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**Stantec**

Stantec Consulting Ltd.  
102 – 40 Highfield Park  
Dartmouth NS B3A 0A3  
Tel: (902) 468-7777  
Fax: (902) 468-9009

**Hants County Aggregate Quarry  
Hydrology Study**

Municipal Enterprises Ltd.  
P.O. Box 48100  
Bedford, NS B4A 3Z2

File: 121510261

March 2010

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## **1.0 Introduction**

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### **1.1 GENERAL**

As part of the requirements of the Environmental Assessment Registration, a hydrology study was conducted for the area that covers the existing Hants County Quarry and the proposed quarry extension project. The main objectives of this assessment were to determine changes on the local hydrologic regime due to the proposed quarry extension, to identify adverse effects on downstream hydrologic elements, and to offer measures to mitigate these effects.

#### **Objectives**

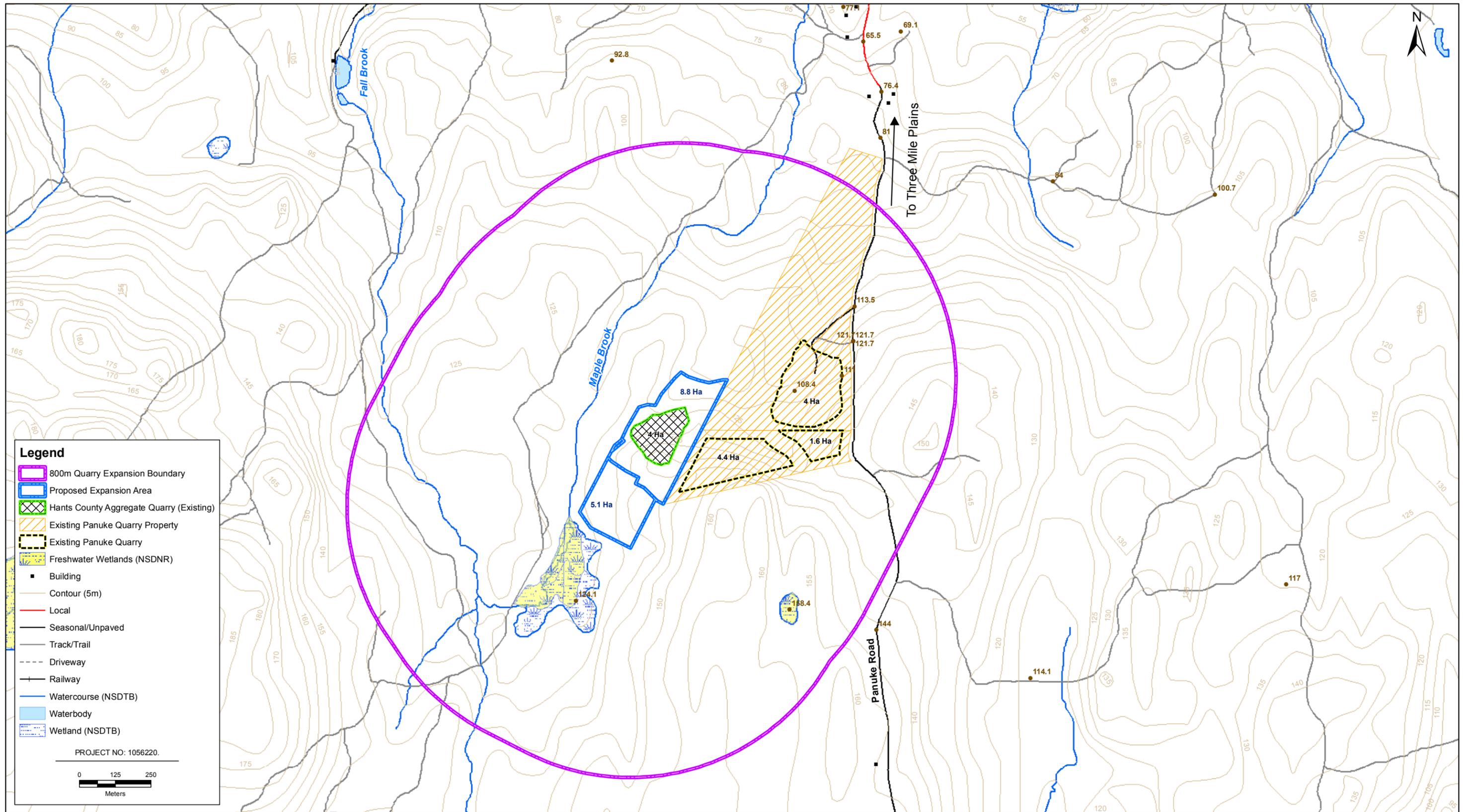
The main objectives of this hydrologic assessment are:

- Estimate the total change in surface water runoff amounts for the pre and post-development conditions;
- Estimate the total capacity of the required flow retention/siltation facilities (*i.e.*, retention pond) for the ultimate level of quarry extension; and
- Assess any potential impacts of the proposed quarry extension on downstream hydrologic elements with respect to water quantity and quality and provide recommendations to mitigate these potential impacts.

### **1.2 SITE DESCRIPTION AND BACKGROUND**

The proposed quarry extension land (referred thereafter as the “site”) is located approximately 8 km south of the town of Windsor, in Hants County, Nova Scotia. The proposed extension is situated around the area of the existing Hants County Quarry which covers approximately 3.9 Ha. The property identification number (PID) is 45007176. The total area of the proposed extension is 13.9 Ha extending from NE to SW and parallel to the property boundaries.

The Site is irregular in shape with its longest dimension extending from NE to SW. As indicated previously, the existing quarry encompasses an area of 3.9 Ha and has been operating for the past 35 years. As the operation progresses, the organic layer at the site is removed and stockpiled for future reinstatement. The aggregates from the quarry are extracted by blasting, crushing and stockpiling of material on site (overburden and bedrock) and are primarily offered to the local construction market. It is expected that the operation of the proposed quarry extension will be the same as the existing quarry. The existing quarry boundary, the proposed extension area and other main features of the area are shown in Figure 1.1.



DATE:	07/06/2010
PREPARED BY:	G. MESHEAU
MUNICIPAL ENTERPRISES LIMITED	

Environmental Assessment of Hants County Aggregate Quarry Extension Project

**PROJECT LOCATION AND PROPOSED EXTENSION AREA**

FIGURE NO.:	<b>Figure 1.1</b>

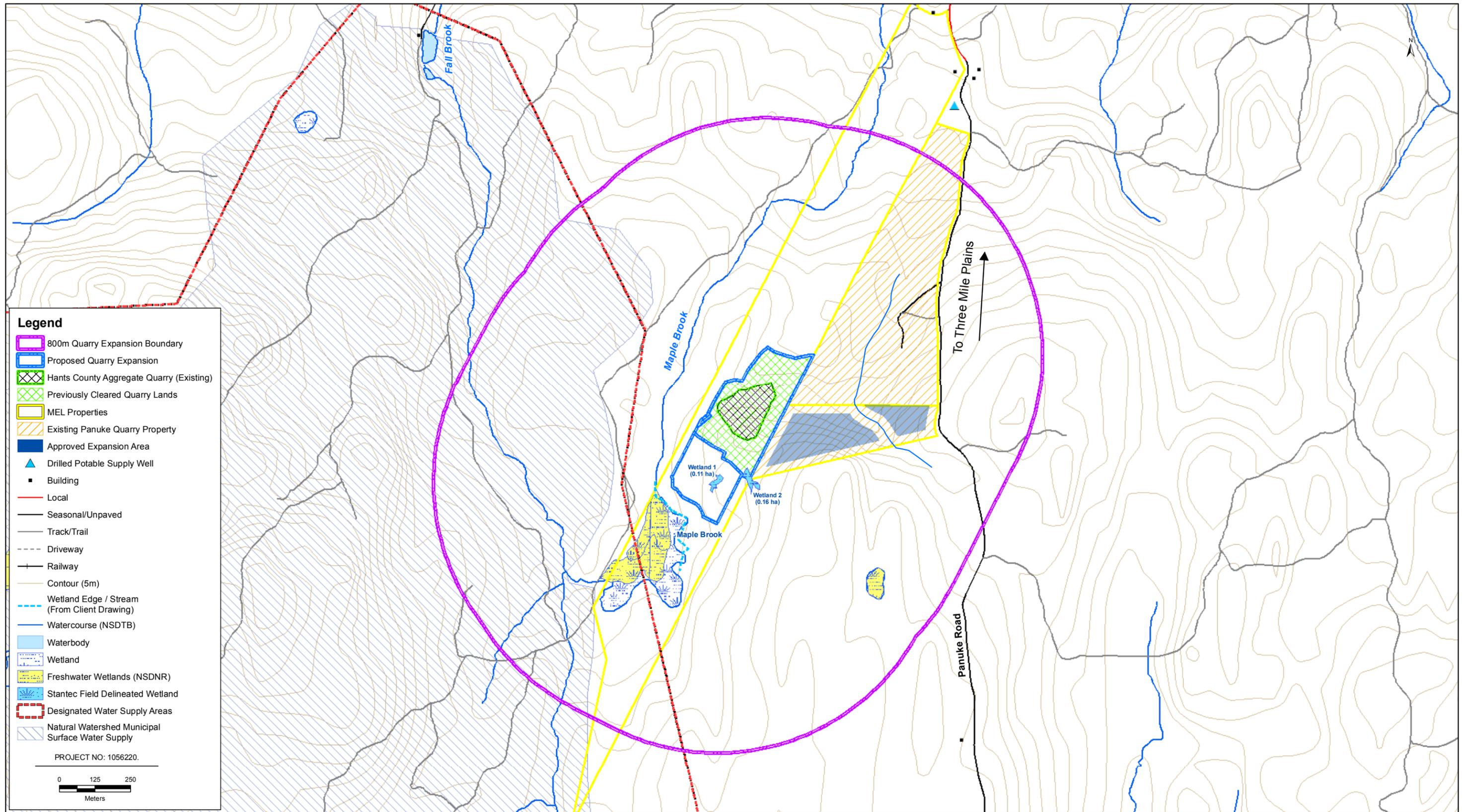
## **Introduction**

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The existing topography for the entire site slopes to the north towards Maple Brook. Surface runoff is directed to one settling pond prior to being discharged to a naturally vegetated area where it is infiltrated. During a site visit conducted by Stantec representatives on October 7, 2009, the presence of a watercourse was confirmed within the property (Maple Brook). According to the available GIS mapping, Maple Brook is located approximately 30 m away from the edge of the proposed quarry extension boundary. At the time, the watercourse exhibited clear flowing water with no apparent barriers to fish passage outside the proposed project extension boundary. A desktop review of the available GIS mapping, specifically the watercourse layer indicated that Maple Brook is likely connected to tributaries that eventually discharge to the St. Croix River.

The site is intended to be developed over the next years until complete extension is achieved. It is our understanding that the site will be expanded gradually to the southwest until the entire proposed development boundary is reached.

Based on available stream and contour mapping (5 m resolution) the site is located within one sub-watershed that drains to the north, towards the St. Croix River. A series of small wetlands located within the site were also identified during the site visit. These along with other hydrologic features of the site are shown on Figure 1.2.



DATE:	25/06/2010
PREPARED BY:	G. MESHEAU
MUNICIPAL ENTERPRISES LIMITED	

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**HYDROLOGICAL FEATURES**

FIGURE NO.:	<b>Figure 1.2</b>

## **2.0 METHODOLOGY**

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### **2.1 MEAN ANNUAL SITE RUNOFF ESTIMATION**

The mean annual site runoff for the entire proposed extension was calculated by comparing the mean annual water balance of both the existing and the proposed conditions. The entire development condition assumes that all the vegetative cover and topsoil layer will be removed from the site which will cause an increase in site runoff due to a decrease in evapotranspiration and infiltration amounts.

### **2.2 FLOW RETENTION AND SILTATION TREATMENT SIZING**

The discharge capacity and dimensions of the required flow retention and siltation treatment structures for the total proposed extension were calculated with the hydrologic model HEC-HMS version 3.3. HEC-HMS was developed by the U.S. Army Corp of Engineers and is widely accepted as a tool to conduct hydrologic modeling by engineers and scientists around the world.

The parameters required for calculations were obtained from different sources. Annual precipitation data was obtained from climate normals from Station 8206415 (Windsor Martock) operated by Environment Canada. Station 8206415 is located approximately 5.5 km to the west of the site. The surface slope, area and other physical parameters were approximated using GIS tools and available mapping. The concentration time was estimated with the Upland Method included in the National Engineering Handbook, Section 4, Natural Resources Conservation Service (NRCS, formerly the USDA Soil Conservation Service).

The required volume capacity for the flow retention and siltation structures was estimated based on a 6 hour duration rainfall with an associated Annual Exceedance Probability (AEP) of 0.04, which is a rainfall event with an associated return period of 25 years. The maximum discharge capacities for the hydraulic discharge structures were based on the 6 hour 0.01 AEP storm (1:100 year return period rainfall event). Rainfall Intensity-Duration-Frequency (IDF) curves were obtained from Station 8202800 (Kentville), operated by Environment Canada. Station 8202800 is the nearest station with available data and is located approximately 35 km to the northwest of the site.

## **2.3 RESULTS**

### **2.3.1 Mean Annual Site Runoff Estimation**

Based on climate normals (1971-2000) from station 8206415 (Windsor Martock), the average total annual precipitation at the site is in the order of 1308.2 mm.

Total annual evapotranspiration in the area has been estimated using the Thornthwaite Equation and average monthly temperature data from Station 8206415. Based on the

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Thornthwaite Equation, the estimated local annual evapotranspiration is in the order of 626 mm, or 48% of the average annual precipitation. Infiltration is assumed to be in the order of 15% of the average annual precipitation based on the hydrologic soil group, vegetation cover and average surface topography at the site combined with previous experience with similar sites in Nova Scotia (David MacFarlane, personal communication, June 22nd 2009). The annual infiltration is therefore in the order of 196.2 mm.

The remaining 37% of the average annual precipitation can contribute to surface runoff to the site which corresponds to 484 mm per year. It has been estimated that surface runoff from the site will increase by approximately 20% as a result of the quarry extension; this takes into account an equivalent decrease in evapotranspiration and infiltration.

Although it is difficult to accurately determine the effects of climate change within the next century, there is a general agreement that the magnitude of precipitation events will likely increase. Since the site will be developed over a long period of time (in the order of 50 years) it is advisable to account for climate change effects, and therefore an extra 10% increase in mean annual precipitation was assumed (Jacques Whitford 2008). Therefore, the annual effective precipitation at the site is assumed to be 638.8 mm.

The existing and post-development surface runoff volumes were estimated by multiplying the estimated annual precipitation by its corresponding catchment area. The results are presented on Table 2.1.

**Table 2.1 Pre and Post Development Site Runoff Volumes**

<b>Scenario</b>	<b>Area (Ha)</b>	<b>Effective annual Precipitation (mm)</b>	<b>Runoff Volume (m<sup>3</sup>)</b>	<b>Mean annual Flow (L/s)</b>
Existing condition	3.9	484.0	18,876.0	0.59
Proposed Extension	13.9	638.8	88,793.2	2.81

Therefore, the expected increase in the average annual site runoff due to the proposed quarry extension is in the order of 69,917.2 m<sup>3</sup> or a 370% increase from the existing condition.

**2.3.2 Flow Retention and Siltation Treatment Sizing**

A summary of the hydrologic model parameters is provided on Table 2.2. These were used as the main input in the hydrologic model HEC-HMS.

**Table 2.2 Summary of Hydrologic Parameters used in HEC-HMS**

<b>Parameter</b>	<b>Quarry Extension Phase</b>
Initial and Constant Loss Method	Initial Loss: 2.5 mm Constant Rate: 7.6 mm/hr Imperviousness: 60%
Clark Unit Hydrograph Routing Method	Concentration Time (Tc): 1.2 hr

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**Table 2.2 Summary of Hydrologic Parameters used in HEC-HMS**

<b>Parameter</b>	<b>Quarry Extension Phase</b>
Included Storms	6 hour 1:25 year return period 6 hour 1:100 year return period
Subcatchment Area	0.139 km <sup>2</sup>
Baseflow	Not considered
Attenuation effects due to channel storage	Not considered
Modeling interval	5 min

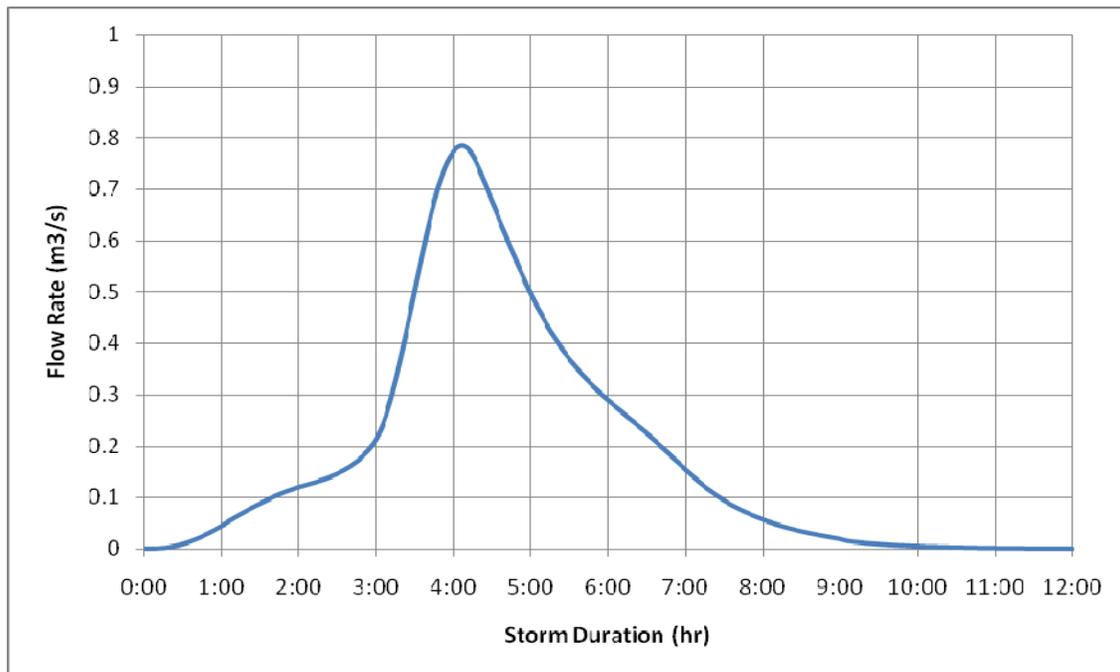
The parameters used in the hydrologic model to calculate the concentration time for the proposed quarry extension are included on Table 2.3.

**Table 2.3 Model Parameters used for the Calculation of Tc**

<b>Scenario</b>	<b>Area (Ha)</b>	<b>Flow Path Length (m)</b>	<b>Slope (m/m)</b>	<b>Concentration Time (min)</b>
Quarry Extension	13.9	600	0.002	72

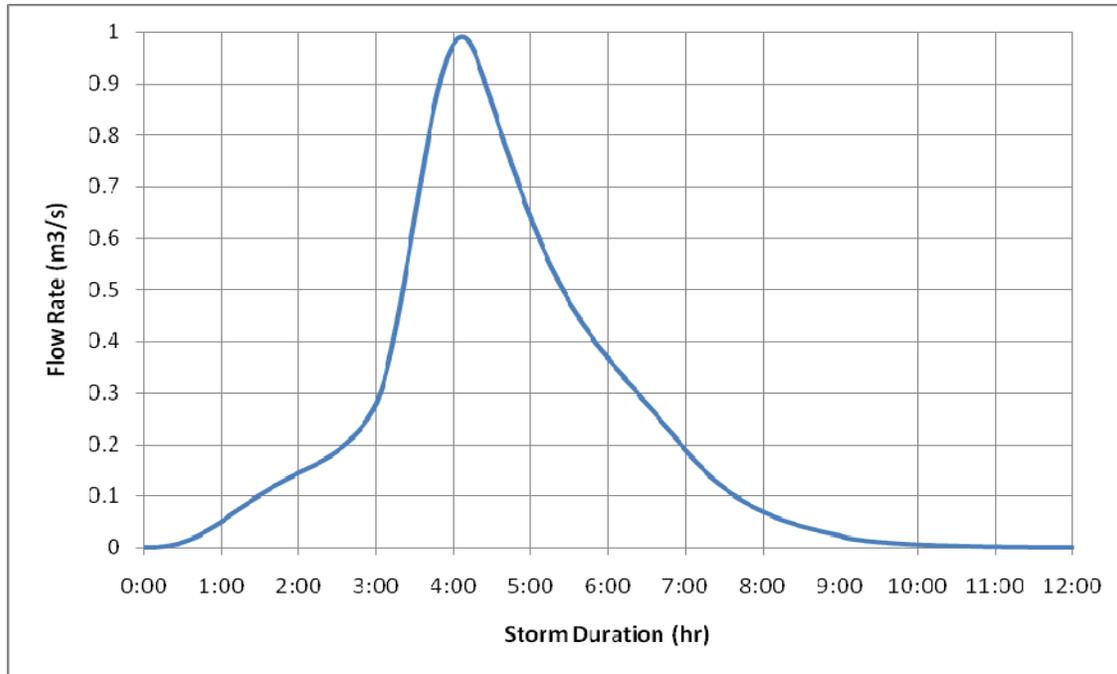
For all calculations it was assumed that all surface runoff originating from the upstream regions of the catchment area located off-site are diverted around the proposed quarry extension, and therefore no off-site catchment area is contributing to on-site surface runoff. Flow hydrographs developed for the 6 hour 1:25 and 1:100 year storms are shown in Figures 2.1 and 2.2, below.

**Figure 2.1 Flow Hydrograph for the 1:25 Year Rainfall Event for Full Quarry Extension**



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**Figure 2.2 Flow Hydrograph for the 1:100 Year Rainfall Event for Full Quarry Extension**



Based on model estimations for the 6 hour 1:25 year and 1:100 year rainfall events, the expected runoff peak flows and volumes as a result of the ultimate level of proposed quarry extension are shown in Table 2.4.

**Table 2.4 Estimated Runoff Peak Flows and Volumes for Different Rainfall Events**

<b>Extension stage</b>	<b>Return Period</b>	<b>Peak Flow (m<sup>3</sup>/s)</b>	<b>Volume (m<sup>3</sup>)</b>
Full quarry extension (proposed)	1:25	0.78	7,790
	1:100	0.98	9,850

It is recommended to size the flow retention structures to retain the volume from the 1:25 year rainfall event. Therefore, the total volume of retention storage for the site for the ultimate level of quarry extension should be in the order of 7,790 m<sup>3</sup>. This volume is only expected after the site has been developed fully, therefore it is feasible to maintain a smaller storage pond capacity which will require to be expanded with the quarry operation.

Based on the simulations completed for the 1:100 year 6 hour duration rainfall event, the peak flow is estimated to be in the order of 0.98 m<sup>3</sup>/s. The construction of stormwater retention structures will have an attenuation effect on the peak flow from the 1:100 year rainfall event, therefore, since the storage pond should be able to store the 1:25 year storm the discharge structure at the exit of the retention ponds should be designed to accommodate as a minimum the excess discharge between the 1:25 and the 1:100 year rainfall events.

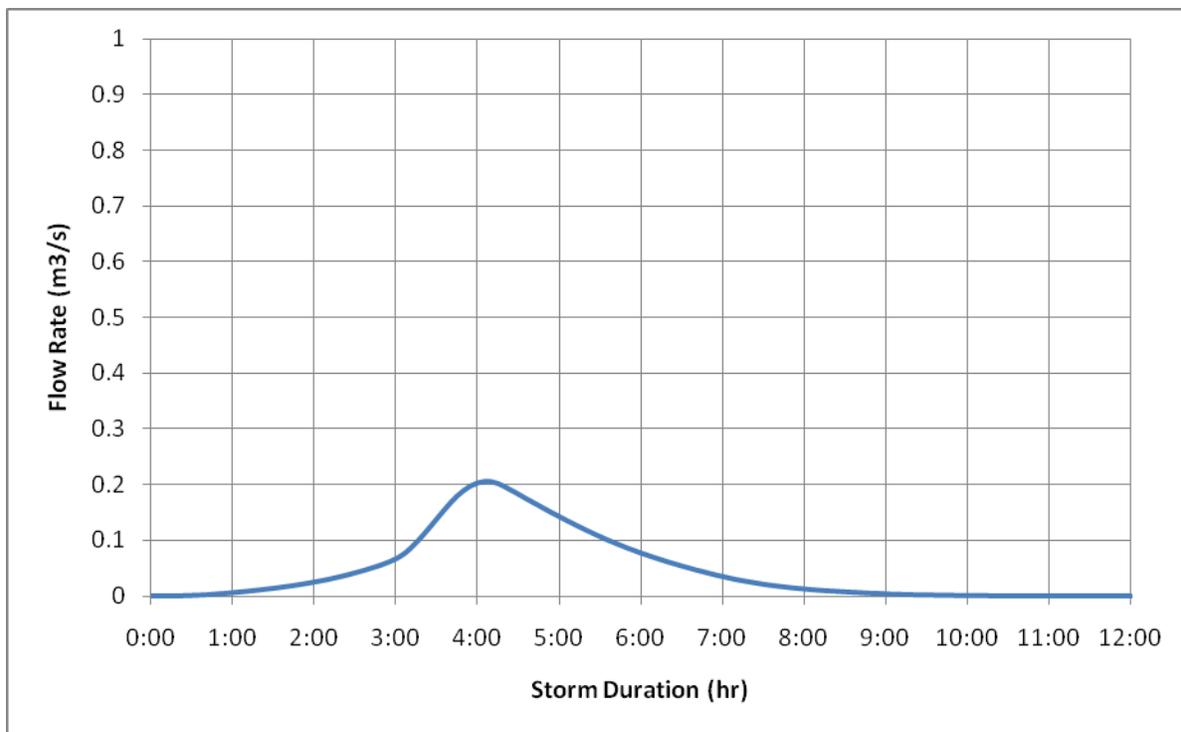
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Therefore, the difference in flow hydrographs between the 1:25 and 1:100 year rainfall events are shown on Figure 2.3. Based on Figure 2.3, the weir structure should be sized as a minimum to convey 0.20 m<sup>3</sup>/s.

Drawdown of water levels from the 1:25 year rainfall event detention storage level to the permanent pool retention level should be estimated based on the detention time that will improve water quality. A recommended drawdown period of 24 hours is expected to decrease suspended sediment concentrations by as much as 80%. Based on the low flow threshold of 24 hour discharge for runoff events equal or smaller than the 1:25 year rainfall event, the mean discharge capacity should be 0.09 m<sup>3</sup>/s. As a result, an appropriately designed weir is recommended as the most suitable discharge structure which is expected to control peak discharge volumes reducing the threat of downstream erosion and extending the discharge time to downstream hydrologic features.

**Figure 2.3 Excess Flow Rate from the 1:100 Year Rainfall Event with Storage Attenuation**



**2.3.3 Effects on Downstream Flows and Water Quality**

The full quarry development is anticipated to increase the total mean annual runoff at the site by 69,917.2 m<sup>3</sup> from the existing condition. As mentioned previously, there are a number of identified wetlands on the site that are not indicated on provincial mapping, it is assumed that the full development of the site as a quarry operation will result in partial and/or total removal of the field identified wetlands from the site. Although it has not been quantified, the elimination of

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these wetlands may also increase peak flows by reducing storage capacity. However, this effect is considered negligible when compared to other factors that influence flow routing and peak flow generation.

It is important to mention that control measurements must be implemented to minimize the impact on any streams and wetlands located downstream of the site. All surface water runoff that is being discharge to downstream receptors must meet all applicable guidelines for the protection of aquatic life and the aquatic environment.

The Nova Scotia Department of Environment Pit & Quarry Guidelines (revised on May, 1999) establishes that the maximum suspended solids concentration in any effluent leaving the site cannot exceed 50 mg/L. In addition, the maximum arithmetic monthly average suspended solids concentration cannot exceed 25 mg/L.

It is anticipated that the largest potential for water quality impacts due to the quarry extension and operation would be erosion and an associated increased in sediment loads. There are certain measures that can be adopted to reduce these impacts, including check dams along collection ditches and the placement of free draining cover materials over disturbed areas. The proper design of the retention ponds should include the capacity to remove sediment as needed to maintain the required volume and extend the life of the structures, or the addition of extra volume to accommodate sediment loads. Even with this measure, maintenance would likely be required from time to time to empty the retention ponds.

Surface runoff from the site should not be sent to downstream receptors before being routed in the retention ponds and the surface water runoff should comply with existing guidelines indicated previously to protect the aquatic environment. The streams are not likely to experience major changes in the flow regime as there are upstream areas of the subwatershed that can contribute to flow. However, a monitoring program for water quality and/or quantity may be warranted if major modifications to the aquatic regime are observed and corrective measures may be necessary to ensure that a good aquatic environment is maintained near the site.

### **3.0 CONCLUSIONS**

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The following conclusions are offered based on the hydrologic assessment for the proposed Hants Quarry extension project.

The existing annual site runoff volume for the site is estimated to be in the order of 18,876 m<sup>3</sup>. The expected total increase in the mean annual runoff for the site resulting from the proposed extension is in the order of 88,973.2 m<sup>3</sup> or a 370% increase from the existing condition.

The flow retention structures for the proposed quarry extension should be able to accommodate a volume of 7,790 m<sup>3</sup> during the 6 hour 1:25 year storm as the largest event. The dimensions of the proposed retention pond(s) will depend on site characteristics, as an example, a retention pond able to accommodate 7,790 m<sup>3</sup> can have approximate dimensions of 45 m x 45 m x 4 m.

The outlet structures for the retention pond should be able to accommodate a discharge of 0.20 m<sup>3</sup>/s, which corresponds to the difference in peak flows between the 1:25 year and the 1:100 year rainfall events.

Based on a recommended retention time of 24 hours for any precipitation event equal or smaller than the 1:25 year rainfall event, the discharge structure should be designed to conform to a mean discharge capacity of 90 L/s. This will facilitate the recommended 24 hour drawdown period. The maximum discharge capacity should be maintained as indicated previously.

Flow retention structures should be placed immediately downstream of the quarry facilities to capture all surface runoff before it is conveyed towards hydrologic features downstream of the site. This will also help to attenuate peak flows, reduce the slope of the recession limb and to some extent maintain pre-development conditions.

Drainage features should be constructed with appropriate erosion and sediment control measures to direct and convey site surface runoff to their corresponding flow retention and sediment control structures.

The surface water runoff from the site should comply with the applicable guidelines for the protection of the aquatic environment.

## **4.0 CLOSURE**

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This report has been prepared on behalf of and for the exclusive use of Municipal Enterprises Limited. This report represents the conditions of the property at the time of the assessment. The conclusions presented in this report represent the best judgment of the assessor based on current environmental standards. Stantec Consulting Ltd. attests that to the best of our knowledge the information presented in this report is accurate.

## **5.0 REFERENCES**

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