APPENDIX F1

TANSLEY BRIDGE EA 2014

CLASS ENVIRONMENTAL ASSESSMENT REPORT

TANSLEY BRIDGE

BRIDGE NO. 005109

DUNDAS STREET AT BRONTE CREEK

CITY OF BURLINGTON

REGIONAL MUNICIPALITY OF HALTON

MTO SITE NO. 10-111

Halton REGION 35 YEARS OF SERVICE

MMM GROUP

MMM Group Limited

August 2014

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MTO SITE NO. 10-111

Report Prepared by:

LICENSED PROFESSIONAL ENGINEER
A. MONTELEONE
100153870
MARCH 24/15
PROVINCE OF ONTARIO

Agostino Monteleone, P. Eng., M.A.Sc.
Project Engineer
Bridge Engineering

Report Reviewed by:

LICENSED PROFESSIONAL ENGINEER
T. P. A. SMALL
March 24/15
PROVINCE OF ONTARIO

Trevor Small, P. Eng., M.Sc.
Senior Project Manager, Associate
Bridge Engineering

MMM GROUP

MMM Group Limited

August 2014

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EXECUTIVE SUMMARY

MMM Group Limited was retained by the Regional Municipality of Halton to review alternatives for the planned widening along Dundas Street from the existing four (4) lanes to six (6) lanes. This section of the Environmental Study Report presents alternatives considered, evaluation of alternatives, and recommendations of technically preferred alternative from a structural perspective for the widening of Tansley Bridge on Dundas Street.

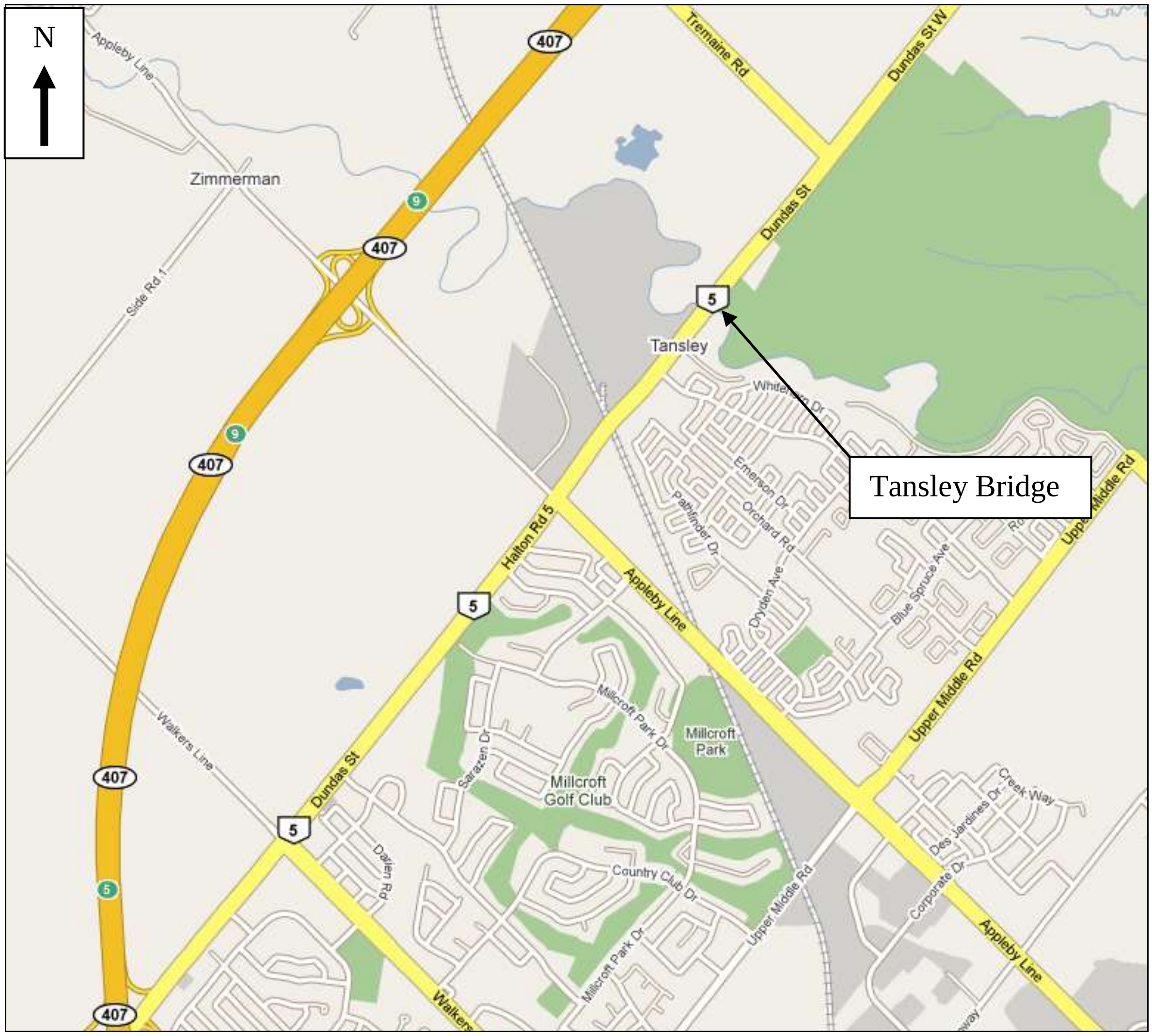
In general, the alternatives considered widening to the north, south, and combination of north and south. Subsets of the alternatives included retaining or replacing the existing EBL truss structure, which has heritage value.

Alternatives were reviewed for additional vehicle traffic lane capacity to be connected to the existing trusses. The addition of increased loads would require extensive strengthening of the truss components. The structural performance issues associated with cantilevering from the existing truss were identified. These issues, such as cracking of the deck and constructability concerns, will likely decrease the desired structural performance. As such, MMM does not believe there are practical engineering advantages in preserving the truss structure. MMM does recognize that removing the truss structure significantly detracts from the heritage value of the Tansley Bridge. It is recommended that a Heritage Bridge Documentation Report and a plaque recording the heritage significance of this structure installed near the west abutment.

The recommended alternative (Alternative 1) comprised widening to the north and replacing the existing EBL truss with a new steel girder bridge similar to the existing WBL structure. Moreover, Alternative 1 better predicts the structural performance and durability of the bridge. Criteria and constraints were used to evaluate Alternative 1, such as pedestrian and traffic impacts, heritage value, constructability, property requirements, impact to utilities, construction duration, future rehabilitation and durability, and cost. The approximate cost of Alternative 1 would be $36M.

Prior to undertaking preliminary design, MMM recommends a detailed slope stability analysis be carried out to assess possible failure of the east embankment during construction and the accessibility requirements for construction near the east pier.

KEY PLAN



Tansley Bridge
Burlington, Ontario

<u>KEY PLAN</u>
Scale: Not to scale

1. INTRODUCTION

MMM Group Limited was retained by the Regional Municipality of Halton to undertake a Municipal Class Environmental Assessment (EA) to address the future requirements for the planned widening of Dundas Street from the existing four (4) lanes to six (6) lanes. The study limits for the widening are from Guelph Line to Appleby Line. The Tansley Bridge, which carries Dundas Street over Bronte Creek, is within the study limits and will also need to be widened to accommodate the planned increase in the number of traffic lanes.

The bridge is a high level four (4) span structure comprising of two independent yet adjacent structures. The original structure was completed in 1948 and comprises a steel deck truss superstructure. The truss deck was modified and a steel girder type bridge was added on the north side of the crossing in 1978 to facilitate the widening of Dundas Street from two (2) lanes to the current four (4) lanes of traffic. The two (2) superstructures act independently of each other and are separated by a 25 mm wide longitudinal joint located in the median. The substructures for each structure also behave independently of each other.

The deck accommodates four (4) lanes of traffic; two (2) eastbound (EBL) and two (2) westbound (WBL) with an overall deck width of 22.25 m. The entire width, including the truss and girder structures, is 22.250 m. This width includes two (2) 0.455 m wide concrete barrier walls with a single parapet rail at the north and south end, one (1) sidewalk at the south side, and a 1.220 m wide concrete median separating the east and west traffic lanes. The 25 mm longitudinal joint is located in the median and the bridge is constructed on tangent with the roadway alignment. The clear width between curbs is 9.17 m.

This report discusses the future requirements for the planned widening and presents the following information:

- Overview of the history of the bridge;
- Detailed description of the structural implications of the four (4) widening alternatives considered;
- Criteria and constraints for the retained alternative;
- Cost estimate of the retained alternative; and
- Concluding remarks of the retained alternative.

A Key Plan showing the structure location is shown above.

2. EXISTING CONDITIONS

2.1 Truss Structure Description

The eastbound lane (EBL) substructure for the truss superstructure was constructed from 1946 to 1947 and the superstructure constructed in 1948. The superstructure comprises four (4) multi-span continuous deck trusses supporting a concrete deck. The four (4) spans are symmetrical about the midspan of the structure, being 45.7 m±; 61.0 m±; 61.0 m±; 45.7 m± from east to west respectively. Approach slabs, each 6.1 m long, flank both ends of the bridge.

The steel truss superstructure is composed of three arched trusses spaced at 5.5 m± centres, which vary in depth from 3.8 m at midspans and abutments to 7.6 m at the piers. Floor beams and stringers support the concrete deck. The reinforced concrete deck slab is 190 mm thick and the waterproofing and asphalt paving system is approximately 90 mm thick.

The substructure includes three piers and two abutments situated on concrete foundations. Each bent-like pier comprises two solid trapezoidal reinforced concrete shafts connected by an arched concrete panel and founded on spread footings on shale bedrock. Due to the steep valley of Bronte Creek, the piers vary in height from approximately 15.2 m to 27.4 m above the founding rock.

Articulation is provided by three fixed, disc steel casting bearings located at the centre pier, and twelve disc steel cast bearings with pintle type rollers at each of the other piers and at the abutments.

In 1971, the deck was strengthened by additional stringers placed at half-spaces between existing stringers.

The truss superstructure was rehabilitated in 1978, when Dundas Street was widened and the westbound lane (WBL) steel girder structure was constructed. The work in 1978 removed the deck cantilevers, constructed a sidewalk and barrier wall with single rail on the south side, constructed new expansion joints at the abutments, and provided a new raised median with longitudinal joint adjacent to the WBL structure. The structure modification reduced the width of the deck from 16.2 m to 12.3 m, and provided a new concrete deck with asphalt wearing surface and waterproofing. The trusses were essentially maintained as they were originally constructed, but the floor beam cantilevers were cut to suit the current deck width and the end floorbeams were replaced.

The bridge was rehabilitated again in 2004. The 2004 rehabilitation replaced the south barrier wall, patched the concrete deck, replaced the asphalt and waterproofing system, and replaced the longitudinal joint seal in the raised median.

Repairs were done in 2010 following the structural evaluation. The 2010 repairs strengthened the deficient truss and gussets to meet current load demands and replaced missing fasteners noted by MMM's inspection.

The EBL roadway cross-section has a 9.17 m travelled roadway comprising two (2) 3.66 m wide lanes, 0.40 m horizontal clearance from the centre median and 1.45 m right shoulder. A 1.81 m wide sidewalk is located on the south side.

2.2 Steel Girder Structure Description

The WBL structure was constructed in 1978. The superstructure is 9.9 m wide with four continuous spans (50.3 m±; 61.0 m±; 61.0 m±; 50.3 m±). The steel plate girder superstructure has three constant depth girders spaced at 3.5 m centres, and remains unlinked with the truss bridge.

The girders are not coated, even at the expansion joints, and comprise atmospheric corrosion resistant structural steel. The girders are composite with the concrete deck and an asphalt wearing surface is provided. The span arrangement matched the centreline of bearings of the truss structure at the piers, but the longer exterior spans extend past the abutments of the adjacent truss structure.

The substructure includes three piers and two abutments situated on concrete foundations. The pier footings were founded on shale bedrock. The abutment footings were constructed on compacted granular fill and founded on steel H-piles driven to bedrock. Each pier comprises one solid tapered reinforced concrete shaft, founded on spread footing. There are three fixed floating bearings located at the centre pier, and twelve guided expansion floating bearings at each of the other piers and abutments.

The roadway cross-section comprises 9.15 m travelled roadway including two (2) 3.66 m wide lanes, 0.40 m horizontal clearance from the centre median and 1.43 m right shoulder.

The bridge was rehabilitated in 2004 under the same contract that rehabilitated the EBL structure. The 2004 rehabilitation replaced the north barrier wall, patched the concrete deck, and replaced the asphalt and waterproofing system. Other work in the 2004 rehabilitation contract included filling of eroded and washed out areas of the east embankments and placing new rip-rap material.

2.3 1971, 1978, 2004 and 2010 Rehabilitation

In 1971, the structure was rehabilitated by the Region under Contract No. 71-137. Based on record drawings completed by the Department of Highways Ontario, the following rehabilitation was completed:

- Additional stringers were installed;
- Stringers were jacked against deck before making connections; and
- Timber beams installed at each manhole (1 at each pier).

In 1978, the structure was widened with a new westbound bridge and the existing deck was replaced by the Region under Contract No. 78-31. Based on record drawings completed by Cole, Sherman & Associates Ltd., the following rehabilitation was completed:

- Removed curb, rail, and part of deck, abutments, wingwalls and floor beams on north side of existing structure;

- Constructed substructure for the new plate girder bridge;
- Completed construction of the new plate girder superstructure;
- Waterproofed and paved the new deck ;
- Removed curb, rail, remainder of deck and cut floor beams on south side of existing structure;
- Conducted a thorough inspection of the bridge after slab removal;
- Replaced all missing and damaged rivets with high strength bolts and 2 washers;
- Replaced any excessively corroded or damaged truss or steel deck member;
- Cleaned and painted top surface of all floor beams with two coats of Koppers Bitumastic No. 50; and
- Replace the deck on the existing structure.

In 2004, the structure was rehabilitated by the Region under Contract No. R-1833B-2003. Based on record drawings completed by MMM, the following rehabilitation was completed:

- Removed asphalt and waterproofing;
- Removed and salvaged steel beam guide rail on approaches as specified;
- Removed and salvaged steel beam guide rail on approaches as specified;
- Install new railing for barrier wall;
- Removed deteriorated concrete from deck surface and patched deck surface;
- Patched the deck soffit beneath the longitudinal expansion joint;
- Place rip rap within washed out areas on embankment;
- Installed steel beam guide rails on approaches;
- Installed seal in longitudinal expansion joint;
- Abrasive blast cleaned and waterproofed remaining deck surfaces, and
- Placed base course hot mix asphalt and surface course asphalt.

In 2010, the structure was rehabilitated by the Region under Contract No. R-2280B-2010. Based on record drawings completed by MMM, the following rehabilitation was completed:

- Repair gusset plates on trusses; and
- Replace missing rivets and laces on trusses.

2.4 2008 Bridge Appraisal Reports

The most recent bridge appraisal report was completed in October of 2008. In this report, the consultant noted the following:

- Narrow to medium cracks, spall and delaminations on curb face
- Joints at piers and abutments, observed were: *"Concrete patches, localized spalls, partially covered with sand…West seals leaking, filled with debris"*
- On deck asphalt wearing surface, observed were: *"Localized cracking, minor rutting"*

- Deck soffits exhibited: *"Delamination …narrow stained crack."*
- Light to medium corrosion was observed in stringers, floor beams, top chords, verticals, diagonals, bracing and bottom chords
- One particular diagonal exhibited 20mm deformation to the flange
- Light to moderate rust jacking was also observed on connections with light corrosion
- Structural steel coatings exhibit localized minor breakdown, particularly on the north truss
- Abutment bearings exhibit light to medium corrosion

The bridge appraisal report also made the following 1-5 year rehabilitation recommendations:

- Patch repair abutment walls, ballast walls and wingwalls, piers, and replace expansion joint seals.
- Clean out debris and replace seals at joints over piers and abutments.
- Patch repair concrete for deck soffits near expansion joints.

2.5 2009 Condition Survey Summary

A detailed condition survey of both structures was performed in August 2009 by MMM. Detailed findings from the survey may be found in the Condition Survey Report by MMM, dated October 2009. The condition survey included corrosion potential survey, core samples, sawn asphalt samples, concrete cover measurements, recording of surface deterioration on half of the deck on each structure. The condition survey also included detailed visual inspection of the soffit of the deck, girders, trusses, gussets, and bearings of the WBL and EBL which was facilitated by an under bridge inspection vehicle. Girders, splices, bracing, and connections on the WBL structure were inspected and areas of corrosion noted, including measurement of remaining metal thicknesses by calliper or ultrasonic thickness gauge.

The truss structural steel was inspected in detail. Member sizes were confirmed including configuration of built-up member components (lattice and batten size and spacing, rivets size and spacing, etc.). Particular attention was paid to the gussets of the trusses. The gussets were photographed with scale and measured, and areas of corrosion and/or deformation recorded including condition of coating. Areas of perforations and corrosion were noted and remaining metal thickness measured with an ultrasonic measuring device at visually corroded locations. Furthermore, rivets were sounded at rust jacking locations and missing rivets recorded. Deformation, corrosion, and coating condition of the truss members and bearings were also noted, measured, and photographed.

2.5.1 Deck Condition Survey Summary

A summary of the significant findings from the deck condition survey is as follows:

- Asphalt paving and waterproofing system was generally in good condition on both structures. The asphalt and waterproofing on the deck varied from 46 to 95 mm and averaged 78 mm based on core and sawn asphalt sample measurements. The waterproofing membrane ranged from 3 to 19 mm thick with an average thickness of 8 mm. The bond and performance of the waterproofing was good.
- The deck surface at the sawn sample locations was fair and concrete in cores was generally good.
- The reinforcing steel in the concrete cores was generally in good condition.
- Concrete cover to reinforcing steel on the deck surface ranged from 64 to 103 mm with an average of 77 mm for the top upper layer (transverse) bars.
- The concrete compressive strength of two sample cores was 52 and 64 MPa with an average of 58 MPa.
- The corrosion potential readings were generally low (where waterproofed) with less than 2% of the deck area more negative than -0.35V and 24% of the deck had readings between -0.2 and -0.35V. Conversely, corrosion potential readings on the exposed concrete sidewalk were high with 57% of the sidewalk concrete more negative than -0.35V.
- Chloride tests on cores indicated relatively low levels of chlorides in the concrete, which based on limited test results does not appear to have reached the reinforcing steel in the deck (where waterproofed).
- The air content of the concrete was greater than 3% and specific surface was > 24 mm^2/mm^3, which is adequate, but the spacing factor of the air voids was slightly less than 0.20 mm.
- The deck soffit is generally in good condition with minor random cracking and staining except at the cantilevers adjacent to median longitudinal joint. Numerous areas with spalls and delaminations with exposed severely corroded reinforcing steel were noted on the soffit adjacent to the longitudinal joint in the median. Conversely, the deck cantilevers at the barriers were generally in good condition with minor spalling at the stringers of the truss bridge.

2.5.2 EBL Structure - Truss Components Condition Summary

A summary of the significant findings of the EBL superstructure truss components is as follows:

- The truss members adjacent to the longitudinal joint in the median had numerous areas of coating failure and exposed lightly corroded structural steel.
- The middle and south truss members were generally in good condition with minor and isolated areas of corrosion of the structural steel and few areas of coating failure.
- Seam corrosion and rust jacking was prevalent in the connections of the top chord and members of the truss adjacent to the longitudinal joint at the median. Isolated areas of seam corrosion and rust jacking were also observed at the connections at the piers of the middle and south truss. Corroded areas on gussets on the south truss were previously cleaned and recoated.
- With the exception of deformations due to rust jacking at some locations, no buckling deformation of the gussets was found. In addition, no coating

breakdown or cracks in the coating associated with buckling of the gussets was found.

- Seam corrosion with up to 30% section loss was found on some gussets along the flanges of the lower chord members. Up to 58% section loss was found along the seam of gusset L22E on the south gusset of the south truss.
- Some minor perforations up to 25 mm in diameter were found on two gussets at insignificant locations.
- A shallow laminar tear was found at the top of the south gusset of the south truss at the east pier.
- Minor perforations in battens and lower flange of truss members were found at four locations.
- A total of 26 fasteners were either missing or loose with no more than 1 fastener missing or loose at any location.
- "Ripples" between rivets due to crevice corrosion in the built-up members was found at several locations.
- Several wind bracing members were damaged or distorted either as a result of erection or platforms suspended for coating operations.
- The lower flange of the bottom chords of the middle and south truss were deformed due to jacking of the superstructure at the west pier bearings.
- Few coating defects were observed.
- The roller bearings are generally in good condition, but the gaps between the rollers are packed with dirt and debris, which may be affecting their performance.

2.5.3 WBL Structure - Steel Girder Components Condition Summary

A summary of the significant findings of the WBL superstructure structural steel is as follows:

- The north girder is in good condition except for areas of light corrosion on the north face of the web within 300 mm of the bottom flange.
- The middle girder is in good condition, with localized areas of light corrosion.
- The south face (adjacent to the longitudinal joint at the median) of the south girder web plate is in fair condition despite the large amounts of corrosion product and rust flakes. The web in the corroded areas measured between 7.7 mm and 10.7 mm with an average thickness of 9.2 mm.
- There was considerable corrosion on the splice places and nuts and bolts heads of the south girder on the south face (adjacent to the longitudinal joint at the median). However, no bolt heads were missing or severed due to rust jacking.
- Approximately 1 mm section loss was measured on the flanges of the north and middle girder, and only up to 2 mm section loss was measured on the flange of the south girder, despite the significant amount of corrosion product.
- Bracing and diaphragms between the girders was in good condition.
- Bearings were in good to fair condition with light to severe corrosion. The bearings at the west abutment were in the worse condition due to build-up of debris, from the expansion joint seal leaks above the bearings.

2.5.4 Substructure Condition Summary

The abutments are generally in good to fair condition with numerous spalls and delaminations on the ballast walls and bearing seats.

The piers of the WBL (girder) structure are generally in good condition with few areas of cracking and spalling.

The piers of the EBL (truss) structure are generally in fair to poor condition with many large areas of delaminated concrete and exposed corroded reinforcing steel along the full height of the columns and at the bearing seats.

2.6 Structural Evaluation Report and Urgent Repairs

A structural evaluation of the Tansley Bridge was performed in June 2009 by MMM. Detailed findings from the evaluation may be found in the Structural Evaluation Report by MMM, dated October 2009. The evaluation provided insight to the current condition of the structure and as well as the potential for widening to accommodate the planned increase in the number of traffic lanes. In this report, MMM noted the following:

- The results of the evaluation indicate theoretical compressive buckling in the unstiffened gusset plates along many of the top diagonal connection member and a few at the bottom diagonal member connections;
- EBL truss structure required strengthening to meet normal traffic load conditions. However, no signs of compressive buckling of the gussets were observed during the inspection. All deficient gusset plates were recommended to be stiffened, within six months. If strengthening the gussets were not feasible within this time frame, then triple posted load limits were recommended until the gussets can be strengthened. The gusset strengthening work was completed in July 2010;
- WBL girder structure has adequate load capacity which may be incorporated into the widening of Dundas Street;
- EBL truss structure has low reserve capacity of some truss members (diagonals and chords). The ongoing deterioration (corrosion) of the truss structure may warrant strengthening of the members, in addition to the repairs done in 2010, within the next 15 to 25 years.

In 2010, the structure was rehabilitated by the Region under Contract No. 2280B-2010 based on the results of the abovementioned MMM evaluation. The Contract drawings designed by the MMM, show the following repairs were completed:

- All deficient gusset plates were strengthened/repaired;
- All defective lace bars were replace; and
- Any missing fasteners noted during inspection or construction were replaced.

2.7 2011 Heritage Report

A Cultural Heritage Evaluation Report of the Tansley Bridge was submitted to MMM in November 2011 by Archaeological Services Inc. to establish the potential cultural heritage significance of the structure. It was reported that the east bound (truss) lanes of the Tansley Bridge retains high heritage value/significance. The following heritage attributes are noted:

- The Tansley Bridge retains important historical associations with the settlement of Tansley and the succession of bridges that have carried Dundas Street over the Bronte Creek since the early 1800s. The bridge is closely tied to the development of Dundas Street which continues to be an important transportation and communication corridor;

- The design of the bridge is an innovate response to the pressures and developments of that time period including economy, scarcity of resources, a general movement towards continuity in design, greater structural rigidity and functionality. It is an early example, and possibly the first in Canada, of a high-level bridge featuring continuous trusses, curved lower chords, and continuous girder;

- The bridge is considered a landmark feature in the context of the Bronte Creek Valley and is a prominent feature in terms of its size and design. It is highly visible and distinctive, and it contributes to the natural beauty of the surrounding landscape; and

- The widening of the bridge to the north in 1979 obscures the view of the Tansley Bridge from the north, but remains intact when viewing from the south. The design, massing and scaling of the new WBL bridge compliments the Tansley Bridge and does not take away from the design or historical values associated with the structure.

3. WIDENING ALTERNATIVES

MMM assessed the following four (4) alternatives. The cross-section of the widened structure will include the following (for all alternatives considered):

- One (1) 0.255 m wide parapet walls at the north end;
- One (1) 2.0 m wide sidewalk at the north end;
- One (1) 0.25 m wide barrier wall at the north end;
- One (1) 1.5 m wide WBL bike lane;
- Three (3) 0.3 wide WBL shoulders;
- One (1) 3.5 m wide WBL HOV lane;
- Two (2) 3.5 m wide WBL vehicle traffic lanes;
- One (1) 1.4 m wide median;

- Two (2) 3.5 m wide EBL vehicle traffic lanes;
- One (1) 3.5 m wide EBL HOV lane;
- Three (3) 0.3 wide EBL shoulders;
- One (1) 1.5 m wide EBL bike lane;
- One (1) 0.25 m wide barrier wall at the south end;
- One (1) 2.0 m wide sidewalk at the south end;
- One (1) 0.255 m wide parapet walls at the south end;

The resulting overall width of the structure will be 32.21 m. The following provides a discussion of each of the four (4) alternatives considered.

3.1 Alternative #1 – Widen Two Lanes to the North

This alternative involves widening the existing structure two (2) lanes to the north to accommodate additional traffic. The existing bridge deck will be removed and replaced with a new 225 mm concrete deck continuous over the entire deck width. The overall width of the bridge increases from 22.25 m to 32.21 m and the crown of the road shifts approximately 4.95± m north. Subsets of this alternative comprising of maintaining the existing truss structure or replacing it are discussed below.

3.1.1 Maintain Existing Truss Structure

MMM recognises the high heritage value of the truss structure, which was documented in the 2011 Heritage report. However, in order to maintain the existing truss, considerations must be made to not only examine the structural feasibility of such an operation, but also consider the on-going future maintenance and rehabilitation needs.

To accommodate the shift in the crown and maintain the existing truss structure, the longitudinal joint separating the two (2) structures will need to be eliminated to accommodate vehicular traffic. In other words, the differential deflections that exist now between the EBL and WBL structures must be eliminated by providing a continuous deck connecting the two (2) structures. This will combine the two dissimilar structures to work in unison. Connecting the two dissimilar structures is a structurally challenging task that requires careful design and detailing of modifying both the truss and girder spans.

To facilitate the connection of the two structures, a flexible (hinge) connection between the structures using a deck link system between the adjacent decks is proposed. However, since the two structures have unequal end span lengths, this is not a simple task. If the structures are connected, cracking is expected along the links caused by stresses due to differential temperature loading, shrinkage and creep, which are all dependent on structural stiffness and span lengths. Differential stresses between the combined structures will lead cracking which will decrease the durability of the structure.

The Condition Survey Report by MMM in 2009 indicates that the existing truss structure has localized areas of coating failure, light corrosion and rust jacking causing deformation. Going forward, this structure will require further maintenance repairs which will have negative implications on local traffic, economy and heritage value.

It is believed that the truss members will require strengthening in the future to make up for steel section losses from corrosion. This will affect the bridges appearance. The impact of such modifications may decrease the heritage value of the structure. A larger contingency allowance for this option would be required for construction and future rehabilitation.

The interaction between the two structures will require more detailed modelling and analysis than MMM has currently undertaken and other design issues may become evident.

As a result of the structural difficulties regarding connecting the EBL and EBL structures and high maintenance needs that the truss structure will require, maintaining the truss structure is not considered a preferred option and is not carried forward for further discussion in this report.

3.1.2 Replace Existing Truss Structure

Currently, the truss and steel girder structures act independently of each other and are separated by a 25 mm wide longitudinal joint located in the median. The substructures for each are also independent of each other.

This alternative involves converting the two (2) existing independent structures to a single steel girder structure by replacing the existing arch truss. The existing truss structure will be completely removed and replaced with a new steel I-girders superstructure, the existing WBL steel I-girders will remain, and a new steel I-girder superstructure will be constructed to the north to accommodate the widening. The existing bridge deck will be removed and replaced with a new 225 mm concrete deck continuous over the entire deck width. The barrier walls will be removed and replaced with new barrier walls.

The longitudinal joint provides a passage way for moisture and road salts to access the steel girders and substructure, as revealed in the Condition Survey Report by MMM in 2009. This has resulted in the large amounts of corrosion and rust flakes on the south face of steel girder adjacent to the joint at the median. Removing the longitudinal joint will benefit the long-term durability of the structure, which should mitigate future rehabilitation, maintenance operations, and avoid interruptions to traffic for joint maintenance.

The existing structure will be converted to semi-integral abutment bridge to enhance the performance and durability of the structure. Expansion joints will be eliminated at the end of the deck. The existing bearings under the steel girder will be replaced to accommodate the new bridge articulation and loads resulting from the semi-integral conversion.

Conventional bearings will be used to allow horizontal movement between the deck and the abutments.

The end spans of the WBL and EBL structures are currently of unequal lengths. This alternative will make the end spans equal across the full bridge width, which should eliminate differential stresses caused by creep, shrinkage and temperature loading.

3.2 Alternative #2 – Widen Four Lanes to the North

This alternative involves the complete removal of the existing truss structure, concrete deck and barrier walls to construct four (4) traffic lanes at the north side of the existing WBL structure. A new 225 mm thick concrete deck will be constructed over the new and existing steel girders. New north and south barrier walls will be replaced to match the new alignment. The existing WBL structure and new bridge sections built will be converted to semi-integral abutment bridge configuration to enhance the performance and durability of the structure.

This alternative is not desirable due to property acquisitions required and potential environmental impacts. Alternative 2 is not carried forward for further consideration in this report.

3.3 Alternative #3 – Widen One Lane to the North and One Lane to the South

This alternative maintains the existing centreline of Dundas Street and adds one (1) lane to the north and one (1) lane to the south of the existing bridge. The existing structure will be converted to semi-integral abutment bridge to enhance the performance and durability of the structure. The arguments for maintaining the existing truss structure or replacing to permit the widening are discussed below.

3.3.1 Maintain Existing Truss Structure

It is believed that there is no real practical solution to widening the bridge at the south end and maintaining the existing truss structure. However, MMM recognizes the benefit of maintaining the existing truss to preserve its high heritage value, and for that reason, this discussion is included.

It would be counterproductive to construct a new steel I-girder superstructure south of the truss to accommodate the widening, as the girders would conceal the arch truss and detract from its heritage value. Accordingly, widening at the south and maintaining the existing truss structure would require modifying the arch truss span to support steel work that will be cantilevered beyond the existing trusses. This is a structurally challenging issue that requires careful design and detailing, and each structure will still behave independently of each other.

Main load carrying flexural members must cantilever from the upper chord at each panel point and support secondary steel, deck and barrier concrete as well as superimposed live loading. Each cantilever member would be attached to the upper chord in a manner similar to the existing floor beams. However, unlike the existing floor beam connection, which currently only carries shear forces, the connection of the new cantilever beam will require both shear and moment capacity.

In addition, the new moment connection will apply a torsional moment to the upper chord which must be resisted by the structure. The vertical and diagonal truss members, due to their general slenderness, are ineffective in resisting this torsional moment. The top and bottom flange of the new cantilever section will need to be connected across the upper chord to the existing floor beam on the opposite side of the chord. In this manner we believe that the torsion on the upper chord can be eliminated.

Cover plates may be feasible however they may interfere with the gusset plates at the truss nodes. We believe it is feasible to install bolts in the interior floor beam web connection and to reduce the length of the connection somewhat. Openings (slots) would be required near the top of the truss member to pass top connection/gusset plates. In place of plates, high strength steel prestressing bars would appear to be more feasible. This is a complex connection detail that will make this connection very difficult however we do not believe the detail is impossible to construct.

The interior floor beam will aid in resisting this torsion however a portion of the bottom flange of the interior floor beam will, in certain loading situations, be in compression and will require lateral support with bracing. Bracing will also be required in the plane of the bottom flange of the cantilever beams to control torsional lateral buckling of these members as well. Deck reinforcement in the transverse direction will also aid in reducing the torsional moment (and rotation) of the lower chord member.

There are, no doubt, other design issues that are anticipated to become evident during detailed design. The interaction between the truss, interior, and exterior floor beams would require more detailed modelling and analysis than MMM has currently undertaken in this comparison of Alternatives. A larger contingency allowance for this option would be required for construction.

Maintaining the existing truss does not eliminate the longitudinal joint in the median. The joint has been found to be problematic as it provides a passage way for moisture and road salts to access the steel girders and substructure. Retaining the joint lessens the performance/durability of the structure, and future rehabilitation, maintenance repairs and interruptions to traffic are anticipated.

As a result of the structural challenges and anticipated performance/durability concerns associated with preserving the longitudinal joint in the median, this alternative is not recommended and is not carried forward for further consideration in this report.

3.3.2 Replace Existing Truss Structure

This alternative involves converting the two existing independent structures to a single steel girder structure. The existing truss structure will be completely removed and replaced with a new steel I-girder superstructure, the existing steel I-girders will remain, and new steel I-girders will be added to the north and south to accommodate the widening.

The existing deck will be completely removed and replaced with a new 225 mm thick concrete deck, with 90 mm thick asphalt wearing surface and waterproofing system. The existing north and south barrier wall will be removed and replaced to the match the new alignment of Dundas Street. The overall width of the existing bridge increases from 22.25 m to 31.31 m.

To facilitate the widening at the south end, an existing watermain utility located just south of the structure will need to be relocated to permit the construction of the substructure. Consideration must be given the other design issues that will become evident during the relocation of existing utilities. A larger contingency allowance for this option would be required for the utility relocation.

This alternative is not carried forward for further consideration because of the impracticality associated with attempting to relocate the watermain utility.

3.4 Alternative #4 – Widen Two Lane to the South

This alternative involves the complete removal of the existing truss structure (see Section 3.3.1 discussion), concrete deck and barrier walls to construct two (2) traffic lanes at the south end. A new 225 mm thick concrete deck will be constructed over the new and existing steel girders. The crown of the road shifts north approximately 15 m from its existing location, and the overall width of the existing bridge increases from 22.25 m to 31.31 m. New north and south barrier walls will be replaced to match the new alignment. The existing structure will be converted to semi-integral abutment bridge to enhance the performance and durability of the structure.

However, as mentioned in Alternative 3, the existence of a watermain utility closely located to the south portion of the bridge makes this an unrealistic alternative, and as such is not carried forward in this report.

4. EVALUATION OF ALTERNATIVES

4.1 Introduction

Alternative 1 is considered to be the most feasible option, and as such is evaluated based on the following constraints:

1. Impact on Heritage Asset;
2. Impact on Pedestrian;
3. Traffic Impacts;
4. Impact on Utilities;
5. Constructability;
6. Construction Duration;
7. Future Rehabilitation, Maintenance and Durability; and
8. Cost.

Each of these eight (8) criterion and constraints are discussed in the following for Alternative 1.

4.2 Impact on Heritage Asset

MMM recognizes the high heritage value of the existing truss structure. However, as discussed in Section 3, MMM does not believe there are practical engineering advantages in preserving the heritage aspects of the site.

A Heritage Bridge Documentation Report and a plaque recording the heritage significance of this structure installed near the west abutments are recommended.

4.3 Impact on Pedestrian

We believe the impacts on pedestrians during Alternative 1 will be minor. Currently, the Tansley Bridge has one (1) sidewalk at the south end for pedestrian use. The final configuration of the structure will have two (2) sidewalks; one (1) at each end. Alternative 1 provides at least one (1) sidewalk for pedestrian use during each phase of construction. Stage 1 construction permits pedestrian use on the existing sidewalk at the south end. During stages 2 and 3 construction, pedestrians will be shifted to the newly constructed sidewalk at the north end.

4.4 Traffic Impacts

Duration of construction may have the most impact on traffic during construction. We believe that Alternative 1 minimizes traffic impacts as four (4) lanes of traffic (two in each direction) will be provided during phases. Currently, four (4) lanes of traffic are currently in use.

4.5 Impact on Utilities

As previously noted, Alternatives 3 and 4 both result in significant impacts to the existing watermain utilities south of the truss span, and as such, these alternatives have been abandoned.

Alternative 1 does not require the relocation of the existing watermain utility south of the truss span.

4.6 Constructability

In broad terms, constructability can include many construction aspects including duration of construction and cost. In the following, MMM has assessed the risk associated with construction activities only, while not considering either cost or construction duration. The following discussion highlights key construction issues related to the steel truss modification, watermain utility, slope stability, erection methods, and temporary access for construction.

As discussed in Section 3.3.1 for Alternatives 3 and 4, cantilevering beyond the existing trusses requires substantial modifications to the existing truss. While this is not unproven construction technology, any modifications as substantial as this on an old structure are prone to extra work claims and construction overruns. The existing conditions cannot definitively be established prior to construction and additional costs can be anticipated as a result. This includes modifications to the steelwork, deck and foundations.

Alternatives 3 and 4 have several issues of constructability associated with the existing watermain utilities south of the truss span. As such, these alternatives are not carried forward for detailed financial analysis because of the impracticality and constructability concerns, such as relocating utilities.

Slope stability is a concern at the east abutment as the embankment is on a 45 degree (approximate) gradient to the pier. All slopes are susceptible to mass movement hazards if "triggering events" occur, and downslope movement is favoured by steeper slope angles. Reduction in slope (shear) strength and overloading from construction loads/operations are potential sources of "triggering events" present for the Tansley Bridge widening.

Slope stability exists in undisturbed slopes by the balance of forces that exist within an embankment. The removal of the east abutment and pier, which presently retain soil, may potentially alter the slope (shear) strength and undermine the slope.

It is recommended to avoid "over-construction" and to transport excess material offsite to avoid potential overloading of the slopes during construction. It is difficult to assess the potential for overloading during construction and its potential impact on constructability at the current level of consideration. This would require more detailed modelling and analysis than MMM has currently undertaken. A larger contingency allowance would be required for construction.

MMM recommends a detailed slope stability analysis be carried out by a geotechnical engineer to assess potential mass movement hazards and constructability near the east abutment and east pier. Detailed information such as characteristics of the soils, groundwater, and geology, are also required.

The construction over the deep valley with steep slopes offers a challenge to place the steel girders. The most reasonable way to place the girders appears to be by longitudinally pushing (or "launching") them into final position.

Launching is never the ideal economical procedure for constructing bridges. Considerable amount of analysis and design expertise and specialized construction equipment is required. More steel is typically required for the giders as they need to be designed to accommodate the cantilever loading during launching. However, it is considered to be the most appropriate erection method for this project as it offers the following advantages:

- Minimal disturbance to the surroundings (including Bronte Creek);
- Smaller, but more concentrated area required for superstructure assembly;
- Increased worker safety since all erection work is performed at a lower elevation; and
- Its an ideal erection method for steep slopes.

Each of the abovementioned alternatives will require access to the east pier to erect steel, install access/protection, strengthen existing foundations, and construction new foundations. All such activities will require a temporary access road to be constructed to support the construction equipment and materials over the existing Bronte Creek. One possible solution is constructing a temporary bridge embedded with corrugate steel pipes (CSP). The CSP would have approximately 30-40% of its diameter filled with original streambed material, a weir built downstream, and geotextile placed at both sides and over the top of the CSP to reduce the entry of fine material from the road fill into the stream.

In MMM's opinion, Alternatives 1 is constructible as it:

- Does not require strengthening/modifications to the existing truss structure;
- Does not require the relocation of utilities;
- Eliminates the longitudinal joint in the median; and
- Ensures the longitudinal spans are of equal lengths.

The abovementioned recommendation is based on the assumption that slope stability concerns are addressed and a temporary access road over Bronte Creek is permitted during construction.

4.7 Construction Duration

Each of the Alternatives represents a substantial construction undertaking as each does have some unique activities which may well affect the overall duration of construction.

Alternative 1 requires the removal of the existing truss, deck, barrier walls, bearings, conversion of the abutments to semi-integral type, and new steel I-girders.

Alternative 1 does not require any new or "unproven" construction technologies be undertaken (provided that abovementioned slope stability concerns are addressed by a geotechnical consultant). Therefore no unique activities, which may affect the overall duration of construction, are expected.

In total, we currently have estimated three-(3)-to-four-(4) years of construction is estimated for Alternative 1.

4.8 Future Rehabilitation, Maintenance and Durability

The combination of converting the two independent structures to a single structure behaving in unison and eliminating the existing longitudinal joint in the median significantly improves the long-term performance and durability of the structure.

The existing steel I-girders, abutments and piers will require substantial maintenance in the future and regular inspections by qualified inspectors to monitor any potential signs of structural distress typical with age, including fatigue damage.

The new structural steel will be a future maintenance requirement to clean and recoat.

Although MMM has not reviewed the Alternative 1 in sufficient detail at this point to fully assess all aspects of the detailed design, we believe that all Alternative 1 enhances the durability and performance of the existing structure, and minimizes future maintenance costs.

4.9 Cost

MMM has estimated the cost of Alternative 1 to be approximately $36M. The following assumptions should be noted:

- Cost is based on the MTO "Parametric Estimating Guide" and previous MMM project database;
- Inflation was not considered;
- Initial construction costs are considered only;
- Traffic control costs are not included;
- Engineering fees are included;
- Contingency fees (30%) is considered;
- Does not include any potential need to stabilize the slope at the east abutment; and
- Prices are in 2012 dollars.

5. CONSTRUCTION STAGING

Currently, Tansley Bridge accommodates four (4) lanes of traffic and one (1) sidewalk for pedestrian use. All construction stages will accommodate an equivalent number of lanes by shifting traffic from the existing portion to the new portion of the structure. Construction staging is discussed for only Alternative 1.

Stage 1 – Construct new substructure and steel girders immediately north of the existing bridge (new north bridge built to extend approximately 9m north from the existing north fascia). Vehicular and pedestrian use will be accommodated using the current configuration of Tansley Bridge. Four (4) traffic lanes and one (1) sidewalk will be maintained at all times.

Stage 2 – Remove the existing truss spans and substructure at the south end of the bridge by shifting the existing four (4) traffic lanes north. The existing truss will be replaced with a newly constructed steel girder superstructure, concrete piers, and semi-integral concrete abutments at the south end. Vehicular and pedestrian traffic will be accommodated on the new north structure and over the existing steel girder structure. A temporary concrete median barrier wall is required to separate east-west traffic. Pedestrian use will now shift to the south end, over the newly constructed sidewalk. Four (4) traffic lanes and one (1) sidewalk will be maintained at all times.

Stage 3 – Remove/replace the concrete deck over the existing steel girder superstructure by shifting two (2) lanes of traffic to the south end. The north end will continue to accommodate two (2) traffic lanes and one (1) sidewalk for pedestrian use from Stage 2. Traffic will shift to the newly constructed south end to accommodate two (2) traffic lanes and one (1) sidewalk for pedestrian use.

Final – Place all six (6) traffic lanes and two (2) sidewalks for pedestrian use onto the structure for permanent use.

6. CONCLUSIONS/RECOMMENDATIONS

Based on the above, Alternative 1 is recommended to be the most feasible alternative when considering practicality, constructability, construction duration, property access, traffic impacts, and economy.

This solution has less construction risk, and avoids the complex and potentially troublesome connections required in Alternatives 3 and 4 to cantilever the steel supporting the sidewalks and traffic lanes to the truss. Furthermore, Alternative 1 better predicts the structural performance and durability of the bridge, while not requiring the relocation of utilities.

The longitudinal joint between the two structures has proven to a source of problems. The elimination of the longitudinal joint in Alternative 1 is considered necessary to enhance long-term performance and durability, minimize future rehabilitation and maintenance, and allow traffic to comfortably cross the joint.

MMM recognizes that Alternative 1 significantly detracts from the heritage value of the structure. It is recommended that a Heritage Bridge Documentation Report and a plaque recording the heritage significance of this structure installed near the west abutment.

To avoid the cost of property acquisition, Alternative 2 was abandoned. However, MMM recognizes merit in Alternative 2 for future widening to accommodate eight (8) traffic lanes (if required).

If heritage preservation is of significant importance, Alternative 3 may be considered. However, the cost premium and technical disadvantages noted above should be recognized. It is MMM's opinion that preserving the existing truss to accommodate the widening has a "forced appearance" solution dictated by the requirement to retain the truss structure.

The construction over the deep valley with steep slopes offers a challenge to place the steel girders. The most reasonable way to place the girders appears to be by longitudinally pushing (or "launching") them into final position. However, other options should be examined.

MMM recommends a detailed slope stability analysis be carried out by a geotechnical engineer to assess potential mass movement hazards and constructability near the east abutment and east pier.

APPENDIX A

PRELIMINARY GENERAL ARRANGEMENT OF RETAINED ALTERNATIVE

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Field Notes
REGION BOOK

Stamp

Regional
ACCEPTED FOR CONSTRUCTION OF REGIONAL INFRASTRUCTURE
Reviewed For Compliance With Regional Standards Only.
Director
Manager

MMM GROUP

Halton REGION

TITLE
GENERAL ARRANGEMENT
TANSLEY BRIDGE WIDENING
BURLINGTON – HALTON
OVER BRONTE CREEK

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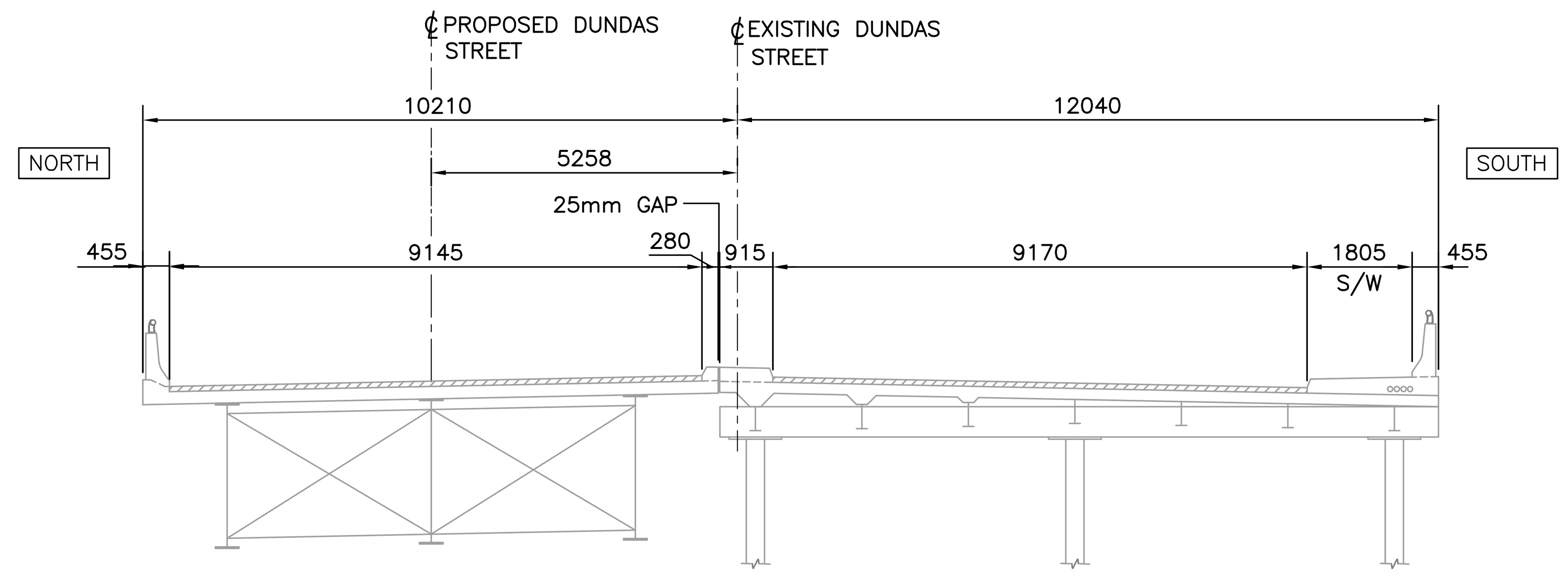

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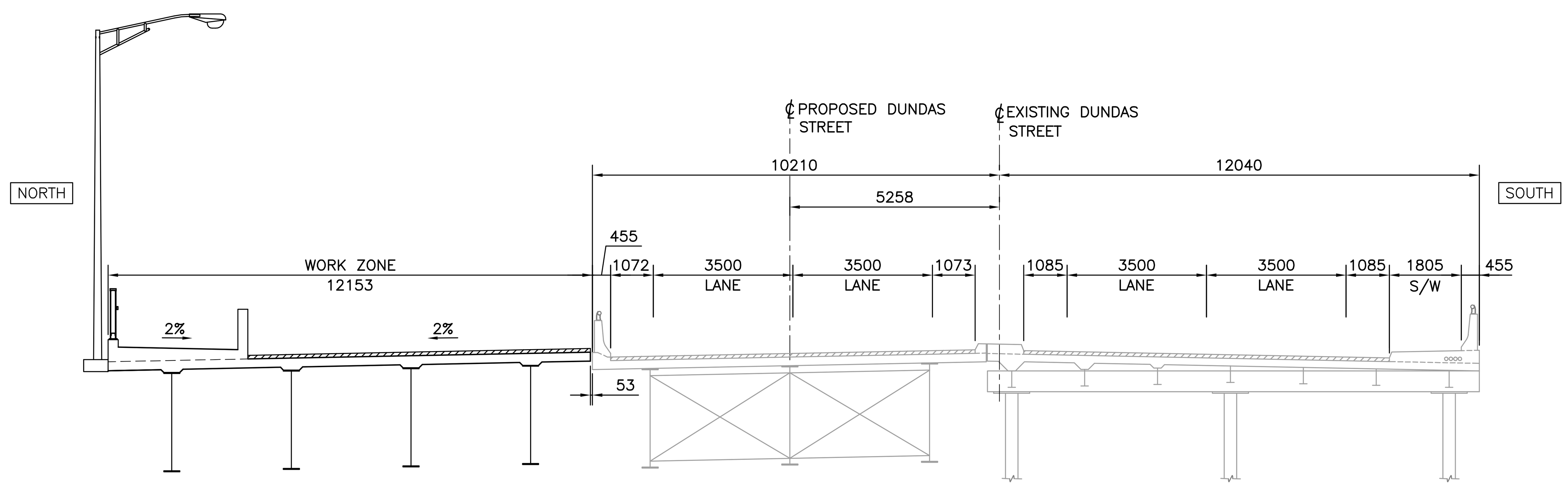

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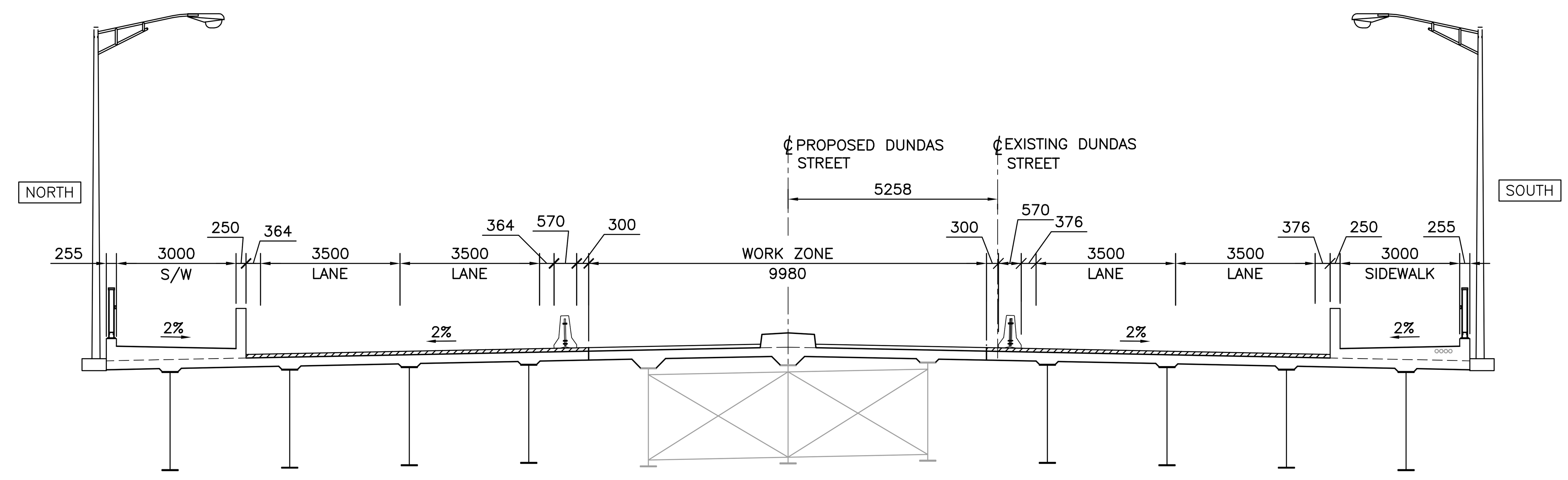

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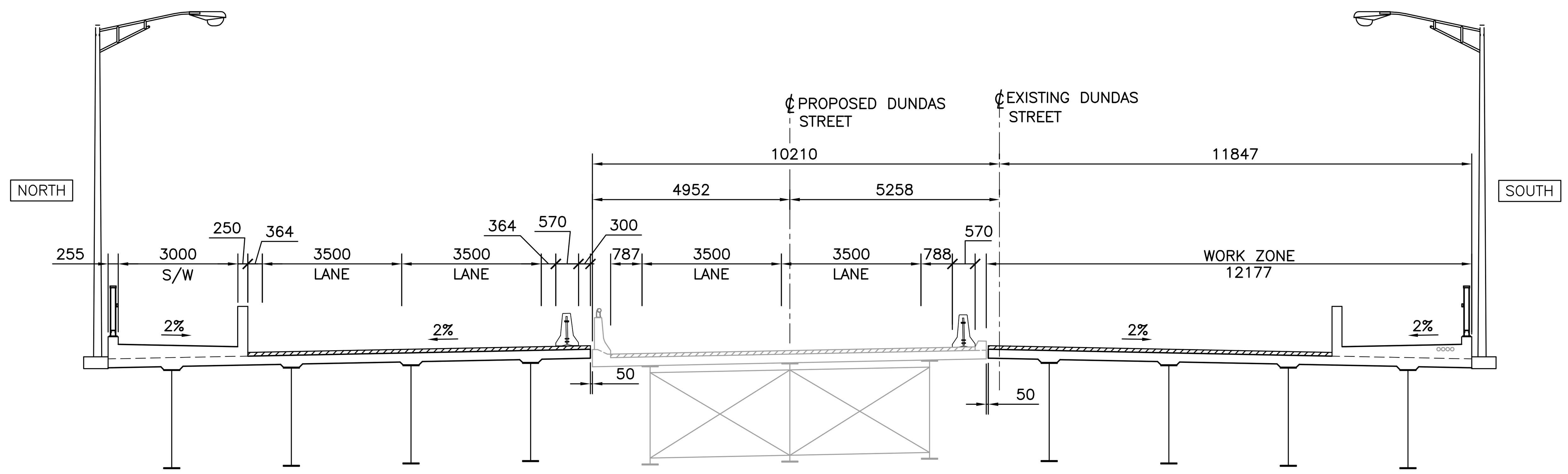

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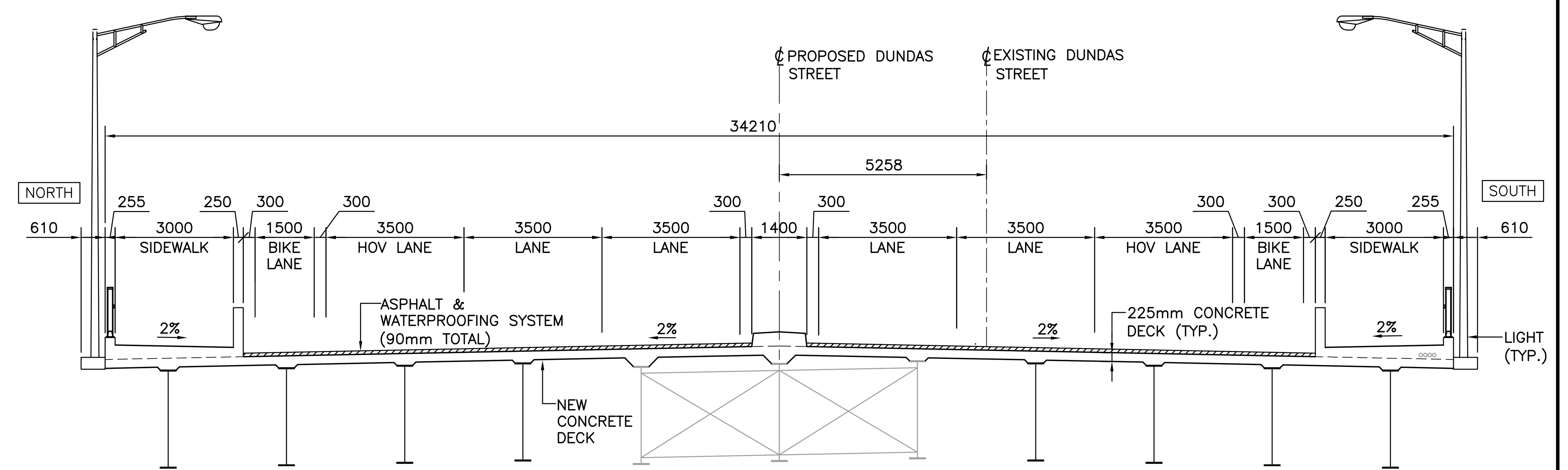

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PRELIMINARY ONLY

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Design	MT	Ch'kd	TS	Date OCT. 2011
Drawn	CA	Ch'kd	MT	
Scale AS SHOWN				References

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TITLE
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TANSLEY BRIDGE WIDENING
BURLINGTON – HALTON
OVER BRONTE CREEK

Consultant File Nº

Regional Drawing Nº

CONTRACT Nº
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Drawing Nº
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PR–XXXXX XX OF XX

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