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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

Dwayne Hogg, M.Sc., P.Eng.
Project Manager/Hydrogeologist

David MacFarlane, M.Sc., P.Geo.
Senior Hydrogeologist

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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

Notes: P:\EnvEng\17XXX\17221 Global Quarry\[water chemistry.xls]Sheet1

* = 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	3/6/1987	460	60			52		
870834	19	Little River	RYAN, TOM	11/9/1987	100	20	3		8	30	60
882304		Little River	TIDD, LAURA	11/14/1988	126	20	3		8		
801892		Little River	BENTON, DALE	6/3/1980	140	23	4		11	60	140
802015	1	Little River	GIDNEY, DAVID	8/31/1980	100	22	5		9	40	100
802193		Little River	SCOTIA FISHERIES	6/2/1980	180	23	35		10	160	180
802238		Little River	TIDD, LAURISTON	8/31/1980	160	22	2		8	140	160
821926	16	Little River	DENTON, CHESTER	6/17/1982	140	22	1.2		12	100	140
822016		Little River	MILLBERRY, ROBERT	6/18/1982	180	53	0.2		20	160	180
841606		Little River	SEOLIN FISHERIES	8/11/1984	180		13				
792177		Little River	DENTON, CLYDE A	2/23/1979	60						
792178		Little River	DENTON, CLYDE E	2/24/1979	100	21	20		15	40	100
791265		Little River	DENTON, BERNARD	4/23/1979	240	20	1		8	200	220
792419		Little River	WALKER, GERALD	3/9/1979	80	20	25		9	70	80
792363		Little River	SCOTIA FISHERIES	2/20/1979	180	22	7		16	55	180
792364		Little River	SCOTIA FISHERIES	2/24/1979	160	22	1		14	155	160
792365		Little River	SCOTIA FISHERIES	2/20/1979	400	20	60		15	100	400
900201		Little River	D & R DENTON FISHERIES LTD	5/8/1990	406	22	1		16	140	395
902751	8	Little River	NESBITT, ARNOLD	1/1/1990	140	20	8	70	8	120	
902761		Little River	RELLY, ANNA MARIE	11/10/1990	80	40	6	14	10	50	70
922033	13	Little River	GIDNEY, KEVIN	5/18/1992	150	20	10		6	100	138
922094		Little River	DENTON, ALLAN	9/4/1992	110	110	10	40	15	100	
932205		Little River	WOOLAVER, MARK	9/17/1993	120	21	8	15	14	85	
932207		Little River	TRASK, EDGAR	9/18/1993	180		7	17	16	110	
972571		Little River	DENTON, CLAYTON	7/12/1997	160	23	3		20	90	130
972615		Little River	DICKINSON, JOHN	7/12/1997	160	22	4	60	16	138	
972841		Little River	TIDD, CHRIS	10/25/1997	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	10/8/1980	160	22	20		6	140	160
792133		Mink Cove	THIBODEAU, CARTY	5/28/1979	500	20	12		8	350	500
851583		Mink Cove	MARITIME SEABRIGHT	6/17/1985	550	72	45		55	80	480
890861		Mink Cove	BANCROFT, D G	8/22/1989	305	187	3		180		
941805		Mink Cove	K & W SEAFOOD LTD.	12/20/1994	528		65			495	
961381		Mink Cove	DOUBLE O FISH FARM	10/8/1996	605	14	17		10	490	605
980753		Mink Cove	DOUBLE O FISH FARM	12/9/1998	909	20	31		6	245	850
992447		Mink Cove	HUTCHINS, RANDY	6/26/1999	300	20	0.5	10	6	100	
990831		Mink Cove	MERRITT, ALLISON	6/7/1999	175	20	40		5	163	
002753		Mink Cove	DIETER, OSWALD	5/17/2000	160	20	3	10	14	80	126
002754		Mink Cove	CHUTE, TONY	5/19/2000	220	20	2		16	100	160
002787		Mink Cove	MCCLOUGH, DORIS	9/12/2000	200	20	2	20	8	140	160
002793		Mink Cove	BISHOP, MAC	10/20/2000	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 Global Quarry\[water well records.xls]Little River & Mink Cove Only

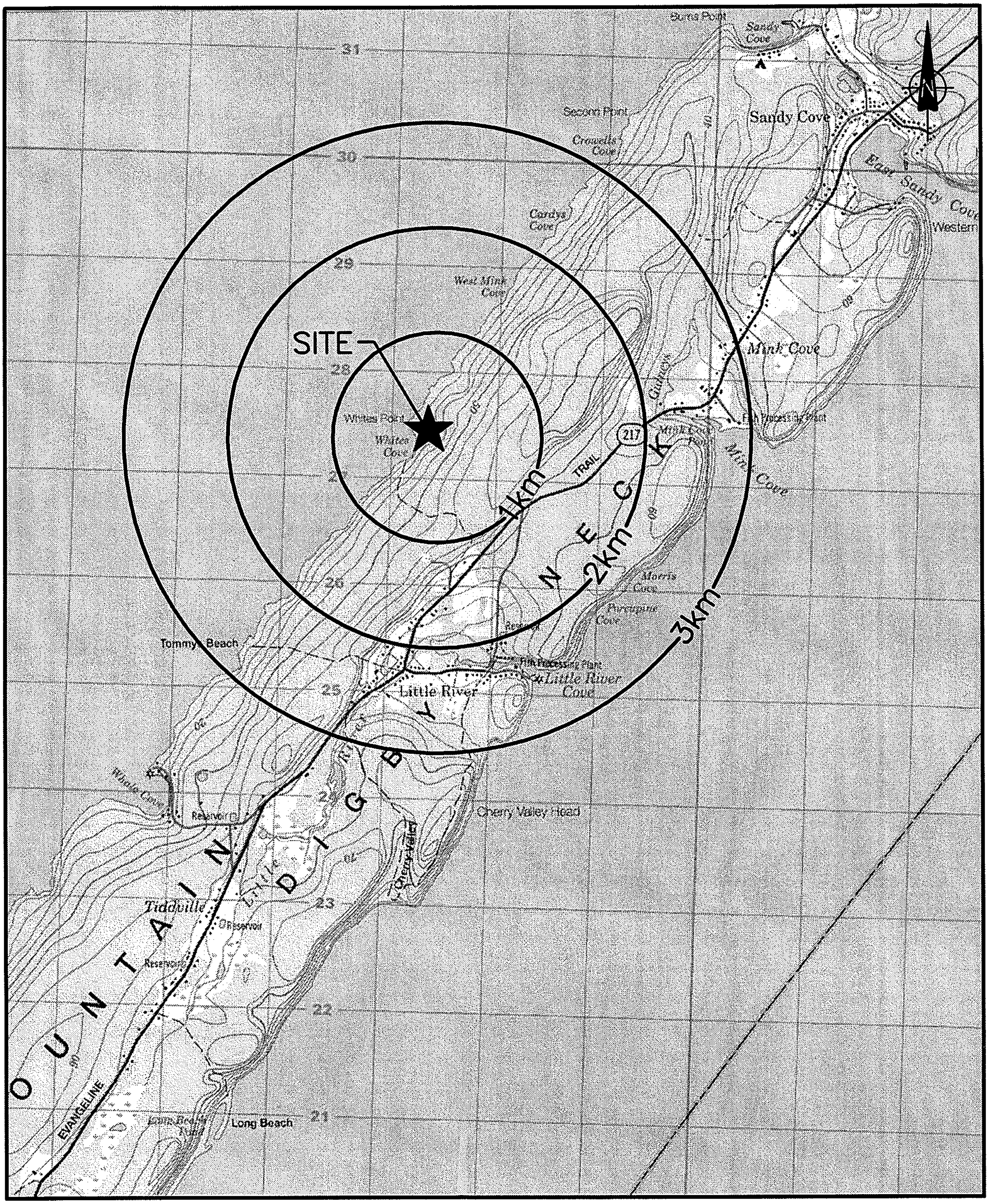
Table 6 **Developed Residential Properties in Vicinity of Proposed Quarry**
White's Point, Digby Neck, NS
JWEL Project No. NSD 17221

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 Global Quarry\[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.



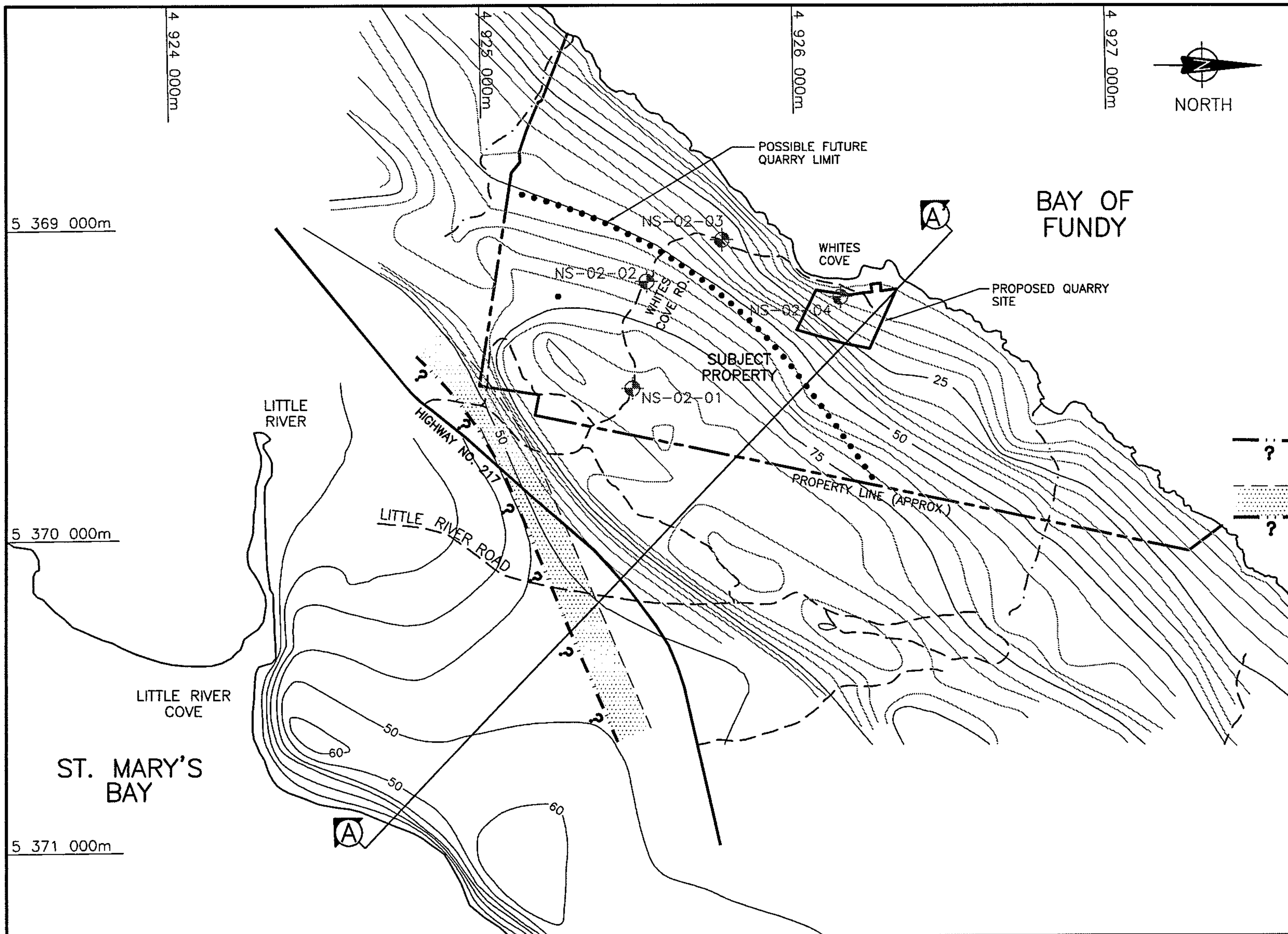
SITE LOCATION AND TOPOGRAPHY

SCALE 1:50000

17221

FIGURE 1

C0397-019



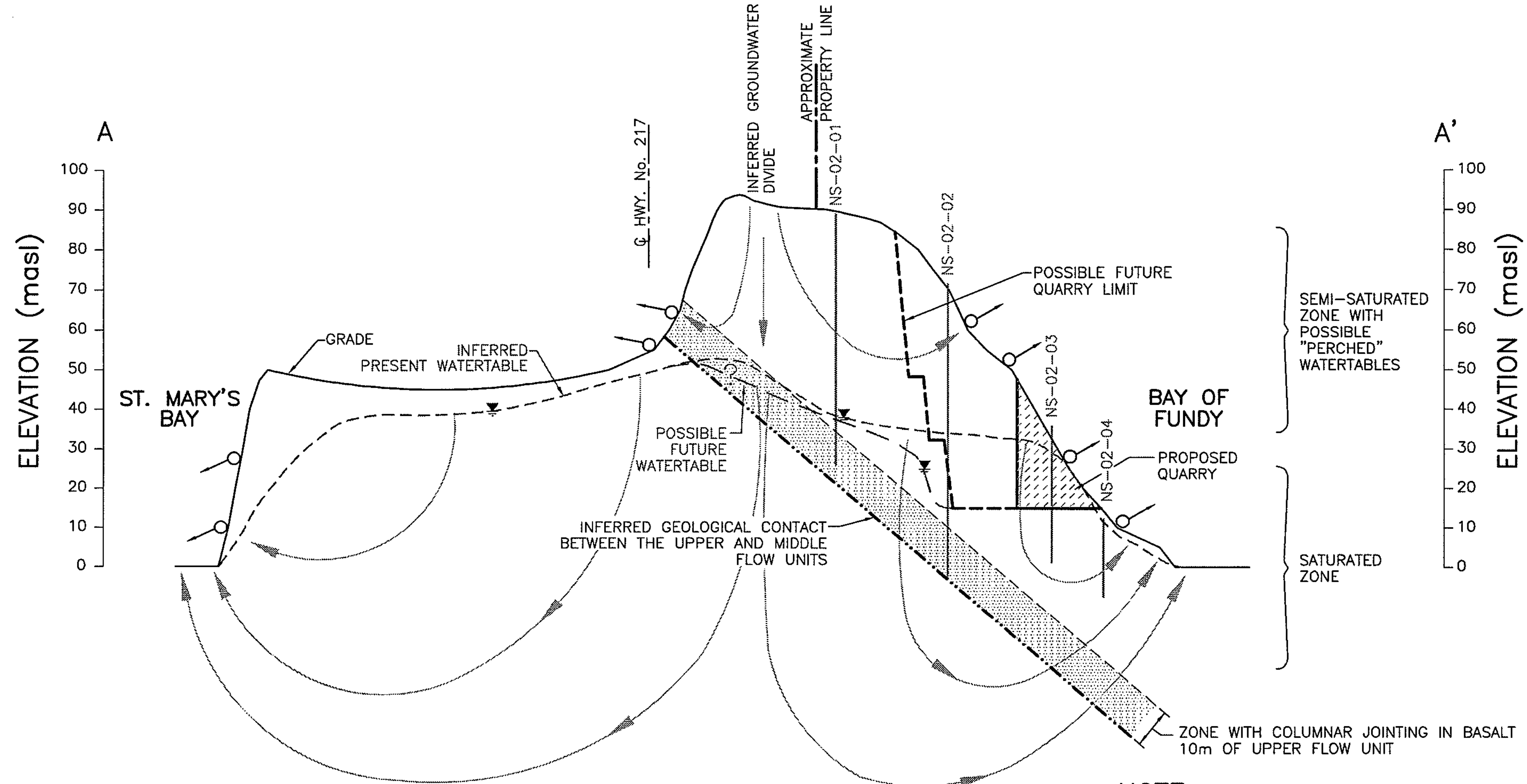
NOTES:

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



LEGEND:

- 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 :

GLOBAL QUARRY PRODUCTS

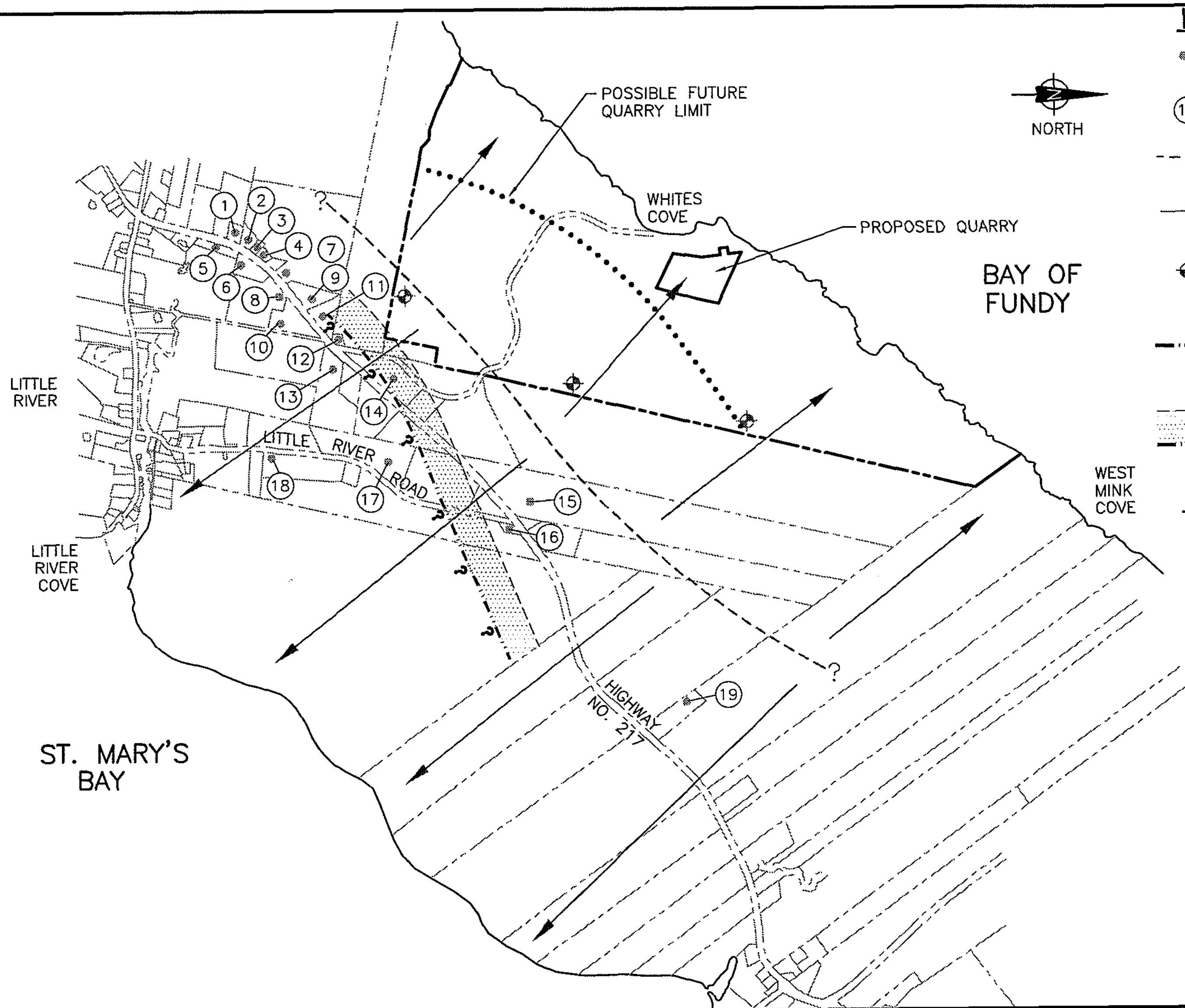
PRELIMINARY HYDROGEOLOGICAL ASSESSMENT

PROPOSED QUARRY, WHITES COVE, DIGBY COUNTY, NS

CROSS-SECTION A-A'

DRAWING NO. 17221-2

C0397-021



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 :	GLOBAL QUARRY PRODUCTS PRELIMINARY HYDROGEOLOGICAL ASSESSMENT PROPOSED QUARRY, WHITES COVE, DIGBY COUNTY, NS	EXISTING RESIDENTIAL HOMES	DRAWING NO. 17221-3