3.8.4 Tile Drains

The presence of tile drains was not confirmed on the subject site, although a potential tile drain outlet was observed in the vicinity of Tributary 2 on the west side of March Road, near borehole BH4/BH4A.

3.9 Streamflow Monitoring

A streamflow monitoring program for the Northwest Branch of Shirley's Brook was undertaken between May and December 2014. The purpose of this program was to gather data to support the existing conditions hydrologic model and the water balance model for the KNUEA. Please refer to the following report for additional information on the methodology used in the streamflow monitoring program:

- *Kanata North Urban Expansion Area – Water Budget Analysis* (Novatech, February 2016)

3.9.1 Monitoring Locations

Stream level loggers were installed in three locations on the Northwest Branch of Shirley's Brook, as shown on **Figure 3.7**.

- Monitoring Station 1: Tributary 2
- Monitoring Station 2: Tributary 3
- Monitoring Station 3: Downstream of the confluence of the Tributaries 2 and 3.

3.9.2 Methodology

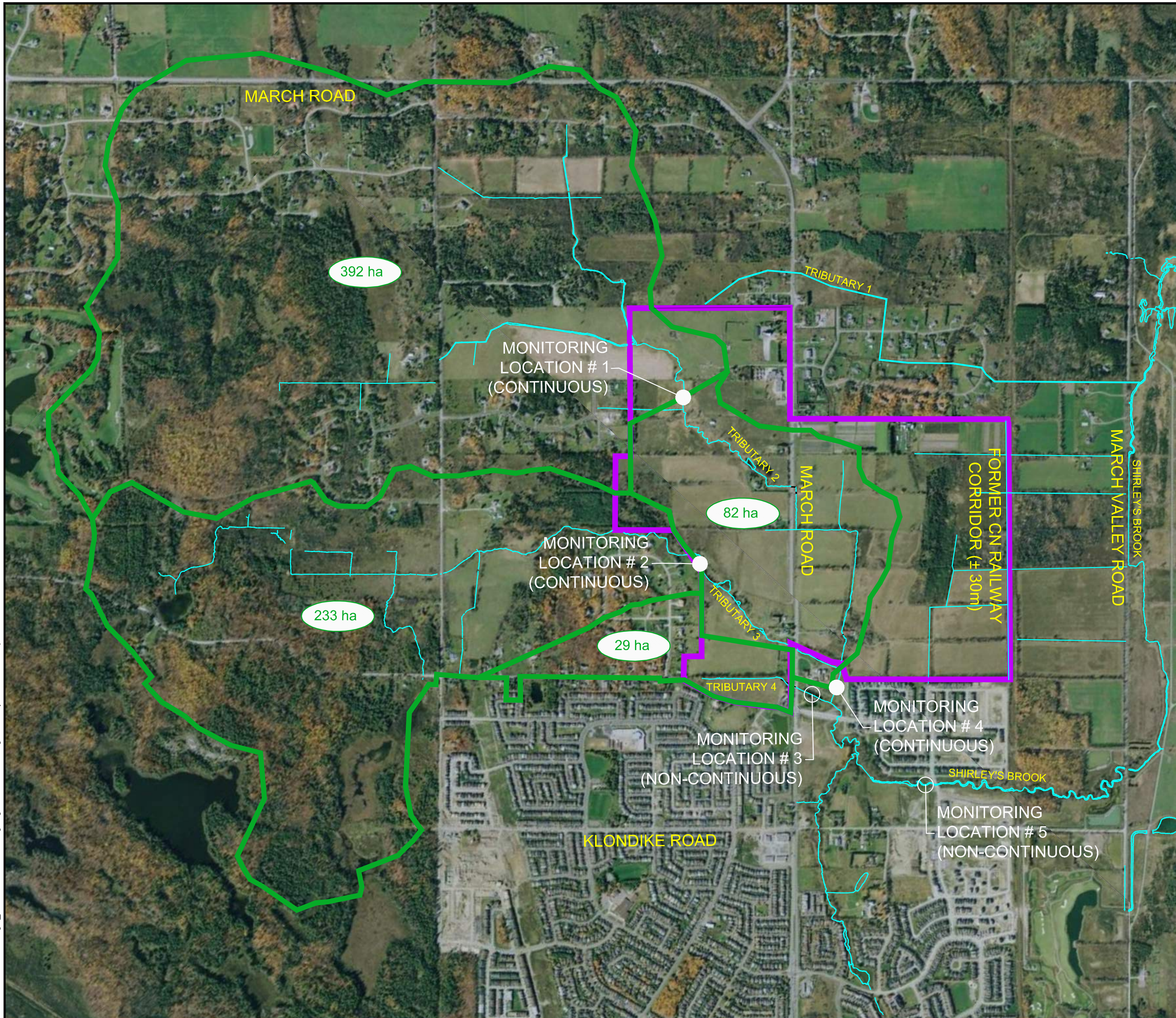
Continuous flow monitoring was performed using pressure transducers, which measure air and water pressure to determine water levels within the watercourse. Field measurements of instantaneous streamflow velocity and depth were recorded on a monthly basis, during both wet and dry periods to gather a range of high/low flow data points.

Detailed cross-sections were surveyed at each of the monitoring stations and used to develop depth vs. flow curves to convert the continuous water level data to flow data based on an adapted version of the *Velocity-Area Procedure for Determining Steam Discharge* (US Environmental Protection Agency, September 1998).

3.9.3 Results

The monthly results of the streamflow monitoring program are summarized in **Table 3.3**. Note that the total monthly precipitation for June 2014 (143.2mm) is significantly higher than the long-term monthly average (92.8mm). This is primarily the result of a storm event on June 24, 2014 which generated approximately 62.7mm of rain over a period of approximately 12 hours, roughly equivalent to a 50-year storm event.

Consequently, the streamflow monitoring data for June was not used in the calibration of the water budget model, as the average monthly streamflow is significantly higher than the long-term average.



LEGEND

- KNUEA
- DRAINAGE CHANNEL
- FLOW MONITORING CATCHMENT AREAS

MONITORING LOCATION #1:
TRIBUTARY 2

MONITORING LOCATION #2:
TRIBUTARY 3 U/S OF CONCRETE WEIR

MONITORING LOCATION #3:
OUTLET OF MORGAN'S GRANT SWMF

MONITORING LOCATION #4:
D/S OF TRIBUTARY 2 & 3 CONFLUENCE

MONITORING LOCATION #5:
MAIN BRANCH OF SHIRLEY'S BROOK AT MARCONI AVE.

KN

KANATA NORTH
COMMUNITY DESIGN PLAN

FIGURE NO. 3.7
STREAMFLOW MONITORING LOCATIONS

DATE MAY 2016
JOB 112117
SCALE NTS

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M:\2012\112117\CAD\Design_EMP\112117-SWM.dwg, Figure 3.7 - Monitoring Loc., May 09, 2016 - 5:08pm, kbanks

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Table 3.3: 2014 Streamflow Monitoring Results (Shirley's Brook Northwest Branch)

Month	Total Precip. (mm/mo)	Tributary 2 (394 ha)		Tributary 3 (233 ha)		Confluence of Tributaries 2 and 3 (706 ha)	
		Streamflow (L/s)	Baseflow (L/s)	Streamflow (L/s)	Baseflow (L/s)	Streamflow (L/s)	Baseflow (L/s)
Jun.	143.2	45.2	22.5	9.8	22.4	137.8	69.1
Jul.	61.8	8.0	4.1	44.9	2.0	19.2	9.7
Aug.	96.8	3.8	1.9	3.9	0.0	1.9	1.0
Sep.	93.0	8.0	4.0	0.0	0.5	8.6	4.3
Oct.	72.3	15.1	7.5	1.0	2.6	35.8	17.7
Nov.	37.2	36.5	18.1	5.2	2.1	52.7	26.3
Dec.	42.1	61.8	30.8	4.3	6.1	83.4	41.8
Jul-Dec	**403.2**	**22.2**	**11.1**	**4.5**	**2.2**	**33.6**	**16.8**

3.9.4 Seasonal Variation in Baseflow

Baseflows in the tributaries comprising the Northwest Branch of Shirley's Brook were observed to vary significantly over the course of the year. Flows during the spring months are relatively high, sustained by the snow and water retained in the wetland areas in the upper portion of the watershed. Over the course of the summer, baseflows decrease as soil moisture is depleted by evapotranspiration until the channels are dry, only flowing for short durations following storm events. In the fall, the wetland areas gradually replenish their storage as evapotranspiration rates decrease and the tributaries begin to flow for longer durations following storm events.

The seasonal variance in baseflow is reflected in the following photographs:

- April 10, 2015: High flows were observed in Northwest Branch tributaries during the spring freshet.
- August 24, 2015: The Northwest Branch tributaries were observed to be dry following 22mm of rain between August 20-24.

Figure 3.8: Tributary 2 (April 10, 2015)

Figure 3.9: Tributary 2 (August 24, 2015)

Figure 3.10: Tributary 3 (April 10, 2015)

Figure 3.11: Tributary 3 (August 24, 2015)

Figure 3.12: Confluence of Tributaries 2 and 3 (April 10, 2015)

Figure 3.13: Confluence of Tributaries 2 and 3 (August 24, 2015)

3.10 Storm Drainage & Hydrology

An existing conditions hydrologic analysis was completed to characterize the rainfall/runoff response for the Northwest Branch of Shirley's brook and provide a benchmark for comparison and evaluation of post-development conditions. The following provides an overview of the existing conditions hydrologic analysis. Please refer to the following report for more detailed information and supporting calculations:

- *Kanata North Urban Expansion Area - Existing Conditions Report – Storm Drainage, Hydrology, Floodplain Mapping* (Novatech, February 2016)

3.10.1 Drainage Areas

The KNUEA is located in the Shirley's Brook watershed (refer to **Figure 3.14**). There is a significant ridge (approximately 9m high) that runs in a north-south direction through the northeast and southeast quadrants of the study area. Generally speaking, the lands west of the ridge are tributary to the Northwest Branch of Shirley's Brook, while the lands east of the ridge are tributary to the Main Branch of Shirley's Brook.

Detailed topographic mapping and aerial photography was used to delineate the catchment areas shown on **Figure 3.15**:

- **Tributary 1 (Confluence with Shirley's Brook Main Branch @ March Valley Road)**

  Approximately 6 hectares in the northwest quadrant of the KNUEA drains north toward Tributary 1 via the roadside ditch on the west side of March Road.

- **Tributary 2**

  Tributary 2 has a drainage area of approximately 379 hectares upstream of the KNUEA and serves as the outlet for approximately 57.6 hectares of the KNUEA west of March Road and approximately 29.4 hectares east of March Road.

- **Tributary 3**

  Tributary 3 has a drainage area of approximately 235 ha upstream of the KNUEA and serves as the outlet for approximately 18.8 hectares of the KNUEA west of March Road.

- **Tributary 4**

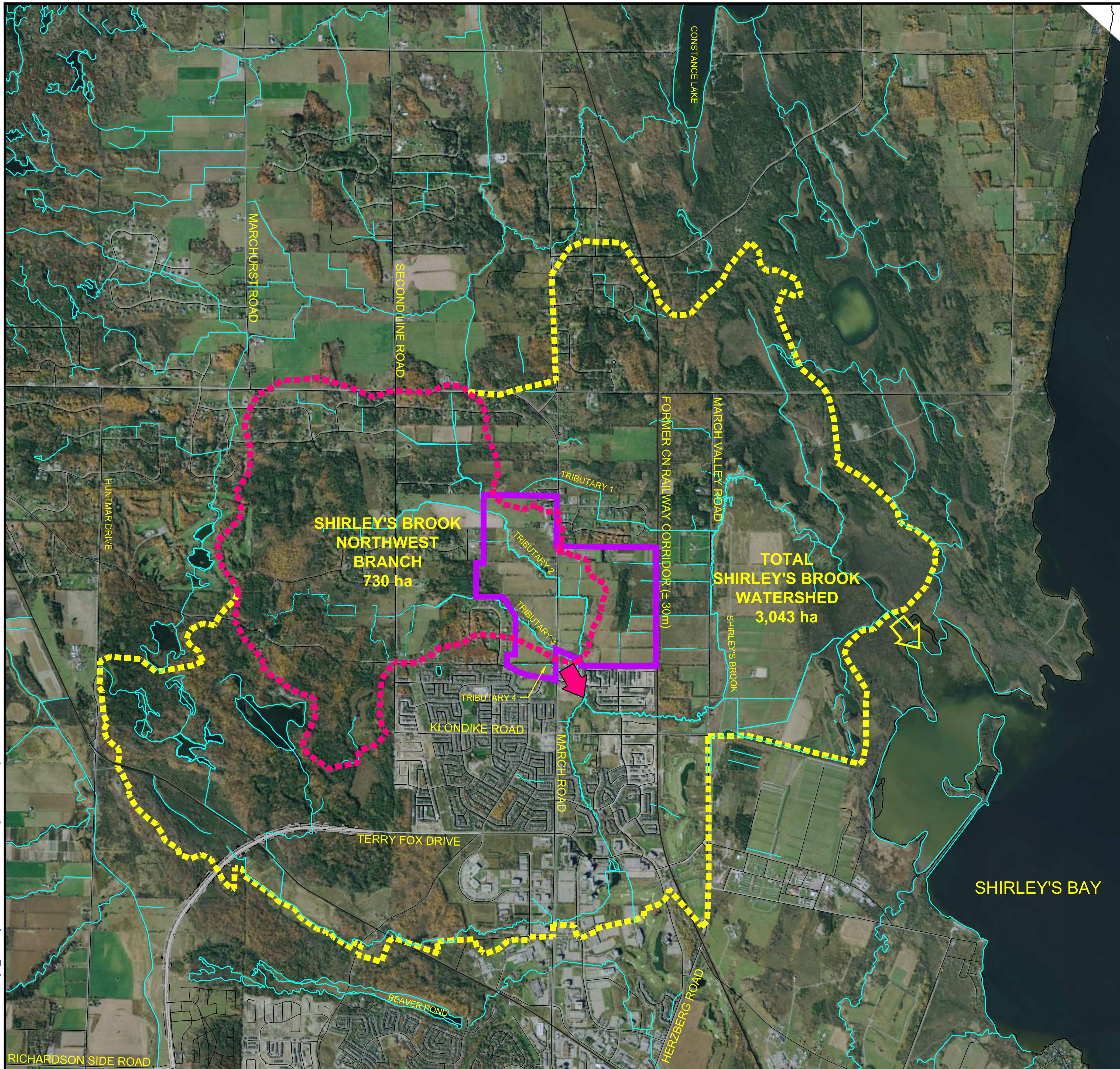
  Tributary 4 has a drainage area of approximately 16.8 ha upstream of the KNUEA and serves as the outlet for approximately 11 hectares of the KNUEA west of March Road.

- **Headwater Drainage Channels**

  Runoff from approximately 62.7ha of the KNUEA east of March Road is conveyed through a series of headwater drainage channels crossing under the abandoned CN Rail corridor to the main branch of Shirley's Brook at March Valley Road.

3.10.2 Inventory of Structures / Crossings

A detailed inventory of all hydraulic structures and crossings within the study area has been created based on field reconnaissance, survey data, and information compiled from previous reports. The inventory of hydraulic structures (structure type, elevations, dimensions, length, condition, etc.) is provided as **Table 3.4**, following this page. The locations of all structures are identified on **Figure 3.16**.



LEGEND

- KNUEA (185 ha)
- DRAINAGE CHANNEL
- SHIRLEY'S BROOK NORTHWEST BRANCH WATERSHED
- SHIRLEY'S BROOK WATERSHED
- SHIRLEY'S BROOK NORTHWEST BRANCH OUTLET
- SHIRLEY'S BROOK WATERSHED OUTLET

KANATA NORTH
COMMUNITY DESIGN PLAN

FIGURE NO. 3.14
SHIRLEY'S BROOK WATERSHED

DATE MAY 2016
JOB 112117
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M:\2012\112117\CAD\Design_EMP\Figure 3.14 SB Watershed.dwg, FIG-3.14, May 16, 2016 - 11:12am, kbanks

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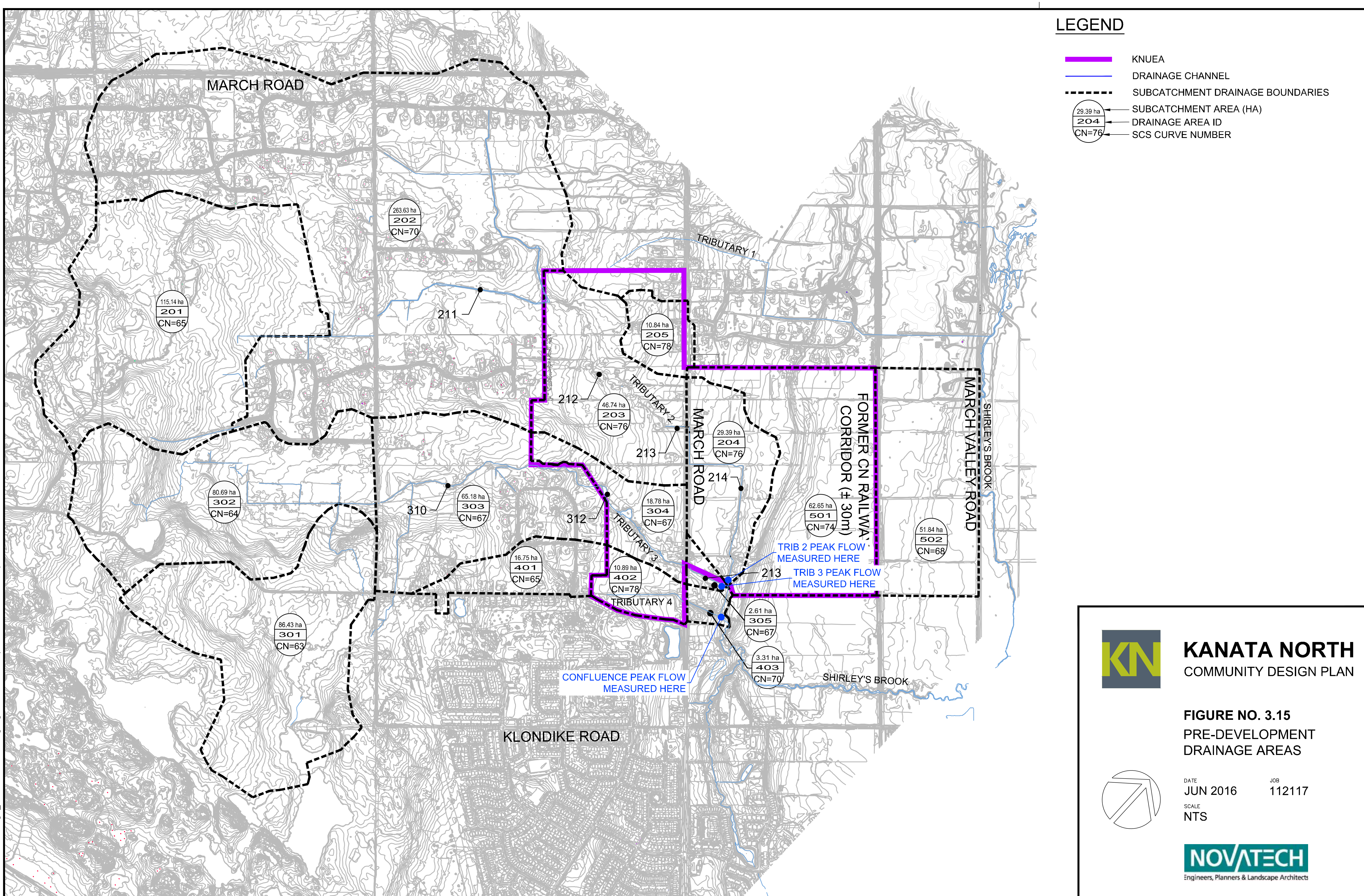

KANATA NORTH

COMMUNITY DESIGN PLAN

FIGURE NO. 3.15

PRE-DEVELOPMENT DRAINAGE AREAS

DATE: JUN 2016

JOB: 112117

SCALE: NTS

NOVATECH

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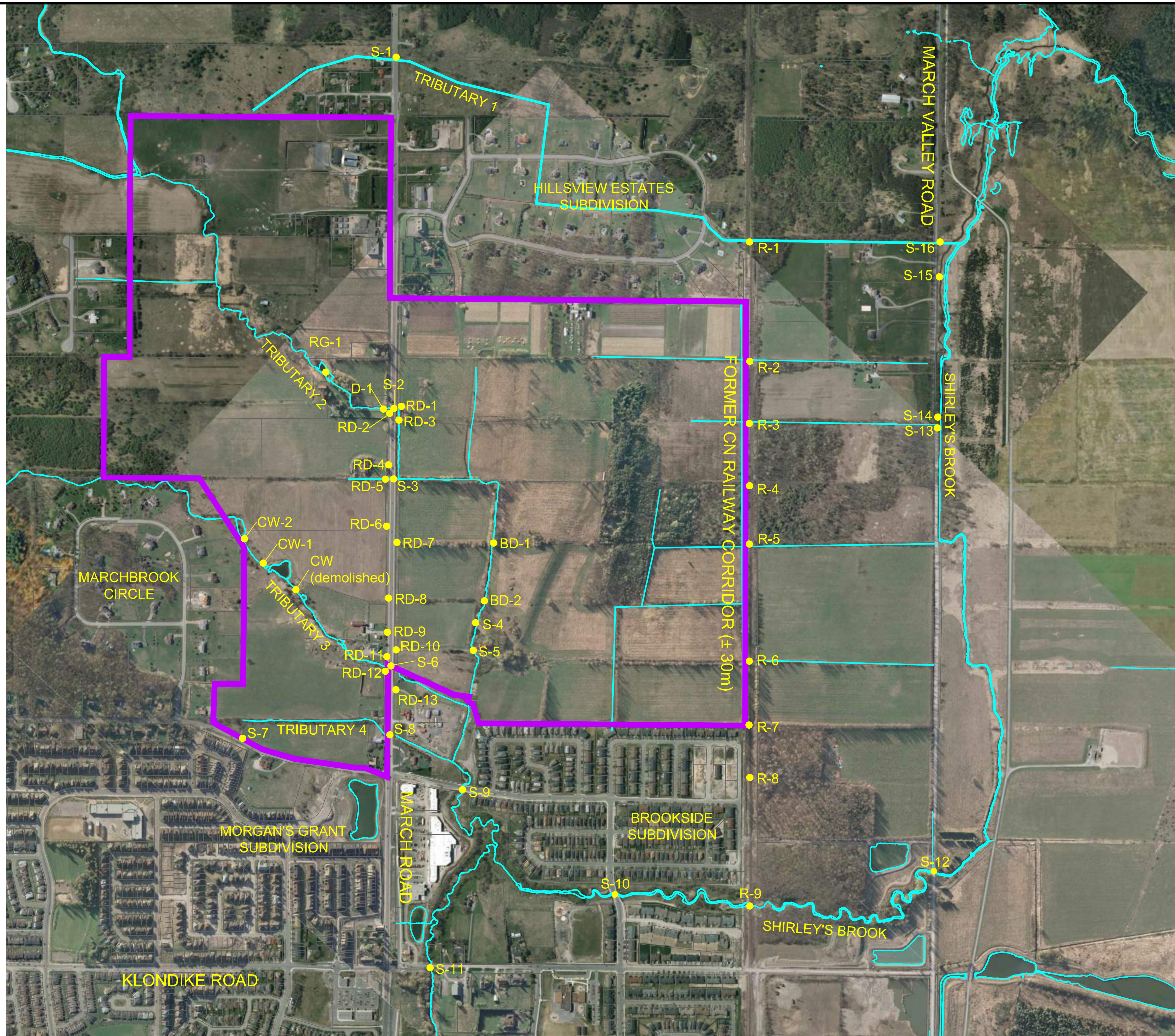
M:\2012\112117\CAD\Design_EMP\112117-SWM.dwg, Figure 3.15 PreDevelopment, Jun 23, 2016 - 5:07pm, kbanks



LEGEND

KNUEA

DRAINAGE CHANNEL

NOTE: SEE ACCOMPANYING TABLE "KNUEA HYDRAULIC STRUCTURES TABLE" FOR DESCRIPTIONS OF EACH STRUCTURE.

HYDRAULIC STRUCTURE ID

- BD BEAVER DAM
- CW CONCRETE WEIR
- D DRIVEWAY CULVERT
- R RAILWAY CULVERT
- RD ROADWAY CULVERT
- RG ROCK GABIAN BASKET
- S SHIRLEY'S BROOK CULVERT

KANATA NORTH

COMMUNITY DESIGN PLAN

FIGURE NO. 3.16

HYDRAULIC STRUCTURE LOCATIONS

DATE MAY 2016

JOB 112117

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0 50m 100m 200m

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M:\2012\112117\CAD\Design_EMP\Figure 3.16 - Hydraulic Structures.dwg, FIG-3.16, Mar 24, 2016 - 12:44pm, kbanks

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Hydraulic Structure Table

NECL Structure No.	Dillon Structure No.	Location	Dillon Size (Diameter/HxW)	NECL Size (Diameter/HxW)	Shape	Dillon Material	NECL Material	Length (m)	U/S Invert (m)	D/S Invert (m)	Culvert Condition/Comments
(refer to Figure 3.9)											
Shirley's Brook											
S-1	S-23	March Road	1.0 x 1.8	-	Box	Concrete		22	-	-	good condition
S-2	S-15	March Road	1.1 x 1.8	1.2 x 1.85	Box	Concrete	Concrete	25	79.24	79.20	good condition
S-3	-	March Road	-	Unknown			Concrete	20	79.11/79.00	79.00/78.99	
S-4	-	Shirley's Brook Main Branch	-	900mm	Circular	Circular	CSP	4.5	76.62	76.59	
S-5	-	Shirley's Brook Main Branch	-	1500mm	Circular	Circular	CSP	6.5	75.40	75.43	
S-6	S-13	March Road	Twin 1650mm	Twin 1500mm	Circular	Steel	CSP	25	77.00/76.95	76.90/76.74	outlet top of culverts partially crushed
S-7	S-12	Old Carp Road	500mm	-	Circular	Steel	-	12	-	-	good condition
S-8	S-11	March Road	1200mm	1200mm	Circular	Steel	Concrete	25	-	-	good condition
S-9	-	Old Carp Road	-	2.1 x 7.0*	Arch	-	CSP*	20	-	-	
S-10	-	Marconi Avenue	-	2.55 x 8.0*	Arch	-	CSP*	20	-	-	
S-11	S-4	Klondike Road	1.45 x 3.1	1.4 X 3.0*	Box	Concrete	Concrete	11	-	-	good condition
S-12	S-1	March Valley Road	2.0 x 2.75	-	Arch	Steel Plate	-	16	-	-	
S-13	-	March Valley Road	-	650mm	Circular	-	CSP	16	63.56	63.77	
S-14	S-27	March Valley Road	600mm	600mm	Circular	Steel	CSP	10	63.84	63.46	
S-15	-	March Valley Road	-	600mm	Circular	-	CSP	15	63.43	63.04	
S-16	S-24	March Valley Road	0.75 x 1.05		Arch	Steel		14			
R-1	S-25	CNR	1050mm	900mm	Circular	Steel	CSP	13	70.46	70.40	good condition
R-2	S-26	CNR	850mm	900mm	Circular	Steel	CSP	12	69.44	69.46	good condition
R-3	S-28	CNR	750mm	-	Circular	Steel	-	-	-	-	good condition
R-4	-	CNR	-	900mm	Circular	-	CSP	11	68.78	68.73	
R-5	S-29	CNR	1500mm	1800mm	Circular	Concrete	Concrete	10	68.69	68.54	good condition
R-6	S-30	CNR	1.0 x 1.2	-	Arch	Steel	-	12	-	-	fair condition
R-7	S-31	CNR	900mm	900mm	Circular	Steel	CSP	12	69.74	69.63	good condition
R-8	S-32	CNR	1400mm	-	Circular	Concrete	-	8	-	-	good condition
R-9	S-2	CNR	Twin 1.45 x 2.8	Twin 1.36 x 2.7*	Box	Concrete	-	6	-	-	good condition
CW-demolished		Shirley's Brook Tributary 3	-		-	-	Concrete				Demolished concrete weir
CW-1	-	Shirley's Brook Tributary 3	-		Rectangular	-	Concrete				Concrete weir - good condition
CW-2		Shirley's Brook Tributary 3	-	55cm x 102cm	Rectangular	-	Concrete	0.57			Concrete weir - good condition
RG-1	-	Shirley's Brook Tributary 2	-		Box	-	-				Gabion Basket Weir
Natural Structures											
BD-1	-	Shirley's Brook	-	Beaver Dam	Natural	-	Wood	-	-	-	build-up slightly obstructing flow
BD-2	-	Shirley's Brook	-	Beaver Dam	Natural	-	Wood	-	-	-	build-up slightly obstructing flow

Kanata North Community Design Plan
Table 3.4: Inventory of Hydraulic Structures

NOVATECH Engineers, Planners & Landscape Architects

Hydraulic Structure Table											
NECL Structure No.	Dillon Structure No.	Location	Dillon Size (Diameter/HxW)	NECL Size (Diameter/HxW)	Shape	Dillon Material	NECL Material	Length (m)	U/S Invert (m)	D/S Invert (m)	Culvert Condition/Comments
(refer to Figure 3.9)											
March Road Roadside Ditch Structures											
D-1	-	March Road	-	900mm	Circular	-	CSP	6.5	79.21	79.02	-
RD-1	-	March Road	-	600mm	Circular	-	CSP	12.5	79.86	79.36	-
RD-2	-	March Road	-	650mm	Circular	-	CSP	9	79.56	79.53	-
RD-3	-	March Road	-	Twin 900mm/Single 600mm	Circular	-	CSP	10	79.15	78.96	-
RD-4	-	March Road	-	650mm	Circular	-	CSP	11	79.66	79.55	-
RD-5	-	Shirley's Brook	-	600mm	Circular	-	Concrete	7	80.18	80.15	-
RD-6	-	March Road	-	400mm	Circular	-	CSP	9.5	80.38	80.31	-
RD-7	-	March Road	-	600mm	Circular	-	CSP	9.5	79.53	79.24	-
RD-8	-	March Road	-	300mm	Circular	-	CSP	-	-	-	-
RD-9	-	March Road	-	600mm	Circular	-	CSP	10	79.01	78.85	-
RD-10	-	March Road	-	600mm	Circular	-	CSP	12	78.42	78.19	-
RD-11	-	March Road	-	600mm	Circular	-	CSP	15.5	78.37	78.29	-
RD-12	-	March Road	-	600mm	Circular	-	CSP	15.5	77.77	77.47	-
RD-13	-	March Road	-	600mm	Circular	-	CSP	10.5	77.49	77.49	-

Notes: * Taken from Shirley’s Brook & Watts Creek Phase 2 –SWM Study Draft Report (AECOM, March 2013).
Dillon Structures taken from 4. Shirley’s Brook and Watts Creek Subwatershed Study (Dillon Consulting, September 1999).

ID	Full Name
BD	Beaver Dam
CW	Concrete Weir
D	Driveway Culvert
R	Railway Culvert
RD	Roadway Culvert
RG	Rock Gabian Basket
S	Shirley's Brook Culvert

3.10.3 Previous Studies

Several previous studies have included a hydrologic analysis of Shirley's Brook. A comparison of the peak flows for the Northwest Branch tributaries from the previous studies is provided in **Table 3.5**.

Table 3.5: Shirley's Brook Northwest Branch – Summary of Peak Flows from Previous Studies

Report Reference	Return Period	Peak Flow (m^3/s)		
		Tributary 2 @ March Road	Tributary 3 @ March Road	Tributary 2 + 3 @ Main Branch
Shirley's Brook Subwatershed Study (Dillon, 1999)	*2-year*	0.25	0.22	0.47
	100-year	1.5	1.3	2.8
*Kanata North EMP** CH2MHill (2001)	*5-year*	3.7	3.2	6.9
	100-year	8.0	7.1	15.1
Shirley's Brook Floodplain Mapping Update (Novatech, 2006)	*5-year*	2.4	1.5	3.6
	100-year	6.9	4.7	10.9
Shirley's Brook Phase 2 Subwatershed Study (AECOM, 2013)	*5-year*	0.45	0.49	0.92
	100-year	1.2	1.4	2.5

* *Flows used in current MVCA regulatory flood mapping.*

The previous hydrologic studies represent a very large range of predicted design flows for the Northwest Branch of Shirley's Brook. The City has indicated that the 2013 AECOM model represents the most up-to-date assessment of the watershed, and should be used as the basis for the existing conditions hydrologic analysis of the KNUEA.

3.10.4 Model Parameters

The SWMHYMO hydrologic model has been used to simulate existing hydrologic conditions for the KNUEA. The catchment areas comprising the Northwest Branch tributaries are generally consistent with the *Shirley's Brook & Watt's Creek Phase 2 Stormwater Management Study* (AECOM 2013), but have been adjusted slightly based on a detailed review of topographic data and field observations. The Northwest Branch catchments have been further discretized compared to the 2013 AECOM model to more accurately reflect the different land uses and topographical features in this area – refer to **Figure 3.15**.

The hydrologic parameters in the KNUEA SWMHYMO model are generally consistent with the the 2013 AECOM model, but have been adjusted where required to ensure the more discretized model generates the same peak flows and has the same hydrologic response characteristics as AECOM model. Model parameters and model schematics are located in **Volume 2**, **Appendix D**. A summary of parameters and supporting text is provided in the *KNUEA Existing Conditions Report – Storm Drainage and Hydrology* (Table 4.1) provided in **Volume 3, Appendix J**.

3.10.5 Model Results

The pre-development SWMHYMO model of Shirley's Brook was run using a variety of storm distributions and durations. The peak flows, runoff volumes, and times to peak from the pre-development SWMHYMO model of the Northwest Branch correlate very closely to the 2013 AECOM model – refer to **Table 3.6**.

The SCS 24-hour storm distribution was found to generate the highest peak flows and was identified as the critical storm distribution for the Northwest Branch subwatershed. Peak flows for all storm distributions used in the analysis are provided in the existing conditions report under separate cover.

Table 3.6: Pre-Development Peak Flows (m^3/s)

Storm Distribution ->	**SCS 24-Hour Distribution**			
Return Period ->	**25mm**	**2 year**	**5 year**	**100 year**
Shirley's Brook Northwest Branch				
Tributary 2 *(±230 m Upstream of Confluence, HEC-RAS Station 266.29)*	0.057	0.266	0.441	1.144
Tributary 3 *(±230 m Upstream of Confluence, HEC-RAS Station 3005.60)*	0.044	0.245	0.426	1.180
Confluence of Tributaries 2 & 3 *(±50 m upstream of Maxwell Bridge Road, HEC-RAS Station 0.86)*	0.110	0.549	0.929	2.481
KNUEA Lands to Main Branch of Shirley's Brook at March Valley Road				
Headwater Channels to Shirley's Brook Main Branch *(Channels A-D)*	0.045	0.237	0.407	1.102

3.11 Floodplain Mapping

Regulatory flood mapping for Shirley's Brook is not available for the tributaries comprising the Northwest Branch of Shirley's Brook east of March Road. The 2013 AECOM study includes an updated hydraulic analysis of the Shirley's Brook floodplain, but did not include floodplain mapping for the Northwest Branch of Shirley's Brook.

As part of the existing conditions analysis, a hydraulic model of the Northwest Branch of Shirley's Brook was developed using HEC-RAS to assess the floodplain limits through the KNUEA. Please refer to the following report (located in **Volume 3**, **Appendix J**) for more detailed information and supporting calculations:

- *Kanata North Urban Expansion Area - Existing Conditions Report – Storm Drainage, Hydrology, Floodplain Mapping* (Novatech, February 2016)

3.11.1 Model Results

A steady-state analysis was performed using the peak flows listed in **Table 3.5** to calculate flood elevations and corresponding floodplain limits for the Northwest Branch tributaries. The water level elevations for the 2-year, 5-year, and 100-year return periods are summarized in **Table 3.7**. The resulting floodplain limits are shown on **Figure 3.17**. Model schematics, input, and output files can be found in **Volume 2**, **Appendix H**.

Table 3.7: HEC-RAS Model Results - Shirley's Brook Northwest Branch

Watercourse	River Station	Peak Flows (m^3/s)			Water Elevation (m)		
		2yr	5yr	100yr	2yr	5yr	100yr
Tributary 2	2310.70	0.17	0.29	0.77	89.01	89.02	89.05
	1920.64	0.17	0.29	0.77	85.92	85.97	86.12
	1589.43	0.17	0.29	0.77	83.31	83.34	83.39
	1293.80*	0.22	0.36	0.95	79.65	79.78	80.21
	1245.94**	0.22	0.36	0.95	79.44	79.53	79.80
	808.91	0.22	0.36	0.95	77.89	77.90	77.95
	514.32	0.22	0.36	0.95	76.57	76.63	76.78
	266.29	0.27	0.44	1.14	74.76	74.83	75.01
Tributary 3	4112.66	0.20	0.36	1.01	89.35	89.38	89.46
	3673.90	0.20	0.36	1.01	81.34	81.37	81.44
	3271.49*	0.24	0.42	1.16	77.79	77.79	78.03
	3158.50**	0.24	0.42	1.16	76.67	76.73	76.90
	3005.60	0.25	0.43	1.18	74.50	74.58	74.76
Northwest Branch (Confluence of Tributaries 2 & 3)	206.99	0.50	0.85	2.29	74.39	74.42	74.54
	0.86	0.55	0.93	2.49	71.88	71.96	72.13

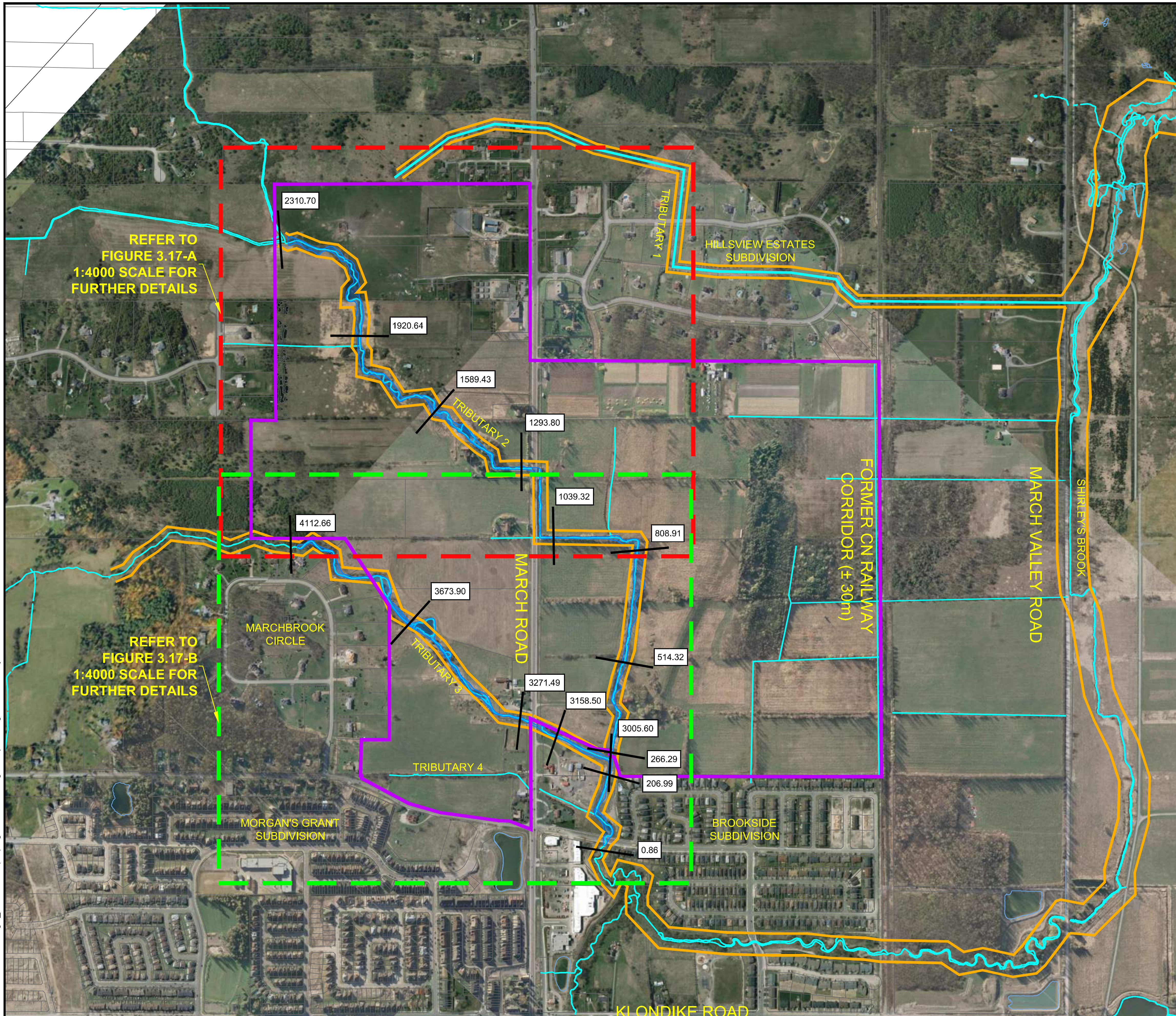
*Cross-Section Upstream of March Road
**Cross-Section Downstream of March Road

Tributary 2

Apart from some localized flooding immediately upstream of March Road (Hydraulic Structure S-2) Tributary 2 has sufficient capacity to confine the 100-year peak flow within the top of bank of the existing channel corridor.

Tributary 3

Tributary 3 has sufficient capacity to confine the 100-year peak flow within the top of bank of the existing channel corridor to the confluence with Tributary 2. The existing culvert crossing March Road (Hydraulic Structure S-6) provides sufficient capacity to convey the 100-year peak flow.



M:\2012\112117\CAD\Design_EMP\MEMO (CS)\Figure 3.17 Existing Floodplain.dwg, FIG-3.17, May 26, 2016 - 10:49am, bthurber

LEGEND

- KNUEA
- MEANDER BELT WIDTH
- DRAINAGE CHANNEL
- 2310.70 HEC-RAS STATION
- FLOODPLAIN EXTENTS

TRIBUTARY 2			
STATION	2-YEAR WL	5-YEAR WL	100-YEAR WL
2310.70	89.03	89.05	89.10
1920.64	86.00	86.11	86.25
1589.43	83.35	83.39	83.43
1293.80	79.86	80.12	80.51
1039.32	78.77	78.87	79.10
808.91	77.91	77.94	78.02
514.32	76.67	76.76	76.92
266.29	74.83	74.93	75.14
TRIBUTARY 3			
STATION	2-YEAR WL	5-YEAR WL	100-YEAR WL
4112.66	89.34	89.37	89.45
3673.90	81.34	81.36	81.43
3271.49	77.81	77.89	78.00
3158.50	76.66	76.72	76.87
3005.60	74.54	74.63	74.84
NORTHWEST BRANCH (CONFLUENCE OF TRIBUTARIES 2 & 3)			
STATION	2-YEAR WL	5-YEAR WL	100-YEAR WL
206.99	74.41	74.47	74.60
0.86	71.92	72.02	72.23

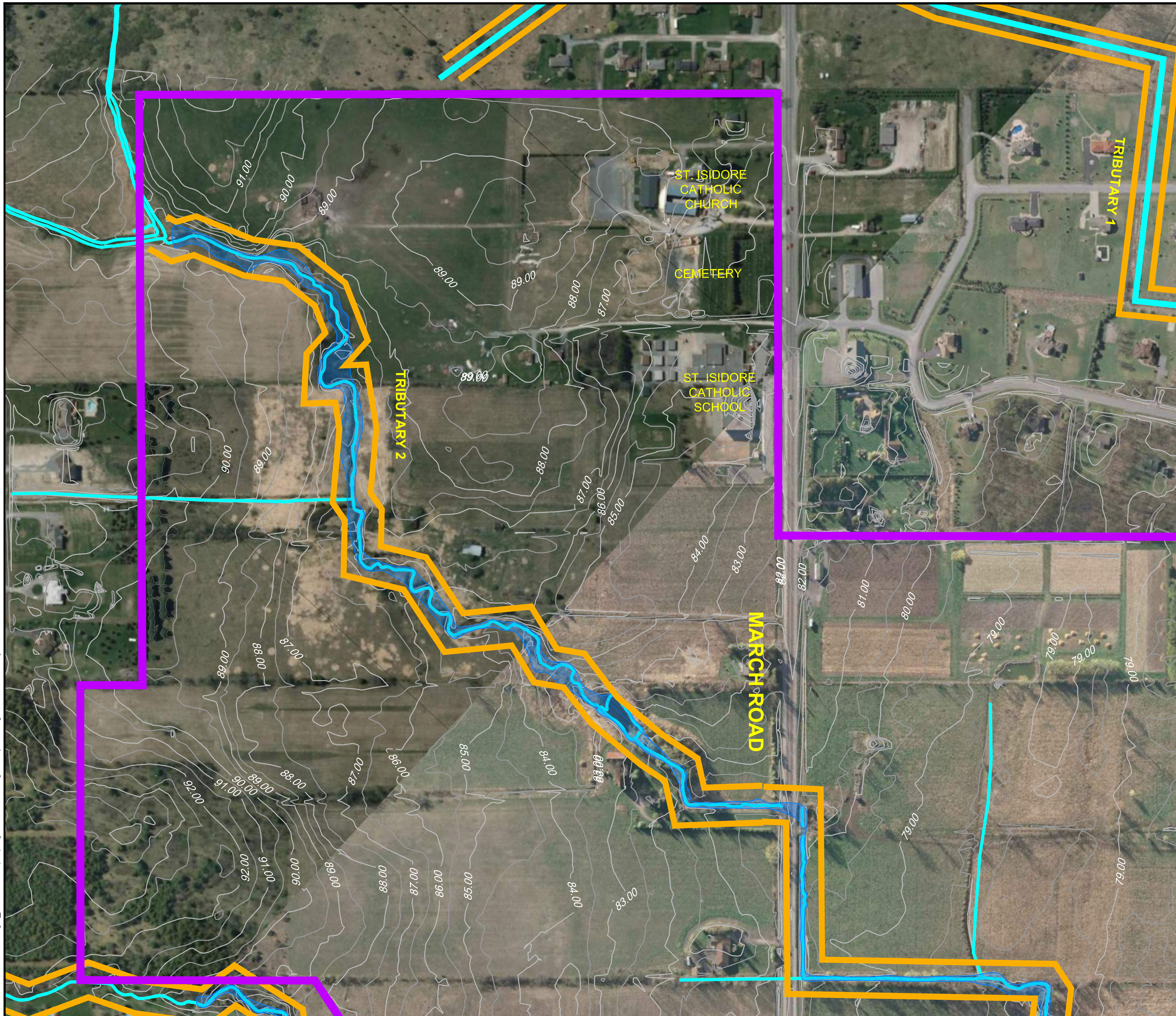
KANATA NORTH
COMMUNITY DESIGN PLAN

FIGURE NO. 3.17
EXISTING FLOODPLAIN LIMITS

DATE MAY 2016
JOB 112117
SCALE 1:10,000
0 50 100m 200m

NOVATECH
Engineers, Planners & Landscape Architects

SHT11x17.DWG - 279mmx432mm



LEGEND

- KNUEA
- MEANDER BELT WIDTH
- DRAINAGE CHANNEL
- FLOODPLAIN EXTENTS

KANATA NORTH
COMMUNITY DESIGN PLAN

FIGURE NO. 3.17-A
EXISTING FLOODPLAIN EXTENTS

DATE
MAY 2016

JOB
112117

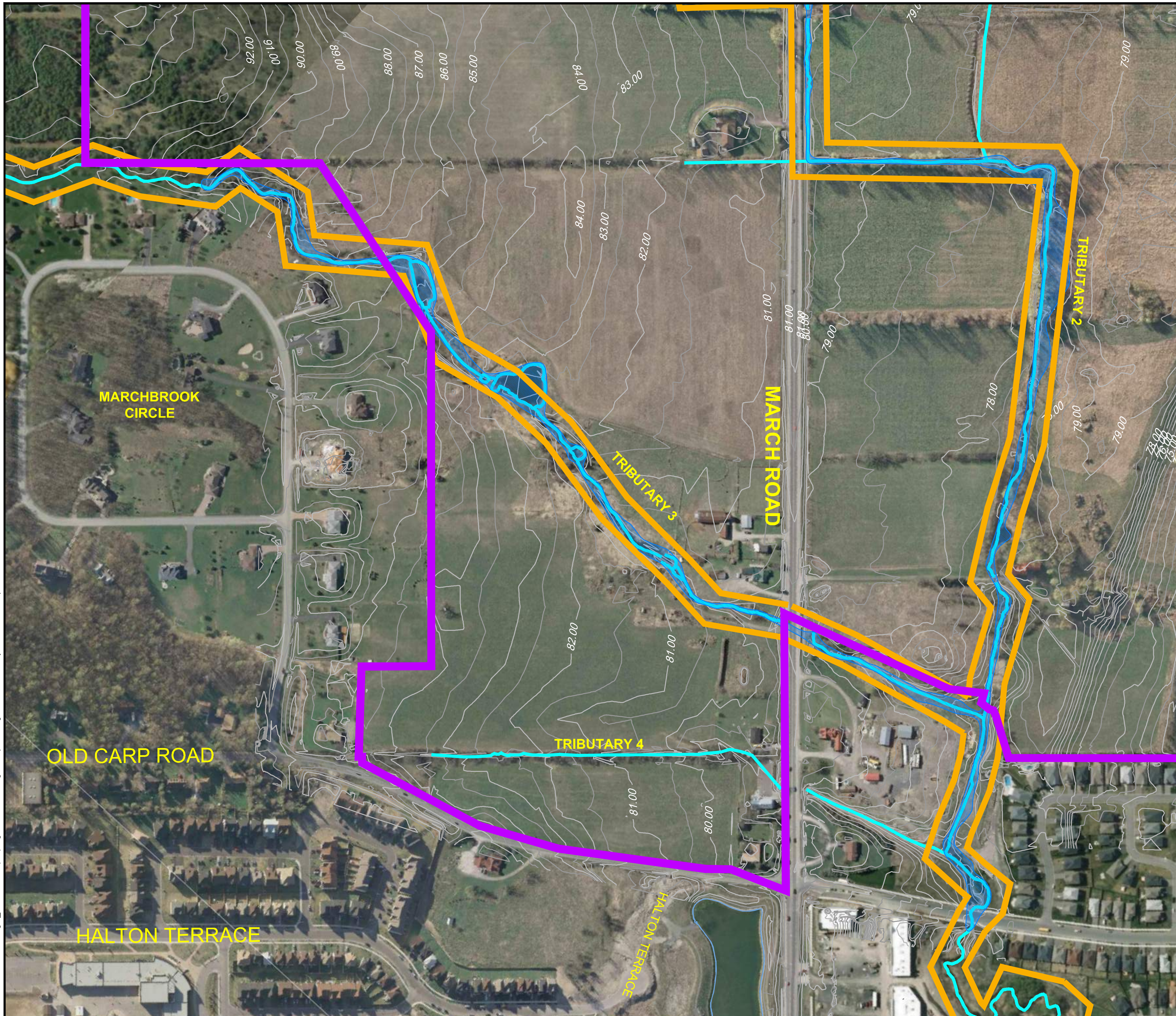
SCALE
1:4,000

0 20m 40m 80m

NOVATECH
Engineers, Planners & Landscape Architects

M:\2012\112117\CAD\Design_EMP\MEMO (CS)\Figure 3.17 Existing Floodplain.dwg, FIG-3.17-A, May 26, 2016 - 11:01am, bthurber

SHT11x17.DWG - 279mmx432mm



LEGEND

- KNUEA
- MEANDER BELT WIDTH
- DRAINAGE CHANNEL
- FLOODPLAIN EXTENTS

KN

KANATA NORTH
COMMUNITY DESIGN PLAN

FIGURE NO. 3.17-B
EXISTING FLOODPLAIN EXTENTS

DATE: MAY 2016
JOB: 112117
SCALE: 1:4,000 (0, 20m, 40m, 80m)

NOVATECH
Engineers, Planners & Landscape Architects

M:\2012\112117\CAD\Design_EMP\MEMO (CS)\Figure 3.17 Existing Floodplain.dwg, FIG-3.17-B, May 26, 2016 - 1:47pm, bthurber

SHT11x17.DWG - 279mmx432mm

3.12 Fluvial Geomorphology

The geomorphology analysis has been used to define cumulative headwater functions within and downstream of the KNUEA, identify linkages with local and regional hydrology, develop recommendations for stream corridors, and to identify opportunities with respect to stream restoration and ultimately in the development of restoration concepts. Please refer to the existing conditions report (located in **Volume 3**, **Appendix O**) for more detailed information and supporting calculations:

- *Kanata North Urban Expansion Study Fluvial Geomorphic Assessment* (Parish Aquatic Services, March 2016)

3.12.1 Previous Studies

As part of the fluvial geomorphology analysis, previous studies related to the fluvial geomorphology of Shirley's Brook and its tributaries have been reviewed with respect to the KNCDP development**:**

- *Shirley's Brook and Watt's Creek Subwatershed Study (Dillon, 1999)*
- *Greater Shirley's Brook Constance Creek Environmental Management Study (Aquafor Beech, 2006)*
- *Shirley's Brook and Watt's Creek Phase 2 Stormwater Management Study (AECOM, 2013)*

3.12.2 Historical Assessment

Historical aerial photographs from 1976, 1991, and 2008 were used to determine changes in land use and channel flow path of the watercourses in the area. The land use of the study area and surrounding land was agriculture, pasture lands, and open fields in 1976 and included some remnant forest and hedgerows. Land use within the KNUEA has not changed substantially since 1976; however, residential development in the surrounding land has increased.

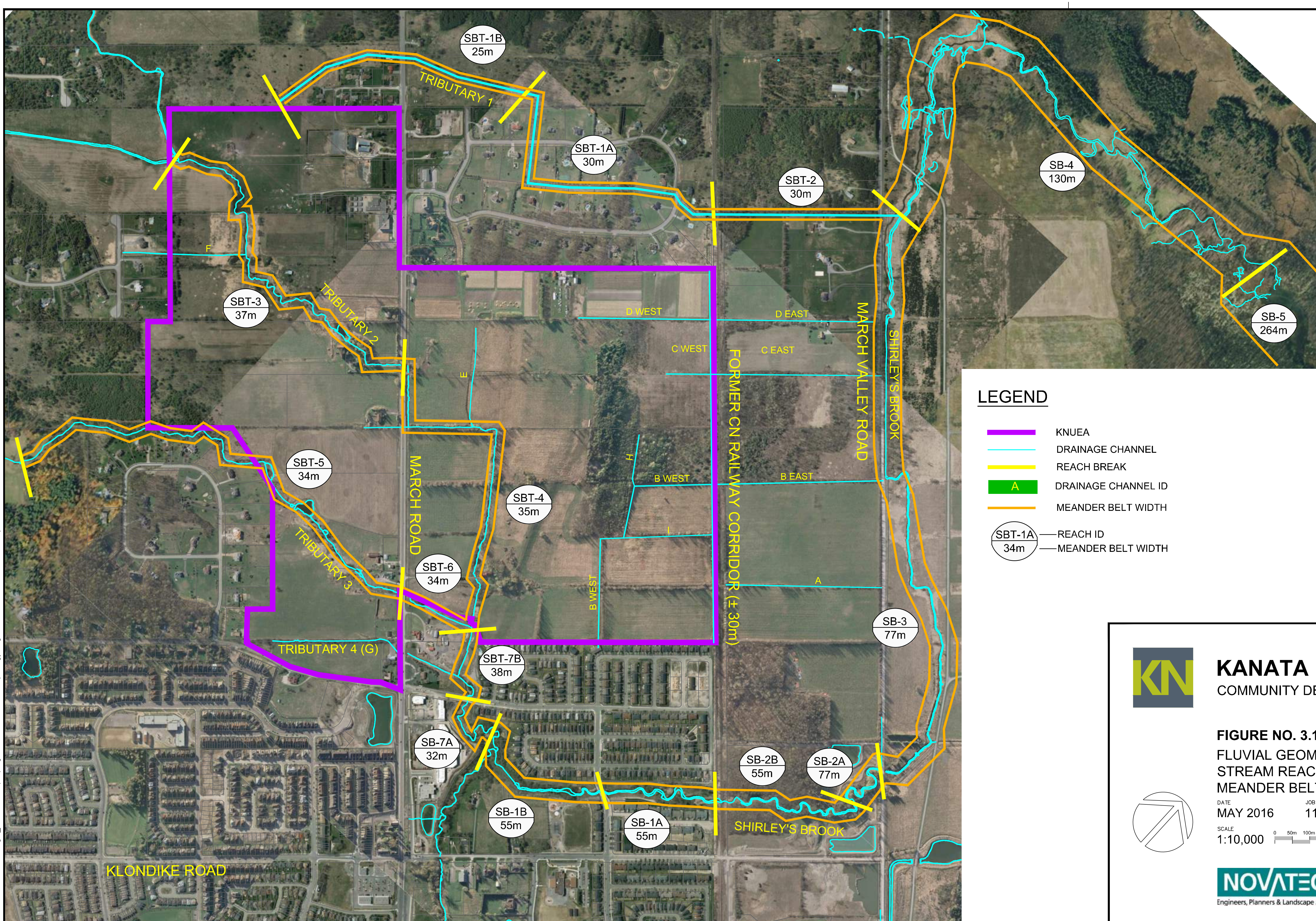
Channel flow paths do not appear to have changed much since 1976 in terms of direction; however the definition of Tributaries 2 and 3 has become more pronounced with time. Aerial photographs from 1976 only show faint outlines of the tributaries, with the ponding area on Tributary 3 being slightly larger than at present. Photographs from 2014 show more well-defined tributaries, a larger ponding area along Tributary 2 and a smaller ponding area along Tributary 3.

3.12.3 Reach Delineation

Stream reaches were delineated as lengths of channel that display similar valley setting, channel planform, floodplain materials, and land use/cover. Reaches were delineated using available aerial photography, watercourse planform, and field investigations – refer to **Figure 3.18**.

The reaches investigated include those tributary to Shirley's Brook throughout the site and those within Shirley's Brook downstream of the KNUEA where the tributaries throughout the site meet Shirley's Brook.

A number of watercourses were excluded from being delineated stream reaches, such as open drains/ditches. These drainage features lack natural geomorphic features and were created primarily to remove excess water from agricultural land.



KANATA NORTH

COMMUNITY DESIGN PLAN

FIGURE NO. 3.18

FLUVIAL GEOMORPHOLOGY STREAM REACHES & MEANDER BELT WIDTHS

DATE MAY 2016

JOB 112117

SCALE 1:10,000

0 50m 100m 200m

NOVATECH Engineers, Planners & Landscape Architects

M:\2012\112117\CAD\Design_EMP\MEMO (CS)\Figure 3.18 Fluvial Geomorphology.dwg, FIG-3.18, Mar 24, 2016 - 12:47pm, kbanks

SHT11x17.DWG - 279mmx432mm

3.12.4 Bed Morphology (Geology)

The bed morphology in much of Shirley's Brook's drainage network is poorly defined and the substrate material is dominated by silts and clays. The bed morphology tends to have a balanced pool-glide-riffle complex coincident with coarser bed materials in the undeveloped areas along Shirley's Brook.

Much of the bed material within Shirley's Brook (silts and clays) is cohesive sediments and when subjected to the same erosive forces as alluvial deposits (non-cohesive materials) they typically do not erode as readily. Therefore, some of the energy available to erode the channel bed will be diverted against the banks, enhancing the erosion / scour potential. The bank materials tend to be fine grained silt and sand mixed with clay and are susceptible to erosion (Dillon, 1999). The river corridor appears to be the origin of much of the sediment that is transported by Shirley's Brook.

3.12.5 Field Reconnaissance

Field walks were undertaken by Parish Geomorphic staff on April 23-25, 2013 and June 12-13, 2013 along the channels identified in **Figure 3.18** (Parish, 2016). The field reconnaissance was performed to provide a characterization of existing geomorphic conditions and document any evidence of active erosion. This robust data set offers the benefits of not only informing any restoration efforts, but also provides for the development of performance targets for stream reaches, which will be receiving flows from the developed lands.

3.12.6 Methodology

Channel conditions along the reaches in the KNUEA were evaluated using two established synoptic surveys:

- Rapid Geomorphic Assessment (RGA)
- Rapid Stream Assessment Technique (RSAT)

<u>Rapid Geomorphic Assessment (RGA)</u>

The RGA was designed by the Ontario Ministry of the Environment and Climate Change (MOECC 2003) to assess reaches in rural and urban channels and document indicators of channel instability. Observations are quantified using an index that identifies channel sensitivity based on evidence of aggradation, degradation, channel widening, and planimetric adjustment. **Table 3.8** provides an explanation of the various RGA classifications.

Table 3.8: Rapid Geomorphic Assessment Classification

Factor Value	Classification	Interpretation
≤0.20	In Regime or Stable (Least Sensitive)	The channel morphology is within a range of variance for streams of similar hydrographic characteristics - evidence of instability is isolated or associated with normal river meander propagation processes.
0.21-0.40	Transitional or Stressed (Moderately Sensitive)	Channel morphology is within the range of variance for streams of similar hydrographic characteristics, but the evidence of instability is frequent.
≥0.41	In Adjustment (Most Sensitive)	Channel morphology is not within the range of variance, and evidence of instability is widespread.

Rapid Stream Assessment Technique (RSAT)

The RSAT (COG 1996) provides a more qualitative and broader assessment of the overall health and functions of a reach. This system integrates visual estimates of channel conditions and numerical scoring of stream parameters using six categories: channel stability, erosion and deposition, instream habitat, water quality, riparian conditions, and biological indicators. Scores can be divided into three classes: low (<20), moderate (20 to 35), and high (>35).

3.12.7 Rapid Stream Assessment Results

Shirley's Brook Main Branch

The main branch of Shirley's Brook was investigated from its confluence with Tributary 3 downstream to March Valley Road (SB-1A, 1B, 2A, 2B). The RGA scores for the main branch of Shirley's Brook in the study area are summarized in **Table 3.9**.

Table 3.9: RGA / RSAT Scoring Summary - Shirley's Brook Main Branch

Reach	Aggradation	Degradation	Widening	Planimetric Adjustment	RGA Index	RGA Condition	RSAT Score
SB-1A	0.22	0.29	0.63	0	0.28	Transitional	25
SB-1B	0.22	0.57	0.63	0.14	0.39	Transitional	23
SB-2A	0.44	0.14	0.63	0	0.30	Transitional	27
SB-2B	0.43	0.14	0.88	0.14	0.40	Transitional	24

The main branch of Shirley's Brook has RSAT scores ranging from 23 to 27, which generally indicates moderate ecological health. All reaches were found to be in a transitional state characterized by bank erosion, slumping, widening, and degradation.

Shirley's Brook Tributaries

The tributaries to Shirley's Brook showed wide variations in channel form. Bankfull widths ranged from 2 to 5m, and average bankfull depths ranged from 0.4 to 0.9m. The RGA scores for the Shirley's Brook tributaries are summarized in **Table 3.10**.

Table 3.10: RGA / RSAT Scoring Summary - Shirley's Brook Tributaries

Reach	Aggradation	Degradation	Widening	Planimetric Adjustment	RGA Index	RGA Condition	RSAT Score
Tributary 1							
SBT-1A	N/A	N/A	N/A	N/A	N/A	In Regime	23
SBT-1B	0.11	0.57	0.25	0	0.23	Transitional	18
SBT-2	0.13	0.57	0.88	0	0.39	Transitional	21
Tributary 2							
SBT-3	0.29	0.43	0	0.14	0.20	In Regime	27
SBT-4	0.29	0.57	0.25	0.29	0.41	Adjusting	26
Tributary 3							
SBT-5	0.29	0.29	0.25	0.14	0.30	Transitional	22
SBT-6	0	0.29	0	0	0.06	In Regime	26
Northwest Branch Confluence							
SBT-7A	0.29	0	0.30	0	0.15	Transitional	25
SBT-7B	0	0.43	0	0	0.11	In Regime	20

The upper reach of Tributary 1 (SBT-1A) was found to be stable. The lower reaches (SBT-1B / SBT-2) are in a transitional state characterized by gullying, bank undercutting, bank erosion, and slumping. The RSAT scores for Tributary 1 indicate low/moderate ecological health.

The western reach of Tributary 2 through the KNUEA (SBT-3) was found to be stable, while the lower reach (SBT-4) is in adjustment as characterized by degradation, incision into bedrock, head cutting and widening. The RSAT scores for Tributary 2 indicate moderate ecological health.

The western reach of Tributary 3 through the KNUEA (SBT-5) can be considered atypical owing to the presence of online ponds and large sections with unconfined sheet flow over bedrock. The RSAT scores for Tributary 3 indicate moderate ecological health.

The reaches downstream of the confluence of Tributaries 2 and 3 are just outside the limits of the KNUEA. The reach immediately upstream of the confluence with Main Branch (SBT-7A) was found to be in a transitional state, while the reach upstream of Maxwell Bridge Road (SBT-7B) was found to be stable with few indicators of adjustment. The RSAT scores for the Northwest Branch confluence indicate low/moderate ecological health.

3.12.8 Meander Belt Width

The meander belt is the space that a meandering watercourse occupies on its floodplain, in which all associated natural channel processes occur. The meander belt width assessment is conducted in order to establish hazard limits from a geomorphic perspective and designate a corridor that is projected to contain all of the natural migration tendencies of the channel. Based on planform, channel dimensions, and relative stability, meander belts were developed for the watercourses. The meander belt widths also include a 10% setback applied to either side of the channel. Refer to **Figure 3.18** for the meander belt widths with setbacks.

Shirley's Brook Main Branch

The meander belt widths within the main branch of Shirley's Brook are either 55m or 77m until the main branch enters a swamp like area downstream of March Valley Road where the meander belt increases to 130m then 264m. The stream reach adjacent to March Valley Road (SB-3) has a meander belt width of approximately 77m.

Shirley's Brook Tributaries

The meander belts for the tributaries of Shirley's Brook are shown below:

- Tributary 1: ranges from 25m (SBT-1B) to 30m (SBT-1A and SBT-2)
- Tributary 2: ranges from 35m (SBT-4) to 37m (SBT-3)
- Tributary 3: both upper (SBT-5) and lower reaches (SBT-6) are 34m
- Tributary 2 / 3 Confluence: ranges from 33m (SBT-7A) to 38m (SBT-7B)

The meander belt widths for all tributaries are less than 40m. This is generally consistent with the findings from Dillon (1999).

3.12.9 Erosion Thresholds

The erosion threshold represents the discharge at which sustained flows will tend to entrain and transport sediment. Selection of an appropriate threshold was dictated, in part, by indicators of active geomorphic processes identified through the rapid assessment phase, as well as convergence within the erosion assessment models; the underlying assumptions upon which the models are based; and whether these assumptions can be deemed applicable to the particular site. Typically the erosion threshold analysis involves the determination of a critical discharge based on the entrainment of the D_{50} or median grain size; however, due to the abundance of fine material within many of the tributaries the D_{84} value was used.

In all cases, a comparison between the critical discharge and bankfull flow was made to determine whether the bed is fully mobilized around bankfull flows. This implies that sediment can be entrained below bankfull flows and that any increase in discharge within these systems will lead to increased sediment transport and would likely exacerbate channel erosion. The resultant threshold values represent performance targets that must be considered when developing a stormwater management plan for the study area. Since they are based on the most sensitive portions of the drainage system, they are inherently conservative and are meant to ensure that channel erosion processes are not exacerbated in the post-development phase.

It should be noted that erosion is a natural process that must occur within a channel in order to maintain a state of equilibrium. As such, the threshold is meant to be exceeded. The overall goal is to ensure that post-development conditions do not see a substantial increase in the frequency or duration of flow events which are in excess of the established thresholds from pre-development conditions. This will ensure that the receiving channels do not experience higher than normal rates of erosion. Erosion thresholds can also be used to inform any rehabilitation measures being undertaken as part of the development process by providing insight into the design of enhancement features and the ultimate channel configuration.

The critical and bankfull discharges derived for the detailed field sites are as listed in **Table 3.11**.

Table 3.11: Average Bankfull and Erosion Threshold Parameters

Reach ID	Location	Critical Discharge[1]	Bankfull Discharge[2]
SBT-3	Tributary 2 – from KNCDP west boundary to March Road	1.32 m^3/s	2.11 m^3/s
SBT-4	Tributary 2 – east of March Road to southern KNCDP boundary	0.73 m^3/s	4.54 m^3/s
SBT-5	Tributary 3 – from KNCDP west boundary to March Road	0.57 m^3/s	4.33 m^3/s
SB-3	Main Branch of Shirley's Brook Adjacent March Valley Road	2.23 m^3/s	3.96 m^3/s
SB-4	Main Branch of Shirley's Brook past DND lands to Shirley's Bay	2.36 m^3/s	4.93 m^3/s

[1]*Critical discharge is defined as the flow associated with incipient motion of the* D_{84}.
[2]*Bankfull discharge is defined as the channel-forming stage, generally associated with a 1.5 to 2-year return period.*

Erosion Analysis Summary

To understand any seeming discrepancy between field-measured bankfull flows (**Table 3.11**) and modeled flows (**Table 3.6**), a consideration of the conditions at individual reaches is required.

Reach SBT-3 is in regime and contains exposed bedrock at its bed through the surveyed reach. A large amount of bank vegetation provides protection for the bank materials upstream of the exposed bedrock. The channel in this area was found to have a large capacity compared to modelled return period events and was dry at the time of the survey. This large channel combined with the erosion resistance of the channel banks and bottom provides an erosion threshold discharge above the 5-year return period event.

Reach SBT-4 is in adjustment but also clearly straightened/channelized. The material here is more exposed than reach SBT-3, and therefore, a lower critical discharge is justified. The level of adjustment observed in the channel is likely the result of a previously straightened/channelized channel attempting to naturalizing itself. The straightening and channelization is also likely to increase the capacity of the channel and can make the determination of an adequate bankfull discharge difficult. An over-estimation of the bankfull discharge does not impact the results of our critical discharge analysis.

Reach SBT-5 was determined to be transitional with obstructions (concrete weir and degraded concrete wall) and exposed bedrock in areas along the bed. Backwatering, due to these types of features, can make an approximation of bankfull discharge difficult for field staff (field notes provided the comment "BF channel not well defined"). The channel was found to be atypical due to the number of online ponds that are backwatering due to flow obstructions. The erosive properties of the sub-materials found on site suggest that the critical discharge (0.54 cms) is above the 5-year return period event (0.430 cms).

The erosion analysis is based on the locations of the proposed SWM facilities, and uses the most appropriate reaches for erosion thresholds:

- Tributary 2 is more sensitive to changes in flow volume than the downstream reaches on the Main Branch of Shirley's Brook. In other words, SBT-3 and SBT-4 are the most sensitive reaches in the system to the addition of a pond along Tributary 2.
- Reach SB-3 has the greatest chance of being affected by the proposed pond adjacent to SB-3. SB-4 was also investigated as it is in a more natural state (not straightened). This reach was found to have an increased stability compared to SB-3. Downstream of SB-4 (SB-5) the channel size increases substantially into a bog with very little erosion potential which outlets to the Ottawa River.

Section 4.0 Environmental Features & Opportunities

The natural features identified and evaluated as part of the existing conditions inventory are shown on the Existing Environmental Inventory provided as **Drawing 112117-ENV** (which can be found in **Volume 2**, **Appendix I**). This drawing provides an overview of the existing natural and man-made features in the vicinity of the KNUEA, and identifies any areas or features that will represent constraints on planned future development.

The evaluation and identification of environmental features was an ongoing process, with input from:

- The authors of the existing conditions reports;
- City staff & regulatory agencies, through regular project team meetings; and
- The public, through open houses.

Initial evaluations of environmental features were completed as part of the existing conditions reports. From the existing conditions reports, significant features were identified and selected for further evaluation. This information has been incorporated into the proposed development plans for the KNUEA, with consideration given to whether protection of a particular feature is warranted.

4.1 Stream Corridors

Stream corridors represent transition zones adjacent to watercourse where the stream and the land interact in a way that is mutually beneficial. Stream corridors serve an important role in maintaining water quality and provide habitat and connectivity for the various species that live within the area.

4.1.1 Official Plan Policy

Section 4.7.3 of the City of Ottawa Official Plan outlines the policies related to the protection of surface water:

Protecting stream corridors and the surface water environment serves the dual purpose of preserving and enhancing the environmental quality of stream and river corridors and their aquatic habitat, as well as reducing risks from natural hazards associated with watercourses. Ensuring that development is set back an appropriate distance from watercourses helps serve these purposes by ensuring a healthy, natural riparian zone and providing a margin of safety from hazards associated with flooding and unstable slopes.

4.1.2 Stream Corridor Evaluation

The corridor width required to support stream functions is based on the sensitivity of the habitat and geomorphic characteristics as documented in the existing conditions reports. Factors included in the evaluation of the required stream corridor widths include:

- Aquatic buffers / aquatic habitat setback;
- Meander belt widths; and
- Hazard limits (geotechnical / floodplain).

4.1.3 Protected Stream Corridors

Based on the watercourse evaluations and discussions with the approval agencies, protected stream corridors of 40m have been identified for Shirley's Brook Tributary 2 and Tributary 3.

The protected corridors will serve to maintain existing drainage patterns, provide connectivity for both terrestrial and aquatic habitat, and provide conveyance of storm runoff from the study area. The stream corridors also provide the opportunity for community connectivity with the potential for a pathway system, which would be located outside the 40m corridor.

4.2 Headwater Drainage Channels

The headwater drainage channels that will be impacted by development of the KNUEA have been evaluated and classified in accordance with the *Headwater Drainage Features Guidelines* (CVC, January 2014):

- The headwater features requiring management and/or compensation are shown on **Drawing 112117-ENV**.
- Opportunities to replace lost headwater functions can be considered both within and outside of the KNUEA – Refer to **Table 3.2** in **Section 3.3.1**.

4.3 Woodlots

4.3.1 Southwest Wooded Area

The southwest wooded area is located in the northwest quadrant of KNUEA and has relatively young tree cover consisting of mixed and cedar forests.

The wooded areas within the proposed creek corridor and along the western border of the KNUEA have been identified as part of the City's Natural Heritage System (NHS) and are to be retained as a part of the proposed development and conveyed to the City for conservation. Where feasible, the retention of other healthy mature trees outside the NHS is recommended.

4.3.2 Woodlot S20

Woodlot S20 is located along the ridge in the eastern portion of the KNUEA, straddling the northeast and southeast quadrants. Although Woodlot S20 is not considered a significant woodland, there is an opportunity to retain a stand of mature, healthy white cedars in the northwest corner of Woodlot S20 as a part of proposed parkland within the KNUEA.

4.3.3 Woodlot S23

Woodlot S23 has an older tree structure, some interior forest habitat, and an existing drainage feature (Channel B) running along the southern boundary between the former railway and March Valley Road.

The functions of the northeast forest adjacent to March Valley Road are reduced due to the dominance of ash and poplar, disturbed and very thick understory, ground flora dominated by non-native and/or invasive flora, road noise, and open canopy.

The reduced functionality of the northeast forest provides an opportunity to integrate a stormwater management facility for the KNUEA into this area. The construction of a SWM facility in Woodlot S23 may require compensation and/or mitigation to offset any negative impacts. This approach could include transferring the remaining portion of Woodlot S23 to the City for conservation as a protected natural area.

4.3.4 Hedgerows

There are potential opportunities to retain individual healthy native trees from hedgerows in the interior of the KNUEA. There are also potential opportunities to retain and/ or enhance the existing perimeter hedgerows with active management and new native plantings to provide more tree cover between the old and new neighbourhoods.

4.4 Species at Risk

4.4.1 Blanding's Turtles

The presence of the Blanding's Turtle will require the creation of additional habitat and/or connectivity to mitigate against the loss of habitat associated with future development.

The stream corridors for Tributaries 2 and 3 provide an opportunity to improve existing habitat and connectivity through the creation of new features such as refuge pools and nesting areas.

There is also opportunity to improve connectivity between the Shirley's Bay and South March Highlands through off-site works such as turtle fencing and a turtle crossing in the area on March Valley Road with documented incidents of road kills.

4.4.2 Butternut Trees

There is a significant number of butternut trees within the KNUEA east of March Road. While there are many healthy trees, there are also many butternuts that have poor leaf-out and have been affected by the butternut canker.

A butternut health assessment will be required for any tree within a 25m radius of any future development that may be harmed, killed, or removed as a result of development.

4.4.3 Barn Swallow

Nine (9) Barn Swallow nests were found within three (3) separate derelict farm structures within the KNUEA. An authorization from the Ontario Ministry of Natural Resources and Forestry to remove the structures where the birds are nesting has been received (Confirmation # M-102-9977528356). The structures containing Barn Swallow nests were removed in the winter of 2015-2016, following the Ontario Endangered Species Act regulatory guidelines. Compensation habitat in the form of artificial Barn Swallow nesting structures will be built northwest of the KNUEA (McKinley Environmental, 2015).

4.5 Water Supply Wells

The locations of existing water supply wells in the vicinity of the KNUEA are shown on both **Figure 3.6** and Drawing **112117-ENV**. Unused and unmaintained wells within the development area must be properly abandoned to reduce the potential for direct contamination of the underlying aquifer.

Private water supply wells adjacent to the development area must be taken into consideration during construction. A monitoring program will be implemented to document any changes to existing wells during and after construction.

The extent of the area where wells will be tested for a baseline on water quality, and the location and number of wells to be monitored for water levels will be confirmed at the time of approval of plans of subdivision.

4.6 Tile Drains

Agricultural tile drains were not encountered in any of the test pits or geotechnical investigations carried out for the KNUEA. Any tile drain systems located during construction should be dewatered and capped to discourage lateral flow within the shallow overburden and encourage vertical infiltration deeper into the underlying soils.

4.7 Tree Planting Restrictions

Tree planting recommendations, if necessary, will be recommended by the geotechnical consultant at the time of processing subdivision applications.

4.8 Existing SWM Facilities

There are several existing SWM facilities in the vicinity of the KNUEA. While these facilities are outside the limits of the study area, they may have indirect impacts on planned development within the KNUEA.

4.8.1 Morgan's Grant SWM Facility (SWF-1227)

The Morgan's Grant SWM Facility is located just outside the southwestern limit of the KNUEA, adjacent to March Road and Halton Terrace. This SWM facility provides quality and quantity control for the Morgan's Grant subdivision. Outflows for this SWM facility are directed to Tributary 4 by an existing storm sewer within the March Road right-of-way.

4.8.2 RioCentre Kanata SWM Facility (SWF-1236)

An existing SWM facility provides water quality and quantity control for the commercial plaza located at the corner of March Road and Maxwell Bridge Road. This SWM facility outlets to the Main Branch of Shirley's Brook immediately upstream of the confluence with the Northwest Branch.

4.8.3 Brookside Subdivision SWM Facilities C & D (SWF-1234 / SWF-1235)

Two existing SWM facilities servicing the Brookside subdivision are located on either side of the main branch of Shirley's Brook immediately upstream of March Valley Road. These facilities provide both water quality and quantity control, and include riparian floodplain storage areas on either side of Shirley's Brook.