BURNSIDE

Flamborough Quarry Haul Route Study

Municipal Structure and Drainage Report

Prepared by

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File No: PIA 14459

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R.J. Burnside & Associates Limited
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1.0 Introduction

St. Marys Cement (Canada) Inc. has proposed to develop a Dolostone Quarry on Part of Lots 1, 2 and 3, Concession 11, Geographic Township of East Flamborough, in the City of Hamilton. The property is located on the north side of 11th Concession, just west of Milburough Line.

In April 2006 Dillon Consulting Limited prepared Terms of Reference for the Quarry Haul Route Evaluation on behalf of the City of Hamilton. Components of the Terms of Reference require that Alternative Haul Routes are identified, that existing baseline conditions of each alternative route are described, and a comparative analysis and evaluation is carried out. iTRANS Consulting Inc. have identified five Alternative Haul Routes, that are described and analyzed in the following report in the context of Municipal Structures and Drainage.

This report documents the consultant team, describes the environment, defines the analysis criteria and indicators, reports the analysis and results, and offers recommendations and mitigating measures.

2.0 Description of the Consultant Team

R.J. Burnside & Associates Limited (Burnside) has been engaged to prepare a report to document our assessment and analysis of various bridge, culvert and/or drainage structures located on the various alternative haul routes for the proposed Flamborough Dolustone Quarry.

The purpose of the report was to examine the location, size, type and general condition of each structure and to comment on the suitability of the structure to function effectively and safely as part of any proposed haul route. Consideration was given to either widening the structures or replacing them as part of any road improvements proposed for each alternative route. The report was also to comment on the various watershed characteristics associated with each of the bridge and culvert structures.

Finally, the report was to provide recommendations, based on these criteria as to the most preferred haul route for integration into a comprehensive report outlining the findings of a number of other specialty disciplines.

The Burnside consultant team for this assignment consisted of Mr. Stephen Riley, P.Eng. and Mr. Mark Hartley, P.Eng.

Mr. Riley is the Manager of Bridge Design for Burnside and has over 20 years experience related to the inspection, planning, design, approval and implementation of bridge and culvert projects. Mr. Riley heads a team of professionals who routinely undertake the inspection of bridge and culvert structures for a larger number of municipal clients, as part of the legislated requirement that all municipal bridge structures are inspected biannually. Developing repair and rehabilitation programs and / or planning for and preparing engineering design and documentation packages for structure replacement projects are day to day activities for the Burnside Bridge Group.

Mr. Hartley is with the Burnside Hydrotechnical Group and has been working around the rivers and streams of Ontario in a variety of capacities for almost 20 years. He has undergraduate degrees in Fisheries Science and Water Resources Engineering as well as a Masters degree in river hydraulics. He has extensive expertise in the areas of valley & stream corridor hydrology/hydraulics, natural channel design, fish habitat assessment and rehabilitation, low-flow hydraulics, fluvial geomorphology, sediment transport and water quality. He has analyzed the condition and capacity of a large number of culverts (CSP and concrete) and has designed and implemented several channel design and bank stabilization projects.

3.0 Description of the Environment

3.1 Haul Routes

The study area comprises five alternative haul routes between the proposed quarry and Highway 401 and Highway 6. Detailed maps of these routes are presented in Figures 1 through Figure 5 and include the following roads:

Alternative Route 1	Conc. 11E between Milburough Line and Highway 6 Highway 6 (Links 17 & 18)
Alternative Route 2	Conc. 11E between Milburough Line and Centre Road Centre Road between Conc. 11E and Campbellville Road Campbellville Road between Centre Road and Hwy 6 Highway 6 (Links 18, 1 & 11)
Alternative Route 3	Milburough Line between Conc 11E and Campbellville Road Campbellville Road between Milburough Line and Twiss Road Twiss Road from Campbellville Road and Reid Side Road Reid Sideroad between Twiss Road and Guelph Line (Links 5, 13, 26, & 27)
Alternative Route 4	Conc. 11E between Milborough Line and Highway 6 Milburough Line between Conc 11E and Campbellville Road Campbellville Road between Milburough Line and Twiss Road Twiss Road from Campbellville Road and Reid Side Road

	Reid Sideroad between Twiss Road and Guelph Line (Links 17,18, 5, 13, 26 & 27)
Alternative Route 5	Conc. 11E between Milborough Line and Centre Road Centre Road between Conc. 11E and Campbellville Road Campbellville Road between Centre Road and Hwy 6 Highway 6 Milburough Line between Conc 11E and Campbellville Road Campbellville Road between Centre Road and Twiss Road Twiss Road from Campbellville Road and Reid Side Road Reid Sideroad between Twiss Road and Guelph Line (Links 11, 1, 18, 5, 13, 26 & 27)

Alternative Haul Route 1

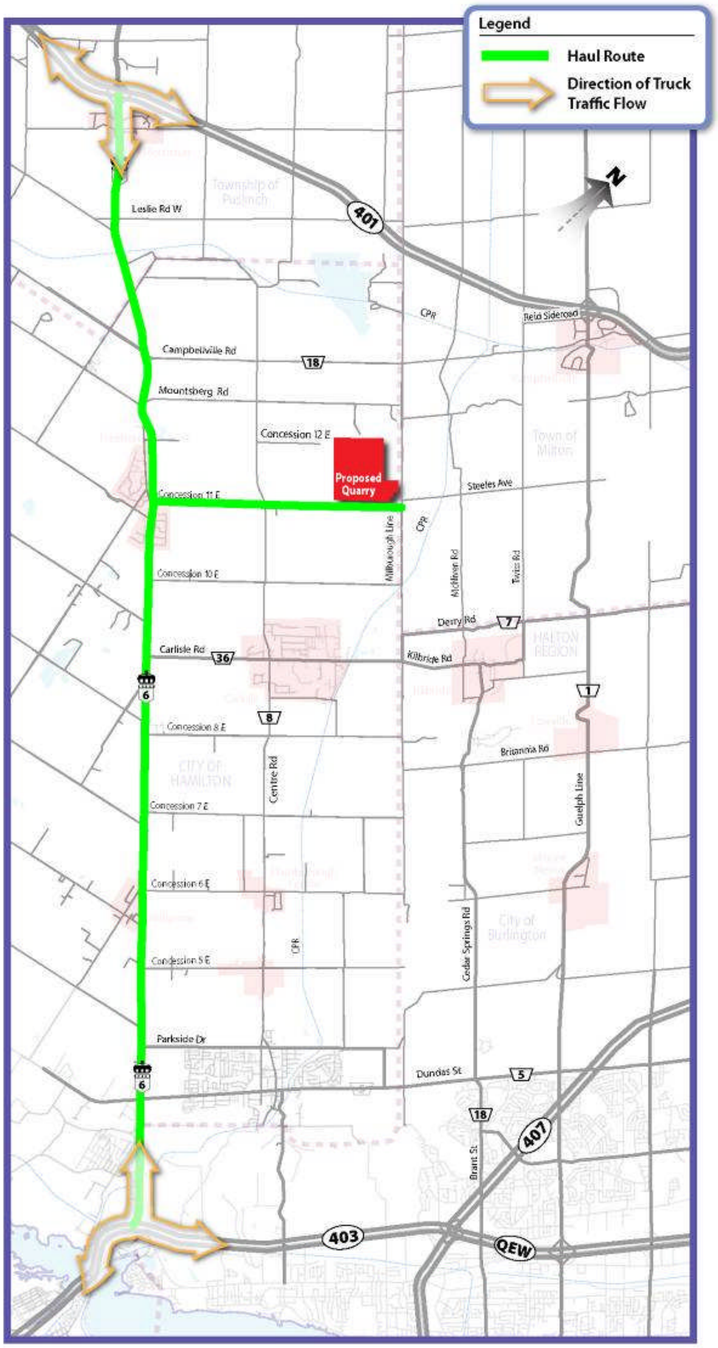

Figure 1: Alternative Haul Route 1

In the case of Alternative Haul Route 1, truck traffic destined for Highway 401 east would travel west on Concession 11 E, and then north on Highway 6 to the Highway 401 eastbound on-ramp.

Truck traffic destined for Highway 401 west would travel west on Concession 11 E, and then north on Highway 6 to the Highway 401 westbound on-ramp.

Truck traffic destined for Highway 403 east would travel west on Concession 11 E, and then south on Highway 6 to the Highway 403/QEW eastbound on-ramp.

Finally, truck traffic destined for Highway 403 west would travel west on Concession 11 E, and then south on Highway 6 to the Highway 403/QEW westbound on-ramp.

Alternative Haul Route 2

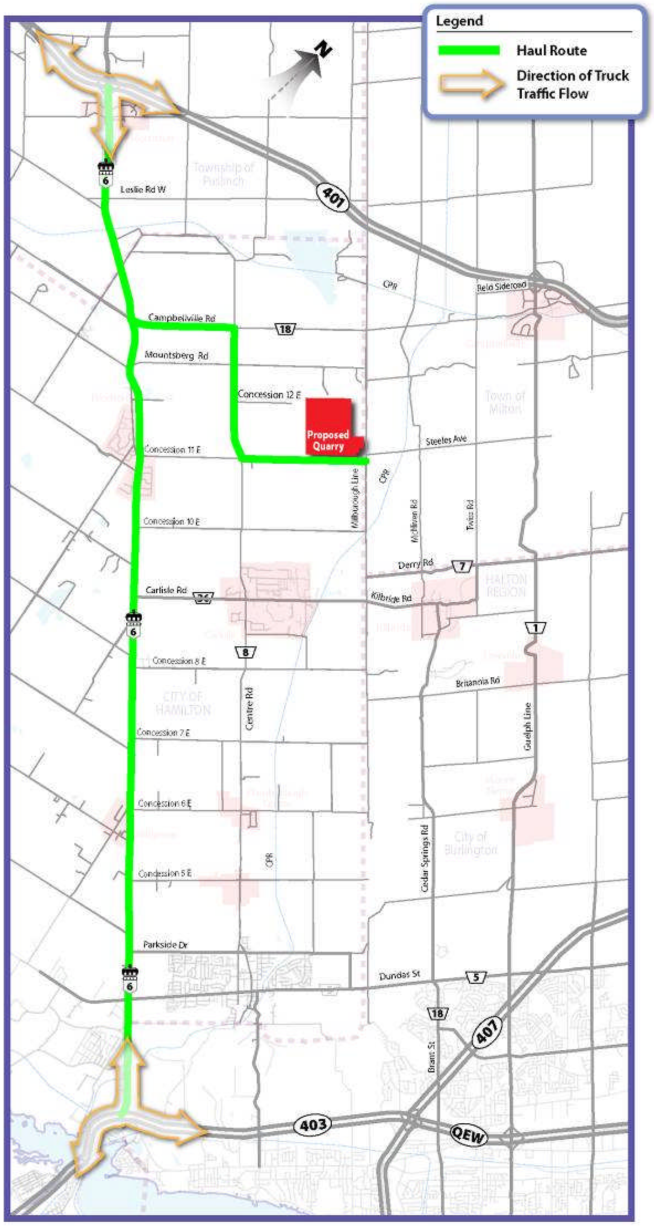

Figure 2: Alternative Haul Route 2

In the case of Alternative Haul Route 2 truck traffic destined for Highway 401 east would travel west on Concession 11 E, then north on Centre Road, west on Campbellville, and north on Highway 6 to the Highway 401 eastbound on-ramp.

Truck traffic destined for Highway 401 west would travel west on Concession 11 E, then north on Centre Road, west on Campbellville, and north on Highway 6 to the Highway 401 westbound on-ramp.

Truck traffic destined for Highway 403 east would travel west on Concession 11 E, then north on Centre Road, west on Campbellville, and south on Highway 6 to the Highway 403/QEW eastbound on-ramp.

Finally, truck traffic destined for Highway 403 west would travel west on Concession 11 E, north on Centre Road, west on Campbellville, and south on Highway 6 to the Highway 403 /QEW westbound on-ramp.

Alternative Haul Route 3

In the case of Alternative Haul Route 3, truck traffic destined for Highway 401 east would travel north on Milburough Line, then east on Campbellville Road, north on Twiss Road, and east on Reid Sideroad to the Highway 401 eastbound on-ramp.

Truck traffic destined for Highway 401 west would travel north on Milburough Line, then east on Campbellville Road, north on Twiss Road, east on Reid Sideroad and north on Guelph Line to the Highway 401 westbound on-ramp

Truck traffic destined for Highway 403/QEW east would travel north on Milburough Line, then east on Campbellville Road, north on Twiss Road, and east on Reid Sideroad to the Highway 401 eastbound on-ramp. From here, there are several alternatives to reach the destination including taking the 407 ETR south to Highway 403.

Finally, truck traffic destined for Highway 403 west would travel north on Milburough Line, east on Campbellville Road, north on Twiss Road, and east on Reid Sideroad to the Highway 401. From here, there are several alternatives to reach the destination including taking the 407 ETR southwest or Highway 6 south to the 403/QEW.

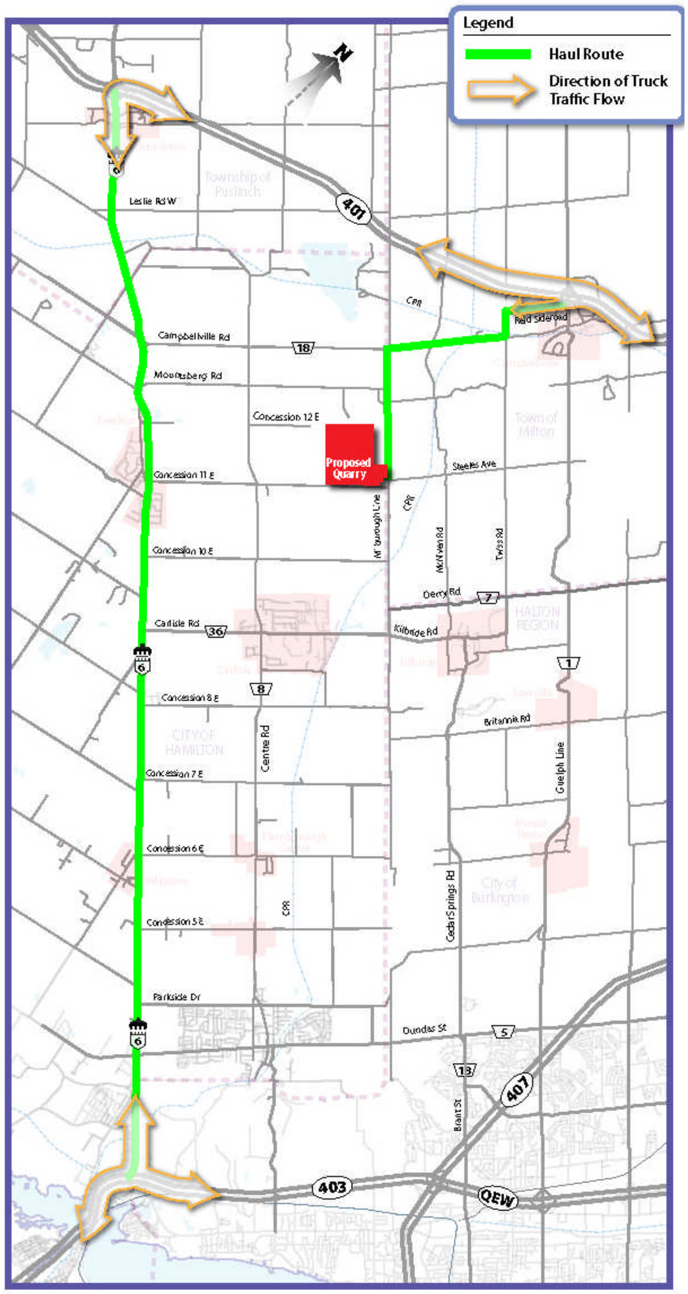

Figure 3: Alternative Haul Route 3

Alternative Haul Route 4

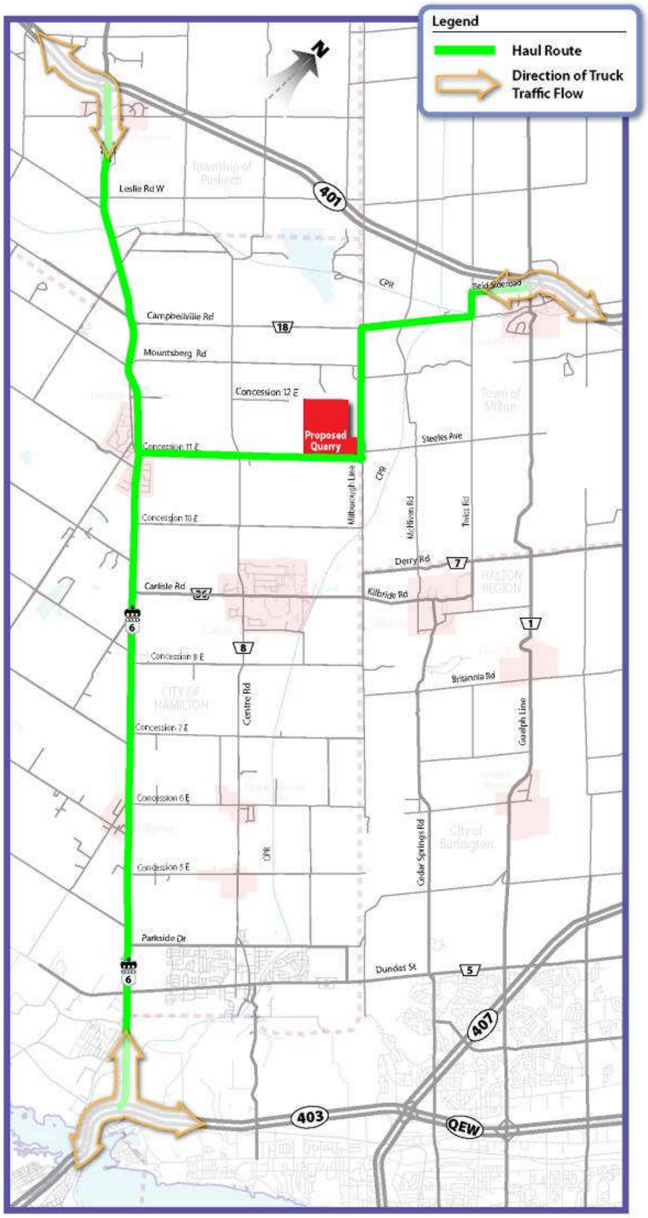

Figure 4: Alternative Haul Route 4

In the case of Alternative Haul Route 4, truck traffic destined for Highway 401 east would travel north on Milburough Line, then east on Campbellville Road, north on Twiss Road, and east on Reid Sideroad to the Highway 401 eastbound on-ramp.

Truck traffic destined for Highway 401 west would travel west on Concession 11 E, and then north on Highway 6 to the Highway 401 westbound on-ramp.

Truck traffic destined for Highway 403 east would travel west on Concession 11 E, and then south on Highway 6 to the Highway 403 eastbound on-ramp.

Finally, truck traffic destined for Highway 403 west would travel west on Concession 11 E, and then south on Highway 6 to the Highway 403 westbound on-ramp.

Alternative Haul Route 5

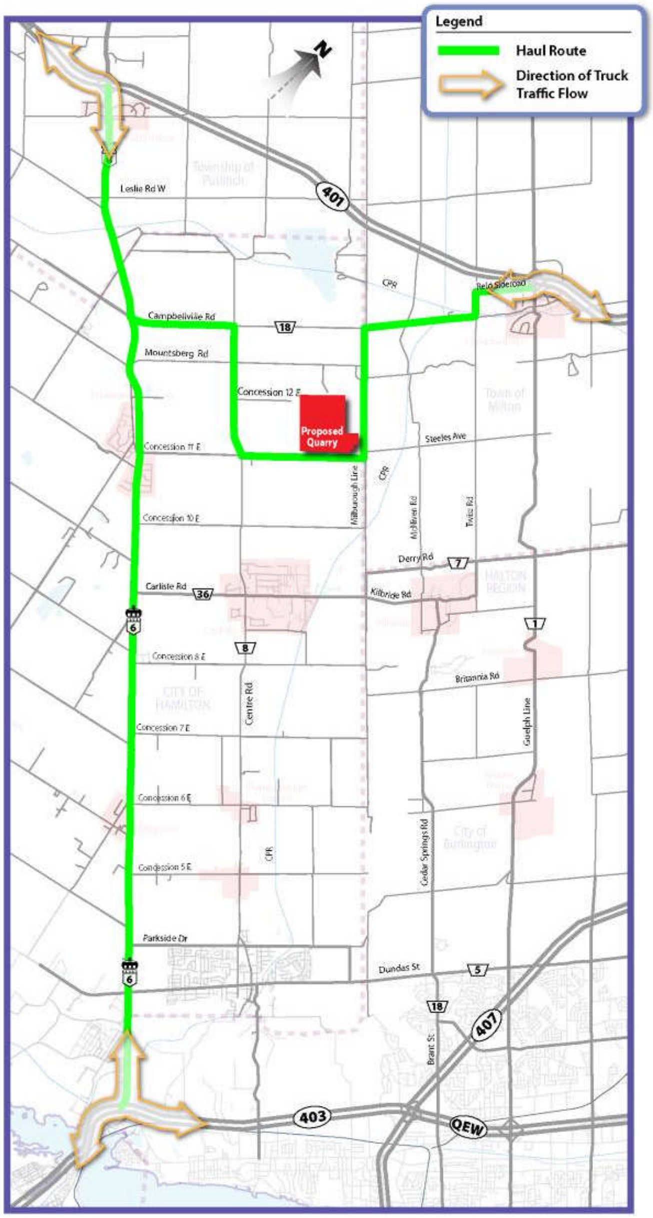

Figure 5: Alternative Haul Route 5

In the case of Alternative Haul Route 5, truck traffic destined for Highway 401 east would travel north on Milburough Line, then east on Campbellville Road, north on Twiss Road, and east on Reid Sideroad to the Highway 401 eastbound on-ramp.

Truck traffic destined for Highway 401 west would travel west on Concession 11 E, then north on Centre Road, then west on Campbellville, and then north on Highway 6 to the Highway 401 westbound on-ramp.

Truck traffic destined for Highway 403 east would travel west on Concession 11 E, then north on Centre Road, west on Campbellville, and south on Highway 6 to the Highway 403/QEW eastbound on-ramp.

Finally, truck traffic destined for Highway 403 west would travel west on Concession 11 E, then north on Centre Road, west on Campbellville, and south on Highway 6 to the Highway 403 /QEW westbound on-ramp.

3.2 Watersheds

These routes cross a number of small watercourses within the Bronte Creek watershed. These watercourses are within four subwatersheds, namely:

- Upper Bronte Creek;
- Mountsberg Creek;
- Flamborough Creek; and
- Killbride Creek

Upper Bronte Creek is approximately 52.0 km^2 in area, has a shallow gradient of 0.3% and flows through a series of wetlands associated with the Beverly Swamp Complex from Morriston to Carlisle where is meets Mountsberg Creek. The proposed haul route crosses Upper Bronte Creek at two locations; C03 and C04 (described below).

Mountsberg Creek is approximately 46.7 km^2 in area, has a shallow gradient of 0.3% and drains predominantly rural and agricultural lands north of Highway 401, through the Mountsberg Reservoir and meets the Upper Bronte Creek in Carlisle. The proposed haul route crosses Mountsberg Creek at one location; C02. This is the same location where flows have been recently monitored (SW-MC3). This work concluded that the Creek routinely experiences flows above 0.3 m^3/s and flows of over 1.0 m^3/s during the spring and fall (Stantec 2007). Baseflows of 0.08 to 0.10 m^3/s have been measured in the Creek.

Kilbride Creek, like Mountsberg Creek, originates well above Highway 401. Its' headwaters are above the Niagara Escarpment within the Guelph Junction Wetland Complex and is fed along much of its length by groundwater. The drainage area is approximately 34.6 km^2 and has a shallow gradient of 0.5%. Land-use is dominated by rural and agricultural activities. The proposed haul route crosses Kilbride Creek at one location, C01.

Flamborough Creek is the smallest subwatershed is the area and drains approximately 8.7 km^2. It originates from a series of wetlands associated with the Lower Mountsberg Creek complex and the North Progreston Swamp. There are no large crossings of the creek associated with the proposed haul route. The tributary of Flamborough Creek that flows past the proposed quarry site frequently experiences flows of 0.02 to 0.10 m^3/s in the spring and fall with prolonged periods of no flow in the summer (Stantec 2007).

The alternative haul routes will not cause a change in the flow regime (2-year return period to 100-year return period events) at any of the crossings. The size of each crossing is dependent on, amongst other factors, the road function and the total span as defined by the Ministry of Transportation. It may be necessary to modify the size of a particular crossing to accommodate the preferred haul route.

3.3 Structures

Four structures are located along the proposed haul routes as follows:

C01 – Located on Link 13 - Campbellville Road East of Nassagawaya 1st Line
C02 – Located on Link 18 - Concession 11 East of Centre Road
C03 – Located on Link 17 - Concession 11 East of Hwy 6
C04 – Located on Link 11 - Campbellville Road East of Hwy 6

A map identifying the location of each of the four structures is included in the appendix. It has been assumed that any structures located on Hwy 6, an existing and designated truck route, are not expected to require improvements.

Each of the haul route alternatives has the potential to be impacted by the presence of one or more of the structures as follows.

Alternative Route 1 – Potential impacts on structures C02 and C03.
Alternative Route 2 – Potential impacts on structures C02 and C04.
Alternative Route 3 – Potential impacts on structure C01.
Alternative Route 4 – Potential impacts on structures C01, C02 and C03.
Alternative Route 5 – Potential impacts on structures C01, C02 and C04.

Each of the four structures was visually inspected to the extent possible, given the weather conditions, snow cover and access limitations on the date of the inspection.

The following observations were made.

C01 – Campbellville Road East of Nassagawaya 1st Line

This structure is more accurately described as a system of three corrugated steel pipe arch culverts. Each culvert is approximately 1.8 x 1.2 meters in size and there is approximately 1.2 - 1.5 meters of fill above the structure obverts.

The roadside slopes are graveled with stacked rock or rip-rap protection to act as headwalls, erosion protection and to provide embankment stability.

The interior of each culvert did not show any significant signs of structure distress or deformation, although there are minor defects noted at the seams between culvert sections. The material is rusted in some locations, but no significant perforations could be seen during our inspection.

The roadside protection across the structure consists of three-cable guiderail on wooden posts. The cable guiderail was noted to be loose and some posts were out of alignment.

A three cable guiderail system may not be an appropriate system for this location.

C02 – Concession 11 East of Centre Road

This structure is a cast-in-place concrete rigid frame type of structure, approximately 7.0 meters in span by 1.5 meters in rise. There is less than 600 mm of fill over the structure, and as such, it is classified as a bridge under the Canadian Highway Bridge Design Code.

The structure is in good structural condition with no evidence of load-related distress. There was evidence that the structure soffit was wet in certain locations, but this may be due to water running in from the fascia rather than seeping through the deck. There was no evidence of material leaching through the concrete. A couple of minor concrete pop-outs were noted.

The structure barrier over the structure is three-cable guiderail on timber posts. This type of system is not appropriate for use on bridge structures.

C03 – Concession 11 East of Highway 6

This structure is a cast-in-place concrete rigid frame type of structure approximately 5.0 meters in span x 1.0 meter rise. There is less than 600 mm of fill over the structure, and as such, it is classified as a bridge under the Canadian Highway Bridge Design Code.

The structure is in good structural condition with no evidence of load-related distress. There is evidence that water is leaking down the face of the fascia and potentially between the concrete curb and the deck. The area is wet and stained, although there is no obvious scaling or deterioration noted at present. The structure soffit was wet in certain areas, but this may be due to water running in from the fascia rather than seeping through the deck. There was no evidence of material leaching through the concrete.

There is no barrier protection provided across the structure.

C04 – Campbellville Road East of Highway 6

This structure is a cast-in-place concrete rigid frame type of structure approximately 6.0 meters in span x 1.0 meter rise. There is less than 600 mm of fill over the structure, and as such, it is classified as a bridge under the Canadian Highway Bridge Design Code.

The structure is in good structural condition with no evidence of load-related distress. The structure soffit was wet in certain areas, but this may be due to water running in from the fascia rather than seeping through the deck. There was no evidence of material leaching through the concrete. There were a few areas of rusting on the soffit where cover to the reinforcement may be an issue. The top of the deck at the exterior was covered with a waterproofing wrap to prevent water (and salts) from seeping into the concrete.

The barrier protection over the structure is steel beam guiderail on timber posts and block-outs. The system has buried end treatments, which are no longer acceptable for systems terminating within the clear zone.

It is anticipated that improvements will be made to roadside facilities located on the final haul route. In evaluating each of the alternatives, the requirements for improvements to the existing structures should be considered. Information previously provided indicates that possible improvements may include:

- widening travel lanes
- adding paved shoulders for bikes
- adding shoulders and rounding
- improving vertical profiles

With this as the backdrop, we note the following:

C01 – Campbellville Road East of Nassagawaya

In assessing the long-term needs at this site, it is anticipated that the hydraulic capacity and performance of the existing structure will be assessed relative to the future road use and classification. The design criteria for the desirable hydraulic capacity of the crossing system, consisting of both the structure opening and the road profile, will be established by the road classification, structure size and return flood criteria as set out in Ministry of Transportation Directive B-100, or alternative criteria as may be set out by other authorities.

If the structure is found to be hydraulically adequate but the road platform is expected to be widened, it is recommended that a detailed inspection of the culvert interiors be completed to make note of any deformations, rust perforations or seam joint dislocations.

The weather was not conducive for this type of inspection at this time. To ensure the long-term service needs at this site, it may be reasonable to expect that these structures will be replaced as part of the road improvements.

If the roadway is not widened, as a minimum, any improvements to this system of culverts should include the construction of headwalls, cut-off walls and wingwalls. The headwalls and cut-off walls provide better roadside stability than the stacked rock walls that currently exist. Cut-off walls minimize water migration below the culverts which can undermine bedding support and backfill.

The roadside barrier protection at the site is not appropriate for this type of crossing. Three-cable guiderail systems are designed to deflect up to 3.0 meters laterally when struck by vehicles. They are supposed to be used where the ground is smooth, traversable and recoverable within the limit of the deflection. At this site, the ends of the culvert and a drop into the waterway are both within the margins of the deflection zone. As such, the three-cable system should be removed and replaced with steel beam guiderail with channel as a minimum. The guiderail system should be designed in accordance with the Ontario Ministry of Transportation - Roadside Safety Manual and should be terminated with an approved end treatment.

C02 – Concession 11 East of Centre Road

In assessing the long-term needs at this site, it is anticipated that the hydraulic capacity and performance of the existing structure will be assessed relative to the future road use and classification. The design criteria for the hydraulic capacity of the crossing system, consisting of both the structure opening and the road profile, will be established by the road classification, structure size and return flood criteria as set out in Ministry of Transportation Directive B-100, or alternative criteria as may be set out by other authorities.

If the structure is found to be hydraulically adequate but the road platform is expected to be widened, it is expected that this structure can be widened with similarly sized, cast-in-place concrete extensions using traditional construction methods. Modifications to the surrounding waterway may be required to align the stream within the new structure limits. A geotechnical investigation will be required to assess the foundation conditions, and approvals may be required from a variety of external agencies.

The roadside barrier protection at the site is not appropriate for this type of crossing. Three-cable guiderail systems are designed to deflect up to 3.0 meters laterally when struck by vehicles. They are supposed to be used where the ground is smooth, traversable and recoverable within the limit of the deflection. At this site, the ends of the structure and a drop into the waterway are both within the margins of the deflection zone. As such, the three-cable system should be removed and replaced with a code-conforming barrier system, such as a Three Beam Guiderail system. The barrier system should be designed in accordance with the barrier protection warrants of the Canadian Highway Bridge Design Code and the approach guiderail should be designed in accordance with the Ontario Ministry of Transportation - Roadside Safety Manual. The approach guiderail must also be terminated with approved end treatments.

C03 – Concession 11 East of Highway 6.

In assessing the long-term needs at this site, it is anticipated that the hydraulic capacity and performance of the existing structure will be assessed relative to the future road use and classification. The design criteria for the hydraulic capacity of the crossing system, consisting of both the structure opening and the road profile, will be established by the road classification, structure size and return flood criteria as set out in Ministry of Transportation Directive B-100, or alternative criteria as may be set out by other authorities.

If the structure is found to be hydraulically adequate but the road platform is expected to be widened, it is expected that this structure can be widened with similarly sized, cast-in-place concrete extensions using traditional construction methods. Modifications to the surrounding waterway may be required to align the stream within the new structure limits. A geotechnical investigation will be required to assess the foundation conditions, and approvals may be required from a variety of external agencies.

As a minimum, the structure must be provided with appropriate roadside barrier protection and approach guiderail. There is no existing roadside barrier protection at the site. The span of the structure is such that barrier protection is warranted, and further, the edge of the bridge structure and the waterway are both considered to be hazards, warranting protection under the Ministry of Transportation – Roadside Safety Manual. A code-conforming barrier system such as the Three Beam Guiderail system is warranted. The barrier system should be designed in accordance with the barrier protection warrants of the Canadian Highway Bridge Design Code, and the approach guiderail should be designed in accordance with the Ontario Ministry of Transportation - Roadside Safety Manual. The approach guiderail must be terminated with approved end treatments.

C04 – Campbellville Road East of Highway 6

In assessing the long-term needs at this site, it is anticipated that the hydraulic capacity and performance of the existing structure will be assessed relative to the future road use and classification. The design criteria for the hydraulic capacity of the crossing system, consisting of both the structure opening and the road profile, will be established by the road classification, structure size and return flood criteria as set out in Ministry of

Transportation Directive B-100, or alternative criteria as may be set out by other authorities.

If the structure is found to be hydraulically adequate, but the road platform is to be widened, it is expected that this structure can be readily widened with similarly sized, cast-in-place concrete extensions using traditional construction methods. Modifications to the surrounding waterway may be required to align the stream within the new structure limits. A geotechnical investigation will be required to assess the foundation conditions, and approvals may be required from a variety of external agencies.

The structure is currently protected with steel beam guiderail, which could be considered tolerable at this location due to the structures span. Steel beam guiderail is not usually considered as an appropriate bridge barrier protection system due to its deflection criteria. The approach guiderail system currently has buried end treatments, which are no longer an acceptable end treatment where a system terminates within the clear zone of a roadway.

As such, as a minimum, if the structure is not widened, the approach guiderail should have the existing end treatments removed and new appropriate end treatments, such as extruders, placed.

If the structure is widened, it would be appropriate to provide a code-conforming barrier system such as the Thrie Beam Guiderail system. The barrier system should be designed in accordance with the barrier protection warrants of the Canadian Highway Bridge Design Code and the approach guiderail should be designed in accordance with the Ontario Ministry of Transportation - Roadside Safety.

3.4 Cross-section Design and Analysis

For this study two types of cross-sections are proposed: rural (requires property acquisition) and urban (within the existing right-of-way). For the purpose of the analysis the rural cross-section was applied as it has the most significant impacts due to property acquisition and was therefore deemed more conservative. However, given the challenges that can be associated with land acquisition, the urban design that fits the existing right-of-way was also given consideration. It was concluded that this design would not require land acquisition however it would have a more significant impact on the existing character of the road and has a higher associated cost of construction.

Figure 6, Figure 7, Figure 8, and Figure 9 illustrate the proposed road bed design and shows rural and urban alternative cross-sections for both Type 1 and Type 3 sections.

Type 1

With the rural cross-section the proposed right-of-way is 2.0m greater than the existing 20m right of way. This cross-section allows for 3.75m travel lanes, 1.0m paved shoulder, 0.5m gravel shoulder, 0.5m rounding, and a drainage ditch.

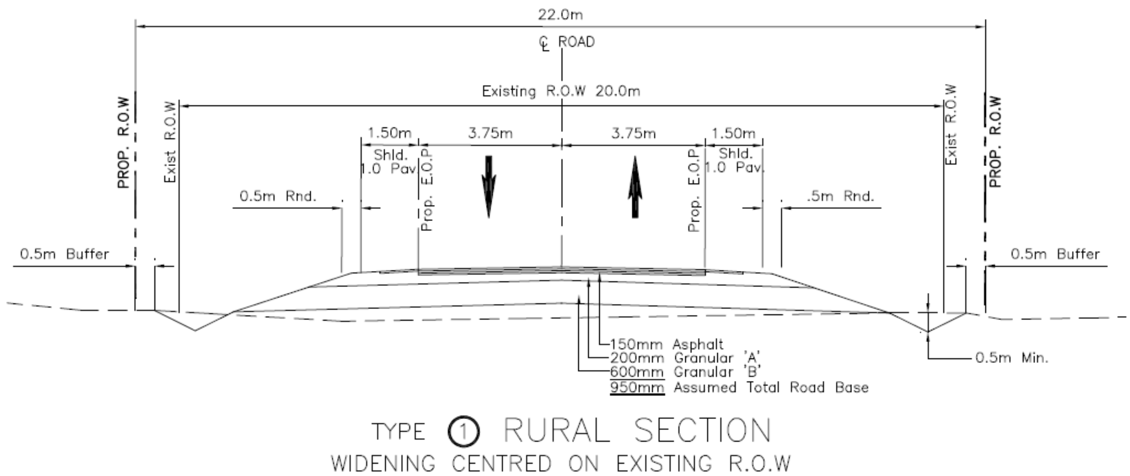

Figure 6: Type 1 Rural Cross-Section

With the urban cross-section the proposed right-of-way fits into the existing 20m right-of-way. The cross-section allows for 3.75m travel lanes, and a 1.5m paved shoulder with curb and gutter.

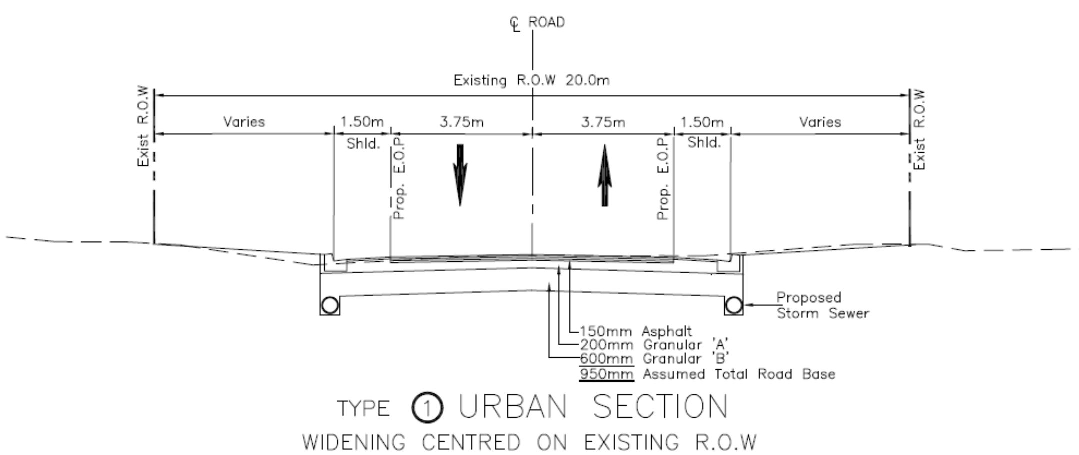

Figure 7: Type 1 Urban Cross-Section

Type 3

With the rural cross-section the proposed right-of-way is 3m to 7.5m greater than the existing right-of-way depending on the varying existing cross-section. This cross-section allows for 3.75m travel lanes, 1.0m paved buffer, 1.5m paved bike lane, 1.0m gravel shoulder, 0.5m rounding, a drainage ditch and a 0.5m buffer.

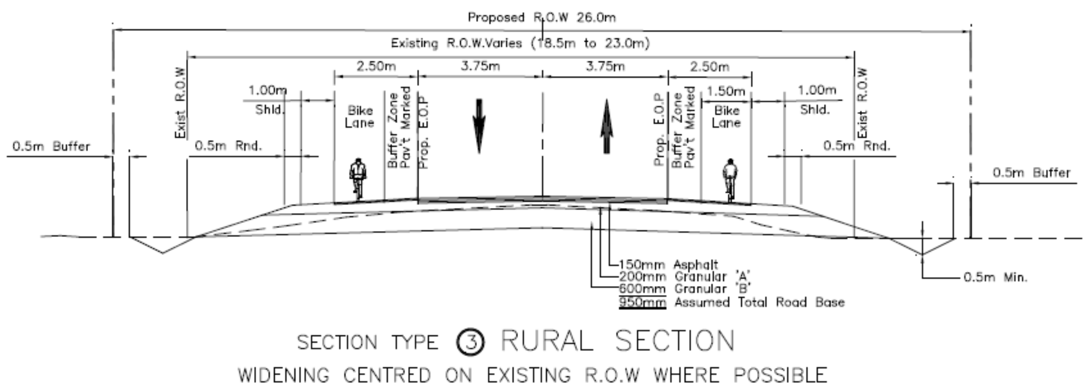

Figure 8: Type 3 Rural Cross-Section

With the urban cross-section the proposed right-of-way can be fit into the existing right-of-way that varies from 18.5m to 23m. The cross-section allows for 3.75m travel lanes, a 1.0m paved buffer, a 1.5m paved bike lake, and curb and gutter with a minimum boulevard of 3m.

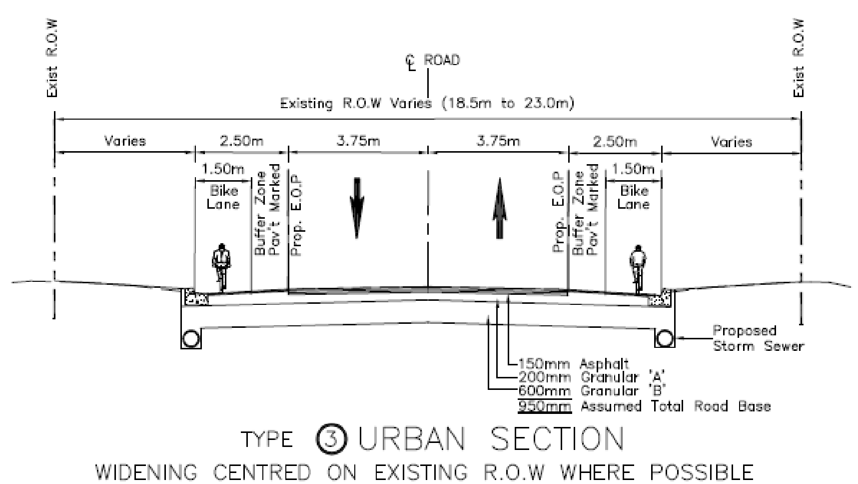

Figure 9: Type 3 Urban Cross-Section

It is important to note that both Type 1 and Type 3 section designs do not account for any changes in the existing profile and assume that widening is at existing profile grade.

While the urban cross-section fits into the existing right-of-ways, the storm sewer infrastructure and appurtenances increase the construction costs approximately 50 percent over the rural design. It is a trade off between the cost (and challenge) of purchasing land and constructing a more expensive infrastructure.

Applying the rural cross-section that would require land acquisition is a conservative approach for haul route comparative evaluation purposes. The decision on which cross-section to move forward with would be decided at the detailed design stage of an Environmental Assessment when pavement recommendations are finalized. Typically, resolution of the design details would occur during the subsequent Municipal Class EA process.

4.0 Analysis Criteria and Indicators

The primary criteria and indicators applicable to the structure and drainage component of evaluating haul route alternatives are the number of sites, the type or structure, and the cost of any upgrades required.

4.1 Number of Sites

Each of the haul routes will cross at least one structure. These were previously outlined as follows:

Alternative Route 1 – Potential impacts on structures C02 and C03.
Alternative Route 2 – Potential impacts on structures C02 and C04.
Alternative Route 3 – Potential impacts on structure C01.
Alternative Route 4 – Potential impacts on structures C01, C02 and C03.
Alternative Route 5 – Potential impacts on structures C01, C02 and C04.

4.2 Type of Structure

The type of structure existing at each location can impact the type and extent of upgrade that is required at each site. Certain types of structures are more easily widened or extended, while others are more difficult to widen. Certain types of structures require more impact on the local environment during construction, while other types an be constructed with less impact and certain types of structures offer more opportunities for habitat and environmental improvements during replacement.

The structure types identified previously are identified as follows:

C01 – Campbellville Road East of Nassagawaya 1st Line –is a series of three (3) - 1.8 meter x 1.2meter corrugated steel pipes.
C02 – Concession 11 East of Centre Road – is a 7.0 meter span x 1.5 meter high open footing cast in place concrete rigid frame.
C03 – Concession 11 East of Highway 6. – is a 5.0 meter span x 1.0 meter high, open footing cost-in-place concrete rigid frame.
C04 – Campbellville Road East of Highway 6 is a 6.0 meter span x 1.0 meter high, open footing, cast-in-place concrete rigid Frame.

4.3 Cost of Improvement

The cost of any improvement required is a reasonable consideration in evaluating the haul route alternatives. For the purposes of this report, the evaluation of the cost components of the necessary structure improvements has been based on anticipated bench mark replacement costs at each site.

The replacement costs can be summarized as follows:

Structure Location	Replacement Cost
C01 – Campbellville Road East of Nassagawaya 1st Line	$750,000
C02 – Concession 11 East of Centre Road	$550,000
C03 – Concession 11 East of Highway 6.	$575,000
C04 – Campbellville Road East of Highway 6	$550,000

5.0 Analysis

5.1 Data Sources

For the purposes of this assessment, the following data and studies were considered:

- A visual inspection of each of the structures undertaken by Burnside staff on February 6, 2008
- Previous Bridge Inspection Reports (various sources)
- Bronte Creek Watershed Study (Conservation Halton, 2002)
- Previous hydrologic studies for Flamborough Quarry (Stantec 2007)
- Ministry of Transportation Directive B- 100 – M.T.C Design Flood Criteria
- Canadian Highway Bridge Design Code
- Geometric Design Standards for Ontario Highways
- Ministry of Transportation - Roadside Safety Manual

5.2 Assumptions

The assumptions made in evaluating the haul routes from a structure and drainage perspective are as follows:

- That given the anticipated increase in both the volume of traffic and the loading of vehicles, it would be preferable to replace any impacted structure rather than to extend or widen the structure. While several of the structures could be widened as their condition is adequate for current loading, upgrading only parts of the structure would not be in the long term best interests as the service life of the structure may be impacted by the future performance of the existing components.
- That each structure would have to be wider than existing to accommodate the road improvements associated with each haul route alternative. In addition to the structural aspects of each site, safety of the public and vehicles would be paramount and adherence to the Geometric Design Standards for Ontario Highways table D7-1 will dictate side clearance and overall structure cross section geometry.
- That increases in traffic volume and truck percentages may result in a change in overall roadway classification, which may in turn, result in changes to the hydraulic performance criteria established by Ministry of Transportation Directive B- 100 – M.T.C Design Flood Criteria. We may find the existing structures are hydraulically undersized.
- That the alternatives that impact the fewest number of structures would be preferable.
- That the alternatives that have the lowest overall cost would be preferable.
- That the alternatives that minimize impacts on the waterway during construction would be preferable. This is advantageous as it minimizes the potential for a Harmful Alteration Disruption or Destruction (HADD) of fish habitat which requires authorization from the federal department of fisheries and oceans. Lost habitat must be compensated for on-site or nearby.
- That the alternatives that provide more opportunities to enhance fish habitat upon completion would be preferable. This is advantageous as, enhancements to fish habitat may qualify as partial compensation for habitat loss where there is a HADD either at the structure site or a nearby site.

5.3 Methodology

To evaluate the various haul routes from a structure and drainage perspective, Burnside considered the primary criteria and indicators identified previously, in conjunction with assumptions listed above to identify how each route compared. This involved the consideration of not only structural adequacy issues, but the broader scope of work and impact on the environment (particularly fish habitat) associated with traditional bridge and culvert structure projects. An acknowledgement of other areas of interest and expertise in related fields was also part of the assessment.

5.4 Results

In keeping with the previously identified primary criteria, the following results are provided:

Number of sites

Alternative Route 1 – Potential impacts on structures C02 and C03 or 2 Structures
Alternative Route 2 – Potential impacts on structures C02 and C04 or 2 Structures
Alternative Route 3 – Potential impacts on structure C01 or 1 Structure
Alternative Route 4 – Potential impacts on structures C01, C02 and C03 or 3 Structures
Alternative Route 5 – Potential impacts on structures C01, C02 and C04 or 3 Structures

Type of Structure

There were two primary types of structures noted in the study. These were open footing cast in place concrete rigid frame structures and corrugated steel, closed bottom structures.

Alternative Route 1 –Structures C02 and C03 are both open footing concrete rigid frames
Alternative Route 2 –Structures C02 and C04 are both open footing concrete rigid frames
Alternative Route 3 –Structure C01 is a closed bottom corrugated steel pipe
Alternative Route 4 –Structure C01 is a closed bottom corrugated pipes while Structures C02 and C03 are both open footing concrete rigid frames
Alternative Route 5 –Structure C01 is a closed bottom corrugated pipes while Structures C02 and C04 are both open footing concrete rigid frames

When replacing a structure, consideration must be given to the impacts of the proposed structure in a number of different areas. These include the obvious such as the structural capacity, structure cross section geometry, traffic service level, and public safety, as well as maintenance long term maintenance issues and structure durability. There are also performance measures relating to the hydraulic capacity of the structure to pass flood water during specified storm events and operational issues such as snow removal.

In addition, and becoming increasingly more important, consideration is given to the impacts on the immediate natural environment in terms of both the final product and the methods of construction required. While this is an area, most likely considered by other areas of expertise, it is also a key consideration for structural planning and design.

Typically, when replacing a structure, there is a need, or desire to nominally increase the span of the new structure over that of the existing. This is often due to a desire to improve hydraulic performance, but is also driven by the desire to have the new structure footprint outside the main channel available for flow passage. Moving footings outside of the main flow area can allow more of the construction work to be completed in the dry with less disturbance of the natural waterway. Where the waterway flows year round, it is often desirable, and requested by local conservation authorities, to maintain the central waterway intact during construction and to isolate the work areas using cofferdams. A larger span keeps the work area further away from the waterway.

This is most applicable to larger span structures anywhere from 8-10 meters and larger. For smaller structures, it is more difficult to maintain this separation due to the work areas required to build new structures and to remove existing foundations. For smaller structures, like those in the study area, it is more difficult to isolate the work area like this, and often by-pass culverts or channels are required.

For open bottom structures, such as C02, C03, and C04, there may be a possibility of preserving the natural channel during construction, which would be seen as an advantage.

For a closed bottom structure, such as C01, regardless of what type of structure is reconstructed, the removal of the existing structure requires considerable effort to reroute, bypass or otherwise manage the waterway. This means there is significantly more disruption of the watercourse during construction which is seen as a disadvantage.

Another aspect of planning for a structure replacement is the consideration of opportunities to enhance or increase fish habitat as a result of the work. Again, this may also be considered by other areas of expertise, but should also be considered by bridge planners.

For open bottom structures such as C02, C03, and C04, any proposed new structure can be made wider, providing more hydraulic capacity as discussed, but also providing additional areas for fish passage and or habitat for fish reproduction or rearing. However, it is unlikely that the new structure would be significantly wider, for hydraulic or other purposes, so there are limits to the ratio of increased habitat opportunities.

For closed bottom structures such as C01, it is likely that a new structure would be an open footing type or structure. This is increasingly becoming the direction taken by many conservation authorities and the Department of Fisheries and Oceans. In this scenario the opportunity to enhance or create fish habitat is significantly higher than that of a closed footing structure. The ratio of new productive habitat to existing habitat is significantly higher than closed footing structures, and as a result, this type of opportunity is considered as a significant advantage.

Generally, this opportunity for long term fish habitat enhancement or improvement would be seen as outweighing the temporary disturbance required to remove any type of structure.

Cost

The cost of the construction of each structure was noted in a previous section. Consideration must also be given to the overall cost of structures associated with each alternative haul route.

Haul Route Alternative	Structures Affected	Opinion of Probable Cost
Alternative 1	C02 and C03	$1, 125,000
Alternative 2	C02 and C04	$1, 100,000
Alternative 3	C01	$ 750,000
Alternative 4	C01, C02 and C03	$1, 875.000
Alternative 5	C01, C02 and C04	$1, 850,000

Estimated costs include the cost of bridge construction under a road closed condition. Costs include environmental controls, removal and replacement of bridge and road approaches, and engineering design but not any property acquisition that may be required.

6.0 Recommendations

Regardless of the haul route ultimately selected for the Flamborough Quarry improvements to the route will include work on one or more structures. Improvements will be required in terms of roadway geometry (lane widths, side clearances and bike paths, or similar) roadside safety (barrier protections, approach guiderail and end treatments) and possibly to improve hydraulic performance to meet minimum municipal standards.

A review of the existing conditions of each site resulted in the acknowledgement that certain structures (C02, C03 and C04) could, theoretically, be widened to accommodate any road improvements but structure C01 would have to be replaced. The conclusion reached about widening reflected the generally satisfactory performance of the structures under existing loads.

Further, long term planning considerations, such as remaining service life of the structures, the anticipated increase in loading and frequency of loading and potential differences in service life between old and new components of a widened structure have led to the conclusion and recommendation that any structure on the selected haul route should be replaced as part of the roadway improvements.

In the planning and design of any new structures the further recommendations would include:

- That consideration be given to providing an open bottom structure to maximize opportunities for fish habitat improvement and ease of construction.
- That the span should be selected to both improve hydraulic performance and minimize the finished footprint within the waterway and overbanks.
- That three sided, open footing, precast structures be considered as these do not require in-stream shoring during construction. This is particularly suited where the natural watercourse is preserved during construction.
- That the structures be designed in accordance with the Canadian Highway Bridge Design Code, the Ontario Geometric Design Standards for Ontario Highways, and the Ontario Roadside Safety Manual.
- That the relevant external agencies be consulted and any permits, approvals and or authorizations required be secured. This includes, but is not limited to the local Conservation Authority, the Federal Department of Fisheries and Oceans and Transport Canada who administer the Navigable Waters Protection Program.

Respectfully submitted,
R.J. Burnside & Associates Limited

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SPR/mjv

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Appendix A
Site Map

Flamborough Bridges
Legend
Labels of GISDBA.ASSET_BRIDGES
GISDBA.ASSET_BRIDGES

BURNSIDE

Appendix B

Site Photos

Photo 1: Structure C01 – View of road over structure.

Photo 2: Structure C01 – Elevation.

Photo 3: Structure C01 – Culvert barrel interior.

Photo 4: Structure C01 – Culvert barrel interior.

Photo 5: Structure C01 – Culvert barrel interior.

Photo 6: Structure C01 – Culvert barrel interior.

Photo 7: Structure C02 – View of road over structure.

Photo 8: Structure C02 – Elevation.

Photo 9: Structure C02 – Structure interior.

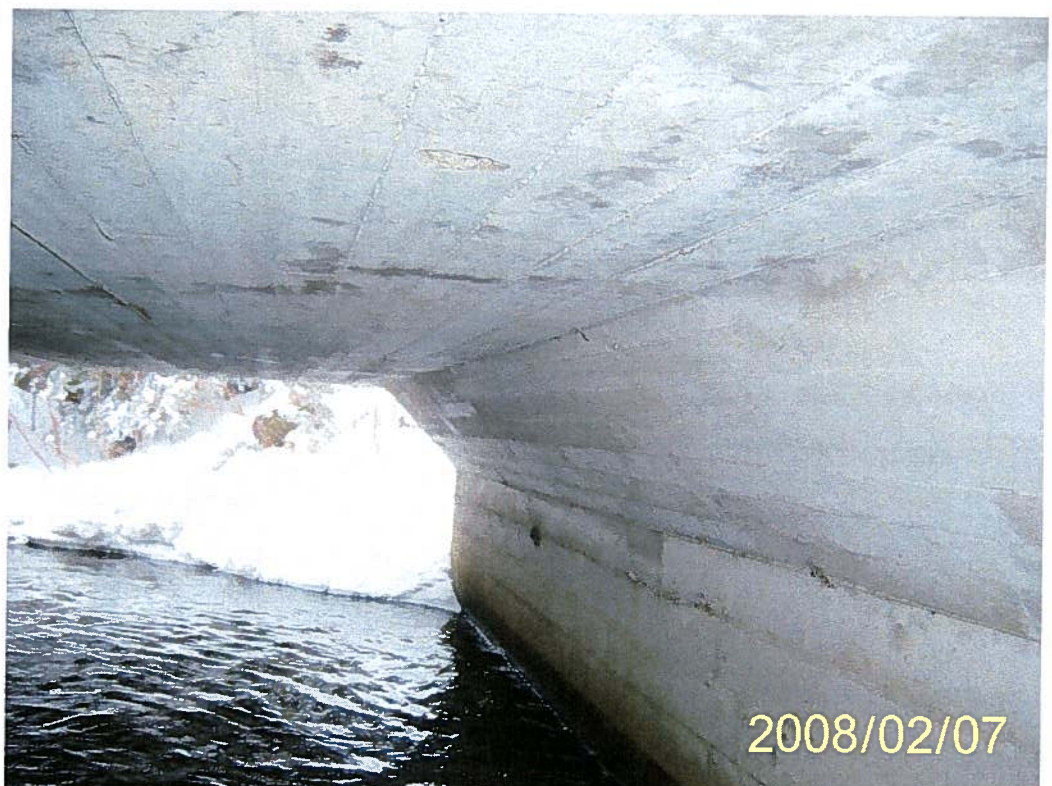

Photo 10: Structure C02 – Structure interior.

Photo 11: Structure C03 – View of road over structure.

Photo 12: Structure C03 – Elevation.

Photo 13: Structure C03 – Structure interior.

Photo 14: Structure C04 – View of road over structure.

Photo 15: Structure C04 – Elevation.

Photo 16: Structure C04 – Structure interior.

Photo 17: Structure C04 – Structure fascia.

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