YORK REGION

CLASS ENVIRONMENTAL ASSESSMENT STUDY FOR IMPROVEMENTS TO LANGSTAFF ROAD FROM WESTON ROAD TO HIGHWAY 7

PRELIMINARY STRUCTURAL DESIGN REPORT CN MACMILLAN YARD CROSSING STRUCTURES

NOVEMBER 26, 2021

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CN MACMILLAN YARD CROSSING STRUCTURES

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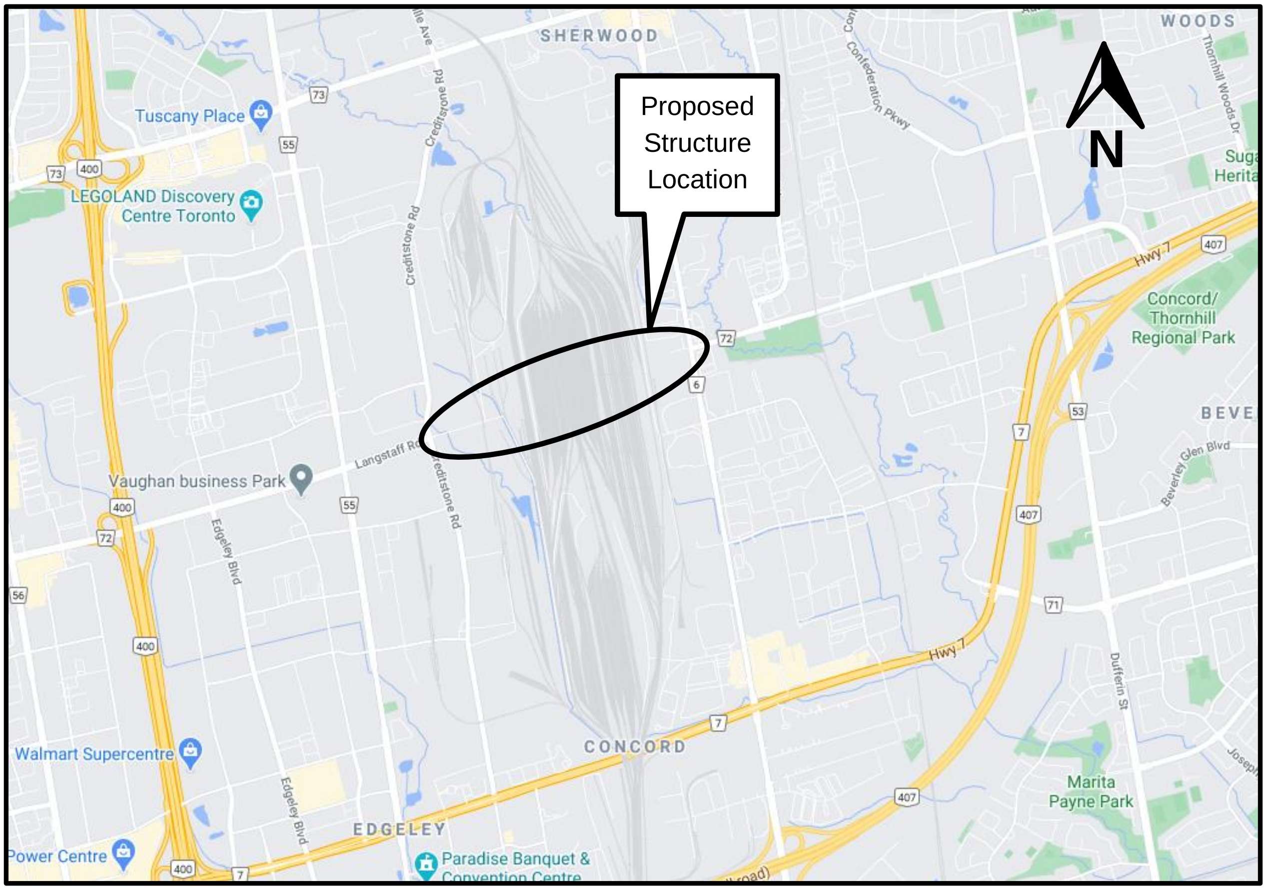


CN MacMillan Yard Crossings

1 INTRODUCTION

The Regional Municipality of York (York Region) retained WSP Canada Inc. (WSP) to undertake the Municipal Class Environmental Assessment (MCEA) Study of Langstaff Road from Weston Road to Highway 7 in the City of Vaughan.

As part of the study, the proposed improvements on Langstaff Road include:

- Widening of Langstaff Road to six lanes from Weston Road to Dufferin Street;
- A connection across the CN MacMillan Yard from Creditstone Road to Keele Street;
- Replacement of the existing bridge over the West Don River;
- New bridge over Metrolinx GO Transit Barrie Line;
- Intersection improvements; and
- Improvements of pedestrian and cycling facilities, and provision for transit amenities.

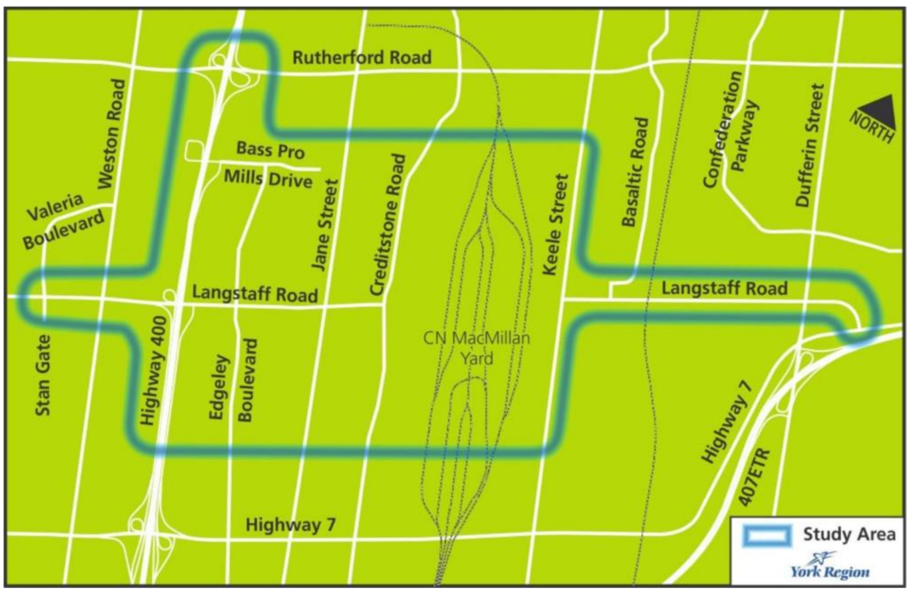
The following Preliminary Structural Design Report (PSDR) presents structural recommendations for the CN MacMillan Yard Crossings.

2 EXISTING CONDITIONS

2.1 GENERAL DESCRIPTION

The CN MacMillan Yard (CN Yard) was developed between Keele Street and Jane Street in the late 1950s. As this area of Vaughan was largely rural at the time, the construction of the CN yard resulted in a discontinuous section of Langstaff Road. The CN yard is one of the largest classification yards in Canada, that operates 24/7 and processes over 1 million carloads per year.

As described above, the CN Yard bisects a large area of the City of Vaughan, including Langstaff Road (i.e. a “missing link”). This missing link on Langstaff Road between Creditstone Road and Keele Street (across the CN MacMillan Yard) has long been established in the York Region Transportation Master Plan 2009. Due to the future planning of the Vaughan Metropolitan Centre, it is critical that this new link be pursued.



Study Area

2.2 TRAFFIC DATA

The posted speed of Langstaff Road at both sides of the CN Yard is 60 km/h.

The average daily traffic (ADT) volumes were 14,836 vehicles (November 2014) and 18,125 vehicles (June 2015) between Keel Street and Dufferin Street. The percentage of trucks were identified to be 6.6% and 5.6%, respectively.

3 GEOTECHNICAL INVESTIGATION AND RECOMMENDATIONS

3.1 GENERAL

A geotechnical investigation was carried out by Thurber Engineer Ltd. (Thurber) on behalf of WSP. The findings are provided in the Preliminary Geotechnical Investigation Report dated February 11, 2021.

The following summarizes the findings of the investigation and its recommendations.

3.2 EXISTING CONDITIONS AND FOUNDATION RECOMMENDATIONS

3.2.1 SUB-SURFACE CONDITIONS

Access to the CN yard was not permitted by CN Rail at the time of study; therefore, the preliminary geotechnical investigation for the crossing structure was limited to two boreholes, Boreholes 19-09 and 19-10, located to the west and east of the yard, respectively. The distance between the boreholes is approximately 1.4 km, and a dissimilar stratigraphy was encountered in the boreholes. Therefore, the preliminary foundation design recommendations, based on the conditions encountered in the two widely spaced boreholes, do not necessarily reflect the actual conditions at the locations of the foundation units, and should be considered for their general implications. A detailed drilling program will be required to confirm conditions at each individual foundation unit.

The stratigraphy encountered in Borehole 19-09 drilled to the west of the CN Yard consisted of a pavement structure overlying silty clay fill to a depth of 2.3 m (Elev. 205.7 m), underlain by a 7.6 m thick deposit of cohesive silty clay to clayey silt till with a lower boundary at 9.9 m depth (Elev. 198.1 m), over 7.1 m of compact to dense sand, then a lower silty clay till unit encountered at 17.0 m depth (Elev. 191.0 m) to the exploration depth of 26.4 m. The consistency of the cohesive till deposit was very stiff to a depth of approximately 4.1 m (Elev. 203.9 m), and then hard below this level.

The stratigraphy encountered in Borehole 19-10 drilled to the east of the CN Yard consisted of pavement structure overlying a 1.1 m thick of very stiff silty clay till and a 1.1 m thick layer of very stiff clayey silt, underlain by 14.2 m of sand to gravelly sand between depths of 2.6 m and 16.8 m (Elev. 203.0 m and 188.8 m), underlain by hard silty clay to the exploration depth of 24.4 m. The relative density of the sand deposit was typically compact to a depth of 7.2 m (Elev. 198.4 m), and very dense below this level.

3.2.2 FOUNDATION DESIGN RECOMMENDATIONS

Based on the borehole data, consideration may be given to supporting the proposed structures on spread footings, driven pile foundations, or augered caissons. The preferred alternative for each foundation unit may depend upon the subsurface conditions specific to that foundation location and will need to be determined/confirmed during detail design. Comments regarding the foundation options at the borehole locations are presented below.

Spready Footing

Spread footings may be founded on the very stiff to hard silty clay till encountered in Borehole 19-09, and on the very stiff silty clay/clayey silt or compact to dense sand encountered in Borehole 19-10. The geotechnical resistances recommended for preliminary design of spread footings founded at or below the levels are as follows:

Preliminary Geotechnical Resistances for Spread Footing Design

Borehole No.	Founding Level	Founding Soil	Factored Resistance at ULS (kPa)	Factored Resistance at SLS (kPa)
19-09	205.7	Very stiff silty clay till	375	250
	203.5	Hard silty clay till	600	400
19-10	204.4	Very stiff silty clay till	330	225
	203.0	Compact to dense sand	500	300

Alternatively, the available geotechnical resistance could be increased and the founding level established by constructing the footings on a pad of compacted Granular A material. Footings constructed on a minimum 2.0 m thick pad of engineered fill may be designed using factored geotechnical resistances of 900 kPa at SLS.

Driven H-piles

The new bridge structure could be supported on driven steel H-piles. For preliminary design purposes, a factored geotechnical resistance of 1,200 kN at ULS and a factored geotechnical resistance of 1,000 kN at SLS are recommended for HP 310x110 piles driven into the hard silty clay till or very dense sand.

The subsurface conditions at the site are variable, and as experienced during the pile driving operations at the Highway 400 underpass, prediction of the depth at which the piles will achieve the required resistance is particularly difficult in this area. For planning purposes, it may be assumed that the above noted resistances will be achieved for a pile tip at a depth of 24.0 m (Elev. 184.0 m) at Borehole 19-09 and 12.0 m (Elev. 193.6 m) at Borehole 9-10.

Considering the variability of the soils in the area and the large number of piles that may be required to support the multiple spans, a program of static pile load tests and/or dynamic monitoring of test piles in recommended to confirm the geotechnical resistances, pile lengths and required number of piles prior to construction.

Augered Caissons

The use of augered caissons may be advantageous in the CN Yard to minimize the disruption to the rail facilities. However, installation of caissons may be particularly problematic due to the presence of the a thick cohesionless sand deposit and high groundwater levels. Construction will require use of a steel liner to maintain stability of the caisson sidewalls as well as techniques such as drilling slurry to prevent disturbance of the caisson base. As a result, the use of caissons is less preferred from a geotechnical point of view.

If employed, caissons should extend into the hard silty clay till in Borehole 19-09 and the very dense sand in Borehole 19-10. The geotechnical resistances recommended for preliminary design of caissons with base levels are as follows:

Preliminary Geotechnical Resistances for Caissons

Borehole No.	Founding Level	Caisson Diameter (m)	Factored Resistance at ULS (kN)	Factored Resistance at SLS (kN)	
				10 mm	25 mm
19-09	203.5	0.9	2400	800	2000
		1.2	4000	1100	2600
		1.5	6000	1300	3300
19-10	203.0	0.9	3600	1200	2300
		1.2	6000	1600	3000
		1.5	9500	2100	3800

The resistance provided in the above table are based on limited boreholes drilled a considerable distance from the structure locations. The depth of caisson and axial resistance of caissons at each foundation unit will need to be determined by further investigation during detail design.

4 PROPOSED STRUCTURE

4.1 GENERAL

The close spacing of the rail tracks in the CN Yard would make pier placement for a multi-span bridge difficult. In addition, construction of piers in the yard could significantly disrupt CN's operations. As part of the study, a total of five crossing alternatives were developed and assessed. The details on the structural alternatives and evaluation are discussed on Section 4.2. Alternative 1A - Steel Box Girder with Long Span Launching Method was ultimately selected as the technically preliminary preferred alternative

The preliminary General Arrangement drawing is included in Appendix A for the preliminary preferred alternative (Alternative 1A).

4.2 STRUCTURE ALTERNATIVES

A total of five alternatives were developed for the structure crossing the CN Yard including four overpass options and a tunnel option. An in-depth evaluation on the alternatives was carried out considering a number of factors including socio-economic, CN operation, roadway geometry, traffic impact, constructability, construction duration, and cost. A summary of these alternatives and evaluations from the structural perspective is as follows. A detailed alternatives evaluation table is included in Appendix C.

- Alternative 1: Steel Box Girder Bridges (Short Spans) – Typical span lengths of up to 78m are configured to cross the CN yard, resulting in a minimum of 11 piers required to be constructed within the yard. A typical launching erection method is recommended for this alternative to minimize the disruption of the CN operation during the superstructure construction. Launching steel girder segments up to 80m has been widely performed and thus less difficulties and challenges are expected for the superstructure construction. However, more disruption of the CN operation is expected during the foundation and substructure construction as there are more piers required within the yard compared to other alternatives. It will also limit the flexibility on future track relocation.
- Alternative 1A: Steel Box Girder Bridges (Long Spans) – This alternative is the same concept as the Alternative 1 except that the span lengths are longer to reduce the number of piers within the CN Yard and the disruption of the CN operation during the foundation and pier construction. A minimum of 6 piers are required to be constructed within the CN Yard. The same launching construction method is recommended for the girder erection to minimize the disruption of the CN operation during superstructure construction. However, a special launching method and a monitoring system need to be developed and further investigated for launching 125 m long girder segments for this alternative. Only few structures have been constructed with the launching

method for more than 125 m girder segment. As such, more difficulties and challenges are expected than those from the Alternative 1.

- Alternative 2: Extradosed Bridges – Longer spans can be achieved for this type of bridge compared to the Alternatives 1 and 1A by utilizing short towers at piers and cables spreading from the tower and supporting the deck. A minimum of 4 piers are required to be constructed within the CN Yard. The knowledge and labour to construct this type of bridge is not entirely available in Ontario and "outside" assistance would be required, and the construction cost is also higher than the Alternatives 1 and 1A.
- Alternative 3: Post-tensioned Segmental Bridge – Longer spans can also be achieved for this type of bridge compared to the Alternatives 1 and 1A, but the spans will be shorter than those of Alternative 2. A minimum of 5 piers are required to be constructed within the CN Yard. Balanced segmental construction will be used for the superstructure construction where the girders are cantilevered to both sides from the pier utilizing longitudinal prestressing tensions. Therefore, the disruption of the CN operation can be minimized during the superstructure construction. Knowledge and labour to construct this type of bridge is available in Ontario, and as such less difficulties and challenges are expected compared to Alternative 2; However, it is more complex compared to the Alternatives 1 and 1A.
- Alternative 4: Tunnel Option –Impact to daily operation of the core area of the CN yard is not expected, with only minor disruption for the installation of instrumentations prior to tunnel construction, while ongoing monitoring of track stability is required during construction. A total of three tunnels are required to accommodate the proposed 6-lane Langstaff Road cross-section. Tunnel Boring Machine will be launched from one end to the other for each tunnel. The construction requirement of the tunnel option is considered to be very complex and challenging compared to the other alternatives. Moreover, the overall construction cost is significantly higher than other alternatives. The tunnel option was developed and reviewed by our tunnel experts from WSP U.S. Details of the review was documented in a technical memo which is included in Appendix D.

Alternative 1A was selected as the Preliminary Preferred Alternative as it has many practical advantages over other alternatives. Two internal workshops were held with rail specialists to further review the feasibility of the Alternative 1A. Analyses and investigations were carried out at each pier and abutment on the construction access, impacts to CN operations (permanent and temporary) and mitigation measures. Details on this feasibility study can be found in the technical memo dated May 14, 2018 which is included in Appendix E.

Alternative 1A can be divided into two sections with two different construction methods. The main bridge spans from pier 2 to pier 8, which is largely on the straight portions of the horizontal and vertical alignments, will be constructed with a launching method where the girder segments will be assembled and slid to the final position by the hydraulic jacking system from the temporary launching platform area which will be constructed in advanced of launching at the west side of the main bridge spans. A 6 m deep steel box section was selected to ensure the strength and stability of the structure during the launching process. See the section shown on Figure 2. Movements and deflections will be carefully monitored throughout the jacking and launching operation. Temporary bearings and guiding assembly with the vertical jacking system will be installed at each pier as required for the girder segment launching. After all girders are launched and positioned to their final locations, a conventional 225 mm cast in place reinforced concrete deck with 90 mm waterproofing and asphalt will be constructed.

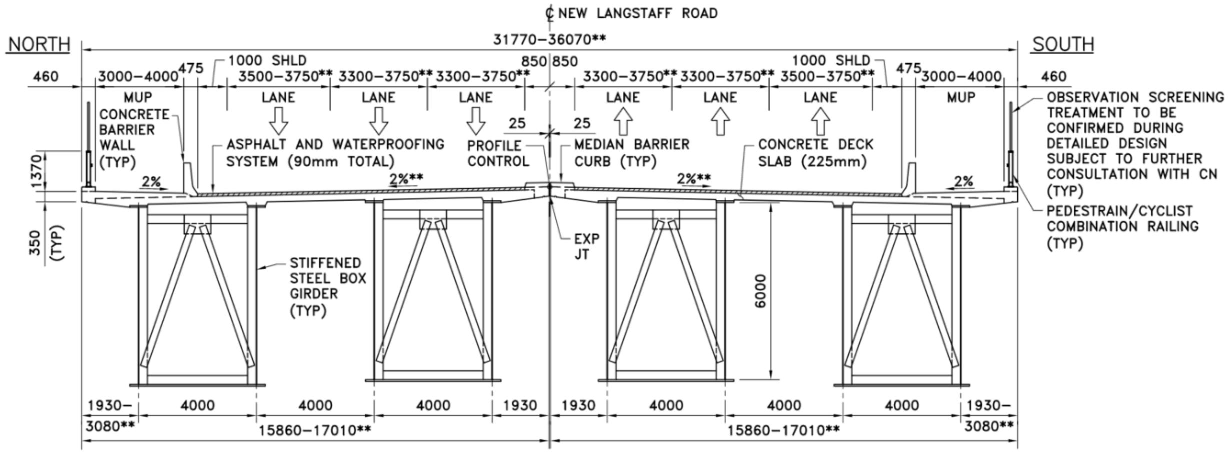


Figure 1: Proposed Cross Section – Main Spans – Steel Box Girder

The approach spans from west abutment to pier 2, and from pier 8 to east abutment, are on the curved portions of the horizontal and vertical alignments. The approach spans will be constructed with the conventional crane erection method from the ground at the approaches after the removal of the temporary launching platform. Steel I girder sections with depths of 2.2 m and 2.8 m were selected to facilitate the crane erection by reducing the weight of the girder. The superstructure will consist of 225 mm think reinforced concrete with 90 mm waterproofing and asphalt. See the section shown on Figure 3.

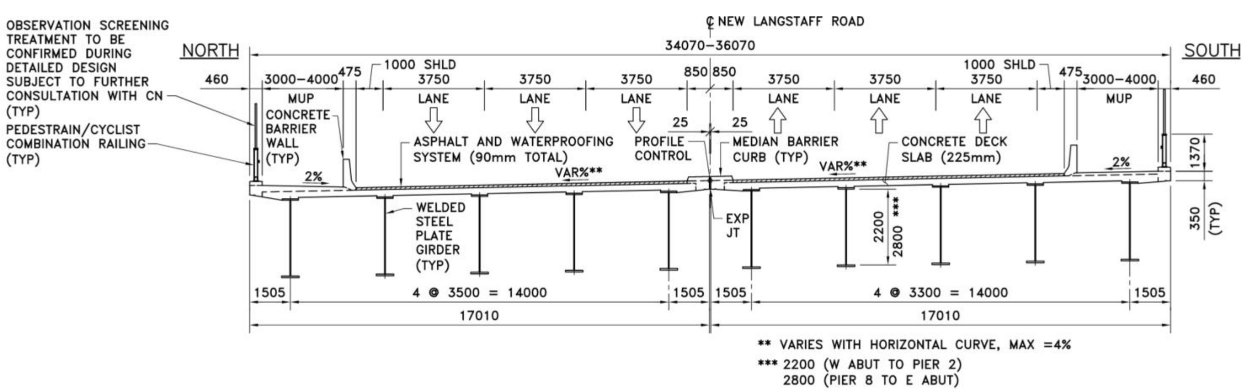


Figure 2: Proposed Cross Section – Approach Spans – Steel I Girder

The approaches beyond bridge limit will be constructed with the Retained Soil System (RSS) walls to minimize the property impact. The section is shown on Figure 4.

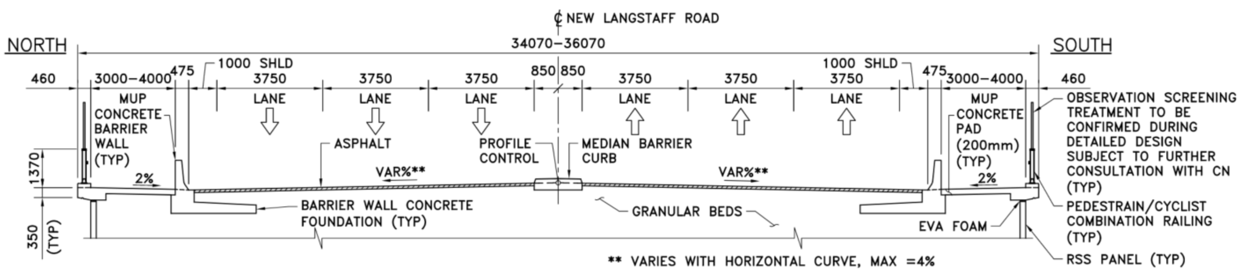


Figure 3: Proposed Cross Section – Approach Fill Sections – RSS Wall

A rigid frame structure with a skew of 53.6° will be constructed at the west approach at approximate station of 4+320 to span over CN tracks at this location. A rigid frame type structure was selected to accommodate the high approach fills and to meet the desirable vertical clearance of the tracks. A span length of 11.8 m perpendicular to the centre of the tracks was established to provide the horizontal clearance. The structure is to be constructed on a curved portion of the horizontal alignment and on a constant 4 % upgrade of the vertical alignment with the total deck width of 34.070 m. The proposed depth of the rigid frame deck slab including 90 mm asphalt and waterproofing is 590mm at mid-span and 1090 mm at the abutments. The deck has a maximum super-elevation of 4.0 %. The cross section of the rigid frame structure is shown on Figure 5.

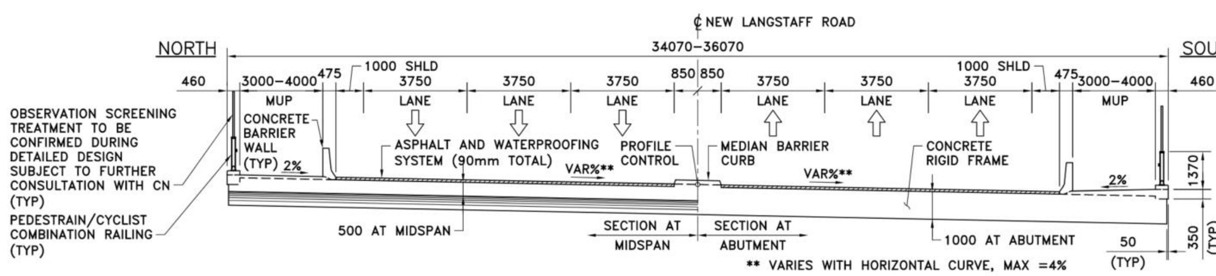


Figure 4: Proposed Cross Section – Approach Rigid Frame

A caisson foundation was selected for the main steel box and steel I girder sections to minimize the footprint impact for foundation construction within the CN yard by providing a higher axial and lateral resistances compared to other foundation types. A spread footing with a granular A pad as required will be used for the approach RSS wall construction. For the rigid frame structure at the west approach a spread footing is selected. As described in Section 3, due to the limited number of boreholes, the selected foundation types are for preliminary design purpose only. A detailed drilling program will be required to confirm conditions at each individual foundation unit in the detailed design phase to confirm the foundation recommendations.

4.3 HORIZONTAL ALIGNMENT AND VERTICAL PROFILE

The west and east approach bridge spans are along curved portions of the horizontal alignment with radii of 200 m. The middle portion of the structure is on a tangent portion of the horizontal alignment.

The vertical profile starts to rise just east of Creditstone Road and continues to rise on a 4% upgrade until it reaches the crest of the vertical curve on the west of the CN Yard. Following the crest curve, the vertical profile continues on a constant 0.5% downgrade across the CN yard until it reaches the crest curve on the east side of CN Yard. On the east approach, the vertical profile continues to fall downwards with a constant grade of 4% until it matches the existing ground near Keele Street.

The details on the vertical crest curves are as follows:

1) At West Approach

   Crest Vertical Curve, LVC = 117.000 m, K = 26
   B.V.C. Station = 4+558.080 Elevation = 226.456 (Top of Pavement)
   P.V.I. Station = 4+616.580 Elevation = 228.796
   E.V.C. Station = 4+675.080 Elevation = 228.504 (Top of Pavement)

2) At East Approach

   Crest Vertical Curve, LVC = 117.000 m, K = 26
   B.V.C. Station = 4+558.080 Elevation = 226.456 (Top of Pavement)
   P.V.I. Station = 4+616.580 Elevation = 228.796
   E.V.C. Station = 4+675.080 Elevation = 228.504 (Top of Pavement)

4.4 BRIDGE GEOMETRY

Bridge Depth

Overall structural depths from top of asphalt to underside of girder are as follows:

1) East approach bridge spans (Steel I girder from west abutment to Pier 2) – 2.56 m
2) Main bridge spans (Steel Box girder from pier 2 to Pier 8) – 6.425 m
3) West approach bridge spans (Steel I girder from pier 8 to east abutment) – 3.16 m

Cross Section

The cross-section comprises the following, from north to south:

- 0.460 m north pedestrian/cyclist railing
- 3.000 m ~ 4.000 m north multi-use path
- 0.475 m north concrete barrier wall
- 1.000 m shoulder
- (3.500 m ~ 3.750 m) + (3.300 m ~ 3.750 m) + (3.500 m ~ 3.750 m) three westbound lanes
- 1.700 m raised median

- (3.500 m ~ 3.750 m) + (3.300 m ~ 3.750 m) + (3.500 m ~ 3.750 m) three eastbound lanes
- 1.000 m shoulder
- 0.475 m south concrete barrier wall
- 3.000 m ~ 4.000 m south multi-use path
- 0.460 m south pedestrian/cyclist railing

The cross-fall of the proposed cross-section varies with a maximum super-elevation of 4% along the horizontal curves on the west and east approaches. Along the tangent portion of the structure, the roadway has a normal crown cross-section with a 2% cross-fall.

See Figures 1 to 4 for transverse slopes at various sections.

5 MISCELLANEOUS

5.1 DESIGN STANDARD

The following design codes and references will be used during the detail design stage:

- Canadian Highway Bridge Design Code (CHBDC) CAN/CSA-S6-19;
- MTO Structural Manual, 2016;
- MTO directives and standards; and
- OPSS.

5.2 MATERIALS AND AVAILABILITY

The concrete for the deck on steel girders and approach rigid frame structure will be class of 35 MPa. 35MPa concrete are available in the area.

5.3 ENVIRONMENTAL ISSUES

This project is subject to the Ontario Environmental Assessment Act and will be completed in accordance with the Municipal Class Environmental Assessment process Schedule C.

5.4 ACCESS

The site is readily accessible from eastbound and westbound of Langstaff Road. Detailed discussion on the construction access to each pier and abutment location is documented in the CN MacMillan Yard Crossing Alternative 1A Evaluation Memo, included in Appendix E.

5.5 CONSTRUCTION STAGING

The construction staging of the CN Yard crossing structure is reviewed at a high-level. The detailed staging strategy is to be reviewed in detailed design phase and through further consultation with CN. The construction could be carried out in three main stages. The estimated construction duration is approximately 5 years.

Under the first Stage, the foundations and substructures (piers and abutments) within the CN Yard are to be constructed and the elevated launching platform with the associated launching assembly can also be constructed simultaneously during the first stage of construction.

Under the second stage, the main steel box girders will be launched and positioned to the final location and the superstructure will be completed.

Under the final stage, the elevated launching platform will be removed and the approach steel I girders spans, approach RSS wall sections, and the rigid frame structure at the west approach will be constructed.

5.6 UTILITIES

The utility information within the CN Yard was not made available to the Project Team. Potential utilities impact during the construction of the abutments and piers are described in CN MacMillan Yard Crossing Alternative 1A Evaluation Memo, included in Appendix E.

A complete utility investigation is required to be carried out during the detailed design phase.

5.7 TRAFFIC BARRIERS AND OBSERVATION SCREENING

In accordance with the CHBDC-S6-19 Clause 12.4.3.2.4, Test Level 4 (TL-4) barriers are required. A standard TL-4 stainless steel reinforced concrete barrier wall with railing (SS 110-54) or GFRP reinforced concrete barrier wall (SS 110-58) will be provided at the edge of the multi-use path on both sides of deck to separate pedestrians and cyclists from vehicular traffic. This bridge will permit the use of an aesthetically attractive combination railing on the outside of the deck.

An observation screening treatment is requested by CN to prevent roadway users from observing CN operations from the overhead structures will be further reviewed during detail design.

5.8 APPROACH SLABS

Approach slabs will be constructed at both ends of the bridge in accordance with the standard MTO drawing SS116-1.

5.9 ILLUMINATION

An illumination plan along Langstaff Road will be confirmed during detail design.

5.10 DRAINAGE

A storm sewer will be provided to collect the surface water from deck drains and the water will be discharged into the stormwater management facility. The details on the drainage and stormwater facility can be found on Drainage and Stormwater Management Report. The detailed storm sewer design on the structure will be carried out during detail design.

No deck drain is required for the rigid frame structure at the west approach.

5.11 DURABILITY

Structural durability will be in accordance with the CHBDC (CAN/CSA S6-19) and MTO Structural Manual. Black reinforcing steel will be used in the abutments, deck and approach slabs. Stainless steel or GFRP reinforcing will be used in the multi-use path and parapet walls.

6 PRELIMINARY CAPITAL CONSTRUCTION COST ESTIMATE

The preliminary construction cost estimates for the main bridge and the approach rigid frame structure are $184.5M and $4.6M, respectively, including 20% contingencies. Prices are based in 2021 dollars. Detailed itemized cost estimates are included in Appendix B.

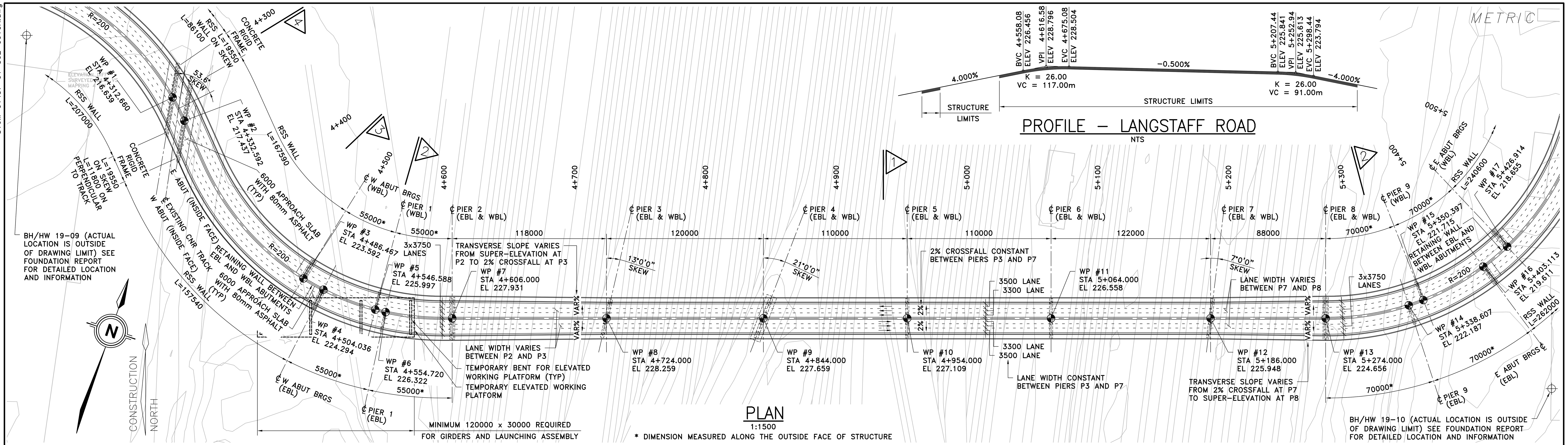
Note that the above cost does not include traffic control and roadwork costs.

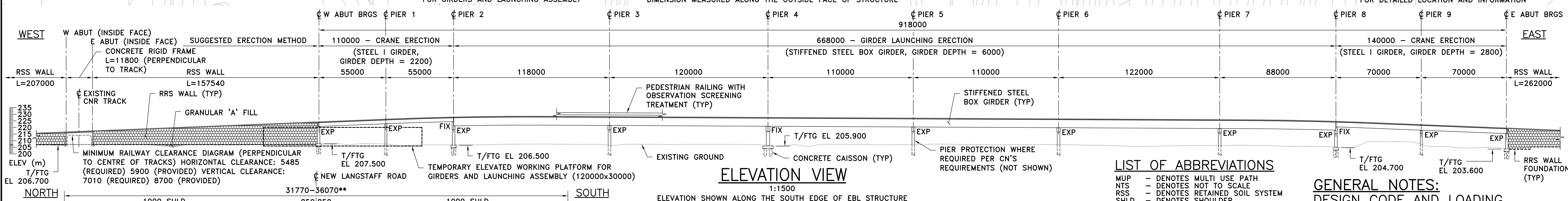
APPENDIX

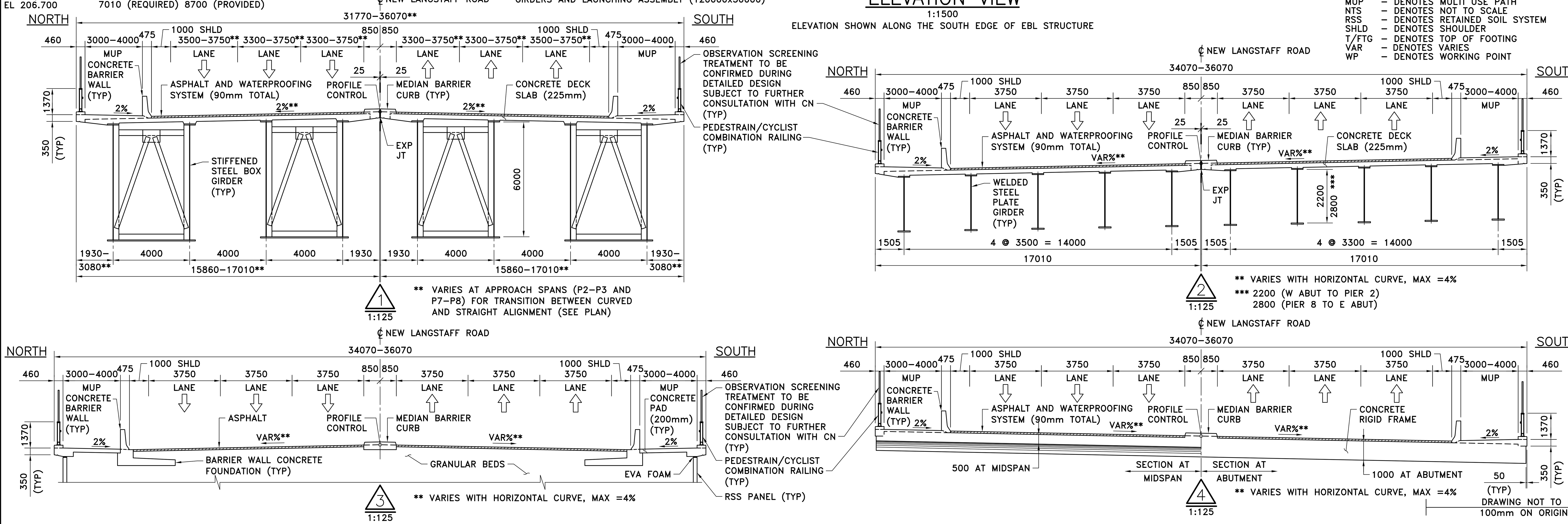
A

PRELIMINARY GENERAL ARRANGEMENT

METRIC







LIST OF ABBREVIATIONS

MUP – DENOTES MULTI USE PATH
NTS – DENOTES NOT TO SCALE
RSS – DENOTES RETAINED SOIL SYSTEM
SHLD – DENOTES SHOULDER
T/FTG – DENOTES TOP OF FOOTING
VAR – DENOTES VARIES
WP – DENOTES WORKING POINT

GENERAL NOTES:

DESIGN CODE AND LOADING

CHBDC CAN/CSA S6-19 CL-625-ONT

CLASS OF CONCRETE

ALL CONCRETE SHALL BE CLASS 35 MPa

CLEAR COVER TO REINFORCING STEEL

DECK	
TOP	70 ± 20mm
BOTTOM	40 ± 10mm
REMAINDER UNLESS OTHERWISE SPECIFIED	70 ± 20mm

REINFORCING STEEL

1. REINFORCING STEEL SHALL BE WELDABLE GRADE 400W.
2. UNLESS SHOWN OTHERWISE, TENSION LAP SPLICES FOR REINFORCING STEEL BARS SHALL BE CLASS B.
3. BAR HOOKS SHALL HAVE STANDARD HOOK DIMENSIONS USING MINIMUM BEND DIAMETERS, WHILE STIRRUPS AND TIES SHALL HAVE MINIMUM HOOK, DIMENSIONS. ALL HOOKS SHALL BE IN ACCORDANCE WITH THE STRUCTURAL STANDARD DRAWING SS12-1 UNLESS INDICATED OTHERWISE.
4. STAINLESS REINFORCING STEEL SHALL BE TYPE 316LN OR DUPLEX 2205 AND HAVE MINIMUM YIELD STRENGTH OF 500 MPa, UNLESS OTHERWISE SPECIFIED.
5. BAR MARKS WITH THE PREFIX "S" DENOTES STAINLESS STEEL BARS.

CONSTRUCTION NOTES

1. ALL ELEVATIONS ARE TO GEODETIC DATUM.
2. THE CONTRACTOR SHALL ESTABLISH THE BEARING SEAT ELEVATIONS BY DEDUCTING THE ACTUAL BEARING THICKNESSES FROM THE TOP OF BEARING ELEVATIONS. IF THE ACTUAL BEARING THICKNESSES ARE DIFFERENT FROM THOSE GIVEN WITH THE BEARING DESIGN DATA, THE CONTRACTOR SHALL ADJUST THE REINFORCING STEEL TO SUIT.
3. BACKFILL SHALL BE PLACED SIMULTANEOUSLY BEHIND BOTH ABUTMENTS KEEPING THE HEIGHT OF THE BACKFILL APPROXIMATELY THE SAME. AT NO TIME SHALL THE DIFFERENCE IN ELEVATION BE GREATER THAN 500mm.
4. THE CONTRACTOR IS TO PROVIDE TEMPORARY PROTECTION SYSTEMS DESIGNED TO PERFORMANCE LEVEL 1 FOR TRACK PROTECTION DURING CONSTRUCTION.
5. THE CONTRACTOR SHALL DESIGN ELEVATED WORKING PLATFORM AND GIRDER LAUNCHING ASSEMBLY REQUIRED FOR THE MAIN SPAN GIRDER ERECTION.

wsp

DRAWING NOT TO BE SCALED
100mm ON ORIGINAL DRAWING

NOTE:
THE LOCATION OF UTILITIES IS APPROXIMATE ONLY, AND THE EXACT LOCATION SHOULD BE DETERMINED BY CONSULTING THE MUNICIPAL AUTHORITIES AND UTILITY COMPANIES CONCERNED. THE CONTRACTOR SHALL PROVE THE LOCATION OF UTILITIES AND SHALL BE RESPONSIBLE FOR ADEQUATE PROTECTION FROM DAMAGE DURING CONSTRUCTION.

No.	DATE	REVISIONS	BY

York Region

Transportation Services

	LOCATION	
DESIGN DESIGN	CN MACMILLAN YARD CROSSING STRUCTURES	DWG. NO. DWG_NUM
DRAWN DRAWN	PRELIMINARY	CONT. NO. CONT_NUM
CHECKED CHECKED	GENERAL ARRANGEMENT	SHEET NO. SHEET_NUM

APPENDIX

B

PRELIMINARY COST ESTIMATE

Preliminary Cost Estimate

New Bridge - CN MacMilan Yard Crossing Structure

10 Spans = 55 m + 55m + 118m + 120m + 110m + 110m + 122m + 88m + 70m +70m
Steel I Girder (Crane Erection) + Steel Box Girder (Launching Erection)
Conventional Abutments and Piers
Skew - Vary

* Cost Estimate is based on 3m Multi-Use Path.

Description of Item	Unit	Unit Price	Quantity	Total
Track Protection System	LS	$3,200,000	1	$3,200,000
Earth Excavation for Structure	m^3	$36	8020	$288,720
Dewatering Structure Excavation	LS	$300,000	1	$300,000
Supply Equipment for Installing Caisson Piles	LS	$450,000	1	$450,000
Caisson Piles - 1200 mm Diameter	m	$2,700	1440	$3,888,000
Caisson Piles - 1500 mm Diameter	m	$2,700	108	$291,600
Caisson Piles - 2000 mm Diameter	m	$4,000	648	$2,592,000
Concrete in Footing	m^3	$800	1950	$1,560,000
Concrete in Substructure	m^3	$1,650	5120	$8,448,000
Concrete in Deck	m^3	$1,900	7746	$14,717,400
Concrete in Sidewalk	m^3	$1,900	1950	$3,705,000
Concrete in Barrier Walls	m^3	$2,500	588	$1,470,000
Concrete in Apporach Slab	m^3	$750	140	$105,000
Fabrication of Structural Steel - Steel I Girder	t	$4,600	2240	$10,304,000
Fabrication of Structural Steel - Steel Box Girder	t	$5,100	9970	$50,847,000
Deliever of Structural Steel	t	$350	12210	$4,273,500
Erection of Structural Steel - Steel I Girder	t	$750	2240	$1,680,000
Erection of Structural Steel - Steel Box Girder*	t	$3,500	9970	$34,895,000
Bearings	each	$6,000	96	$576,000
Bicycle Railing with Pickets	m	$500	1865	$932,500
Reinforcing Steel Bars	t	$3,000	1496	$4,488,000
Stainless Steel Bars	t	$13,000	293	$3,809,000
Waterpoofing	m^2	$45	24150	$1,086,750
Form and Fill Grooves	m	$75	53	$3,975

*Temporary Launching Platform and Jacking System are included in this item

**Approach grading and RSS wall quantities are not included (See grading quantities

Sub-total	$153,911,445
Contingency (20%)	$30,782,289
Total	**$184,693,734**

Deck Area	29,740 m^2
Cost/m^2 of deck area without contingencies	$ 5,175
Cost/m^2 of deck area with contingencies	$ 6,210

Preliminary Cost Estimate

New Bridge - Rigid Frame Structure at West Approach

Single Span 11.8m
Concrete Rigid Frame Structure

Skew 53.6 degree

* Cost Estimate is based on 3m Multi-Use Path.

Description of Item	Unit	Unit Price	Quantity	Total
Earth Excavation for Structure	m^3	$35	1020	$35,700
Dewatering Structure Excavation	LS	$50,000	1	$50,000
Concrete in Footing	m^3	$800	320	$256,000
Concrete in Substructure	m^3	$1,650	930	$1,534,500
Concrete in Deck	m^3	$1,900	540	$1,026,000
Concrete in Sidewalk	m^3	$1,900	50	$95,000
Concrete in Barrier Walls	m^3	$2,500	15	$37,500
Concrete in Apporach Slab	m^3	$750	140	$105,000
Bicycle Railing with Pickets	m	$500	40	$20,000
Reinforcing Steel Bars	t	$3,000	193	$579,000
Stainless Steel Bars	t	$13,000	7	$91,000
Waterpoofing	m^2	$45	610	$27,450
Form and Fill Grooves	m	$75	90	$6,750
*Approach grading and RSS wall quantities are not included (See grading quantities)			Sub-total	$3,863,900
			Contingency (20%)	$772,780
			Total	**$4,636,680**

Deck Area	792	m^2
Cost/m^2 of deck area without contingencies	$ 4,879	
Cost/m^2 of deck area with contingencies	$ 5,854	

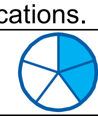
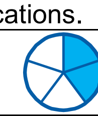
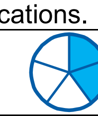
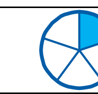
APPENDIX

C

ALTERNATIVE EVALUATION TABLE

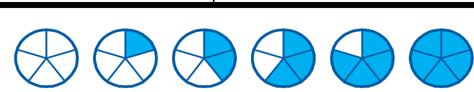
Updated June 13, 2021

Langstaff Road Improvements EA Study – CN MacMillan Yard Crossing Alternatives Evaluation Table

Factors/Criteria	Alternative 1A - Steel Box Girder Bridge – Long Spans (South Alignment)	Alternative 1B - Steel Box Girder Bridge – Short Spans (South Alignment)	Alternative 2 - Extradosed Bridge (South Alignment)	Alternative 3 - Post-tensioned Segmental Concrete Bridge (South Alignment)	Alternative 4 - Tunnel Option (Central Alignment)
1.0 Socio-Economic					
1.1 Property Impact – Adjacent Businesses (# of Property Areas)	• Minimum 4 adjacent properties are potentially impacted (approximately 13.8 hectares).	• Minimum 3 adjacent properties are potentially impacted (approximately 8.2 hectares).	• Minimum 3 adjacent properties are potentially impacted (approximately 8.2 hectares).	• Minimum 3 adjacent properties are potentially impacted (approximately 8.2 hectares).	• Minimum 3 adjacent properties are potentially impacted (approximately 5.2 hectares). 2 of which are required to provide connections to Keele Street east of the CN yard.
1.2 Access Impact – Adjacent Businesses	• All existing accesses to adjacent businesses will be maintained with minor modifications.	• All existing accesses to adjacent businesses will be maintained with minor modifications.	• All existing accesses to adjacent businesses will be maintained with minor modifications.	• All existing accesses to adjacent businesses will be maintained with minor modifications.	• Minimum 5 existing accesses to adjacent businesses are potentially impacted.
Preference					
Summary	All alternatives result in various degrees of property impacts with Alternative 1A having the largest property requirement; however, the overall impacts in terms of the number of potentially impacted properties are similar in scale.				
2.0 Structural Engineering					

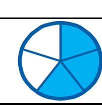
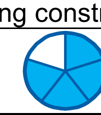
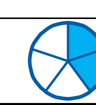
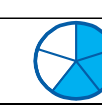
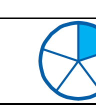
2.1 Structure Type & Requirement	• Span range: 75m to 130m
	• Superstructure Height: 6.0m constant depth for incremental launching
	• Required footprint width for pier foundation: 8.0m for main fixed pier and 2.0m for other piers
	• A minimum of **6 piers** are required to be constructed within core area of the yard.
		• Span range: 60m to 80m
		• Superstructure Height: 3.5m constant depth for incremental launching
		• Smallest pier foundation footprint: 1.5m at expansion piers and 4.0m at fixed piers
		• A minimum of **11 piers** are required to be constructed within core area of the yard.
		•
			• Span range: 180m to 230m for Extradosed Bridge
			• Maximum Superstructure Height:
			  • At pier: 7.3m
			  • At midspan: 3.3m
			• Approximate Tower Height: 20.0m
			• Required footprint width for pier foundation: 12.0m for main fixed pier and 2.5m for other piers.
			• A minimum of **4 piers** are required to be constructed within core area of the yard.
			• Towers above the deck need to be evaluated for safety and impact on the Pearson Airport and Transport Canada regulations or height restrictions related to airport landing glide slopes.
				• Span range: 80m to 140m
				• Maximum Superstructure Height:
				  • At Pier: 7.2m
				  • At midspan: 3.2m
				• Required footprint width for pier foundation: 10.0m for main fixed pier and 2.5m for other piers
				• A minimum of **5 piers** are required to be constructed within core area of the yard.
					• East and west open approaches are a total of 470 m long.
					• East and west cut and cover tunnel are a total of 535 m long.
					• Tunnel length is 780 m with the tunnel invert at each portal about 20 m below ground surface.
					• The radius of the tunnel is 13.4 m including the roadway, emergency walkway and ventilation allowance.
					• A total of **three tunnels** are provided. Each of the two outside tunnels allow for a single direction of travel. Reversible lanes are provided in the middle tunnel.

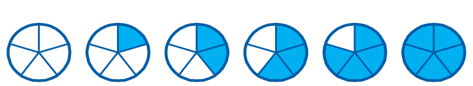
2.2 Constructability	• Pier foundation construction may require track protections and temporary disruption to adjacent tracks. Less disruption is expected than Alternative 1B due to less number of piers and foundations to be constructed. • Incremental launching method to be used for superstructure construction where the girders to	• Pier foundation construction may require track protections and temporary disruption to adjacent tracks. More disruption is expected than other alternatives due to largest number of piers and foundations to be constructed. • Incremental launching method to be used for superstructure construction where the girders to be launched	• Pier foundation construction may require track protections and temporary disruption to adjacent tracks. Less disruption is expected than any other alternatives due to least number of piers and foundations to be constructed. • Balanced segmental construction method to be used for superstructure construction where	• Pier foundation construction may require track protections and temporary disruption to adjacent tracks. Less disruption is expected than Alternatives 1 and 1A due to less number of piers and foundations to be constructed. • Balanced segmental construction method to be used for superstructure construction where	• The Tunnel Boring Machine will be launched from one end to the other. The excavated material will be removed by muck cars and disposed off-site. • Ground improvement is needed to stabilize the ground and minimize ground movement and ground loss outside of the core area of the yard.

LEGEND  **Less Preferred → More Preferred**

Regional Municipality of York
Langstaff Road Class Environmental Assessment Study
CN MacMillan Yard Crossing Alternatives Analysis and Evaluation

Updated June 13, 2021

Langstaff Road Improvements EA Study – CN MacMillan Yard Crossing Alternatives Evaluation Table					
Factors/Criteria	**Alternative 1A - Steel Box Girder Bridge – Long Spans (South Alignment)**	**Alternative 1B - Steel Box Girder Bridge – Short Spans (South Alignment)**	**Alternative 2 - Extradosed Bridge (South Alignment)**	**Alternative 3 - Post-tensioned Segmental Concrete Bridge (South Alignment)**	**Alternative 4 - Tunnel Option (Central Alignment)**
	be launched from the temporary platform area, and as such, the disruption of CN operation to be minimized during superstructure construction. • Special launching method and monitoring system need to be developed and further investigated for launching 130m long girders. Only few structures have been constructed worldwide for launching 130m long girders (Typical span for the launching method is up to 85m). As such, more difficulties and challenges are expected than other alternatives. • Temporary platform will be required for girder and launching nose assembly. A minimum of 130m platform length is required. Lead time for girder fabrication and delivery to the temporary platform will be required.	from the temporary platform area, and as such, the disruption of CN operation to be minimized during superstructure construction. • Temporary platform will be required for girder and launching nose assembly. A minimum of 85m platform length is required. • Lead time for girder fabrication and delivery to the temporary platform will be required. • Less difficulties and challenges are expected than other alternatives due to short span bridge construction with the use of conventional launching method.	the girders to be cantilevered to both sides from the pier and tower utilizing prestressing tendons and cables; therefore, the disruption of CN operation to be minimized during superstructure construction. • Knowledge and labour to construct this bridge is not entirely available in Ontario. “Outside” assistance would be required. Similar cable supported bridges have been built in Ontario recently (Nipigon Bridge).	the girders to be cantilevered to both sides from the pier utilizing prestressing tendons and therefore, the disruption of CN operation to be minimized during superstructure construction. • Knowledge and labour to construct this bridge is available in Ontario. Similar construction methodology has been employed recently on the Fairway Road Bridge (Region of Waterloo). In addition, MTO is planning to build other segmental concrete bridge.	• A monitoring program is required to monitor ground response within the core area of the yard. Rail operations will be maintained at all time during construction, although minor disruption to a single track maybe required. Track re-ballasting may be needed occasionally to maintain track vertical alignment. • Personnel entry into working chamber of the boring machine is required if obstructions (boulders) are encountered. The machine will be equipped with personnel and equipment locks and fitted for compressed air entry. • Complex and challenging construction requirements comparing to the other alternatives.
2.3 Construction Access	• Existing CN maintenance//access road might be utilized as an access for the foundation and pier construction. • New temporary access road for temporary CN track crossing would need to be installed as required (Less temporary crossing would be required than Alternative 1B due to the less number of foundations and piers) • Temporary work platform to assemble launching nose and girders will require the parking/storage area on the west of CN yard during construction.	• Existing CN maintenance/access road might be utilized as an access for the foundation and pier construction. • New temporary access road for temporary CN track crossing would need to be installed as required (More temporary crossing would be required than other alternatives due to the greatest number of foundations and piers for this alternative) • Temporary work platform to assemble launching nose and girders will require the parking/storage area on the west of CN yard during construction.	• Existing CN maintenance/access road might be utilized as an access for the foundation and pier construction. • New temporary access road for temporary CN track crossing would need to be installed as required (Least temporary crossing would be required than other alternatives due to least number of foundations and piers required for this alternative.	• Existing CN maintenance/access road might be utilized as an access for the foundation and pier construction. • New temporary access road for temporary CN track crossing would need to be installed as required (Less temporary crossing would be required than Alternatives 1 and 1A due to less number of foundations and piers.	• The access with be from areas outside of the yard. Temporary access may be required for monitoring purposes during construction within the core area of the yard.
Preference					

LEGEND  **Less Preferred → More Preferred**

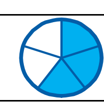
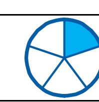
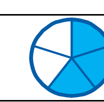
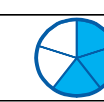
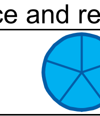
Langstaff Road Improvements EA Study – CN MacMillan Yard Crossing Alternatives Evaluation Table					
Factors/Criteria	**Alternative 1A - Steel Box Girder Bridge – Long Spans (South Alignment)**	**Alternative 1B - Steel Box Girder Bridge – Short Spans (South Alignment)**	**Alternative 2 - Extradosed Bridge (South Alignment)**	**Alternative 3 - Post-tensioned Segmental Concrete Bridge (South Alignment)**	**Alternative 4 - Tunnel Option (Central Alignment)**
Summary	In terms of construction access, the alternatives with more piers would require more complex access strategy; however, it is determined that the access to the bridge piers can be accommodated for all alternatives and construction access is not considered to be a critical factor in selecting the preferred alternative. Alternative 4 has the most complex and challenging construction requirements, thus is the least preferred alternatives. Alternative 1B is the most preferred alternative as it is the least difficult structure type to construct. Alternative 2 is the second least preferred as special knowledge and construction method are required. Alternatives 1A and 3 are similar in the terms of degrees of difficulties to construct and are the second most preferred alternatives.				
3.0 CN Operation					
3.1 Track Displacement (Permanent/Temporary)	• Relatively large number of tracks may be required to be temporarily realigned during construction as this alternative has the second largest number of piers.	• Permanent displacement or realignment of the service tracks on the west side of the yard may be required. • Temporary realignment of the service tracks on the east side of the yard may be required during construction. • Largest number of tracks may be required to be temporarily realigned during construction as this alternative has the largest number of piers.	• Temporary realignment of the service tracks on the east side of the yard may be required during construction. • Least number of tracks may be required to be temporarily realigned during construction as this alternative has the least number of piers.	• Temporary realignment of the service tracks on the east side of the yard may be required during construction. • Relatively low number of tracks may be required to be temporarily realigned during construction as this alternative has less piers than Alternatives 1, 1A and 2.	• Long-term displacement or realignment of the service tracks on the east and west side of the yard may be required. • No permanent displacement of tracks is expected within the core area of the yard.
3.2 CN Daily Operation Impact	• Relatively high potential for temporary disruption to tracks adjacent to pier locations as construction as this alternative has the second largest number of piers. • Relatively high level of coordination with CN for flagging will be required during construction. • Relative short-term disruption of CN operation during launching of steel girders. After girder launching is completed, relatively short duration of overhead construction over the live train traffic is expected to install formworks for bridge deck construction. A “netting” system will be installed prior to the formwork installation to prevent the workers and construction debris/equipment from falling on the train tracks.	• Highest potential for temporary disruption to tracks adjacent to pier locations as this alternative has the largest number of piers. • Highest level of coordination with CN for flagging will be required during construction. • Short term disruption of CN operation during launching of steel girders. After girder launching is completed, relatively short duration of overhead construction over the live train traffic is expected to install formworks for bridge deck construction. A “netting” system will be installed prior to the formwork installation to prevent the workers and construction debris/equipment from falling on the train tracks.	• Lowest potential for temporary disruption to tracks adjacent to pier locations as this alternative has the least number of piers. • Lowest level of coordination with CN for flagging will be required during construction. • Longest duration of overhead construction over live traffic is expected as this alternative has the longest span length. • A “netting” system will be incorporated into the balanced segmental construction method to prevent the workers and construction debris/equipment from falling on the train tracks during construction.	• Relatively low potential for temporary disruption to tracks adjacent to pier locations as this alternative has less piers than Alternatives 1, 1A and 2. • Relatively low level of coordination with CN for flagging will be required during construction. • Relative Long duration of overhead construction over live traffic is expected as this alternative has the second longest span length. • A “netting” system will be incorporated into the balanced segmental construction method to prevent the workers and construction debris/equipment from falling on the train tracks during construction.	• Ongoing monitoring of track stability required during construction. • Impacts to daily operation of the core area of the yard is not expected. • Minor disruption of a single track is expected for installation of instrumentation prior to tunnel construction.

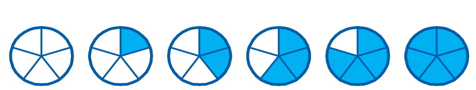
LEGEND **Less Preferred → More Preferred**

Regional Municipality of York
Langstaff Road Class Environmental Assessment Study
CN MacMillan Yard Crossing Alternatives Analysis and Evaluation

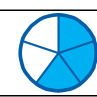
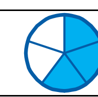
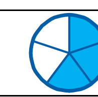
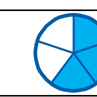
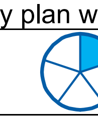
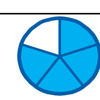
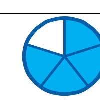
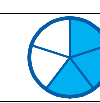
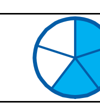
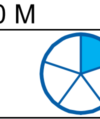
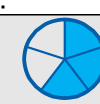
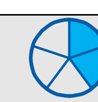
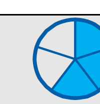
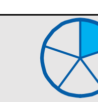
Updated June 13, 2021

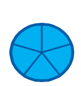
Langstaff Road Improvements EA Study – CN MacMillan Yard Crossing Alternatives Evaluation Table

Factors/Criteria	Alternative 1A - Steel Box Girder Bridge – Long Spans (South Alignment)	Alternative 1B - Steel Box Girder Bridge – Short Spans (South Alignment)	Alternative 2 - Extradosed Bridge (South Alignment)	Alternative 3 - Post-tensioned Segmental Concrete Bridge (South Alignment)	Alternative 4 - Tunnel Option (Central Alignment)
3.3 CN Internal Access Road Impact	• Interference with traffic along the existing access roads is expected during construction. • Loss of pavement width along the access road to the mechanic shop due to the placement of the pier.	• Interference with traffic along the existing access roads is expected during construction. • Loss of pavement width along the access road to the mechanic shop due to the placement of the pier. • One access road on the east side of yard is potentially blocked by the pier.	• Interference with traffic along the existing access roads is expected during construction. • One access road on the east side of yard is potentially blocked by the pier.	• Interference with traffic along the existing access roads is expected during construction. • One access road on the east side of yard is potentially blocked by the pier.	• Access roads on the west and east edges of the yard are required to be realigned. • Impacts to the access roads are not expected within the core area of the yard.
3.4 Yard Security	• Potential for public to observe CN operation from the structure or throw objects into the yard. Barrier / screening may be installed.	• Potential for public to observe CN operation from the structure or throw objects into the yard. Barrier / screening may be installed.	• Potential for public to observe CN operation from the structure or throw objects into the yard. Barrier / screening may be installed.	• Potential for public to observe CN operation from the structure or throw objects into the yard. Barrier / screening may be installed.	• No security concerns.
3.5 Flexibility for Future track relocation	• Relative low flexibility is provided for as this alternative provides second smallest clear spacing between each pier.	• Flexibility of future track relocations will be very limited due to the limited clear spacing between each pier.	• The most flexibility will be provided as this alternative provides the largest clear spacing between each pier.	• Relatively more flexibility is provided as this alternative provides larger clear spacing between each pier than Alternatives 1, 1A and 2.	• No impact to the flexibility for future track relocation within the core area of the yard.
3.6 Utilities Impact	• Relatively high potential of utility impacts as this alternative has the second largest number of piers.	• Highest potential of utility impacts as this alternative has the largest number of piers.	• Lowest potential of utility impacts as this Alternative has the least number of piers.	• Relatively Lower potential of utility impacts as this alternative has less number of piers than Alternative 1, 1A and 2.	• Relatively high potential of underground utility impacts.
3.7 Maintenance/Inspection Accessibility	• Inspection catwalk will be provided and biennial inspection using bridge master will be required to avoid access to CN Yard. No special consideration required for inspection and maintenance schedule.	• Inspection catwalk will be provided and biennial inspection using bridge master will be required to avoid access to CN Yard. • No special consideration required for inspection and maintenance schedule.	• Inspection can be done from inside of boxes and catwalk will be provided for exterior inspection. • High level of maintenance and inspection for towers and cables are expected.	• Inspection can be done from inside of boxes and catwalk will be provided for exterior inspection. • No special consideration required for inspection and maintenance schedule.	• Dedicated operational approach is required where trained human operators will be monitoring the tunnel 24/7. • Periodic tunnel closures are required to allow for system maintenance and repairs.
Preference					
Summary	Impact to CN operation is considered to be a key factor in selecting the preferred alternative. Alternatives with a greater number of piers would have higher impact to the CN operation. Alternative 4 is the most preferred alternative as it has minimum impact to CN operation during and post construction; whereas, Alternative 1B is the least preferred due to the largest number of piers. Alternatives 1A, 2 and 3 require 6 piers, 5 piers and 4 piers, respectively, resulting in similar impacts to CN operations.				
4.0 Transportation & Other Considerations					
4.1 Geometrics (Alignment and Profile)	• The equivalent design speed is equal or great than 70 km/h on both approaches of the structure.	• The equivalent design speed is equal or great than 70 km/h on both approaches of the structure.	• The equivalent design speed is equal or great than 70 km/h on both approaches of the structure.	• The equivalent design speed is equal or great than 70 km/h on both approaches of the structure.	The equivalent design speed is equal or great than 70 km/h on both approaches of the structure.
4.2 Traffic Operation (i.e. Impact to Adjacent Intersection)	• Temporary impacts to Langstaff Road/Creditstone Road intersection and Langstaff Road/Keele Street intersection during construction.	• Temporary impacts to Langstaff Road/Creditstone Road intersection and Langstaff Road/Keele Street intersection during construction.	• Temporary impacts to Langstaff Road/Creditstone Road intersection and Langstaff Road/Keele Street intersection during construction.	• Temporary impacts to Langstaff Road/Creditstone Road intersection and Langstaff Road/Keele Street intersection during construction.	• Temporary impacts to Langstaff Road/Creditstone Road intersection. • Langstaff Road will go under Keele Street east of the Yard. Alternative access from Langstaff Road to

LEGEND  **Less Preferred → More Preferred**

Updated June 13, 2021

Langstaff Road Improvements EA Study – CN MacMillan Yard Crossing Alternatives Evaluation Table					
Factors/Criteria	**Alternative 1A - Steel Box Girder Bridge – Long Spans (South Alignment)**	**Alternative 1B - Steel Box Girder Bridge – Short Spans (South Alignment)**	**Alternative 2 - Extradosed Bridge (South Alignment)**	**Alternative 3 - Post-tensioned Segmental Concrete Bridge (South Alignment)**	**Alternative 4 - Tunnel Option (Central Alignment)**
					Keele Street will be provided via slip ramps (a 'jug-handle' intersection)
4.3 Active Transportation	• Active Transportation facilities can be accommodated.	• Active Transportation facilities can be accommodated.	• Active Transportation facilities can be accommodated.	• Active Transportation facilities can be accommodated.	• Sidewalk and bike-lanes cannot be accommodated within a tunnel.
4.4 Safety	• No new challenges to incident management is anticipated.	• No new challenges to incident management is anticipated.	• No new challenges to incident management is anticipated.	• No new challenges to incident management is anticipated.	• Significant safety concerns for explosive goods transportation within the tunnel. • Emergency egress/access will be provided and the installed ventilation system capacity is ultimately determined by requirement for emergency smoke control during a tunnel fire incident. • Emergency plan will be in place.
Preference					
Summary	Alternative 4 has the greatest impact to the adjacent intersections as alternate connection from Keele Street is required due to the grade separation at Keele Street. Active Transportation facilities will not be accommodated in the tunnel due to significant safety concerns and the difficulties in providing emergence egress/access. The discontinuity of active transportation under Alternative 4 is not consistent with York Region's policy to enhance the active transportation network. Other alternatives result similar transportation improvements.				
5.0 Cost					
5.1 Capital Cost (in 2018 dollars)	• $ 180 M	• $145 M	• $210 M	• $200 M	• $949 M
5.2 Maintenance Cost	• $ 18 M	• $14 M	• $21 M	• $20 M	• $8 M - $10 M
					
Summary	The cost for Alternatives 4 is significantly higher compared to the other alternatives. The costs for all the other alternatives are in a similar range with Alternative 1B being the lowest and Alternative 2 being the highest. Alternative 1A has the second lowest cost.				
Overall Preference	 **Recommended**				
Overall Summary	Alternative 4 has the least impact to CN operation; however, the cost is not economically feasible, therefore it is not considered to be a preferred alternative. Amongst Alternatives 1A, 1B, 2 and 3, Alternative 1B has the greatest impact to CN operation, and therefore it is not considered to be a preferred alternative. . The remaining alternatives (1A, 2 and 3) all have similar socio-economic and transportation impacts and similar impacts to CN operation. Given Alternative 1A has the lowest cost of the remaining three alternatives and is the simplest structure to construct, **Alternative 1A is selected as the technically preferred alternative.**				

LEGEND       **Less Preferred → More Preferred**

APPENDIX

D

TECHNICAL MEMO – TUNNEL OPTION

MEMO

TO: Katherine Jim

FROM: Kyle R. Ott/ Dave Diponio

SUBJECT: LANGSTAFF ROAD CANADIAN NATIONAL MACMILLAN YARD CROSSING – TUNNEL OPTION

DATE: January 19, 2018

INTRODUCTION

WSP Canada Inc. (Oakville Office) is carrying out a Municipal Class Environmental Assessment (Class EA) Study for the Regional Municipality of York regarding improvements of Langstaff Road between Weston Road and Highway 7. The proposed improvements include widening Langstaff Road to 6 general purpose lanes, reconstructing the Highway 400 / Langstaff Road interchange to become a full interchange, as well as connecting Langstaff Road across the Canadian National MacMillan Yard (CN Yard).

A number of design alternatives are being developed for the Langstaff Road connection across the CN Yard, including a tunnel option.

WSP USA Inc. tunneling staff in New York, Detroit and Baltimore carried out a conceptual level study for constructing a new six lane road tunnel under the CN Yard to connect Langstaff Road from one side of the CN Yard to the other.

The scope of work included the following:

1. Develop a conceptual tunnel crossing under the CN Yard.
2. Estimate a rough order of magnitude construction cost – 2018 basis.
3. Estimate the rough order of magnitude construction schedule.
4. Provide tunnel related input to analysis and evaluation table of design alternatives.
5. Prepare this Memorandum including the items listed above.

REFERENCES

The following references were used in development of this Memorandum:

1. Chapman, L.J, and Putman, D.F, 2007, *Physiography of Southern Ontario*; Ontario Geological Survey, Miscellaneous Release – Data 228.
2. Ontario Geological Survey, 2010, *Surficial Geology of Southern Ontario*; Ontario Geological Survey, Miscellaneous Release – Data 128 – Revised.

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3. Ontario Geological Survey, 2011, 1:250 000 scale *Bedrock Geology of Ontario*; Ontario Geological Survey, Miscellaneous Release – Data 126 – Revision 1.
4. Ontario Ministry of Transport, *Foundation Investigation Report for CNR Overhead at MacMillan Yard*, W.P. 181-86-01, Site 37-682, September 22, 1988.
5. Ontario Ministry of Transport, *Foundation Investigation Report for CNR Overhead (MacMillan Yard) Approaches*, W.P. 112-87-01, Site 37-682, November 8, 1988.
6. Ontario Ministry of Transportation and Communications, *Foundation Investigation Report for Dufferin St. over Hwy. 7N, Bridge #14*. W.P. 89-78-03, Site 37-80-1126, January 19, 1983.
7. Ontario Ministry of Transport, *Foundation Investigation Report for Proposed High Mat Lighting, Highway 400/Highway 7 to North of Langstaff Road*, W.P. 528-91-01, Site 37-682, March 9, 1992.
8. WSP, *Draft Contamination Overview Study, Class Environmental Assessment Study for Improvements to Langstaff Road from Weston Road to Highway 7*, for The Regional Municipality of York, Project No. 16M-01457-0, December 2017.
9. AACE International Recommended Practice No. 18R-97, Cost Estimate Classification System, TCM Framework: 7.3—Cost Estimating and Budgeting, February 2, 2005.

Note: US based guidelines were used in consideration of the tunnel clearance envelop, USDOT/Federal Highway Administration Publication, *Technical Manual for Design and Construction of Road Tunnels – Civil Elements*, No. FHWA-NHI-10-134, December 2009 and fire-life safety aspects, National Fire Protection Association (NFPA) 502, *Standard for Road Tunnels, Bridges, and Other Limited Access Highways*. We believe the guidelines noted above are appropriate for this level of study, however, Canadian codes and guidelines need to be reviewed and incorporated if further study of a tunnel option is considered.

GEOLOGIC CONDITIONS

The CN Yard is located within the Peel Plain physiographic region (Chapman and Putnam, 2007), which is characterized by a relatively flat lying to slightly undulating surface, with a gradual slope toward the south. Geologic conditions within the tunnel area consists of Quaternary deposits of glaciolacustrine deposits (primarily fine-grained soils), with glaciofluvial (coarse-grained soils) interlayered within glacial till deposits (fine- and coarse-grained soils) (OGS, 2010). Below the overburden is the Georgian Bay Formation, which is composed of shale and interbeds of limestone, siltstone and sandstone and trends in a northwest direction from Lake Ontario toward Georgian Bay.

Groundwater within the site area is expected to be primarily unconfined with groundwater levels close to the ground surface.

ASSUMED GEOTECHNICAL CONDITIONS

Based on geotechnical information from the Ontario Ministry of Transportation reports noted above, the assumed ground conditions for the CN Yard tunnel crossing are as follows:

- Fill – up to 4m thick, consisting of loose to compact fine and coarse grained materials. No obstructions in the fill are assumed to be present.
- Upper till – about 7m thick, consisting of firm to hard clayey silt with occasional cobbles (<0.3m in diameter) and boulders (>0.3m, up to 1.5m in diameter).

- Sands – about 14m thick, consisting of loose to very dense sandy silts to silty sands.
- Lower till – about 4m thick, consisting of stiff to hard clayey silt with occasional boulders.
- Clays – about 4m thick, consisting of hard silty clay.
- Rock – bedrock is not anticipated to be encountered in the tunnel horizon. Borings completed south of the site did not encounter rock and were terminated in soil as deep as El. 180. (Datum not known.)
- Groundwater is assumed to be 1m below the ground surface.
- Naturally occurring gases (methane and hydrogen sulfide) and contamination are not expected in the ground or groundwater for this site.

In addition, it has been assumed that no structures, such as deep foundations or other buried utilities, will be encountered within the tunnel horizon.

TUNNEL CONCEPT

A conceptual plan and profile of an alignment connecting Langstaff Road across the CN Yard has been prepared along the proposed corridor and is presented at the end of this memorandum. The following elements of the tunnel crossing are assumed for cost and schedule development.

- East and west open approaches are a total of 470m long.
- East and west cut and cover tunnels are a total of 535m long.
- Tunnel length is 780m with the tunnel invert at each portal about 20m below the ground surface.

The maximum grade of the east and west approaches was assumed to be 4% and the tunnel crown (top of the tunnel liner) was assumed to be about ½ tunnel diameter below the ground surface at the bored tunnel portal. A grade of 1% in the bored tunnels is suitable. The tunnel option considered for this study consists of three two-lane bored tunnels with the associated approaches on each end. A mid-tunnel sump pump station is assumed for each tunnel.

TUNNEL CLEARANCE ENVELOPE

The internal clearance envelope for a two-lane roadway tunnel is based on the following:

- (2) – 3.66m travel lanes;
- (2) – 1.22m shoulders;
- (1) – 1.22m emergency walkway (need two for the center tunnel);
- (1) – 0.46m side barrier;
- 4.9m vertical clearance;
- 0.6m signage allowance;
- Ventilation allowance.

The ventilation allowance, assuming a longitudinal scheme with jet fans, would require vertical clearance of 2m for the fans and frame. Fans would need to be installed at a spacing of around 100m.

The travel lane widths are 3.66m wide as per AASHTO/USDOT (FHWA). Although AASHTO states that it is preferable to carry the full left and right shoulder widths of the approach roadway through the tunnel, it also recognizes that the cost of providing full shoulders widths may be significant. If wider shoulders are desired, further study would be required and the cost of the tunnel option would increase. In addition, we have assumed all tunnels will have uni-directional traffic flow, such as four lanes eastbound and two lanes westbound or two lanes eastbound and four lanes westbound. Bi-directional traffic in one tunnel is not recommended due to safety and ventilation issues. Given that Langstaff Road is proposed to be six lanes, it is assumed that reversible lanes may be implemented through the middle tunnel.

To consider a multiuse path in the tunnels several aspects need to be considered, such as the vertical and horizontal geometry to provide sufficient site distance for the roadway that accommodates bicycles and pedestrians. A properly designed barrier between the pathway and the traffic lanes is suggested. For a two-way path, 3.4m is recommended in the AASHTO bicycle publication for a shared use path. In addition, separate ventilation to maintain tenable conditions within the space may be required. The tunnel lighting system needs to be designed for pedestrian and bicycle use. There needs to be safe method that will allow cyclists and pedestrians to get from paths that may be on both sides of the approach roadway to the dedicated path that goes through the tunnel. There are a few precedents for such paths in tunnels, however, there are increased costs and risks for accommodating such use.

To accommodate the connection of the 3m multi-use path on Langstaff Road, a separate fully enclosed or isolated area within the tunnels is recommended at this time. A multiuse path within the tunnel, although possible, would add substantial costs to the project and was not considered in the tunnel clearance envelope for this study.

OPEN APPROACH AND CUT AND COVER TUNNEL

For the bored tunnels, the approaches will consist initially of open cut or boat sections, which will transition to cut and cover sections that will extend to the bored tunnel portals. For this study, it is assumed that the tunnels will be spaced ½ diameter (6.7m) apart for a clear span width in the cut and cover section of 57m.

To excavate a depressed roadway trench, or cut and cover tunnel, the adjacent soil and structures must be retained using a support of excavation (SOE) system. Methods that may be applicable include:

- Slurry walls (also known as diaphragm walls), and
- Secant pile walls.

Slurry walls are constructed as panels within trenches stabilized with bentonite slurry during excavation. Panel width is typically about 1m and length may vary from 3m up to 6m, based on soil and groundwater conditions and slurry wall design details. The slurry, containing either bentonite clay or polymer, stabilizes the soil while a trench panel is excavated. The general procedure is to excavate and concrete alternate panels. After these panels have reached the required concrete strength, as determined from concrete cylinder testing, the intermediate panels are constructed. When the excavation terminates in soil, the slurry wall panels extend beneath the base of the excavation a depth sufficient to develop soil passive resistance. The flexural strength of slurry walls is provided by either reinforcing cages or multiple steel H-piles. Concrete is placed in the panel using the tremie method, which displaces the slurry. When all panels are complete, the wall is essentially watertight.

Secant piles are installed in overlapping drilled holes, typically 1m to 1.5m in diameter, stabilized by steel casing or by drilling mud to minimize settlement. The general procedure is to install primary piles first and filled with unreinforced concrete as the casing is withdrawn. The infill piles – secondary piles – are then constructed and reinforced with steel reinforcement cages or soldier-piles. When the excavation terminates in soil, the secant piles extend beneath the base of the excavation a depth sufficient to develop soil passive resistance. Water tightness can be achieved, but leakage is generally higher than with slurry walls.

Prior to excavation of the open section and cut and cover section, the excavation invert will require ground improvement or dewatering to allow excavation to occur safely and to maintain stability of the invert. For either SOE method, as excavation proceeds, the SOE system requires a system of wales and either internal bracing or tiebacks to be installed to resist the lateral force of the soil and groundwater. The slurry wall or secant pile wall will serve as a water barrier and will be designed for water pressure as well as lateral earth pressure.

For this study, it is assumed that one single large span approach will be constructed for all three tunnels. Tiebacks with walers on each side of the excavation, typically at 3m to 6m centers, will run horizontally across the SOE walls at typical vertical spacing of 3m to 6m and allow the walls to act monolithically. Tieback anchors will be installed and extend outside the line of the excavation; therefore, the nature of adjacent structures and land ownership must be considered and temporary easements obtained for the tieback installation.

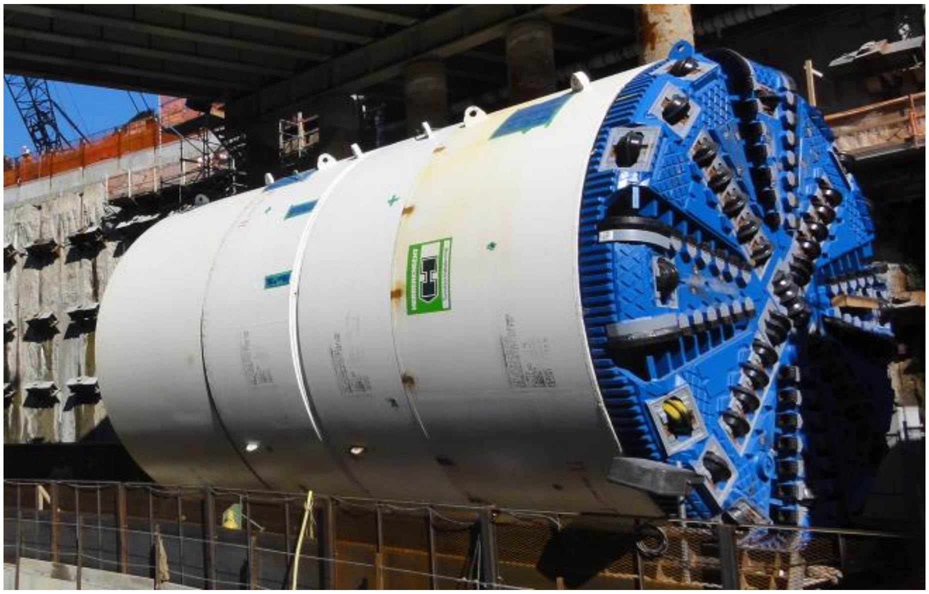
The permanent construction of approach structures is assumed to be a continuous U-wall type to better resist buoyancy. Cut and cover structures would be similar, except with backfill on the roof and interior walls, placed between tunnels, to reduce cover spans. The structure would be designed to resist hydrostatic uplift pressures by using self-weight of the structure and the (buoyant) weight of any backfill. Buoyancy of the final structure will likely result in a thicker invert than would be necessary to resist structural stresses.

The open approach section will consist of a reinforced concrete invert and side walls of varying height. The side walls will be designed to resist lateral earth pressure and groundwater pressure, while the invert will be designed to resist hydrostatic uplift forces.

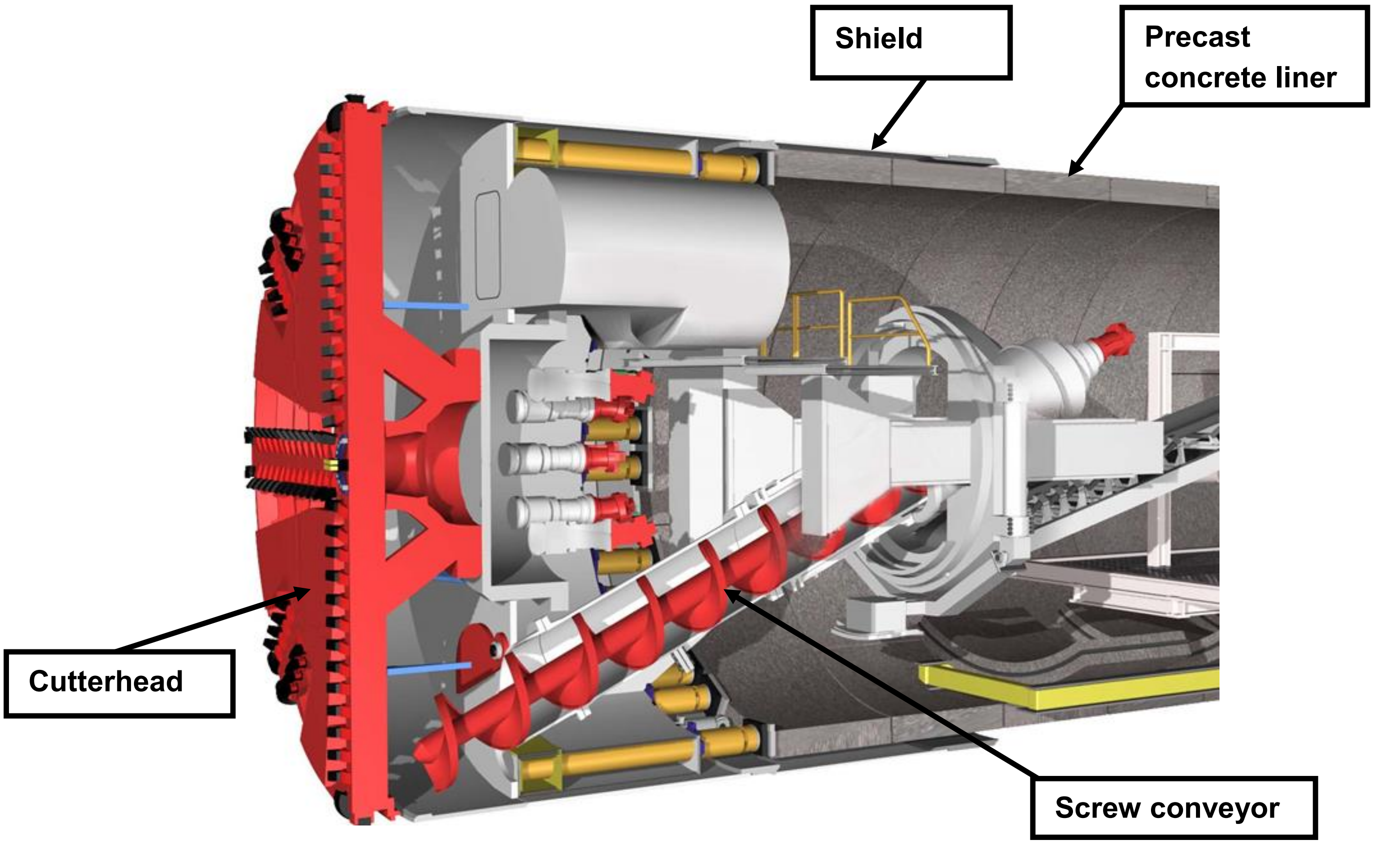
The cut and cover section consists of three-cells with the interior dimensions of each cell identical to provide the necessary space for operating systems and arterial lanes. The rectangular box will be designed to resist lateral earth pressure and groundwater pressure, hydrostatic uplift, backfill weight, and appropriate surcharge loads. The cut and cover section will be constructed of reinforced concrete and designed with a full perimeter waterproofing membrane to control groundwater inflow.

TUNNEL

The bored tunnel excavation requires a 13.4m diameter tunnel boring machine (TBM) to provide the internal clearance envelope noted above. A pressurized face TBM (see photos below) capable of excavating through soil and cobbles and boulders below the water table is required for the mined tunnel portions of this project. There are two general types of pressurized face TBMs: the slurry shield and the earth pressure balance (EPB) TBM. Slurry TBMs are generally used in cohesion-less soils (sand, non-plastic silt, gravel), while EPB TBMs generally are used in cohesive soils (plastic silts and clays). Slurry TBMs require more space at the ground surface to house a separation plant that removes bentonite slurry from the excavated material prior to disposal. This can be an important consideration in a confined urban site.



Pressurized Face Tunnel Boring Machine



EPB TBM Schematic

The portals for bored tunnel construction will be located at the end of the cut and cover section of the tunnel approaches. The bored tunnels will be lined with a "one-pass" lining installed concurrently with tunnel excavation, forming a continuous ring from which the TBM pushes forward by thrust jacks. After the ring is shoved out of the shield tail, contact grouting to fill the annulus between the ground and the lining is performed. This lining will consist of gasketed, reinforced concrete segments erected in a circular configuration (see photos below). For this study, a thickness of 0.6m has been assumed.

Stacked Segment Panels in Storage

Concrete Segmental Tunnel Lining

In addition, tanker trucks transporting explosive and flammable liquids and gasses will be allowed to pass through the tunnels. For this study, a tunnel fire, blast or explosion has not been considered regarding the tunnel liner thickness or sustainability of the liner under such extreme conditions.

For this study, no additional thickness of the segmental liner is assumed. Conventional reinforcement is expected to be used in the tunnel segments. Steel fibers, often used in lieu of conventionally reinforced segments, are typically used for smaller diameters tunnels but are not well suited to the larger stresses induced when handling larger segments. The segmental liner can be designed to accept future loadings due to expansion or enhancement of the CN Yard, if such future loadings are included in the liner design criteria.

TUNNEL CONSTRUCTION

For purposes of this memorandum, the TBM would initially be launched from the west side of the first of three proposed bored tunnels which cross beneath the rail yard and continue to advance the bored tunnel excavation or mine toward the east where it would be recovered from the east side cut and cover tunnel excavation. The excavated material would be removed from the tunnel by muck cars. After completion of the first tunnel, the second tunnel, using the same machine, would be mined from the east toward the west. After mining the second tunnel, the TBM would be recovered and mining would commence toward the east. For a construction project of this magnitude, a large site is critical for storage of excavated material, cranes and other equipment, material laydown, and truck routes. The excavated material would be loaded onto trucks and disposed off site.

To enhance the start of excavation from the portal, the use of ground improvement is needed to stabilize the ground and minimize ground movement and ground losses at the face in front of the TBMs as they enter the ground. For this memorandum, break-outs indicate that the tunnel advance is from the cut and cover tunnel into the tunnel and break-ins are when the tunnel enters the cut and cover tunnel. Ground improvement operations are assumed to be performed from the ground surface before the start of TBM excavation (break-out) and before the TBM enters the cut and cover tunnel (break-in). Penetration with the TBM through the SOE elements requires a soft-eye (non-steel support elements) along with a seal ring.

Ground improvement within the CN Yard is not anticipated, other than at the tunnel break-in/out areas. A monitoring program is needed to monitor ground response prior to and within the CN Yard crossing area. The instrumentation program will provide an early warning to the contractor if excavation below the CN Yard is not meeting pre-defined movement criteria and will trigger corrective measures to improve TBM control and or mitigation measures, such as compensation grouting or ground improvement, for subsequent TBM runs below the CN Yard. Rail operations during TBM excavation below the CN Yard will be maintained at all times, although some minor disruption to a single track may be needed for installation of instrumentation prior to tunnel construction. In addition, track re-ballasting may be needed occasionally to maintain track vertical alignment.

Based on the ground conditions described above, obstructions are expected to be encountered. For obstructions (boulders) too large or the time to advance through them is excessive, personnel entry into the working chamber is required (called an “intervention”). To allow this to happen the machine will be required to be equipped with personnel and equipment locks and fitted for compressed air entry by having the necessary compressors, decompression chambers, and personnel specially qualified and trained to do compressed air work. Interventions into the plenum chamber for cutterhead maintenance/cutter replacement are anticipated. Interventions for boulder removal that cannot be excavated by the cutterhead and for inspection/change of cutters, we have assumed four work stoppages and 80 hours of intervention time per tunnel.

An excavation rate for tunnel advancement is assumed to be 10m per day.

An estimated volume of muck generated by the TBM is based on the following:

- Three 13.4m outside diameter tunnels with an overcut of 0.15m, for an in-place volume of 147.4m^3 per m of tunnel.

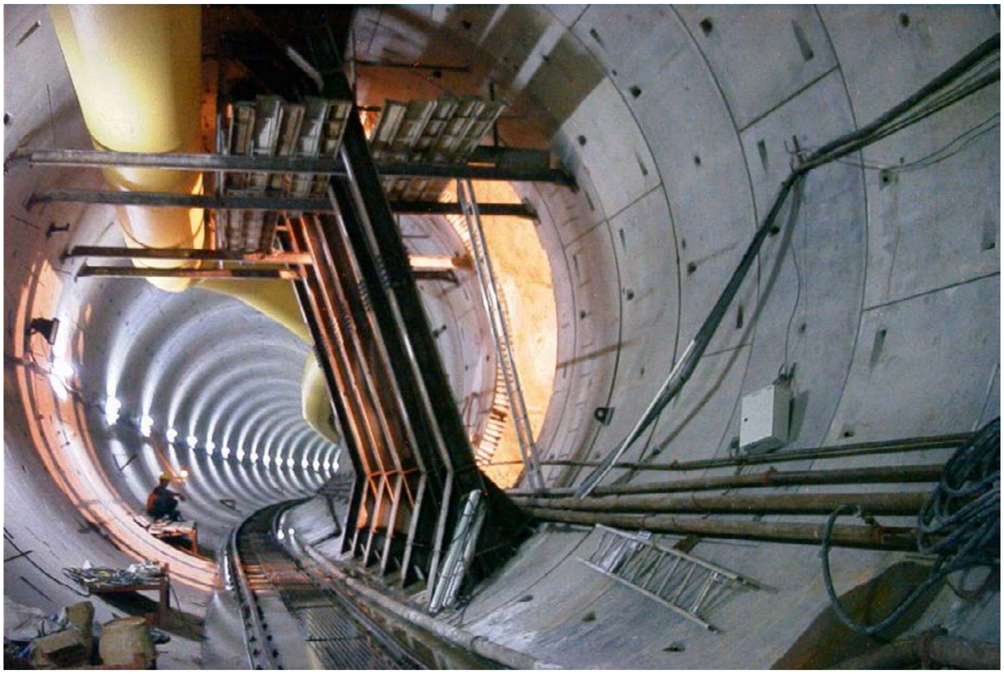
Locating a disposal site is not part of this study. For estimating purposes, the haul distance for muck disposal is less then 40km.

CROSS PASSAGES

Emergency egress/access will be required, in conformance with National Fire Protection Association (NFPA 502) requirements for vehicular tunnels. For the three bored tunnels, four cross passages (eight total between the three bored tunnels) are assumed to be required between adjacent tunnels (one every 180m). (For estimating purposes, two cross passages, four total between the three cut and cover tunnels, are assumed.) Each cross passage must accommodate a minimum 1.12m wide evacuation walkway, along with utility and conduit spaces and partition walls. Space for utilities for the tunnel systems (suppression system valves (see photo below), fire panels, fan motor control centers) and conduit spaces will require additional width/space in the cross passage; a minimum width of around 2m is recommended for planning purposes. Additionally, it is assumed that the cross passages will have a reinforced concrete lining thickness of 0.45m, to resist loads from groundwater and soil.

TBM tunnel cross passage with deluge valves

Cross passage construction between the tunnels will be in soft ground (soil). The construction methodology will require ground treatment to stabilize the soil units to prevent ground loss and possible surface subsidence associated with ground loss. Because of the variable soil conditions, and the inability to obtain surface access at cross passage locations, ground freezing is proposed as the optimal method for ground stabilization and groundwater control. Ground freezing involves installing a series of horizontal freeze pipes drilled around the perimeter of the cross passage section from within the tunnels. Brine is circulated to the individual cross passage freeze pipes which in turn freezes the ground around the pipes. This results in a self-supporting mass of frozen ground that provides strength and groundwater cut-off. A structural frame to support the tunnel segments (see photo below) is installed at the cross-passage area prior to excavation of the cross passage. After freezing is completed, segments are removed and the frozen ground is excavated using mechanical excavation. Initial ground support is typically provided by shotcrete in combination with steel fibers or welded-wire fabric reinforcement, and lattice girders. After excavation and support is completed, a waterproofing membrane is installed followed by placement of a cast-in-place reinforced concrete liner.



Typical steel propping in TBM tunnel

TUNNEL SYSTEMS

Several operational systems and features are required within the tunnel to support safe traffic operations and to provide the necessary level of fire protection and life safety. These tunnel systems and features include:

- Ventilation
- Fire-Life safety
- Emergency egress
- Fire protection (fixed firefighting system, standpipe)
- Fire detection and alarm
- Drainage
- Lighting

- Traffic control and monitoring
- Electrical
- Tunnel finishes
- Communications
- Equipment control and monitoring (SCADA)
- Security
- Operations and maintenance

Below are brief discussions of several critical systems and features.

TUNNEL VENTILATION

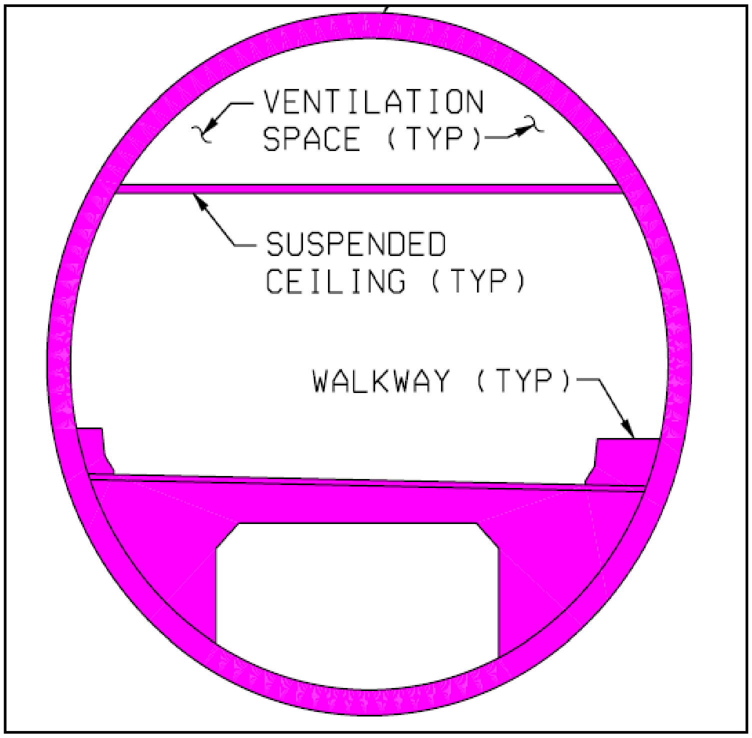
Ventilation is a critical key to providing safe conditions within road tunnels. During normal traffic operations, ventilation is required to maintain the in-tunnel air quality by preventing the dangerous accumulation of vehicle-emitted pollutants (i.e., carbon monoxide and oxides of nitrogen) and to maintain visibility in the tunnel by preventing the accumulation of haze-producing pollutants. In the event of a fire emergency the tunnel ventilation system performs a major role in providing life safety support by controlling the flow of smoke and heat in a manner that protects motorists and facilitates evacuation and fire fighter access.

Tunnel ventilation methods are categorized as either natural or mechanical systems. Natural systems rely on the piston-effect of moving vehicles, external wind, and temperature and pressure differentials between the portals to generate airflow through the tunnel. Mechanical systems use fans to generate airflow. Due to the length and traffic flows, this tunnel will require mechanical ventilation to conform to National Fire Protection Association 502 requirements for vehicular tunnels. There are three types of mechanical systems which are typically classified as longitudinal, semi-transverse or transverse:

- Longitudinal systems have air introduced to a tunnel or removed from a tunnel at a limited number of points, such as at portals. A popular example of this type of system employs ceiling-mounted jet fans (see photo below) to produce the required airflow through the tunnel. Longitudinal systems are typically used in tunnels with unidirectional traffic to take advantage of the vehicle piston effect.

Longitudinal ventilation with jet fans

- Semi-transverse systems use an air duct to either supply or remove air uniformly along the length of a tunnel (see figure below). In this configuration, reversible fans are typically used to provide for smoke and emissions management. A semi-transverse system typically requires a ventilation building at each portal to house the ventilation fans and the operational equipment needed for the system. An order of magnitude estimate for the (minimum) size of a ventilation building is 35m x 30m x 18m (height).



Semi-transverse ventilation

- Transverse systems use both a supply and an exhaust air duct to uniformly distribute air to and from a tunnel. Typically, air is supplied low near the roadway level to promote the rapid dilution of the vehicle-emitted pollutants. Air is exhausted into a ventilation plenum above the roadway through inlets in the tunnel ceiling. This is advantageous for exhausting hot smoke in the event of a vehicle fire. This system also requires a ventilation building(s).

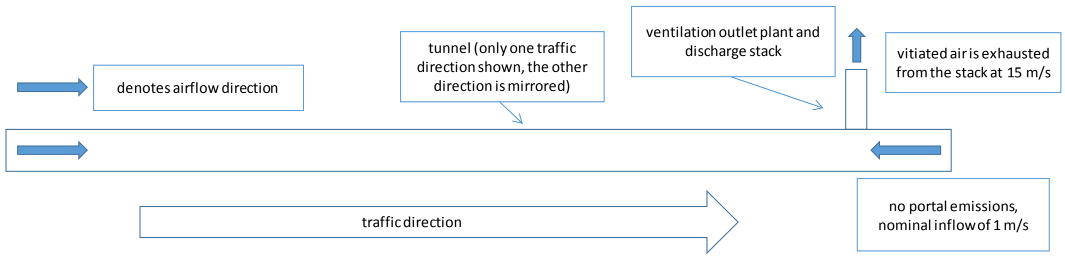
For normal tunnel operations, the tunnel length, traffic volume, and the direction of traffic movement (unidirectional versus bi-directional) are key factors in determining the mechanical ventilation system required. The installed ventilation system capacity is ultimately determined by the requirement for emergency smoke control during a tunnel fire incident (emergency operations).

A longitudinal system is suitable for unidirectional traffic, which would likely be a workable system for the tunnels assuming unidirectional traffic. If bi-directional traffic is required, then longitudinal ventilation would not be effective. Due to limited information and the nature of this study, a longitudinal ventilation system has been selected for costing purposes.

With any ventilation system, there are two critical factors to be resolved at a conceptual design (permitting) phase:

1. Emissions from the tunnel during normal traffic operations must be quantified and air quality (environmental) compliance in areas surrounding the tunnels assessed. For a tunnel of the length contemplated, with a longitudinal ventilation system in place, emission levels at the portals might be more than allowable. To improve portal air quality, ventilation buildings at each end of the tunnel may be required. A single point

exhaust would be used near the end of the tunnel to capture vitiated air prior to the portal and eject it through a vertical shaft. The figure below shows the concept.



Longitudinal ventilation concept

2. The design fire for the ventilation system is a critical input. The design fire depends on the traffic using the tunnel. A typical heavy goods vehicle fire is in the order of 100MW to 150MW, however, a dangerous goods vehicle fire (such as a tanker) is in the order of 300MW. Ventilation systems can be (typically) designed to manage the smoke from a heavy goods vehicle fire. However, a design fire based on a dangerous goods vehicle event can result in an excessive ventilation design and can cause safety and tunnel fire durability issues. Rather than design for this extreme event, typical practice is to find an alternative route and ban these vehicles from using the tunnel.

FIRE-LIFE SAFETY

The specific requirements for the systems and elements necessary to meet the fire protection and life safety goals would be based on the minimum requirements established in National Fire Protection Association 502. The document is a standard and not a legal code requirement unless explicitly called out in the relevant fire code. In most jurisdictions, authorities and agencies will at a minimum adopt NFPA 502 as a guideline. NFPA 502 has been followed as a basis for the recommendations herein.

Tunnel life-safety features primarily indicated by NFPA 502 include:

- Ventilation
- Tunnel Cross-Passages/Emergency Egress
- Fire Protection (Fixed Firefighting System, Fire Standpipe, Extinguishers)
- Fire Alarm System (panel, manual and automatic detection)
- CCTV
- Communications (telephones, radio/cell phone)
- Traffic Control
- Drainage
- Lighting (normal and emergency)
- Power (with redundancy)

- Signage
- Structural Fire Protection
- Operation and Maintenance

An emergency pull over area (alcove) for vehicles was not considered in this study. The shoulder widths vary widely depending upon the authority having jurisdiction. Shoulders in US projects vary from minimal, less than 0.3m, to full shoulders, greater than 3m. If an emergency alcove or wider shoulders are desired, further study would be required and the cost of the tunnel option will increase.

EMERGENCY EGRESS

Emergency egress requirements, as noted earlier, are established in NFPA 502 with cross passages to the non-incident tunnel at a maximum distance of 300m. Typical international practice is to space exits at around 120m to 200m, and for this tunnel a spacing of 180m is recommended. The minimum egress path width is 1.12m and fire rated doors are required to separate the egress pathway from the tunnel.

Consideration also needs to be made regarding wheelchair access and this requires passages to be designed at the same elevation as the roadway, with no steps in the egress path. It is also commonplace to provide wheelchair holding areas in the cross passages (see photo below).

Wheelchair holding space

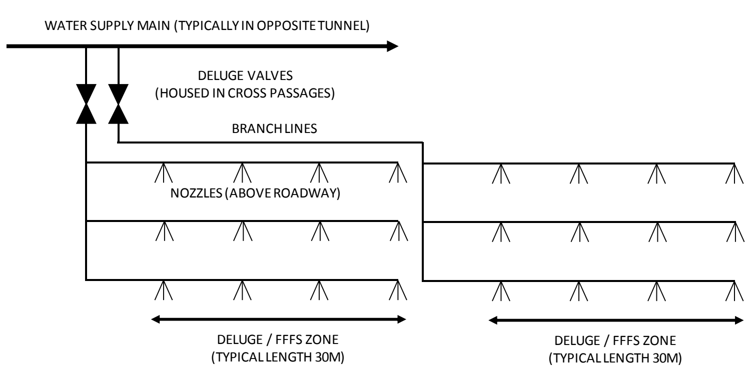
Signage to identify egress points, and protection around doors leading to/from the tunnel is also necessary. Doors are typically sliding doors. The photo below shows an example of a cross passage with signage.

Egress passage with signage

FIRE PROTECTION

Standpipe systems are utilized to provide a water supply to remote locations within a facility for use by firefighters. Standpipes are considered a manual system that allows firefighters the ability to connect hoses to the system at locations where needed to fight the fire. A dry standpipe system would be ideal at this location, where freezing is an issue, however, the length of this tunnel means that fill times might be too long, which would require a wet system with freeze protection (heat tracing, insulation, circulation).

Fixed firefighting systems (FFFS) are becoming 'standard' features in modern road tunnels. The most common system used for road tunnels is an open-nozzle deluge type. This type of system consists mainly of a water supply main connected to a series of deluge valves. The deluge valves open upon activation allowing water flow to the normally "dry" distribution piping over the roadways and then discharge onto the fire site through the open nozzles. The tunnel operator typically manually activates a fixed firefighting system, which introduces additional considerations regarding training and system control capabilities. When designed, and used properly an FFFS can greatly reduce the life safety risk and property risk posed by a tunnel fire. The figures below show some examples of aspects of an FFFS.



FFFS schematic

FFFS operation in a road tunnel

Based on the length of the tunnel, it is recommended to include both a standpipe system and an FFFS in the design. Fire extinguishers are also required per NFPA 502.

TUNNEL DRAINAGE

Tunnel drainage systems normally consist of two independent systems; a storm water control system and a tunnel drainage system.

Storm water control systems are required at the tunnel portals to intercept storm water flows that accumulate on the open approaches and transition roadways leading into and out of the tunnel. A separate tunnel drainage system, designed to be independent of inflow from sources outside the tunnel, is required to collect and discharge water and effluents generated within the tunnel. These effluent flows result from tunnel washing, use of fire suppression systems, vehicle carryover, and some groundwater seepage. The tunnel drainage system must also be designed and equipped to accommodate a potential fuel spill.

The profile of the selected tunnel alignment will dictate the location the tunnel drainage pumping station and sumps, as the drainage collection needs to occur at the lowest point in the roadway profile.

The storm water collected at the tunnel portals is typically assumed to be clean and therefore does not require special treatment prior to discharge. However, the tunnel drainage effluent may require some form of pre-treatment prior to discharge depending on local permitting requirements.

TUNNEL LIGHTING

The tunnel lighting system provides the required illumination so that motorists can safely navigate and maintain speed while in the tunnel. Illumination levels differ for daytime, nighttime, and during an emergency. Daylight conditions require high levels of illumination at the portal to avoid the “black-hole” effect. Nighttime levels, which are significantly lower than daytime levels, need to be consistent throughout the tunnel. Emergency lighting allows for safe egress.

TRAFFIC CONTROL

Roadway tunnels are required by NFPA 502 to provide a means for control of traffic within the tunnel, as well as traffic on the approach roadways leading into the tunnel. These systems are necessary to control traffic within the tunnel and/or to prevent vehicles from entering the tunnel in the event of an incident or emergency and for purposes of tunnel maintenance. Traffic control systems will be required for the Langstaff Road Tunnel. The types of traffic control systems and devices likely to be required include:

- Automatic Incident Identification, based on an intelligent, programmable, CCTV video stream.
- Closed Circuit Television (CCTV), for general surveillance, would typically be monitored from a dedicated tunnel operations control center.
- Dynamic (Variable) Message Signs are typically provided in the tunnel and tunnel approaches at regular intervals above the travel lanes to display instructions and emergency messages to motorists.
- Lane Use/Control Signals are typically located along the tunnel walls or ceiling, and over the roadway at the tunnel portal approaches, at regular intervals to indicate the status of each travel lane as either opened or closed.
- Over-Height Vehicle Detection/Protection.

ELECTRICAL

A variety of electrical systems are required to support safe traffic operation. The required installation methods and performance criteria of these various electrical systems for road tunnel application have been generally defined within applicable codes and standards including NFPA 502 and the National Electrical Code. The required tunnel electrical systems include:

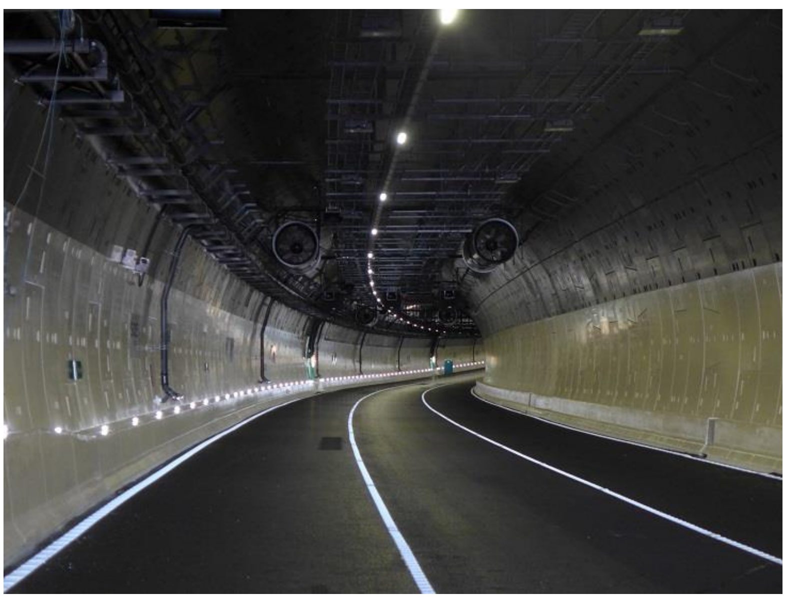
- Power Distribution.
- Fire Alarm and Detection.
- Emergency Communications.
- Security.
- Supervisory Control and Monitoring (SCADA).

Critical systems, such as lighting and ventilation, are required to have a redundant power supply. This is typically achieved via an independent feed or a backup generator.

TUNNEL FINISHES AND STRUCTURAL FIRE PROTECTION

Structural fire protection will be required for this facility. The final measure could include a protective board, microfibers in the concrete or a spray on material. In addition, there are features required such as signage and architectural elements, internal and external to the tunnel. An example is shown in the photos below.

External view of a tunnel, with the ventilation shaft in the foreground

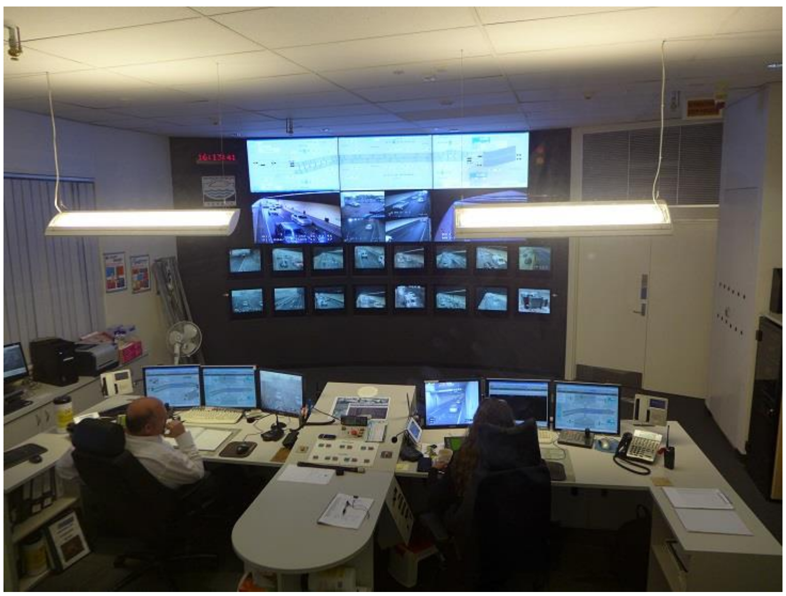


Internal view of a finished TBM tunnel

OPERATIONS AND MAINTENANCE

A roadway tunnel will require a substantial investment in operations and maintenance. With a daylight to daylight length of over 1000m, this tunnel will require a dedicated operational approach. This approach, in line with international practice, consists of a full-time staff, with trained human operators monitoring the tunnel 24/7. Some of the key features related to operations and maintenance (O&M) include:

- Operation and control room for tunnel operational staff and operation interfaces (SCADA system).
- Maintenance facilities which may include maintenance workshops, garage facilities and other storage space to house equipment and parts needed to maintain the tunnel.
- Staffing requires a mix of capabilities including electricians, millwrights, mechanics, general staff and operations personnel.
- Planning and coordination for incidents and emergencies. This involves periodic exercises with local emergency services departments.
- Periodic tunnel closures to allow for system maintenance and repairs.



Tunnel control room

CONSTRUCTION STAGING

The contractor's main staging or work areas for excavating and constructing the tunnels will be located at each portal. Work phases will include the following:

- Site preparation work and surface demolition of right of way (ROW),
- Boat and cut and cover sections,
- Tunnel construction, and
- Tunnel fit out and connection to the existing roadway.

The bored tunnels are assumed to be constructed sequentially using a single tunnel boring machine.

For this study, a conceptual-level tunnel construction sequence has been developed. With more definition of project design and project constraints, the overall construction schedule duration may be modified. We have assumed that bored tunnel works are staged from the cut and cover areas on the east and west sides of the CN Yard.

The construction staging of the cut and cover construction is assumed to be slurry walls constructed with precast concrete decking where required to maintain traffic across the cut and cover areas. Construction across an existing street or spur rail is assumed to be performed with a lane/track closure or diverted street traffic. Once a section of slurry wall and temporary deck is installed, normal road or rail traffic may resume on that particular lane/track. In open sections, temporary decking will not be installed and street closures will be necessary. Some accesses to adjacent businesses will need to be rerouted and businesses within the ROW will be demolished as needed. Restoration of businesses on top of cut and cover sections is feasible. Below the precast panels, a reinforced box structure will be built with no disruption to the street above. Once completed, the precast panels would be removed, tunnel backfilled, and the permanent surface restored. An in-depth construction staging and maintenance of traffic (MOT) plan was not performed for this study.

PREPARATORY

Typically for the three tunnel bores of the anticipated diameter, a minimum area of 8,000 to 12,000 m^2 is desirable for the contractor's needed support elements, which include: a location for positioning a crane for assembly of the tunnel boring machine (TBM) and other assorted servicing on site, precast concrete segment storage, temporary muck storage, lay down area, contractor office trailers, electrical sub-station, workshops and change houses for the tunnel crews, air compressors, temporary construction ventilation fans, pump station for dewatering and associated treatment facilities, vehicular access and parking for staff and labor crews, and an access/haul road from the muck loading and segment storage area to a pubic road.

The work that occurs at the staging area during this phase consists of:

- Preparing the site for the tunnel construction activities, erecting a secure perimeter boundary including a sound attenuation barriers, clearing and grubbing, and demolition of existing structures, if any.
- Constructing the support facilities outside of the active construction zone; bring in the necessary utilities, construct temporary electrical substation.
- Excavation and support of ground (construction of SOE) to develop the open cut and cut and cover approaches to the mining portal areas.
- Establishing temporary muck storage area.
- Establishing precast segmental liner storage area.
- Providing general laydown area.
- Support of ground improvement efforts.
- Office Complete/Change Houses/Personnel parking.
- Safety Trailer.
- Utility/service crane(s).

- Mechanic's and Carpenter shops.
- Rough grading.
- Grading internal circulation and haulage roads and truck wash down area.
- Install and obtain background readings of the construction instrumentation program to monitor CN Yard tracks and other structures and utilities.

TUNNEL CONSTRUCTION

At the mining portal, construction changes from above ground to underground construction. During this phase of activity, the following work items include:

- Assembly and launching of the TBM followed by support of the TBM while it is mining and lining the tunnel.
- Delivery of and temporary on-site storage of precast concrete segments, which are used to permanently support the ground as tunneling advances.
- Material handling equipment (mining trains or conveyors) to move the muck from the TBM in the tunnel to the staging area.
- Dust suppression equipment, for haul roads and other traffic areas.
- Handling of the muck from the tunneling equipment to the temporary muck storage piles or directly to over-the-road trucks.
- Removal of the tunnel excavated material (muck or spoil) from the staging area by over-the-road trucks.
- Set up and running of ventilation fans, which provide fresh air to the tunnel during construction through a ventilation duct that is extended as the TBM progresses down the tunnel. (These fans are temporary and not the permanent ventilation fans.)
- Excavation and support and lining of cross passages after the first two tunnels are completed and after the third tunnel is completed.

This study assumes one TBM will be operated, which will require the TBM to drive three tunnels. After completing one tunnel, the TBM will be dismantled and reassembled to drive the second tunnel and repeated for the third tunnel.

The tunneling operations are assumed to be performed during both day and night shifts so spoil generation should be anticipated on all working shifts. This may require the project to provide adequate storage capacity for spoil that is generated during potentially restricted haul times. The TBM will be utilized on a continuous basis, other than during shift changes, stoppages for general maintenance, stoppages for interventions and inspection/change cutters or due to other mechanical problems.

FIT OUT

After the tunneling is completed, the TBM would be dismantled and trucked off-site and the muck piles fully removed, and the precast liners storage area vacated. However, construction activities at the portals continues and includes:

- Dismantling and removal of all mining/tunnel equipment, muck handing equipment.
- Delivery of the roadway systems that go into the tunnel.
- Construction of the final lining and inverts of the open cut and cut and cover sections.
- Permanent utility work.
- Construction of the interior elements of the tunnel (benchwalls, roadway deck slab, vent fans, installation of the electrical and mechanical equipment).
- Construction of the approach roads.
- Site clean-up.
- Test and activate tunnel systems.
- Place tunnels in operation.

CONSTRUCTION IMPACTS

The impacts with tunnel construction are typically dust, noise, traffic impacts, vibration, settlement and groundwater migration.

The contractor will be responsible for controlling visible dust caused by the construction operations and the moving of vehicles and equipment. The contractor's operations should include air monitoring and dust minimization measures.

As the site for the construction activities is prepared, erection of a secure perimeter boundary is needed for protection of the public and security of the equipment and materials on the working site. Typically included in the security boundary is a sound attenuation barrier, which significantly reduce noise levels emanating from the construction site.

The contractor should prepare a Construction Traffic Plan, which typically includes the haul routes that contractor's and subcontractor's trucks will utilize, cranes and other heavy equipment delivery will follow to and from the work sites and off-site disposal or storage areas. Truck traffic through local streets and commercial areas will need to be controlled.

Vibrations from various construction activities should be considered and mitigations to limit vibrations should be implemented. Sources of vibration include the following construction activities:

- Tunnel excavation by tunnel boring machine (TBM). (For soft ground tunneling this is usually not an issue.)
- Open cut and cut and cover excavation.
- Major construction equipment in excavations.
- Truck traffic.

Vibration levels of the various equipment are expected to be low and should not induce damaging vibrations to adjacent structures.

Settlement of the ground may be induced by the TBM. A precast concrete segmental lining will be installed within the TBM shield concurrently with excavation. The most appropriate TBM technology for tunneling in the anticipated soil and groundwater conditions along the alignment is a pressurized face TBM. By using a pressurized face TBM ground control is greatly enhanced and therefore any resulting settlement is minimal. To monitor ground loss or settlement, an instrumentation program should be developed and implemented during construction. Monitoring devices may include structure monitoring points, surface settlement points, deep settlement points, utility settlement indicators, crack gages, tiltmeters, inclinometers and groundwater monitoring wells. Review and alert levels of various measured settlements or deformations should be developed.

The ground cover over the tunnel at the portal areas will be about ½ tunnel diameter, which is not ideal for pressurized face tunneling. There is more risk of larger surface settlements than if the tunnel were deeper.

Example of tunneling through major rail yard: On the East Side Access Project in New York City, one aspect of that project involved tunneling below Sunnyside Yard, a major rail yard in Queens and the Northeast Corridor. Ground conditions in Queens were predominantly shallow fill deposits overlaying organic materials in some areas followed by glacial tills, composed of gravel and silty sand with some clay lenses, and shallow bedrock. The groundwater level was close to the ground surface. WSP designed four 6m diameter tunnels, lined with precast concrete segments. The tunnels were constructed through soft ground and mixed face conditions using pressurized face TBMs. Tunneling was completed with no disruption to rail operations despite mining to within 1.8 to 3.3m of the surface. Extensive instrumentation demonstrated that track settlements were negligible.

Groundwater may migrate towards and into excavations if the ground support for the structure being constructed is not watertight. Groundwater migration can cause settlement of certain types of ground or could cause migration of contaminated water/materials toward the excavation. The precast concrete tunnel segments will have gaskets around each segment that will not allow water to enter through the tunnel liner. Permanent structures open cut, cut and cover sections and cross passages are constructed within the excavations that have been stabilized by the excavation support system. Waterproofing systems should be applied to the interior surface of the excavation support system before the final reinforced concrete structure is constructed to guard against water inflows.

Note that ROW acquisitions and easements have not been identified in this memorandum.

ROUGH ORDER OF MAGNITUDE (ROM) COST ESTIMATE

A conceptual construction cost estimate was prepared and is summarized in Table 1 below. The costs include mobilization and surface work; open cut and cut and cover tunnel sections; bored tunnel sections; civil, electrical, mechanical and ancillary systems for the tunnels. A 50 percent contingency was included on the construction costs, which is in accordance with AACE Cost Estimate Classification System as Applied in Engineering, Procurement, and Construction for the Process Industries. All costs in this memorandum are based on 2018 labor and material costs. Costs are shown in Canadian dollars, using a conversion factor of 1.25 times US dollars (January 2018 basis).

Soft costs related to administration, project management, design, construction management, procurement, public outreach and ROW and easement acquisitions have not been included. Tunnel operation and maintenance costs (considered separately) were not included in the construction estimate and escalation and risk reserve have not been included.

Table 1 - Rough Order of Magnitude Construction Costs

Item	Description	Quantity	Total Cost (CA$)
1	**Mobilization/ Demobilization**	Lump Sum	$57,500,000
2	**TBM procurement, excavation and support**	2,340m	$272,346,000
3	**Tunnel fit out - civil, electrical, mechanical, fire-life safety and ancillary systems**	2,340m	$107,114,000
4	**Cut and cover sections with CIP concrete and fit out**	535m	$160,481,000
5	**Open sections with CIP concrete and fit out**	470m	$31,800,000
6	**East and west portal structures**	2	$3,125,000
	Subtotal		$632,366,000
	Contingency (50%)		$316,183,000
	Total Estimated Construction Cost (2018)		**$948,549,000**

OPERATIONS AND MAINTENANCE COST

Operations and maintenance costs will vary based on but not limited to the following: tunnel length, tunnel traffic flow (average daily traffic), type of ventilation and number of fans, number of lighting fixtures and ease of access, supervision and alarm equipment, fire suppression systems, communication facilities, systems power consumption and energy costs, safe and easy access to the tunnels and ancillary spaces, management and O & M personnel, contracting for various services and preventative and corrective maintenance. O & M costs are based on an annual basis for operations and maintenance costs for the year. A rough estimate of O & M costs on an annual basis for the tunnels described herein may range from $8 to $10 million. Note these costs do not include major equipment replacement/renewal, repaving or cyclical equipment replacement.

ROUGH ORDER OF MAGNITUDE (ROM) SCHEDULE

A conceptual level project schedule was developed for the bored tunnel and is provided below. The schedule is based on our knowledge of underground construction and experience on similar types of large underground construction projects. The time frame for each activity or task is approximate and would change depending on many variables. The estimated construction time to complete the tunnel option is about 5 years. The schedule does not include time for planning, permitting or design.

Factors that may affect the construction schedule include:

- Availability of funding;
- Environmental and permitting processes;
- Land acquisitions and easements;
- Availability of contractors and skilled tunnel labor; and
- Unforeseen ground conditions.

One or more of these factors may disrupt schedules and cause tunnel costs to increase.

Rough Order of Magnitude Construction Schedule

Work Item (Time in Years)	1	2	3	4	5	6
Site Mobilization – site prep, SOE, TBM procurement Demolition						
TBM excavation and support - three two-lane tunnels with precast segmental liner and eight cross passages						
Open/boat sections with CIP concrete liner and fit out						
Cut and cover sections with CIP concrete liner and fit out						
East and west portals						
Tunnel fit out - civil, electrical, mechanical, fire-life safety and ancillary systems						
Place Langstaff Road tunnels in operation						

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LANGSTAFF ROAD CN YARD TUNNEL OPTION

PLAN AND PROFILE

LANGSTAFF ROAD CN CROSSING

TUNNEL OPTION - PLAN

Scale: 1:1100

Date:
February 21, 2018

LANGSTAFF ROAD CN CROSSING
TUNNEL OPTION - PROFILE

Scale: 1:1500(H) 1:150(V)

Date:
January 18, 2018

APPENDIX

E

TECHNICAL MEMO - ALTERNATIVE 1A EVALUATION

TECHNICAL MEMO

TO: Brian Wolf, P.Eng., York Region
Tim Kwan, P.Eng., York Region

FROM: Hugh Robinson, P.Eng., Robinson Project Services

CC: Neil Ahmed, P.Eng., Katherine Jim, P. Eng., Cam Tytgat, Allan Mielke, P. Eng.

SUBJECT: Langstaff Road - CN MacMillan Yard Crossing Alternative 1A Evaluation Memo

DATE: May 14, 2018

1. ASSESSMENT FRAMEWORK

1.1 SUMMARY

In order to provide sufficient detail to CN in regards to the technical feasibility of constructing a new structure over the rail yard, two internal workshops were scheduled and follow up analysis completed by the rail specialists on the team with a focus on construction access to each pier and abutment construction site and implications to CN operations during construction of the structure. Following is a summary of the approach to this analysis and outcomes regarding the potential construction and staging.

The framework will illustrate that all possible and reasonable measures have been considered regarding construction access, the placement and construction of piers and abutments, including the construction methodology for installing spans.

Option 1 A (Exhibit 1-1) was identified as the preferred alternative to use for this framework as it reduces the number of pier locations required while minimizing the interference with yard operations for span installation. This information has been developed without any CN consultation specific to any particular option nor any ground trothing due to access restrictions to the yard and adjacent properties; however, it has been developed with the assistance of experienced railway operating and construction resources available within the WSP team in addition to readily available aerial photography and mapping through public sources. Note that there is little information yet available regarding the various buried utilities in the yard, e.g. sewer, water, gas, electrical, communication, and drainage.

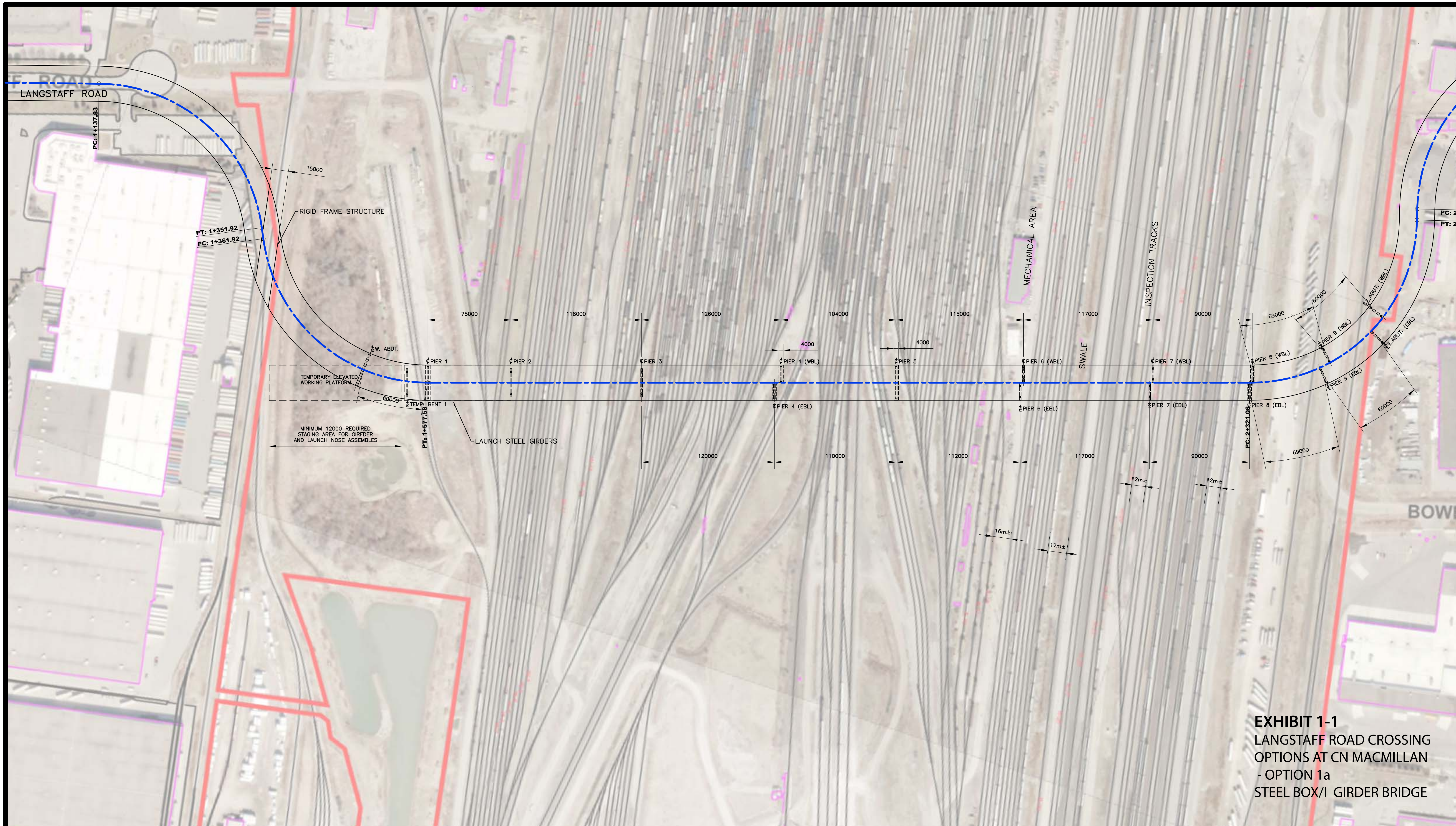


EXHIBIT 1-1
LANGSTAFF ROAD CROSSING OPTIONS AT CN MACMILLAN
- OPTION 1a
STEEL BOX/I GIRDER BRIDGE

The assessment addresses the following major areas of concern to CN:

- Design
- Construction
- Interference with Operations
- Impact on flexibility to modify operations

The issues addressed in this framework are primarily in respect of those issues which might impact current CN operations and how it is proposed that those issues be avoided or mitigated. Specific criteria and methodology may need to be adjusted to suit final design and construction equipment being used.

Generally, in consultation with CN, some or all of the design and construction criteria outlined in this document will become parameters which a construction contractor must adhere to and accommodate in their work plans.

1.2 DESIGN

Option 1A consists of a long tangential steel box which will be constructed at the west side of the yard and hydraulically pushed across the yard pier by pier from the west end.

The deck and superstructure elements will be constructed from above. Access in the yard will only be required for access to pier locations during their construction and access to the pier locations while pushing the bridge across the yard once the piers have been constructed. Typical vehicles requiring access would be low bed trucks, cranes, concrete trucks, and small tonnage service vehicles and pickup trucks. The curved sections at each side of the yard will be constructed in a more conventional way requiring access for cranes to lift span sections into place. This approach has been successfully used in other similar yards and is expected to be feasible in this yard.

With this minimally intrusive construction methodology, the bridge North/South position and supporting pier locations have been selected to maximize span lengths while situating piers in locations that minimize permanent and temporary impacts. Each pier consists of bored caisson piling, a buried concrete foundation, and 2 columns each about 2 m in diameter. Note that a number of piers have been staggered to either better fit the available space or maximize roadway access clearances.

A number of bridge design elements that have been considered are as follows:

- Vertical and horizontal clearances. Except as may otherwise be required by CN, Minimum standard railway clearances will be maintained. Minimum permanent lateral clearance to any structure will be 10 ft. (3.05m) from centerline of track.
- All rainwater from the roadway above will be controlled and directed off railway property.
- Potential interference of completed structure on railway train communications will be assessed and mitigated prior to construction.
- Pier locations have been selected such that train movement sight lines are not obstructed.
- Existing yard camera system will be enhanced and added to as necessary to account for any 'blind' spots including potential cameras mounted on the structure.
- Yard lighting will be added to account for the presence of the bridge and piers. Existing yard lighting will also be reviewed relative to potential impact on vehicles using the proposed bridge.
- Piers will be designed according to CN's requirements for crash wall protection.
- Barriers and fencing will be designed into the structure to obstruct views to the rail yard and prevent objects from being thrown off the bridge into the yard, and to avoid vehicles involved in accidents from scattering debris or liquids from the bridge into the yard below.

1.3 CONSTRUCTION

All construction activities will be planned in detail ahead of time and, approved and coordinated on a daily basis with CN Operations. For a successful project there will be activities specifically assigned to CN and York Region and York Region contractor. It will be necessary to define these responsibilities by way of an agreement between CN and York Region. York Region will then include all information in their request for proposals. CN must be involved in the review of design and construction proposals (e.g. including site access for soils and foundations testing), and necessarily will have a veto over any proposed activity they deem too invasive or detrimental to their yard operation.

Each pier will have its own:

- Site layout drawing and laydown area;
- Construction sequence plan;
- Supervision plan;
- Construction schedule:

- A well-developed work plans, and contingency plans for all construction activities.
    - Changes to plans should not be made at the last minute given the complexity of the rail yard operation.
    - Planning is generally done as a rolling process on a monthly, bi-weekly, weekly and daily basis, requiring a constant high degree of communication and coordination.
    - Note that emergency or suddenly changing conditions within the rail yard or affecting the rail yard may result in the sudden cessation or modification of the contractor's planned activities.

- Access plan & drawing:
    - This plan will include provisions for emergency response access and emergency egress.
    - All access will be controlled and will be coordinated with CN daily.
    - All crossings utilized by contractor will be controlled/flagged by railway or railway-trained personnel.

1.4 RAILWAY SPECIFIC CONSTRUCTION CONTRACT CRITERIA

For the bridge construction contract there are a number of criteria which would be developed in concert with CN. The following is an early list of topics that this document would need to cover. This can be developed independently but would require CN review, input, and agreement.

1. Scope of Work
2. Responsibilities
3. Reference Documents
4. Yard/Site Access
5. Rail Operation Safety
6. Design Requirements
7. Plans, Design Submittals & Review
8. Construction Requirements
9. Pre-Construction Activities
10. Mitigation Works and Activities
11. Utilities
12. Site Restoration
13. Security
14. Flagging
15. Supervision, Reporting & Management
16. Emergency Conditions & Delays

17. Schedule
18. Quality Assurance
19. Environment
20. Health & Safety
21. Traffic Management
22. Reports & Documentation

1.5 AGREEMENTS

There are, at a minimum, two agreements that York Region will establish with CN:

- *Construction Agreement:* This is an agreement between CN and York Region that will allow construction to proceed. No work will be done on CN property without this agreement. This agreement will likely include a series of approval steps regarding the design, development of construction criteria for tender documents, responsibilities of the various parties, review and approval of tenders, processes during construction, and inspection and acceptance of the work, including items in clause 1.4 above.
- *Crossing Agreement:* This is an agreement between CN and York Region covering the ownership, maintenance, responsibilities, and costs for the completed structure into the future.
- Other agreement including access to the yard during detailed design for soils and foundation testing should also be established

2. PIER AND ABUTMENT ASSESSMENT

Each abutment and pier is described below in suitable detail to provide the approach, site access, potential impact and tentative mitigation. These are presented starting from the west side to the east.

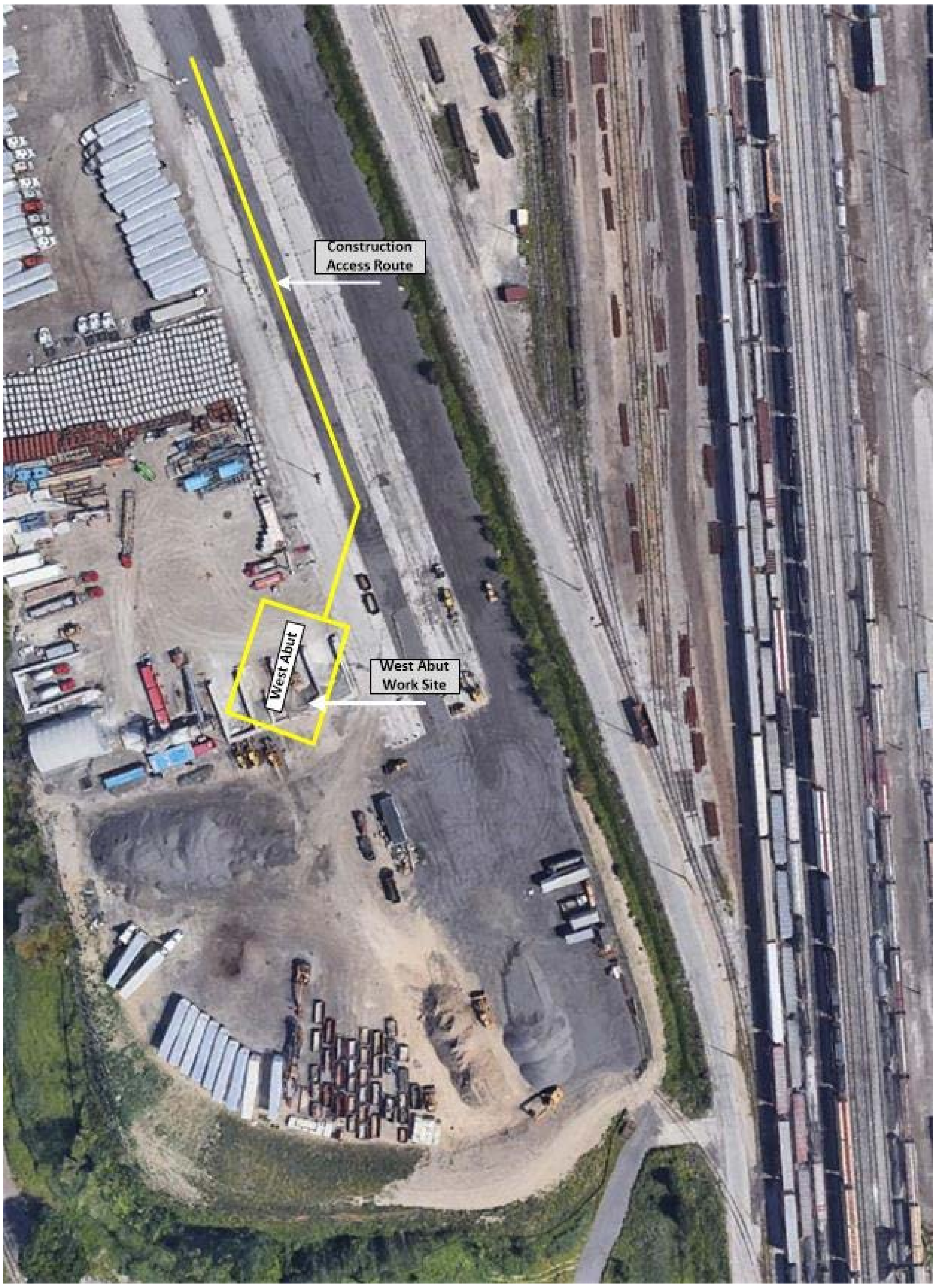
2.1 WEST ABUTMENT

2.1.1 Site Description

The West Abutment is located within an area of the yard being used by a third party for a granular material recycling/batch plant operation at the west side of the yard immediately south of the west Langstaff Road/Jane Street yard access. Refer to Exhibit 2-1.

It appears this area is used for trailer storage (perhaps for the business located immediately to the west). The area is flat and access will not impede rail operations. In the past there was track access into this area which has been discontinued. The tracks have either been buried or removed (CN to advise).

Exhibit 2-1: West Abutment Site Schematic



- *Utilities:*
    - Definitive utility information is unknown.

- *Possible utilities:*
    - U/G power line in vicinity.
    - Power poles along access to third party operator.

2.1.2 Access

Directly from the north off the west Langstaff Road/Jane Street yard access road.

One track crossing on Langstaff Road. This track is used for accessing a number of industries on the west side of the yard. Note that it is also connected to the diesel shop tracks toward the north end of the yard on the west side and at the far north end connected to the tail track.

2.1.3 Impacts

- *Temporary:*
    - Loss of storage/work area for the business occupying this area needed by the construction contractor.

- *Permanent:*
    - Area occupied by abutment and approach grade.
    - Possible discontinuation (relocation) of the business occupying this area.

2.1.4 Mitigation

- *Temporary:*
    - Unless business discontinued, rearrange the business operation to allow construction.
    - Utilize some of the surrounding area for material storage relative to the impacts at Pier 2. CN may require a fenced and locked compound because of the location.
    - Roadway maintenance and repair.

- *Permanent:*
    - Third party business to permanently discontinue use of this property and relocate to another site off CN property.

2.1.5 Notes

The business operation at this location will need to be discontinued temporarily to allow for span launching and associated staging.

Separate emergency egress and safety plans will be required for each pier site. These plans will need to be coordinated with CN emergency response and egress plans in the yard.

A comprehensive traffic plan will be required to deal with co-mingled yard operations traffic and construction traffic. This may include roadway and crossing upgrades to segregate certain activities and provide opportunities for staging construction traffic and to allow vehicles to pass by. This plan will include roadway flagging to manage traffic as needed.

A specific construction plan and schedule will be required at each pier location.

2.2 PIER #1

2.2.1 Site Description

Pier 1 is located west of the south end of Yard M, immediately west of the yard access road parallel to Yard M lead which leads to the Langstaff Rd/Jane St access to the yard. Refer to Exhibit 2-2.

It appears this area is used for trailer storage (perhaps for the business located immediately to the west). The area is flat and access will not impede rail operations.
In the past there was track access into this area which has been discontinued. The tracks have either been buried or removed (CN to advise).

- *Utilities:*
  - Definitive utility information is unknown.

- *Possible utilities:*
  - U/G power line in vicinity.
  - Power poles along access to third party operator.

Exhibit 2-2: Pier #1 Site Schematic

2.2.2 Access

Directly from the north off the west Langstaff Road/Jane Street yard access road.

One track crossing on Langstaff Road. This track is used for accessing a number of industries on the west side of the yard. Note that it is also connected to the diesel shop tracks toward the north end of the yard on the west side and at the far north end connected to the tail track.

2.2.3 Impacts

- *Temporary:*
  - Loss of storage/work area for the business occupying this area needed by the construction contractor.
  - Beginning at Pier 1, additional area is required to construct and launch spans.
  - Work site fencing.

- *Permanent:*
  - Area occupied by abutment and approach grade.

2.2.4 Mitigation

- *Temporary:*
  - In addition to the area needed for pier construction, a much greater area is required for assembly and launching spans across the yard.
  - Flagging at the work site.
  - Roadway maintenance and repair.

- *Permanent:*
  - Third party business to permanently discontinue use of this property and relocate to another site off CN property.

2.2.5 Notes

Given the large area required for launching spans, it is not practical that the current business will be able to continue to operate from this location during construction. It is therefore suggested that the business operation at this site be permanently discontinued.

Separate emergency egress and safety plans will be required for each pier site. These plans will need to be coordinated with CN emergency response and egress plans in the yard.

A comprehensive traffic plan will be required to deal with co-mingled yard operations traffic and construction traffic. This may include roadway and crossing upgrades to segregate certain activities and provide opportunities for staging construction traffic and to allow vehicles to pass by. This plan will include roadway flagging to manage traffic as needed.

A specific construction plan and schedule will be required at each pier location.

2.3 PIER #2

2.3.1 Site Description

Pier 2 is located at the south end of M Yard between tracks M-1 and M-2, in an area of the yard used for maintenance material storage. Refer to Exhibit 2-3.

Approximate distance between tracks M-1 and M-2 is 65 ft. (19.8 m) centre to centre. The area is flat and access will not impede yard operations Based on available aerial imagery, it appears that turnouts for tracks M-2, and M-3 have been removed; CN to confirm.

- *Utilities:*
  - Definitive utility information is unknown.

- *Possible utilities:*
  - None known in immediate vicinity of proposed pier location.

2.3.2 Access

The access to pier #2 is presented in Exhibit 2-4.

Directly from the north between tracks entering the yard via Langstaff Road. Install crossings on material storage tracks on the east side of the work site. Utilize roadway parallel to storage track yard lead. The area between tracks north of the work site will be utilized as a laydown area for the contractor.

- *Utilities:*
  - Definitive utility information is unknown.

- *Possible utilities:*
  - Power poles along lead at turnout locations for tracks M-2 to M-6.

Exhibit 2-3: Pier #2 Site Schematic

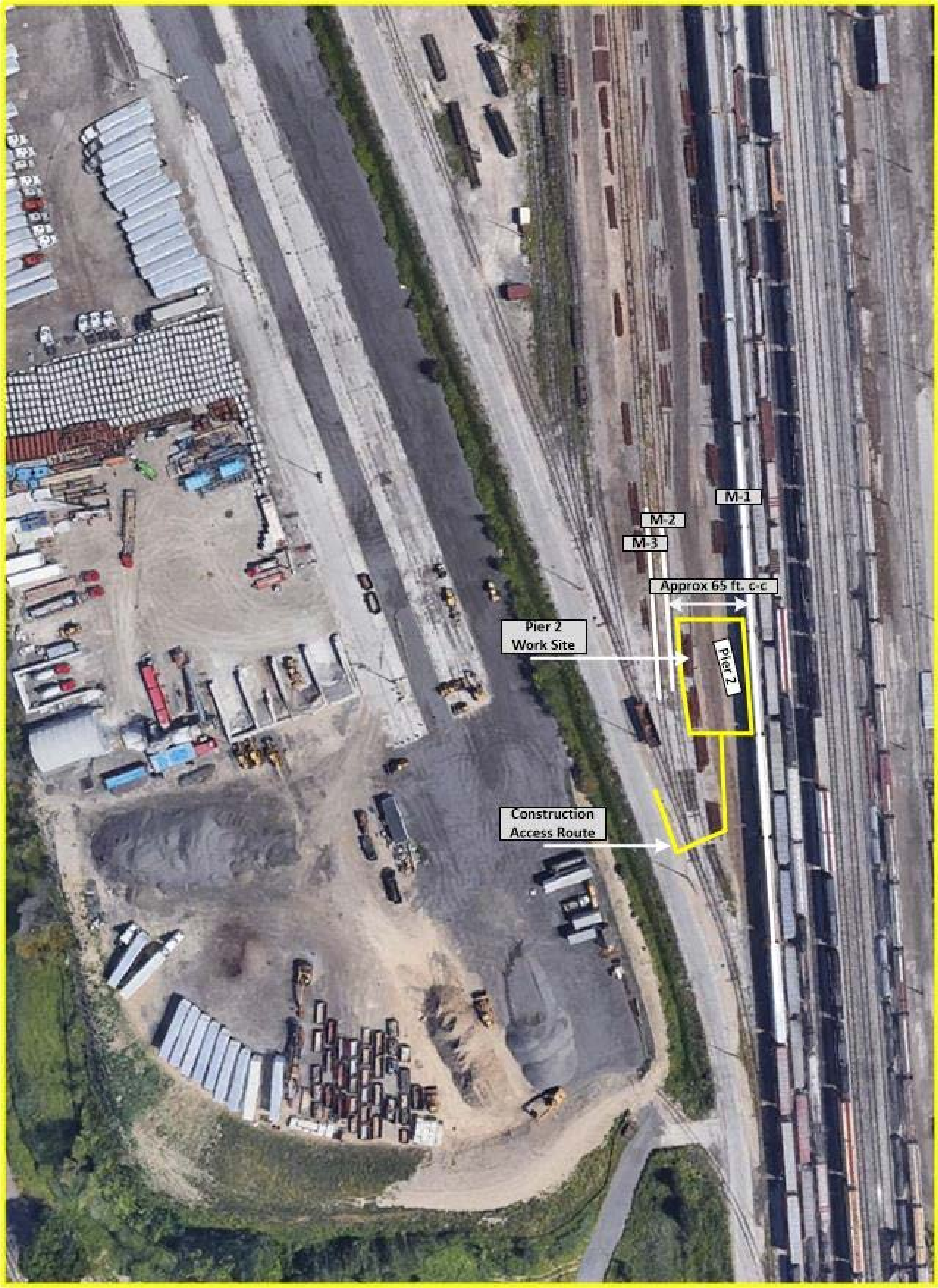
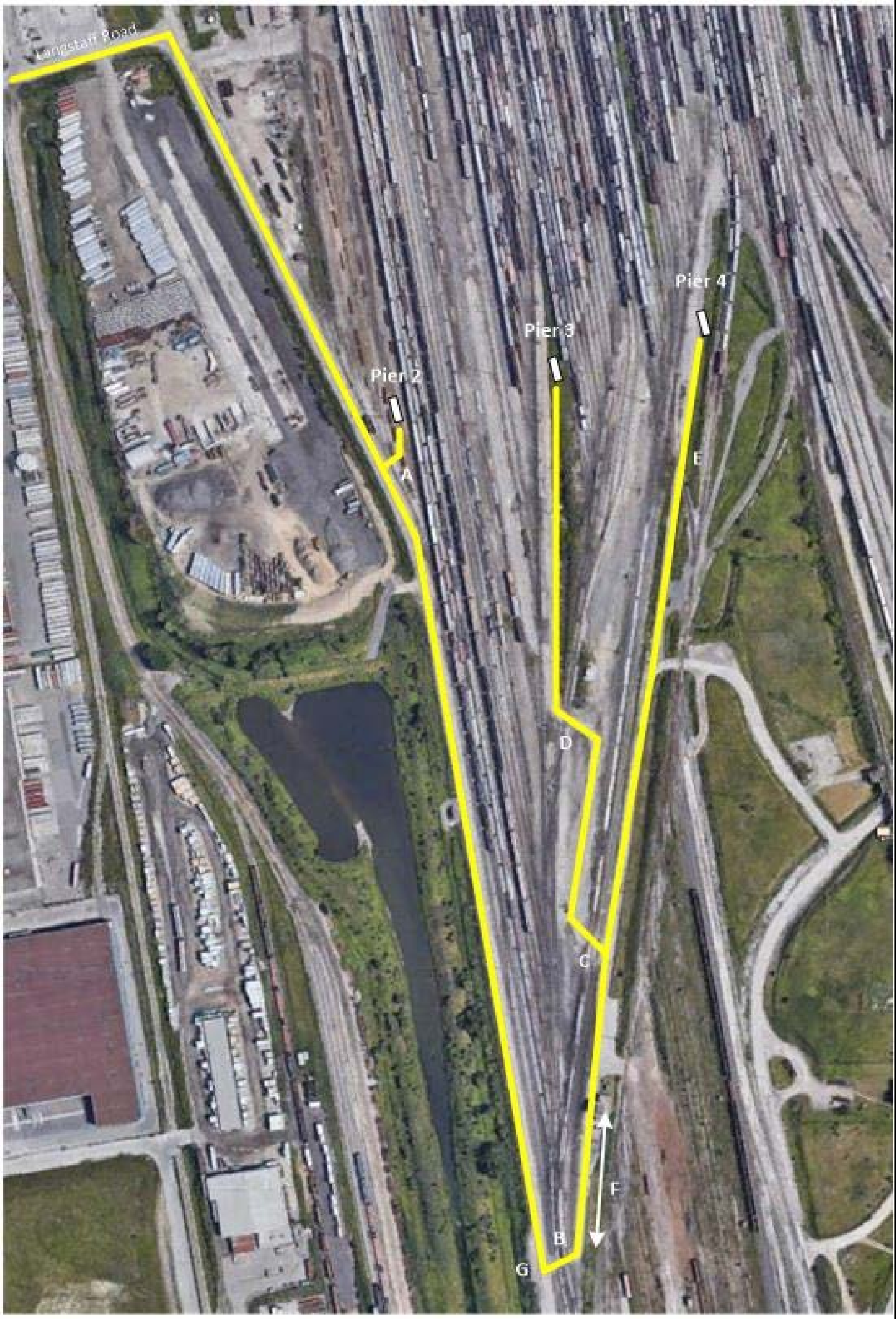


Exhibit 2-4: Proposed Pier Access – Pier #2, #3 and #4

MacMillan Yard Langstaff Road Bridge
Proposed Pier Access West Side

Option 1 A - Piers 2, 3, 4



Notes:

- Crossings at A, B, C, D, E will need to be widened and improved for expected traffic
- Location F may require road upgrades on both sides and barriers and method to ensure the building overhang is not damaged
- Location G may require widening to accommodate turning trucks

2.3.3 Impacts

- *Temporary:*
    - Loss of storage area between tracks north of the work site, if area required by contractor for staging materials.
    - Loss of a small amount of track capacity to keep crossings clear.
    - Impact to adjacent track on east side of work site is temporary and minimal.
    - Coordination of yard movements switching material storage area to maintain access during critical construction procedures, e.g. pouring concrete.
    - Track M-2 out of service while pier is constructed. Duration to be determined.

- *Permanent:*
    - Area occupied by columns.
    - Reduced roadway width next to columns.
    - Loss of some unloading area along track M-2.

2.3.4 Mitigation

- *Temporary:*
    - Relocate storage materials to an area of CN's choosing – it may be necessary to construct an area and provide access.
    - Possible flagging for train movements on M-1.
    - Fully fenced work site.
    - Flagging for crossing movements.
    - Flagging at work site.
    - Roadway maintenance and repair.

- *Permanent:*
    - It is suggested that the pier be constructed closest to track M-2 to leave as much adjacent clearance to track M-1 as possible.
    - Loss of unloading area along track M-2.

2.3.5 Notes

Potentially a material unloading track could be reconstructed on the west side of the west access road between Pier 1 and Pier 2. This track could be used to load construction materials for other piers onto flat cars or gondolas for delivery by rail to other pier locations within the yard. This would need to be carefully planned with CN and there would be a cost for this service. When construction is completed, the track and adjacent area could be used by CN for additional material storage and mitigation for the impacts of Pier 2.

Separate emergency egress and safety plans will be required for each pier site. These plans will need to be coordinated with CN emergency response and egress plans in the yard.

A comprehensive traffic plan will be required to deal with co-mingled yard operations traffic and construction traffic. This may include roadway and crossing upgrades to segregate certain activities and provide opportunities for staging construction traffic and to allow vehicles to pass by. This plan will include roadway flagging to manage traffic as needed.

A specific construction plan and schedule will be required at each pier location.

2.4 PIER #3

2.4.1 Site Description

Pier 3 is located at the south end of C Yard, west of C-11 between C-10 lead and track C-11. Refer to Exhibit 2-5.

This area identified for this pier is essentially unused except for a roadway along the C-10 lead. Distance between tracks in the area of the pier is approximately 60 ft. (18.3 m), tapering more or less, depending on where the measurement is taken and exactly where the pier is located. The area is relatively flat with a rainwater drainage ditch running through the middle of the area.

- *Utilities:*
  - Definitive utility information is unknown.

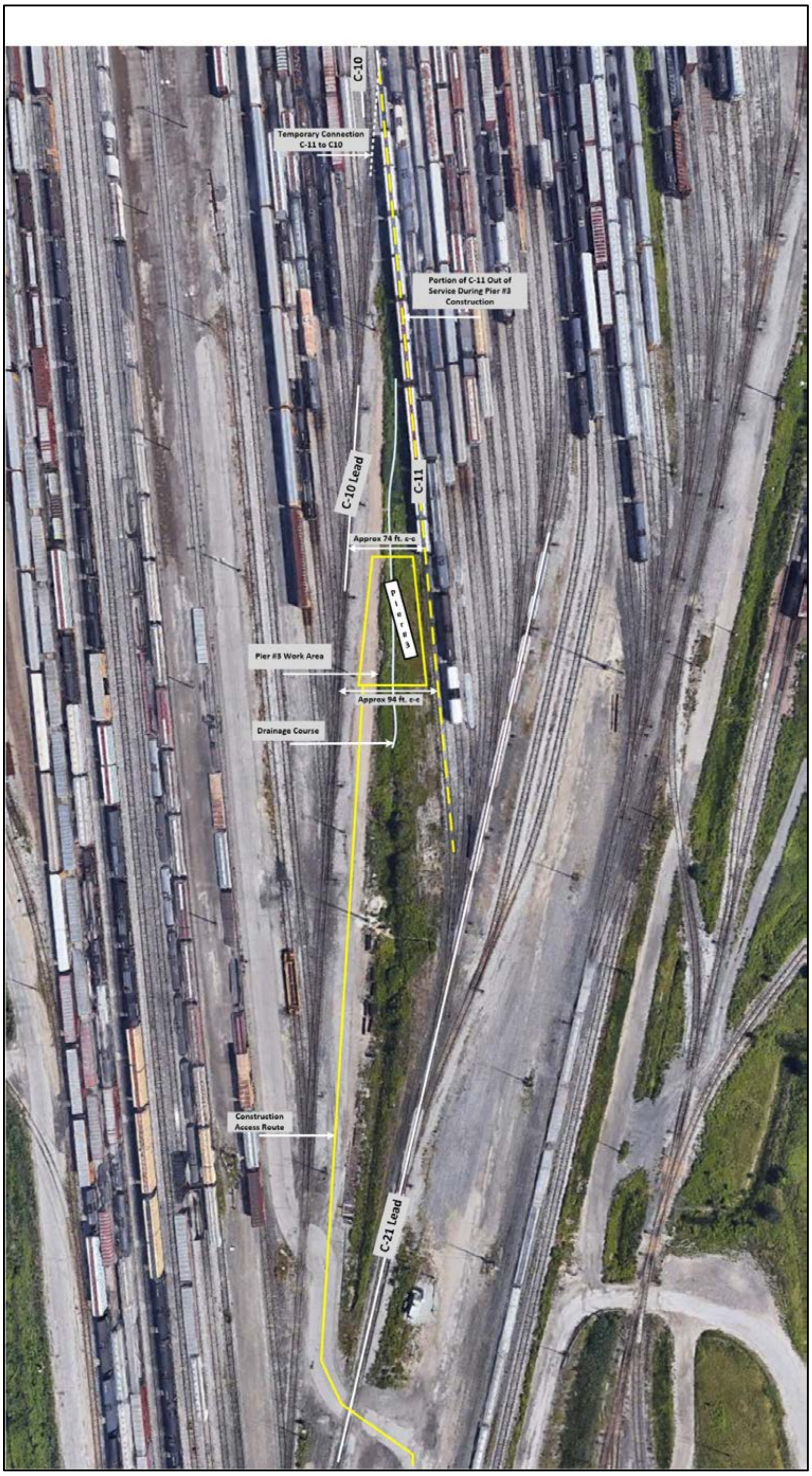
- *Possible utilities:*
  - U/G power line in vicinity.
  - O/H power line immediately north.
  - Lighting poles along C-10 lead.

2.4.2 Access

The access to pier #3 is presented in Exhibit 2-4.

Access to this general area will be from the west Langstaff Road/Jane Street yard access and yard road parallel to the west side of the yard. Access at the specific site will utilize the existing C-21 lead crossing to the south of the pier location. Access from the west yard road to the pier site will be along existing yard roads and across existing crossings (5 tracks).

Exhibit 2-5: Pier #3 Site Schematic



- *Utilities:*
    - Definitive utility information is unknown.

- *Possible utilities:*
    - U/G power lines.
    - U/G water, sewer, gas, communications.

2.4.3 Impacts

- *Temporary:*
    - There will be a need to coordinate access along C-21 lead in the area of the pier between contractor and CN activities.
    - Train movements over crossings will impede site access.
    - Train operations on adjacent tracks, particularly C-11. For additional working room, a fence could be installed along C-11 with C-11 being taken out of service for the duration of the construction.
    - Crossings will be upgraded and widened as necessary.
    - Fully fenced work site.

- *Permanent:*
    - Area occupied by columns.
    - Possible open drainage course modifications.

2.4.4 Mitigation

- *Temporary:*
    - Proximity flagging and possible need to stop adjacent train movements for certain construction activities. This would typically be for a construction activity that would foul an adjacent track for a few minutes or perhaps a few hours, such as positioning a crane, swinging a load, or unloading materials from rail cars.
    - CN may require moderate additional switching if C-10 taken out of service.
    - Option to shorten C-11 and add a turnout from C-11 to C-10 lead instead of taking the track out of service for the duration of construction.
    - High degree of coordination for concrete delivery to site.
    - Flagging for crossing movements.
    - Flagging at work site.
    - Roadway maintenance and repair.

- *Permanent:*
  - Relocate/bury drainage course as needed.
  - Lighting modifications.

2.4.5 Notes

There is an open area on the east side of the C-21 lead that could be used for staging traffic at the immediate site.

To the south, the original Car Repair Shop and surrounding area appears to be relatively unused, perhaps mostly for the maintenance and repair of M/W equipment. Perhaps a portion of this area would be available and useful to the contractor as a central staging area for Piers 3 and 4. It might also be useful as a location to load equipment and materials onto rail cars for delivery to the Pier sites. Unloading at Pier sites would have to be planned and coordinated with CN but may mitigate some crossing issues.

Separate emergency egress and safety plans will be required for each pier site. These plans will need to be coordinated with CN emergency response and egress plans in the yard.

A comprehensive traffic plan will be required to deal with co-mingled yard operations traffic and construction traffic. This may include roadway and crossing upgrades to segregate certain activities and provide opportunities for staging construction traffic and to allow vehicles to pass by. This plan will include roadway flagging to manage traffic as needed.

A specific construction plan and schedule will be required at each pier location.

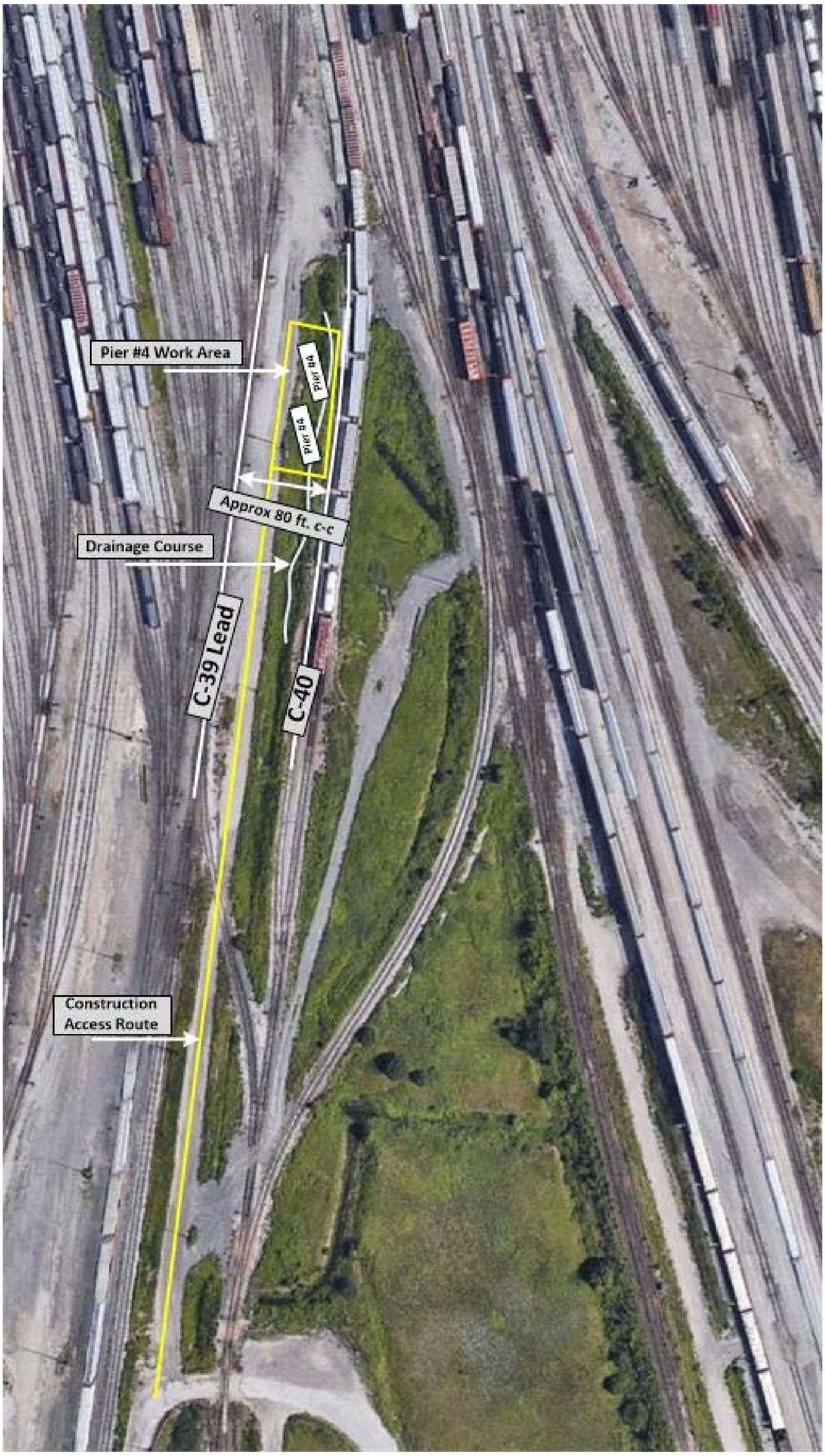
2.5 PIER #4

2.5.1 Site Description

Pier 4 is located at the south end of C Yard, west of C-40 between C-40 and C-39 lead. The distance between these tracks is approximately 80 ft. (24.4 m) center to center. Refer to Exhibit 2-6.

This area of the yard is essentially unused except for a roadway along C-39 lead. Protective fencing will be erected and maintained around the immediate work site. The area at the pier site is reasonably flat with a rainwater ditch running along one side of the area between tracks.

Exhibit 2-6: Pier #4 Site Schematic



- *Utilities:*
  - Definitive utility information is unknown.

- *Possible utilities:*
  - U/G power line in vicinity.
  - Communication tower and U/G line.

2.5.2 Access

The access to pier #4 is presented in Exhibit 2-4.

Access to this general area will be the same as for Pier 3 and extend from it, from the west Langstaff Road/Jane Street yard access and yard road parallel to the west side of the yard. Access at the site itself will be along the road between track C-40 and C-39 lead, across the cross-over between those 2 tracks. Access from the west yard road to the pier site will be along existing yard roads. Crossings will be upgraded and widened as necessary

- *Utilities:*
  - Definitive utility information is unknown.

- *Possible utilities:*
  - U/G power lines.
  - U/G water, sewer, gas, communications.

2.5.3 Impacts

- *Temporary:*
  - There will be a need to coordinate access along the roadway next to C-39 lead for train operations. Yard crews must walk along the C-39 lead when throwing switches. This roadway also provides access to the roadway between tracks C-37 and C-36.
  - Long and frequent train movements on adjacent tracks and over crossings needed to access the site.

- *Permanent:*
  - Area occupied by columns.
  - Possible drainage course modifications.
  - The roadway width next to the columns will not be impacted.

2.5.4 Mitigation

- *Temporary:*
  - Proximity flagging and possible need to stop adjacent train movements for certain construction activities.
  - High degree of coordination for concrete delivery to site.
  - Flagging for crossing movements.
  - Fully fenced work site.
  - Flagging at work site.
  - Roadway maintenance and repair.
  - Work area fully fenced.

- *Permanent:*
  - Relocate/bury drainage course as needed.
  - Possible lighting modifications.

2.5.5 Notes

Assuming a 10 ft. (3.05 m) min offset from the centerline of track C-40 and 25 ft. (7.6 m) from C-39 lead to allow for the roadway, there is a working width available of about 45 ft. Assuming the drainage is addressed, there would be an area of about 45 ft. x 300 ft. south of the proposed pier location that could be utilized during construction.

There is no way to practically provide additional working width in this area.

To the south, the original Car Repair Shop and surrounding area appears to be relatively unused, perhaps mostly for the maintenance and repair of Maintenance of Way equipment. Perhaps a portion of this area would be available and useful as a location to load equipment and materials onto rail cars for delivery to the pier sites. Unloading at pier sites would have to be planned and coordinated with CN but may mitigate some crossing issues.

Separate emergency egress and safety plans will be required for each pier site. These plans will need to be coordinated with CN emergency response and egress plans in the yard.

A comprehensive traffic plan will be required to deal with co-mingled yard operations traffic and construction traffic. This may include roadway and crossing upgrades to segregate certain activities and provide opportunities for staging construction traffic and to allow vehicles to pass by. This plan will include roadway flagging to manage traffic as needed.

A specific construction plan and schedule will be required at each pier location.

2.6 PIER #5

2.6.1 Site Description

Pier 5 is located at the south end of C Yard, east of C-55, between C-55 and C-54 lead track. The distance between these tracks at the pier site is approximately 65 ft. (19.8 m) center to center. Refer to Exhibit 2-7.

This area of the yard is relatively unused except as needed for crews to throw switches along the C-54 lead track. The area is flat between C-55 and C-54 lead track. There are light poles along the lead track

- *Utilities:*
  - Definitive utility information is unknown.

- *Possible utilities:*
  - U/G communication.
  - Power poles along C-54 lead.

2.6.2 Access

The access to pier #5 is presented in Exhibit 2-8.

Access to the pier site is from the south along existing yard roads and then under the tunnel exiting the yard at the Keele Street main entrance. The width between C-55 and C-54 lead track at the south end narrows to about 40 ft. (12.2 m) center to center. There is a possible alternate level crossing access approximately 1150 ft. (350.5 m) north of the tunnel. There are 9 tracks to cross and crossings and roadways in the yard would need considerable upgrading for use by heavy vehicles if the alternate access was used.

- *Utilities:*
  - Definitive utility information is unknown.

- *Possible utilities:*
  - U/G power lines.
  - U/G water, sewer, gas, communications.

Exhibit 2-7: Pier #5 Site Schematic

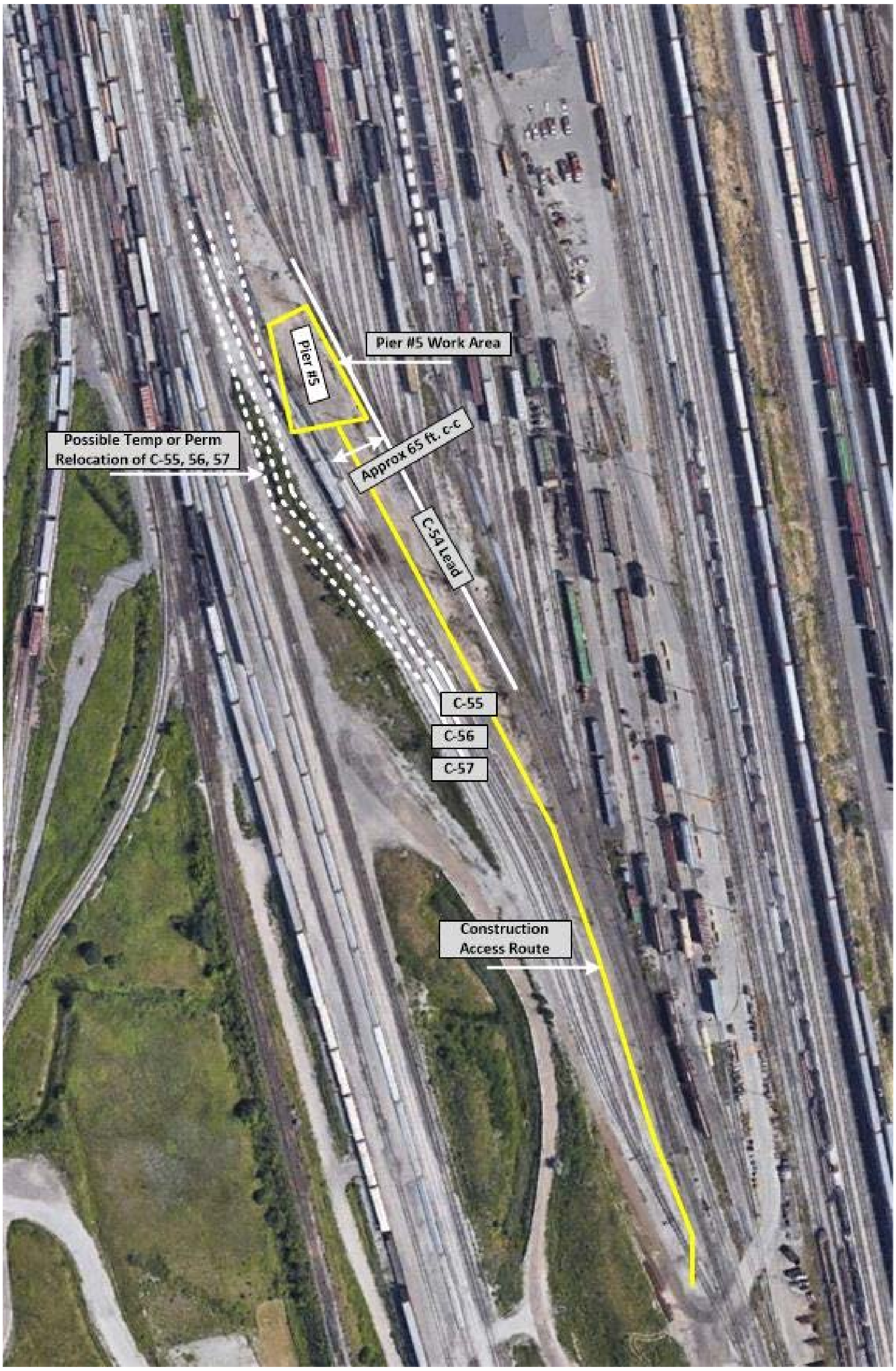
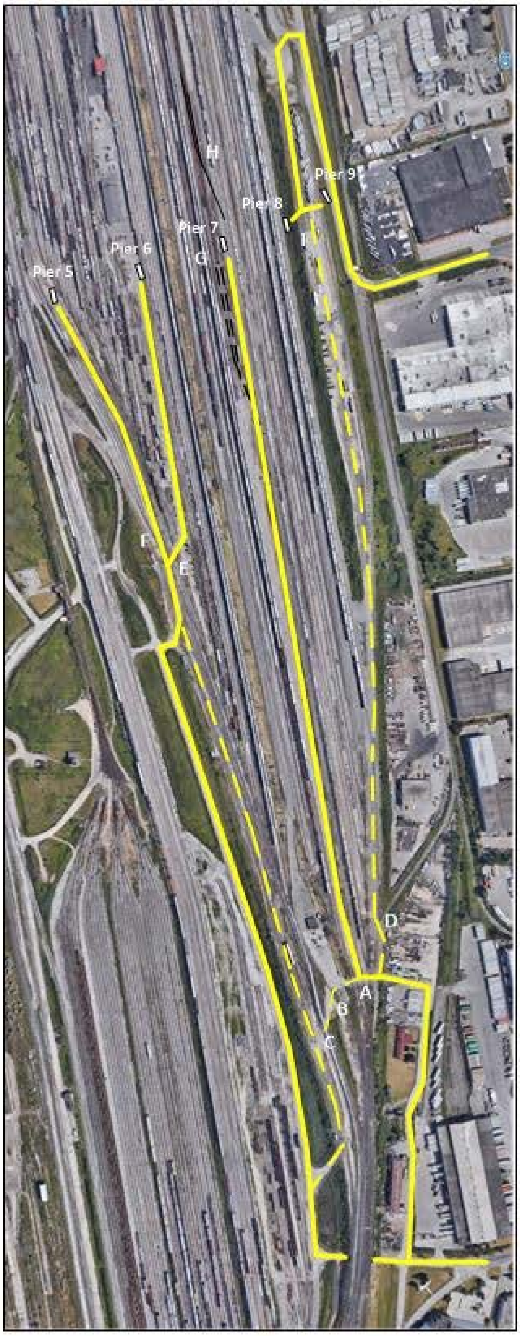


Exhibit 2-8: Proposed Pier Access – Pier #5, #6, #7, #8 and #9

MacMillan Yard Langstaff Road Bridge
Proposed Pier Access East Side

Option 1 A - Piers 5, 6, 7, 8, 9



Notes:

- Crossings at A, B, C, D, E, F will need to be widened and improved for expected traffic
- At location G temporarily remove enough track for working area around Pier 7
- At location H temporarily connect tracks north of Pier 7 working area
- Alternate access at crossings A, B, C for traffic too large for tunnel
- At Pier 8 alternate access may be possible in a number of ways pending 3rd party operation needs and how slope along roadway can be dealt with

2.6.3 Impacts

- *Temporary:*
  - Train movements over the one crossing into this area.
  - Frequent train operations on adjacent tracks.
  - Clearance restrictions at tunnel. (CN to advise)
  - Intermingling/interference with vehicle traffic along access roads.

- *Permanent:*
  - Area occupied by columns.
  - Reduced roadway width next to columns.
  - Lighting modifications.

2.6.4 Mitigation

- *Temporary:*
  - Coordinate access along C-54 lead track for train operations.
  - Proximity flagging and possible need to stop adjacent train movements for certain construction activities.
  - High degree of coordination for concrete delivery to site.
  - Possible pull-outs for construction traffic staging along access roads.
  - Vehicle traffic management at tunnel.
  - Design construction process such that materials and equipment can pass through access tunnel.
  - It may be necessary to relocate tracks C-55, 56, 57 farther west to create as much working room as possible (see Exhibit 2-7).
  - Roadway maintenance and repair.
  - The 1 crossing to access this area may need to be widened and upgraded.
  - Fully fenced work site.
  - Flagging for crossing movements.
  - Flagging at work site.
  - Roadway maintenance and repair.

- *Permanent:*
  - Lighting modifications.
  - It may be necessary to relocate tracks C-55, 56, 57 farther west to provide enough clearance between the permanent pier and C-54 track lead.

2.6.5 Notes

Without moving tracks C-55, 56, 57 a little farther west, the max working room between tracks may only be approximately 35 ft. (10.7 m). This allows a 10 ft (3.05 m) clearance from C-55 and 20 ft. (6.09 m) clearance from C-54 lead track for crews to walk along switches.

Another way to achieve some additional clearance would be to temporarily tie C-55 into the C-54 lead, and if necessary tie C-56 into C-57 north of the pier site.

The likely scenario at this site is to permanently move C-55, 56, 57 as far west as possible, and temporarily tie C-55 into the C-54 lead north of the pier location.

Separate emergency egress and safety plans will be required for each pier site. These plans will need to be coordinated with CN emergency response and egress plans in the yard.

A comprehensive traffic plan will be required to deal with co-mingled yard operations traffic and construction traffic. This may include roadway and crossing upgrades to segregate certain activities and provide opportunities for staging construction traffic and to allow vehicles to pass by. This plan will include roadway flagging to manage traffic as needed.

A specific construction plan and schedule will be required at each pier location.

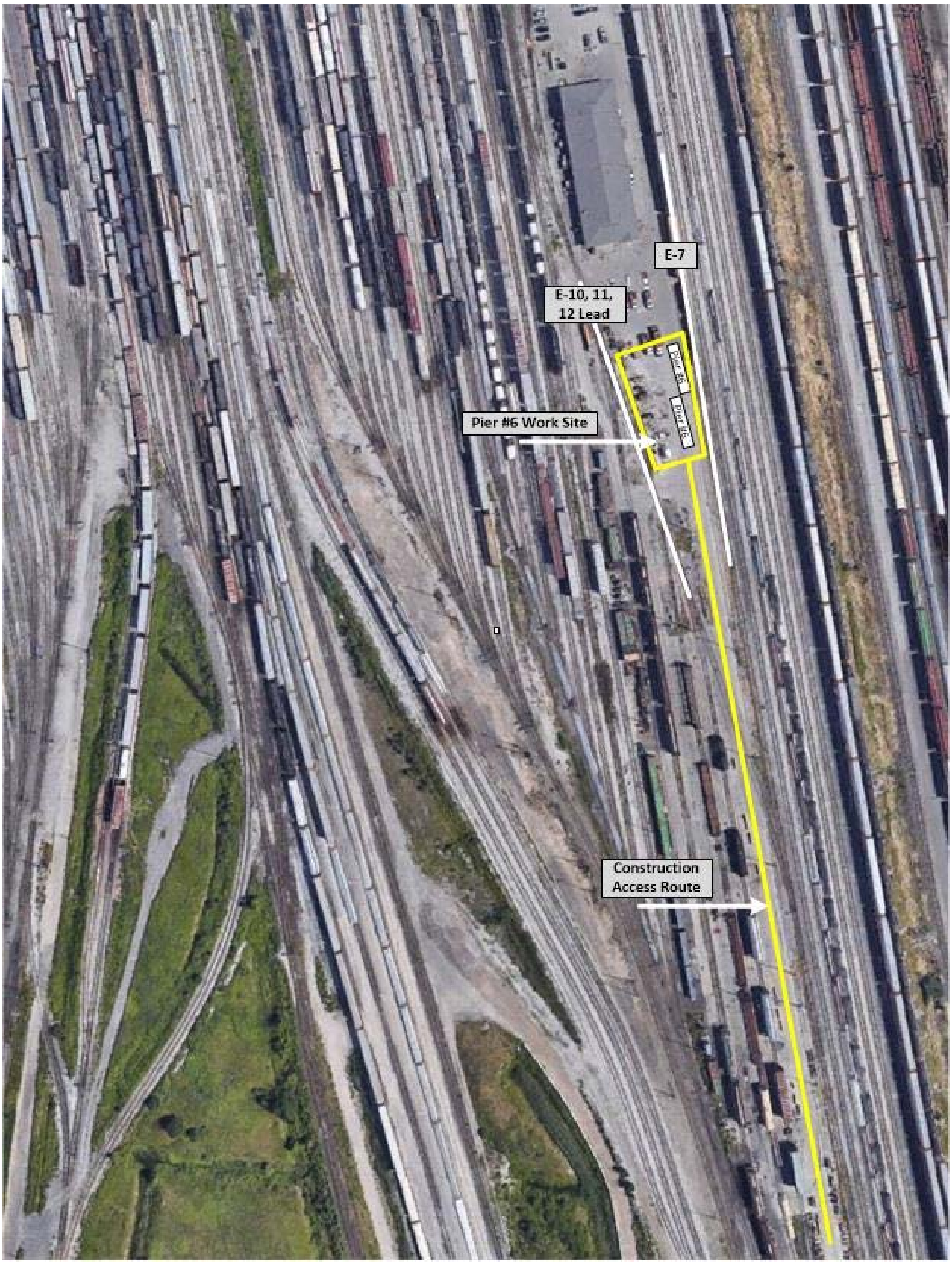
2.7 PIER #6

2.7.1 Site Description

Pier 6 is located west of E-7 immediately north of the E-10, 11, 12 lead. Refer to Exhibit 2-9.

The distance between the lead and E-7 at the pier location is approximately 80 ft., (24.4 m) center to center depending on exactly where the measurement is taken. This area of the yard is used for in-track rail car repair. The area is flat and good portions are paved. There are light poles in the area. At the specific pier site there is a fuel storage tank and parking for various maintenance vehicles. The area is congested with various vehicles and materials for rail car maintenance.

Exhibit 2-9: Pier #6 Site Schematic



- *Utilities:*
  - Definitive utility information is unknown.

- *Possible utilities:*
  - U/G power line for flood lights in vicinity.
  - Lighting poles in car repair area.
  - U/G air lines.
  - U/G communication lines.

2.7.2 Access

The access to pier #6 is presented in Exhibit 2-8.

Access to this pier location is essentially the same as for pier 5, except there are more tracks to cross. As for pier 5, access is from the south via the main yard entrance to Keele St and through the tunnel. There is a possible alternate level crossing access approximately 1150 ft. (350.5 m) north of the tunnel. There are 9 tracks to cross and crossings and roadways in the yard would need considerable upgrading for use by heavy vehicles if the alternate access was used.

- *Utilities:*
  - Definitive utility information is unknown.

- *Possible utilities:*
  - U/G power lines.
  - U/G water, sewer, gas, communications.

2.7.3 Impacts

- *Temporary:*
  - Train movements over crossings impeding access.
  - Train operations on adjacent tracks.
  - Access and working/storage area for maintenance operations.
  - Clearance restrictions at the tunnel.
  - Intermingling/interference with vehicle traffic along access road from Keele Street.

- *Permanent:*
  - Area occupied by columns.
  - Reduced roadway width next to columns.
  - Lighting modifications.

2.7.4 Mitigation

- *Temporary:*
    - Take track E-10 out of service during construction to ensure there's sufficient room for co-mingled access along the roadway.
    - As much as possible, restrict yard operation vehicle access to the area from the north only.
    - Relocate the fuel storage facility.
    - Create a working area around the work site by utilizing some of the parking area to the north towards the mechanical building.
    - Re-route yard maintenance traffic right at the pier site to the west across the lead and back immediately south of the mechanical building.
    - Fence and barricade all areas and provide signage as needed.
    - Possible pull-outs for construction traffic staging along access roads.
    - Vehicle management at the tunnel.
    - Design construction process such that materials and equipment can pass through access tunnel.
    - Widen and upgrade crossings as required.
    - Flagging for vehicle and rail traffic at the work site and crossings.
    - It may be necessary to develop an area for temporary parking or equipment storage, perhaps south of the crossings.
    - Fully fenced work site.
    - Flagging for crossing movements.
    - Flagging at the work site.
    - Roadway maintenance and repair.

- *Permanent:*
    - Lighting modifications.

2.7.5 Notes

Construction of pier 6 will require a high degree of planning and coordination with CN on a continual basis. There may be times when access is blocked by construction equipment and/or deliveries. These need to be well planned, and scheduled.

Separate emergency egress and safety plans will be required for each pier site. These plans will need to be coordinated with CN emergency response and egress plans in the yard.

A comprehensive traffic plan will be required to deal with co-mingled yard operations traffic and construction traffic. This may include roadway and crossing upgrades to segregate certain activities and provide opportunities for staging construction traffic and to allow vehicles to pass by. This plan will include roadway flagging to manage traffic as needed.

A specific construction plan and schedule will be required at each pier location.

2.8 PIER #7

2.8.1 Site Description

Pier 7 is located between in R Yard between tracks R-17 and R-19 approximately 700 Ft. (213 m) north of the R-19/R-20 switch. Refer to Exhibit 2-10.

The distance between track R-17 and R-19 is approximately 40 ft. (12.2 m) center to center. This area of the yard, R Yard, is used receiving/departing trains and inspection. The tracks are in pairs with track centers at either 14 ft. (4.3 m) center to center or 26 ft. (7.9 m) center to center, with inspection roadways between each pair. The location of this pier is in a yard roadway used by yard operations travelling north-south. There appears to be a pole line along the north side of R-17. The area is level.

- *Utilities:*
  - Definitive utility information is unknown.

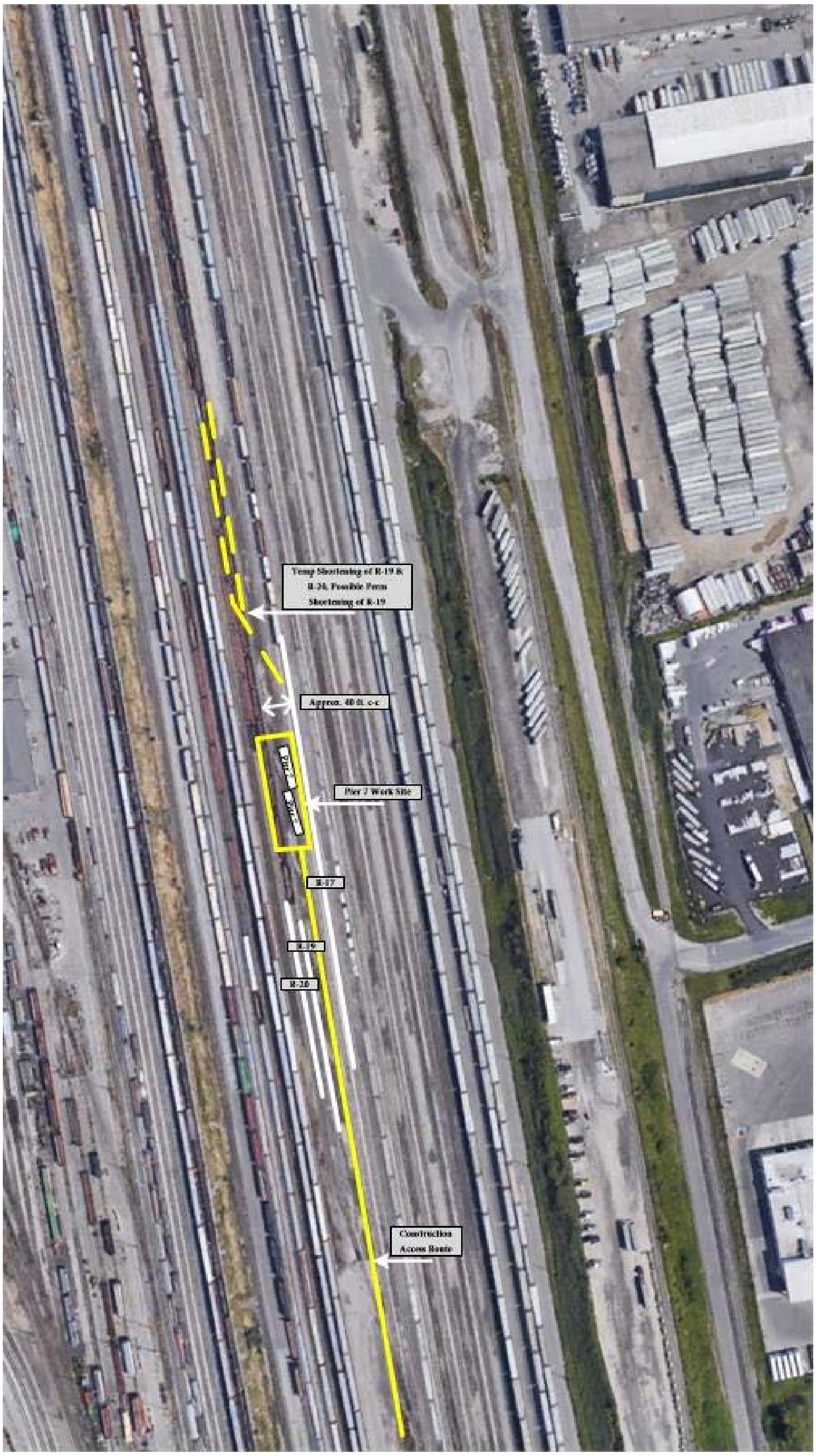
- Possible utilities:
  - U/G power flood lighting cable.
  - Pole line along R-17.

2.8.2 Access

The access to pier #7 is presented in Exhibit 2-8.

Access to pier 7 is from the south across a number of yard tracks to either access the tunnel to Keele Street or the level crossings approximately 1150 ft. (350.5 m) north of the tunnel. Yard roadway and crossing modifications would be required. The level crossing access from Keele St to the site crosses the leads for trains leaving/arriving from/to Yard R and Yard E. A possible alternate access route is out to Bowes Rd as per Pier 8 access. There is some area to the south of the R-19/R-20 lead that could be used as a laydown/staging area. The area south of Pier 8 could also be utilized.

Exhibit 2-10: Pier #7 Site Schematic



- *Utilities:*
    - Definitive utility information is unknown.

- *Possible utilities:*
    - U/G power lines.
    - U/G water, sewer, gas, communications.

2.8.3 Impacts

- *Temporary:*
    - Train movements over crossings impeding access.
    - The distance between tracks R-17 and R-19 results in a maximum available construction width of 20 ft., which is likely not be enough.
    - Construction of this pier will essentially block yard operations vehicles from passing by this area during construction
    - Adjacent tracks will be impacted by construction activities. The full impact will be dictated by working room required.
    - Coordination of yard movements to maintain access during critical construction procedures, e.g. pouring concrete.
    - Scheduling of contractors movements to/from the site around yard train activity.

- *Permanent:*
    - Area occupied by columns.
    - Reduced roadway width passing the columns.

2.8.4 Mitigation

- *Temporary:*
    - Reduce length on R-19 and R-20 to provide enough room for construction. This would be done by temporarily tying in both R-19 and R-20 to R-17 some distance north of the pier location. This would keep both R-19 and R-20 in service, albeit shorter, and provide enough room for yard operations vehicles to pass by the construction site with proper traffic management.
    - Fully fenced work site.
    - Flagging for crossing movements.
    - Flagging at work site.
    - Roadway maintenance and repair.

- *Permanent:*
    - Assuming columns are approximately 2m dia, and that they would be aligned parallel to the track and 10 ft. (3.05 m) offset from centerline of R-19, there would be approximately 17 ft. (5.2 m) clearance to the north from a typical standing rail car, which should be sufficient for CN yard operations.
    - If columns can't be aligned parallel to track R-19, then track R-19 may need to be permanently shortened to provide clearance for yard vehicles to pass by the piers. Shortening R-19 would effectively also permanently shorten the useable length of R-20.
    - Relocation or burial of the pole line.

2.8.5 Notes

Separate emergency egress and safety plans will be required for each pier site. These plans will need to be coordinated with CN emergency response and egress plans in the yard.

A comprehensive traffic plan will be required to deal with co-mingled yard operations traffic and construction traffic. This may include roadway and crossing upgrades to segregate certain activities and provide opportunities for staging construction traffic and to allow vehicles to pass by. This plan will include roadway flagging to manage traffic as needed.

A specific construction plan and schedule will be required at each pier location.

2.9 PIER #8

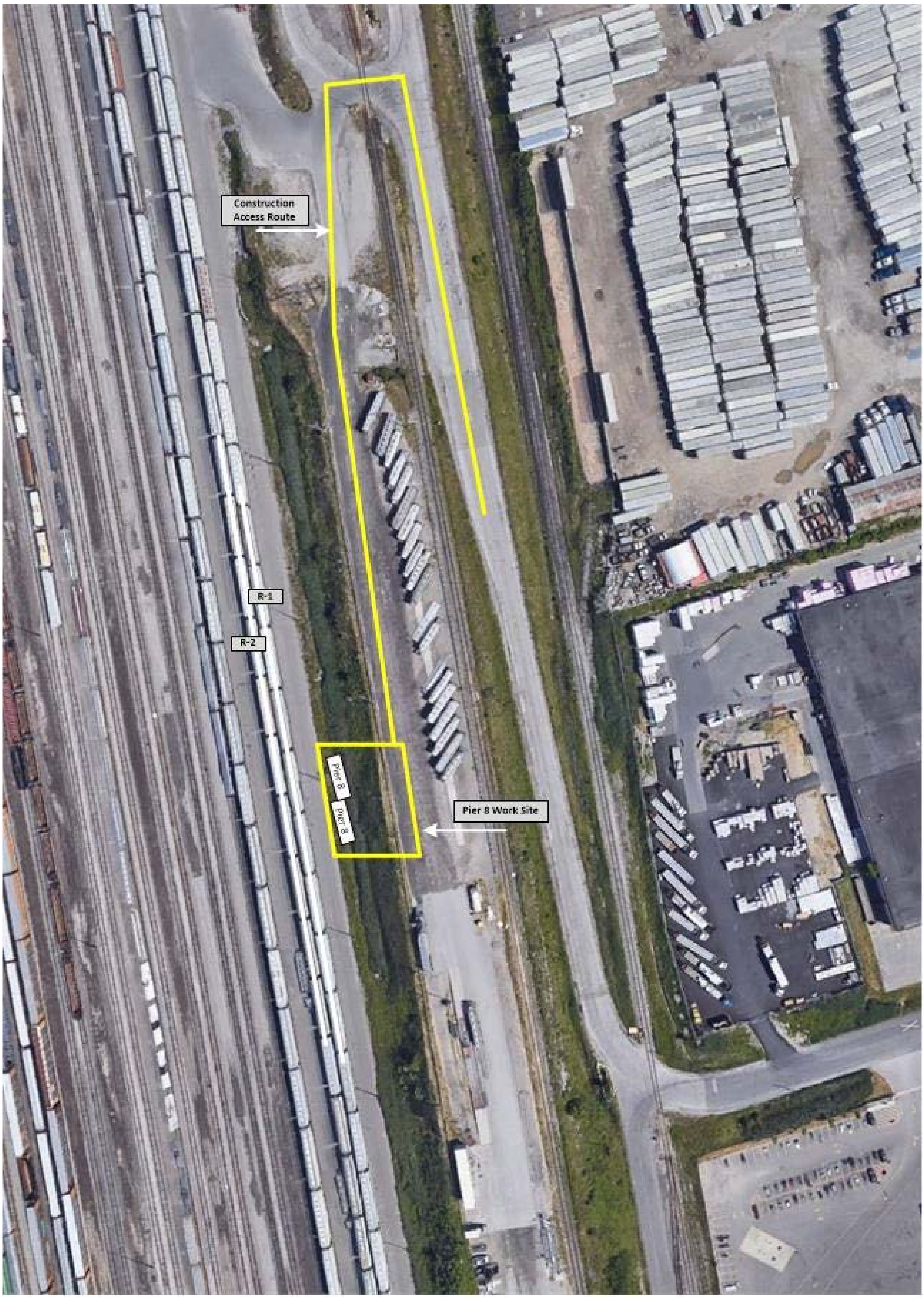
2.9.1 Site Description

Pier 8 is located in R Yard immediately east of the roadway on the east side of track R-1. Refer to Exhibit 2-11.

The adjacent yard roadway on the west side is paved and, along with track R-2, appears to be used by highway trucks for trans-loading. The immediate area of the pier site is undeveloped and appears to be a drainage course. Elevation differences are difficult to ascertain based on Google Earth. There is a pole line along the east side of the paved roadway. The area east of the undeveloped area is a trans-load/staging area for a third party operator.

- *Utilities:*
    - Definitive utility information is unknown.

Exhibit 2-11: Pier #8 Site Schematic



- *Possible utilities:*
    - U/G power line and lighting poles along roadway.

2.9.2 Access

The access to pier #8 is presented in Exhibit 2-8.

Access to the pier site will be via the third party operator area on the east side of R-1. Yard access will be via a crossing over a lead track approximately 850 ft. (259 m) to the north, and then south along a parallel access road to Bowes Road access to Keele Street. There is an area to the south that could be utilized for laydown/staging for both Pier 7 and Pier 8.

- *Utilities:*
    - Definitive utility information is unknown.

- *Possible utilities:*
    - U/G power lines.

2.9.3 Impacts

- *Temporary:*
    - Third party operator disruption/relocation of activities.
    - Coordination of construction traffic with vehicle activity from R-1/R-2.
    - Yard drainage modifications in undeveloped area.

- *Permanent:*
    - Area occupied by columns.
    - Drainage modifications.

2.9.4 Mitigation

- *Temporary:*
    - Relocate/rearrange third party operator area as needed.
    - Fully fenced work site.
    - Flagging for crossing movements.
    - Flagging at work site.
    - Roadway and crossing maintenance and repair.

- *Permanent:*
    - Yard drainage modifications.

2.9.5 Notes

Separate emergency egress and safety plans will be required for each pier site. These plans will need to be coordinated with CN emergency response and egress plans in the yard.

A comprehensive traffic plan will be required to deal with co-mingled yard operations traffic and construction traffic. This may include roadway and crossing upgrades to segregate certain activities and provide opportunities for staging construction traffic and to allow vehicles to pass by. This plan will include roadway flagging to manage traffic as needed.

A specific construction plan and schedule will be required at each pier location.

2.10 PIER #9

2.10.1 Site Description

Pier 9 is located immediately east of the long south A Yard lead, between the A Yard lead and the access road to the Bowles Road/Keele Street entrance to the yard approximately 350 ft. (107 m) north of Bowles Road. Refer to Exhibit 2-12.

This area proposed for the offset piers is an undeveloped area between the A Yard lead and the parallel access road to Bowles Road. There is approximately 30 ft. (9.1 m) clear from the A Yard lead to the edge of the access road. The undeveloped area is sloped up from the access road to the A Yard lead. The access road slopes up from the Bowles Road access to the A Yard lead crossing.

- *Utilities:*
  - Definitive utility information is unknown.

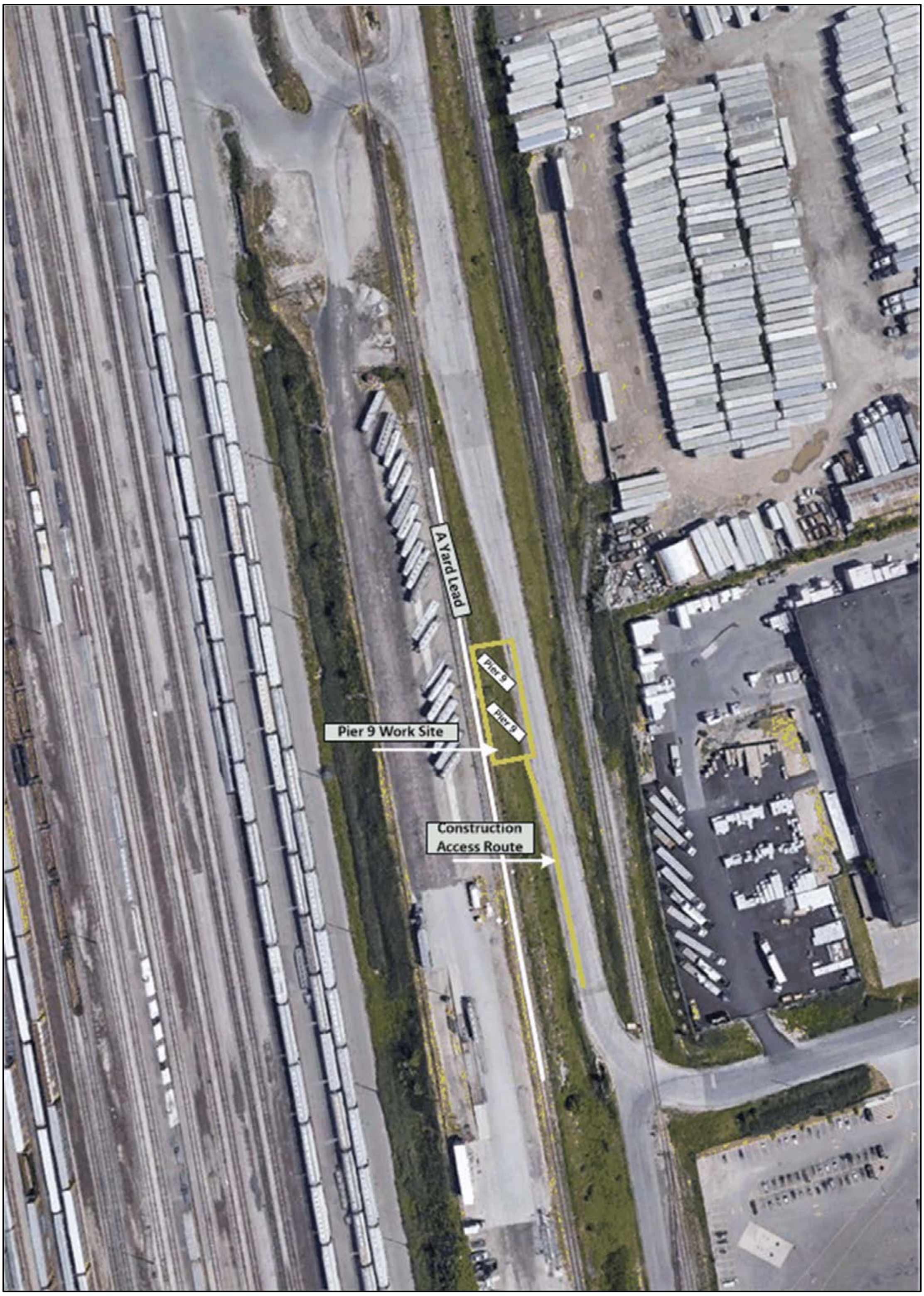
- *Possible utilities:*
  - None known.

2.10.2 Access

The access to pier #9 is presented in Exhibit 2-8.

Access is via the adjacent access roadway to Bowles Road leading to Keele Street. The area east of the A Yard lead could be used as a laydown area as suggested for Pier 8.

Exhibit 2-12: Pier #9 Site Schematic



- *Utilities:*
  - Definitive utility information is unknown.

- *Possible utilities:*
  - None known.

2.10.3 Impacts

- *Temporary:*
  - The tight work area and sloped ground condition will impact the A Yard lead, the access road and possibly the industrial lead on the east side of the access road.
  - Coordination of traffic utilizing the access road to Bowles Road. This is the road that trans-load vehicles from R-1 and R-2 utilize.
  - Possible relocation/rearrangement of third party operator facility.
  - Flagging and coordination of yard movements during construction.

- *Permanent:*
  - Area occupied by columns.
  - Possible modification to access.

2.10.4 Mitigation

- *Temporary:*
  - Possible modification to access road and/or A Yard lead track to provide room for construction.
  - It may be necessary to temporarily shift A Yard lead track westward in the area of the pier during construction. Note that this may result in a secondary impact to sight lines for trains using this track and may need to be flagged for all movements. The shift would likely be in the order of 20 ft over a length of approximately 1500 ft. (457 m).
  - It may also be necessary to modify the access road by shifting it slightly to the east and the construction of some small retaining structures on the west side of the industrial lead.
  - Fully fenced work site.
  - Flagging for train movements.
  - Flagging for crossing movements.
  - Flagging at work site.
  - Roadway maintenance and repair.

- *Permanent:*

- If the access road is shifted to provide room for construction, this should be designed as a permanent shift.

2.10.5 Notes

The area to the west of A Yard lead could also be utilized for staging materials for this pier location.

Separate emergency egress and safety plans will be required for each pier site. These plans will need to be coordinated with CN emergency response and egress plans in the yard.

A comprehensive traffic plan will be required to deal with co-mingled yard operations traffic and construction traffic. This may include roadway and crossing upgrades to segregate certain activities and provide opportunities for staging construction traffic and to allow vehicles to pass by. This plan will include roadway flagging to manage traffic as needed.

A specific construction plan and schedule will be required at each pier location.

2.11 EAST ABUTMENT

2.11.1 Site Description

The East Abutment immediately east of the industrial lead located on the east side of the Bowes Road access road approximately 480 ft. (146 m) north of Bowes Road. Refer to Exhibit 3-14.

This area is for the most part outside of the yard operations, except for its proximity to the industrial lead. There appears to be a berm of pushed-up material along the east side of the industrial lead through this area. There is ditching for drainage along the east side of the industrial lead.

- *Utilities:*
  - Definitive utility information is unknown.

- *Possible utilities:*
  - Off CN property, none known.

Exhibit 2-13: East Abutment Site Schematic

2.11.2 Access

It is assumed that access to this location will be from the east beyond the CN property line.

- *Utilities:*
  - Definitive utility information is unknown.

- *Possible utilities:*
  - None known.

2.11.3 Impacts

- *Temporary:*
  - Clearance during construction to the industrial lead.
  - Possible drainage impacts during construction.

- *Permanent:*
  - Clearance from A Yard lead to columns

2.11.4 Mitigation

- *Temporary:*
  - Ensure sufficient clearance to industrial lead during construction as required by CN.
  - Fencing along west side of work site to separate work site from industrial lead.
  - Flagging at work site.

- *Permanent:*
  - It is suggested that the abutment be either fully outside the CN property at this location or a min of 18 ft. (5.5 m) from the centerline of the industrial lead. This would be in accordance with standard clearances for overpasses.

2.11.5 Notes

Although this construction is located outside of the yard area, it is suggested that safety and traffic plans below be incorporated at this site as well because of the proximity to the yard and it will likely be constructed by the same contractor.

Separate emergency egress and safety plans will be required for each pier site. These plans will need to be coordinated with CN emergency response and egress plans in the yard.

A comprehensive traffic plan will be required to deal with co-mingled yard operations traffic and construction traffic. This may include roadway and crossing upgrades to segregate certain activities and provide opportunities for staging construction traffic and to allow vehicles to pass by. This plan will include roadway flagging to manage traffic as needed.

A specific construction plan and schedule will be required at each pier and abutment location.