

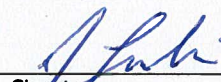


<b>Document Type:</b>	<b>TECHNICAL APPRAISAL FORM Tunnels</b>
<b>Submission Name:</b>	T8- Geraedts Tunnel
<b>Document Number:</b>	285380-03-127-0022

<b>Design Consultant:</b>		<b>HMM</b>
<b>Date</b>	<b>Revision</b>	<b>Description</b>
Sept 14, 2012	0	Issued for Construction

Issued by: Jeffrey Luckai, Stephen Fuheng Yang  
Name

Sept 14, 2012  
Date

  
Signature

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## TABLE OF CONTENTS

<b>1</b>	<b>PROJECT DESCRIPTION .....</b>	<b>5</b>
1.1	NAME AND LOCATION OF TUNNEL .....	5
1.2	PERMITTED TRAFFIC SPEED .....	5
<b>2</b>	<b>TUNNEL DETAILS.....</b>	<b>5</b>
2.1	BASIC LAYOUT.....	5
2.2	RESTRICTIONS TO TRAFFIC.....	6
<b>3</b>	<b>BRIEF DESCRIPTION OF TUNNEL, TRAFFIC AND TUNNEL GEOMETRY .....</b>	<b>6</b>
3.1	STRUCTURAL FORM OF TUNNEL .....	6
3.2	STRUCTURAL FORM OF PORTAL STRUCTURES .....	7
3.3	TRAFFIC AND GEOMETRY .....	8
3.3.1	Horizontal and vertical alignment of tunnel and tunnel approaches .....	8
3.3.2	Cross-section .....	8
3.3.3	Standards used .....	8
3.3.4	Accommodation of mechanical and electrical services in the tunnel .....	8
3.3.5	Minimum vertical clearance, horizontal clearances.....	8
3.4	PROPOSED ARRANGEMENTS FOR INSPECTION AND MAINTENANCE .....	8
3.5	PROVISION TO BE MADE IN THE TUNNEL LAYOUT FOR EMERGENCY COMMUNICATION AND ESCAPE FACILITIES, FIRE, ETC.....	8
3.6	LANDSCAPING ABOVE TUNNEL AND PROTECTION OF TUNNEL ROOF .....	9
3.7	FINISHES .....	9
<b>4</b>	<b>DESIGN ASSESSMENT CRITERIA .....</b>	<b>9</b>
4.1	LIVE LOADING.....	9
4.1.1	Loading relating to normal traffic under applicable code loading and regulation .....	9
4.1.2	Design vehicle .....	9
4.1.3	Provision for exceptional abnormal loads .....	10
4.1.4	Any special loading not covered above .....	10
4.1.5	Heavy or high load route requirements and arrangements being made to preserve the route and any provisions for future heavier loads or future widening .....	10
4.1.6	Authorities consulted or any special conditions required .....	10
4.2	OTHER RESTRICTIONS .....	10
4.2.1	Parapet walls .....	10
<b>5</b>	<b>STRUCTURAL ANALYSIS.....</b>	<b>10</b>
5.1	METHODS OF ANALYSIS PROPOSED .....	10
5.2	ASSUMPTIONS OF STRUCTURAL ELEMENTS .....	10
5.2.1	Cast-In-Place Concrete .....	10
5.2.2	Precast Prestressed Concrete.....	10
5.2.3	Reinforcing Steel.....	11
5.2.4	Prestressing Steel .....	11
5.2.5	Structural Stiffness.....	11
5.3	PROPOSED EARTH PRESSURE COEFFICIENT ( $K_a$ , $K_o$ OR $K_p$ ).....	11
5.4	PROPOSED FIRE DESIGN INCLUDING PROTECTION OF STRUCTURE AND CABLE.....	11
<b>6</b>	<b>GROUND CONDITIONS.....</b>	<b>11</b>

6.1	GROUND CONDITIONS.....	11
6.2	GEOTECHNICAL DESIGN PARAMETERS.....	11
6.3	DIFFERENTIAL SETTLEMENT .....	11
6.4	ANTICIPATED GROUND MOVEMENTS OR SETTLEMENT .....	11
6.5	GROUNDWATER CONDITIONS AND MITIGATIVE MEASURES.....	12
6.6	VARIANCE FROM GEOTECHNICAL MEMO RECOMMENDATIONS .....	12
<b>7</b>	<b>DRAINAGE AND WATERPROOFING .....</b>	<b>12</b>
7.1	DETAILS OF PROPOSED/EXISTING DRAINAGE.....	12
7.1.1	Ground water seepage and run off.....	12
7.1.2	Accidental spillage, water carried in by vehicles .....	12
7.1.3	Fire main burst .....	12
7.1.4	Tunnel washing .....	12
7.2	DETAILS OF PROPOSED WATERPROOFING.....	13
7.3	LIST SPECIAL REQUIREMENTS OF LOCAL DRAINAGE AUTHORITY .....	13
<b>8</b>	<b>TUNNEL SUPPORT SYSTEM AND METHOD OF CONSTRUCTION.....</b>	<b>13</b>
8.1	BASIS OF THE DESIGN OF THE TUNNEL SUPPORT SYSTEM FOR TEMPORARY AND PERMANENT CONDITIONS AND ANY PROPOSALS FOR GROUND TREATMENT .....	13
8.2	SHOW HOW THE PROPOSED METHOD OF CONSTRUCTION, I.E. EXCAVATION AND APPLICABLE GROUND SUPPORT, WILL ENSURE THE CONTINUED SAFE USE OF THE PARKWAY AND PREVENT STRUCTURAL FAILURE .....	13
8.3	GIVE DETAILS OF PREDICTED SETTLEMENTS ON ADJACENT STRUCTURES.....	14
8.4	STATE METHODS TO BE ADOPTED TO MONITOR AND CONTROL THE EFFECTS OF TUNNEL CONSTRUCTION TO ENSURE COMPLIANCE WITH ANY CRITERIA IMPOSED TO LIMIT SURFACE MOVEMENTS OR VIBRATION (IF APPLICABLE) .....	14
<b>9</b>	<b>CHECKING .....</b>	<b>14</b>
9.1	INDEPENDENT CHECK.....	14
9.2	RESPONSIBLE DESIGN PERSONNEL.....	14
<b>10</b>	<b>DRAWINGS AND DOCUMENTS .....</b>	<b>14</b>
10.1	LIST OF DRAWINGS (INCLUDED IN THIS SUBMISSION): .....	14
10.2	LIST OF DOCUMENTS (INCLUDED IN THIS SUBMISSION):.....	16
10.3	LIST OF REFERENCE DRAWINGS AND DOCUMENTS (NOT INCLUDED IN THIS SUBMISSION).....	16

## Appendix A – Design Documentation

## 1 Project Description

This submission contains design drawings and geotechnical recommendations associated with Geraedts Tunnel T8. This is the submission intended for IFC.

### 1.1 Name and location of tunnel

Geraedts Tunnel is designed for the westbound and eastbound traffic of Highway 401 at Geraedts Drive, parallel to Highway 3 at the location of this tunnel. The center of the tunnel has a Station 11+660.000. Geraedts Drive crosses over the tunnel to connect to HWY3 at grade.

### 1.2 Permitted traffic speed

Highway Classification:	UFD – HWY 401
Design Speed:	120 km/h for HWY401 under the structure
Posted Speed:	100 km/h for HWY401 under the structure
Lanes:	4 lanes on Geraedts Drive cross over the structure 8 lanes under the structure for HWY401
Design Clearance:	Provided 5.100 m vertical clearance, 5.0m is required
Bridge Design Vehicle:	CL-625-ONT

## 2 Tunnel Details

### 2.1 Basic layout

Geraedts Dive Tunnel is 120.2m long, cut and covered tunnel with a two span bridge structure, and the total width of the tunnel varies from 46.8m to 43.9m. The tunnel has three 3.75m wide westbound lanes, three 3.75m wide eastbound lanes, and 3.5m wide eastbound and westbound speed change lanes (SCL). Minimum 2.5m wide shoulders are accommodated along the pier sides. At the abutment sides, barrier walls are provided. There are piers and dedicated median to divide the westbound and eastbound lanes.

#### Basic Layout Summary

Length	120.2m
Clear Roadway Width	46.8m to 43.9m
Alignment	HWY401 centerline
Lanes	3 – 3.75m wide westbound lanes under 3 – 3.75m wide eastbound lanes under 2 – 3.50m wide SCL lanes under 1 – 3.25m wide over 3 – 3.50m wide lanes over
Shoulder	Minimum 2.5m wide along the pier Barrier walls at the abutments
Median Barrier	Tall wall to protect pier



Road side Barrier	Along shoulders
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## 2.2 Restrictions to traffic

N/A

# 3 Brief Description of Tunnel, Traffic and Tunnel Geometry

## 3.1 Structural form of tunnel

Geraedts Drive Tunnel is a cut-and-cover structure; its main bearing structure is composed of 43 lines of NU1400 modified girders, each with two spans of about 23.5m and 23.3m. These girders are derived from the standard NU1900 girders with 35mm concrete added to each face of the web and 50mm added to the bottom of the bottom flange of the girders to enhance their resistance to RWS tunnel fires according to the Memo 285380-03-109-0004 Rev. 0 Tunnel Fire Design Criteria. The NU girders are precast prestressed concrete girders, transported and erected on-site, then connected together to make them continuous to bear SDL and live loads. Semi-integral abutments over driven deep HP steel piles are used; the central piers consist of 1.5mx1.5m pier caps supported by 1.2m diameter of circular columns over 1.25m deep and 3.2m wide concrete footings, which are in turn also supported by driven deep HP steel piles.

The 235mm thick concrete slab on top of the Modified NU1400 girders are divided into segments of lengths no more than 45m long, separated by 50mm wide gap expansion joints, due to thermal expansion and contraction of temperature changes from -32°C to +20°C if the construction temperature is set to 15°C. With a maximum 45m wide deck segment, the movement of decks at the expansion joints due to temperature changes would be -14.4mm to +9.0mm, which is good for 47mm thick elastomeric bearings and could be accommodated by the 50mm wide gaps at the expansion joints. The uneven settlements of the tunnel foundations also need expansion joints in the superstructure for stress release.

The tunnel superstructure is expected to expand and/or contract immediately after construction and during its service life due to creep, shrinkage and thermal movement. Dividing the tunnel superstructure into segments using expansion joints significantly reduces the demand on the bearings caused by these movements, and reduces bending demand on piles perpendicular to the girder center lines, thus resulting in a more efficient design. Most of the strip seals are to be installed 0.85m below backfill. They are also covered by a metal plate or board for further protection from vertical live load/impact. The expansion joints are not expected to require frequent maintenance. Inspection (e.g. for signs of leakage) can be undertaken from beneath the deck using a lifting platform or similar. The replacement procedure for expansion joints is expected to be similar to that of replacing buried utilities on top of tunnels. For joints exposed to traffic, appropriate standard joints have been specified with input from suppliers.

There are no escape facilities proposed for the tunnels.

See summary below for general arrangement.

**Structure Summary**

Structural Type:	Prestressed concrete NU1400 modified girders, semi-integral abutments and frame piers.
Span Arrangement:	Two span structure with modified NU girders spaced at 2.825m, except at expansion joint which is 2.5 m. Span length is 23.5-20.6m for the north spans and 23.3m for the south spans.
Foundation Type:	Concrete footings on deep HP steel piles
North Abutment	Semi-integral abutment (1.7m width and 1.5m depth) supported on deep HP 310x110 steel piles.
South Abutment	Semi-integral abutment (1.7m width and 1.5m depth) supported on deep HP 310x110 steel piles.
Central Pier	1.5mx1.5m Cap beam supported on 1.2m diameter of columns over 3.2m wide and 1.25m deep concrete footings. Columns on footing supported on deep HP 310x110 steel piles.
Span Articulation:	Semi-integral support at abutments, concrete footing for central piers. Girders are supported by laminated plate bearings, and the longitudinal translation of girders is fixed at the central pier. 2 expansion joints parallel to girders are provided on the deck along the full length of the tunnel.
Deck:	235mm thick concrete deck comprising 90mm thick precast panels and cast-in-place concrete topping; 1.8mx0.45m parapet wall at each end of the tunnel. 1m or 0.85m maximum soil fill is over the concrete deck where no roadway is present, and the soil fill could be replaced with 0.5m asphalt or concrete pavement for normal traffic use. The 0.85m soil fill could be reduced to 0.5m to facilitate landscaping. 0.5m in total of concrete pavement+asphalt over the concrete deck where roadways are required is considered.

### 3.2 Structural form of portal structures

N/A.

### 3.3 Traffic and geometry

#### 3.3.1 Horizontal and vertical alignment of tunnel and tunnel approaches

**Tunnel:** 8 lanes in total of traffic for east- and west-bound traffic.

**Horizontal alignment:** The tunnel is located on a tangent section of the highway 401. The centerline of the tunnel is at STA. 11+660.000.

**Vertical alignment:** Hwy 401-120k sag curve at west half of tunnel changing to a 0.5% grade from center rising to the east edge of the tunnel. 0.5% slope from East to West at the top slab level.

**Above tunnel:** 4 lanes of Geraedts Drive crosses over the tunnel to access HWY3; two sidewalks are also provided for pedestrian.

#### 3.3.2 Cross-section

Tunnel satisfied 5.0 m minimum vertical clearance. 5.3 m vertical clearance is provided.

#### 3.3.3 Standards used

Design Criteria in accordance with Part 2 of Project Agreement – Schedule 15-2:

Article 1 – Highway Geometrics Design Criteria

Article 3 – Structural Design Criteria

Article 4 – Tunnel Design Criteria

Article 5 – Geotechnical and Foundation Design Criteria

Referenced Documents as specified in these Articles following the order of precedence as instructed.

No deviation from the standards used including design traffic flows and speeds.

#### 3.3.4 Accommodation of mechanical and electrical services in the tunnel

Electrical arrangements are as shown on drawings.

#### 3.3.5 Minimum vertical clearance, horizontal clearances

Minimum headroom (vertical clearance) is 5.3 m.

### 3.4 Proposed arrangements for inspection and maintenance

All exposed structure elements will be accessible for inspection and maintenance. Some elements may require use of an inspection platform.

### 3.5 Provision to be made in the Tunnel layout for emergency communication and escape facilities, fire, etc.

Emergency communication details are shown on ATMS New Construction drawings which is not included in this submission.

No escape facilities will be provided.



### 3.6 Landscaping above Tunnel and protection of Tunnel roof

Landscaping above tunnel is shown on Landscape Construction drawings which is not included in this submission. Tunnel has been designed with 0.85 m soil layer on top deck to accommodate the requirement for drainage and landscaping.

### 3.7 Finishes

Concrete finishes on exterior of the parapet wall will have grassland pattern. All remaining finishing are specified in the General Notes, Doc No. 285380-03-060-SEG1-2802.

## 4 Design Assessment Criteria

### 4.1 Live Loading

#### 4.1.1 Loading relating to normal traffic under applicable code loading and regulation

One truck of CL-625-ONT or one emergency truck applied anywhere over the tunnel is used as vehicle load and 4kPa of uniform pressure load is used as pedestrian loads in the design of T8, which are as per the Canadian Highway and Bridge Design Code (CHBDC) S6-06 for the parts of the structure where no traffic lanes are present. This conforms to the requirement defined in Clause 3.3 of the Project Agreement – Schedule 15.2. The DLA with reduced load effect is considered as per Clause 6.9.6 of CHBDC S6-06 if the truck travels over the part of the tunnel where the earth fill on top of the structure is more than 0.6m thick.

Normal live loads and pedestrian loads are considered as per CHBDC S6-06 for the parts of the structure where traffic lanes are present.

The pedestrian load used in the design of T-8 is as per Clause 3.8.9 of the CHBDC S6-06. The equivalent load pressure from the pedestrian load is 4kPa.

Lateral pressure induced by the traffic loads or pedestrian loads is also considered when designing the parapet walls.

#### 4.1.2 Design vehicle

One CHBDC CL-625-ONT truck applied anywhere on the tunnel was used in the design of T8 for the parts where there is no designated traffic lanes on the tunnel but with 0.85m soil fill.

Normal CL-625-ONT traffic live loads, including multilane loads of CHBDC CL-25-ONT trucks and CL-625-ONT lane loads, are used in designing the parts of the structure where normal traffic lanes are present. The 0.85m maximum soil fill over the tunnel could be replaced with 0.5m concrete pavement and multilane traffic could be placed on top of this pavement.

#### 4.1.3 Provision for exceptional abnormal loads

According to Clause 3.3 of the Project Agreement – Schedule 15.2, one emergency vehicle defined in this agreement is also considered. The load effect of this vehicle on the structure is smaller than one CHBDC CL-625-ONT truck.

#### 4.1.4 Any special loading not covered above

N/A

#### 4.1.5 Heavy or high load route requirements and arrangements being made to preserve the route and any provisions for future heavier loads or future widening

N/A

#### 4.1.6 Authorities consulted or any special conditions required

N/A

### 4.2 Other restrictions

#### 4.2.1 Parapet walls

1.8m x 0.45m parapet walls + 2.3m fence over the parapet wall at the overhangs of exterior girders are considered; the fence has an assumed equivalent weight of 1kN/m for this submission

## 5 Structural Analysis

### 5.1 Methods of analysis proposed

T8 has been analysed in accordance with CHBDC S6-06 and S6S1-10 (Supplement No. 1 to CAN/CSA-S6-06). Software design aids including Canadian Bridge Analysis System (CANBAS) version 2.0.1, STAAD Pro 2007 version 20.07.02.15 and Microsoft Office Excel 2003 were used.

### 5.2 Assumptions of structural elements

#### 5.2.1 Cast-In-Place Concrete

Minimum compressive strength at 28 days: 30MPa (substructure)

Minimum compressive strength at 28 days: 40MPa (deck and diaphragms)

#### 5.2.2 Precast Prestressed Concrete

Minimum compressive strength at transfer: 42MPa (girders)

Minimum compressive strength at 28 days: 60MPa (girders)

Minimum compressive strength at transfer: 24MPa (girders)

Minimum compressive strength at 28 days: 40MPa (deck panels)

### 5.2.3 Reinforcing Steel

Plain reinforcing steel bars: CAN/CSA G30.18-M92; Grade 400W

Coated reinforcing steel bars: CAN/CSA G30.18-M92; Grade 400W unless otherwise noted.

Stainless steel reinforcing bars: Type 316LN or Duplex 2205 or Type XM-28; Grade 500

### 5.2.4 Prestressing Steel

Strands shall be low-relaxation, size designation 15, Grade 1860 in accordance with CSA Standard G279.

### 5.2.5 Structural Stiffness

Structural stiffness is calculated according to CAN/CSA S6-06 Clause 5.9.1 grillage model and finite element method.

### 5.3 Proposed earth pressure coefficient ( $K_a$ , $K_o$ , or $K_p$ )

Refer to Geotechnical Investigation and Design Report, Doc No. 285380-04-119-0032.

### 5.4 Proposed fire design including protection of structure and cable

For proposed fire design refer to the following fire protection documents:

- Tunnel Structural Fire Assessment, Doc. No. 285380-03-126-0045;
- Tunnel Structural Fire Assessment – Deck Slab, Doc. No. 285380-03-126-0049;
- Tunnel Fire Design Criteria, Doc. No. 285380-03-109-0004.

Only non-combustible materials are used in tunnel for electrical and ATMS works.

## 6 Ground Conditions

### 6.1 Ground Conditions

Refer to Geotechnical Investigation and Design Report, Doc No. 285380-04-119-0032.

### 6.2 Geotechnical Design Parameters

Refer to Geotechnical Investigation and Design Report, Doc No. 285380-04-119-0032.

### 6.3 Differential Settlement

Refer to Geotechnical Investigation and Design Report, Doc No. 285380-04-119-0032.

### 6.4 Anticipated Ground Movements or Settlement

Refer to Geotechnical Investigation and Design Report, Doc No. 285380-04-119-0032.

## 6.5 Groundwater Conditions and Mitigative Measures

Refer to Geotechnical Investigation and Design Report, Doc No. 285380-04-119-0032.

## 6.6 Variance from Geotechnical Memo Recommendations

N/A

# 7 Drainage and Waterproofing

## 7.1 Details of proposed/existing drainage

### 7.1.1 Ground water seepage and run off

Refer to Highway and Roadway Drainage Design Report, Doc No. 285380-70-119-0001 for Phase 1.

### 7.1.2 Accidental spillage, water carried in by vehicles

Drainage structures have been placed along the tunnel to collect runoff from vehicles and any accidental spills. These liquids would then be conveyed to the spill containment units located upstream of each pumping station. See Highway New Construction Drawings for more details.

### 7.1.3 Fire main burst

The runoff from a fire main burst would be less than the 100yr storm flow, which the storm system is designer for. The flow would be collected within two or three inlets. Watermains crossing Highway 401 and Highway 3 will be installed in steel casings per MTO requirements. Casing material will be stronger than the watermain material to be used. Additionally, the casing void (area between outside of watermain pipe and casing pipe) will be fill with cement based grout. Grouting the void area will provide added strength to the pipe system crossing the Highways, and minimize the potential for watermain breaks underneath a travel lane. Should a break occur under the travelled portion of the Highway, the casing will direct water flow to the shoulder areas where the subdrains and catchbasins will direct the water into the storm system. Water valves are placed along the watermain along Highway 401. This will permit the watermain to be isolated in the area of a break. Once the valves are closed, the water flow will be shut off.

### 7.1.4 Tunnel washing

The runoff from tunnel washing would be less than the 100yr storm flow, which the storm system is designer for. The flow would be collected within two or three inlets. Watermains crossing Highway 401 and Highway 3 will be installed in steel casings per MTO requirements. Casing material will be stronger than the watermain material to be used.

Additionally, the casing void (area between outside of watermain pipe and casing pipe) will be fill with cement based grout. Grouting the void area will provide added strength to the pipe system crossing the Highways, and minimize the potential for watermain breaks underneath a travel lane. Should a break occur under the travelled portion of the Highway, the casing will direct water flow to the shoulder areas where the subdrains and catchbasins will direct the water into the storm system. Water valves are placed along the watermain along Highway 401. This will permit the watermain to be isolated in the area of a break. Once the valves are closed, the water flow will be shut off.

#### 7.2 Details of proposed waterproofing

The entire area of the T8 deck will be sealed with a waterproofing system as per Project Agreement requirement. Refer to Tunnel Watertightness REV E, Doc No. 285380-03-126-0039 and notes provided on General Notes sheet.

#### 7.3 List special requirements of local drainage authority

Not applicable.

## 8 Tunnel Support System and Method of Construction

#### 8.1 Basis of the design of the Tunnel support system for temporary and permanent conditions and any proposals for ground treatment

Structural form as described on Section 3.1 is one of the effective support system commonly used to carry roadway above for highway underpass. This support system is also cable of satisfying the design requirements for permanent conditions of the WEP tunnels.

Refer to Geotechnical Investigation and Design Report for the basic of permanent ground treatment design.

Refer to Geotechnical Investigation and Design Report for support design for temporary conditions.

#### 8.2 Show how the proposed method of construction, i.e. excavation and applicable ground support, will ensure the continued safe use of the Parkway and prevent structural failure

Permanent design is based on the Construction Sequence provided on the Foundation Plan, Abutment Layout and Ground Improvements Plan. Instrumentation and monitoring of the temporary works during construction should be implemented



by the Contractor in addition to the limited instrumentation already installed during the geotechnical investigation.

8.3 Give details of predicted settlements on adjacent structures

Refer to Geotechnical Investigation and Design Report for anticipated deformation of the ground around the structure.

8.4 State methods to be adopted to monitor and control the effects of tunnel construction to ensure compliance with any criteria imposed to limit surface movements or vibration (if applicable)

A program of site instrumentation and monitoring will be developed and implemented during construction, but is not part of this submission.

## 9 Checking

9.1 Independent Check

Independent check is required as per Project Agreement – Schedule 15-2, Part 2, Article 3 3.2 (c) (i).

Independent Checking Team: INTERNATIONAL BRIDGE TECHNOLOGIES.

9.2 Responsible Design Personnel

Originator: Stephen Fuheng Yang, P. Eng.

Checker: Matthias Yu, P.Eng.

Reviewer: Biljana Rajlic, P.Eng.

## 10 Drawings and Documents

10.1 List of Drawings (included in this submission):

Drawing No.	Revision	Drawing Name
285380-03-060-SEG1-2800	0	COVER SHEET
285380-03-060-SEG1-2801	0	GENERAL ARRANGEMENT
285380-03-060-SEG1-2802	0	GENERAL NOTES
285380-04-090-SEG1-2803	0	BOREHOLE LOCATION & SOIL STRATA
285380-04-091-SEG1-2804	0	SOIL STRATIGRAPHY
285380-03-061-SEG1-2805	0	FOUNDATION LAYOUT
285380-03-061-SEG1-2806	0	FOUNDATION DETAILS
285380-03-060-SEG1-2807	0	GROUND IMPROVEMENTS - PLAN

285380-03-061-SEG1-2808	0	ABUTMENT LAYOUT I
285380-03-061-SEG1-2809	0	ABUTMENT LAYOUT II
285380-03-061-SEG1-2810	0	ABUTMENT REINFORCEMENT
285380-03-061-SEG1-2811	0	RSS WALL LAYOUT
285380-03-061-SEG1-2812	0	RSS WALL DETAILS
285380-03-061-SEG1-2813	0	RSS WALL DETAILS II
285380-03-061-SEG1-2814	0	PIER LAYOUT
285380-03-061-SEG1-2815	0	PIER REINFORCEMENT
285380-03-062-SEG1-2816	0	PRESTRESSED GIRDER AND BEARING LAYOUT
285380-03-062-SEG1-2817	0	BEARING DETAILS
285380-03-063-SEG1-2819	0	PRESTRESSED GIRDER ELEVATIONS
285380-03-063-SEG1-2820	0	PRESTRESSED GIRDER DETAILS
285380-03-064-SEG1-2821	0	INTERIOR PRECAST DECK PANELS
285380-03-064-SEG1-2822	0	PRECAST PANELS AT EXPANSION JOINTS
285380-03-064-SEG1-2823	0	DECK LAYOUT AND REINFORCEMENT
285380-03-064-SEG1-2824	0	ABUTMENT DIAPHRAGM LAYOUT & REINFORCEMENT
285380-03-064-SEG1-2825	0	PIER DIAPHRAGM LAYOUT & REINFORCEMENT
285380-03-064-SEG1-2826	0	DECK DETAILS
285380-03-065-SEG1-2827	0	PARAPET WALL FINISH (GRASSLAND PATTERN)
285380-03-065-SEG1-2828	0	6000 mm APPROACH SLAB
285380-03-065-SEG1-2829	0	FENCE DETAILS
285380-03-065-SEG1-2830	0	DETAILS OF CONCRETE SLOPE PAVING
285380-03-066-SEG1-2831	0	STANDARD DETAILS
285380-07-444-SEG1-2832	0	EMBEDDED ELECTRICAL WORK I
285380-07-444-SEG1-2833	0	EMBEDDED ELECTRICAL WORK II
285380-07-444-SEG1-2834	0	EMBEDDED ELECTRICAL WORK III
285380-07-444-SEG1-2835	0	EMBEDDED ELECTRICAL WORK IV
285380-03-060-SEG1-2836	0	GROUND IMPROVEMENTS – SECTIONS I
285380-03-060-SEG1-2837	0	GROUND IMPROVEMENTS – SECTIONS II
285380-04-094-SEG1-2838	0	CONSTRUCTION NOTES – BACKFILL AT STRUCTURES
285380-04-094-SEG1-2839	0	CONSTRUCTION NOTES – LIGHTWEIGHT FILL MATERIAL
285380-04-094-SEG1-2840	0	CONSTRUCTION NOTES – EXPANDED POLYSTYRENE
285380-03-060-SEG1-2841	0	GROUND IMPROVEMENTS – SECTIONS III
285380-03-061-SEG1-2842	0	LIGHT/SIGNAL/COMMUNICATION FOUNDATION
285380-03-060-SEG1-2843	0	FIRE SUPPRESSION PLAN
285380-03-060-SEG1-2844	0	FIRE SUPPRESSION PROFILE
285380-03-060-SEG1-2845	0	FIRE SUPPRESSION DETAILS
285380-07-067-SEG1-2846	0	LUMINAIRE STRUCTURAL SUPPORT OPTION 1
285380-07-067-SEG1-2847	0	LUMINAIRE STRUCTURAL SUPPORT OPTION 2
285380-07-067-SEG1-2848	0	WIREWAY STRUCTURAL SUPPORT

10.2 List of Documents (included in this submission):

Document No.	Revision	Document Name
285380-04-119-0032	0	Geotechnical Investigation and Design Report – T-8
285380-03-127-0022	0	Technical Appraisal Form
285380-03-126-0039	E	Tunnel Watertightness

10.3 List of Reference Drawings and Documents (not included in this submission)

See Appendix A.

**The above design and construction proposals are submitted for review**

Signed: *Biljana Rajlic*  
Design Manager

Name: BILJANA RAJLIC

Engineering Qualifications: P.Eng.

Date: Sept. 14 2012

Professional Registration Number: 100041385

Affix Professional Seal



Signed: *[Signature]*  
Project Co Representative

Name: *LANA D. LAD*

Date: *24 Sep 2012*

Professional Registration Number: .....

Affix Professional Seal

## Appendix A – Referenced Drawings and Documents

### Referenced Drawing(s)

Drawing No.	Revision	Drawing Name

### Certificate(s)

Certificate No.	Revision	Certificate Name

### Special Provision(s)

Document No.	Revision	Document Name
285380-70-119-0001	C	Highway and Roadway Drainage Design Report
285380-83-119-0013	B	Tunnel Top Soil- Proposed Soil Profiles and Corresponding Unit Weight
285380-03-126-0045	D	Tunnel Structural Fire Assessment
285380-03-126-0049	A	Tunnel Structural Fire Assessment – Deck Slab
285380-03-109-0004	3	Tunnel Fire Design Criteria