GEOLOGY AND GROUNDWATER ASSESSMENT WHITES POINT QUARRY SITE

Digby County, Nova Scotia

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Reference 3 – Jacques Whitford, "Preliminary Hydrogeological Assessment, Proposed Quarry Whites Cove, Digby Neck, Nova Scotia", December 2002.

GEOLOGY

Overview

This report is intended to address the geotechnical issues associated with Bilcon of Nova Scotia's (Bilcon's) Whites Point quarry project. The findings are an outgrowth of Mineral Valuation & Capital, Inc.'s (MVC's):

- Regional and local field investigations
- Analysis of the ten test holes drilled by Bilcon within the project area
- Discussions and meetings with geology, mining and environmental experts at the Nova Scotia Department of Natural Resources (NSDNR) and the Nova Scotia Department of Environment and Labour (NSEL) many of which took place at the Whites Point site and the regional project area. MVC is particularly grateful for the technical assistance provided by Dan Kontak, Ph.D., Regional Geologist with the NSDNR, Minerals and Energy Branch.
- Inspection and/or analysis of thirteen quarry operations in Nova Scotia and New Brunswick with NSDNR and NBDNR geology and quarry experts
- Review of geological, mining, and environmental reports, maps, and databases published by the NSDNR, NSEL, etc.
- Review of NSEL's Terms and Conditions for Environmental Assessment Approval for relevant projects such as the Point Tupper Marine Coal Terminal, the Kennedys Big Brook Red Marble Mine, etc.
- Experience with comparable quarry projects in the US, Canada, and elsewhere
- Review of the public comments regarding the draft guidelines for the Whites Point Quarry Environmental Impact Study
- Discussions with individuals and groups that attended the "open house" held on Digby Neck in November 2005.

This report is intended to be a summary of MVC's data and interpretations. Additional information is available for review at MVC's and Bilcon's offices.

Introduction

The bedrock on the Whites Point quarry site is composed of the Jurassic North Mountain Basalt. The North Mountain Basalt is present along the Bay of Fundy from Brier Island to Cape Blomidon, a distance of over 200-km. The basalt at Whites Point is typical of the onshore geology on Digby Neck and it continues seaward into the Bay of Fundy. The rocks underlying the North Mountain Basalt are red to pale green-gray, fluvial-lacustrine siltstones and shales of the Late Triassic Wolfville or Blomidon Formations. The regional geology is shown on Map 1.

Unconsolidated Quaternary aged glacial and colluvial deposits overlay portions of the basalt bedrock (see Map 2). The glacial deposits are part of the Basalt Till Facies of the Beaver River Till Unit. The till on the site is typically thin and stony with a sand matrix.

The entire site is covered by Rossway Soils (see Map 3), which are generally stony, well drained, and forested.

The topography of the quarry site slopes steeply toward the Bay of Fundy. Relief at the highest point is over 100 meters. The slope typically ranges from 10% to 20% but the steepest gradients attain a slope of 50% (see Map 4). Several areas along the shoreline, the existing quarry, and the southwest ridge of the site are relatively flat.

The North Mountain ridgeline and the surface watershed divide are shown on Map 5 and Figures 1 and 2. Surface water runoff from the site flows toward the Bay of Fundy except for a small 21-acre area at the southeast corner, which drains toward Saint Mary's Bay. Several small, intermittent, irregularly defined watercourses, typical of the North Mountain, flow down the mountainside and disperse into the Bay of Fundy.

The thermal regime on the site is typical for the area. There is no permafrost, ground ice, or unusual geothermal activity (geothermal hotspots, underground mine fires, etc,).

Research and Analysis

Much of the information on the regional geology has been excerpted from NSDNR Report of Activities 2001 published by D.J. Kontak titled "Internal Stratigraphy of the Jurassic North Mountain Basalt, Southern Nova Scotia". The North Mountain Basalt has been subdivided into three units based on the nature of the basalt flows. The units are called the lower, middle and upper flow units.

The thickness of the upper flow unit reportedly varies from 0 to 154 meters in the region. The upper flow is sometimes subdivided into the columnar jointed lower part and the upper part, which is more massive and often contains a honeycomb network of quartz veins. The middle flow unit is amygdaloidal, vesicular and zeolite rich in marked contrast to the massive, and generally vesicle-free, lower and upper flow units. The thickness of the middle flow ranges from 9 to 165 meters and it contains 4 to15 flows. The lower flow unit varies from 40 to 185 meters and consists of one flow. The unit is a uniform textured, massive, holocrystalline basalt with well developed columnar jointing. The regional dip of the North Mountain Basalt is 3 to 8 degrees to the northwest and it is offset at several locations by northeast trending right lateral faults.

The geology of the Whites Point site was initially investigated and evaluated by Mineral Valuation & Capital Inc. in 2002– see Lizak, John, "Geological Assessment of the Whites Cove Site" December 2002 (ref. 1). The initial geologic assessment was primarily based upon the drilling program and field investigation that was conducted in the spring of 2002. Four core holes were drilled on-site in April and May of 2002 (see Map 5 and ref. 1). All four holes were continuously cored to depths ranging from 35.0 to 74.5 meters.

Six additional holes were drilled in September of 2005 and completed as monitoring wells (see Map 5 and App. 2). The monitoring wells were drilled to depths ranging from 36.0 to 79.0 meters. The author was on site during the drilling to sample and describe the drill cuttings.

Field investigations were conducted with Dan Kontak, Ph.D., Regional Geologist with the NSDNR, Minerals and Energy Branch, the recognized expert on the North Mountain Basalt, in December 2004 and May 2005 to supplement the geologic information obtained from the drill holes. Dr. Kontak also examined, described and sampled the drill core. The primary objectives of the fieldwork were to delineate the structure and the stratigraphy of the upper and middle basalt flow units, to delineate the contact between the units, and to further describe the physical, chemical, and hydrogeologic characteristics of the upper and middle basalt unit.

The drill data and the fieldwork confirm that the bedrock and the quarry at Whites Point will be comprised exclusively of the upper flow unit of the North Mountain Basalt. Core holes #1 and #2 penetrated the contact between the upper flow and middle flow units at drill depths of approximately 60 meters and 70 meters respectively. Core holes #3 and #4 penetrated the upper flow unit from the surface to the total depth of the holes. Monitoring wells #1, #2, and #3 penetrated the upper and middle flow units. Monitoring well #6 penetrated just the upper flow unit and monitoring wells #4 and #5 penetrated the middle flow unit.

The upper flow unit is a uniform, hard, massive, vesicle free, medium dark gray to black basalt. The unit attains a maximum thickness of approximately 76 meters on the quarry site. It is virtually unweathered with vertical quartz veins present in the upper third of the unit. Some of the veins show red iron oxidation and some contain calcite. Minor vertical joints were occasionally observed in the basal portion of the upper flow unit, which may indicate the presence of narrow, possibly lenticular band of columnar jointing. There is, however, virtually no communication between the joints due to the paucity of horizontal fractures and/or the sealing of the original fractures with secondary mineralization. The orientation, spacing, and sealing of the limited fractures in the basalt appear to be random and hence unpredictable.

The top portion of the middle flow unit was penetrated by core hole #1 and #2 and monitoring well #1, #2, and #3. In the southern part of the project area, the top portion consists of a medium dark gray to dark gray, vesicular, amygdaloidal, zeolite rich basalt with rust colored bands. The contact between the upper unit and middle unit is virtually indistinguishable on the northern part of the property because the vesicular, amygdaloidal zone is absent or isolated. Unlike the massive upper unit, the vesicular, amygdaloidal, zeolite rich upper part of the middle basalt unit is not suitable for the production of construction aggregate.

The outcrop of the contact between the upper and middle flow unit is located along, or near, the southeast flank of North Mountain (see Map 6). Consequently, the bedrock in the valley along Highway 217 is composed of the middle and lower flow units of the

North Mountain Basalt. Unconsolidated, Quaternary aged glacial deposits and colluvium that range in thickness from 1m to over 50m purportedly sometimes overlie the bedrock in the valley along Highway 217.

The North Mountain Basalt strikes northeast-southwest and dips approximately 6 degrees to the northwest in the vicinity of the Whites Point site. No evidence of faulting or unique geological features was observed on, or adjacent to, the Whites Point Quarry site.

The North Mountain Basalt contains no acid producing minerals as evidenced by:

- The regional work done by Dr. Kontak of the NSDNR
- Analysis and sampling of local outcrops
- Analysis of water from the site
- A petrographic study done by the NSDNR on the Whites Point basalt
- Sampling and chemical testing of the Whites Point core

Basalt bedrock samples from core #1 were analyzed by PSC Analytical Services for potential acid rock drainage. Core samples from depths of 5 meters, 33 meters, and 61 meters were analyzed. The analytical test results for acid rock drainage are presented below.

				SAMPLE	
Analyte	Units	EQL	*RWP-01-5*	*RWP-01-33*	*RWP-01-61*
Sulphate Sulphur	%(w)	0.001	0.001	0.003	0.001
Sulphide Sulphur	%(w)	0.03	nd	nd	nd
Max. Potential Acidity	ppt	1.0	nd	nd	nd
Neutralization Potential	ppt	1.0	26	25	24
Net Neut. Potential	ppt	1.0	26	25	24
Fizz Rating		-	None	Moderate	None
Leach, Aqueous Prep		0.01	5:1	5:1	5:1
PH paste		-	9.3	9.8	9.3
Sulphur Sub	%(w)	0.020	0.020	nd	0.020

The units for Maximum Potential Acidity, Neutralization potential and Net Neutralization Potential are: tonne CaCOэ/1000 tonne.
EQL = Estimated Quantitation Limit is the minimum concentration that can be reliably reported. It is not a regulatory limit.
nd = Not Detected, instruments did not detect anything above standard EQL.

It should be noted that sulphide and sulfate sulphur and maximum potential acidity were virtually undetected in the samples. Furthermore, the net neutralization potential ranged from 24 – 26 ppt (EQL 1.0) in the samples. This was expected because acid producing rocks and minerals such as acid slates do not exist on the quarry property or within the

North Mountain Basalt. Based on the aforementioned evidence, acid production will not occur during, or after, quarrying the basalt.

Basalt bedrock samples from core #1 were also analyzed by PSC Analytical Services for baseline metals. Rock samples from depths of 5 meters, 33 meters, and 61 meters were analyzed for metals in the bedrock (see Appendix 1).

As expected, the basalt is rich in iron and aluminum as indicated by the 14,000 – 24,000 mg/kg of aluminum and the 20,000 to 23,000 mg/kg of iron in the rock samples. Iron and aluminum in combination with organic matter benefit soil structure and cation exchange capacity. Thus, the minute amount of iron and aluminum released during rock processing will benefit soil productivity when the fines are mixed with stripped, stockpiled, and composted organic material and spread in quarry reclamation.

Additional physical and chemical characterization of the upper flow unit on the Whites Point site indicates that it is a large source of high quality construction aggregate. The upper flow unit contains in excess of 100 million tons of in-place stone, which is ideally suited for quarrying and processing.

Quarrying and related activities will not adversely impact the bedrock stability, the thermal regime, or the infrastructure within and near the Whites Point site. The evidence to support this conclusion comes from an array of sources including:

- Investigation of local and Provincial quarries
- Assessments of local infrastructure and construction projects
- Physical and chemical characterization of the surficial material and the bedrock

The upper flow unit is a uniform, hard, massive, stable basalt with an extremely high compressive strength, which is one of the reasons it is an advantaged source of construction aggregate. Bedding is absent and fracturing is absent or, at most, moderately developed and typically filled with secondary mineralization. As a result, the porosity and permeability are secondary and low. The unit is also resistant to weathering, is stable, has good cut-slope stability, and is able to stand in steep cuts. The upper flow unit makes a good quality foundation for heavy structures. Blasting will not reduce the stability of the bedrock beyond the quarry face.

Concern about impacts on the thermal regime is typically limited to permafrost regions. The permafrost table may shift upward or downward, sometimes with undesirable consequences, when the thermal regime is upset by natural factors or human activities. However, because there is no permafrost, ground ice, or unusual geothermal activity (geothermal hotspots, underground mine fires, etc,) in the area, quarrying will not impact a permafrost zone or the thermal regime.

Quarrying and the related activities will not adversely impact the local infrastructure. The quarrying activities will be limited to the Whites Point site and, unlike other County projects, there will be no increased use of the land based infrastructure. Because there will be no quarry pumping or offsite discharge, the proposed activities will not contribute to frost heaving. Overall, quarrying will have less of an impact on the local infrastructure than the residential, non-residential building (schools, stores, hospitals, etc.) and non-building (roads, bridges, harbors, etc.) projects occurring in the area.

The Digby Neck region is located within the Northern Appalachian Seismic Zone (NAN). Maps of seismic risk in the 1995 National Building Code of Canada by the Geological Survey of Canada show the area occurs within Zone 1 and is considered to have a low earthquake risk. Historically, earthquakes in the Digby Neck Region have been infrequent and of small magnitude. The nearest zone of earthquake activity is across the Bay of Fundy in the Passamaquoddy Bay region. The Oak Bay Fault is considered to be the site of the activity for that region. Two small earthquake epicenters have been reported to the northeast of Digby. Further, an assessment of the proposed quarry site was requested from the Geological Survey of Canada for evaluation against the 1995 National Building Code of Canada. Results of this assessment are contained in a report prepared by Atlantic Marine Geological Consulting Ltd. 2005 (ref 2).

Mitigation and Monitoring

Quarrying will result in the removal of approximately 100 million tons of naturally occurring basalt rock over the 50 year life of the project, which will be processed into high quality, value added construction aggregate. This natural geologic resource will be irretrievably lost from the site. Site clearing and quarry development will proceed in a northerly and southerly direction from Whites Cove Road. The site clearing will average approximately six acres per year. No excavation will occur below sea level or the contact between the upper and middle flow units. Reclamation will begin after approximately five years of operation and will be concurrent in order to promote habitat maintenance and to maximize restoration during quarrying. The site will be totally restored after quarrying to enhance biological productivity, biodiversity, preservation and sustainable development. Details of the reclamation plan are provided in the comprehensive environmental impact report.

Bilcon will conduct ongoing monitoring of the surface water, marine water, groundwater, noise, blasting, air quality, and selected biological parameters to ensure that there is no adverse environmental impact. The details of the monitoring programs are presented in the comprehensive environmental impact report.

GROUNDWATER

Overview

This report is intended to address the hydrogeologic issues associated with Bilcon of Nova Scotia's (Bilcon's) Whites Point quarry project. The findings in the report are an outgrowth of Mineral Valuation & Capital, Inc.'s (MVC's):

- Regional and local hydrogeological field investigations
- Analysis of the data obtained from the four core holes and the six monitoring wells drilled by Bilcon in the project area
- Discussions and meetings with geology, hydrogeology, mining and environmental experts at the Nova Scotia Department of Natural Resources (NSDNR) and the Nova Scotia Department of Environment and Labour (NSEL), many of which took place at the Whites Point site and the regional project area
- Discussions with water well drillers, water purveyors, and water consumers in Nova Scotia and New Brunswick
- Inspection and/or analysis of thirteen quarry operations in Nova Scotia and New Brunswick with NSDNR and NBDNR quarry and hydrogeology experts.
- Review of geological, hydrogeological, mining, and environmental reports, maps, and databases published by the NSDNR, NSEL, etc.
- Review and analysis of the Jacques Whitford report titled "Preliminary Hydrogeological Assessment, Proposed Quarry Whites Cove, Digby Neck, Nova Scotia"
- Review of NSEL's Terms and Conditions for Environmental Assessment Approval for Groundwater Resources for comparable projects
- Review of the public comments regarding the draft guidelines for the Whites Point Quarry Environmental Impact Study
- Discussions with the individuals and groups that attended the "open house" held on Digby Neck in November, 2005. The local knowledge and experience gleaned from these discussions helped MVC to better understand and address areas of public concern
- Experience with comparable quarry projects in the US, Canada, and elsewhere. Specifically, water supply, enhancement, and protection projects located in, and near, construction aggregate operations (see Lizak, John, O'Reilly, Steve and Schmitz, Gary, "Aquifer Protection In and Near Aggregate Operations" 1998, National Stone Association). Clients on these projects included State and city governments and conservation groups such as The Nature Conservancy and the Trust for Public Land.

The study methodology was designed to ensure that the investigation was comprehensive and that it focused on the practical, verifiable, "hands on" aspects of hydrogeology versus the more academic, speculative and theoretical pursuits. The U.S. Geological Survey notes in a classic groundwater report "…. That one of the most valuable clues in studying groundwater supplies are the rocks…what the hydrogeologist can see of the rocks as they are exposed at the land surface or in road cuts, quarries, tunnels or mines and what he can learn from wells". To that end, considerable effort was spent investigating local field conditions and relevant quarry operations in addition to installing a comprehensive array of monitoring wells.

This report is intended to be a summary of MVC's data and interpretations. Additional information is available for review at MVC's and Bilcon's offices.

Research and Analysis

Jacques Whitford Environment Ltd. conducted preliminary hydrogeological investigations during September, 2002 – see Hogg, Dwayne, M.Sc. P.Eng. and MacFarlane, David M.Sc. P. Geo. "Preliminary Hydrogeological Assessment, Proposed Quarry, Whites Cove, Digby Neck, Nova Scotia" December 2002 (see ref. 3). The preliminary investigation included literature research and a preliminary inspection of the site, the drill holes, and the surrounding area. The preliminary groundwater assessment has since been supplemented with:

- The drilling and analysis of six monitoring wells
- Comprehensive field investigations of the local geology and hydrogeology that included surveying the locations of the local wells
- Consultations with Provincial mining and hydrogeology experts
- Inspection and/or analysis of thirteen quarry operations in Nova Scotia and New Brunswick

The six monitoring wells were drilled in September of 2005 (see Map 5) by Mowat's Well Drilling Ltd., a certified well driller. The wells were drilled to determine if the quarry will impact groundwater quantity or quality and to acquire additional data on groundwater chemistry, the water table, the local aquifer characteristics, etc. The 6in. diameter monitoring wells were completed "open hole" and drilled to depths ranging from 125 ft. to 260 ft. (36 to 79 meters). A licensed professional geologist was on site at all times to prepare well logs and completion reports and to conduct tests for each well (see App.2). Monitoring wells #1, #2, and #3 penetrated the upper and middle flow units. Monitoring wells #4 and #5 penetrated the middle flow unit, and monitoring well #6 penetrated just the upper flow unit. Monitoring well #4 and #5 were drilled in the midst of the local residential wells to directly monitor the impact of the quarry on the local groundwater supply.

Step down "air blow" tests and recharge tests were conducted to determine the yield of the hydrostratigraphic units, the aquifer characteristics, etc. Water levels were recorded. The water level is being measured in each monitoring well on an ongoing basis to delineate the water table. Precipitation is also being measured and recorded.

Quarries are routinely being used for water supply and aquifer enhancement in North America. The literature and MVC's experience is replete with examples of large and small aggregate projects in which aquifers were protected and water supply was enhanced. The thirteen quarries listed in Appendix 3 were investigated, in many instances with Provincial experts, as part of the MVC's hydrogeology study. Investigation of these quarries is relevant to the project because, like the Whites Point quarry, they are surrounded by water wells and, with the exception of the gypsum operation, they occur in crystalline bedrock. Most of the quarries have been operating and monitored for at least fifteen years. The Porcupine Mountain and Bayside quarries are large operations located on tidewater which export in excess of 3 million tons of stone per year. The practical insight obtained from the experience at these quarries has been integrated into the findings in this report.

The regional hydrogeology will be examined first, followed by a discussion of the local groundwater conditions. The main aquifers in the region occur primarily in certain zones within the North Mountain Basalt and the Blomidon Formation, and to lesser extent in unconsolidated glacial deposits and colluvium. The permeability in the bedrock aquifers is secondary with water flowing mainly through fractures in the rock. The upper and lower flow units of the North Mountain Basalt are fairly tight. Trescott (1969) notes in his investigation of the groundwater resources and hydrogeology of the Annapolis Valley that much of the original fracture permeability in the basalt has been lost due to secondary mineralization and that the permeability is primarily along weathered zones between flows. He notes that the columnar joints and vesicular zones within the basalt flows may store and transmit small amounts of groundwater, however the amount is typically minimal. Most of the water flows through the horizontal to sub-horizontal fractures located along contacts between flows, primarily in the middle flow. Consequently, the highest well yields in the basalt typically occur from individual flows associated with the middle flow unit and poor well yields occur in the upper and lower flow units.

The depth to the natural water table is variable and is dependent upon weather conditions and geology. The water table is an undulating surface, which more or less reflects the topography. It is typically at, or near, the surface in the valleys and deeper under the hills. Thus, groundwater typically occurs in larger quantities under valleys than under hills. The water table on Digby Neck is usually unconfined. A groundwater divide occurs near the crest of North Mountain. Consequently, the main groundwater flow direction on the north side of North Mountain is northwest to the Bay of Fundy, while groundwater flow on the south side of the mountain is southeast.

Based on ten pump tests conducted between Halls Harbour and Digby Neck, transmissivity in the basalt ranged from 0.27 to 78.8 m^2/d, with a geometric mean of 5.75 m^2/d. The pump tests also indicate that the basalt is typically anisotropic.

Hydraulic testing indicates a safe sustainable well yield of 1.3 imperial gallons per minute (igpm) to 94 ipgm with a geometric mean of 14.4 ipgm for wells with an average depth of 71.6m and depth ranging from 22.9m to 141.7m. Well yields ranged from 0.2 igpm to 65 igpm with a median yield of 7 igpm for 47 wells drilled from 18m to 277m in depth (55m median depth) between Little River and Mink Cove. Regional data indicate that there is poor correlation between well depth and yield. However, yields increase significantly at depths exceeding 107m, which penetrate the underlying Blomidon Unit.

Information on the local groundwater regime was obtained from Bilcon's core holes and monitoring wells, analysis of local water wells and outcrops, geologic mapping (surface and subsurface), etc. Comprehensive field investigations were conducted and six monitoring wells were drilled (see Map 5 and 6) to supplement the preliminary work done by Jacques Whitford and to address the local hydrogeological issues that have been raised.

The North Mountain Basalt is the main local aquifer. Most the original fracture permeability of the basalt has been lost due to secondary mineralization. Due to the massive nature of the basalt, groundwater flow occurs primarily along horizontal discontinuities between lava flows with very limited flow along vertical discontinuities. The columnar joints transmit minimal, if any, amounts of groundwater. As a result, the massive upper and lower flow units are relatively tight. Groundwater flows mainly through the horizontal to sub-horizontal fractures located along contacts between flows in the middle unit. This was demonstrated on the Whites Point site when circulation was lost in Drill Hole #1 and #2 when the middle flow unit was penetrated. The information obtained from the monitoring wells also supports these findings.

The water yield estimates for the basalt flow units are summarized on Table 1. The yield estimates were obtained from step down "air blow" tests conducted during drilling and from recharge tests conducted after completing the wells. The results demonstrate that the upper flow unit is fairly tight and that groundwater flows mainly through the isolated horizontal to sub-horizontal fractures located along the flow contacts in the middle unit. The well yields and hydraulic statistics suggest that the local permeability for the upper unit is extremely low and that the transmissivity is close to, or less than, the minimum reported for the region.

The yield from the middle flow unit ranged from less than 1imperial gallon per day to 24 imperial gallons per minute. The yield from the middle flow unit appears to decrease from south to north probably because the number of basalt flows, horizontal discontinuities, and vesicular zones decreases.

Table 1 – Monitoring Well Characteristics

Monitoring Well	**Well Depth (feet)**	**Water Yield Estimate (Imperial Gals. Per Minute unless noted)**	
		Upper Flow Unit	**Middle Flow Unit**
MW-1	245.0	Less than 1 ***per day***	Less than 1 per **day**
MW-2	220.0	Less than 1 ***per day***	4.0 ***per hour***
MW-3	260.0	Less than 1 ***per day***	24.0
MW-4	120.0	N/A	13.5
MW-5	150.0	N/A	2.5
MW-6	130.0	Less than 1 ***per day***	NP

N/A-Not applicable, flow unit is absent
NP -Not Penetrated

Water table data were obtained from the core test wells, the six monitoring wells, the local wells, etc. The groundwater regime and the hydrostratigraphic units are shown on Figure 1 and Figure 2. The two cross-sections depict a "snapshot" of the water table, the hydraulic gradient; etc. in the fall of 2005. The data show that the local water table mimics the topography. It is at or near the surface in the valley along Highway 217 and deep below the surface under North Mountain. The water level measurements taken on site show that the depth to the water table is considerable under North Mountain. For example, the water level recorded in monitoring well #1 is deeper than 220 feet (67 meters), or below elevation 55 feet (17 meters).

The groundwater divide occurs near the crest of North Mountain (see Figures 1 and 2). The main groundwater flow direction on the north side of the mountain is northwest to the Bay of Fundy, while groundwater flow on the south side of the mountain is southeast towards St. Mary's Bay. The natural flow to St. Mary's Bay may be locally intercepted by the drawdown associated with the deep commercial wells located between St. Mary's Bay and North Mountain.

The recharge area for the valley located along Highway 217 and its wells is essentially the valley, or the area south of the groundwater divide that occurs near the crest of North Mountain. The recharge area for the quarry area is north of the divide. Groundwater contributions to stream base flows appear to minimal in the study area.

A principal objective of this investigation is to determine if the quarry will impact the quality and quantity of the groundwater and the local wells. Consequently, an inventory was compiled of the wells located within approximately 1.5km of the quarry (see ref. 2, Jacques Whitford report titled "Preliminary Hydrogeological Assessment, Proposed Quarry, Whites Cove, Digby Neck, Nova Scotia" December 2002). The inventory includes the available construction details and hydraulic characteristics of the wells. The locations of the wells in the immediate vicinity of the quarry were surveyed in 2005 if permission was obtained from the well owner.

The nearest drilled water wells are located on the south side of North Mountain along Highway 217. Approximately seventeen drilled wells were identified within 1.0 to 1.5km of the quarry. Records were found for only 5 of the 17 drilled wells because of their age. The drilled wells are completed in the middle unit of the North Mountain Basalt, the lower flow unit of the North Mountain Basalt, and possibly the Blomidon Formation. The dug wells are likely completed in unconsolidated glacial or colluvial deposits. The wells will be in a different groundwater watershed and/or hydraulically down-gradient of the quarry.

The Whites Point quarry will not adversely impact the quality or the quantity of the groundwater supply or the local wells. The evidence to support this conclusion is obtained from analysis of the local geology, the local hydrogeology, the monitoring well data, the quarry's operating parameters, and relevant case studies and quarry investigations. The salient evidence is as follows:

1. Quarrying and local water production will occur in different geologic horizons or hydrostratigraphic units. Quarrying will take place in the upper unit of the North Mountain Basalt, whereas the drilled wells are completed in the middle unit of the North Mountain Basalt, the lower unit of the North Mountain Basalt, and the Blomidon Formation. The dug wells appear to be completed in unconsolidated glacial and colluvial deposits.

2. The local domestic and commercial wells will be located hydraulically down-gradient of the quarry and/or on opposite sides of the groundwater divide that is near the crest of North Mountain. The recharge and the discharge areas for the quarry and the wells are also located in different watersheds on opposite sides of the divide. The recharge area for the wells is in the valley not the quarry area. Consequently, the quarry will not adversely impact the relevant recharge regime.

3. Quarrying will be initiated above the natural water table. Consequently, mine dewatering and pumping will not be needed and there will be no groundwater withdrawal or drawdown. Bilcon will essentially be dry mining. Quarrying will be a non-consumptive use because none of the water that enters the relevant watershed will leave the watershed as a result of the proposed activity.

4. Blasting will not impact the groundwater supply. Agencies such as the U.S. Bureau of Mines, the Montana Bureau of Mines & Geology, etc. have done studies to evaluate the effects of blasting on groundwater supplies and wells. These studies have investigated, among other things, the issues of blasting residue and groundwater chemistry, water well stability and turbidity, yield, etc. No change in groundwater quality or quantity was observed in these studies as a result of blasting in comparable mines.

5. Analysis of core hole #1 (see Appendix 1) and groundwater samples (see ref. 3) indicates that the chemistry of the basalt, the groundwater, and the surface water is excellent. The basalt will provide an electrochemically neutral, naturally soft, low total dissolved solids, calcium-magnesium bicarbonate groundwater of very good chemical quality. All parameters except occasional manganese can be expected to meet the "Guidelines for Canadian drinking Water Quality" (2001).

6. Construction aggregate operations have been used to enhance recharge via artificial surface recharge. Quarrying at Whites Point may enhance the local groundwater regime by increasing stormwater retention and aquifer recharge.

7. The project will not cause saltwater intrusion. Quarrying will occur well above sea level and the fresh water-saltwater interface. No quarry pumping will take place. Construction aggregate mines have been used in coastal areas to prevent saltwater intrusion. The quarry could be part of a long term, comprehensive strategy to protect the local water supply from the seawater intrusion that could result from the unregulated pumping from the deep commercial wells.

An ongoing mitigation and monitoring program has been implemented to ensure and to further demonstrate that there will be no diminution in groundwater quantity or quality.

Mitigation and Monitoring

As previously noted, certain features of the Whites Point project will naturally prevent the diminution of groundwater quantity and quality and may enhance the groundwater regime. For example, quarrying will be initiated above the natural water table. Consequently, no quarry pumping or dewatering will be required and Bilcon will be dry mining. The locals wells will be located hydraulically down-gradient of the quarry and/or in different geologic horizons and groundwater watersheds. The recharge and discharge areas for the quarry and the wells are also located in different watersheds. Bilcon will slope the bench floors towards the quarry highwalls to decrease stormwater runoff and increase stormwater retention and aquifer recharge.

A comprehensive groundwater monitoring program has been implemented in accordance with the recommendations of Provincial experts, as part of Bilcon's hydrogeologic investigation. The objectives of the monitoring program are to:

- Demonstrate that the quarry project will not diminish the quality or the quantity of the groundwater supply.
- Acquire additional data on groundwater chemistry, the water table, the local aquifer characteristics, etc.
- Address the groundwater issues raised by the neighbors and educate the public about the nature of the local groundwater supply, well design, well maintenance, etc.
- Provide a failsafe, early detection system should groundwater issues arise that are not related to Bilcon's quarrying activities.

The construction and implementation of a six well, multi-level monitoring program was completed in September 2005 (see Map 5 and 6). The specifications and completion intervals for the six wells are shown on Table 1. Two of the wells were drilled along Highway 217 in the midst of the closest domestic wells. Three of the wells were drilled along Bilcon's property line. One of the wells was drilled in the vicinity of the existing quarry. The monitoring wells were designed and located in consultation with Provincial experts so that they can be incorporated in NSEL's Groundwater Observation Well Network.

The monitoring wells are being used to acquire additional data on groundwater chemistry, the water table, and the hydraulic properties of the groundwater regime. The multi-level option allows water level monitoring from discreet depths or geologic horizons. Bilcon is conducting ongoing water level and precipitation monitoring. Water quality monitoring will be performed annually by Bilcon on monitoring well #2 and #4 for bacteriology, general chemistry (including Br/Cl rations), and trace metals. Summary reports on groundwater levels and water quality will be provided to NSEL.

Pump or aquifer testing is not proposed. As previously noted, quarrying will be limited to the upper flow unit. It has already been shown that this unit is fairly tight. It is arguably impractical and unnecessary to pump test a unit that yields less than 1 imperial gallon per day. It has also a fact that there will be no quarry pumping because Bilcon will initially be dry mining above the natural water table. There is arguably little reason to pump test a unit that will not be pumped. Pump tests could be conducted on the monitoring wells that were completed in the middle flow unit, but is has been demonstrated that quarrying will not occur in, or impact, this unit. Furthermore, groundwater models can have serious limitations in crystalline bedrock. Consequently, the monitoring and testing efforts will focus on the collection of practical, verifiable, useful hydrogeologic information versus theoretical modeling.

There are reasons to anticipate local groundwater supply challenges in the absence of quarrying at Whites Point. The reasons are as follows:

- Well age – Studies have shown that the average domestic well and well pump have a life expectancy of less than 20 years and 10 years, respectively, but owners expect their wells and the pumps to last indefinitely. Fifteen of the 19 domestic wells identified within 1.0 to1.5 km of the quarry appear to be at least 20 years old. The newest well is roughly 13 years old.

- Well design and water storage – Some of the pressure tanks are relatively small, some of the wells are relatively shallow, and some of the pump capacities may exceed the recharge rate of the wells. Consequently, there may not be enough water entering the well to provide for continuous pumping once the well storage is pumped out. The water level can be pulled down rapidly exposing the rock to the atmosphere. This action can accelerate deterioration of the rock wall, cause sloughing, and increased turbidity.

- Neighborhood development and demographics – If too many wells are drilled in close proximity to each other and if household consumption increases, the normal level of the local water table may decline possibly resulting in decreased hydraulic head and well storage.

- Commercial pumping – The deep commercial wells require much higher demands for process water. Some of the wells purportedly produce seawater. Excessive, unregulated commercial pumping could cause a decline in the natural water table and encourage salt water intrusion.

- Seasonal fluctuations – There is a normal seasonal fluctuation in precipitation and in the depth to water table. Problems sometimes occur in the normal, low recharge seasons, particularly when they are aggravated by abnormal dry spells.

- Iron and manganese – Some of the wells could have high iron and/or manganese content (in excess of 0.3 and 0.1 parts per million, respectively). Bacteria in the well may develop a coating of iron and manganese that when oxidized creates a deleterious slime that builds up in the well, the water line, and the pump.

The proposed monitoring program will serve as an early detection system that will enable the neighbors to anticipate and confront these challenges before they occur. The program will also demonstrate on an ongoing basis that the quarry will not adversely impact groundwater quality or quantity.

As previously noted, many of the closest wells identified within approximately 1.5km of the proposed quarry were inventoried and located in the field. Additionally, Bilcon proposes a limited well survey of roughly nineteen properties. The survey will be conducted to enable the owners to anticipate non-quarry related groundwater issues that may occur, so that they can take proactive measures before problems arise. The survey will be initiated before quarrying commences but not before the regulatory approvals to quarry are obtained. The survey will be done in consultation with the NSEL according to their guidelines "Procedure for Conducting a Pre-Blast Survey" November 1993, to establish baseline water quality data. This would include analysis of bacteriology, general chemistry, and trace metals on a limited number of wells. Additional information on well design, pump and storage capacities, etc. will also be obtained.

A community liaison committee will be established to keep the public informed on groundwater issues. The community group will include at least two local well owners.

Respectfully submitted by:

John Lizak, B.Sc., M.Sc., Licensed Professional Geologist
Principal

STATEMENT OF QUALIFICATIONS
JOHN B. LIZAK

John Lizak graduated with a B.Sc. degree in Fundamental Science & Engineering from Lehigh University with specialty in geology and geotechnical engineering. He received a M.Sc. degree in geology from Purdue University. Mr. Lizak also has considerable post-graduate study in hydrogeology, mining engineering, and mineral economics. He is a Licensed Professional Geologist in Pennsylvania, Indiana, and Kentucky.

John Lizak has been involved in geoscience, mining and environmental projects for over twenty-five years with "Fortune 500" and private companies. He worked as a senior geologist with Exxon Coal & Minerals, Inc. and served as a Geologic Project Manager with British Petroleum's mineral group. He was also Chief Geologist and Manager of Environmental Affairs with the Millington Group of Companies. His geographic and project experience is extensive.

Mr. Lizak is a principal in LIZAK GEOSCIENCE & ENGINEERING, INC. (LGE) a geoscience, mining and environmental consulting company with offices in Indiana and Pennsylvania. The firm is a respected advisor on resource extraction, geoscience, and environmental issues as evidenced by the fact that LGE's clients include international and domestic "Fortune 500" and private companies, law firms, State and city governments, public agencies such as the U.S. Park Service, and international conservation groups such as the Nature Conservancy. Mr. Lizak has been directly involved in hundreds of geoscience, mining, and environmental projects in the U.S. and overseas. These projects include over 20 groundwater and water supply investigations dealing with aggregate operations in environmentally sensitive locales.

Mr. Lizak is also a principal in MINERAL VALUATION & CAPITAL, INC. (MVC), a consulting company specializing in mineral valuation, mergers and acquisitions, and capital sourcing. MVC's clients include banks, law firms, the IRS, investment companies, mineral trusts, governments, international and domestic mineral extraction companies and individuals. John Lizak specializes in the valuation, acquisition, and development of industrial mineral and construction material ventures. His experience with MVC includes the evaluation of numerous domestic and international mineral ventures and markets. He has also been directly involved in numerous "Greenfield" start-ups.

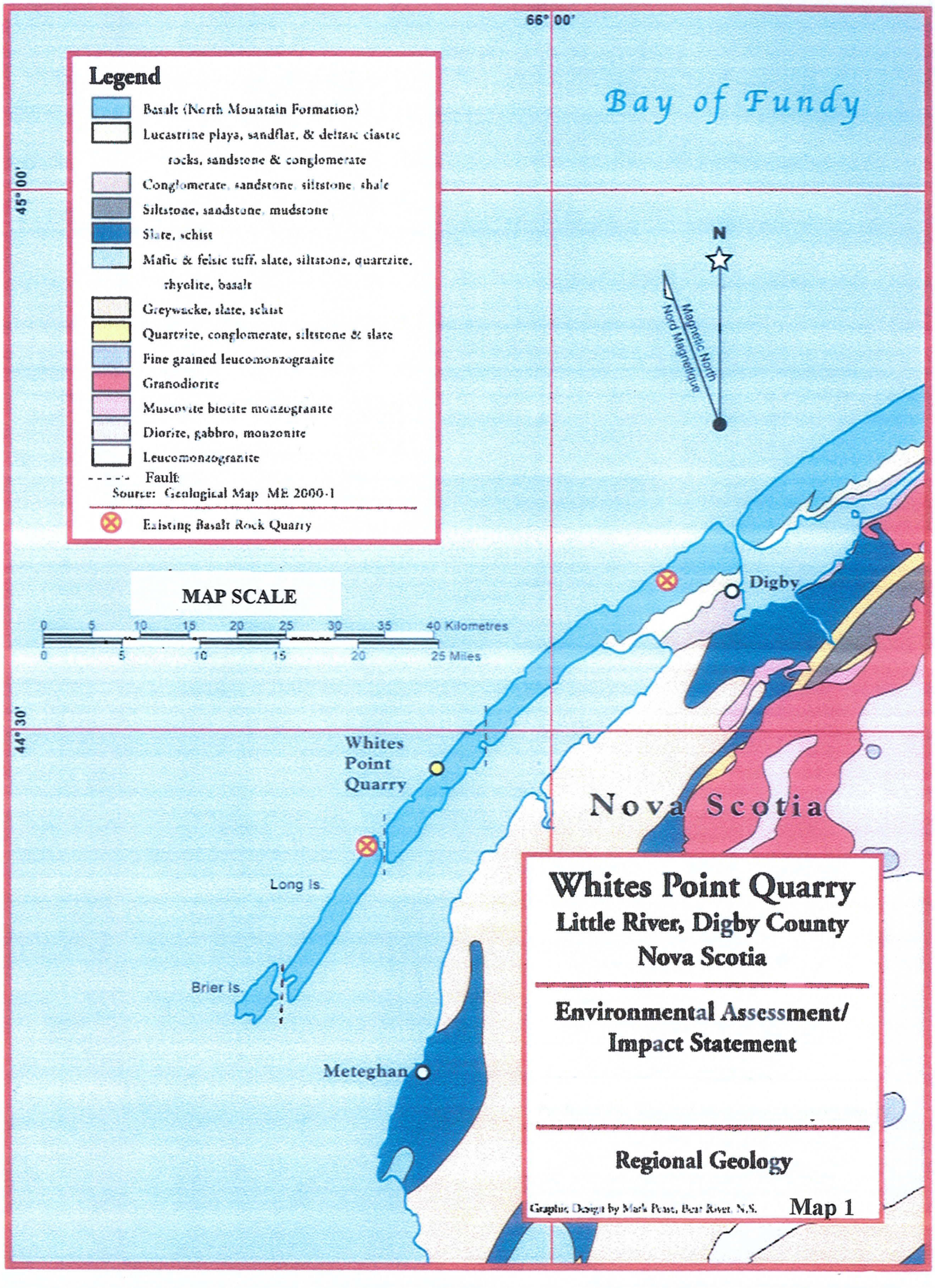
John Lizak is a recognized expert on geoscience, resource extraction, and environmental issues. He has testified in numerous federal and state courts and has been appointed as a "court master" to arbitrate cases dealing with geoscience and mining issues. He has written numerous scientific papers and reports including "Aquifer Protection Within And Near Aggregate Operations" (National Stone Association 1998).

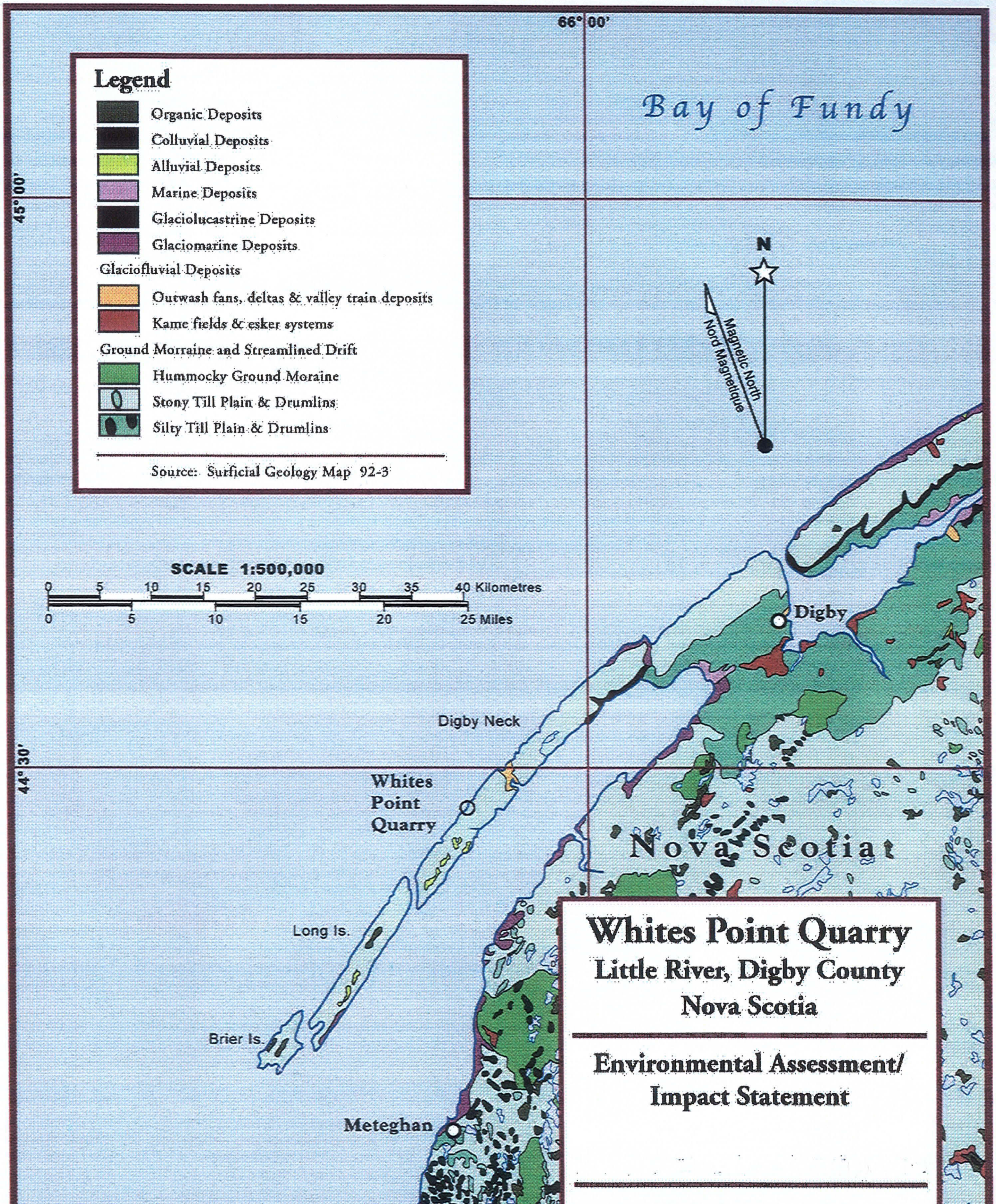
Mr. Lizak was Vice-Chairman of the Society of Mining & Exploration's (SME) Mineral Management Resource Committee and past President of the Indiana-Kentucky

Geological Society. He was a delegate to the Environmental Division of the American Association of Petroleum Geologists (AAPG). He is a member of SME, AAPG, the Forum on Industrial Minerals, and the National Water Well Association. He was also a member of the American Institute of Professional Geologists and the American Society of Appraisers.

Mr. Lizak was an Adjunct Professor of Geology in the University of Evansville's Mineral Land Management Program. He was also an Adjunct Professor of Geology at Raritan Valley College.

MAPS


66° 00'
Bay of Fundy
45° 00'
44° 30'
Legend
Basalt (North Mountain Formation)
Lucastrine playa, sandflat, & deltaic clastic rocks, sandstone & conglomerate
Conglomerate, sandstone, siltstone, shale
Siltstone, sandstone, mudstone
Slate, schist
Mafic & felsic tuff, slate, siltstone, quartzite, rhyolite, basalt
Greywacke, slate, schist
Quartzite, conglomerate, siltstone & slate
Fine grained leucomonzogranite
Granodiorite
Muscovite biotite monzogranite
Diorite, gabbro, monzonite
Leucomonzogranite
Fault
Source: Geological Map ME 2000-1
Existing Basalt Rock Quarry
N
Magnetic North
Nord Magnetique
MAP SCALE
0 5 10 15 20 25 30 35 40 Kilometres
0 5 10 15 20 25 Miles
Digby
Whites Point Quarry
Long Is.
Brier Is.
Meteghan
Nova Scotia
Whites Point Quarry
Little River, Digby County
Nova Scotia
Environmental Assessment/
Impact Statement
Regional Geology
Graphic Design by Mark Pease, Bear River, N.S.
Map 1



Whites Point Quarry

Little River, Digby County
Nova Scotia

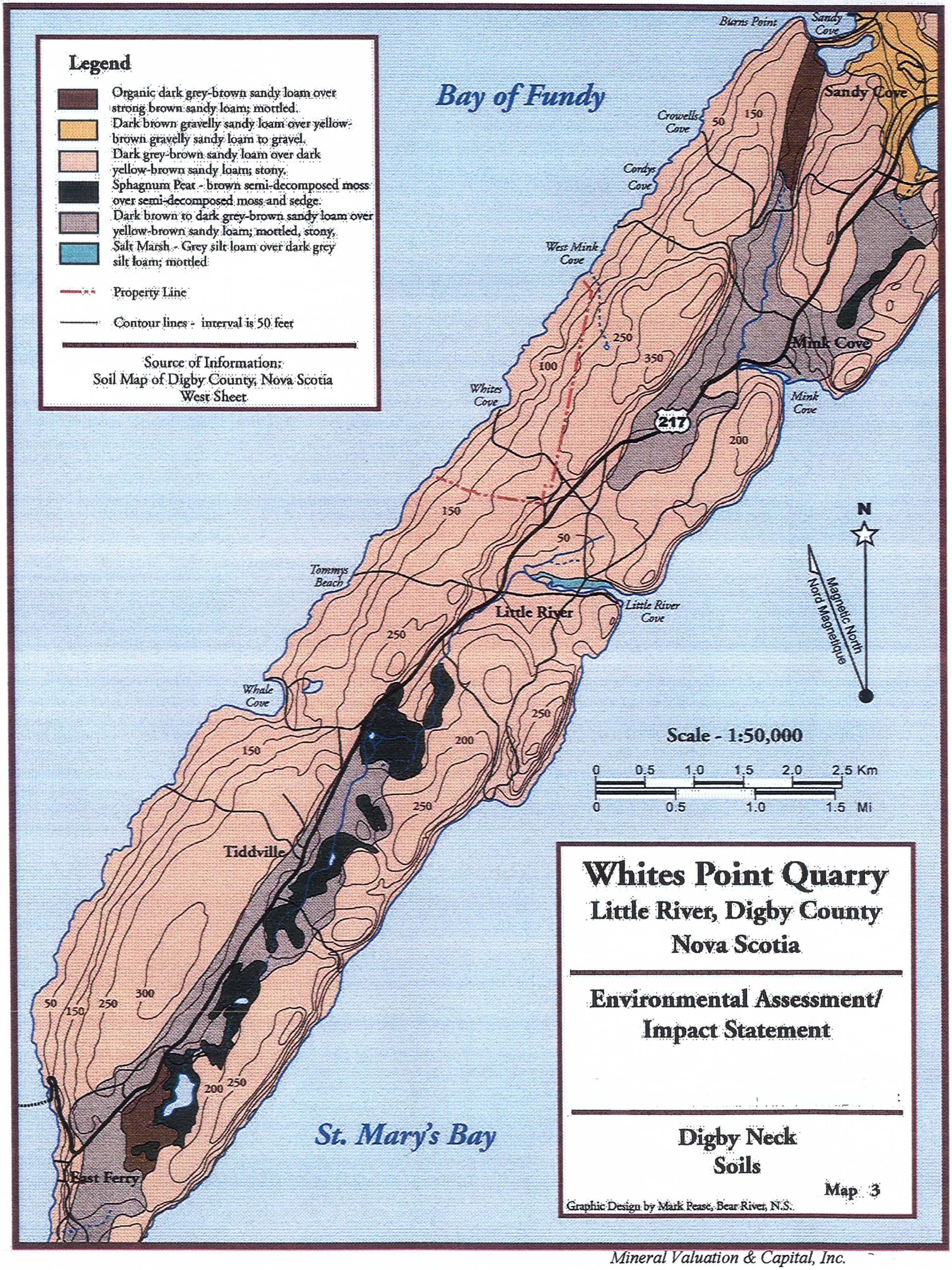
Environmental Assessment/ Impact Statement

Surficial Geology

Graphic Design by Mark Pease, Bear River, N.S.

Map 2

Mineral Valuation & Capital, Inc.



Whites Point Quarry
Little River, Digby County
Nova Scotia

Environmental Assessment/ Impact Statement

Digby Neck
Soils

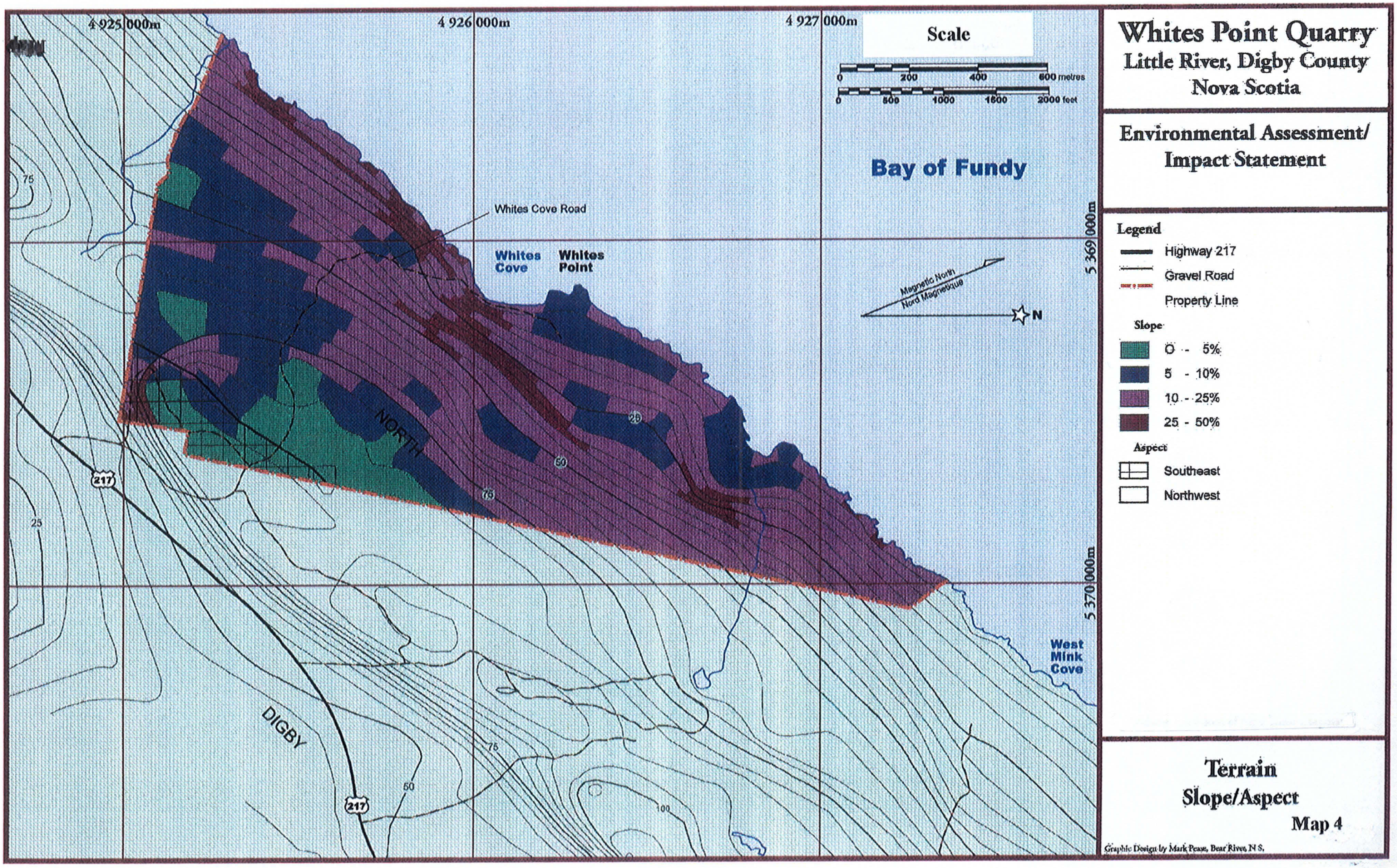
Map 3

Graphic Design by Mark Pease, Bear River, N.S.

Legend

- 🟫 Organic dark grey-brown sandy loam over strong brown sandy loam; mottled.
- 🟧 Dark brown gravelly sandy loam over yellow-brown gravelly sandy loam to gravel.
- ▨ Dark grey-brown sandy loam over dark yellow-brown sandy loam; stony.
- ⬛ Sphagnum Peat - brown semi-decomposed moss over semi-decomposed moss and sedge.
- ▨ Dark brown to dark grey-brown sandy loam over yellow-brown sandy loam; mottled, stony.
- 🟦 Salt Marsh - Grey silt loam over dark grey silt loam; mottled
- Property Line
- Contour lines - interval is 50 feet

Source of Information:
Soil Map of Digby County, Nova Scotia
West Sheet

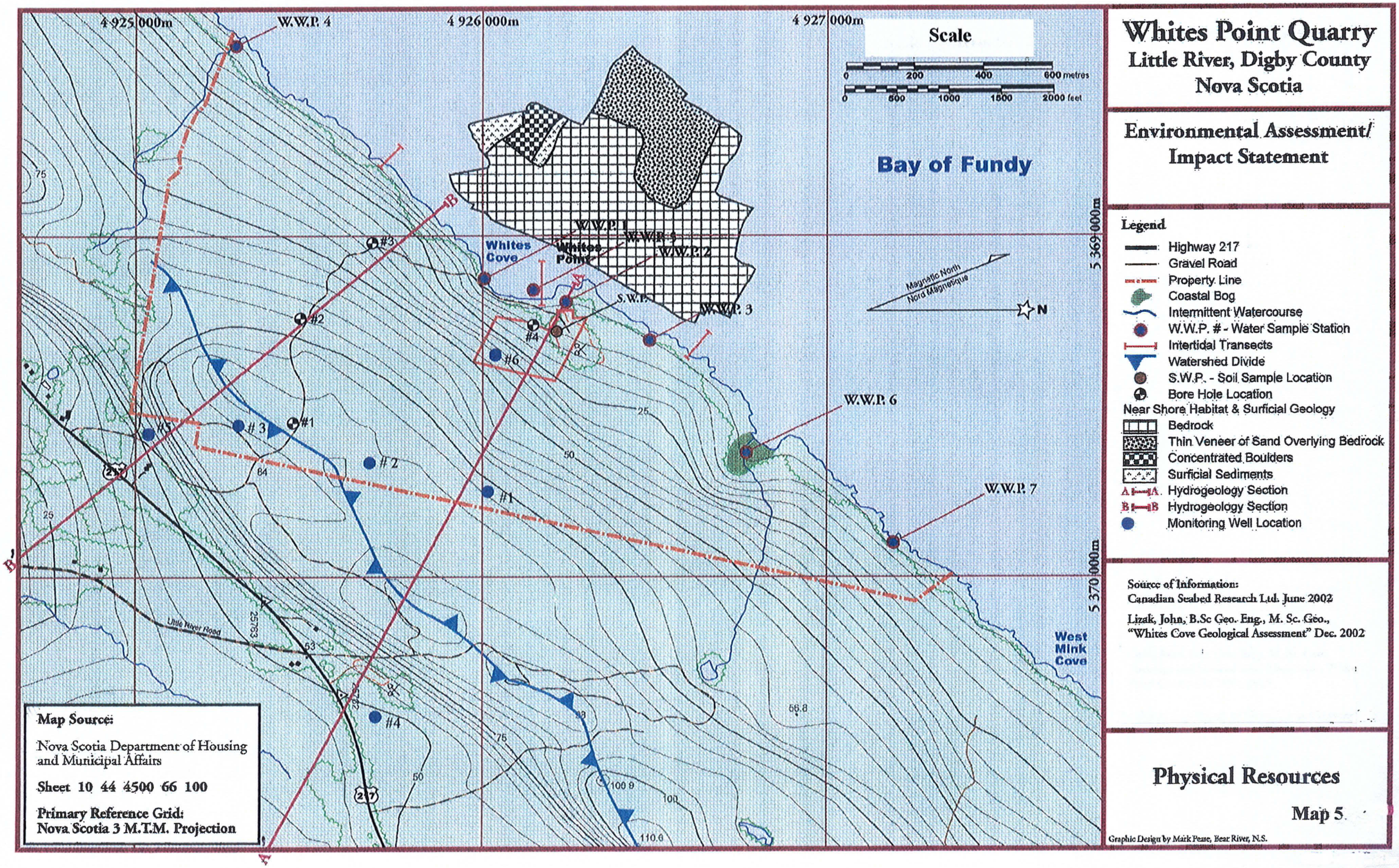


Whites Point Quarry
Little River, Digby County
Nova Scotia

Environmental Assessment/
Impact Statement

Terrain
Slope/Aspect
Map 4

Graphic Design by Mark Pease, Bear River, N.S.



Whites Point Quarry
Little River, Digby County
Nova Scotia

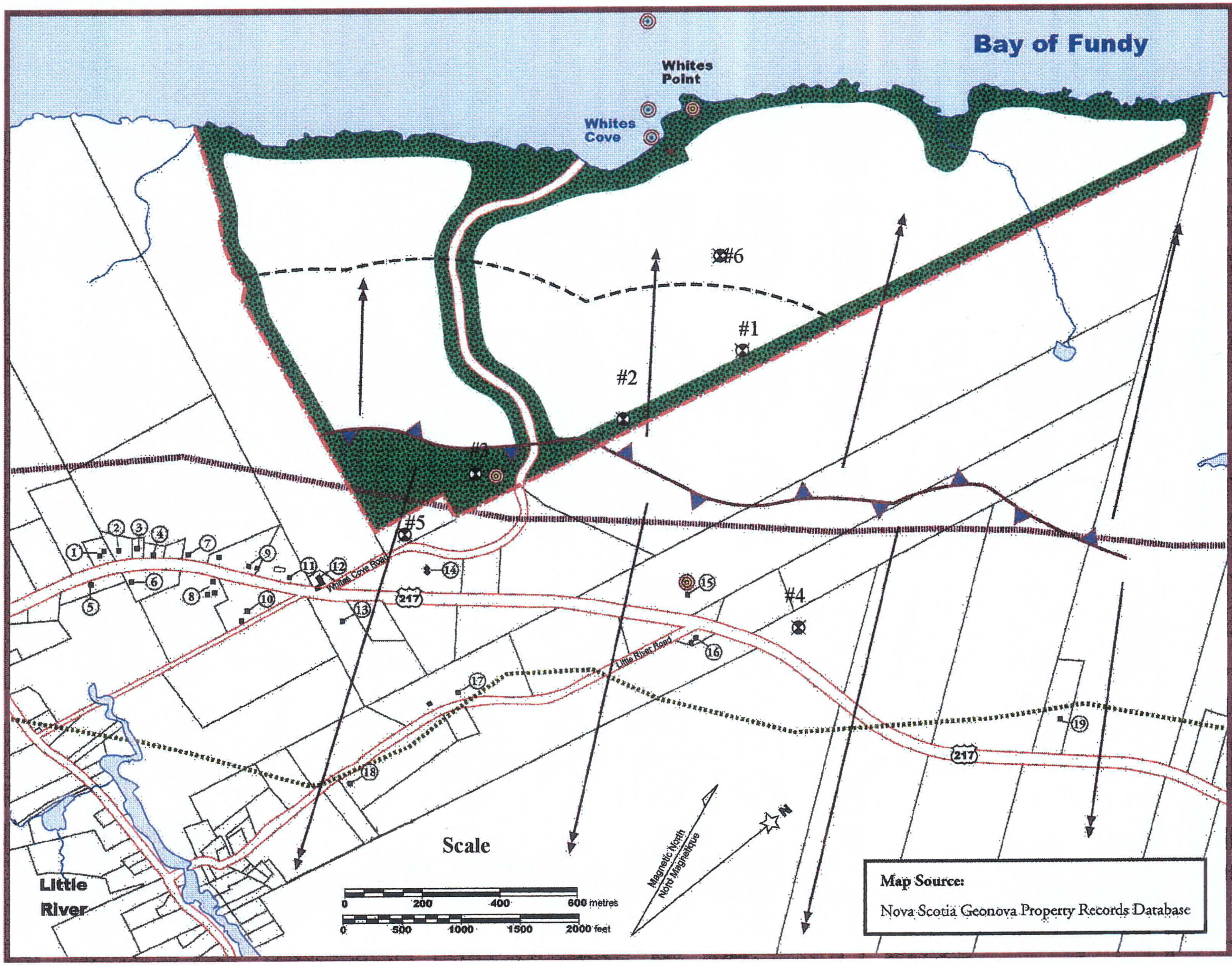
Environmental Assessment/ Impact Statement

Source of Information:
Canadian Seabed Research Ltd. June 2002
Lizak, John, B.Sc Geo. Eng., M. Sc. Geo., "Whites Cove Geological Assessment" Dec. 2002

Map Source:
Nova Scotia Department of Housing and Municipal Affairs
Sheet 10 44 4500 66 100
Primary Reference Grid:
Nova Scotia 3 M.T.M. Projection

Physical Resources
Map 5

Graphic Design by Mark Pease, Bear River, N.S.



Map Source:
Nova Scotia Geonova Property Records Database

Whites Point Quarry
Little River, Digby County
Nova Scotia

Environmental Assessment/ Impact Statement

Legend

- Property Line
- Intermittent Watercourse
- Surface/Groundwater Divide
- Inferred Groundwater Flow Direction
- Groundwater Monitoring Well
- Residence Reference Number
- Private Land
- 800 Meter Setback
- Proposed Blast Monitoring Location- Land
- Proposed Blast Monitoring Location- Water
- Environmental Preservation Zone
- Projected outcropping of geological contact between basalt upper flow unit and middle flow unit.
- Projected outcropping of geological contact between basalt middle flow unit and lower flow unit.

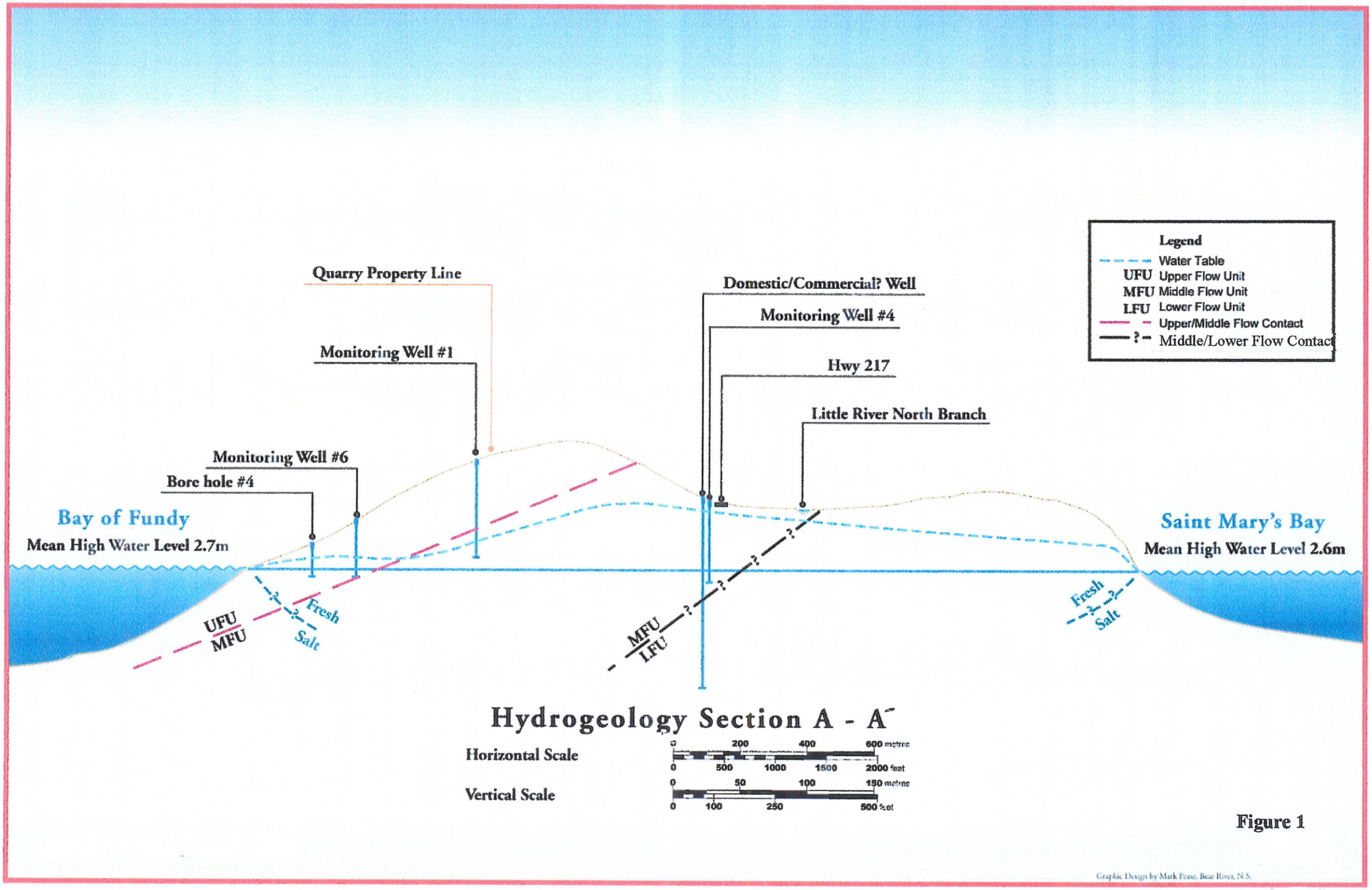
Source of Information:
Jaques Whitford Environment Ltd. - Hogg, Dwayne, M.Sc., P. Eng. and MacFarlane, David, M. Sc., P. Geo. " Preliminary Hydrological Assessment, Proposed Quarry, Whites Cove, Digby Neck, Nova Scotia" Dec. 2002

Property Map

Map 6

Graphic Design by Mark Pease, Bear River, N.S.

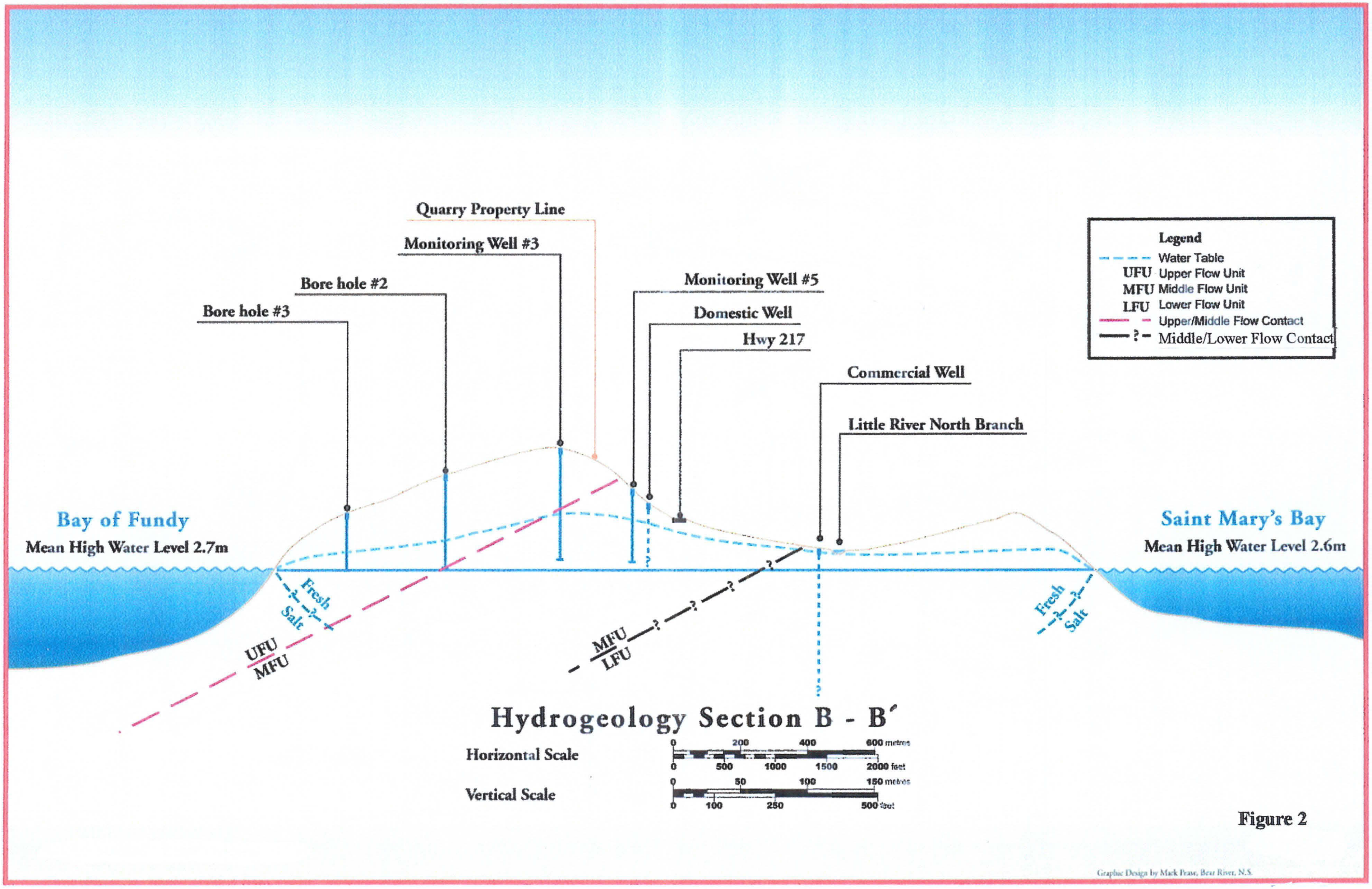
FIGURES



Hydrogeology Section A - A´

Figure 1

Graphic Design by Mark Pease, Bear River, N.S.



Hydrogeology Section B - B′

Figure 2

APPENDICES

Appendix 1

Whites Point Quarry
Basalt Rock - Metals

			Sample		
ANALYTE	**Units**	**EQL**	**RWP - 01-5**	**RWP - 01- 33**	**RWP - 01 - 61**
MN03 Peroxide Digestion		-	20041231 - A	20041231 - A	20041231 - A
Aluminum	mg/kg	10	14000	24000	17000
Antimony	mg/kg	2	nd	nd	nd
Antimony Recovery	%	-	40	40	40
Arsenic	mg/kg	2	nd	nd	nd
Barium	mg/kg	5	66	30	93
Beryllium	mg/kg	2	nd	nd	nd
Boron	mg/kg	5	nd	nd	nd
Cadmium	mg/kg	0.3	nd	nd	nd
Chromium	mg/kg	2	18	89	58
Cobalt	mg/kg	1	14	16	12
Copper	mg/kg	2	27	48	170
Iron	mg/kg	50	20000	22000	23000
Iron Recovery	%	-	80	80	80
Lead	mg/kg	0.5	4.2	1	1.5
Manganese	mg/kg	2	190	170	300
Molybdenum	mg/kg	2	nd	13	16
Nickel	mg/kg	2	32	120	130
Selenium	mg/kg	2	nd	nd	nd
Silver	mg/kg	0.5	nd	nd	nd
Strontium	mg/kg	5	130	57	44
Thallium	mg/kg	0.1	nd	nd	nd
Uranium	mg/kg	0.1	0.6	0.2	0.2
Vanadium	mg/kg	2	37	45	41
Zinc	mg/kg	5	52	29	43
Sulphur Sub	% (w)	0.02	0.02	nd	0.02

Legend

EQL = Estimated Quantitation Limit is the minimum concentration that can be reliably reported. It is not a regulatory limit.

nd = Not Detected, instrument did not detect anything above standard EQL.

nd () Not Detected at the elevated EQL specified, due to matrix interference or sample pre-dilution.

- Dash is reported when parameter not requested in sample.

Note: Soil results are expressed as air dry weight basis.

Appendix 2

DRILL HOLE COMPLETION REPORT
LIZAK GEOSCIENCE & ENGINEERING, INC.
Northeast Office-1805 Evans St.
Northampton, PA 18067
*Phone 610-262-9120 * Fax 610-262-4212*

Hole No: MW-1 Property/Project: Whites Point

Location: ≈ 2000 Ft. north of W.P. road on new road; ≈ 100 Ft W. of PL Gr. Elevation: 275 Ft.

Location Surveyed: [✓ (Yes)] (No) Surveyor's Name: Bill Ross

County: Digby State/Province NS Country: Canada

Surface Owner: – Option No.: –

Spud Date: 9-20-05 Completion Date: 9-20-05

Hole Size: Surface 8 3/4" Interval 0-20

Main Hole 6 1/8" Interval 20-TD

Total Depth: 245.0 Ft Air to: – Water/Mud to: 0-TD

Cored: (Yes) [✓ (No)]: If yes, intervals

Core Barrel Type: I.D. O.D. Length

Lost Circulation at: Regained: (Yes) (No)

Static Water Level: Initial Final

Noticeable Water Invasion: (Yes) [✓ (No)]; Intervals

Casing: Depth 20' Diameter 6 1/4 ID Recovered: (Yes) [✓ (No)]

Contractor's name and address: Mowat's Well Drilling (506) 339-6214
722 Cox Point Road; Cumberland Bay, NB E4A 2Y5

Hole Plugged: (Yes) [✓ (No)] Name/address if company differs from contractor

Samples and core descriptions by: MVC - J. Lizak

Report prepared by: J. Lizak Date: 9-20-05

Comments:

Location Sketch

SAMPLE DESCRIPTION

Hole Number: MW-1
Description By: J. Lizak

Prospect/Property: Whites Point
Drilled By: Mowat Drilling

Page: 1 of 1
Date: 9-20-05 to 9-20-05

DEPTH (ft.)		**SAMPLE DESCRITION**
From	**To**	
0	5	Overburden
5	10	Basalt, gray black to black
10	20	SAA (Same as above)
20	30	SAA
30	40	SAA
40	50	SAA
50	60	SAA
60	70	SAA
70	80	SAA
80	90	SAA
90	100	SAA
100	110	SAA
110	120	SAA
120	130	SAA
130	140	SAA
140	150	SAA with slight red color
150	160	Basalt, medium dark gray/dark gray to black
160	170	SAA
170	180	SAA, slightly softer
180	190	SAA
190	200	SAA
200	210	SAA
210	220	SAA
220	230	SAA, drilling mud tinged slightly red at 225
230	240	Basalt, red gray,vesicular,some light colored minerals in cuttings; drilling mud tinged red
240	245TD	SAA

DRILL HOLE COMPLETION REPORT
LIZAK GEOSCIENCE & ENGINEERING, INC.

Northeast Office-1805 Evans St.
Northampton, PA 18067
*Phone 610-262-9120 * Fax 610-262-4212*

Hole No: MW-2 Property/Project: Whites Point

Location: ≈ 800'N of WC road on new access road; ≈ 100 W of P.Line Gr. Elevation: 296 ft.

Location Surveyed: [✓ (Yes)] (No) Surveyor's Name: Bill Ross

County: Digby State/Province N.S. Country: Canada

Surface Owner: ________ Option No.: ________

Spud Date: 9-21-05 Completion Date: 9-21-05

Hole Size: Surface 8 3/4 Interval 20'

Main Hole 6 1/2 Interval 20-TD

Total Depth: 220 ft Air to: ________ Water/Mud to: 0-TD

Cored: (Yes) [✓ (No)]: If yes, intervals ________

Core Barrel Type: ________ I.D. ________ O.D. ________ Length ________

Lost Circulation at: ________ Regained: (Yes) (No) ________

Static Water Level: Initial ________ Final ________

Noticeable Water Invasion: (Yes) [✓ (No)]; Intervals ________

Casing: Depth 20 Diameter 6 1/4 ID Recovered: (Yes) [✓ (No)]

Contractor's name and address: Mowat's Well Drilling (506) 339-6214
722 Cox Point Road, Cumberland Bay, NB E4A 2Y5

Hole Plugged: (Yes) (No) Name/address if company differs from contractor ________

Samples and core descriptions by: J. Lizak

Report prepared by: J. Lizak Date: 9-21-05

Comments:

Location Sketch

SAMPLE DESCRIPTION

Hole Number: MW-2
Description By: J. Lizak

Prospect/Property: Whites Point
Drilled By: Mowat Drilling

Page: 1 of 1
Date: 9-21-05 to 9-21-05

DEPTH (ft.)		SAMPLE DESCRITION
From	**To**	
0	6	Overburden
6	10	Basalt, gray black to black
10	20	SAA (Same as above)
20	30	SAA
31	40	SAA
40	50	SAA
50	60	Basalt, medium light gray
60	70	SAA
70	80	Basalt, medium gray to gray black with slight red cast
80	90	Basalt, dark gray to gray black
90	100	Basalt, dark gray with very slight red tinge
100	110	SAA
110	120	Basalt, dark gray to gray black
120	130	SAA with slight red tinge
130	140	Basalt, gray black
140	150	SAA
150	160	SAA
160	170	SAA
170	180	SAA,
180	190	SAA
190	200	Basalt, dark gray to red gray, vesicular with light colored minerals; drill mud turned red
200	210	SAA, bottom 10' softer
210	215	SAA
215	220 TD	Basalt, gray black

DRILL HOLE COMPLETION REPORT
LIZAK GEOSCIENCE & ENGINEERING, INC.
Northeast Office-1805 Evans St.
Northampton, PA 18067
*Phone 610-262-9120 * Fax 610-262-4212*

Hole No: MW-3 Property/Project: Whites Point

Location: ≈400 S of W.C. road on property road; ≈200' W of P. Line Gr. Elevation: 286 Ft

Location Surveyed: [✓ Yes] (No) Surveyor's Name: Bill Ross

County: Digby State/Province NS Country: Canada

Surface Owner: Option No.:

Spud Date: 9-22-05 Completion Date: 9-22-05

Hole Size: Surface 8 3/4" Interval 0-20'

Main Hole 6 1/8" Interval 20-TD

Total Depth: 260 Ft Air to: – Water/Mud to: 0-TD

Cored: (Yes) [✓ No]: If yes, intervals

Core Barrel Type: I.D. O.D. Length

Lost Circulation at: Regained: (Yes) (No)

Static Water Level: Initial Final

Noticeable Water Invasion: [✓ Yes] (No); Intervals 160-163'

Casing: Depth 20 Diameter 6 1/4 ID Recovered: (Yes) [✓ No]

Contractor's name and address: Mowat's Well Drilling (506) 339-6214
722 Cox Point Road, Cumberland Bay, NB E4A 2Y5

Hole Plugged: (Yes) [✓ No] Name/address if company differs from contractor

Samples and core descriptions by: J Lizak

Report prepared by: J. Lizak Date: 9-22-05

Comments:

Location Sketch

SAMPLE DESCRIPTION

Hole Number: MW-3
Description By: J. Lizak
Prospect/Property: Whites Point
Drilled By: Mowat Drilling
Page: 1 of 1
Date: 9-22-05 to 9-22-05

DEPTH (ft.)		**SAMPLE DESCRITION**
From	**To**	
0	5	Overburden
5	10	Basalt, dark gray to gray black
10	20	SAA
20	30	Basalt, dark gray to gray black with trace red quartz filled fractures
32	40	SAA
40	50	SAA
50	60	SAA
60	70	SAA
70	80	Basalt, gray black
80	90	SAA
90	100	SAA with slight red tinge
100	110	SAA
110	120	SAA
120	130	Basalt, dark gray to gray black
130	140	SAA with occasional red color
140	150	Basalt, dark gray or red brown to rust brown, slightly vesicular with light colored minerals, soft from 143-145
150	160	Basalt, dark gray
160	170	Basalt, dark gray or red brown to rust brown, slightly vesicular with light colored minerals, soft from 160-163, drilling mud turned red
170	180	Basalt, medium dark gray to dark gray with blue-green cast
180	190	SAA
190	200	SAA
200	210	SAA
210	220	SAA
220	230	SAA
230	240	Basalt, dark gray to gray black
240	250	Basalt, rust brown to red brown, vesicular, some light colored minerals, drilling mud turned red at 248
250	260 TD	Basalt, dark gray to gray black with occasional chalcedony?

DRILL HOLE COMPLETION REPORT

LIZAK GEOSCIENCE & ENGINEERING, INC.

Northeast Office-1805 Evans St.
Northampton, PA 18067
*Phone 610-262-9120 * Fax 610-262-4212*

Hole No: MW-4 Property/Project: Whites Point

Location: North side of HWY 217 ≈ 800 Ft East of ∩ of HWY 217 & L. River Rd Gr. Elevation: 167 Ft.

Location Surveyed: [✓ Yes] (No) Surveyor's Name: Bill Ross

County: Digby State/Province NS Country: Canada

Surface Owner: – Option No.:

Spud Date: 9-22-05 Completion Date: 9-22-05

Hole Size: Surface 8 3/4" Interval 0-20'

Main Hole 6 1/4" Interval 0 - TD

Total Depth: 120 Ft Air to: Water/Mud to: 0 - TD

Cored: (Yes) [✓ No]: If yes, intervals

Core Barrel Type: I.D. O.D. Length

Lost Circulation at: Regained: (Yes) (No)

Static Water Level: Initial Final

Noticeable Water Invasion: [✓ Yes] (No); Intervals 40 - 50

Casing: Depth Diameter Recovered: (Yes) (No)

Contractor's name and address: Mowat's Well Drilling (506) 339-6214
722 Cox Point Road, Cumberland Bay, NB E4A 2Y5

Hole Plugged: (Yes) [✓ No] Name/address if company differs from contractor

Samples and core descriptions by: J. Lizak

Report prepared by: J. Lizak Date: 9-22-05

Comments:

Location Sketch

SAMPLE DESCRIPTION

Hole Number: MW-4
Description By: J. Lizak

Prospect/Property: Whites Point
Drilled By: Mowat Drilling

Page: 1 of 1
Date: 9-22-05

DEPTH (ft.)		**SAMPLE DESCRITION**
From	**To**	
0	7	Overburden
6	10	Basalt, medium dark gray to dark gray
10	20	SAA
20	30	Basalt, medium gray with red tinge
33	40	Basalt, medium gray
40	50	Basalt, gray black with some light colored minerals
50	60	SAA, gray black to red, drilling mud is tinged with red
60	70	SAA
70	80	Basalt, gray black
80	90	SAA
90	100	Basalt, gray black to black, very hard drilling
100	110	SAA
110	120 TD	SAA

DRILL HOLE COMPLETION REPORT
LIZAK GEOSCIENCE & ENGINEERING, INC.

Northeast Office-1805 Evans St.
Northampton, PA 18067
*Phone 610-262-9120 * Fax 610-262-4212*

Hole No: MW-5 Property/Project: Whites Point

Location: ≈600 Ft W of HWY 217 on Whites Cove road Gr. Elevation: 157 Ft.

Location Surveyed: [✓ Yes] (No) Surveyor's Name: Bill Ross

County: Digby State/Province NS Country: Canada

Surface Owner: – Option No.:

Spud Date: 9-22-05 Completion Date: 9-22-05

Hole Size: Surface 8 3/4" Interval 0-20

Main Hole 6 1/8" Interval 20-TD

Total Depth: 150 Ft. Air to: Water/Mud to: 0-TD

Cored: (Yes) [✓ No]: If yes, intervals

Core Barrel Type: I.D. O.D. Length

Lost Circulation at: Regained: (Yes) (No)

Static Water Level: Initial Final

Noticeable Water Invasion: [✓ Yes] (No); Intervals 80-100'

Casing: Depth 20' Diameter 6 1/4" ID Recovered: (Yes) [✓ No]

Contractor's name and address: Mowat's Well Drilling (506) 327-6344
722 Cox Point Road, Cumberland Bay, NB E4A 2Y5

Hole Plugged: (Yes) [✓ No] Name/address if company differs from contractor

Samples and core descriptions by: J. Lizak

Report prepared by: J. Lizak Date: 9-22-05

Comments:

Location Sketch

SAMPLE DESCRIPTION

Hole Number: MW-5
Description By: J. Lizak

Prospect/Property: Whites Point
Drilled By: Mowat Drilling

Page: 1 of 1
Date: 9-22-05 to 9-22-05

DEPTH (ft.)		SAMPLE DESCRITION
From	To	
0	10	Overburden
10	20	Basalt, dark gray to gray black
20	30	Basalt, brown gray with light colored minerals, vesicular, soft, drilling mud turned red
34	40	Basalt, dark gray to brown gray with light colored minerals, soft
40	50	SAA
50	60	SAA
60	70	SAA
70	80	SAA, drilling mud turned red
80	90	SAA with increase in light colored minerals, mud still red
90	100	SAA
100	110	SAA
110	120	Basalt, dark gray to rust brown, considerable light colored minerals, drilling mud still red
120	130	SAA
130	140	SAA
140	150 TD	SAA rock turned much harder at base

DRILL HOLE COMPLETION REPORT
LIZAK GEOSCIENCE & ENGINEERING, INC.

Northeast Office-1805 Evans St.
Northampton, PA 18067
*Phone 610-262-9120 * Fax 610-262-4212*

Hole No: MW-6 Property/Project: Whites Point

Location: ≈ 150' SE of the Bay in the quarry permit area Gr. Elevation: 147 ft

Location Surveyed: [✓ (Yes)] (No) Surveyor's Name: Bill Ross

County: Digby State/Province NS Country: Canada

Surface Owner: - Option No.:

Spud Date: 9-23-05 Completion Date: 9-23-05

Hole Size: Surface 8 3/4" Interval 0-20

Main Hole 6 1/8" Interval 20-TD

Total Depth: 130 ft Air to: - Water/Mud to: 0 - TD

Cored: (Yes) [✓ (No)]: If yes, intervals

Core Barrel Type: I.D. O.D. Length

Lost Circulation at: Regained: (Yes) (No)

Static Water Level: Initial Final

Noticeable Water Invasion: (Yes) [✓ (No)]; Intervals

Casing: Depth 0-20 Diameter 6 1/4 ID Recovered: (Yes) [✓ (No)]

Contractor's name and address: Mowat's Well Drilling (506) 339-6214
722 Cox Point Road, Cumberland Bay, NB E4A 2Y5

Hole Plugged: (Yes) [✓ (No)] Name/address if company differs from contractor

Samples and core descriptions by: J. Lizak

Report prepared by: J. Lizak Date: 9-23-05

Comments:

Location Sketch

SAMPLE DESCRIPTION

Hole Number: MW-6
Description By: J. Lizak

Prospect/Property: Whites Point
Drilled By: Mowat Drilling

Page: 1 of 1
Date: 9-23-05

DEPTH (ft.)		**SAMPLE DESCRITION**
From	**To**	
0	10	Basalt, gray black with trace red brown
10	20	Basalt, gray black with trace quartz filled veins
20	30	SAA with red stained quartz filled veins
35	40	SAA
40	50	Basalt, gray black with trace red, drill mud slightly tinged red
50	60	SAA
60	70	Basalt, gray black
70	80	SAA
80	90	SAA
90	100	SAA
100	110	Basalt, gray black to black
110	120	SAA
120	130 TD	SAA, very hard drilling especially below 50ft.

Appendix 3

PARTIAL LIST OF THE QUARRIES THAT WERE INSPECTED AND/OR INVESTIGATED AS PART OF THIS STUDY

1. Martin Marietta Material's Porcupine Mountain quarry on the Straight of Canso at Mulgrave, N.S.
2. Florida Rock's Bayside quarry located at the Bayside Marine Terminal in the resort town of St. Andrew, N.B.
3. Northumberland Rock, Ltd.'s quarry located on Northumberland Strait near Georgeville, N.S.
4. Mosher Limestone Co., Ltd.'s Kellys Mountain quarry located on Great Bras d'Or near New Harris, N.S.
5. Conrad Brother's quarry located in Dartmouth, N.S.
6. Gateway Materials quarry located in Halifax, N.S.
7. Three basalt/gabbro quarries located in Belledune, N.B.
8. Three quarries located in the North Mountain Basalt on Digby Neck
9. Various gypsum quarries located near Windsor, N.S.

REFERENCES

Reference 1

GEOLOGICAL ASSESSMENT OF THE WHITES COVE SITE

Digby County, Nova Scotia

Prepared By:

MINERAL VALUATION & CAPITAL, INC.
Northeast Office
1805 Evans St.
Northampton, PA 18067

Phone 610-262-9120
Fax 610-262-4212

December 2002

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FIGURES

APPENDIX

PLATES

Overview

The 370-acre Whites Cove (Denton) site is located on the north shore of Digby Neck and North Mountain in Digby County, Nova Scotia (Figure 1). It is approximately 30 kilometers (18.5 miles) west of the town of Digby between Little River and East Ferry. The property can be accessed via Highway 217. The elevation of the site ranges from sea level to 96.0 meters (315 ft.).

The Whites Cove site is being evaluated as a source of high quality construction aggregate. This report will focus on the geological aspects of the construction aggregate project.

The findings in this report are an outgrowth of:

- Mineral Valuation & Capital, Inc.'s (MVC's) regional and local field investigations
- A review of geological reports and maps published by the Nova Scotia Department of Natural Resources (NSDNR)
- Discussions and meetings with personnel of the NSDNR.
- Analysis of drill hole data obtained on the Whites Cove site
- MVC's experience with comparable projects

This report is intended to be a summary of MVC's data and interpretations. Additional information is available for review at MVC's offices.

Drilling Information

Four core holes were drilled on the Whites Cove property during April and May of 2002 to provide comprehensive information on the geology of the site. The hole locations are shown on the Whites Cove Site Map (Plate 1).

The four holes were continuously cored. They range in depth from 35.0 (115 ft.) to 74.5 meters (244 ft.). All but one of the four holes was drilled to a depth below sea level. The holes were not plugged so that they could be used for hydrogeological testing and monitoring.

The core was boxed, described, and sampled by a licensed professional geologist. The Drill Hole Completion Reports and the Core Descriptions are appended.

Regional Geologic Setting

Much of this section on the regional geology has been excerpted from NSDNR Report of Activities 2001 published by D.J. Kontak titled "Internal Stratigraphy of the Jurassic North Mountain Basalt, Southern Nova Scotia".

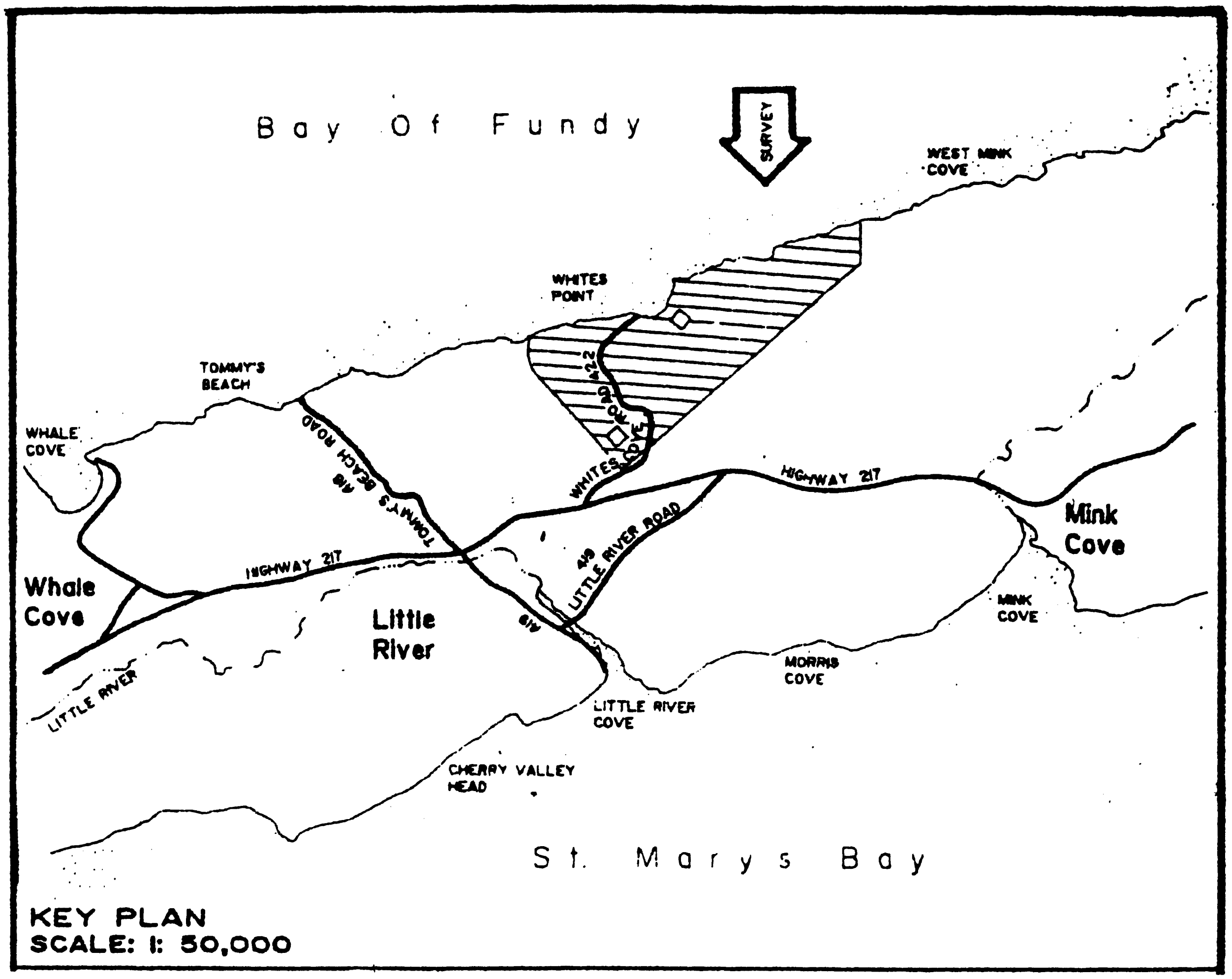


Figure 1 – Location Map

The Whites Cove site is composed of the Jurassic North Mountain Basalt (NMB). The NMB forms a prominent cuesta along the Bay of Fundy, which extends along the length of the Annapolis Valley and the project area. The NMB rocks are well exposed along the coastline and inland. The topographic relief of the area is primarily a reflection of the distribution of the underlying massive basalt flows. The region's prominent topographic features are primarily made up of hard massive basalt flows versus the softer amygdaloidal, vesicle rich basalt flows that weather and erode more easily.

The rocks underlying the NMB are red to pale green-gray, fluvial-lacustrine siltstones and shales of the Late Triassic Wolfville and overlying Blomidon Formations. The rocks that overlay the NMB in the Annapolis Valley are composed of the Jurassic lacustrine limestones of the Scots Bay Formation. The time equivalent red fluvial-lacustrine siltstones and shales of the McCoy Brook Formation overlay the NMB along the north side of the Fundy Basin.

The NMB has been subdivided into three units based on the nature of the basalt flows. The units are called the lower, middle and upper flow units.

The lower flow unit reportedly varies from 40 meters (131 ft.) to 185 meters (607 ft.) and consists of one flow. The unit is a uniform textured, massive, holocrystalline basalt with well developed columnar jointing in the Annapolis Royal area.

The middle flow unit is amygdaloidal, vesicular and zeolite rich in contrast to the massive, and generally vesicle-free, lower and upper flow units. The thickness and the number of flows in the middle flow unit vary considerably. The thickness ranges from 9 meters (30 ft.) to 165 meters (541 ft.) and the unit contains 4 to 15 flows. The unit appears to thin to the southwest.

The thickness of upper flow unit reportedly varies from 0 to 154 meters (505 ft.). The unit has been subdivided into the columnar jointed lower part and the massive upper part, which often contains a honeycomb network of quartz veins.

The regional dip of the NMB is 3 to 8 degrees to the northwest. The NMB is offset at several locations by northeast trending right lateral faults.

Site Geology

The Whites Cove site consists almost exclusively of the upper flow unit of the NMB. Core holes NS-02-01 and NS-02-02 penetrated the contact between the upper flow and middle flow units at drill depths of 60 meters (197 ft.) and 70 meters (230 ft.), respectively (see Figure 2). Core holes NS-02-03 and NS-02-04 drilled through the upper flow unit from the surface to the total depth of the holes.

The upper flow unit is a uniform, hard, massive, vesicle free, medium dark gray to black basalt. The unit attains a maximum thickness of approximately 76 meters (250ft.) on the

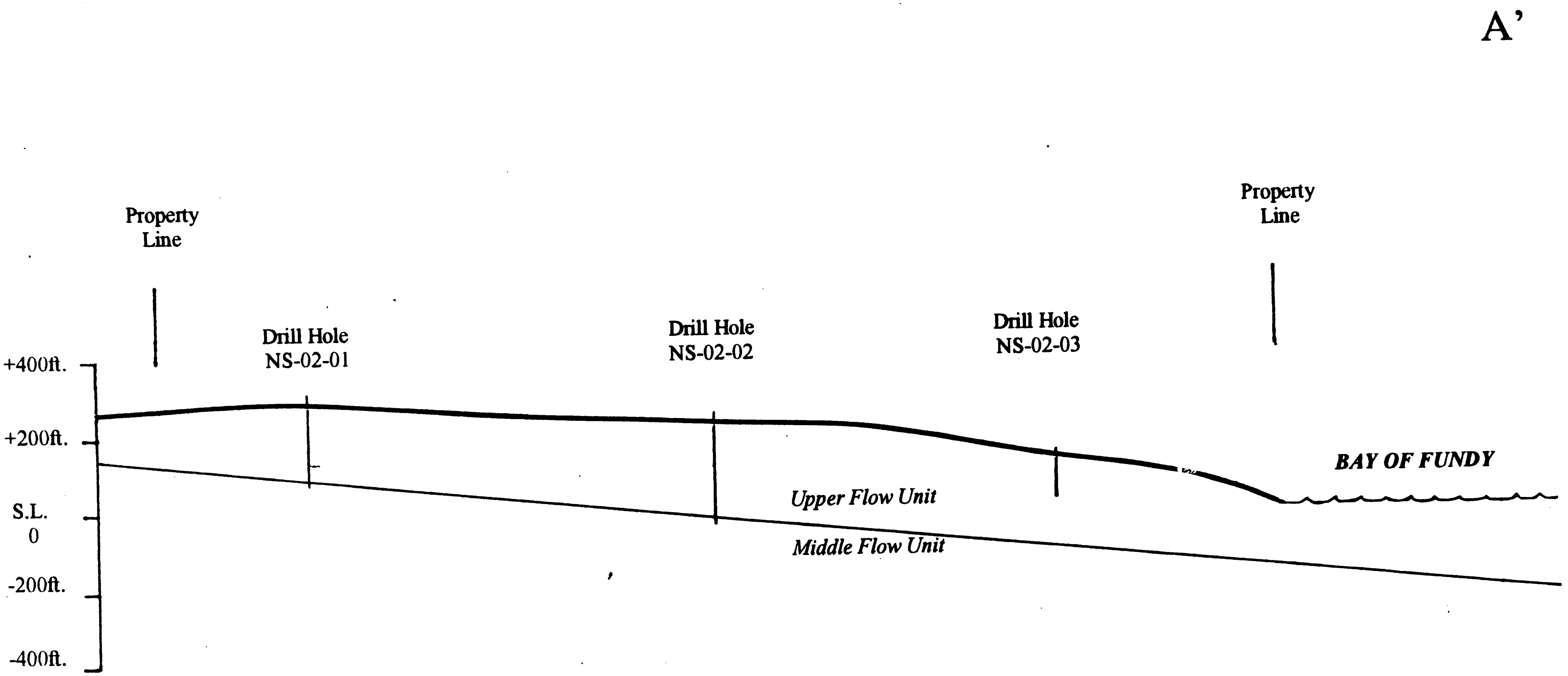


Figure 2 – Cross Section A-A'

Horizontal and Vertical Scale 1in.=400ft.

Whites Cove property. It is virtually unweathered. Vertical, quartz veins were occasionally observed in the upper third of the upper flow unit. Some of these veins showed red iron oxidation and some contained calcite. Horizontal veins and fractures were occasionally observed in the middle portion of the upper flow unit. The basal 10 meters (33ft.) of the upper flow unit displayed some vertical fracturing, which may indicate the presence of a narrow band of columnar jointing.

The top two meters of the middle flow unit were penetrated in drill holes NS-02-01 and NS-02-02. The top of the middle unit consists of a medium dark gray to dark gray, vesicular, amygdaloidal, zeolite rich basalt, which contains rust colored bands.

The NMB dips approximately 6 degrees to the northwest on the site (see Figure 2). No evidence of faulting was observed on, or near, the Whites Cove property.

Construction Aggregate Potential

Physical lab tests, chemical lab tests, and examination of the core samples and outcrop exposures indicate that the Whites Cove site contains an advantaged, large reserve of high quality construction aggregate. The site contains in excess of 200 million tons (English) of in-place stone, which is ideally suited for quarrying, processing, shipping, and construction.

Submitted by:

John Lizak, Licensed Professional Geologist
Principal

DRILL HOLE COMPLETION REPORT
LIZAK GEOSCIENCE & ENGINEERING, INC.
Northeast Office-1805 Evans St.
Northampton, PA 18067
*Phone 610-262-9120 * Fax 610-262-4212*

Hole No: NS-02-01 Property/Project: Denton

Location: ≈ 630 ft. N. of property line, on road Gr. Elevation: 291.6 ft.

Location Surveyed: [✓ Yes] (No) Surveyor's Name: Scotia Surveys Ltd.

County: Digby State/Province N. Scotia Country: Canada

Surface Owner: Johnson Option No.:

Spud Date: 4-30-02 Completion Date: 5-2-02

Hole Size:

Surface NW Interval 0 - 5.0 Ft.

Main Hole Interval 5.0 Ft. - 63.0 m

Total Depth: 63.0 m Air to: Water/Mud to: 0 - 63.0 m

Cored: [✓ Yes] (No): If yes, intervals 5.0 Ft. - 63.0 m

Core Barrel Type: NQ I.D. 47.6 mm 1 7/8" O.D. Length 4.0 m

Lost Circulation at: 63.0 Regained: (Yes) [✓ No]

Static Water Level: Initial - Final

Noticeable Water Invasion: (Yes) [✓ No] Intervals

Casing: Depth 5.0 Ft. Diameter NW Recovered: [✓ Yes] (No)

Contractor's name and address: Logan Drilling - P.O. Box 189
Stewiacke, NS, Canada, B0N 2S0
Ph. 902-639-2311

Hole Plugged: (Yes) [✓ No] Name/address if company differs from contractor

Samples and core descriptions by: John Lizak

Report prepared by: John Lizak Date: 4-30-02

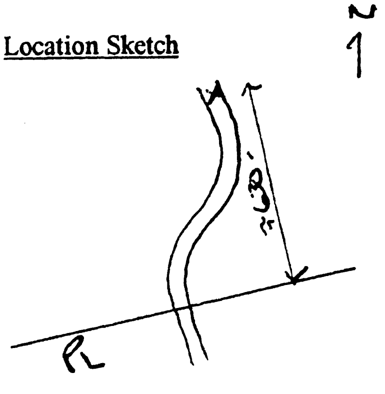
Comments:

4-30-02 Driller on site @ 1:00 PM; Rig set up; started coring @ 5:30; Drilled to 7:00 PM

5-1-02 On site 7:00 AM - 6:30 PM; Drilled to 46 m

5-2-02 L.C. @ 63.0 m. Could not regain

Location Sketch



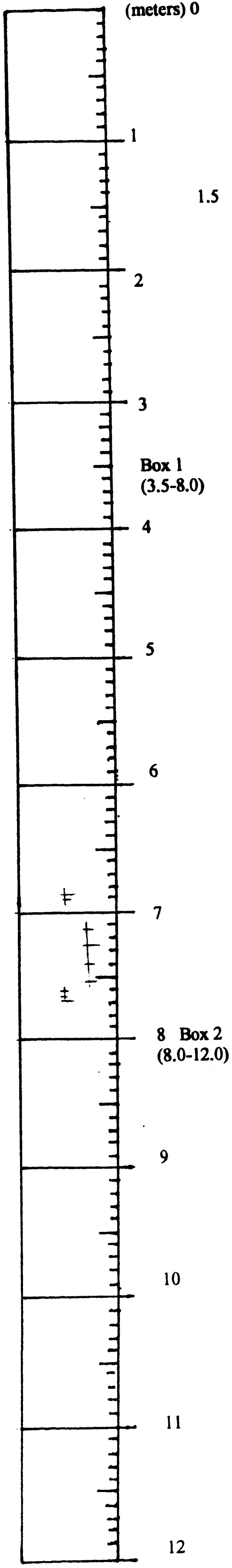
CORE DESCRIPTION

Hole No.: NS-02-01
Description By: J. Lizak

Prospect: Denton
Drilled By: Logan Drilling

Page: 1 of 6
Date: 4-30-02 to 5-2-02

Depth (meters) From	to	Thick.	Core Description
0	1.5	1.5	Drill to set casing. Drill samples: basalt; dark gray-gray black; no weathering observed
1.5	13.0	11.5	Basalt; dark gray-gray black; occasional olive crystals up to 2mm in size; massive.
			Quartz vein from 7.1-7.4 surrounded by iron stained mineral and calcite; vertical. Occasional thin vertical veins above and below

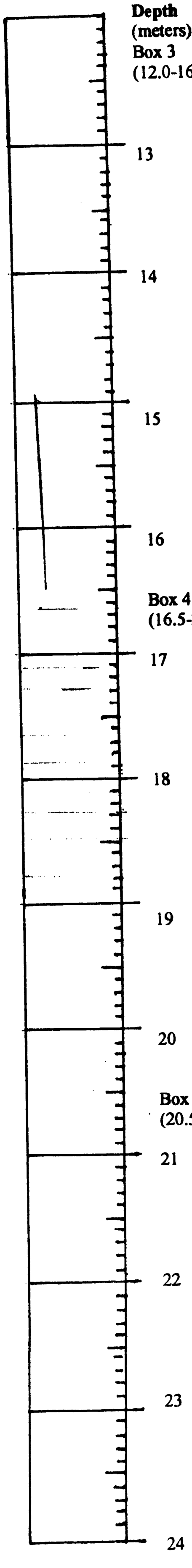


CORE DESCRIPTION

Hole No.: NS-02-01
Description By: J. Lizak

Prospect: Denton
Drilled By: Logan Drilling

Page: 2 of 6
Date: 4-30-02 to 5-2-02



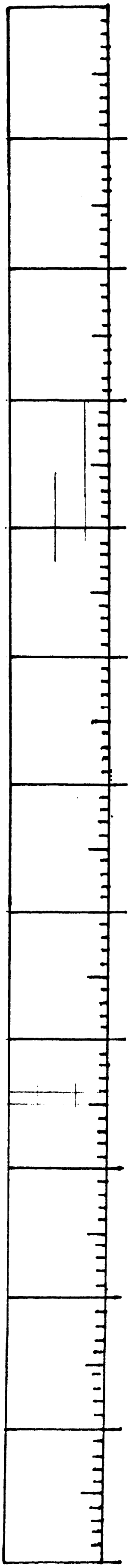
Depth (meters)	From	to	Thick.	Core Description
Box 3 (12.0-16.5)	13.0	15.0	2.0	Basalt; dark gray-gray black; massive
15	15.0	16.5	1.5	Basalt; medium dark gray-dark gray; occasional iron stained, vertical fracture
Box 4 (16.5-20.5)	16.5	19.0	2.5	Basalt; dark gray-gray black; horizontal fractures spaced 1-6 in. apart; fractures are calcareous (zeolitized?)
19	19.0	27.0	8.0	Basalt; dark gray-gray black; massive
Box 5 (20.5-25.0)				

CORE DESCRIPTION

Hole No.: NS-02-01
Description By: J. Lizak

Prospect: Denton
Drilled By: Logan Drilling

Page: 3 of 6
Date: 4-30-02 to 5-2-02



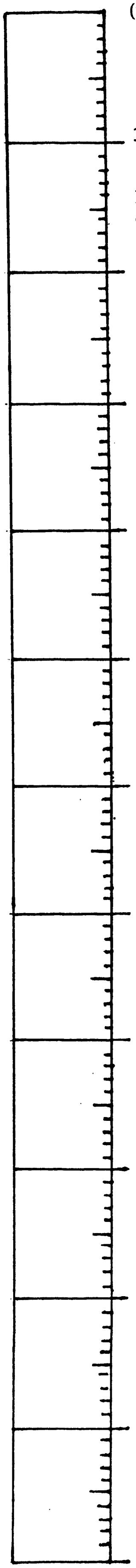
Depth (meters)	From	to	Thick.	Core Description
25 Box 6 (25.0-29.3)				
26				
27	27.0	33.0	6.0	Basalt; medium dark gray-gray black; massive except for occasional vertical fracturing from 27.0 to 28.3 and 6in. fracture zone at 32.5
28				
29 Box 7 (29.3-33.0)				
30				
31				
32				
33 Box 8 (33.0-37.5)	33.0	42.0	9.0	Basalt; dark gray-gray black; massive; occasional vertical, calcareous veins
34				
35				
36				

CORE DESCRIPTION

Hole No.: NS-02-01
Description By: J. Lizak

Prospect: Denton
Drilled By: Logan Drilling

Page: 4 of 6
Date: 4-30-02 to 5-2-02



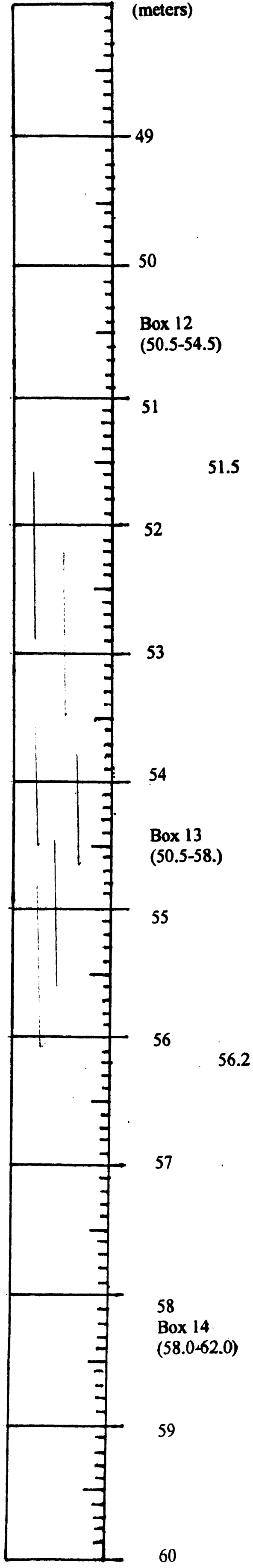
Depth (meters)	**From**	**to**	**Thick.**	**Core Description**
42 Box 10 (42.0-46.3)	42.0	51.5	9.5	Basalt; medium dark gray-dark gray; massive

CORE DESCRIPTION

Hole No.: NS-02-01
Description By: J. Lizak

Prospect: Denton
Drilled By: Logan Drilling

Page: 5 of 6
Date: 4-30-02 to 5-2-02



From	to	Thick.	Core Description
51.5	56.2	4.7	Basalt; dark gray-gray black; trace amounts of olive crystals up to 1mm; vertically fractured.
56.2	62.0	5.8	Basalt; medium dark gray-dark gray; massive; rust colored horizontal and vertical veins near base (up to 1in. thick); vesicles and mineralized nodules (zeolites?) near base.

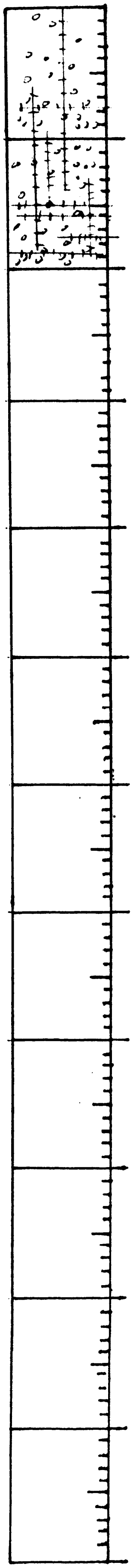
CORE DESCRIPTION

Hole No.: NS-02-01
Description By: J. Lizak

Prospect: Denton
Drilled By: Logan Drilling

Page: 6 of 6
Date: 4-30-02 to 5-2-02

Depth (meters) **From** **to** **Thick.** **Core Description**



62 TOTAL DEPTH LOST CIRCULATION

DRILL HOLE COMPLETION REPORT
LIZAK GEOSCIENCE & ENGINEERING, INC.

Northeast Office-1805 Evans St.
Northampton, PA 18067
*Phone 610-262-9120 * Fax 610-262-4212*

Hole No: NS-02-02 Property/Project: Denton

Location: ≈ 1500 Ft N. along road Gr. Elevation: 234.6ft.

Location Surveyed: [✓ Yes] (No) Surveyor's Name: Scotia Surveys

County: Digby State/Province N.S. Country: Canada

Surface Owner: Johnson Option No.:

Spud Date: 5-3-02 Completion Date: 5-4-02

Hole Size: Surface NW Interval 0 - 2.0 Ft.

Main Hole Interval 2.0 ft. - 74.5 m

Total Depth: 74.5 m Air to: Water/Mud to: 0- T.D.

Cored: [✓ Yes] (No): If yes, intervals 2.0 Ft. - 74.5 m

Core Barrel Type: NQ I.D. O.D. Length 4.0 m

Lost Circulation at: 74.5m Regained: (Yes) [✓ No]

Static Water Level: Initial - Final -

Noticeable Water Invasion: (Yes) [✓ No]; Intervals

Casing: Depth 2.0 Ft Diameter NW Recovered: [✓ Yes] (No)

Contractor's name and address: Logan Drilling - P.O. Box 189
Stewiacke, NS, Canada B0N 2J0

Hole Plugged: (Yes) [✓ No] Name/address if company differs from contractor

Samples and core descriptions by: John Lizak

Report prepared by: J. Lizak Date: 5-4-02

Comments:

Location Sketch

5-3-02 On site 7:00 AM. Cored to 44 m.

5-4-02 On site 7:00 AM cored to T.D.

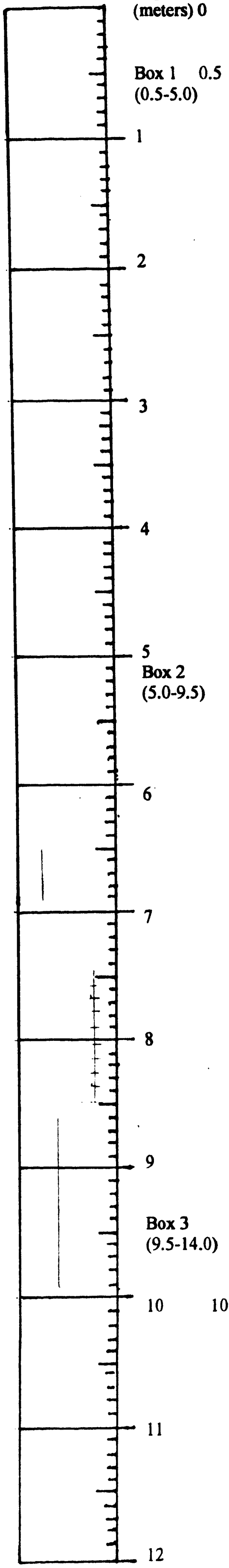
CORE DESCRIPTION

Hole No.: NS-02-02
Description By: J. Lizak

Prospect: Denton
Drilled By: Logan Drilling

Page: 1 of 7
Date: 5-3-02 to 5-4-02

Depth (meters)	From	to	Thick.	Core Description
	0	0.5	0.5	Drill to set casing. Drill samples: basalt; dark gray-gray black; no weathering
Box 1 (0.5-5.0)	0.5	10.0	9.5	Basalt; dark gray-gray black; fairly massive; small number of vertical, rust colored fractures and veins from 6.0 to 10.0
10	10.0	18.0	8.0	Basalt; dark gray-gray black; massive; occasional olive, 1-2mm phenocrysts

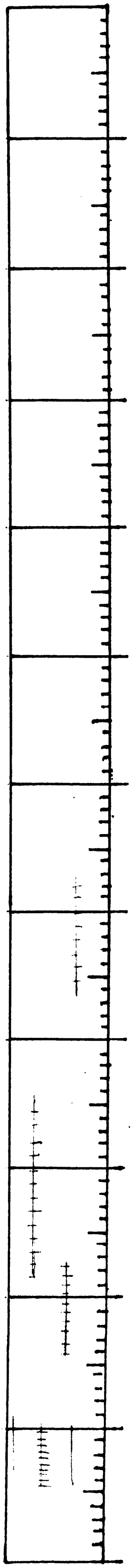


CORE DESCRIPTION

Hole No.: NS-02-02
Description By: J. Lizak

Prospect: Denton
Drilled By: Logan Drilling

Page: 2 of 7
Date: 5-3-02 to 5-4-02



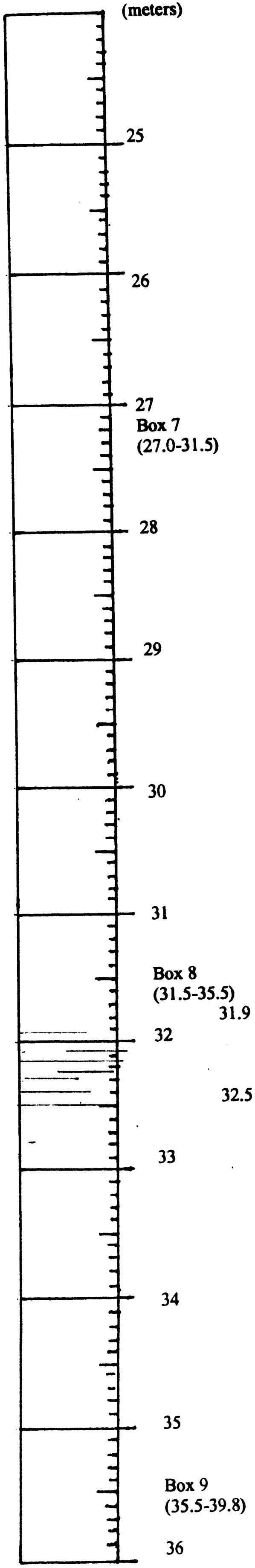
Depth (meters)	From	to	Thick.	Core Description
18	18.0	23.0	5.0	Basalt; medium dark gray-gray black; fairly massive; occasional vertical quartz/iron stained veins
23	23.0	23.5	0.5	Basalt; near vertical fractures and veins with white non-calcareous mineral and/or iron staining; fractures roughly ½in. thick.
	23.5	31.9	8.4	Basalt; dark gray-gray black; massive

CORE DESCRIPTION

Hole No.: NS-02-02
Description By: J. Lizak

Prospect: Denton
Drilled By: Logan Drilling

Page: 3 of 7
Date: 5-3-02 to 5-4-02



Depth (meters) From	to	Thick.	Core Description
31.9	32.5	0.6	Basalt; dark gray-gray black; horizontally fractured, fractures partly iron stained
32.5	36.3	3.7	Basalt; dark gray-gray black; horizontal fractures/veins approximately every 6in.; veins are thin and mainly sealed with a white, calcareous mineral?

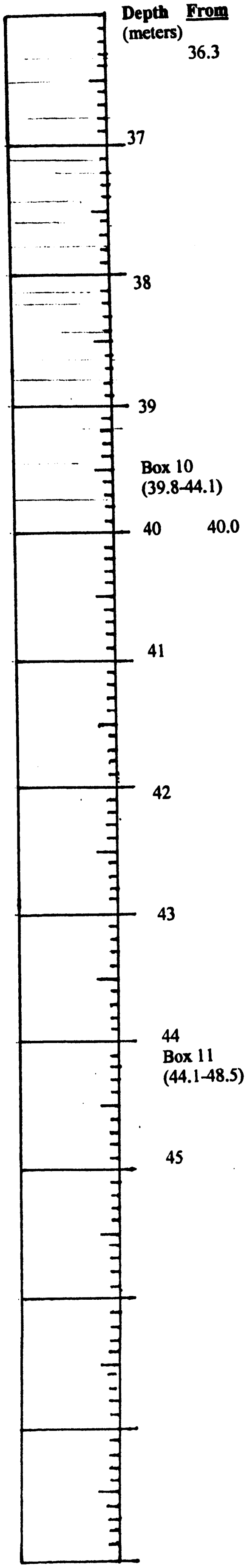
CORE DESCRIPTION

Hole No.: NS-02-02
Description By: J. Lizak

Prospect: Denton
Drilled By: Logan Drilling

Page: 4 of 7
Date: 5-3-02 to 5-4-02

Depth (meters)



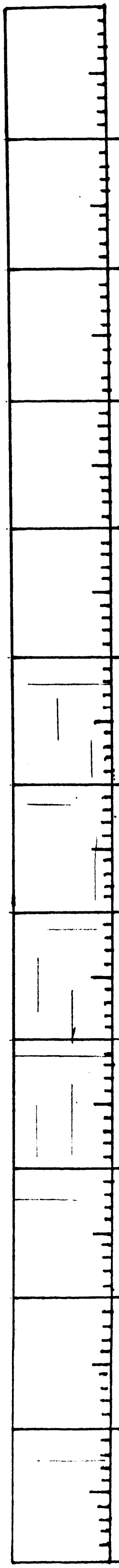
From	to	Thick.	Core Description
36.3	40.0	3.7	Basalt; dark gray-gray black; horizontal fractures spaced 4-6 in. apart.
40.0	46.0	6.0	Basalt; medium dark gray-dark gray; occasional olive 2-4 mm phenocrysts; massive; occasional rust colored veins.

CORE DESCRIPTION

Hole No.: NS-02-02
Description By: J. Lizak

Prospect: Denton
Drilled By: Logan Drilling

Page: 5 of 7
Date: 5-3-02 to 5-4-02



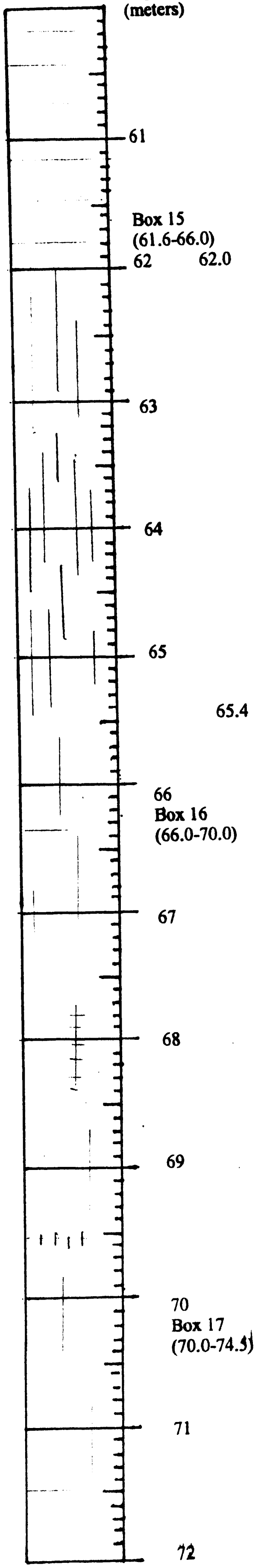
Depth (meters)	From	to	Thick.	Core Description
Box 12 (48.5-53.0)				
49				
50				
51				
52				
53 Box 13 (53.0-57.1)	53.0	57.0	4.0	Basalt; dark gray-gray black; vertical/horizontal fractures every 6 in.
54				
55				
56				
57 Box 14 (57.1-61.7)	57.0	62.0	5.0	Basalt; dark gray-gray black; occasional 2-3mm olive phenocryst; horizontal fractures spaced about 1ft. apart.
58				
59				
60				

CORE DESCRIPTION

Hole No.: NS-02-02
Description By: J. Lizak

Prospect: Denton
Drilled By: Logan Drilling

Page: 6 of 7
Date: 5-3-02 to 5-4-02



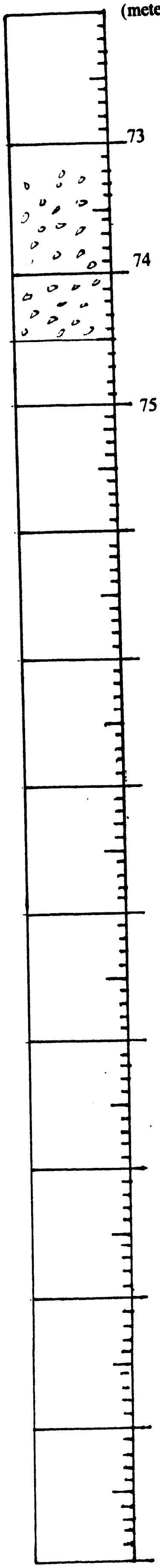
Depth (meters)	**From**	**to**	**Thick.**	**Core Description**
	62.0	65.4	3.4	Basalt; medium dark gray-gray black; vertically fractured; some fractures are rust colored; major fracture at 65.2.
	65.4	72.0	6.6	Basalt; medium dark gray-dark gray; "clangy"; with thin (< 1/8in) iron-stained veins and fractures; fractures are horizontal and vertical.

CORE DESCRIPTION

Hole No.: NS-02-02
Description By: J. Lizak

Prospect: Denton
Drilled By: Logan Drilling

Page: 7 of 7
Date: 5-3-02 to 5-4-02



Depth (meters) From	to	Thick.	Core Description
72.0	73.2	1.2	Basalt; gray black
73.2	74.5	1.3	Basalt; medium dark gray-dark gray; some vesicles up to 1/8in.; some red banding; some nodules filled with calicite?
74.5	TOTAL DEPTH LOST CIRCULATION		

DRILL HOLE COMPLETION REPORT

LIZAK GEOSCIENCE & ENGINEERING, INC.

Northeast Office-1805 Evans St.
Northampton, PA 18067
*Phone 610-262-9120 * Fax 610-262-4212*

Hole No: NS-02-03 Property/Project: Denton

Location: ≈ 2200 ft N of PL, along road Gr. Elevation: 118.2 ft.

Location Surveyed: [✓ (Yes)] (No) Surveyor's Name: Scotia Surveys

County: Digby State/Province N.S Country: Canada

Surface Owner: Johnson Option No.:

Spud Date: 5-4-02 Completion Date: 5-7-02

Hole Size: Surface Interval 0-2.0 ft

Main Hole Interval 2.0 ft.- 35.0 m

Total Depth: 35.0 m Air to: Water/Mud to: 0-T.D

Cored: [✓ (Yes)] (No): If yes, intervals 2.0 ft. - 35.0 m

Core Barrel Type: NQ I.D. O.D. Length 4.0 m

Lost Circulation at: - Regained: (Yes) (No)

Static Water Level: Initial - Final -

Noticeable Water Invasion: (Yes)[✓ (No)]; Intervals

Casing: Depth 2.0 ft Diameter NW Recovered: [✓ (Yes)] (No)

Contractor's name and address: Logan Drilling - P.O Box 133
Stewiacke, NS, Canada B0N 2J0

Hole Plugged: (Yes) [✓ (No)] Name/address if company differs from contractor

Samples and core descriptions by: John Lizak

Report prepared by: J. Lizak Date: 5-7-02

Comments:

Location Sketch

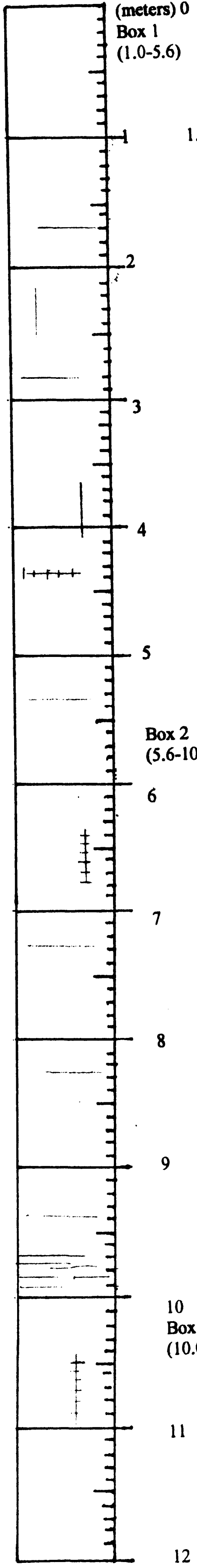
5-4-02 Move on site late PM
5-5-02 Drilled to 26 m
5-6-02 OFF
5-7-02 Drilled to TD. Moved onto site 4.

CORE DESCRIPTION

Hole No.: NS-02-03
Description By: J. Lizak

Prospect: Denton
Drilled By: Logan Drilling

Page: 1 of 3
Date: 5-4-02 to 5-7-02



Depth (meters)	From	to	Thick.	Core Description
Box 1 (1.0-5.6)	0	1.0	1.0	Drilled to set casing. Drill samples: basalt; dark gray-gray black.
Box 2 (5.6-10.0)	1.0	9.7	8.7	Basalt; dark gray-gray black; fairly massive with a few horizontal and minor vertical rust colored fractures and veins spaced roughly 4-12in. apart
	9.7	10.0	0.3	Basalt; dark gray-gray black; intense horizontal fracturing
Box 3 (10.0-14.3)	10.0	11.0	1.0	Basalt; dark gray-gray black; occasional 1-2mm olive phenocrysts; massive; a few rust colored veins.
	11.0	20.0	9.0	Basalt; dark gray-gray black; massive with occasional vertical veins filled with quartz and calcite; a few horizontal fractures

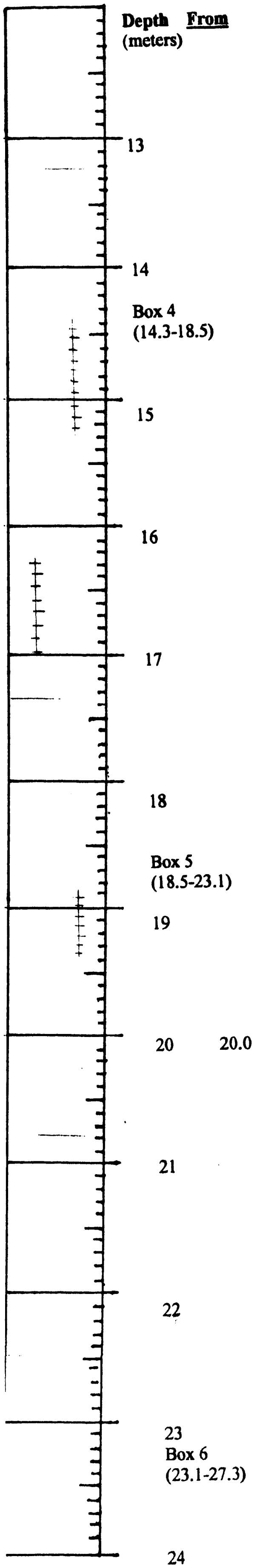
CORE DESCRIPTION

Hole No.: NS-02-03
Description By: J. Lizak

Prospect: Denton
Drilled By: Logan Drilling

Page: 2 of 3
Date: 5-4-02 to 5-7-02

Depth (meters)	From	to	Thick.	Core Description
20	20.0	32.0	12.0	Basalt; dark gray-gray black; massive with occasional horizontal and trace vertical fracture.

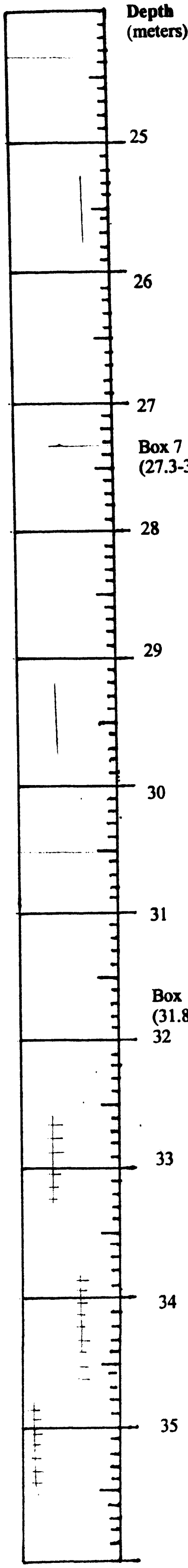


CORE DESCRIPTION

Hole No.: NS-02-03
Description By: J. Lizak

Prospect: Denton
Drilled By: Logan Drilling

Page: 3 of 3
Date: 5-4-02 to 5-7-02



Depth (meters)	From	to	Thick.	Core Description
32	32.0	35.0	3.0	Basalt; dark gray-black; massive with occasional veins filled with quartz or rust colored minerals.

DRILL HOLE COMPLETION REPORT
LIZAK GEOSCIENCE & ENGINEERING, INC.
Northeast Office-1805 Evans St.
Northampton, PA 18067
*Phone 610-262-9120 * Fax 610-262-4212*

Hole No: NS-02-04 Property/Project: Denton

Location: Near end of road, shore Gr. Elevation: 40.7 Ft.

Location Surveyed: [✓ (Yes)] (No) Surveyor's Name: Scotia Surveys

County: Digby State/Province NS Country: Country

Surface Owner: Johnson Option No.: ______

Spud Date: 5-7-02 Completion Date: 5-8-02

Hole Size: Surface NW Interval 0 - 6.0 Ft.

Main Hole ______ Interval 6.0 Ft. - 20.0 m

Total Depth: 20 m Air to: ______ Water/Mud to: T.D.

Cored: [✓ (Yes)] (No): If yes, intervals 2.0 m - 20.0 m

Core Barrel Type: NQ I.D. ______ O.D. ______ Length 4.0 m

Lost Circulation at: – Regained: (Yes) (No) ______

Static Water Level: Initial – Final –

Noticeable Water Invasion: (Yes) [✓ (No)] Intervals ______

Casing: Depth 6.0 Ft Diameter ______ Recovered: [✓ (Yes)] (No)

Contractor's name and address: Logon Drilling - P.O. Box 188
Stewiake, NS, Canada B0N 2J0

Hole Plugged: (Yes) [✓ (No)] Name/address if company differs from contractor ______

Samples and core descriptions by: John Lizak

Report prepared by: J. Lizak Date: 5-8-02

Comments:

Location Sketch

5-7-02 Moved on site PM.
5-8-02 Drilled to TD.

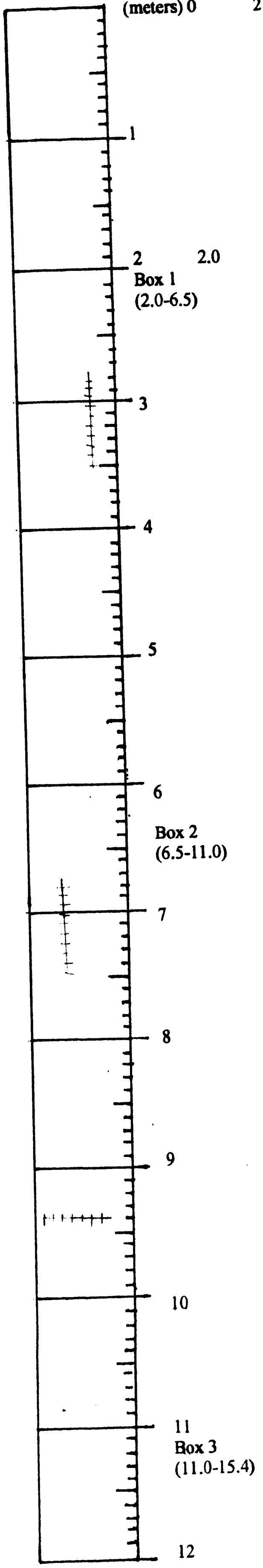
CORE DESCRIPTION

Hole No.: NS-02-04
Description By: J. Lizak

Prospect: Denton
Drilled By: Logan Drilling

Page: 1 of 2
Date: 5-7-02 to 5-8-02

Depth (meters)	From	to	Thick.	Core Description
	0	2.0	2.0	Drilled to set casing. Drill samples: basalt; dark gray-gray black.
2	2.0	20.0	18.0	Basalt; dark gray-gray black; massive; trace horizontal and vertical veins



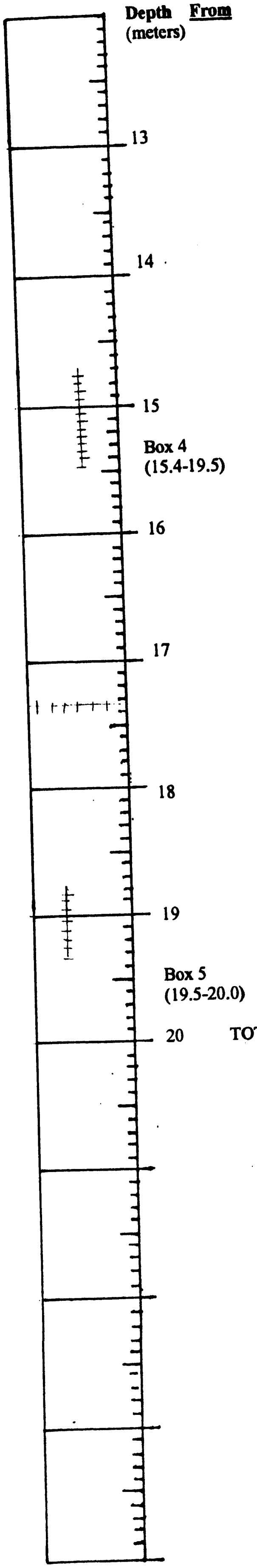
CORE DESCRIPTION

Hole No.: NS-02-04
Description By: J. Lizak

Prospect: Denton
Drilled By: Logan Drilling

Page: 2 of 2
Date: 5-7-02 to 5-8-02

Depth (meters) **From** **to** **Thick.** **Core Description**



TOTAL DEPTH

Reference 2

SEISMIC HAZARD, FAULTS AND EARTHQUAKES
DIGBY NECK, BAY OF FUNDY

Prepared by

Gordon Fader
Atlantic Marine Geological Consulting Ltd.
2901 Parkdale Avenue
Halifax, Nova Scotia
B3L 3Z2

March, 2005

TABLE OF CONTENTS

Introduction

This report provides an assessment of the seismic hazard for the area of the proposed basalt quarry and marine terminal on Digby Neck as well as the regional and local distribution of faults and earthquakes. Within Canada, the Bay of Fundy area occurs within the Northern Appalachian Seismic Zone (NAN). Figure 1 below shows the historical seismicity in eastern Canada and Figure 2 is a more detailed map of the location of seismicity in NAN.

Figure 1

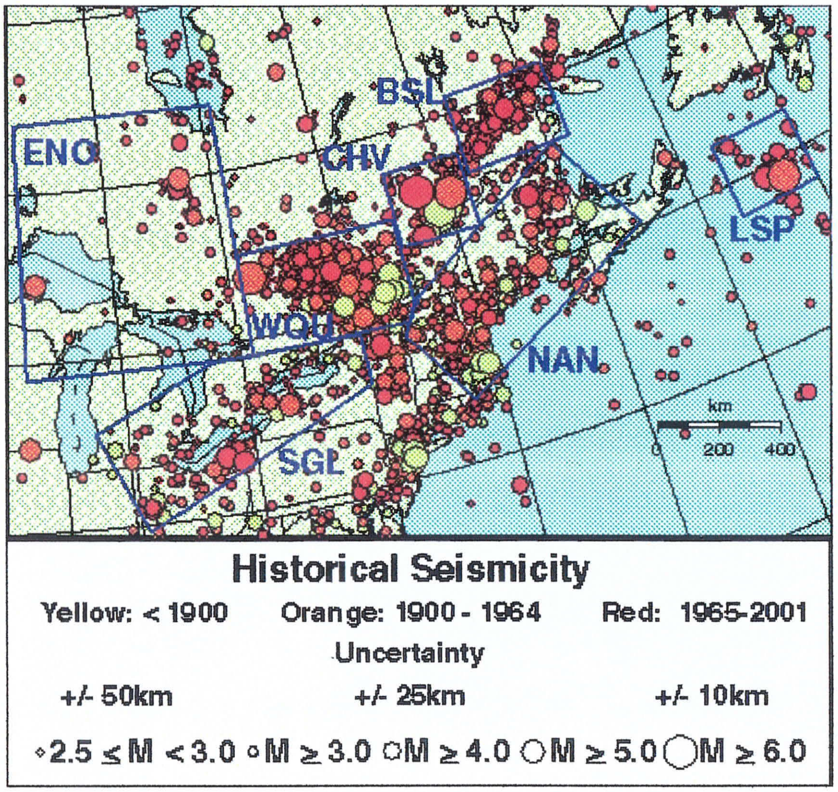


Figure 2

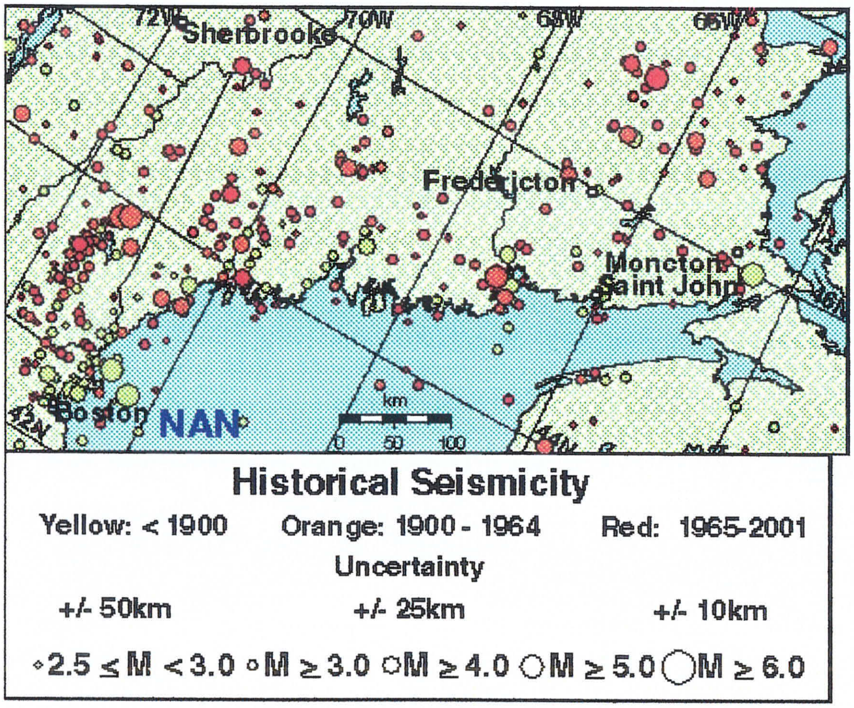


Figure 2

The Northern Appalachians Seismic Zone (NAN) includes most of New Brunswick and extends into New England. It shows the locations of a few earthquakes to the northeast of Digby with a magnitude of 3 or less. None occur on Digby Neck, Nova Scotia.

The National Building Code of Canada (1995) is the present document that provides the control on building design for various earthquake loads. A new seismic hazard model, the fourth national model for Canada, is presently being developed by the Geological Survey of Canada (Adams and Atkinson, 2005) to update Canada's current (1985) seismic hazard maps. The new proposed model incorporates data from recent earthquakes and includes a number of other improvements. This report will summarize the 1995 building code as it pertains to southeastern Canada as well as review the proposed changes for 2005.

In Canada, the evaluation of regional seismic hazard for the purposes of the National Building Code is the responsibility of the Geological Survey of Canada and this report draws from their web site and many published documents. The seismic zoning maps prepared by the Geological Survey are derived from analysis of past earthquakes and from knowledge of Canada's tectonic and geological structure. Seismic hazard is expressed as the most powerful ground motion that is expected to occur in an area for a given probability level. Contours on the maps delineate zones likely to experience similarly strong ground motions.

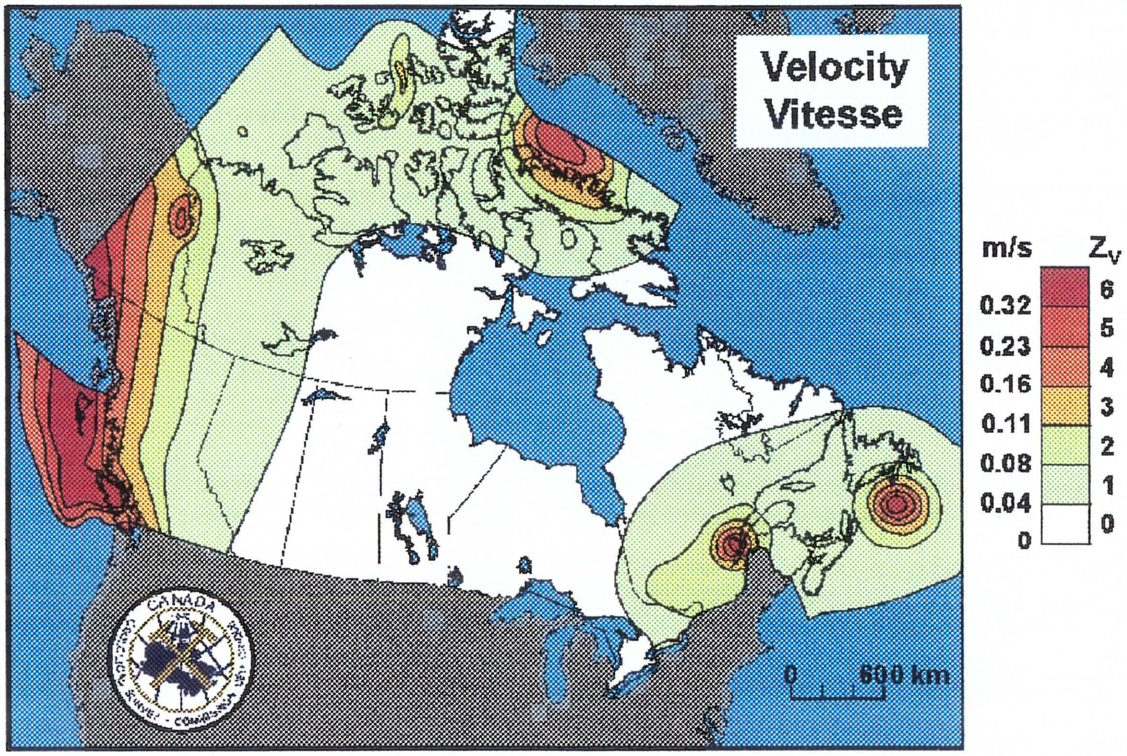
The seismic zoning maps and earthquake load guidelines included in the National Building Code are used to design and construct buildings and other structures to be as earthquake proof as possible. The provisions of the building code are intended as a minimum standard and are meant to prevent structural collapse during major earthquakes and to protect human life.

Seismic Hazard Information in the 1995 National Building Code

Building design for earthquake loads is addressed in sections 4.1.9, 9.20.17 and 9.24.1.5 of the 1995 National Building Code of Canada. The seismic zoning maps are found in Chapter 4, Commentary J, Figures J-1 and J-2 of the User's Guide to the 1995 edition. In addition, a table in Appendix C starting on page 483 of the Code, provides ground motion design values for many communities across Canada. While the National Building Code is chiefly intended for new buildings (Subsection 1.2.1), appendix A (Section A-1.1.2.1) outlines the principles by which the code should also be applied to the use and modification of existing buildings.

The two seismic zoning maps each divide Canada into seven zones of ground motion. Figure 3 has been prepared on the basis of probable ground velocity and Figure 4 according to acceleration. Velocity is given in metres per second; acceleration is expressed as a fraction of gravity.

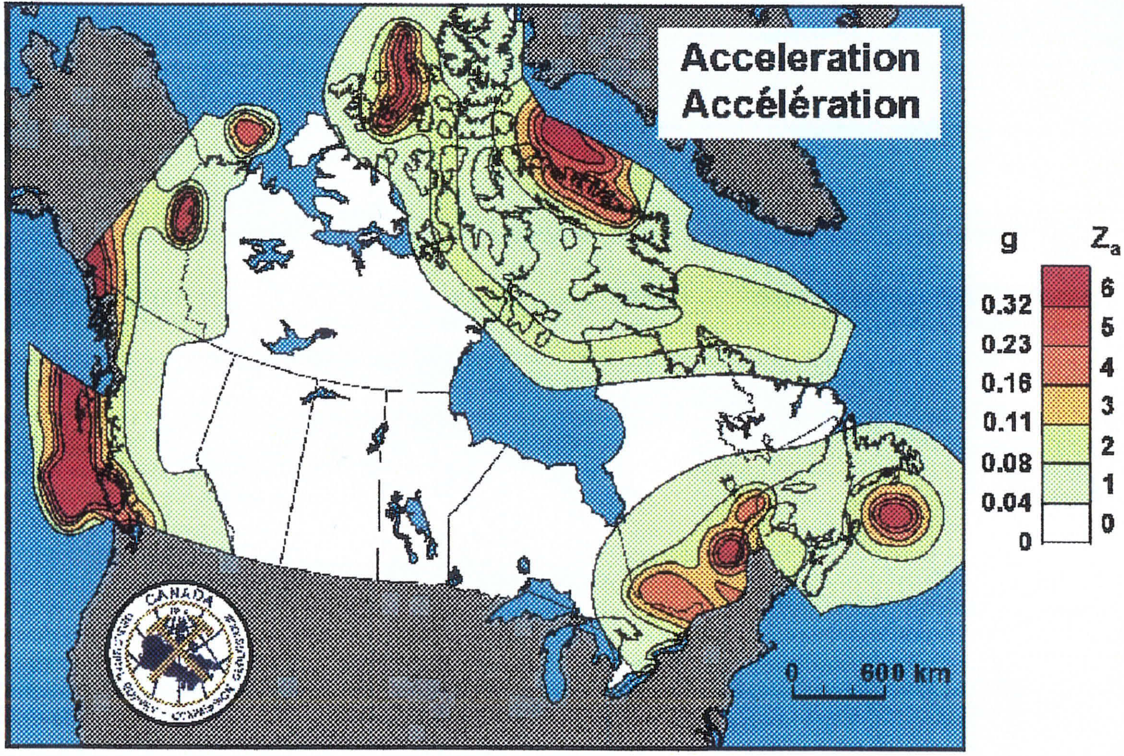
Figure 3



Velocity Seismic Zoning Map

This map first appeared in the Supplement to the 1985 National Building code. The map is appropriate for large structures (e.g., 10-story buildings).

Figure 4



Acceleration Seismic Zoning Map

This map first appeared in the Supplement to the 1985 National Building code. It is appropriate for small structures (e.g., 1-2 story buildings).

Ground motion probability values are given in terms of probable exceedence, that is the likelihood of a given horizontal acceleration or velocity being exceeded during a particular period. The probability used in the National Building Code is 0.0021 per annum, equivalent to a 10-per-cent probability of exceedence over 50 years. This means that over a 50-year period there is a 10-per-cent chance of an earthquake causing ground motion greater than the given expected value.

Most buildings are well-designed to withstand vertical forces, but the horizontal component of ground motion is critical to earthquake-resistant building design. In the urban areas of coastal British Columbia, for example, 20-per-cent gravity is a typical seismic load at an appropriate probability for buildings. A building, designed to tolerate a sideward pushing force equal to 20 per cent of its own weight, should prove earthquake resistant.

Earthquakes and Seismicity

The area of Canada east of the Cordillera (western area), extending north from the United States to the Arctic Ocean, comprises about two-thirds of the stable craton of the North American plate. Much of this area appears to be substantially aseismic, although it contains several zones of significant seismicity and a few other regions of lower-level seismicity. The seismicity of the southern part, together with the adjacent United States, was compiled comprehensively by Smith (1962, 1966), who collected earthquake reports compiled by others, analysed original records where possible, and decided on the best location and magnitude for each earthquake. Further earthquake analysis, including spatial distibution, recurrence rates, and relationship to geological structure was modified by Basham et al. (1982). The latter paper, although the most thorough seismicity compilation to date, was compiled for an engineering seismic hazard study and the conclusions were published in Basham et al., (1985).

Using P-wave polarities, Sv/P amplitude ratios, and the program FOCMEC, the focal mechanisms of 21 recent earthquakes in southeastern Canada have been determined. The mechanisms show systematic thrust faulting throughout eastern Canada from nearly-horizontal compression. Local differences in the direction of compression and the strike of the fault planes provide valuable insights into the seismotectonics of the western Quebec, Charlevoix, Lower St Lawrence, and northern Apalachian regions.

The continual shifting of large segments of the earth's crust (called tectonic plates) causes more than 97% of the world's earthquakes. Eastern Canada is located in a stable continental region within the North American Plate and has a relatively low rate of earthquake activity. Nevertheless, large and damaging earthquakes have occurred here in the past and will inevitably occur in the future.

Rate of Earthquake Activity

Approximately 300 earthquakes occur yearly in eastern Canada. Four will exceed magnitude 4, thirty will exceed magnitude 3, and about fifteen events will be reported only as felt. A decade will, on average, include three events greater than magnitude 5. A magnitude 3 event is sufficiently strong to be felt in the immediate area, and a magnitude 5 event is generally the threshold of damage. The seismograph network of the Geological Survey of Canada can detect all events exceeding magnitude 3 in eastern Canada and all events magnitude 2.5 or greater in densely populated areas.

Earthquake Causes

The causes of earthquakes in eastern Canada are not well-understood. Unlike plate boundary regions where the rate and size of seismic activity is directly correlated with plate interaction, eastern Canada is part of the stable interior of the North American Plate which extends across the western Atlantic Ocean to the mid-ocean ridge. Seismic activity in these areas is thought to be related to regional stress fields, with the earthquakes concentrated in regions of crustal weakness. Although earthquakes can and do occur throughout most of eastern Canada, years of instrumental recordings have identified clusters of earthquake activity.

Calculation of Seismic Hazard

The seismic hazard for a given site is determined from numerous factors. Canada is divided into earthquake source regions based on past earthquake activity and tectonic structure. The relationship between earthquake magnitude and the average rate of occurrence for each region is weighed, along with variations in the attenuation of ground motion with distance.

The acceleration and velocity seismic zoning maps show levels of ground shaking over different frequency ranges: centred near 5 hertz (oscillations per second) for the acceleration map and near 1 hertz for the velocity map. This is important because different buildings are susceptible to different frequencies of earth motion, and damage is frequently associated with a resonance between earthquake ground motion and the building's own natural frequency. Low brick buildings for example can be severely damaged by a moderate (magnitude 5.5) local earthquake that has most of its energy in the high-frequency range. High-rises may be affected more acutely by larger, more distant sources. In building construction and design, not only the size of a probable earthquake should be considered, but also the nature of the ground motion most likely to occur at the site. Seismic hazard calculations provide part of this information. As the understanding of earthquakes and of their effects on engineered structures continues to develop, the seismic provisions of the National Building Code are revised to enhance public safety and minimize earthquake losses.

Proposed 2005 National Building Code of Canada

A new seismic hazard model, the fourth national model for Canada, has been devised by the Geological Survey of Canada (Adams and Atkinson, 2005) to update Canada's current (1985) seismic hazard maps. The model incorporates new knowledge from recent earthquakes, new strong ground motion relations to describe how shaking varies with magnitude and distance, the newly recognized hazard from western Canadian Cascadia subduction earthquakes, and a more systematic approach to reference site conditions. Other new innovations are hazard computation at the 2% in 50 year probability level, the use of the median ground motions, the presentation of results as uniform hazard spectra, and the explicit incorporation of uncertainty via a logic-tree approach. These new results provide a more reliable basis for characterizing seismic hazard across Canada and have been approved by the Canadian National Committee on Earthquake Engineering (CANCEE) as the basis of the seismic loads in the proposed 2005 edition of the National Building Code of Canada.

The seismic hazard maps in the current NBCC (1995) were developed in the early 1980s. Since that time, there have been significant advances in our understanding of seismicity (Fig. 1) and ground motions in Canada and corresponding advances in methodologies to assess seismic hazard. The following is a discussion of the advances and how they have shaped the new seismic hazard maps intended for use in the proposed 2005 edition of the NBCC extracted from Adams and Atkinson (2005).

Seismic hazard analysis has been an element of good engineering design practice through the NBCC for many decades. Since 1970, seismic hazard maps have been developed for building code applications based on a probabilistic approach. The current code maps were developed using the well-known Cornell–McGuire probabilistic approach (Cornell 1968; McGuire 1976; Basham et al. 1982, 1985). In this method, the spatial distribution of earthquakes is described by seismic source zones, which may be either areas or faults; the source zones are defined based on seismotectonic information. The spatial distribution of earthquakes within each source is assumed to be random (i.e., uniformly distributed), and the temporal distribution of events as a function of magnitude is specified from historical seismicity supplemented by geologic or geodesic data where practicable. The exponential relation of Gutenberg and Richter (Richter 1958), asymptotic to an upper bound magnitude (*M*x), is used to describe the magnitude–recurrence statistics. Magnitude (*M*) in this work is intended to be equivalent to moment magnitude, the standard measure of earthquake size and the magnitude type used in most strong ground motion relations. An alternative magnitude scale, *m*bLg, is used for eastern earthquakes and then converted to moment magnitude using an empirical relationship (Atkinson and Boore1995). The link between earthquake occurrence within a zone and ground motions experienced at a site is provided by ground motion relations. These are equations specifying the median (50th percentile) amplitude of a ground motion parameter, such as peak ground acceleration (PGA) or spectral acceleration (*S*a(*T*), where *T* is the period in seconds), as a function of earthquake magnitude and distance, and the distribution of ground motion amplitudes about the median value (i.e., variability). To compute the probability of exceeding a specified ground motion amplitude at a site, hazard contributions are integrated over all magnitudes and distances, for all source zones, according to the total probability theorem (in practice, sensible limits are placed on the integration range for computational efficiency). Calculations are performed for a number of ground motion amplitudes, and interpolation is used to find the ground motions associated with the chosen probability levels. The basic procedures are described by the EERI Committee on Seismic Risk (1989) and the NRC Committee on Seismology (1988). Because of its ability to incorporate both seismicity and geologic information, the Cornell–McGuire method is the most widely used seismic hazard evaluation technique in North America and perhaps the world.

Another important change in the new maps is the lowering of the probability level from 10% in 50 years (0.002 per annum) to 2% in 50 years (0.000404 per annum) (Adams et al. 1999). This change was motivated by studies over the last 10–20 years that have shown that the best way to achieve uniform reliability across the country is by basing the seismic design on amplitudes that have a probability close to the target reliability level (Whitman 1990).

Seismic source parameters

Source models for Canada

The 1985 hazard maps described the distribution of seismicity using a single set of seismic source zones. Since then, two decades of additional knowledge about earthquakes have revealed clearer epicentre patterns in some places but "unexpected" events in others. This has led to a better understanding of the seismotectonics behind the seismicity, but also an appreciation that much is unknown about how the future pattern of seismicity will resemble or differ from the historical pattern. For eastern Canada, the credible range of models was represented by two philosophically distinct probabilistic models: the H (historical seismicity) model uses relatively small source zones drawn around historical seismicity clusters, whereas the R (regional) model establishes larger, regional zones (Fig 5).

In eastern Canada, the R model often combines a number of seismicity clusters that are inferred to have a common cause into large source zones, the larger of which are the Arctic Continental Margin (ACM), the Eastern Continental Margin (ECM), and the Iapetan Rifted Margin (IRM). For each, the R model zone implies that currently aseismic regions between adjacent seismicity clusters (e.g., the St. Lawrence valley near Trois-Rivières) are capable of large earthquakes. Over the long run, the rate of activity along these extensive tectonic zones (e.g., at any place along the continental margin) may be constant; the current seismicity "hot spots" may be just a temporary clustering, speculatively representing prolonged aftershock sequences.

Contour maps of hazard computed using the R model have long "ridges" of moderate hazard and lack the "bull's eyes" of high hazard produced by the H model (and that exist in the 1985 maps). If only the R model hazard were implemented in a building code, it would reduce the seismic protection significantly in regions of high historical seismicity while increasing protection only slightly in other places. A probabilistic combination of the two models would involve their weighted sum, but any weight given to the R model would reduce the protection in regions of high historical seismicity. This dilemma is addressed by performing calculations for both models, then adopting the more conservative result, the so-called "robust" approach, as described.

Strong Ground Motion Relations

Ground motion relations are a key component of any seismic hazard model, as they control the amplitudes of motion predicted for any magnitude and distance. No matter how accurate the seismotectonic source models, the reliability of the final hazard values is highly dependent on the reliability of the strong motion relations and on the extrapolations within them, as observational data from large earthquakes in Canada are sparse. The different physical properties of the crust in eastern and western Canada require the use of separate strong ground motion relations for different regions, as was the case for the 1985 maps, which used the eastern and western relations of Hasegawa et al. (1981).

Eastern Canada

For eastern Canada, ground motion relations are a major source of uncertainty in seismic hazard estimation because of the paucity of observations in the magnitude–

distance range of engineering interest. Consequently, eastern ground motion relations may change significantly as new events are recorded. For example, the recordings of the 1988 Saguenay earthquake caused ground motion modellers to revise their prior relationships to account for its unexpectedly large short-period motions. Deliberations of the Senior Seismic Hazard Analysis Committee (SSHAC) suggested an emerging consensus. On that basis the GSC adopted a suite of relationships with their aleatory uncertainty (the base relations of Atkinson and Boore 1995), and their epistemic uncertainty (Atkinson 1995), consistent with that consensus (Adams and Atkinson, 2005). These represent the available published ground motion relationships, but there is considerable controversy in this field (Atkinson and Boore 1997, 2000*a*). The Atkinson–Boore suite of relationships was derived to fit observational data on hard-rock seismometer sites and so needs adjustment to represent the ground motions on the "firm ground" reference ground condition chosen for Canada .

Summary of the New Seismic Hazard model

The seismic hazard results generated from a new national model will provide a more reliable basis for seismic design of new buildings across Canada. They provide an updated depiction of hazard across Canada, including its variability with spectral period. The spectral parameters used will describe the expected shaking better than the peak motion parameters used in the 1995 NBCC. Understanding of the new results will be aided by new ways of presenting the information, such as deaggregation. The model is planned to be released in late 2005.

Earthquakes In New Brunswick

A summary of the historical earthquake activity in the province of New Brunswick is extracted from a report by Burke, (2005). The first recorded account of an earthquake in New Brunswick is from the *Royal Gazette* published in Halifax, on December 13th, 1764, "We hear from St John's (Saint John) in this province that on the 30th of September last, about 12 o'clock noon, that a very severe shock of an earthquake was felt there". Since then many hundreds of earthquakes have been reported or recorded in the province. In fact, most of New Brunswick lies within the Northern Appalachian Zone (NAN), as shown on the map of earthquakes in Eastern Canada and has experienced several earthquakes in the magnitude 5 to 6 range. The exception is the northwestern part of the province with a few smaller magnitude earthquakes, which lies within the Eastern Background Zone. New Brunswick has also felt the effects of larger events from the Charlevoix-Kamouraska Zone, Lower St. Lawrence Zone and the Laurentian Slope Zone.

A more detailed map of the Northern Appalachian Zone shows epicentres distributed throughout New England and New Brunswick. Epicentres for many of the twentieth century earthquakes have been determined from the analysis of seismograph records, but some of the lower magnitude events and the pre-1900 events have been assigned epicentres based on historical accounts in newspapers and journals. Reports of effects of the earthquakes in different communities allow Modified Mercalli intensity values to be determined and an isoseismal map can then be constructed. The epicentre is chosen to be at the place where the most severe effects are felt, or at the centre of the felt area, if only limited information is available. Magnitude values can be calculated from the felt area (Nuttli and Zollweg, 1974 and Street and Lacroix, 1979), the area contained within the IV isoseismal, (Street and Turcotte, 1977) or a combination of intensity and felt areas (Sibol *et al.*, 1987).

In New Brunswick, epicentres cluster in three regions (Burke, 1984); Passamaquoddy Bay region, Central Highlands (Miramichi) region, and the Moncton region. Earthquakes have been more frequent in these regions and sometimes of a size to be potentially damaging (larger than magnitude 5).

Passamaquoddy Bay Region.

Since the Passamaquoddy region is the area with the largest reported earthquakes closest to the Digby Neck area of Nova Scotia it is important to assess the nature of seismic activity in that region. Passamaquoddy Bay was identified as a seismically active region by Barosh (1981), who stated that more than 50 earthquakes had been reported from the area since 1870. He reports that after a network of seismograph stations was installed in southeastern Maine in 1975, an average of 7 earthquakes per year had been recorded with a magnitude range of 1 to 3.2. A search of the Canadian National Seismological Database for dates between 1800 and October 1, 1999 found 77 earthquakes for the region (44.5°N to 45.5°N; 66.5°W to 67.5°W). Twelve unlisted events found by scanning of local newspapers await evaluation for inclusion in the database (Burke *et al.*, 1987 and Burke and Comeau, 1988).

The largest historically reported event in this region was in the early morning hours (2:04 a.m. local time) on March 21st, 1904, when a strong earthquake was felt throughout the Maritime Provinces, the St Lawrence Lowlands and the New England states. Minor damage to buildings was reported from several communities along the coasts of New Brunswick and Maine and chimneys were thrown down at St Stephen in southwestern New Brunswick and Eastport in southeastern Maine. Using the area within the IV isoseismal, Leblanc and Burke (1985) estimated a felt area IV magnitude of 5.9, although there is a lack of intensity information from the Atlantic Ocean to the south. However, the earthquake has been given a magnitude of m_N = 5.9 in the Canadian National Seismological Database. A possible foreshock was reported felt from Camden in southern Maine at midnight on March 20th, 1904 (*Camden Herald*, March 25th, 1904) and aftershocks reported felt at Bar Harbour in southern Maine and Fredericton in central New Brunswick at 5 am (local time) on March 21st, 1904. (*Bar Harbour Record*, March 23rd, 1904 and *Daily Herald*, March 21st, 1904). There is also a report of several aftershocks being felt at West Gouldsboro, on the southern coast of Maine, in the days following the earthquake (*Bar Harbour Record*, March 30, 1904). These reports of a foreshock and aftershocks from widespread communities are not too useful in pinpointing an epicentre for this earthquake, but the activity confirms that a sizeable main shock occurred. Smith's estimate of the epicentre at 45.0°N, 67.2°W, based on the location of the strongest intensities (Smith, 1962), is the epicentre adopted in the Canadian National Seismological Database.

An earthquake at 5:45 am (local time) on October 22nd, 1869 was found to have a similar isoseismal map to the 1904 earthquake This earthquake was relocated to Passamaquoddy Bay and given a magnitude of 5.7 based on the area within the IV isoseismal by Leblanc and Burke, (1985). It has now been assigned an epicentre of 45.0°N, 67.2°W and a magnitude of m_N= 5.7 in the Canadian National Seismological Database. Minor damage to chimneys and walls were reported from a widespread distribution of communities; e.g. Eastport in southeastern Maine, Fredericton and Woodstock in central New Brunswick, Newcastle (Miramichi City) in northern New Brunswick and Saint John, along the southern coast of New Brunswick. This wider distribution of masonry damage than with the 1904 event probably reflects the poorer construction practices and state of repair in the nineteenth century. Damage and changes to spring water flow at more northerly locations, e.g. Newcastle (Miramichi City), suggest the possibility of an epicentre in the Central Highlands (Leblanc and Burke, 1985). This idea is also supported by reports of possible aftershock activity felt in the Fredericton area and possible foreshocks felt in the Tobique valley, in northwestern New Brunswick, (from a letter to the editor in the October 30, 1869 issue of the *Carlton Sentinel* " .....It is said by some that there was a shock some six hours previous to the one spoken of, and also another on Friday noon, but they were slight.) The similarity of the isoseismal map of the 1869 earthquake to that of the 1904 earthquake is strong evidence of this being a Passamaquoddy Bay event.

A May 22nd, 1817 event was for many years assigned to a central Maine location, but a study of newspaper and journal accounts by Leblanc and Burke (1985) clearly identifies this as another Passamaquoddy Bay earthquake. The same study assigned a magnitude between 4.5 and 5 based on the area enclosed within the IV isoseismal. This earthquake is now listed at an epicentral position of 45.0°N, 67.2°W and given a magnitude of m_N = 4.8 in the Canadian National Seismological Database. Newspapers and diaries of the day gave accounts of violent shaking of houses from Calais in southern Maine, Grand Manan Island in the Bay of Fundy and St Stephen in southwestern New Brunswick, but no damage was reported. An interesting reference to this earthquake was found recently in a collection of letters from the 1780s to 1830s, purchased by the University of New Brunswick from a Sotheby's auction in London in 1994 (Kathryn Hilder, personal communication, June 20th, 1994). This was in a letter from a Jane Moore, who was living in St Mary's, then a small community just north of Fredericton, written on June 3rd, 1817 to her sister, Elizabeth Moore, in New Town, New York "*I was very much alarmed a few nights ago at the shock of an earthquake it awoke me out of a soun(sic) sleep when I found the house and bed where I slept in the most violent motion it appeared to rock as if it was upon rockers it lasted however but a short time* ".

Plots of epicentres on a geological map of the Passamaquoddy Bay region in the 1970s suggested that earthquake activity might be related to movement on the Oak Bay Fault (Rast *et al.*,1979). This north to northwest trending fault offsets Silurian and Devonian rock units with a regional strike direction of northeast and shows a major discontinuity in aeromagnetic and gravity contours associated with these units. However, a Triassic dyke that crosses the fault in the St Croix River is not offset by the Oak Bay Fault, showing that there has been no recent movement along the fault, (Burke and

Stringer, 1993). Glacial striations checked at twenty-four locations showed no sign of postglacial displacement and no disturbances of Quaternary sediments were found along the faults examined on land. However, a marine geophysical survey, in 1988, did map pockmarks (gas escape craters) and plumose structures (linear erosional features) on the bottom of Passamaquoddy Bay and the northwestern alignment of some of the pockmarks (pockmark chains) may be associated with northwest trending faults (Pecore and Fader, 1990). Recent movement along these faults may have allowed the release of gas that created the pockmarks in the soft sediments. Other workers have related the earthquake activity to a general subsidence of Passamaquoddy Bay with accompanying minor movements on the faults in the area, (Barosh, 1981).

Faulting in the Bay of Fundy Region

The most widespread and significant fault or fault zone in the Bay of Fundy region is a westward extension of the Chedabucto-Cobequid fault system in Nova Scotia. It is part of a much larger transform fault system that extends from the Grand Manan area of the Bay of Fundy, north of Minas Basin, across Nova Scotia, through Chedabucto Bay to the Laurentian Channel. The name "Glooscap Fault System" has been proposed for this system (King and MacLean, 1976). They further proposed that it might join with the Newfoundland fracture zone in deep water to the east and involve oceanic crust in this area. The fault system is essentially Triassic and earlier in age but there is evidence for additional faulting in Cretaceous time and perhaps recent activity on the eastern Scotian Shelf and in the adjacent Laurentian Channel. Map 812H (King and Maclean, 1976) shows the distribution of faults of the Glooscap Fault Syatem in the Bay of Fundy. It consists of a linear continuous – discontinuous fault that extends from Ile Haut in the east, westerly to a few kilometers off the coast of New Brunswick at Cape Spencer where it changes direction and continues southwesterly to Grand Manan. There it joins a series of other faults bordering pre-Pennsylvanian acoustic basement. North of this western area of the fault, the Triassic sediments are structurally disturbed in a broad zone that continues to the Passamaquoddy Bay region in the north. As reported in King and MacLean 1976, in the disturbed zone the aeromagnetic data shows considerable variation in contrast to the typically smooth signature of the Triassic rocks through the remainder of the basin.

Fader (1989) conducted a high-resolution seismic reflection survey over the northern part of the disturbed zone to determine if any of the faults had affected the Quaternary overlying sediments in order to assess recent activity. The faulted Triassic sediment is overlain by thick glaciomarine stratified sediments that would record any activity on the faults below. The survey showed that the overlying sediments were not disturbed in any way indicating no activity of the faults over the past 15 – 18 000 years. This is contrast to the eastern Scotian Shelf where north of Banquereau, both glaciomarine Emerald Silt and LaHave Clay Holocene sediments are faulted and contorted along the same fault system.

The closest mapped faults to Digby Neck are a series of oblique short faults that offset the basalt ridge of North Mountain along its length. These occur in Digby Gut, on

Digby Neck and between Digby Neck, Long and Brier Islands. They do not extend into the Triassic sediments that occur a few km offshore and are interpreted to be inactive (Map 812H). Most of these faults are associated with offsets in the trend of North Mountain. Later erosion appears to have removed considerable basalt from these offsets and has resulted in the location of coves and or flooded marine passages.

Whites Point Site Assessment

At the request of the quarry developers an assessment of the site has been evaluated against the 1995 National Building Code of Canada by the Geological Survey of Canada. Provisional 2005 NBCC values for the site have also been provided although these values are intended to form the basis of the 2005 edition of the National Building Code of Canada, they have yet to be formally adopted and are subject to change. The next National Building Code of Canada is expected to be adopted in the third quarter of 2005. Peak and spectral hazard values are determined for an exceedence of 2%/50 years. Values are for "firm ground" (NBCC 2005 soil class C - average shear wave velocity 360-750 m/s). Median (50th percentile) values are given in units of g for peak horizontal and 5% damped spectral horizontal acceleration.

Lattitude N and Longitude W are latitude (decimal degrees North) and longitude (decimal degrees West), respectively. Peak Ground Acceleration (PGA) and spectral acceleration (Sa(T), where T is the period in seconds) values are tabulated.

Located at 44.43 North 66.20 West

Zoning for Above Site

Acceleration zone	Za = 1	Zonal acceleration	0.05 g
Velocity zone	Zv = 1	Zonal velocity	0.05 m/s

Ground motions for selected probability levels for above site

Probability of exceedence per annum	0.010	0.005	0.0021	0.001
Probability of exceedence in 50 years	40%	22%	10%	5%
Peak horizontal ground acceleration (g)	0.036	0.050	0.075	0.099
Peak horizontal ground velocity (m/s)	0.017	0.030	0.054	0.084

1995 NBCC seismic zones
probability level: 10% in 50 years

g or m/s	0.00	0.04	0.08	0.11	0.16	0.23	0.32
ZONE	0	1	2	3	4	5	6*
zonal value	0.00	0.05	0.10	0.15	0.20	0.30	0.40

* zone 6: nominal value 0.40;
site-specific studies suggested for important projects

Proposed 2005 National Building Code of Canada hazard values

Site values at a probability of 0.000404 p.a.
50th PERCENTILE values tabulated

Lat N	Lon W	Sa(0.2)	Sa(0.5)	Sa(1.0)	Sa(2.0)	PGA
44.433	66.200	0.298	0.153	0.073	0.022	0.165

The Geological Survey of Canada discourages the use of the "peak horizontal ground acceleration" measure of hazard and suggests using the spectral parameter most relevant to the period of the proposed facility. The proposed 2005 seismic hazard values should not be used with the 1995 NBCC.

Summary and Conclusions

Seismic zoning maps for Canada are derived from analysis of past earthquakes, and from advancing knowledge of Canada's tectonic and geological structure. Canada is divided into earthquake source regions based on past earthquake activity and tectonic structure. The relation between earthquake magnitude and the average rate of occurrence for each region is considered, along with variations in the attenuation of ground motion with distance. In calculating seismic hazard, scientists consider all earthquake source regions within a relevant distance of the proposed site. In the building code there are two seismic zoning maps for Canada - one showing maximium horizontal ground velocity (appropriate for large structures), and the other showing maximum horizontal ground acceleration (appropriate for small structures

Both seismic hazard maps are probabilistic maps. They provide the likelihood of a given horizontal acceleration or velocity being exceeded during a particular time period. The probability used in the National Building Code is 0.0021 per annum, equivalent to a 10-per-cent probability of exceedance over 50 years. This means that over a 50-year period there is a 10-per-cent chance of an earthquake causing ground motion greater than the given expected value (or a 90-per-cent chance of non-exceedance). On the maps, seismic hazard is expressed as the maximum ground motion that is expected to occur in an area with a given probability. Contours delineate zones likely to experience similar intensities of shaking.

Digby Neck is located within the Northern Appalachian Seismic Zone (NAN). Maps of seismic risk in the 1995 code show the area occurs within Zone 1 and is considered to have a low earthquake risk. In fact, Canada to the east of the Cordillera, extending north from the United States border to the Arctic Ocean, comprises about two-thirds of the stable craton of the North American plate. Much of this large area appears to be substantially aseismic, although it contains several zones of significant seismicity and a few other regions of lower-level seismicity. The areas of high seismicity appear to occur in zones of horizontal compression associated with thrust faulting.

Historically, earthquakes in this Digby Neck region have been infrequent and of small magnitude. The nearest zone of earthquake activity is across the Bay of Fundy in the Passamaquoddy Bay region. The Oak Bay Fault is considered to be the site of the activity for that region. Two small earthquakes epicenters have been reported to the northeast of Digby.

A new seismic hazard model, the fourth national model for Canada, has recently been devised by the Geological Survey of Canada (Adams and Atkinson, 2005) to update Canada's current (1985) seismic hazard maps and is planned to be implemented in late 2005.

Figures

Figure 1. A map of the historical seismicity in eastern Canada.

Figure 2. A more detailed map of the location of seismicity in the NAN area of eastern Canada.

Figure 3. A seismic zoning map of Canada which has been divided into seven zones of ground motion. It has been prepared on the basis of probable ground velocity. Velocity is given in metres per second.

Figure 4. A seismic zoning map of Canada prepared according to acceleration. Acceleration is expressed as a fraction of gravity.

Figure 5. Source zones used in the H and R models. Certain shaded zones show how small clusters of seismicity in the H model are combined into large zones in the R model. Seismicity for relatively aseismic regions outside of zones is accounted for by the stable Canada model: (*a*) H model; (*b*) R model. ACM, Arctic Continental Margin; CASR, Cascade Mountains; CHV, Charlevoix; ECM, Eastern Continental Margin; IRM, Iapetan Rifted Margin; NAT, Niagara–Attica. From Adams and Atikson, (2003).

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Figure 5

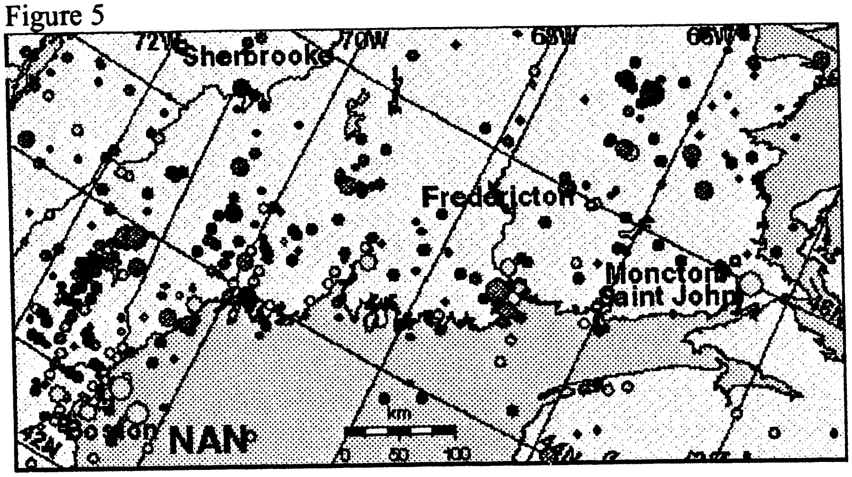
72W
Sherbrooke
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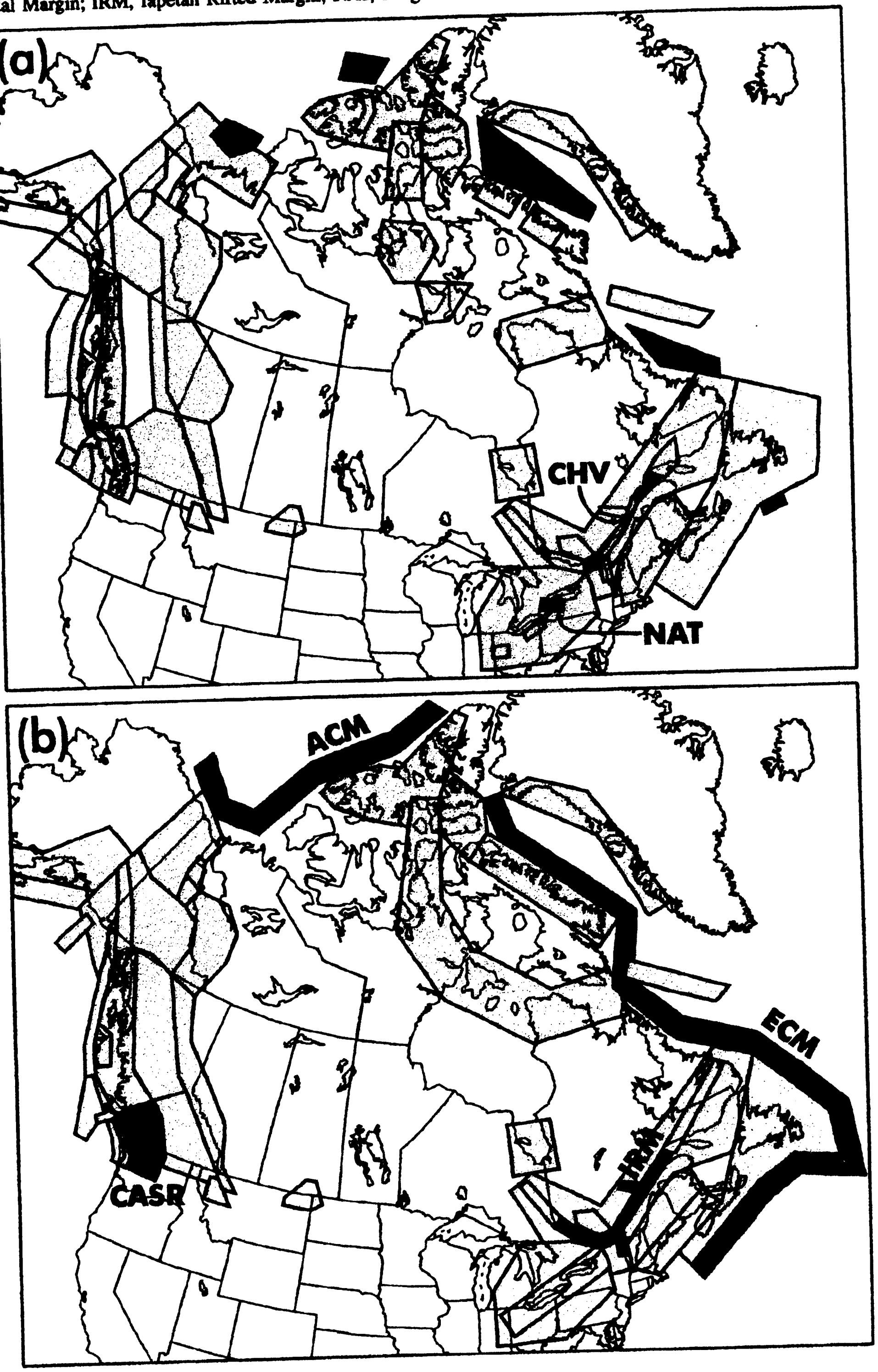
Figure 6

tinental Margin; IRM, Iapetan Rifted Margin; NAT, Niagara–Attica.



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Project No. NSD17221

December 6, 2002

Global Quarry Products Inc.
c/o Mr. Paul Buxton
P.O. Box 98
Annapolis Royal, Nova Scotia
B0S 1A0

Dear Mr. Buxton:

Re: Preliminary Hydrogeological Assessment, Proposed Quarry Whites Cove, Digby Neck, Nova Scotia

1.0 INTRODUCTION

On behalf of Global Quarry Products Inc. (Global), Jacques Whitford Environment Limited (JWEL) has carried out a Preliminary Hydrogeological Assessment for a proposed rock quarry to be developed near Whites Cove, Digby Neck, Nova Scotia. The objectives of this study were to compile and review available hydrogeological information, provide an opinion of possible impacts to nearby residential water wells, and assess the availability of water for the quarry's operation. A preliminary opinion of transient or long term potential impacts, as the quarry progresses is also provided.

1.1 Background

Global proposes to mine basalt bedrock near the shore of Whites Cove (Figure 1) on the north side of Digby Neck, Nova Scotia. The proposed quarry would commence at an existing abandoned quarry and be advanced in lifts north and east into the cliff face and parallel to the shoreline, with a floor elevation of approximately 15m above mean sea level. Although the proposed quarry site is understood to be located near the shoreline and will be approximately 9.68 acres in size, consideration may be given to extending the quarry further to the north and northeast, in a direction that is away from the residences located along Highway No. 217 (Drawing No. 17221-1). The mining would include localized controlled blasting and ultimately up to 2 million tonnes of basalt aggregate may be removed annually. The mined rock would be crushed and washed on-site, and the aggregate then would be trans-shipped to Global's operations in New Jersey where it would be used for concrete production. In order to accommodate loading ships, a pier and load-out structure would be constructed on the rocky shoreline adjacent to the quarry, that would accommodate an estimated 40 to 50 ships per year.

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Global recently retained Mineral Valuation & Capital Inc. (MVC) to carry out a geological assessment of the quarry site (draft report dated October 2002). That assessment included continuous NQ size (3 inch) coring of four vertical boreholes across the site in May 2002.

2.0 SITE DESCRIPTION

The proposed quarry site is situated near Whites Cove on the northwest side of Digby Neck, in Digby County, Nova Scotia. Digby Neck is a 2.5 to 3 km wide elongated peninsula of hard basalt bedrock that extends 60 km (kilometers) southwest from the Town of Digby into the Bay of Fundy. The peninsula is bounded on the northwest by the Bay of Fundy and by St. Mary's Bay on the southeast. The local topographic relief that is primarily controlled by North Mountain which lies along the central axis of the peninsula (Figure 1).

The proposed quarry is located within a wooded 360 acre undeveloped property (PID No. 30161160) approximately 2.5 km long as measured along the shoreline (in a northeast/southwest direction) and extends into the peninsula (i.e. to the southeast) a distance of 0.2 to 1 km. The topographic relief across the property varies from approximately 90 m (metres) at the top of North Mountain in the southeast, to sea level at the Bay of Fundy in the northwest. Access to Whites Cove is via Highway No. 422 from Highway No. 217 that crosses over the mountain. The proposed quarry site and topographic elevation contours are presented on Drawing No. 17221-1. A topographic cross-section that extends north to south across Digby Neck and through the proposed quarry site is presented as Drawing No. 17221-2.

The nearest residential developments are located on the south side of the mountain along Highway No. 217 and Little River Road. The nearest community is Little River which is situated on the southeast side of Digby Neck, and approximately 2 km south of the proposed quarry site. Mink Cove lies approximately 3 km east of the site, on the southeast side of Digby Neck (Figure 1). The closest residential water wells are located along Highway No. 217 at distances ranging from 120 m from the southeast corner of the property boundary, to 1,000 m east of the property boundary. There are an estimated fifty wells located within 1 km of the southeast property boundary, with most of these being in the rural community of Little River. Approximately nineteen of these wells are situated within 1 to 1.5 km of the proposed quarry site as indicated on Drawing No. 17721-3.

Based on a Scotia Surveys Limited drawing entitled 'Site Plan Showing Proposed Quarry Site', scale 1": 400', the proposed quarry will be 9.68 acres in size, and lie within the central portion of the property, near the shoreline. If the quarry is expanded beyond the 9.68 acres in the future, controlled blasting would be kept at least 800 m from any existing residence. Based on this 800 m set-back, the possible future quarry boundary across the subject property is indicated on Drawings No. 17221-1 and No. 17221-3.

3.0 FIELD PROGRAM

JWEL visited the site between September 5 to 10, 2002, to carry out the field program for this study. The field program included the following:

- Measure water levels and collect water samples for laboratory analysis from each of the four open boreholes;

- Carry out a site reconnaissance along the shore line to identify any surface water flows that discharge from the property and into the bay; and

- Confirm the location of existing developed residential properties within an approximate 500 m radius of the quarry property.

3.1 Water Level Measurements

JWEL confirmed the locations of the four abandoned exploration boreholes, which are identified as NS-02-01, NS-02-02, NS-02-03 and NS-02-04, on Drawing No. 17221-1. The boreholes were completed with a steel casing that extended to surface, and were sealed with a wooden plug inserted into the top of each casing. However, JWEL found that several of the boreholes had been vandalized with the wooden plugs pushed down into the casing along with other rock debris dropped on top of the plugs. JWEL was successful in dislodging the obstructions within NS-02-01, but was unable to dislodge obstructions within NS-02-03 and NS-02-04 at depths of 2 to 3 m. An obstruction was encountered within NS-02-02 at 22.2 m depth.

An effort was made to measure the depth to the water table within each borehole. The water table in NS-02-01 was measured at 53 m below grade. While the water table in NS-02-02 was not encountered above the 22 m obstruction, the sound of cascading water was heard within the borehole. This observation suggests the presence of possible perched water table conditions associated with shallow bedrock fractures, and a downward vertical hydraulic gradient.

The water levels in both NS-02-03 and NS-02-04 were measured to be near grade, and above the shallow obstruction encountered within each borehole. This was confirmed by observing a rapid recovery of water level after the boreholes were bailed down. While it is not known whether the source of the recharging water in these boreholes was from a perched shallow water table or from the true water table, in consideration of the location and elevation of these boreholes, a shallow water table depth is expected.

The reported and measured borehole depths, along with the measured depth to groundwater levels and calculated groundwater elevations at each borehole are summarized in Table 1.

Table 1 Summary Of Water Level Information

Borehole	**NS-02-01**	**NS-02-02**	**NS-02-03**	**NS-02-04**
Reported Borehole Depth	63.0 m	74.5 m	35.0 m	20.0 m
Surface Elevation	88.9 m	71.5 m	36.0 m	12.4 m
Bottom Elevation	25.9 m	-3.0 m	1.0 m	-7.6 m
Unobstructed Borehole Depth	60.7 m	22.2 m	1.2 m	2.6 m
Measured Depth to Water	53.0 m	> 22.2 m	1.1 m	2.2 m
Inferred Groundwater Elevation	35.9 m	< 64.9 m	34.9 m	10.2 m

Following the collection of the available water level measurements, JWEL installed a flush-mounted surface casing over each of the boreholes to protect them from further vandalism.

A 25 mm diameter PVC pipe was inserted into NS-02-01 to the full borehole depth. The bottom 6 m section of the pipe was slotted whereas the remaining upper portion of the pipe was solid. This standpipe had two purposes: it allows future measurement of water levels even if loose rock from the borehole wall shifts and collapses in to the borehole; and it permitted the collection of a water sample from the bottom of the borehole during the site visit. The water sample was collected using an inertia sampling device consisting of a foot-valve installed on the bottom of a continuous length of polyethylene tubing placed inside PVC pipe. The sample for analysis of trace metals collected from this well was field filtered to 0.45 micron size, preserved with 1% nitric acid, and placed in an iced cooler. The sample for analysis of general chemistry was collected unfiltered and untreated. The sample was taken to PSC Analytical Services for analysis of general water chemistry (i.e. RCAp/MS).

3.2 Site Reconnaissance

The shoreline was traversed along the length of the property for the purpose of locating and sampling any surface water flows leaving the site. Although several small dry creek beds were noted, no surface flow was found leaving the property. It is expected that surface water flows occur in each of these creeks during rain events and following the snow melt in the spring.

3.3 Drive-By Inspection for Nearby Residential Wells

JWEL conducted a visual survey along Highway No. 217 and the nearby Little River Road to locate existing homes in the vicinity of the proposed quarry site. These sites are discussed further in Section 5.

4.0 HYDROGEOLOGICAL SETTING

4.1 Overburden

The overburden in the area is described as a yellowish-grey, loose, stoney till with a sand matrix. The Quaternary aged glacial deposits along the Digby Neck are mapped as the Basalt Till Facies of the Beaver River Till Unit (Stea & Grant, 1982). This till is generally thin and mantled over the bedrock topography, and may overlie older till deposits. Rock fragments in the till are locally derived from the underlying bedrock. A trace metals analysis of a till sample collected at 1 m depth from the area was carried out as part of the Nova Scotia Till Geochemical Survey (Stea & Grant, 1982). These metal results are summarized on Table 2. All metals except arsenic meet the CCME Soil Quality Guidelines for commercial and industrial sites (CCME, 1999). Arsenic slightly exceeded the 12 ppm CCME guidelines, but is within the range of values natural to Nova Scotia till.

Based on a review of available Nova Scotia Department of Environment (NSDEL) water well records for drilled water wells constructed in Little River and Mink Cove, the overburden ranges from 1 m (3 ft) to 55 m (180 ft) in thickness, averaging 5 m (19 ft). (See Section 5.0 for further discussion of the available water well records).

Table 2 Beaver River Till Sample 341A

Parameter	Sample 341A	Concentration (ppm)		CCME Criteria[1] (ppm)
		mean	range	
Cadmium	0.10	0.16	0.1-0.3	22
Silver	0.70	0.31	0.05-0.70	20 (I)
Copper	80	131	80-218	91
Nickel	20	24	17-37	50
Lead	15	10	4-15	260
Zinc	52	53	40-70	360
Cobalt	19	22	14-36	300 (I)
Iron	3.75	-	-	-
Manganese	1000	-	-	-
Calcium	3800	-	-	-
Magnesium	14,800	-	-	-
Molybdenum	3.0	3.0	2-4	40 (I)
Uranium	2.8	2.3	1.6-3.1	-
Arsenic	16.0	10.0	3-16	12
Tin	10	10.0	1-20	300 (I)

Note: The soil metal criteria are the CCME Soil Quality Guidelines for commercial and industrial sites (CCME 1999).

4.2 Bedrock

The bedrock in the area is the North Mountain Basalt (NMB) of the Fundy Group which is the erosion resistant cap-rock of North Mountain that was deposited as a series of basalt flows in late Triassic to early Jurassic times (about 180 to 210 million years ago). The basalt flows may be up to 275 m thick (Crosby, 1963), and dip about 5 degrees to the northwest under the Bay of Fundy.

Up to three distinct and massive basaltic flows were reported in the Blomidon area of the eastern Annapolis Valley by early geology writers (Powers, 1913; Crosby 1963). Up to 18 individual flows, ranging in thickness from 9.8 m in the shallow zones to 180 m in the basal units, are reported to occur between Margaretsville and Digby (Trescott, 1969), quoting exploration drilling by Sladen Ltd. in 1967. Numerous zeolite (a clay) and quartz-based minerals such as amethyst, are found in the basalt units. Columnar jointing is a characteristic of the massive basalt flows along the crest of North Mountain.

Along the south coast of Digby Neck, the basalt may locally be underlain by shale and minor sandstone of the Blomidon Formation. The Blomidon shale outcrops along the entire length of the Annapolis-Cornwallis Valley, forming the steep south-facing slopes of the North Mountain escarpment, and extends eastward beneath the basalt and under the Minas Basin. The stratum is estimated to be about 244 m in thickness, and dips 5° northwest. The Blomidon shale is described as a relatively homogeneous, soft, brick-red arenaceous (sandy) shale with thin interbeds or lenses containing chlorite, calcite and gypsum (Crosby, 1965). The Blomidon unit can provide a moderate yield to water wells similar to the basalt, but may experience poor water quality in areas with gypsum or salt mineralisation.

Mineral Valuation & Capital. Inc. (2002) reported that the basalt in the Whites Cove consists almost exclusively of the upper basalt flow unit based on the findings from four geological boreholes drilled across the proposed quarry property. The inferred contact between the upper and middle flow units was encountered at approximate depths of 60 m in NS-02-01 and 70 m at NS-02-02, as indicated on Drawing No. 17221-2. They report that "*the upper flow unit at the site is a uniform, hard, massive, vesicle free, medium dark gray to black basalt. The unit attains a maximum thickness of approximately 76 m on the Whites Cove (proposed quarry) property. It is virtually unweathered. Vertical, quartz veins were occasionally observed in the upper third of the upper flow unit. Some of these veins showed red iron oxidation and some contained calcite. Horizontal veins and fractures were occasionally observed in the middle portions of the upper flow unit. The basal 10 m of the upper flow unit displayed some vertical fracturing, which may indicate the presence of a narrow bank of columnar jointing.*"

Based on the borehole records for NS-02-01 and NS-02-02, the geological contact between the upper and middle flow units within the basalt is expected to extend to the ground surface southeast of the quarry property. Based on the reported depth of the geological contact at borehole NS-02-02 and assuming it dips 5° to the northwest, the inferred location where this geological contact may extend to the surface is illustrated on Drawing No. 17221-1 and 17221-2. The inferred outcrop zone of the basal 10m of the upper flow zone which may contain columnar jointing, is also presented on these drawings. Water wells constructed in bedrock northwest of this area may receive groundwater recharge from the potentially permeable basal zone in the upper flow zone.

4.3 Groundwater Flow

The North Mountain Basalt is the primary groundwater aquifer in the Digby Neck area. This bedrock aquifer is inferred to be in an unconfined to possibly semi-confined condition, and receives recharge from the overlying overburden. With groundwater flow generally occurring from an area of high elevation (recharge zone) to an area of low elevation (discharge zone), the groundwater flow across Digby Neck is inferred to mimic the surface watershed as defined by the mountains peak (elevation of about 90 m) and the coastlines (i.e. sea level). The main groundwater flow direction on the north side of the mountain is northwest towards the Bay of Fundy, while groundwater flow on the south side of the mountain is southeast towards St. Mary's Bay. The inferred groundwater divide and the expected groundwater flow directions through the bedrock aquifer are indicated on Drawing No. 17221-2.

The water table at borehole NS-02-01 is 53 m below grade at an elevation of 35.9 m, indicative of a groundwater recharge area. The average hydraulic gradient between boreholes NS-02-01 and NS-02-03 located 562 m to the northwest is 0.17 percent. The gradient increases towards the coast at an average of 24 percent.

Due to the massive nature of the basalt bedrock, groundwater flow through the basalt is believed to occur primarily along the horizontal discontinuities between lava flows (Trescott, 1968, 1969), with a lesser component of flow along the vertical fractures. An increased degree of vertical flow may occur in areas containing columnar jointing (ie. the basal 10m of the upper flow unit). However, vertical flow is expected to be limited in much of the massive basalt. This condition results in the occurrence of perched water tables within the basalt. Water wells drilled through basalt generally encounter progressively deeper water tables as drilling progresses. Cascading flows of water may occur above the static water level in some deeper wells. This condition is illustrated at borehole NS-02-02, where water was heard cascading from within the open borehole. It is inferred that the water was discharging from a shallow fracture(s) within the upper portion of the borehole. Further, the borehole logs for both NS-02-01 and NS-02-02 reported a loss of drill-water circulation near the bottom of each borehole during drilling. This implies that a significant open discontinuity exists near the bottom of both boreholes (i.e. the inferred geological contact between the upper flow unit and middle flow unit). The wide variation in domestic and commercial well depth, yield and water table elevations described below further illustrate the presence of perched water table conditions that is related to the sub-horizontal structure of the basalt.

4.4 Aquifer Hydraulic Properties

Available hydraulic testing data from the NSDEL pumping test inventory for the Digby area is summarized on Table 3. Based on 10 pumping tests in basalt between Halls Harbor and Digby Neck, the basalt aquifer has an apparent transmissivity of 0.27 to 78.8 m^2/d, with a geometric mean of 5.75 m^2/d. Hydraulic testing suggests a safe sustainable well yield of 1.3 igpm (5.7 L/min) to 94 igpm (427 L/min), with a geometric mean of 14.4 igpm (54.4 L/min) for wells ranging in depth from 22.9 to 141.7 m., mean 71.6 m.

Table 3 Summary of Pumping Test Information for North Mountain Basalt, N.S.

	Well Depth (m)	Casing Length (m)	Test Duration (hrs)	Water Level (m)	Test Yield (igpm)	Well Transmissivity (m2/d)	Specific Capacity (m3/d/m)	Safe Yield (igpm)
Minimum	22.9	5.2	24.0	1.5	3.4	0.3	0.4	1.3
Maximum	141.7	13.7	122.0	36.8	30.0	78.8	77.8	94.0
Mean	79.5	8.1	67.5	18.6	13.2	15.3	21.1	30.6
Geomean	71.6	7.3	61.5	11.9	11.1	5.7	7.8	14.4
Median	88.7	5.4	72.0	22.0	12.3	5.8	6.9	21.7
Sdev	31.6	4.0	25.7	13.0	7.4	22.6	25.4	31.1
Number	10	3	10	10	10	10	10	10

Much of the original fracture permeability of the basalt has been lost due to secondary mineralisation (calcite and zeolites). The dominant permeability is associated with horizontal to sub-horizontal fractures zones located along the numerous contacts between individual flows, particularly in the middle flow zone, and the columnar jointing structures reported along the base of the upper flow unit (Trescott, 1969, Lollis, 1959). The highest well yields are therefore expected from the highly fractured bottom zones of the upper flow unit, and from the numerous individual flows associated with the middle unit. Poor well yields are expected in the upper unit and the basal unit.

Based on the well logs, the basalt in the south side of the Digby Neck appears to be 120 to 150 m in thickness, and is underlain by shale and minor sandstone of the Blomidon formation. Deep wells (> 120 m) for fish plants that require higher than domestic demands for process water, often penetrate the basal unit and continue into the underlying Blomidon shale. Excluding the very deep fish plant wells that penetrate the basalt unit, a correlation of well depth and well yield for 32 available well logs for the Little River and Mink Cove areas indicates a poor correlation between well depth and yield (R = -0.11), with the higher yield wells being between depths of 25 to 30 m (80 to 100 ft) and 50 to 55 m (160 to 180 ft). Mean well yield was 37 L/min (8.2 gpm). A similar poor correlation is seen with 72 wells over a larger area from Lake Medway to Tiddville (R = -0.24). However, again the higher yield wells occur between depths of 25 m to 30 m (80 to 100 ft) and 50 to 55 m (160 to 180 ft). Significant yield increases at depths exceeding 107 m (350 ft) are associated with the underlying Blomidon Shale unit.

4.5 Groundwater Quality

Based on the single analysis of water quality at the quarry site (Table 4), and other samples of basalt groundwater, the basalt can be expected to provide an electrochemically neutral, naturally soft, low total dissolved solids, calcium-magnesium bicarbonate groundwater of very good chemical quality. All parameters except occasional manganese can be expected to meet Guidelines for Canadian Drinking Water Quality (Health Canada, 2001). The presence of zeolite minerals in the basalt may contribute to the natural softness. Common man-made water quality problems reported in the basalt wells include road salt, bacteria from septic fields and manure.

5.0 REVIEW OF NEARBY RESIDENTIAL WATER SUPPLIES

Residences in the surrounding communities are expected to obtain domestic water from private water wells constructed at each residential property. Most wells are expected to have been constructed in bedrock, but some shallow dug wells or springs may have been constructed in glacial deposits. To assess the typical well construction details for drilled wells in the region, JWEL reviewed the Nova Scotia Department of Environment and Labour (NSDEL) well records for drilled water wells located within and between the communities of Little River and Mink Cove. The NSDEL electronic database includes all registered water wells constructed since 1979, and well records for the period 1965 through 1978 are contained in annual publications. Forty-seven (47) drilled water wells were found for the Little River to Mink Cove area. Since these records are considered to represent only a percentage of the residences within these communities, the other residences are expected to be serviced with either pre-1965 drilled wells, non-registered wells, dug wells or springs. Also, two or more adjacent lots may share a common well.

A statistical analysis of the reported construction details of these forty-seven wells is provided on Table 5. These results indicate the well depths ranged from 18 m (60 ft) to 277 m (909 ft), with a median depth of 55 m (180 ft). The wells yielded 0.2 igpm to 65 igpm, with a median yield of 31.8 L/min (7 igpm). These results could be considered representative of domestic drilled water wells in the surrounding communities.

Based on a review of 1:10,000 scaled aerial photographs taken of the area in 2001 by Service Nova Scotia & Municipal Relations, and the observations from the visual assessment conducted during the field program, JWEL identified nineteen (19) residences within an approximate 1.0 to 1.5 km radius of the proposed quarry area as indicated on Drawing No. 17221-3. These residences were located along Highway No. 217 and Little River Road. Based on information obtained from the provincial Geonova Property Records Database, the inferred street address, property owner and Property Identification Number (PID) for each of these properties is presented on Table 6. As indicated on Drawing No. 17221-3, most of these residences are inferred to be located near the geological contact between the upper and middle units, and the potentially more permeable columnar jointed basal 10 m of the upper flow unit. Residences located to the southeast of this area which would be stratigraphically below the upper flow zone, would be expected to have drilled wells constructed within the middle or lower flow units, or alternatively in the deeper Blomidon Formation.

Of these nineteen residences, only five (5) water well records were matched to specific properties, indicated on Table 5 as Residential Property Reference No. 1, 8, 13, 16 and 19. The well depths ranged from 30 to 140 m (100 to 460 ft), with casing depth from 6 to 18 m (20 to 60 ft). The reported well yields ranged from 5 to 45 L/min (1 to 10 gpm).

6.0 DISCUSSION

6.1 Potential Quarry Effects on the Groundwater Flow Regime

The main potential impacts from the proposed quarry operation include temporary siltation of nearby wells due to intermittent blasting and possible reduced water levels in wells hydraulically up-gradient of the quarry. Deterioration in water quality is not expected, since the residential wells are located up-gradient of the proposed quarry. Potential impacts to residential water wells will be a function of distance, location of a well with respect to groundwater flow directions, intensity and frequency of blasting, and individual well construction methods. Each of these potential concerns is discussed below.

6.1.1 Water Level Impacts

As the proposed quarry advances northeast and east into the side of North Mountain, the water table in the immediate vicinity of the quarry wall (currently estimated to be 10.2 m to 35.9 m elevation) will begin to decline as water drains into the quarry through numerous fractures in the bedrock. Conceptually, an approximate 25 to 30 meter cut into the cliff face, could theoretically lower local water levels by 10 meters, depending on current static levels and bedrock hydraulic properties. This will reduce the hydraulic gradient both inland (south) and seaward of the quarry (and possibly shift the current groundwater divide southeastwards away from the quarry). This process of water table lowering would be slow, and would occur over several years as the quarry face advances into the side of the mountain. In consideration of the distance to residential wells (900 to 1,500 m) from the rock face of the porposed 9.6 acre quarry, negligible water level decline is anticipated. In addition, the moderate yields of these wells (e.g., median yield of 32 L/min (7 igpm), Table 5), significant decline in water level and/or loss of yield are not anticipated during the proposed 9.6 acre quarry operation. Small declines in water level should be offset by the excess capacity of the well to supply typical domestic demands of about 5 L/min (1 igpm).

If in the future the quarry operation extends further into the property and beyond the proposed 9.6 acres (i.e. up to 800 m from existing residential properties), the advancing quarry face could cut 20 m below the inferred existing water table, resulting in a gradual lowering of water levels in the bedrock south of the quarry face, in the vicinity of the interpreted current watershed divide, and possibly in the vicinity of Highway No. 217. The present groundwater divide would be expected to shift slightly towards the southeast as drainage into the quarry occurs. The degree of this shift, and degree of water level decline would depend on the site-specific hydrogeological properties of the bedrock, and seasonal recharge conditions. The closest wells under this scenario would be located 800 m from the quarry face. Again, the degree of impact would be related to individual well yields, distance from the drainage face, well depth and time of year. Greater potential drawdown would be expected to occur in late summer than in the wet periods.

6.1.2. Potential Water Quality Impacts

Changes in water quality may occur due to excavations in the recharge area of wells. Wells located north west and down-gradient of the quarry would be at greater risk from accidental releases of hazardous materials than would be wells located hydraulically up-gradient or cross-gradient of the quarry, due to the location of the local groundwater and surface water divide.

Under the two mining scenarios (present proposed 9.6 acre quarry and a future 800 m set-back quarry boundary), the groundwater divide would be expected to remain between the quarry and the nearest residential wells in Little River. Under the worst case scenario, should water levels drop significantly at Highway No. 217, drainage would be expected to continue to be towards the quarry, rather than away from it.

An on-site process water well located down-gradient of the advancing face would need to be protected from surface drainage, blasting, storage of fuel, and other sources of potential impact. Proper site operation and maintenance can accommodate this.

Water quality impacts to residential wells at Highway No. 217 or Little River from this quarry operation are therefore considered to be negligible. Water level declines are possible under the large long term mining scenario, and will need to be addressed through a program of long term monitoring and mitigation, if a concern is detected.

6.1.3 Blasting Effects

Wells which potentially could be affected by blasting would be drilled wells located nearest the quarry operation, including the above noted nineteen residential properties. Drilled wells at these properties may be constructed within the upper flow zone containing the major geological contact basal 10 m zone which may contain columnar jointing. Wells located to the southwest of this area are expected to be constructed in the middle and lower flow units, and are not expected to experience impacts associated with dewatering, but may exhibit minor effects from blasting vibration.

The main potential impacts from blasting include temporary siltation of nearby wells due to seismic energy and intermittent blasting. Well collapse is highly unlikely on consideration of the distances involved (> 800 m). Loss of yield due to fracture closing is rare, but possible when large excavations are made close to wells or in the recharge areas of wells. Blasting-related impacts to wells are expected to be short term and minimal, due to distance to receptor wells, and the expected low frequency of blasting operations.

Short term impacts may include temporary discoloration of water due to blasting vibrations. Mitigation could include reducing size of individual blast events, or provision of a dirt filter or bottled water during periods of intensive blasting.

Blasting impact is considered to be the most likely source of complaint from this operation. The sensitivity of individual wells to blasting will need to be addressed through a residential well survey, and through careful attention to blasting operations.

6.1.4 Acidic Drainage

Another possible long term impact of well water quality from open pit quarries in Nova Scotia is associated with decreased pH or increased dissolved solids and dissolved metals from attenuation of acidic drainage from exposed sulfide-rich bedrock. Acidic drainage is not expected in the basalt bedrock in this area due to the chemical nature of the bedrock. However, the absence of sulfide mineralization should be confirmed. As discussed above, the location of the existing domestic wells with respect to the groundwater flow directions should mitigate any concern respecting acidic runoff in the remote event that it might occur. No acidic drainage impacts are therefore anticipated.

6.1.5 Mitigative Measures

Mitigation of short term turbidity impacts caused by blasting vibration would likely involve temporary provision of bottled water to affected residents, or provision of a in-line dirt filter. Reducing the size of individual blasts should also mitigate this concern.

In the unlikely event of a persisting long term water quality or well yield loss event, the proponent will be required to replace or repair any water supply well found to be adversely affected by this quarry operation to the satisfaction of the owner. Remediation, if needed, would involve deepening affected wells or constructing them further from the quarry's face.

6.2 Groundwater and Rainwater Inflow To Quarry

Groundwater seepage through the quarry face and rainfall into the quarry will need to be controlled using on-site seepage and rainfall collection structures. It is understood that this water could be used for washing the aggregate and for dust suppression if needed. The well yield and hydraulic statistics suggest that the bedrock in the vicinity of this quarry has a low to moderate degree of permeability. This suggests that a moderate inflow of groundwater could occur to the quarry. Using the Darcy Approach ($Q = TiL$), average inflow into the proposed 9.6 acre quarry is estimated to be in the order 430 m^3/d or 78 USgpm assuming an average hydraulic gradient (i) of 25 percent, an average transmissivity (T) of 5.7 m^2/d for basalt bedrock (NSDEL Pumping Test inventory), and a 300 m wide effective seepage face width (L). This predicted inflow would vary seasonally. Site observations have indicated minimal seepage flows from the existing abandoned quarry during the summer of 2002.

Rainfall into the proposed 9.6 acre sized quarry would be in the order of 35 USgpm assuming an annual rainfall of 1400 mm, again varying seasonally. A typical 51 mm (2 inch) rainstorm could produce 2,000 m^3 (365 USgpm) of storm water over a 24 hour period.

The above estimates provide an initial indication of available operation water sources. Test drilling and hydraulic testing would be needed to further assess available of on-site groundwater supplies.

7.0 RECOMMENDATIONS

7.1 Pre-Construction Residential Well Survey

Due to the lack of water well records and the absence of well water quality data for the surrounding area, it is recommended that a pre-mining survey of domestic wells be performed to establish baseline conditions in the area surrounding the proposed quarry property. The actual number of wells requiring baseline water quality sampling should be determined in consultation with NSDEL regulatory officials, however it is suggested the survey include the nineteen identified closest residential properties situated within a 1 to 1.5 km radius of the property. These wells would provide monitoring points between the proposed quarry and the larger number of domestic wells lying towards Little River and Mink Cove.

A pre-construction survey would include a door to door survey of residences to obtain technical information on well construction and water quality prior to initiation of the quarry. The survey would include field location of each residential water well within 1 to 1.5 km of the quarry, interview of each resident for well construction and water quality testing history, collection of a sample for general chemistry and bacteria analysis, and matching of wells to available well drillers logs.

The survey would allow JWEL to provide a more informed opinion on the potential risk to individual wells based on well location and apparent construction condition. Any wells deemed to be at particular risk from the proposed development would be identified for closer monitoring during the initial mining operations. The water quality analyses would also provide a characterization of existing pre-construction water quality, which could be used in the arbitration of any possible future damage claims, and also to identify existing water quality problems reported to occur in the area, such as road salt, hardness, iron and manganese.

7.2 Perimeter Groundwater Monitoring Wells

It is recommended that three groundwater monitoring wells be located along the southern quarry property boundaries as indicated on Drawing No. 17221-3, or at suitable locations between the quarry and the residential wells. Each of these locations would be constructed with a borehole drilled to sea level and completed as either an open well or fitted with nested piezometers, and equipped with automated water level recorders. The multi-level option would allow water level monitoring from discreet depths or across bedrock fractures, such as the inferred discontinuity between the basalt upper and middle flow units. This approach would monitor groundwater levels between the quarry operation and the residential wells over several years, to confirm seasonal water level variation, and should provide an early warning of water level changes that might require cessation or changes in the quarry operation. The perimeter monitor wells will also provide an indication of blast effects on wells by real-time monitoring of water levels during basting events, and changes in well yield through annual short term pumping tests.

7.3 Up-grade On-site Monitor Wells

It is recommended that the obstructions within the three existing geological boreholes be removed and that these boreholes be fitted with either a standpipe similar to NS-02-01 or with nested piezometers. Water level data obtained from these locations would supplement the information collected from the perimeter wells, and would assist in assessing the changes in the water table across the quarry property.

8.0 CLOSURE

We trust the above will be of assistance. Please contact me if there are any questions.

Yours very truly,

JACQUES WHITFORD ENVIRONMENT LIMITED

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TABLE 4

Water Chemistry
Proposed Quarry, Whites Cove, Digby Neck, NS
JWEL Project No NSD17221

Parameters	EQL	Units	Criteria*	NS-02-01 (Sept 9, 2002)
Sodium	0.1	mg/L	200 AO	18
Potassium	0.1	mg/L	-	0.7
Calcium	0.1	mg/L	-	17.5
Magnesium	0.1	mg/L	-	5.4
Alkalinity (as CaCO3)	1	mg/L	-	63
Sulfate	2	mg/L	500 AO	8
Chloride	1	mg/L	250 AO	25
Reactive Silica (as SiO2)	0.5	mg/L	-	26
Ortho Phosphate (as P)	0.01	mg/L	-	0.02
Nitrite	0.01	mg/L	3.2 MAC	< 0.01
Nitrate + Nitrite (as N)	0.05	mg/L	-	0.18
Nitrate (as N)	0.05	mg/L	10 MAC	0.18
Ammonia (as N)	0.05	mg/L	-	0.05
Color	5	TCU	15 AO	< 5
Turbidity	0.1	NTU	5 AO	2.3
Conductance (RCAp)	1	uS/cm	-	224
pH	-	Units	6.5-8.5 AO	7.4
Hardness (as CaCO3)	0.1	mg/L	-	65.9
Bicarbonate (as CaCO3)	1	mg/L	-	63
Carbonate (as CaCO3)	1	mg/L	-	< 1
TDS (Calculated)	1	mg/L	500 AO	139
Cation Sum	0.1	meq/L	-	2.12
Anion Sum	0.1	meq/L	-	2.14
Ion Balance	-	%	-	0.52
Langlier Index @ 4C	-	Units	-	-1.40
Langlier Index @ 20C	-	Units	-	-1.00
Saturation pH @ 4C	-	Units	-	8.8
Saturation pH @ 20C	-	Units	-	8.4
Aluminum	10	ug/L	-	< 10
Antimony	2	ug/L	6 IMAC	< 2
Arsenic	2	ug/L	25 IMAC	< 2
Barium	5	ug/L	1000 MAC	6
Beryllium	5	ug/L	-	< 5
Bismuth	2	ug/L	-	< 2
Boron	5	ug/L	5000 IMAC	16
Cadmium	0.3	ug/L	5 MAC	< 0.3
Chromium	2	ug/L	50 MAC	< 2
Cobalt	1	ug/L	-	< 1
Copper	2	ug/L	1000 AO	< 2
Iron	20	ug/L	300 AO	30
Lead	0.5	ug/L	10 MAC	< 0.5
Manganese	2	ug/L	50 AO	**100**
Molybdenum	2	ug/L	-	< 2
Nickel	2	ug/L	-	< 2

TABLE 4

Water Chemistry
Proposed Quarry, Whites Cove, Digby Neck, NS
JWEL Project No NSD17221

Parameters	EQL	Units	Criteria*	NS-02-01 (Sept 9, 2002)
Selenium	2	ug/L	10 MAC	< 2
Silver	0.5	ug/L	-	< 0.5
Strontium	5	ug/L	-	57
Thallium	0.1	ug/L	-	< 0.1
Tin	2	ug/L	-	< 2
Titanium	2	ug/L	-	< 2
Uranium	0.1	ug/L	20 IMAC	< 0.1
Vanadium	2	ug/L	-	< 2
Zinc	2	ug/L	5000 AO	19
Phosphorus	0.1	ug/L	15 AO	< 0.1
Total Org. Carbon	0.5	ug/L	-	< 0.5
Total Suspended Solids	0.5	mg/L	-	7.5

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Notes:

* = Summary of Guidelines for Canadian Drinking Water Quality (GCDWQ), Health Canada, April 1999, unless otherwise noted

EQL = Estimated Quantification Limit, TDU = True Colour Units, NTU = Nephelometric Turbidity Units

mg/L = milligrams/litre; ug/L = micrograms/litre; us/cm = microosienens/centimeter; meq/L = milliequivalents/litre

nd = not detected above laboratory EQL, nd ( ) = not detected at elevated EQL specified due to matrix interferences or sample pre-dilution

MAC = maximum acceptable concentrations for substances known or suspected to cause adverse effects on health

IMAC = interim maximum acceptable concentrations for those substances for which there are insufficient toxicological data to derive a MAC

AO = asthetic objective applicable to certain substances that can affect its acceptance

Bold font = indicates the value exceeds applicable criteria

Sample analysis by Philip Analytical Services Ltd, Bedford, NS

Table 5 Well Construction Details from NSDEL Records
Little River and Mink Cove, Digby Neck, NS

JWEL Project No. NSD 17221

NSDEL Well Number	Residential Property Reference No.	Community	Registered Well Owners Name	Date Drilled	Well Depth (ft)	Casing Depth (ft)	Yield (gpm)	Water Table Depth (ft)	Bedrock Depth (ft)	Depth to Main Water Bearing Fractures (ft)	
870205	16	Little River	DENTON, CHESTER	3/6/87	460	60			52		
870834	19	Little River	RYAN, TOM	11/9/87	100	20	3		8	30	60
882304		Little River	TIDD, LAURA	11/14/88	126	20	3		8		
801892		Little River	BENTON, DALE	6/3/80	140	23	4		11	60	140
802015	1	Little River	GIDNEY, DAVID	8/31/80	100	22	5		9	40	100
802193		Little River	SCOTIA FISHERIES	6/2/80	180	23	35		10	160	180
802238		Little River	TIDD, LAURISTON	8/31/80	160	22	2		8	140	160
821926	16	Little River	DENTON, CHESTER	6/17/82	140	22	1.2		12	100	140
822016		Little River	MILLBERRY, ROBERT	6/18/82	180	53	0.2		20	160	180
841606		Little River	SEOLIN FISHERIES	8/11/84	180		13				
792177		Little River	DENTON, CLYDE A	2/23/79	60						
792178		Little River	DENTON, CLYDE E	2/24/79	100	21	20		15	40	100
791265		Little River	DENTON, BERNARD	4/23/79	240	20	1		8	200	220
792419		Little River	WALKER, GERALD	3/9/79	80	20	25		9	70	80
792363		Little River	SCOTIA FISHERIES	2/20/79	180	22	7		16	55	180
792364		Little River	SCOTIA FISHERIES	2/24/79	160	22	1		14	155	160
792365		Little River	SCOTIA FISHERIES	2/20/79	400	20	60		15	100	400
900201		Little River	D & R DENTON FISHERIES LTD	5/8/90	406	22	1		16	140	395
902751	8	Little River	NESBITT, ARNOLD	1/1/90	140	20	8	70	8	120	
902761		Little River	RELLY, ANNA MARIE	11/10/90	80	40	6	14	10	50	70
922033	13	Little River	GIDNEY, KEVIN	5/18/92	150	20	10		6	100	138
922094		Little River	DENTON, ALLAN	9/4/92	110	110	10	40	15	100	
932205		Little River	WOOLAVER, MARK	9/17/93	120	21	8	15	14	85	
932207		Little River	TRASK, EDGAR	9/18/93	180		7	17	16	110	
972571		Little River	DENTON, CLAYTON	7/12/97	160	23	3		20	90	130
972615		Little River	DICKINSON, JOHN	7/12/97	160	22	4	60	16	138	
972841		Little River	TIDD, CHRIS	10/25/97	100	20	8	10	20	60	80
782351		Little River	DENTON FISHERIES	1978	360	21			3		
782352		Little River	DENTON FISHERIES LTD	1978	460	22			17		
782569		Little River	SCOTIA FISHERIES	1978	420	22			10		
book		Little River	SCOTIA FISHERIES	1978	350		60	6	6	6	
book		Little River	HEBB, EARLE	1978	125	75	6	20	70		
book		Little River	JOHNSON, ANGUS	1978	250		6		32		
book		Mink Cove	E&R Const Ltd	1974	175	20	30	35	4		
802111		Mink Cove	MERRITT, PATRICIA	10/8/80	160	22	20		6	140	160
792133		Mink Cove	THIBODEAU, CARTY	5/28/79	500	20	12		8	350	500
851583		Mink Cove	MARITIME SEABRIGHT	6/17/85	550	72	45		55	80	480
890861		Mink Cove	BANCROFT, D G	8/22/89	305	187	3		180		
941805		Mink Cove	K & W SEAFOOD LTD.	12/20/94	528		65			495	
961381		Mink Cove	DOUBLE O FISH FARM	10/8/96	605	14	17		10	490	605
980753		Mink Cove	DOUBLE O FISH FARM	12/9/98	909	20	31		6	245	850
992447		Mink Cove	HUTCHINS, RANDY	6/26/99	300	20	0.5	10	6	100	
990831		Mink Cove	MERRITT, ALLISON	6/7/99	175	20	40		5	163	
002753		Mink Cove	DIETER, OSWALD	5/17/00	160	20	3	10	14	80	126
002754		Mink Cove	CHUTE, TONY	5/19/00	220	20	2		16	100	160
002787		Mink Cove	MCCLOUGH, DORIS	9/12/00	200	20	2	20	8	140	160
002793		Mink Cove	BISHOP, MAC	10/20/00	180	20	3	15	10	100	160
				Minimum =	60	14	0.2	6	3	6	60
				Maximum =	909	187	65	70	180	495	850
				Mean =	245	32	14	24	19	133	226
				Median =	180	21	7	16	11	100	160
				Number =	47	41	42	14	44	36	27
				Standard Deviation =	173	31	18	20	28	109	189

P:\EnvEng\17xxx\17221\[water well records.xls]Little River & Mink Cove Only

Table 6 Developed Residential Properties in Vicinity of Proposed Quarry

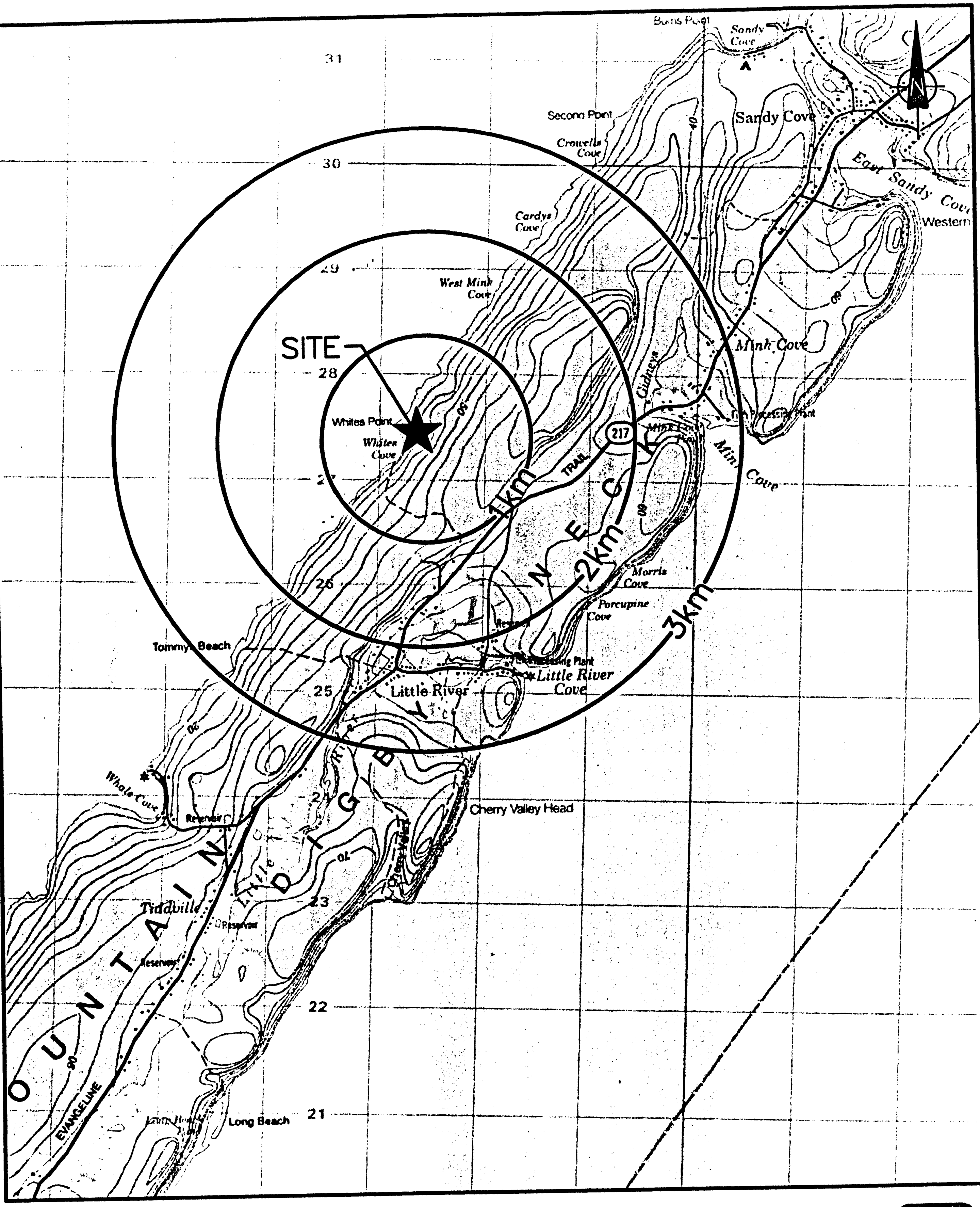
White's Point, Digby Neck, NS
JWEL Project No. NSD 17221

Residential Property Reference No.	Street Address ^{2}	Property Owner ^{2}	PID ^{2,3}	Miscellaneous ^{4}
1	5163 Highway No. 217	David H. Gidney	30161004	NSDEL Well Record No. 802015
2	5171 Highway No. 217	Lawrence R. Trask	30264626	
3	5191 Highway No. 217	Brian Allen Walker	30256275	
4	unknown	Brian Allen Walker	30256283	
5	unknown	Dav-Jo Fisheries Ltd.	30160998	
6	5172 Highway No. 217	Laura K. & Norman C. Rice	30161038	
7	5207 Highway No. 217	Lawrence R. Trask	30161012	
8	5216 Highway No. 217	Arnold & Evelyn Nesbitt	30161061	NSDEL Well Record No. 902751
9	5239 Highway No. 217	Mark Jeffery	30161079	
10	unknown	Evelyn H Dickinson	30161095	
11	5261 Highway No. 217	Zora Walker	30161087	
12	5275 Highway No. 217	Curtis & Yvonne Addington	30161111	
13	5274 Highway No. 217	Kevin & Rhonda Gidney	30322630	NSDEL Well Record No. 922033
14	5327 Highway No. 217	Richard B. & Marcella M. Towle	30161145	
15	5441 Highway No. 217	Frederick O. & Stephanie Trask	30132559	
16	unknown	Chester & Stacey Denton	30161269	NSDEL Well Record No. 821926 and 870205
17	183 Little River Road	Sarah M. & Travis Denton Frost, and Price Waterhouse Limited	30160857	
18	184 Little River Road	Royce Dwayne Elderkin	30160824	
19	unknown	Thomas M. Ryan	30161327	NSDEL Well Record No. 870834

P:\EnvEng\17xxx\17221\[Developed Residential Properties.xls]Sheet1

Notes:

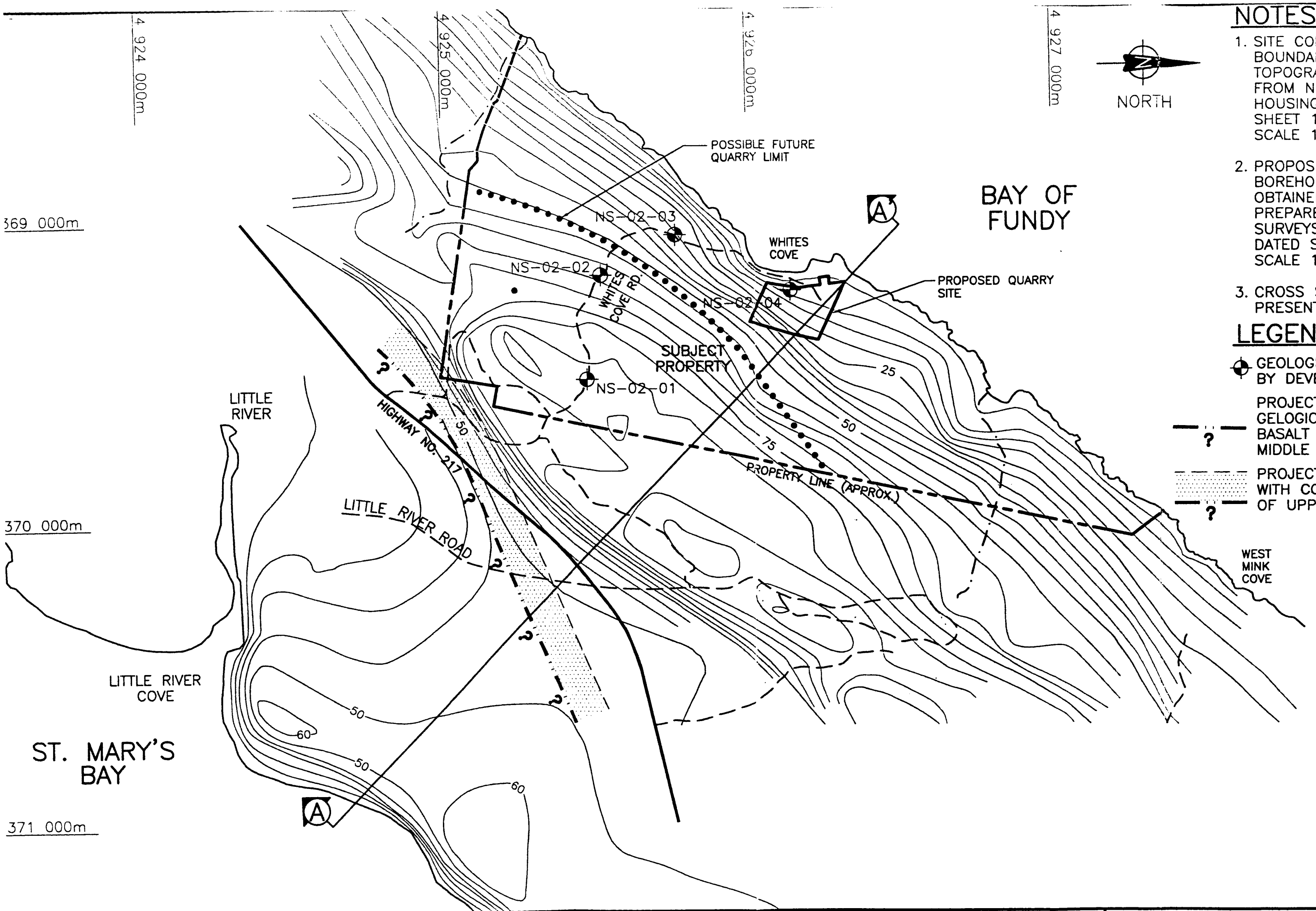
1. This table lists the developed residential properties in the vicinity of the proposed quarry.
2. The residential houses were identified from the highway. An attempt was made to match the houses with the name of the property owner, the property's PID and street address.
3. PID = Property Identification Number
4. A review of the NSDEL water well record database for drilled water wells constructed in Little River matched several of the property owner name's with registered drilled wells.



SITE LOCATION AND TOPOGRAPHY

SCALE 1:50000

FIGURE 1



NOTES:

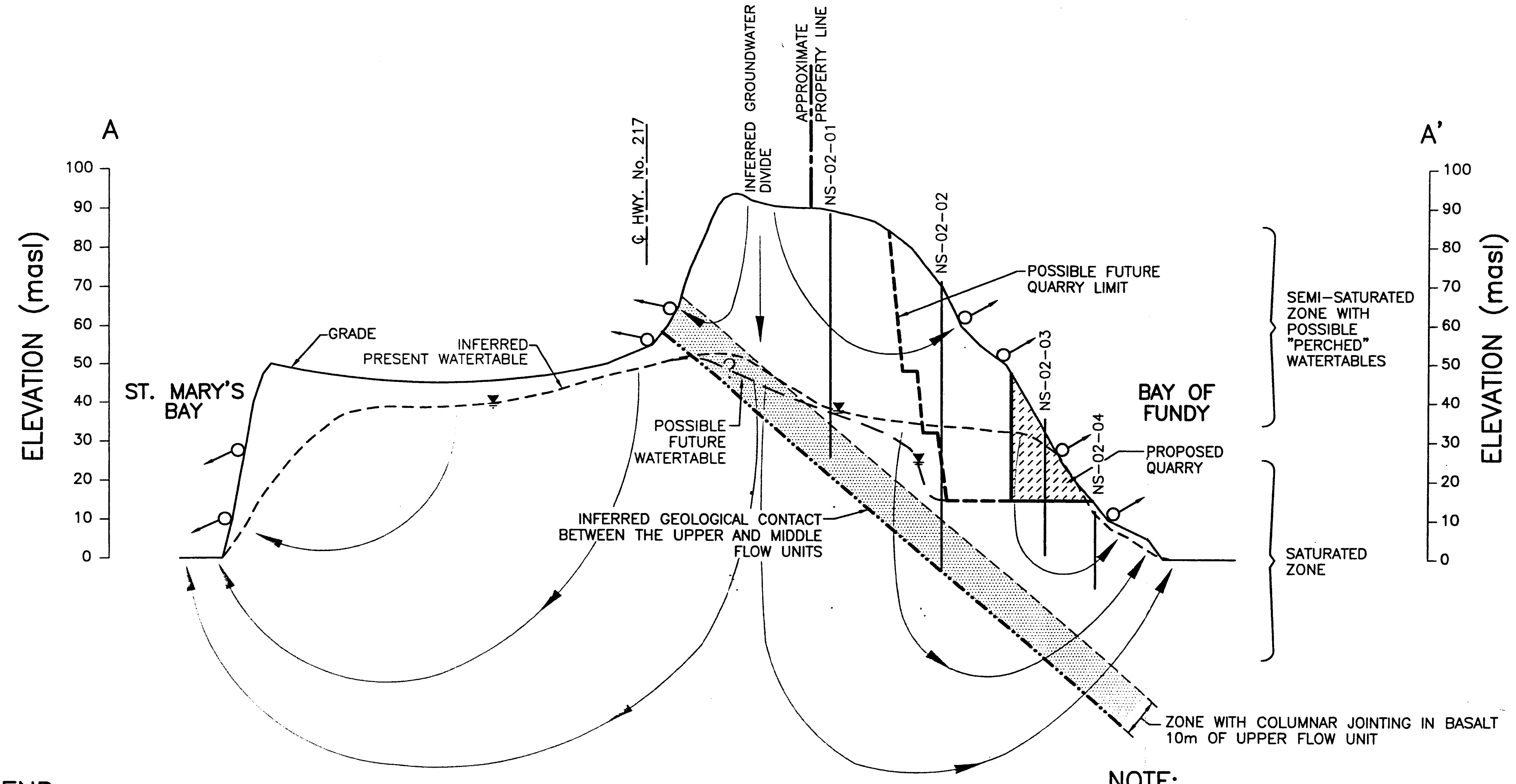
1. SITE CONFIGURATION, PROPERTY BOUNDARIES AND SURFACE TOPOGRAPHY WERE OBTAINED FROM NOVA SCOTIA DEPARTMENT OF HOUSING AND MUNICIPAL AFFAIRS, SHEET 10 44 4500 66 100, SCALE 1:10,000
2. PROPOSED QUARRY SITE AND BOREHOLE LOCATIONS WERE OBTAINED FROM SITE PLAN PREPARED BY NOVA SCOTIA SURVEYS LIMITED, JOB NO.D6153-02 DATED SEPTEMBER 16, 2002, SCALE 1":400'.
3. CROSS SECTION A-A' IS PRESENTED ON DWG. NO.17221-2

LEGEND:

⊕	GEOLOGICAL BOREHOLE CONSTRUCTEL BY DEVELOPER
— ? —	PROJECTED OUTCROPPING OF GELOGICAL CONTACT BETWEEN BASALT UPPER FLOW UNIT AND MIDDLE FLOW UNIT.
▨ ?	PROJECTED OUTCROPPING OF ZONE WITH COLUMNAL JOINTING AT BOTTOM OF UPPER FLOW UNIT

Jacques Whitford

REFERENCE:	SCALE : 1:12500	GLOBAL QUARRY PRODUCTS	SITE PLAN	DRAWING NO. 17221-1
	DATE : 02/10/30	PRELIMINARY HYDROGEOLOGICAL ASSESSMENT		
	DRAWN BY : PB			
	APPROVED BY : DH	PROPOSED QUARRY, WHITES COVE, DIGBY COUNTY, NS		



EGEND:

- - -▼- - - INFERRED GROUNDWATER TABLE
⟶ INFERRED GROUNDWATER FLOW DIRECTION
—○ EXPECTED SPRING FLOW

SCALE

1:10000 HORIZ.
1:1000 VERT.

NOTE:

1. REFER TO DWG. NO. 17221-1 FOR CROSS-SECTION LOCATION.
2. THE BOREHOLES AND THE INFERRED GEOLOGICAL CONTACT AT NS-02-02 WERE PROJECTED ONTO THE CROSS-SECTION.

Jacques Whitford

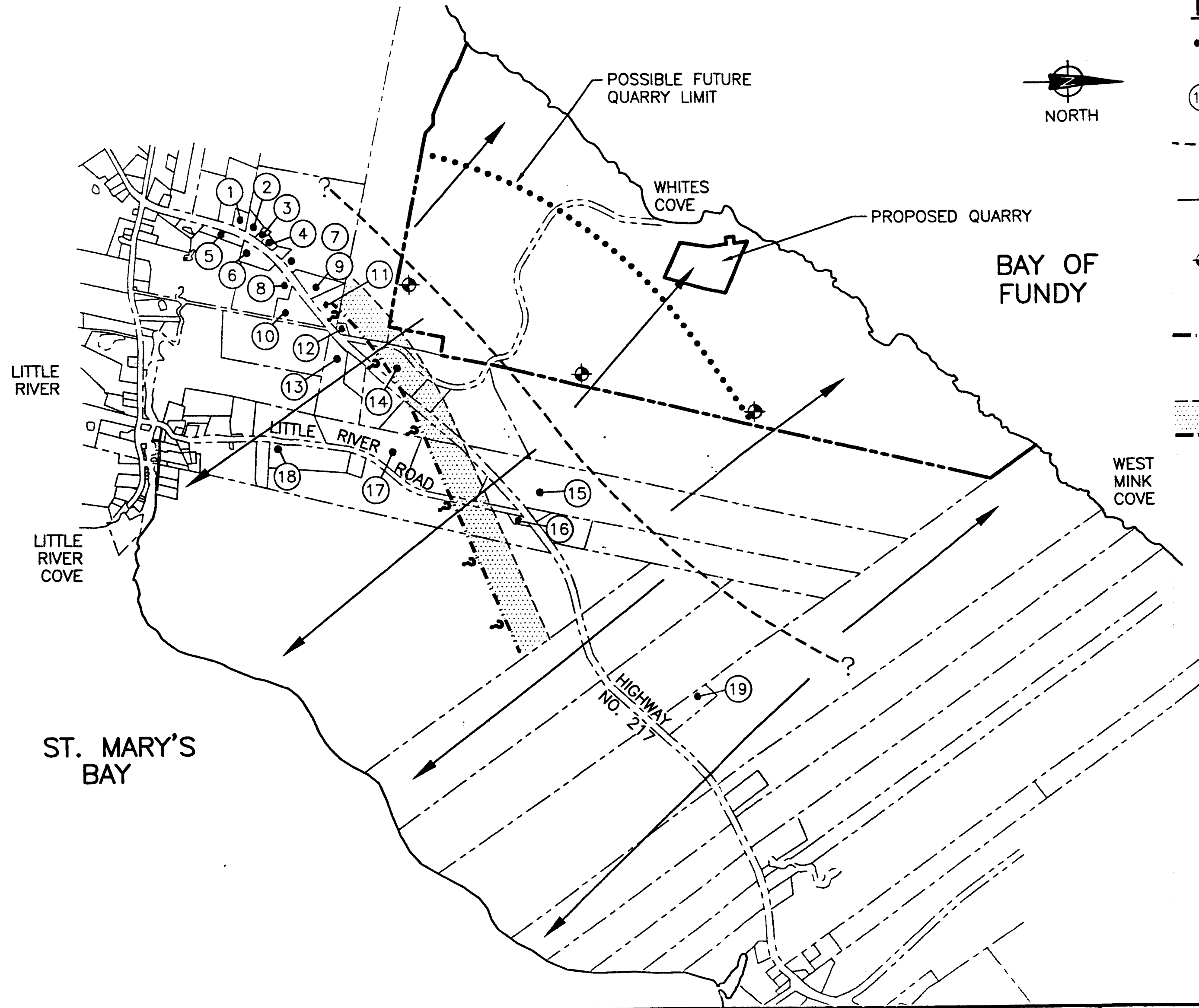
REFERENCE:

SCALE : AS NOTED
DATE : 02/10/30
DRAWN BY :
APPROVED BY : DH

GLOBAL QUARRY PRODUCTS
PRELIMINARY HYDROGEOLOGICAL ASSESSMENT
PROPOSED QUARRY, WHITES COVE, DIGBY COUNTY, NS

CROSS-SECTION
A-A'

DRAWING NO.
17221-2



LEGEND:

- • APPROX. LOCATION OF EXISTING RESIDENCE
- ⑲ RESIDENCE REFERENCE NUMBER (REFER TO TABLE 6 IN REPORT)
- - - - - INFERRED GROUNDWATER FLOW DIVIDE
- → INFERRED GROUNDWATER FLOW DIRECTION
- ⌖ RECOMMENDED LOCATION OF BOREHOLE WITH NESTED PIEZOMETERS
- —·—·— ? PROJECTED OUTCROPPING OF GELOGICAL CONTACT BETWEEN BASALT UPPER FLOW UNIT AND MIDDLE FLOW UNIT.
- ▨ ? PROJECTED OUTCROPPING OF ZONE WITH COLUMNAL JOINTING AT BOTTOM OF UPPER FLOW UNIT

NOTES:

1. THE BASEPLAN SHOWING PROPERTY BOUNDARIES WAS OBTAINED FROM NOVA SCOTIA GEONOVA PROPERTY RECORDS DATABASE.
2. THE PLOTTED LOCATIONS OF RESIDENTIAL HOMES IS BASED ON A REVIEW OF 2001 AERIAL PHOTOGRAPHS (01306)

Jacques Whitford	REFERENCE:	SCALE : 1:15000 DATE : 02/10/30 DRAWN BY : APPROVED BY : DH	GLOBAL QUARRY PRODUCTS PRELIMINARY HYDROGEOLOGICAL ASSESSMENT PROPOSED QUARRY, WHITES COVE, DIGBY COUNTY, NS	EXISTING RESIDENTIAL HOMES	DRAWING NO. 17221–3