King Road/CN Rail Grade Separation

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SUBMITTED BY:

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The following is a summary of a project conducted in the City of Burlington, on behalf of the Municipality, by Hatch Mott MacDonald (HMM) and AMEC Environment & Infrastructure, referred to as the King Road/CN Grade Separation. This summary provides background to the project need and process, focusing on the Environmental Achievements of the project.

BACKGROUND

In the early 2000's, the City of Burlington recognized that the Aldershot area, located in the north western part of the municipality was ripe for employment development. This zone is strategically located between Highway 403 and the Canadian National Railway (CN) corridor, which provides a good opportunity for high-value industrial and commercial development. King Road is a two-lane arterial road intersecting four tracks along the CN Rail (Oakville Subdivision). Although within an urban area, the road had not been upgraded from its rural origins, and still had granular shoulders. A key constraint to effective realization of the full potential of the Aldershot development area related to the bottleneck associated with the at-grade crossing of King Road and the CNR Oakville Subdivision.

The CN Oakville Subdivision, locally known in the rail community as "The Throat", has five separate subdivisions feeding over 100 trains per day through the three mainline track gauntlet. The 129 km/hour (80mph) rail corridor consists of a three-track mainline – the third track expansion occurred in 2009 as part of GO Transit's GOTRIP infrastructure improvement program. This corridor hosts Metrolinx commuter trains, VIA and Amtrak intercity passenger service, along with CN's transcontinental and international gateway freight traffic. In addition, a fourth track to the north serves as a lead track into CN's Aldershot yard and for routine shunting, interchange and storage of freight cars.

In recent years, this rail corridor has expanded and the increase in volume of rail traffic made the need for a grade separation imperative. The challenge was to develop a solution which would allow a grade separated crossing to be implemented while ensuring that the railway operated virtually uninterrupted during construction, as the volume of rail traffic did not allow for practical work blocks.

In addition, the Indian Creek, a locally-sensitive watercourse, flows immediately north of the existing railway. The creek conveys a 165ha drainage area, and is home to diverse wildlife and fish. The movement of fish and related passage was restricted by the existing corrugated steel pipes which crossed under King Road. As well, the local Conservation Authority who regulates the water course identified the Indian Creek, as having overall poor aquatic ecosystem health, and indicated that the area offered opportunities to enhance fish and wildlife habitat and water quality through stream morphology enhancements, and riparian plantings and naturalization.

Figure 1, included in the photo appendix, outlines the relation of King Road to the CN Railway Tracks and Indian Creek. As shown the site was highly constrained, and many innovative solutions were necessary to address the challenging conditions, which are outlined below.

PROJECT CHALLENGES

Premised on the foregoing, the City of Burlington commissioned a Municipal Engineers Association Class Environmental Assessment (MEA Class EA) in 2005. Hatch Mott MacDonald (HMM) and AMEC collaborated to complete a multi-disciplinary assessment of the local environment (technical, natural, social, and economic) leading to a preferred solution. Based on the outcome of the Class EA, a road underpass was selected as the most cost effective option. The key objective was to ensure minimal impact to the public, businesses, and the rail service during construction. However, the location of the grade separation, with its inherent physical constraints, and the fact that Oakville Subdivision is a major rail corridor that could not be shut down for long periods, required a new "out of the box" engineering solution. The Design Team led by Hatch Mott MacDonald called on its local and worldwide expertise to develop a solution that involved constructing a 2,400 tonne reinforced concrete bridge structure 'off-line' and then sliding it under the railway tracks over a 72-hour long Thanksgiving weekend in October 2012. To achieve the necessary clearances between Indian Creek and the underpass structure, the creek was realigned to the north. This allowed work to continue unimpeded, while protecting the conveyance and natural function of the existing creek.

Concurrently, given that the roadway was to be built under the railway, a solution to manage and maintain the Indian Creek was required. The Project Team evaluated a number of alternatives, and while typically these constraints are addressed by way of creek realignments and diversions, this was deemed neither feasible nor practical in this setting due to the proximity of industrial development east of King Road, and the residential development south of the railway. Hence, there was no practical alignment to relocate the Indian Creek away from the grade separation, short of purchasing existing residential property or existing businesses along King Road.

Due to the significant socio-economic disruption that this would have caused, the Design Team advanced an innovative solution which involved constructing the creek conveyance system "over" King Road by way of a creek bridge. To effectively implement this solution however, numerous physical and technical challenges had to be overcome through design and analysis. In addition, new design standards were required to successfully implement the first operating creek bridge to be built in Canada in over a century. The most fundamental of these related to raising the Indian Creek gradually so that its longitudinal gradient could be established for it to be effectively and sustainably conveyed over the roadway. This involved a creek realignment of some 480 m, negotiation with upstream property owners, and application of innovative Natural Channel Design principles. An overview of the relationship between the CN structure and the Creek Bridge is shown on Figure 2 in the photo appendix. In addition, Figure 3, 4, and 5 in the photo appendix show the reconstructed creek, along with the creek bridge shown in a temporary configuration.

In addition to reconstruction of the creek, AMEC's designers needed to conduct a number of complementary investigations and design tasks including the following:

Frazil Ice Assessment

Conservation Halton, the regulatory body for this watercourse system, conveyed concerns regarding the potential for frazil ice buildup in the creek bridge structure due to differential cooling of the concrete structure (conveying the water over the road) and the water flowing through the system. The concern related to the potential buildup of this ice over appropriate meteorological conditions leading to potential blockages and possible flooding of the underpass. This investigation determined that the potential was low and mitigating elements (insulation) was added to the creek bridge structure accordingly.

Natural Substrate

Conservation Halton and Department of Fisheries and Oceans jointly manage the fisheries interests for projects of this nature and hence required that there be consideration for naturalizing the creek bridge bottom. The objective was to allow fisheries and aquatic organisms to use and migrate the structure effectively. AMEC worked with HMM to develop a unique cellular bottom for the creek bridge which would hold natural stone and vegetation in-place during storm events and also provided a mild meander, which again promotes a more natural character to the structure.

Regulatory Event Capacity

Conservation Halton manages and regulates watercourses on the basis of extreme storm events. In this location, in Ontario, the Regulatory Event is a Regional Storm, based on Hurricane Hazel transposed to the Indian Creek watershed. AMEC and HMM worked to develop the geometry of a creek structure which could transition flows from the open waterway across the roadway and safely convey the Regulatory Event. The resultant creek bridge is a post-tensioned concrete U-shaped channel with 4.5m in width and 1.95m in height. As noted, the bridge can convey upwards of 17m^3/s of water which exceeds the Regulatory Event.

Leak Prevention

One of the fundamental concerns of all parties related to the potential for creek water to leak in this location into the underpass causing functional and maintenance concerns. In order to address this potential, the Study Team specified a unique clay liner, which covers the apron area and approaches. The liner is on the upstream side of the structure and is also attached to the vertical face of the creek structure using a concrete cap, which sandwiches the liner between two layers of concrete.

Erosion Protection

Given that the creek has been raised from its in-situ condition, regulators expressed concern about the potential for the system to downcut and thereby render the creek bridge ineffective or at worst result in ponding on the upstream and downstream sides. As such, the Study Team worked to implement a high-standard of erosion protection on the upstream and downstream approaches of the creek bridge. The protection on the upstream side of the creek bridge consists of a layer of impermeable material with clay soil placed in the embankments to provide permanent erosion protection. A particular focus was put on the embankment between the roadway and the creek block, which required additional protection to ensure erosion did not cause ‘breaching’ of the berm during significant storm events. The downstream protection was provided by a 4.5m wide and 20m long concrete protection system under the creek, which would protect the integrity of the creek and in turn the structure during significant storm events. Over 1500m^3 of impermeable clay liner and 3000m^3 of clay soil were placed to protect the creek structure from this erosion.

Flood Warning

Since the creek crosses over the road, Conservation Halton expressed concern regarding the potential for water to suddenly discharge from the creek onto motorists and flood the underpass. To mitigate this risk, AMEC designed a monitoring station consisting of a water depth sensor and associated recording equipment which communicates in real time directly with the City staff. As water in the structure rises, the sensor would determine the depth of water in the structure, which would then be communicated to the City maintenance staff, who can take appropriate action to protect the community.

Subway Drainage

Roadways which are oriented in an underpass configuration typically result in the roadway below the grade of an adjacent waterway receiver, resulting in the need for a pumping station to pump surface water to a suitable receiver. The original concept was advanced on this basis, however pumping stations are costly to construct, consume land which is often not readily available (for housing wet wells, pumps, power generators, and fuel, particularly in settings where there is existing development such as the King Road/CN area), and also require long-term maintenance (and liability) to keep the pumping station functional. AMEC again worked with HMM and the City of Burlington to examine various alternatives and developed a design for the construction of over 700m of storm sewer through the residential community to the south, ultimately discharging to the main branch of the Indian Creek, east of the site. This construction was quite complex given the amount of existing infrastructure in the area and the substantial depth of the system. The outlet point at the Indian Creek was only 4m below the low point of the Grade Separation; hence the longitudinal gradient only reached 0.3%. A 975mm diameter concrete sewer was required. Again construction was challenging given the high groundwater elevations and soil conditions, consisting mainly of sand. The storm sewer was constructed through the residential subdivision which in certain locations required a jack and bore operation under pedestrian pathways, with homes in close proximity.

PERMIT APPROVALS

Until the Class EA for the King Road Grade Separation was advanced by the Project Team of HMM, AMEC and City of Burlington, Conservation Halton and other regulators had not been previously involved in a project which proposed conveyance of a creek over a road structure. As would be expected, regulators had numerous technical and functional concerns, given the lack of a track record or precedence for this form of infrastructure.

Given the innovative and new concept, the regulators required numerous supplemental investigations to demonstrate that the system would work and would be sustainable in the long-term. The analytical approach and the design elements developed by AMEC, HMM, the City, and Conservation Halton in a partnership, have established a template for future designs with similar characteristics.

LONG-TERM COST BENEFITS

One of the more fundamental positive effects of the creek bridge solution was that it avoided all creek enclosures for this environmentally significant feature (the Indian Creek). By minimizing private driveway entrances, and a major culvert crossing of King Road, the creek is now fully open to the environment, and has the ability to function “naturally”.

The City has also dramatically reduced its maintenance and liability for what would have been four (4) long culvert enclosures. These typically give rise to managing sediment and debris at the inlets and also promote concerns associated with flooding. A fully open and unencumbered watercourse has effectively reduced this maintenance liability in the long term.

The gravity drain approach has similarly eliminated a long-term public liability associated with the upkeep of a grade separation pumping station. As noted, pumping stations typically require frequent and on-going maintenance to ensure that they are operable during storm events. This requires backup pumps and backup power systems, which despite all planning provisions, can still fail, thereby rendering the underpass impassable. The gravity drain solution has resulted in eliminating this risk and also the long-term liability associated with maintaining a pumping station. In addition, a secondary by-product of the gravity drain system through the residential area to the south of the railway has been improved drainage of the local streets and homes in this area.

CONCLUSIONS

With the system fully open to the environment, and through elimination of a number of barriers, fish passage has been dramatically improved with the creek reconstruction. As well, the reconstructed creek now has a defined low flow channel (thalweg) determined through the stream morphology assessment, which will improve the long term stability of the creek. Improved wildlife habitat has also been realized through creation of a Savannah Plain vegetation system, including creation of various habitat features. All of these features culminate to improve the long-term health of Indian Creek.

The non-conventional and innovative Creek Bridge concept proved to be environmentally superior and cost effective. In total, the Creek Bridge and creek reconstruction cost the City and CN approximately $2.2 million. The alternative would have cost approximately $9.4 million, as it would have had to include four long culvert crossings, along with the purchase of existing commercial properties in the area. While unusual to have a creek flow above a roadway, this innovation may lead others to adopt this approach in similar settings. The standards and techniques applied to analyze and permit the structure to be built provide a precedent for the industry, and the knowledge gained by Hatch Mott Macdonald and AMEC Environment & Infrastructure should be shared with others for future projects having similar challenges.

ORGANIZATION OR PERSON BEING NOMINATED

The key project participants consisted of:

- **City of Burlington** – project owner and proponent;
- **Canadian National Railway** (CN) – rail corridor owner and project co-owner;
- **Hatch Mott MacDonald – prime consultant responsible for overall project management and jacked structure planning and design;**
- **AMEC Environment & Infrastructure – consultant responsible for planning and design of the creek realignment, creek bridge, road and drainage; Thurber Engineering** – geotechnical consultant;
- **Dufferin Construction** – prime contractor responsible for the construction of the CN box structure and the aqueduct structure;
- **Western Mechanical** – jacking specialty contractor;
- **Esposito Construction –** responsible for road and creek construction.

Figure 1 - Existing Site Configuration

Figure 2 - Underpass structure under construction with creek diversion in place
(Background image courtesy of Rocco Cacchiotti)

Figure 3 - North/ south creek reach overbanks just planted and thalweg vegetated

Figure 4 - Temporary interim channel to Creek Bridge

Figure 5 – Indian Creek on structure (temporary connection)