PRELIMINARY ONLY

DRAFT

ZONES:
RED ZONE - BANKFULL (3m)
ORANGE ZONE - MEANDER BELT
YELLOW ZONE - 30m EITHER SIDE OF THE MEANDER BELT

(19th CENTURY) HERITAGE REGISTER - CUL # 3269 / 3271

3365

3316

WAG - A - WAY XPRESS

19+000 19+100 19+200 19+300 19+400

CONCEPTUAL CHANNEL

LIMIT OF CONSTRUCTION

1.5m BIKE LANE WITH 0.3m BUFFER

PROPOSED REGION RIGHT-OF-WAY

TEMPORARY CONSTRUCTION EASEMENT

EXISTING SIGNALIZED INTERSECTION

WB ZENON STATION

EB ZENON STATION

ZENON DRIVE

COLONEL WILLIAM PKWY

RAISED MEDIAN WITH LANDSCAPE

PASSENGER PLATFORM

BUS BAY

R=3200m

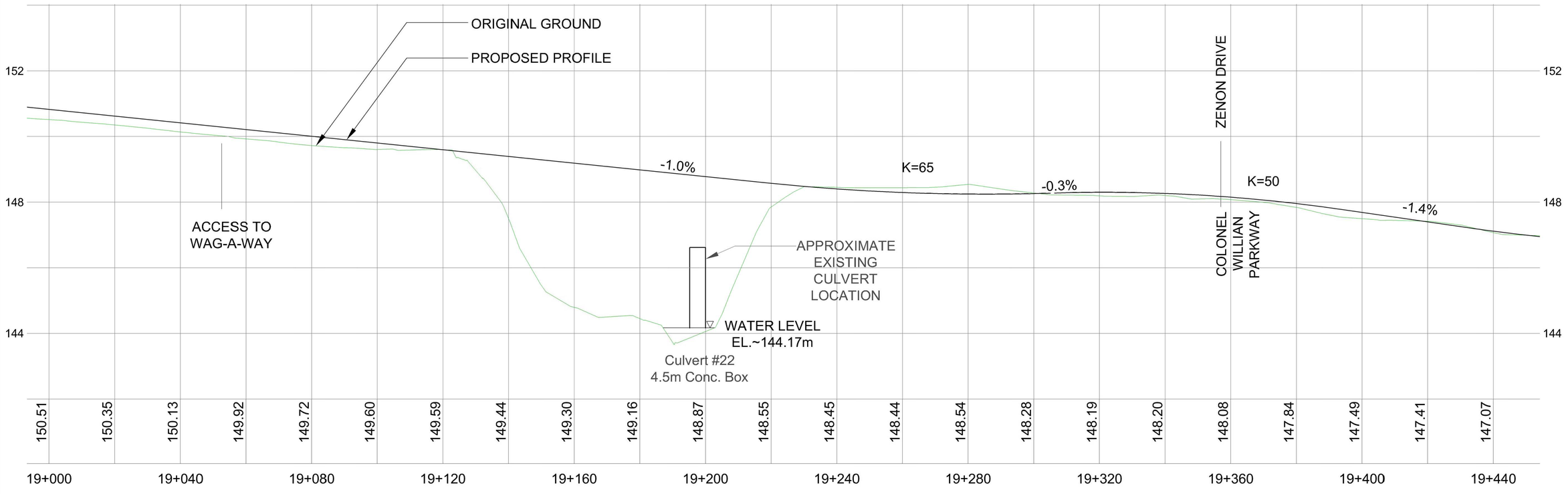
600mm ø CSP

EXISTING PROPERTY LINE

PROPOSED REGION RIGHT-OF-WAY

FOURTEEN MILE CREEK

TEMPORARY CONSTRUCTION EASEMENT



MMM GROUP

HALTON REGION
DUNDAS STREET (REGIONAL ROAD No.5) CLASS EA STUDY
BRANT STREET TO BRONTE ROAD

CULVERT # 22
PLAN AND PROFILE - ALTERNATIVE 1
EXISTING CULVERT EXTENSION

LEGEND:
EXISTING PROPERTY LINE
PROPOSED REGION RIGHT-OF-WAY
TEMPORARY CONSTRUCTION EASEMENT

2.5 0 10
SCALE 1:500

FEBRUARY 3, 2015

PRELIMINARY ONLY

DRAFT

ZONES:
- RED ZONE - BANKFULL (3m)
- ORANGE ZONE - MEANDER BELT
- YELLOW ZONE - 30m EITHER SIDE OF THE MEANDER BELT

(19th CENTURY) HERITAGE REGISTER - CU
3269 / 3271

3365

3316

WAG – A – WAY XPRESS

19+000 19+100 19+200 19+300 19+400

EXISTING PROPERTY LINE

RAISED MEDIAN WITH LANDSCAPE

CONCEPTUAL CHANNEL

1.5m BIKE LANE WITH 0.3m BUFFER

PROPOSED REGION RIGHT-OF-WAY

TEMPORARY CONSTRUCTION EASEMENT

EXISTING SIGNALIZED INTERSECTION

WB ZENON STATION

EB ZENON STATION

ZENON DRIVE

COLONEL WILLIAM PKWY

FOURTEEN MILE CREEK

PASSENGER PLATFORM

BUS BAY

R=3200m

600mm ø CSP

ORIGINAL GROUND

PROPOSED PROFILE

-1.0% K=65 -0.3% K=50 -1.4%

2.5m

ACCESS TO WAG-A-WAY

WATER LEVEL EL.~144.17m

Culvert #22
4.5m Conc. Box

152 148 144

150.51 150.35 150.13 149.92 149.72 149.60 149.59 149.44 149.30 149.16 148.87 148.55 148.45 148.44 148.54 148.28 148.19 148.20 148.08 147.84 147.49 147.41 147.07

19+000 19+040 19+080 19+120 19+160 19+200 19+240 19+280 19+320 19+360 19+400 19+440

MMM GROUP

HALTON REGION
DUNDAS STREET (REGIONAL ROAD No.5) CLASS EA STUDY
BRANT STREET TO BRONTE ROAD

CULVERT # 22
PLAN AND PROFILE - ALTERNATIVE 2 (9m SPAN)

LEGEND:
EXISTING PROPERTY LINE
TEMPORARY CONSTRUCTION EASEMENT
PROPOSED REGION RIGHT-OF-WAY

2.5 0 10
SCALE 1:500

FEBRUARY 3, 2015

PRELIMINARY ONLY

DRAFT

PROPOSED WORKS START AT UPSTREAM EXTENT AT CONCRETE CHANNEL AND TIE INTO THE MORE NATURAL UPSTREAM REACH

SCOUR AT UPSTREAM EXTENTS OF CONCRETE WALL TO BE RESTORED

CONCRETE BED AND BANKS TO BE REPLACED WITH NATURAL CHANNEL DESIGN. USE OF RIVER STONE WOULD BE REQUIRED DUE TO EXISTING GROUND AND ANTICIPATED VELOCITIES. DESIGN TO INCLUDE ASYMMETRICAL CROSS SECTION WITH AN AVERAGE BANKFULL WIDTH OF 3.0m

RIPARIAN PLANTING

EXISTING PROPERTY LINE

RAISED MEDIAN WITH LANDSCAPE

19+000

19+100

19+200

19+300

3365

(19th CENTURY) HERITAGE REGISTER # 3269 / 3271

APPROXIMATE TOE OF SLOPE

CONCEPTUAL CHANNEL DESIGN

CONCEPTUAL CHANNEL CENTRE

LIMIT OF CONSTRUCTION

1.5m BIKE LANE WITH 0.3m BUFFER

PROPOSED REGION RIGHT-OF-WAY

TEMPORARY CONSTRUCTION EASEMENT

EXISTING SIGNALIZED INTERSECTION

WB ZENON STATION

ZENON DRIVE

PASSENGER PLATFORM

BUS BAY

R=3200m

ZONES:
RED ZONE - BANKFULL (3m)
ORANGE ZONE - MEANDER BELT
YELLOW ZONE - 30m EITHER SIDE OF THE MEANDER BELT

IN STRUCTURE DETAIL

20m STRUCTURE

3.0m BANKFULL WIDTH

ROUNDED RIVER STONE RANGING IN SIZE TO BE STABLE AT 100 YR FLOWS. SHOULD BE WELL MIXED PRIOR TO PLACEMENT AND INCLUDE SAME NATIVE MATERIAL D_{50} AND GRADATION TO BE CONTINUE AT DETAILED DESIGN.

$2xD_{50}$ DEPTH

EXISTING PROPERTY LINE

PROPOSED REGION RIGHT-OF-WAY

3316

WAG-A-WAY XPRESS

FOURTEEN MILE CREEK

TIE IN TO EXISTING BANKS

PROPOSED BRIDGE WOULD INVOLVE REMAINING PERCHED CULVERT

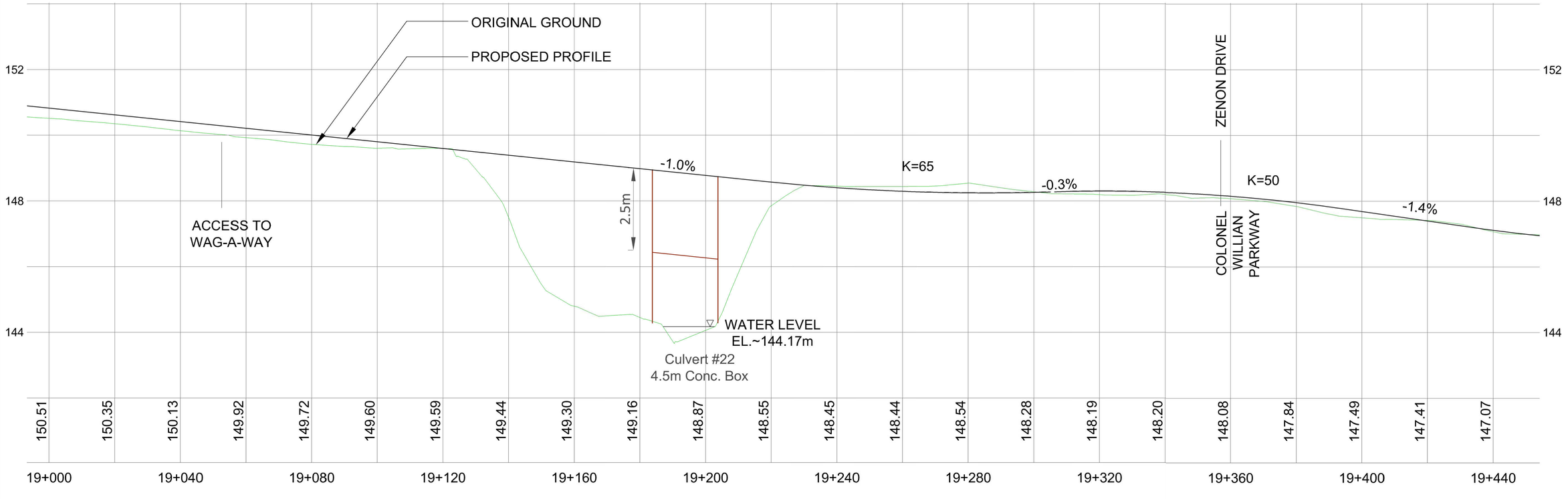
COLONEL WILLIAM PKWY

EB ZENON STATION

TEMPORARY CONSTRUCTION EASEMENT

OPTION 1
AIM: MAXIMIZE CHANNEL LENGTH TO REDUCE EROSION POTENTIAL
.
NOTES: -A STAGED CONSTRUCTION WOULD BE REQUIRED.
-RIVERSTONE WOULD BE USED WHERE CHANNEL COINCIDES WITH DISTURBED GROUND

OPTION 2
AIM: MAXIMIZE CHANNEL LENGTH AS FAR AS POSSIBLE WHILE NOT CROSSING EXISTING CHANNEL
NOTES: -RIVERSTONE WOULD LIKELY BE REQUIRED DUE TO ANTICIPATED VELOCITIES



MMM GROUP

HALTON REGION
DUNDAS STREET (REGIONAL ROAD No.5) CLASS EA STUDY
BRANT STREET TO BRONTE ROAD

CULVERT # 22
PLAN AND PROFILE - ALTERNATIVE 3 (20m SPAN)

LEGEND:
EXISTING PROPERTY LINE
TEMPORARY CONSTRUCTION EASMENT
PROPOSED REGION RIGHT-OF-WAY

2.5 0 10
SCALE 1:500

FEBRUARY 3, 2015

PRELIMINARY ONLY

DRAFT

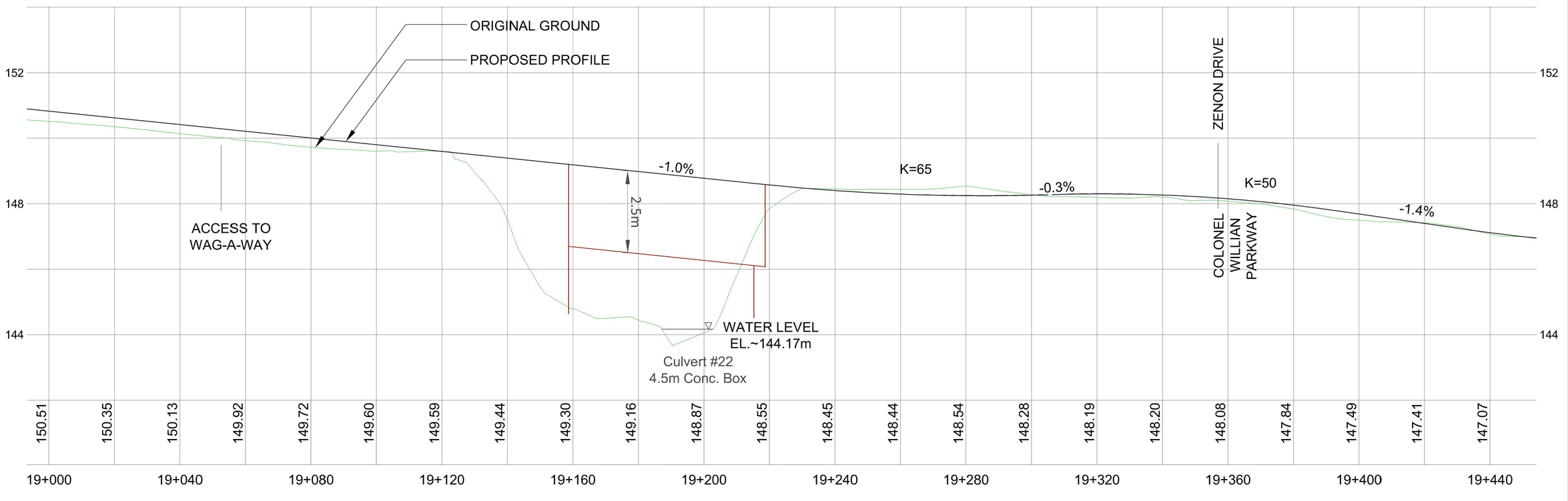
ZONES:
RED ZONE - BANKFULL (3m)
ORANGE ZONE - MEANDER BELT
YELLOW ZONE - 30m EITHER SIDE OF THE MEANDER BELT

IN STRUCTURE DETAIL
60m STRUCTURE
3.0m BANKFULL WIDTH
ROUNDED RIVER STONE RANGING IN SIZE TO BE STABLE AT 100 YR FLOWS. SHOULD BE WELL MIXED PRIOR TO PLACEMENT AND INCLUDE SAME NATIVE MATERIAL D_{50} AND GRADATION TO BE CONTINUE AT DETAILED DESIGN.
$2xD_{50}$ DEPTH

PROPOSED WORKS START AT UPSTREAM EXTENT AT CONCRETE CHANNEL AND TIE INTO THE MORE NATURAL UPSTREAM REACH
SCOUR AT UPSTREAM EXTENTS OF CONCRETE WALL TO BE RESTORED
CONCRETE BED AND BANKS TO BE REPLACED WITH NATURAL CHANNEL DESIGN. USE OF RIVER STONE WOULD BE REQUIRED DUE TO EXISTING GROUND AND ANTICIPATED VELOCITIES. DESIGN TO INCLUDE ASYMMETRICAL CROSS SECTION WITH AN AVERAGE BANKFULL WIDTH OF 3.0m
RIPARIAN PLANTING
EXISTING PROPERTY LINE
RAISED MEDIAN WITH LANDSCAPE
LIMIT OF CONSTRUCTION
1.5m BIKE LANE WITH 0.3m BUFFER
PROPOSED REGION RIGHT-OF-WAY
TEMPORARY CONSTRUCTION EASEMENT
CONCEPTUAL CHANNEL- OPTION 2
CONCEPTUAL CHANNEL- OPTION 1
EXISTING SIGNALIZED INTERSECTION
(19th CENTURY) HERITAGE REGISTER - CHs # 3269 / 3271
3365
3316
19+000
19+100
19+200
19+300
WB ZENON STATION
EB ZENON STATION
ZENON DRIVE
COLONEL WILLIAM PKWY
PASSENGER PLATFORM
BUS BAY
R=3200m
600mm ø CSP
WAG-A-WAY XPRESS
FOURTEEN MILE CREEK
TIE IN TO EXISTING BANKS
PROPOSED BRIDGE WOULD INVOLVE REMAINING PERCHED CULVERT
TEMPORARY CONSTRUCTION EASEMENT

OPTION 1
AIM: MAXIMIZE CHANNEL LENGTH TO REDUCE EROSION POTENTIAL
NOTES: -A STAGED CONSTRUCTION WOULD BE REQUIRED.
-RIVERSTONE WOULD BE USED WHERE CHANNEL COINCIDES WITH DISTURBED GROUND

OPTION 2
AIM: MAXIMIZE CHANNEL LENGTH AS FAR AS POSSIBLE WHILE NOT CROSSING EXISTING CHANNEL
NOTES: -RIVERSTONE WOULD LIKELY BE REQUIRED DUE TO ANTICIPATED VELOCITIES



MMM GROUP

HALTON REGION
DUNDAS STREET (REGIONAL ROAD No.5) CLASS EA STUDY
BRANT STREET TO BRONTE ROAD

CULVERT # 22
PLAN AND PROFILE - ALTERNATIVE 4 (60m SPAN)

LEGEND:
EXISTING PROPERTY LINE
TEMPORARY CONSTRUCTION EASEMENT
PROPOSED REGION RIGHT-OF-WAY

2.5 0 10
SCALE 1:500

FEBRUARY 3, 2015

PRELIMINARY ONLY

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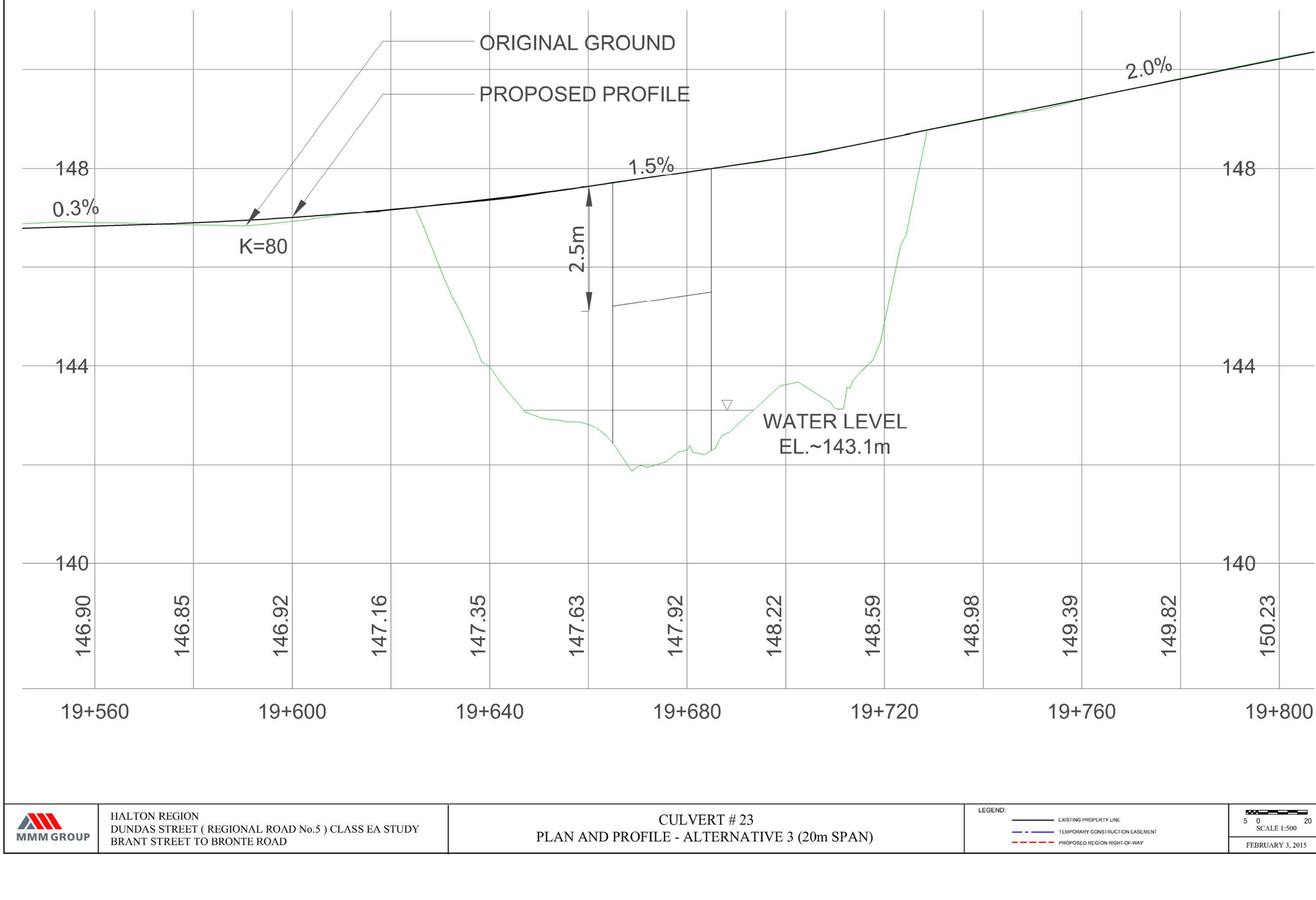
DRAFT

ZONES:
- RED ZONE - BANKFULL (1.6m)
- ORANGE ZONE - MEANDER BELT
- YELLOW ZONE - 30m EITHER SIDE OF THE MEANDER BELT

3185
NE NEW ELECTRIC
3175
FORESTVIEW BIBLE CHURCH
19+600
19+700
19+800
EXISTING PROPERTY LINE
PROPOSED REGION RIGHT-OF-WAY
TEMPORARY CONSTRUCTION EASEMENT
CONCEPTUAL CHANNEL
3.0m MULTI-USE PATH
1.5m BIKE LANE WITH 0.3m BUFFER
Metal Post with Light
ASPHALT
5.6m WIDE CONC. BOX CULVERT
500mm CSP
400mm CSP GRAVEL
BMH
NOTE: MOUNTABLE CURB FOR EMERGENCY VEHICLES
CURB
RAISED MEDIAN WITH LANDSCAPE
PROPERTY LINE
PROPOSED SIX STOREY RETIREMENT RESIDENCE 3136 DUNDAS ST WEST
3114
SURFACE PARKING 33 CARS



MMM GROUP

HALTON REGION
DUNDAS STREET (REGIONAL ROAD No.5) CLASS EA STUDY
BRANT STREET TO BRONTE ROAD

CULVERT # 23
PLAN AND PROFILE - ALTERNATIVE 3 (20m SPAN)

LEGEND:
- EXISTING PROPERTY LINE
- TEMPORARY CONSTRUCTION EASEMENT
- PROPOSED REGION RIGHT-OF-WAY

5 0 20
SCALE 1:500

FEBRUARY 3, 2015

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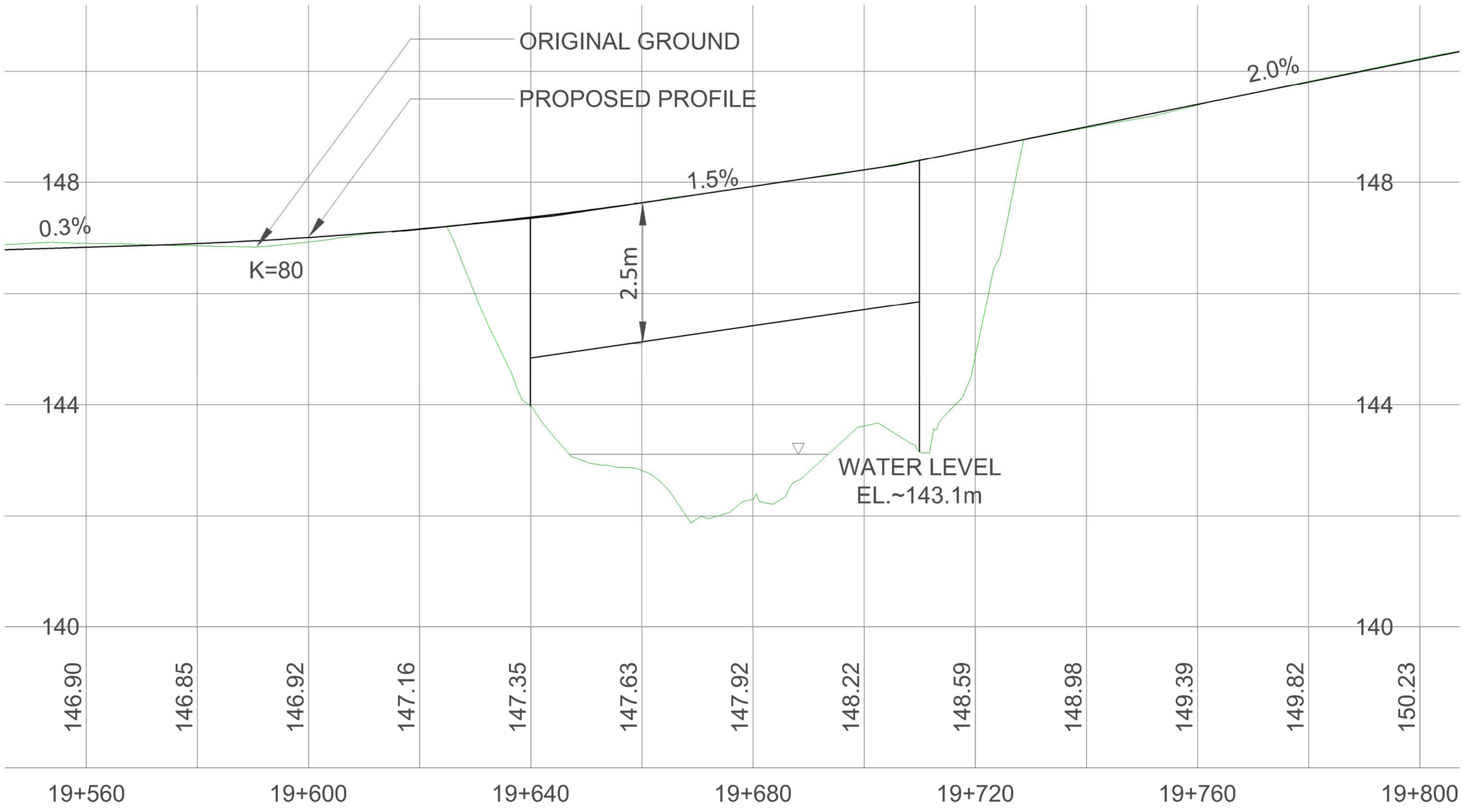
DRAFT

ZONES:
- RED ZONE - BANKFULL (1.6m)
- ORANGE ZONE - MEANDER BELT
- YELLOW ZONE - 30m EITHER SIDE OF THE MEANDER BELT

3185
NE NEW ELECTRIC
3175
FORESTVIEW BIBLE CHURCH
19+600
19+700
19+800
EXISTING PROPERTY LINE
PROPOSED REGION RIGHT-OF-WAY
TEMPORARY CONSTRUCTION EASEMENT
CONCEPTUAL CHANNEL
3.0m MULTI-USE PATH
1.5m BIKE LANE WITH 0.3m BUFFER
Metal Post with Light
ASPHALT
5.6m WIDE CONC. BOX CULVERT
700mm ø CSP
500mm ø CSP
400mm ø CSP GRAVEL
BMH
NOTE: MOUNTABLE CURB FOR EMERGENCY VEHICLES
CURB
RAISED MEDIAN WITH LANDSCAPE
PROPERTY LINE
9m LANDSCAPE BUFFER
PROPOSED SIX STOREY RETIREMENT RESIDENCE 9130 DUNDAS ST. WEST
3114
PART 3
PLAN 20R



MMM GROUP

HALTON REGION
DUNDAS STREET (REGIONAL ROAD No.5) CLASS EA STUDY
BRANT STREET TO BRONTE ROAD

CULVERT # 23
PLAN AND PROFILE - ALTERNATIVE 4 (70m SPAN)

LEGEND:
- EXISTING PROPERTY LINE
- TEMPORARY CONSTRUCTION EASEMENT
- PROPOSED REGION RIGHT-OF-WAY

5 0 20
SCALE 1:500

FEBRUARY 3, 2015

PRELIMINARY ONLY

DRAFT

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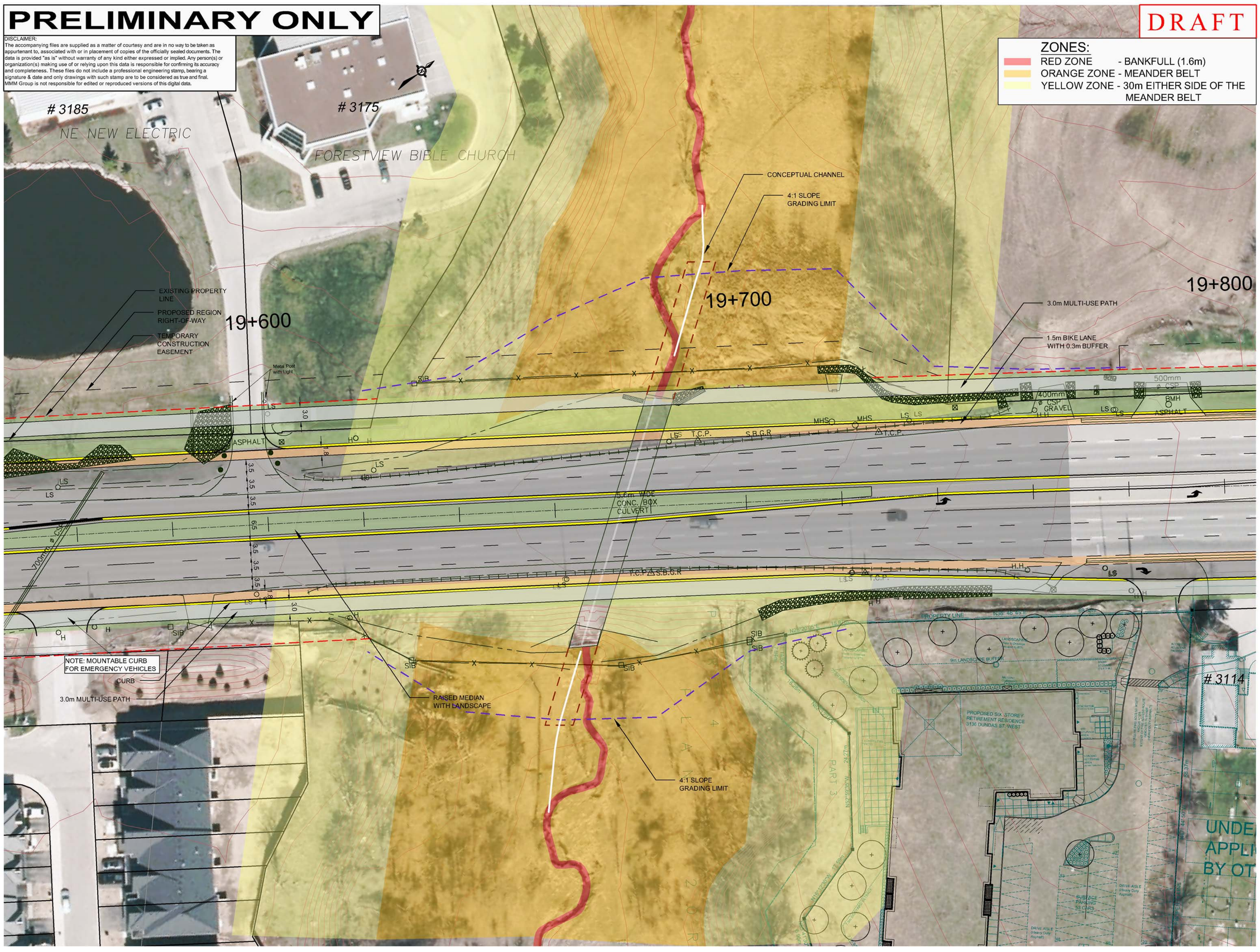
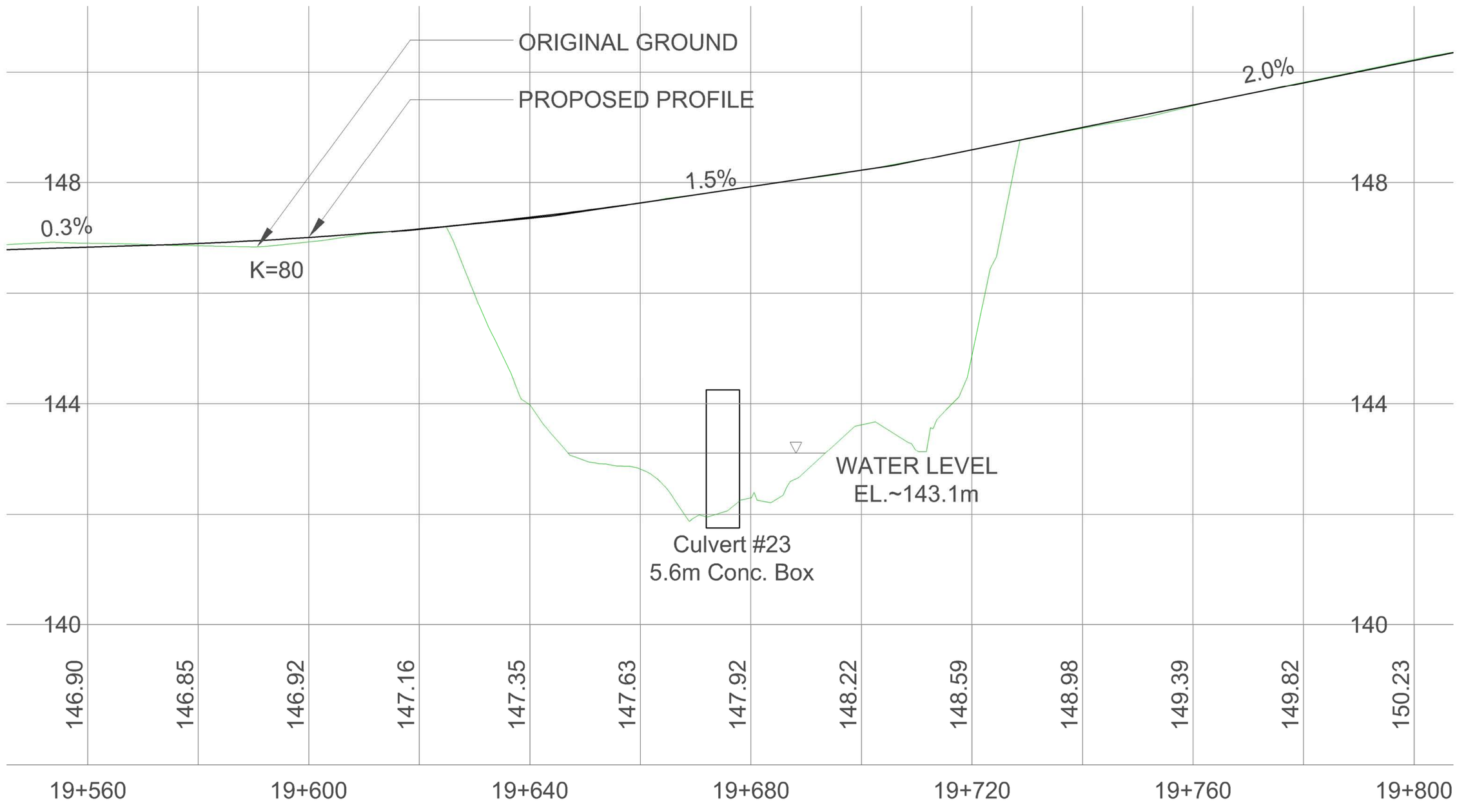
ZONES:
- RED ZONE - BANKFULL (1.6m)
- ORANGE ZONE - MEANDER BELT
- YELLOW ZONE - 30m EITHER SIDE OF THE MEANDER BELT





MMM GROUP

HALTON REGION
DUNDAS STREET (REGIONAL ROAD No.5) CLASS EA STUDY
BRANT STREET TO BRONTE ROAD

CULVERT # 23
PLAN AND PROFILE -ALTERNATIVE 1
EXISTING CULVERT EXTENSION

LEGEND:
- EXISTING PROPERTY LINE
- TEMPORARY CONSTRUCTION EASEMENT
- PROPOSED REGION RIGHT-OF-WAY

5 0 20
SCALE 1:500

FEBRUARY 3, 2015

PRELIMINARY ONLY

DRAFT

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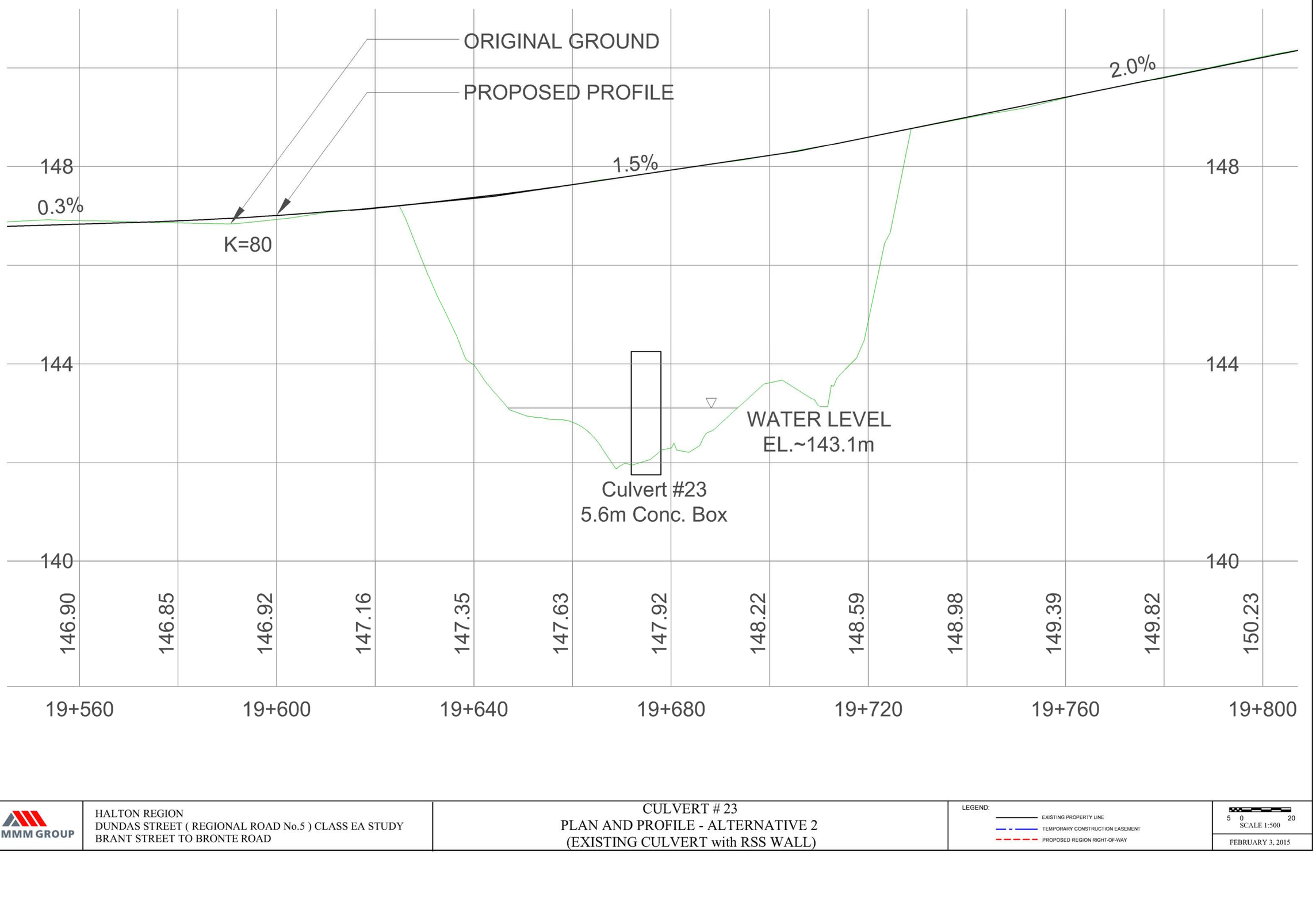
ZONES:
RED ZONE - BANKFULL (1.6m)
ORANGE ZONE - MEANDER BELT
YELLOW ZONE - 30m EITHER SIDE OF THE MEANDER BELT

3185
NE NEW ELECTRIC
3175
FORESTVIEW BIBLE CHURCH
19+600
19+700
19+800
EXISTING PROPERTY LINE
PROPOSED REGION RIGHT-OF-WAY
TEMPORARY CONSTRUCTION EASEMENT
CONCEPTUAL CHANNEL
RSS WALL
Metal Post with Light
3.0m MULTI-USE PATH
1.5m BIKE LANE WITH 0.3m BUFFER
ASPHALT
5.7m WIDE CONC. BOX CULVERT
700mm ø CSP
500mm ø CSP
400mm ø CSP
GRAVEL
BMH
NOTE: MOUNTABLE CURB FOR EMERGENCY VEHICLES
CURB
RAISED MEDIAN WITH LANDSCAPE
PROPERTY LINE
0m LANDSCAPE BUFFER
PROPOSED SIX STOREY RETIREMENT RESIDENCE 3136 DUNDAS ST. WEST
3114
PART 3 PLAN 20



MMM GROUP

HALTON REGION
DUNDAS STREET (REGIONAL ROAD No.5) CLASS EA STUDY
BRANT STREET TO BRONTE ROAD

CULVERT # 23
PLAN AND PROFILE - ALTERNATIVE 2
(EXISTING CULVERT with RSS WALL)

LEGEND:
EXISTING PROPERTY LINE
TEMPORARY CONSTRUCTION EASEMENT
PROPOSED REGION RIGHT-OF-WAY

5 0 20
SCALE 1:500

FEBRUARY 3, 2015

APPENDIX E

Dundas Street Class EA – Brant Street to Bronte Road
Crossing of Fourteen Mile Creek West (Culvert 22) Alternatives
February 2015

Description of Alternatives

General:

- Through the area of Culvert 22, Dundas Street is to be widened from 4 to 6 lanes (@3.5 m each) with on-road bike lanes (1.8 m, including a 0.3 m stripped buffer). A raised median is proposed separating eastbound and westbound traffic. A 3.0 m multi-use path is proposed on both sides of the road. The multi-use path on the south side is proposed to be curb-faced to minimize impact to adjacent lands.
- Based on the hydraulic review, the existing culvert is able to convey the storm runoff under all storm events including the Regional Storm event without overtopping Dundas Street.
- The existing culvert will not accommodate the widening for the roadway improvements noted above and requires modification (i.e. extension) or replacement.
- While the most recent culvert inspection conducted by Halton Region indicated that the culvert is in good condition and requires only minor repairs, the culvert has previously been extended (at a skewed angle). Therefore, it is not desirable for the culvert to be further extended.

Alternative 1: Extension of Existing Culvert by ~11 m Upstream:

- As noted above, the hydraulic review has indicated that the existing culvert is able to convey the storm runoff under all storm events including the Regional Storm event without overtopping Dundas Street. Under this alternative, it is proposed to extend the existing culvert by 11 m upstream to accommodate the widening of Dundas Street.

Alternative 2: Replacement with Clear-span Structure at 3x Bankfull Channel (~9 m)

- While the hydraulic review indicated that the existing culvert is able to convey the storm runoff under all storm events including the Regional Storm event without overtopping Dundas Street, it is recognized that Fourteen Mile Creek West is Redside Dace habitat. Therefore, a ~9 m span structure, which is three times the existing bankfull width of approximately 3 m, is proposed as an alternative.

Alternative 3: Replace with Clear-span Structure (~20 m) Addressing and Enhancing Environmental Functions

- The existing culvert will be removed and will be replaced with a ~20 m span structure. The span width in this alternative was developed based on the required openness ratio for wildlife crossing that would accommodate large animals (e.g. White-tailed deer) as well as consideration of in-channel velocities and associated fluvial geomorphic implications. A retaining wall is proposed in the northwest side of the structure to minimize and avoid encroaching into the channel and minimize the fill footprint in the regulated Redside Dace habitat beyond the bankfull channel.

Alternative 4: Replacement with Clear-span structure Spanning Planning Level MBW (~ 60m)

- Based on work by others, the meander belt width associated broadly with this tributary is approximately 60 m. The existing culvert will be removed and will be replaced with a ~60 m span structure. This alternative is developed to span this general meander belt width; however, it should be noted that the meander belt at the crossing may be narrower than 60 m. A retaining wall is proposed on the northwest side of the structure to avoid encroachment into the channel.

Factors	Extension of Existing Culvert ~ Add 11 m Upstream	Replacement with Clear-span structure Spanning 3X Bankfull Channel (~ 9m)	Replacement with Clear-span structure (~ 20 m) Addressing and Enhancing Environmental Functions[i]	Replacement with Clear-span structure Spanning Planning Level MBW (~ 60m)
Socio-Economic				
Property	No impacts	Possible minor requirement	Possible minor requirement	Likely property impact due to relocation of north side driveway as noted below (access).
Noise	No impacts	More extensive construction related noise. Anticipated increased noise due to tire interaction with expansion joints.	More extensive construction related noise. Anticipated increased noise due to tire interaction with expansion joints.	More extensive construction related noise. Anticipated increased noise due to tire interaction with expansion joints.
Access	No impacts	Possible minor impact to existing pedestrian connection on south side to Colonel William Parkway.	Possible minor impact to existing pedestrian connection on south side to Colonel William Parkway.	Possible minor impact to existing pedestrian connection on south side to Colonel William Parkway.

Factors	Extension of Existing Culvert ~ Add 11 m Upstream	Replacement with Clear-span structure Spanning 3X Bankfull Channel (~ 9m)	Replacement with Clear-span structure (~ 20 m) Addressing and Enhancing Environmental Functions[i]	Replacement with Clear-span structure Spanning Planning Level MBW (~ 60m)
				Likely **impact to driveway east of crossing** to north of Dundas property – may require relocation to east, may be complicated by proximity to proposed bus bay.
Built Heritage/Heritage Landscape	Little impact to heritage landscape	Possible minor impact to heritage landscape (CHL 14 – 3269 Dundas Street).	Possible impact to heritage landscape (CHL 14 – 3269 Dundas Street).	Possible major impact to heritage landscape (CHL 14 – 3269 Dundas Street)
Aesthetics	No impacts	More significant intrusion to current landscape, particularly to homes south of Dundas Street.	More significant intrusion to current landscape, particularly to homes south of Dundas Street.	More significant intrusion to current landscape, particularly to homes south of Dundas St and heritage property north of Dundas Street.
Utilities	Impact to Town monitoring station for C22 – to be relocated.	May impact hydro pole location south of Dundas Street. Impact to Town monitoring station for C22 – to be relocated.	May impact hydro pole location south of Dundas Street. Impact to Town monitoring station for C22 – to be relocated.	May impact hydro pole location south of Dundas Street. Impact to Town monitoring station for C22 – to be relocated.
Socio-Economic Summary	**Preferred** due to limited impacts to adjacent properties.	**Moderately preferred** as it would have less property impacts compared to the 60 m span structure alternative. Similar impacts to the 20 m span structure alternative.	**Moderately preferred** as it would have less property impacts compared to the 60 m span structure alternative. Similar impacts to the 9 m span structure alternative.	**Not preferred** due to property requirement and intrusion into adjacent properties.
Natural Environment[ii]				
Natural Heritage System (NHS)	Nominal direct impacts given existing conditions. However, no opportunities to enhance the existing road crossing conditions.	Nominal direct impacts given existing conditions. • Good opportunities to enhance the existing road crossing conditions, which currently fragment the NHS / habitat continuity and provides a barrier to fish movement and wildlife (see other natural environment factors below). • A structure (9m) provides for movement of fish and small wildlife. • Habitat continuity can be reasonably re-instated with some limitations, such as substrate sizing in the structure vis-à-vis up and downstream channel sections, and no opportunities for habitat features through crossing itself.	Nominal direct impacts given existing conditions. • Excellent opportunities to enhance the existing road crossing conditions, which currently fragment the NHS and habitat continuity, and provides a barrier to fish movement and wildlife (see other natural environment factors below). • A structure (20 m) provides for movement of fish and wildlife, including large mammals (e.g., deer). • Habitat continuity can be re-instated along the channel (with some limitations related to vegetation control of channel and minor limitations re substrate sizing), and opportunities for provision of some habitat features through crossing itself.	Nominal direct impacts given existing conditions. • Excellent opportunities to enhance the existing road crossing conditions, which currently fragment the NHS and habitat continuity, and provides a barrier to fish movement and wildlife (see other natural environment factors below). • A structure (70 m) provides for movement of fish and wildlife, including large mammals (e.g., deer). • Habitat continuity can be re-instated along the channel (with some limitations related to vegetation control of channel and minor limitations re substrate sizing), and opportunities for provision of some habitat features through crossing itself. Little incremental benefit beyond 20m span.
Fisheries	Nominal change/adverse impact of culvert extension relative to existing conditions given existing concrete slab 'floor' and concrete walls through extension zone.	Nominal adverse impact of longer structure relative to existing conditions given existing concrete slab 'floor' and concrete walls through extent of longer structure.	Nominal adverse impact of longer structure relative to existing conditions given existing concrete slab 'floor' and concrete walls through extent of longer structure.	Nominal adverse impact of longer structure relative to existing conditions given existing concrete slab 'floor' and concrete walls through extent of longer structure.

Factors	Extension of Existing Culvert ~ Add 11 m Upstream	Replacement with Clear-span structure Spanning 3X Bankfull Channel (~ 9m)	Replacement with Clear-span structure (~ 20 m) Addressing and Enhancing Environmental Functions[i]	Replacement with Clear-span structure Spanning Planning Level MBW (~ 60m)
	Localized incremental reduction in solar inputs. Nominal temporary construction impacts if floor and walls retained. **No or nominal opportunities for enhancement** (unless existing floor and walls removed and extension inset below existing slab invert to enable re-establishment of substrates and low flow channel)	Localized incremental reduction in solar inputs. Required embankment fills around the end of the longer culvert require realignment of a section of the existing channel. While there are significant opportunities to re-naturalize the existing hardened channel and remove the upstream retaining wall as part of this realignment, a relatively long realignment may be required and there may be challenges, including groundwater management, in maintaining refuge pooling associated with the retaining wall section. Typical temporary construction-related impacts during removal of existing concrete floor and walls and re-grading of new channel and overbank sections and transitions become much more complex with the anticipated requirement to realign the upstream channel section and remove the existing retaining wall). Opportunity to enhance habitat significantly relative to existing condition by insetting new structure and installing stable substrates and low flow channel, and providing an overbank area of ~3m in both sides of the bankfull channel. **Substrate composition somewhat limited by flow velocities and associated sizing requirement's to maintain stability**.	Localized incremental reduction in solar inputs given longer structure, with nominal localized incremental increase in light penetration relative to smaller culvert. Typical temporary construction-related impacts during removal of existing concrete floor and walls and re-grading of new channel section and transitions (limitations at upstream end given existing retaining wall). Opportunity to enhance habitat significantly relative to existing condition by re-constructing natural bankfull channel section through new structure with stable substrates and low flow channel and a functional floodplain zone, and potential morphological enhancements. Best opportunities to incorporate realignment of existing channel as well. **'Natural' substrate options enhanced as span increased further and overbank flow velocities decreased further relative to 9m span.** However, natural channel migration opportunities limited by inability to grow vegetation to maintain channel stability (or contribute to local food and cover sources). Without some degree of physical control on channel form and therefore location, channel likely to widen out laterally or move catastrophically during storm events, potentially reducing function and creating other secondary impacts (e.g., erosion and downstream sediment release, channel splitting, potential barrier creation, etc.).	Localized incremental reduction in solar inputs given longer structure, with nominal localized incremental increase in light penetration relative to other alternatives. Typical temporary construction-related impacts during removal of existing concrete floor and walls and re-grading of new channel section and transitions (limitations at upstream end given existing retaining wall). Opportunities to enhance habitat significantly relative to existing condition using larger clear span structure. However, **limited incremental opportunities beyond ~20m span given limited opportunities to grow vegetation to maintain channel stability (or contribute to local food and cover sources).** Without some degree of physical control on channel form and therefore location, channel likely to widen out laterally or move catastrophically during storm events, potentially reducing function and creating other secondary impacts (e.g., erosion and downstream sediment release, channel splitting, potential barrier creation, etc.).
Species At Risk / Redside Dace; Impacts to Regulated Habitat Zones (see also Fish Habitat above) *Note:* *Category 1/Red zone,*	Realignment of ~135 m^2 (~45m of channel w 3m wide bankfull currently channelized in concrete) of channel/red zone habitat required (upstream portion of which is within culvert extension). No opportunities to re-naturalize 'concrete'	Realignment of ~135 m^2 of channel/red zone habitat required due to fill slopes (same as Alternative 1) plus similar area/~135 m^2 of channel currently enclosed in culvert plus transitions. However significant opportunities are present to re-naturalize 'concrete' lined channel habitat and realignment	Impacts to red zone habitat can be avoided (i.e., fill slopes for new bridge do not impact existing channel). However assuming objective is to re-naturalize concrete channel section, recommended realignment and re-naturalization work would impact similar areas (~135 m^2 of inlet channel and ~135 m^2 within existing	Slightly greater restoration and enhancement opportunities and incrementally less impacts than 20 m span alternative, specifically: Impacts and proposed restoration opportunities with culvert removal same as 20 m span alternative.

Factors	Extension of Existing Culvert ~ Add 11 m Upstream	Replacement with Clear-span structure Spanning 3X Bankfull Channel (~ 9m)	Replacement with Clear-span structure (~ 20 m) Addressing and Enhancing Environmental Functions[i]	Replacement with Clear-span structure Spanning Planning Level MBW (~ 60m)
Category 2/Orange Zone and Category 3/Yellow Zone habitat per MNRF (2012) Categorizing and Protecting Habitat under the Endangered Species Act. Defined as: • *Category 1/Red Zone: Redside Dace as bankfull channel* • *Category 2/Orange Zone: meander belt* • *Category 3/Yellow Zone: 30m each side of meander belt*	lined channel habitat. Removal of ~70 m^2 of orange zone habitat for the road widening and multi-use path. Infill of ~180 m^2 of orange zone habitat, which will become grassed embankment/yellow zone habitat. Removal of ~1330 m^2 of yellow zone embankment habitat for the road widening and multi-use path. Infill or re-grading/disturbance of ~1390 m^2 of yellow zone habitat for widening of embankment slopes, most of which is on the existing road embankment or modified slope above the concrete channel. Re-instatement of ~60 m^2 of yellow zone/embankment habitat as open floodplain/orange zone habitat along the realigned channel section. SAR Summary: • Temporary impact (realignment of channel) to ~135m^2 of channel/red zone habitat. • ~250 m^2 of orange zone habitat impacted (~28% removed and ~75% becomes grassed embankment) • ~2780 m^2 of yellow zone habitat impacted (~48% removed and ~49% becomes grassed	recommended regardless of alternative (see also Fisheries and Fluvial Geomorphic). Removal of ~75 m^2 of orange zone habitat for the road widening and multi-use path. Infill of ~275 m^2 of orange zone habitat, which will become grassed embankment/yellow zone habitat. Removal of ~1315 m^2 of yellow zone embankment habitat for the road widening and multi-use path. Infill or re-grading/disturbance of ~1295 m^2 of yellow zone habitat for widening of embankment slopes, most of which is on the existing road embankment or modified slope above the concrete channel. Re-instatement of ~100 m^2 of yellow zone/embankment habitat as open floodplain/orange zone habitat along the realigned channel section. SAR Summary: • Temporary impact (realignment of channel) to ~270m^2 of channel/red zone habitat (half of which is currently channelized in concrete upstream and the other enclosed in culvert). • ~350 m^2 of orange zone habitat impacted (~21% removed and ~79% becomes grassed embankment) • ~2710 m^2 of yellow zone habitat impacted (~48% removed and ~48%	culvert) of channel/red zone habitat (see also Fisheries). Significant opportunities to re-naturalize the concrete lined channel section and associated habitat are present, without or with (provides better enhancement opportunities) realignment. Alteration of ~50 m^2 of orange zone habitat that will be shaded under the edge of the new bridge (although channel fixed and cannot meander in this area now). Infill of ~55 m^2 of orange zone habitat, which will become grassed embankment/yellow zone habitat. Removal of ~1290 m^2 of yellow zone embankment habitat for the road widening and multi-use path. Infill or re-grading/disturbance of ~1210 m^2 of yellow zone habitat for widening of embankment slopes, most of which is on the existing road embankment or modified slope above the concrete channel. Re-instatement of ~165 m^2 of yellow zone/embankment habitat as open floodplain/orange zone habitat following removal of the culvert and re-instatement of an open channel section. SAR Summary: • Temporary impact (realignment of channel) to ~270m^2 of channel/red zone habitat (half of which is currently channelized in concrete upstream and the other enclosed in culvert; can be avoided but pursue as a benefit). • Alteration of ~105 m^2 of orange zone habitat (~45% shaded under edge of bridge and ~55% becomes grassed embankment)	Alteration of ~50 m^2 of orange zone habitat that will be shaded under the edge of the new bridge (although channel fixed and cannot meander in this area now). Removal of ~690 m^2 of yellow zone embankment habitat for the road widening and multi-use path. Infill or re-grading/disturbance of ~1250 m^2 of yellow zone habitat for widening of embankment slopes, most of which is on the existing road embankment or modified slope above the concrete channel. Re-instatement of ~430 m^2 of yellow zone/embankment habitat as open floodplain/orange zone habitat following removal of the culvert and re-instatement of an open channel section. SAR Summary: • Temporary impact (realignment of channel) to ~270m^2 of channel/red zone habitat (half of which is currently channelized in concrete upstream and the other enclosed in culvert; can be avoided but pursue as a benefit). • Alteration of ~50 m^2 of orange zone habitat (shaded under edge of bridge) • ~2370 m^2 of yellow zone habitat impacted (~29% removed and ~53%

Factors	Extension of Existing Culvert ~ Add 11 m Upstream	Replacement with Clear-span structure Spanning 3X Bankfull Channel (~ 9m)	Replacement with Clear-span structure (~ 20 m) Addressing and Enhancing Environmental Functions[i]	Replacement with Clear-span structure Spanning Planning Level MBW (~ 60m)
	embankment and 2% becomes orange zone habitat along realigned channel section).	becomes grassed embankment and 4% becomes orange zone habitat along realigned channel section). • Significant opportunities are present to re-naturalize 'concrete' lined channel habitat.	• ~2665 m^2 of yellow zone habitat impacted (~48.5% removed and ~45.5% becomes grassed embankment and 6% becomes orange zone habitat along realigned channel section). • Significant opportunities to re-naturalize the concrete lined channel section and associated habitat upstream of bridge and good opportunities to re-naturalize the habitat in the channel section now enclosed in the culvert under the new bridge.	becomes grassed embankment and 18% becomes orange zone habitat along realigned channel section). • Significant opportunities to re-naturalize the concrete lined channel section and associated habitat upstream of bridge and good opportunities to re-naturalize the habitat in the channel section now enclosed in the culvert under the new bridge.
Wildlife	Nominal impact relative to existing conditions since nominal potential for movement of most animals presently; channel width spans the culvert width during typical flow conditions. **Negligible opportunity to enhance wildlife movement** other than retrofitting of culvert with hanging metal racks for movement of small animals	Nominal impact relative to existing conditions since nominal potential for movement of most animals presently. **Good opportunity to enhance movement of small animals**; 3m wide overbank/bench areas beyond bankfull channel more than adequate for movement of small animals (restriction at upstream end due to existing retaining wall).	Significant benefit for movement of both small as well as large animals. **Movement of large mammals (e.g., White-tailed Deer) can be easily accommodated with a span of ~20m,** which will provide a target OR of ~1.0 and enable provision of an opening height of ~2.5m (restriction at upstream end due to existing retaining wall)	**No real commensurate benefit for movement of wildlife of wider structure beyond ~20m span.** As clear span width increased, depth of deck also increases reducing height of opening for large mammals (restriction at upstream end due to existing retaining wall).
Vegetation	Localized removal of riparian vegetation for construction access and to extend structure upstream. Young Norway Maple, American Elm and Black Walnut are growing directly adjacent to the top of the existing concrete walls. **No opportunities for enhancement of riparian vegetation functions** through crossing or upstream without removal of retaining wall upstream.	Localized removal of roadside, riparian and floodplain vegetation for construction access and for longer structure upstream, and immediately at the culvert outlet. Vegetation includes some mid-aged Crack Willow, and young Norway Maple, American Elm and Black Walnut. Woody cover relatively open. **Local opportunities for enhancement of riparian vegetation functions along east bank** within the disturbed portions of the floodplain at the edge of the right-of-way (up and downstream) and moving upstream on to adjacent lands through planting of native shrubs (and trees with consideration of terrestrial insect production) and Buckthorn removal; very limited opportunity on west bank without removal of upstream retaining wall.	Removal of commensurately more roadside, riparian and floodplain vegetation for construction access and construction of longer structure upstream. Disturbance locally at outlet, and for wider bridge generally, as well as immediately at the culvert outlet. **Local opportunities for enhancement of riparian and floodplain vegetation functions** at the edge of the right-of-way (downstream) and in the construction zone (upstream) and potentially moving further upstream on to adjacent lands (particularly in conjunction with removal of the retaining wall along the channel) through planting of native shrubs (and trees with consideration of terrestrial insect production) and Buckthorn removal. The small area of floodplain that would be re-instated following culvert removal can also be planted. Structure height insufficient to allow much light	Removal of commensurately more roadside, riparian and floodplain vegetation for construction access and construction of longer structure upstream, as well as disturbance locally at outlet, and for wider bridge generally. and immediately at the culvert outlet. **Local opportunities for enhancement of riparian and floodplain vegetation functions** at the edge of the right-of-way (downstream) and in the construction zone (upstream) and potentially moving further upstream on to adjacent lands (particularly in conjunction with removal of the retaining wall along the channel) through planting of native shrubs (and trees with consideration of terrestrial insect production) and Buckthorn removal. The small area of floodplain that would be re-instated following culvert removal can also be planted. Structure height insufficient to allow much light

Factors	Extension of Existing Culvert ~ Add 11 m Upstream	Replacement with Clear-span structure Spanning 3X Bankfull Channel (~ 9m)	Replacement with Clear-span structure (~ 20 m) Addressing and Enhancing Environmental Functions[i]	Replacement with Clear-span structure Spanning Planning Level MBW (~ 60m)
			penetration other than right at the inlet and outlet.	penetration other than right at the inlet and outlet.
Natural Environment Summary	**Not preferred** as there would be no opportunities for enhancement of fisheries, wildlife movement and riparian vegetation functions.	**Moderately preferred** – in terms of fisheries, the substrate composition is somewhat limited by flow velocities and associated sizing requirement's to maintain stability. There are good opportunities to enhance movement of small animals (however, not large mammals), and there are local opportunities for enhancement of riparian vegetation functions along the east bank.	**Preferred** – in terms of fisheries, the natural substrate options enhanced as the span increased further and overbank flow velocities decreased further relative to the ~9 m span. This alternative easily accommodates the movement of large mammals, and there are local opportunities for enhancement of riparian vegetation functions along the east bank.	**Moderately preferred** – in terms of fisheries, there are limited incremental opportunities beyond the ~20 m span given limited opportunities to grow vegetation to maintain channel stability. While the ~60 m span would accommodate movement of large mammals, there would be no real commensurate benefit of wider structure beyond ~20 m. There are local opportunities for enhancement of riparian vegetation functions along the east bank.
Drainage/Water Resources				
Hydrologic /Hydraulic	Minimal impact on the water surface elevations. The water level will increase in by 0.02 m for Regional and 1.2xRegional storm events; 0.01m for 50 year and 100 year storm event under proposed conditions. No overtopping of Dundas Street occurs during Regional and 1.2xRegional storm events. It is noted that the losses due to the beds in the culverts were not considered in the hydraulic model.	The water surface elevations at the upstream of Dundas Street will be lower than the existing conditions.	Water surface elevations upstream of Dundas Street will be lower. The water levels will be lower by 0.99 m for 1.2xRegional storm event and 0.79 m for Regional storm event.	No significant change in water level elevations for increase in bridge span from 20m to 60m.
	In terms of quality control of storm runoff from Dundas Street, the "Jellyfish" filtration system is proposed since it is a regulated Redside Dace habitat watercourse. It would provide a higher level of quality control compared to conventional oil grit separator.			
Fluvial Geomorphic	Upstream of Dundas Street the channel has concrete banks and bed which impacts sediment transport and natural fluvial processes. It is over-wide compared to the natural channel upstream. Deposition has occurred along the left bank (which in the larger context of the meander pattern would be a point bar) while along the right bank (which is the natural direction of lateral migration) the stream bed is scoured and the protective wall is undercut by over 0.2 m. As such the reach is attempting to adjust laterally through deposition on the	Benefits associated with these alternatives would have to include a plan for restoration of the existing channel upstream of the culvert. Constructing a wider bridge but maintaining the existing concrete channel upstream could lead to erosion at the interface. Benefits in terms of sediment transport and fluvial morphology would be negligible without upstream channel works as the existing concrete channel would continue to impact processes and disrupt sediment transfer due to the over wide cross section and hard bed acting as a grade control. Removing the concrete bed and banks would be a significant improvement to the fluvial processes and channel morphology upstream of the culvert. Replacement of the culvert at an improved angle would minimize erosion risk. An appropriately sized low flow channel would be installed through the structure allowing for sediment transport and fish passage. The new culvert design would ensure that the proposed culvert is not perched at its downstream extent. The channel downstream would be better connected to the upstream reaches through enhancement of the sediment transfer system. However, consideration should be given to the benefit of channel enhancement works that tie into a heavily impacted and poorly defined reach downstream.		

Factors	Extension of Existing Culvert ~ Add 11 m Upstream	Replacement with Clear-span structure Spanning 3X Bankfull Channel (~ 9m)	Replacement with Clear-span structure (~ 20 m) Addressing and Enhancing Environmental Functions[i]	Replacement with Clear-span structure Spanning Planning Level MBW (~ 60m)
	left bank and erosion on the right bank. The hard bank and bed protection appears to be in poor condition. The existing culvert angle is out of alignment with the channel's course and the channel turns abruptly south to flow under Dundas Street. Downstream of Dundas Street, the channel lies within a steep, asymmetric forested valley and channel is constrained by a very steep right bank and a moderately steep left bank near Dundas Street. The culvert outlet is perched by approximately 0.3 m. Near Dundas Street the channel appears to have been widened (up to 6 m wide) and straightened. Modification continues to downstream of Colonel Williams Parkway. **Extending the existing culvert would have a negligible impact on these already modified existing conditions**. An additional 11 m of channel (that currently has concrete bed and banks) would be covered by the culvert. This alternative would also necessitate the realignment of approximately 45 m of the existing creek and grading into the hill slope to the east to tie in with the culvert extension. An awkward channel alignment with the culvert similar to exiting conditions would be the ultimate condition.	In terms of velocities [iii], a 9 m span represents an **improvement compared to existing conditions**. Velocities for the 2 year event are 1.3 m/s downstream compared to 1.9 m/s under existing conditions. For the 25 year event proposed velocities are to 1.88 m/s compared to 2.56 m/s compared under existing conditions. These velocities are still higher than those seen in channel downstream of the bridge influence. Upstream the existing velocities are lower than proposed due to the backwater affect created by the existing culvert. Velocities upstream are quite consistent between the span alternatives considered and are all within the range of velocities seen in cross sections outside of the bridge zone. **The north west embankment footprint of a 9 m structure would directly impact the creek.** This would necessitate realignment into the hill slope to the east and an awkward channel alignment with the culvert. This is not considered a feasible alternative. This alternative would also necessitate the realignment of approximately 45 m of the existing creek and grading into the hill slope to the east to tie in with the culvert extension. In total approximately 100 m of creek would be realigned upstream and through the proposed culvert offering an opportunity for enhancement of channel morphology. This alternative maintains a crossing that is smaller than the valley upstream and downstream of Dundas Street.	In terms of velocities [iii], a 20 m span represents **a significant improvement compared to existing conditions**. A preliminary belt width was defined by the widest meanders in the reaches upstream and downstream of Dundas Street. **The unconfined belt width upstream of Dundas Street is 14 m and downstream is 20 m**. Locally there is valley confinement which reduces the belt width in places. This is true at the crossing where the upstream meander belt width is reduced to approximately 7 m. As such the 20 m structure would span the meander belt width for the reaches upstream and downstream of Dundas Street. Velocities for the 2 year event are 0.79 m/s downstream compared to 1.9 m/s under existing conditions. (Note: the velocities at lower flows would be managed through inclusion of an appropriately sized low flow channel at detailed design). For the 25 year event proposed velocities are to 1.22 m/s compared to 2.56 m/s under existing conditions. These velocities are generally within the range seen in the channel downstream of the bridge influence apart from for the Regional event which is typically marginally lower. Upstream the existing velocities are lower than proposed due to the backwater affect created by the existing culvert. Velocities upstream are quite consistent between the span alternatives considered and are all within the range of velocities seen in cross sections outside of the bridge zone. The embankment footprints of this structure would not directly impact the creek allowing for a far more acceptable tie in between the realigned watercourse upstream and the proposed culvert compared to Alternatives 1	In terms of velocities [iii], a 60 m span represents **a significant improvement compared to existing conditions**. A preliminary belt width was defined by the widest meanders in the reaches upstream and downstream of Dundas Street. **The unconfined belt width upstream of Dundas Street is 14 m and downstream is 20 m**. Locally there is valley confinement which reduces the belt width in places. This is true at the crossing where the upstream meander belt width is reduced to approximately 7 m. As such, the 60 m structure would exceed the meander belt width for the reaches upstream and downstream of Dundas Street. The maximum valley width is approximately 50 m wide downstream of the culvert. Further, the creek is confined on the west by the valley side. The channel's planform means that the outside of the bend runs along the western valley toe. As the focus of the creek's energy is on the western valley, it is not migrating to the east. Velocities for the 2 year event are 0.67 m/s downstream compared to 1.9 m/s under existing conditions. (Note: the velocities at lower flows would be managed through inclusion of an appropriately sized low flow channel at detailed design). For the 25 year event proposed velocities are to 0.94 m/s compared to 2.56 m/s compared under existing conditions. These velocities are lower than the range seen in the channel downstream of the bridge influence and **this is not considered an enhancement over the 20 m span from a geomorphic perspective.** Upstream the existing velocities are lower than proposed due to the backwater affect created by the existing culvert. Velocities upstream are quite consistent between the span alternatives

Factors	Extension of Existing Culvert ~ Add 11 m Upstream	Replacement with Clear-span structure Spanning 3X Bankfull Channel (~ 9m)	Replacement with Clear-span structure (~ 20 m) Addressing and Enhancing Environmental Functions[i]	Replacement with Clear-span structure Spanning Planning Level MBW (~ 60m)
			(Extension) and 2 (9m span structure). In total, approximately 100 m of creek would be realigned upstream and through the proposed culvert offering an opportunity for enhancement of channel morphology. Only minimal grading into the hill slope to the east would be required.	considered and are all within the range of velocities seen in cross sections outside of the bridge zone. The embankment footprints of this structure would not directly impact the creek allowing for a far more acceptable tie in between the realigned watercourse upstream and the proposed culvert compared to Alternatives 1 (Extension) and 2 (9m span structure). In total, approximately 100 m of creek would be realigned upstream and through the proposed culvert offering an opportunity for enhancement of channel morphology. Only minimal grading into the hill slope to the east would be required.
Drainage / Water Resources Summary	**Not preferred** – While extending the existing culvert would have negligible impact on the already modified existing conditions, this alternative would not offer any opportunities to enhance fluvial geomorphology conditions.	**Not preferred** – While this alternative would provide an improvement compared to existing conditions, the north west embankment footprint of the 9 m span structure would directly impact the creek.	**Preferred** – This alternative would provide a significant improvement compared to existing conditions. The ~20 m span structure would span the meander belt width for the reaches upstream and downstream of Dundas Street.	**Moderately preferred** – While this alternative would provide a significant improvement compared to existing conditions, the ~60 m structure would exceed the meander belt width for the reaches upstream and downstream of Dundas Street. This alternative is not considered an enhancement over the 20 m span from a geomorphic perspective.
Geometric				
Vertical Profile	No change	No change	No change	No change
Sight Distance	No change	No change	No change	No change
Adjacent Intersection	No impacts	No impacts	No impacts	No impacts
Transit Facilities	No impacts	No impacts	No impacts	Proximity of possible realigned driveway to proposed bus bay may be less desirable
Streetscaping Opportunities	No impacts	Median streetscaping not possible on structure	Median streetscaping not possible on structure	Median streetscaping not possible on structure
Structure Condition	The existing culvert will not accommodate the widening for the roadway improvements noted above and requires modification (i.e. extension) or replacement.			
	While the most recent culvert inspection conducted by Halton Region indicated that the culvert is in good condition and requires only minor repairs, the culvert has previously been extended (at a skewed angle). Therefore, it is not desirable for the culvert to be further extended.	While the most recent culvert inspection conducted by Halton Region indicated that the culvert is in good condition and requires only minor repairs, the culvert has previously been extended (at a skewed angle). Replacement with a new clear span structure is preferred over extension of the existing culvert.		
Constructability/Staging	Very little impact due to work being outside of traffic lanes	Construction complicated and extended by staging while retaining 4 lanes of traffic	Construction complicated and extended by staging while retaining 4 lanes of traffic during	Construction complicated and extended by staging while retaining 4 lanes of traffic during

Factors	Extension of Existing Culvert ~ Add 11 m Upstream	Replacement with Clear-span structure Spanning 3X Bankfull Channel (~ 9m)	Replacement with Clear-span structure (~ 20 m) Addressing and Enhancing Environmental Functions[i]	Replacement with Clear-span structure Spanning Planning Level MBW (~ 60m)
		during required periods. Extension of existing culvert may be required during construction to facilitate temporary road detour for the construction of the new structure. **Length of the road detour would be less compared to the 20 m span and 60 m span structure alternatives.**	required periods. Extension of existing culvert may be required during construction to facilitate temporary road detour for the construction of the new structure. **Length of the road detour would be less compared to the 60 m span structure alternative.**	required periods. Extension of existing culvert may be required during construction to facilitate temporary road detour for the construction of the new structure. **Due to the proximity to the Colonial William Parkway intersection, the road detour may impact the operation of the intersection during construction**.
Geometric Summary	**Preferred** as it would have the least impact to adjacent properties during construction.	**Moderately preferred** – construction and staging would be less intrusive compared to the ~20 m span and ~60 m span alternatives.	**Moderately preferred** – construction and staging would be less intrusive compared to the ~60 m span alternative.	**Not preferred** due to significant impact to nearby intersection and properties during construction.
Capital Costs				
Order of Magnitude – Capital [v]	$65,000	$1.3 M	$2.9 M	$8.7M
OVERALL SUMMARY	Least community impacts, least capital, simple construction staging, shortest construction schedule, least impacts to current vegetation, negligible/no opportunity for enhancements to creek environs and fisheries. **NOT RECOMMENDED**	Replacement with a 9 m span structure will accommodate opportunities for movement of small animals. While this alternative would improve the flow velocity compared to existing conditions, the fill from the structure will have direct impact to the creek and channel, and would have limited ability to provide overall improvements in the fluvial geomorphology conditions. **NOT RECOMMENDED**	Replacement with a 20 m span structure will accommodate opportunities for movement of large animals, and also provide significant improvement in fluvial geomorphology compared to existing conditions (e.g. reduced flow velocity, replacing concrete bed and banks with natural channel design, etc.). **RECOMMENDED**	Greatest community impacts, significantly higher capital costs, more complicated construction staging, longest construction schedule, opportunities for enhancement to creek environs and fisheries; however, the longer span is not a notable enhancement over other alternatives. **NOT RECOMMENDED**

[i] Natural and water resources
[ii] Considering potential for adverse effects of the works as well as opportunities for enhancement
[iii] Comments are based on coarse HEC-RAS models. These are useful to provide comparison between structure sizes but cannot be used to finalise appropriate structure size or in channel dimensions. In particular, the model:

- Is not based on detailed survey
- Assumes a 7m wide channel through the structure based on the existing upstream and downstream cross sections. Bankfull width is 3.0 m. At detailed design, analysis would need to be completed to confirm an appropriate low flow width through the culvert and this would affect the HEC-RAS results. As the results presented here are based on 7 m wide channel, the velocities would likely be higher in an appropriately size channel.
- The mannings n values used for the upstream reach reflects the existing concrete channel and not any proposed channel works. Enhancement works would likely lead to a rougher channel and therefore lower velocities entering the structure.

Preliminary in-channel velocities (m/s) downstream and upstream of Dundas Street

		Existing	9 m	15 m	20 m	40 m	60 m
Downstream	1.2 x Reg.	4.01	2.96	2.52	1.85	1.23	1.23
	Reg.	3.77	2.79	2.37	1.77	1.2	1.2
	100YR	2.79	2.06	1.75	1.35	1.02	1.02
	50YR	2.68	1.97	1.67	1.28	0.98	0.98
	25YR	2.56	1.88	1.56	1.22	0.94	0.94
	10YR	2.36	1.74	1.35	1.08	0.87	0.87
	5YR	2.21	1.63	1.21	0.98	0.8	0.8
	2YR	1.9	1.3	0.94	0.79	0.67	0.67
Upstream	1.2 x Reg.	2.46	2.66	2.99	2.99	2.99	2.99
	Reg.	2.33	2.49	2.8	2.79	2.79	2.79
	100YR	1.6	1.8	1.8	1.8	1.8	1.8
	50YR	1.5	1.72	1.72	1.72	1.72	1.72
	25YR	1.4	1.64	1.64	1.64	1.63	1.63
	10YR	1.24	1.5	1.5	1.5	1.5	1.5
	5YR	1.11	1.39	1.39	1.39	1.39	1.39
	2YR	0.85	1.16	1.16	1.16	1.16	1.16

[iv] Meander Belt Width is based on empirical equations completed by others
[v] Assume $6000/m unit cost for culvert extension; $3800/$m^2$ unit cost for crossing structure

Dundas Street Class EA – Brant Street to Bronte Road
Crossing of Fourteen Mile Creek West (Culvert 23) Alternatives
February 2015

Description of Alternatives

General:

- Through the area of Culvert 23, Dundas Street is to be widened from 4 to 6 lanes (@3.5 m each) with on-road bike lanes (1.8 m, including a 0.3 m stripped buffer). A raised median is proposed separating eastbound and westbound traffic. Dundas Street is generally at 6 lanes through this area (i.e. start and end of taper lanes). A 3.0 m multi-use path is proposed on both sides of the road. The multi-use path on the south side is proposed to be curb-faced to minimize impact to adjacent lands.
- Based on the hydraulic review, the existing culvert can convey the 50 year, 100 year and Regional Storm flows without overtopping Dundas Street.
- The most recent culvert inspection conducted by Halton Region indicated that the culvert is in good condition and only requires minor repairs. The length of the existing culvert will accommodate the widening for the roadway improvements (i.e. addition of bike lanes and multi-use paths).

Alternative 1: Full Dundas Street Cross Section with 4:1 Slope and Extension of Existing Culvert by ~30 m Upstream and ~15 m Downstream

- As noted above, the existing culvert can convey the 50 year, 100 year and Regional Storm flows without overtopping Dundas Street based on the hydraulic review. Under this alternative, it is proposed to extend the existing culvert by 35 m upstream and 20 m downstream to accommodate the grading requirement for the widening of Dundas Street from 4 to 6 lanes. A boulevard is proposed on the north side to provide a buffer between the multi-use path and the travel lanes.

Alternative 2: Reduced Dundas Street Cross Section with 2:1 Slope and Retaining Walls, No Culvert Extension

- As noted above, the existing culvert can convey the 50 year, 100 year and Regional Storm flows without overtopping Dundas Street based on the hydraulic review. Under this alternative, the cross section is modified to include a curb-faced multi-use path on the north side and the length of the existing culvert is able to accommodate the cross sectional elements of Dundas Street. To reduce footprint into the valley, a 2:1 slope is proposed as well as the implementation of retaining walls. This would eliminate the need to extend the existing culverts. This is similar to treatment in other sections of Dundas Street (e.g. West Morrison Creek and Joshua Creek).

Alternative 3: Replace with Clear-span Structure (~20 m) Addressing and Enhancing Environmental Functions

- The existing culvert will be removed and will be replaced with a ~20 m span structure. The span width in this alternative was developed based on the required openness ratio for wildlife crossing that would accommodate large animals (e.g. White-tailed deer).

Alternative 4: Replacement with Clear-span structure Spanning Planning Level MBW (~ 70m)

- Based on work by others, the planning level meander belt width associated broadly with this tributary is approximately 70 m. The existing culvert will be removed and will be replaced with a ~70 m span structure. This alternative is developed to span this general meander belt width.

Factors	Full Dundas Street Cross Section with 4:1 Slope and Culvert Extension	Reduced Dundas Street Cross Section with 2:1 slope and Retaining Walls	Replacement with Clear-span structure (~ 20 m)	Replacement with Clear-span structure Spanning Planning Level MBW (~ 70m)
Socio-Economic				
Property	Minimal direct impact to adjacent as fills would generally be within the valley. Minor impact to the landscaping features on the St. Luke's Retirement Home property.	No additional property required.	No additional property required.	No additional property required.
Noise	No significant noise impact to adjacent residential properties as a result of the widening of Dundas Street.			
Access	No direct impact to accesses in the adjacent properties.	No direct impact to accesses in the adjacent properties.	No direct impact to accesses in the adjacent properties.	No direct impact to accesses in the adjacent properties. However, existing access to the

Factors	Full Dundas Street Cross Section with 4:1 Slope and Culvert Extension	Reduced Dundas Street Cross Section with 2:1 slope and Retaining Walls	Replacement with Clear-span structure (~ 20 m)	Replacement with Clear-span structure Spanning Planning Level MBW (~ 70m)
				#3175 and #3185 Dundas Street will be located only 20 m west of the structure and may lead to sight distance issues.
Built Heritage/Heritage Landscape	No direct impact to built heritage properties and heritage landscape.			
Aesthetics	No impact	No impact	The existing culvert will be replaced with a 20 m span structure; changing the streetscape from existing condition.	The existing culvert will be replaced with a 70 m span structure; changing the streetscape from existing condition..
Utilities	May impact hydro poles south of Dundas Street.	May impact hydro poles south of Dundas Street.	Relocation of hydro poles south of Dundas Street.	Relocation of hydro poles south of Dundas Street.
Socio-Economic Summary	**Preferred** due to limited impacts to adjacent properties.	**Preferred** due to limited impacts to adjacent properties.	**Moderately preferred** as it would have less property impacts compared to the 70 m span structure alternative.	**Not preferred** due to property requirement and potential intrusion into adjacent properties.
Natural Environment				
Natural Heritage System (NHS)	While the existing culvert already provides wildlife passage opportunities for small mammals to some degree, the infilling of floodplain for fill slopes require associated incremental encroachment into valley corridor and extension of culvert on upstream side of road. No opportunities to enhance the existing road crossing conditions, which fragment the NHS and habitat continuity to some degree, and create barriers to movement of wildlife under most flow conditions (see other natural environment factors below).	No permanent footprint impacts as retaining wall will avoid infill into floodplain. The existing culvert already provides wildlife passage opportunities for small mammals to some degree. However, no opportunities to enhance the existing road crossing conditions, which fragment the NHS and habitat continuity to some degree, and create barriers to movement of wildlife under most flow conditions (see other natural environment factors below).	No permanent impacts as infill/re-grading at edges of structure is generally confined to existing road embankments. Provide opportunities to enhance the existing road crossing conditions (e.g. Provides for movement of fish and wildlife, including large mammals, such as deer). Habitat continuity can be re-instated along the channel (with some limitations related to vegetation control of channel and minor limitations re substrate sizing), and opportunities for provision of some habitat features through crossing itself.	Nominal direct impacts given existing conditions. Provide opportunities to enhance the existing road crossing conditions (e.g. Provides for movement of fish and wildlife, including large mammals, such as deer). Habitat continuity can be re-instated along the channel (with some limitations related to vegetation control of channel and minor limitations re substrate sizing), and opportunities for provision of some habitat features through crossing itself. However, little incremental benefit beyond 20 m span.
Fisheries	Fill slopes require extension of culvert with commensurate enclosure related impacts to habitat along channel sections ~30 m and ~15 m long on the up and downstream sides of road, respectively (e.g., local loss of solar and allochthanous inputs, removal of riparian vegetation, change in substrate composition and instream/overhanging cover), straightening of channel sections). See also directly related fluvial geomorphic implications and SAR/Redside Dace discussion.	No change to in-water habitat as no culvert works required. Potential for localized disturbance of riparian vegetation for construction access, similar to the 20 m and 70 m clear span structure alternatives. However, no opportunities for enhancement of channel and associated habitat conditions through existing culvert. There are no substrates and no low flow channel through the concrete box culvert, the floor of which is at same invert as the channel. See also directly related fluvial geomorphic	Temporary impacts to channel and associated fish habitat to remove the existing culvert and re-instate an open channel section under new bridge. Opportunity to enhance habitat conditions along the re-instated channel as much wider span reduces overbank channel velocities significantly and allows for use of more natural substrate composition. However, natural channel migration opportunities limited by inability to grow vegetation to maintain channel stability (or	Same temporary impacts to channel and associated fish habitat to remove the existing culvert and re-instate an open channel section under new bridge as 20 m span alternative. Slightly greater impacts to floodplain habitat. Nominal incremental enhancement opportunities relative to 20 m span. However, limited incremental opportunities beyond ~20 m span given limited opportunities to grow vegetation to maintain channel stability (or contribute to local food and cover sources) and same limitations w.r.t. channel stability.

Factors	Full Dundas Street Cross Section with 4:1 Slope and Culvert Extension	Reduced Dundas Street Cross Section with 2:1 slope and Retaining Walls	Replacement with Clear-span structure (~ 20 m)	Replacement with Clear-span structure Spanning Planning Level MBW (~ 70m)
	No opportunities for enhancement of channel and associated habitat conditions through existing culvert where there are no substrates and no low flow channel. Per fluvial geomorphic recommendations, naturalized bank remediation and bank re-grading works to improve floodplain connectivity, in conjunction with appropriate vegetation planting to enhance terrestrial insect production and overhanging cover, present enhancement opportunities generally in the up and downstream reaches.	implications and SAR/Redside Dace discussion. Per fluvial geomorphic recommendations, naturalized bank remediation and bank re-grading works to improve floodplain connectivity, in conjunction with appropriate vegetation planting to enhance terrestrial insect production and overhanging cover, present enhancement opportunities generally in the up and downstream reaches.	contribute to local food and cover sources). Without some degree of physical control on channel form and therefore location, channel likely to widen out laterally, reducing function, or 'blow-out' in storm events, with associated impacts such as erosion and downstream sediment release, channel splitting, potential barrier creation, etc. See also directly related fluvial geomorphic implications and SAR/Redside Dace discussion. Per fluvial geomorphic recommendations, naturalized bank remediation and bank re-grading works to improve floodplain connectivity, in conjunction with appropriate vegetation planting to enhance terrestrial insect production and overhanging cover, present enhancement opportunities generally and would further enhance habitat benefits associated with the alternative.	Same opportunities for additional incremental habitat enhancement up and downstream as other alternatives.
Species At Risk *Note:* *Category 1/Red zone, Category 2/Orange Zone and Category 3/Yellow Zone habitat per MNRF (2012) Categorizing and Protecting Habitat under the Endangered Species Act. Defined as:* • *Category 1/Red Zone: Redside Dace as bankfull channel* • *Category 2/Orange Zone: meander belt* • *Category 3/Yellow Zone: 30m each side of meander belt*	Enclosure in culvert extension and associated impacts to ~80 m^2 of red zone habitat (see Fisheries above, with additional site specific considerations pertaining to local food production and morphology, e.g., potential loss of pool habitat). Localized adjacent construction disturbance. Infill of ~2250 m^2 of orange zone habitat, of which the majority will become the new grassed embankment slope (new yellow zone habitat) and a small portion will be lost to the multi-use path on the west side. Removal of ~1870 m^2 of yellow zone embankment habitat for the road widening and multi-use path. Temporary disturbance of ~1005 m^2 of yellow zone habitat on the existing embankment for re-grading/widening of the embankment.	Infill of a small area ~80 m^2 of orange zone habitat in the southwest quadrant, which will become grassed embankment/yellow zone habitat. Removal of ~1315 m^2 of yellow zone embankment habitat for the road widening and multi-use path. Temporary disturbance of ~560 m^2 of yellow zone habitat on the existing embankment for re-grading/widening of the embankment. Alteration of ~650 m^2 of yellow zone habitat from valley habitat to grassed embankment. Re-instatement of ~160 m^2 of yellow zone/embankment habitat as open floodplain/orange zone habitat following construction of retaining wall.	Impacts to red zone habitat can be avoided, however, assuming objective is to remove the existing culvert and re-naturalize the channel section, re-naturalization work would temporarily impact ~ 100 m^2 (~55m x 1.8m bankfull) of channel/red zone habitat (see also Fisheries and Fluvial Geomorphic). Good opportunities to re-naturalize the habitat in the channel section now enclosed in the culvert under the new bridge (see also Fisheries and Fluvial Geomorphic). Infill of ~290 m^2 of orange zone habitat, which will become grassed embankment/yellow zone habitat. Removal of ~1760 m^2 of yellow zone embankment habitat for the road widening and multi-use path. Temporary disturbance of ~295 m^2 of yellow zone habitat on the existing embankment for re-	Slightly greater restoration and enhancement opportunities and incrementally less impacts than 20 m span alternative, specifically: Impacts and proposed restoration opportunities with culvert removal same as 20 m span alternative. Same 'temporary impacts' to red zone habitat to achieve benefit. Infill of ~65 m^2 of orange zone habitat, which will become grassed embankment/yellow zone habitat. Removal of ~1505 m^2 of yellow zone embankment habitat for the road widening and multi-use path. Temporary disturbance of ~20 m^2 of yellow zone habitat on the existing embankment for re-grading/widening of the embankment.

Factors	Full Dundas Street Cross Section with 4:1 Slope and Culvert Extension	Reduced Dundas Street Cross Section with 2:1 slope and Retaining Walls	Replacement with Clear-span structure (~ 20 m)	Replacement with Clear-span structure Spanning Planning Level MBW (~ 70m)
	Alteration of ~465 m^2 of yellow zone habitat from valley habitat to grassed embankment. SAR Summary: • ~80 m^2 of channel/red zone habitat impacted/enclosed in culvert extension. • ~2250 m^2 of orange zone habitat impacted, of which the majority will become the new grassed embankment slope and a small portion will be removed • ~3340 m^2 of yellow zone habitat impacted (~56% removed, ~30% is existing embankment temporarily disturbed for re-grading and 14% altered from valley habitat to grassed embankment).	SAR Summary: • ~80 m^2 of orange zone habitat impacted, which will become grassed embankment slope • ~2685 m^2 of yellow zone habitat impacted (~49% removed, ~21% is existing embankment temporarily disturbed for re-grading, 24% altered from valley habitat to grassed embankment and 6% re-instated as floodplain/orange zone habitat).	grading/widening of the embankment. Alteration of ~620 m^2 of yellow zone habitat from valley habitat to grassed embankment Re-instatement of ~315 m^2 of yellow zone/embankment habitat as open floodplain/orange zone habitat following removal of culvert and associated embankment. SAR Summary: • ~100 m^2 of channel/red zone habitat impacted/enclosed in culvert extension. • ~290 m^2 of orange zone habitat impacted, which will become grassed embankment slope • ~2990 m^2 of yellow zone habitat impacted (~59% removed, ~10% is existing embankment temporarily disturbed for re-grading, 21% altered from valley habitat to grassed embankment and 10% re-instated as floodplain/orange zone habitat). • Good opportunities to re-naturalize the habitat in the channel section now enclosed in the culvert under the new bridge.	Alteration of ~360 m^2 of yellow zone habitat from valley habitat to grassed embankment Re-instatement of ~785 m^2 of yellow zone/embankment habitat as open floodplain/orange zone habitat following removal of culvert and associated embankment SAR Summary: • ~100 m^2 of channel/red zone habitat impacted/enclosed in culvert extension. • ~65 m^2 of orange zone habitat impacted, which will become grassed embankment slope • ~2670 m^2 of yellow zone habitat impacted (~65% removed, ~1% altered from valley habitat to grassed embankment and 34% re-instated as floodplain/orange zone habitat). • Good opportunities to re-naturalize the habitat in the channel section now enclosed in the culvert under the new bridge.
Wildlife	Much longer culvert, further impeding potential wildlife movement and encroaching into valley, although existing potential limited under all but very low flow conditions as flow spreads across breadth of culvert. Limited opportunity to enhance wildlife movement other than retrofitting of culvert with hanging metal racks for movement of small animals.	The existing culvert already provides wildlife passage opportunities for small mammals to some degree. Nominal impact relative to existing conditions since no change in culvert. Limited opportunity to enhance wildlife movement other than retrofitting of culvert with hanging metal racks for movement of small animals	Significant benefit for movement of both small as well as large animals. Provide opportunities to improve movement of large mammals (e.g., White-tailed Deer) which can be accommodated with a span of ~20 m, which will provide a target OR of ~1.0 and enable provision of an opening height of ~2.5m (restriction at upstream end due to existing retaining wall).	No real commensurate benefit for movement of wildlife of wider structure beyond ~20m span. As clear span width increased, depth of deck also increases reducing height of opening for large mammals (restriction at upstream end due to existing retaining wall).
Vegetation	Removal of riparian and floodplain vegetation in ~2800 m^2 area of the valley for embankment fill encroachment. Vegetation generally disturbed. Upstream, comprised of predominantly Cultural	Nominal localized removal of roadside, riparian and floodplain vegetation for construction access for retaining wall immediately at the culvert.	Localized removal of roadside, riparian and floodplain vegetation for construction access to build new bridge and remove existing culvert. Structure height insufficient to allow much light	Localized removal of roadside, riparian and floodplain vegetation for construction access to build new bridge and remove existing culvert. Structure height insufficient to allow much light

Factors	Full Dundas Street Cross Section with 4:1 Slope and Culvert Extension	Reduced Dundas Street Cross Section with 2:1 slope and Retaining Walls	Replacement with Clear-span structure (~ 20 m)	Replacement with Clear-span structure Spanning Planning Level MBW (~ 70m)
	Meadow with small patch of Cattail Mineral Shallow Marsh in floodplain and young Cultural Woodland on valley slopes. Downstream, mid-aged Deciduous Forest on slope and Cultural Meadow with some wetland species and scattered deciduous trees in floodplain. Opportunities to enhance riparian vegetation up and downstream of new fill slopes could be pursued beyond new right-of-way.	Other opportunities to enhance riparian vegetation could also be pursued up and downstream independently of retaining wall construction.	penetration other than right at the inlet and outlet. Restoration and re-planting following construction could be combined with other opportunities to enhance riparian vegetation up and downstream of new bridge.	penetration other than right at the inlet and outlet. Restoration and re-planting following construction could be combined with other opportunities to enhance riparian vegetation up and downstream of new bridge.
Natural Environment Summary	**Not preferred** – most impact to Redside Dace habitat (red/orange/yellow zones) due to additional footprint. The longer culvert would impede wildlife movement and encroaching into valley.	**Moderately preferred** – Least impact to the Redside Dace habitat (red/orange/yellow zones) as the overall footprint will largely be the same as existing. Limited opportunities to enhance wildlife crossing for larger animals; however, the existing culvert already provides wildlife passage opportunities for small mammals.	**Moderately preferred** – Provide opportunities to enhance wildlife crossing for larger animals. However, greater impact to the Redside Dace habitat (red/orange/yellow zones) with the construction of a clear span structure.	**Preferred** – Provide slightly greater restoration and enhancement opportunities for Redside Dace habitat (red/orange/yellow zones) and incrementally less impacts than 20 m span alternative. Similar to the 20 m span alternative, it would provide opportunities enhance wildlife crossing for larger animals.
Drainage/Water Resources				
Hydrologic /Hydraulic	Existing culvert (good condition) is approximately 54 m in length and can accommodate Dundas Street widening. No overtopping of Dundas Street occurs during Regional Storm event.	Existing culvert (good condition) is approximately 54 m in length and can accommodate Dundas Street widening. No overtopping of Dundas Street occurs during Regional Storm event.	Water surface elevation immediately upstream of Dundas Street would be lowered by 0.08 m for the Regional Storm event.	Water surface elevation immediately upstream of Dundas Street would be lowered by 0.08 m for the Regional Storm event. Note that water surface elevations do not decrease further for bridge span of 70 m.
	In terms of quality control of storm runoff from Dundas Street, the "Jellyfish" filtration system is proposed since it is a regulated Redside Dace habitat watercourse. It would provide a higher level of quality control compared to conventional oil grit separator.			
Fluvial Geomorphic*	The creek upstream and downstream of the existing crossing is not in dynamic equilibrium. It is transitional and is adjusting to modifications including changes in hydrology. Downcutting and widening are the predominant fluvial processes with frequent bank slumping as a result. The channel is generally confined on the upstream side of Dundas Street and is partially confined downstream. The existing culvert is influencing local geomorphological processes. It is causing ponding upstream. Downstream a scour pool has formed and the culvert is outflanked by approximately 0.5 m on the right bank and by nearly 1.0 m on the left bank. There is no low flow channel through the culvert.			
	This alternative is the least preferred from a geomorphology perspective due to the direct loss of open watercourse under the proposed 4:1 road embankment. In total a culvert extension of ~30 m upstream and ~15 m downstream would be required. Tie in works would result in a loss of channel	This alternative maintains existing conditions. No culvert extension would be required. This is considered acceptable from a geomorphology perspective. It is not possible to create a low flow channel through the existing culvert as it is closed	This alternative is to replace the culvert with a wider structure that includes a low flow channel (approximately 44 m long through the structure) and an overbank zone to reduce in structure velocities compared to existing conditions. It would also allow for a proposed channel profile that ties in better to the creek inverts with	This alternative is to replace the culvert with a structure that spans the Meander Belt Width. The North Oakville Creeks Subwatershed Study (NOCSS) provides a planning-level meander belt width of 70 m for the C23 channel upstream of Dundas Street. This is based on topographic mapping and

Factors	Full Dundas Street Cross Section with 4:1 Slope and Culvert Extension	Reduced Dundas Street Cross Section with 2:1 slope and Retaining Walls	Replacement with Clear-span structure (~ 20 m)	Replacement with Clear-span structure Spanning Planning Level MBW (~ 70m)
	length of approximately 3 m in addition to the 47 m of culvert extension. It is not possible to create a low flow channel through the existing culvert as it is closed bottom (the channel would not match the creek profile upstream and downstream and it would have hydraulic capacity implications). Upstream and downstream of the crossing, bank remediation works (bioengineering), bank re-grading to improve floodplain connectivity, formalization of the scour pool and planting of a riparian corridor would improve this system. This would partially mitigate the loss of channel length but the culvert would continue to cause an impact on local geomorphology. Monitoring of bank erosion could be completed through repeat surveys to determine whether the culvert is at risk from erosion. This is not considered to be likely.	bottom (the channel would not match the creek profile upstream and downstream and it would have hydraulic capacity implications). Upstream and downstream of the crossing, bank remediation works (bioengineering), bank re-grading to improve floodplain connectivity and planting of a riparian corridor would improve this system. This would be a small enhancement over existing conditions but the culvert would continue to cause an impact on local geomorphology. Monitoring of bank erosion could be completed through repeat surveys to determine whether the culvert is at risk from erosion. This is not considered to be likely.	localised tie in works. Approximately 10 m of creek would be day lighted. This would be an enhancement from the existing conditions and is preferred from a geomorphic perspective. Bank remediation works (bioengineering), bank re-grading to improve floodplain connectivity and planting of a riparian corridor would further enhance this system.	would need to be refined should this be taken forward as a preferred alternative. This alternative would include construction of a low flow channel (approximately 44 m long through the structure) and creation of an overbank zone to reduce in structure velocities compared to existing conditions. It would also allow for a proposed channel profile that ties in better to the creek inverts with localised tie in works. Approximately 10 m of creek would be day lighted. This would be an enhancement from the existing conditions and is preferred from a geomorphic perspective. Bank remediation works (bioengineering), bank re-grading to improve floodplain connectivity and planting of a riparian corridor would further enhance this system.
Drainage / Water Resources Summary	**Not preferred** – The alternative would result in a direct loss of open watercourse due to culvert extension upstream and downstream.	**Moderately preferred** – This alternative is acceptable from a fluvial geomorphology perspective. Upstream and downstream of the crossing, bank remediation works (bioengineering), bank re-grading to improve floodplain connectivity and planting of a riparian corridor would improve this system and would provide an enhancement over existing conditions.	**Preferred** – The replacement of the existing culvert with a 20 m span structure would reduce in structure velocities compared to existing conditions and allow for a proposed channel profile that ties in better to the creek inverts. This would be an enhancement from a geomorphic perspective.	**Preferred** – Similar to the 20 m span structure alternative, the replacement of the existing culvert with a 70 m span structure would reduce in structure velocities compared to existing conditions and allow for a proposed channel profile that ties in better to the creek inverts. This would be an enhancement from a geomorphic perspective.
Geometric				
Vertical Profile	No change	No change	No change	No change
Sight Distance	No change	No change	No change	No change
Adjacent Intersection	No impact	No impact	No impact	No impact
Transit Facilities	No impact	No impact	No impact	No impact
Streetscaping Opportunities	New vegetation over grading area.	New vegetation in the proximity of the retaining walls.	May result in narrower median on structure. New vegetation in the proximity of the abutments.	May result in narrower median on structure. New vegetation in the proximity of the abutments.

Factors	Full Dundas Street Cross Section with 4:1 Slope and Culvert Extension	Reduced Dundas Street Cross Section with 2:1 slope and Retaining Walls	Replacement with Clear-span structure (~ 20 m)	Replacement with Clear-span structure Spanning Planning Level MBW (~ 70m)
Structure Condition	The most recent culvert inspection conducted by Halton Region indicated that the culvert is in good condition and only requires minor repairs. The length of the existing culvert will accommodate the widening for the roadway improvements (i.e. addition of bike lanes and multi-use paths); however, an extension of the culvert will be required to accommodate grading.	The most recent culvert inspection conducted by Halton Region indicated that the culvert is in good condition and only requires minor repairs. The length of the existing culvert will accommodate the widening for the roadway improvements (i.e. addition of bike lanes and multi-use paths). Retaining walls will be provided in this alternative for grading purposes; no extension of the culvert will be required.	The most recent culvert inspection conducted by Halton Region indicated that the culvert is in good condition and only requires minor repairs. The length of the existing culvert will accommodate the widening for the roadway improvements (i.e. addition of bike lanes and multi-use paths) and grading can be accommodated with the construction of retaining walls. From a roadway improvement perspective, the replacement with a clear-span structure is not required.	
Constructability/Staging	Very little impact due to work being outside of traffic lanes.	Construction (including the construction of the retaining walls) is expected to be generally contained within the temporary easement.	Dundas Street is already at 6 lanes through this area. Dundas Street may have to be reduced to 4 lanes during construction to facilitate construction staging (i.e. not feasible to maintain 6 lanes of traffic during construction). Lane reductions over period of construction will likely impact travel efficiency, travel time, travel reliability, emergency response time, and goods movement. Construction staging would be complex in order to maintain 4 lanes of traffic during construction. Access to Forestview Bible Church, and St. Luke's retirement home, which are in close proximity to C23, will have to be maintained during construction. Extension of existing culvert would be required during construction to accommodate temporary road detour for the construction of the new structure. Length of the road detour would be less compared to the 70 m span structure alternatives.	Dundas Street is already at 6 lanes through this area. Dundas Street may have to be reduced to 4 lanes during construction to facilitate construction staging (i.e. not feasible to maintain 6 lanes of traffic during construction). Lane reductions over period of construction will likely impact travel efficiency, travel time, travel reliability, emergency response time, and goods movement. Construction staging would be complex in order to maintain 4 lanes of traffic during construction. Accesses to Forestview Bible Church, and St. Luke's retirement home, which are in close proximity to C23, will have to be maintained during construction. Extension of existing culvert would be required during construction to accommodate temporary road detour for the construction of the new structure. Due to the proximity to the Valleyridge Drive intersection, the road detour may impact the operation of the intersection during construction.
Geometric Summary	**Moderately preferred** – Construction would lead to additional footprint impact to the valley. However, construction staging would be less complex compared to the construction of a clear span structure.	**Preferred** – Construction is expected to be generally contained within the temporary easement. Overall, construction staging would be significantly less complex compared to the construction of a clear span structure.	**Not preferred** – Construction staging would be complex and would lead to impacts to adjacent properties in addition to operational impacts to other corridors during construction.	**Not preferred** – Construction staging would be complex and would lead to impacts to adjacent properties and intersection in addition to operational impacts to other corridors during construction.
Capital Costs				
Order of Magnitude – Capital**	$260,000	$340,000	$3.0 M	$10.2 M

Factors	Full Dundas Street Cross Section with 4:1 Slope and Culvert Extension	Reduced Dundas Street Cross Section with 2:1 slope and Retaining Walls	Replacement with Clear-span structure (~ 20 m)	Replacement with Clear-span structure Spanning Planning Level MBW (~ 70m)
Summary	While the existing culvert is in good condition, it will have to be extended to accommodate the additional fill for the widening of Dundas Street. There will be some minor impacts to adjacent properties. From a natural environment perspective, it is the least preferred as it would have direct impacts to the valley due to the additional fill and would not have any opportunity to enhance wildlife crossing opportunities. This is also least preferred from a geomorphology perspective. **NOT RECOMMENDED**	The existing culvert is in good condition and would not have to be extended with the implementation of retaining walls. There will be no impact to adjacent properties. From a natural environment perspective, there will be limited impacts to the valley due to the retaining walls. The existing culvert already accommodates wildlife crossing of small animals. This is considered to be acceptable from a geomorphology perspective. Construction staging can be accommodated with minimal disruption to the community. This alternative is the best balance amongst all factors in the evaluation. **RECOMMENDED**	The existing culvert is in good condition but will be removed under this alternative and will be replaced with a 20 m span structure. There will be no direct impact to adjacent properties; however, construction staging will be complex and will be disruptive to the community. From a natural environment perspective, there will be impacts to the valley due to the new structure; however, it would offer enhancement opportunity to improve wildlife crossing to accommodate larger animals. This is considered to be an enhancement from a geomorphology perspective. Estimated construction cost is significantly higher (nearly 10 times) than the "2:1 slope and retaining walls" alternative. **NOT RECOMMENDED**	The existing culvert is in good condition but will be removed under this alternative and will be replaced with a 70 m span structure. There will be no direct impact to adjacent properties; however, construction staging will be complex and will be disruptive to the community (e.g. potential impacts to the Valleyridge Drive intersection). From a natural environment perspective, there will be some impacts to the valley due to the structure. It would offer enhancement opportunity to improve wildlife crossing to accommodate larger animals; however, not significantly better than the 20 m span alternative. **NOT RECOMMENDED**

* No hydraulic modelling is available at this time to compare velocities and shear stress between alternatives.
**Assume \$6000/m unit cost for culvert extension; \$800/m^2 unit cost for retaining wall, \$3800/m^2 unit cost for crossing structure