BEAR CREEK – SOUTH TRIB, MAIN BRANCH
FLOODPLAIN ANALYSIS REPORT

DIPOCE (INNISFIL) INC. DEVELOPMENT

PROPOSED RESIDENTIAL DEVELOPMENT

CITY OF BARRIE

PROJECT 2017-4560 **OCTOBER 2019**

Revision	Description	Prepared		Checked	
		By	Date	By	Date
0.	Original Submission	M. Ventresca	Oct. 2019	K. Shahbikian	Oct. 2019

SCHAEFFERS
CONSULTING ENGINEERS
6 Ronrose Drive
Concord, Ontario L4K 4R3

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF APPENDICES

1.0 Introduction

Schaeffer & Associates Ltd. [herein referred to as Schaeffers Consulting Engineers (SCE)] has been retained by DiPoce Management Limited to prepare floodplain mapping in support of the proposed residential & commercial development in the City of Barrie.

This report presents the floodplain results analysis for the main branch of the south tributary of Bear Creek, through the DiPoce Lands in the City of Barrie within the limits of the Salem Secondary Plan. In this study, the hydraulic model of Bear Creek has been developed based on the best available data including detailed topographic survey data, AMEC's HEC-RAS model and hydrologic models' outputs for both the existing and post-development conditions.

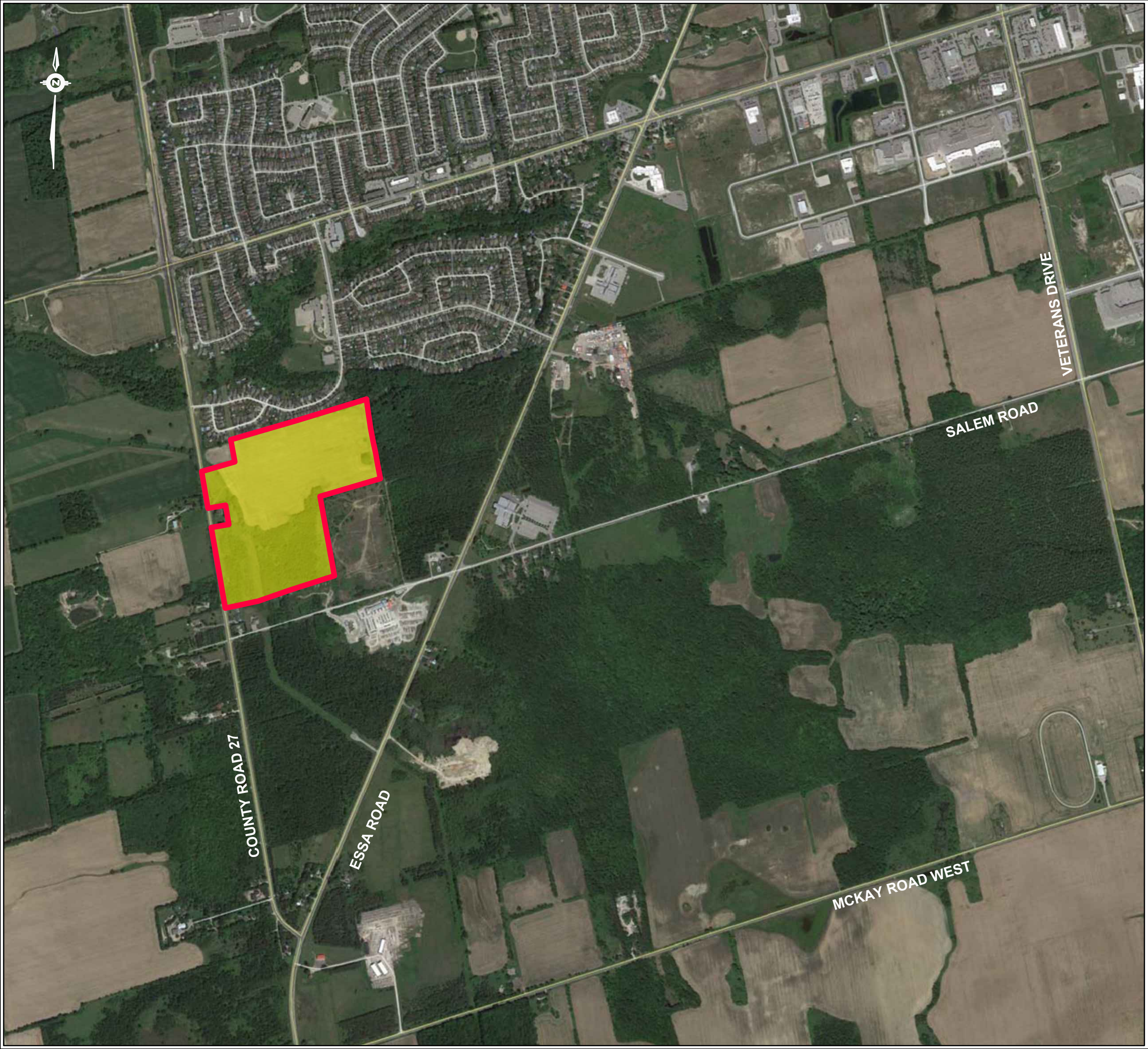
The main objective of this study is to confirm the floodplain establish in the Subwatershed Impact Study (SIS) phase and to prepare a revised regulatory floodplain for the south tributary of Bear Creek through the proposed DiPoce Inc. mixed-use development lands within Nottawasaga Valley Conservation Authority (NVCA) limits based on the calculated flows and updated topographic data. The subject site is located in the Barrie Annexed Lands, North of Salem Road, West of Essa Road, East of Country Road 27, and South of an existing residential area, as illustrated in **Figure 1-1** & **Figure 1-2**.

GeoHEC-RAS, which is a GIS based software that conducts analysis using the HEC-RAS engine, was used for the digital floodplain mapping in this study.

This report will address the background information, methodology, hydraulic modelling procedure and floodplain preparation.

W:\4500's\4560 DiPoce - Barrie\Drawings\Servicing\2018-12-10-4560-Servicing.dwg

Michael Ventresca



DI POCE (INNISFIL) INC.
CITY OF BARRIE

LEGEND

SUBJECT SITE

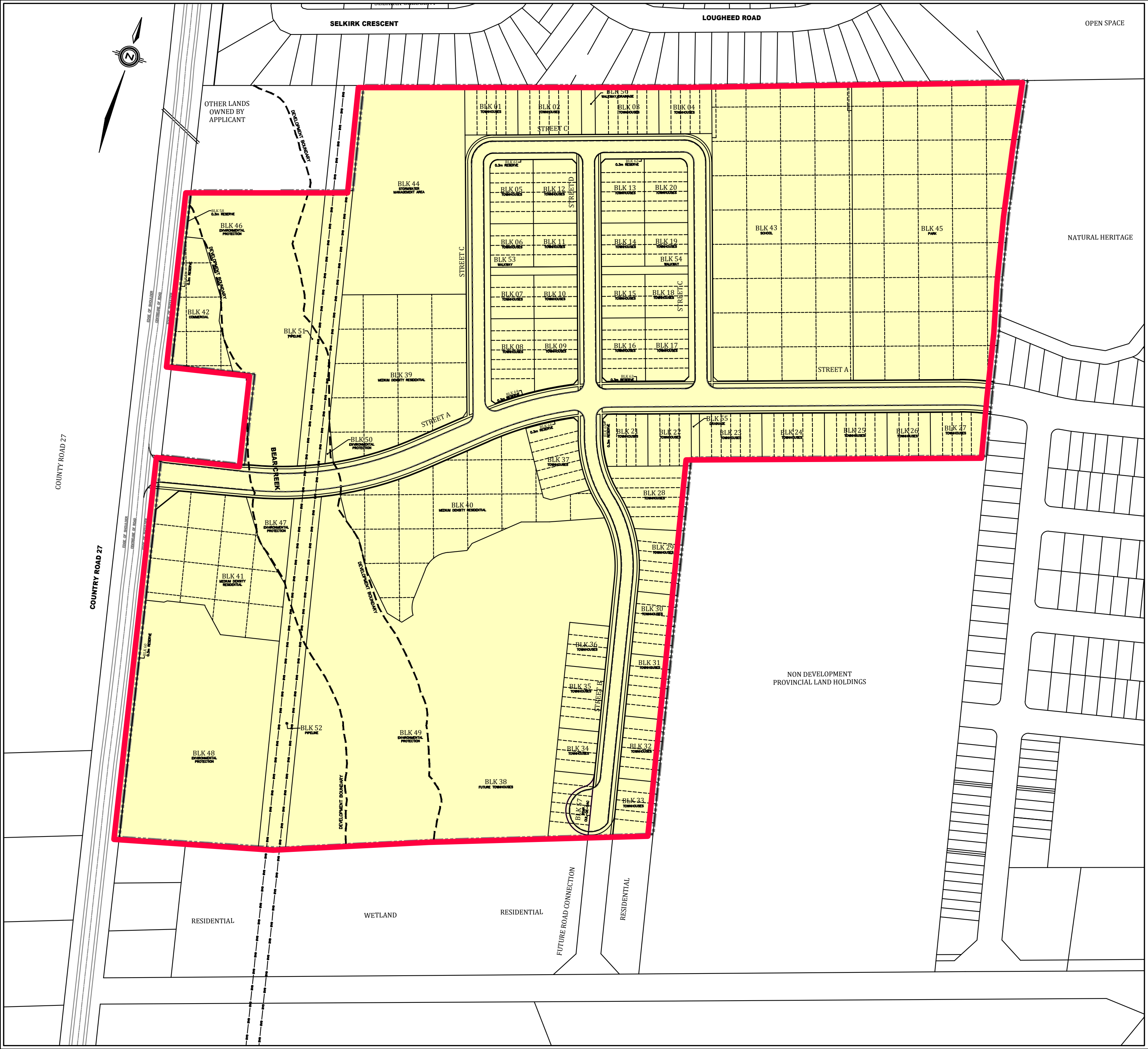
SCHAEFFERS
CONSULTING ENGINEERS
6 Ronrose Drive, Concord, Ontario L4K 4R3
Tel: (905) 738-6100 Email: general@schaeffers.com
www.schaeffers.com

FIGURE 1-1
LOCATION PLAN

2017-4560	OCTOBER 2019	SCALE: N.T.S.

W:\4500's\4560 DiPoce - Barrie\Drawings\Servicing\2018-12-10-4560-Servicing.dwg

Michael Ventresca



DI POCE (INNISFIL) INC.
CITY OF BARRIE

LEGEND

SUBJECT SITE

SCHAEFFERS
CONSULTING ENGINEERS
6 Ronrose Drive, Concord, Ontario L4K 4R3
Tel: (905) 738-6100 Email: general@schaeffers.com
www.schaeffers.com

FIGURE 1-2
DEVELOPMENT PLAN

2017-4560	OCTOBER 2019	SCALE: N.T.S.

2.0 Methodology of GeoHECRAS Modeling and Floodplain Analysis

A hydraulic model for the subject site has been created using GeoHECRAS® Version 2.7 to analyze high water surface profile elevations and generate floodplains. The models' parameters and geometric data (i.e., reach alignment, cross-sections' location and geometry, hydraulic structures data) have been developed based on the best available data including detailed topographic data, aerial topographic data and the original HEC-RAS models which was first used by AMEC and later revised at the SIS stage by Schaeffers in December 2017. Hydraulic modelling and steady flow analysis are performed for both the existing and post-development conditions.

It should be noted that the post-development flows and upgraded culverts are considered for this scenario. The model development procedure can be summarized as following:

- Determine georeferenced alignment of the reach (NAD83/UTM zone 17N);
- Generate surface terrain layer based on the elevation data source;
- Determine cross-section locations considering the hydraulic characteristics of the study area and HEC-RAS Hydraulic Reference Manual criteria;
- Generate geo-referenced cross-sections using digital terrain layer along a watercourse reach;
- Add hydraulic structures data to the model;
- Determine key model parameters (e.g., Loss Coefficients and Manning's 'n' values and Flow lengths);
- Import the existing HEC-RAS model received from AMEC, namely in the Main Branch and of South Tributary to Bear Creek into GeoHECRAS;
- Check the provided boundary conditions for the hydraulic modelling;
- Conduct Steady Flow analysis and Water Surface Profile calculation; and
- Generate required floodplains for the most conservative storm event.

3.0 Development of the Model

The following sections will delve into the methodology behind arriving at the modelling parameters.

3.1 Input Data

The input data for the hydraulic model including the hydrologic flow data and the topographic information is detailed in the section below.

3.1.1 Hydrologic Data

GeoHEC-RAS model flows have been updated based on the VO2 hydrologic model outputs for the uncontrolled 100-year and Regional storm events (i.e., Timmins). According to the current provincial policy peak flows cannot be controlled by Stormwater Management for regulatory floodplain analysis. Based on the NVCA guidelines, the uncontrolled Regional Storm (i.e., Timmins Storm) and the 100-year storm events should be considered for the floodplain mapping. It should be noted that the Regional and 100-year SCS type II 24 hour and 100-year Chicago 4 hour uncontrolled storm flows are modelled using VO2 and considered for the hydraulic modelling of Bear Creek.

According to the NVCA Natural Hazards Technical Guide, the 100-year flood is determined by the greater runoff generated by either the 1:100-year SCS Type II 24 hour or the 1:100-year 4 hour Chicago storms. **Table 3-1** below presents the design flows for hydraulic modelling of Bear Creek under the existing condition and **Table 3-2** presents simulated peak flows for Bear Creek under the post-development condition. Please note that the IDF curve generated from the MTO IDF Lookup Tool was run in the SIS hyrologic model to ensure that the peak flows were less than the Barrie 4-Hour Chicago Storm. The peak flows for the MTO's IDF curve are provided in the table below for reference.

Table 3-1: Flows for the Hydraulic Modelling of Bear Creek – Existing Condition

Reach	Node	Cross Section Station	SCS II 24HR (UC 100YR)	Regional	Barrie Chicago 4HR (UN 100YR)	MTO Chicago 4HR (UN 100YR)
Main South Tributary	506/9003	2034	0.335	0.506	0.271	0.180
	9001	1493.186	1.856	2.481	1.506	1.017

Table 3-2: Flows for the Hydraulic Modelling of Bear Creek – Future Condition

Reach	Node	Cross Section Station	SCS II 24HR (UC 100YR)	Regional	Barrie Chicago 4HR (UN 100YR)	MTO Chicago 4HR (UN 100YR)
Main South Tributary	9003	2034	4.886	2.118	6.480	6.001
	9004	1493.186	4.368	2.327	5.179	4.647
	9001	1290.42	10.340	5.179	12.305	10.480

3.1.2 Topographic Data

With reference to the City of Barrie Secondary plan, the existing HEC-RAS models which were proposed by AMEC were developed based on the digital elevation model (DEM, 10 m resolution). It is indicated that there is room for revising these models based on more accurate data. Hence, in order to increase the accuracy of the hydraulic modelling, in the DiPoce Lands areas, detailed topographic data was collected and used for creating a Triangular Irregular Network (TIN). These sources of elevation data are used for generating digital terrain layers in GeoHEC-RAS.

Please refer to **Appendix A** for a drawing reflecting the detailed topographic data available. It should be noted that, aerial topographic data and the DSWMMP HEC-RAS models which were proposed by AMEC are used for the upstream and downstream sections of the studied watercourse.

3.2 Modelling Procedure in GeoHEC-RAS

3.2.1 Cross-Sections

Based on the HEC-RAS computational method, topographic data should be converted to geometric configuration which is represented by the cross-sections. Cross-sections' geometries are extracted at the required locations from the generated ground terrain layer. The alignment of the cross-sections should be perpendicular to the direction of the flow. Hence, for the left and the right overbanks, cross-sections alignments are drawn considering the flow directions based on the drawn flow centerline for the right and the left overbanks. Flow length for the main channel and centre line of the flow mass is used for manual calculation of overbank flow lengths using GeoHEC-RAS.

Considering the lack of available observed information, Manning's values for the main channel and the left and the right overbanks are determined based on the best available information using *Table 3-1* of the HEC-RAS hydraulic reference manual and DSWMMP HEC-RAS models.

Contraction and Expansion Coefficients which are used for calculating losses in HEC-RAS steady flow computations should be considered in hydraulic modelling. In the current study, Contraction and Expansion Coefficients are set to 0.1 and 0.3 respectively where the changes in river cross-sections are small and the flow is subcritical (*Table 3-3* HEC-RAS hydraulic reference manual). It should be noted that, Contraction and Expansion Coefficients are set to 0.3 and 0.5, respectively, at two upstream and downstream sections around the hydraulic structures boundaries.

3.2.2 Boundary Conditions

The boundary condition for the South Tributary of Bear Creek is set to the junction of the intersection of the Upper Bear Creek and South Tributary; the boundary for Upper Bear Creek is set to the Normal Depth. The Normal Depth is calculated based on the slope of channel at the downstream of the reaches. Since the location of the introduced boundary conditions are far from the subject study area, it can be anticipated that these normal depth conditions will not significantly impact on the analysis. Furthermore, Critical Depth is considered as the upstream boundary condition of the model.

3.2.3 Hydraulic Structures

Hydraulic structures including culverts are modelled based on the best available data including field surveys and detailed topographic data or information from the current DSWMMP HEC-RAS model. In addition, considering the recommendations of the City of Barrie Stormwater Management Policies and Design Guidelines, the location of the controlling cross-sections at the culvert points are determined based on the HEC-RAS hydraulic reference manual recommendations.

In order to define ineffective flow areas at the boundary cross-sections of the culverts, the contraction reaches at the upstream side of the culverts are based on a 1:1 contraction rate and the expansion reaches at the downstream side of the culverts consider a 2:1 expansion rate. As mentioned before, HEC-RAS hydraulic reference manual recommends values of 0.3 and 0.5 for contraction and expansion, respectively, for the two boundary cross-sections of the culverts both upstream and downstream, these values are used in the current study as well. Based on the obtained hydraulic modelling results, the existing culverts were analyzed and assessed. With the aim of conveying flows under the post-development condition a new culvert size for the existing culvert conveying flows westerly under County Road 27 has been proposed and considered based on the City of Barrie standards. It should be noted, the HEC-RAS hydraulic model has been used to size the proposed culverts. The impact on upstream floodplain is also considered in culvert sizing analysis. **Table 3-3** presents the existing and proposed culverts information for Bear Creek.

Culvert No.	Location	Cross Section	Design Peak Flow (m^3/s)		Structure		
			Existing Regulatory [1]	Proposed Regulatory[1]	Type	Existing (mm)	Proposed (mm)
1	Salem Road	1946	0.51	6.48	Concrete Circular	500mmØ	500mmØ
2	Country Rd. 27	1264	2.48	12.31	--	CSP-1400	Conc. 2.4 x 1.5m box
3	Street ‘A’	1549	0.51	6.48	Concrete Box	--	3.0 x 1.5m

[1] *Greater of 100 Year SCS Type II 24 hour, 100 Year Chicago 4 hour and Regional*

3.3 Analysis of GeoHEC-RAS Model Results and Floodplain Mapping

The following sections delve into an analysis of the results from the GeoHEC-RAS modelling and subsequent floodplain generation for both the existing and proposed conditions.

3.3.1 Existing Condition

Under the existing condition, the Bear Creek cross-sections have been updated based on available field survey information.

Hydraulic modeling has been done in GeoHEC-RAS to calculate the water surface elevations and flood lines for the existing condition scenario. Simulated peak flows have been used in the hydraulic modeling procedure and the summary of the modeling results have been presented in **Table 3-4** below for the South Tributary of Bear Creek.

Table 3-4: South Tributary of the Bear Creek GeoHEC-RAS Water Surface Elevation Results – Existing Condition

Cross Section Station	Min Channel Elevation	SCS II 24HR (UN 100YR)		Chicago 4HR (UN 100YR)		Regional		Regulatory
		Total Flow	W.S. Elev.	Total Flow	W.S. Elev.	Total Flow	W.S. Elev.	W.S. Elev.
	(m)	(m^3/s)	(m)	(m^3/s)	(m)	(m^3/s)	(m)	(m)
2034	305.50	0.33	305.86	0.27	305.80	0.51	305.92	305.92
2024	305.16	0.33	305.86	0.27	305.80	0.51	305.92	305.92
2003	304.48	0.33	305.86	0.27	305.80	0.51	305.92	305.92
1975	304.43	0.33	305.86	0.27	305.80	0.51	305.92	305.92
1957.6	304.72	0.33	305.86	0.27	305.80	0.51	305.92	305.92
1952.89	305.18	0.33	305.86	0.27	305.80	0.51	305.92	305.92
1939.98	304.62	0.33	304.71	0.27	304.70	0.51	304.73	304.73
1933.82	304.26	0.33	304.33	0.27	304.33	0.51	304.34	304.34
1914	303.98	0.33	304.09	0.27	304.08	0.51	304.11	304.11
1896	303.75	0.33	303.83	0.27	303.83	0.51	303.84	303.84
1882	303.06	0.33	303.22	0.27	303.22	0.51	303.25	303.25
1849	303.07	0.33	303.16	0.27	303.16	0.51	303.19	303.19
1773	300.27	0.33	300.35	0.27	300.35	0.51	300.35	300.35
1730.224	299.09	0.33	299.18	0.27	299.18	0.51	299.18	299.18
1654	297.11	0.33	297.23	0.27	297.21	0.51	297.25	297.25
1599.655	295.54	0.33	295.38	0.27	295.36	0.51	295.40	295.40

Cross Section Station	Min Channel Elevation	SCS II 24HR (UN 100YR)		Chicago 4HR (UN 100YR)		Regional		Regulatory
		Total Flow	W.S. Elev.	Total Flow	W.S. Elev.	Total Flow	W.S. Elev.	W.S. Elev.
	(m)	(m^3/s)	(m)	(m^3/s)	(m)	(m^3/s)	(m)	(m)
1549	293.63	0.33	293.55	0.27	293.53	0.51	293.58	293.58
1493.186	292.22	1.86	292.41	1.51	292.39	2.48	292.44	292.44
1460	291.58	1.86	292.15	1.51	292.09	2.48	292.22	292.22
1430.742	290.69	1.86	290.94	1.51	290.92	2.48	290.97	290.97
1381	289.79	1.86	290.29	1.51	290.25	2.48	290.35	290.35
1351	289.19	1.86	289.64	1.51	289.61	2.48	289.68	289.68
1290.42	288.41	1.86	289.22	1.51	289.10	2.48	289.42	289.42
1283	288.20	1.86	289.20	1.51	289.08	2.48	289.40	289.40
1240	286.89	1.86	287.26	1.51	287.22	2.48	287.31	287.31
1233.458	286.74	1.86	287.25	1.51	287.22	2.48	287.31	287.31
1189	286.74	1.86	287.05	1.51	287.03	2.48	287.09	287.09

3.3.2 Post-Development Condition

Steady flow analysis was performed for the hydraulic modelling of Bear Creek for the Regional storm (i.e., Timmins Storm); 100-year SCS type II 24 hour, and 100-year Chicago 4 hour storm were each considered for floodplain preparation. Based on the hydrology simulation results, the uncontrolled 100-year 4 hour Chicago storm event creates the highest flows and is considered as the regulatory storm event for the South Tributary of Bear Creek.

Bear Creek's GeoHEC-RAS water surface elevation results for the post-development scenario are presented in **Table 3-5** for the South Tributary of Bear Creek, please note that this scenario considers upgrading the existing culvert crossing County Road 27 from a 1.47mØ CSP culvert to a 2.4 x 1.5m concrete box culvert. It should be noted that the full GeoHEC-RAS model summary outputs are presented in **Appendix B** for reference.

As discussed before, throughout the DiPoce Lands, where field topographic information is available, GeoHEC-RAS ultra-resolution terrain elevation layer was used for generating the floodplains for uncontrolled 100-year and Regional storms from the obtained water surface elevations of Bear Creek. Floodplains drawings of the South Tributary of Bear Creek are presented in **Appendix C** for visual reference. It should be noted that, according to NVCA

Natural Hazards Technical Guide, 100-year uncontrolled floodplains are created considering the widest generated floodplains by 100-year SCS type II 24 hour and 100-year Chicago 4 hour storms.

Table 3-5: South Tributary of Bear Creek GeoHEC-RAS Water Surface Elevation Results – Proposed Condition

Cross Section Station	Min Channel Elevation	SCS II 24HR (UN 100YR)		Chicago 4HR (UN 100YR)		Regional		Regulatory
		Total Flow	W.S. Elev.	Total Flow	W.S. Elev.	Total Flow	W.S. Elev.	W.S. Elev.
	(m)	(m^3/s)	(m)	(m^3/s)	(m)	(m^3/s)	(m)	(m)
2034	305.50	4.89	306.07	6.48	306.11	2.12	305.99	306.11
2024	305.16	4.89	306.07	6.48	306.11	2.12	305.99	306.11
2003	304.48	4.89	306.07	6.48	306.11	2.12	305.99	306.11
1975	304.43	4.89	306.07	6.48	306.11	2.12	305.99	306.11
1957.6	304.72	4.89	306.07	6.48	306.11	2.12	305.99	306.11
1952.89	305.18	4.89	306.07	6.48	306.11	2.12	305.99	306.11
1939.98	304.62	4.89	305.00	6.48	305.06	2.12	304.85	305.06
1933.82	304.26	4.89	304.45	6.48	304.47	2.12	304.40	304.47
1914	303.98	4.89	304.29	6.48	304.32	2.12	304.21	304.32
1896	303.75	4.89	303.99	6.48	304.02	2.12	303.92	304.02
1882	303.06	4.89	303.47	6.48	303.52	2.12	303.37	303.52
1849	303.07	4.89	303.33	6.48	303.36	2.12	303.26	303.36
1773	300.27	4.89	300.46	6.48	300.48	2.12	300.41	300.48
1730.224	299.09	4.89	299.35	6.48	299.38	2.12	299.26	299.38
1654	297.11	4.89	297.42	6.48	297.45	2.12	297.33	297.45
1599.655	295.55	4.89	295.90	6.48	295.96	2.12	295.79	295.96
1584	294.78	4.89	295.54	6.48	295.77	2.12	295.16	295.77
1574	294.69	4.37	295.51	5.18	295.75	2.33	294.97	292.75
1531	292.92	4.37	293.45	5.18	293.51	2.33	293.29	293.51
1519	292.58	4.37	293.28	5.18	293.36	2.33	293.13	293.36
1493.186	292.20	4.37	292.90	5.18	292.91	2.33	292.76	292.91
1460	291.46	4.37	292.26	5.18	292.24	2.33	291.14	292.26
1430.742	290.69	4.37	291.07	5.18	291.14	2.33	290.98	291.14
1381	289.75	4.37	290.51	5.18	290.72	2.33	290.34	290.72
1351	289.12	4.37	290.34	5.18	290.74	2.33	289.61	290.74
1290.42	288.41	10.34	290.34	12.31	290.74	5.18	289.49	290.74
1283	288.20	10.34	290.31	12.31	290.71	5.18	289.46	290.71
1240	286.89	10.34	287.65	12.31	287.70	5.18	287.48	287.70
1233.458	286.74	10.34	287.71	12.31	287.78	5.18	287.50	287.78
1189	286.74	10.34	287.36	12.31	287.41	5.18	287.21	287.41

4.0 Summary and Conclusion

This document has provided the water surface elevation results and associated floodplains of the south tributary of Bear Creek through the DiPoce Lands in the Salem Secondary Plan-Annexed Lands for both the existing and post-development conditions. In preparation of the modelling, SCE coordinated with the floodplain submission in the SIS and the original HEC-RAS models presented in the DSWMMP. Using the GeoHEC-RAS software the original models have been recreated to determine flood plain limits for the existing and post-development conditions of the DiPoce Lands ensuring that adequate buffers are maintained from the development boundary. A summary of the analysis results and findings are presented as follow:

- The South Tributary of Bear Creek is under NVCA Jurisdiction;
- Hydraulic modelling of the South Tributary of Bear Creek was performed using GeoHEC-RAS software for both the existing and post-development conditions;
- Under the post-development condition, the obtained flows from the SIS' VO2 model were used and the existing culverts are proposed to be upsized in accordance to the City of Barrie standards to support the additional flow directed to the South Tributary of Bear Creek under the post-development scenario;
- Considering Nottawasaga Valley Conservation Authority (NVCA) Natural Hazards Technical Guide, Regional and uncontrolled 100-year SCS type II 24 hour and 100-year Chicago 4 hour storm events are simulated based on the current hydrology information as well as detailed topographic survey information;
- The regulatory floodplain for the South Tributary of Bear Creek and throughout the DiPoce Lands was established based on the uncontrolled 100-year 4-hour Chicago storm event;
- The regulatory floodline in the critical future scenario is outside of the 10m buffer from the proposed development limit of the DiPoce Lands.

Respectfully Submitted,

SCHAEFFER & ASSOCIATES LTD.

Michael Ventresca, M.Eng., E.I.T.
Water Resources Analyst

Koryun Shahbikian, M.Eng., P.Eng., LLM
Partner

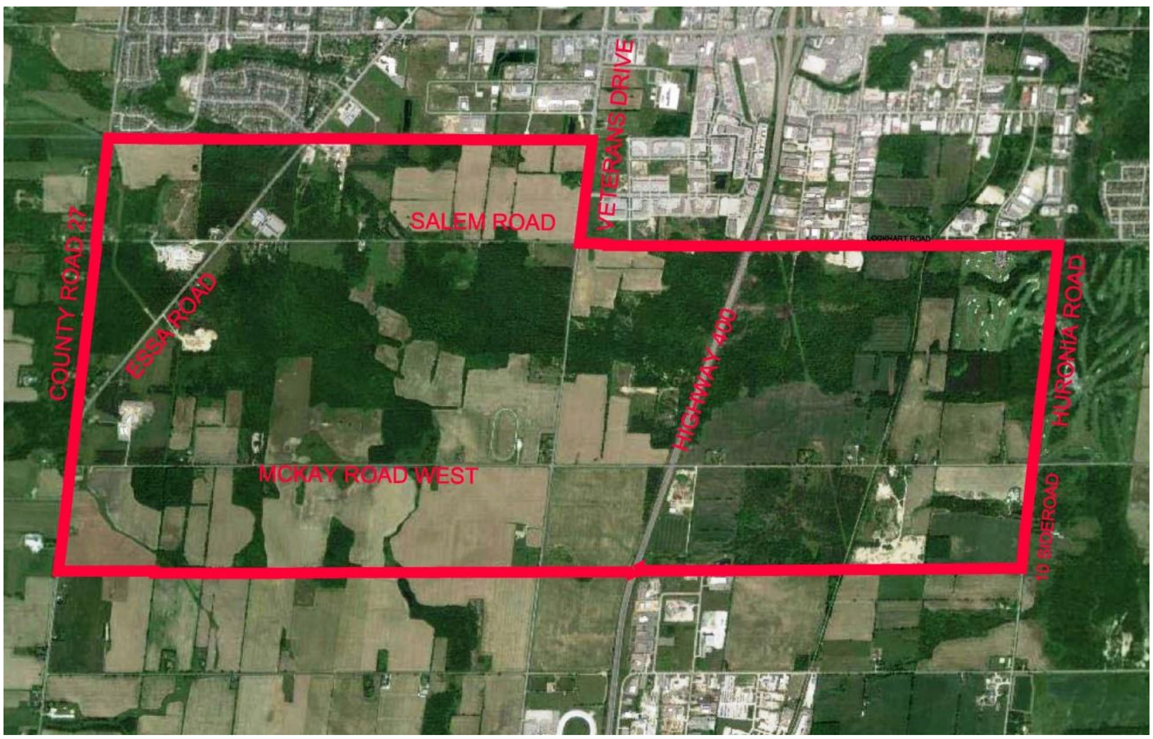
Appendix A: Hydrologic Modelling – SIS Study Excerpt

SUBWATERSHED IMPACT STUDY REPORT

SALEM ANNEXED LANDS

CITY OF BARRIE

PROJECT 4074 **DECEMBER 2017**



BURNSIDE
SCHAEFFERS CONSULTING ENGINEERS
Michalski Nielsen Associates Limited
Cunningham Environmental Associates
KLM PLANNING PARTNERS INC.

December 18, 2017

Our File: 2014-4074

City Hall, 70 Collier Street
P.O. Box 400, Barrie, ON, L4M 4T5

SCHAEFFERS
CONSULTING ENGINEERS

6 Ronrose Drive, Vaughan, Ontario L4K 4R3
Tel: (905) 738-6100 Fax: (905) 738-6875
Tor. Line: (416) 213-5590 E-mail: general@schaeffers.com

Attention:

Frank Palka, C.E.T.,
Manager of Development Services,
Engineering Department

Dear Mr. Palka,

Re: Salem Subwatershed Impact Study (SIS) Report final submission

In response to comments provided by the City of Barrie, Lake Simcoe Region Conservation Authority and Nottawasaga Valley Conservation Authority, please find enclosed a revised and updated Salem SIS report.

The report includes text additions, clarifications and additional analysis, including supporting figures and digital files, requested by the review agencies. The tabulated comments along with the project team's responses and cross-references to the respective sections of the report can be found in Appendix A "Reference Materials".

As preparation of draft plans of subdivision has advanced by some of the participating land owners during preparation of this report, detailed topography and updated planning layouts for selected properties became available. Also additional field data on the natural environment components was collected during the 2016 – 2017 growing seasons and revisions to some Ecological Land Classifications (ELCs) were made, where warranted. Please refer to Appendix B "Natural Environment" for the most recent limits and policy mandated buffers of Natural Heritage features on participating land owners' parcels.

Significant efforts have been made to incorporate the new data into the latest submission. For example, ground water table elevations have been updated based on detailed topography. The change required further updates to proposed ground surface grading and stormwater management solutions. At the same time, continuous updating of the report is not feasible. Therefore, the digital data received after November 1, 2017 was not considered.

It should be noted that the analyses completed as part of the SIS were conducted at the regional scale. It seems reasonable for the recently identified development constraints to be evaluated on a site specific basis at the time when site specific plans are brought forward.

If you have any questions, please do not hesitate to contact the undersigned.

Yours truly,
SCHAEFFER & ASSOCIATES LTD.

Koryun Shahbikian, P.Eng., PMP
Associate

Cc: Charles Burgess, Lake Simcoe Region Conservation Authority
Chris Hibberd, Nottawasaga Valley Conservation Authority
Al Steedman, Schaeffers Consulting Engineers
Keith MacKinnon, KLM Planning

Record of Revisions

Revision	Date	Description
00	July 14, 2016	Submission to Salem Landowners Group
01	Sept 6, 2016	Draft submission to Review Agencies
02	Nov 14, 2017	Final submission to address Review Agencies’ comments
03	Dec 18, 2017	Updated final submission to address Review Agencies’ comments

Table of Contents

List of Tables

List of Figures

Appendices

APPENDIX D

Stormwater Modelling

APPENDIX D1

Pre Development –Hydrology parameters calculations

SCHAEFFERS Consulting Engineers

SCHAEFFER & ASSOCIATES LTD.

6 Ronrose Drive, Concord,
Ontario L4K 4R3
Tel: (905) 738-6100
Fax: (905) 738-6875
design@schaeffers.com

PRJECT: 4074

SALEM IMPACT STUDY

Hydrology Parameters - Based on catchment area

SUB CATCHMENT ID	Area (ha)	L* (m)	H (m)	SLP* (%)	Vel m/s	CN	T_P (hr) Airport
520	21.59	785	3.6	1.09	0.28	64.0	0.84
521	4.33	247	0.8	1.89	0.37	65.5	0.39
523	9.64	548	0.9	0.43	0.18	65.2	0.96
524	25.47	722	2.3	0.19	0.12	63.4	1.44
525	13.68	544	3.3	3.73	0.52	67.8	0.47
526	15.27	691	2.0	0.33	0.15	68.1	1.18
527	17.34	680	4.5	0.92	0.26	68.6	0.83
528	9.19	487	8.1	2.94	0.29	68.0	0.48
529	3.03	276	6.1	5.89	0.66	68.0	0.29
530	32.61	1040	5.5	0.67	0.19	60.2	1.14
531	23.65	622	2.8	0.81	0.21	57.9	0.83
532	9.06	832	3.8	0.51	0.09	36.2	1.11
533	17.72	413	6.4	2.16	0.40	60.8	0.49
534	12.37	450	3.8	2.07	0.39	68.7	0.52
535	61.31	1775	5.5	0.27	0.19	55.6	2.02
536	78.34	1400	4.5	0.22	0.03	51.5	1.91
537	24.65	514	4.0	0.45	0.04	55.3	0.92
538	65.59	1130	4.6	0.20	0.12	48.2	1.76
539	5.94	798	62.3	1.86	0.08	38.2	0.71
540	12.15	633	6.5	0.88	0.25	65.2	0.81
541	8.07	426	0.9	0.40	0.17	78.2	0.87
542	10.49	645	2.0	0.79	0.24	78.2	0.85
543	2.69	292	2.8	5.26	0.62	68.0	0.31
545	3.51	412	7.0	2.32	0.41	66.1	0.48
546	3.62	385	4.5	0.88	0.25	68.0	0.63
601	12.92	562	2.1	1.00	0.27	67.6	0.73
602	75.08	675	2.5	0.64	0.05	53.2	0.93
603	37.95	645	2.5	0.08	0.02	53.9	1.81
604	13.43	510	4.5	1.65	0.35	51.9	0.59
605	15.57	214	1.0	2.83	0.45	58.5	0.32
606	92.85	1155	8.5	1.57	0.34	37.8	0.91
607	7.10	464	5.8	1.67	0.08	60.7	0.56
608	3.41	197	1.0	2.96	0.10	75.0	0.30

NOTE:

SLP* = equivalent slope Method (refer to the detail calculations in the Appendix)   Tp=

SLP = H/L* x 100 (for Roads)   L* = Measured

Airport uses L, SLP, C.

Upland uses SLP, V, L $(3.26*(1.1-C)*L^{0.5}) /s^{0.33}$ minutes

SCS uses CN, L, SLP   L/(V*60) Minutes

$1.7*(L^{0.8}(0.039*CN + 1)^{0.7}/735*SLP^{0.5})$ H

SCHAEFFERS
Consulting Engineers
SCHAEFFER & ASSOCIATES LTD.
6 Ronrose Drive, Concord,
Ontario L4K 4R3
Tel: (905) 738-6100
Fax: (905) 738-6875
design@schaeffers.com

Pre - development Velocity Calculation

Sub catchment-545

Sample Calculations

$V = C_u (S)^{0.5}$ $C_u =$ 2.7 Short grass/pasture

$S =$ 0.0230

V (m/s)= 0.41

<u>Storm Drainage and SWM Policies and Design Guidelines (Nov 2009)</u>

<u>Uplands Method</u>

The Uplands Method is appropriate when the flow path consists of a number of different land covers. The average overland flow velocity is determined for a catchment based on the catchment slope and land cover type. The individual travel time for each land cover is summed to obtain the total travel time. The velocity used in the Uplands Method is calculated as follows:

V =(Cu)(S)^0.5
where,
V = average overland flow velocity (m/s)
Cu = V/S0.5 (Uplands coefficient)
S = average slope (m/m)
And the Uplands coefficient for different land covers is defined in the following table:

Table 7.3: Uplands Coefficients for Different Land Covers

Land Cover Cu (V/S^0.5)

Land cover	Cu
Forest with heavy ground litter, meadow (overland flow)	0.6
Fallow or minimum tillage cultivation (overland flow)	1.5
Short grass pasture and lawns (overland flow)	2.3
Cultivated, straight row (overland flow)	2.7
Nearly bare ground (overland flow)	3
Grassed waterway (ditch)	4.6
Paved areas (sheet flow) and shallow gutter flow	6.1

Source: modified from Figure 3.11, American Iron and Steel Institute,
“Modern Sewer Design: Canadian Edition,” Corrugated Steel Pipe Institute, 1996
and Stormwater Conveyance Modeling and Design, Haestad Methods, First Edition, 2003.

The time to peak should be calculated based on the following formula:

Tp =0.67(tc)

SCHAEFFERS Consulting Engineers
SCHAEFFER & ASSOCIATES LTD.
6 Ranrose Drive, Concord, Ontario L4K 4R3
Tel: (905) 738-6100
Fax: (905) 738-6875
design@schaeffers.com

PROJECT : 4074

SALEM IMPACT STUDY -EXISTING HYDROLOGY PARAMETERS

Bear & Thornton Creek

Catchment ID	520	521	522	523	524	525	526	527	528	529	530	531	532	533	534	535
Area (ha) *	64.74	4.33	14.33	9.64	25.47	13.68	15.27	17.34	3.61	3.03	32.61	23.65	9.06	17.72	12.37	61.31
Hydrogeology Report†	Silty Sand	Silty sand	Sand/silty	Sand/silty	Sand/silty	Sand/Silty	Sand/Silty	Silty Sand	Silty Sand	Sand/Silty	Sand/Silty	Sand/Silty	Sand/silty	Sand	Sand	Sand
Weighted CN II	64.0	65.5	37.1	65.2	63.4	67.8	68.1	68.6	68.0	68.0	60.2	57.9	36.2	60.8	68.7	55.6
Weighted CN III Δ	81.5	82.5	82.5	82.3	81.0	84.2	84.4	84.7	84.3	84.3	78.5	76.7	55.5	79.0	84.8	74.7
Initial Abstraction (Ia)	7.0	6.5	8.7	7.4	7.2	6.9	7.0	6.9	7.5	7.0	6.9	8.0	8.8	6.8	6.9	9.8
Length (L) *	645	230	287	316	640	258	121	680	271	276	1040	810	832	222	450	1115
Slope (S)	0.009	0.017	0.035	0.012	0.004	0.023	0.069	0.009	0.035	0.059	0.007	0.008	0.129	0.129	0.021	0.007
Time of Conc (Tc)	73	35	31	46	95	34	16	74	30	26	102	74	100	18	46	145
Time to peak (Tp) ¤	0.81	0.39	0.35	0.51	1.06	0.38	0.18	0.83	0.33	0.29	1.14	0.83	1.11	0.20	0.52	1.61
Cu (upland coeff)¥	2.7	2.7	0.6	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.3	2.3	0.6	2.7	2.7	2.3
Velocity ($V=Cu (S)^{0.5}$)	0.26	0.35	0.11	0.30	0.17	0.41	0.71	0.26	0.50	0.66	0.19	0.21	0.22	0.97	0.39	0.19

Catchment ID	536	537	538	539	540	541	542	543	545	546	601	602	603	604	605	606	607	608
Area (ha) *	78.34	15.69	65.59	5.94	19.28	8.07	10.49	2.69	3.51	3.62	12.92	75.08	37.95	13.43	15.57	92.85	7.1	3.41
Hydrogeology Report†	Sand/silty	Sand	Sand/ Gravelly sand	Sand/ Gravelly sand	Sand/ silty	Silty Clay/ Silty Sand	Silty Clay/ Silty Sand	Sand/Silty	Sand/silty	Sand/silty	Silty Clay	Sand/silty	Sand/silty	Sand/silty	Sand/gravel	Sand/gravel	Sand/silty	Sand/silty
Weighted CN II	51.5	55.3	48.2	38.2	65.2	78.2	78.2	68.0	66.1	68.0	67.6	53.2	53.9	51.9	58.5	37.8	60.7	75.0
Weighted CN III Δ	71.1	74.5	68.0	57.8	82.3	90.6	90.6	84.3	83.0	84.3	84.0	72.7	73.3	71.5	77.2	57.2	78.9	88.8
Initial Abstraction (Ia)	9.0	8.7	8.4	9.4	8.4	8.4	6.0	7.0	7.3	7.0	6.3	8.8	8.2	7.3	7.3	8.9	7.7	5.6
Length (L) *	1140	121	1048	798	633	426	180	292	412	385	447	675	420	510	214	657	464	125
Slope (S)	0.002	0.182	0.002	0.019	0.009	0.004	0.043	0.053	0.023	0.009	0.008	0.006	0.008	0.017	0.028	0.026	0.017	0.069
Time of Conc (Tc)	172	12	167	64	73	77	23	27	43	57	64	83	62	53	29	52	50	16
Time to peak (Tp) ¤	1.92	0.13	1.86	0.71	0.81	0.87	0.26	0.31	0.48	0.63	0.71	0.93	0.70	0.59	0.32	0.58	0.56	0.18
Cu (upland coeff)¥	0.6	0.6	2.7	0.6	2.7	2.7	2.7	2.7	2.7	2.7	2.7	0.6	0.6	2.7	2.7	2.7	0.6	0.6
Velocity ($V=Cu (S)^{0.5}$)	0.02	0.26	0.11	0.08	0.25	0.17	0.56	0.62	0.41	0.25	0.24	0.05	0.05	0.35	0.45	0.43	0.08	0.16

† - Salem Secondary Plan Area, Hydrogeological Assessment- Part 1 (Existing Conditions) by R.J.Burnside (Feb 2016)

¥ - Upland coefficient for different landuse; List is provided in the Appendix

* - Measured in AutoCAD

¤ - Calculated using Airport Method

Δ - AMC conversion table and the chart are included in the Appendix

APPENDIX D2

Weighted Average CN calculations for ponds

SCHAEFFERS
Consulting Engineers
SCHAEFFER & ASSOCIATES LTD.

6 Ronrose Drive, Concord,
Ontario L4K 4R3
Tel: (905) 738-6100
Fax: (905) 738-6875
design@schaeffers.com

PROJECT: 4074

Date: 06 Nov 2017

Weighted Average CN Determination for SWM Ponds

POND ID	SUB CATCHMENTS	CN	POND DRAINAGE AREA (ha)	WEIGHTED AVERAGE CN
A	525	67.84	15.28	68.2
	527	68.64	14.62	
B	526	68.08	11.51	68.1
C	523	65.19	8.94	66.2
	528	68.00	5.06	
D	540	65.16	12.15	65.16
E1	538	48.19	10.21	48.19
E2	538	48.19	15.90	48.19
F	602	53.23	19.69	53.23
K	520	64.04	16.40	59.92
	536	51.55	8.08	
N	530	60.17	30.30	59.15
	535	55.62	8.70	
O	533	60.83	14.74	60.83
P	534	68.68	11.76	68.68
Q	606	37.76	2.81	59.91
	607	60.69	6.96	
	608	74.99	3.77	
R	606	37.76	5.34	37.76
U	602	53.23	23.09	53.23
S	604	51.9	10.28	44.4
	605	58.5	16.11	
	606	37.8	44.61	

APPENDIX D4

Comparison for unitary rate and 25mm erosion calculations

SCHAEFFERS
Consulting Engineers
SCHAEFFER & ASSOCIATES LTD.

6 Ronrose Drive, Concord,
Ontario L4K 4R3
Tel: (905) 738-6100
Fax: (905) 738-6875
design@schaeffers.com

PROJECT: 4074

DATE: 5-Oct-17

A Comparison of Extended Volume Calculations based on AMEC's Unitary rate and 25mm average detention rate

Pond details					Unit Flow rate (AMEC)					25mm		
PONDS	REACH	DRAINAGE AREA (ha)	IMPERV (%)	UNITARY RATE (m^3/imp.ha)	VOLUME USING UNIT RATE (m^3)	UNIT DISCH-RATE (m^3/s/ha)	AVG-DISCH-RATE (m^3/s)	PEAK DISCH RATE (m^3/s)	Drawdown Time (days)	VOLUME USING 25mm (m^3)	Average Discharge Rate (m^3/s	Drawdown time (days)
A	THO2	56.56	60%	370	12,556	0.0013	0.0735	0.110	2.0	8,484	0.0982	1.0
B	THO2	19.59	60%	370	4,349	0.0013	0.0255	0.038	2.0	2,939	0.0340	1.0
C	THO1	31.11	60%	430	8,026	0.0011	0.0342	0.051	2.7	4,667	0.0540	1.0
D	THO1	49.68	60%	430	12,817	0.0011	0.0546	0.082	2.7	7,452	0.0863	1.0
E1	THO2	8.59	62%	370	1,971	0.0013	0.0112	0.017	2.0	1,331	0.0154	1.0
E2	THO2	22.66	62%	370	5,198	0.0013	0.0295	0.044	2.0	3,512	0.0407	1.0
F	LOV8	33.99	60%	460	9,381	0.0012	0.0408	0.061	2.7	5,099	0.0590	1.0
G	BEA2	21.96	53%	440	5,121	0.0012	0.0264	0.040	2.2	2,910	0.0337	1.0
H	BEA1	27.10	60%	410	6,667	0.0012	0.0325	0.049	2.4	4,065	0.0470	1.0
I	BEA1	24.15	60%	410	5,941	0.0012	0.0290	0.043	2.4	3,623	0.0419	1.0
J	BEA1	4.69	60%	410	1,154	0.0012	0.0056	0.008	2.4	704	0.0081	1.0
K	THO1	27.63	67%	430	7,960	0.0011	0.0304	0.046	3.0	4,628	0.0536	1.0
M	LOV4	57.85	82%	400	18,975	0.0012	0.0694	0.104	3.2	11,859	0.1373	1.0
N	THO1	49.53	60%	430	12,779	0.0011	0.0545	0.082	2.7	7,430	0.0860	1.0
O	THO1	15.90	60%	430	4,102	0.0011	0.0175	0.026	2.7	2,385	0.0276	1.0
P	THO1	17.54	60%	430	4,525	0.0011	0.0193	0.029	2.7	2,631	0.0305	1.0
Q	BEA2	14.98	68%	440	4,482	0.0012	0.0180	0.027	2.9	2,547	0.0295	1.0
R	BEA2	5.34	47%	440	1,104	0.0012	0.0064	0.010	2.0	627	0.0073	1.0
S	BEA2	71.00	86%	440	26,866	0.0012	0.0852	0.128	3.6	15,265	0.1767	1.0
U	LOV8	24.69	90%	460	10,222	0.0012	0.0296	0.044	4.0	5,555	0.0643	1.0
V	LOV8	20.72	90%	460	8,578	0.0012	0.0249	0.037	4.0	4,662	0.0540	1.0
W	LOV8	39.02	90%	460	16,154	0.0012	0.0468	0.070	4.0	8,780	0.1016	1.0

APPENDIX D6

Existing and proposed flow comparison for all creeks

SCHAEFFERS
Consulting Engineers
SCHAEFFER & ASSOCIATES LTD.
6 Ronrose Drive, Concord,
Ontario L4K 4R3
Tel: (905) 738-6100
Fax: (905) 738-6875
design@schaeffers.com

PROJECT: 4074
DATE: Nov-08-2017

A COMPARISON OF PEAK FLOWS FOR BEAR CREEK

NODE	24HR SCSII-EXISTING		24HR SCSII-PROPOSED	
	2YR flow (m^3/s)	100YR flow (m^3/s)	2YR flow (m^3/s)	100YR flow (m^3/s)
508/9039	0.242	1.016	0.141	0.537
9012	0.756	3.277	0.347	2.336
9010	0.765	3.294	0.374	3.083
9005	0.966	4.155	0.653	3.241
9543	9.177	25.172	8.385	23.096
9001	0.429	1.856	0.159	1.572
9521	10.108	28.233	8.660	26.970

APPENDIX D7

Uncontrolled flow summary for all creeks

SCHAEFFERS
Consulting Engineers
SCHAEFFER & ASSOCIATES LTD.
6 Ronrose Drive, Concord,
Ontario L4K 4R3
Tel: (905) 738-6100
Fax: (905) 738-6875
design@schaeffers.com

PROJECT: 4074
DATE: Nov-13-2017

A SUMMARY OF PEAK FLOWS FOR BEAR CREEK -UNCONTROLLED

NODE	POST DEVELOPMENT-UNCONTROLLED		
	24HR SCS-100YR (m^3/s)	TIMMINS (m^3/s)	4HR-CHICAGO-100YR (m^3/s)
508/9039	1.639	1.494	2.020
9012	20.687	9.402	27.242
9010	24.449	13.286	28.135
9005	23.668	13.987	29.108
9503	26.799	16.362	32.077
9543	59.117	37.723	66.099
9003	4.886	2.118	6.480
9004	4.368	2.327	5.197
9001	10.340	5.179	12.305
9521	69.123	48.760	75.652
9000	N/A	N/A	N/A

Appendix B: Geo-HEC-RAS Model Summary Output

HEC-RAS Plan: Ex. Condition Locations: User Defined

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
South_trib	main	2034	100YR-SCS 24 hr	0.33	305.50	305.86	305.60	305.86	0.000014	0.05	11.06	50.66	0.03
South_trib	main	2034	Regional	0.51	305.50	305.92	305.60	305.92	0.000016	0.06	13.91	53.28	0.03
South_trib	main	2034	100YR-Chicago 4	0.27	305.50	305.80	305.60	305.80	0.000023	0.05	7.97	47.67	0.03
South_trib	main	2024	100YR-SCS 24 hr	0.33	305.16	305.86		305.86	0.000001	0.02	33.06	71.26	0.01
South_trib	main	2024	Regional	0.51	305.16	305.92		305.92	0.000001	0.02	37.03	73.15	0.01
South_trib	main	2024	100YR-Chicago 4	0.27	305.16	305.80		305.80	0.000001	0.02	28.67	68.25	0.01
South_trib	main	2003	100YR-SCS 24 hr	0.33	304.48	305.86		305.86	0.000000	0.01	77.07	83.46	0.00
South_trib	main	2003	Regional	0.51	304.48	305.92		305.92	0.000000	0.01	81.71	85.11	0.00
South_trib	main	2003	100YR-Chicago 4	0.27	304.48	305.80		305.80	0.000000	0.01	71.89	81.58	0.00
South_trib	main	1975	100YR-SCS 24 hr	0.33	304.43	305.86		305.86	0.000000	0.01	72.12	85.81	0.00
South_trib	main	1975	Regional	0.51	304.43	305.92		305.92	0.000000	0.01	76.89	87.82	0.00
South_trib	main	1975	100YR-Chicago 4	0.27	304.43	305.80		305.80	0.000000	0.01	66.79	83.43	0.00
South_trib	main	1957.6	100YR-SCS 24 hr	0.33	304.72	305.86		305.86	0.000000	0.02	46.84	78.36	0.00
South_trib	main	1957.6	Regional	0.51	304.72	305.92		305.92	0.000000	0.02	51.21	80.67	0.01
South_trib	main	1957.6	100YR-Chicago 4	0.27	304.72	305.80		305.80	0.000000	0.01	42.00	75.74	0.00
South_trib	main	1952.89	100YR-SCS 24 hr	0.33	305.18	305.86	305.29	305.86	0.000001	0.02	31.90	77.59	0.01
South_trib	main	1952.89	Regional	0.51	305.18	305.92	305.32	305.92	0.000001	0.03	36.26	81.02	0.01
South_trib	main	1952.89	100YR-Chicago 4	0.27	305.18	305.80	305.28	305.80	0.000027	0.10	2.61	73.62	0.04
South_trib	main	1946		Culvert									
South_trib	main	1939.98	100YR-SCS 24 hr	0.33	304.62	304.71	304.71	304.74	0.037820	0.81	0.41	8.38	1.10
South_trib	main	1939.98	Regional	0.51	304.62	304.73	304.73	304.77	0.026067	0.84	0.60	10.19	0.96
South_trib	main	1939.98	100YR-Chicago 4	0.27	304.62	304.70	304.70	304.73	0.041283	0.77	0.35	7.78	1.12
South_trib	main	1933.82	100YR-SCS 24 hr	0.33	304.26	304.33	304.36	304.38	0.099451	0.95	0.35	10.29	1.64
South_trib	main	1933.82	Regional	0.51	304.26	304.34	304.37	304.42	0.174098	1.30	0.39	10.82	2.19
South_trib	main	1933.82	100YR-Chicago 4	0.27	304.26	304.33	304.36	304.37	0.085559	0.85	0.32	9.76	1.51
South_trib	main	1914	100YR-SCS 24 hr	0.33	303.98	304.09	304.06	304.10	0.008567	0.38	0.87	15.67	0.52
South_trib	main	1914	Regional	0.51	303.98	304.11	304.07	304.12	0.007224	0.41	1.22	17.42	0.50
South_trib	main	1914	100YR-Chicago 4	0.27	303.98	304.08	304.06	304.09	0.009251	0.37	0.73	14.90	0.53
South_trib	main	1896	100YR-SCS 24 hr	0.33	303.75	303.83	303.83	303.85	0.026096	0.56	0.60	14.36	0.87
South_trib	main	1896	Regional	0.51	303.75	303.84	303.84	303.86	0.035169	0.69	0.73	15.63	1.03
South_trib	main	1896	100YR-Chicago 4	0.27	303.75	303.83	303.83	303.84	0.019713	0.48	0.57	13.99	0.75
South_trib	main	1882	100YR-SCS 24 hr	0.33	303.06	303.22	303.14	303.23	0.000306	0.11	3.14	31.88	0.11
South_trib	main	1882	Regional	0.51	303.06	303.25	303.14	303.25	0.000340	0.13	4.02	34.36	0.12
South_trib	main	1882	100YR-Chicago 4	0.27	303.06	303.22	303.14	303.22	0.000252	0.09	2.92	31.45	0.10
South_trib	main	1849	100YR-SCS 24 hr	0.33	303.07	303.16	303.16	303.19	0.028074	0.82	0.53	11.85	0.98
South_trib	main	1849	Regional	0.51	303.07	303.19	303.19	303.22	0.015629	0.78	0.95	15.95	0.78
South_trib	main	1849	100YR-Chicago 4	0.27	303.07	303.16	303.16	303.18	0.024887	0.73	0.47	11.13	0.91
South_trib	main	1773	100YR-SCS 24 hr	0.33	300.28	300.35	300.36	300.37	0.050328	0.66	0.51	15.26	1.16
South_trib	main	1773	Regional	0.51	300.28	300.35	300.36	300.42	0.163831	1.17	0.43	13.53	2.08
South_trib	main	1773	100YR-Chicago 4	0.27	300.28	300.35	300.36	300.37	0.059485	0.67	0.40	13.42	1.24
South_trib	main	1730.224	100YR-SCS 24 hr	0.33	299.09	299.18	299.18	299.19	0.017933	0.50	0.67	14.39	0.73
South_trib	main	1730.224	Regional	0.51	299.09	299.19	299.19	299.21	0.022451	0.60	0.85	16.38	0.83
South_trib	main	1730.224	100YR-Chicago 4	0.27	299.09	299.18	299.18	299.19	0.013956	0.43	0.63	13.82	0.64
South_trib	main	1654	100YR-SCS 24 hr	0.33	297.11	297.23	297.23	297.26	0.044158	0.75	0.45	10.09	1.14
South_trib	main	1654	Regional	0.51	297.11	297.25	297.25	297.27	0.032358	0.71	0.72	13.99	1.00
South_trib	main	1654	100YR-Chicago 4	0.27	297.11	297.21	297.22	297.25	0.070204	0.86	0.31	8.16	1.40
South_trib	main	1599.655	100YR-SCS 24 hr	0.33	295.54	295.63	295.63	295.67	0.032236	0.83	0.40	6.25	1.04
South_trib	main	1599.655	Regional	0.51	295.54	295.66	295.66	295.70	0.027505	0.90	0.57	6.87	1.00
South_trib	main	1599.655	100YR-Chicago 4	0.27	295.54	295.63	295.63	295.65	0.019097	0.65	0.42	6.30	0.80
South_trib	main	1549	100YR-SCS 24 hr	0.33	293.63	293.82	293.84	293.90	0.035105	1.26	0.27	2.28	1.18
South_trib	main	1549	Regional	0.51	293.63	293.85	293.88	293.96	0.040470	1.49	0.34	2.54	1.29
South_trib	main	1549	100YR-Chicago 4	0.27	293.63	293.78	293.82	293.90	0.072366	1.54	0.18	1.93	1.63
South_trib	main	1493.186	100YR-SCS 24 hr	1.86	292.22	292.69	292.70	292.86	0.016473	1.87	1.19	4.91	0.98
South_trib	main	1493.186	Regional	2.48	292.22	292.76	292.79	292.95	0.015469	2.03	1.57	6.02	0.98
South_trib	main	1493.186	100YR-Chicago 4	1.51	292.22	292.66	292.66	292.80	0.016384	1.73	1.01	4.44	0.96
South_trib	main	1460	100YR-SCS 24 hr	1.86	291.58	292.10	292.15	292.28	0.019307	2.14	1.34	6.35	1.07
South_trib	main	1460	Regional	2.48	291.58	292.15	292.22	292.37	0.020769	2.41	1.72	8.04	1.13
South_trib	main	1460	100YR-Chicago 4	1.51	291.58	292.06	292.09	292.23	0.019232	2.00	1.11	5.33	1.05
South_trib	main	1430.742	100YR-SCS 24 hr	1.86	290.69	290.94	291.01	291.18	0.083502	2.21	0.84	6.24	1.89
South_trib	main	1430.742	Regional	2.48	290.69	290.97	291.06	291.26	0.074674	2.39	1.05	7.10	1.85
South_trib	main	1430.742	100YR-Chicago 4	1.51	290.69	290.92	290.98	291.14	0.084584	2.06	0.73	5.88	1.87
South_trib	main	1381	100YR-SCS 24 hr	1.86	289.79	290.29	290.29	290.42	0.020250	1.60	1.16	4.55	1.02
South_trib	main	1381	Regional	2.48	289.79	290.35	290.35	290.50	0.020081	1.71	1.45	5.13	1.03
South_trib	main	1381	100YR-Chicago 4	1.51	289.79	290.25	290.25	290.37	0.020747	1.54	0.98	4.20	1.01
South_trib	main	1351	100YR-SCS 24 hr	1.86	289.19	289.64	289.65	289.77	0.023544	1.62	1.23	7.58	1.08
South_trib	main	1351	Regional	2.48	289.19	289.68	289.74	289.83	0.024370	1.74	1.65	11.55	1.11
South_trib	main	1351	100YR-Chicago 4	1.51	289.19	289.61	289.62	289.72	0.022192	1.52	1.02	6.34	1.04

HEC-RAS Plan: Ex. Condition Locations: User Defined (Continued)

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
South_trib	main	1290.42	100YR-SCS 24 hr	1.86	288.41	289.22	288.65	289.22	0.000043	0.15	23.67	63.35	0.06
South_trib	main	1290.42	Regional	2.48	288.41	289.42	288.69	289.42	0.000023	0.13	36.98	68.43	0.04
South_trib	main	1290.42	100YR-Chicago 4	1.51	288.41	289.10	288.63	289.10	0.000075	0.18	16.10	60.82	0.07
South_trib	main	1283	100YR-SCS 24 hr	1.86	288.20	289.20	288.55	289.22	0.000414	0.57	3.28	49.31	0.18
South_trib	main	1283	Regional	2.48	288.20	289.40	288.61	289.42	0.000397	0.63	3.95	62.45	0.19
South_trib	main	1283	100YR-Chicago 4	1.51	288.20	289.08	288.50	289.09	0.000422	0.52	2.87	45.87	0.18
South_trib	main	1264		Culvert									
South_trib	main	1240	100YR-SCS 24 hr	1.86	286.89	287.26	287.14	287.31	0.004312	0.93	2.06	13.70	0.50
South_trib	main	1240	Regional	2.48	286.89	287.32	287.19	287.38	0.004651	1.06	2.43	14.37	0.53
South_trib	main	1240	100YR-Chicago 4	1.51	286.89	287.23	287.11	287.26	0.004133	0.84	1.82	13.26	0.48
South_trib	main	1233.458	100YR-SCS 24 hr	1.86	286.74	287.26		287.28	0.001130	0.53	3.97	12.71	0.26
South_trib	main	1233.458	Regional	2.48	286.74	287.32		287.34	0.001249	0.60	4.74	13.69	0.28
South_trib	main	1233.458	100YR-Chicago 4	1.51	286.74	287.22		287.23	0.001052	0.48	3.50	12.08	0.25
South_trib	main	1189	100YR-SCS 24 hr	1.86	286.74	287.05	287.05	287.13	0.021881	1.25	1.49	9.60	0.99
South_trib	main	1189	Regional	2.48	286.74	287.09	287.09	287.18	0.020916	1.35	1.86	10.73	1.00
South_trib	main	1189	100YR-Chicago 4	1.51	286.74	287.03	287.03	287.10	0.023639	1.20	1.26	8.82	1.01

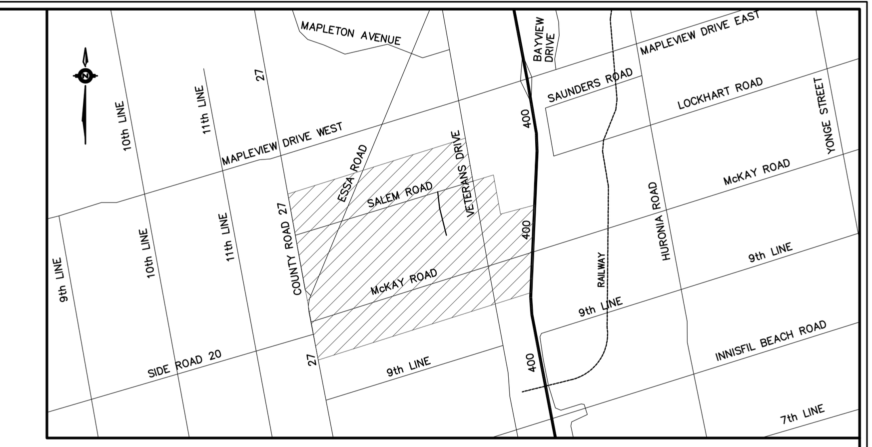
HEC-RAS Plan: Post Development Locations: User Defined

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
South_trib	main	2034	100 UC SCS 24 hr	4.89	305.50	306.07	305.75	306.08	0.000370	0.36	22.89	60.77	0.16
South_trib	main	2034	Regional	2.12	305.50	305.99	305.70	306.00	0.000134	0.19	18.19	56.97	0.09
South_trib	main	2034	Chicago UC 100 4	6.48	305.50	306.11	305.78	306.11	0.000505	0.43	25.02	62.35	0.19
South_trib	main	2024	100 UC SCS 24 hr	4.89	305.16	306.07		306.08	0.000045	0.18	49.03	78.59	0.06
South_trib	main	2024	Regional	2.12	305.16	305.99		305.99	0.000013	0.09	42.83	75.83	0.03
South_trib	main	2024	Chicago UC 100 4	6.48	305.16	306.11		306.11	0.000068	0.22	51.80	79.79	0.07
South_trib	main	2003	100 UC SCS 24 hr	4.89	304.48	306.07		306.08	0.000005	0.09	95.56	89.85	0.02
South_trib	main	2003	Regional	2.12	304.48	305.99		305.99	0.000001	0.04	88.43	87.44	0.01
South_trib	main	2003	Chicago UC 100 4	6.48	304.48	306.11		306.11	0.000009	0.12	98.72	90.90	0.03
South_trib	main	1975	100 UC SCS 24 hr	4.89	304.43	306.07		306.07	0.000007	0.11	91.24	93.61	0.03
South_trib	main	1975	Regional	2.12	304.43	305.99		305.99	0.000002	0.05	83.84	90.67	0.01
South_trib	main	1975	Chicago UC 100 4	6.48	304.43	306.11		306.11	0.000012	0.13	94.52	94.87	0.03
South_trib	main	1957.6	100 UC SCS 24 hr	4.89	304.72	306.07		306.07	0.000022	0.16	64.63	89.98	0.05
South_trib	main	1957.6	Regional	2.12	304.72	305.99		305.99	0.000006	0.08	57.64	85.02	0.02
South_trib	main	1957.6	Chicago UC 100 4	6.48	304.72	306.11		306.11	0.000035	0.21	67.78	92.12	0.06
South_trib	main	1952.89	100 UC SCS 24 hr	4.89	305.18	306.07	305.71	306.07	0.000054	0.19	49.76	90.77	0.07
South_trib	main	1952.89	Regional	2.12	305.18	305.99	305.49	305.99	0.000015	0.10	42.73	85.85	0.03
South_trib	main	1952.89	Chicago UC 100 4	6.48	305.18	306.11	305.81	306.11	0.000081	0.24	52.91	92.90	0.08
South_trib	main	1946		Culvert									
South_trib	main	1939.98	100 UC SCS 24 hr	4.89	304.62	305.00	305.00	305.16	0.016567	1.79	2.73	32.07	0.98
South_trib	main	1939.98	Regional	2.12	304.62	304.85	304.85	304.95	0.020363	1.36	1.55	19.88	0.99
South_trib	main	1939.98	Chicago UC 100 4	6.48	304.62	305.06	305.06	305.26	0.016172	1.99	3.26	36.70	1.00
South_trib	main	1933.82	100 UC SCS 24 hr	4.89	304.26	304.45	304.54	304.75	0.136902	2.43	2.01	18.30	2.34
South_trib	main	1933.82	Regional	2.12	304.26	304.40	304.46	304.55	0.094947	1.67	1.27	15.41	1.85
South_trib	main	1933.82	Chicago UC 100 4	6.48	304.26	304.47	304.58	304.84	0.146718	2.70	2.40	19.65	2.46
South_trib	main	1914	100 UC SCS 24 hr	4.89	303.98	304.29	304.24	304.32	0.008055	0.67	7.31	54.85	0.58
South_trib	main	1914	Regional	2.12	303.98	304.21	304.16	304.23	0.007860	0.57	3.73	35.20	0.56
South_trib	main	1914	Chicago UC 100 4	6.48	303.98	304.32	304.26	304.35	0.008404	0.75	8.67	56.79	0.61
South_trib	main	1896	100 UC SCS 24 hr	4.89	303.75	303.99	303.99	304.04	0.025036	1.08	4.52	38.73	1.01
South_trib	main	1896	Regional	2.12	303.75	303.92	303.92	303.96	0.027030	0.92	2.31	26.69	1.00
South_trib	main	1896	Chicago UC 100 4	6.48	303.75	304.02	304.02	304.08	0.023554	1.12	5.77	44.51	1.00
South_trib	main	1882	100 UC SCS 24 hr	4.89	303.06	303.47	303.26	303.48	0.000894	0.36	13.47	48.68	0.22
South_trib	main	1882	Regional	2.12	303.06	303.37	303.20	303.37	0.000654	0.25	8.54	43.14	0.18
South_trib	main	1882	Chicago UC 100 4	6.48	303.06	303.52	303.29	303.53	0.000999	0.41	15.71	50.83	0.24
South_trib	main	1849	100 UC SCS 24 hr	4.89	303.07	303.33	303.33	303.39	0.023895	1.10	4.45	35.93	1.00
South_trib	main	1849	Regional	2.12	303.07	303.26	303.26	303.30	0.026435	0.94	2.25	24.69	0.99
South_trib	main	1849	Chicago UC 100 4	6.48	303.07	303.36	303.36	303.43	0.023112	1.15	5.64	41.37	0.99
South_trib	main	1773	100 UC SCS 24 hr	4.89	300.27	300.46	300.49	300.59	0.054735	1.63	3.00	24.96	1.50
South_trib	main	1773	Regional	2.12	300.27	300.41	300.43	300.48	0.048377	1.18	1.79	21.93	1.32
South_trib	main	1773	Chicago UC 100 4	6.48	300.27	300.48	300.53	300.65	0.056570	1.80	3.60	26.32	1.56
South_trib	main	1730.224	100 UC SCS 24 hr	4.89	299.09	299.35	299.35	299.42	0.024236	1.20	4.06	28.76	1.02
South_trib	main	1730.224	Regional	2.12	299.09	299.26	299.26	299.32	0.032078	1.06	1.99	20.95	1.10
South_trib	main	1730.224	Chicago UC 100 4	6.48	299.09	299.38	299.38	299.46	0.022451	1.26	5.14	32.08	1.01
South_trib	main	1654	100 UC SCS 24 hr	4.89	297.11	297.42	297.43	297.53	0.026641	1.50	3.27	17.95	1.12
South_trib	main	1654	Regional	2.12	297.11	297.33	297.33	297.40	0.030831	1.17	1.82	16.20	1.11
South_trib	main	1654	Chicago UC 100 4	6.48	297.11	297.45	297.48	297.59	0.028130	1.68	3.86	18.63	1.18
South_trib	main	1599.655	100 UC SCS 24 hr	4.89	295.55	295.90	295.94	296.08	0.028507	1.84	2.66	11.30	1.21
South_trib	main	1599.655	Regional	2.12	295.55	295.79	295.81	295.89	0.026921	1.40	1.51	9.23	1.11
South_trib	main	1599.655	Chicago UC 100 4	6.48	295.55	295.96	296.00	296.15	0.026796	1.95	3.33	12.32	1.20
South_trib	main	1584	100 UC SCS 24 hr	4.89	294.78	295.54	295.23	295.56	0.001622	0.64	7.65	18.40	0.32
South_trib	main	1584	Regional	2.12	294.78	295.17	295.09	295.21	0.006886	0.88	2.40	10.53	0.59
South_trib	main	1584	Chicago UC 100 4	6.48	294.78	295.77	295.29	295.79	0.000740	0.51	12.67	23.64	0.22
South_trib	main	1574	100 UC SCS 24 hr	4.89	294.69	295.51	295.12	295.54	0.001142	0.76	6.69	24.48	0.29
South_trib	main	1574	Regional	2.12	294.69	294.97	294.97	295.07	0.021940	1.39	1.54	11.21	1.02
South_trib	main	1574	Chicago UC 100 4	6.48	294.69	295.75	295.19	295.78	0.000746	0.74	9.10	30.55	0.25
South_trib	main	1548		Culvert									
South_trib	main	1531	100 UC SCS 24 hr	4.89	292.92	293.45		293.60	0.010675	1.67	2.93	15.08	0.82
South_trib	main	1531	Regional	2.12	292.92	293.29		293.36	0.010492	1.19	1.78	11.04	0.75
South_trib	main	1531	Chicago UC 100 4	6.48	292.92	293.51	293.47	293.70	0.012583	1.96	3.30	16.40	0.90
South_trib	main	1519	100 UC SCS 24 hr	4.89	292.58	293.28	293.28	293.44	0.018066	1.77	2.76	8.67	1.00
South_trib	main	1519	Regional	2.12	292.58	293.13		293.22	0.014788	1.34	1.58	6.47	0.87
South_trib	main	1519	Chicago UC 100 4	6.48	292.58	293.36	293.36	293.54	0.017267	1.87	3.47	9.77	1.00
South_trib	main	1493.186	100 UC SCS 24 hr	4.37	292.20	292.90	292.92	293.06	0.021734	1.79	2.44	8.70	1.08
South_trib	main	1493.186	Regional	2.33	292.20	292.76	292.76	292.89	0.018587	1.58	1.48	5.60	0.98
South_trib	main	1493.186	Chicago UC 100 4	5.18	292.20	292.91	292.96	293.12	0.028023	2.04	2.54	8.99	1.22
South_trib	main	1460	100 UC SCS 24 hr	4.37	291.46	292.26	292.28	292.42	0.023102	1.73	2.53	9.70	1.08
South_trib	main	1460	Regional	2.33	291.46	292.14	292.14	292.26	0.021406	1.55	1.50	6.36	1.02

HEC-RAS Plan: Post Development Locations: User Defined (Continued)

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
South_trib	main	1460	Chicago UC 100 4	5.18	291.46	292.24	292.32	292.50	0.041853	2.28	2.27	8.99	1.45
South_trib	main	1430.742	100 UC SCS 24 hr	4.37	290.69	291.07	291.16	291.34	0.055839	2.31	1.89	9.41	1.65
South_trib	main	1430.742	Regional	2.33	290.69	290.98	291.05	291.20	0.063827	2.07	1.12	7.30	1.68
South_trib	main	1430.742	Chicago UC 100 4	5.18	290.69	291.14	291.19	291.34	0.033141	1.98	2.61	11.03	1.30
South_trib	main	1381	100 UC SCS 24 hr	4.37	289.75	290.51	290.51	290.61	0.022937	1.38	3.17	17.52	1.03
South_trib	main	1381	Regional	2.33	289.75	290.34	290.34	290.49	0.019426	1.67	1.39	4.94	1.01
South_trib	main	1381	Chicago UC 100 4	5.18	289.75	290.73	290.53	290.75	0.002541	0.67	7.73	24.52	0.38
South_trib	main	1351	100 UC SCS 24 hr	4.37	289.12	290.35	289.76	290.35	0.000163	0.31	18.65	41.04	0.11
South_trib	main	1351	Regional	2.33	289.12	289.61	289.64	289.75	0.031172	1.62	1.44	7.79	1.20
South_trib	main	1351	Chicago UC 100 4	5.18	289.12	290.74		290.74	0.000043	0.21	38.77	61.52	0.06
South_trib	main	1290.42	100 UC SCS 24 hr	10.34	288.41	290.35	288.92	290.35	0.000013	0.15	106.36	82.00	0.04
South_trib	main	1290.42	Regional	5.18	288.41	289.49	288.79	289.49	0.000051	0.18	41.59	68.91	0.06
South_trib	main	1290.42	Chicago UC 100 4	12.31	288.41	290.74	288.98	290.74	0.000008	0.14	139.73	88.64	0.03
South_trib	main	1283	100 UC SCS 24 hr	10.34	288.20	290.31	288.89	290.34	0.000264	0.75	14.21	79.18	0.17
South_trib	main	1283	Regional	5.18	288.20	289.46	288.66	289.48	0.000399	0.64	8.29	63.76	0.19
South_trib	main	1283	Chicago UC 100 4	12.31	288.20	290.71	288.96	290.73	0.000209	0.75	16.94	85.17	0.15
South_trib	main	1264		Culvert									
South_trib	main	1240	100 UC SCS 24 hr	10.34	286.89	287.65	287.61	287.92	0.010082	2.33	4.94	18.37	0.87
South_trib	main	1240	Regional	5.18	286.89	287.48	287.36	287.60	0.006439	1.56	3.57	16.29	0.66
South_trib	main	1240	Chicago UC 100 4	12.31	286.89	287.70	287.68	288.03	0.011689	2.61	5.30	18.89	0.94
South_trib	main	1233.458	100 UC SCS 24 hr	10.34	286.74	287.71		287.78	0.002231	1.22	11.39	20.06	0.42
South_trib	main	1233.458	Regional	5.18	286.74	287.50		287.53	0.001686	0.87	7.40	16.58	0.35
South_trib	main	1233.458	Chicago UC 100 4	12.31	286.74	287.78		287.85	0.002422	1.33	12.66	21.05	0.44
South_trib	main	1189	100 UC SCS 24 hr	10.34	286.74	287.36	287.36	287.54	0.015793	1.93	5.98	19.02	0.98
South_trib	main	1189	Regional	5.18	286.74	287.21	287.21	287.34	0.017498	1.59	3.45	14.63	0.97
South_trib	main	1189	Chicago UC 100 4	12.31	286.74	287.41	287.41	287.61	0.014736	2.02	6.96	20.50	0.97

Appendix C: Geo-HEC-RAS Model Floodplains Drawings



LEGEND

REGIONAL FLOOD ELEVATION

305.89 2843 CROSS SECTION ID
305.89

100 YEAR UNCONTROLLED FLOOD ELEVATION

DIRECTION OF FLOW

100 YEAR UNCONTROLLED FLOODLINE

REGIONAL STORM FLOODLINE

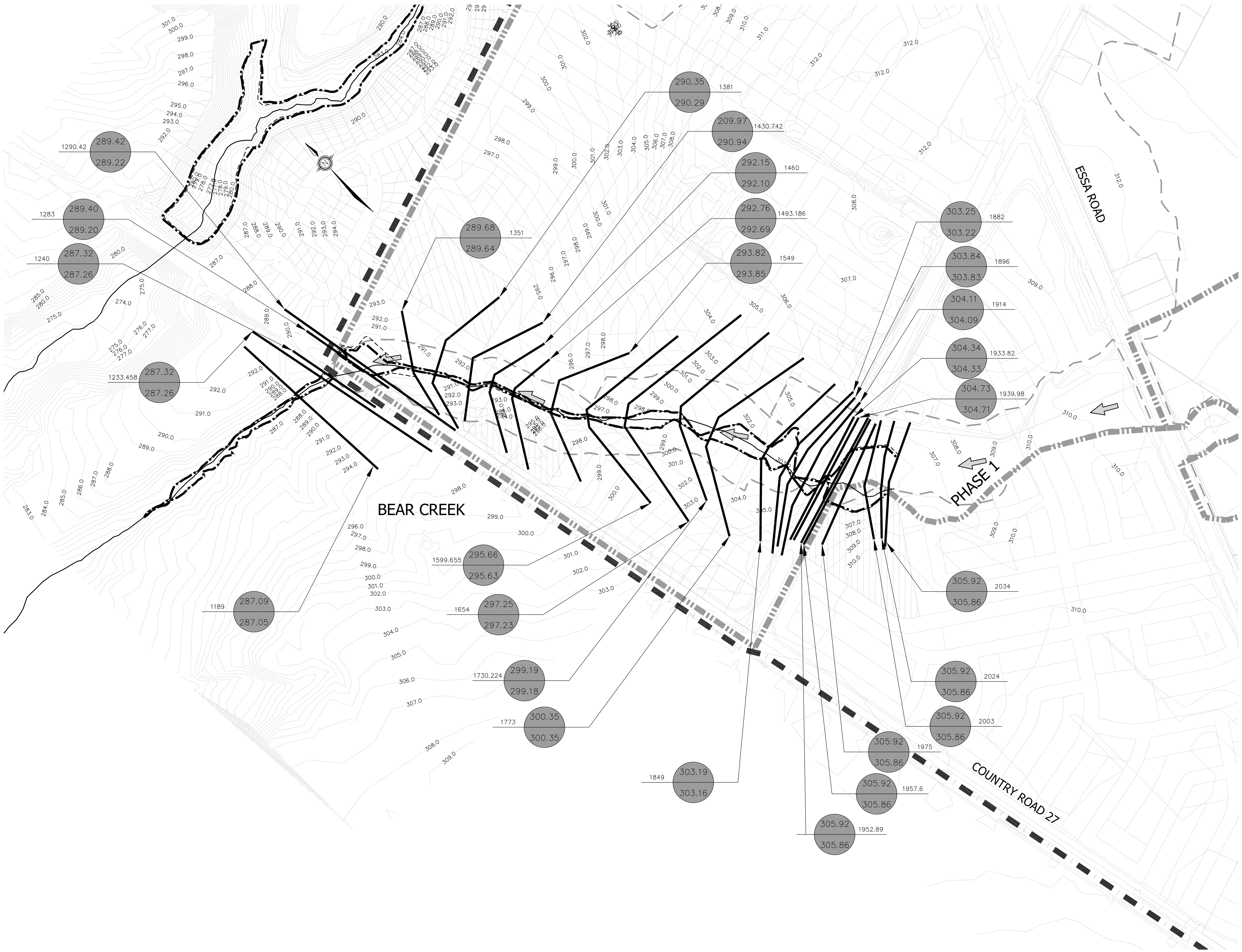
307.00 EXISTING CONTOUR AND ELEVATION

SECONDARY PLAN BOUNDARY

PHASING LIMITS

2031 PHASE LIMITS

SURVEYED NATURAL HERITAGE SYSTEM LIMIT



0 50 100 150 200
SCALE 1:2500

No.	DESCRIPTION	CITY	DATE	BY
3.	REVISED BASED ON NEW DETAILED TOPO	BARRIE	2019-10-28	MV/PG
2.	REVISED BASED ON NEW PEAK FLOWS	BARRIE	2017-12-11	AC
1.	REVISED NHS BASED ON KLM LIMITS	BARRIE	2016-09-01	AC

REVISIONS

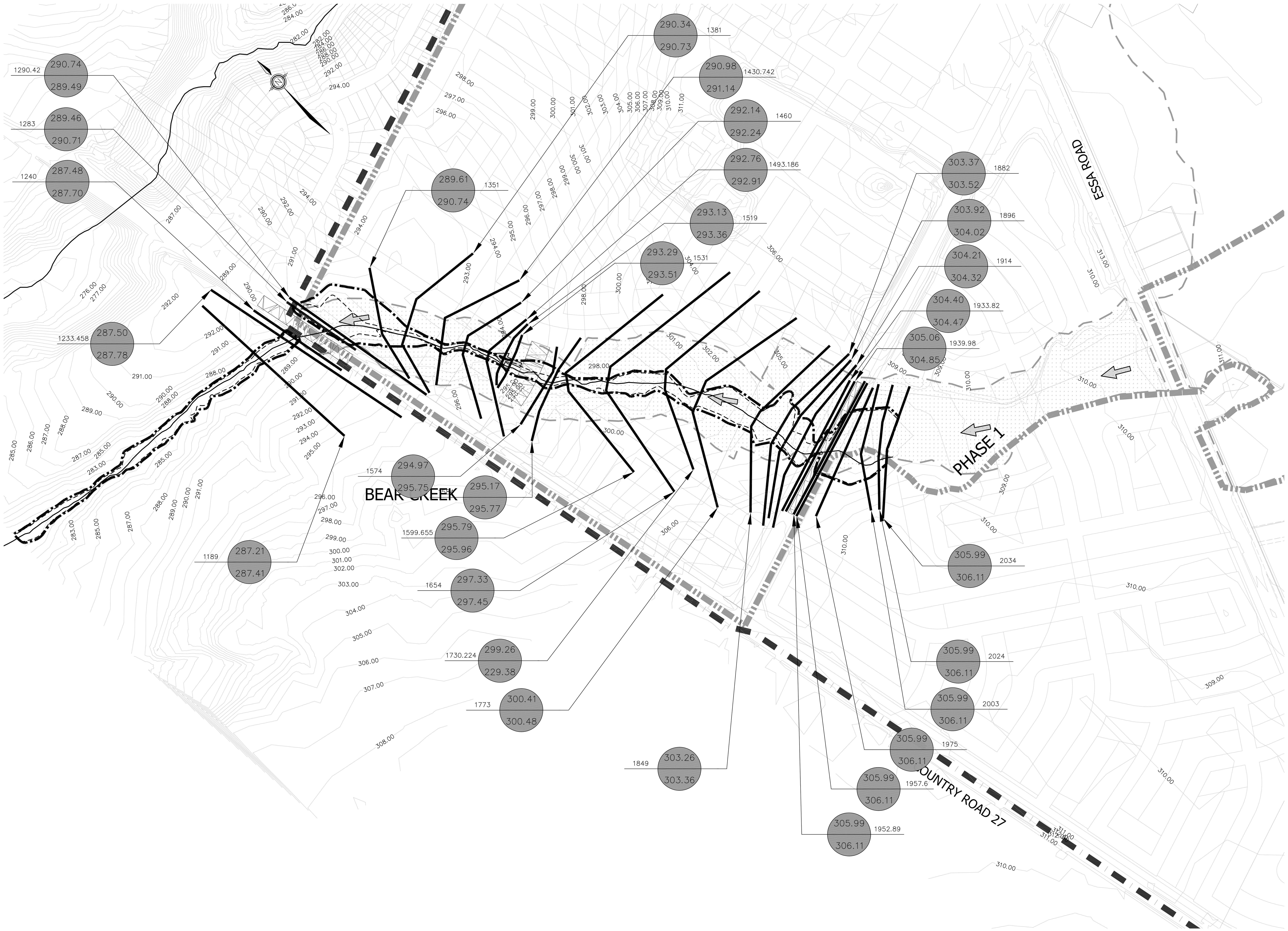
SCHAEFFERS CONSULTING ENGINEERS
SCHAEFFER & ASSOCIATES LTD.
6 Ronrose Drive, Concord, Ontario L4K 4R3
Tel: (905) 738-6100
Fax: (905) 738-6875
E-mail: design@schaeffers.com

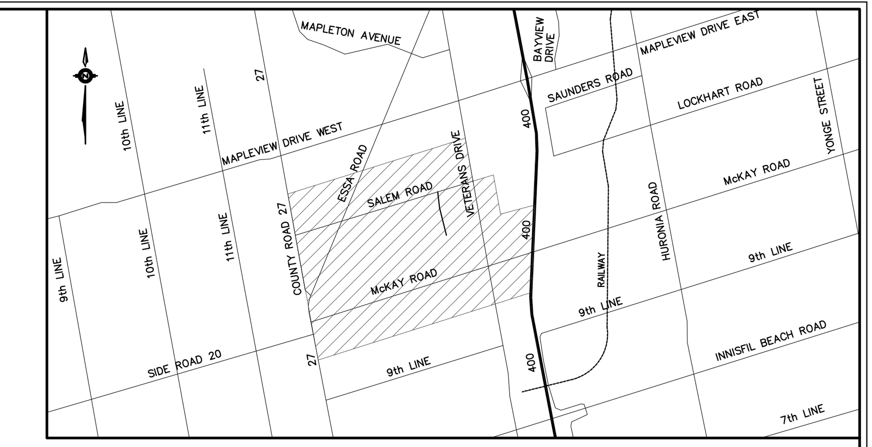
DIPOCE (INNISFIL) INC.

SALEM SECONDARY PLAN AREA FLOODPLAIN ANALYSIS

EXISTING REGULATORY FLOOD MAP BEAR CREEK SOUTH

Drawn	Checked	Date	Figure No.
PG	KS	19/10/28	1
Scale 1: 2500		Project No. 2017-4560	





LEGEND

- 305.89 / 2843 / 305.89 — REGIONAL FLOOD ELEVATION; CROSS SECTION ID; 100 YEAR UNCONTROLLED FLOOD ELEVATION
- DIRECTION OF FLOW
- 100 YEAR UNCONTROLLED FLOODLINE
- REGIONAL STORM FLOODLINE
- 307.00 — EXISTING CONTOUR AND ELEVATION
- SECONDARY PLAN BOUNDARY
- PHASING LIMITS
- 2031 PHASE LIMITS
- SURVEYED NATURAL HERITAGE SYSTEM LIMIT

0 50 100 150 200
SCALE 1:2500

No.	DESCRIPTION	CITY	DATE	BY
3.	REVISED BASED ON NEW DETAILED TOPO	BARRIE	2019-10-28	MV/PG
2.	REVISED BASED ON NEW PEAK FLOWS	BARRIE	2017-12-11	AC
1.	REVISED NHS BASED ON KLM LIMITS	BARRIE	2016-09-01	AC

REVISIONS

SCHAEFFERS
CONSULTING ENGINEERS
SCHAEFFER & ASSOCIATES LTD.
6 Ronrose Drive, Concord, Ontario L4K 4R3
Tel: (905) 738-6100
Fax: (905) 738-6875
E-mail: design@schaeffers.com

DIPOCE (INNISFIL) INC.

SALEM SECONDARY PLAN AREA
FLOODPLAIN ANALYSIS

POST DEVELOPMENT REGULATORY FLOOD MAP
BEAR CREEK SOUTH

Drawn	Checked	Date	Figure No.
PG	KS	19/10/28	2
Scale 1:2500		Project No. 2017-4560	

Appendix D: Digital Hydrologic & Hydraulic Model