APPENDIX E

Structural Options Evaluation

Project No. **8645**	Phase **430**	Date **10 March, 2011**
From **Patrick Chan**	To **Rick Krutzler, LEA**	C.C. **Andrew Brown, LEA**

Subject: **Dufferin Bridge EA Study – Structural Engineering Evaluation**

LEA Consulting Ltd. has undertaken a structural review of various crossing options for the Dufferin Street crossing between the Parkdale Neighbourhood and the Canadian National Exhibition (CNE) grounds. Two bridges combine to span the Canadian National Railway (CNR) tracks and the Gardiner Expressway. The purpose of this review is to investigate options for replacing these two crossings to ensure that the two bridges can support the existing and future demands in the area.

1.0 Background

Currently, the Dufferin Street bridges operate with one lane of traffic in either direction. In a review of the existing conditions of the bridges conducted in February of 2008 by UMA|AECOM, it was determined that there was a need to improve the bridge over the CNR tracks. Key deficiencies noted include the primary steel members (main girders, floor beams, stringers) severely corroded, the uncertain condition of the encased floor beam to main girder connections, the concern of the structure not having an alternate load path if such connection failure occurs, and the scaling of the concrete bridge deck due to freeze/thaw damage.

In addition to work being required on the bridge structure, the configuration of the bridge over the CNR tracks will no longer meet future service needs and was close to the end of its service life. The bridge over the CNR tracks needs to provide one meter of additional vertical clearance and two metres of additional horizontal clearance to meet current railway clearances. Furthermore, GO Transit plans to add two outside tracks to the existing four tracks, which would require additional horizontal clearance.

If changes are made to the bridge over the CNR tracks to bring it up to standard, significant changes would be required to the bridge over the Gardiner Expressway. Most significantly, the profile over the bridge would need to be raised to match with the required height for the bridge over the CNR tracks.

2.0 Feasibility Review

In order to determine whether the crossing is feasible, the review was undertaken considering various superstructures that could be used to make the crossing. With the intent of meeting a railway vertical clearance standard of 7.01 metres (existing being only 6.07 metres) and consequently minimizing the required grade raise, the depth of the superstructure must be minimized for which the following five options for the crossing were considered:

- Replace with a 2-span 75 m (45m-30m spans) welded steel plate box girder bridge (**Option 1**);
- Replace with a 1-span 78 m hung arch bridge (**Option 2**);
- Replace with a 1-span 78 m cable stayed bridge (**Option 3**)

- Replace with a 1-span 30 m precast concrete B900 box girder bridge over CNR tracks and a 1-span 35 m welded steel plate box girder bridge over Gardiner Expressway (**Option 4**); and
- Rehabilitate bridge over Gardiner Expressway and replace bridge over CNR tracks with a 1-span 30 m precast concrete B900 box girder, and lower the existing CNR tracks to avoid grade raise (**Option 5**).

For each option, it was assumed that Dufferin Street would be constructed with a design speed of 50 km/h and incorporate a 2% crossfall. The elevations and cross-sections for Options 1, 2, 3 and 4 are provided in **Appendix A**.

To determine the feasibility of each of these options, an evaluation matrix was prepared (**Appendix B**) that considered superstructure options with respect to the following criteria:

- Span Configuration and Superstructure Type;
- Substructure;
- Constructibility and Access;
- Aesthetics; and
- Long-term Performance.

The option of lowering the CNR tracks (Option 5) involves the greatest effort and impact. Although existing grades on the bridges are maintained and vertical railway clearance could be achieved, the scale of impact for lowering the tracks and providing sufficient transition distance for tie-ins is far more significant compare to impact due to grade raise at the bridges and the approaches beyond. As a result, the most feasible crossing option would involve replacement of the existing two bridges.

The most critical distinction between Options 1, 2, 3 and 4 is the respecting overall structure depths. The depths of the welded steel plate box girders and the precast concrete box girders under Options 1 and 4 depend on the span length. The longer the span length, the deeper the superstructure has to be. In contrast, the overall structure depths under Options 2 and 3 are dictated by the load carrying transverse floor beams. For the scope of providing the required vertical railway clearance and minimizing the associated grading impacts at the same time, the preferred crossing is Option 4 where it has the least overall structure depth and hence the least grade raise.

After subsequent discussions/meetings, the new crossing was determined to have an overall width of 25 metres, measured between the outside faces of the parapet walls. Also, the new crossing at the south end must accommodate streetcar manoeuvring which can only tolerate a maximum vertical slope of 0.5%. Because of the relatively flat slope introduced along the crossing, the use of precast concrete I-girders (CPCI) for the bridge over the Gardiner Expressway was considered. Initial review under Option 4 considered welded steel plate box girder for the same bridge span because this superstructure type provides the flexibility in matching with any vertical profile. However, with the streetcar manoeuvring constraint limiting the vertical profile, the use of the less expensive CPCI girders was considered more appropriate.

During the Public Information Centre #2, a suggestion was made to provide a less appearing (i.e., thinner) bridge structure over the Gardiner Expressway so that the preserved heritage features remain being the centre of attention rather than the proposed stocky CPCI superstructure, for traffic on Gardiner Expressway approaching the overpass. A shallower superstructure was considered which involve the use of welded steel plate box girder similar to Option 4 of the initial review. It was found that the option of using welded steel plate box girder over the Gardiner Expressway has an approximately 5% construction cost increase as oppose to the CPCI option, however the aesthetics more than offset the cost premium.

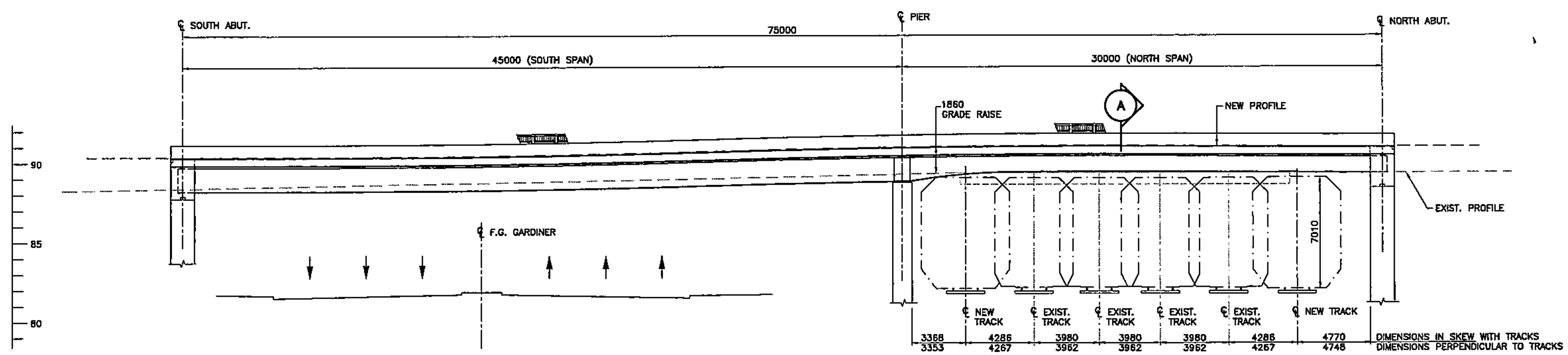
The recommended Dufferin Street crossing between the Parkdale Neighbourhood and the CNE grounds will be a single span (30 m) bridge over the CNR tracks with B1000 precast concrete box girders, a single span (35 m) bridge over the Gardiner Expressway with welded steel plate box girders and a retained soil system (RSS) in between the two bridges. The cast-in-place concrete deck will be covered with an asphalt wearing surface and a waterproofing membrane. The median portions of the bridges are anticipated to have the interim configuration first in-place and subsequently modify to accommodate the exclusive transit lanes by placing infill concrete at the ultimate stage. The two bridges will have cast in place semi-integral abutments supported on spread footings found on bedrock. Sleeper slab systems are required at the end of approaches between the two bridge structures. A General Arrangement Drawing of the preferred option and the cost estimates are included in **Appendix C**. The estimated structure construction cost of the crossing is $11.0 million, including the bridge over the CNR tracks, the bridge over Gardiner Expressway and the RSS in between.

3.0 Conclusion

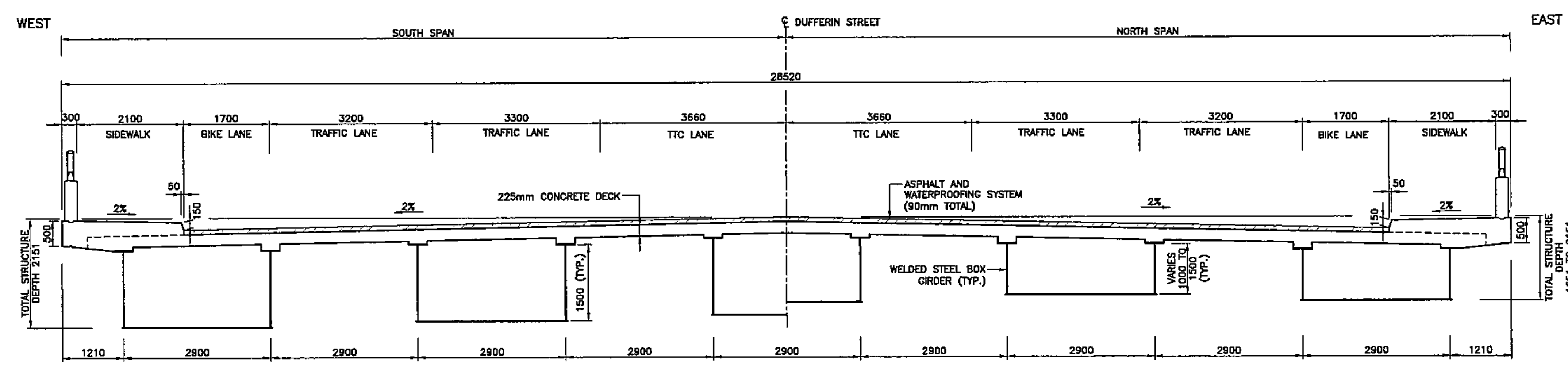
Given the initial evaluation, it has been determined that precast concrete box girder superstructure for the bridge span over the CNR tracks provides the least structure depth and hence the grade raise required is the least among all other bridge options. The surrounding heritage features are instated as the centre of attention by the use of a shallower bridge structure over the Gardiner Expressway involving welded steel plate box girders. However, the limiting vertical profile imposed for streetcar manoeuvring at the south end of the crossing enable the use of cost efficient precast concrete I-girders CPCI 1900 for the bridge span over the Gardiner Expressway, with a marginal cost reduction of 5%, but such a bridge option is less appealing.

APPENDIX A

Option Elevation and Cross-Section



ELEVATION
1:150



SECTION (A)
1:50

DRAFT

METRIC
ALL DIMENSIONS SHOWN HERE ARE IN MILLIMETRES UNLESS OTHERWISE NOTED

DRAWING NAME: F:\6545\Drafting\Structural\OPTIONS\OPTION-1.dwg
MODIFIED: Jan 31, 2011-4:47pm

PLOTTING INFO

COLOUR	WIDTH
30	.444
60	.762
120	.825
140	.889
200	.952
230	1.016
240	1.08

LEA Consulting Ltd.
Consulting Engineers and Planners
www.LEA.ca

No.	DATE	REVISIONS	INITIAL	SIGNED

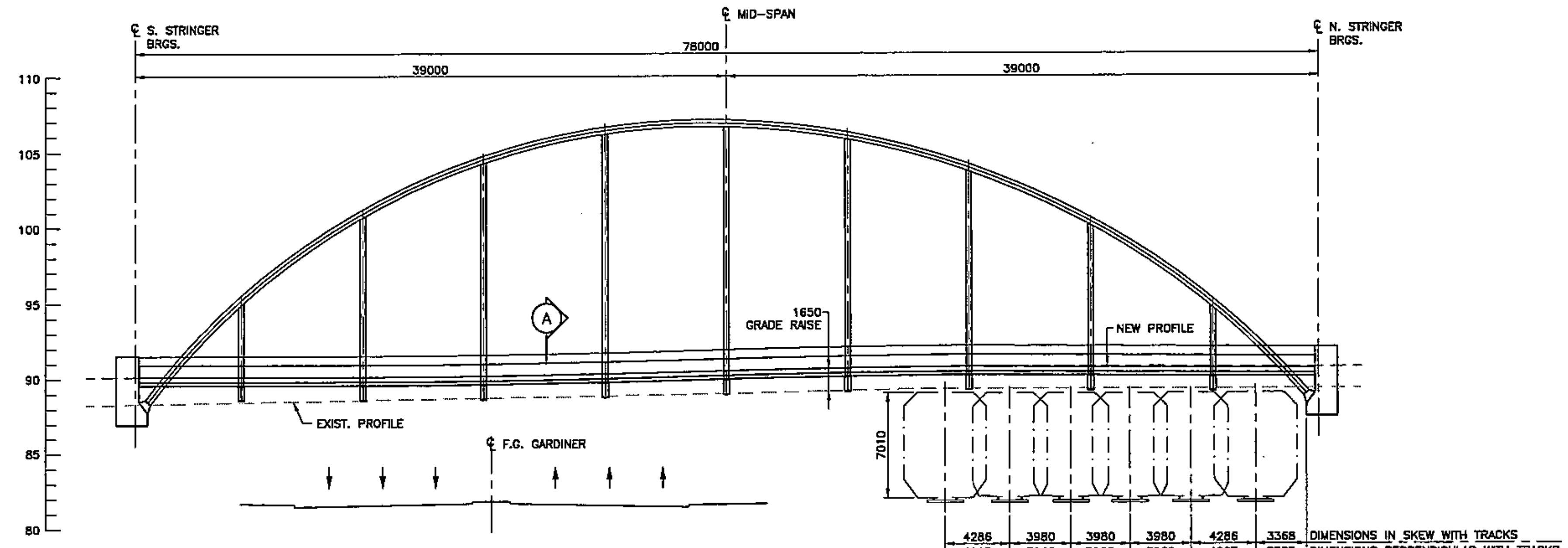
TORONTO

NEW DUFFERIN STREET BRIDGE

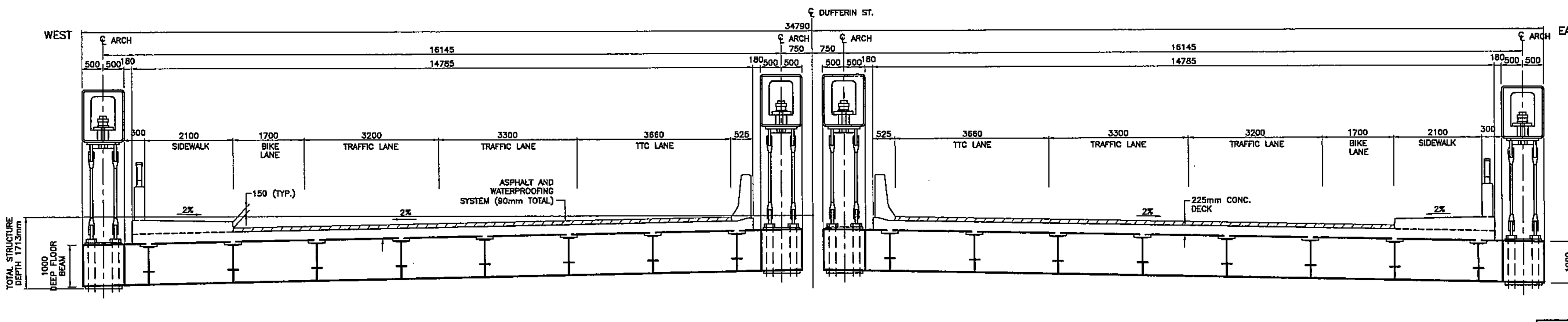
ENVIRONMENTAL ASSESSMENT STUDY
TORONTO ONTARIO

OPTION 1 - WELDED STEEL PLATE BOX GIRDER BRIDGE (7010mm CLEARANCE)

DESIGN:	PC	DRAFTING:	AA	CHECK:	RTK	CONTRACT No. -	
SCALE:	AS SHOWN			DRAWING NUMBER:	-		SHEET No. -
DATE:	FEBRUARY 2009						



ELEVATION
1:200



SECTION (A)
1:50

DRAFT

METRIC
ALL DIMENSIONS SHOWN HERE ARE IN MILLIMETRES UNLESS OTHERWISE NOTED

DRAWING NAME: F:\8645\Drafting\Structural\OPTIONS\OPTION-2.dwg
MODIFIED: Jan 31, 2011-4:47pm

PLOTTING INFO

COLOUR	WIDTH
30	.444
60	.762
120	.825
140	.889
200	.952
230	1.016
240	1.08

LEA Consulting Ltd.
Consulting Engineers and Planners
www.LEA.ca

No.	DATE	REVISIONS	INITIAL	SIGNED

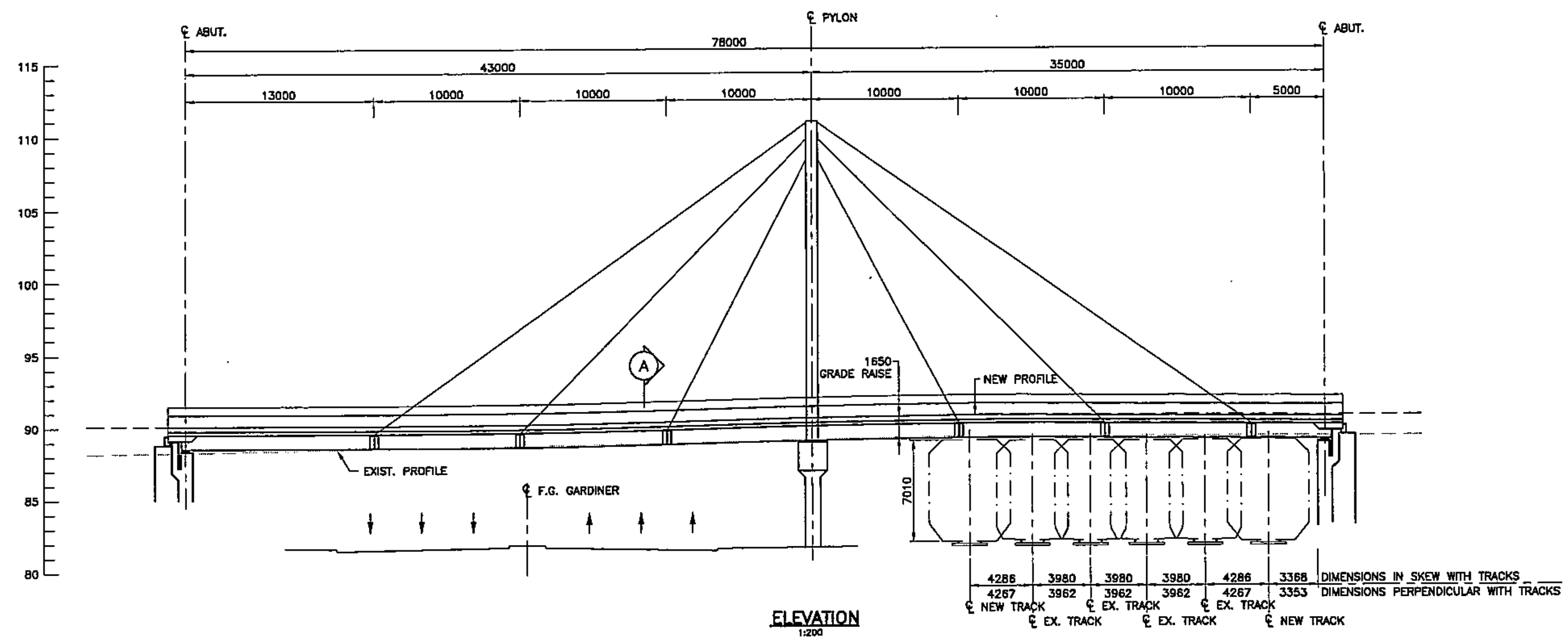
TORONTO

NEW DUFFERIN STREET BRIDGE

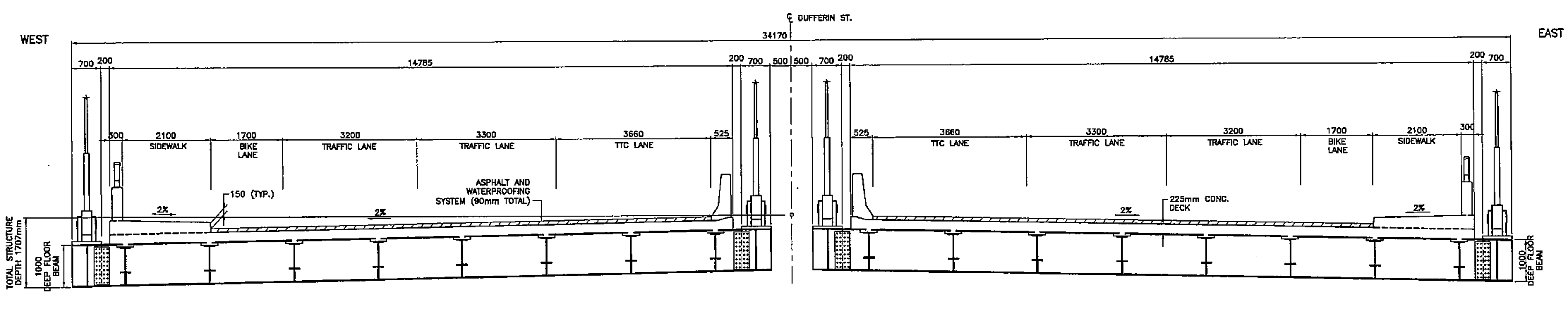
ENVIRONMENTAL ASSESSMENT STUDY
TORONTO ONTARIO

OPTION 2 - HUNG ARCH BRIDGE (7010mm CLEARANCE)

DESIGN:	PC	DRAFTING:	DT	CHECK:	RTK	CONTRACT No. -
SCALE:	AS SHOWN			DRAWING NUMBER:	-	SHEET No. -
DATE:	FEBRUARY 2009					



ELEVATION
1:200



SECTION (A)
1:50

DRAFT

METRIC
ALL DIMENSIONS SHOWN HERE ARE IN MILLIMETRES UNLESS OTHERWISE NOTED

DRAWING NAME: F:\8645\Drafting\Structural\OPTIONS\OPTION-3.dwg
MODIFIED: Jan 31, 2011-4:47pm

PLOTTING INFO	
COLOUR	WIDTH
30	.444
60	.762
120	.825
140	.889
200	.932
230	1.016
240	1.08

LEA Consulting Ltd.
Consulting Engineers and Planners
www.LEA.ca

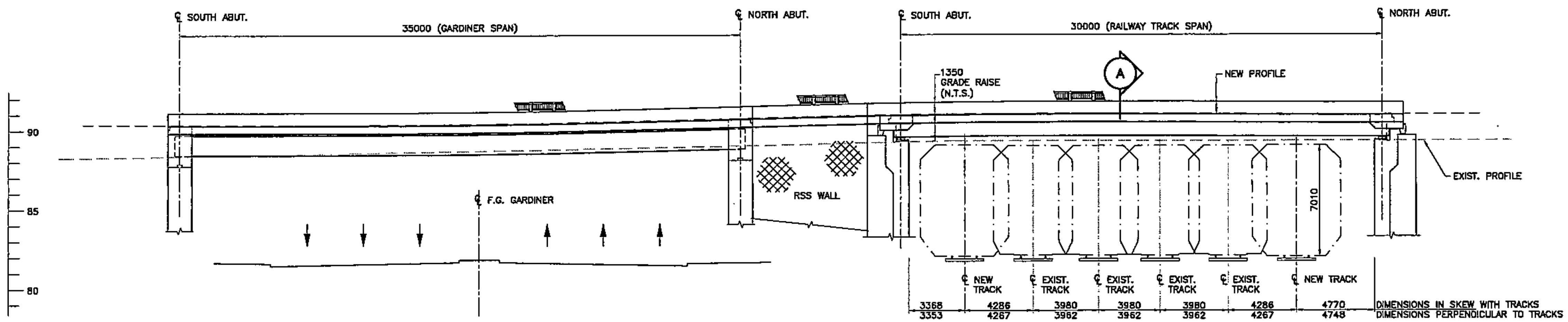
No.	DATE	REVISIONS	INITIAL	SIGNED

TORONTO

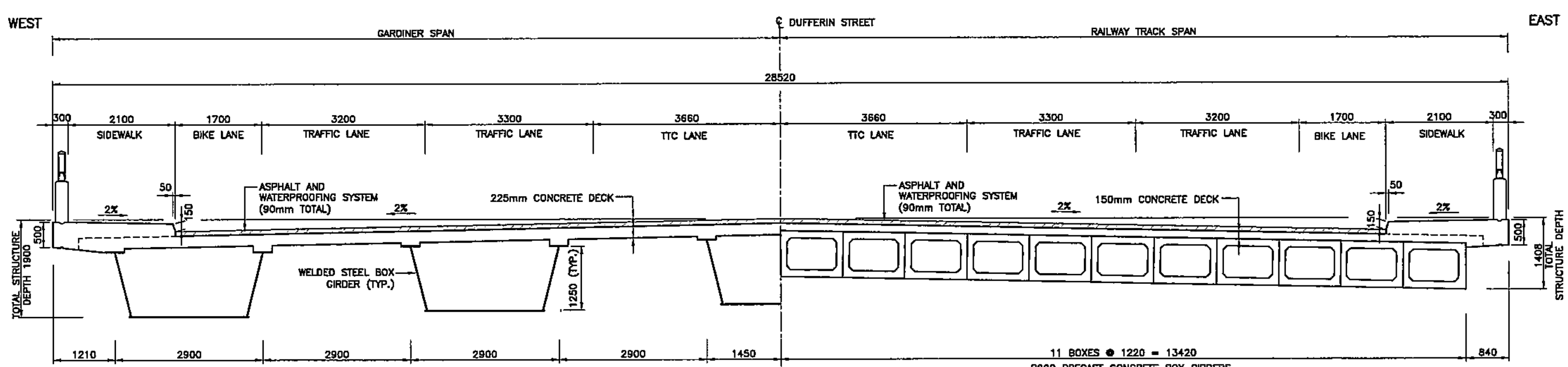
NEW DUFFERIN STREET BRIDGE
ENVIRONMENTAL ASSESSMENT STUDY
TORONTO ONTARIO

OPTION 3 - CABLE STAYED BRIDGE (7010mm CLEARANCE)

DESIGN:	PC	DRAFTING:	DT	CHECK:	RTK	CONTRACT No. -
SCALE:	AS SHOWN			DRAWING NUMBER:	-	SHEET No. -
DATE:	FEBRUARY 2009					



ELEVATION
1:150



SECTION (A)
1:50

DRAFT

METRIC
ALL DIMENSIONS SHOWN HERE ARE IN MILLIMETRES UNLESS OTHERWISE NOTED

DRAWING NAME: F:\8645\Drafting\Structural\OPTIONS\OPTION-4.dwg
MODIFIED: Jan 31, 2011-4:48pm

PLOTTING INFO

COLOUR	WIDTH
30	.444
60	.762
120	.825
140	.889
200	.952
230	1.016
240	1.08

LEA Consulting Ltd.
Consulting Engineers and Planners
www.LEA.ca

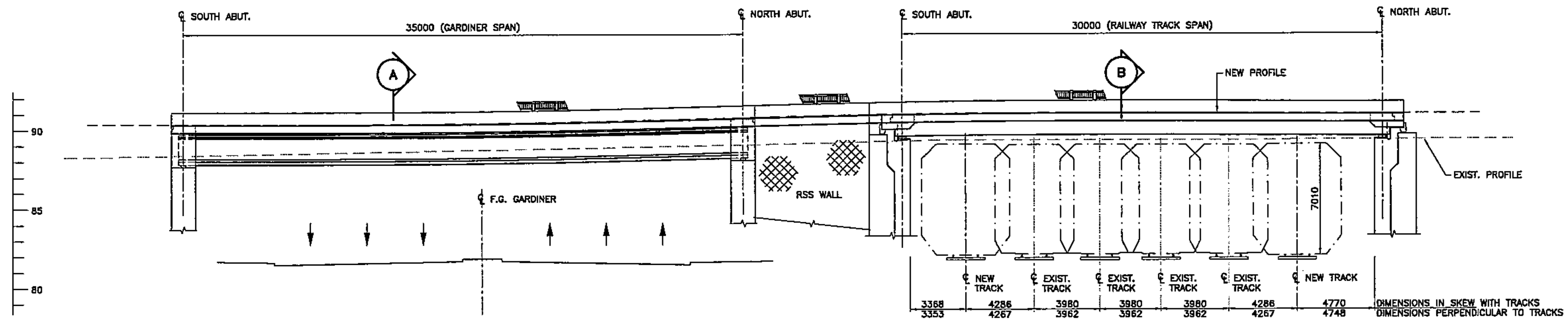
No.	DATE	REVISIONS	INITIAL	SIGNED

TORONTO

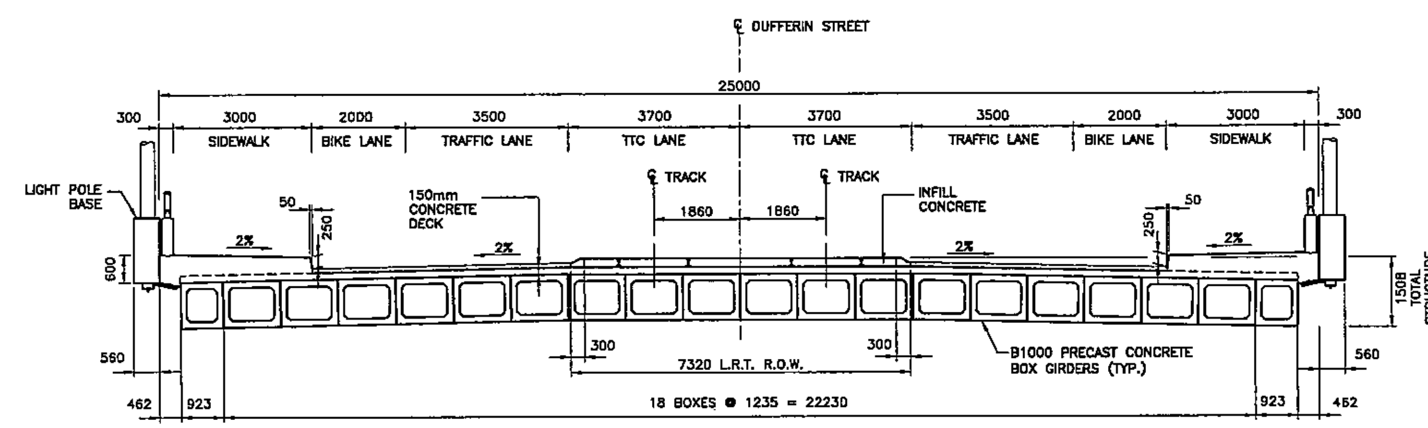
NEW DUFFERIN STREET BRIDGE

ENVIRONMENTAL ASSESSMENT STUDY
TORONTO ONTARIO
OPTION 4 (7010mm CLEARANCE)

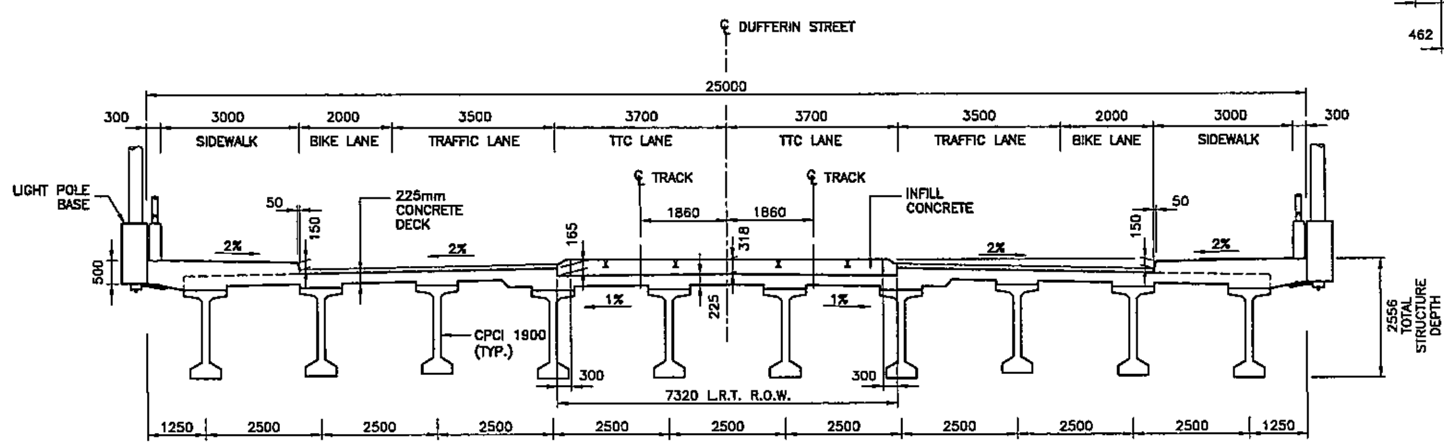
DESIGN:	PC	DRAFTING:	AA	CHECK:	RTK	CONTRACT No. -
SCALE:	AS SHOWN	DRAWING NUMBER:	-		SHEET No. -	
DATE:	FEBRUARY 2009					



ELEVATION
1:150



SECTION B
1:75



SECTION A
1:75

DRAFT

METRIC
ALL DIMENSIONS SHOWN HERE ARE IN MILLIMETRES UNLESS OTHERWISE NOTED

DRAWING NAME: F:\8545\Drafting\Structural\OPTIONS\25m Bridge Options-Elev.dwg
MODIFIED: Feb 01, 2011-10:03am

PLOTTING INFO

COLOUR	WIDTH
30	.444
60	.762
120	.825
140	.889
200	.952
230	1.016
240	1.08

LEA Consulting Ltd.
Consulting Engineers and Planners
www.LEA.ca

No.	DATE	REVISIONS	INITIAL	SIGNED

TORONTO

NEW DUFFERIN STREET BRIDGE
ENVIRONMENTAL ASSESSMENT STUDY
TORONTO ONTARIO
25m BRIDGE WITH EXCLUSIVE TRANSIT LANES

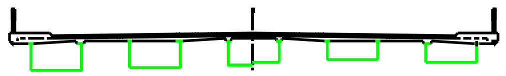
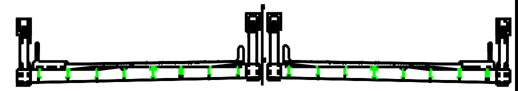
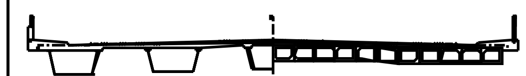
DESIGN:	PC	DRAFTING:	AA	CHECK:	RTK	CONTRACT No. -
SCALE:	AS SHOWN			DRAWING NUMBER:	-	SHEET No. -
DATE:	NOVEMBER 2010					

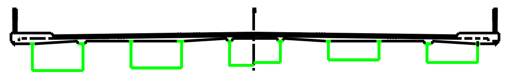
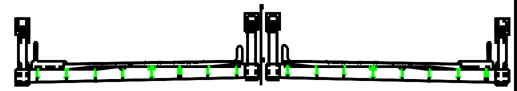
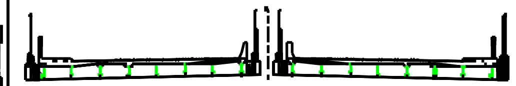
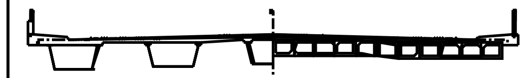
APPENDIX B

Evaluation Matrix Summary

DUFFERIN STREET EA
CITY OF TORONTO

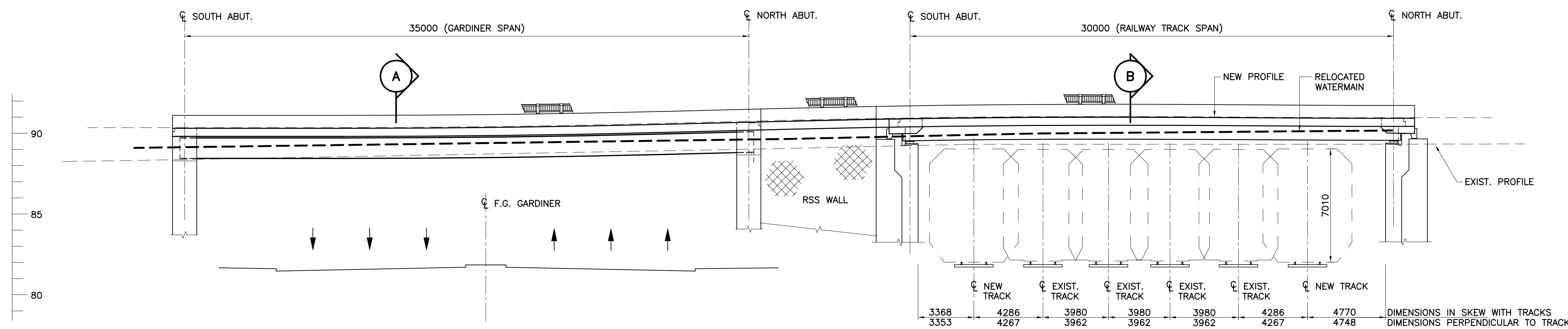
EVALUATION OF BRIDGE OPTIONS

OPTION / FACTORS	OPTION 1 STEEL PLATE BOX GIRDER 	OPTION 2 HUNG ARCH 	OPTION 3 CABLE STAYED 	OPTION 4 	OPTION 5 TRACK LOWERING
Roadway Geometrics					
Design Speed	50 km/hr	50 km/hr	50 km/hr	50 km/hr	50 km/hr
Cross Fall	2.0%	2.0%	2.0%	2.0%	2.0%
STRUCTURAL ENGINEERING					
SPAN CONFIGURATION & SUPERSTRUCTURE TYPE	• 2-span (45m south span, 30m north span) welded steel plate box girder with 225mm concrete deck; 75m total length • Superstructure depth: 1500mm (south span), 1000 to 1500mm (north span) • Single structure, overall cross sectional width 28.52m	• 1-span 78m hung arch bridge with 225mm concrete deck • Superstructure depth: 1000mm • Twin structure side-by-side, overall cross sectional width 34.79m	• 1-span 78m cable stayed bridge with 225mm concrete deck • Superstructure depth: 1000mm • Twin structure side-by-side, overall cross sectional width 34.17m	• Dufferin Street overhead at CNR will be replaced by a 1-span 30m concrete B900 box girder with 150mm concrete deck; superstructure depth of 900mm • Dufferin underpass over F.G. Gardiner will be replaced by a 1-span 35m welded steel plate box girder with 225mm concrete deck; superstructure depth of 1250mm • Single structure, overall cross sectional width 28.52m	• Dufferin Street overhead at CNR will be replaced by a 1-span 30m concrete B900 box girder with 150mm concrete deck; superstructure depth of 900mm • Dufferin underpass over F.G. Gardiner will be rehabilitated • Single structure, overall cross sectional width remains as existing
SUBSTRUCTURE	• Semi-integral abutments; spread footing founded on bedrock • Conventional pier cap beam on 3 columns; spread footing founded on bedrock • Skewed abutments and pier	• Abutments anchor onto the underlying bedrock • Abutments squared to bridge	• Abutments anchor onto the underlying bedrock • Abutments squared to bridge	• Semi-integral abutments; spread footing founded on bedrock • Skewed abutments • Retained soil system (RSS), 10m long in between the two bridge structures • Sleeper slab system requires at end of approaches in between the two bridge structures	• Semi-integral abutments; spread footing founded on bedrock • Skewed abutments
CONSTRUCTIBILITY & ACCESS	• Dufferin Street will be closed for construction. Traffic to be detoured during construction • Minimum grade raise: 1860mm	• Dufferin Street will be closed for construction. Traffic to be detoured during construction • Minimum grade raise: 1650mm	• Dufferin Street will be closed for construction. Traffic to be detoured during construction • Minimum grade raise: 1650mm	• Dufferin Street will be closed for construction. Traffic to be detoured during construction • Minimum grade raise: 1350mm	• Dufferin Street will be closed for construction. Traffic to be detoured during construction • Grade raise not required
AESTHETICS	Slenderness – Span to depth ratio of 30; semi-integral abutments maintain continuity of span at abutments Cantilevers – 1.21 m cantilevers with straight box girder side does not provide shadow effect to enhance superstructure slenderness Continuity of Horiz. Lines – Haunched parabolic girder provide smooth continuity between north and south spans Discoloration – Discoloration of ACR steel	Slenderness – Span to depth ratio of 78 Cantilevers – 1.57 m cantilevers Continuity of Horiz. Lines – No change in bridge sectional depths throughout entire length of bridge Discoloration – Discoloration of ACR steel contrasts with concrete deck Skew – No skew Reveals – Open steel railing enhances superstructure slenderness	Slenderness – Span to depth ratio of 78 Cantilevers – No cantilevers Continuity of Horiz. Lines – No change in bridge sectional depths throughout entire length of bridge Discoloration – Discoloration of ACR steel contrasts with concrete deck Skew – No skew Reveals – Open steel railing enhances superstructure slenderness	Slenderness – Span to depth ratio of 30; semi-integral abutments maintain continuity of span at abutments Cantilevers – 1.21 m cantilevers for south span with 4:1 deck side slopes provides shadow effect to enhance superstructure slenderness Continuity of Horiz. Lines – No change in bridge sectional depths throughout entire length of bridge in either structures Discoloration – Uniform construction	Slenderness – Span to depth ratio of 33; semi-integral abutments maintain continuity of span at abutments Cantilevers – Cantilevers with shallow B900 superstructure provide shadow effect to enhance superstructure slenderness Continuity of Horiz. Lines – No change in bridge sectional depths throughout entire length of bridge Discoloration – Uniform construction appearance Skew – Minor skew, no effect

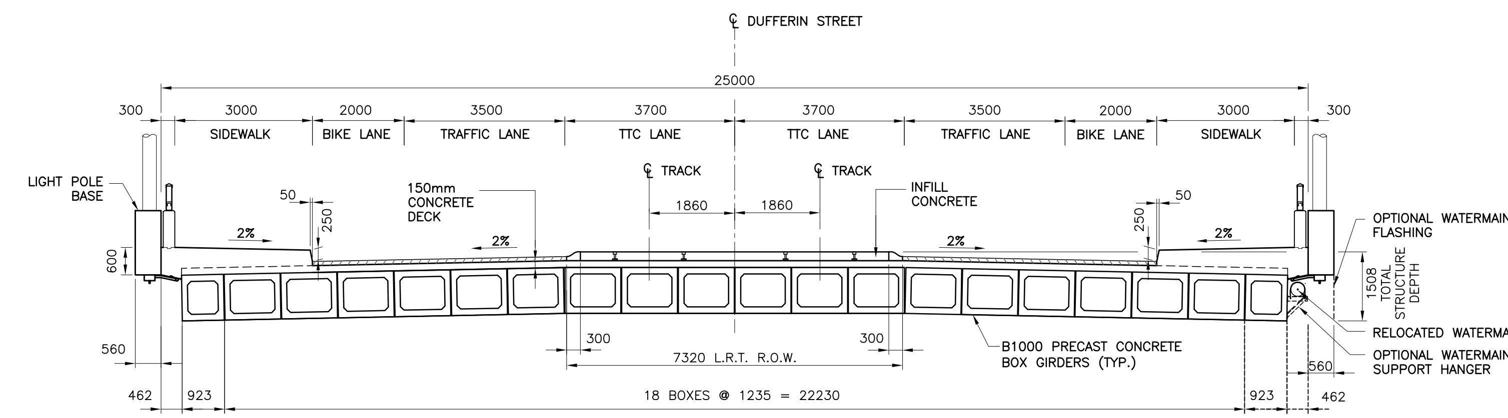
OPTION / FACTORS	OPTION 1 STEEL PLATE BOX GIRDER 	OPTION 2 HUNG ARCH 	OPTION 3 CABLE STAYED 	OPTION 4 	OPTION 5 TRACK LOWERING
	contrasts with concrete deck Skew – Minor skew, no effect Reveals – Open steel railing enhances superstructure slenderness			appearance on the north span, discoloration of ACR steel contrasts with concrete deck on south span Skew – Minor skew, no effect Reveals – Open steel railing enhances superstructure slenderness	Reveals – Open steel railing enhances superstructure slenderness
LONG-TERM PERFORMANCE	• Corrosion in structural steel box girder will be minimized with no direct exposure to de-icing salts and other chemicals and contaminants • Inspection inside the boxes will be restricted	• Bottom flanges of stringers and floor beams encourage bird roosting and collect deleterious materials • The structural arches expose to environment will be subjected to deteriorations	• Bottom flanges of stringers, floor beams and exterior supporting longitudinal girder encourage bird roosting and collect deleterious materials	• Corrosion in structural steel box girder will be minimized with no direct exposure to de-icing salts and other chemicals and contaminants	
SUMMARY COMMENTS	Option requires the greatest overall superstructure depth and grade raise.	Intermediate grade raise governs by the required transverse floor beam depth.	Intermediate grade raise governs by the required transverse floor beam depth.	Option requires the least overall superstructure depth and grade raise over the railway span.	Grade raise is not required by lowering the existing railway tracks.

APPENDIX C

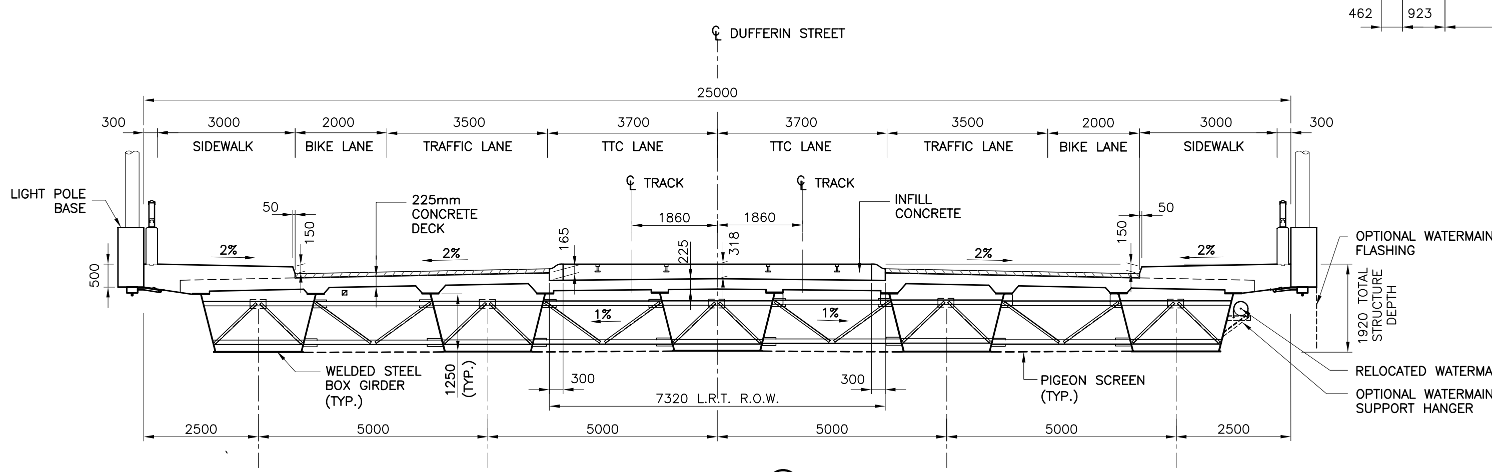
Proposed Bridge Option and Cost Estimates



ELEVATION
1:150



SECTION (B)
1:75



SECTION (A)
1:75

DRAFT

METRIC
ALL DIMENSIONS SHOWN HERE ARE IN MILLIMETRES UNLESS OTHERWISE NOTED

DRAWING NAME: F:\8645\Drafting\Structural\OPTIONS\25m Bridge Options (Box&steel)-Elev.dwg
MODIFIED: Apr 06, 2011-3:36pm

PLOTTING INFO

COLOUR	WIDTH
30	.444
60	.762
120	.825
140	.889
200	.952
230	1.016
240	1.08

LEA Consulting Ltd.
Consulting Engineers and Planners
www.LEA.ca

No.	DATE	REVISIONS	INITIAL	SIGNED

TORONTO

NEW DUFFERIN STREET BRIDGE
ENVIRONMENTAL ASSESSMENT STUDY
TORONTO ONTARIO

25m BRIDGE WITH EXCLUSIVE TRANSIT LANES

DESIGN:	PC	DRAFTING:	AA	CHECK:	RTK	CONTRACT No. -
SCALE:	AS SHOWN			DRAWING NUMBER:	-	SHEET No. -
DATE:	NOVEMBER 2010					

DUFFERIN BRIDGE EA STUDY

DUFFERIN BRIDGE OVER C.N.R. (25m Overall Bridge Deck Width) **Width: 25**
1-Span (30m Railway Span) Prestressed B1000 Box Girder **Length: 30**

Item	L	W	H	No.	Other	Units	Q	Unit Cost	Cost
Track Protection	45.0		5.0	2		m^2	450.0	2,000	900,000
Roadway Protection	50.0		14.0	1		m^2	700.0	800	560,000
Removal of Bridge Structure				1		LS	1.0	250,000	250,000
CN Flagging				1		LS	1.0	250,000	250,000
Earth Excavation for Structure	4.0	26.0	4.4	2		m^3	915.2	70	64,064
Granular 'A'	4.0	26.0	2.0	2		m^3	416.0	80	33,280
Concrete in Abutment Footings	4.0	26.0	1.5	2		m^3	312.0	1,400	436,800
Abutment Footing Reinf. (110kg/m^3)					0.110	t	34.3	3,500	120,120
Concrete in Abut. Walls and Cleats	1.2	25.0	6.2	2		m^3	372.0	1,700	632,400
Abut. Wall Reinf. (110kg/m^3)					0.110	t	40.9	3,500	143,220
Concrete in Wingwalls	4.2	0.3	2.6	4		m^3	13.1	1,700	22,277
WIngwall Reinf. (85kg/m^3)					0.085	t	1.1	3,500	3,898
Concrete in Deck	32.4	25	0.15	1		m^3	121.5	1,800	218,700
Deck Reinf. (150kg/m^3)					0.150	t	18.2	3,500	63,788
Concrete in Sidewalk	38.4	3.3	0.41	2		m^3	103.9	1,800	187,039
Sidewalk Reinf. (85kg/m^3)					0.085	t	8.8	3,500	30,913
Concrete in Approach Slabs	6.0	24.4	0.25	1		m^3	36.6	1,500	54,900
App. Slab Reinf. (90kg/m^3)					0.090	t	3.3	3,500	11,529
Concrete in Parapet Walls	38.4	0.25	0.825	2		m^3	15.8	2,000	31,680
Parapet Reinf. (S.S.) (110kg/m^3)					0.110	t	1.7	15,000	26,136
Parapet Wall Railing	38.4			2		m	76.8	175	13,440
Fabrication, B900 Box Girders				20	30.6	m	612.0	800	489,600
Delivery, B900 Box Girders				20	30.6	m	612.0	250	153,000
Erection, B900 Box Girders				20	30.6	m	612.0	300	183,600
Bridge Deck Waterproofing	38.4	18.4		1		m^2	706.6	60	42,394
Bearings-Elastomeric				42		Ea	42.0	300	12,600
Sub-Total									**4,935,377**
20% Contingency									987,075
TOTAL									**5,922,453**
Deck Area	32.40	25.00				m^2	810		
Cost per Sq. m of Deck (\$/m^2)									**7,312**
Cost per m of Deck (\$/m)									**182,792**

DUFFERIN BRIDGE EA STUDY

RSS WALL BETWEEN DUFFERIN STREET BRIDGES OVER C.N.R. & GARDINER (25m OVERALL BRIDGE WIDTH)

7.6m Total Length

Item	L	W	H	No.	Other	Units	Q	Unit Cost	Cost
Roadway Protection	7.6		3.0	2		m^2	45.6	800	36,480
Earth Excavation for Structure	7.6	1.5	6.0	2		m^3	136.8	70	9,576
Granular 'A'	7.6	0.9	1.0	2		m^3	13.7	200	2,736
RSS Walls	7.6		7.5	2		m^2	114.0	800	91,200
Concrete in Footings	7.6	0.8	0.6	2		m^3	7.3	1,400	10,214
Concrete in Copings	7.6	0.6	0.7	2		m^3	6.4	700	4,469
Concrete in Sidewalk	7.6	3.3	0.41	2		m^3	20.6	1,800	37,018
Sidewalk Reinf. (Coated) (85kg/m^3)					0.085	t	1.7	4,000	6,992
Concrete in Slab	7.6	25	0.25	1		m^3	47.5	1,500	71,250
Slab Reinf. (90kg/m^3)					0.090	t	4.3	3,500	14,963
Concrete in Parapet Walls	7.6	0.25	0.825	2		m^3	3.1	2,000	6,270
Parapet Reinf. (S.S.) (110kg/m^3)					0.110	t	0.3	15,000	5,173
Parapet Wall Railing	7.6			2		m	15.2	175	2,660
Bridge Deck Waterproofing	7.6	18.4		1		m^2	139.8	60	8,390
Sub-Total									**307,391**
20% Contingency									61,478
TOTAL									**368,869**
Deck Area	7.60	25.00				m^2	190		
Cost per Sq. m of Deck (\$/m^2)									**1,941**
Cost per m of Deck (\$/m)									**48,535**

DUFFERIN BRIDGE EA STUDY

DUFFERIN BRIDGE OVER GARDINER (25m Overall Bridge Deck Width) **Width: 25**
1-Span (35m Gardiner Span) Welded Steel Plate Box Girder **Length: 35**

Item	L	W	H	No.	Other	Units	Q	Unit Cost	Cost
Roadway Protection	50.0		14.0	1		m^2	700.0	800	560,000
Removal of Bridge Structure				1		LS	1.0	250,000	250,000
Earth Excavation for Structure	4.0	26.0	4.4	2		m^3	915.2	70	64,064
Granular 'A'	4.0	26.0	2.0	2		m^3	416.0	80	33,280
Concrete in Abutment Footings	4.0	26.0	1.5	2		m^3	312.0	1,400	436,800
Abutment Footing Reinf. (110kg/m^3)					0.110	t	34.3	3,500	120,120
Concrete in Abut. Walls and Cleats	1.2	25.0	6.2	2		m^3	372.0	1,700	632,400
Abut. Wall Reinf. (110kg/m^3)					0.110	t	40.9	3,500	143,220
Concrete in Wingwalls	4.2	0.3	2.6	4		m^3	13.1	1,700	22,277
WIngwall Reinf. (85kg/m^3)					0.085	t	1.1	3,500	3,898
Concrete in Deck	37.4	25	0.225	1		m^3	210.4	1,800	378,675
Deck Reinf. (150kg/m^3)					0.150	t	31.6	3,500	110,447
Concrete in Sidewalk	43.4	3.3	0.31	2		m^3	88.8	1,800	159,834
Sidewalk Reinf. (85kg/m^3)					0.085	t	7.5	3,500	26,417
Concrete in Approach Slabs	6.0	24.4	0.25	1		m^3	36.6	1,500	54,900
App. Slab Reinf. (90kg/m^3)					0.090	t	3.3	3,500	11,529
Concrete in Parapet Walls	43.4	0.25	0.825	2		m^3	17.9	2,000	35,805
Parapet Reinf. (S.S.) (110kg/m^3)					0.110	t	2.0	15,000	29,539
Parapet Wall Railing	43.4			2		m	86.8	175	15,190
Fabrication of Structural Steel					150.0	t	150.0	4,000	600,000
Delivery of Structural Steel					150.0	t	150.0	100	15,000
Erection of Structural Steel					150.0	t	150.0	1,200	180,000
Bridge Deck Waterproofing	43.4	18.4		1		m^2	798.6	60	47,914
Bearings-Elastomeric				20		Ea	20.0	500	10,000
Sub-Total									**3,941,308**
20% Contingency									788,262
TOTAL									**4,729,570**
Deck Area	37.40	25.00				m^2	935		
Cost per Sq. m of Deck (\$/m^2)									**5,058**
Cost per m of Deck (\$/m)									**126,459**