

Empire (Grand Niagara) Project GP Inc.

GRAND NIAGARA MIXED-USE DEVELOPMENT

Floodplain Mapping Study

February 03, 2023

Confidential





GRAND NIAGARA MIXED-USE DEVELOPMENT

Floodplain Mapping Study

Empire (Grand Niagara) Project GP Inc.

Confidential

Project No.: 211-08936-00

Date: February 03, 2023

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February 03, 2023

Confidential

Empire (Grand Niagara) Project GP Inc.
7077 Keele Street, Suite 400
Vaughan, ON
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Attention: John Castro, Project Manager

Dear Mr. Castro:

Subject: Floodplain Study for First DPA Submission – Grand Niagara Mixed-Use Development

We are pleased to submit an electronic copy of the Floodplain Study report for the Grand Niagara Mixed-Use Development. This report documents the findings of the Floodplain Study.

We trust the submission of this documents meets your requirements. Should you have any comments we look forward to your response.

Yours sincerely,

Albert Zhuge, M.Sc., P.Eng., PMP
Senior Project Manager, Water Resources

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Revision History

FIRST ISSUE

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Xiaoxu (Iris) Qu, P.Eng.
Senior Project Engineer, Water Resources

February 3, 2023

Date

Approved¹ by (must be reviewed for technical accuracy prior to approval)

Albert Zhuge, M.Sc., P.Eng., PMP
Senior Project Manager, Water Resources

Date

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- A** Draft Plan and Grading Plan
- B** HEC-RAS Model Results

1 INTRODUCTION

WSP Canada Inc. (WSP) has been retained by Empire (Grand Niagara) Project GP Inc. (the Owner) to prepare a Floodplain Study Report in support of a proposed Draft Plan of Subdivision for the Grand Niagara Mixed-Use Development located in Niagara Falls, Ontario.

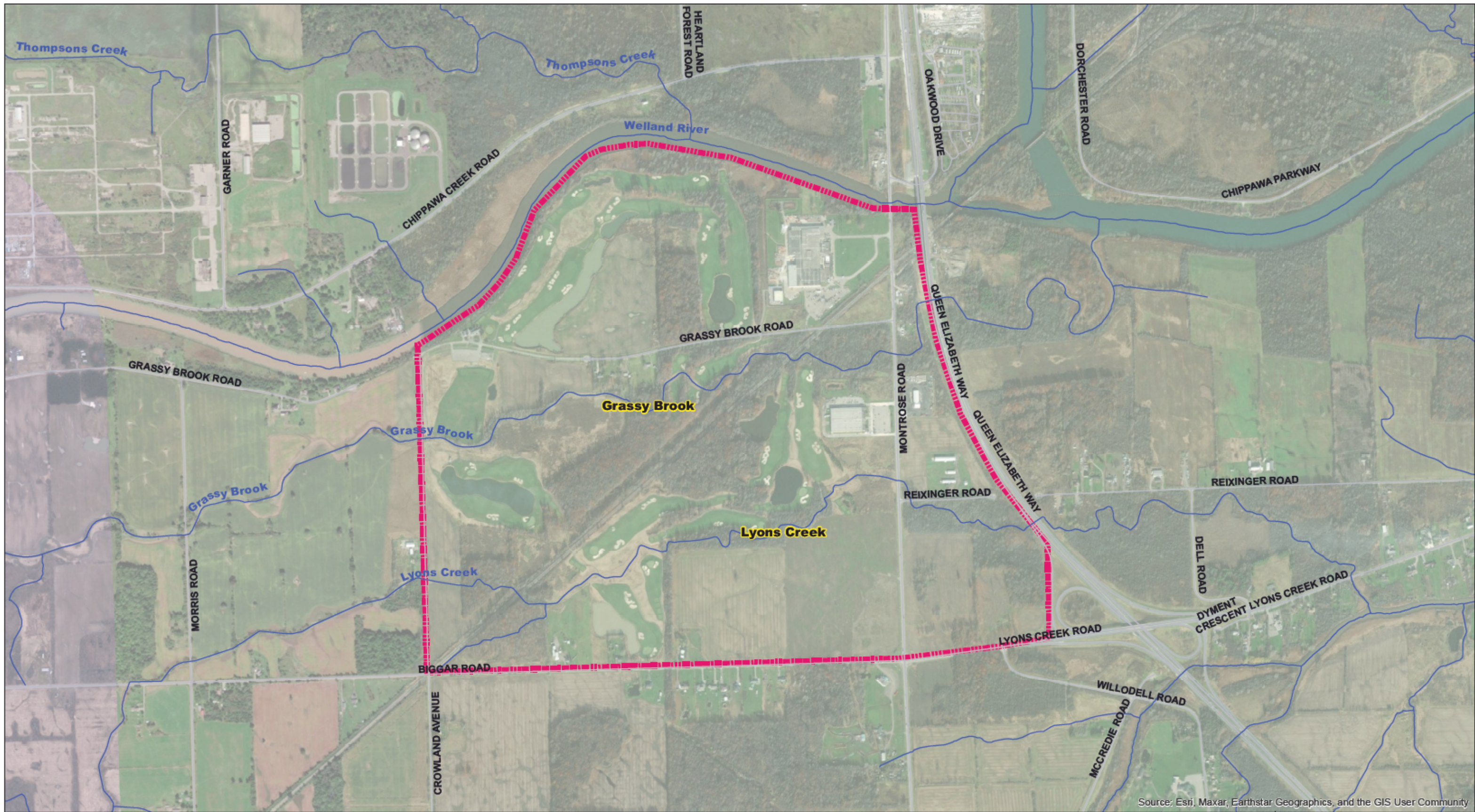
1.1 Site Location

The subject property is located at 8547 Grassy Brook, in the city of Niagara Falls, Ontario, and occupies an area of approximately 184.5 hectares (455.8 acres). The site is bounded by Biggar Road to the south, the Welland River to the north, Crowland Road to the West, and the Montrose Road to the east. Refer to **Figure 1** for the site location plan. The site has the following characteristics:

- The majority of the subject lands is currently occupied by a golf course, with some residential and employment uses along the Grassy Brook Road and Montrose Road frontages.
- An elevated Canadian Pacific (CP) rail corridor runs diagonally through the site.
- Welland River runs along the north border of the site from the west to the east.
- Two tributaries of the Welland River - Grassy Brook Creek and Lyons Creek Tributary 1 run through the site from the west to the east.
- The site topography is generally flat, sloping from south to north.

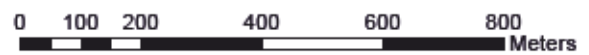
The subject lands are designated for low / medium density residential and mixed-use, as outlined in the City's Official Plan under the Grand Niagara Secondary Plan.

As shown in **Figure 1**, two watercourses - Grassy Brook and Lyons Creek Tributary 1 drain the Grand Niagara from west to east. These watercourses are located within the watershed of the Welland River, which falls under the jurisdiction of the Niagara Peninsula Conservation Authority (NPCA).



Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

- Legend**
-  Watercourse
 -  Roads
 -  Grand Niagara Limit



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TITLE
GRAND NIAGARA MIXED-USE DEVELOPMENT
FLOODPLAIN MAPPING STUDY



Checked	I.Q.	Drawn	J.C.
Date	September 2022	Proj. No.	211-08938-00
Scale	1:12,500	Figure No.	1

SITE LOCATION

1.2 Scope

Key scope items for the study include:

- Review of current NPCA hydraulic modelling / mapping of the subject site.
- Updating the current hydraulic model based on available topographic survey for the subject site to define the existing Regulatory floodplain extent.
- Developing a post-development hydraulic model and evaluating the potential impacts on the existing Regulatory floodplain.
- Examining the floodplain management options.
- Drafting a study report documenting the above tasks.

1.3 Background Information

WSP conducted the Secondary Plan for Grand Niagara in 2016. The relevant reports, hydraulic models, and current floodplain elevation data were collected and reviewed for the background use in the assessments and analyses of this study. The following documents were reviewed:

- Report “Stormwater Management Plan – Grand Niagara Secondary Plan” dated November 2016, prepared by WSP.
- NPCA a geo-referenced HEC-RAS model named “Lyons Creek including Tee Creek”, developed in 2009, revised in 2011.
- NPCA a non-geo-referenced HEC-RAS model named “Grassy Brook – Grand Niagara Golf Course”, developed in 2000.
- Report “Floodline Analysis for the Grand Niagara Resort” dated October 2000, prepared by R.J.Burnside & Associates Ltd.
- Report “Floodplain Mapping – Lyons Creek Including Tee Creek” dated December 2009, revised in March 2011, prepared by NPCA.

2 BACKGROUND DATA REVIEW

2.1 Review of Grand Niagara Secondary Plan Report

The Grand Niagara Secondary Plan report was prepared by WSP in November 2016. The report includes the review of the relevant NPCA's background data associated with the floodplain analysis. This background data includes the hydrologic and hydraulic analyses for the Lyons Creek and its tributaries (Section 2.5, NPCA Floodplain Mapping – Lyons Creek); and the hydrologic and hydraulic analyses for the Grassy Brook (Section 2.6, Floodplain Analysis for the Grand Niagara Resort).

The report also describes the Floodplain Limits in Section 3, which includes Existing Floodplain Limits of the Grassy Brook and Lyons Creek Tributary 1 (Section 3.1) and Development Impacts on Floodplain Limits (Section 3.2).

In Section 3.1, it states "*The floodplain limits of the Grassy Brook and Lyons Creek Tributary 1 had been determined by the following studies and are illustrated in the NPCA's online information system:*

- *Floodplain Mapping – Lyons Creek including Tee Creek, NPCA, December 2009 (revised March 2011)*
- *Floodline Analysis for the Grand Niagara Resort, Burnside Golf Services, October 2000"*

In Section 3.2, it states "*The urbanization in Grand Niagara will increase the impervious coverage, therefore, the investigation of the development impacts on the current floodplain limits was carried out*". The findings of this investigation are described in Section 3.2.1 to 3.2.3 and are summarized as following:

- Lyons Creek Tributary 1: the hydrologic model HEC-HMS used for the NPCA's hydrology study was revised to reflect the imperviousness increase of the proposed development. Based on the revised HEC-HMS model, the flow rate changes were minor. Then the hydraulic HEC-RAS model was updated to the post-development conditions and it was concluded that these minor flow changes would not impact the flood elevations at Tributary 1.
- Grassy Brook: the hydrologic SWMHYMO model used in the Floodline Analysis conducted by in 2000 was converted to a VisualHYMO (VO2) model. The flow rates produced from the VO2 model generally match the original model results. Then the VO2 model was revised to reflect future conditions. Based on the revised VO2

model results, the 100-year peak flows used in the floodplain limit delineation would not be impacted by the proposed development in Grand Niagara.

- Lower Welland River: The proposed Grand Niagara development covers a negligible downstream portion of the Lower Welland River, as such, the development would not have hydraulic impacts on the current floodplain limits.

2.2 Review of NPCA HEC-RAS Models

As stated above, two HEC-RAS models were received from the NPCA. One model is for the Lyons Creek, and the other is for Grassy Brook. The Lyons Creek HEC-RAS model is a geo-referenced model, which was developed in 2009 and was revised in 2011. The Lyons Creek Tributary 1 runs through the subject site from west to east. Six watercourse crossings are within / adjacent to the subject site. The locations and structure sizes are provided in **Table 2.1**.

Table 2.1: Watercourse Crossings along Lyons Creek Tributary 1 Within / Adjacent to Subject Site

Location	Structure Type	Openings	Material	Span (m)	Height (m)	Length (m)
Crowland Avenue	Box Culvert	1	Concrete	3.1	1	9.0
CN Railway	Box Culvert	1	Concrete	2.15	1.8	14.6
Grand Niagara Golf Course	Box Culvert	1	Concrete	3.7	0.85	5.63
Montrose Road	Box Culvert	1	Concrete	4.26	1.42	18.66
Rexinger Road	Circular	3	CMP	Ø0.78		10.9
QEW	Box Culvert	1	Concrete	4.85	1.75	65

The Grassy Brook model is a non-geo-referenced model, which starts from approximately 900 m west of Crowland Avenue and ends at approximately 250 m east of Montrose Road with a total length of approximately 3.1 km. It was originally developed in 2000 by Burnside. Three watercourse crossings were coded in the model. The locations and structure sizes are provided in **Table 2.2**.

Table 2.2: Watercourse Crossings along Grassy Brook

Location	Structure Type	Openings	Material	Span (m)	Height (m)	Length (m)
Crowland Avenue	Box Culvert	1	Concrete	4.25	1.52	15.1
CN Railway	Bridge	1	Concrete	6.7	3.8	11.8
Montrose Road	Box Culvert	2	Concrete	3.1	2.13	18.8
				2.43	1.8	

3 HEC-RAS MODEL AND FLOODLINE REVISIONS UNDER EXISTING CONDITIONS

3.1 Topographic Survey

A topographic survey for the subject site was conducted in 2016. The survey data was used to create a terrain for this study. The coverage of the survey data is shown in Figure 2.

3.2 Lyons Creek Model Revision

The cross-sections in the NPCA existing model were compared with the cross-sections cut from the terrain created from the 2016 topographic survey within the site boundary. Significant discrepancies were found between these two data sets. Exhibit 1 shows an example of the cross-section comparison at Lyons Creek Tributary 1 RS 4403.044.

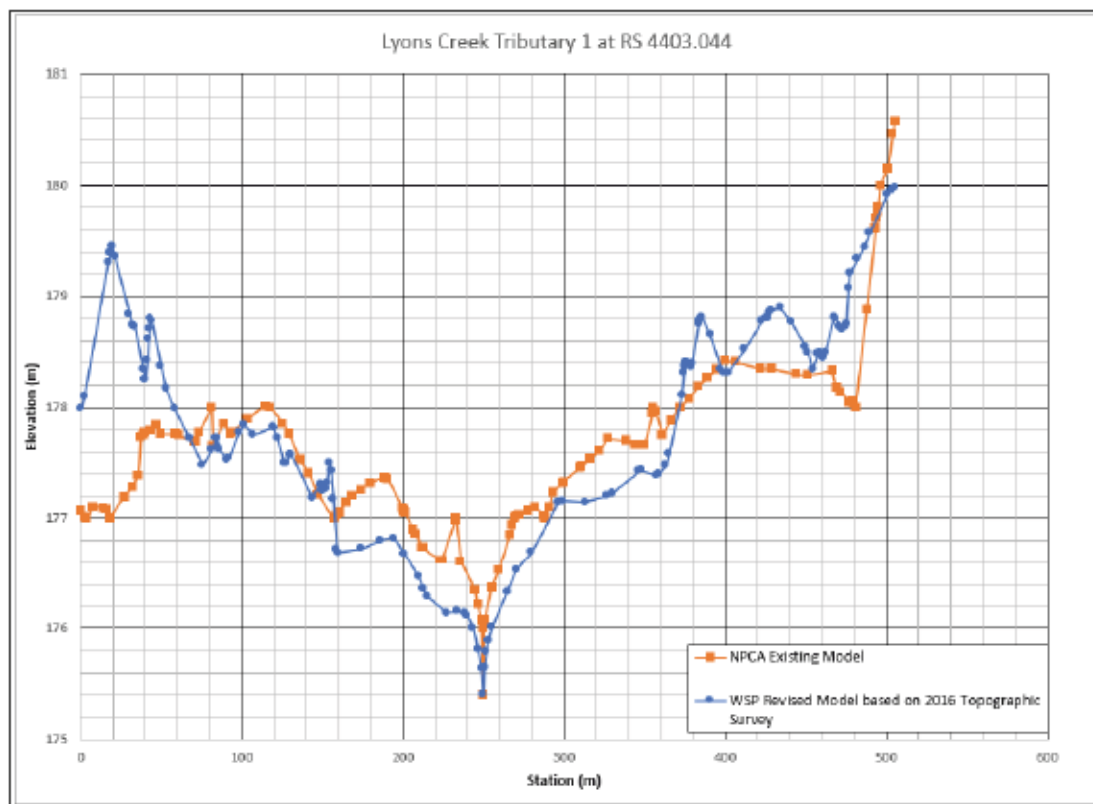


Exhibit 1: Example of Cross-Section Comparison

In order to understand how the cross-sections were generated in the NPCA's existing model, WSP reviewed the report "Floodplain Mapping – Lyons Creek Including Tee Creek" prepared by NPCA in March 2011. In the report, the data collection was documented (Section 2.1), it states that *"In spring 2002 orthographic images were flown for the entire jurisdiction of NPCA; these images were then rendered stereoscopically and digital elevation data was created"*. In Conclusions (Section 4.1), it states that *"The NPCA Digital Elevation Model was found to accurately replicate the in-situ topographic conditions based upon verification in the field"*. For the channel bathymetry, the report states that *"Channel bathymetry was estimated using the surveyed stream depths recorded at stream crossings. The depths between the surveyed stream crossings were estimated by assuming that the slope of the steam surface closely approximates the slope of the stream bed. It was also assumed that the channel cross section below the water surface captured in the orthographic images was uniform between surveyed crossings"*.

Since the 2016 topographic survey at the subject site was the most recent data, WSP revised the NPCA's existing HEC-RAS model in Tributary 1 from RS 4708 to RS 1787 based on the survey. The channel bed elevations were adjusted to match the channel bottoms in the NPCA's existing model for these cross-sections. In addition to the revisions of the cross-section geometries, the bank stations were placed in the proper locations to define the river channels. Manning's N for the main channel was assigned to 0.035 to comply with the standard Manning's N that is commonly used for the channel. Levees were added in some cross-sections. **Exhibit 2** shows an example of the cross-section revision at Lyons Creek Tributary 1 RS 4403.044. The road top elevations at six watercourse crossings (**Table 2.1**) were updated using the 2016 topographic survey. Additional cross-sections were generated at these watercourse crossings to comply with the HEC-RAS guidelines that four cross-sections are required to compute the structures. The schematic of the HEC-RAS model is shown in **Figure 2**.

The flows remain unchanged in the WSP revised Lyons Creek model. The 100-year flow rate associated with the subject site is 10.3 m³/s.

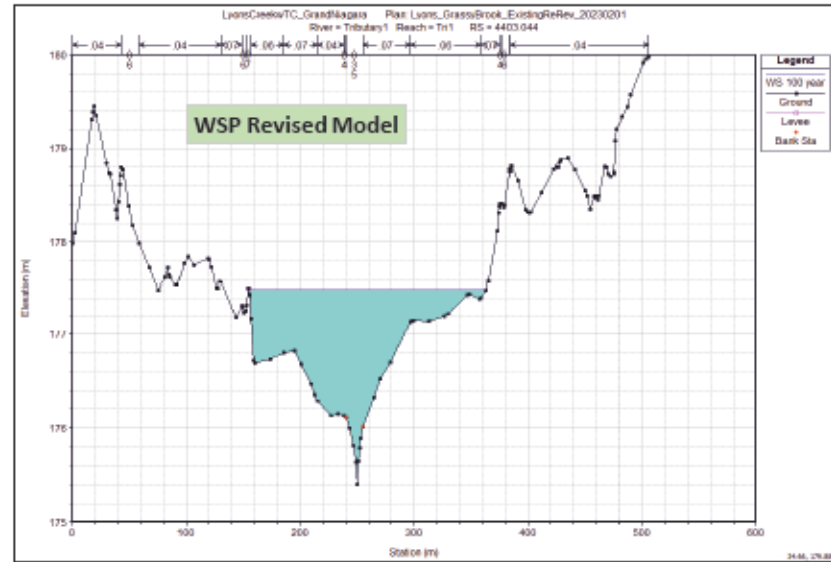
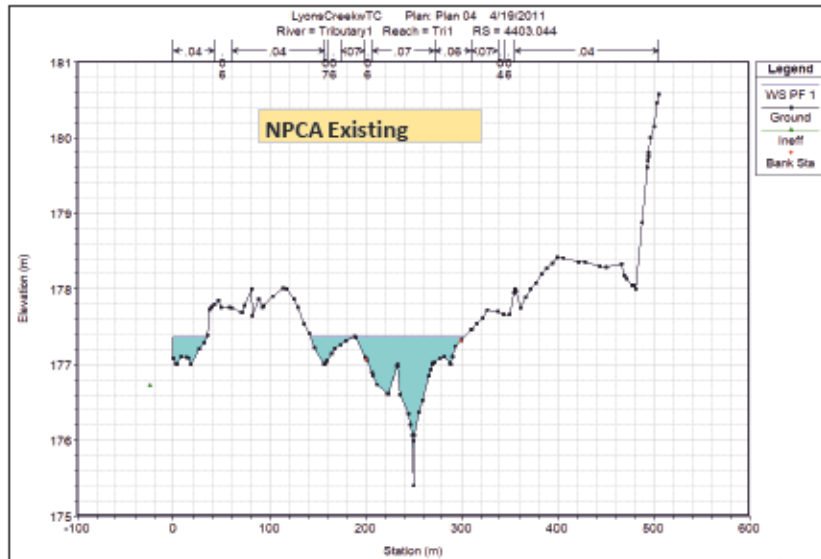
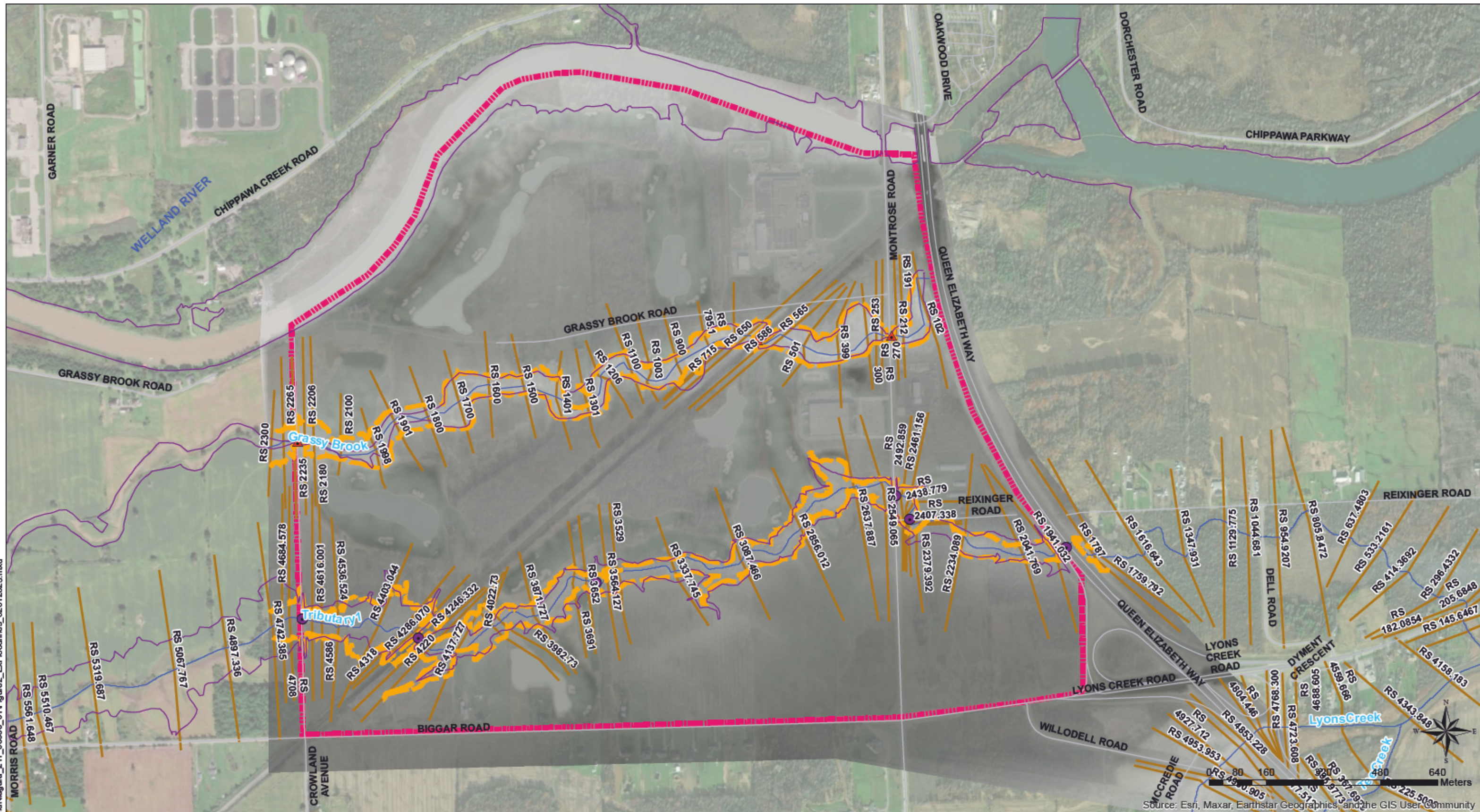


Exhibit 2 Example of Cross Section - NPCA Existing Model vs. WSP Revised Model

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Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

Legend

- Structure (Grassy Brook)
- Structure (Lyons Creek)
- Grand Niagara Limit
- Roads
- HecRas River
- HecRAS cross sections
- NPCA Existing 100-Year Floodline
- WSP Revised 100-Year Floodline under Existing Conditions

2016 Topographic Survey



CLIENT
EMPIRE (GRAND NIAGARA) PROJECT GP INC.

TITLE
GRAND NIAGARA MIXED-USE DEVELOPMENT
FLOODPLAIN MAPPING STUDY

**100-Year Floodlines
under Existing Conditions**

		Checked	I.Q.	Drawn	J.C.
		Date	February 2023	Proj. No.	211-08938-00
Scale	1:10,000	Figure No.	2		

3.3 Grassy Brook Model Revision

As stated above, the NPCA existing Grassy Brook HEC-RAS model is a non-geo-referenced model. Based on the report “*Floodline Analysis for the Grand Niagara Resort*” prepared by R.J. Burnside & Associates Ltd. in October 2000, “A field survey of the Grand Niagara Resort site was conducted by R.J. Burnside and Associates in April 2000. The survey was required to obtain more detailed information on the configuration of the channels as well as some specific crossing structure data” (Section 5.1), and “Cross-section information generated from detailed 1:2000 topographic plan completed specifically for the development site has been enhanced with the field survey data” (Section 5.2).

To maintain the consistency with the Lyons Creek which was simulated in a geo-referenced model, WSP developed a geo-referenced HEC-RAS model for the Grassy Brook starting from approximately 65 m west of Crowland Avenue and ending at approximately 100 m east of Montrose Road with a total length of approximately 2.2 km. Thirty-one cross-sections were generated from the 2016 topographic survey. The channel bed elevations were adjusted to match the channel bottoms in the NPCA’s existing model. The Manning’s N of 0.035 for the main channel and 0.045 to 0.075 for the overbank remain unchanged. The 2016 topographic survey was used to define the road top elevations at three watercourse crossings (**Table 2.2**) in the model. The schematic of the HEC-RAS model is shown in **Figure 2**.

As stated above, in the 2016 Grand Niagara Secondary Plan study, WSP converted the original SWMHYMO hydrologic model to a VO2 model and confirmed that the flow rates produced from these two models generally match. As such, the peak flows were extracted from the VO2 model and were provided in **Table 3.1**. These flows were entered into the HEC-RAS model developed by WSP for this study. A channel slope of 0.00095 was used as “Normal Depth” to define the downstream boundary.

Table 3.1: VO2 Produced Flows under Existing Conditions - Grassy Brook

Location	NHYD VO2 Model	Area (ha)	Peak Flow Rates (m ³ /s)					
			2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
Crownland Ave	12	1191.8	5.83	8.51	10.44	12.97	14.89	16.88
CN Railway	13	1257.1	5.81	8.46	10.37	12.88	14.78	16.73
Montrose Rd	14	1273.8	5.82	8.48	10.39	12.89	14.79	16.75
QEW	15	1283.1	5.82	8.47	10.38	12.89	14.78	16.74

3.4 Floodline Revisions under Existing Conditions

The revised HEC-RAS model was simulated under the existing conditions. The revised 100-year floodlines were plotted, as shown in **Figure 2**. The NPCA existing 100-year floodlines are also illustrated in **Figure 2**.

4 PROPOSED CONDITIONS

4.1 Proposed Draft Plan and Grading Plan

As stated above, the subject lands are designated for low / medium density residential and mixed-use, as outlined in the City's Official Plan under the Grand Niagara Secondary Plan. The draft plan of subdivision is provided in **Appendix A**. Based on the draft plan, three new watercourse crossings are proposed in this development. One structure will cross Grassy Brook at proposed Street A and two structures will cross the Lyons Creek Tributary 1 at proposed Street A and proposed Street HH, respectively. The site grading plan is also provided in **Appendix A**.

4.2 HEC-RAS Model under Proposed Conditions

The revised HEC-RAS model was modified based on the proposed draft plan and grading plan. **Exhibit 3** and **Exhibit 4** illustrate two examples of the cross-section comparisons (existing vs. proposed) at Lyons Creek Tributary 1 RS 4137.727 and Grassy Brook RS 2206, respectively.

Three new watercourse crossings were sized under the proposed conditions. The flow inputs and downstream boundary remain unchanged.

4.3 Model Results and Floodplain Impacts

The HEC-RAS model under the proposed conditions was simulated for the 100-year flood event. A single CON / SPAN culvert was proposed to be installed in three new watercourse crossings. **Table 4.1** summarizes the proposed sizes of these new structures.

Exhibit 5 and **6** show the 100-year water surface profiles under both the existing and proposed conditions along the Grassy Brook and Lyons Creek Tributary 1, respectively. The model results show that the proposed 100-year water levels would have minor increases (0.01 m to 0.03 m) compared to the existing 100-year water levels. As such, the proposed developments have negligible hydraulic impacts on the existing floodplain. **Figure 3** shows the site draft plan, the new watercourse crossings and the 100-year floodlines. The HEC-RAS model results are provided in **Appendix B**.

Lyons Creek Tributary 1 RS 4137.727

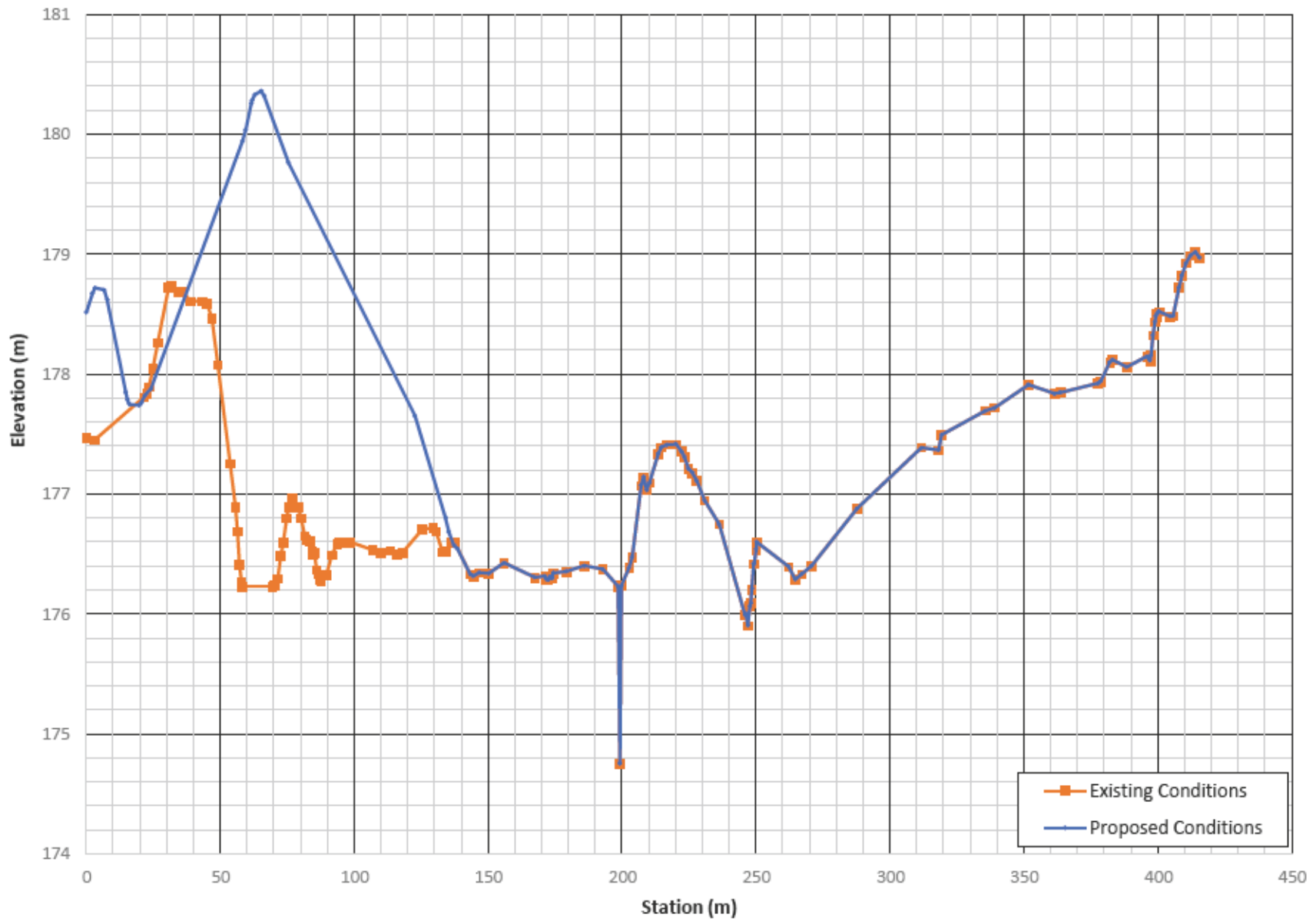


Exhibit 3 Example of Cross Section Comparison (Existing vs. Proposed)

Grassy Brook RS 2206

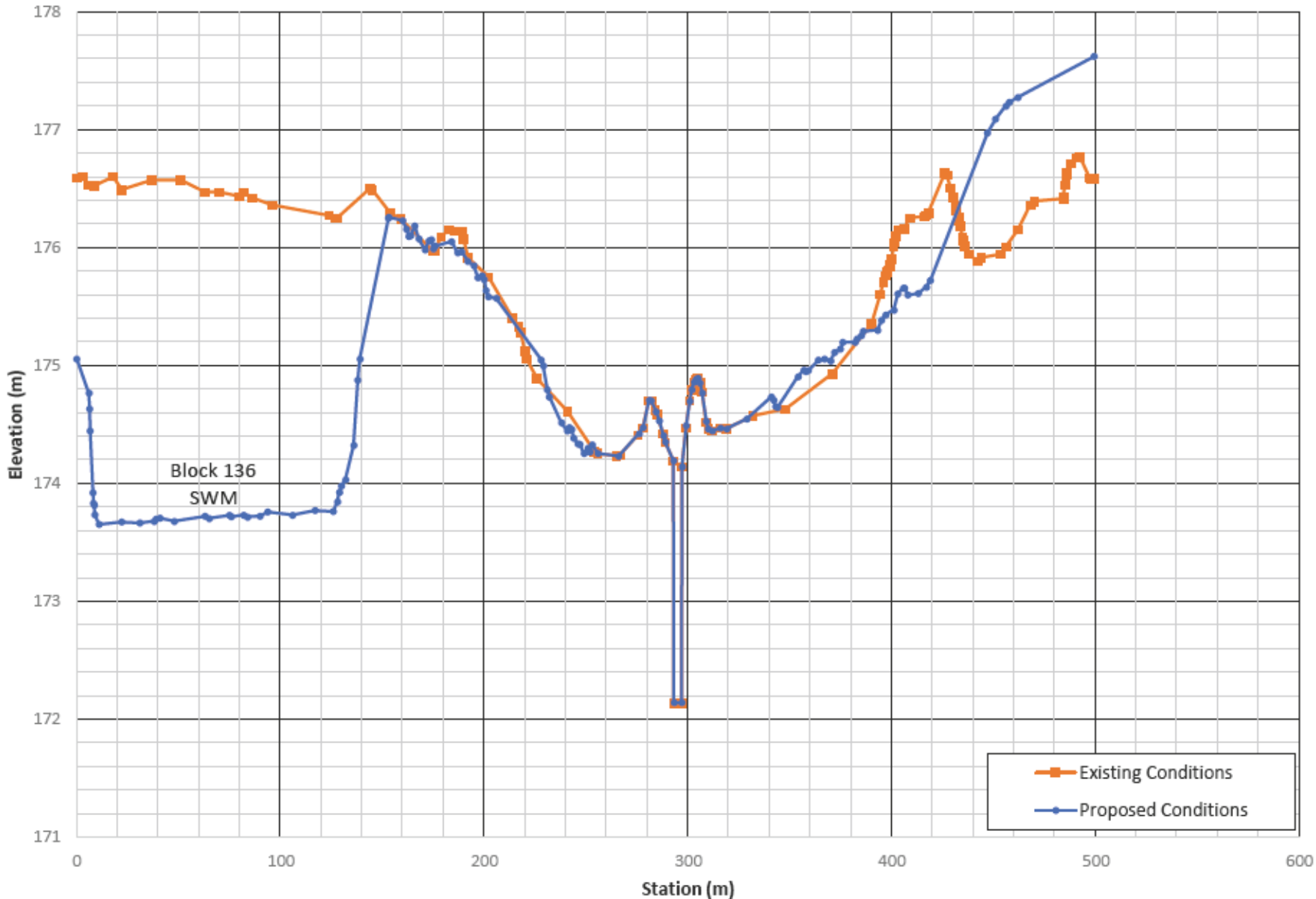


Exhibit 4 Example of Cross Section Comparison (Existing vs. Proposed)

Table 4.1: Sizing of Three New Watercourse Crossings

Location	River	Reach	River Station	Proposed Structure Type	Proposed Culvert Size			Proposed Culvert Obvert (m)	Modelled 100-Year Water Level (m)	Clearance (m)	Overtopping
					Width (m)	Height (m)	Proposed Road Top (m)				
Proposed Street A	Grassy Brook	Reach 1	1920	Conspan Culvert	9.755	3.05	178.00	175.09	174.35	0.74	No
Proposed Street A	Lyons Creek Tributary 1	Trib 1	4000	Conspan Culvert	8.535	3.05	180.55	177.71	176.61	1.10	No
Proposed Street HH	Lyons Creek Tributary 1	Trib 1	2800	Conspan Culvert	9.755	3.05	178.25	177.45	175.97	1.48	No

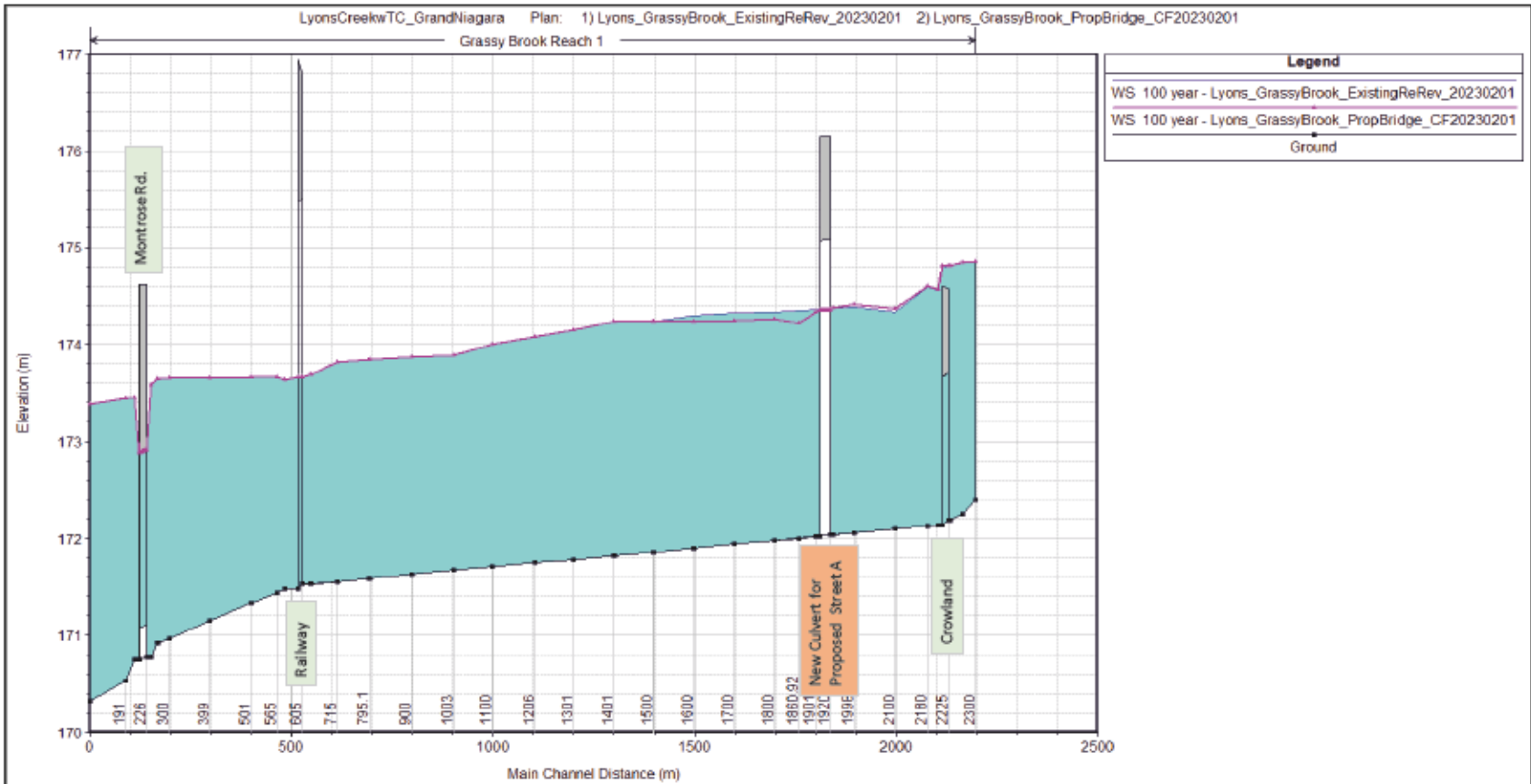


Exhibit 5 Water Surface Profiles along Grassy Brook

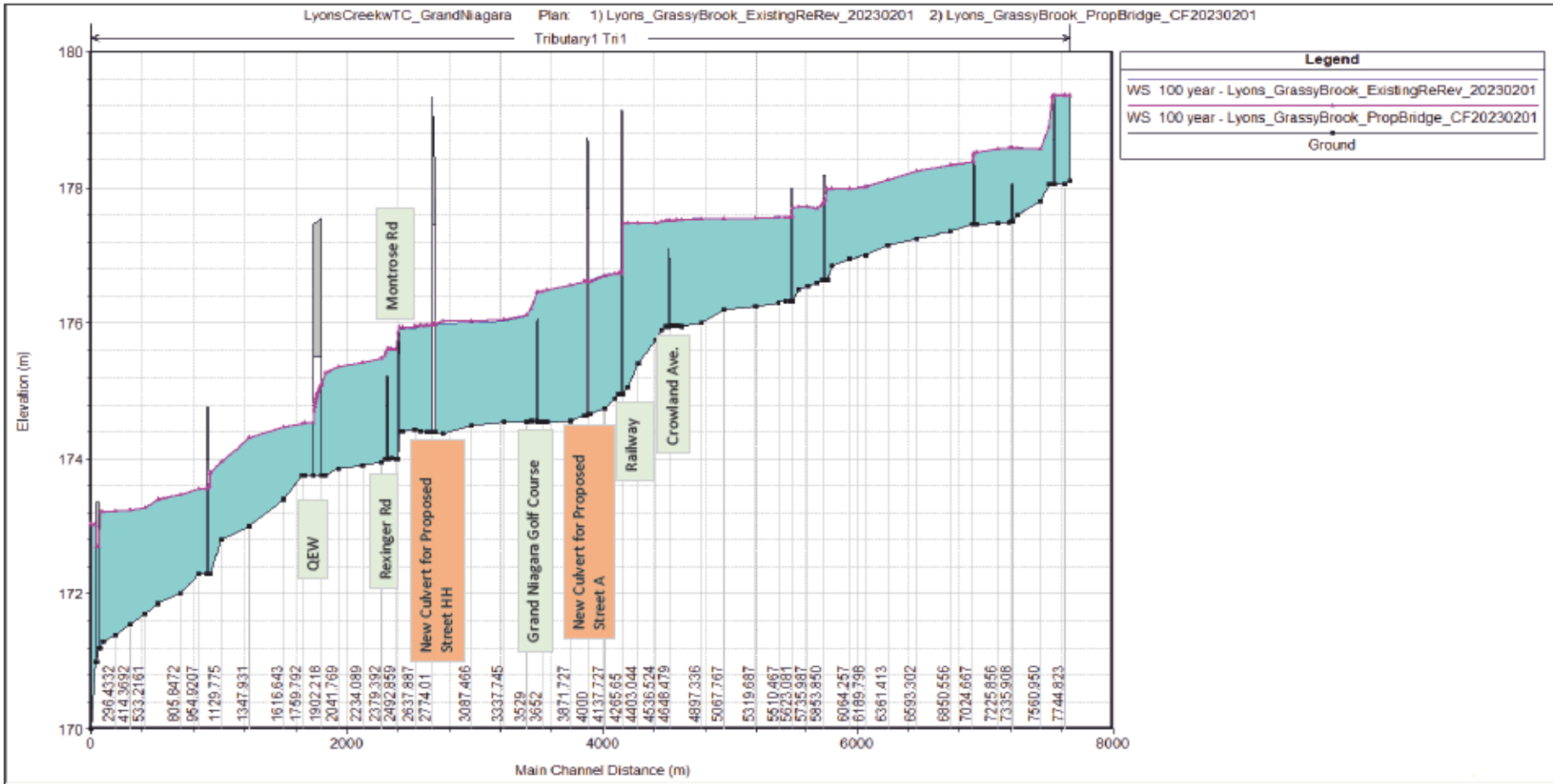
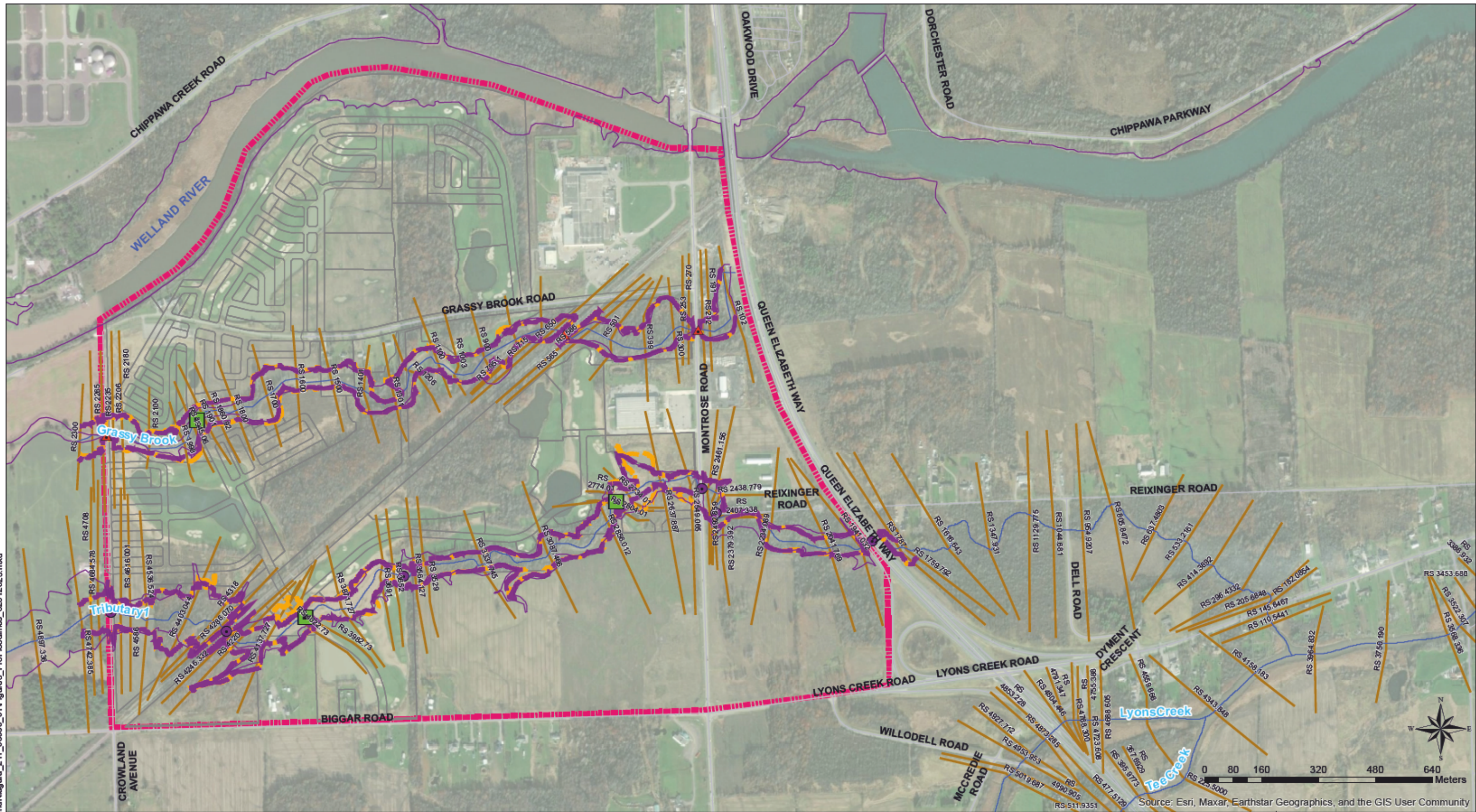


Exhibit 6 Water Surface Profiles along Lyons Creek Tributary 1

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Legend			
■	Proposed Structures	—	NPCA Existing 100-Year Floodline
▲	Structure (Grassy Brook)	—	WSP 100-Year Floodline under Proposed Conditions
●	Structure (Lyons Creek)	—	WSP Revised 100-Year Floodline under Existing Conditions
—	HecRas River	—	HecRAS cross sections
—	Proposed Site Plan (Jan 2023)	—	Grand Niagara Limit
—	Roads		

CLIENT	EMPIRE (GRAND NIAGARA) PROJECT GP INC.	
TITLE	GRAND NIAGARA MIXED-USE DEVELOPMENT FLOODPLAIN MAPPING STUDY	
	100-Year Floodlines under Proposed Conditions	

Checked	I.Q.
Drawn	J.C.
Date	February 2023
Proj. No.	211-08936-00
Scale	1:10,000
Figure No.	3

5 CONCLUSION

A floodplain study was completed for Empire (Grand Niagara) Project GP Inc. to support the proposed Draft Plan of Subdivision for the Grand Niagara Mixed-Use Development located in Niagara Falls, Ontario.

Two existing HEC-RAS models (one for Lyons Creek and the other for Grassy Brook) and Regulatory flood maps were collected from the NPCA for this study. WSP reviewed and revised the existing HEC-RAS models and Regulatory floodlines within the site development boundary based on the latest information.

The revised HEC-RAS model was then modified using the proposed site draft plan and grading plan to simulate the post-development conditions. Three new watercourse crossings were coded and properly sized in the proposed HEC-RAS model. The model results show that the proposed 100-year water levels would have minor increases (0.01 m to 0.03 m) compared to the existing 100-year water levels. As such, the proposed development would have negligible hydraulic impacts on the existing floodplain.

APPENDIX

A

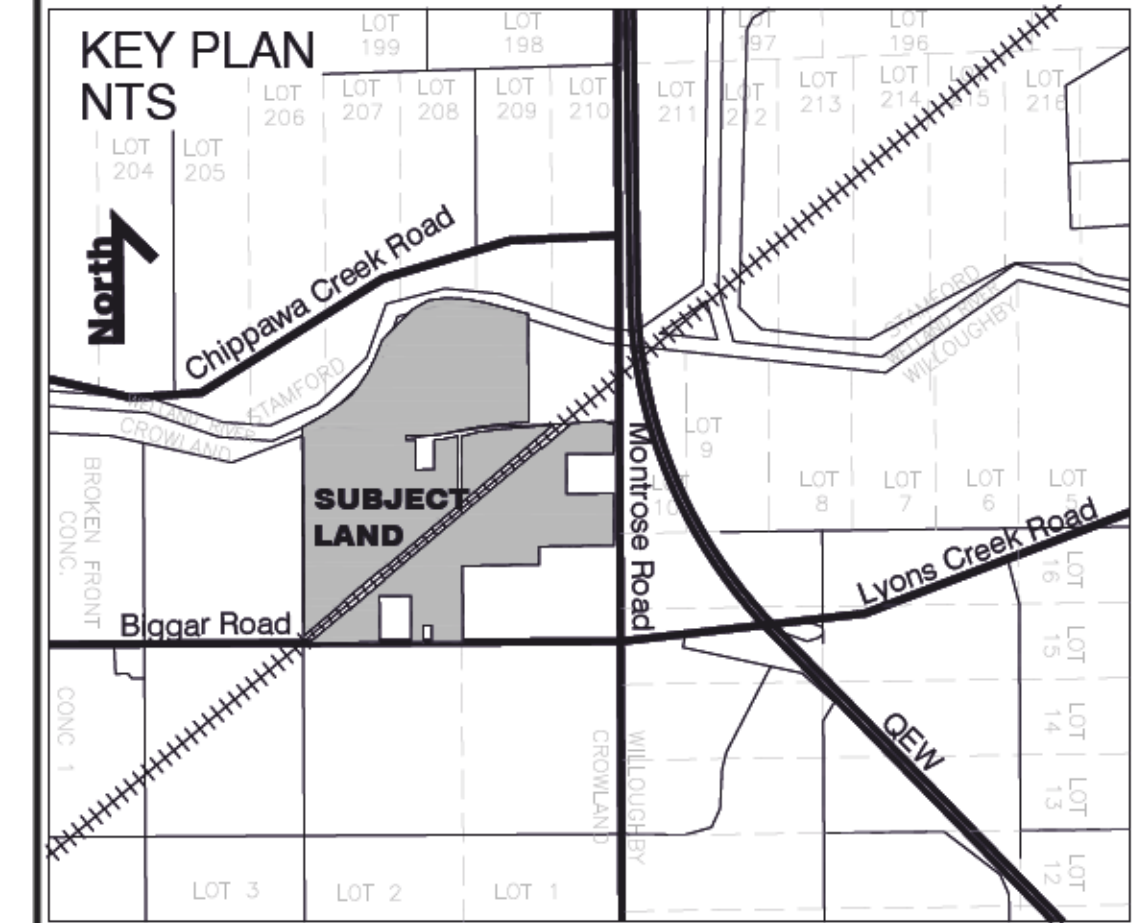
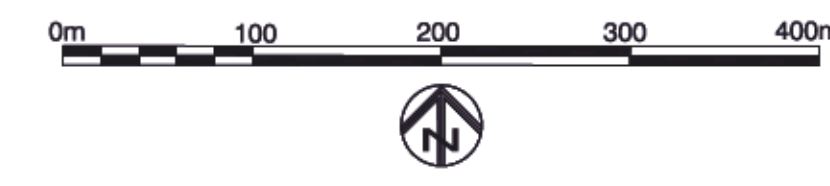
Draft Plan and Grading Plan



DRAFT PLAN OF SUBDIVISION

FOR PART OF LOTS 1 & 2
BROKEN FRONT CONCESSION
(GEOGRAPHIC TOWNSHIP OF CROWLAND)
REGIONAL MUNICIPALITY OF NIAGARA

January 26, 2023



LAND USE	Block Number	Units	Area (ha)	LAND USE	Block Number	Units	Area (ha)
Residential	100-103	15.13	26.0	Hospital Employment/Hospice	96-97	-	1.35
Residential	104-109	1.87	4.6	Schools	98-99	-	5.78
Residential	110-120	2.21	5.5	SWM	100-103	-	8.78
Residential	121-125	15.39	38.0	Parks	104-109	-	5.23
Residential	126	0.82	1.9	EPA (Environmental Protection Area)	110-120	-	79.38
Residential	127	2.81	6.9	Road Widening	121-125	-	0.49
Residential	85-88	403.39	8.07	Bioswale	126	-	0.09
Residential	89-92	633.39	8.44	Roads	Streets A-NN	-	23.00
Residential	93-95	1478.82	9.84	Subtotal	-	-	124.10
Subtotal	3,558.19	60.36	148.2	Total	-	-	3,558.19

- - - - - Development Limit
 ■ ■ ■ ■ ■ 2.0km to Cytec property
 - - - - - 200m buffer to Cytec 2.0km line
 - - - - - 15.0m setback from rail line

* DENSITY RANGE BASED ON 60/75 LUPHA FOR MEDIUM, 75/150 LUPHA FOR APARTMENT AND 150/200 LUPHA FOR MIXED

ADDITIONAL INFORMATION REQUIRED UNDER SECTION 51 (17) OF THE PLANNING ACT, R.S.O., 1990

- (a) AS SHOWN ON DRAFT AND KEY PLANS
 - (b) AS SHOWN ON DRAFT PLAN AS SHOWN ON DRAFT AND KEY PLANS
 - (c) AS SHOWN ON DRAFT PLAN AS SHOWN ON DRAFT AND KEY PLANS
 - (d) THE LAND IS TO BE USED ACCORDING TO THE SCHEDULE OF LAND USE
 - (e) AS SHOWN ON DRAFT AND KEY PLANS
 - (f) AS SHOWN ON DRAFT PLAN
 - (g) AS SHOWN ON DRAFT AND KEY PLANS
 - (h) MUNICIPAL WATER SUPPLY TO BE MADE AVAILABLE
 - (i) SOIL IS SILTY CLAY
 - (j) AS SHOWN ON DRAFT PLAN
 - (k) FULL MUNICIPAL SERVICES TO BE MADE AVAILABLE
 - (l) SUBJECT TO EASEMENTS AS SHOWN ON THE DRAFT PLAN
- Note:
All dimensions on curves are chord lengths unless otherwise indicated.

OWNER'S AUTHORIZATION

I AUTHORIZE WSP CANADA GROUP LTD. TO PREPARE AND SUBMIT THIS DRAFT PLAN OF SUBDIVISION TO THE CITY OF NIAGARA FALLS FOR APPROVAL.

Daniel Guizzetti, President _____ DATE _____
Empire (Grand Niagara) Project GP Inc.

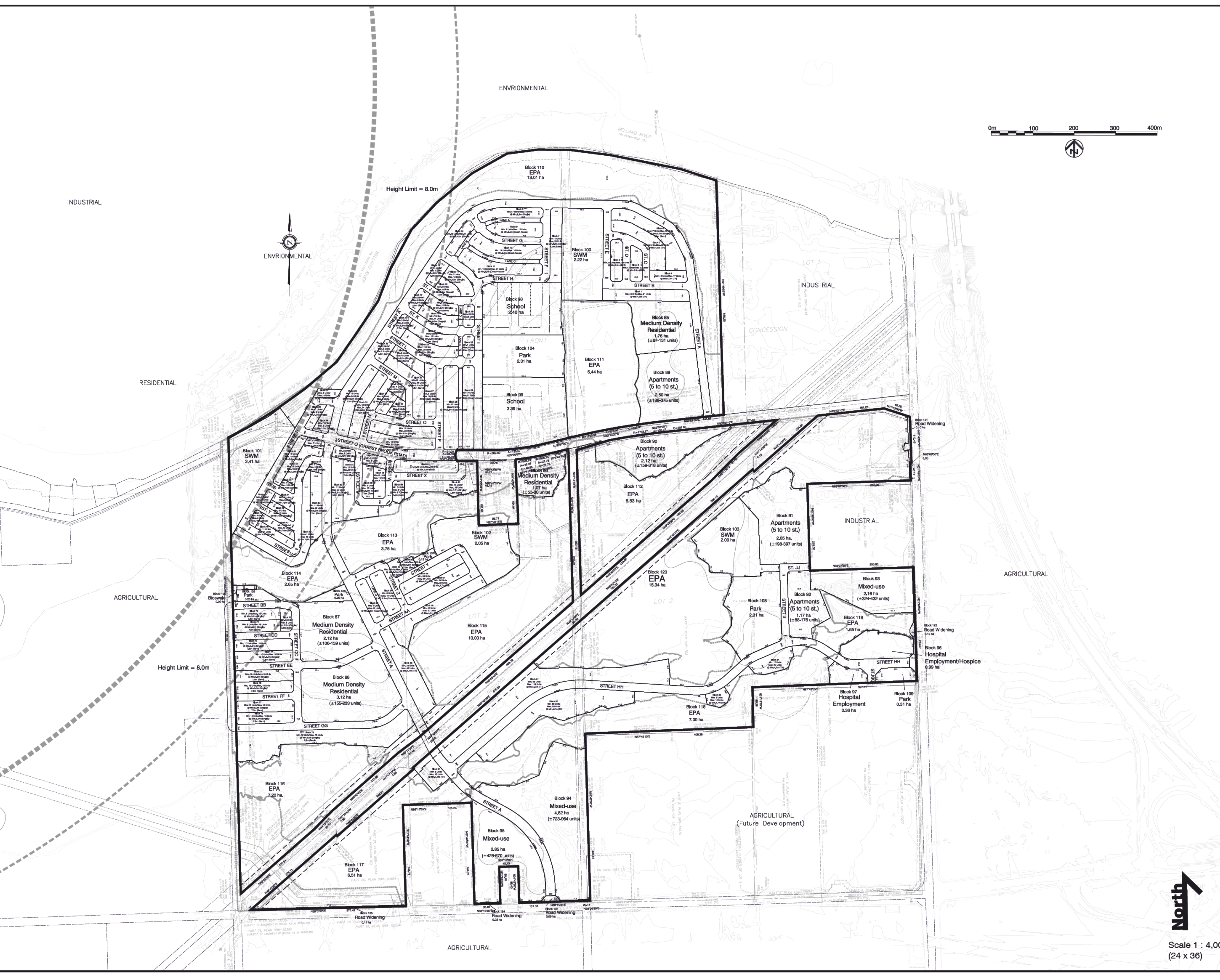
SURVEYOR'S CERTIFICATE

I HEREBY CERTIFY THAT THE BOUNDARIES OF THE LAND TO BE SUBDIVIDED AS SHOWN ON THIS PLAN AND THEIR RELATIONSHIP TO THE ADJACENT LANDS ARE ACCURATELY AND CORRECTLY SHOWN.

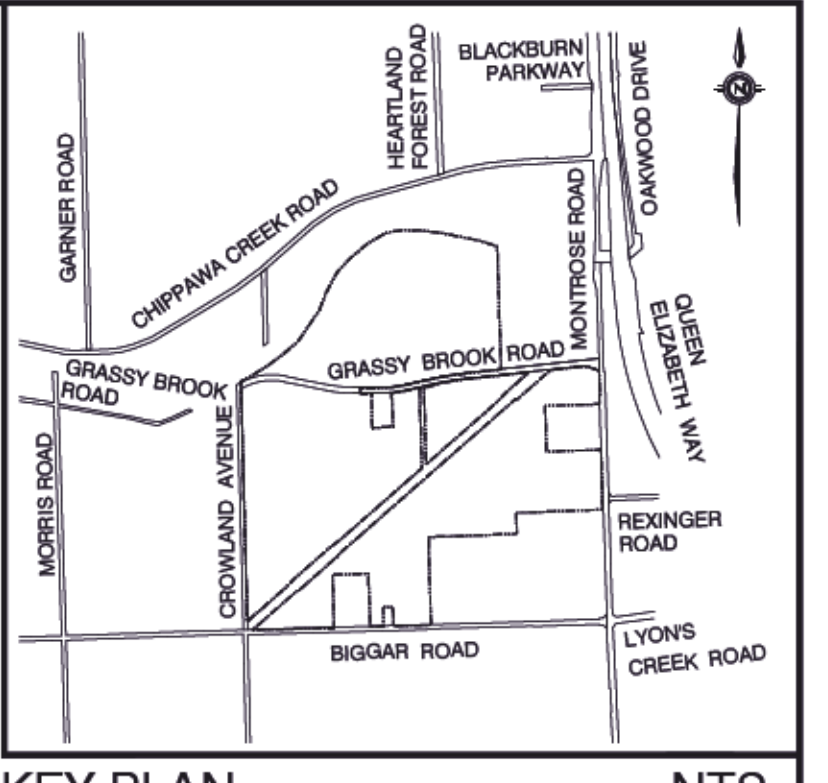
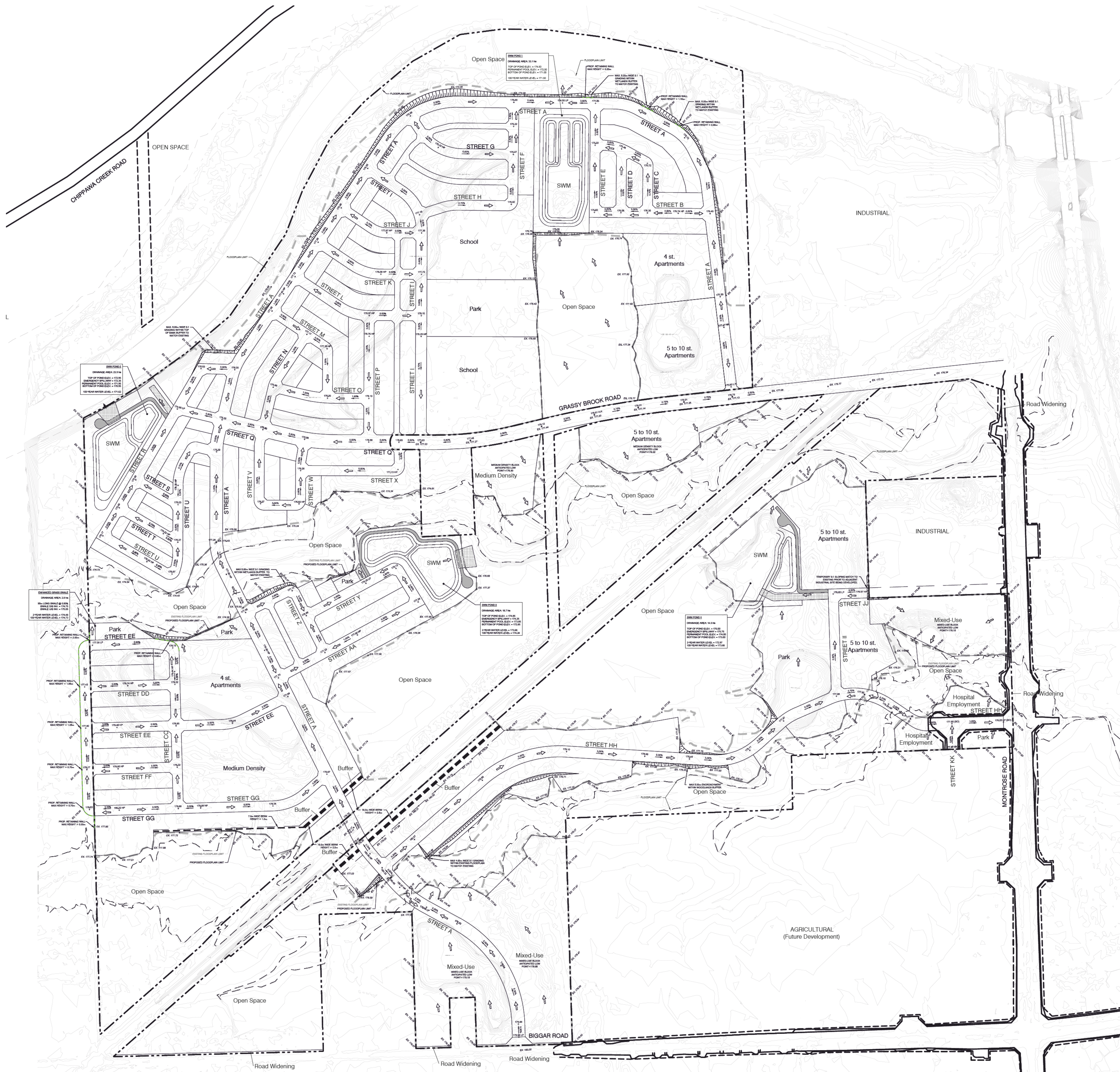
Yuriy Bogdanov, Ontario Land Surveyor, OLP _____ DATE OCT. 30, 2023
Geoverro

PLAN PREPARED BY

Nathan Honas, CPT _____ DATE JAN. 26, 2023
WSP CANADA GROUP LTD. _____
211-08936-00-PL2



North
Scale 1 : 4,000
(24 x 36)



KEY PLAN NTS

- LEGEND**
- LIMIT OF PROPERTY
 - - - - - LIMIT OF SUBDIVISION
 - - - - - EXISTING FLOODPLAIN
 - - - - - PROPOSED FLOODPLAIN (WHERE APPLICABLE)
 - x EX 176.34 EXISTING GRADE
 - + 245.50 PROPOSED GRADE
 - 1.0% PROPOSED SLOPE
 - PROPOSED RETAINING WALL
 - DIRECTION OF OVERLAND FLOW
 - - - - - EXISTING GROUND CONTOUR
 - █ PROPOSED 1.0m HIGH BERM
 - █ PROPOSED 2.5m HIGH BERM
 - - - - - PROPOSED SWALE

NOTE: PLEASE REFER TO THE DESIGN BY PARSONS CORPORATION FOR PORTION OF STREET FF AND STREET NN LABELED AS 'BY OTHERS'.

NOTE: PROPOSED GRADES AND SLOPES ARE CONCEPTUAL ONLY AND ARE SUBJECT TO DETAILED DESIGN

NOTE: 0.3% ROAD SLOPE REPRESENTS SAW-TOOTHING TO BE DETAILED FURTHER AT DETAILED DESIGN

1	FIRST OPA SUBMISSION	ZBVL	2025/01/18	ADR
No.	REVISION TO DRAWING	BY	DATE	APPR
ALL PREVIOUS ISSUES OF THIS DRAWING ARE SUPERSEDED				
CLIENT EMPIRE (GRAND NIAGARA) GP INC.				
MUNICIPALITY CITY OF NIAGARA FALLS				
PROJECT TITLE GRAND NIAGARA MIXED-USE SUBDIVISION				
SHEET TITLE PRELIMINARY GRADING PLAN				
CONSULTANT wsp 100 Commerce Valley Dr., West, Thornhill, ON, Canada L3T 0A1 1-905-881-1100 1-905-881-0255 www.wsp.com				
DESIGNED ZBVL		DRAWN ZBVL		CHECKED ADR
SCALE 1:2500		DATE JANUARY 2023		
PROJECT NUMBER 211-08936		DWG. NUMBER SG1		

FILENAME: C:\Users\jg\OneDrive\Documents\211-08936\211-08936-01-01-0000-0000-0000-0000-0000-0000-0000-0000-0000-0000.dwg
 PLOT DATE: 2023-01-18 10:00:00 AM

APPENDIX

B

HEC-RAS Model Results



HEC-RAS Profile: 100 year (Continued)

River	Reach	River Sta	Profile	Plan	Q Total (m ³ /s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m ²)	Top Width (m)	Friction # CH
Grassy Brook	Reach 1	900	100 year	Lyons_Grassybrook_Prop@Edge_CF20230201	18.73	171.83	173.87	173.00	173.87	0.000146	0.48	59.79	83.65	0.11
Grassy Brook	Reach 1	795.1	100 year	Lyons_Grassybrook_Existing@Rev_20230201	18.73	171.59	173.84	172.88	173.88	0.000238	0.85	42.45	41.01	0.15
Grassy Brook	Reach 1	795.1	100 year	Lyons_Grassybrook_Prop@Edge_CF20230201	18.73	171.59	173.84	172.88	173.88	0.000238	0.85	42.45	41.01	0.15
Grassy Brook	Reach 1	715	100 year	Lyons_Grassybrook_Existing@Rev_20230201	18.73	171.25	173.82	172.96	173.82	0.000310	0.82	43.18	52.52	0.18
Grassy Brook	Reach 1	715	100 year	Lyons_Grassybrook_Prop@Edge_CF20230201	18.73	171.25	173.82	172.96	173.82	0.000310	0.82	43.18	52.52	0.18
Grassy Brook	Reach 1	650	100 year	Lyons_Grassybrook_Existing@Rev_20230201	18.73	171.03	173.80	172.88	173.79	0.001041	1.40	11.98	106.62	0.32
Grassy Brook	Reach 1	650	100 year	Lyons_Grassybrook_Prop@Edge_CF20230201	18.73	171.03	173.80	172.88	173.79	0.001041	1.40	11.98	106.62	0.32
Grassy Brook	Reach 1	605		Railway										
Grassy Brook	Reach 1	596	100 year	Lyons_Grassybrook_Existing@Rev_20230201	18.75	171.48	173.63	172.51	173.71	0.000689	1.40	14.03	119.90	0.31
Grassy Brook	Reach 1	596	100 year	Lyons_Grassybrook_Prop@Edge_CF20230201	18.75	171.48	173.63	172.51	173.71	0.000689	1.40	14.03	119.90	0.31
Grassy Brook	Reach 1	565	100 year	Lyons_Grassybrook_Existing@Rev_20230201	18.75	171.44	173.66		173.67	0.000778	0.41	88.78	86.77	0.09
Grassy Brook	Reach 1	565	100 year	Lyons_Grassybrook_Prop@Edge_CF20230201	18.75	171.44	173.66		173.67	0.000778	0.41	88.78	86.77	0.09
Grassy Brook	Reach 1	501	100 year	Lyons_Grassybrook_Existing@Rev_20230201	18.75	171.33	173.66		173.66	0.000685	0.37	90.78	91.44	0.08
Grassy Brook	Reach 1	501	100 year	Lyons_Grassybrook_Prop@Edge_CF20230201	18.75	171.33	173.66	172.66	173.66	0.000685	0.37	90.78	91.44	0.08
Grassy Brook	Reach 1	369	100 year	Lyons_Grassybrook_Existing@Rev_20230201	18.75	171.15	173.65		173.65	0.000101	0.46	75.14	87.40	0.10
Grassy Brook	Reach 1	369	100 year	Lyons_Grassybrook_Prop@Edge_CF20230201	18.75	171.15	173.65		173.65	0.000101	0.46	75.14	87.40	0.10
Grassy Brook	Reach 1	300	100 year	Lyons_Grassybrook_Existing@Rev_20230201	18.75	170.97	173.65		173.65	0.000103	0.19	189.70	128.98	0.04
Grassy Brook	Reach 1	300	100 year	Lyons_Grassybrook_Prop@Edge_CF20230201	18.75	170.97	173.65		173.65	0.000103	0.19	189.70	128.98	0.04
Grassy Brook	Reach 1	270	100 year	Lyons_Grassybrook_Existing@Rev_20230201	18.75	170.92	173.65		173.65	0.000394	0.29	85.33	66.95	0.08
Grassy Brook	Reach 1	270	100 year	Lyons_Grassybrook_Prop@Edge_CF20230201	18.75	170.92	173.65		173.65	0.000394	0.29	85.33	66.95	0.08
Grassy Brook	Reach 1	253	100 year	Lyons_Grassybrook_Existing@Rev_20230201	18.75	170.78	173.59	171.81	173.64	0.000427	1.07	18.07	51.37	0.20
Grassy Brook	Reach 1	253	100 year	Lyons_Grassybrook_Prop@Edge_CF20230201	18.75	170.78	173.59	171.81	173.64	0.000427	1.07	18.07	51.37	0.20
Grassy Brook	Reach 1	228		Monroe Rd										
Grassy Brook	Reach 1	212	100 year	Lyons_Grassybrook_Existing@Rev_20230201	18.74	170.75	173.45	171.70	173.48	0.000368	0.80	29.64	44.44	0.18
Grassy Brook	Reach 1	212	100 year	Lyons_Grassybrook_Prop@Edge_CF20230201	18.74	170.75	173.45	171.70	173.48	0.000368	0.80	29.64	44.44	0.18
Grassy Brook	Reach 1	191	100 year	Lyons_Grassybrook_Existing@Rev_20230201	18.74	170.53	173.45		173.47	0.000441	0.83	41.81	60.41	0.19
Grassy Brook	Reach 1	191	100 year	Lyons_Grassybrook_Prop@Edge_CF20230201	18.74	170.53	173.45		173.47	0.000441	0.83	41.81	60.41	0.19
Grassy Brook	Reach 1	102	100 year	Lyons_Grassybrook_Existing@Rev_20230201	18.74	170.32	173.36	172.76	173.41	0.000661	0.80	31.37	36.80	0.25
Grassy Brook	Reach 1	102	100 year	Lyons_Grassybrook_Prop@Edge_CF20230201	18.74	170.32	173.36	172.76	173.41	0.000661	0.80	31.37	36.80	0.25