Appendix X: Hydrogeology Assessment and Groundwater Monitoring Program

ENVIRONMENTAL ASSESSMENT and GROUNDWATER MONITORING PROGRAM PHASE I

REGARDING

SHAW RESOURCES, a Member of the Shaw Group Limited

AGGREGATE PIT EXPANSION

LOVETT ROAD, COLDBROOK

KINGS COUNTY

NOVA SCOTIA

BY

Water & Aquifer Technical Environmental Resources
TERRY W. HENNIGAR WATER CONSULTING
Hydrogeologist & Groundwater Specialist
59 Birch Drive, RR#2 Wolfville, NS B4P 2R2
Tel. 902 542 3003 Fax. 902 542 1100

SEPTEMBER 2006

TABLE OF CONTENTS

Figures

Tables

Appendices

INTRODUCTION

This report addresses the requirement for a hydrogeology and groundwater component of the environmental assessment of the Shaw Resources aggregate extraction operation in Coldbrook. This site is located south of Highway 101, and east of Lovett Road. A groundwater monitoring program is also presented as typically required in the terms and conditions included in Environmental Assessment Approvals as issued by the Nova Scotia department of the Environment and Labour for similar aggregate pit operations.

Description of the Aggregate Extraction Operation

Shaw Resources has been operating an aggregate extraction facility under approval from the Province of Nova Scotia under the Environment Act since 2004. The operations have been carried out on a 2.2 hectare site. This environmental assessment is for an expansion of the sand and gravel extraction operation for a remaining 4.6 hectares and associated works at the site in Coldbrook, Kings County.

Location of site

The Shaw Resources aggregate extraction operation and facility is located in the village of Coldbrook, approximately 1 kilometre west of the town limits of Kentville. The site is specifically located south and west of Highway 101, east of the Lovett Road, and north of the Dominion Railway. Figure 1 shows the location of the existing aggregate extraction operation, and the area of interest for the expansion, in relation to the topography, drainage, highways, and structures in the Coldbrook area.

Methodology and Rationale

All readily available and relevant information on the water resources and hydrogeology of the site was reviewed and interpreted for this study. Soils, glacial geology, bedrock geology, water well records, and other groundwater information were reviewed to assess the sensitivity of the environment to groundwater impacts from the proposed aggregate extraction operation at the site.

Recommendations are made for verifying and quantitatively defining the hydrogeological framework of the site and characterizing the groundwater quality, levels, and flow patterns in the area. This work will include test well drilling, monitoring well construction, water sampling and analyses, documentation, and reporting. Information from this hydrogeological field work will provide Shaw Resources Limited and Nova Scotia Department of Environment and Labour with baseline data with which to assess environmental impacts on the groundwater resources from the undertaking if any are documented. Water quality data from the monitoring wells will also provide baseline data on groundwater quality entering the site, as well as that leaving the site. These data will prove very useful for assessing off site impacts and provide critical information required for appropriate remediation work.

The need for monitoring water quality at the site is emphasized by the location of the undertaking within the well recharge zone as outlined in the source water protection area for the Town of Kentville. This water supply draws groundwater from the Quaternary and Wolfville HU aquifers underlying the area approximately one kilometer east of, and down gradient of the site.

PHYSICAL SETTING

Precipitation

Table 1 shows the amount of precipitation and the variance from the long-term averages, as reported at the Agri-Food Research Station in Kentville during the growing seasons of the years 2005 and 2006. Several points of interest are worthy of note from this data.

The growing season for year 2005 was considered by many in the agricultural community to be a normal year for growing many crops in the valley. The growing season for year 2006 was considered as a wet year by most growers of field crops. The major influence during year 2005 may have been the lack of precipitation received during the middle of the growing season in June and August. Precipitation during May in 2005 was well above average, while the precipitation during May in 2006 was average. What may be the most critical period of low precipitation occurs during three successive months during the growing season in 2005. Precipitation during May 2005 and during June and July 2006 was more than double the normal for those months.

Knowledge of the precipitation patterns in the area during the growing season will help understand the potential groundwater recharge periods when high water tables may interfere with extraction operations. Recharge does occur following intense precipitation during the growing season resulting in raised groundwater levels underlying the site.

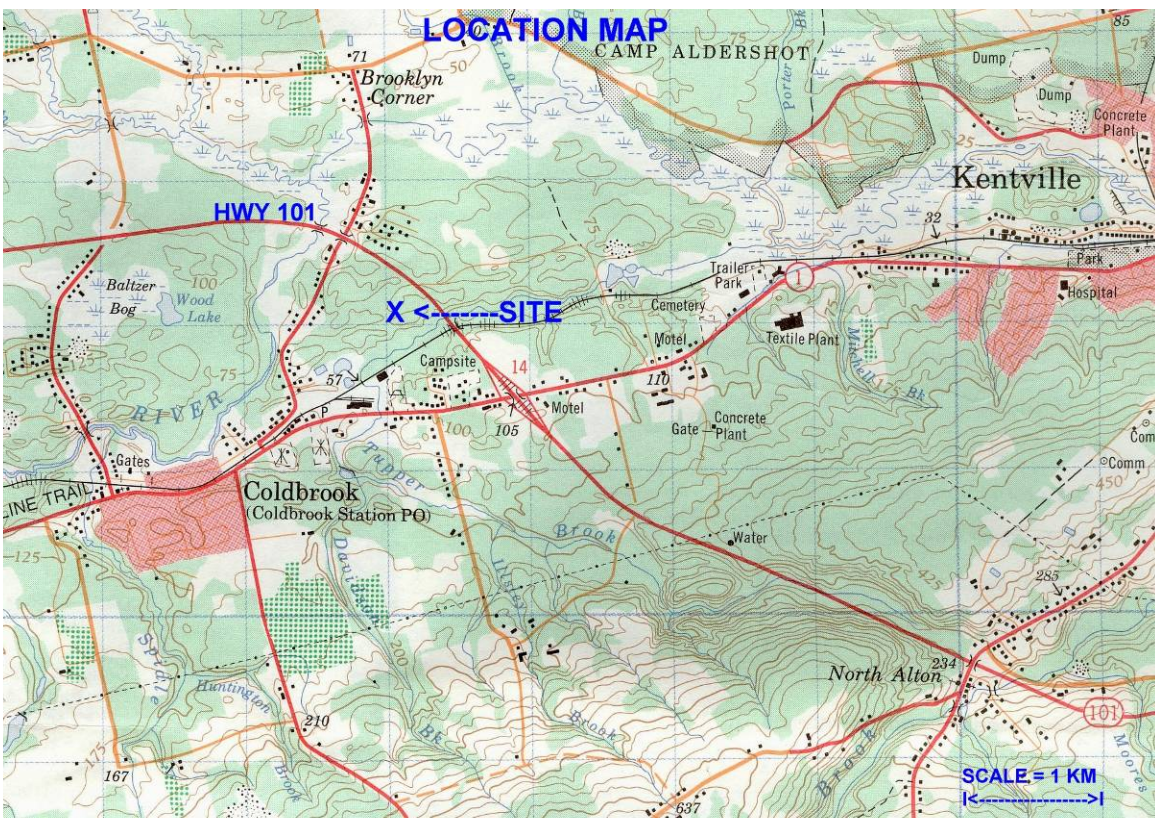

FIGURE 1: Location Map of the Site

TABLE 1: Summary of Precipitation Data at Kentville

Month	Precipitation	Long-Term Average	Variance from Long-Term Average	
			MM	Percentage
YEAR 2005				
MAY	180.0	77.6	102.4	+132
JUNE	39.2	66.8	27.6	-41
JULY	67.5	68.9	1.4	< 1
AUGUST	29.5	89.4	59.9	- 67
SEPTEMBER	78.5	94.4	15.9	-17
YEAR 2006				
MAY	75.3	77.6	2.1	<1
JUNE	221.5	66.8	154.7	+232
JULY	129.4	68.9	60.5	+88
AUGUST	64.6	89.4	24.8	-28
SEPTEMBER	NA	94.4	NA	NA

Land use and zoning in the area

The area of the Shaw Resources aggregate extraction operation is located east of the Coldbrook Growth Centre. Land use in the area of the Coldbrook Growth Centre is a mix of residential, commercial, open space, and institutional development. The area surrounding the Shaw Resources aggregate extraction operation is mixed land use. The aggregate extraction operation is located entirely within an area zoned as R1. Generally, areas that are zoned R1 allow for aggregate extraction operations, which is applicable in this case. Figure 2 shows the mix of land use and urban zoning in the area as mapped by the Municipality of the County of Kings. Properties immediately adjacent to the site are zoned as follows:

East side*: Zoning is R1, Residential.*

North side: *Zoning is R1, Residential*

West side: *Zoning is R1, Residential.*

South side: *Zoning is M1, Light Commercial Industrial, and R2, Residential.*

SOIL TYPES AND CHARACTERISTICS

The soils are mapped and described in three Agriculture Canada Soils Reports. The first was published in 1965 by Cann, MacDougall, and Hilchey as the ‘Soil Map of Kings County’ at a scale of 1 inch to 1 mile. The second map published in 1988 by D. Holmstrom covers Map Sheet 21H/02-T3 at a scale of 1:20,000 and is listed as Nova Scotia Soil Survey Report No. 25. The third report is Report No.26, Supplement to: Soils of the Annapolis Valley Area of Nova Scotia, 1993, authored by D. R. Langille, K. T. Webb, and T. J. Soley. A summary of the description and characteristics of Cornwallis soils types which underlie the site are shown in Table 2.

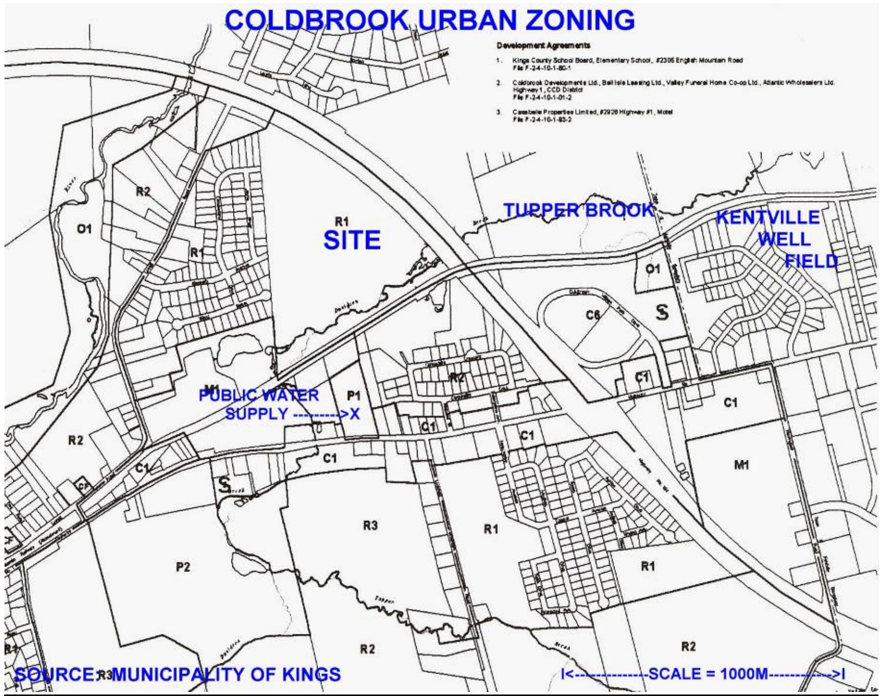

FIGURE 2: Land Use Zoning In the Area

One of the characteristics of the Cornwallis and Hebert soils that makes them distinctive from other soils in the Valley is the dominant very coarse sand size in the B and C horizons. The three soils types in the area have high percentages of sand overall in the A, B, and C horizons and increasing with depth. These attributes of coarse sand and low percentage of finer grained soil particles contributes to the well-drained nature, and low soil moisture holding capacity, of the soils.

TABLE 2: Summary of Soil Characteristics Mapped In the Study Area

Soil Type	Sand Percentage		Dominant Size	Organic Carbon Percentage
	Range	Mean		
Cornwallis (CNW) 85				
A Horizon	75-95	84	Fine	2.1
B Horizon	72-97	90	Very Coarse	0.6
C Horizon	67-99	91	Very Coarse	NA
Hebert (HBT) 86				
A Horizon	76-93	81	Very Coarse	3.3
B Horizon	78-98	87	Very Coarse	1.3
C Horizon	78-99	91	Very Coarse	NA
Truro (TUO) 84				
A Horizon	79-89	84	Fine	2.3
B Horizon	76-90	84	Fine	1.4
C Horizon	72-98	90	Fine	NA

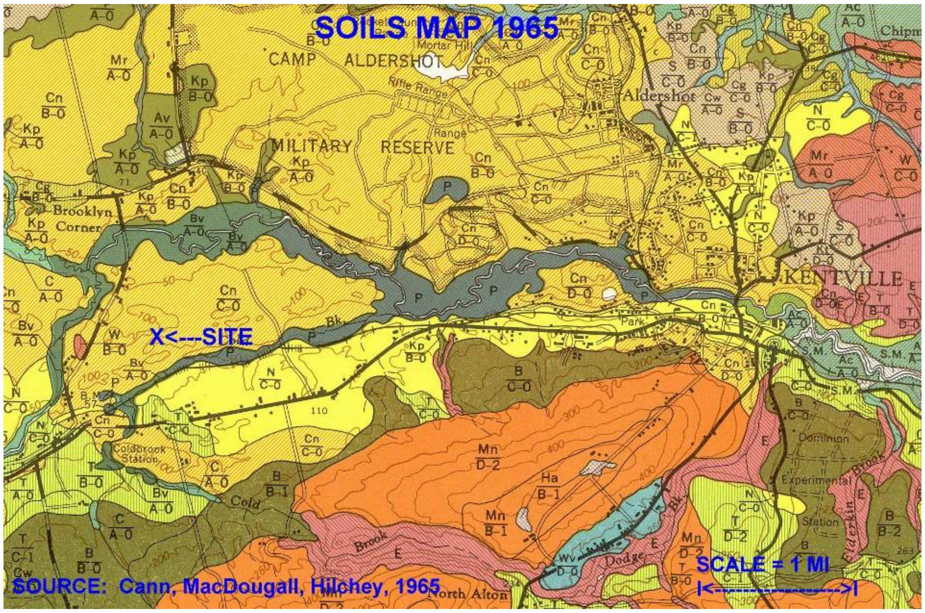

Figure 3: Soils Map of the Area 1965

Table 3 shows a summary of information on thickness and hydraulic conductivity of the Cornwallis and Truro soils types summarized above. This information also shows the higher order of hydraulic conductivity of Cornwallis soils compared to the finer grained Truro soils in the area. The two attributes of these sandy soils that account for heavier water demands in agricultural use include their high hydraulic conductivity and low silt/clay content which reduce the water holding capacity during the growing season.

The average thickness of the Cornwallis soils to the bottom of the B Horizon is 29.5 cm. The average hydraulic conductivity is 11.9 cm/hr, which is high compared to that of other soils in the valley.

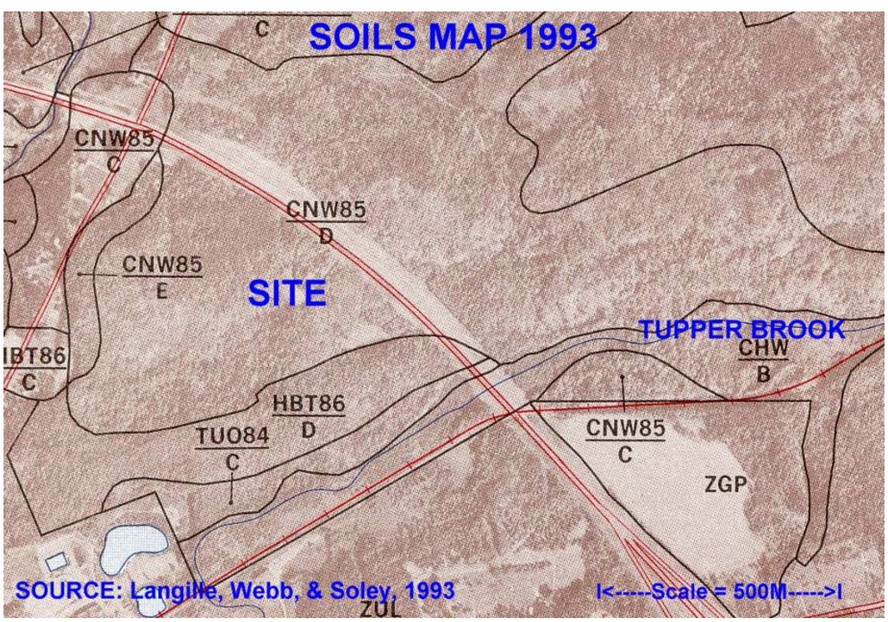

Figure 4: Soils of the site as mapped in 1993

Table 3: Summary of Hydraulic Conductivity of Three Soil Types in the Study Area

Soils Type	Thickness (cm)		Hydraulic Conductivity (cm/hr)	
	Range	Mean	Range	Mean
Cornwallis(CNW) 85				
A Horizon	12-57	26	7.2 - 24.9	14
B Horizon	6 - 75	33	8.2 - 23.0	14.1
C Horizon	NA	NA	5.2 - 9.3	7.6
Hebert (HBT) 86				
A Horizon	10 – 40	24	NA	NA
B Horizon	11 – 50	37	NA	NA
C Horizon	NA	NA	NA	NA
Truro (TUO) 84				
A Horizon	10 - 55	26	0.6 – 4.4	2.6
B Horizon	10 – 70	32	1.0 – 9.4	4.3
C Horizon	NA	NA	5.0 - 7.9	6.7

Notes:
1. Drainage of Cornwallis 85 soils ranges from well to rapid.
2. Drainage of Hebert 86 soils reported as rapid.
3. Drainage of Truro 84 soils reported as well drained.
4. Source Holmstrom and Thompson, 1989.

The high hydraulic conductivity values of the Cornwallis soils at the site give rise to high values of groundwater recharge and low values of surface water runoff from the area. Accordingly this means no pronounced surface drainage or well developed water courses draining the site. Surface drainage from the site is most likely overland flow during periods of snow melt or spring runoff, and following high intensity precipitation events.

GEOLOGY OF THE AREA

Overview

The Cornwallis River Valley is bounded on the south by the South Mountain, which is composed of a mix of igneous and metamorphic rocks. These resistant rocks form a large part of the watersheds that drain the Valley's south flank. The structural pattern of the geological features in these rocks tends to be approximately parallel to the orientation of the Valley, which is in a northeast-southwest direction. These rocks are classed as non-porous, but fractured, which host small aquifers defined entirely by the nature of structural stress breaks that occurred during the past several hundred million years of tectonic activity in Nova Scotia.

These igneous and metamorphic rocks are generally overlain by glacial till deposits, which vary in thickness from 0 to approximately 5 metres. Thickness of these deposits may be over 10 metres where drumlins have formed. Along the Valley flanks and in glacial valleys cut into these rocks, local deposits of glaciofluvial sands and gravels may be found to depths of 100 feet (30 m) or more.

Bedrock Units under the Site

The Valley floor is underlain by soft Triassic sediments, which have been eroded to form an open-ended valley, bounded by the Minas Basin in the east. These sediments are made up of weakly cemented, and easily eroded, sandstones, and sandy shales, which are the most common rock types. The Cornwallis River Valley in the vicinity of Coldbrook is drained by the Cornwallis River, and contributing tributaries, flowing east. The lower reaches of the river, and tributaries, have been drowned as sea level has risen during the past 4,000 years or so, leaving the stream channels below present day sea level. These Triassic rocks dip 4 to 12 degrees to the northwest towards the Bay of Fundy and overlie with angular unconformity the deformed much older Paleozoic metamorphic rocks forming the South Mountain, which dip beneath the Valley.

The Triassic sediments under the Valley floor in the Coldbrook area have been classified as the Wolfville Formation. The Wolfville Formation increases in thickness northward across the outcrop belt to a maximum of over 3,000 feet in places at the base of the North Mountain escarpment. This formation is composed of interbedded red and grey conglomerates, sandstones, siltstones, and claystones. The sandstones and conglomerates are poorly sorted, cross-stratified, contain intra-formational claystone and siltstone, and show lateral changes in stratification, composition, and thickness. The composition of the Wolfville Formation may vary widely from place to place along the Valley floor.

Test holes drilled into the Wolfville Formation and logged by geologists show the type of variation in rock types over relatively short distances. For example, a test hole (T.H. #372) was drilled and logged by a qualified hydrogeologist with the Nova Scotia Department of Mines, in 1968 in the Coldbrook area, approximately 1 km southwest of the Shaw Resources aggregate extraction site. The log from this test hole showed a percentage of sandstone and conglomerate at 22% over a drilled depth of 314 feet in the Triassic sediments. The entire portion of the property is underlain by the Wolfville Formation as shown in Figure 5.

Quaternary Units under the Site

Overlying the bedrock units in the vicinity of the sand and gravel extraction operation are surficial glacial materials, collectively referred to as Quaternary deposits. These deposits are reported to be greater than 100 feet in the Coldbrook area as interpreted from water well records drilled near the study area. The depths to bedrock, as reported by drilling contractors for other water supply wells in the area, are shown in Appendix A.

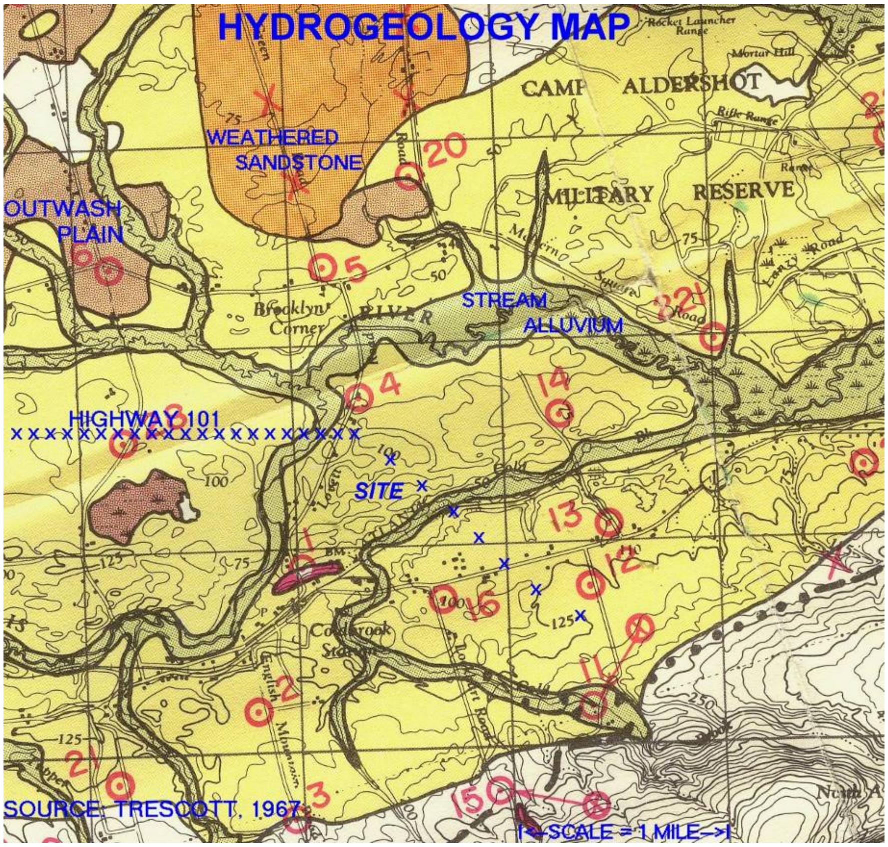

Figure 5: Geology of the Coldbrook and surrounding area

During the Quaternary Period, which covers 1.6 million years of earth history, the climate cooled and large glaciers periodically covered Eastern Canada. Nova Scotia was affected by at least four ice advances from 75,000 to 10,000 years ago. During these glacial periods, ice advanced from different directions. During the first and second glacial periods the ice advanced from the North. During the third period ice advanced from the Scotian Ice Divide to the South, which extended from Yarmouth east to Canso. Ice advanced from the Antigonish Highland Ice Cap during the last ice period about 30,000 years ago.

Today, ridges and hills of sand and gravel deposits called eskers and kames respectively, form the topography on the valley floor in the vicinity of the sand and gravel operation. These deposits vary widely over short distances both laterally and vertically. The distribution of these deposits both laterally and with depth are of particular interest because of their potential as aquifers to store and transmit large quantities of good quality groundwater. The entire property is underlain by ice-contact stratified drift (sand and gravel deposits). The extreme southern portion of the property is underlain by alluvial deposits of silt, sand, and gravel along the drainage system of Tupper Brook. These areas are shown in Figure 5. More detail on the stratigraphy of the Quaternary deposits is provided in the report augmenting the environmental assessment, prepared by Dr. Ian Spooner, Professor of Geology at Acadia University.

HYDROGEOLOGY OF THE SITE

Two major hydrostratigraphic units, as previously mapped within the study area by Trescott (1968), underlie the site. These units are delineated on Figure 5, which also shows the site which is the subject of this study. The Wolfville Formation is referred to as the Wolfville Hydrostratigraphic Unit (Wolfville HU), while the ice-contact stratified drift deposits are referred to as the Quaternary Hydrostratigraphic Unit (Quaternary HU).

The latest edition, February 2005, of the Water Well Records Database maintained by the NSDEL was searched for well logs with information on depth of overburden, water levels, and other relevant information on the hydrogeology of the area. In addition, values of transmissivity, storativity, and safe yield have been summarized from the Pumping Test Database (2005) provided by the Nova Scotia Department of the Environment. Other data on groundwater fluctuations and water quality in the area have been reviewed, interpreted, and summarized for this report to characterize the hydrogeological framework in the area of the proposed undertaking.

Water Well Records:

Any well constructed since 1963 should have a well record on file with the Nova Scotia Department of the Environment & Labour (NSDEL). The record is entered under the name of the original owner of the well. Well records submitted between 1963 and 1978 were published in annual reports available from NSDEL. Records submitted since 1978 are on a computerized database and have been assigned a unique well log number. The Water Well Records Database for Nova Scotia includes information on nearly 100,000 wells throughout the province. Well construction contractors are required to register with the regulatory agency and to keep records of wells constructed, documenting the location, geological conditions encountered, groundwater occurrences, well construction details, and an estimate of well yield.

For domestic well records there is no detailed geological log required under the well construction regulations in Nova Scotia. Available databases on groundwater resources and existing supply records were reviewed, interpreted, and assessed in terms of capability of these records to assist in providing an understanding of the hydrogeological framework of the sand and gravel extraction area, and designing a groundwater monitoring plan for the site.

The Nova Scotia Water Well Records Database maintained by the Department of the Environment was reviewed and summarized. Records were abstracted from this database and summarized on a grid basis to determine the number of wells in the area, range of values for total depth, yield, and depth to bedrock for Waterville area. These records available for the area northeast of the Village of Coldbrook are included in Appendix A. The two grid locations searched for water well records include those in which the proposed aggregate extraction operation is located.

Up until about 1988, well locations were determined by using the National Topographic Map Series, and locating the well site down to the nearest mining tract, which covers an area of one square mile. The sand and gravel extraction operation is located in mining tract 69 of map sheet 21H2A. Sixteen water well records for wells drilled prior to 1979 in mining tract #69 were found in the data base.

In 1988 a new map reference system was introduced based on the 1: 250,000 scale provincial map booklet. This system allows location by page number and site within a 10 square kilometer area, and further by a secondary grid determining the well site within a one square kilometer area. The sand and gravel extraction operation is located in grid P13C5L14. Twenty-three water well records were found as reportedly drilled in this grid. Table 4 shows a summary of water well data as recorded in the NSDEL records for wells reported to be drilled in the bordering area of the site.

Depth of casing used in well construction was selected as the indicator parameter to give an estimate of the depth to bedrock, or the depth of the overlying Quaternary deposits in Kings County. In most cases of well construction, the amount of casing required is dependent on the depth of these unconsolidated and unstable glacial deposits of clay, silt, sand, and gravel. Since approximately 95%+ wells drilled in the Province are for domestic water supplies, the target aquifer is the underlying bedrock; therefore it is assumed that this depth of casing is considered as a reasonable estimate of the depth to bedrock.

As seen in the data presented in Table 4, 39 water wells are reported in the vicinity of map grid locations in the general area where the sand and gravel extraction operation is located. The data recorded for wells in the area also show that well depths vary considerably, from 44 feet to 162 feet. Depths to static water level in wells also vary from 5 to 56 feet below ground surface. Reported well yields ranged from 4 to 70 imperial gallons per minute. The water well data is summarized in Table 4 by grid area. This table shows the number of wells, range of depth to bedrock, range of depth to water level, and range of well yield in each grid area.

Table 4: Summary of Water Well Records Found In the Study Area

Grid Area	Number of wells	Range of depth to bedrock	Range of depth to Water level	Range of yield
21H2A69	16	44 - 136	8 - 50	8 – 70
P13C5L14	23	60 - 162	5 - 56	4 - 35

Notes: 1. Depths in feet.
2. Yield in gallons per minute.

Pumping Test Data

The pumping test database for large capacity wells and public water supplies was initiated in the 1960's. Geological data collected for such wells was often logged by a professional hydrogeologist. In addition a properly organized and conducted pumping test was carried out, the data interpreted and analyzed, and a safe yield based on a continuous 20 year production life was determined. This database was reviewed and all data sets for the Coldbrook area were interpreted and summarized. Four sets of pumping test data from test wells, or large capacity wells, were found for the Coldbrook area. Three pumping tests were carried out on wells constructed in the Wolfville Hydrostratigraphic Unit (HU), and one test was carried out on a well constructed in the Quaternary sand and gravel Hydrostratigraphic Unit. A summary of the pertinent and related information from this database for Kings County is presented in Appendix B.

The information in Appendix B shows the hydrostratigraphic units, transmissivity, storativity, and expected yields from wells drilled into these units. Expected well yields shown in the tables are based on the average T (transmissivity; a measure of an aquifers ability to transmit water) and a total available drawdown of 100 feet. No wells found in this database are located within the foot print of the site, but are located nearby and are considered to be representative and typical of the hydrogeological conditions found within the site.

The pumping test database is the best and most reliable source of well yield and aquifer characteristics available to hydrogeologists and groundwater managers. Aquifer testing is a very important component in development of any water supply that withdraws more than 23,000 liters per day from an aquifer, or for water supplies other than domestic. Under the Well Construction Regulations of Nova Scotia, a pump test of not less than 72 hours duration is required for all non-domestic wells, unless otherwise approved in writing (variance) by an inspector. The purpose of the test is to determine the long-term safe yield of the well, potential impacts on other existing wells in the area, and other environmental impacts. Municipal and industrial wells may require a longer test, if there is a perceived, or potential, environmental concern related to the withdrawal of large volumes of groundwater in the area.

Pumping tests are carried out by certified individuals and follow a well established protocol. The typical data and procedure followed in conducting such a test includes the following:

- Regulating and monitoring pumping rate;
- Measuring and recording water levels in the pumping well and nearby observation wells;
- Collecting samples for water quality analyses;
- Interpreting and analyzing the pumping test data;
- Determining the sustainable yield of the well; and
- Reporting to the Nova Scotia Department of the Environment.

The above data is required by the Nova Scotia Department of the Environment & Labour for the processing of water approvals to withdraw groundwater for non-domestic water supply purposes and public drinking water supplies.

The large number of pumping test data sets for wells completed in the Wolfville HU is a reflection of the wide distribution of the use of these hydrogeological units under the Valley floor. The Wolfville HU contains the major bedrock aquifers under the Valley floor and is the source of water for most domestic supplies. The wells reported to be completed in a Quaternary sand and gravel aquifer may or may not overlie the Wolfville Formation on the Valley floor. Some of these Quaternary aquifers, although thought to be extensive over the Valley floor, are also found on the south flank of the Valley overlying other bedrock types, such as the Halifax Formation. The Quaternary aquifers are also known to produce large quantities of very good quality water in other parts of the province of Nova Scotia.

Groundwater Hydrographs

The Province of Nova Scotia initiated in 1964 a systematic evaluation of regional groundwater resources through the Groundwater Section of the Department of Mines. This work continued with the assistance of various federal programs and Departments until the mid 1980's. Exploratory wells developed for the various regional projects were monitored to obtain specific baseline data of groundwater elevations and to document groundwater level fluctuations. A report "Groundwater Hydrographs in Nova Scotia 1965-1981" was published by the Nova Scotia Department of the Environment in 1984. This report presents a summary of recorded groundwater levels in tabular and graphical formats. These data and graphs illustrate the probable occurrence, by extension, of groundwater levels in the hydrogeologic units surrounding the wells.

A partial record of a time series of groundwater hydrographs from the 1960's to the present are in various databases maintained by the Nova Scotia Department of the Environment & Labour. These records were published in a report by the NSDEL entitled 'Groundwater Hydrographs in Nova Scotia 1965 -1981'. The closest groundwater hydrograph records available to the sand and gravel extraction operation are in the Coldbrook, Berwick, and Prospect (South Waterville) areas. These records were reviewed and interpreted to determine natural seasonal changes in the groundwater reservoir in the study area. A summary of the published hydrograph data for the observation well located in Coldbrook is presented in Figure 6.

Groundwater hydrograph records in the general area of Coldbrook indicate periods of recession during the summer months followed by recovery during the autumn over a 16 year period from 1965 to 1981. The groundwater level monitoring wells were constructed in different hydrostratigraphic units in the Valley. Observation well #001 (OW#001) was constructed in the Quaternary sand and gravel HU aquifer, in 1964, underlying the Coldbrook area north of Highway #1. It is located approximately 1 km west of the Shaw Resources aggregate site. This hydrograph is included because it is considered relevant to the study and representative of the site.

During the period of record, water level fluctuations of approximately 10 feet were documented in the Coldbrook area, where water levels fluctuated between 40 and 50 feet above mean sea level. Over the sixteen year period of record a maximum water level of 49.90 feet above mean sea level was recorded on 31 May 1971. The minimum water level was recorded at 39.62 feet above mean sea level on 28 November 1965. The range of fluctuations and seasonal trends in groundwater levels are shown in the hydrograph included in Figure 6.

Observation well #001 was drilled to a depth of 86 feet through Quaternary sand and gravel deposits. Triassic sandstones (Wolfville Formation) were encountered between 86 and 93 feet where drilling was discontinued. A well screen was installed in the well over the interval between 81 and 93 feet below ground surface. The well was used as an observation well during a pumping test of a nearby well, also constructed in the Quaternary HU. From these data a value for T (transmissivity) was calculated as 85,000 igpd/ft, and a value of S (specific storage) was calculated to be 2.21×10^{-4}.

Note that the minimum recorded low water levels fall on dates late in the growing season, whereas the maximum recorded high water levels occur during the winter or spring seasons. This distribution of lows and highs strongly suggests that there is no downward trend in groundwater levels in the area during that period. These lows are related to climatic cycles of low precipitation rather than increased withdrawals of groundwater from the aquifer in the area.

TABLE 5: Groundwater Observation Wells near the Study Area

Site	Well Number	Status	Aquifer
Coldbrook	001	Abandoned	Quaternary HU
Sharpe Brook	011	Abandoned	Halifax HU
Berwick	032	Abandoned	Wolfville HU

Table 5 identifies three groundwater observation wells near the study area that have been, or are now being, monitored by staff of the NSDEL. The status of a number of other former monitoring wells is being reviewed and their condition assessed for reactivation and upgrading with new digital recording equipment. The nearest other groundwater level monitoring activities are ongoing in and around the Kentville West Well Field.

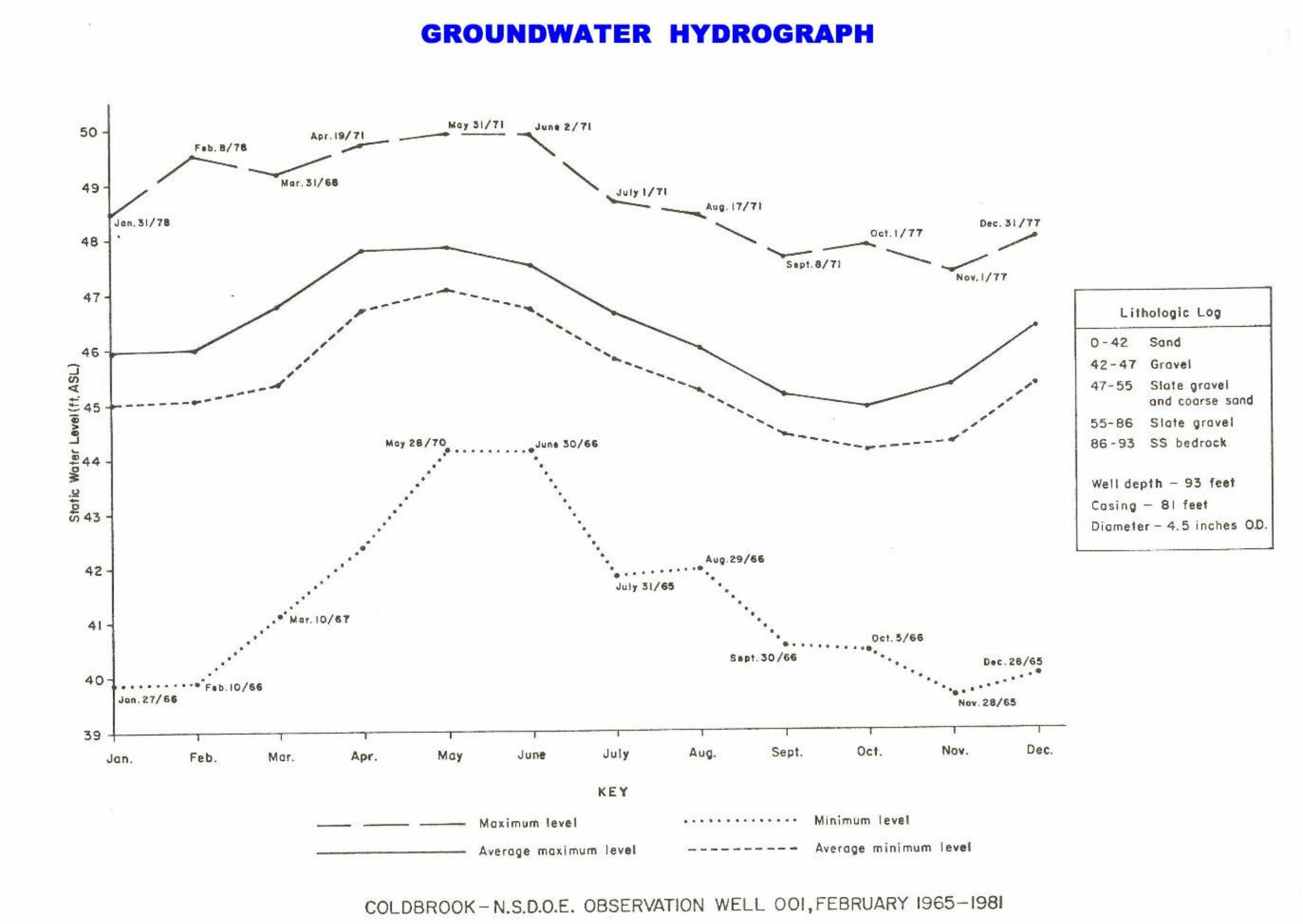

FIGURE 6: Record of Groundwater Fluctuations in Coldbrook

In 1984 eleven groundwater observation wells were being monitored in Kings County. Water level changes documented in these observation well network records show fluctuations in groundwater levels due to precipitation, tidal influence, seasonal variations, and water removal from nearby pumping wells. Many of these observation wells were installed in the vicinity of newly constructed, large capacity industrial or municipal water supply wells, the purpose being to monitor and observe drawdown trends in the aquifers being pumped at high rates for the first time on a sustained basis.

Of the eleven monitoring wells in Kings County, five were constructed in Quaternary HUs. Another five of the wells were constructed in Wolfville HUs, and one monitoring well records water level changes in the Halifax Formation (Halifax HU) near Sharpe Brook. Records of water level changes in the five wells located in the Quaternary sand and gravel deposits are of particular importance to this study. The groundwater hydrograph at Coldbrook is considered to represent what is occurring to the groundwater levels under the site. The hydrograph for Berwick is considered representative of water level changes in bedrock wells drilled in the area. The hydrograph at Sharpe Brook is expected to be typical of drilled bedrock wells along the South Mountain.

Bedrock Aquifers

Bedrock aquifers underlying the Coldbrook area are located in Triassic sediments of the Wolfville HU. The most reliable and complete information on the characteristics of these aquifers comes from water well and pumping test records maintained by the Nova Scotia Department of the Environment and Labour. Records were found for 39 wells in the water well records database within the two map reference grids in which the study area lies.

It is estimated that thirty-five, or approximately 90%, of these wells were constructed in the Wolfville HU. The average depth of well constructed in the Wolfville HU is 136 feet, with a range of 60 to 215 feet. One of the deepest reported wells was rated at 4.0 igpm based on a preliminary air lift test. The bedrock well with the highest reported yield is 135 feet deep and has an estimated preliminary yield of 50 igpm.

Three pumping test records were found for wells constructed in the Wolfville HU in the Coldbrook area. The yield of a well is primarily dependent on the transmissivity (T) of the aquifer supplying water to the well, and the saturated thickness of the section penetrated. As seen in Appendix B, transmissivity values vary significantly from site to site thus giving higher yields for shallower wells with higher transmissivity values. The variation of transmissivity in these aquifers is related to the grain size and fracturing, which can be seen to vary over short vertical and horizontal distances in local outcrops. The range of transmissivity values in the Wolfville HU underlying the Coldbrook area varies from 1.2 to 321 m^2/d. Based on these values and 100 feet of available drawdown, the safe 20 year continuous well yield ranges from 3.2 to 400 igpm. The average depth of these wells is 73.4 m, and range from 35.1 to 121.9 metres.

The nearest Halifax Formation bedrock units are mapped approximately 1.5 kilometres south of the site as shown on Figure 5. These rocks and associated acid rock drainage issues are not expected to be a concern at the Shaw Resources Coldbrook aggregate extraction site.

Quaternary Aquifers

The shallow Quaternary deposits, those most recently deposited by the last glacial activity on the Valley floor have been mapped in two dimensions at a reconnaissance scale by Trescott, 1968. The depth, stratigraphy, subsurface extension, and distribution of older Quaternary deposits are not known. However, water well records and pumping test data indicate a complex system of interstratified deposits of different ages underlying the Valley floor in the vicinity of the aggregate extraction site in Coldbrook. The most productive wells, i.e. highest capacity, have been constructed in Quaternary aquifers from Wolfville through to Greenwood.

Eight pumping test records were found for wells in the Quaternary HU in Kings County; one reported in Coldbrook. A summary of the well and pumping test information is provided in Appendix B. The depths of these wells are significantly less than that for bedrock wells, and the yield is much higher, which is normal for wells constructed in these types of aquifers. The range of transmissivity values in Quaternary deposits underlying Kings County are similar to those underlying the Coldbrook area, and vary from 94 to 1307 m^2/d. From the above values of transmissivity, and a total available drawdown of 100 feet, the 20 year continuous safe yield of wells constructed in the Quaternary HU range from 60 to 1,000+ igpm. The average depth of these wells is 32.9 m, and range from 18.3 to 47.6 metres.

Groundwater Quality

Groundwater quality can change significantly over a very short horizontal and or vertical distance because of the influence of minerals in the host bedrock or overburden material. A distinctive difference between water from the Wolfville HU and the Quaternary HU is often the presence of greater hardness and total dissolved solids, and higher pH in water from the Wolfville HU.

Because of the nature of the sand and gravel extraction operation at the Coldbrook site, and the distance from problematic bedrock mineralization such as that in the Halifax Formation, no adverse water quality impacts are expected at the site.

The only available data of unbiased background groundwater quality in the valley is that collected and reported by Trescott (1968) as part of the Groundwater and Hydrogeology Study of the Annapolis-Cornwallis Valley. A summary of the findings of groundwater quality based on the Trescott study is presented in Table 6 for the hydrostratigraphic units occurring under the area of Coldbrook. The parameters selected for comparison and shown in Table 6 are pH, total hardness (T.H.), iron (Fe), manganese (Mn), sulphate ($S0_4$), chloride (Cl), total dissolved solids (TDS), and nitrate-nitrogen ($N0_3$-N).

Table 6: Summary of Groundwater Quality in the Coldbrook Area

UNIT	pH	T.H.	Fe	Mn	$S0_4$	Cl	TDS	$N0_3$-N
Wolfville HU	7.4	117	0.22	0.02	20.0	33.7	190	2.1
Quaternary HU	6.8	62	0.30	0.04	11.7	19.2	120	1.7

GROUNDWATER MONITORING PROGRAM

Water quality monitoring in the vicinity of the sand and gravel extraction operation will serve four main purposes. These are listed as:

- To determine the background quality of groundwater in the area up-gradient of the extraction operation.
- To assess whether groundwater contamination is occurring from the sand and gravel extraction operations.
- To assess and characterize potential migration pathways of potential contaminants off the site.

- To determine presence of, and risk to, receptors of contamination if it does exist. The main receptor identified in this study is the Town of Kentville water which is down gradient of the sand and gravel extraction site, and within the well field recharge zone, Zone D.

The groundwater monitoring program planned for the aggregate extraction operation is scheduled to operate during the life of the aggregate extraction activities.

This report presents the results of the Phase I work carried out during September 2006. Field work included a reconnaissance of the area, a review of groundwater data available, and selection of sites for future monitoring wells.

During the first year of sand and gravel extraction operations in the expansion area, Phase II will be implemented. This work will include drilling of boreholes, construction of monitoring wells, sample collection from the monitoring wells for chemical analyses, observation and recording of water level observations, determination of groundwater flow patterns, and determinations of vertical field hydraulic gradient at strategic locations in the site. A report will be prepared and submitted to NSDEL reporting progress, results, and interpretation of the data over the first quarter for water quality and water level data.

Monitoring Wells

Strategic locations for boreholes, in which monitoring wells will be constructed, will be identified based on the hydrogeological setting of the site, soils types, drainage patterns, topography, and proposed active extraction areas. Locations and construction details of monitoring wells constructed on the site for this phase of the project will be documented.

Overview

Most of the monitoring wells will be single level structures which penetrate the water table in the underlying surficial and/or bedrock materials. At least one monitoring well will be a multilevel type with a shallow and a deeper portion designed to determine vertical groundwater gradients in a selected area of the site. Following well development, water levels will be determined for each of the monitoring wells. Water samples will be collected and analysed for selected chemical and physical parameters. Elevations of all monitoring wells will be determined to assist in calculating groundwater flow gradients and groundwater flow direction.

Well construction will be accomplished with either a hydraulic rotary drill using a tri-cone bit, or a hollow stem auger drill, operated by an experienced drilling company. Temporary six inch diameter casing, or a hollow stem auger, will be driven into the geological materials, and the samples will be collected from inside the casing by drilling out the plug at 10 foot intervals, or when a change in geology is noted. Two inch diameter PVC casing and screens will be installed at selected depth intervals in the wells, gravel packing will be installed around the screen, and the upper cased portion of the wells will be grouted with bentonite. Once the casing, screen, gravel, and bentonite are in place the six inch diameter casing will be withdrawn to expose the screen to the water bearing zone to be monitored. Well development will be carried out by pumping with a bailer, a Waterra sampling device, or electric pump. Typical design and construction of monitoring wells to be used for this project is shown in Figure 8.

Existing wells

There appears to be no existing wells in strategic areas on or around the property that are considered suitable for monitoring groundwater quality of relevance to this project. All existing wells are considered to be outside the area of influence, and outside the footprint of the proposed aggregate extraction undertaking. It was reported by the proponent that a number of exploratory test holes and pits were constructed on the site to assess the aggregate resources of the site. These test holes will be reviewed and assessed to determine their usefulness as monitoring wells, and to assist in final location of monitoring well construction.

All private water supply wells in the area are either too far removed from the site, up the inferred groundwater gradient, or occur on the other side of a natural hydraulic barrier provided by Tupper Brook. Construction characteristics of the wells in the area are presented in Appendix A. Assuming that each residence in the area has a water supply well, it can be expected that a well northwest of the site may be within 100 metres (300 feet) of the active working face at some stage during the history of the excavation project. During work for Phase II of the groundwater monitoring program it is proposed that a 'Water Supply Investigation' be carried out for wells within a 100 metre radius of the proposed active extraction area. The separation distances from the sand and gravel pit operations can be seen in a general sense on Figure 2.

A review was carried out of the Public Drinking Water registration data base for Kings County as maintained by the NSDEL. Based on this review there are no public drinking water supplies registered in the immediate study area. The nearest public drinking water supplies registered are in the Coldbrook area, west and south of and up-gradient of the site. These areas are at least one kilometer or more from the site of interest for this study. In addition the well field for the Town of Kentville is located approximately one kilometer east and down gradient of the site.

New Monitoring Wells

The location, design, and construction of monitoring wells will follow approved methods adopted as standard operating procedures for the industry and are appropriate for the site and nature of groundwater monitoring planned for the site. Based on results of this study, three monitoring wells are recommended as shown in Figure 7.   Basic criteria for the location, design, and construction of the monitoring wells include the following:

- Separation distances in compliance with well construction regulations.
- Location and number of monitoring wells based on consideration of the hydrogeological framework of the site and sensitive area identified in the environmental assessment report.
- Depths of wells determined by the stratigraphic sequence encountered during drilling, depth to water table, and expected annual and seasonal groundwater level range of fluctuations.
- Minimum diameter of wells to be 50 mm inside diameter.
- Use of PVC schedule 40 flush joint pipe and screens with a minimum 50 mm thick gravel pack and bentonite grout in the appropriate sections of the borehole surrounding the well casing and screen.
- An approved plug on the bottom and an approved cap on the top of the casing will be placed to ensure the integrity of the monitoring well from the intrusion of surface water.
- Groundwater and well head elevations, and horizontal references for the well head, will be determined and documented as part of the record of the monitoring well construction.

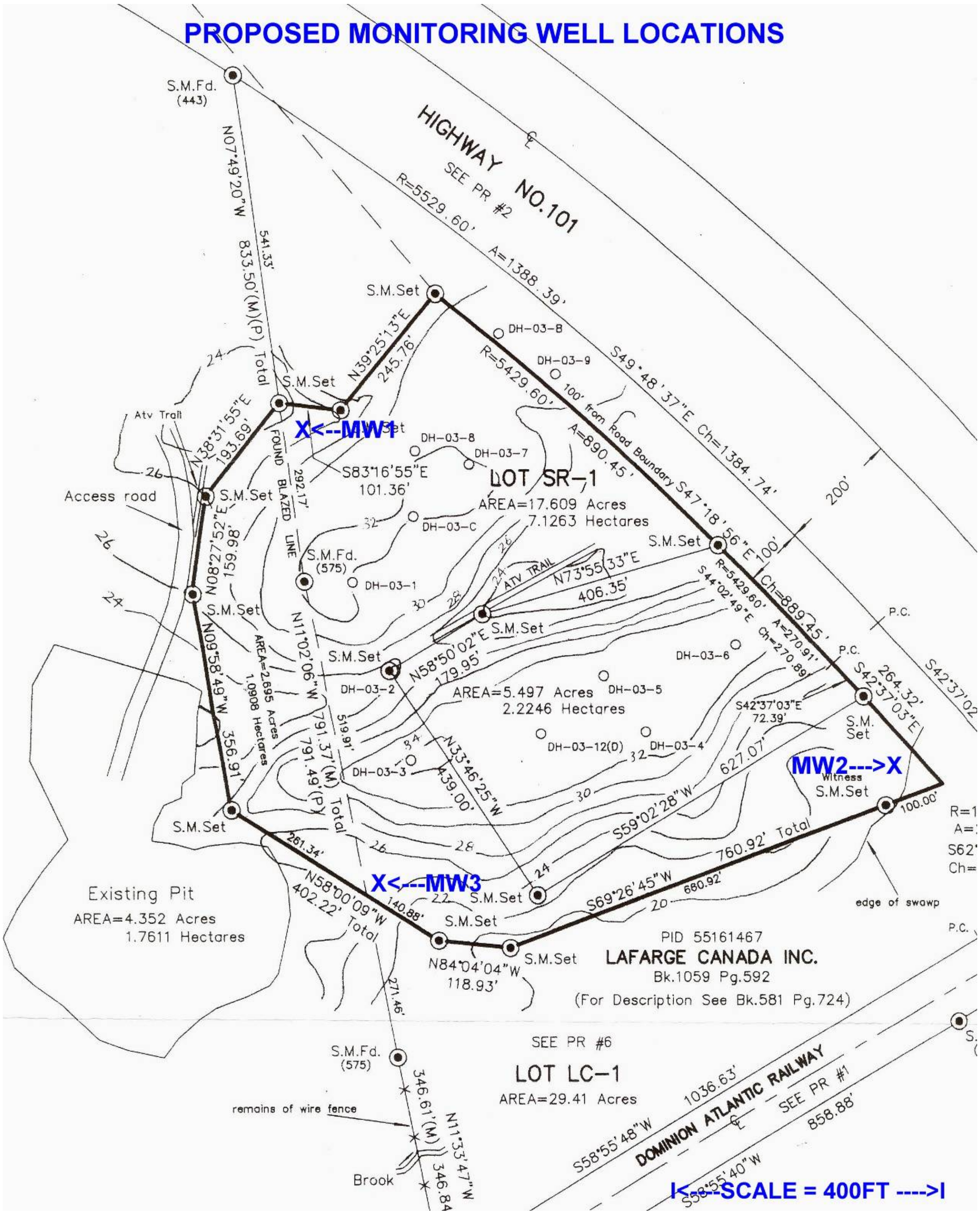

FIGURE 7: Proposed Monitoring Well Locations at the Site

- The selection of screened sections will be based on the hydrogeologic conditions encountered and the stratigraphic section penetrated.
- A graphic sketch of the typical well construction planned during this project is included in Figure 2 showing construction details and the use of casing, screens, sand, and grout to ensure integrity of the sample source.
- Well heads will be protected from traffic in the area by use of locking plugs in above grade steel casing serving as manholes to provide protective cover and security.

Monitoring well design and construction applied during this project are those that are typical of acceptable standards in the environmental industry. Figure 8 shows the typical design characteristics for monitor well construction planned for use during this project. All monitoring wells completed will have protective steel casing installed with caps locked in place to ensure security and protection of the monitoring system.

Final monitoring well locations will be selected after consideration of local hydrogeological conditions of the site, traffic patterns in the area, and sensitive environmental components identified in the Environmental Assessment Report prepared by Hendricus Van Wilgenburg. The general area is shown as 'site' on Figures 1, 2, 3, 4, 5. The specific area of the proposed undertaking is shown in Figure 7. The proposed locations for monitoring wells to be constructed during Phase II of the groundwater monitoring program for this project are also shown in Figure 7.

It is anticipated that the shallow groundwater flow system immediately under the site is unconfined and within the Quaternary ice-contact stratified deposits of sand and gravel. It is also expected that the shallow groundwater flow system on the south side of the east-west trending ridge flows south towards Tupper Brook. Groundwater flow on the north side of the ridge is suspected to flow north contributing directly to flows in tributaries flowing north to the Cornwallis River.

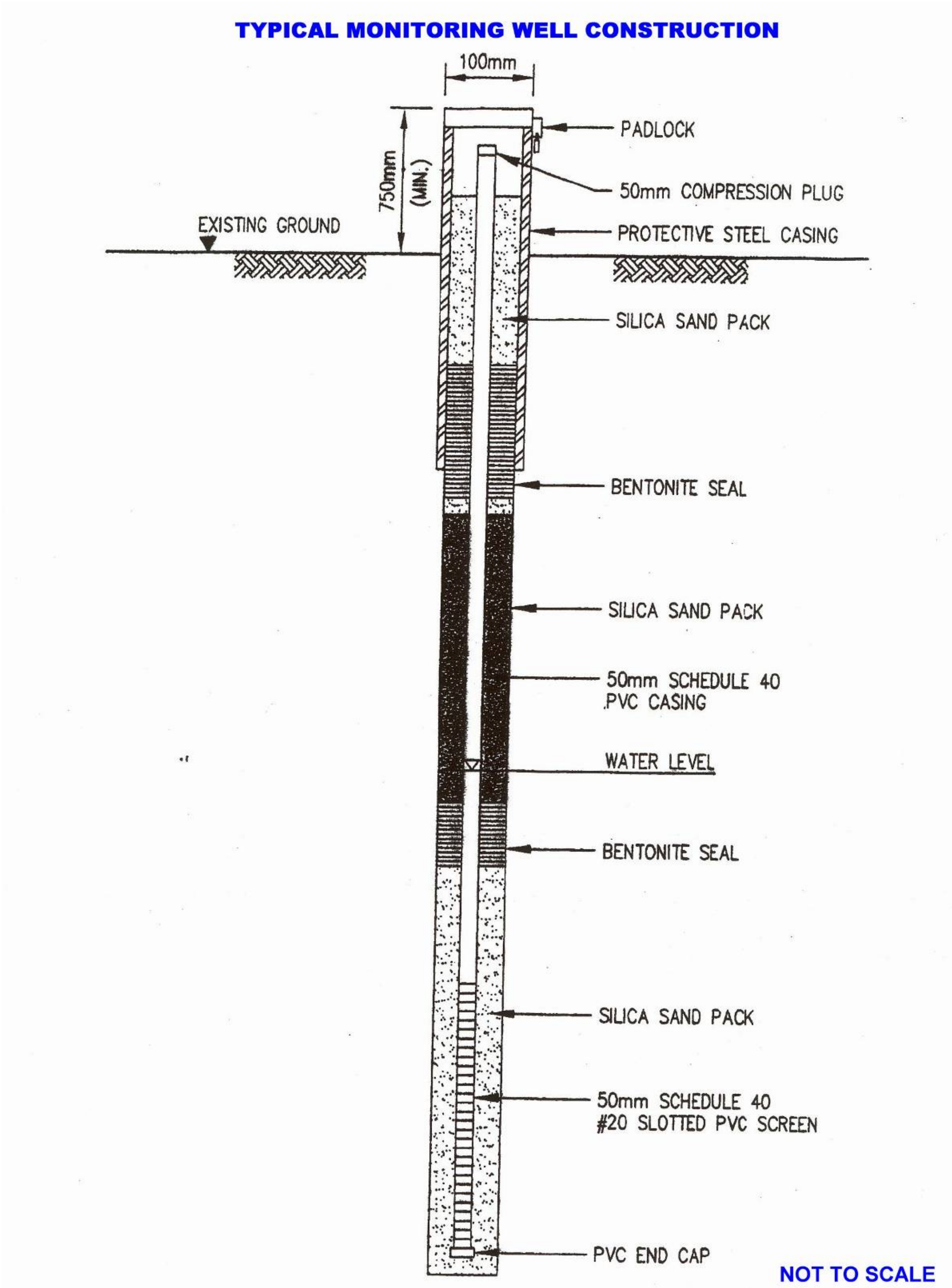

FIGURE 8: Typical Monitoring Well Construction Recommended For the Site

The groundwater flow system in the vicinity of the northwest corner of the site is considered most likely to be in a local recharge zone, based on a review of hydrogeological factors from existing maps. Three monitoring wells, MW-1, MW-2 and MW-3, are therefore proposed for construction at the site. MW-1 will be constructed as a multi- level monitoring well and will be located up-gradient and nearest Joyce Street and the nearest residence with a water supply well. MW-2 will be located southeast of MW-1 near the boundary of the site and is planned as a single-level monitoring well. MW-3 is planned near the existing pit west of the proposed pit and also between the proposed working area and the domestic wells on Joyce Street west of the site. Water levels in these monitoring wells, together with water levels at strategic points of Tupper Brook will be used to determine groundwater gradients and flow direction. The proposed locations of MW-1, MW-2 and MW-3, are shown on Figure 7. The recommended type of monitoring well construction is shown in Figure 8.

Groundwater Flow Patterns

Elevations and horizontal location coordinates of the monitoring well reference points and surface water points of interest will be determined. Elevations will be referenced to mean sea level within approximately 1.2 inches (3.0cm). Horizontal location coordinates will be determined within 0.40 inch (10 mm). The locations and elevations of the points of interest will be shown in the Phase II report.

Groundwater flow patterns will be determined for the area within the sand and gravel extraction operation in Coldbrook. A general groundwater flow pattern, and gradient, will be determined for the area by using data from the monitoring wells and the surface reference points.

An assessment of groundwater flow in the vicinity of existing water supply wells near each of the monitoring areas will also be made based on water heads and the stratigraphic sections interpreted in the monitoring wells.

Static water levels for the monitoring wells will be measured using an electronic water level meter to within an accurate reading as is practical. The static water levels will be referenced to the top of the monitoring well casings, and converted to head above mean sea level.

The groundwater elevations from the monitoring wells and the surface water reference points will be used to calculate the hydraulic gradient and determine groundwater flow direction in the vicinity of the area. The control point locations, separation distances of the control points, equipotential lines, and groundwater flow direction in the area will be shown on a map of appropriate scale. The vertical groundwater flow gradient will be determined in MW-1 to assess whether this area is located in a recharge or discharge part of the groundwater flow system(s) in the area. This information will also allow interpretation of flow between the overlying Quaternary sand deposits and the underlying Triassic sandstones underlying the site.

WATER QUALITY

Sampling Protocols and Procedures

All monitoring wells will be developed by pumping at rates varying between one and two gallons per minute. Pumping will be carried out initially by bailing with one litre volume disposable plastic bailers. After this initial development, a dedicated Waterra sampling device will be installed in each well for the purpose of purging and sampling.

When collecting samples from monitoring wells for chemical analyses, protocols developed and used in the industry will be followed to ensure representative samples of groundwater are obtained. At the time of entry to a monitoring well a measurement of the depth to water will be taken and recorded for later use in determining groundwater flow. Prior to sampling the well will be purged to remove at least three (3) pore volumes of water from the monitoring well before a sample is collected.

Water samples will be collected using approved equipment. For this project dedicated Waterra tubing and foot valves will be installed in all three monitoring wells for the purposes of well development and collection of water samples. Samples will be collected in clean plastic bottles, as supplied by an approved Laboratory. These bottles are of sufficient quantity for the desired suite of parameters for RaCAP-MS analyses. Storage of the samples will be in a controlled cool environment and delivered to the analytical laboratory within 24 hours of sample collection for analyses.

Monitoring Schedule

For operation of the facility the suite of parameters and frequency of sampling and analyses is based on requirements to determine the chemical characteristics of groundwater in the vicinity of the site. This information will be used for future comparisons of groundwater quality within the area of influence of the sand and gravel extraction operation and the quality of groundwater in the immediate vicinity outside the area of influence of the aggregate extraction operations. The water quality parameters of interest include those of general chemical, metals, and physical nature.

During Phase II of the program, or the first month of monitoring, a water sample will be collected from each of the monitoring wells. Analyses for these samples will include the following parameters: calcium; magnesium; sodium; potassium, chloride; sulphate; iron; arsenic, uranium, manganese; copper; nitrate; nitrite; ammonia; alkalinity; pH; total hardness; total dissolved solids; specific conductance; a metal scan, and temperature.

As a guide for future seamless planning and operation of the groundwater monitoring program for the Shaw Resources aggregate extraction undertaking at the Coldbrook site, a schedule of monitoring is proposed and outlined in Table 9. This schedule will assist future work and allow for a continuity of sampling and analyses of the environmental groundwater conditions of the site. Modifications to the sampling frequency, wells to be sampled, and parameters of interest may be made based on results obtained during Phase II and discussions with NSDEL staff.

Table 7: Proposed Monitoring Requirements During Extraction Operations

Parameter	Source	Frequency	Reporting
Quantity			
Water Level	MWs	Quarterly	Quarterly
" "	BRs	"	"
Quality			
Field Measurements:			
Conductance	All MWs	"	"
Temperature	All MWs	"	"
PH	All MWs	"	"
Laboratory Analyses:			
RcAP-MS	All MWs	Annual	Annual
Other Analyses			
Iron	All MWs	Quarterly	Quarterly
Manganese	"	"	"
Calcium	"	"	"
Magnesium	"	"	"
Potassium	"	"	"
Chloride	"	"	"
Total hardness	"	"	"
Alkalinity	"	"	"
pH	"	"	"
Sulphate	"	"	"
Specific conductance	"	"	"
Copper	"	"	"
Zinc	"	"	"
Nitrate-N	"	"	"
Sodium	"	"	"
Ammonia	"	"	"
Total Dissolved solids	"	"	"

The quantity and quality field measurement parameters listed in Table 7 will be documented during each monitoring event. Laboratory analyses for RcAP-MS, which includes general chemistry and metals, will be performed on an annual basis. The other analyses listed in Table 7 include a less rigorous analytical review of general chemistry, but include parameters that will indicate change in groundwater quality.

Water quality monitoring in the vicinity of the sand and gravel extraction operation will serve four main purposes. The first objective is to determine the background quality of groundwater in the area up-gradient of the extraction operation. The second objective is to assess whether groundwater contamination is occurring from the sand and gravel extraction operations. The third objective is to assess and characterize potential migration pathways of potential contaminants off the site. The fourth objective is to determine presence of, and risk to, receptors of contamination if it does exist. The groundwater monitoring program planned for the aggregate extraction operation is scheduled to be fully implemented over a six month period.

This report is intended to serve as Phase I which documents the physical setting, describes the related available data bases for the area, and outlines the scope of work to be carried out during Phase II and Phase III.

Phase I - Completed during September, 2006, includes compilation of data and documentation on geology, hydrogeology, and water quality in the area. This information was assessed and interpreted to design a drilling and monitoring well construction program. This report is to be submitted to the NSDEL, as part of the Environmental Assessment of the project, to outline the plan and maintain dialogue on the monitoring program.

Phase II - During December, 2006, will include the construction of a minimum of three (3) groundwater monitoring wells, preparation of a log of the stratigraphy under the site, determination of groundwater levels, sampling of groundwater for initial water quality characteristics, determination of groundwater flow patterns and gradients, and identification of potential down gradient receptors. A report will be prepared and submitted to the NSDEL for review and information.

Phase III - During the first year of sand and gravel extraction operations, December 2006 to December 2007. This phase will include collection of samples from the monitoring wells for chemical analyses. A report will be prepared and submitted to NSDEL reporting progress, results, and trends in data over the one year period for water quality and water level data.

Kentville Well Field

One of the main objectives of implementing a groundwater monitoring program for this aggregate extraction undertaking is to provide an early warning for water quality impacts to the Town of Kentville water supply. The Town of Kentville has recently converted from a surface source to a groundwater source for its municipal drinking water supply.

Hydrogeological studies were carried out to delineate the capture zones of the well field and the area to be protected to ensure the natural water quality integrity of the water source. These studies have shown that the well field recharge zone extends beyond the proposed aggregate extraction site. The proposed aggregate extraction site and the limits of the well recharge zone are shown in Figure 9.

The well field recharge zone, Zone D, and the proposed aggregate extraction site are shown in Figure 9. Zone D represents the area where groundwater times-of- travel vary from one to 25 years to the well head. As part of the source water protection plan adopted by the Town of Kentville, and the Municipality of Kings, a number of prohibited land uses have been identified within Zone D. These prohibited land uses primarily relate to commercial storage and distribution of petroleum fuels, solvents, chlorinated compounds, pesticides, herbicides, and salt. Dry cleaning operations and scrap and salvage yards are also prohibited in Zone D.

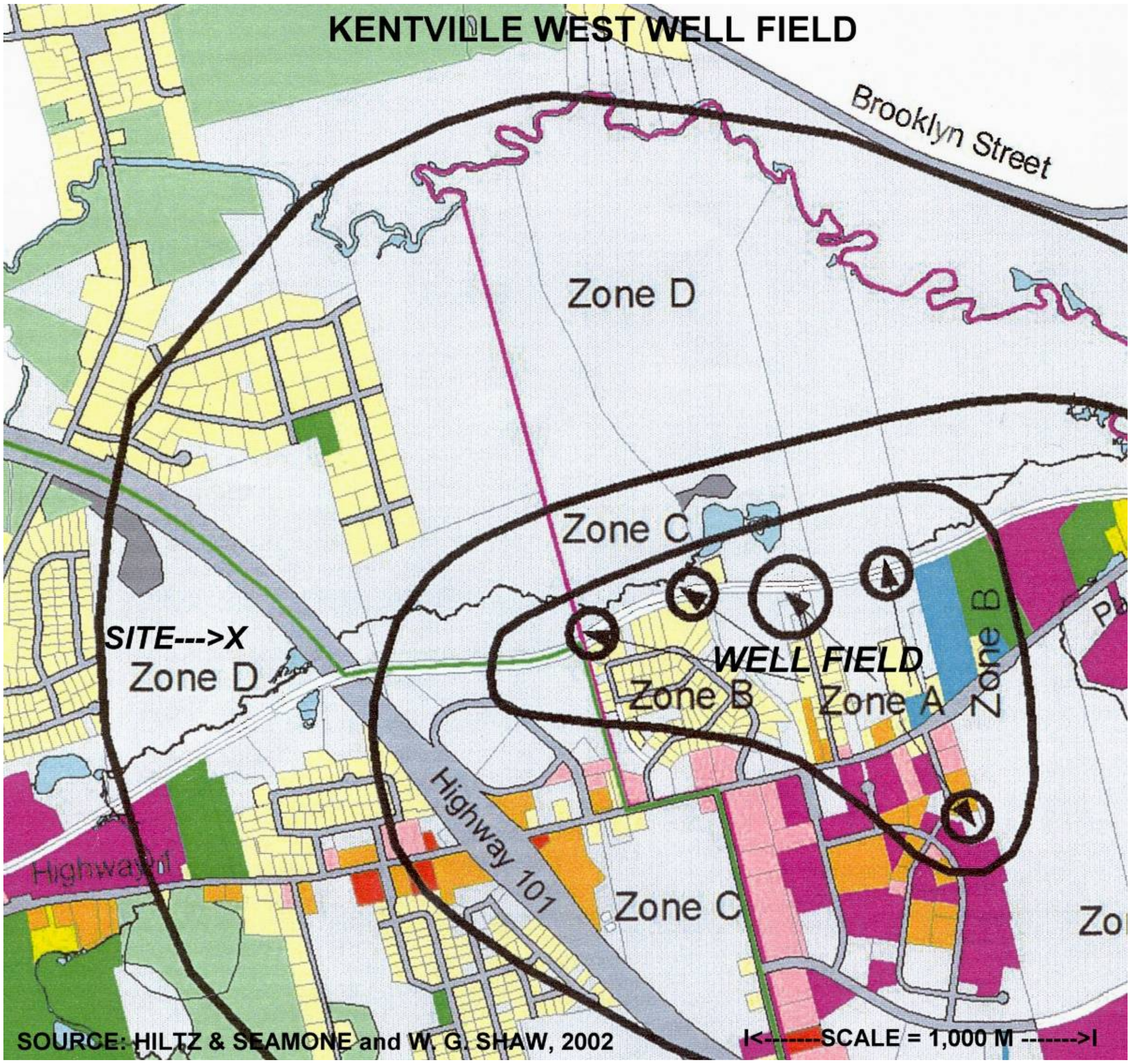

FIGURE 9: Town of Kentville Well Field and Capture Zones

SUMMARY OF FINDINGS

The following summarizes the findings of this environmental assessment and groundwater monitoring plan for the proposed expansion of the aggregate extraction operation by Shaw Resources at the Coldbrook site:

- The aggregate materials of interest under the site are classified as Ice-contact Stratified Drift of Quaternary age.
- No existing, private or public, water supplies are believed to exist within the footprint of the proposed expanded aggregate extraction area.
- The nearest private water supply well to the proposed expanded area appears to be approximately 200 metres west of the site.
- All private water supply wells in the area are removed from the site, up the inferred groundwater gradient, or occur on the other side of a natural hydraulic barrier provided by Tupper Brook.
- Bedrock aquifers underlying the site are classified as the Wolfville Hydrostratigraphic Unit.
- The main source of domestic water supplies in the surrounding area appears to be from bedrock wells constructed in the Wolfville Hydrostratigraphic Unit.
- No adverse groundwater supply impacts on wells in the surrounding area because of current well depths and the propensity towards use of bedrock wells.
- No bedrock units of the Halifax Formation that may contain sulphide mineralization capable of producing acid rock drainage when disturbed during aggregate extraction operations occur in the area.
- No adverse water quality impacts are expected at the site because of the distance from problematic bedrock mineralization, such as that in the Halifax Formation.
- No points of permitted water withdrawals, as allocated by the NSDEL, are located within or adjacent to the site.
- A groundwater monitoring program has been outlined for implementation as part of the environmental assessment for this project.
- Groundwater sampling protocols, procedures, and monitoring schedule have been outlined for this project.
- The Town of Kentville well field has been identified as an offsite receptor because the site falls within the well field recharge zone.
- The recommended groundwater monitoring program is designed to provide baseline data on groundwater quality entering the site at MW1.
- The recommended groundwater monitoring program is also designed to provide data on groundwater quality leaving the site at MW2 and MW3.

REFERENCES

1. Trescott, P. C. 1968. Groundwater Resources and Hydrogeology of the Annapolis-Cornwallis Valley, Nova Scotia. Memoir 6, Nova Scotia Department of Mines. 159 pages.
2. Trescott, P. C. 1967. Bedrock and Surficial Geology of the Annapolis-Cornwallis Valley, Nova Scotia. Map 1 (east sheet), Scale 1: 63,360. Nova Scotia Department of Mines.
3. Van Wilgenburg, Hendricus. 2003. Cambridge Aggregate Pit Expansion Environmental Assessment registration. 168 pages.
4. McIntosh, J. Robert. 1984. Groundwater Hydrographs in Nova Scotia 1965-81. Nova Scotia Department of the Environment. 185 pages.
5. Langille, D. R., K. T. Webb, T. J. Soley. 1993. Supplement to: Soils of the Annapolis Valley Area of Nova Scotia. Agriculture Canada. 67 pages.
6. Holstrom, D. A., B. L. Thompson. 1989. Soils of the Annapolis Valley Area of Nova Scotia. Agriculture Canada. 184 pages.
7. Nova Scotia Department of the Environment and Labour; 2005. Pumping Test Inventory.
8. Nova Scotia Department of the Environment and Labour; 2005. Water Well Records Database.
9. Nova Scotia Department of the Environment and Labour. Naturally Occurring Arsenic and Uranium in Groundwater.
10. Fetter, C. W. 1994. Applied Hydrogeology. Maxwell MacMillan Canada. 691 pages.
11. Driscoll, F. G. 1986. Groundwater and Wells, Second Edition. Johnson Division, St. Paul, Minnesota. 1089 pages.
12. Hennigar, Terry W., et al. 1999. Hydrogeological Field Methods. Centre For Water Resources Studies, and the Nova Scotia Community College, Halifax, Nova Scotia.
13. Nielsen, David M., 1991, Practical Handbook of Ground-Water Monitoring, Lewis Publishers, 717 pp.
14. Anderson, Keith, E., 1993; Ground Water Handbook; National Ground Water Association, 401 pp.
15. Nova Scotia Community College, 2001; Hydrogeological Field Methods, Notes and Course Outline.
16. Hiltz & Seamone and W. G. Shaw, 2002; Kentville Well Field Protection Zones
17. Spooner, Ian. S. P. (2006); Environmental Assessment of Shaw Resources-Lovett Road Site, Geology, Geomorphology, Surface Water.

APPENDIX A

Water Well Records In The Study Area

NS Atlas or Map Book (e.g. 26C4K10):		NTS Map Reference (e.g. 11D12D5F):		UTM coordinates between :	
Map Page (e.g. 26)		Map Sheet (e.g. 11D12)	21H2	Northing	and
Reference Letter (e.g. C)		Reference Map (e.g. D)	A	Easting	and
Reference Number (e.g. 4)		Tract (e.g. 5)	69		
Roamer Letter (e.g. K)		Claim (e.g. F)			
Roamer Number (e.g. 10)					

NOVA SCOTIA
Environment and Labour

Search Now | Get Well Log | Main Menu

Search Results (depths in feet; well yield in gpm)

Well#	Address	Community	County	Date	Well Depth	Casing	Bedrock	Static	Yield	Driller
640985		COLDBROOK	KINGS	31-Dec-64						
782140		COLDBROOK	KINGS	31-Dec-78	160	110		10	15	18
800743	HOUSE	COLDBROOK	KINGS	23-Aug-80	97	94		45	20	18
810593	LAUROE LANE	COLDBROOK	KINGS	19-Jul-81	66	63		18	70	18
820677		COLDBROOK	KINGS	10-Nov-82	140	136		50	50	58
830382		CAMBRIDGE	KINGS	26-Nov-83	75	44		8	25	18
830854		BROOKLYN CORNER	KINGS	15-Apr-83	110	62			10	110
830915		COLDBROOK	KINGS	28-Jun-83	150	115			40	110
831593		COLDBROOK	KINGS	29-Mar-83	125	117			12	210
831599	1033 DOCO ROAD	COLDBROOK	KINGS	13-Jun-83	135	66			50	210
831608		COLDBROOK	KINGS	11-Aug-83	135	110			12	210
831609		COLDBROOK	KINGS	14-Jun-83	135	71			12	210
831617		COLDBROOK	KINGS	13-Jun-83	125	94			8	210
831625		COLDBROOK	KINGS	14-Jun-83	145	88			12	210
831641		COLDBROOK	KINGS	15-Jun-83	125	66			30	210
840451		COLDBROOK	KINGS	10-Jul-84	60	57		9	30	18

NS Atlas or Map Book (e.g. 26C4K10):

Map Page (e.g. 26) 13

Reference Letter (e.g. C) C

Reference Number (e.g. 4) 5

Roamer Letter (e.g. K) L

Roamer Number (e.g. 10) 14

NTS Map Reference (e.g. 11D12D5F):

Map Sheet (e.g. 11D12)

Reference Map (e.g. D)

Tract (e.g. 5)

Claim (e.g. F)

UTM coordinates between :

Northing and

Easting and

NOVA SCOTIA
Environment and Labour

Search Now | Get Well Log | Main Menu

Search Results (depths in feet; well yield in gpm)

Well#	Address	Community	County	Date	Well Depth	Casing	Bedrock	Static	Yield	Driller
012316	3083 LOVETT ROAD, CO	BROOKLYN CORNER	KINGS	06-Dec-01	175	159		5	35	110
850484		COLDBROOK	KINGS	28-Sep-85	155	132		43	15	18
871644		COLDBROOK	KINGS	20-May-87	135	106		45	20	110
890631		COLDBROOK	KINGS	13-Jun-89	120	100		30	25	110
890898		COLDBROOK	KINGS	17-Aug-89	180	105			8	307
891219		COLDBROOK	KINGS	28-Oct-89	140	100			7.5	307
911607		COLDBROOK	KINGS	18-Dec-91	170	140		40	20	110
921377	BISHOP ROAD	COLDBROOK	KINGS	07-Oct-92	115	60		21	20	110
921948	AARON DRIVE	COLDBROOK	KINGS	09-Sep-92	215	120		42	10	255
930658		COLDBROOK	KINGS	08-Apr-93	195	95			5	307
932470	LOVETT ROAD	COLDBROOK	KINGS	14-Jul-93	165	105		32	4	255
932508	AARON DRIVE	COLDBROOK	KINGS	13-Jan-93	140	100		52	8	256
952271		COLDBROOK	KINGS	19-Sep-95	140	85		40	4	256
952276	43 CUMBERLAND DRIVE	COLDBROOK	KINGS	08-Mar-95	180	162		56	4	256
952304		COLDBROOK	KINGS	14-Apr-95	100	66		35	3	255
952312		COLDBROOK	KINGS	04-Oct-95	140	125		48	10	255
952317		COLDBROOK	KINGS	01-Apr-95	140	130		40	10	255
952324	121 LOVETT ROAD	COLDBROOK	KINGS	21-Oct-95	100	82		21	6	255
971920	LOVETT ROAD	COLDBROOK	KINGS	28-Jul-97	155	120		15	25	110
972265		COLDBROOK	KINGS	26-Feb-97	215	78		30	4	255
980243		COLDBROOK	KINGS	18-Apr-98	135	80			30	307
991153		BROOKLYN CORNER	KINGS	07-Sep-99	165	151			15	307
992006		COLDBROOK	KINGS	15-Apr-99	125	75		38	5	256

APPENDIX B

Pumping Test Data Relevant to the Study Area

SUMMARY PUMPING TEST DATA QUATERNARY HU KINGS COUNTY

No.	Location	Well Details				Pumping Test Information								Pumping Well Hydraulic Properties			Aquifer Properties	
		Well	Casing		Screen													
		Depth (m)	Dia. (mm)	Length (m)	Length (m)	Test Date	Duration Hrs	Static Water (m)	Avail dd (m)	Total dd (m)	% Avail. dd	Average Yield (igpm)	Stable dd (y/n)	T (m2/d)	Q/s (m3/d/m)	Q20 (igpm)	T (m2/d)	S imensionles
1	Tremont	27.4		24.4	9.1	7/9/1966	24	1.9	18.3	12.3	67	189.0	N	775.5	100.24		775.5	0.000310
2	BERWICK	18.3	203			6/1/1966	6	2.0	13.7	4.9	35	45.0	N	177.5	60.57	203.0	177.5	0.000330
3	COLDBRO	24.1	203			7/1/1964	48	3.1	18.3	1.9	10	400.0	N	242.4	1401.44	369.0	242.4	0.002600
4	KENTVILL	34.4	305			8/1/1978	72	8.2	18.0			900.0	N				5967.4	0.160000
5	Waterville	30.5	152	27.1	1.8	12/13/1979	72	5.1	19.6	2.3	12	60.0	N	726.5	173.18	60.0	929.2	0.043000
6	Waterville	41.9	254	41.9	7.6	3/15/1981	168	5.8	22.9	2.4	11	325.0	N	357.9	872.4	300.0	357.9	0.00045
7	Waterville	33.7	203	33.7	3.0	1/16/1981	168	6.2	18.0	5.1	28	185.0	N	93.9	238.9	120.0	93.9	0.05
8	Wolfville	42.4	254	34.4	7.6	8/17/2000	25	7.6	21.3	5.3	25	645.0		1307.4	789.86	500.0	1620.1	0.022000
9	Wolfville	47.6	15	18.3	12.2	29/10/1968	72	4.2	15.2	4.0	35	400.0	Y	1,920		1000 +		0.0039
10	Wolfville	28.7	15	18.0	7.6	13/11/2002	51	7.9	6.1	1.0	16	90.0	Y	850		400+		0.00203
MEANS		32.9						5.2				323.9		716.8	519.51	258.7		0.028462

Summary of pumping test data for the Wolfville HU in Kings County

NSDOE		Well Details			Pumping Test Information							Pumping Well Hydraulic Properties			Aquifer Hydraulic Properties		
		Well	Casing														
No.	Location	Depth (m)	Dia. (mm)	Length (m)	Duration Hrs	Static Water (m)	Avail dd (m)	Total dd (m)	% Avail. dd	Average Yield (igpm)	Stable dd (y/n)	T (m2/d)	Q/s (m3/d/m)	Q20 (igpm)	No. Obs Wells	T (m2/d)	S dimensionless)
1	COLDBROOK	54.9	155		72	15.8	29.9	9.4	31	30.0	Y	19.4	20.83	48.3			
2	KENTVILLE	85.3	155	27.7	72	39.0	37.2	6.9	19	5.0	Y	1.5	4.73	4.5			
3	KINGSTON	53.3	155		72	3.2	41.1	7.7	19	30.0	Y	23.6	25.56	81.0			
4	WATERVILLI	64.0	155		72	15.8	39.0	25.5	65	20.0	Y	3.4	5.15	11.2			
5	BERWICK	38.1	155		72	14.4	14.6	5.5	38	35.0	N	27.6	41.67	33.6			
6	BERWICK	65.5	155		72	10.8	45.7	1.4	3	11.0	Y	26.3	50.69	100.0			
7	CANNING	63.4	203		72	15.6	38.7	20.1	52	60.0	N	18.8	19.54	60.6			
8	CANNING	91.4			72	11.1	71.0	9.5	14	75.0	N	11.4	51.33	67.2			
9	KINGSTON	53.3	155		72	4.6	39.6	5.2	13	15.0	N	14.5	19.12	47.8			
10	BERWICK	71.6			24	0.0	62.5	45.0	72	160.0	N	48.5	23.41	252.0		48.5	0.000200
11	HILLATON	.			48	7.6		19.1		200.0	N	65.6	68.73			65.6	0.000150
12	Port Williams	73.2	305		72	9.9	54.3	21.9	40	171.0	N	320.80	51.33				
13	COLDBROOK	70.7			1	13.3	48.5	3.5	7	2.0	N		3.65				
14	CLAIRMONT	63.7			4	14.4	40.2	3.9	10	3.0	N	2.70	5.15	9.2			
15	NORTH KING	73.2	155		47	6.6	57.3	25.1	44	30.0	Y	7.0	7.73	33.0			
16	Greenwood	70.1	356	11.9	72	0.0	64.0	44.8	70	147.0	N	15.2	21.47	81.2			
17	New Minas	68.6	155		72	9.4	50.0	10.7	21	15.0	N	4.1	9.24	16.9			
18	CANNING	45.7	155		72	5.4	31.1	32.0	100	10.0	N	1.2	2.58	3.2			
19	KENTVILLE	91.4			72	0.0	82.3	46.9	57	100.0	N	11.3	13.96	77.0			
20	GREENWOOI	.			72	0.3		37.5		50.0	N		8.81				
21	COLDBROOK	61.0	155		72	13.4	38.4	7.6	20	15.0	N	32.8	12.89	105.0			
22	New Minas	99.1	203		72	4.9	85.0	35.7	42	125.0	Y	15.9	22.98	112.5			
23	KENTVILLE	91.4	203		72	4.3	78.0	20.2	26	150.0	Y	61.5	48.76	400.0			
24	BERWICK	53.3			73	7.0	37.2	8.7	23	30.0	Y	21.5	22.55	66.6			
25	CAMBRIDGE	43.6	155		24	8.0	26.5	17.1	64	15.0	N	6.0	5.80	13.2		6.0	0.00017
26	KENTVILLE	121.9	203		72	6.1	118.9	42.7	36	150.0	Y	26.9	22.98	266.0		26.9	0.0003
27	New Minas	97.5	152		72	10.7	77.7	33.3	43	93.3	N	16.9	18.33	109.6			
28	Berwick	76.2	203	39.6	72	3.2	52.7	40.4	77	237.4	Y	49.2	38.42	216.0			
29	Waterville	61.3	152	61.3	72	4.8	15.2	8.4	55	50.0	N	49.2	38.76	50.0			
30	Centreville	53.3	152	36.6	72	11.1	22.9	2.6	11	16.0	Y	45.0	40.61	16.0			
31	Port Williams	198.1	152	126.2	72	16.8	175.3	60.6	35	90.0	N	9.1	9.76	90.0			
32	Somerset	35.1	152	26.5	72	7.6	12.5	0.3	2	20.0	Y	315.0	477.21	20.0			
33	Berwick	61.0	152	25.9	71	9.8	35.9	11.1	31	20.0	N	9.6	11.83	20.0			
34	New Minas	66.1	203.2	66.1	72	6.1	54.9	32.6	59	70.4	N	11.6	14.16	53.1	1		
35	New Minas	78.9	203.2	78.9	65	11.0	63.1	56.9	90	82.7	N	25.12	9.51	94.4	7	25.1	0.000041
36	New Minas	60.9	203.2	29.9	71.75	22.9	18.0	7.2	40	50.2	Y	67.22	45.54	100.8	4		0.0000626
37	New Minas	1.34 or 106	203	10.0	73	18.7	39.0	12.1	31	11.8	Y	3.9	6.40	12.6			
38	Wolfville	99.1	254	25.6	72	6.7	66.1	45.6	69	209.0	N	32.0	28.30	189.9	3	31.0	0.000330
39	Auburn	54.9	155	19.2	72	10.8	34.0	7.2	21	30.0	N	70.0	27.24	33.3			
40	Medford	105.2	203	15.2	72	0.0	91.4	82.3	90	92.5	N	10.5	7.36	83.3	1		
41	Hillaton	84.8	254	<17.00	72	6.4	74.1	32.0	43	165.2	Y	71.3	33.80	173.3	2	146.0	0.001000
42	Hillaton	.	.		24			0.4		356.0	N				1	409.7	0.001000
43	New Minas	70.1	552	16.2	72	6.7	14.6			75.0		61.5		75.0			
44	New Minas	77.7	254	30.2	78	29.8	14.5	6.1	42	139.4	N	67.0	148.85	81.0	3		
45	New Minas	55.4	250	15.1	36	25.4	26.4	15.2	58	74.2	N	49.8	31.92	92.0			0.004080
46	New Minas	77.7	254	30.2	45			9.2		130.0	N	42.3	92.48	108.0	2	58.2	0.007140
MEANS		73.4		36.4		10.2	50.5	21.7		79.7		41.7	37.98	85.6			0.001316

APPENDIX C

Procedures and Protocols for Field methods

PROCEDURE FOR DOCUMENTATION OF FIELD DATA

Documentation of field information should include sufficient material so that the field program can be reconstructed without relying on the memory of field personnel. Data must be collected and documented in a clear, concise and organized manner. Ideally this information should be recorded in a bound logbook. For legality reasons, the pages of the field book should be numbered consecutively. All entries in logbooks should be made in waterproof ink and corrections should be lined-out deletions that are initialled and dated. Field books should be kept in a secure place and copied as soon as possible. The completion of daily logs may be beneficial. Entries in the logbook may include the following:

- Site name
- Borehole or well number
- Field Supervisor's name and company affiliation
- Date and time of sample collection
- Sample number, location, and depth
- Sampling method
- Observations at the sampling site
- Unusual conditions
- Information concerning drilling decisions
- Decontamination observations
- Weather conditions
- Names and addresses of field contacts
- Names and responsibilities of field crew members
- Names and titles of any site visitors
- Location, description, and log of photographs
- References for all maps and photographs
- Information concerning sampling changes, scheduling modification, and change orders
- Summary of daily tasks and documentation on any cost or scope of work changes required by field conditions
- Signature and date by personnel responsible for observations

PROCEDURE FOR DECONTAMINATION

The overall objective of multimedia sampling programs is to obtain samples which accurately depict the chemical, physical, and/or biological conditions at the sampling site. Extraneous contaminant materials can be brought onto the sampling location and/or introduced into the medium of interest during the sampling program (e.g., by bailing or pumping of groundwater with equipment previously contaminated at another sampling site). Trace quantities of these contaminant materials can consequently be captured in a sample and lead to false positive analytical results and, ultimately to an incorrect assessment of the contaminant conditions associated with the site. Decontamination of sampling equipment (e.g., bailers, pumps, tubing, soil and sediment sampling equipment) and field support equipment (e.g., drill rigs, vehicles) is therefore generally required prior to use at sites to ensure that sampling cross-contamination is prevented and that on-site contaminants are not carried off-site.

The following is a list of equipment that may be needed to perform decontamination:

- brushes
- wash tubs
- buckets
- scrapers, flat bladed
- hot water - high-pressure sprayer
- disposal drums (205 litre with secure lids)
- sponges or paper towels
- detergent (simple green)
- potable tap water
- garden-type water sprayers
- spray bottles
- methanol

Personnel

A temporary personnel decontamination line may be set up around the exclusion zone at each site. If contamination is not encountered, a dry decontamination station may be established which consists of discarding of disposable personal protective equipment (PPE).

If HNu or Gastector readings indicate that contamination has been encountered (i.e., action levels are exceeded requiring an upgrade from initial PPE levels), or if the initial PPE is B or C, a complete personnel decontamination station will be established.

The temporary decontamination line should provide space to wash and rinse rubber boots, gloves, and all sampling or measuring equipment prior to placing the equipment into a vehicle. It should provide a container to dispose of used disposable items such as gloves, tape or tyvek (if used).

The decontamination procedure for field personnel may include:

1. glove and rubber boot wash in a detergent solution
2. glove and rubber boot rinse
3. scraping soil from non-rubber boots
4. duct tape removal, if appropriate
5. outer glove removal
6. coverall removal
7. respirator removal (if used)
8. inner glove removal (if used)

PROCEDURE FOR ENVIRONMENTAL DRILLING

This procedure describes the methodologies associated with drilling and typical monitor well installations used for environmental testing purposes. The following is a list of materials which may be required during an environmental drilling program:

- drill rig capable of installing wells to the desired depth
- well construction materials:
  - threaded PVC casing (typically 50 mm diameter & minimum schedule 40)
  - screen (typically 50 mm diameter, slot size to vary dependant on geological formation)
- bentonite pellets/chips
- filter pack sand (no. 2 or coarser)
- cement/bentonite mixture for grouting
- stainless steel centralizers, if appropriate
- protective well casing with locking cap
- high-pressure steamer/cleanser
- decontamination equipment/supplies
- wash/rinse tub
- detergent
- sampling containers (ie plastic ziplock bags) & labels
- weighted tape
- water level tape
- deionized water
- appropriate health and safety equipment
- log book
- borehole log sheets
- geotechnical field guide

The most common methods of drilling within surficial deposits involve the use of either *hollow stem auger flights (HSA)* or *continuous flight augers (CFA)*. Auger drilling allows for borehole penetration without introducing water which could inhibit the collection of representative soil samples.

The flanges of the HSAs are welded onto a larger diameter pipe than the CFAs. The flights are linked together such that the stem is hollow throughout the drill string. The cutting bit has a finger plug which prevents loose soil from entering the stem. A split-spoon sampling device may be lowered inside the drill string and driven through the finger plug and ahead of the cutting bit for an in situ sample as required. The HSA string, therefore, serves as a form of casing because it does not have to be withdrawn each time a sample is collected. One can obtain more accurate samples using this method.

There are several advantages of HSA boreholes. First, the method is rapid in most unconsolidated, fine to medium-grained geologic materials. Second, drilling fluids are not used to remove cuttings and, therefore, the in situ chemical conditions of the borehole are not further degraded by either diluting contaminants with added water or contributing suspended solids from drilling muds used to stabilize the borehole walls in soft materials. Third, HSA flights are easily cleaned and decontaminated. Fourth, the auger flights serve as a form of casing, which allows monitoring wells to be constructed by raising the flights as needed. Fifth, the drilling rate is better than with the CFA because the drill string remains in the boring until it is completed.

One minor disadvantage of the HSA is that clearing and decontamination require more time than with the CFA due to the interior surfaces present. Another disadvantage is that drilling below the water table, especially in fluid soils such as supersaturated or "flowing" sands, may be difficult if the head in the string is less than the head in the formation. Such a head difference may result in the inflow of groundwater and sediment around the cutting bit and finger plug. .

The most common methods of drilling within bedrock involve the use of either a *tricone* or *diamond drill bit* for coring. Coring provides several advantages. Most importantly, it allows for the retrieval of in-situ bedrock samples rather than drill cuttings.

The core barrel is approximately 1.5 m in length and is equipped with a diamond coring bit. The nominal core diameter will be 8 cm (i.e., 3 inches - NQ size). The water supply should be obtained from a source known to be clean (free of contaminants). Optimally it should be sampled prior to use. If not, obtain a sample and have it analysed as part of the testing program.

<u>Monitor Well Installations</u>

The procedure for monitoring well installation using HSAs is as follows (a typical construction diagram is shown on Figure 1):

1. Measure and record depth of completed boring using a weighted tape.

2. Prepare all well construction materials. All personnel that handle the casing should don a clean pair of rubber or surgical gloves.

3. Assemble screen and casing as it is lowered into the boring inside the hollow stem augers. Attach stainless steel centralizers as required. Be sure that the end cap is well secured on the bottom length of pipe. The tops of all well casings will be fitted with slip caps which can be easily removed by hand.

   The screen length of the monitoring wells will vary, dependant on the design and overall objectives of the field testing program. For instance, where the presence of volatile compounds less dense than water (LNAPLs) is a potential concern, care must be taken to ensure that the

PROCEDURE FOR GROUNDWATER SAMPLING

A typical sample collection exercise involves a number of steps including pre-trip planning and preparation, on-site work, sample storage and shipping and laboratory analysis.

Pre-trip preparations include identifying the location of the site, how many wells are to be sampled, their sizes and construction details, the required analyses, what duplicate or control samples are needed and where the samples will be sent for analysis. The field equipment needed for the job should also be identified and prepared. Preparation may include the decontamination of equipment or the acquisition of equipment designed for one-time use only. Environment Canada's TABS on Contaminated Sites, TABS #5 provides a good summary of pre-trip planning and equipment decontamination techniques.

On-site work includes measuring static groundwater levels, inspecting wells, collecting samples and storing samples for transport to the laboratory. These steps, and quality assurance and quality control procedures, are described in detail in the sections that follow.

Measuring Static Water Levels

Upon arriving at a site to collect groundwater samples from monitoring wells, the first step should be to locate each monitoring well and remove the well covers and caps. Sealed well caps, such as rubber J-Plugs should be removed with caution as pressure may have built up in the well since the well was last opened. Reasons for this include rising groundwater levels in the well resulting in compression of the air above the water surface or the potential build-up of hydrocarbon vapours in the air space. All well caps should be removed to allow the water levels to stabilize.

Static water levels should be recorded in all wells over as short a time period as possible. This is particularly important in coastal areas, such as Nova Scotia, where tidal fluctuations could result in changes in groundwater levels over a short period of time. Groundwater levels may also change as recently infiltrated rainwater discharges from the system or in response to changes in atmospheric pressure. Although these variations may be small, they may be significant in areas with very shallow groundwater gradients and could result in the misinterpretation of groundwater flow directions.

Water levels should be measured twice in each well to verify the accuracy of the reading. It is also a good practice to re-measure the static water level in the first well at the end of the procedure to verify that the level has not changed.

When using measuring devices that must contact the water, it is important to thoroughly clean the device between monitoring wells. The method of decontamination will vary depending on the contaminants in question and may involve the use of soaps, alcohol or special solvents to ensure all traces of the contaminant are removed. Rinsing with distilled water is often done as a final step of the decontamination process. If relative contaminant levels are known in the monitoring wells, starting with the least contaminated well and moving to progressively more contaminated wells is one approach to minimizing the potential for cross-contamination.

A number of methods are available for determining static water levels, however the most common is to use a water level probe and meter. These devices usually consist of a plastic or fiberglass tape measure connected to a probe. Wires running inside the tape connect the probe to an audible and/or visual indicator that signals when the probe touches the water surface. The depth to the water at this point is measured off of the tape. Water levels are usually recorded relative to the top of the well casing which has been previously surveyed. This allows for the comparison of relative water levels in the monitoring wells so that groundwater flow directions and gradients may be determined. It is good practice to mark the top of the well casing, in a permanent manner, at the location where the elevation was surveyed. All subsequent water levels are then recorded relative to this position to ensure accurate water level elevations are calculated.

Other methods are available for measuring water levels. A weighted tape measure, coated with water finding paste or chalk, may be lowered into the well until the end of it is definitely below the water surface. The tape is read at the position of the top of the casing and the tape is withdrawn. The location of the water surface, relative to the tape, is determined from the location where the chalk or paste is still present. The difference between the two readings is the depth to the water from the top of the well. Another method involves the use of ultrasonic devices that do not contact the water but rather measure the time it takes sound waves to travel to the water surface and back again. These devices are calibrated to convert this time to a distance.

At some sites, the measurement of free product thickness may also be necessary. Free product refers to free phase hydrocarbons floating on the surface of the water as opposed to being dissolved in it. Again a number of methods are available for determining free product thickness. Product probes are available that emit a specific sound when in contact with hydrocarbons and another sound in the presence of water. The difference between the locations where each sound is first heard is the free product thickness. Another method is to use a weighted tape measure coated with chalk on one side and water finding paste on the other. After submerging the tape a sufficient distance to ensure it has fully penetrated the free product layer, the tape is withdrawn and the two sides of the tape are compared. The chalk will be washed away from that portion of the tape that penetrated both the free product and the water whereas the water finding paste will only be washed away from the portion of the tape that contacted the water. The difference between the two readings is the free product layer thickness.

Monitoring Well Inspections

While measuring the static water level in each well, it is also a good time to inspect the well for damage or other potential problems. This could include damage from vehicles, vandalism or frost heaving. In addition the ground in the vicinity of the well may be washed away or caving in allowing surface water to move down the outside of the well casing. The integrity of the well seal must be determined whenever any damage is found. If the possibility exists that water in the well is being influenced by the entry of surface water, soil particles and/or soil organisms, a decision will have to be made as to whether a sample should be collected. In some cases, analytical costs may be low enough that it is worth submitting the sample and then interpreting what effects, if any, the damage has had on water quality from the results. In other cases, however, analytical costs may be high enough that it is not worth the risk of submitting a sample for which the results may not be valid. In still other cases, such as regulatory compliance monitoring programs, anomalous results may result in problems for yourself and the client and it may not be worth the risk of collecting samples from damaged wells.

In any event, the damage should be recorded. If possible, well repairs may be carried out at the time, the well thoroughly purged, and samples collected as usual. If immediate repair is not possible, subsequent site visits should include provisions to repair the damaged well.

<u>Well Purging</u>

The purpose of purging a well prior to sample collection is to ensure that samples are representative of groundwater conditions. Purging may not always be necessary. In deeper wells, the use of dedicated submersible pumps allows sample collection within the screened portion of the well without disturbing stagnant water at the air-water interface. This is more appropriate in coarse grain geologic materials. Purging should always be carried out in low to moderate permeability formations.

In some cases purging will be completed when the well goes dry. However in many cases the well will recover at a rate faster than it is being purged. In these cases an accepted rule of thumb is to purge three

Appendix XI: Acid Rock Drainage & Surface Water Assessment Supplemental

WATER & AQUIFER TECHNICAL ENVIRONMENTAL RESOURCES
TERRY W. HENNIGAR WATER CONSULTING
Hydrogeologist & Groundwater Specialist
59 Birch Drive, RR2 Wolfville, NS B4P 2R2
Tel. 902 542 3003 Fax. 902 542 1100
Email: terryhennigar@eastlink.ca

May 10, 2007

Mr. Hendricus Van Wilgenburg
1396 Sherman Belcher Road
RR #2 Centerville
Kings County NS B0P 1J0

Dear Mr. Van Wilgenburg:

Regarding: Shaw Resources ESA, Coldbrook Site.

This is response to your request for additional information as identified by the regulatory agencies regarding stream flow monitoring at the proposed aggregate extraction site in Coldbrook. The main points addressed in the following relate to stream flows and water quality in Tupper Brook down gradient of the proposed site.

Acid Rock Drainage

Acid rock drainage in Nova Scotia is primarily related to sulphide mineralization associated with various minerals found in Carboniferous sedimentary rocks, and Meguma metamorphic rocks. The nearest rocks of these types are in the Meguma Group which are located along the South Mountain approximately two kilometers south of the proposed site (Figure 5, page 10, ***WATER,*** *Sept. 2006),* also included as Figure 1 attached. The Meguma Group is shown on the map as the white area south of Test Hole 15 on the bottom portion of the map. Freshly broken slate containing sulphide minerals, i.e. pyrite also known as fools gold, from the Meguma Group reacts with water, oxygen, and bacteria to produce acid and in the process releases other metals present in the slate such as arsenic, aluminum, and iron.

The bedrock under the site is mapped as the Wolfville Formation which has no record of sulphide mineralization and/or acid rock producing potential. The plan of operation for the aggregate extraction facility is to excavate to a maximum depth of one meter above the water table. At this depth the bottom of the pit is estimated to be 30 to 50 feet 10 to 15 m) or more above the bedrock underlying the site. Extraction of aggregates to a depth above the water table is not expected to pose any potential threat to the production of acid rock drainage or resulting impacts to receiving waters down gradient of the site. Sand/gravel clasts in the aggregate materials have been weathered and any acid production potential neutralized over the past 10,000 years since glaciation. The absence of crushing, washing, and processing of aggregate on site also minimizes the potential of acid rock drainage from the site.

Surface Water Quality Impacts

The configuration of proposed monitoring well locations (see Figure 7, page 21, ***WATER**, Sept. 2006) also Figure 2 attached,* shows two down gradient monitoring wells and one up gradient well. An appropriate location for a fourth monitoring well, if considered necessary, would be along the east border of the site between MW2 and MW3. The main purpose of the proposed two down gradient wells is to serve as water quality monitoring sites where groundwater flow is believed to leave the working area towards Tupper Brook. This flow pattern is to be confirmed, or to be otherwise determined, on the basis of results of monitoring well installation and the associated groundwater study.

It our opinion that the main concern with respect to groundwater quality deterioration and/or contamination at the site would be the result of a release(s) of petroleum products and/or hydraulic fluids.

There are no water courses on the property where surface flow is collected and transported off site. The high infiltration rate, as indicated by the hydraulic conductivity of the soils, (see Table 2, page 8, ***WATER**, Sept. 2006),* also shown as Table 1 attached, allows surface water to move vertically on the site rather than horizontally overland. The natural filtration capacity of the sand and gravel deposits on site are expected to remove colour, sediment, and turbidity from the surface water on the pit floor as it moves eastward towards Tupper Brook a separation distance of approximately 60 metres (200 feet).

Surface Water Quantity Impacts

One of the prime objectives for installing monitoring wells on the site is to determine depths to the water table at various locations within and/or near the footprint of the active area. Data collected on a temporal basis will allow determinations of water quality, water levels, groundwater gradients, and groundwater flow direction(s), and how these change seasonally. It is a well recognized hydro-geologic relationship that stream flows decrease in groundwater discharge areas during groundwater recession periods. The section of Tupper Brook east of the site is considered to be in a groundwater discharge area which receives base flow from the shallow groundwater flow system in the area. Information from the proposed monitoring wells will either verify, or otherwise determine differently, this relationship.

Figure 3 attached shows a section of Tupper Brook approximately 50 metres upstream of the Highway 101 culvert, and east of the proposed site. This photo taken on April 26 2007 during a dry period shows stream flow which is in large part, if not totally, base flow from groundwater influx to the stream channel. It is expected that estimations of base flow to the stream could be determined from water level and hydraulic conductivity data collected from the proposed monitoring wells.

Development of a stage-discharge relationship for Tupper Brook in the area will be complicated by at least two factors as observed from a reconnaissance of the area. These are:

- The storage and other stream uses upstream of the site.
- The unstable stream channel as observed in Figure 3.

For fish habitat impact assessment, stream flow measurements of some reliability could be collected at the culverts of Tupper Brook where it flows under Highway 101. Figure 4 shows the inverts to the double culvert system of Tupper Brook. This appears to be a stable section where stream measurements could be determined by measuring the wetted perimeter of the culverts, determining the cross sectional area, and measuring flow velocity on a regular basis, especially during low flow periods.

Stream flow data collected at the culverts would provide baseline data for the site. These data could assist in determining, at least on a first order basis, a water budget of the area. The data may also prove useful in correlating with other small stream flow hydrometric data being collected on the Valley floor from Annapolis River, Pereau River, and Cornwallis River tributaries.

It is our understanding that the data collected during water quality and quantity monitoring activities as proposed would address the adaptive management-phased development approach as suggested in review of the Environmental Assessment document. Baseline water quality and quantity data would be established during installation of the proposed monitoring wells and collection of surface water samples and flow measurements. Subsequent quarterly monitoring would identify the natural seasonal variations, trends, anomalies, suspected impacts, and the need for alternative actions.

I trust this addresses the points raised regarding groundwater and surface water quality and quantity at the Coldbrook site. If you require clarification or more information I am available to assist wherever possible.

Yours Very Truly,

Terry W. Hennigar, P. Eng.
President, ***WATER***

Attachments:

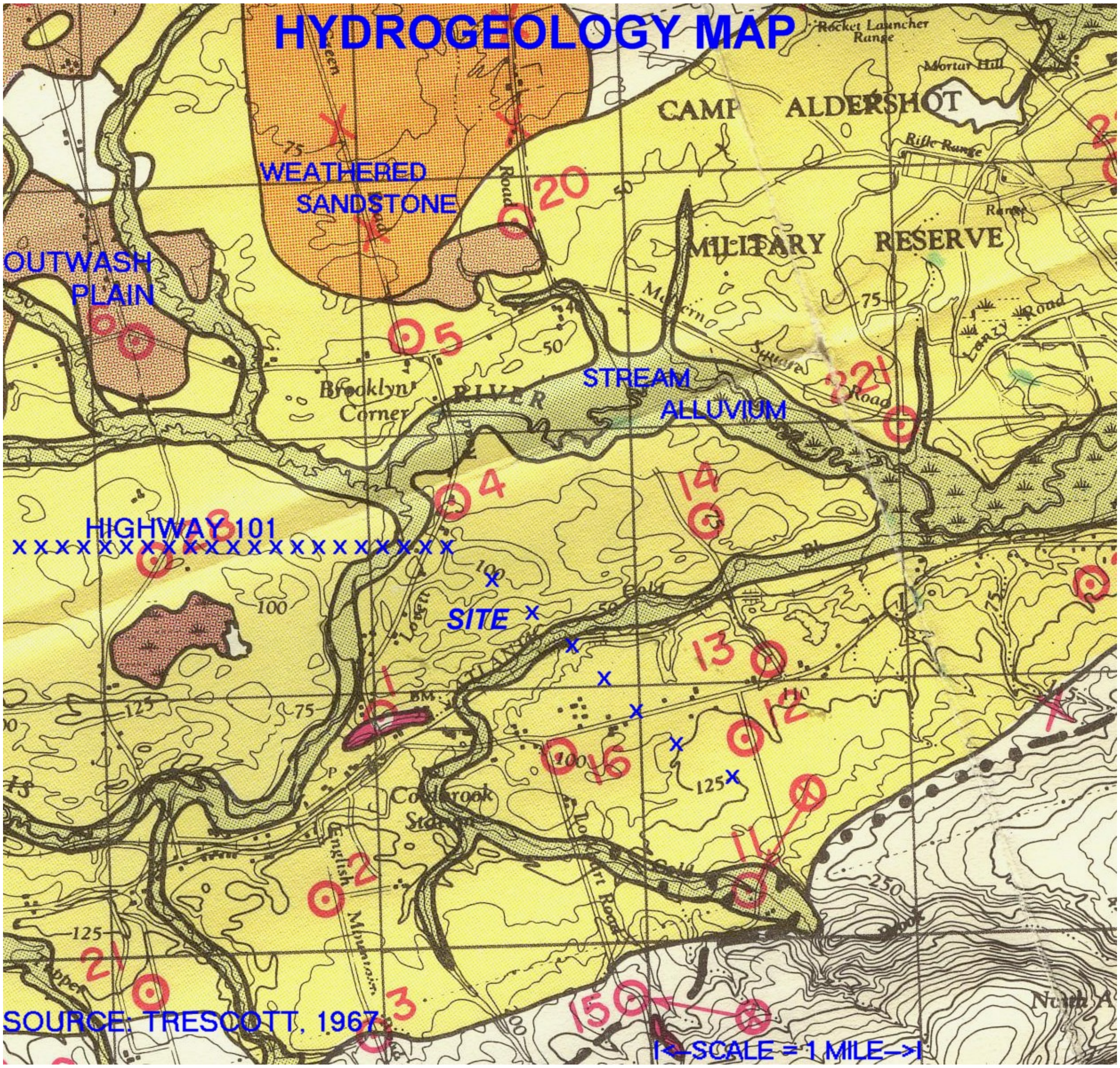

FIGURE 1. Meguma Group Shown on Map of Coldbrook Area. The White Area at The Bottom Right Portion of The Map Is Meguma Group Rocks.

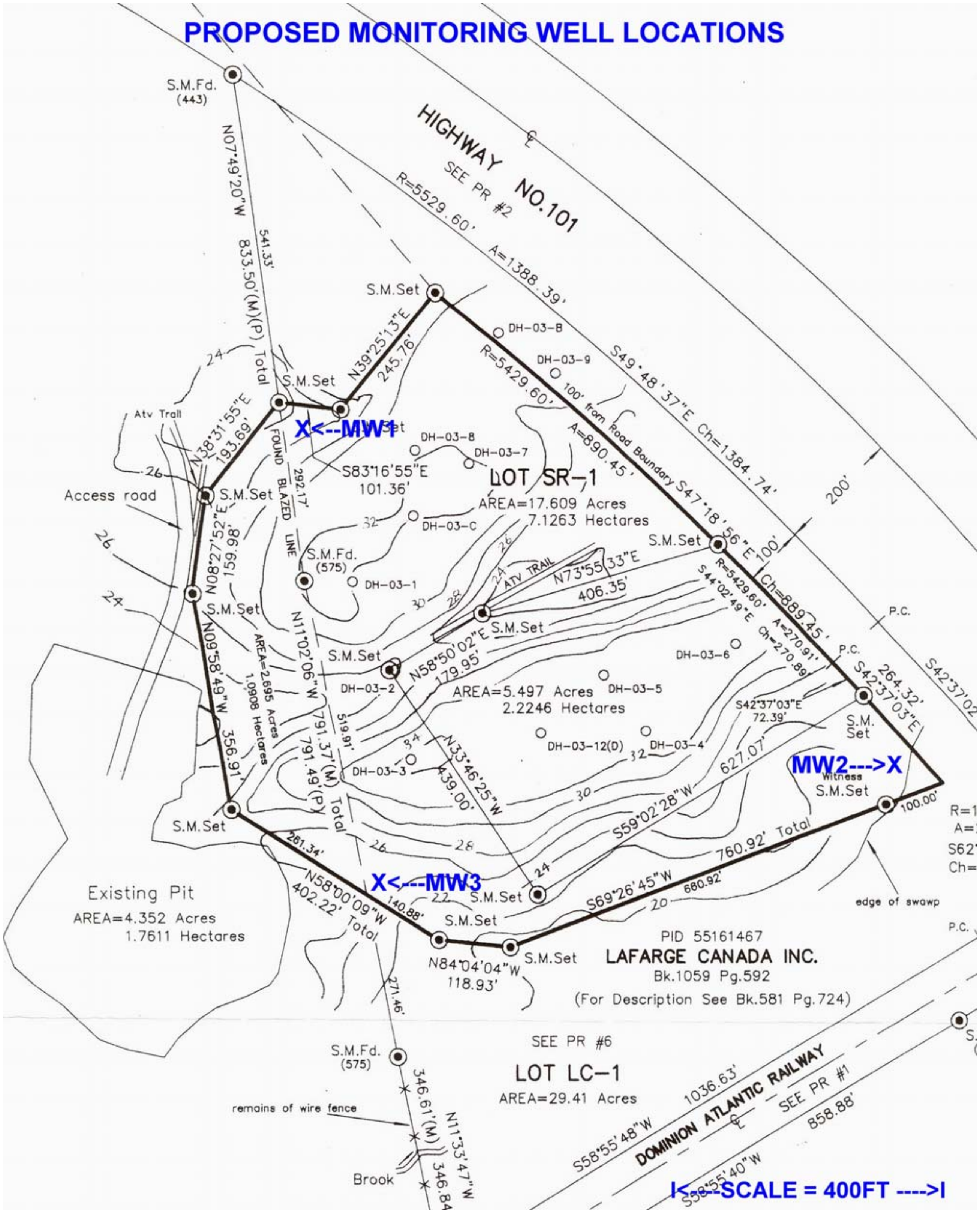

FIGURE 2. The Three Monitoring Wells Proposed. A Fourth MW If Necessary Could Be Midway Between MW2 and MW3.

Table 1. Summary of Hydraulic Conductivity of three soil types in the study area.

Soils Type	Thickness (cm)		Hydraulic Conductivity (cm/hr)	
	Range	Mean	Range	Mean
Cornwallis(CNW) 85				
A Horizon	12-57	26	7.2 - 24.9	14
B Horizon	6 - 75	33	8.2 - 23.0	14.1
C Horizon	NA	NA	5.2 - 9.3	7.6
Hebert (HBT) 86				
A Horizon	10 – 40	24	NA	NA
B Horizon	11 – 50	37	NA	NA
C Horizon	NA	NA	NA	NA
Truro (TUO) 84				
A Horizon	10 - 55	26	0.6 – 4.4	2.6
B Horizon	10 – 70	32	1.0 – 9.4	4.3
C Horizon	NA	NA	5.0 - 7.9	6.7

Notes: 1. Drainage of Cornwallis 85 soils ranges from well to rapid.
3. Drainage of Hebert 86 soils reported as rapid.
3. Drainage of Truro 84 soils reported as well drained.
4. Source Holmstrom and Thompson, 1989.

FIGURE 3. Unstable Stream Channel Up stream of Culverts.

FIGURE 4. Potential Site for Establishing Stage-Discharge Relationship for Tupper Brook.

Appendix XII: Contingency Plans for Emergencies

CONTINGENCY PLAN	**Shaw Resources**	**Contingency #1**
SOP developed by: Hendricus Van Wilgenburg	**SOP approved by: Scott Smith**	**Version #1**
EMERGENCY RESPONSE PROCEDURES FOR ACCIDENTAL UPSET OR SPILLS INVOLVING FUELS, LUBRICANTS, ETC.	**ONSITE OR OFFSITE**	**May 14, 2007**

Procedure:

In case of accident or injury call:

- For an ambulance and/or the Police call 911.
- To report a fire or to advise the Fire Department of a chemical spill - call 911.
- To advise the Valley Regional Hospital of an emergency - call (902) 679-2830

In case of spill involving fuels or other contaminant:

- Take immediate steps to stop source of leak / spill from continuing. This may involve righting tipped over vessels, buckets to catch and collect leaks, etc.
- Take immediate steps required to contain spill and minimize spread through the use of sand / aggregate or other available materials.
- If applicable, take immediate action to prevent the spill from entering any body of water. This may require a dike of sand / aggregate.
- Wear the appropriate personal protective equipment to safely contain the spill.
- Spread sand / aggregate or other absorbent materials to soak up the spill.
- As soon as possible after the spill has been controlled, notify the shipping office at Keddy Aggregate 679 – 6606 and Jeff Newton (902) 758 – 4756 office / (902) 456 – 8539 cell. If Jeff is unavailable, continue with the following call list until one individual has been notified. Danny Kennedy (902) 758 – 4753 office / (902) 483 – 7785 cell, Matt Ferguson (902) 758 – 4719 office / (902) 233 – 1126 cell, Scott Smith (902) 758 – 4727 office / (902) 456 – 7729 cell.
- Alert any other parties who may be affected by the fuel spill.
- Once the spill has been absorbed, the contaminated material should be promptly shoveled into drums or plastic garbage drums with tight fitting lids and/or scoped up using loader and loaded on trucks and tarped. Removal of impacted soils or aggregates should continue until there is no visual or odor indication of the spilled contaminant remaining in the on-site soil / aggregates.
- Transport contaminated materials to the Envirosoil recycling facility in Bedford, Nova Scotia (or other Approved facility) for processing.
- If necessary, call the Fire Department at 911 and advise them of a fuel spill and that assistance may be required.
- If necessary, call cleanup specialist for assistance.
- Within 24 hours of the incident, Scott Smith or a designated employee should report any spill which exceeds 100 litres to 24-hour environmental emergencies centre at (902) 426-6030 or 1-800-565-1633. Spills which are <100 litres but represent a potential unique hazard (i.e. potential to impact a watercourse) should also be reported.
- Restock spill response equipment and supplies.
- Debrief responders and discuss response.
- Prepare an incident report for review by Shaw Resources.