APPENDIX F

Fluvial Geomorphology Assessment

MEMO

TO: Ministry of Transportation of Ontario – Eastern Region

FROM: Peter Hayes, P.Geo., WSP and Emily Stephenson, P.Geo., WSP

SUBJECT: **Highway 401 Planning Study from Colborne to Brighton – Preliminary Design and Class Environmental Assessment Study (GWP 4054-17-00) – Four Structural Culverts Fluvial Geomorphology Assessment**

DATE: **August 30, 2023**

Project No.: **MTO GWP 4054-17-00 / WSP #17M-01712-11**

1 INTRODUCTION

WSP was retained by the Ontario Ministry of Transportation (MTO), Eastern Region to undertake the Planning, Preliminary Design and Class Environmental Assessment (Class EA) Study on Highway 401 for the replacement / rehabilitation of bridges and structural culverts, establishing the future Highway 401 footprint for an interim six lanes and ultimate eight lanes to address current and future transportation needs, and commuter parking lot improvements from 0.8 km east of Percy Street to 0.4 km west of Christiani Road (**Figure 1**). The study area traverses Northumberland County, the Township of Cramahe, Municipality of Brighton, and borders the City of Quinte-West and Hastings County. The Class EA involves the rehabilitation or replacement of seven bridges and culverts, and commuter parking lot improvements at County Road 30.

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This memo summarizes the fluvial geomorphology assessment for the four structural culvert replacements proposed as a part of this project. The site location is shown on attached **Figure 1**.

1.1 APPROACH

WSP's approach for the fluvial geomorphology assessment was as follows:

- Reviewing fisheries, drainage and hydrology assessments;
- Obtaining historical aerials;
- Adding watercourse alignments on historical aerials; including preparing a composite figure;
- Completing a site visit (including a site walk along the watercourse, collecting site photographs, measuring watercourse widths and depths and completing the Rapid Geomorphic Assessment form);
- Reviewing relevant guidance documents;
- Complete a 100-year erosion rate assessment and meander belt assessment; and
- Finally making recommendations for the culverts based on the findings.

2 BACKGROUND

2.1 SITE SETTING

The site is located in a rural area, with natural areas including forests, watercourses and wetlands, along with rural resident and agricultural land uses. All four structural culverts convey the Biddy Creek.

The site is in the South Slope physiographic regions as per Chapman and Putnam (1984), generally consisting of till. Surficial geology at the site consists of foreshore-basinal deposits with pockets of modern alluvial deposits, organic deposits, littoral-foreshore deposits and stone-poor, carbonate-derived silty to sandy till. Surficial geology is shown on attached **Figure 2**.

Topographic contours generally range from 175 m above sea level (masl) up to 225 masl. Topographic contours are shown on attached **Figure 1**.

2.2 DRAINAGE AND HYDROLOGY ASSESSMENT

Under a separate cover WSP (2023) prepared a Draft Drainage and Hydrology report. This report included an assessment for the four structural culverts, as well as the non-structural culverts. The following **Table 1** summaries the existing and proposed structural culverts.

Table 1: Existing and Proposed Structural Culvert Dimension (WSP, 2023)

Culvert	Existing Dimension (mm) and Type	Proposed Recommendations
471	4200 x 2400 Rigid Frame Box (RFB)	Replace with 4800 x 2400 mm box culvert embedded 300 mm

472	4200 x 2400 RFB	Replace with 4800 x 2400 mm box culvert embedded 300 mm
473	4200 x 2400 RFB	Replace with 4800 x 2400 mm box culvert embedded 300 mm
474	4200 x 2400 RFB	Replace with 4800 x 2400 mm box culvert embedded 300 mm

Based on WSP's assessment "All proposed structural culverts meet relevant design criteria and have a lower observed water level compared to existing conditions due to the flattening of the proposed culvert to better follow the watercourse slope and increased width of culvert" (WSP, 2023).

2.3 FISHERIES ASSESSMENT

Under a separate cover WSP (2021) completed a Fish and Fish Habitat Existing Conditions Investigation.

Between October 14th and 16th, 2020 WSP completed field investigations, the structural culvert findings are summarized in **Table 2** below.

Table 2: Existing Structural Culvert Fisheries Investigation Findings (WSP, 2021)

Culvert	Fish Habitat	Reach Sensitivity	Thermal Regime	Wetted Width / Depth (m)	Bankfull Width / Depth (m)	Bed Materials
471 (C3)	Direct	High	Coldwater	1.3 – 3 / 0.1 – 0.2	3 – 7 / 0.2 – 0.4	Gravel, sand, silt and clay
472 (C4)	Direct	High	Coldwater	2.3 – 3.5 / 0.1 – 0.3	2.4 – 4 / 0.5	Boulders, cobbles, gravel, sand and silt
473 (C5)	Direct	High	Coldwater	1.9 – 3.2 / 0.1 – 0.3	2.3 – 4 / 0.4 – 0.5	Cobbles, gravel and sand
474 (C6)	Direct	High	Coldwater	4.2 / 1.3	6.6 / 1.6	Cobbles, gravel, sand and muck

Design considerations finding for these culverts included the following:

- The timing window where work can occur is July 1st to September 30th;
- Design shall avoid disturbing spawning areas;
- Natural channel design should be completed by a fluvial geomorphologist for C3 and C6; and
- Culvert built on the same alignment as existing to avoid unnecessary realignments to tie the culverts into the channel, as well as no widening of the watercourse.

3 FLUVIAL GEOMORPHOLOGY ASSESSMENT

3.1 HISTORICAL AERIAL IMAGERY

As a part of the desktop background review, WSP retrieved aerial imagery of the site from 1929 to 2018 (1929, 1948, 1962, 1967, 1976, 1987, 1995, 2004, 2018), attached **Figures 3 to 12**. WSP approximated the channel for each available aerial and overlaid them onto one figure to highlight the historical variations of both watercourses (**Figure 13**). Watercourse alignments have various colours for individual historical aerial watercourse alignments such that each can be easily identified on the composite figure (**Figure 13**).

The area has remained a rural setting since 1929 to 2018, with agricultural and natural land uses. The Highway 401 corridor was added through the area between 1948 and 1962. Residential homes were added around Little Lake after 1948, by 1967 the entire lake was surrounded by residential homes.

Based on the composite **Figure 13**, the watercourse channel has been fairly consistent between 1929 and 2018, with some slight fluctuations generally within an approximate 50 m width.

3.2 FIELD VISIT

WSP completed a field visit at the site on June 9th, 2021, site photos are provided in **Appendix A**. During the site visit WSP noted the composition of the watercourse stream bed to consist of clay and silt, sand, gravel, cobbles, boulders; descriptions for individual culverts are provided in attached **Table 3**. Bed materials observed were comparable with the WSP fisheries observations (WSP, 2021), as summarized above in **Table 2**. No excessive erosion was observed during field inspections

WSP measured wetted and bankfull widths and depths, as provided in the attached **Table 3**. Wetted widths ranged between 1.0 and 5.3 m, with wetted depths between 0.03 and 0.9 m. Bankfull widths ranged between 1.8 and 6.3 m, with bankfull depths between 0.1 and 1.0 m.

Wetted and bank full field measurements were comparable with WSP fisheries observations (WSP, 2021), as summarized above in **Table 2**. WSP fisheries wetted widths ranged between 1.3 and 4.2 m, with wetted depths between 0.1 and 1.3 m. WSP fisheries bankfull widths ranged between 2.3 and 7 m, with bankfull depths between 0.2 and 1.6 m.

An average bankfull width of 4.4 m has been approximated based on the measured minimum and maximum bankfull widths of 1.8 m and 7m, respectfully.

WSP completed Rapid Geomorphic Assessment at the culverts, all were found to be in regime, with the exception of the downstream (South of Highway 401) Culvert 21-473 which was classified as transitional.

3.3 LATERAL AND DOWN-VALLEY EROSION RATES

As a part of this assessment measurements of the lateral (extension) and down valley (translation) 100-year erosion rates were completed based on the Toronto and Region

Conservation Authority (TRCA) (2015) *Crossing Guidelines for Valley and Corridors (Appendix 2.A)*.

The TRCA (2015) methodology is used in place of the Lower Trent Region Conservation Authority (LTRCA) (2022) 100-year erosion rate definition: the average annual rate of recession extended over a one hundred-year time span, as the TRCA (2015) includes a detailed methodology for estimating the erosion rate.

As per the TRCA (2015) erosion rates were measured for four meanders, typically this is completed for two meanders immediately upstream and downstream of each crossing; however, given the close proximity of the four crossing a total of four meanders in the vicinity of all the crossings were assessed. Watercourse alignments for the historical aerial images (1929, 1948, 1962, 1967, 1987, 2004 and 2018; an 89-year timespan) were overlaid onto **Figure B-1** for comparison, provided in **Appendix B**. Meander wavelengths and meander amplitudes were then marked-up for each of the assessed meanders. Finally, meander extension (lateral migration) and meander translation (down-valley migration) values were measured for each meander, as possible some outliers were not included.

Based on the TRCA (2015) *"the 100-year migration rate of the watercourse channel in the vicinity of the crossing are assumed equal to the migration rate of the bend immediately upstream of the crossing, or the average rate of the four bends measured in the analysis, whichever is greater".*

As depicted on **Figure B-1** in **Appendix B** the lateral migration (extension) values ranged from approximately 17 m to 32 m and the down-valley migration (translation) values ranged from approximately 42 m to 60 m, with an overall average of 35 m. Based on this assessment the 100-year extension / translational erosion rate for this watercourse at these four structural culverts is 39 m (based on the average / timeframe; 35 m / 89 years times 100 years).

3.4 MEANDER BELT ASSESSMENT

The Parish Geomorphic Ltd. (2001) meander belt assessment procedure has been used in place of the LTRCA as there is no clear meander belt assessment procedure defined in the LTRCA (2022).

As per Parish Geomorphic Ltd. (2001) *"Meander belt width is a term that quantifies the lateral extent of a river's occupation on the floodplain. The meander belt is measured for a reach between lines drawn tangentially to the outside bends of the laterally extreme meander bends in a reach."*

As a part of this investigation WSP completed a meander belt assessment in accordance with Parish Geomorphic (2004) Belt Width Delineation Procedures – Accurate Quantification I (when the hydrologic regime of the subject watercourse is not expected to be altered) for a simple meander pattern in a partially confined valley setting.

Valley Settings are defined as follows:

— Unconfined – where there are no natural limits or controls on the spatial occupation of the floodplain by a watercourse

- Partially confined – where the meander bends are adjacent to only one valley wall with the reach. The watercourse is restricted in migration and floodplain occupation along one side of the valley
- Confined – where meander bends are adjacent to both valley walls within the reach; the watercourse may be restricted from occupying it potential meander belt by the valley walls
- Incised – where the watercourse is actively incising into the floodplain or valley

To complete the meander belt assessment WSP compiled the aerial imagery (1929, 1948, 1962, 1967, 1987, 2004 and 2018; an 89-year timespan) onto one figure for comparison. WSP outlined the meander belt and the meander axis on **Figure B-2** based on Parish Geomorphic (2004). This figure is provided in **Appendix B**. The following are the assumptions and limitations associated with this method:

Assumptions

- The meander migration and evolution processes that occur within the reach will continue to occur into the future; and
- The meander belt, as defined in Parish Geomorphic (2004), encompasses the area in which all future meandering and migration tendencies of the watercourse are anticipated to occur.

Limitations

- Calculated meander migration rates are dependant on quality and time-span of historical air photo record;
- Precise direction and sequence of meander evolution and migration direction cannot be easily predicted;
- Meander belt does not take into account any consideration of geotechnical slope set-backs for valley walls (e.g. confined or partially confined setting);
- Accuracy of meander belt is dependent on the care taken to complete the work described in this document; and
- There is some subjectivity in the meander belt delineation procedure although when it is defined by a practitioner who has a general appreciation of planform processes the subjectivity decreases.

Next WSP used the Parish Geomorphic (2004) equation for when no change in hydrology is anticipated, and the meander belt is greater then 50 metres to calculate the final belt width (Procedure 2). From the compiled figure WSP estimated the average meander belt width of 71 m, with the exclusion of some outliers. From the maximum field bankfull widths range of 1.8 m to 7 m (measure as a part of this investigation and the Fish and Fish Habitat Existing Conditions (WSP, 2021)) WSP calculated an average field bankfull width of 4.4 m. No shift in the belt axis was observed from the historical aerial assessment.

*Final Belt Width = (average meander belt width + the average field bankfull width) * 1.10 + 100 year shift in belt axis*

*As such Final Belt Width = (71 m + 4.4 m)*1.10 + 0 =* ***75 m***

The final meander belt width for this watercourse at these four structural culverts is 75 m.

3.5 CROSSING GUIDELINES FOR VALLEY AND STREAM CORRIDORS ASSESSMENT

A meander belt and erosion rate analyses were performed to assess the risk associated with migration of the watercourse channel across the floodplain and the potential for future destructive contact between the channel and crossing / road infrastructure. All to minimize the risk of channel contact with abutments, footings and fill slopes.

In order to assess whether channel migration will affect the proposed structure the migration rate should be applied to the existing plan form with the watercourse such that the future location of the channel within the anticipated structure lifespan has been accounted for.

In the plan form when extended and then translated according to the calculated erosion rate, falls outside the proposed crossing structure opening, the width of the opening should be increased to accommodate the anticipated future alignment to the watercourse. As noted above if the projected future plan form is narrower than the crossing structure opening a reduction in the opening size may be considered.

It is evident from the review of the 89 year period of aerial photography that the channel meanders have been relatively static and no excessive erosion was observed during field inspections. All of which would indicate that the existing / and larger proposed culvert sizing is not an adverse constraint with respect to the natural channel meander migration and form. However, as proposed culverts are sized smaller than the meander belt, erosion protection will be required and must be added to the design for review by a fluvial geomorphologist.

Additionally, WSP completed a review the preliminary culvert general arrangements, provided in **Appendix C,** and noted that each of the proposed culvert locations have been shifted from the existing culvert locations and will require stream channel tie-in.

Additional topographic surveys at the existing and proposed channel inlet and outlet locations will be required as a part of detailed design of the channel connections so as to facilitate the incorporation al fluvial geomorphological features / erosion protection as appropriate for the connecting channel tie in.

4 CONCLUSIONS AND RECOMMENDATIONS

Based on the fluvial assessment the following conclusion and recommendations are presented:

1. Based on the Drainage and Hydrology Study (WSP, 2023) the existing structural culverts are 4200 x 2400 RFB and the proposed structural culverts are 4800 x 2400 mm box culvert embedded 300 mm.
2. Based on the Fish and Fish Habitat Existing Conditions Investigation (WSP, 2021) it was recommended that natural channel design should be completed by a fluvial geomorphologist for C3 and C6 during the detailed design phase.
3. Based on WSP's review of the preliminary general arrangements all four culverts will require additional topographic surveys at the detailed design phase for existing and proposed channel inlet and outlet locations to facilitate the incorporation of natural channel fluvial geomorphological features and erosion protection as appropriate in the connecting channel tie in design.
4. Based on the historical aerials, the area is rural and the channel meanders have been relatively static

5 Based on the field visit for this investigation and the Fish and Fish Habitat Existing Conditions report (WSP, 2021) the watercourse has an average bankfull width of 4.4 m based on measured bankfull widths between 1.8 m and 7 m. No excessive erosion was observed during field inspections

6 The watercourse was generally found to be in regime based on the rapid geomorphic assessments, with one exception where it was found to be transitional, Culvert 21-473.

7 Based on the lateral (extension) and down-valley (translation) erosion rate assessment (TRCA, 2015) this watercourse was found to have a 100 year extension / translational erosion rate of 39 m.

8 Based on the meander belt assessment (Parish Geomorphic, 2004) this watercourse was determined to have a final belt width of 75 m.

9 Based on this fluvial assessment the proposed culvert sizes are smaller than the calculated meander belt; however, the culvert sizes are slightly larger than the average bankfull width. Therefore eroison protection will be required at the culverts and must be added to the design drawings during detail design for review by a fluvial geomorphologist.

5 REFERENCES

- Chapman, L.J. and Putnam, D.F., 1984. The Physiography of Southern Ontario, Ontario Geological Survey Special Volume 2.
- Lower Trent Region Conservation Authority, 2022. Ontario Regulation 163/06 Policy Document. URL: https://ltc.on.ca/newContent/LTC%20OReg163-06%20Policy%20Document-2022-02-10%20Approved.pdf
- Parish Geomorphic, 2004. Belt Width Delineation Procedures prepared for the Toronto and Region Conservation Authority.
- Toronto and Region Conservation, 2015. Crossings Guideline for Valley and Stream Corridors.
- WSP, 2021. Fish and Fish Habitat Existing Conditions Report. Environmental Assessment and Preliminary Design along Highway 401 from 0.8 km East of Percy Street to 0.4 km West of Christiani Road.
- WSP, 2023. Draft Highway 401 Colborne to Brighton Drainage and Hydrology Study and Preliminary Design Report.

ATTACHMENTS:

Table 3: Field Visit Summary
Figure 1: Site Plan
Figure 2: Surficial Geology
Figure 3 through 12: Individual Historical Aerials (1929, 1948, 1966, 1967, 1976, 1987, 1995, 2004, 2018)
Figure 13: Historical Watercourse Composite
Appendix A: Site Photographs
Appendix B: Erosion Rate and Meander Belt Assessment Figures
Appendix C: Preliminary General Arrangements

TABLE

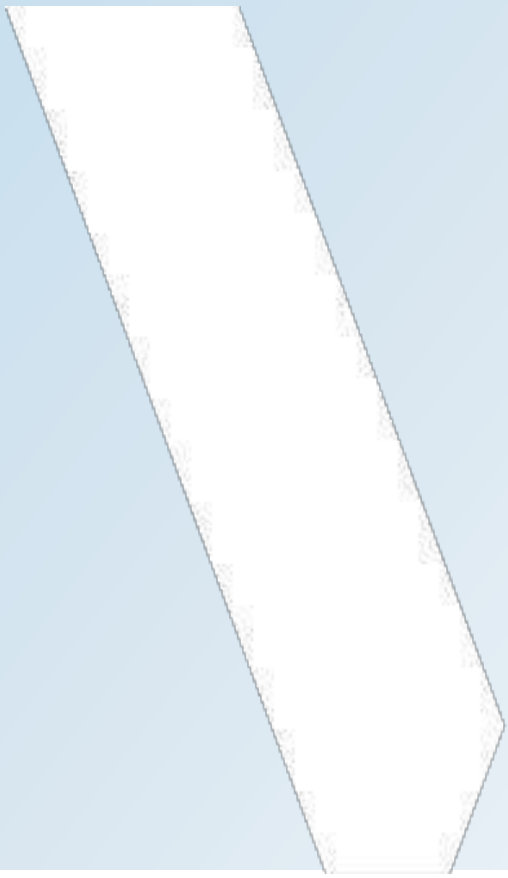
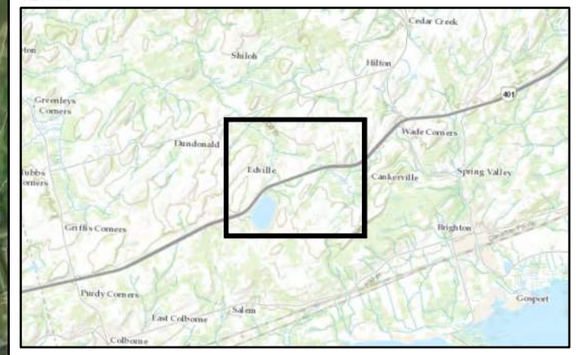


Table 3: Field Visit Summary
Highway 401 Colborne to Brighton - 4 Structural Culverts Fluvial Geomorphology Assessment

Culvert	Location		Bed Material	RGA Classification	Riffle				Pool				Run			
					Wetted		Bankfull		Wetted		Bankfull		Wetted		Bankfull	
					Width (m)	Depth (m)	Width (m)	Depth (m)	Width (m)	Depth (m)	Width (m)	Depth (m)	Width (m)	Depth (m)	Width (m)	Depth (m)
21-471	Upstream	South of Hwy 401	Clay and Silt	In Regime					2.84	0.22	5.59	0.93	3.50	0.15	6.30	0.84
21-471	Downstream	North of Hwy 401	Clay and Silt	In Regime					3.30	0.14	3.50	0.20	4.20	0.08	4.70	0.18
									2.60	0.16	3.10	0.22	2.20	0.05	3.10	0.12
21-472	Upstream	South of Hwy 401	Sand, Gravel, Cobbles and Boulders	In Regime	3.09	0.10	3.50	0.35	2.89	0.33	3.78	0.39	2.90	0.12	3.87	0.73
21-472	Downstream	North of Hwy 401	Sand, Gravel and Cobbles	In Regime	1.20	0.03	3.56	0.22					1.00	0.03	3.31	0.17
21-473	Upstream	North of Hwy 401	Sand, Gravel and Cobbles	In Regime	2.56	0.03	3.36	0.23	2.50	0.20	3.25	0.40	2.23	0.10	4.30	0.60
21-473	Downstream	South of Hwy 401	Silt, Sand, Gravel, Cobbles and Boulders	Transitional	1.25	0.10	1.84	0.35	2.58	0.50	3.09	0.73	2.18	0.16	2.50	0.42
					1.78	0.10	2.80	0.56	1.96	0.18	3.30	0.33	2.30	0.11	2.94	0.57
					1.76	0.05	3.73	0.23	2.74	0.30	3.45	0.60	1.40	0.15	3.59	0.52
21-474	Upstream	South of Hwy 401	Sand and Gravel	In Regime					5.34	0.75	5.60	0.86				
21-474	Downstream	North of Hwy 401	Not Visible	In Regime					3.10	0.90	4.20	1.00				

FIGURES

KEY MAP



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LEGEND

- CULVERT
- WATERCOURSE
- TOPOGRAPHIC CONTOUR (mASL)
- WATERBODIES
- WETLAND

DRAFT

0 145 290 580

SCALE 1:15,000 METRES

NOTE(S)

1. ALL LOCATIONS ARE APPROXIMATE

REFERENCE(S)

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SOURCE: ESRI, MAXAR, EARTHSTAR GEOGRAPHICS, AND THE GIS USER COMMUNITY
3. COORDINATE SYSTEM: NAD 1983 UTM ZONE 18N

CLIENT
MINISTRY OF TRANSPORTATION

PROJECT
FLUVIAL ASSESSMENT
HIGHWAY 401 - COLBORNE TO BRIGHTON

TITLE
SITE LOCATION

CONSULTANT

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PREPARED	JJ
REVIEWED	PH
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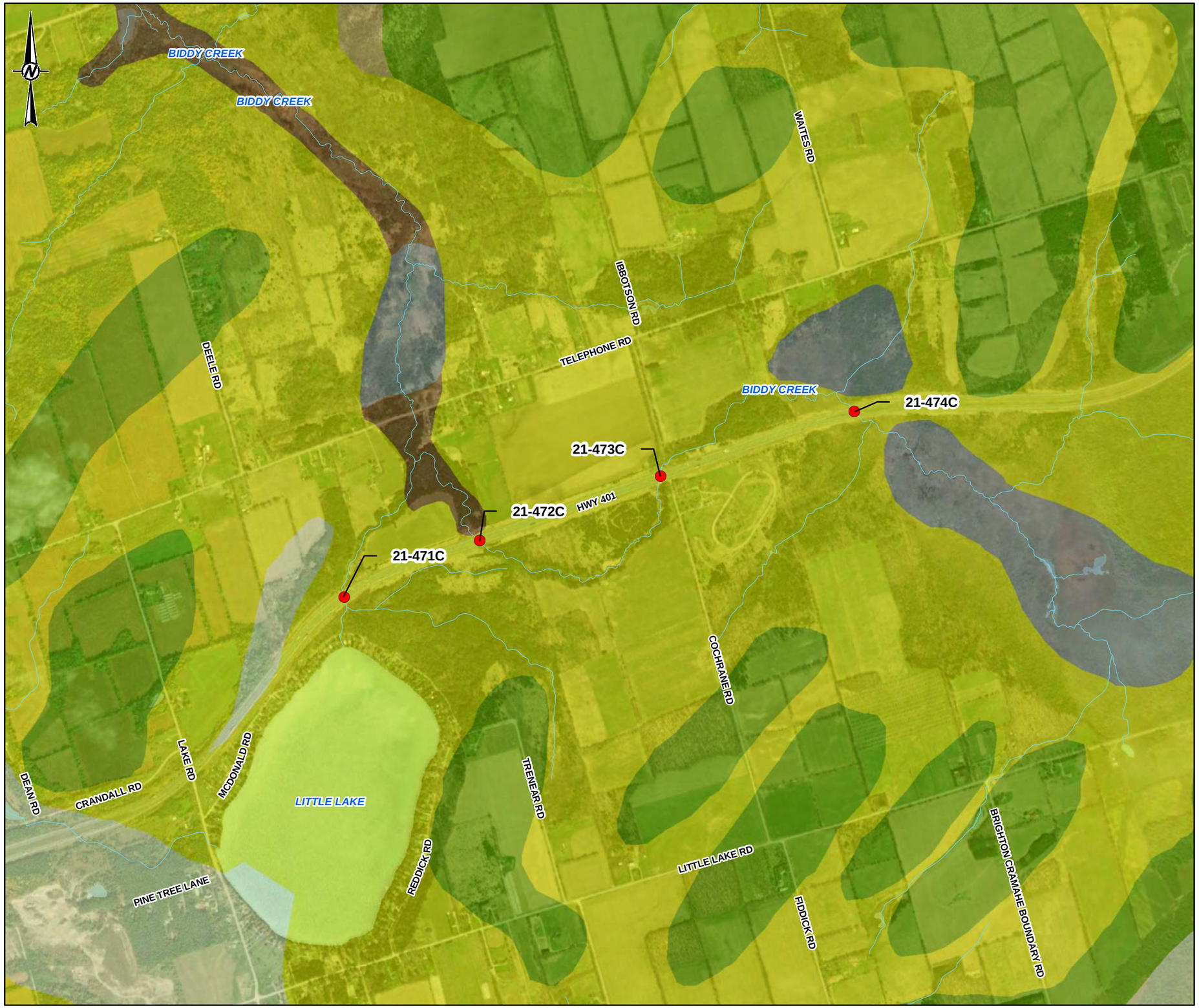

LEGEND

- CULVERT
- WATERCOURSE
- WATERBODIES
- MODERN ALLUVIAL DEPOSITS
- ORGANIC DEPOSITS
- STONE-POOR, CARBONATE-DERIVED SILTY TO SANDY TILL
- SANDY DEPOSITS
- LITTORAL-FORESHORE DEPOSITS
- FORESHORE-BASINAL DEPOSITS

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SCALE 1:15,000 METRES

NOTE(S)

1. ALL LOCATIONS ARE APPROXIMATE

REFERENCE(S)

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3. COORDINATE SYSTEM: NAD 1983 UTM ZONE 18N
4. SURFICIAL GEOLOGY OF SOUTHERN ONTARIO, OGS, MRD 128 - REVISED

CLIENT
MINISTRY OF TRANSPORTATION

PROJECT
FLUVIAL ASSESSMENT
HIGHWAY 401 - COLBORNE TO BRIGHTON

TITLE
SURFICIAL GEOLOGY

CONSULTANT

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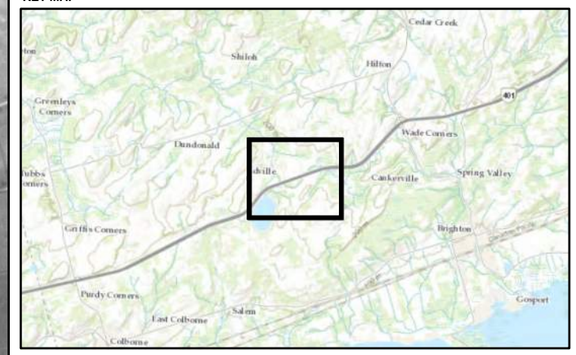

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LEGEND

- CULVERT
- 1929 WATER COURSE

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NOTE(S)

1. ALL LOCATIONS ARE APPROXIMATE

REFERENCE(S)

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CLIENT
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PROJECT
FLUVIAL ASSESSMENT
HIGHWAY 401 - COLBORNE TO BRIGHTON

TITLE
1929 AERIAL PHOTOGRAPH

CONSULTANT

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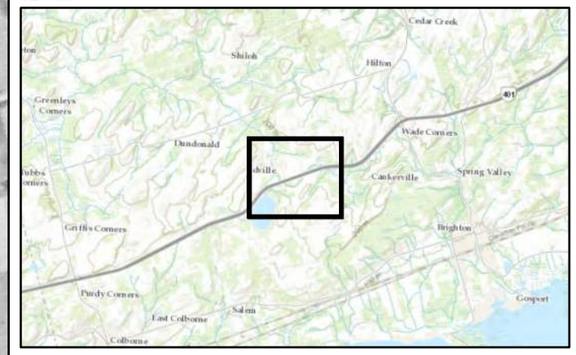

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LEGEND

- CULVERT
- 1948 WATERCOURSE

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NOTE(S)

1. ALL LOCATIONS ARE APPROXIMATE

REFERENCE(S)

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2. COORDINATE SYSTEM: NAD 1983 UTM ZONE 18N

CLIENT
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PROJECT
FLUVIAL ASSESSMENT
HIGHWAY 401 - COLBORNE TO BRIGHTON

TITLE
1948 AERIAL PHOTOGRAPH

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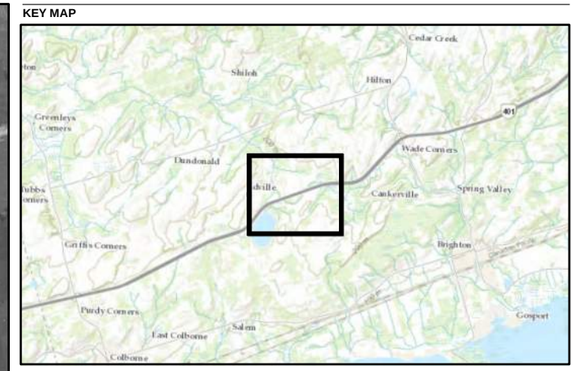

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LEGEND

- CULVERT
- 1962 WATERCOURSE

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0 95 190 380

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NOTE(S)

1. ALL LOCATIONS ARE APPROXIMATE

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CLIENT
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PROJECT
FLUVIAL ASSESSMENT
HIGHWAY 401 - COLBORNE TO BRIGHTON

TITLE
1962 AERIAL PHOTOGRAPH

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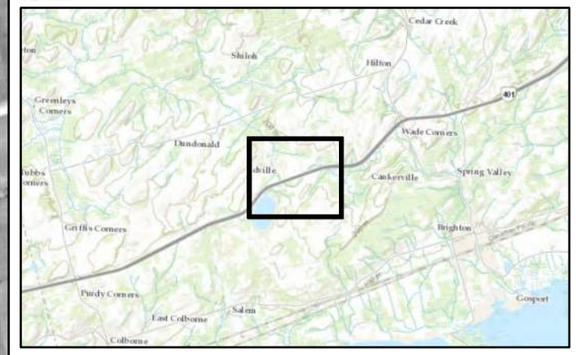
17M-01712-11	0003	A	5

KEY MAP



SCALE 1:200,000

LEGEND

- CULVERT
- 1967 WATERCOURSE

DRAFT

0 95 190 380

SCALE 1:10,000 METRES

NOTE(S)

1. ALL LOCATIONS ARE APPROXIMATE

REFERENCE(S)

1. BASEMAP: NATIONAL AIRPHOTO LIBRARY
2. COORDINATE SYSTEM: NAD 1983 UTM ZONE 18N

CLIENT

MINISTRY OF TRANSPORTATION

PROJECT

FLUVIAL ASSESSMENT
HIGHWAY 401 - COLBORNE TO BRIGHTON

TITLE

1967 AERIAL PHOTOGRAPH

CONSULTANT

wsp

YYYY-MM-DD	2023-04-25
DESIGNED	JJ
PREPARED	JJ
REVIEWED	PH
APPROVED	----

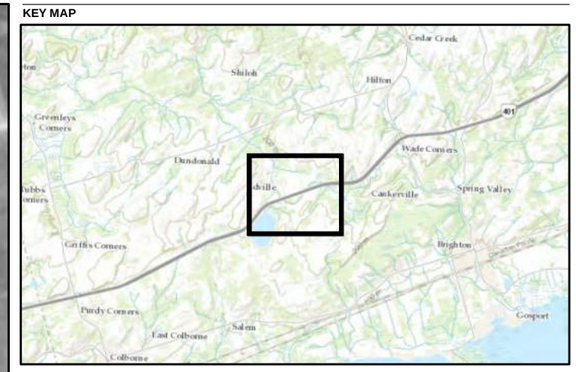
PROJECT NO.	CONTROL	REV.	FIGURE
17M-01712-11	0003	A	6

PATH: S:\Clients\MTO\Hwy_401_Colborne_to_Brighton\99_PROJ\17M-01712-11_EIA\40_PROD\0003_Fluvial\17M-01712-11-0003-HS-0006-1967.mxd PRINTED ON: 2023-04-25 AT: 11:00:27 PM

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

0 25mm

KEY MAP



SCALE 1:200,000

LEGEND

- CULVERT
- 1976 WATERCOIRSE

DRAFT

0 95 190 380

SCALE 1:10,000 METRES

NOTE(S)

1. ALL LOCATIONS ARE APPROXIMATE

REFERENCE(S)

1. BASEMAP: NATIONAL AIRPHOTO LIBRARY
2. COORDINATE SYSTEM: NAD 1983 UTM ZONE 18N

CLIENT
MINISTRY OF TRANSPORTATION

PROJECT
FLUVIAL ASSESSMENT
HIGHWAY 401 - COLBORNE TO BRIGHTON

TITLE
1976 AERIAL PHOTOGRAPH

CONSULTANT

YYYY-MM-DD	2023-04-25
DESIGNED	JJ
PREPARED	JJ
REVIEWED	PH
APPROVED	----

PROJECT NO.	CONTROL	REV.	FIGURE
17M-01712-11	0003	A	7

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25mm

0

PATH: S:\Client\MTO\Hwy_401_Colborne_to_Brighton\99_PRO\17M-01712-11_EIA\40_PROD\0003_Fluvial\17M-01712-11-0003-HS-0007-1976.mxd PRINTED ON: 2023-04-25 AT: 11:01:47 PM

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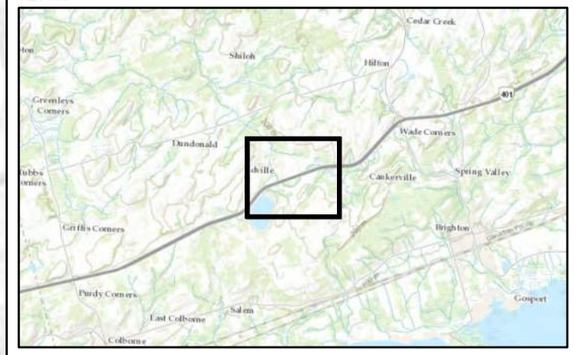


SCALE 1:200,000

LEGEND

- CULVERT
- 1987 WATERCOURSE

DRAFT

0 95 190 380

SCALE 1:10,000 METRES

NOTE(S)

1. ALL LOCATIONS ARE APPROXIMATE

REFERENCE(S)

1. BASEMAP: NATIONAL AIRPHOTO LIBRARY
2. COORDINATE SYSTEM: NAD 1983 UTM ZONE 18N

CLIENT
MINISTRY OF TRANSPORTATION

PROJECT
FLUVIAL ASSESSMENT
HIGHWAY 401 - COLBORNE TO BRIGHTON

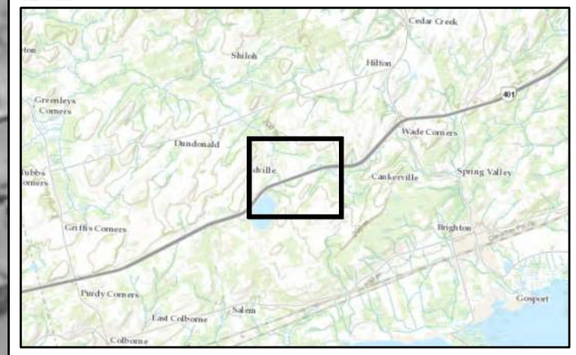
TITLE
1987 AERIAL PHOTOGRAPH

CONSULTANT

YYYY-MM-DD	2023-04-25
DESIGNED	JJ
PREPARED	JJ
REVIEWED	PH
APPROVED	----

PROJECT NO.	CONTROL	REV.	FIGURE
17M-01712-11	0003	A	9

KEY MAP



SCALE 1:200,000

LEGEND

- CULVERT
- 1995 WATERCOURSE

DRAFT

0 95 190 380

SCALE 1:10,000 METRES

NOTE(S)

1. ALL LOCATIONS ARE APPROXIMATE

REFERENCE(S)

1. BASEMAP: NATIONAL AIRPHOTO LIBRARY
2. COORDINATE SYSTEM: NAD 1983 UTM ZONE 18N

CLIENT
MINISTRY OF TRANSPORTATION

PROJECT
FLUVIAL ASSESSMENT
HIGHWAY 401 - COLBORNE TO BRIGHTON

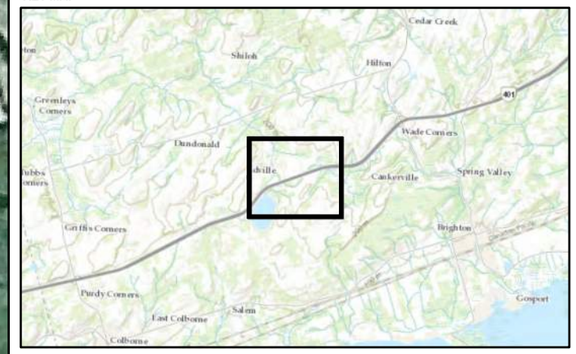
TITLE
1995 AERIAL PHOTOGRAPH

CONSULTANT
wsp

YYYY-MM-DD	2023-04-25
DESIGNED	JJ
PREPARED	JJ
REVIEWED	PH
APPROVED	----

PROJECT NO.	CONTROL	REV.	FIGURE
17M-01712-11	0003	A	10

KEY MAP



SCALE 1:200,000

LEGEND

- CULVERT
- 2004 WATERCOURSE

DRAFT

0 95 190 380

SCALE 1:10,000 METRES

NOTE(S)

1. ALL LOCATIONS ARE APPROXIMATE

REFERENCE(S)

1. BASEMAP: NATIONAL AIRPHOTO LIBRARY
2. COORDINATE SYSTEM: NAD 1983 UTM ZONE 18N

CLIENT
MINISTRY OF TRANSPORTATION

PROJECT
FLUVIAL ASSESSMENT
HIGHWAY 401 - COLBORNE TO BRIGHTON

TITLE
2004 AERIAL PHOTOGRAPH

CONSULTANT

YYYY-MM-DD	2023-04-25
DESIGNED	JJ
PREPARED	JJ
REVIEWED	PH
APPROVED	----

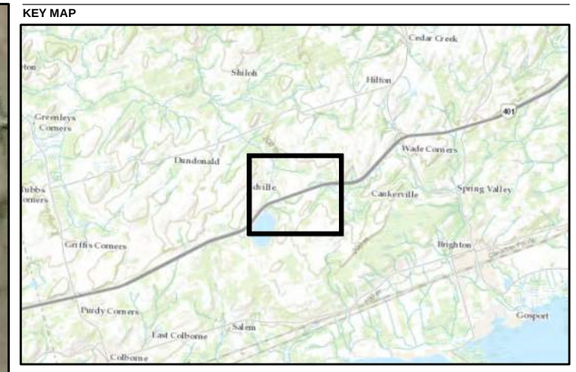
PROJECT NO.	CONTROL	REV.	FIGURE
17M-01712-11	0003	A	11

PATH: S:\Clients\MTO\Hwy_401_Colborne_to_Brighton\99_PROJ\17M-01712-11_EIA\40_PROD\0003_Fluvial\17M-01712-11-0003-HS-0011-2004.mxd PRINTED ON: 2023-04-25 AT: 11:06:13 PM

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

0 25mm

KEY MAP



SCALE 1:200,000

LEGEND

- CULVERT
- 2018 WATERCOURSE

DRAFT

0 95 190 380

SCALE 1:10,000 METRES

NOTE(S)

1. ALL LOCATIONS ARE APPROXIMATE

REFERENCE(S)

1. BASEMAP: NATIONAL AIRPHOTO LIBRARY
2. COORDINATE SYSTEM: NAD 1983 UTM ZONE 18N

CLIENT
MINISTRY OF TRANSPORTATION

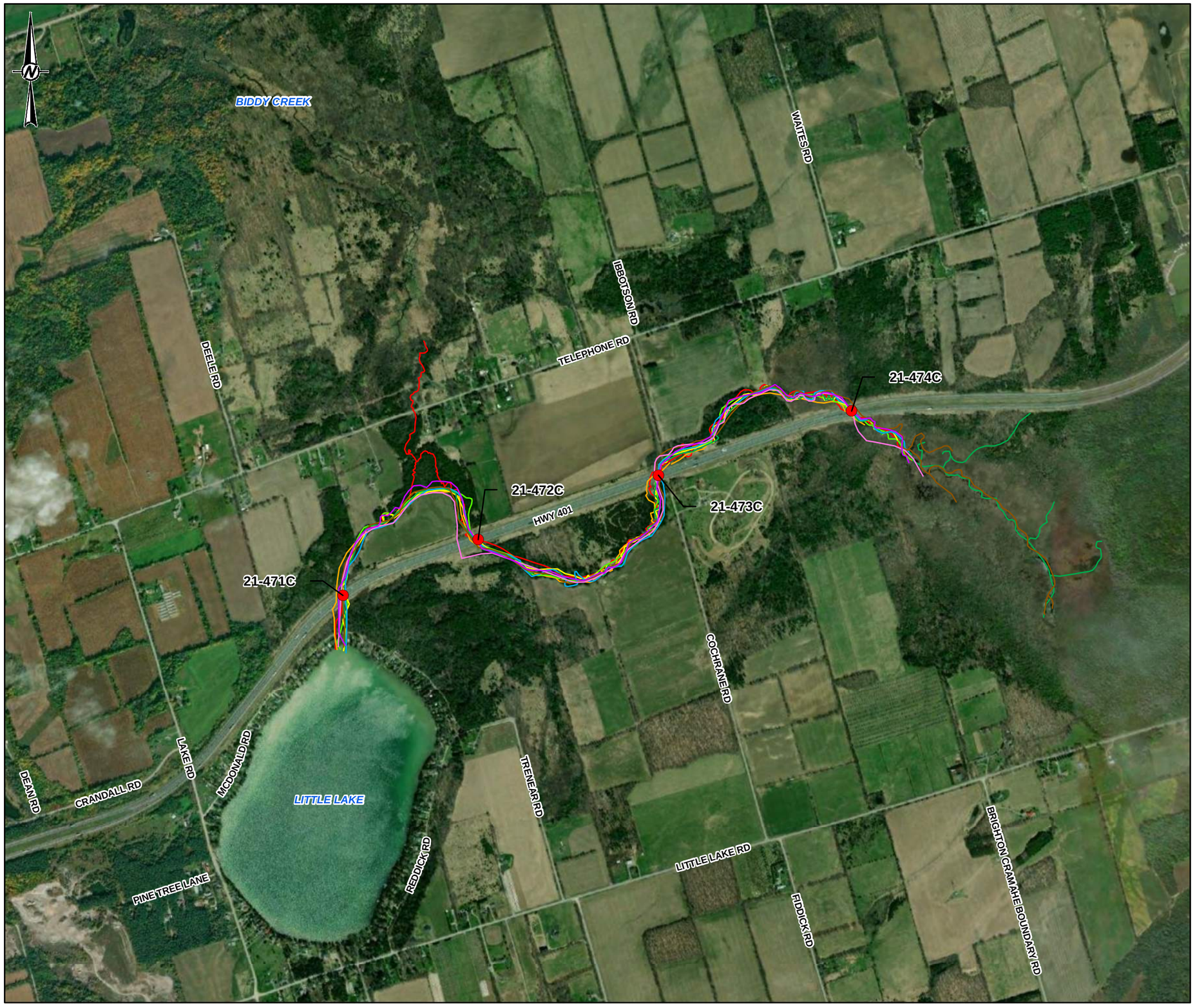
PROJECT
FLUVIAL ASSESSMENT
HIGHWAY 401 - COLBORNE TO BRIGHTON

TITLE
2018 AERIAL PHOTOGRAPH

CONSULTANT

YYYY-MM-DD	2023-04-25
DESIGNED	JJ
PREPARED	JJ
REVIEWED	PH
APPROVED	----

PROJECT NO.	CONTROL	REV.	FIGURE
17M-01712-11	0003	A	12



LEGEND

- CULVERT
- 2018 WATERCOURSE
- 2004 WATERCOURSE
- 1995 WATERCOURSE
- 1987 WATERCOURSE
- 1976 WATERCOURSE
- 1967 WATERCOURSE
- 1962 WATERCOURSE
- 1948 WATERCOURSE
- 1929 WATER COURSE

DRAFT

0 145 290 580

SCALE 1:15,000 METRES

NOTE(S)

1. ALL LOCATIONS ARE APPROXIMATE

REFERENCE(S)

1. BASEMAP: NATIONAL AIRPHOTO LIBRARY
2. COORDINATE SYSTEM: NAD 1983 UTM ZONE 18N

CLIENT
MINISTRY OF TRANSPORTATION

PROJECT
FLUVIAL ASSESSMENT
HIGHWAY 401 - COLBORNE TO BRIGHTON

TITLE
COMPILED HISTORICAL WATERCOUSES

CONSULTANT

YYYY-MM-DD	2023-04-25
DESIGNED	JJ
PREPARED	JJ
REVIEWED	PH
APPROVED	----

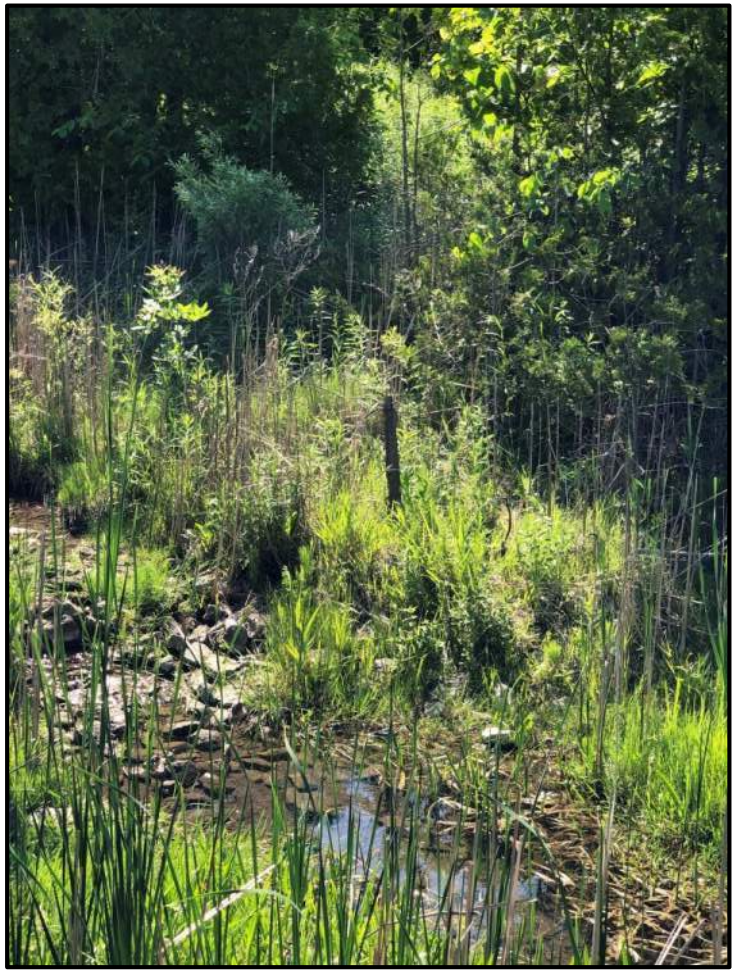
PROJECT NO.	CONTROL	REV.	FIGURE
17M-01712-11	0003	A	13

APPENDIX

A SITE PHOTOGRAPHS

Highway 401 Colborne to Brighton – Site Photos June 9, 2021

Culvert 21-471 Downstream – North of Highway 401



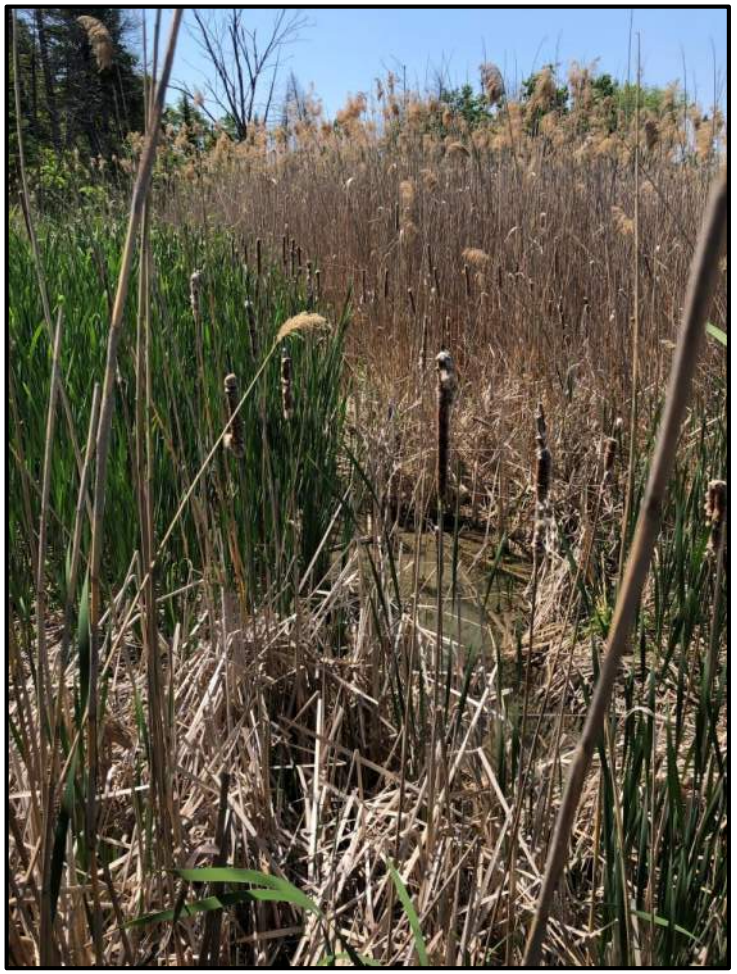
Looking upstream (South) from approximately 10m downstream of the culvert

Looking downstream (North) from approximately 10m downstream of the culvert

Highway 401 Colborne to Brighton – Site Photos June 9, 2021

Culvert 21-471 Upstream – South of Highway 401

Looking upstream (South) from the culvert



Looking upstream (South) from the culvert

Highway 401 Colborne to Brighton – Site Photos June 9, 2021

Culvert 21-472 Downstream – North of Highway 401

Looking upstream (South) from the culvert

Looking downstream (North) from the culvert

Highway 401 Colborne to Brighton – Site Photos June 9, 2021

Culvert 21-472 Upstream – South of Highway 401

Looking downstream (North) from approximately 5m upstream of the culvert

Looking upstream (South) from the culvert

Highway 401 Colborne to Brighton – Site Photos June 9, 2021

Culvert 21-473 Downstream – South of Highway 401

Looking upstream (North) from approximately 10m downstream of the culvert

Looking downstream (South) from the culvert

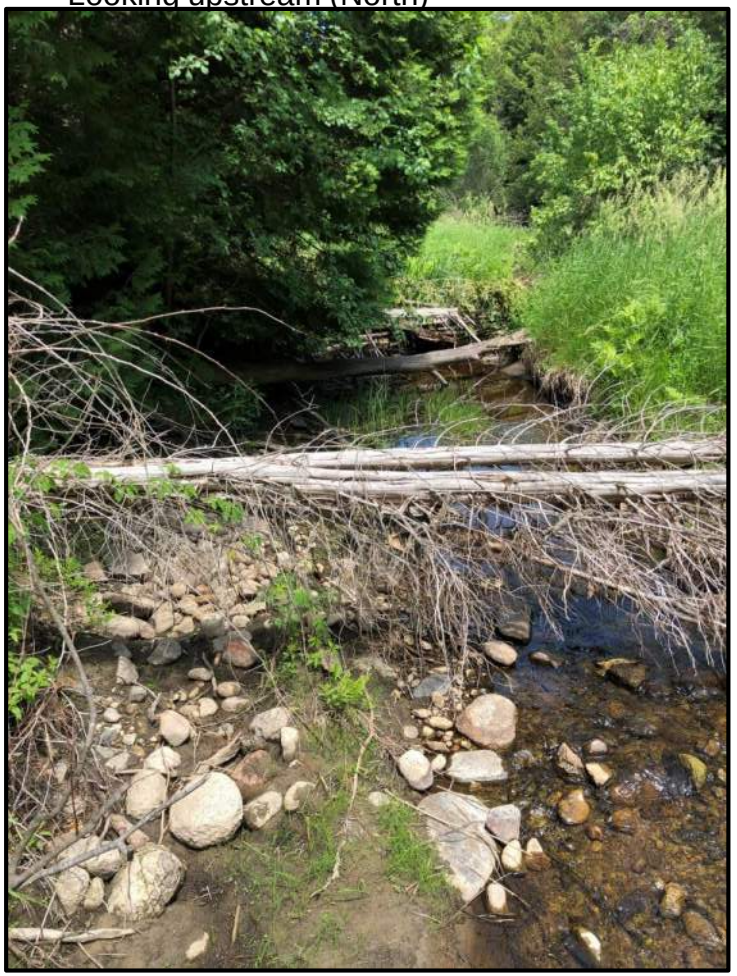
Highway 401 Colborne to Brighton – Site Photos June 9, 2021

Culvert 21-473 Downstream – South of Highway 401

Looking downstream (South)

Looking downstream (South) from approximately 50m downstream of the culvert

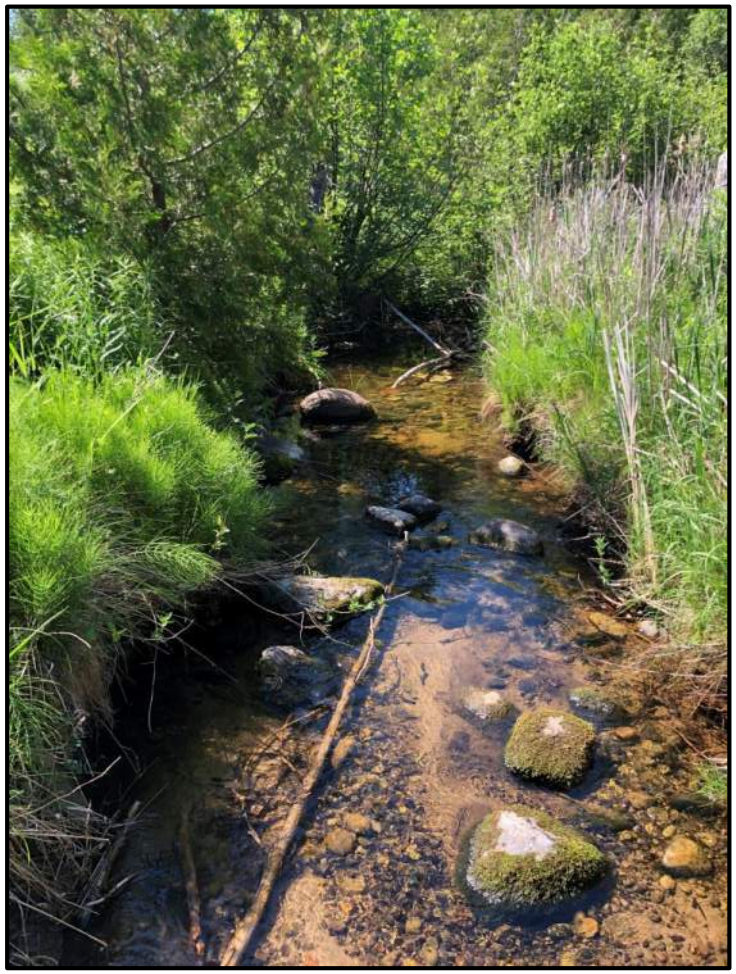
Looking upstream (North)



Looking upstream (North) from approximately 50m downstream of the culvert

Highway 401 Colborne to Brighton – Site Photos June 9, 2021

Culvert 21-473 Upstream – North of Highway 401

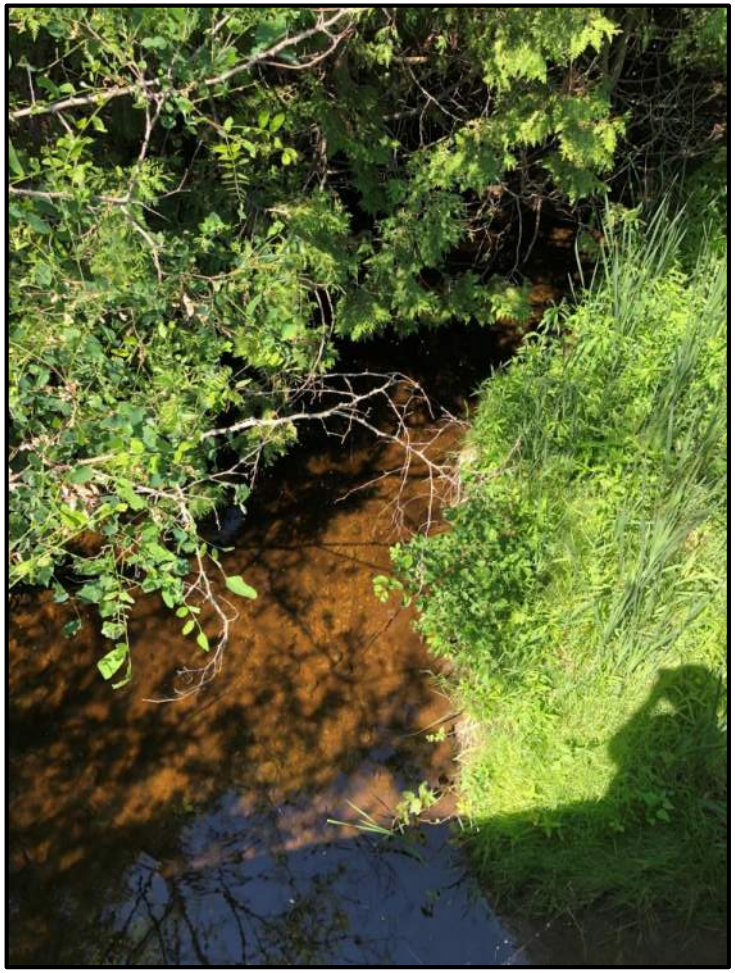


Looking downstream (South) from the culvert

Looking downstream (South) from the culvert

Highway 401 Colborne to Brighton – Site Photos June 9, 2021

Culvert 21-474 Downstream – North of Highway 401



Looking downstream (North) from the culvert

Looking downstream (North) from approximately 10m downstream of the culvert

Highway 401 Colborne to Brighton – Site Photos June 9, 2021

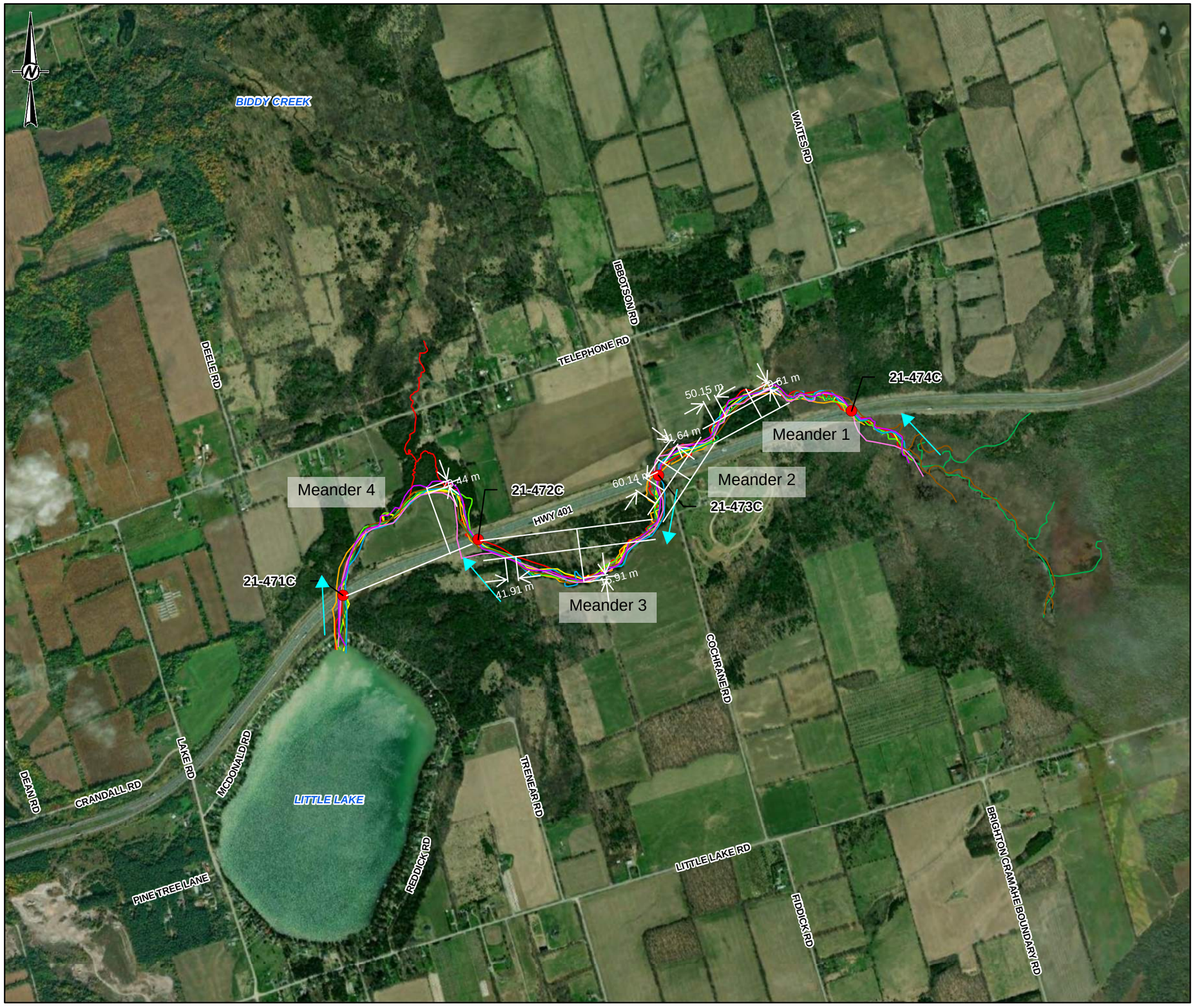
Culvert 21-474 Upstream – South of Highway 401

Looking upstream (South) from the culvert

Looking upstream (South) from the culvert

APPENDIX

B EROSION RATE AND MEANDER BELT ASSESSMENT FIGURES



LEGEND

- CULVERT
- 2018 WATERCOURSE
- 2004 WATERCOURSE
- 1995 WATERCOURSE
- 1987 WATERCOURSE
- 1976 WATERCOURSE
- 1967 WATERCOURSE
- 1962 WATERCOURSE
- 1948 WATERCOURSE
- 1929 WATER COURSE

DRAFT

0 145 290 580

SCALE 1:15,000 METRES

NOTE(S)

1. ALL LOCATIONS ARE APPROXIMATE

REFERENCE(S)

1. BASEMAP: NATIONAL AIRPHOTO LIBRARY
2. COORDINATE SYSTEM: NAD 1983 UTM ZONE 18N

CLIENT
MINISTRY OF TRANSPORTATION

PROJECT
FLUVIAL ASSESSMENT
HIGHWAY 401 - COLBORNE TO BRIGHTON

TITLE
COMPILED HISTORICAL WATERCOUSES

CONSULTANT

YYYY-MM-DD	2023-04-25
DESIGNED	JJ
PREPARED	JJ
REVIEWED	PH
APPROVED	----

PROJECT NO.	CONTROL	REV.	FIGURE
17M-01712-11	0003	A	B-1

LEGEND

- CULVERT
- 2018 WATERCOURSE
- 2004 WATERCOURSE
- 1995 WATERCOURSE
- 1987 WATERCOURSE
- 1976 WATERCOURSE
- 1967 WATERCOURSE
- 1962 WATERCOURSE
- 1948 WATERCOURSE
- 1929 WATER COURSE

DRAFT

0 145 290 580

SCALE 1:15,000 METRES

NOTE(S)

1. ALL LOCATIONS ARE APPROXIMATE

REFERENCE(S)

1. BASEMAP: NATIONAL AIRPHOTO LIBRARY
2. COORDINATE SYSTEM: NAD 1983 UTM ZONE 18N

CLIENT
MINISTRY OF TRANSPORTATION

PROJECT
FLUVIAL ASSESSMENT
HIGHWAY 401 - COLBORNE TO BRIGHTON

TITLE
COMPILED HISTORICAL WATERCOUSES

CONSULTANT

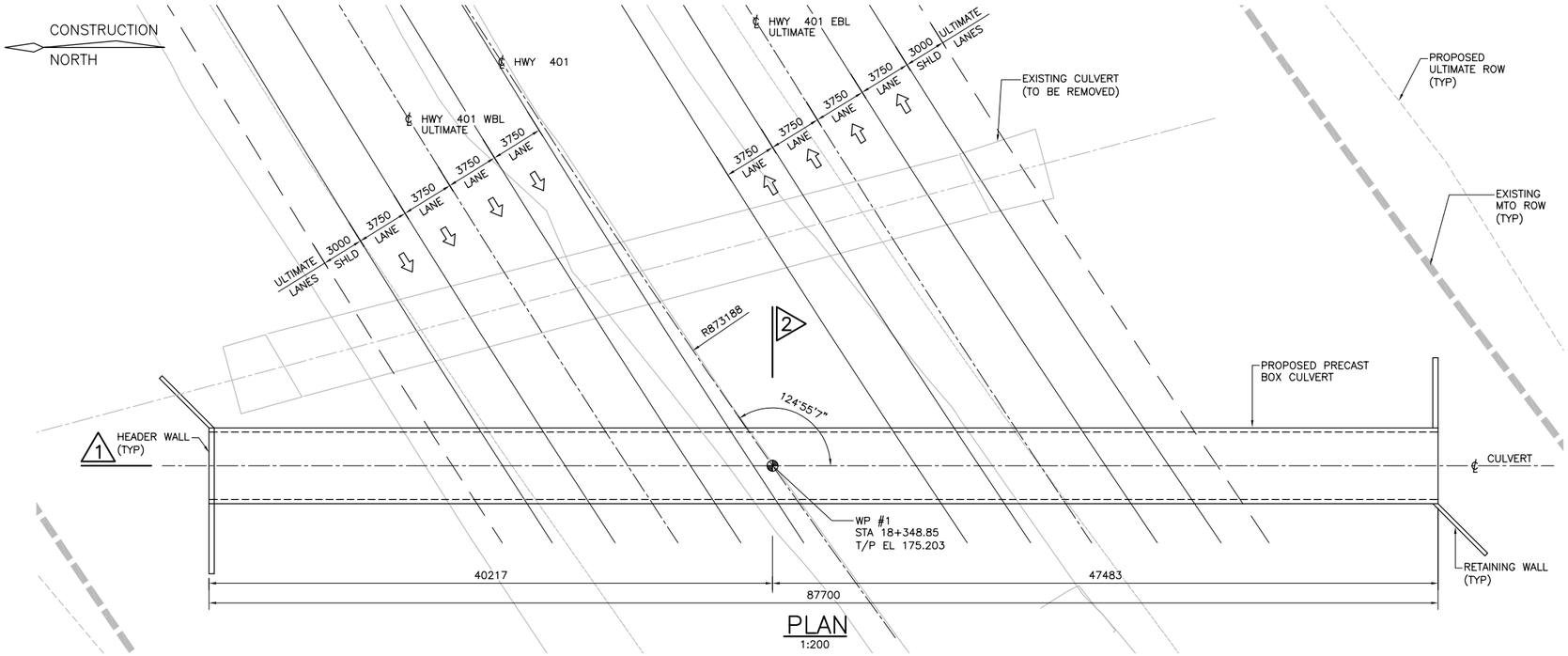
YYYY-MM-DD	2023-04-25
DESIGNED	JJ
PREPARED	JJ
REVIEWED	PH
APPROVED	----

PROJECT NO.	CONTROL	REV.	FIGURE
17M-01712-11	0003	A	B-2

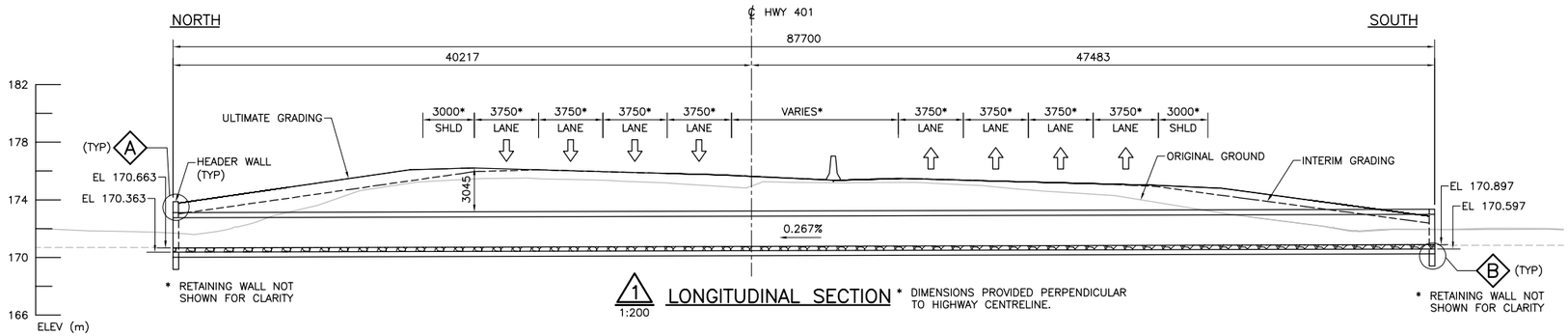
APPENDIX

C

PRELIMINARY GENERAL ARRANGMENTS

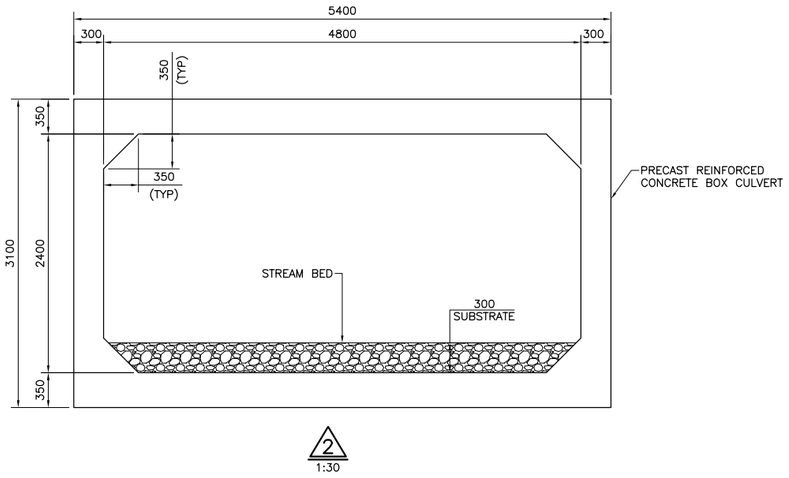


PLAN
1:200

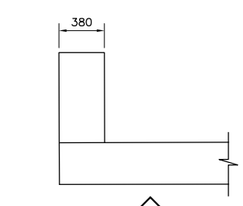


LONGITUDINAL SECTION
1:200

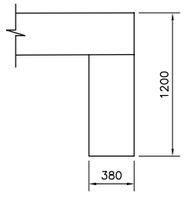
* DIMENSIONS PROVIDED PERPENDICULAR TO HIGHWAY CENTRELINE.



2
1:30



A
HEADER WALL DETAIL
(WHERE REQUIRED)
NTS



B
APRON WALL DETAIL
(INLET AND OUTLET)
NTS

DRAWING NOT TO BE SCALED
100mm ON ORIGINAL DRAWING

DRAFT

DISTRICT CONT. No. WP No.	
HWY 401 COLBORNE TO BRIGHTON CULVERT #1	SHEET
PRELIMINARY GENERAL ARRANGEMENT	
wsp	METRIC

GENERAL NOTES:

CLASS OF CONCRETE:

PRECAST CONCRETE	45 MPa
CAST–IN–PLACE	30 MPa

CLEAR COVER TO REINFORCING STEEL:

PRECAST CONCRETE	50 ± 10
CAST–IN–PLACE CONCRETE	70 ± 20

REINFORCING STEEL:

REINFORCING STEEL SHALL BE GRADE 400W.

1. UNLESS SHOWN OTHERWISE, TENSION LAP SPLICES FOR REINFORCING STEEL BARS SHALL BE CLASS 'B'.
2. BAR HOOKS SHALL HAVE STANDARD HOOK DIMENSIONS USING MINIMUM BEND DIAMETERS, WHILE STIRRUPS AND TIES SHALL HAVE MINIMUM HOOK DIMENSIONS. ALL HOOKS SHALL BE IN ACCORDANCE WITH THE STRUCTURAL STANDARD DRAWINGS SS12–1 UNLESS INDICATED OTHERWISE.

CONSTRUCTION NOTES:

1. BACKFILL SHALL BE PLACED SIMULTANEOUSLY BEHIND BOTH SIDES OF CULVERT KEEPING THE HEIGHT OF THE BACKFILL APPROXIMATELY THE SAME. AT NO TIME SHALL THE DIFFERENCE IN ELEVATION BE GREATER THAN 500mm.
2. SUPPORTS FOR REINFORCING STEEL SHALL BE AS PER OPSD 3329.101 AND OPSD 3329.100 ON FORMED SURFACES. ON NON–FORMED SURFACES, CONCRETE BLOCKS (MIN. 20MPa) SHALL BE USED.

APPLICABLE STANDARD DRAWINGS:

OPSD 803.010	BACKFILL AND COVER FOR CONCRETE CULVERTS
OPSD 3190.100	WALLS RETAINING AND ABUTMENT WALL DRAIN
OPSD 3941.200	FIGURES IN CONCRETE SITE NUMBER AND DATE LAYOUT

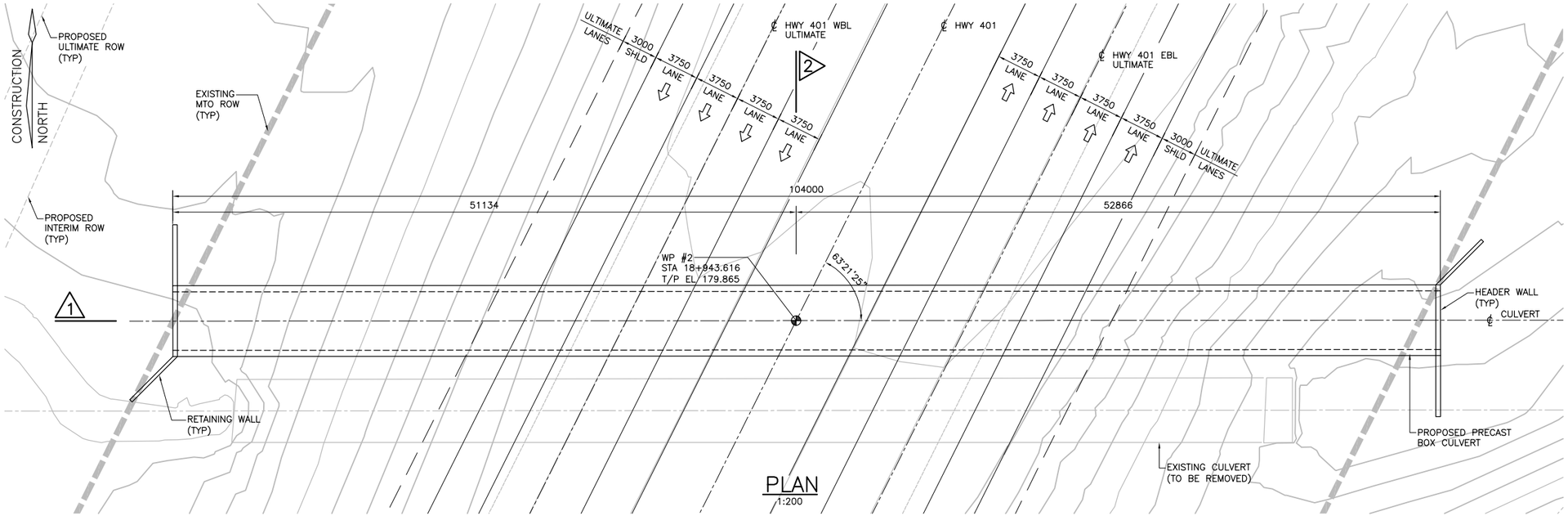
LIST OF ABBREVIATIONS:

T/P – DENOTES TOP OF PAVEMENT
WP – DENOTES WORKING POINT
EL – DENOTES ELEVATION
STA – DENOTES STATION
CL – DENOTES CENTRELINE
TYP – DENOTES TYPICAL

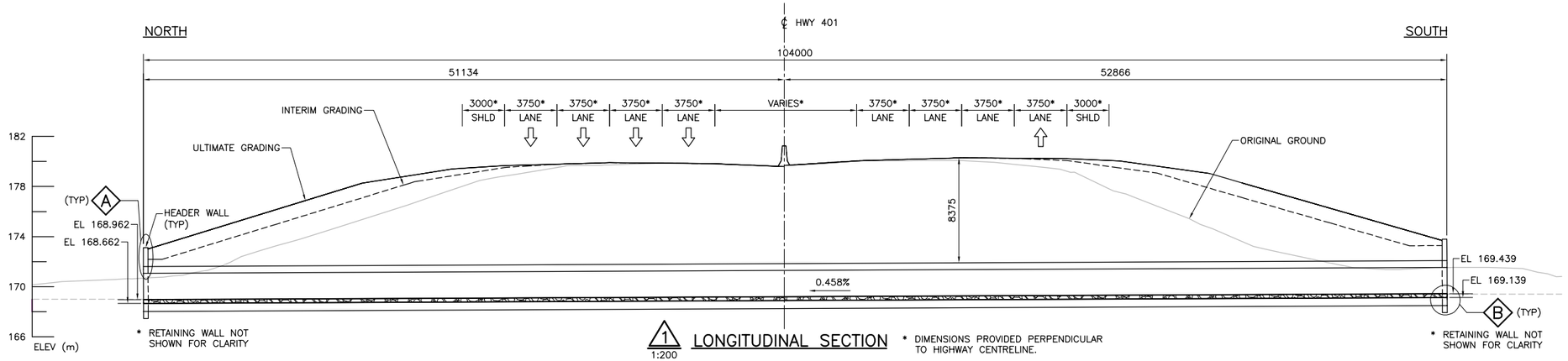
REVISIONS		
DATE	BY	DESCRIPTION

DESIGN		CHK	CODE CHBDC 2019	LOAD CL–625–ONT	DATE AUG/22
DRAWN R.A.		CHK S.O.	SITE 21X–0471/C0		DWG

CAD FILE LOCATION AND NAME: X:\DIV16\2021\17M–0172–11 – Hwy 401 Colborne to Brighton\CAD\303 Culvert C1–Site No. 21X–0471C0\17M–01712–11–303–001GA.dwg
MODIFIED: 8/17/2022 8:04:23 AM BY: OBAIDS
DATE PLOTTED: 8/17/2022 8:04:52 AM BY: OBAID, SUBOOHI
MINISTRY OF TRANSPORTATION, ONTARIO PR–D–707 88–05

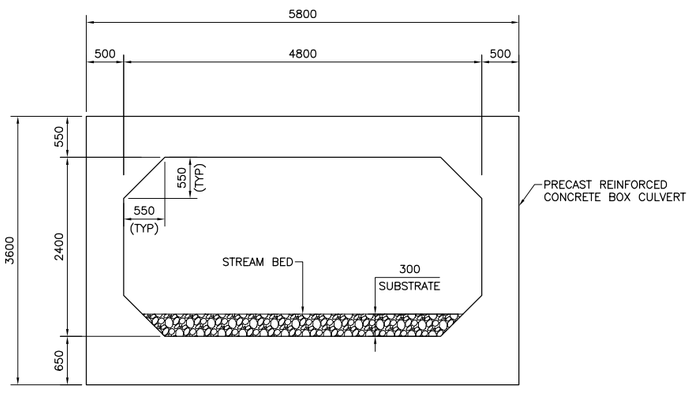


PLAN
1:200

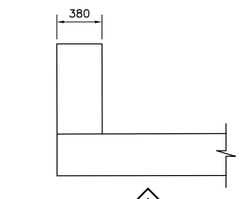


1 1:200 LONGITUDINAL SECTION

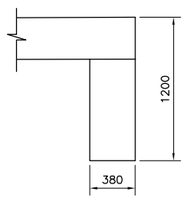
* DIMENSIONS PROVIDED PERPENDICULAR TO HIGHWAY CENTRELINE.



2 1:40



HEADER WALL DETAIL
(WHERE REQUIRED)
NTS



APRON WALL DETAIL
(INLET AND OUTLET)
NTS

DRAFT

DRAWING NOT TO BE SCALED
100mm ON ORIGINAL DRAWING

REVISIONS			
	DATE	BY	DESCRIPTION

DESIGN	CHK	CODE CHBDC 2019	LOAD CL-625-ONT	DATE AUG/22
DRAWN R.A.	CHK S.O.	SITE 21X-0472/C0		DWG

DISTRICT
CONT. No.
WP No.

HWY 401
COLBORNE TO BRIGHTON
CULVERT #2

PRELIMINARY
GENERAL ARRANGEMENT

SHEET

METRIC

GENERAL NOTES:

CLASS OF CONCRETE:

PRECAST CONCRETE	45 MPa
CAST-IN-PLACE	30 MPa

CLEAR COVER TO REINFORCING STEEL:

PRECAST CONCRETE	50 ± 10
CAST-IN-PLACE CONCRETE	70 ± 20

REINFORCING STEEL:

REINFORCING STEEL SHALL BE GRADE 400W.

1. UNLESS SHOWN OTHERWISE, TENSION LAP SPLICES FOR REINFORCING STEEL BARS SHALL BE CLASS 'B'.
2. BAR HOOKS SHALL HAVE STANDARD HOOK DIMENSIONS USING MINIMUM BEND DIAMETERS, WHILE STIRRUPS AND TIES SHALL HAVE MINIMUM HOOK DIMENSIONS. ALL HOOKS SHALL BE IN ACCORDANCE WITH THE STRUCTURAL STANDARD DRAWINGS SS12-1 UNLESS INDICATED OTHERWISE.

CONSTRUCTION NOTES:

1. BACKFILL SHALL BE PLACED SIMULTANEOUSLY BEHIND BOTH SIDES OF CULVERT KEEPING THE HEIGHT OF THE BACKFILL APPROXIMATELY THE SAME. AT NO TIME SHALL THE DIFFERENCE IN ELEVATION BE GREATER THAN 500mm.
2. SUPPORTS FOR REINFORCING STEEL SHALL BE AS PER OPSD 3329.101 AND OPSD 3329.100 ON FORMED SURFACES. ON NON-FORMED SURFACES, CONCRETE BLOCKS (MIN. 20MPa) SHALL BE USED.

APPLICABLE STANDARD DRAWINGS:

OPSD 803.010	BACKFILL AND COVER FOR CONCRETE CULVERTS
OPSD 3190.100	WALLS RETAINING AND ABUTMENT WALL DRAIN
OPSD 3941.200	FIGURES IN CONCRETE SITE NUMBER AND DATE LAYOUT

LIST OF ABBREVIATIONS:

T/P – DENOTES TOP OF PAVEMENT
WP – DENOTES WORKING POINT
EL – DENOTES ELEVATION
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TYP – DENOTES TYPICAL

MINISTRY OF TRANSPORTATION, ONTARIO PR-D-707 88-05
CAD FILE LOCATION AND NAME: X:\DW16\2021\17M-0172-11 – Hwy 401 Colborne to Brighton\CAD\304 Culvert C2-Site No. 21X-0472C0\17M-01712-11-304-001GA.dwg
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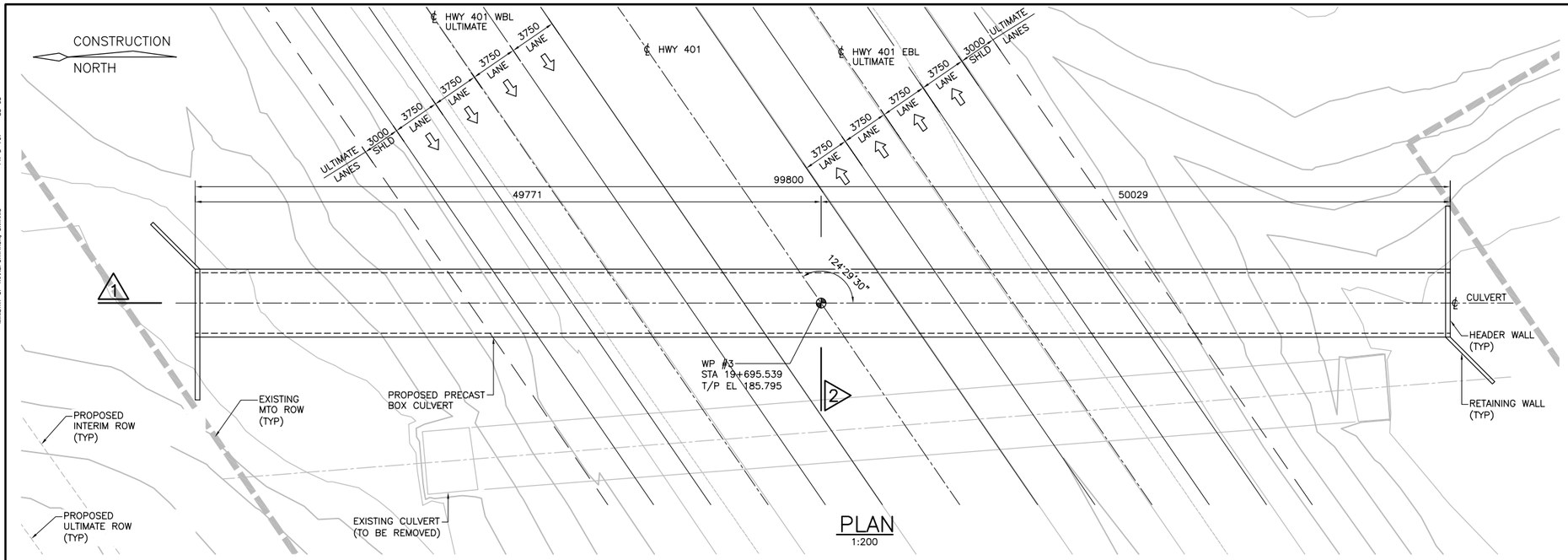
DATE PLOTTED: 8/17/2022 8:16:17 AM BY: OBAID, SUBOOHI



PLAN
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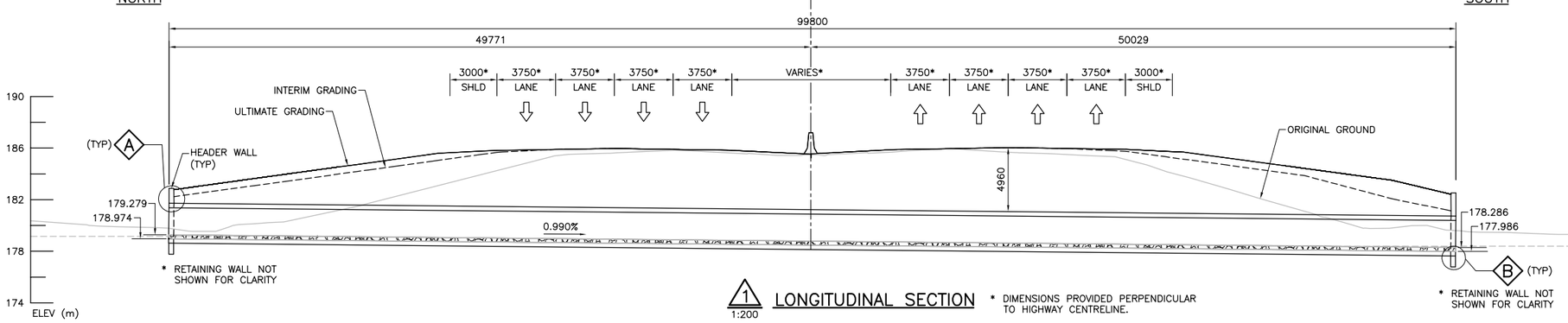

1 LONGITUDINAL SECTION
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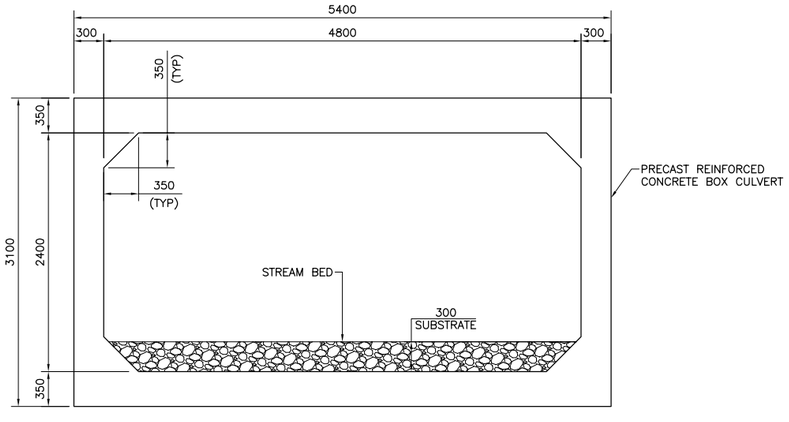
* DIMENSIONS PROVIDED PERPENDICULAR TO HIGHWAY CENTRELINE.



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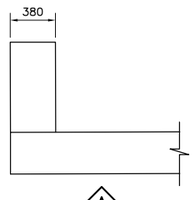
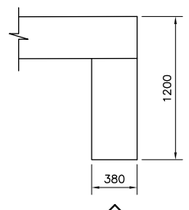


A
HEADER WALL DETAIL
(WHERE REQUIRED)
NTS



B
APRON WALL DETAIL
(INLET AND OUTLET)
NTS

DRAWING NOT TO BE SCALED
100mm ON ORIGINAL DRAWING

DRAFT

DISTRICT CONT. No. WP No.	
HWY 401 COLBORNE TO BRIGHTON CULVERT #3	SHEET
PRELIMINARY GENERAL ARRANGEMENT	
wsp	METRIC

GENERAL NOTES:

CLASS OF CONCRETE:

PRECAST CONCRETE	45 MPa
CAST–IN–PLACE	30 MPa

CLEAR COVER TO REINFORCING STEEL:

PRECAST CONCRETE	50 ± 10
CAST–IN–PLACE CONCRETE	70 ± 20

REINFORCING STEEL:

REINFORCING STEEL SHALL BE GRADE 400W.

1. UNLESS SHOWN OTHERWISE, TENSION LAP SPLICES FOR REINFORCING STEEL BARS SHALL BE CLASS 'B'.
2. BAR HOOKS SHALL HAVE STANDARD HOOK DIMENSIONS USING MINIMUM BEND DIAMETERS, WHILE STIRRUPS AND TIES SHALL HAVE MINIMUM HOOK DIMENSIONS. ALL HOOKS SHALL BE IN ACCORDANCE WITH THE STRUCTURAL STANDARD DRAWINGS SS12–1 UNLESS INDICATED OTHERWISE.

CONSTRUCTION NOTES:

1. BACKFILL SHALL BE PLACED SIMULTANEOUSLY BEHIND BOTH SIDES OF CULVERT KEEPING THE HEIGHT OF THE BACKFILL APPROXIMATELY THE SAME. AT NO TIME SHALL THE DIFFERENCE IN ELEVATION BE GREATER THAN 500mm.
2. SUPPORTS FOR REINFORCING STEEL SHALL BE AS PER OPSD 3329.101 AND OPSD 3329.100 ON FORMED SURFACES. ON NON–FORMED SURFACES, CONCRETE BLOCKS (MIN. 20MPa) SHALL BE USED.

APPLICABLE STANDARD DRAWINGS:

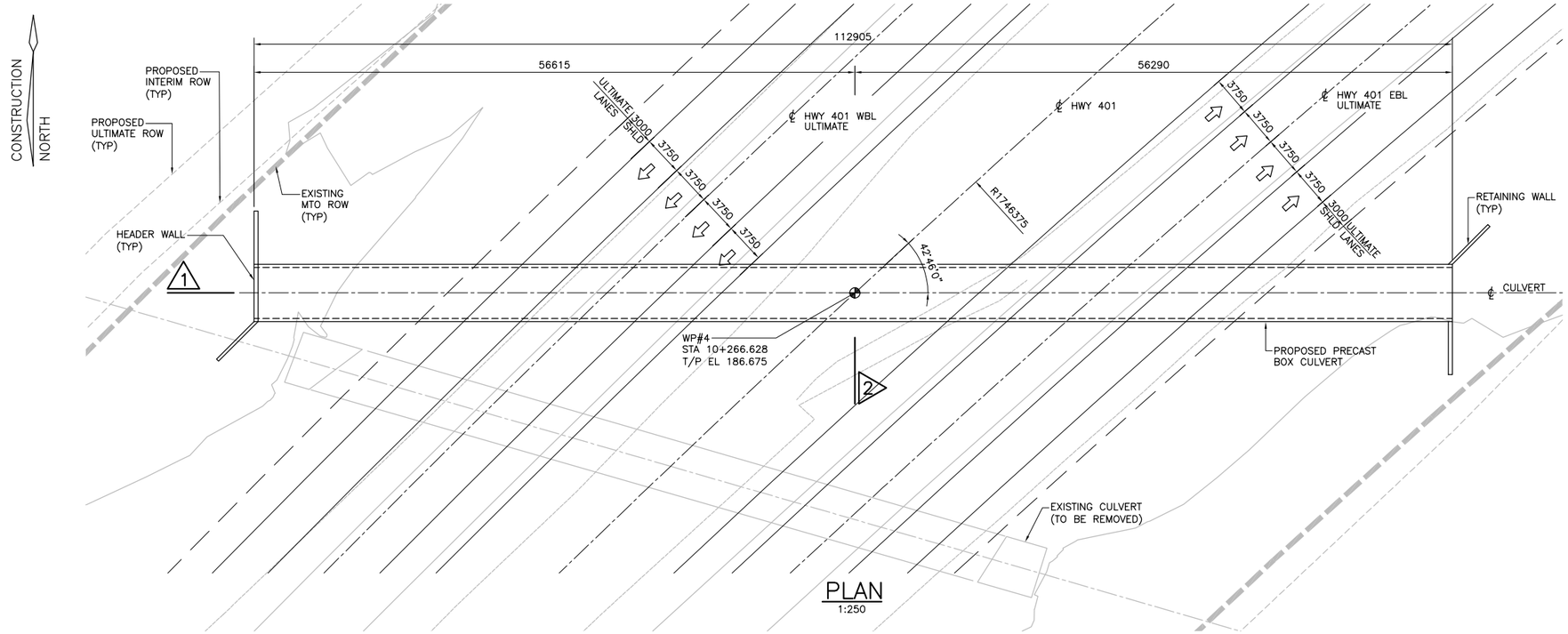
OPSD 803.010	BACKFILL AND COVER FOR CONCRETE CULVERTS
OPSD 3190.100	WALLS RETAINING AND ABUTMENT WALL DRAIN
OPSD 3941.200	FIGURES IN CONCRETE SITE NUMBER AND DATE LAYOUT

LIST OF ABBREVIATIONS:

T/P – DENOTES TOP OF PAVEMENT
WP – DENOTES WORKING POINT
EL – DENOTES ELEVATION
STA – DENOTES STATION
CL – DENOTES CENTRELINE
TYP – DENOTES TYPICAL

REVISIONS		
DATE	BY	DESCRIPTION

DESIGN	CHK	CODE CHBDC 2019	LOAD CL–625–ONT	DATE AUG/22
DRAWN R.A.	CHK S.O.	SITE 21X–0473/C0		DWG



DRAWING NOT TO BE SCALED
100mm ON ORIGINAL DRAWING

DISTRICT
CONT. No.
WP No.

HWY 401
FROM COLBORNE TO BRIGHTON
CULVERT #4

PRELIMINARY
GENERAL ARRANGEMENT

SHEET

METRIC

GENERAL NOTES:

CLASS OF CONCRETE:

PRECAST CONCRETE	45 MPa
CAST–IN–PLACE	30 MPa

CLEAR COVER TO REINFORCING STEEL:

PRECAST CONCRETE	50 ± 10
CAST–IN–PLACE CONCRETE	70 ± 20

REINFORCING STEEL:

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CONSTRUCTION NOTES:

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APPLICABLE STANDARD DRAWINGS:

OPSD 803.010	BACKFILL AND COVER FOR CONCRETE CULVERTS
OPSD 3190.100	WALLS RETAINING AND ABUTMENT WALL DRAIN
OPSD 3941.200	FIGURES IN CONCRETE SITE NUMBER AND DATE LAYOUT

LIST OF ABBREVIATIONS:

T/P – DENOTES TOP OF PAVEMENT
WP – DENOTES WORKING POINT
EL – DENOTES ELEVATION
STA – DENOTES STATION
CL – DENOTES CENTRELINE
TYP – DENOTES TYPICAL

DRAFT

REVISIONS			
DATE	BY	DESCRIPTION	

DESIGN	CHK	CODE CHBDC 2019	LOAD CL–625–ONT	DATE AUG/22
DRAWN R.A.	CHK S.O.	SITE 21X–0474/C0		DWG

CAD FILE LOCATION AND NAME: X:\DIV16\2021\17M-0172-11 - Hwy 401 Colborne to Brighton\CAD\306 Culvert C4-Site No. 21X-0474C0\17M-01712-11-306-0016A.dwg
MODIFIED: 8/17/2022 9:08:31 AM BY: OBAIDS
DATE PLOTTED: 8/17/2022 9:09:40 AM BY: OBAID, SUBODHI
MINISTRY OF TRANSPORTATION, ONTARIO PR-D-707 88-05