m) | Lithology | USCS Classification | Description | Elevation (mamsl) | Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Headspace (ppm/% LEL) | Analysis | Well Construction | Well Details |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 0.0 | | | | | | | | Stick Up Protector |
| 0.0 | | | Surface Organics | | 1 | SS | 2 | NS | NS | NA | | Silica Sand Packing |
| | | | Silty Clay Till | | 2 | SS | 3, 4.5 | NS | NS | NA | | Bentonite Plug |
| | | | | | 3 | SS | 14.5, 13 | NS | NS | NA | | |
| | | | | | 4 | SS | 14, 15 | NS | NS | NA | | |
| | | | | | 5 | SS | 14, 19 | NS | NS | NA | | |
| | | | | | 6 | SS | 5, 10.5 | NS | NS | NA | | |
| | | | | | 7 | SS | 10.5, 16 | NS | NS | NA | | |
| | | | | | 8 | SS | 37 | NS | NS | NA | | |
| | | | | | 9 | SS | 6, 13 | NS | NS | NA | | PVC Well Casing |
| | | | | | 10 | SS | 12, 23.5 | NS | NS | NA | | |
| | | | | | 11 | SS | 12, 26.5 | NS | NS | NA | | |
| | | | | | 12 | SS | 27, 18 | NS | NS | NA | | |
| | | | | | 13 | SS | 9, 16 | NS | NS | NA | | |
| | | | | | 14 | SS | 25, 33.5 | NS | NS | NA | | Silica Sand Packing |
| | | | | | 15 | SS | 11.5, 22 | NS | NS | NA | | |
| | | | | | 16 | SS | Refusal | NS | NS | NA | | |
| | | | | | | | | | | | | |
| | | | Medium Grey Sand Lens | | 17 | SS | 18.5, 30 | NS | NS | NA | | |
| | | | Silty Clay Till | | 18 | SS | 34.5, 41 | NS | NS | NA | | |
| | | | | | 19 | SS | 14.5, 28 | NS | NS | NA | | 50 mmPVC"20 Slot" Well Screen |
| | | | | | 20 | SS | 21.5, 26 | NS | NS | NA | | |
| | | | | | 21 | SS | 11, 20 | NS | NS | NA | | |
| | | | | | 22 | SS | Refusal | NS | NS | NA | | |
| 15.0 | | | Limestone Bedrock | | | | | | | | | Well Point |

**Client:** *Fundy Gypsum Company*
**Project No:** *820677-K*
**Civic Address:** *Undeveloped land*
**City & Province:** *Miller's Creek Extention*
**PID Number:** *45286861*
**UTM Easting:** *412752.118*
**UTM Northing:** *4985892.197*
**Date Started:** *June 30, 2006*
**Date Finished:** *June 30, 2006*

**Drilling Contractor:** *Logan Drilling*
**Drill Type:** *CME*
**Drill Method:** *Hollow Stem Auger*
**Logged By:** *Sherman Jackson*
**TOC Elevation:** *0*
**GL Elevation:** *61.4 m*
**Final Depth:** *44.3 m*
**Depth to Water Strike:**
**Depth to Bedrock** *14.94 m*

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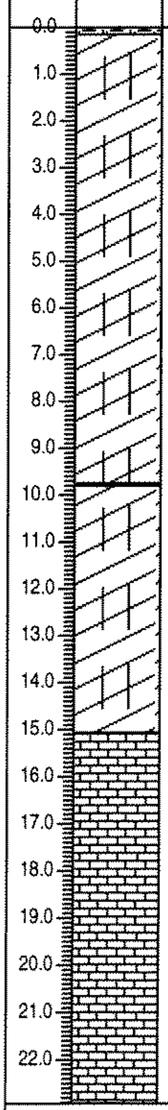
## Monitor Well: MW2 D

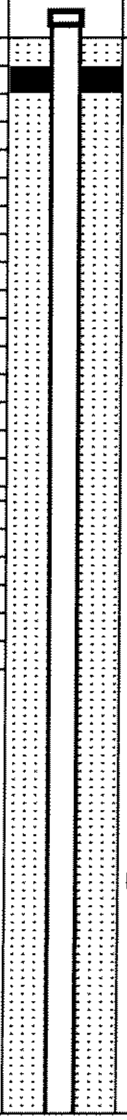
**Page:** *1 of 2*

Depth (m) | Lithology



| USCS Classification | Description | Elevation (mamsl) | Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Headspace (ppm/% LEL) | Analysis |
|---|---|---|---|---|---|---|---|---|
| | | 0.0 | | | | | | |
| | Surface Organics | | 1 | SS | 2 | NS | NS | NA |
| | Silty Clay Till | | 2 | SS | 3, 4.5 | NS | NS | NA |
| | | | 3 | SS | 14.5, 13 | NS | NS | NA |
| | | | 4 | SS | 14, 15 | NS | NS | NA |
| | | | 5 | SS | 14, 19 | NS | NS | NA |
| | | | 6 | SS | 5, 10.5 | NS | NS | NA |
| | | | 7 | SS | 10.5, 16 | NS | NS | NA |
| | | | 8 | SS | 37 | NS | NS | NA |
| | | | 9 | SS | 6, 13 | NS | NS | NA |
| | | | 10 | SS | 12, 23.5 | NS | NS | NA |
| | | | 11 | SS | 12, 26.5 | NS | NS | NA |
| | | | 12 | SS | 27, 18 | NS | NS | NA |
| | | | 13 | SS | 9, 16 | NS | NS | NA |
| | | | 14 | SS | 25, 33.5 | NS | NS | NA |
| | | | 15 | SS | 11.5, 22 | NS | NS | NA |
| | | | 16 | SS | Refusal | NS | NS | NA |
| | | | | | | | | |
| | Medium Grey Sand Lens | | 17 | SS | 18.5, 30 | NS | NS | NA |
| | Silty Clay Till | | 18 | SS | 34.5, 41 | NS | NS | NA |
| | | | 19 | SS | 14.5, 28 | NS | NS | NA |
| | | | 20 | SS | 21.5, 26 | NS | NS | NA |
| | | | 21 | SS | 11, 20 | NS | NS | NA |
| | | | 22 | SS | Refusal | NS | NS | NA |
| | Limestone Bedrock | | | | | | | |

Well Construction | Well Details



Stick Up Protector
Silica Sand Packing
Bentonite Plug
Silica Sand Packing
PVC Well Casing

**Client:** Fundy Gypsum Company

**Project No:** 820677-K

**Civic Address:** Undeveloped land

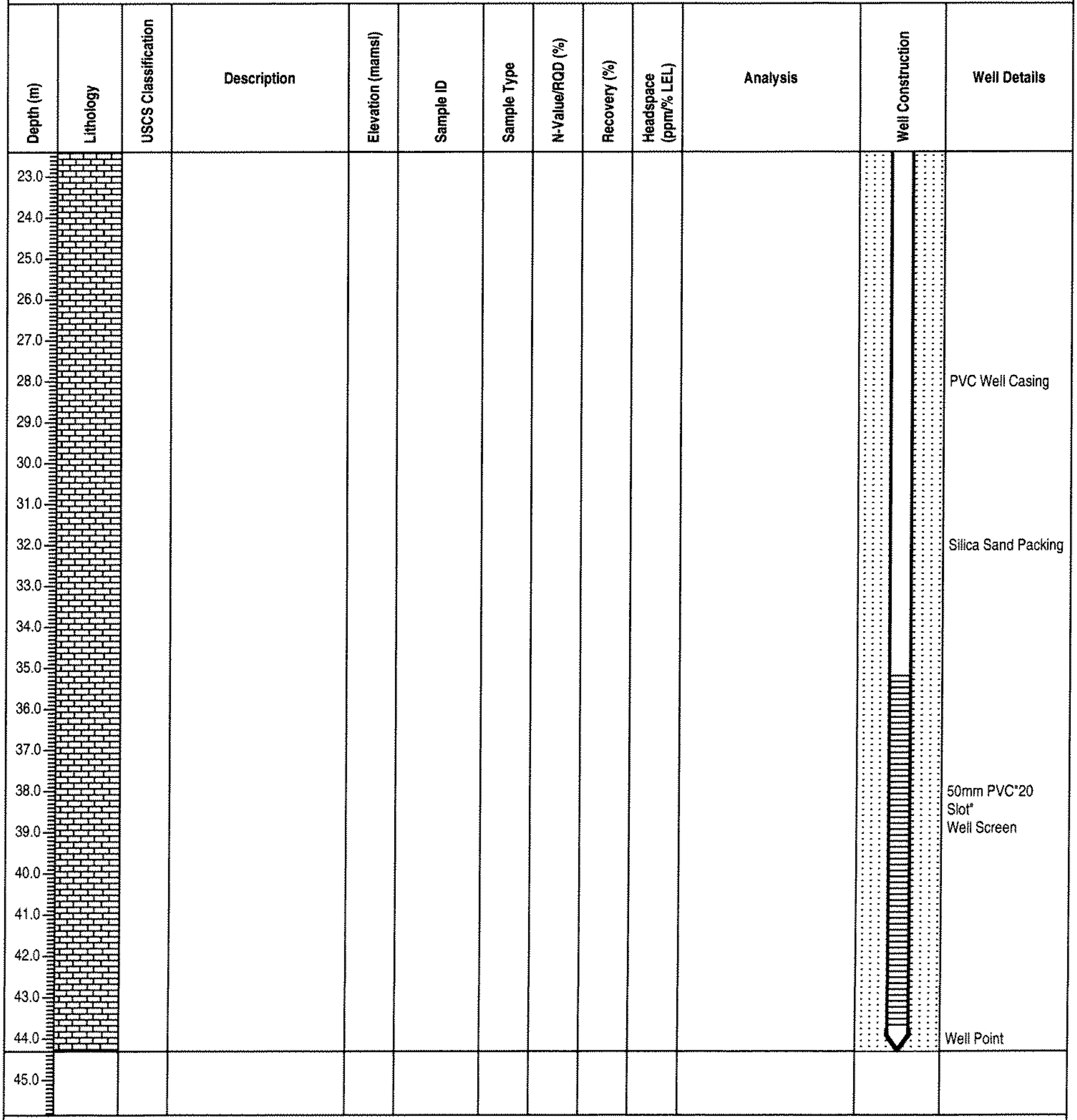
**City & Province:** Miller's Creek Extention

**Monitor Well:** MW2 D

**Page:** 2 of 2

CONESTOGA-ROVERS
& ASSOCIATES

# Monitor Well: MW2 D



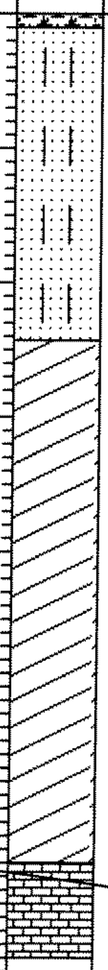
**Client:** *Fundy Gypsum Company*
**Project No:** *820677-K*
**Civic Address:** *Undeveloped land*
**City & Province:** *Miller's Creek extention*
**PID Number:** *45362431*
**UTM Easting:** *413165.206*
**UTM Northing:** *4987463.467*
**Date Started:** *July 6, 2006*
**Date Finished:** *July 6, 2006*

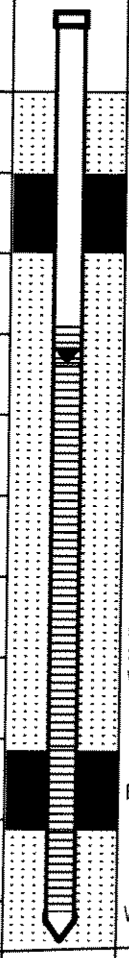
**Drilling Contractor:** *Logan Drilling*
**Drill Type:** *CME*
**Drill Method:** *Hollow Stem Auger*
**Logged By:** *Sherman Jackson*
**TOC Elevation:** *0*
**GL Elevation:** *62.51 m*
**Final Depth:** *6.3 m*
**Depth to Water Strike:** *2.02 m*
**Depth to Bedrock** *6.3 m*

CONESTOGA-ROVERS & ASSOCIATES

## Monitor Well: MW3 S

**Page:** *1 of 1*





| Depth (m) | Lithology | USCS Classification | Description | Elevation (mamsl) | Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Headspace (ppm/% LEL) | Analysis | Well Construction | Well Details |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | Stick Up Protector |
| 0.0 | | | Surface Organics<br>Silty Fine Sand With Minor Clasts | 0.0 | 1 | SS | 2, 3 | NS | NS | NA | | Silica Sand Packing |
| 1.0 | | | | | 2 | SS | 3, 3.5 | NS | NS | NA | | Bentonite Plug |
| | | | | | 3 | SS | 2.5, 2 | NS | NS | NA | | PVC Well Casing |
| 2.0 | | | | | 4 | SS | 4, 2 | NS | NS | NA | | |
| | | | Soft clay Till | | 5 | SS | 6, 10.5 | NS | NS | NA | | |
| 3.0 | | | | | 6 | SS | 6, 10 | NS | NS | NA | | Silica Sand Packing |
| 4.0 | | | | | 7 | SS | 16, 25 | NS | NS | NA | | 50mm PVC"20 Slot" Well Screen |
| | | | | | 8 | SS | 31.5, 16 | NS | NS | NA | | |
| 5.0 | | | | | 9 | SS | 11.5, 10 | NS | NS | NA | | Bentonite Plug |
| | | | | | 10 | SS | Refusal | NS | NS | NA | | |
| 6.0 | | | | | | | | | | | | Well Point |
| | | | Limestone Bedrock | | | | | | | | | |
| 7.0 | | | | | | | | | | | | |

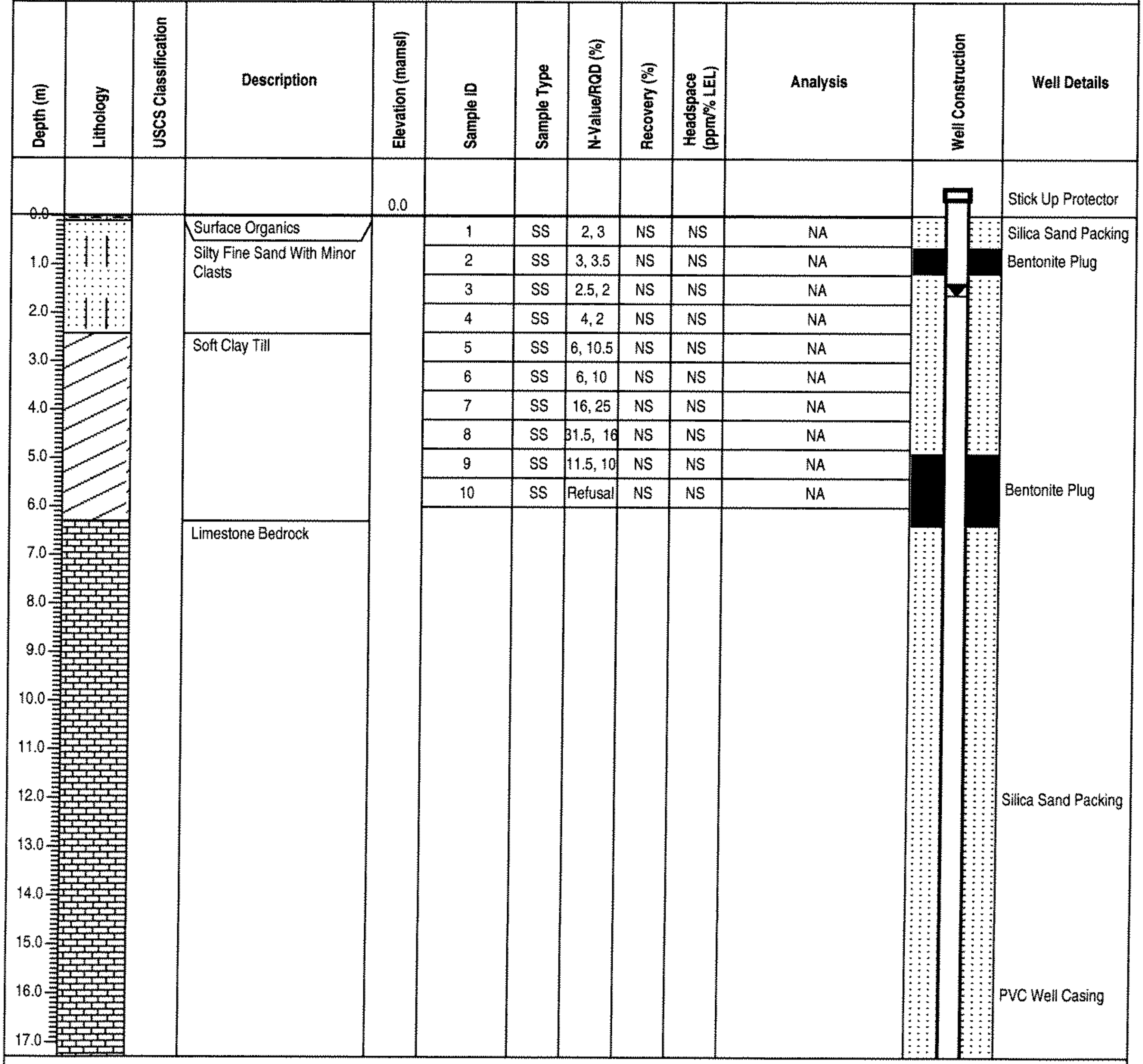
**Client:** *Fundy Gypsum Company*
**Project No:** *820677-K*
**Civic Address:** *Undeveloped land*
**City & Province:** *Miller's Creek extention*
**PID Number:** *45362431*
**UTM Easting:** *413165.206*
**UTM Northing:** *4987463.467*
**Date Started:** *July 6, 2006*
**Date Finished:** *July 6, 2006*

**Drilling Contractor:** *Logan Drilling*
**Drill Type:** *CME*
**Drill Method:** *Hollow Stem Auger*
**Logged By:** *Sherman Jackson*
**TOC Elevation:** *0*
**GL Elevation:** *62.51 m*
**Final Depth:** *34.3 m*
**Depth to Water Strike:** *1.63 m*
**Depth to Bedrock** *6.3 m*

CONESTOGA-ROVERS
& ASSOCIATES

# Monitor Well: MW3 D

**Page:** *1 of 2*



| Description | Elevation (mamsl) | Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Headspace (ppm/% LEL) | Analysis | Well Details |
|---|---|---|---|---|---|---|---|---|
| | 0.0 | | | | | | | Stick Up Protector |
| Surface Organics | | 1 | SS | 2, 3 | NS | NS | NA | Silica Sand Packing |
| Silty Fine Sand With Minor Clasts | | 2 | SS | 3, 3.5 | NS | NS | NA | Bentonite Plug |
| | | 3 | SS | 2.5, 2 | NS | NS | NA | |
| | | 4 | SS | 4, 2 | NS | NS | NA | |
| Soft Clay Till | | 5 | SS | 6, 10.5 | NS | NS | NA | |
| | | 6 | SS | 6, 10 | NS | NS | NA | |
| | | 7 | SS | 16, 25 | NS | NS | NA | |
| | | 8 | SS | 31.5, 16 | NS | NS | NA | |
| | | 9 | SS | 11.5, 10 | NS | NS | NA | |
| | | 10 | SS | Refusal | NS | NS | NA | Bentonite Plug |
| Limestone Bedrock | | | | | | | | Silica Sand Packing |
| | | | | | | | | PVC Well Casing |

**Client:** *Fundy Gypsum Company*

**Project No:** *820677-K*

**Civic Address:** *Undeveloped land*

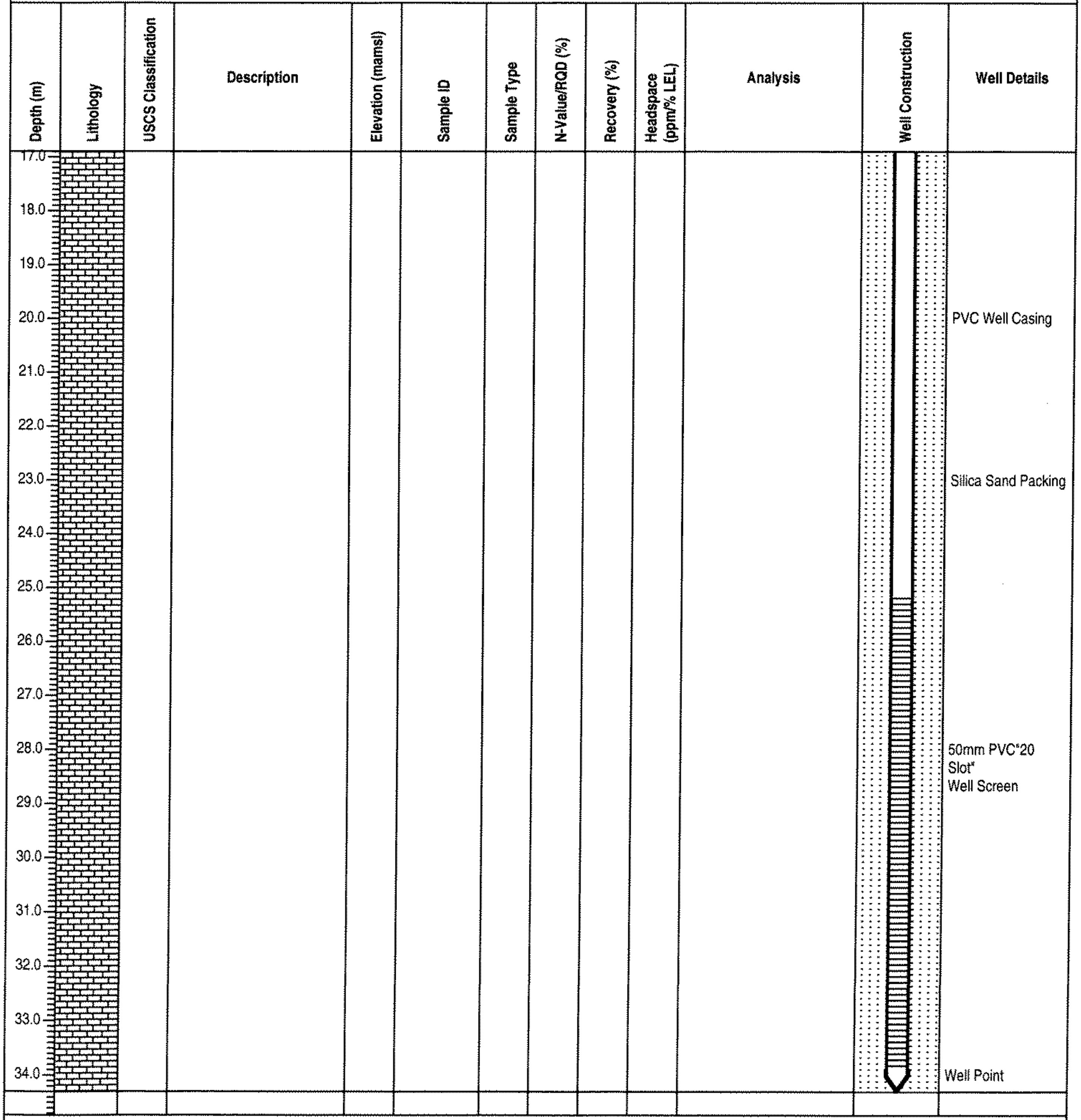
**City & Province:** *Miller's Creek extention*

**Monitor Well:** *MW3 D*

**Page:** *2 of 2*

CONESTOGA-ROVERS
& ASSOCIATES

# Monitor Well: MW3 D



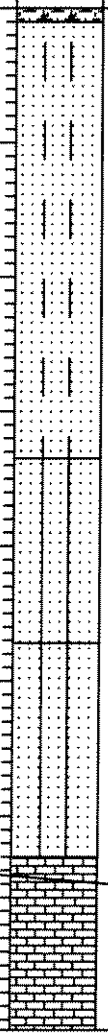
**Client:** *Fundy Gypsum Company*
**Project No:** *820677-K*
**Civic Address:** *Undeveloped land*
**City & Province:** *Miller's Creek Extention*
**PID Number:** *45194461*
**UTM Easting:** *415268.532*
**UTM Northing:** *4987756.477*
**Date Started:** *July 10, 2006*
**Date Finished:** *July 10, 2006*

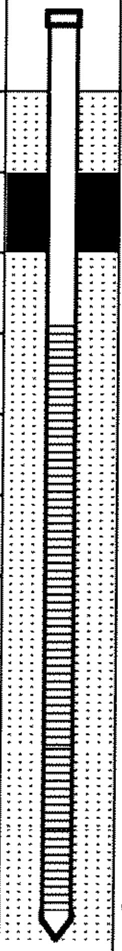
**Drilling Contractor:** *Logan Drilling*
**Drill Type:** *CME*
**Drill Method:** *Hollow Stem Auger*
**Logged By:** *Sherman Jackson*
**TOC Elevation:** *0*
**GL Elevation:** *25.11 m*
**Final Depth:** *6.4 m*
**Depth to Water Strike:**
**Depth to Bedrock** *6.4 m*

CONESTOGA-ROVERS & ASSOCIATES

# *Monitor Well: MW4 S*

**Page:** *1 of 1*





| Depth (m) | Lithology | USCS Classification | Description | Elevation (mamsl) | Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Headspace (ppm/% LEL) | Analysis | Well Construction | Well Details |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 0.0 | | | | | | | | Stick Up Protector |
| 0.0 | | | Surface Organics<br>Silty Fine Sand With Occasional Clasts | | 1 | SS | 3, 2.5 | NS | NS | NA | | Silica Sand Packing |
| 1.0 | | | | | 2 | SS | 7, 8.5 | NS | NS | NA | | Bentonite Plug |
| | | | | | 3 | SS | 4, 2 | NS | NS | NA | | PVC Well Casing |
| 2.0 | | | | | 4 | SS | 4, 5 | NS | NS | NA | | |
| | | | | | 5 | SS | 3, 6.5 | NS | NS | NA | | |
| 3.0 | | | Gray Sandy Silt | | 6 | SS | 4.5, 27 | NS | NS | NA | | Silica Sand Packing |
| 4.0 | | | | | 7 | SS | 9, 14 | NS | NS | NA | | 50mm PVC"20 Slot" Well Screen |
| | | | | | 8 | SS | 13, 25 | NS | NS | NA | | |
| 5.0 | | | Very Hard Molttled Red Grey Silty Clay Till | | 9 | SS | 9, 18.5 | NS | NS | NA | | |
| | | | | | 10 | SS | 38, 50 | NS | NS | NA | | |
| 6.0 | | | Limestoen Bedrock | | 11 | SS | Refusal | NS | NS | NA | | Well Point |
| 7.0 | | | | | | | | | | | | |

**Client:** *Fundy Gypsum Company*
**Project No:** *820677-K*
**Civic Address:** *Undeveloped land*
**City & Province:** *Miller's Creek extention*
**PID Number:** *45194461*
**UTM Easting:** *415268.532*
**UTM Northing:** *4987756.477*
**Date Started:** *July 10, 2006*
**Date Finished:** *July 10, 2006*

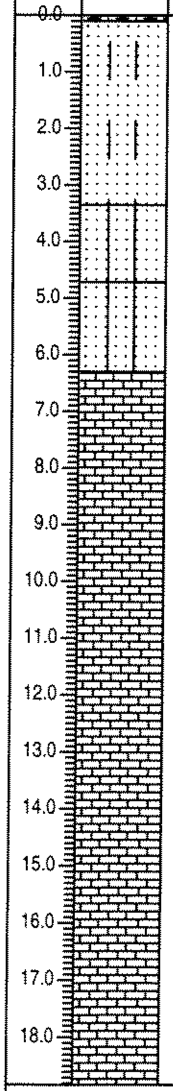
**Drilling Contractor:** *Logan Drilling*
**Drill Type:** *CME*
**Drill Method:** *Hollow Stem Auger*
**Logged By:** *Sherman Jackson*
**TOC Elevation:** *0*
**GL Elevation:** *25.11 m*
**Final Depth:** *36.5m*
**Depth to Water Strike:**
**Depth to Bedrock** *6.4 m*

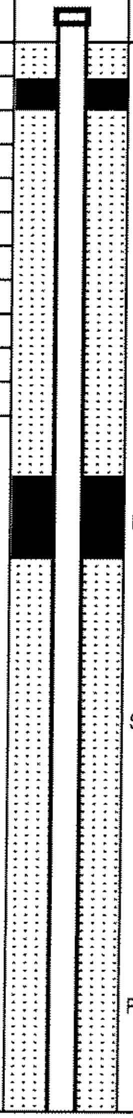
CONESTOGA-ROVERS & ASSOCIATES

## Monitor Well: MW4 D

**Page:** *1 of 2*

| Depth (m) | Lithology | USCS Classification | Description | Elevation (mamsl) | Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Headspace (ppm/% LEL) | Analysis | Well Construction | Well Details |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | | | | 0.0 | | | | | | | | Stick Up Protector |
| | | | Surface Organics | | 1 | SS | 3, 2.5 | NS | NS | NA | | Silica Sand Packing |
| | | | Silty fine Sand With Occasional Clasts | | 2 | SS | 7, 8.5 | NS | NS | NA | | Bentonite Plug |
| | | | | | 3 | SS | 4, 2 | NS | NS | NA | | |
| | | | | | 4 | SS | 4, 5 | NS | NS | NA | | |
| | | | | | 5 | SS | 3, 6.5 | NS | NS | NA | | |
| | | | Gray Sandy Silt | | 6 | SS | 4.5, 27 | NS | NS | NA | | |
| | | | | | 7 | SS | 9, 14 | NS | NS | NA | | |
| | | | | | 8 | SS | 13, 25 | NS | NS | NA | | |
| | | | Very Hard Molttled Red/Grey Silty Clay Till | | 9 | SS | 9, 18.5 | NS | NS | NA | | |
| | | | | | 10 | SS | 38, 50 | NS | NS | NA | | |
| | | | Limestoen Bedrock | | 11 | SS | Refusal | NS | NS | NA | | |
| | | | | | | | | | | | | Bentonite Plug |
| | | | | | | | | | | | | Silica Sand Packing |
| | | | | | | | | | | | | PVC Well Casing |

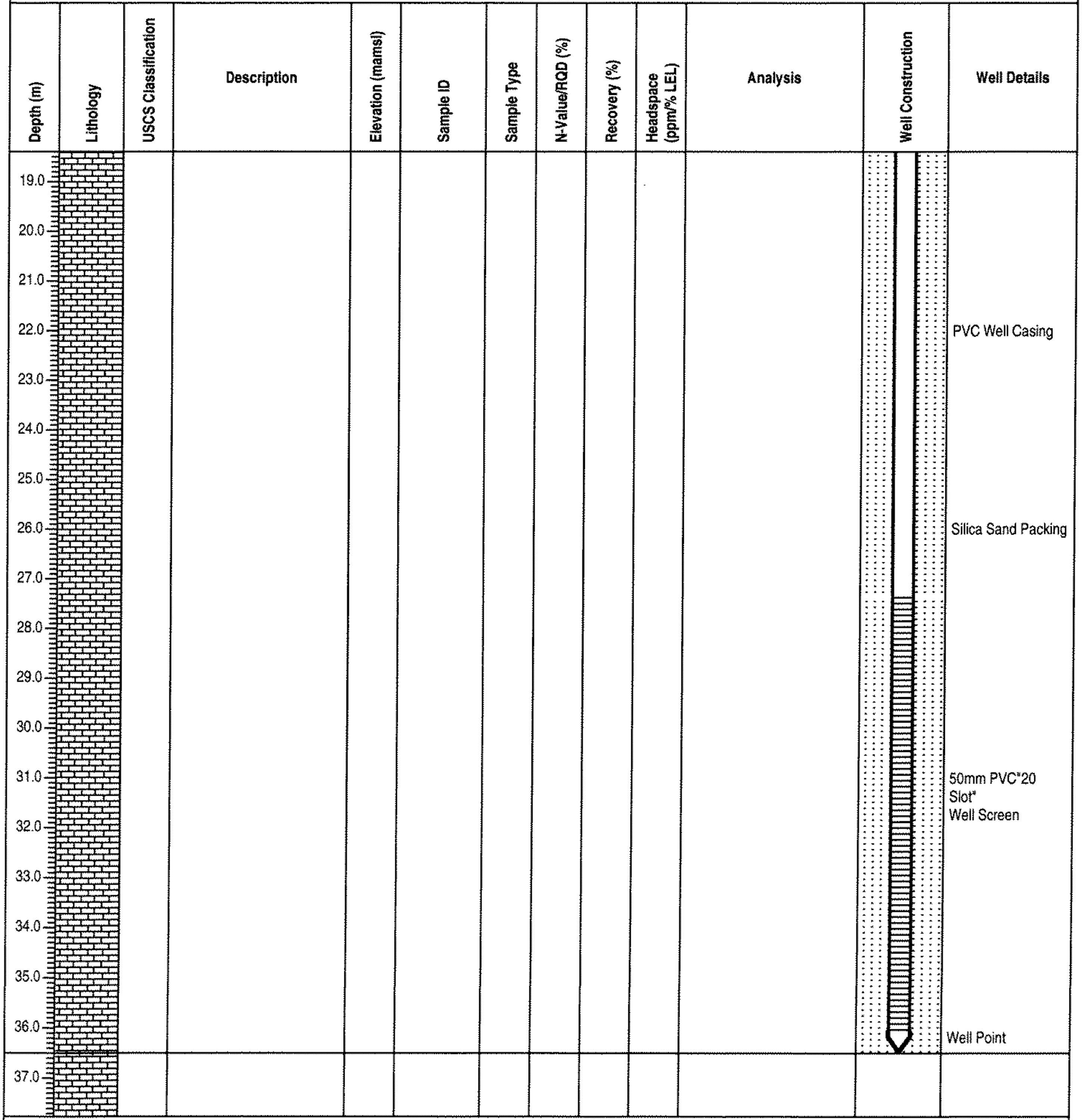




**Client:** *Fundy Gypsum Company*
**Project No:** *820677-K*
**Civic Address:** *Undeveloped land*
**City & Province:** *Miller's Creek extention*
**Monitor Well:** *MW4 D*
**Page:** *2 of 2*

CONESTOGA-ROVERS
& ASSOCIATES

## Monitor Well: MW4 D



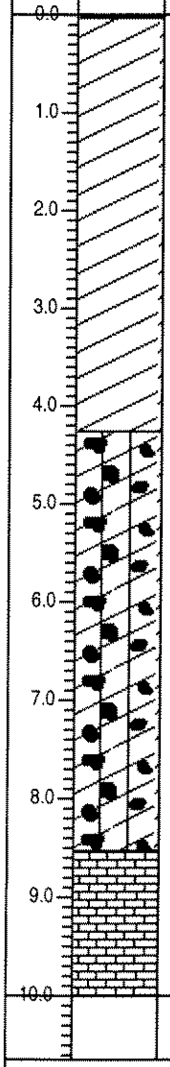
**Client:** *Fundy Gypsum Company*
**Project No:** *820677-K*
**Civic Address:** *Undeveloped land*
**City & Province:** *Miller's Creek extention*
**PID Number:** *45286994*
**UTM Easting:** *416110.154*
**UTM Northing:** *4986766.937*
**Date Started:** *June 29, 2006*
**Date Finished:** *June 29, 2006*

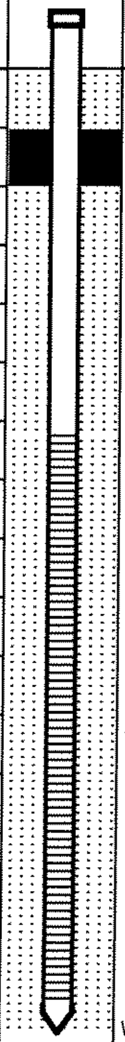
**Drilling Contractor:** *Logan Drilling*
**Drill Type:** *CME*
**Drill Method:** *Hollow Stem Auger*
**Logged By:** *Sherman Jackson*
**TOC Elevation:** *0*
**GL Elevation:** *38.86 m*
**Final Depth:** *9.8 m*
**Depth to Water Strike:** *Artesian*
**Depth to Bedrock** *8.53 m*

**CONESTOGA-ROVERS & ASSOCIATES**

## Monitor Well: MW5 S

**Page:** *1 of 1*





| Depth (m) | Lithology | USCS Classification | Description | Elevation (mamsl) | Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Headspace (ppm/% LEL) | Analysis | Well Construction | Well Details |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 0.0 | | | | | | | | Stick Up Protector |
| 0.0 | | | Surface Organics<br>Silty Clay Till | | 1 | SS | 1, 1 | NS | NS | NA | | Silica Sand Packing |
| | | | | | 2 | SS | 4.5, 6.5 | NS | NS | NA | | Bentonite Plug |
| | | | | | 3 | SS | 8.5, 11 | NS | NS | NA | | |
| | | | | | 4 | SS | 12.5, 19 | NS | NS | NA | | PVC Well Casing |
| | | | | | 5 | SS | 17.5, 23 | NS | NS | NA | | |
| | | | | | 6 | SS | 4, 16.5 | NS | NS | NA | | |
| | | | | | 7 | SS | 20, 23.5 | NS | NS | NA | | Silica Sand Packing |
| | | | Silty Clay Till With Higher Rock Content | | 8 | SS | 12, 19.5 | NS | NS | NA | | |
| | | | | | 9 | SS | 29, 29.5 | NS | NS | NA | | |
| | | | | | 10 | SS | 29, 33 | NS | NS | NA | | |
| | | | | | 11 | SS | 13, 21.5 | NS | NS | NA | | PVC"20 Slot" Screen |
| | | | | | 12 | SS | 36, 31 | NS | NS | NA | | |
| | | | | | 13 | SS | 30, 20 | NS | NS | NA | | |
| | | | | | 14 | SS | Refusal | | | | | |
| | | | Limestone Bedrock | | | | | | | | | Well Point |

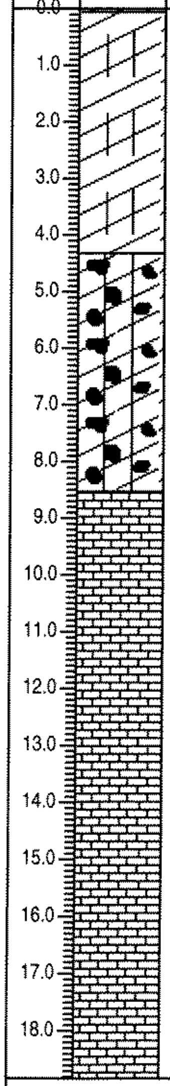
**Client:** *Fundy Gypsum Company*
**Project No:** *820677-K*
**Civic Address:** *Undeveloped land*
**City & Province:** *Miller's Creek extention*
**PID Number:** *45286994*
**UTM Easting:** *416110.154*
**UTM Northing:** *4986766.937*
**Date Started:** *June 28, 2006*
**Date Finished:** *June 29, 2006*

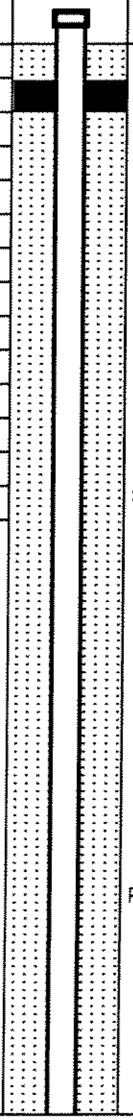
**Drilling Contractor:** *Logan Drilling*
**Drill Type:** *CME*
**Drill Method:** *Hollow Stem Auger*
**Logged By:** *Sherman Jackson*
**TOC Elevation:** *0*
**GL Elevation:** *38.86 m*
**Final Depth:** *37.6 m*
**Depth to Water Strike:** *Artesian*
**Depth to Bedrock** *8.23*

CONESTOGA-ROVERS & ASSOCIATES

# Monitor Well: MW5 D

**Page:** *1 of 2*



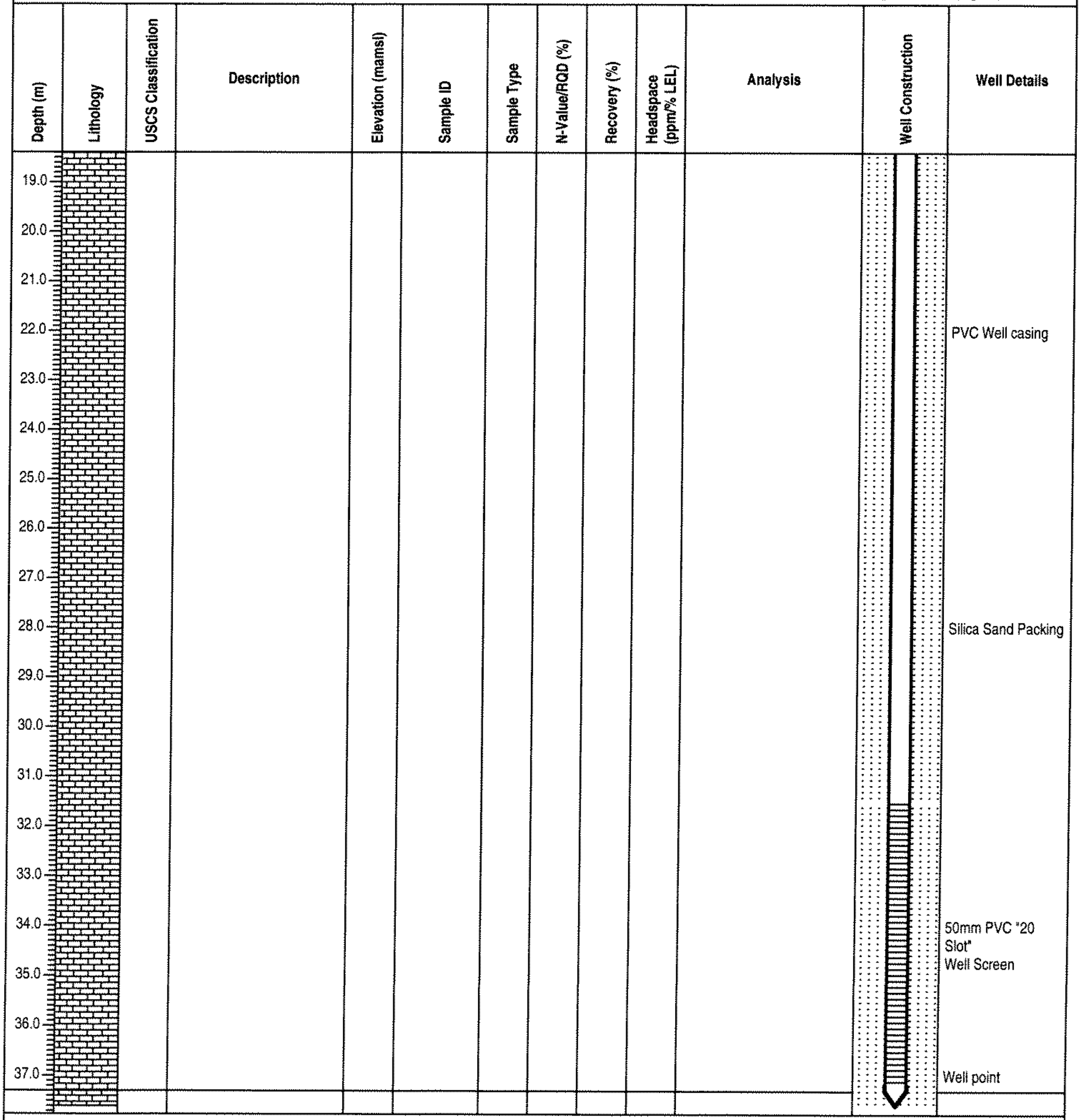


| Depth (m) | Lithology | USCS Classification | Description | Elevation (mamsl) | Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Headspace (ppm/% LEL) | Analysis | Well Construction | Well Details |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 0.0 | | | | | | | | Stick Up Protector |
| 0.0 | | | Surface Organics | | 1 | SS | 1, 1 | NA | NA | NA | | |
| 1.0 | | | Silty Clay Till | | 2 | SS | 4.5,6.5 | NA | NA | NA | | Bentonite Plug |
| | | | | | 3 | SS | 8.5, 11 | NA | NA | NA | | |
| 2.0 | | | | | 4 | SS | 12.5, 19 | NA | NA | NA | | |
| 3.0 | | | | | 5 | SS | 17.5, 23 | NA | NA | NA | | |
| | | | | | 6 | SS | 4, 16.5 | NA | NA | NA | | |
| 4.0 | | | | | 7 | SS | 20, 23.5 | NA | NA | NA | | |
| | | | Silty Clay Till With Higher Rock Content | | 8 | SS | 12, 19.5 | NA | NA | NA | | |
| 5.0 | | | | | 9 | SS | 29, 29.5 | NA | NA | NA | | |
| | | | | | 10 | SS | 29, 33 | NA | NA | NA | | |
| 6.0 | | | | | 11 | SS | 13, 21.5 | NA | NA | NA | | |
| 7.0 | | | | | 12 | SS | 36, 31 | NA | NA | NA | | |
| | | | | | 13 | SS | 30, 20 | NA | NA | NA | | |
| 8.0 | | | | | 14 | SS | Refusal | NA | NA | NA | | Silica Sand Packing |
| 9.0 | | | Limestone Bedrock | | | | | | | | | |
| 10.0 | | | | | | | | | | | | |
| 11.0 | | | | | | | | | | | | |
| 12.0 | | | | | | | | | | | | |
| 13.0 | | | | | | | | | | | | |
| 14.0 | | | | | | | | | | | | |
| 15.0 | | | | | | | | | | | | PVC Well Casing |
| 16.0 | | | | | | | | | | | | |
| 17.0 | | | | | | | | | | | | |
| 18.0 | | | | | | | | | | | | |

**Client:** *Fundy Gypsum Company*
**Project No:** *820677-K*
**Civic Address:** *Undeveloped land*
**City & Province:** *Miller's Creek extention*
**Monitor Well:** *MW5 D*
**Page:** *2 of 2*

**CONESTOGA-ROVERS**
**& ASSOCIATES**

## Monitor Well: MW5 D

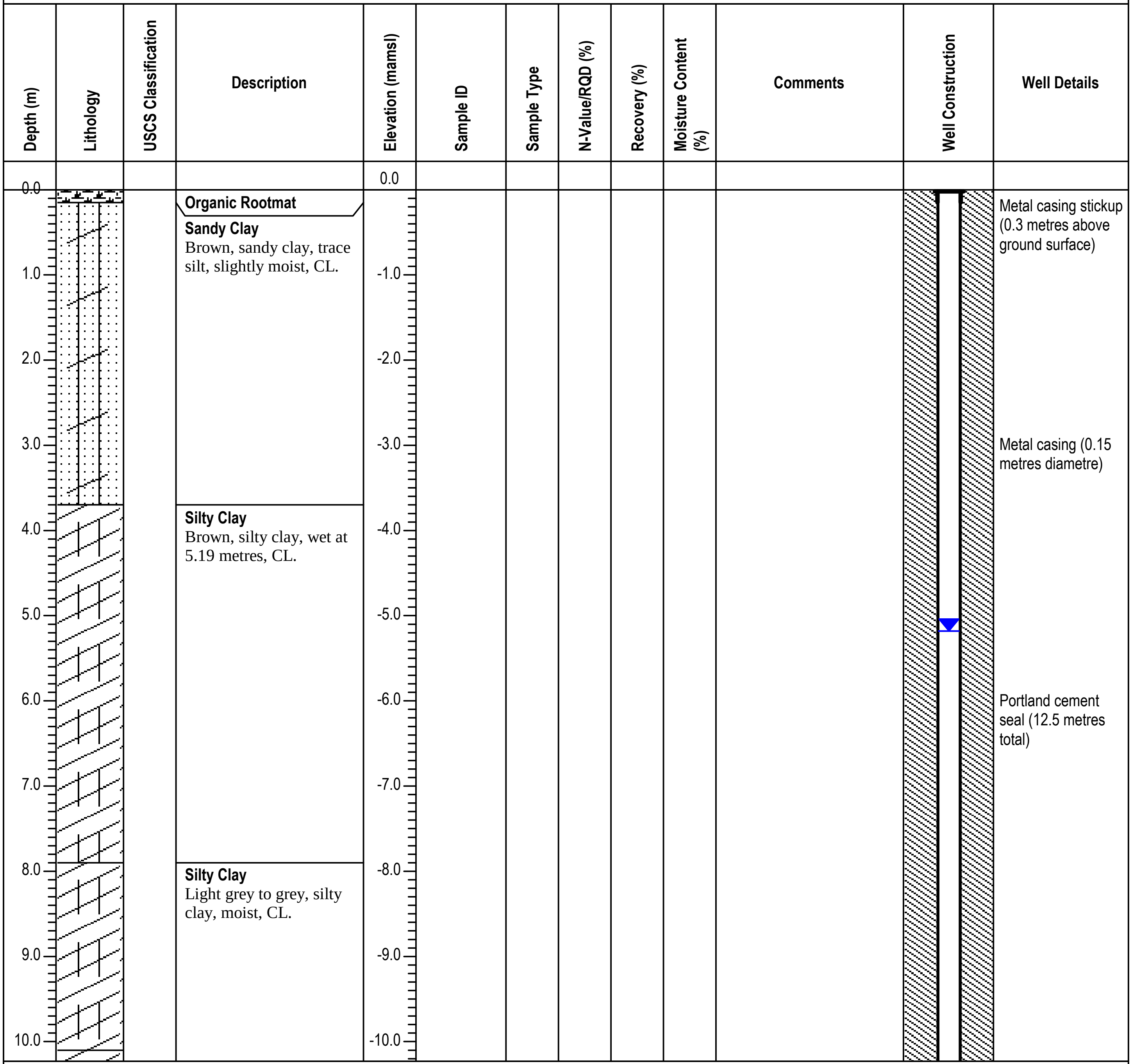


Client: **CGC Inc.**
Project No: **820677-K**
Civic Address: **Miller's Creek Extension**
City & Province: **Windsor Plant, NS**
PID Number:
UTM Easting: **0**
UTM Northing: **0**
Date Started: **March 28, 2009**
Date Finished: **April 2, 2009**

Drilling Contractor: **Logan Geotech Inc.**
Drill Type: **CME 75**
Drill Method: **Hollow Stem & Rock Coring**
Logged By: **Richard Hollet**
TOC Elevation: **N/A**
GL Elevation: **N/A**
Final Depth: **54.0 metres**
Depth to Water Strike: **5.19 metres**
Depth to Bedrock **11.0 metres**

# Monitor Well: MW6

Page: **1 of 6**



**Organic Rootmat**

**Sandy Clay**
Brown, sandy clay, trace silt, slightly moist, CL.

**Silty Clay**
Brown, silty clay, wet at 5.19 metres, CL.

**Silty Clay**
Light grey to grey, silty clay, moist, CL.

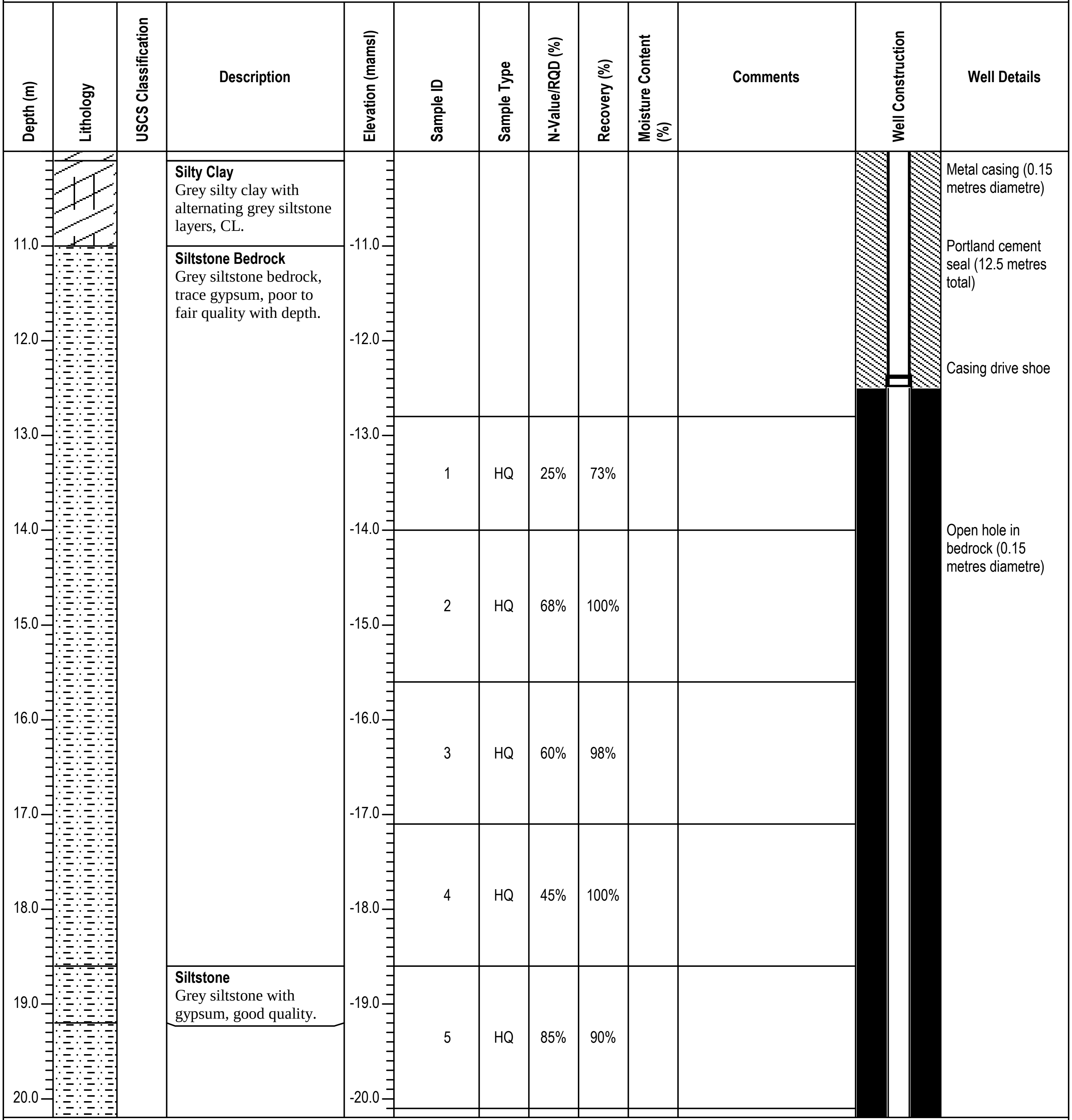
Metal casing stickup (0.3 metres above ground surface)

Metal casing (0.15 metres diametre)

Portland cement seal (12.5 metres total)

Client: **CGC Inc.**
Project No: **820677-K**
Civic Address: **Miller's Creek Extension**
City & Province: **Windsor Plant, NS**
Monitor Well: **MW6**
Page: **2 of 6**

# Monitor Well: MW6



| Depth (m) | Lithology | USCS Classification | Description | Elevation (mamsl) | Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Moisture Content (%) | Comments | Well Construction | Well Details |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **Silty Clay** Grey silty clay with alternating grey siltstone layers, CL. | | | | | | | | | Metal casing (0.15 metres diametre) |
| 11.0 | | | **Siltstone Bedrock** Grey siltstone bedrock, trace gypsum, poor to fair quality with depth. | -11.0 | | | | | | | | Portland cement seal (12.5 metres total) |
| 12.0 | | | | -12.0 | | | | | | | | Casing drive shoe |
| 13.0 | | | | -13.0 | 1 | HQ | 25% | 73% | | | | |
| 14.0 | | | | -14.0 | | | | | | | | Open hole in bedrock (0.15 metres diametre) |
| 15.0 | | | | -15.0 | 2 | HQ | 68% | 100% | | | | |
| 16.0 | | | | -16.0 | 3 | HQ | 60% | 98% | | | | |
| 17.0 | | | | -17.0 | | | | | | | | |
| 18.0 | | | | -18.0 | 4 | HQ | 45% | 100% | | | | |
| 19.0 | | | **Siltstone** Grey siltstone with gypsum, good quality. | -19.0 | 5 | HQ | 85% | 90% | | | | |
| 20.0 | | | | -20.0 | | | | | | | | |

*Client:* ***CGC Inc.***

*Project No:* ***820677-K***

*Civic Address:* ***Miller's Creek Extension***

*City & Province:* ***Windsor Plant, NS***

*Monitor Well:* ***MW6***

*Page:* ***3 of 6***

CONESTOGA-ROVERS
& ASSOCIATES

# *Monitor Well: MW6*

| Depth (m) | Lithology | USCS Classification | Description | Elevation (mamsl) | Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Moisture Content (%) | Comments | Well Construction | Well Details |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **Siltstone**<br>Brown and grey alternating siltstone layers, trace gypsum, good to fair quality with depth. | | | | | | | | | |
| 21.0 | | | | -21.0 | 6 | HQ | 63% | 100% | | | | |
| | | | **Siltstone**<br>Brown siltstone, fair quality. | | | | | | | | | |
| 22.0 | | | | -22.0 | | | | | | | | |
| | | | | | 7 | HQ | 53% | 97% | | | | |
| 23.0 | | | | -23.0 | | | | | | | | Open hole in bedrock (0.15 metres diametre) |
| 24.0 | | | | -24.0 | 8 | HQ | 47% | 98% | | | | |
| 25.0 | | | | -25.0 | | | | | | | | |
| | | | | | 9 | HQ | 53% | 80% | | | | |
| 26.0 | | | | -26.0 | | | | | | | | |
| 27.0 | | | | -27.0 | 10 | HQ | 52% | 100% | | | | |
| 28.0 | | | | -28.0 | 11 | HQ | 58% | 100% | | | | |
| | | | **Siltstone**<br>Grey siltstone intermixed with layer of gypsum, fair quality. | | 12 | HQ | 70% | 88% | | | | |
| 29.0 | | | | -29.0 | | | | | | | | |
| 30.0 | | | | -30.0 | | | | | | | | |

Client: **CGC Inc.**

Project No: **820677-K**

Civic Address: **Miller's Creek Extension**

City & Province: **Windsor Plant, NS**

Monitor Well: **MW6**

Page: **4 of 6**

CONESTOGA-ROVERS & ASSOCIATES

# Monitor Well: MW6

| Depth (m) | Description | Elevation (mamsl) |
|---|---|---|
| | **Siltstone**<br>Brown siltstone, good quality. | |
| 31.0 | **Gypsum**<br>Grey gypsum, good quality. | -31.0 |
| 32.0 | | -32.0 |
| 33.0 | **Siltstone**<br>Brown siltstone, good quality. | -33.0 |
| 34.0 | | -34.0 |
| 35.0 | **Gypsum** | -35.0 |
| | **Siltstone**<br>Brown siltstone, excellent to good quality with depth. | |
| 36.0 | | -36.0 |
| 37.0 | | -37.0 |
| | **Limestone**<br>Grey limestone | |
| 38.0 | **Siltstone**<br>Brown siltstone with bands of gypsum (0.11 metres thickness), excellent quality. | -38.0 |
| 39.0 | **Limestone**<br>Grey limestone | -39.0 |
| | **Siltstone**<br>Brown siltstone, excellent quality. | |
| 40.0 | | -40.0 |

| Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Moisture Content (%) | Comments |
|---|---|---|---|---|---|
| 13 | HQ | 83% | 100% | | |
| 14 | HQ | 88% | 98% | | |
| 15 | HQ | 73% | 98% | | |
| 16 | HQ | 95% | 100% | | |
| 17 | HQ | 86% | 98% | | |
| 18 | HQ | 97% | 98% | | |
| 19 | HQ | 95% | 95% | | |

Well Details: Open hole in bedrock (0.15 metres diametre)

Client: **CGC Inc.**
Project No: **820677-K**
Civic Address: **Miller's Creek Extension**
City & Province: **Windsor Plant, NS**
Monitor Well: **MW6**
Page: **5 of 6**

CONESTOGA-ROVERS & ASSOCIATES

# Monitor Well: MW6

| Depth (m) | Description | Elevation (mamsl) |
|---|---|---|
| | **Limestone**<br>Grey limestone, excellent quality. | |
| 41.0 | | -41.0 |
| | **Limestone**<br>Grey limestone with band of gypsum (0.01 metres thickness), excellent quality. | |
| 42.0 | | -42.0 |
| 43.0 | | -43.0 |
| | **Siltstone**<br>Brown siltstone, excellent quality. | |
| 44.0 | | -44.0 |
| | **Limestone**<br>Grey limestone, excellent quality. | |
| | **Gypsum**<br>Gypsum, excellent quality. | |
| 45.0 | | -45.0 |
| 46.0 | | -46.0 |
| | **Siltstone**<br>Brown siltstone, with gypsum seam (0.05 metres thickness between 47.9 and 49.4 metres below ground surface). | |
| 47.0 | | -47.0 |
| 48.0 | | -48.0 |
| | **Gypsum**<br>Grey gypsum, excellent quality. | |
| 49.0 | | -49.0 |
| | **Siltstone**<br>Brown siltstone, excellent quality. | |
| 50.0 | | -50.0 |

| Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Moisture Content (%) | Comments |
|---|---|---|---|---|---|
| 20 | HQ | 98% | 98% | | |
| 21 | HQ | 97% | 100% | | |
| 22 | HQ | 90% | 95% | | |
| 23 | HQ | 92% | 98% | | |
| 24 | HQ | 98% | 98% | | |
| 25 | HQ | 93% | 98% | | |

Well Details: Open hole in bedrock (0.15 metres diametre)

*Client:* **CGC Inc.**

*Project No:* **820677-K**

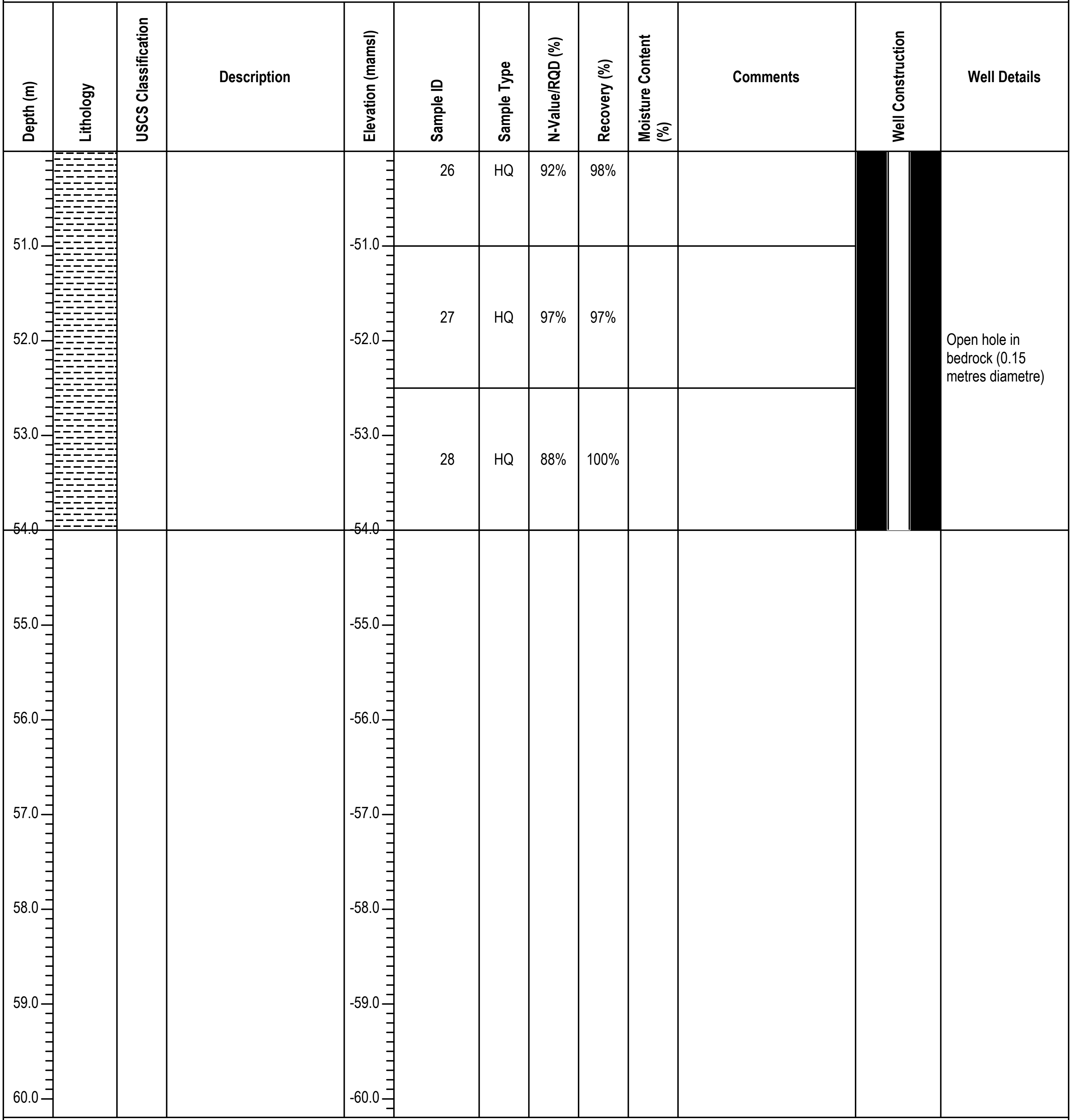
*Civic Address:* **Miller's Creek Extension**

*City & Province:* **Windsor Plant, NS**

*Monitor Well:* **MW6**

*Page:* **6 of 6**

# Monitor Well: MW6



| Depth (m) | Lithology | USCS Classification | Description | Elevation (mamsl) | Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Moisture Content (%) | Comments | Well Construction | Well Details |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 26 | HQ | 92% | 98% | | | | |
| | | | | | 27 | HQ | 97% | 97% | | | | Open hole in bedrock (0.15 metres diametre) |
| | | | | | 28 | HQ | 88% | 100% | | | | |

Fredericton, NB Corner Brook, NL St. John's, NL Dartmouth, NS Sydney, NS Charlottetown, PEI

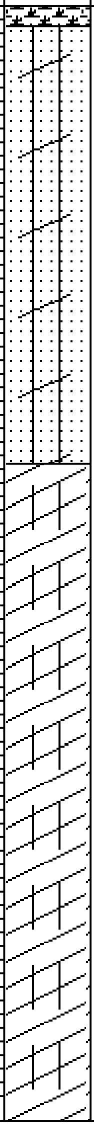
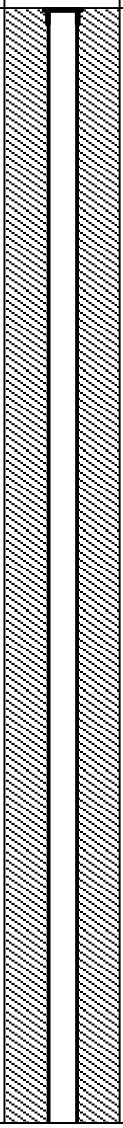
**Client:** CGC Inc.
**Project No:** 820677-K
**Civic Address:** Miller's Creek Extension
**City & Province:** Windsor Plant, NS
**PID Number:**
**UTM Easting:** 0
**UTM Northing:** 0
**Date Started:** April 10, 2009
**Date Finished:** April 22, 2009

**Drilling Contractor:** Logan Geotech Inc.
**Drill Type:** CME 75
**Drill Method:** HWT Casing & Rock Coring
**Logged By:** Richard Hollet; Rob Tucker
**TOC Elevation:** N/A
**GL Elevation:** N/A
**Final Depth:** 53.7 metres
**Depth to Water Strike:** Artesian
**Depth to Bedrock** 10.5 metres

CONESTOGA-ROVERS & ASSOCIATES

# Monitor Well: MW7

**Page:** 1 of 7

| Depth (m) | Lithology | USCS Classification | Description | Elevation (mamsl) | Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Moisture Content (%) | Comments | Well Construction | Well Details |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 |  | | **Organic Rootmat** | 0.0 | | | | | | |  | Metal casing stickup (0.25 metres above ground surface) |
| | | | **Sandy Clay**<br>Brown, sandy clay, trace silt and fine gravel, dry to slightly moist, CL. | | | | | | | | | |
| 1.0 | | | | -1.0 | | | | | | | | |
| 2.0 | | | | -2.0 | | | | | | | | Metal casing (0.15 meters diametre) |
| 3.0 | | | | -3.0 | | | | | | | | |
| | | | **Silty Clay**<br>Brown, silty clay, trace fine gravel, wet at 5.18 metres, CL. | | | | | | | | | |
| 4.0 | | | | -4.0 | | | | | | | | Portland cement seal (12.5 metres total) |
| 5.0 | | | | -5.0 | | | | | | | | |
| 6.0 | | | | -6.0 | | | | | | | | |
| 7.0 | | | | -7.0 | | | | | | | | |
| 8.0 | | | | -8.0 | | | | | | | | |

*Client:* ***CGC Inc.***

*Project No:* ***820677-K***

*Civic Address:* ***Miller's Creek Extension***

*City & Province:* ***Windsor Plant, NS***

*Monitor Well:* ***MW7***

*Page:* ***2 of 7***

# *Monitor Well: MW7*

| Depth (m) | Lithology | USCS Classification | Description | Elevation (mamsl) | Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Moisture Content (%) | Comments | Well Construction | Well Details |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 9.0 | | | | -9.0 | | | | | | | | Metal casing (0.15 meters diametre) |
| 10.0 | | | | -10.0 | | | | | | | | Portland cement seal (12.5 metres total) |
| 11.0 | | | **Siltstone Bedrock**<br>Brown siltstone bedrock, wet, very poor rock quality. | -11.0 | | | | | | | | |
| 12.0 | | | | -12.0 | | | | | | | | Casing drive shoe |
| 13.0 | | | | -13.0 | 1 | HQ | 25% | 100% | | | | |
| 14.0 | | | **Limestone**<br>Grey limestone,trace gypsum, fair rock quality. | -14.0 | 2 | HQ | 60% | 100% | | | | Open hole in bedrock (0.15 metres diametre) |
| 15.0 | | | **Siltstone**<br>Brown siltstone, trace limestone, fair to good rock quality. | -15.0 | | | | | | | | |
| 16.0 | | | | -16.0 | | | | | | | | |

*Client:* ***CGC Inc.***

*Project No:* ***820677-K***

*Civic Address:* ***Miller's Creek Extension***

*City & Province:* ***Windsor Plant, NS***

*Monitor Well:* ***MW7***

*Page:* ***3 of 7***

CONESTOGA-ROVERS
& ASSOCIATES

# Monitor Well: MW7

| Depth (m) | Elevation (mamsl) | Description |
|---|---|---|
| | | **Gypsum**<br>Grey gypsum, trace limestone and siltstone, good rock quality. |
| 17.0 | -17.0 | **Siltstone**<br>Grey siltstone, trace gypsum and limestone, good rock quality. |
| 18.0 | -18.0 | **Siltstone**<br>Brown siltstone, trace gypsum, good rock quality. |
| 19.0 | -19.0 | |
| 20.0 | -20.0 | **Gypsum**<br>Grey gypsum, trace limestone, good rock quality. |
| | | **Siltstone**<br>Grey siltstone,excellent rock quality. |
| 21.0 | -21.0 | **Siltstone**<br>Brown siltstone, trace gypsum, excellent rock quality. |
| 22.0 | -22.0 | **Siltstone**<br>Grey siltstone, trace gypsum, excellent rock quality. |
| | | **Siltstone**<br>Brown siltstone, trace gypsum, excellent rock quality. |
| 23.0 | -23.0 | **Siltstone**<br>Grey siltstone, trace gypsum, excellent rock quality. |
| 24.0 | -24.0 | |

| Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Moisture Content (%) | Comments |
|---|---|---|---|---|---|
| 3 | HQ | 87% | 100% | | |
| 4 | HQ | 87% | 100% | | |
| 5 | HQ | 80% | 100% | | |
| 6 | HQ | 98% | 100% | | |
| 7 | HQ | 97% | 100% | | |
| 8 | HQ | 98% | 100% | | |

Well Details: Open hole in bedrock (0.15 metres diametre)

*Client:* ***CGC Inc.***

*Project No:* ***820677-K***

*Civic Address:* ***Miller's Creek Extension***

*City & Province:* ***Windsor Plant, NS***

*Monitor Well:* ***MW7***

*Page:* ***4 of 7***

**CONESTOGA-ROVERS**
& ASSOCIATES

# *Monitor Well: MW7*

| Depth (m) | Lithology | USCS Classification | Description | Elevation (mamsl) | Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Moisture Content (%) | Comments | Well Construction | Well Details |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **Siltstone**<br>Brown siltstone, trace gypsum and limestone,excellent rock quality. | | | | | | | | | |
| 25.0 | | | **Limestone**<br>Grey limestone, trace gypsum, excellent rock quality. | -25.0 | | | | | | | | |
| 26.0 | | | **Siltstone**<br>brown siltstone, trace gypsum, excellent rock quality. | -26.0 | 9 | HQ | 90% | 100% | | | | |
| | | | **Limestone**<br>Grey limestone, trace gypsum, excellent rock quality. | | | | | | | | | |
| 27.0 | | | **Siltstone**<br>Brown siltstone, trace limestone and gypsum, excellent rock quality. | -27.0 | 10 | HQ | 97% | 100% | | | | Open hole in bedrock (0.15 metres diametre) |
| 28.0<br>29.0 | | | **Limestone**<br>Light grey limestone, some gypsum, trace grey siltstone, excellent rock quality. | -28.0<br>-29.0 | 11 | HQ | 100% | 100% | | | | |
| 30.0 | | | **Siltstone**<br>Brown siltstone, trace limestone and gypsum, excellent rock quality. | -30.0 | 12 | HQ | 100% | 100% | | | | |
| 31.0 | | | **Siltstone**<br>Grey siltstone, trace gypsum, excellent rock quality. | -31.0 | | | | | | | | |
| 32.0 | | | **Siltstone**<br>Brown siltstone, trace gypsum and limestone, excellent rock quality. | -32.0 | 13 | HQ | 100% | 100% | | | | |

*Client:* ***CGC Inc.***

*Project No:* ***820677-K***

*Civic Address:* ***Miller's Creek Extension***

*City & Province:* ***Windsor Plant, NS***

*Monitor Well:* ***MW7***

*Page:* ***5 of 7***

CONESTOGA-ROVERS
& ASSOCIATES

# Monitor Well: MW7

| Depth (m) | Lithology | USCS Classification | Description | Elevation (mamsl) | Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Moisture Content (%) | Comments | Well Construction | Well Details |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **Siltstone**<br>Grey siltstone, trace gypsum and limestone, excellent rock quality. | | | | | | | | | |
| 33.0 | | | | -33.0 | 14 | HQ | 99% | 100% | | | | |
| | | | **Gypsum**<br>Light grey gypsum, trace limestone and grey siltstone, excellent rock quality. | | | | | | | | | |
| 34.0 | | | **Siltstone**<br>Brown siltstone, trace limestone and gypsum, excellent rock quality. | -34.0 | | | | | | | | |
| | | | | | 15 | HQ | 100% | 100% | | | | |
| | | | **Sandstone**<br>Brown sandstone, trace siltstone, excellent rock quality. | | | | | | | | | |
| 35.0 | | | | -35.0 | | | | | | | | Open hole in bedrock (0.15 metres diametre) |
| 36.0 | | | | -36.0 | 16 | HQ | 100% | 100% | | | | |
| | | | **Siltstone**<br>Light brown siltstone, trace sandstone, limestone, and gypsum, excellent rock quality. | | | | | | | | | |
| 37.0 | | | | -37.0 | | | | | | | | |
| | | | **Sandstone**<br>Brown sandstone, trace siltstone and gypsum, excellent rock quality. | | 17 | HQ | 99% | 100% | | | | |
| 38.0 | | | | -38.0 | | | | | | | | |
| 39.0 | | | | -39.0 | 18 | HQ | 100% | 100% | | | | |
| 40.0 | | | | -40.0 | | | | | | | | |

*Client:* ***CGC Inc.***

*Project No:* ***820677-K***

*Civic Address:* ***Miller's Creek Extension***

*City & Province:* ***Windsor Plant, NS***

*Monitor Well:* ***MW7***

*Page:* ***6 of 7***

**CONESTOGA-ROVERS & ASSOCIATES**

## Monitor Well: MW7

| Depth (m) | Lithology | USCS Classification | Description | Elevation (mamsl) | Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Moisture Content (%) | Comments | Well Construction | Well Details |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 41.0 | | | **Siltstone** Brown siltstone, trace sandstone and gypsum, excellent rock quality. | -41.0 | 19 | HQ | 100% | 100% | | | | Open hole in bedrock (0.15 metres diametre) |
| 42.0 | | | **Gypsum** Light grey gypsum, some grey siltstone, trace limestone, excellent rock quality. | -42.0 | 20 | HQ | 100% | 100% | | | | |
| 43.0 | | | **Sandstone** Brown sandstone, trace siltstone and gypsum, excellent rock quality | -43.0 | 21 | HQ | 93% | 100% | | | | |
| 44.0<br>45.0 | | | **Gypsum** Light grey gypsum, trace siltstone, sandstone, and limestone, excellent rock quality. | -44.0<br>-45.0 | 22 | HQ | 99% | 100% | | | | |
| 46.0<br>47.0 | | | | -46.0<br>-47.0 | 23 | HQ | 99% | 100% | | | | |
| 48.0 | | | | -48.0 | | | | | | | | |

*Client:* ***CGC Inc.***

*Project No:* ***820677-K***

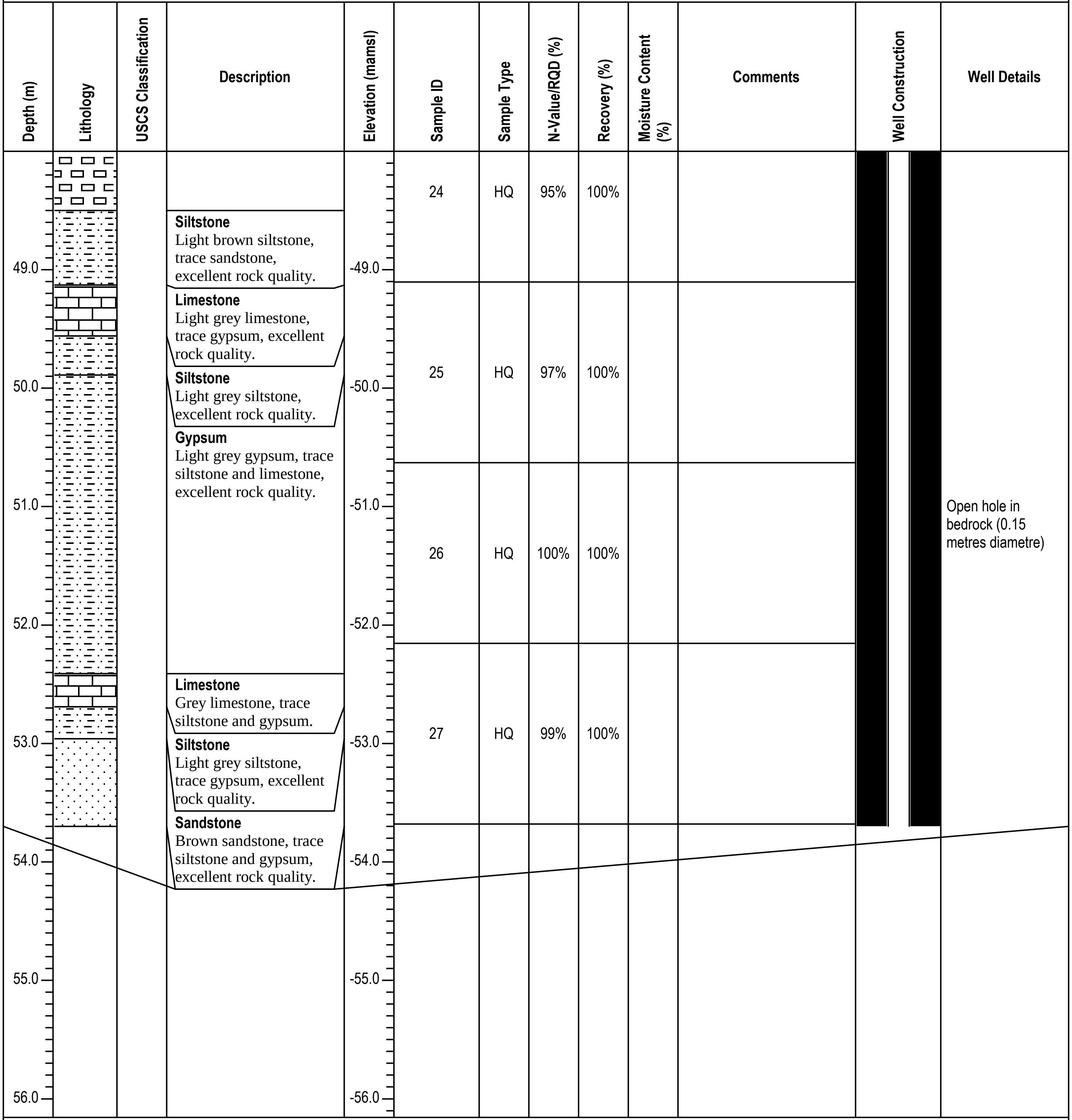
*Civic Address:* ***Miller's Creek Extension***

*City & Province:* ***Windsor Plant, NS***

*Monitor Well:* ***MW7***

*Page:* ***7 of 7***

# *Monitor Well: MW7*



| Description |
|---|
| **Siltstone**<br>Light brown siltstone, trace sandstone, excellent rock quality. |
| **Limestone**<br>Light grey limestone, trace gypsum, excellent rock quality. |
| **Siltstone**<br>Light grey siltstone, excellent rock quality. |
| **Gypsum**<br>Light grey gypsum, trace siltstone and limestone, excellent rock quality. |
| **Limestone**<br>Grey limestone, trace siltstone and gypsum. |
| **Siltstone**<br>Light grey siltstone, trace gypsum, excellent rock quality. |
| **Sandstone**<br>Brown sandstone, trace siltstone and gypsum, excellent rock quality. |

| Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Moisture Content (%) | Comments |
|---|---|---|---|---|---|
| 24 | HQ | 95% | 100% | | |
| 25 | HQ | 97% | 100% | | |
| 26 | HQ | 100% | 100% | | |
| 27 | HQ | 99% | 100% | | |

**Well Details**

Open hole in bedrock (0.15 metres diametre)

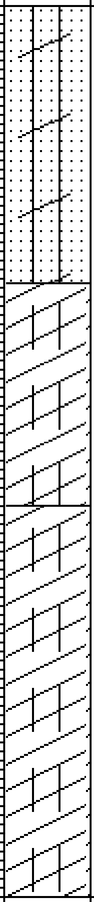
Client: CGC Inc.
Project No: 820677-K
Civic Address: Miller's Creek Extension
City & Province: Windsor Plant, NS
PID Number:
UTM Easting: 0
UTM Northing: 0
Date Started: April 6, 2009
Date Finished: April 6, 2009

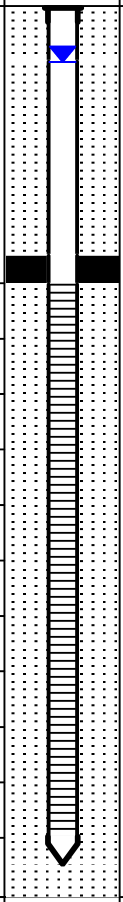
Drilling Contractor: Logan Geotech Inc.
Drill Type: CME 75
Drill Method: Hollow Stem
Logged By: Richard Hollett
TOC Elevation: 0
GL Elevation: 0
Final Depth: 9.8 metres
Depth to Water Strike: 5.3 metres
Depth to Bedrock 9.8 metres

CONESTOGA-ROVERS & ASSOCIATES

# Monitor Well: OB1

Page: 1 of 1





| Depth (m) | Lithology | USCS Classification | Description | Elevation (mamsl) | Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Moisture Content (%) | Comments | Well Construction | Well Details |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  |  | 0.0 |  |  |  |  |  |  |  |  |
| 0.0<br>1.0<br>2.0 |  |  | **Sandy Clay**<br>Brown sandy clay, some silt, dry to moist with depth. | -1.0<br>-2.0 |  |  |  |  |  |  |  | Casing Stickup (0.6 metres above ground surface)<br>PVC Casing<br>Silica Sand |
| 3.0 |  |  | **Silty Clay**<br>Compact, brown silty clay, trace cobbles, wet at 5.3 metres below ground surface. | -3.0 | 1 | SS | 24 | 12 |  |  |  | Bentonite Seal |
| 4.0 |  |  |  | -4.0 | 2 | SS | 32 | 91 |  |  |  | PVC Screen "20 Slot" |
|  |  |  |  |  | 3 | SS | 26 | 75 |  |  |  |  |
| 5.0 |  |  |  | -5.0 | 4 | SS | 63 | 70 |  |  |  |  |
|  |  |  | **Silty Clay**<br>Very dense to dense, brown silty clay, trace fine gravel, wet to moist with depth. |  | 5 | SS | 50 | 66 |  |  |  | Silica Sand |
| 6.0 |  |  |  | -6.0 | 6 | SS | 33 | 75 |  |  |  |  |
| 7.0 |  |  |  | -7.0 | 7 | SS | 69 | 87 |  |  |  |  |
|  |  |  |  |  | 8 | SS | 58 | 83 |  |  |  |  |
| 8.0 |  |  |  | -8.0 | 9 | SS | 45 | 87 |  |  |  |  |
| 9.0 |  |  |  | -9.0 | 10 | SS | 39 | 83 |  |  |  |  |
|  |  |  |  |  | 11 | SS | 50 | 79 |  |  |  | Well Point |
| 10.0<br>11.0<br>12.0 |  |  |  | -10.0<br>-11.0<br>-12.0 |  |  |  |  |  |  |  |  |

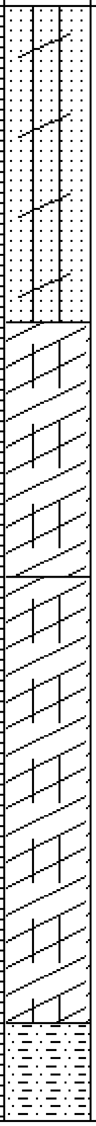
**Client:** CGC Inc.
**Project No:** 820677-K
**Civic Address:** Miller's Creek Extension
**City & Province:** Windsor Plant, NS
**PID Number:**
**UTM Easting:** 0
**UTM Northing:** 0
**Date Started:** April 7, 2009
**Date Finished:** April 8, 2009

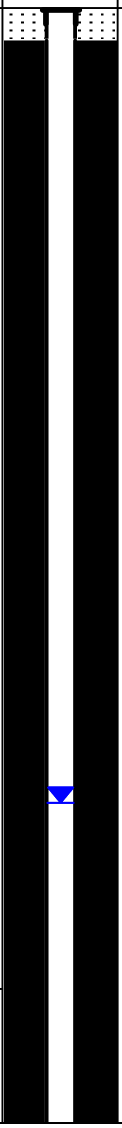
**Drilling Contractor:** Logan Geotech Inc.
**Drill Type:** CME 75
**Drill Method:** HWT Casing and Rock Coring
**Logged By:** Rob Tucker
**TOC Elevation:** 0
**GL Elevation:** 0
**Final Depth:** 20.1 metres
**Depth to Water Strike:** 5.3 metres
**Depth to Bedrock** 9.8 metres

CONESTOGA-ROVERS & ASSOCIATES

# Monitor Well: OB2

**Page:** 1 of 2





| Depth (m) | Lithology | USCS Classification | Description | Elevation (mamsl) | Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Moisture Content (%) | Comments | Well Construction | Well Details |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | | | | 0.0 | | | | | | | | |
| 0.0 | | | **Sandy Clay**<br>Brown sandy clay, some silt, dry to moist with depth. | | | | | | | | | Casing Stickup (0.6 metres above grade) |
| 1.0 | | | | -1.0 | | | | | | | | |
| 2.0 | | | | -2.0 | | | | | | | | |
| 3.0 | | | **Silty Clay**<br>Compact, brown silty clay, trace cobbles, wet at 5.3 metres below ground surface. | -3.0 | | | | | | | | |
| 4.0 | | | | -4.0 | | | | | | | | PVC Casing |
| 5.0 | | | | -5.0 | | | | | | | | |
| 6.0 | | | **Silty Clay**<br>Very dense to dense, brown silty clay, trace fine gravel, wet to moist with depth. | -6.0 | | | | | | | | |
| 7.0 | | | | -7.0 | | | | | | | | Bentonite Seal |
| 8.0 | | | | -8.0 | | | | | | | | |
| 9.0 | | | | -9.0 | | | | | | | | |
| 10.0 | | | | -10.0 | 1 | HQ | 86% | 100% | | | | |

*Fredericton, NB* *Corner Brook, NL* *St. John's, NL* *Dartmouth, NS* *Sydney, NS* *Charlottetown, PEI*

*Client:* ***CGC Inc.***

*Project No:* ***820677-K***

*Civic Address:* ***Miller's Creek Extension***

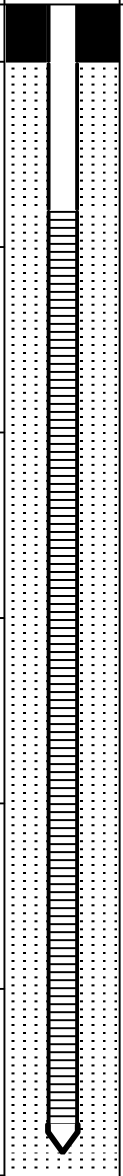
*City & Province:* ***Windsor Plant, NS***

*Monitor Well:* ***OB2***

*Page:* ***2 of 2***

CONESTOGA-ROVERS & ASSOCIATES

## Monitor Well: OB2



| Depth (m) | Lithology | USCS Classification | Description | Elevation (mamsl) | Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Moisture Content (%) | Comments | Well Construction | Well Details |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **Siltstone Bedrock**<br>Grey siltstone bedrock, trace gypsum, wet, good to poor rock quality with depth. | | | | | | | | | |
| 11.0 | | | | -11.0 | | | | | | | | |
| | | | | | 2 | HQ | 35% | 100% | | | | Silica Sand |
| 12.0 | | | | -12.0 | | | | | | | | |
| | | | **Limestone**<br>Grey limestone, trace gypsum, wet, poor to fair rock quality with depth. | | | | | | | | | |
| 13.0 | | | | -13.0 | 3 | HQ | 81% | 100% | | | | Silica Sand |
| 14.0 | | | | -14.0 | | | | | | | | |
| | | | | | 4 | HQ | 70% | 98% | | | | |
| 15.0 | | | | -15.0 | | | | | | | | |
| 16.0 | | | | -16.0 | 5 | HQ | 56% | 100% | | | | PVC Screen "20 Slot" |
| | | | **Siltstone**<br>Grey siltstone, trace gypsum, wet, poor to good rock quality. | | | | | | | | | |
| 17.0 | | | | -17.0 | | | | | | | | |
| | | | | | 6 | HQ | 95% | 100% | | | | |
| 18.0 | | | | -18.0 | | | | | | | | |
| 19.0 | | | | -19.0 | | | | | | | | |
| | | | **Siltstone**<br>Brown siltstone, wet, good rock quality. | | 7 | HQ | 78% | 100% | | | | Well point |
| 20.0 | | | **Siltstone**<br>Grey siltstone, wet, good rock quality. | -20.0 | | | | | | | | |
| 21.0 | | | | -21.0 | | | | | | | | |

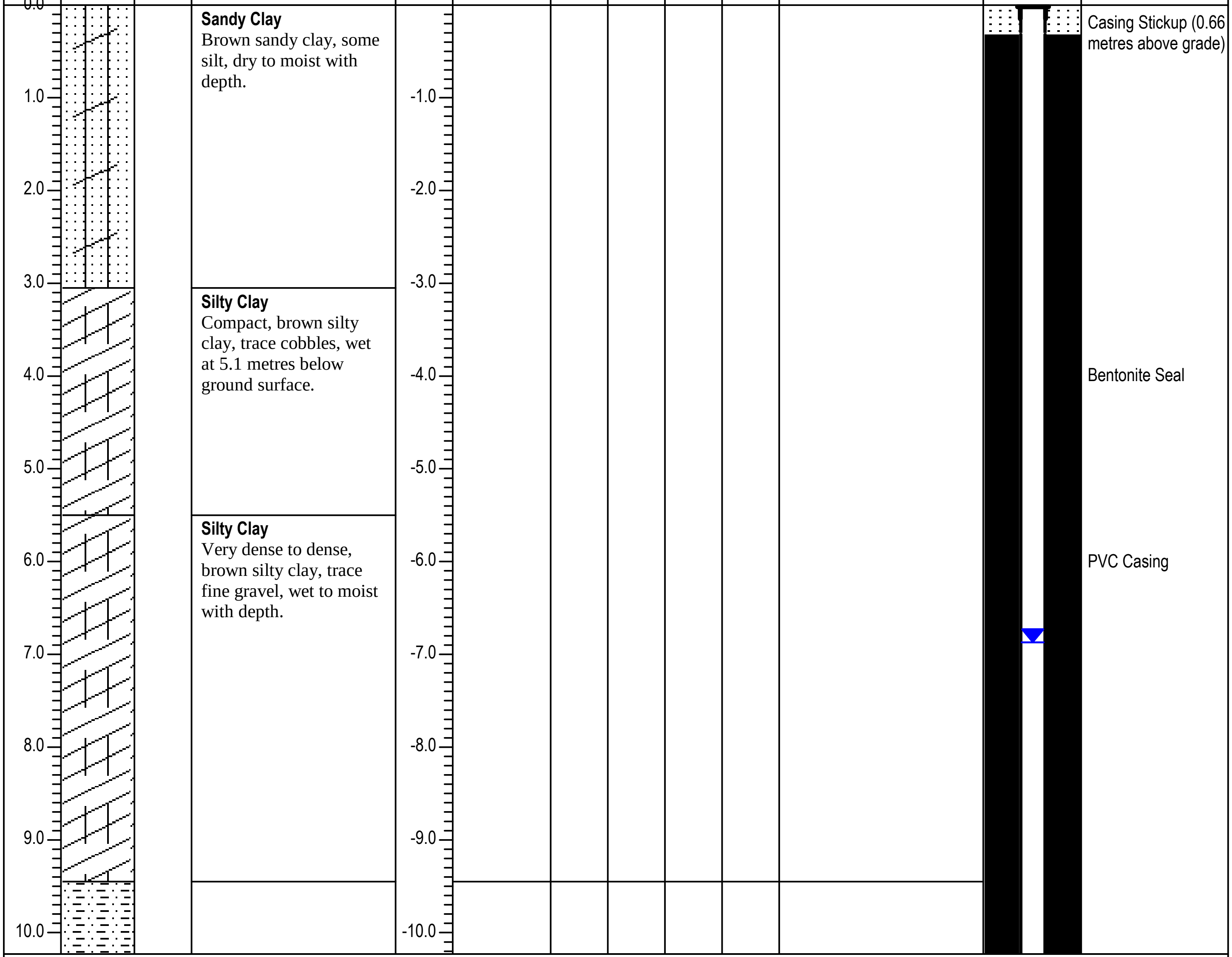
*Client:* **CGC Inc.**
*Project No:* **820677-K**
*Civic Address:* **Miller's Creek Extension**
*City & Province:* **Windsor Plant, NS**
*PID Number:*
*UTM Easting:* **0**
*UTM Northing:* **0**
*Date Started:* **April 8, 2009**
*Date Finished:* **April 9, 2009**

*Drilling Contractor:* **Logan Geotech Inc.**
*Drill Type:* **CME 75**
*Drill Method:* **HWT Casing and Rock Coring**
*Logged By:* **Rob Tucker**
*TOC Elevation:* **0**
*GL Elevation:* **0**
*Final Depth:* **26.2 metres**
*Depth to Water Strike:* **5.1 metres**
*Depth to Bedrock* **9.45 metres**

# Monitor Well: OB3

*Page:* **1 of 3**

| Depth (m) | Lithology | USCS Classification | Description | Elevation (mamsl) | Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Moisture Content (%) | Comments | Well Construction | Well Details |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | | | | 0.0 | | | | | | | | |



**Sandy Clay**
Brown sandy clay, some silt, dry to moist with depth.

**Silty Clay**
Compact, brown silty clay, trace cobbles, wet at 5.1 metres below ground surface.

**Silty Clay**
Very dense to dense, brown silty clay, trace fine gravel, wet to moist with depth.

Casing Stickup (0.66 metres above grade)

Bentonite Seal

PVC Casing

Client: **CGC Inc.**

Project No: **820677-K**

Civic Address: **Miller's Creek Extension**

City & Province: **Windsor Plant, NS**

Monitor Well: **OB3**

Page: **2 of 3**

# Monitor Well: OB3

| Depth (m) | Lithology | USCS Classification | Description | Elevation (mamsl) | Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Moisture Content (%) | Comments | Well Construction | Well Details |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **Siltstone Bedrock**<br>Grey siltstone bedrock, trace gypsum and limestone, wet, excellent rock quality with depth. | | 1 | HQ | 96% | 100% | | | | |
| 11.0 | | | **Limestone**<br>Grey limestone, trace gypsum, wet, very poor rock quality with depth. | -11.0 | 2 | HQ | 13% | 100% | | | | |
| 12.0 | | | **Siltstone**<br>Grey siltstone, trace gypsum and limestone, wet, very poor rock quality. | -12.0 | | | | | | | | |
| 13.0 | | | **Limestone**<br>Grey limestone, trace gypsum and siltstone, wet, good rock. | -13.0 | 3 | HQ | 80% | 98% | | | | Bentonite Seal |
| 14.0 | | | | -14.0 | | | | | | | | |
| 15.0 | | | | -15.0 | 4 | HQ | 85% | 100% | | | | PVC Casing |
| 16.0 | | | | -16.0 | 5 | HQ | 78% | 100% | | | | |
| 17.0 | | | **Siltstone**<br>Grey siltstone, wet, good rock quality. | -17.0 | | | | | | | | |
| 18.0 | | | **Limestone**<br>Grey limestone, trace gypsum, good rock quality. | -18.0 | 6 | HQ | 78% | 100% | | | | |
| 19.0 | | | **Siltstone**<br>Grey siltstone, trace gypsum, good rock quality. | -19.0 | 7 | HQ | 81% | 100% | | | | |
| 20.0 | | | **Siltstone**<br>Brown siltstone, good rock quality. | -20.0 | | | | | | | | |

*Fredericton, NB* *Corner Brook, NL* *St. John's, NL* *Dartmouth, NS* *Sydney, NS* *Charlottetown, PEI*

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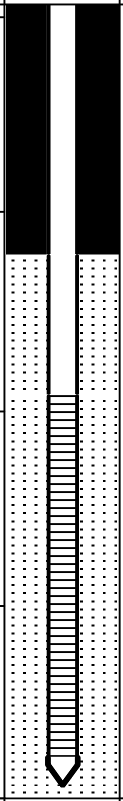
*Civic Address:* ***Miller's Creek Extension***

*City & Province:* ***Windsor Plant, NS***

*Monitor Well:* ***OB3***

*Page:* ***3 of 3***

# *Monitor Well: OB3*



| Depth (m) | Lithology | USCS Classification | Description | Elevation (mamsl) | Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Moisture Content (%) | Comments | Well Construction | Well Details |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 21.0 | | | **Siltstone**<br>Grey siltstone, trace gypsum, good rock quality. | -21.0 | 8 | HQ | 90% | 100% | | | | Bentonite Seal |
| 22.0 | | | **Siltstone**<br>Brown siltstone, trace gypsum and limestone, wet, good rock quality. | -22.0 | 9 | HQ | 80% | 100% | | | | Silica Sand |
| 23.0 | | | | -23.0 | | | | | | | | |
| 24.0 | | | | -24.0 | 10 | HQ | 63% | 100% | | | | PVC Screen "20 Slot" |
| 25.0 | | | | -25.0 | 11 | HQ | 78% | 100% | | | | |
| 26.0 | | | | -26.0 | | | | | | | | Well Point |
| 27.0 | | | | -27.0 | | | | | | | | |
| 28.0 | | | | -28.0 | | | | | | | | |
| 29.0 | | | | -29.0 | | | | | | | | |
| 30.0 | | | | -30.0 | | | | | | | | |

# (B.2) GROUNDWATER MODELING REPORT

## TABLE OF CONTENTS

## LIST OF FIGURES
(Following Text)

## LIST OF TABLES
(Following Text)

# 1.0 INTRODUCTION

In February 2008, CGC Inc. (CGC) (formerly Fundy Gypsum Company) registered the proposed Miller's Creek Mine Extension Project, Hants County (the Site) for environmental assessment, in accordance with Part IV of the Environment Act. On March 17, 2008, the Minister of Environment and Labour released a decision on the proposed Undertaking. The Minister determined that a Focus Report was required, with an original submission date of April 11, 2009. A request for a revised submission date of October 16, 2009 was submitted and approved.

The Terms of Reference (ToR) for the Focus Report released on April 11, 2008 require that a numerical groundwater model be constructed for the proposed mine pit and surrounding area to support the Miller's Creek Mine Extension. The groundwater flow model was developed for the Site and vicinity to estimate potential future conditions in order to help evaluate and support the mining and mitigation plans. Surface water (hydrologic) modelling and related analyses have also been undertaken to address the ToR. These and overall water resource analyses are reported separately.

## 1.1 OBJECTIVES OF GROUNDWATER MODELING

The objectives related to the groundwater modeling and/or other analyses related to the modelling as outlined in the ToR are summarized below:

- To predict the groundwater flow rate to the proposed mine
- To predict the extent of the groundwater cone of depression caused by the proposed mine dewatering operations
- To help identify the number and location of water wells lying within the predicted cone of depression
- To help predict the extent of potential salt water intrusion effects and identify which drilled wells may be potentially affected by salt water intrusion
- To predict the amount of baseflow reduction at nearby surface water courses and wetlands (expressed as percent reduction in baseflow)
- To predict the amount of drawdown in any proposed "conservation areas" to help estimate what effect the drawdown may have on habitats in these areas
- To estimate the time it will take for groundwater levels to rebound to pre-mining conditions once dewatering has stopped

The developed model was based on all existing available data and provides a simplified representation of the interpreted groundwater flow system. It is useful as a conceptual tool to assist in the water resources assessment, mine extension design, and design of monitoring and mitigation systems. Due to the inherent variability of the groundwater flow system and associated water resources and ecological resources, the actual implementation and operation of the mining and mitigation plans will be based on a program of an "adaptive management" (to be proposed) which includes performance monitoring and mitigation measures for water resources.

A comprehensive surface water and groundwater monitoring program is proposed for the operations phase of the project. The data from these programs will be used as additional input for the model and future predictions will be based on an ever increasing amount of actual Site data.

## 2.0 HYDROGEOLOGIC AND HYDROLOGIC CONDITIONS

The hydrogeologic and hydrologic conditions are described in Section 2.0 of the main report. A brief overview of the primary components of the groundwater flow system is presented here.

The following summarizes the geology and hydrostratigraphic conditions:

- Located on the Avon Peninsula, the Site is bounded on the north, west, and south by Kennetcook, Avon, and St. Croix Rivers, which control surface water and groundwater discharge in the area. The existing mine and the proposed mine extension area is sitting in the topographically high area. Numerous creeks/streams flow from the topographically high areas towards the surrounding rivers. Within the peninsula, the topography consists of tidal marshlands, dyked land, small drainage areas and many hills. The peninsula itself is drained by several small streams and creeks, as well as man-made agricultural drainage ditches. Many of the streams are ephemeral in nature, flowing only after rainfall events and during the spring freshet period. The drainage pattern is generally radially outward from the centre of the peninsula to the north, south and west, with ultimate discharge across the Avondale and Belmont Roads into the Kennetcook, St. Croix and Avon Rivers (Figure 4.2-1 of the main report).
- The surficial material over the area consists of primarily clay, silt and mud with scattered cobbles and some limited new surface sandy areas with a thickness ranging from 1 to 20 m based on the overburden identified drilled boreholes and the available water well records in the area. There are a number of "dug" water wells in overburden, however, the overburden cannot provide enough water due to its clayey nature, and therefore, these dug wells generally behave as a water storage "tank" to collect/hold surface water.
- The overburden is underlain by bedrock of the Windsor Group and the Horton Group. The Windsor Group consists of interbedded gypsum, anhydrite, limestone, and siltstone. The Horton Group consists of interbedded sandstone with shale/shalestone.
- The area is geologically complex. The bedrock is highly fractured evidenced by the existence of very common faults and folds within the area (Figure B.2.1).
- Karst features are also observed as described in the main report. The karst is primarily featured with small water pools/ponds. These features are primarily isolated and have no obvious inflow or outflow channels. Vernal pools are small pools which are filled with water from snow melt and surface runoff in early spring.

- Wetlands occur in areas along the lowland areas and the river banks.
- Surface topography is variable due, in part, to irregular surface of bedrock units, as well as varying overburden thickness.
- Away from the sea shoreline, salty water is generally not a problem because the land and water table rise rapidly away from the sea and the majority of domestic water wells are dug overburden wells (as above) and produce only very limited water.
- Groundwater generally flows from areas of high elevation to areas of low elevation and eventually flows to the surrounding rivers (Figure B.2.2). Groundwater occurs primarily in bedrock, and discharges primarily to the surrounding rivers. Groundwater discharges to certain streams, such as the Shaw Brook, have been observed.
- The bedrock aquifer ranges from low hydraulic conductivity to high depending on the degree of fracture and presence of solution channels. Based on the following line of evidence, it is less permeable in the north (primary zone) and relatively permeable south of Avondale Road:
    - The slug test results in all of the Site monitoring wells which are located in this primary bedrock zone demonstrated a lower hydraulic conductivity in an order of $2.5 \times 10^{-6}$ cm/s to $1.3 \times 10^{-4}$ cm/s with an geometric mean of $2.9 \times 10^{-5}$ cm/s
    - Step tests at MW-6 installed in the primary bedrock zone demonstrated a very low yield of less than 2 imperial gallons per minute (Igpm)
    - The available reported well yield in all the bedrock water wells along Avondale Road was relatively high ranging from 5 Igpm to 20 Igpm; while the available reported well yield in the bedrock water wells along Belmont Road was very low based on the limited domestic bedrock wells in the north area
- Due to the fractured nature of the bedrock and the complexity of the highly faulted/folded bedrock geology relative to any practicable level of data collection or characterization, the bedrock may be simplified/treated as one hydrostratigraphic unit that is the principal hydrogeological unit for modeling purpose.
- No apparent hydraulic aquitard to depth can be established. Due to the fact of the thick bedrock materials, an arbitrary bottom of –80 metres above mean sea level (m AMSL), which is considered to be deep enough to have no significant hydraulic impact to the model, was considered as the bottom of the model (i.e., the base of the simulated groundwater flow zone).

Groundwater flow occurs under unconfined conditions in most areas. In the lowland areas where the groundwater in bedrock tends to discharge to streams, groundwater appears to be under pressurized (confined or semi-confined) conditions as evidenced in MW-5D (where an upwelling condition was observed).

Groundwater flow in the region is controlled by precipitation, surface water features where applicable, topography, and human activities such as mine dewatering/discharge.

The water level of the dewatering sump in the existing mine (Bailey Quarry) was measured at 23 m below mean sea level (i.e., -23 m AMSL). Therefore, the groundwater discharge in the vicinity of the sump is largely controlled by dewatering operations, which cause groundwater flow towards the mine area. Under the existing mine dewatering condition, water levels in the domestic water wells in the vicinity do not appear to be impacted, perhaps due to distance and/or well completion.

Groundwater discharges to the creeks/streams primarily occur in the wet flow condition (i.e., spring) based on observed surface water data. During periods of low precipitation, most creeks/streams exhibit either insignificant flow or dry conditions.

## 3.0 CONCEPTUAL HYDROGEOLOGIC MODEL

The conceptual hydrogeologic model was developed to represent the average hydrogeologic conditions observed in 2006-2009. The conceptual model consists of a model domain, boundary conditions, and a representation of the observed stratigraphy. The assumptions used for the model conceptualization are as follows:

- The bedrock is extremely complex with numerous known crossed faults and folds with secondary fractures that can be observed at outcrop/existing and historic quarry walls. In theory, two approaches can be used for fractured media - a continuum approach and a non-continuum/discrete approach. The selection of using either approach is based on the manner in which flow occurs in individual fractures, the model scale, and the objectives of the study. The continuum approach can reasonably treat flow in fractured bedrock as equivalent porous media (EPM) in a relatively large scale (Bradbury et al., 1991). In this case, hydrogeologic properties such as hydraulic conductivity are averaged over appropriate rock volumes, so that existing numerical models for porous media can be used. As a result, the local and/or specific features, such as the variations of apertures, sizes, or orientations of fractures can not be represented with the EPM approach. The non-continuum/discrete fracture model can, in theory, explicitly represent the geometric features of fractures. Once all geometric information of all fractures with the model domain is available, this approach can be used. However, in practice, detailed information on fracture geometry is not available and is impractical to obtain, especially for a large area. Quite often, this approach can be useful only for studying very small areas. For the scale of this study, sufficient fracture geometry information is not available; nor can it feasibly be obtained. Also, even if the fractured network were represented statistically within the model, still there would be no assurance that local fractures within the area of potential impact of mining were reasonably represented; and therefore, there would be no additional certainty of the model results with respect to local groundwater flow conditions. Thus, a discrete approach was not used for this study and the EPM approach is considered to be more practical and reasonably representative of the flow conditions over the scale of interest. The EPM approach is generally appropriate for a large scale flow analyses, although it may not be reliable for travel times (not part of this study) particularly over small distances.
- The model domain limits and boundary conditions were based on large-scale hydrogeologic features such as rivers, creeks, etc.

- The bedrock formations behave as a single hydrostratigraphic unit with two different hydraulic property zones, one approximately north of Avondale Road (the primary hydraulic conductivity zone) and the other approximately south of Avondale Road.
- The groundwater flow system is recharged by infiltration of precipitation, entering the top of the model domain through the overburden.
- Overburden, as a thick new impermeable blanket covering the bedrock aquifer in most of the area, can not be considered as an aquifer in the area due to its clayey nature. Any water residue in the clay blanket would serve as a persistent leaking recharge to groundwater in the bedrock aquifer. Therefore, it is not included in the flow model domain (by making it inactive model cells), except for the areas where groundwater in bedrock was shallow and potentially discharges through the overburden to surface water features.
- The bedrock aquifer flow system is bounded on the bottom by a no-flow boundary and is hydraulically controlled by the nearby rivers and sea at the horizontal limits. The eastern model boundary was represented as a flowline/divide (i.e., no-flow boundary) estimated based on surface water features and local topography.
- Hydrological features (e.g., creeks) that potentially receive groundwater discharge from the bedrock aquifer are represented as head-dependent drain boundaries which reflect their characterization as generally being groundwater discharge zones. The areas of groundwater discharge (as presented on Figure B.2.3) were estimated by comparing the estimated groundwater elevation in the bedrock aquifer with the ground surface. If the water table is shallower than 4 m, then groundwater was allowed to discharge to streams in the model.
- Dewatering effects of the existing gypsum mine are represented by the specification of a head-dependent drain boundary condition with a dewatering floor and a lake level of -23 m AMSL as the lowest drain stage elevation.
- Steady-state simulations can adequately represent average annual conditions.
- The model uses five layers. The top layer is the overburden and the remaining four layers are bedrock. The top three model layers are simulated as a convertible type, i.e., either confined (when groundwater elevation is over the top of the model layer) or unconfined conditions (when groundwater elevation is below the top of the model layer). All other two deep model layers are simulated as confined conditions.

Two types of data sets were used for the model calibration process, i.e., groundwater elevation observations and creek baseflow data. Two groundwater observation data sets, i.e., domestic well static water levels and observations at the monitoring wells at the

Site, were used as calibration targets. Due to the fact that static water levels at the domestic water wells were observed in different times of the year and even in different years, the level of uncertainty with respect to average conditions is not as high as for monitoring wells. Therefore, a weighting factor of 0.2 to 0.5 (See Section 6.2) was used during the model calibration and the Site monitoring data were used as the primary calibration targets (i.e., a weighting factor of 1.0). The model was also calibrated to average baseflow conditions in four creeks that exhibit relatively consistent degrees of baseflow. This approach of calibrating to both water levels and stream flow helped ensure the calibrated groundwater flow model parameters (recharge, hydraulic conductivities, etc.) are reasonably representative of the area under the average groundwater flow conditions.

## 4.0 SIMULATION PROGRAM SELECTION

The following computer programs were selected for the completion of this analysis:

- MODFLOW-2000 (Harbaugh et al., 2000), a United States Geological Survey (USGS) modular finite-differences groundwater flow model. MODFLOW has been extensively verified and readily accepted by many regulatory agencies
- The PCG2 (Preconditioned Conjugate-Gradient) solver package (Hill, 1990) to solve the equations for hydraulic head produced by MODFLOW
- Groundwater Vistas version 5.0 (Rumbaugh, 2007) as a graphical interface to create datasets and provide post-processing
- PEST (Doherty, 2000), the model-independent automatic Parameter Estimation software, to adjust the input parameters in order to match the calibration targets of observed groundwater heads to both the Site and domestic water well datasets

## 5.0 GROUNDWATER FLOW MODEL CONSTRUCTION

The groundwater flow model construction is presented in the following sections in terms of the spatial domain and discretization, boundary condition implementation, and hydraulic properties that are applied.

### 5.1 SPATIAL DOMAIN AND DISCRETIZATION

- Overall model domain has dimensions of 9.5 kilometres (km) by 12.5 km, oriented parallel to the true north (Figure B.5.1). The NAD 83 (Zone 20) UTM coordinate system was used.
- The finite-difference grid used for model calibration consists of 324 rows, 739 columns and five layers and is presented on Figure B.5.2.
- The finite-difference grid cell size was 10 m by 10 m in the vicinity of the existing and the proposed mine areas that in fact are the majority of the flow domain, expanding up to 60 m by 60 m cells at edges of the model (Figure B.5.2).
- Although the bedrock was characterized as a uniform unit, the bedrock was vertically subdivided into four model layers in addition to the overburden layer. Thus, the top model layer (Layer 1) represents the overburden and the second to the fifth model layers represent the bedrock. Generally, Layer 1 is partially active to represent the potential bedrock groundwater discharge to the surface water features. Layer 1 is partially saturated though in some areas it is flooded (i.e., the simulated water level is above the ground surface) where wetlands are formed. Model Layers 2 to 5 were used to represent the bedrock.
- An interpolated base of model Layer 1 was used to represent the bottom of the overburden (top of bedrock). Layer 1 was given a minimum thickness of 5 m below ground surface (m bgs). In the area where no overburden thickness data was available, an average thickness (of 13.6 m) was estimated for the interpolation process. In areas where the overburden is absent, i.e., the existing mined pit area, hydraulic properties for bedrock were used for Layer 1.
- The ground surface, though not required for an unconfined aquifer, was imported from Digital Elevation Model (DEM) and Site-specific topographic survey data obtained in the model area.

## 5.2 BOUNDARY CONDITION IMPLEMENTATION

- Implemented boundary conditions consistent with the conceptual hydrogeologic model are presented on Figure B.5.1.
- The recharge to groundwater (infiltration of precipitation through the overburden clay layer) was simulated using an average (uniform) recharge rate which was calibrated.
- A no-flow boundary condition was applied at the base of the model at -80 m AMSL as previously described.
- Kennetcook River, Avon River, and the major part of St. Croix River are represented by Specified heads (or constant heads) at sea level (i.e., 0 m AMSL) (Figure B.5.1). These specified heads are applied in the top two model layers and no flow boundaries were specified in underlying layers.
- A seepage face along the existing mining pit area and the lowland/wetland areas, where applicable, is represented by drain cells. Conductances are a calibrated parameter; however, they were initially estimated based on grid cell dimensions and the permeability of the aquifer material using Equation (1), as follows:

$$C = \frac{KLW}{M} \tag{1}$$

where:

$C$ = conductance (m$^2$/day)

$K$ = hydraulic conductivity of drain-bottom sediments (m/day)

$L$ = drain cell length (m)

$W$ = drain cell width (m)

$M$ = thickness of drain cell bedding material (m)

- A no-flow boundary condition was applied along a potential groundwater divide boundary occurring approximately east of the model domain.
- Creeks/wetlands represented by drain cells allowed groundwater to discharge to these features, but did not allow them to act as a source of groundwater recharge. This characterization was selected to provide a conservative representation under mining conditions.
- Discharge elevations for drain cells representing creeks/wetlands were set based upon available topographic mapping information and estimated water level at the mine dewatering sump.
- Drain cell conductances were conservatively prescribed to represent a full hydraulic connection between the aquifer and the associated drain features, ensuring a

maximum sensitivity of these features to changes in groundwater flow conditions, and ranged from 21.6 $m^2$/day to 3,780 $m^2$/day depending on cell dimensions and locations.

- Under the proposed mine extension condition, the extraction area was represented by drain cells to reflect the drainage condition due to mine dewatering. Based on the design, the mine extension will cut through three model layers. For model Layers 1 and 2, the drain cell stage elevations were set at approximately 0.1 m above the bottom elevation of model layers in the corresponding cells. For model Layer 3, drain cell stage elevations were approximated based on the mine floor elevation. The mine drain cell conductances were set to be high enough to allow water flowing out freely to the extraction area.

## 5.3 HYDRAULIC PROPERTIES

- Hydraulic properties applied within the model domain consist of hydraulic conductivity and recharge from precipitation infiltration
- Hydraulic properties were estimated within reasonable bounds from a variety of sources and adjusted during the model calibration process. Initial estimates of parameters were:

| *Parameter* | *Initial Estimate* |
|---|---|
| Hydraulic Conductivity for Overburden | $1 \times 10^{-6}$ to $1 \times 10^{-4}$ cm/s |
| Hydraulic Conductivity for bedrock | $1 \times 10^{-6}$ to $5 \times 10^{-4}$ cm/s |
| Recharge | 20 to 100 mm/year |

Hydraulic tests, including slug tests and a step-pumping test that were carried out by CRA, were considered (refer to Section 2.0 of the main report). The hydraulic conductivity varies within the model domain. The field-observed hydraulic conductivity was generally on the order of $10^{-6}$ cm/s to $10^{-4}$ cm/s for the bedrock. The wide range of the tested K value is partially due to the variability of the fractured bedrock as well as the different testing methods. The details of these features and the associated implementation in the model are discussed in Section 6.3 of this report.

# 6.0 GROUNDWATER FLOW MODEL CALIBRATION

## 6.1 CALIBRATION OBJECTIVES

The primary objective of the model calibration was to obtain an acceptable match between the observed and simulated groundwater levels under the average flow conditions by adjustment of input parameter values within the range indicated by available information.

The secondary objectives were:

- To obtain overall regional groundwater contour patterns
- To reasonably match the model simulated baseflow rates with the observed flow rates

## 6.2 METHODOLOGY

Model calibration was conducted in an iterative manner with a combination of manual and automatic adjustment of the input parameters and property zones. The automatic adjustments were accomplished by running PEST (Doherty, 2000). In the early stage of the flow model calibration, the parameters and property zones were primarily changed manually, while in the later stage of the flow model calibration, the parameters were changed automatically to obtain a set of input parameters with minimized residuals between the model-simulated and field-observed data. In the final stage, the conductances of the drain cells along creeks were fine-tuned. In total, over 16 versions of flow models with numerous calibration runs were completed without including the PEST runs that consist of many more individual runs.

Adjusted input parameters consisted of the hydraulic conductivity; conductance of head-dependent discharge boundaries at the creeks, extraction area and some wetlands; and the recharge rate in the model domain. Further information is described below:

- Groundwater flow model was calibrated to both the Site monitoring dataset and the domestic water well data, which together provides a larger data coverage area, to provide a reasonable representation of available groundwater flow conditions in the model.
- Within the active flow model area, groundwater levels measured at 17 locations from 2006 to 2009 were selected as primary model calibration Site targets. These Site

monitoring wells are described as Site wells, herein. As regional flow model calibration targets, available static water levels from 19 domestic water wells were selected within the model domain. It should be noted that the regional water level data covers a wide range of time periods, meaning that the regional water levels were taken in different years, different times of a year, and/or may be influenced by water well use, which makes the well data less reliable as calibration targets (water levels can vary seasonally by several metres or more). Uncertainty over well locations and elevations also limits reliability. Therefore, a weighting factor of 0.5 for wells with verified locations and of 0.2 otherwise was used during the calibration to reduce the potential bias caused by the data uncertainties.

- Quantitative evaluation of the calibration was achieved by examining the calibration target residuals that were calculated as the simulated water level minus the measured groundwater level at the target locations where the observed data exists. As a result, a negative residual indicates an under-estimation by the model while a positive residual indicates an over-estimation by the model.
- Qualitative evaluation of model calibration and of spatial distribution of calibration residual was accomplished by:
  - Visual comparison of simulated hydraulic head and groundwater flow patterns/directions to the existing flow conditions
  - Comparison of simulated groundwater discharges to creeks
  - Preparation of calibration residual plots to identify areas of biased residuals
  - Preparation of scatter plots of the observed groundwater levels versus the simulated water levels
- Another measure of model reliability is provided by the MODFLOW volumetric water balance output at the end of a simulation. This budget indicates the calculated quantities of flow into and out of the model domain via the particular groundwater flow components specified in the model (i.e., recharge, drain and river cell discharge/recharge boundaries, etc.). A percent discrepancy between the simulated inflow and outflow quantities is reported. The absolute value of the mass balance discrepancy was consistently less than 0.05 percent, indicating satisfactory mass balance.
- Model calibration was initiated by applying a uniform hydraulic conductivity and a uniform recharge rate to the entire model domain; and later on, was carried out by introducing multiple conductivity zones that would be considered more representative of the Site characterization and, hence, would provide a better representation of the flow conditions.

## 6.3 FINAL CALIBRATED MODEL RESULTS

As described previously, the groundwater flow model was calibrated to different data sets (i.e., groundwater elevations and baseflow rates), to ensure the model representation of the Site conditions. The input parameters must reasonably satisfy the model under the long-term flow conditions. This section presents the calibrated results thereafter.

### 6.3.1 CALIBRATED GROUNDWATER ELEVATIONS

Final simulated steady-state groundwater levels in the Site vicinity for the average flow condition are presented on Figure B.6.1. Visual comparison of the simulated groundwater levels and flow directions to the estimated groundwater elevation contours (Figure B.2.2) shows a reasonable correlation. Similar to the estimated observed flow conditions, simulated groundwater flows radially from the proposed mine extension area towards the surrounding rivers.

The observed groundwater levels and simulated groundwater elevations at each calibration target location within the model domain, as well as the residuals, are presented in Table B.6.1. The distribution of residuals between the model-simulated and the field-observed groundwater elevation at each calibration target is presented on Figure B.6.1.

A scatter plot of the observed groundwater levels against the calibrated hydraulic head at each target location is presented on Figures B.6.2 and B.6.3 for the Site monitoring wells and all targets including domestic wells, respectively.

For Site monitoring wells, the plotted points lie close to the line representing equality (for a perfect fit) between the simulated and the observed water levels. This indicates that simulated groundwater levels provide a reasonable match to the observed groundwater levels at the Site monitoring well locations. For all of the domestic wells, the plotted points lie reasonably close to the line representing equality (for a perfect fit) between the simulated and the observed water levels with some wells noticeably lying outside the lines standard deviation; which is not surprising given the uncertainties associated with the domestic well water levels.

The statistics for the Site monitoring wells are shown on Figure B.6.2. Statistically, the residual mean indicates that, on average, the simulated groundwater levels are within -0.15 m of the observed groundwater levels. The absolute residual mean is 1.04 m which is approximately 2 percent of the observed range in data and less than the standard deviation of 1.36 m. These results indicate that, on average, the simulated groundwater levels are reasonably close to the observed groundwater levels. The statistics for all targets are presented on Figure B.6.3. Generally, the statistical results indicate that the calibrated model can reasonably represent the overall flow conditions in the area.

The simulated groundwater elevations provide a reasonable overall match to the groundwater flow patterns and elevations. The higher residuals occurred generally in the domestic well targets and deeper bedrock wells (Table B.6.1).

A simple volumetric water balance determined by MODFLOW summarizes the simulated water volume inputs and outputs via the represented groundwater components in the model. The mass balance discrepancy of zero percent demonstrates the model is satisfying mass balance principles.

### 6.3.2 CALIBRATED BASEFLOW

In total, CRA has observed the surface water flow rates for 19 creeks (Figure 4.2-1 of the main report). The flow observations were carried out in different months representing both relatively dry and wet conditions. Only four of these 19 surface water stations, SW-01, SW-11, SW-17, and SW-18, that are located in the potential groundwater discharge areas (i.e., within the flow model domain) were selected for this comparison (Figure B.2.3). The model-simulated baseflow rates were compared to the observed flow range to ensure that the model is generally consistent with the base flow rates in the surface water courses. The results are presented in Table B.6.2. Table B.6.2 shows that most of the model-simulated baseflow rates are in the lower end of the available observed flow range except for SW-01. The stream flow observation event with the lowest flow (September 29, 2006) was performed during and after precipitation (5.1 millimetres [mm] of rain), which may suggest that the actual stream baseflow may be at or lower than the lower end of the available observed flow ranges.

The reasonable matches in groundwater elevations and consistent flow rates indicate a satisfactory representation of the hydrologic processes occurring in the area.

The rate of recharge from precipitation in the final calibrated model was 35 mm/year.

The final calibrated model included one hydraulic conductivity zone in model Layer 1 and two hydraulic conductivity zones in bedrock. All layers/zones used an anisotropy ratio (Kx:Ky:Kz) of 1:1:1 which will be discussed in the following section.

### 6.3.3 HYDRAULIC CONDUCTIVITY DISTRIBUTION

The available hydraulic conductivity testing results indicate a typical range of hydraulic conductivity over the study area: generally $10^{-6}$ to $10^{-4}$ cm/s for the bedrock. A satisfactory match to the groundwater flow conditions could not be obtained with the specification of a uniform hydraulic conductivity throughout the model domain, especially along and south of Avondale Road. Therefore, during the model calibration process, varying hydraulic conductivity values were used in order to improve the match to observed water level conditions along and south of Avondale Road.

Two hydraulic conductivity zones were assigned to bedrock. A somewhat higher hydraulic conductivity zone was specified in bedrock along and south of Avondale Road. The shape and hydraulic conductivity value applied to this zone were adjusted during model calibration. The two calibrated hydraulic conductivity zones are shown on Figure B.6.4. The hydraulic conductivity calibrated for the bulk of the model domain was isotropic and $1.0 \times 10^{-5}$ cm/s, whereas the value in the southern area was isotropic and $2.3 \times 10^{-4}$ cm/s as presented on Figure B.6.4. This is a relatively modest hydraulic conductivity contrast (less than a factor of 5) and is in reasonable agreement with the expected range of hydraulic conductivity for the bedrock and with all available published data.

A single hydraulic conductivity value of $5.0 \times 10^{-6}$ cm/s was calibrated for overburden. The calibrated hydraulic conductivity values for both overburden and bedrock are close to the field-tested range as presented in the main report.

### 6.3.4 SUMMARY OF THE FINAL CALIBRATED MODEL RESULTS

As mentioned above, numerous simulations were completed to assess model calibration.

Multiple aspects of the groundwater flow system were available for model calibration (as described in Section 6.1) providing a significant advantage over most modelling studies. These aspects and the quality of the model calibration included:

| | | |
|---|---|---|
| 1 | Site monitored groundwater elevations (Site Monitoring Wells) | Very good |
| 2 | Domestic water well groundwater elevations | Fair |
| 3 | Overall groundwater contour patterns | Good |
| 4 | Stream flow rates | Fair |

The overall conclusion regarding model calibration is that the model provides a reasonable match to observed groundwater flow conditions, though with limited data, and, therefore, is useful as a simplified "tool" to assist in the development of designs and in the understanding of how the systems are expected to behave. The model can be further reviewed/refined in the future as more data becomes available during the mine extension.

### 6.4 SENSITIVITY ANALYSIS

A sensitivity analysis of the calibrated model was conducted. The primary parameters such as hydraulic conductivity and recharge rate were analysed. The calibrated hydraulic conductivities of overburden, bedrock and recharge rates were varied individually with certain factors. The variation factors for hydraulic conductivity were 0.1, 0.2, 0.5, 2, 5, and 10 times of the calibrated value. The variation factors for recharge were 0.5, 0.75, 1.25, and 1.5 times of the calibrated value. The sensitivity analysis results are presented on Figures B.6.5a to B.6.5d as model simulated sum of residual squares at the Site monitoring target locations over the varied factors.

The sensitivity analysis results demonstrate the following:

1. The model calibrated parameter set provided minimized model residuals at the calibration targets, i.e., the calibrated model achieved the best representation of the observed flow conditions.

2. The model was not very sensitive to the overburden hydraulic conductivity at the given range.
3. The model was sensitive to the bedrock hydraulic conductivity at the given ranges. However, the model was not as sensitive to a higher hydraulic conductivity for the bedrock in the south (the high K zone).

## 7.0 MINE DESIGN SIMULATIONS

Simulation runs were completed to help assess the potential impact of future quarry conditions on the groundwater flow system. These runs used steady-state simulations to represent anticipated average groundwater conditions. The following mining stages were simulated and are presented herein:

- End of 20-Year Extraction
- End of 40-Year Extraction
- End of Mine Life (about 70 years)
- Proposed Full Rehabilitation

These are discussed in turn in the following sections. The results of each evaluated stage are presented as simulated groundwater elevation contours, groundwater drawdown, and the stream baseflow changes are tabulated. When evaluating groundwater drawdown, the existing pre-extension (i.e., the calibrated) flow condition was used as the baseline condition.

### 7.1 END OF 20 YEARS MINE EXTENSION CONDITION

The purpose for this simulation was to investigate the groundwater flow pattern and the groundwater drawdown effect of the completed extraction at the end of 20 years with gypsum mined out at the east corner of the proposed extension area (Figure B.7.1).

- Similar to the existing mine, drain elevations were assigned to be either at mine floor in model Layer 3, and at the top elevation plus 0.1 m from model Layers 1 and 3 around the perimeter of the staged mine limit; the drain conductance was assigned to be high to allow free drainage to the mine
- In model Layers 1 and 2 where the mine pit would be, the model cells were made inactive (i.e., model cells were taken out of model flow domain)
- The simulation was conducted in a steady-state

The simulated groundwater elevation contours are presented on Figure B.7.1 which shows the stabilized groundwater depression cone due to this phase of quarry operation.

**Evaluation of Drawdown Effect:** The simulated groundwater drawdown with respect to the existing condition is presented on Figure B.7.2. Figure B.7.2 demonstrates that the 1 m drawdown contour does not extend to the drilled water wells. The predicted drawdown contours at this stage of mine extension indicate that no drilled domestic wells will be practically impacted.

**Estimated Dewatering Rate:** The predicted average annual groundwater inflow (that is purely from groundwater) was 3.1 litres per second (L/s). The actual average annual dewatering rate is estimated to be 7.2 L/s (or 94.6 Imperial gallons per minute - Igpm) including an additional estimated runoff of 690 mm/year collected within a dry mine floor area of 184,000 $m^2$.

**Evaluation of Stream Flow Effect:** The stream baseflow changes at this stage are presented in Table B.7.1. No significant stream baseflow reduction was predicted at this phase of extraction at SW-11. However, baseflow reductions were predicted at the other three stations with a reduction ranging from 22 to 74 percent (Table B.7.1). The stream flow reduction can be compensated by discharging dewatered flow.

## 7.2 END OF 40 YEARS MINE EXTENSION CONDITION

This section presents the simulation results of the groundwater flow pattern and the groundwater drawdown effect upon the completed extraction at the end of 40 years with gypsum mined out at the eastern portion of the proposed extension area (Figure B.7.3).

- Similar to the model implementation for Phase 1, drain elevations were assigned to be either at mine floor in model Layer 3, and at the top elevation plus 0.1 m from model Layers 1 and 3 around the perimeter of the staged mine limit; the drain conductance was assigned to be high to allow free drainage to the mine
- In model Layers 1 and 2 where the mine pit would be, the model cells were made inactive (i.e., model cells were taken out of model flow domain)
- The simulation was conducted in a steady-state
- No backfilling of the open pit was assumed to simulate a worst case dewatering condition

The simulated groundwater elevation contours are presented on Figure B.7.3 which shows the stabilized groundwater depression cone due to this stage of quarry operation.

**Evaluation of Drawdown Effect:** The simulated groundwater drawdown is presented on Figure B.7.4. The groundwater drawdown was relative to the existing flow conditions. Figure B.7.4 demonstrates that the 1 m drawdown contour is minimum 300 m north of Avondale Road where the drilled water wells are located.

**Estimated dewatering Rate:** The predicted groundwater inflow (that is purely from groundwater) was 5.7 L/s. The actually average annual dewatering rate is estimated to be 19.4 L/s (or 256.0 Igpm) including an additional estimated runoff of 690 mm/year collected within a dry mine floor area of 625,500 $m^2$.

**Evaluation of Stream Flow Effect:** The stream baseflow changes at this stage are presented in Table B.7.2. Predicted baseflow at SW-11 did not reduce significantly. However, a significant stream base flow rate reduction was predicted at SW-01, SW-17 and SW-18 (Table B.7.2). The reduction of baseflow rates can be compensated by redirecting water from dewatering to the impacted streams accordingly.

## 7.3 END OF MINE LIFE FULL EXTENSION CONDITION

This section presents the simulation results of the groundwater flow pattern and the groundwater drawdown effect upon the full extraction of the entire proposed mine area (Figure B.7.5).

- Similar to the model implementation for Phases 1 and 2, drain elevations were assigned to be either at mine floor in model Layer 3, and at the top elevation plus 0.1 m from model Layers 1 and 3 around the perimeter of the staged mine limit; the drain conductance was assigned to be high to allow free drainage to the mine
- In model Layers 1 and 2 where the mine pit would be, the model cells were made inactive (i.e., model cells were taken out of model flow domain)
- The simulation was conducted in a steady-state
- No backfilling of the extraction area was assumed to simulate a worst case dewatering condition

The simulated groundwater elevation contour is presented on Figure B.7.5 which shows the stabilized groundwater depression cone at the end of mine full extension (or the end of mine life).

<u>**Evaluation of Drawdown Effect**</u>**:** The simulated groundwater drawdown is presented on Figure B.7.6. The groundwater drawdown was relative to the existing flow conditions. Figure B.7.6 demonstrates that the 1 m drawdown contour reached further south beyond Avondale Road where the drilled water wells are located. The predicted drawdown at these drilled water wells were between 2 m to 3 m.

<u>**Estimated Dewatering Rate**</u>**:** The predicted groundwater inflow was 19.5 L/s. The actually average annual dewatering rate is estimated to be 53.9 L/s (or 710.8 Igpm) including an additional estimated runoff of 690 mm/year collected within a dry mine floor area of 1,571,580 m$^2$.

<u>**Evaluation of Stream Flow Effect**</u>**:** The stream baseflow changes at the end of mine life are presented in Table B.7.3. Stream flow rate reductions ranged from 23 to 100 percent depending on the stations. The reduction of baseflow rates can be compensated by redirecting water from dewatering to the impacted streams accordingly.

## 7.4 PROPOSED FULL REHABILITATION

The proposed rehabilitation condition is shown on Figure B.7.7. Two lakes (i.e., the West Lake and the East Lake) are proposed with backfill in-between the two lakes with rock and overburden materials from the mine. Both lake levels were set to the nearest topographical low. The West Lake has a lake level of 45 m AMSL and the East Lake has a lake level of 21 m AMSL. This simulation was used for the assessment of groundwater flow pattern and the potential impact when the full rehabilitation is in place.

Rehabilitation measures were configured in the following settings:

- The simulation for the post-mine extension rehabilitation was conducted by converting cells within the mine areas where the two lakes would be to active and by applying a very high hydraulic conductivity (K=10,000 m/day) to represent the open-water areas for the two lakes. At the potential lake overflow areas, drain cells were applied with stages of corresponding ground surface elevations (i.e., 45 m AMSL for the West Lake and 21 m AMSL for the East Lake) to represent the natural draining conditions.
- The backfilled material was converted to be active model cells and was assumed to have the same hydraulic properties as the native overburden and rock.
- The groundwater drawdown was calculated in comparison with the base case (i.e., the existing flow condition).

**Evaluation of Drawdown Effect:** The simulated groundwater elevation contour is presented on Figure B.7.7. The simulated groundwater drawdown is presented on Figure B.7.8. As shown on this figure, the groundwater drawdown was not predicted to extend far enough to have a potential impact on the drilled water wells along the Avondale Road.

**Evaluation of Stream Flow Effect:** The stream baseflow changes at this stage are presented in Table B.7.4. Based on the simulation results, Shaw Brook (SW-01) is expecting flow increase by 26.2 percent due to the direct overflow of the East Lake. The stream flow rates would potentially reduce at other simulated stations, SW-11, SW-17 and SW-18, however, the stream flow reductions were not very significant and can be easily managed.

**Estimate of Lake Filling Times:** The filling times for the West Lake and the East Lake were estimated with considerations of available water from both the groundwater inflow at the full extension and the net recharge over the lakes. With the lakes being filled up, the groundwater inflow rates will be reduced. As a rough estimate, half of the groundwater inflow rate at the full scale mine extension was used as an average available groundwater inflow for lake-filling. Half of this available groundwater inflow was assumed flowing towards the West Lake and the other half towards the East Lake. The lake volumes were calculated using Surfer 8.0 (Golden Software, 2007) based on the corresponding mine floor elevations and the lake water levels. The available water from precipitation (without lake surface evapotranspiration as a net recharge) was calculated over the areas of the corresponding lakes. Based on Environment Canada, the net recharge over surface water is about 690 mm/year. The details of parameters and the results of the lake-filling times are presented in Table B.7.5. It is estimated to take 47 years and 24 years to fill the West Lake and the East Lake, respectively.

## 8.0 REFERENCES

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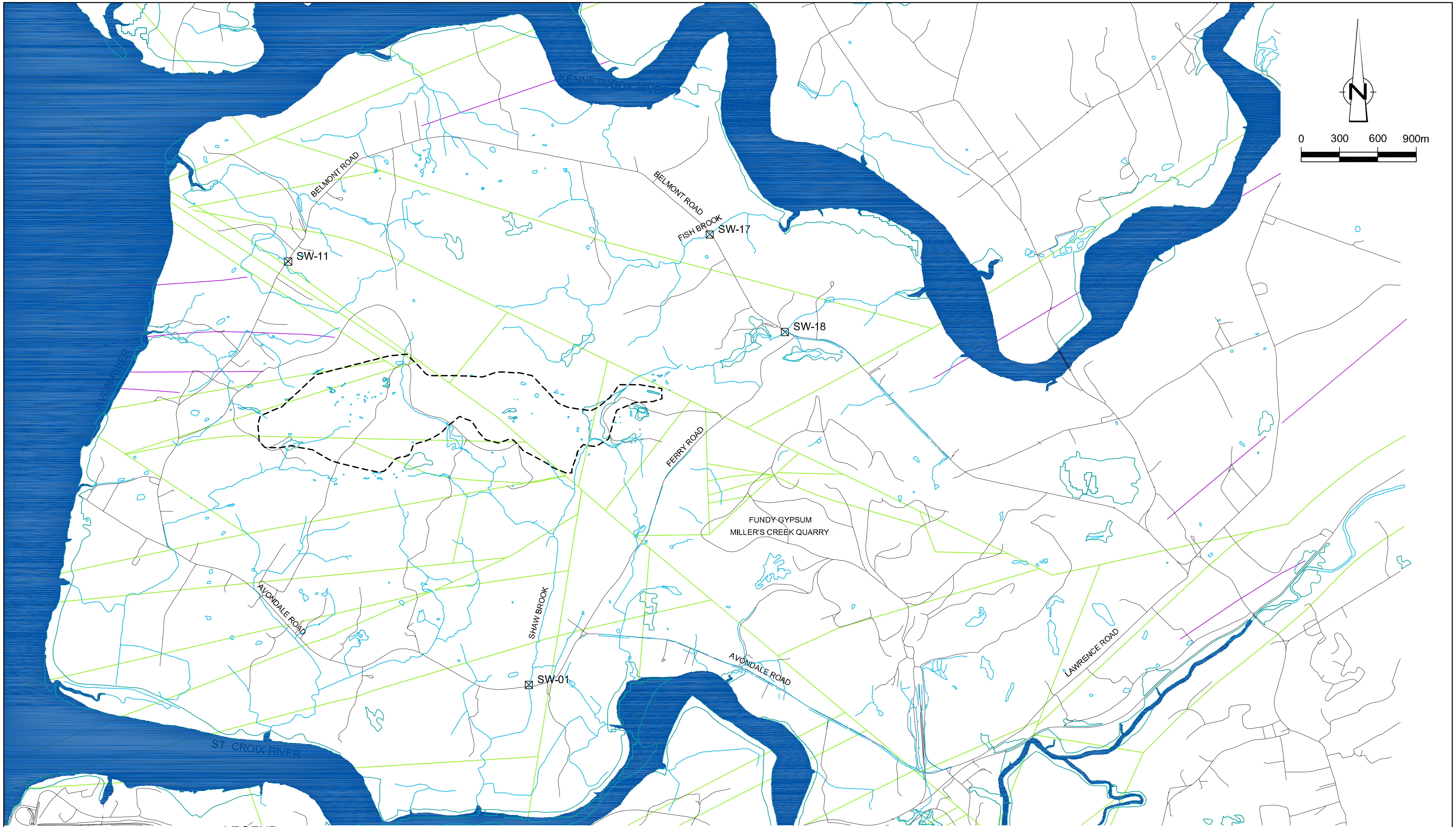


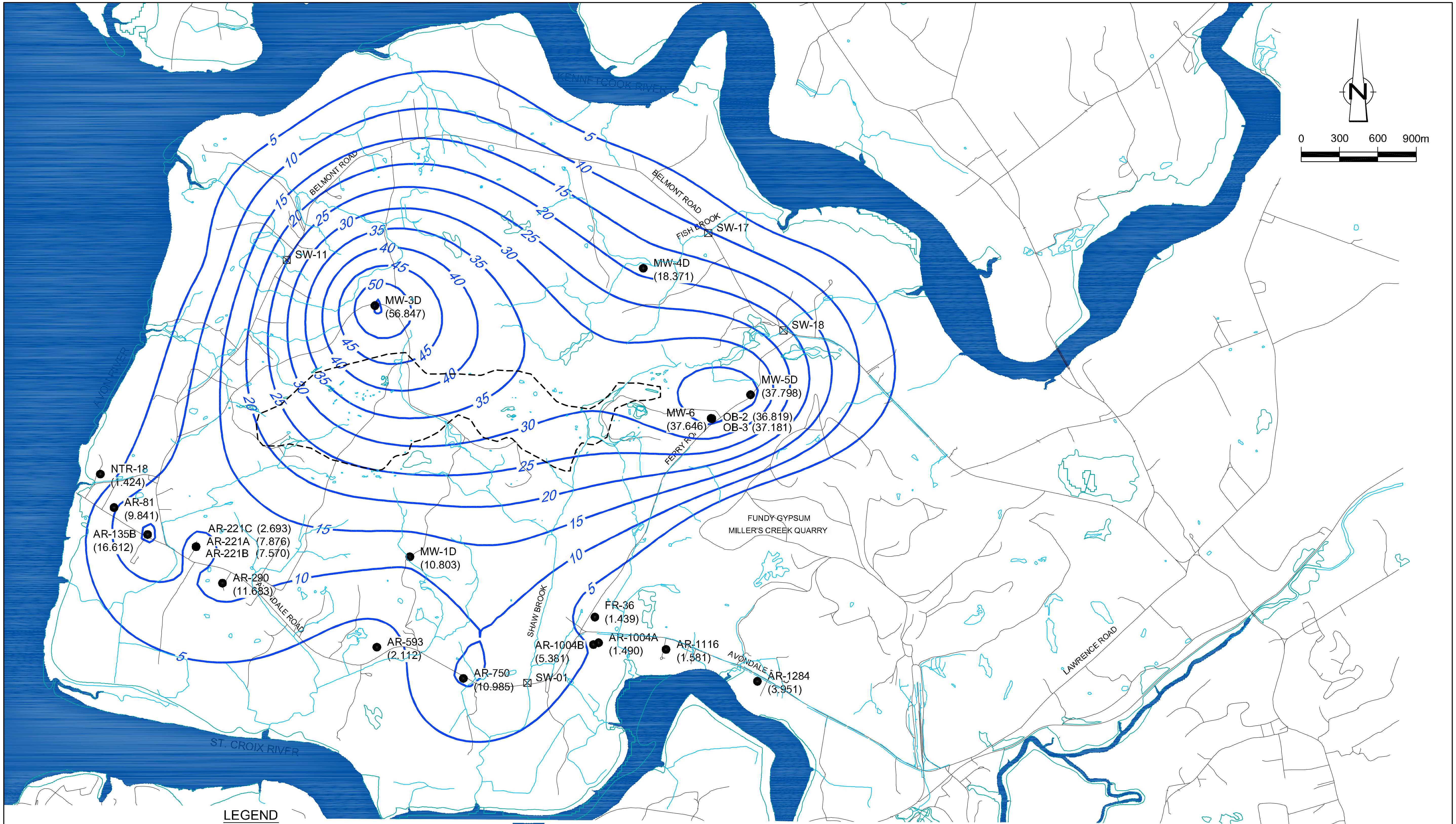
LEGEND

- - - - PROPOSED MILLER'S CREEK EXTENSION AREA
—— ROAD
—— WATER FEATURE
—— WETLAND
☒ SURFACE WATER STATION
—— FAULT
—— FOLD
▬ RIVER

figure B.2.1

FAULTS AND FOLDS
MILLER'S CREEK MINE EXTENSION PROJECT
CGC INC. - WINDSOR PLANT
*Hants County, Nova Scotia*

820677-K(009)GN-DA001 AUGUST 12/2009



LEGEND

| | |
|---|---|
| - - - - | PROPOSED MILLER'S CREEK EXTENSION AREA |
| —— | ROAD |
| —— | WATER FEATURE |
| —— | WETLAND |
| ⊠ | SURFACE WATER STATION |
| ● | BEDROCK MONITORING LOCATION |
| (5.381) | GROUNDWATER ELEVATION (m AMSL) |
| — 4 — | INTERPOLATED GROUNDWATER ELEVATION CONTOUR |
| ▨ | RIVER |

NOTE:
THE ILLUSTRATED GROUNDWATER ELEVATION CONTOURS MAY NOT BE REPRESENTATIVE IN THE NORTHERN AREA AND ALONG THE SURFACE WATER COURSES OR OTHER TOPOGRAPHICALLY LOW AREAS DUE TO INTERPOLATION BETWEEN DATA POINTS.

figure B.2.2

INTERPOLATED GROUNDWATER ELEVATION CONTOURS (BEDROCK)
MILLER'S CREEK MINE EXTENSION PROJECT
CGC INC. - WINDSOR PLANT
*Hants County, Nova Scotia*

820677-K(009)GN-DA002 AUGUST 21/2009

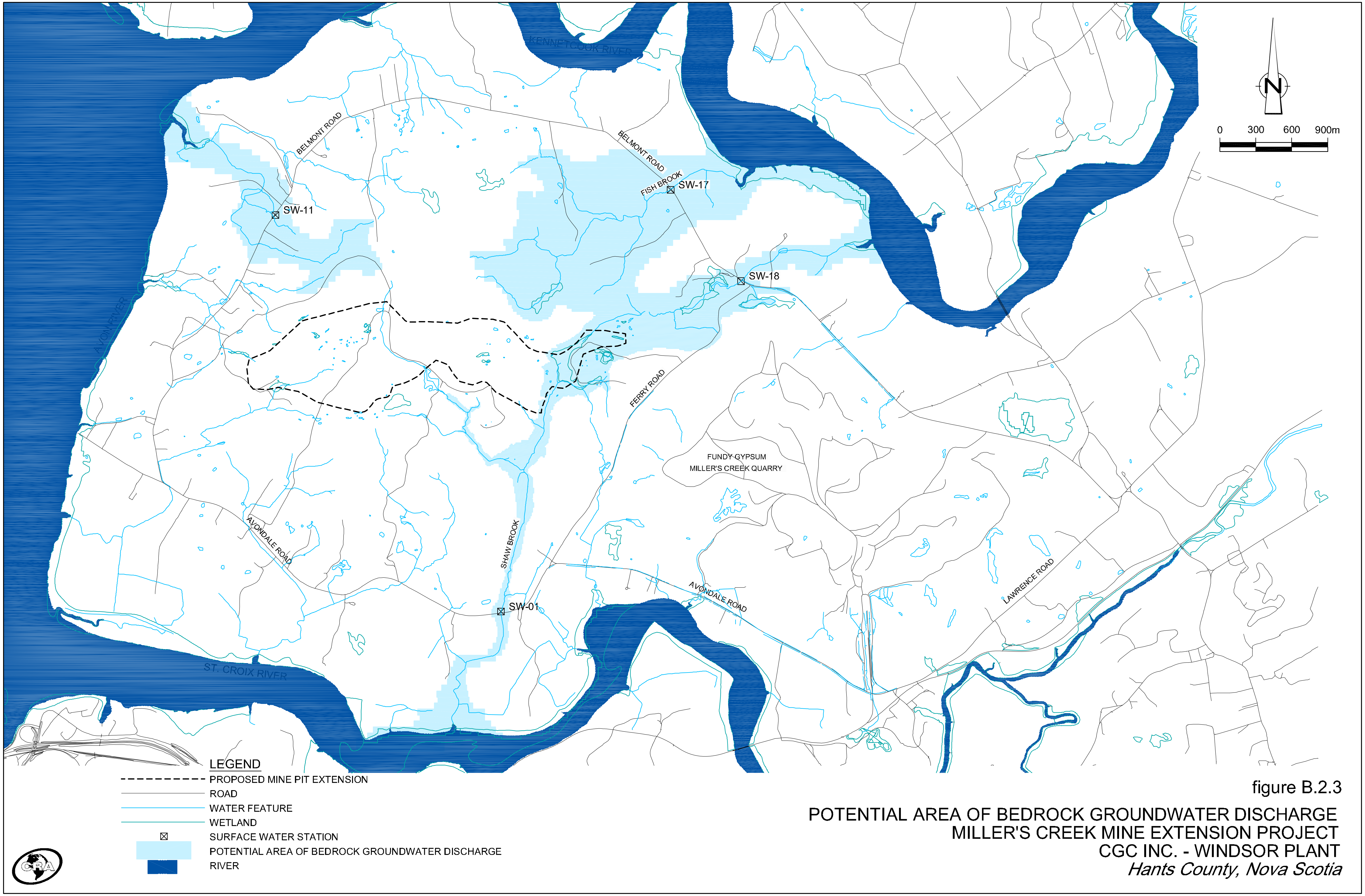
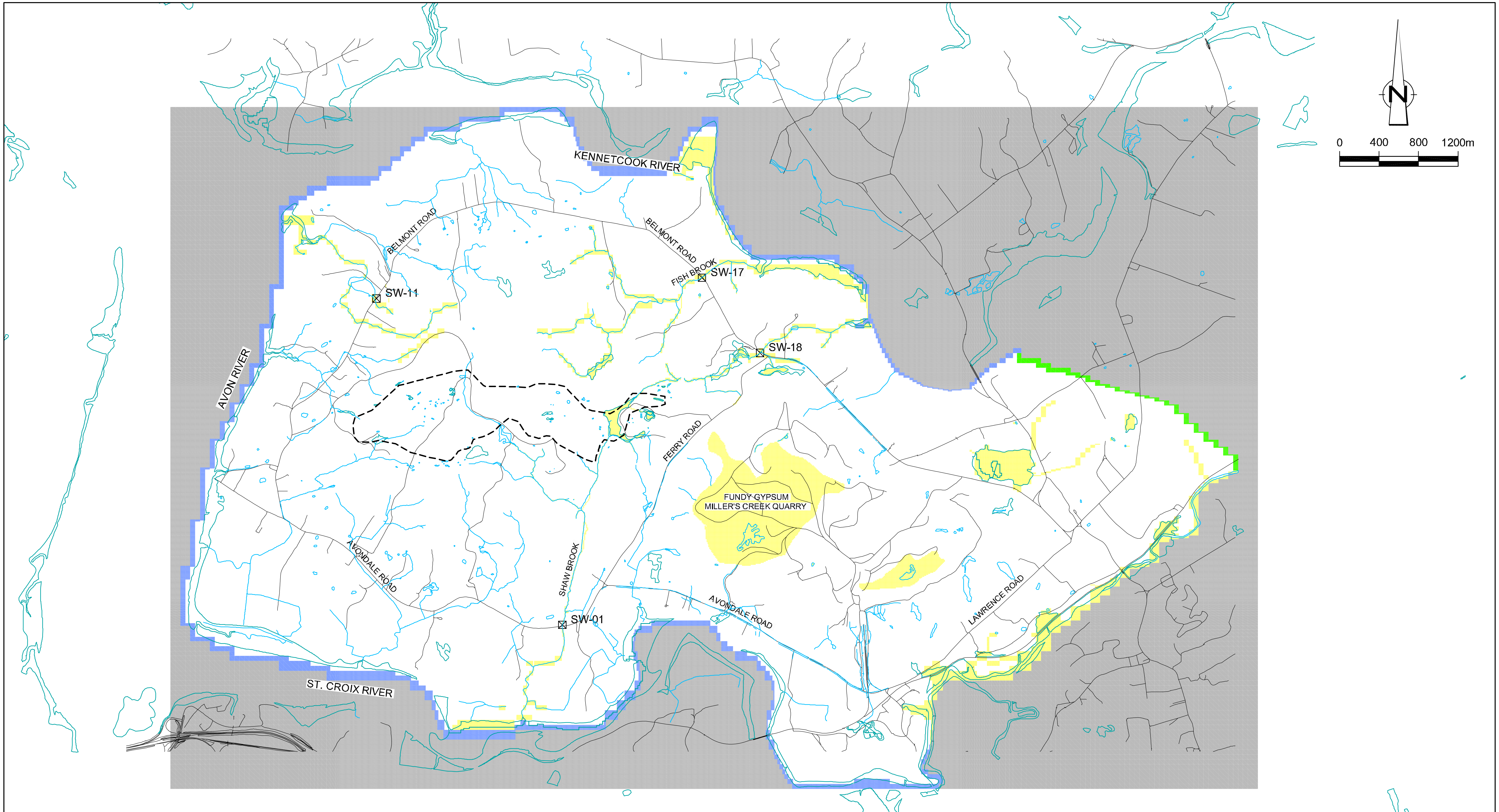


figure B.2.3

POTENTIAL AREA OF BEDROCK GROUNDWATER DISCHARGE
MILLER'S CREEK MINE EXTENSION PROJECT
CGC INC. - WINDSOR PLANT
*Hants County, Nova Scotia*

820677-K(009)GN-DA003 AUGUST 21/2009



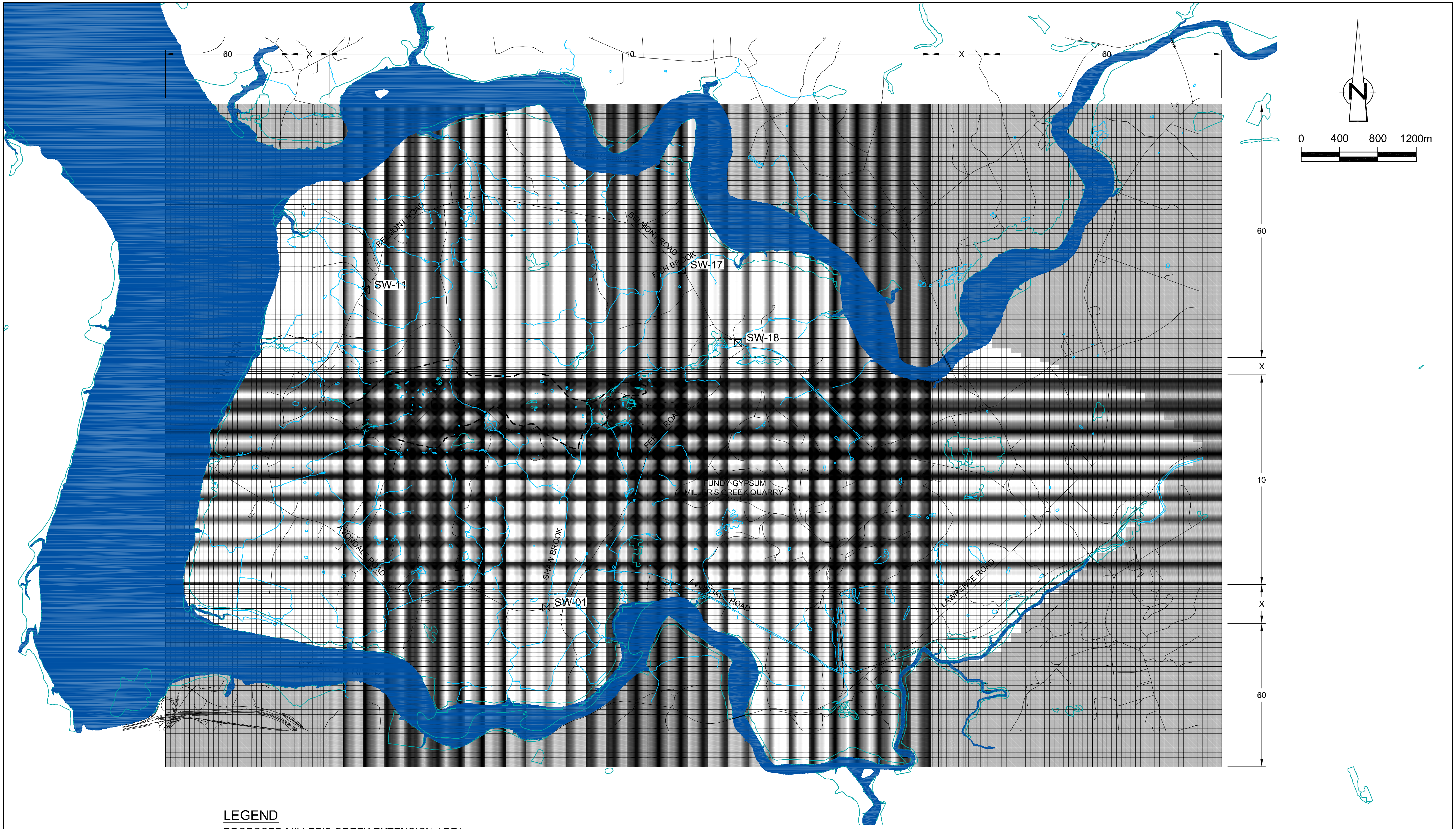
LEGEND

- - - - PROPOSED MILLER'S CREEK EXTENSION AREA
— ROAD
— WATER FEATURE
— WETLAND
⊠ SURFACE WATER STATION
▨ INACTIVE MODEL CELL (NO FLOW)
☐ ACTIVE MODEL CELL (MODEL DOMAIN)
🟦 CONSTANT HEAD CELL
🟨 DRAIN CELL
🟩 NO FLOW BOUNDARY

figure B.5.1

MODEL DOMAIN AND BOUNDARY CONDITIONS
MILLER'S CREEK MINE EXTENSION PROJECT
CGC INC. - WINDSOR PLANT
*Hants County, Nova Scotia*

820677-K(009)GN-DA004 AUGUST 21/2009



LEGEND

- - - - - PROPOSED MILLER'S CREEK EXTENSION AREA

——— ROAD

——— WATER FEATURE

——— WETLAND

☒ SURFACE WATER STATION

▨ INACTIVE MODEL CELL (NO FLOW)

☐ ACTIVE MODEL CELL (MODEL DOMAIN)

▦ MODEL GRID

|← 10 →| FINITE-DIFFERENCE GRID SPACING (meters)

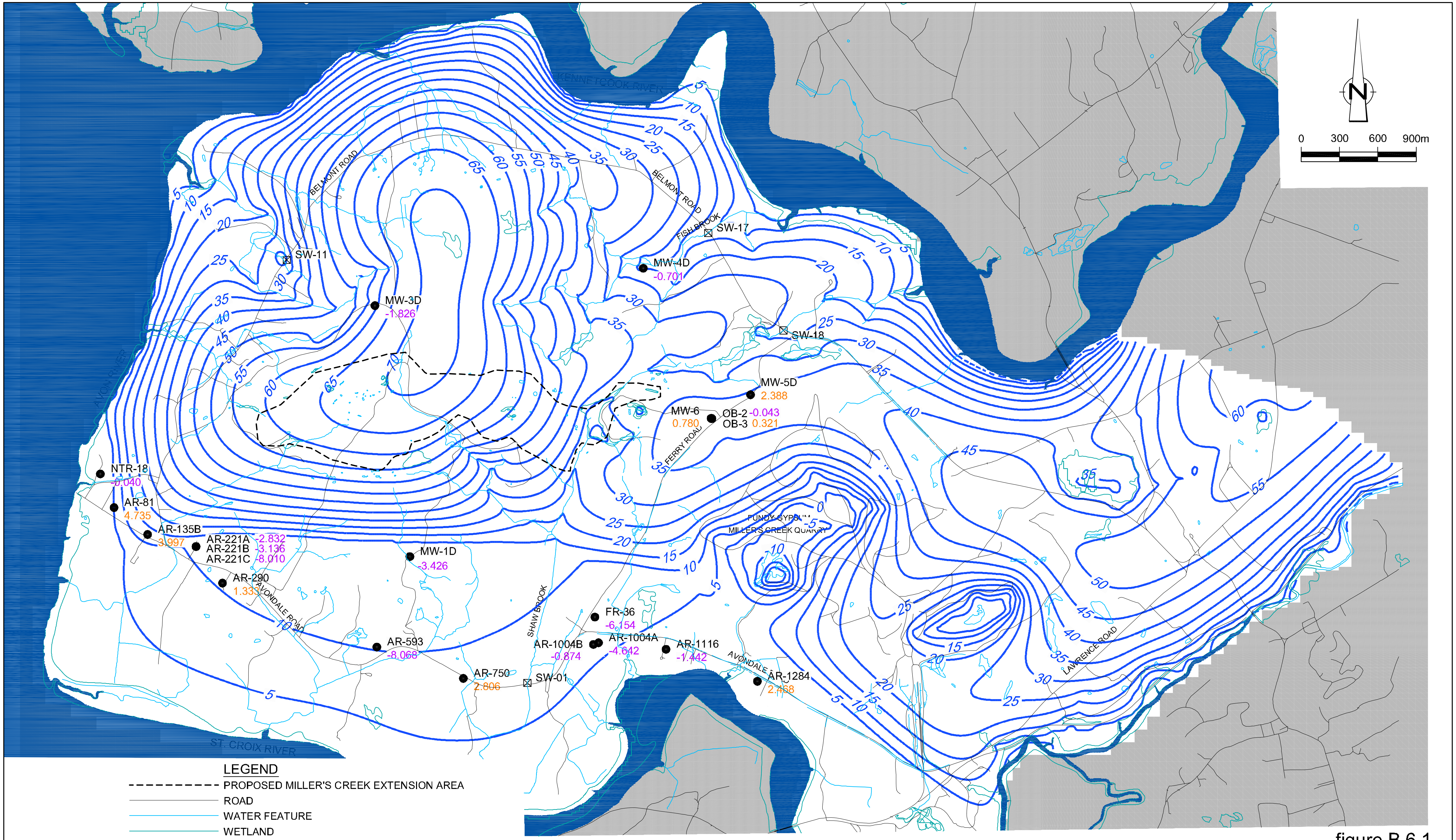
|← X →| TRANSITION FROM 10m TO 60m GRID SPACING

■ RIVER

figure B.5.2

## HORIZONTAL MODEL DOMAIN DISCRETIZATION
## MILLER'S CREEK MINE EXTENSION PROJECT
## CGC INC. - WINDSOR PLANT
*Hants County, Nova Scotia*

820677-K(009)GN-WA005 AUGUST 21/2009



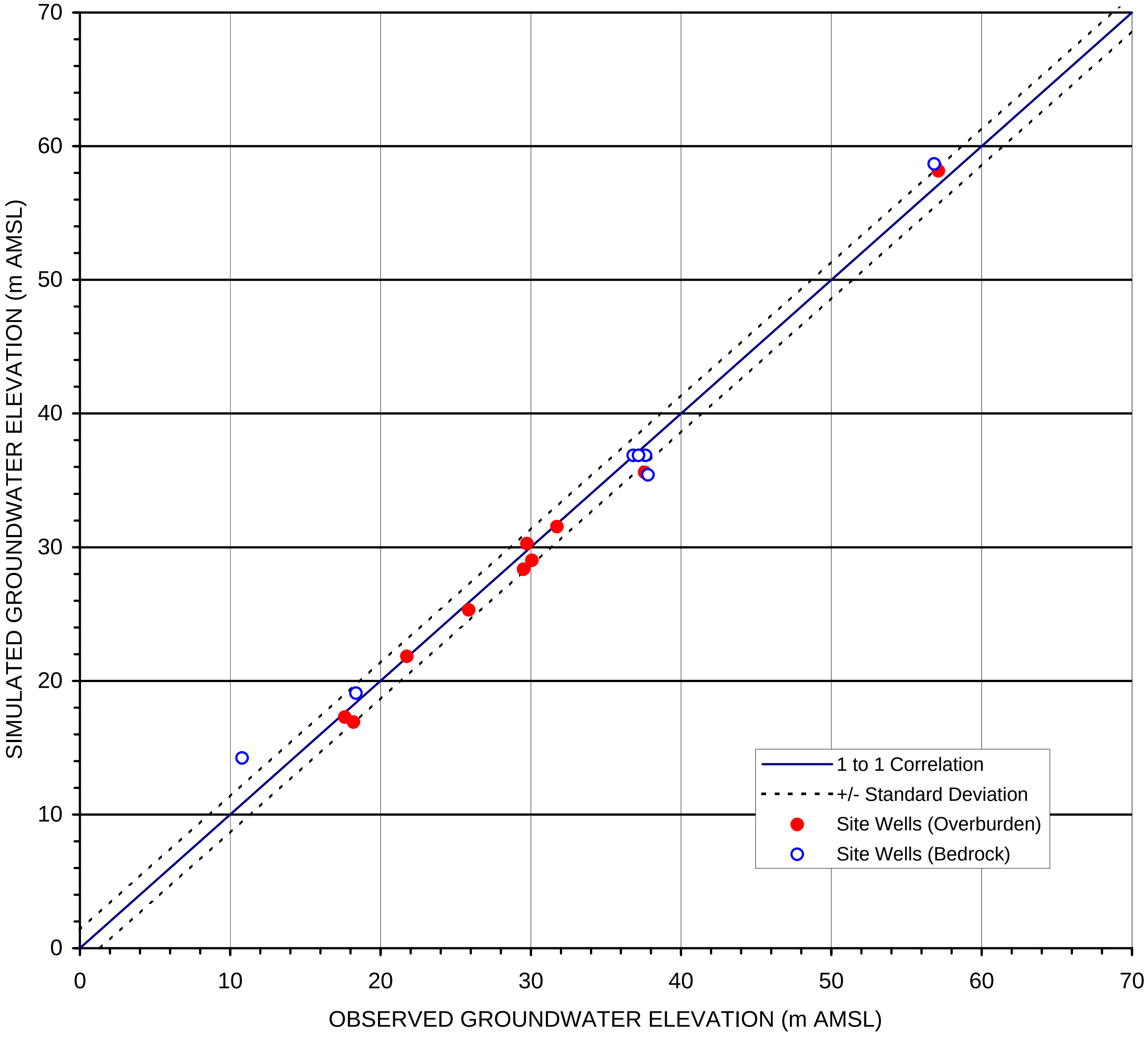
## LEGEND

| | |
|---|---|
| - - - - - - | PROPOSED MILLER'S CREEK EXTENSION AREA |
| ―― | ROAD |
| ―― | WATER FEATURE |
| ―― | WETLAND |
| ☒ | SURFACE WATER STATION |
| ▨ | INACTIVE MODEL CELL (NO FLOW) |
| ☐ | ACTIVE MODEL CELL (MODEL DOMAIN) |
| ● | BEDROCK MONITORING LOCATION |
| 2.806 | POSITIVE RESIDUAL *(m) |
| -8.068 | NEGATIVE RESIDUAL *(m) |
| —— 4 —— | SIMULATED GROUNDWATER ELEVATION CONTOUR |

NOTE:
* RESIDUAL REPRESENTS SIMULATED MINUS MEASURED WATER LEVEL. POSITIVE RESIDUAL REPRESENTS AN OVERESTIMATION OF THE MEASURED WATER LEVEL.

figure B.6.1

SIMULATED GROUNDWATER ELEVATION CONTOURS AND RESIDUALS
MILLER'S CREEK MINE EXTENSION PROJECT
CGC INC. - WINDSOR PLANT
*Hants County, Nova Scotia*



RESIDUAL STATISTICS

| | |
|---|---|
| Number of Targets = | 17 |
| Residual Mean (m) = | -0.15 |
| Residual Standard Deviation (m) = | 1.36 |
| Residual Sum Of Squares ($m^2$) = | 31.98 |
| Absolute Residual Mean (m) = | 1.04 |
| Minimum Residual (m) = | -2.39 |
| Maximum Residual (m) = | 3.43 |
| Observed Head Range (m) = | 46.33 |
| Residual Standard Deviation / Head Range (-) = | 0.03 |

figure B.6.2

SCATTER PLOT OF CALIBRATION WATER LEVELS (SITE TARGETS)
MILLER'S CREEK MINE EXTENSION PROJECT
CGC INC. - WINDSOR PLANT
*Hants County, Nova Scotia*

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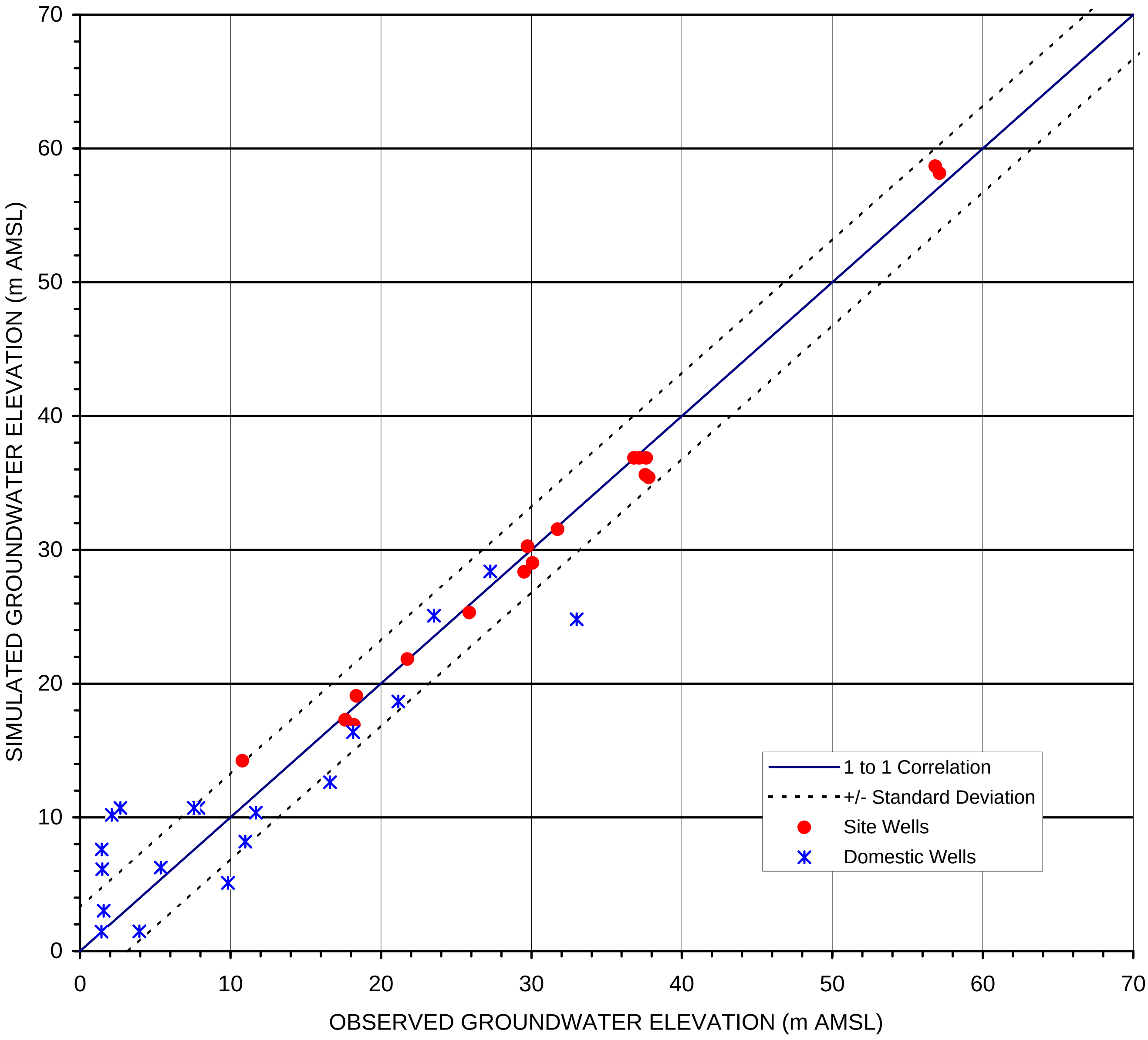
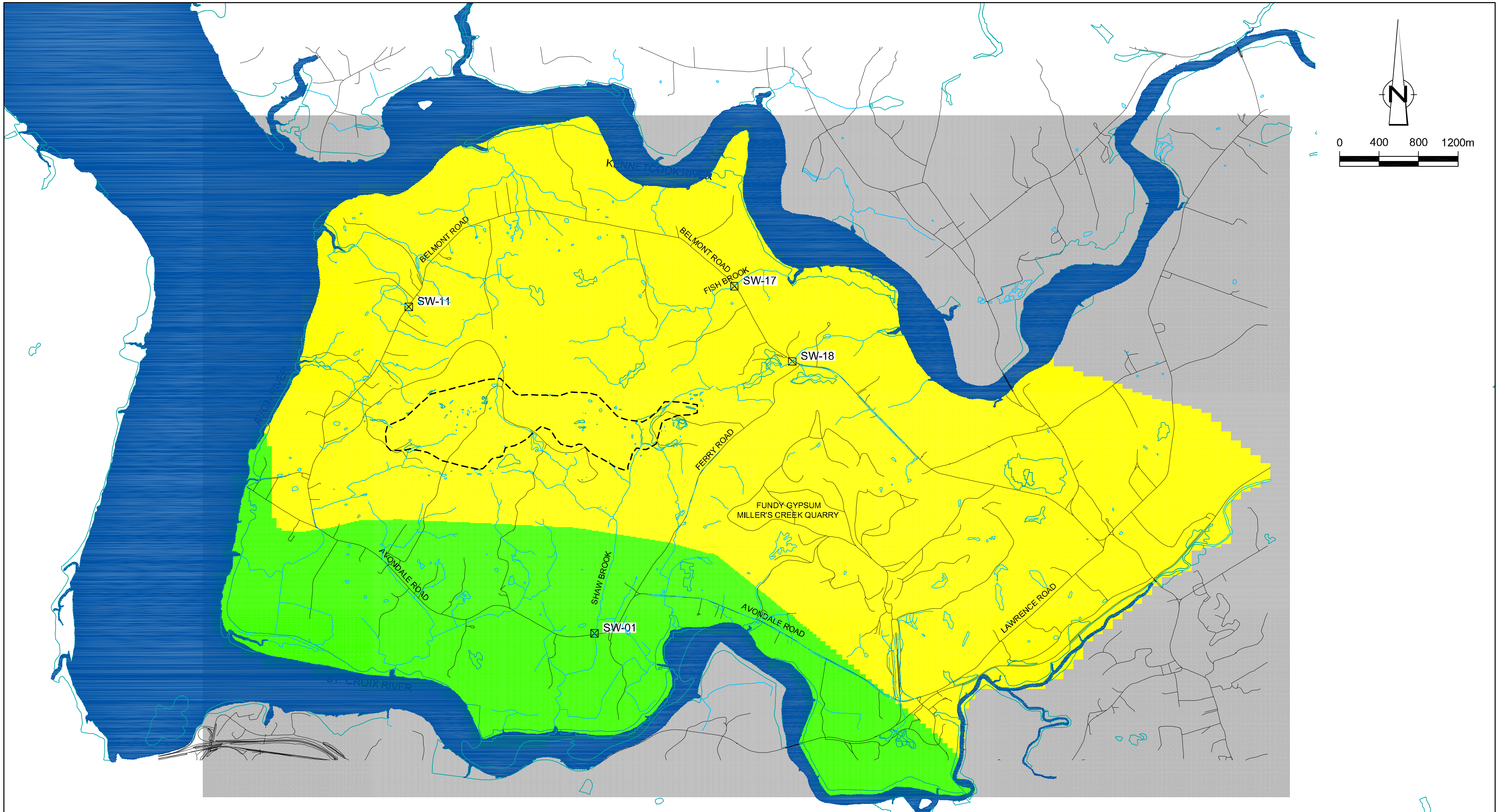


RESIDUAL STATISTICS

| | |
|---|---|
| Number of Targets = | 36 |
| Residual Mean (m) = | 0.21 |
| Residual Standard Deviation (m) = | 3.22 |
| Residual Sum Of Squares ($m^2$) = | 375.92 |
| Absolute Residual Mean (m) = | 2.32 |
| Minimum Residual (m) = | -8.21 |
| Maximum Residual (m) = | 8.07 |
| Observed Head Range (m) = | 55.71 |
| Residual Standard Deviation / Head Range (-) = | 0.06 |

figure B.6.3

SCATTER PLOT OF CALIBRATION WATER LEVELS (ALL TARGETS)
MILLER'S CREEK MINE EXTENSION PROJECT
CGC INC. - WINDSOR PLANT
*Hants County, Nova Scotia*



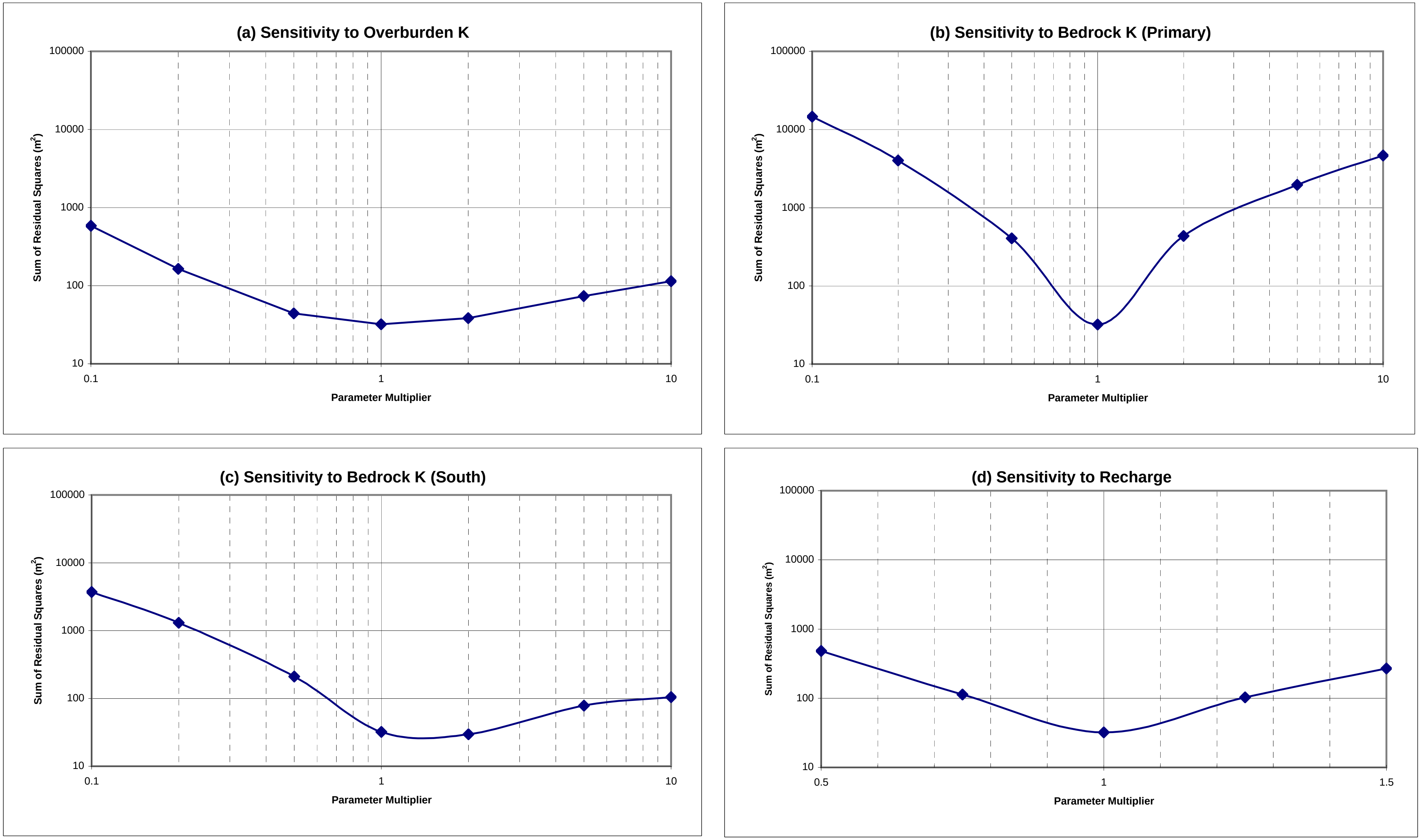
LEGEND

- - - - PROPOSED MILLER'S CREEK EXTENSION AREA
— ROAD
— WATER FEATURE
— WETLAND
☒ SURFACE WATER STATION
▨ INACTIVE MODEL CELL
🟨 K = 1.0E-5 cm/s
🟩 K = 2.3E-4 cm/s

figure B.6.4

CALIBRATED HYDRAULIC CONDUCTIVITIES (BEDROCK)
MILLER'S CREEK MINE EXTENSION PROJECT
CGC INC. - WINDSOR PLANT
*Hants County, Nova Scotia*

820677-K(009)GN-DA007 AUGUST 21/2009



Note:1) Site monitoring wells were used
to calculate the Sum of Residual Squares
2) A multiplier of 1 indicates the calibrated parameter set

figure B.6.5
MODEL SENSITIVITY
MILLER'S CREEK MINE EXTENSION PROJECT
CGC INC. - WINDSOR PLANT
*Hants County, Nova Scotia*

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