Appendix N.3 – Structural Design Report – CN Rail

Kennedy Road Environmental Assessment between Steeles Avenue and Major Mackenzie Drive

CN Rail Crossing

Structural Design Report

Class EA Study for Improvements to Kennedy Road from Steeles Avenue to Major Mackenzie Drive

Regional Municipality of York

January 26, 2021

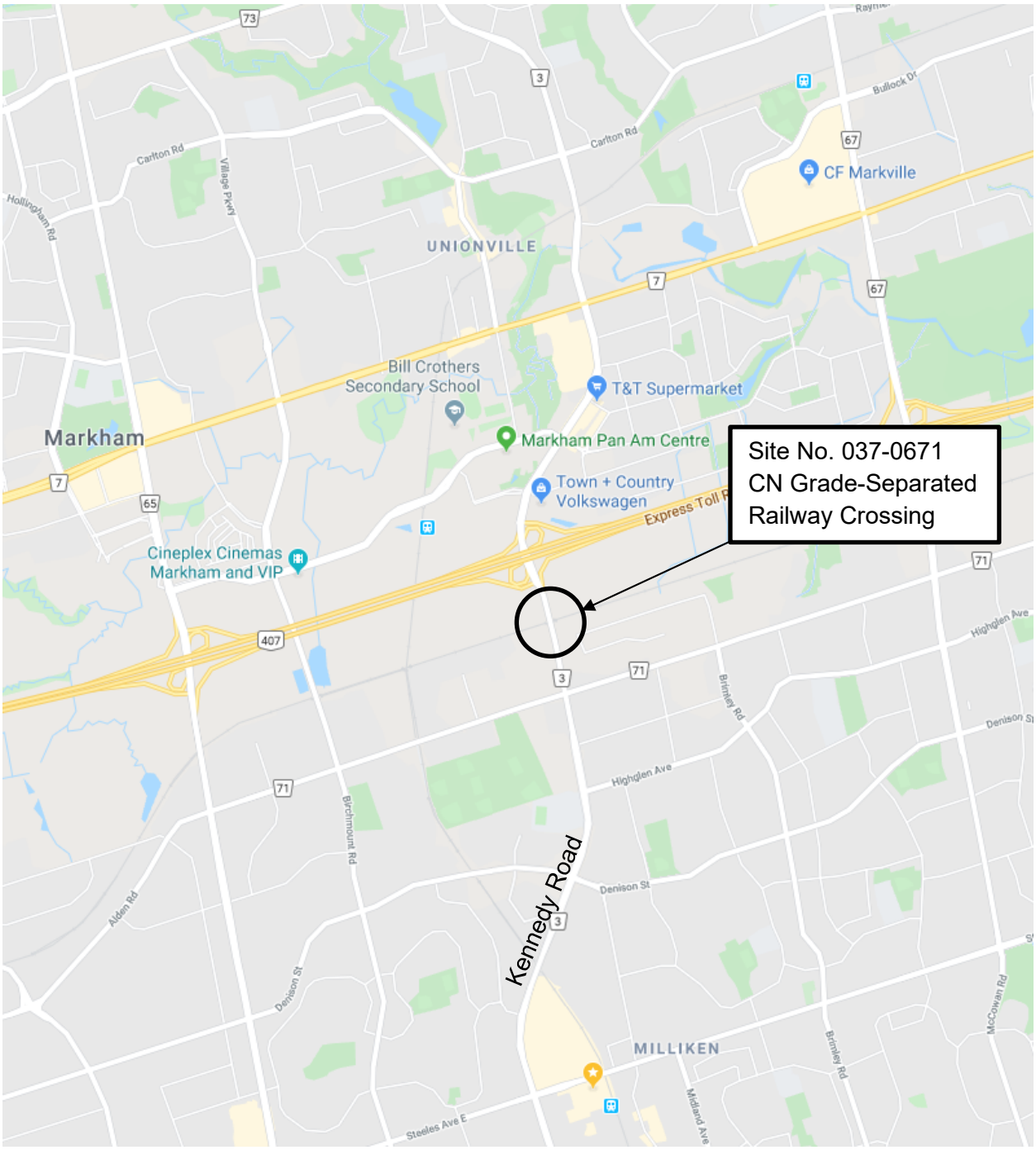
Disclaimer

The material in this report reflects HDR's professional judgment considering the scope, schedule and other limitations stated in the document and in the contract between HDR and the client. The opinions in the document are based on conditions and information existing at the time the document was published and do not consider any subsequent changes. In preparing the document, HDR did not verify information supplied to it by others. Any use which a third party makes of this document is the responsibility of such third party. Such third party agrees that HDR shall not be responsible for costs or damages of any kind, if any, suffered by it or any other third party resulting from decisions made or actions taken based on this document.

In preparing this report, HDR relied, in whole or in part, on data and information provided by the Client and third parties that was current at the time of such usage, which information has not been independently verified by HDR and which HDR has assumed to be accurate, complete, reliable, and current. Therefore, while HDR has utilized its best efforts in preparing this report, HDR does not warrant or guarantee the conclusions set forth in this report which are dependent or based upon data, information or statements supplied by third parties or the client, or that the data and information have not changed since being provided in the report. Any use which a third party makes of this document is the responsibility of such third party. Such third party agrees that HDR shall not be responsible for costs or damages of any kind, if any, suffered by it or any other third party resulting from decisions made or actions taken based on this document.

Contents

Key Plan


Site No. 037-0671
CN Grade-Separated
Railway Crossing
Kennedy Road
UNIONVILLE
MILLIKEN
Markham
CF Markville
Bill Crothers
Secondary School
T&T Supermarket
Markham Pan Am Centre
Town + Country
Volkswagen
Cineplex Cinemas
Markham and VIP
Express Toll R
Carlton Rd
Village Pkwy
Hollingham Rd
Bullock Dr
Highglen Ave
Denison St
Birchmount Rd
Alden Rd
Brimley Rd
McCowan Rd
Midland Ave
Steeles Ave E
73
3
7
67
65
407
71

1. Introduction

HDR is undertaking the Municipal Class Environmental Assessment Study (Schedule 'C') and the Preliminary Design for improvements to Kennedy Road from Steeles Avenue to Major Mackenzie Drive for The Regional Municipality of York (York Region). The recently completed York Region Transportation Master Plan Update 2016 designates this section of Kennedy Road for future widening to 6 lanes as part of the Frequent Transit Network.

It is HDR's mandate to provide bridge engineering services and preliminary design for the proposed improvement of the bridge and culvert structures along the corridor to accommodate the road widening.

An existing grade separated railway crossing (rail over road) under the jurisdiction of Canadian National Railway (CN) is located in the corridor. HDR is mandated to analyze and develop all structural design options to accommodate the widening of Kennedy Road at this crossing.

This Structural Design Report provides a comparison of the options for the Bridge Site No. 03-03 B0380. Based on HDR recommendation, CN comments, and York Region decision, HDR performed a Preliminary Design of the preferred alternative.

2. Location

The CN York Subdivision Bridge over Kennedy Road is located approximately 400 m north of 14th Avenue, in the City of Markham. The location of the overpass is indicated on the Key Plan.

3. Existing Conditions

3.1 General Conditions

Kennedy Road between Steeles Avenue and Major Mackenzie Drive is a four-lane, north-south Regional Arterial located in the City of Markham. The road is crossing with CN rail track between 14th Avenue and 407ETR Interchange. The CN York Subdivision underpass currently carries two rail tracks and is 85% owned by the Region of York and 15% owned by CN.

The CN Rail Underpass is a steel bridge, one span, through plate girder (girder-floor beam-stringer) that was constructed in 1962. The structure has a span of 22.25 m and a width of 9.3m.

The through plate girder is 2.55 m deep and the floor beam size is W24x160 covered with railway ballast, which carries two railway tracks.

The bridge spans over two 3.50 m traffic lanes, two 3.50 m boulevards (including sidewalks), and has a vertical clearance of 4.57m (derived from existing drawings).

The substructure consists of reinforced concrete abutments supported on concrete spread footings, and wingwalls.

3.2 Alignment and Profile

The alignments and profiles for the CN rail and for Kennedy Road are not being adjusted and will match existing, however minor modifications to the Kennedy Road vertical profile are anticipated.

3.3 Utilities

The CN right-of-way is bordered by the Hydro One corridor to the north, with 500 kV towers. They appear to be located away from the bridge and will likely not impact any construction / modifications on the bridge.

3.4 Bridge Condition

An OSIM inspection was carried out by AECOM on September 18, 2014 and by York Region on October 03, 2016. The findings of the most recent report showed that the bridge was in good condition, but needed minor repairs, including:

- Wide, stained, and map cracks on abutments
- Minor impact damage on Southeast girder's bottom flange
- Light to moderate corrosion of soffit

The site visual inspection carried out on June 8, 2017, verified that the 2016 OSIM report findings and recommendations are consistent with the current site conditions, with the addition of missing sections of the South trainmen's walk and wet areas on the soffit.

4. Horizontal Alignment and Vertical Profile

4.1 Horizontal Alignment

The horizontal alignments for the CN rail and for Kennedy Road are not being adjusted and will match existing. The horizontal alignment of the Kennedy Road remains unchanged after the construction.

4.2 Vertical Profile

The existing vertical profile of Kennedy Road as well as the vertical profile of the proposed options for Kennedy Road have sag vertical curves, however minor modifications to the Kennedy Road vertical profile are anticipated.

5. Cross-Section

5.1 Existing Cross-Section

The existing Kennedy Road carries two (2) lanes of traffic in each direction. Sidewalks are located on both sides of Kennedy Road.

5.2 Proposed Cross-Section

The proposed cross-section of Kennedy Road will consist of two (2) 3.3m wide traffic lanes and a 3.5m Transit / HOV lane in each direction. Two (2) 3.0m wide multi-use paths (MUP) will be located on both sides of the roadway. The traffic lanes will be divided by a raised centre median.

6. Proposed Structure

6.1 Bridge Options

The existing CN bridge will need to be replaced as there is insufficient width to provide 3 lanes of traffic in each direction.

The following potential options at the CN grade separation at Kennedy Road were considered feasible and developed for further considerations. Descriptions of each alternative along with the estimated structure construction costs are listed below.

6.1.1 Option 1 – Post-tensioned solid concrete slab bridge

This option proposes to construct a four span bridge over Kennedy Road. The proposed structure is a continuous, cast-in-place, post-tensioned solid slab concrete. The structure has spans of 11.0m, 18.2m, 18.2m, and 11.0m, with total length of 58.4m and a width of 10.3m, with a design speed of 60 km/hr.

The bridge deck is 1.15m deep, is covered with railway ballast, and carries two railway tracks. There are paved concrete slopes under both end spans and hand railing systems on each side of the deck.

The bridge spans over four 3.3m (inner) traffic lanes, two 3.5m (outer) traffic lanes, two 6.0 m boulevards with two 3.0 m multi-use paths, one 6.2m median, and has a min. vertical clearance of 4.8m.

The substructure consists of reinforced concrete abutments and piers supported on steel piles.

The preliminary cost estimate for Option 1 is $34.48 M.

6.1.2 Option 2 – TPG bridge

This option proposes to construct a two span bridge over Kennedy Road. The proposed structure is through-plate-girder. The structure has spans of 21.5m and. 20.0m, with total length of 58.4m and a width of 9.5m, with a design speed of 60 km/hr.

It is anticipated that a 2.55 m deep through-plate-girder ballasted structure will be required.

The bridge spans over four 3.3m (inner) traffic lanes, two 3.5m (outer) traffic lanes, two 6.0 m boulevards (including multi-use paths), one 6.2m median, and has a min. vertical clearance of 4.8m.

The substructure consists of reinforced concrete abutments and piers supported on steel piles.

The preliminary cost estimate for Option 2 is $32.8 M.

6.2 Discussion

A comparison of the advantages and disadvantages of both options are summarized in table below.

Options	1	2
Description	Post-tensioned solid concrete slab bridge, four spans	TPG bridge, two spans
Constructability Issues	Temporary Rail Detour required; Temporary Shoring required; More complex	Temporary Rail Detour required; Temporary Shoring required; Proximity of overhead power line - potential constraint to use of cranes for girder erection etc.
Maintenance	Less	More
Construction Duration	Longer	Shorter
Cost	$34.48 M	$32.38 M

The constructability of Option 1 is more complex in comparing to Option 2. It is expected all lanes (2 in each direction) on Kennedy Road and pedestrian passage can be maintained by carrying the detour tracks on temporary bridge supported on trestles. The temporary bridge arrangement provides for minimal impact to the daily rail operation throughout the construction except at the time of shifting train traffic to the detour alignment and back on to the new structure. The construction of the overpass bridge can be completed within a single construction season not including the construction duration required for the temporary detour and roadway Detour for the existing tracks is required and will require the construction of a temporary rail bridge and rail detour. A comparison of north rail detour and south rail detour is discussed in **Section 7**.

During a meeting with Canadian National Railway (CN), they expressed their preference to have a post-tension concrete structure similar to the grade separation at McCowan Road.

6.3 Recommended Option

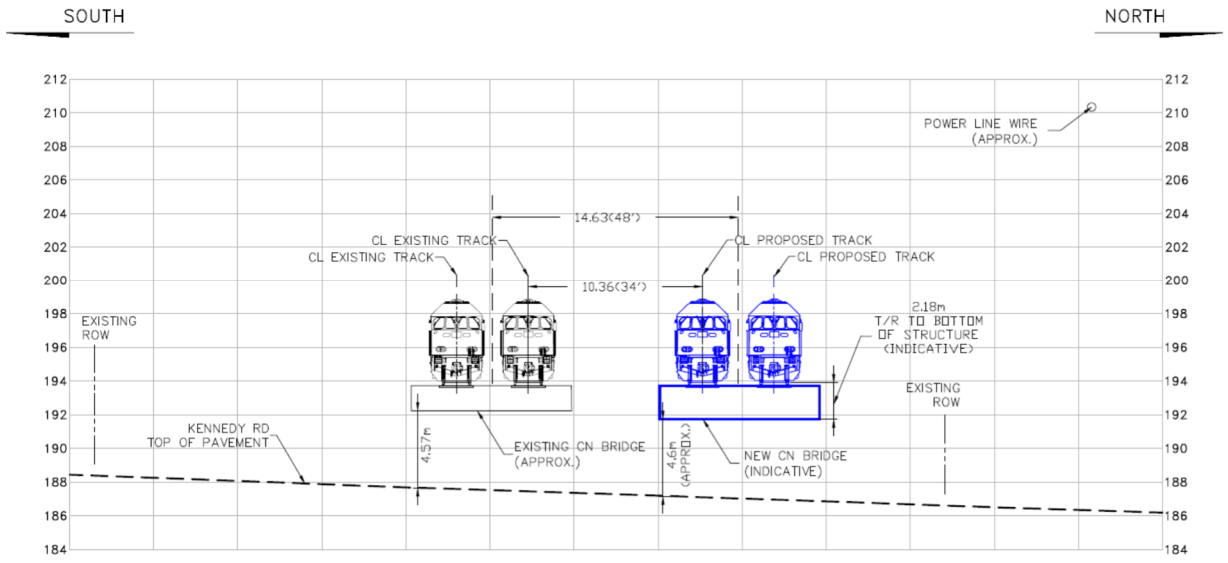
Option 1 – Post-tensioned solid concrete slab bridge is the recommended option for the CN Rail Crossing. This option was chosen due to the cost not being substantially different than the other options, but the less maintenance will be required in the stage of serviceability.

Please refer to **Appendix A** for the proposed general arrangement drawing.

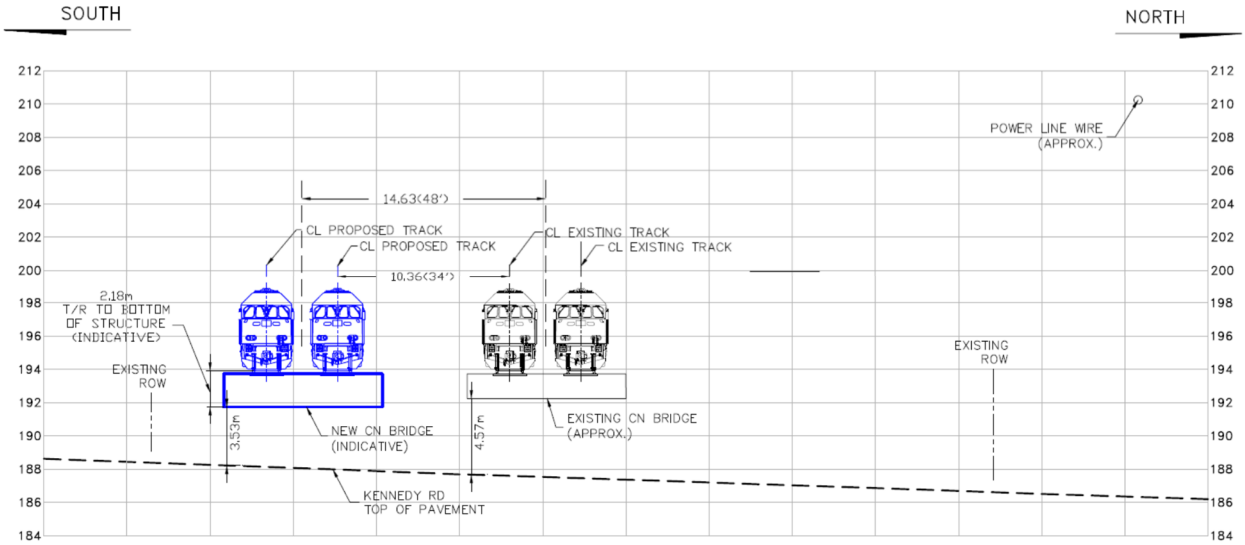
7. Construction Staging

The construction of the replacement of the bridge, Option 1, is proposed to be undertaken in multiple stages. During the construction, all four (4) lanes of road traffic, pedestrian passage and railway traffic will be maintained throughout the construction. A track detour will be required to carry out the construction while maintaining the railway traffic and will require construction of a temporary rail bridge to support the detour.

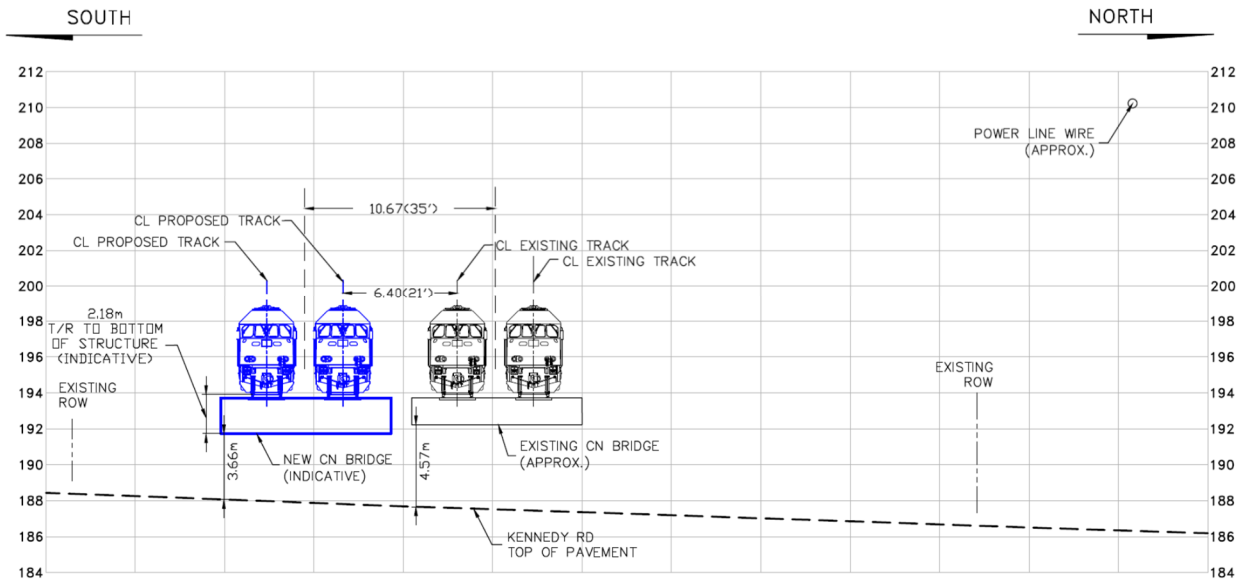
Rail diversion concept plans and typical sections were developed by HDR for the following options: North Rail Diversion, South – 1 Rail Diversion and South -2 Rail Diversion. Please refer to **Appendix B** for the track detours.



North Rail Diversion



South-1 Rail Diversion



South-2 Rail Diversion

North Rail Detour option is carried forward as it meets the current vertical clearance requirements for the structure.

Rail Detour Option	Preliminary Considerations	Recommendation
North	• No property impacts to commercial and residential properties adjacent to the CN Rail Line • Impacts to hydro lands and access road to DH Cockburn Transformer Station • No impacts to hydro towers and operations • Greatest vertical clearance from bottom of temporary rail bridge and Kennedy Road, meets new standard for vertical clearance.	**Carried Forward**
South – 1	• Impacts to commercial and residential properties south of the CN Rail Line • No impacts to hydro lands, access road to DH Cockburn Transformer Station • Detour is longer in length, greater impacts to CN Rail Line • Reduction in vertical clearance from bottom of temporary rail bridge and Kennedy Road. Rail raise not acceptable to CN; lowering of Kennedy Road profile has potential impacts to Duffield Drive and cemeteries	Not carried forward – Does not meet standard for vertical clearance for new structure.

Rail Detour Option	Preliminary Considerations	Recommendation
South – 2	• Reduced separation between temporary bridge structure and existing bridge structure • Reduced impacts to commercial and residential properties south of the CN Rail Line • No impacts to hydro lands, access road to DH Cockburn Transformer Station • Reduction in vertical clearance from bottom of temporary rail bridge and Kennedy Road. Rail raise not acceptable to CN; lowering of Kennedy Road profile has potential impacts to Duffield Drive and cemeteries	Not carried forward – Does not meet standard for vertical clearance for new structure.

8. Geotechnical Investigation

Golder Associates Ltd. carried out a preliminary foundation investigation in November 2018. The following summarizes the findings of the investigation and foundation recommendations. The Preliminary Foundation Investigation Report was issued on March 20, 2019.

8.1 Existing Conditions

Approximately 350 mm of asphalt was encountered at ground surface in both boreholes.

Non-cohesive and cohesive fill was encountered underlying the asphalt in both boreholes. The non-cohesive fill is comprised of gravelly sand containing trace fines. One SPT “N” value of 14 blows per 0.3 m of penetration was measured within the non-cohesive fill, indicating a compact level of compactness. The cohesive fill consists of sandy silty clay containing trace gravel and a black silty layer. The SPT “N” values measured within the cohesive fill range from 7 blows to 23 blows per 0.3 m of penetration, indicating a firm to very stiff consistency.

A glacial till deposit was encountered underlying the fill in both boreholes and varies in composition from silty sand, some gravel to clayey silt and sand, trace to some gravel. The cohesive portion of the till deposit was encountered at around 1.80 m below ground surface in Borehole CNR-101 extending to 11.7 m below ground surface. The non-cohesive component of the till was encountered in Boreholes CNR-101 and CNR-102 at depth of about 11.7 m and 2.1 m below ground surface, respectively, and extended to the borehole’s termination depth of about 15.7 m below ground surface. During drilling, the augers were grinding in Borehole CNR-101 between 13.4 m and 13.7 m below ground surface. It can be inferred that boulders and/or cobbles are present at the depth where the augers were grinding. The SPT “N” values measured within the cohesive till deposit range 9 blows to 17 blows per 0.3 m of penetration, indicating a stiff to very stiff consistency. The SPT “N” values measured in the non-cohesive till deposit range from 12 blows to 78 blows per 0.3 m of penetration, indicating a compact to very dense level of compactness.

A deposit consisting of silty clay, some sand, and some gravel was encountered in Borehole CNR-102, within the till deposit. The silty clay was encountered at a depth of about 10.1 m below ground surface and extended to a depth of about 13.2 m below ground surface. The SPT "N" values in the deposit are 8 blows and 10 blows per 0.3 m of penetration, indicating a firm to stiff consistency.

8.2 Foundation Recommendation

Both shallow and deep foundation options have been considered for support of the abutments and piers for the proposed temporary and permanent bridges.

Shallow Foundations

Strip or spread footings founded on the stiff to very stiff clayey silt and sand till and /or compact to dense silty sand till. Although shallow footings are typically the most economical foundation option, considering the structural loads required to the support the new or temporary bridge structures, shallow foundations may not be suitable for support of the bridge abutments at this site due to the relatively low capacities available in these materials. In addition, the fill extends to about 2 m depth below the kennedy Road grade and must be sub-excavated and replaced with compacted granular fill prior to footing construction.

Deep Foundations

Driven steel H-piles founded in very dense silty sand till assumed to be present below Elevation 170 m. Steel H-piles driven to "100 blow" glacial till would be considered feasible to support the proposed temporary or permanent abutments. The advantage of driven piles is that it is relatively straightforward design and construction and sub-excavation of the fill would not be required for pile-cap construction. The disadvantage of steel H-piles is that all glacial tills are known to contain cobbles and boulders and if present, the piles may 'hang-up' on these obstructions.

Drilled shafts (Caissons) founded on/in the very dense silty sand till assumed to be present below Elevation 170 m. Drilled shafts are not recommended for the support of the proposed structure due to the potential presence of water-bearing sand and gravel layers as well as the fact that the bases would be below the prevailing groundwater level. These conditions would require the use of temporary or permanent liners. In addition, due to the relatively deep depth required for the caissons to reach the competent till deposit, cleaning out any disturbed soils and inspection of the caisson base subgrade would be challenging, or potentially result in lower capacities.

9. CN Constraints

All works on, above or below CN property will need to be coordinated with railway operations and comply with the following CN requirements:

- Rules, policies, standards and procedures for working within CN right-of-way;

- Liability insurance requirements for works performed on and/or in proximity to the railway or within railway right-of-way; and,
- Safety and related requirements and instructions for work on railway right-of-way by non-CN personnel.

All works during prearranged work blocks under railway flagging protection have to be planned and carried out in a manner to leave the work zone at the end of work block in safe condition for railway traffic and operations.

10. Miscellaneous

10.1 Design Code

The design of the railway bridge will be undertaken in accordance with the CN Guidelines for Design of Railway Structures and American Railway Engineering and Maintenance of Way Association (AREMA).

10.2 Access to The Site

The site is readily accessible from Kennedy Road. The number of lanes will be maintained on Kennedy Road throughout the construction. The construction is anticipated to be three (3) to four (4) years. A traffic staging plan will be developed during the detailed design in consultation with the City of Markham and York Region.

10.3 Property

Property acquisition is anticipated on the east side of the Kennedy Road within the project limits to accommodate a wider cross-section. Extent of the property acquisition will be determined during detailed design.

10.4 Utilities

The proposed grade separation on Kennedy Road has a significant impact to the existing underground utilities. Relocation of existing sanitary sewer and gas line maybe required.

10.5 Drainage

The proposed grade separation on Kennedy Road has a sag vertical curve, with the road going under the railway. A surface drainage system must be installed along the road along the depressed corridor.

10.6 Concrete

All cast-in-place concrete will be class C—1 concrete as per CSA A23.I.

10.7 Structural Steel

All main plate girder, web flanges, and bearing stiffeners shall be CSA G40.21 Grade 350 at category 5. Other non-fracture critical members including connecting angles, rolled section

diaphragms and all secondary members shall be CAN3-G40.21 Grade 350A. The bearing plates shall be CAN3-G40.21 Grade 300W.

10.8 Reinforcing Steel

Stainless steel reinforcement will be used in areas of the components where their surfaces are within the splash zone, including the front face of the retaining wall, front face of the abutment wall, and the centre pier.

For all other components, black steel (Grade 400W) will be used as specified in Section 12 of the MTO Structural Manual and the MTO Bridge Office Memorandum dated November 22, 2010 “Reinforcing Steel”.

Prepared by

Geffrey Huang
Bridge Engineer
HDR Inc.

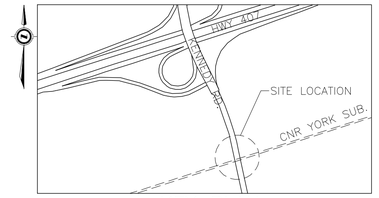
Reviewed by

Jared Monkman, P.Eng
Bridges & Structures Lead Canada
HDR Inc.

A

Appendix

METRIC



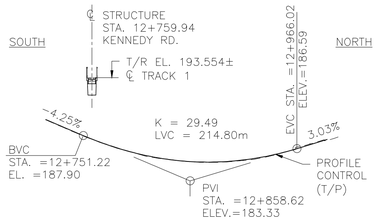
KEY PLAN

LIST OF ABBREVIATION:

ABUT.	DENOTES ABUTMENT
BRGS.	DENOTES BEARINGS
CONC.	DENOTES CONCRETE
EXIST.	DENOTES EXISTING
EXP.	DENOTES EXPANSION
FIX.	DENOTES FIXED
T/FTG	DENOTES TOP OF FOOTING
BOTT./FTG	DENOTES BOTTOM OF FOOTING
W.P.	DENOTES WORKING POINT
T/C	DENOTES TOP OF CONC. DECK
T/P	DENOTES TOP OF PAVEMENT
T/R	DENOTES TOP OF RAIL
TYP.	DENOTES TYPICAL

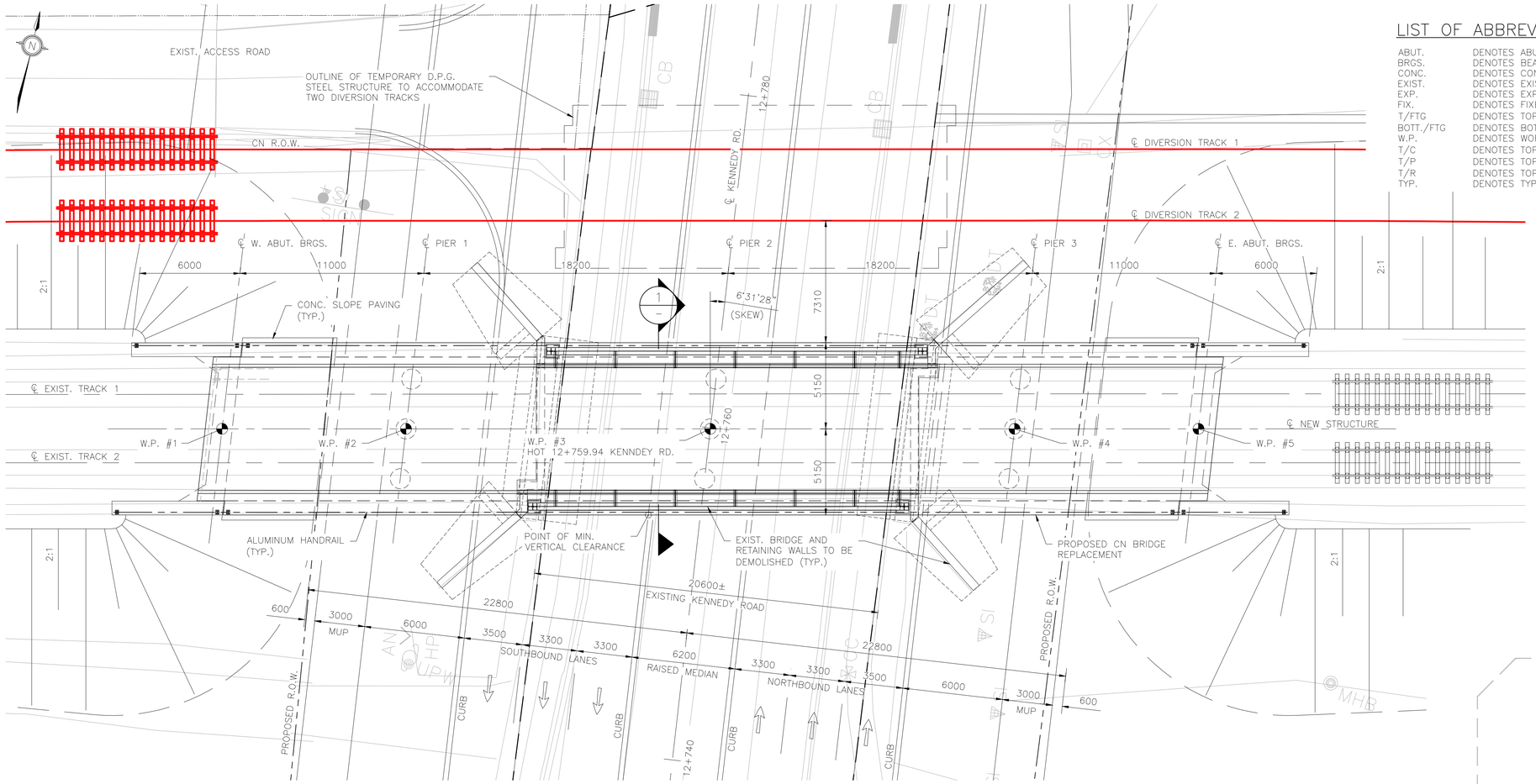
NOTES:

1. STRUCTURES SUBJECTED TO RAILWAY LOADING WILL BE DESIGNED IN ACCORDANCE WITH SCHEDULE 15 PART 3 DESIGN AND CONSTRUCTION REQUIREMENTS, AREMA MANUAL OF RAILWAY ENGINEERING, METROLINX DESIGN REQUIREMENT MANUAL AND CN GUIDELINES FOR THE DESIGN OF RAILWAY STRUCTURES.
2. LIVE LOAD: COOPER E90 PLUS DIESEL IMPACT AND ALTERNATE LOADING AS PER AREMA CLAUSE 1.3.3.



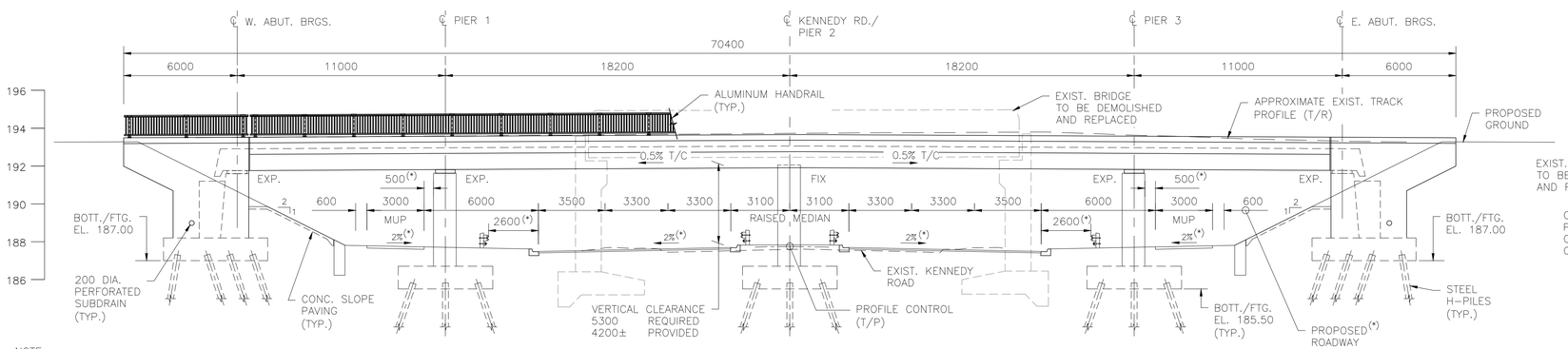
PROFILE OF KENNEDY RD.

SCALE: NTS



PLAN

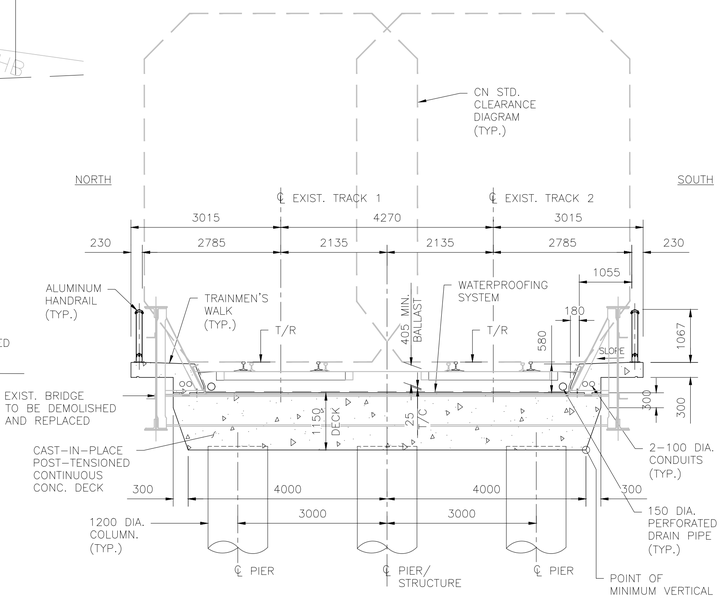
SCALE: 1:150



NOTE:
(*) DENOTES DIMENSIONS AND CROSSFALL MEASURED PERPENDICULAR TO ℄ OF KENNEDY ROAD

ELEVATION

SCALE: 1:150



SECTION 1 / –

SCALE: 1:60

NOTES:
THE LOCATION OF UTILITIES IS APPROXIMATE ONLY. CONSULT THE RESPECTIVE MUNICIPAL AUTHORITIES AND UTILITY COMPANIES TO DETERMINE THE EXACT LOCATION OF THEIR UTILITIES. THE CONTRACTOR SHALL VERIFY THE LOCATION OF UTILITIES AND SHALL ADEQUATELY PROTECT AND SUPPORT THEM DURING CONSTRUCTION.

NOT FOR CONSTRUCTION

HDR
100 York Blvd., Suite 300,
Richmond Hill, ON, L4B 1J8
Phone (289) 695-4600
Fax (289) 695-4601

No.	DATE	REVISIONS	BY
1	27.JULY.2020	PRELIMINARY	AB

York Region Transportation Services

DESIGN	G.H.
DRAWN	M.V.
CHECKED	S.M.B.

KENNEDY ROAD.
CN RAILWAY BRIDGE

GENERAL ARRANGEMENT

DWG. NO.	S01
CONT. NO.	10056259
SHEET NO.	–

B

Appendix

PLAN

0 25 50 SCALE 1:800

CURVE TABLES

CURVE DATA					
	Dc	RADIUS (m)	LENGTH (m)	Vp/Vfr (mph)	Ea/Eu (")
S1			50.00		
C1	2°00'	873.23	28.68	55	2.5/1.8
S2			50.00		
S3			50.00		
C2	2°00'	873.23	28.98	55	2.5/1.8
S4			50.00		
S5			50.00		
C3	2°00'	873.23	28.12	55	2.5/1.8
S6			50.00		
S7			50.00		
C4	2°00'	873.23	28.42	55	2.5/1.8
S8			50.00		

CURVE DATA					
	Dc	RADIUS (m)	LENGTH (m)	Vp/Vfr (mph)	Ea/Eu (")
S9			50.00		
C5	2°00'	873.23	29.32	55	2.5/1.8
S10			50.00		
S11			50.00		
C6	2°00'	873.23	29.45	55	2.5/1.8
S12			50.00		
S13			50.00		
C7	2°00'	873.23	29.48	55	2.5/1.8
S14			50.00		
S15			50.00		
C8	2°00'	873.23	29.88	55	2.5/1.8
S16			50.00		

LEGEND

- ℄ PROPOSED RE-ALIGNED TRACK
- ℄ EXISTING MAIN TRACK
- PROPERTY LINE
- CN PROPERTY LINE

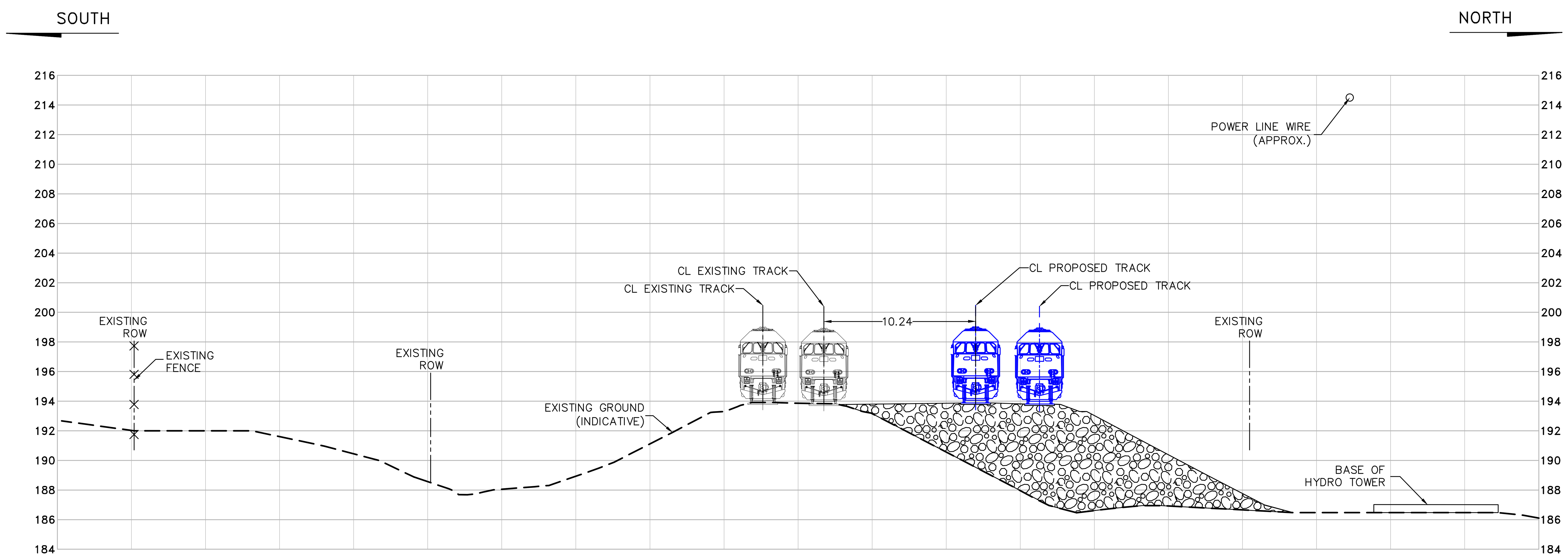
CONCEPTUAL
NOT FOR CONSTRUCTION

HDR | York Region Transportation Services

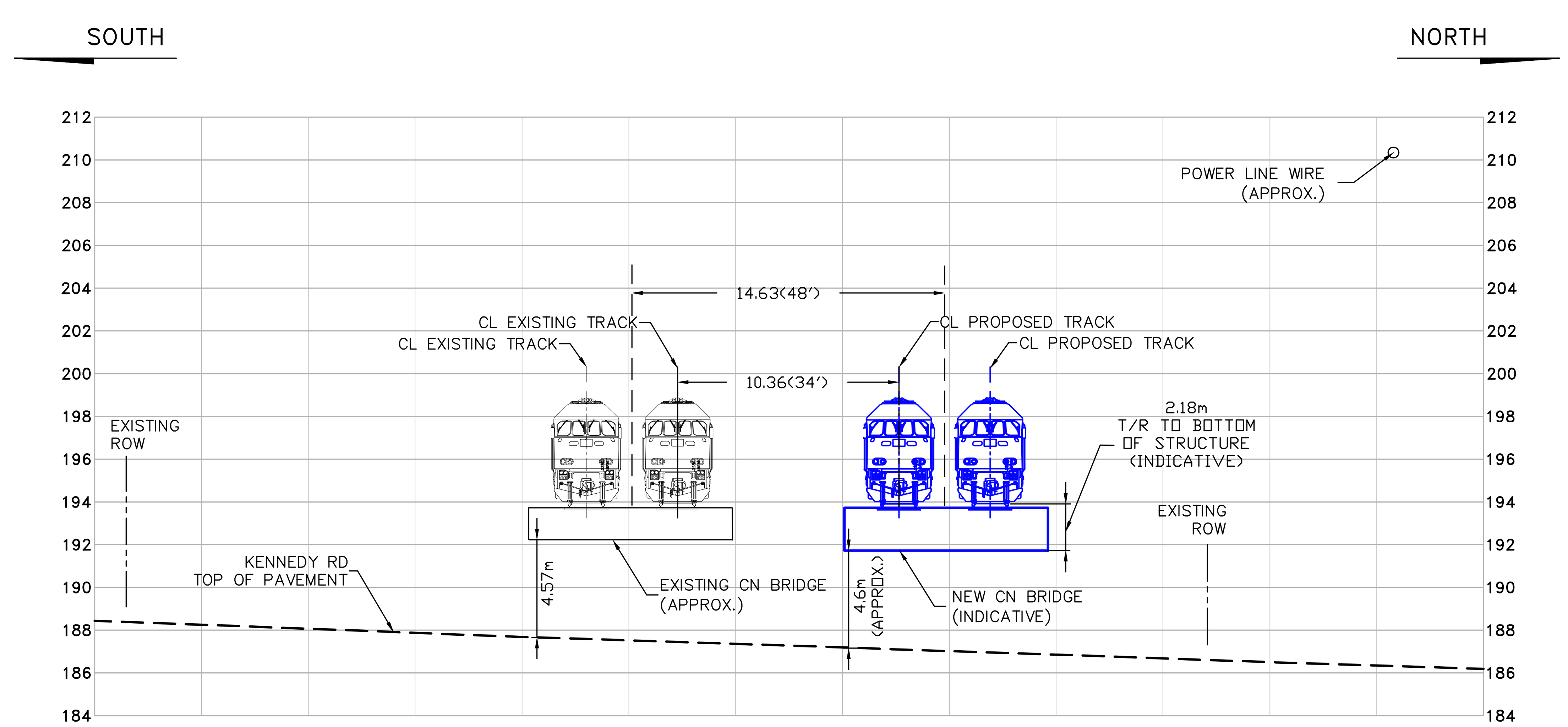
KENNEDY ROAD
ENVIRONMENTAL ASSESSMENT
POTENTIAL CN TRACK NORTH DIVERSION
PLAN

SHEET NO.
C11-001-RP03

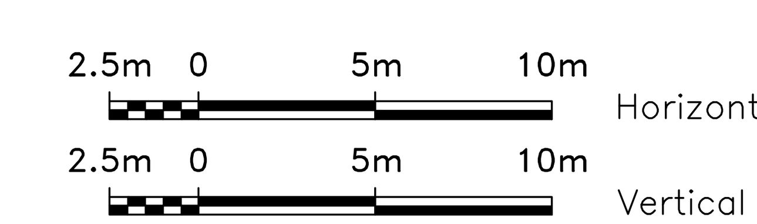
JUL 04 2018



SECTION 'A' – 49m EAST FROM CL KENNEDY RD
SCALE 1:200



SECTION 'B' – AT CL KENNEDY RD
SCALE 1:200



CONCEPTUAL
NOT FOR CONSTRUCTION

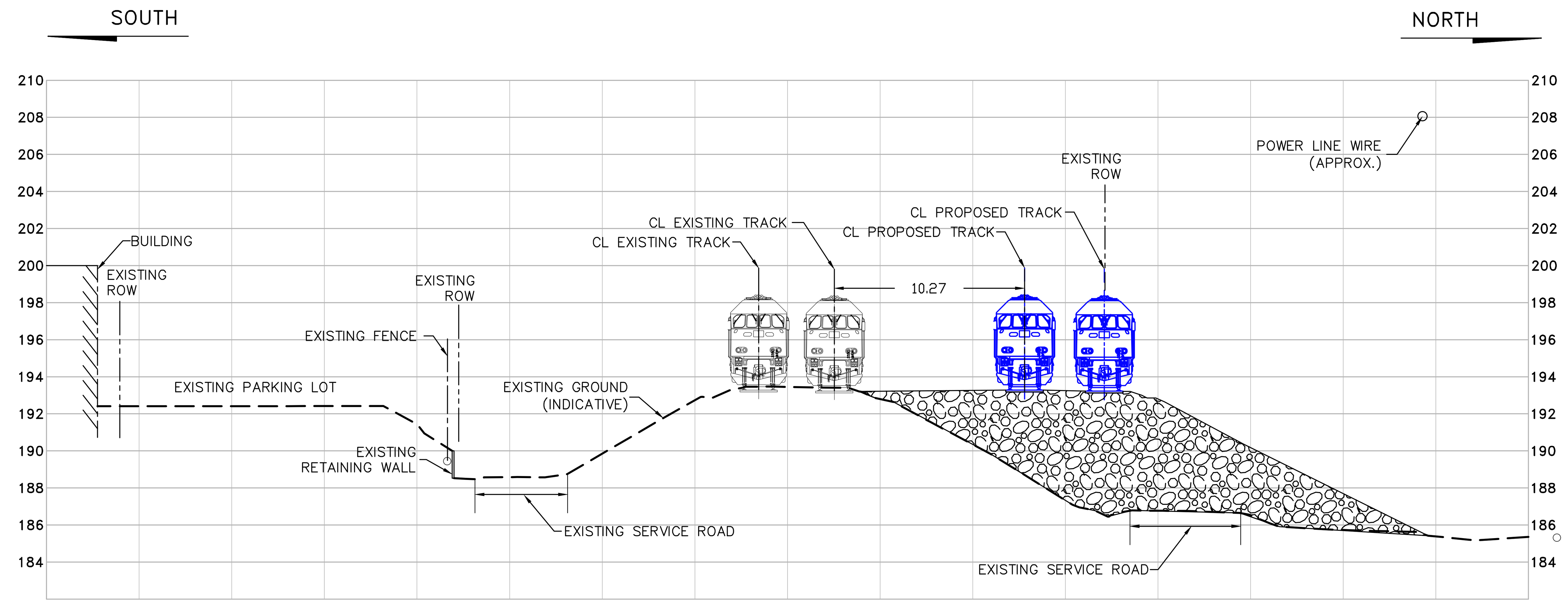
HDR

York Region Transportation Services

KENNEDY ROAD
ENVIRONMENTAL ASSESSMENT
POTENTIAL CN TRACK NORTH DIVERSION
TYPICAL SECTIONS 1

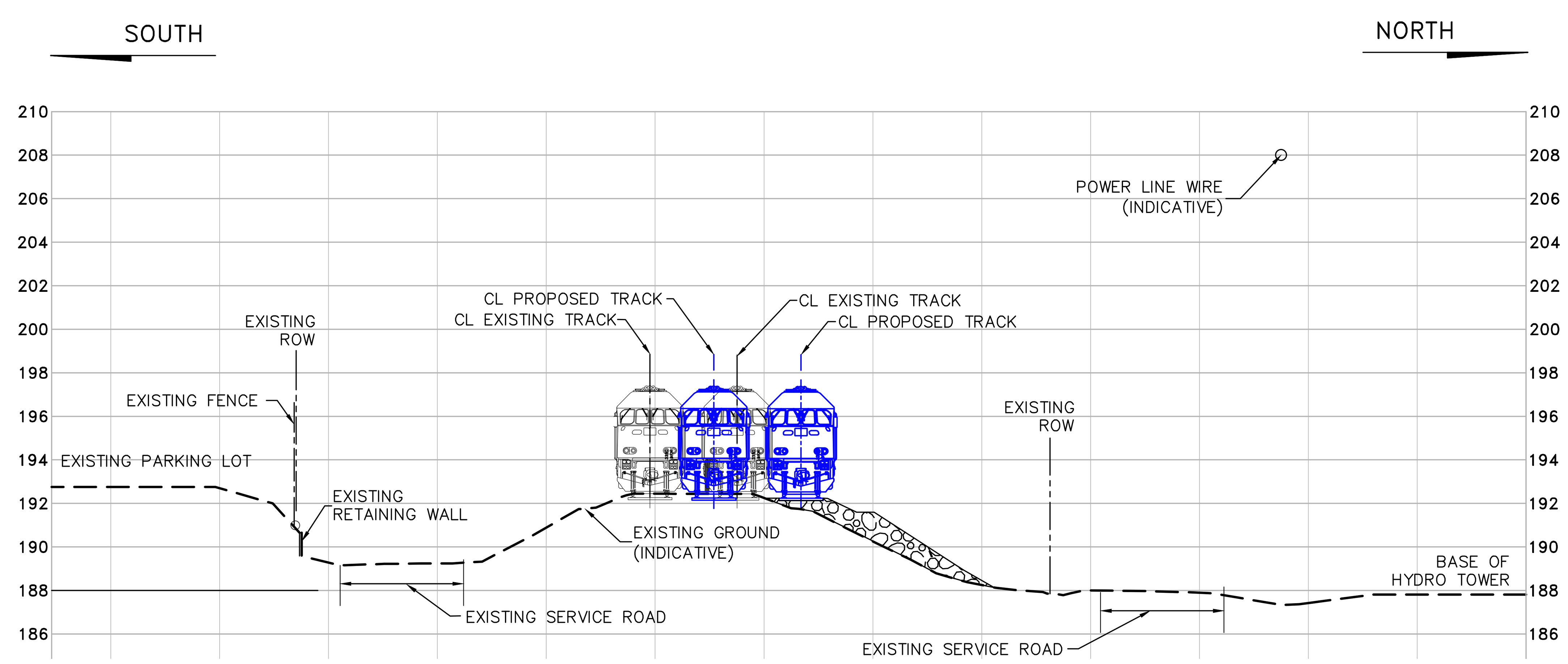
SHEET NO.
C11-001-EX01

JUL 04 2018



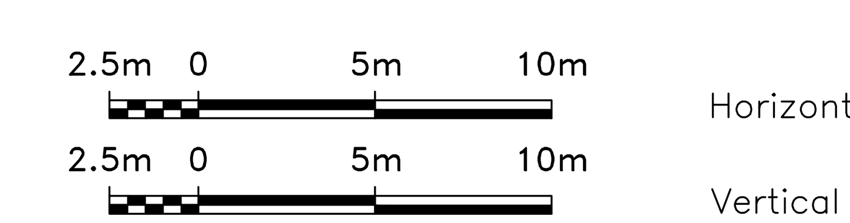
SECTION 'C' – 51m WEST FROM CL KENNEDY RD

SCALE 1:200



SECTION 'D' – 206m WEST FROM CL KENNEDY RD

SCALE 1:200



CONCEPTUAL
NOT FOR CONSTRUCTION

HDR | York Region Transportation Services

KENNEDY ROAD
ENVIRONMENTAL ASSESSMENT

POTENTIAL CN TRACK NORTH DIVERSION
TYPICAL SECTIONS 2

SHEET NO.
C11-001-EX02

JUL 04 2018

FILENAME: C:\pwworking\canada01\dms27885\10056259-C11-001-EX02.dwg
PLOTDATE: Jul 11, 2018 – 11:48am
PLOTTED BY: JGRANOVS