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Upper Welland River Tributaries Floodplain Mapping Hydrological Modelling Report



Submitted by:
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July 28, 2026

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Bridge Crossing at Smithville Road along Mill Creek

ACKNOWLEDGEMENTS

Aquafor Beech Limited gratefully acknowledges the efforts and contributions of the following partners and individuals participating in the funding, project management, technical analysis, and detailed hydrologic modelling of the Upper Welland River Tributaries Floodplain Mapping study. This document has been prepared by Aquafor Beech Limited for the Niagara Peninsula Conservation Authority in July 2026.

Federal and Provincial Partners

This project is funded in part by the Government of Canada

Canada

This project was made possible in part by the Province of Ontario

Ontario

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EXECUTIVE SUMMARY

Aquafor Beech Limited (Aquafor) was retained by the Niagara Peninsula Conservation Authority (NPCA) to establish updated regulatory floodplain mapping for 19 tributaries to the Upper Welland River through detailed hydrologic and hydraulic modelling, and analyses of any flood hazards. These tributaries include the Little Forks Creek, Buckhorn Creek, Elsie Creek, Little Wolf Creek, Mill Creek, Moores Creek, Black Creek Drain, Wilson Creek, Wolf Creek, and West Wolf Creek, as well as 9 unnamed tributaries. Together, these watercourses drain a total area of 212.7 km².

The 100-year storm event has been adopted by the NPCA to regulate development within the floodplain and to identify risks to properties and roads within the study area. The NPCA received funding to conduct this study, partnering with the with the Government of Canada (Natural Resources Canada) and the Province of Ontario (Ministry of Natural Resources) as part of the Flood Hazard Identification and Mapping Program (FHIMP) to develop flood hazard maps for municipalities and territories.

As part of the hydrologic component of the study, Aquafor developed a hydrologic model using the US Army Corps of Engineers HEC-HMS software (Ver. 4.10). The model was evaluated by comparing the estimated design storm peak flows to those simulated in a previous study that was undertaken in 2018 to establish regulatory floodplain mapping along the main branch of the Welland River, and by performing a sensitivity analysis. Simulations were performed for the 2-year, 5-year, 10-year, 25-year, 50-year, 100-year (regulatory), 200-year, and 350-year design storms, with the 200-year and 350-year storms serving as proxies for evaluating the regulatory storm under the effects of climate change, per FHIMP guidelines. Junctions were strategically placed throughout the watershed to ensure adequate discretization, as well as to provide flow inputs to the hydraulic model at key locations along the reaches included in the floodplain mapping study. In total, the hydrologic model contains 259 flow nodes (junctions), 228 subbasins, and 164 reaches.

The hydrologic modelling approach was consistent with the HEC-HMS User and Technical Reference Manuals (US Army Corps of Engineers, 2000, 2022), the Federal Flood Mapping Guidelines Series, the Technical Guide for River & Stream Systems: Flood Hazard Limit (MNR, 2002), and the Flood Hazard Identification and Mapping Program – Program Guide (MNR, 2024). A digital terrain model (DTM) having a 0.5 m resolution, produced by NRCan based on LiDAR data collected in 2021, covered the majority of the study area and was used as the primary data source for determining subbasin and reach characteristics. An older DTM having a 0.5 m resolution that was produced by OMAFRA from LiDAR data collected between 2016 and 2018 was used for areas along the edge of the study area that were not covered by the NRCan DTM.

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1 INTRODUCTION

Aquafor Beech Limited (Aquafor) was retained by the Niagara Peninsula Conservation Authority (NPCA) to establish updated regulatory floodplain mapping for 19 tributaries to the Upper Welland River. The tributaries to be mapped include the Little Forks Creek, Buckhorn Creek, Elsie Creek, Little Wolf Creek, Mill Creek, Moores Creek, Black Creek Drain, Wilson Creek, Wolf Creek, and West Wolf Creek. Additionally, the study includes 9 unnamed tributaries, herein referred to Tributaries 1 to 9. The NPCA received funding to conduct this study, partnering with the with the Government of Canada (Natural Resources Canada) and the Province of Ontario (Ministry of Natural Resources) as part of the Flood Hazard Identification and Mapping Program (FHIMP) to develop flood hazard maps for municipalities and territories.

As part of this study, Aquafor built a hydrologic model to simulate watershed response to rainfall and rain-on-snowmelt events over a range of return periods, producing estimates of peak flood flows at key locations throughout each subwatershed. The estimated flood flows will subsequently be used for hydraulic modelling, which will in turn be used to simulate water surface elevations and update the regulatory floodplain mapping for the reaches shown in **Figure 2-1** and **Figure 2-2** below. Aquafor developed the hydrologic model using the US Army Corps of Engineers HEC-HMS software (Ver. 4.10), with the goal of simulating real watershed and watercourse responses following major rainfall and snowmelt events.

The main tasks of the hydrologic component of this study are as follows:

- Review all available background information provided by the NPCA;
- Describe the watershed characteristics;
- Accurately delineate the watershed boundary;
- Build the HEC-HMS model by discretizing the watershed into smaller subbasins, placing junctions, and defining reaches for routing flows;
- Develop design storms from rainfall intensity-duration-frequency (IDF) curves;
- Select an appropriate set of design storms for hydrologic modelling, which will be used to produce flows for subsequent hydraulic modelling and floodplain mapping;
- Simulate flows for the 2-year to 350-year events under existing and future land use conditions; and
- Perform a sensitivity analysis.

2 DESCRIPTION OF THE WATERSHED

2.1 Drainage Network

The study area includes 19 subcatchments having a total drainage area of 212.7 km². As shown in **Figure 2-1** and **Figure 2-2**, each tributary discharges directly into the Welland River, with the exception of Moores Creek and Little Wolf Creek, which discharge into Mill Creek and Wolf Creek, respectively. There are no hydrometric gauges located along any of the individual watercourses included in this study; however, a WSC flow gauge located along the main branch of the Welland River below Caistor Corners was used in a previous study (NPCA, 2018) for calibration.

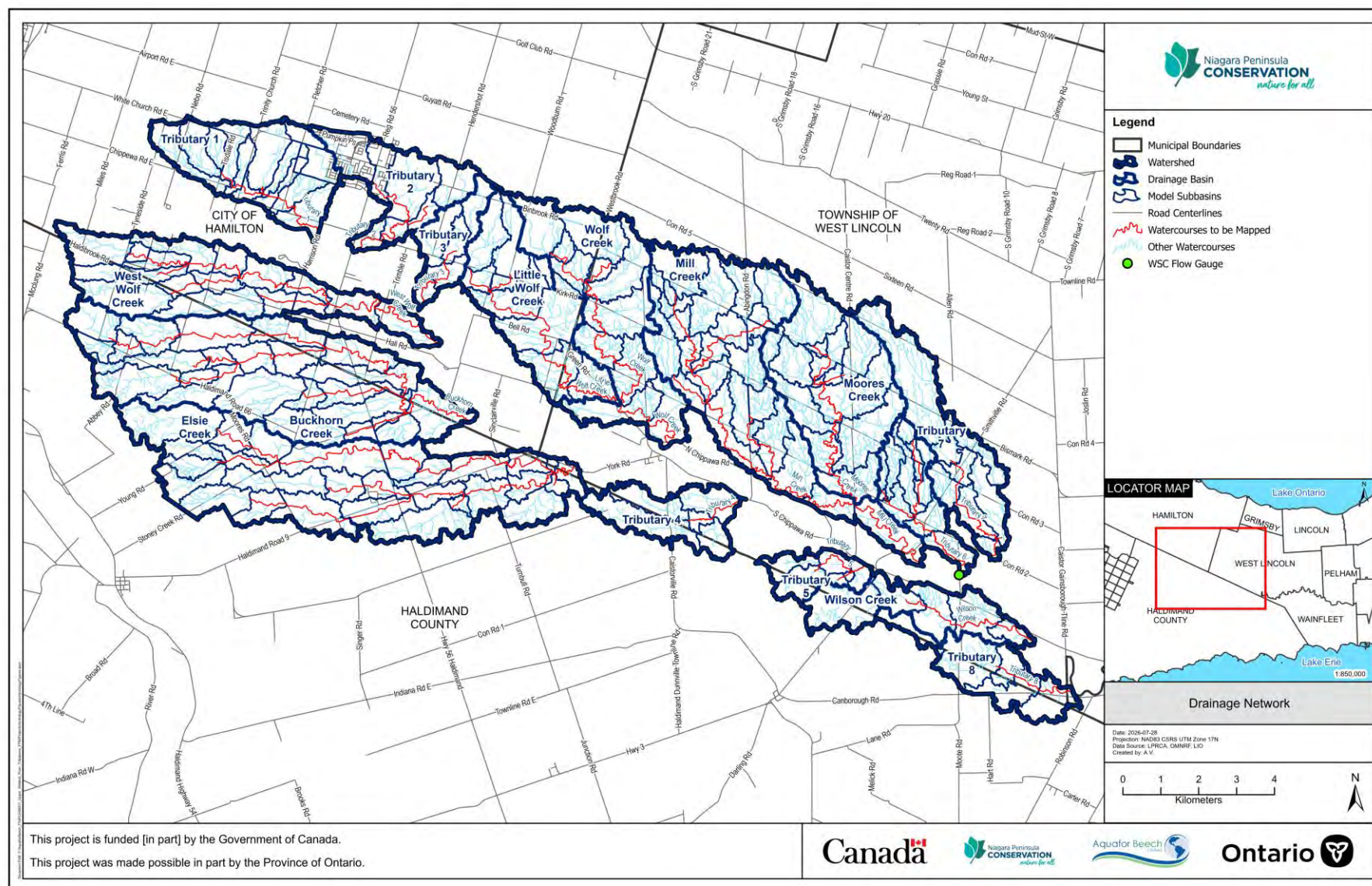


Figure 2-1: Upper Welland Tributaries Drainage Network (Western Subwatersheds)

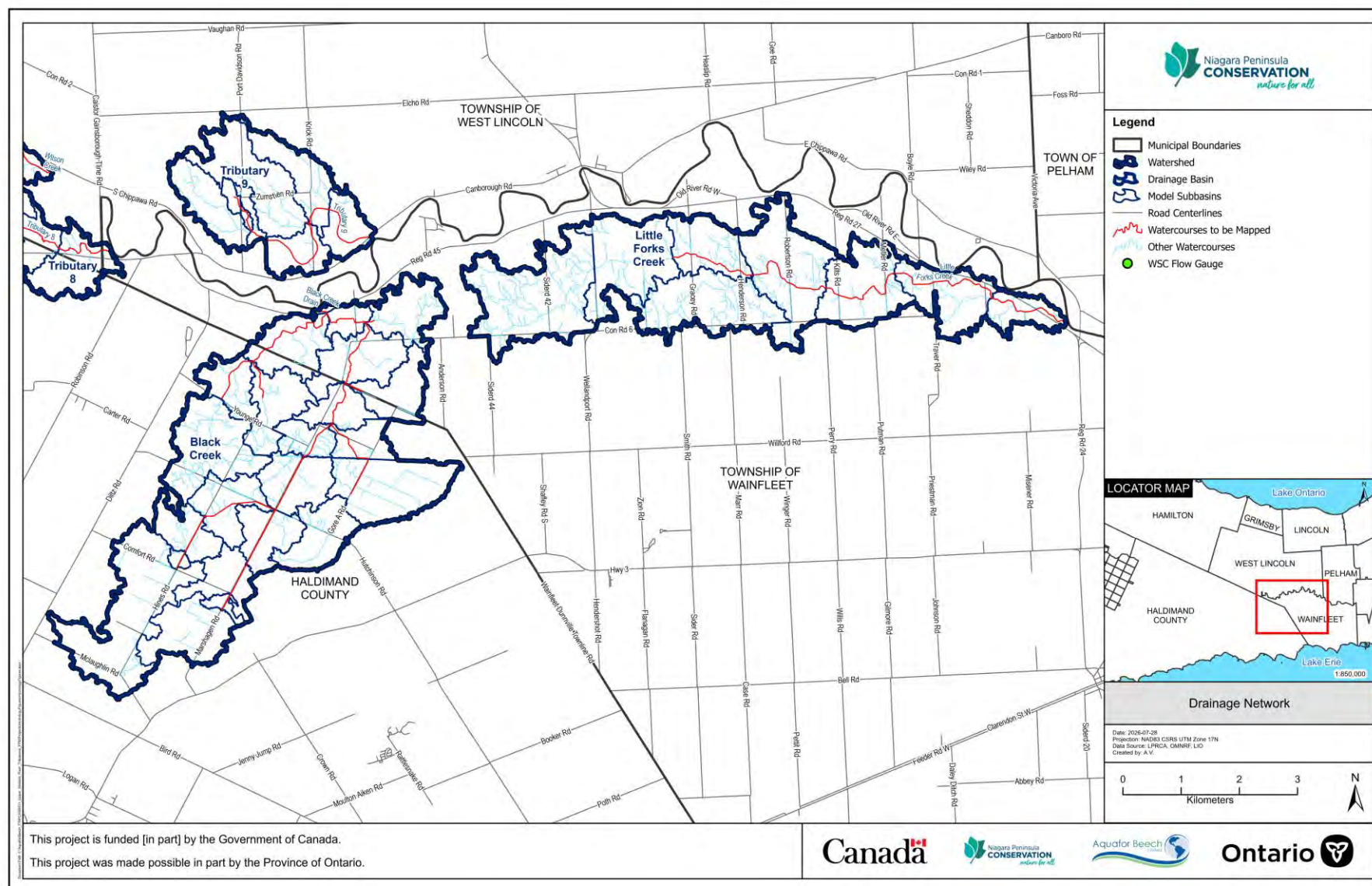


Figure 2-2: Upper Welland Tributaries Drainage Network (Eastern Subwatersheds)

2.2 Land Use

The Southern Ontario Land Resource Information System (SOLRIS, ver. 3.0) was used as a basis for determining existing land use within the study area. Aquafor modified the database in order to more accurately represent existing and future urban areas based on aerial imagery and the Binbrook Village Secondary Plan (City of Hamilton, May 2026), respectively. The file was also modified to differentiate between urban and rural areas for roads and built-up areas.

As shown in **Figure 2-3** and **Figure 2-4**, the study area predominantly rural, with Binbrook representing the most significant area of development. Agricultural and undifferentiated land (which mainly corresponds to agricultural land) account for 75.1% of the watershed area. Other land uses include: forests (10.4%); wetlands (9.3%); transportation (2.8%); built-up impervious areas (1.7%); built-up pervious areas (0.5%), which consist of very low-density development; and gravel lots (0.1%).

The application of land use and soil hydrological classification for calculating runoff is described in **Sections 4.7** and **4.8**, with CN values and other key parameters shown in **Table 4-2**.

2.3 Hydrological Soil Groups and Surficial Geology

Soil classification data was obtained from the MNR's Soil Survey Complex GIS file. Undefined soil groups within alluvial deposits were manually assigned Group D to be conservative, while unmapped areas were assigned hydrologic soil groups based on surrounding mapped soils. The resulting distribution of hydrologic soil groups is shown in **Figure 2-5** and **Figure 2-6**.

Nearly all soils within the study area are characterized as poorly drained (Hydrologic Soil Groups C and D). These soils generally correspond to fine-textured glaciolacustrine deposits – typically clayey soils, silt loam, or loamy sediments over clayey subsoil – which occupy the majority of the study area, as shown in **Figure 2-7** and **Figure 2-8**. In total, soil Group C occupies 64.9% of the total area, followed by Groups D (34.9%), and B (0.1%).

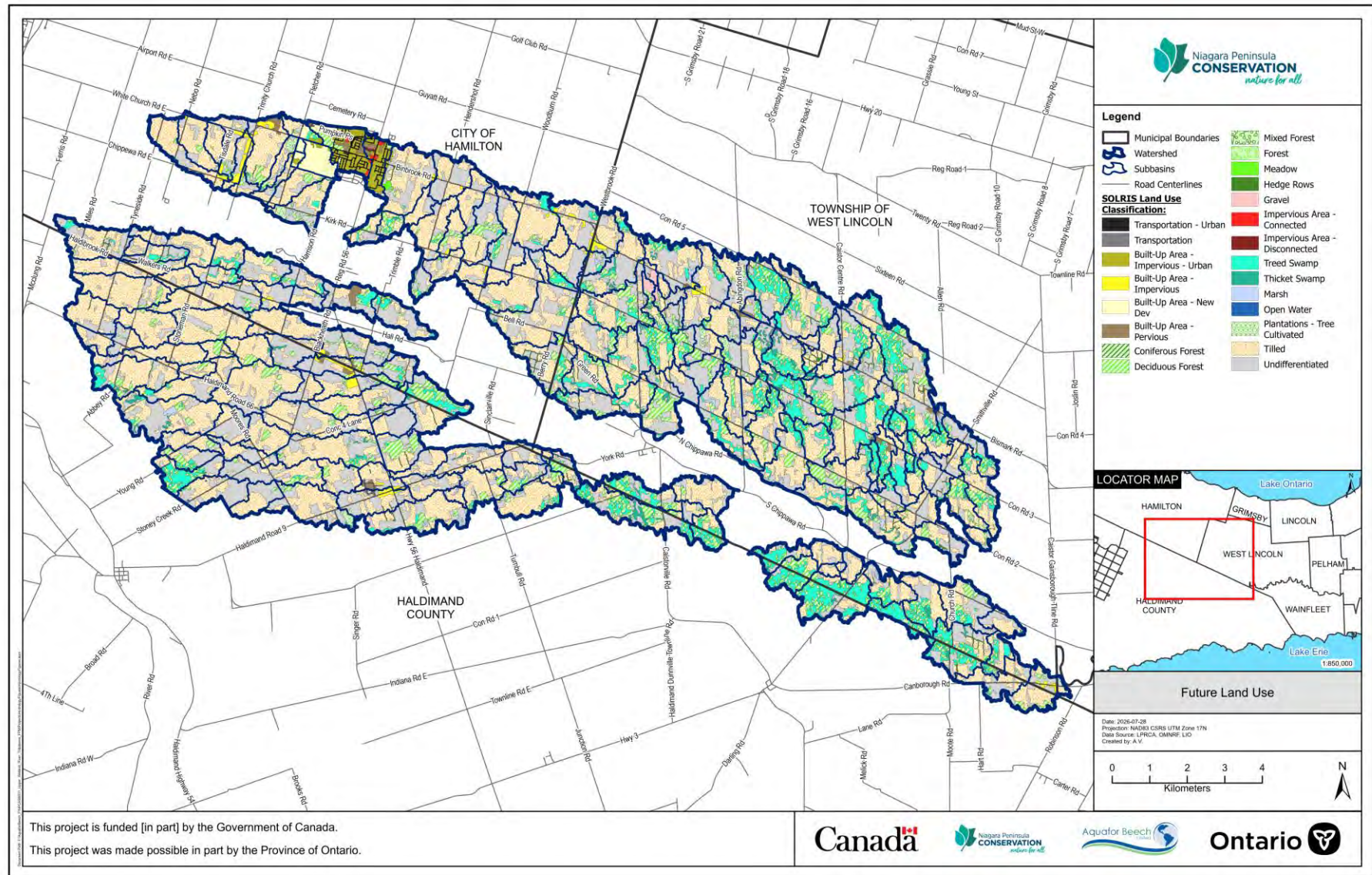


Figure 2-3: Future Land Use (Western Subwatersheds)

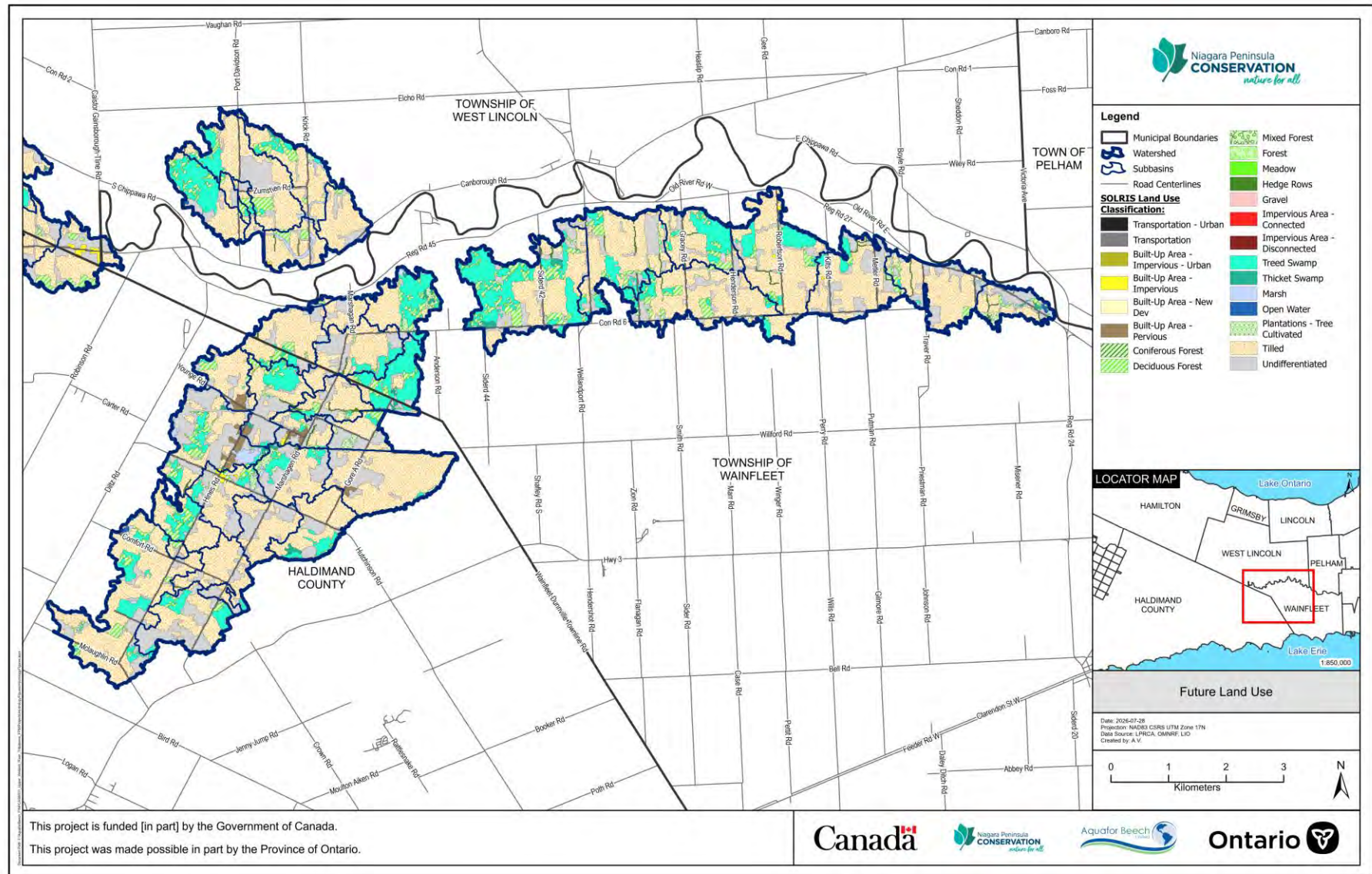


Figure 2-4: Future Land Use (Eastern Subwatersheds)

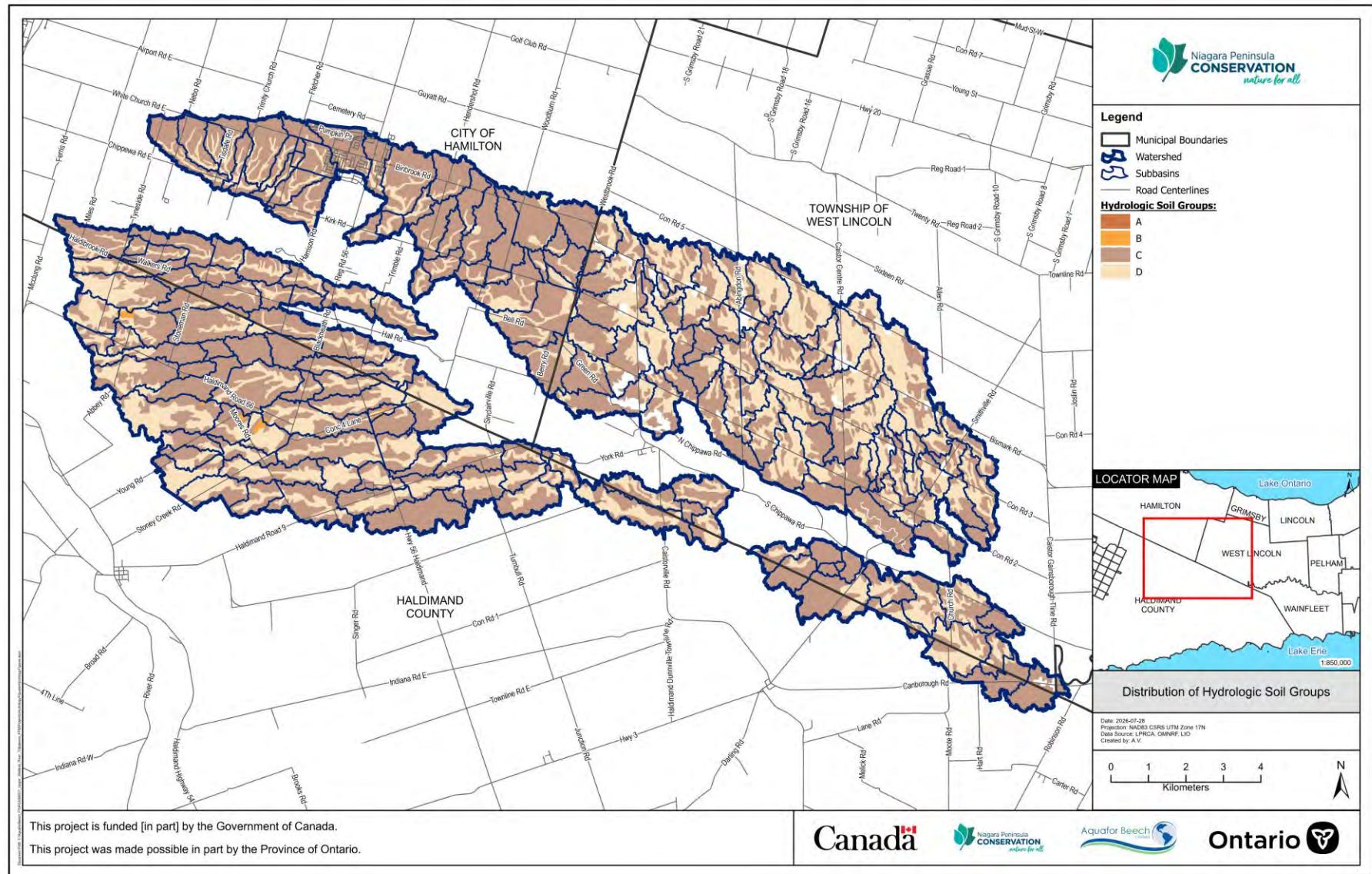


Figure 2-5: Distribution of Hydrologic Soil Groups (Western Subwatersheds)

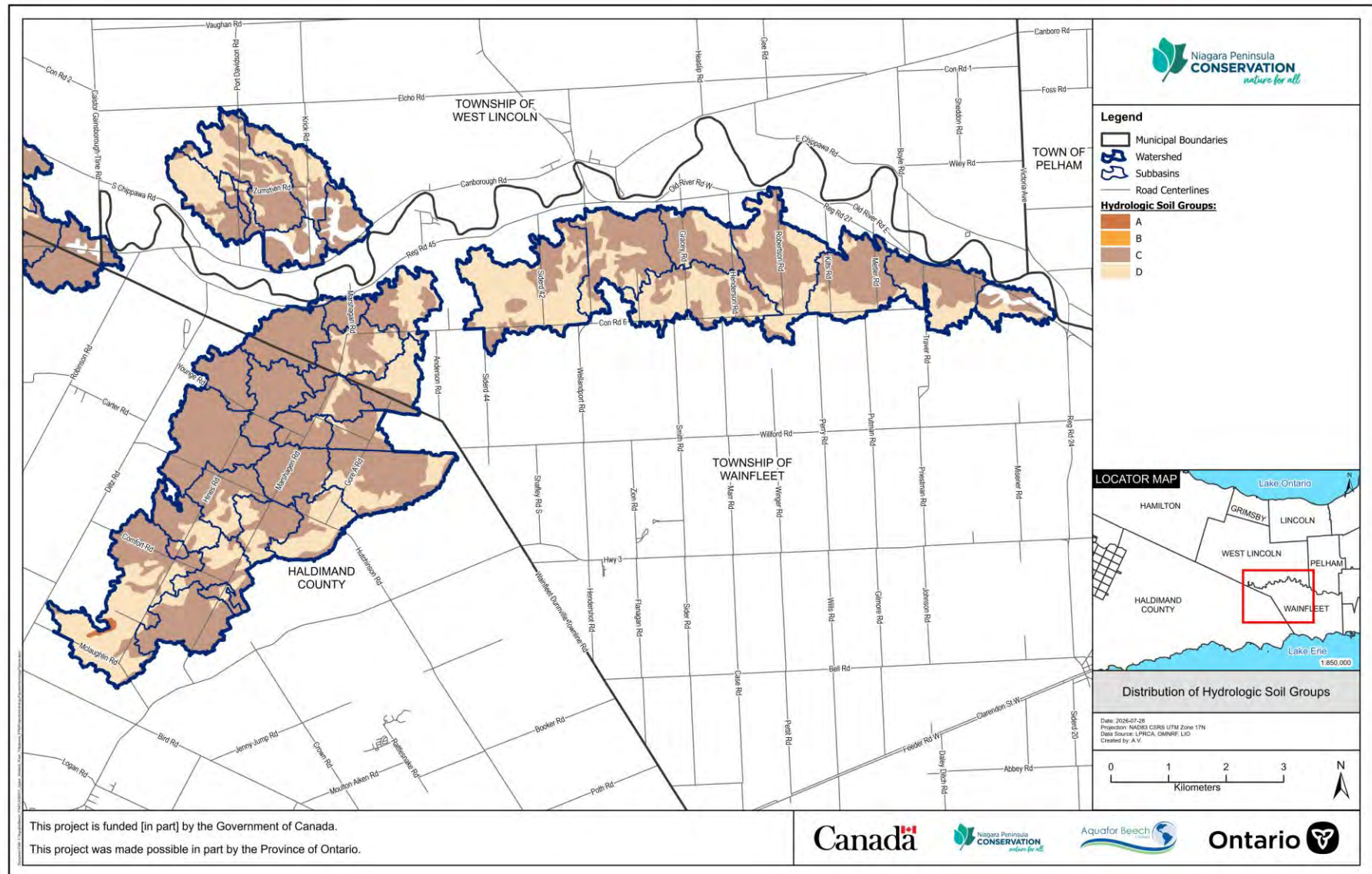


Figure 2-6: Distribution of Hydrologic Soil Groups (Eastern Subwatersheds)

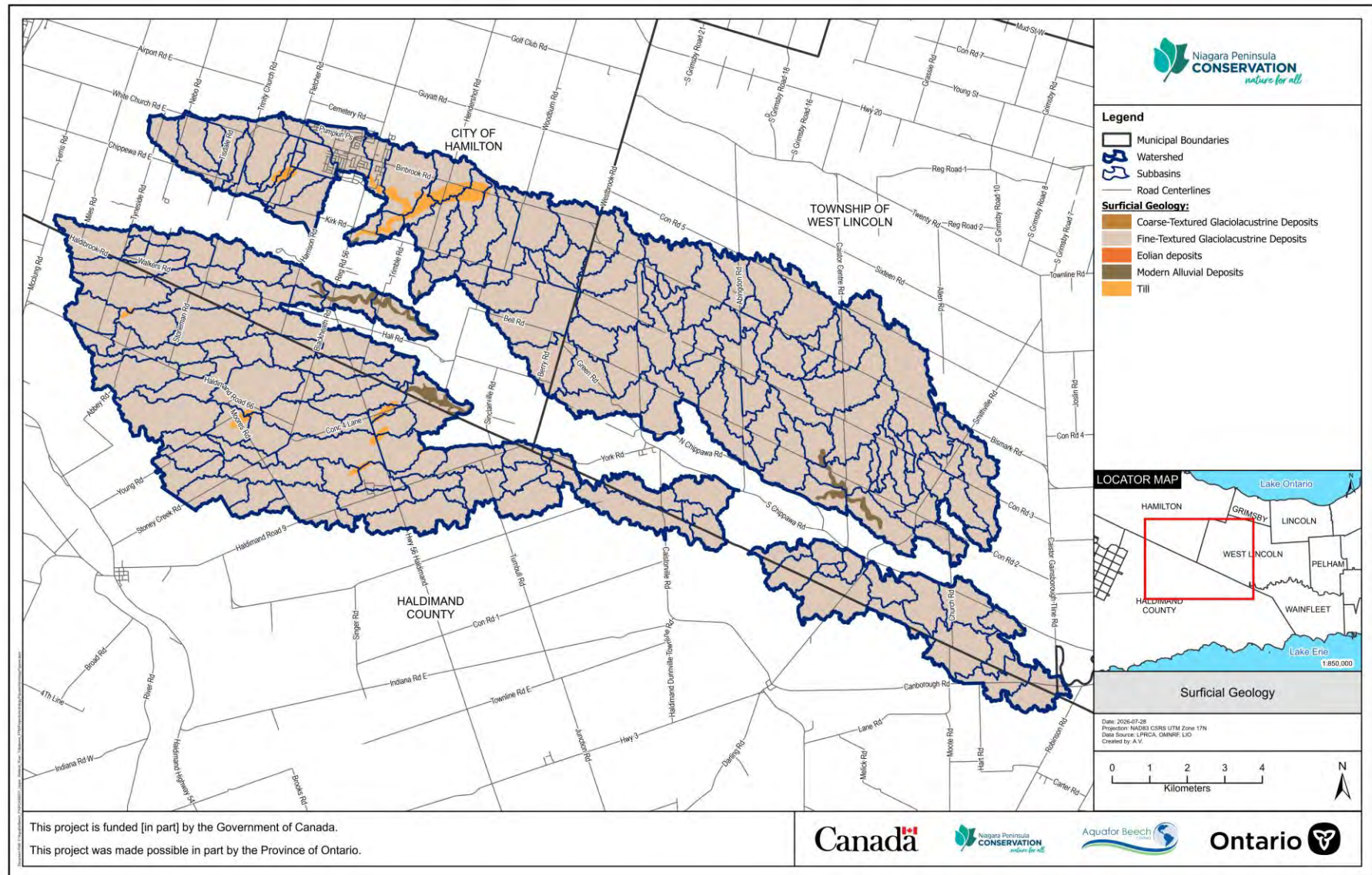


Figure 2-7: Surfacial Geology (Western Subwatersheds)

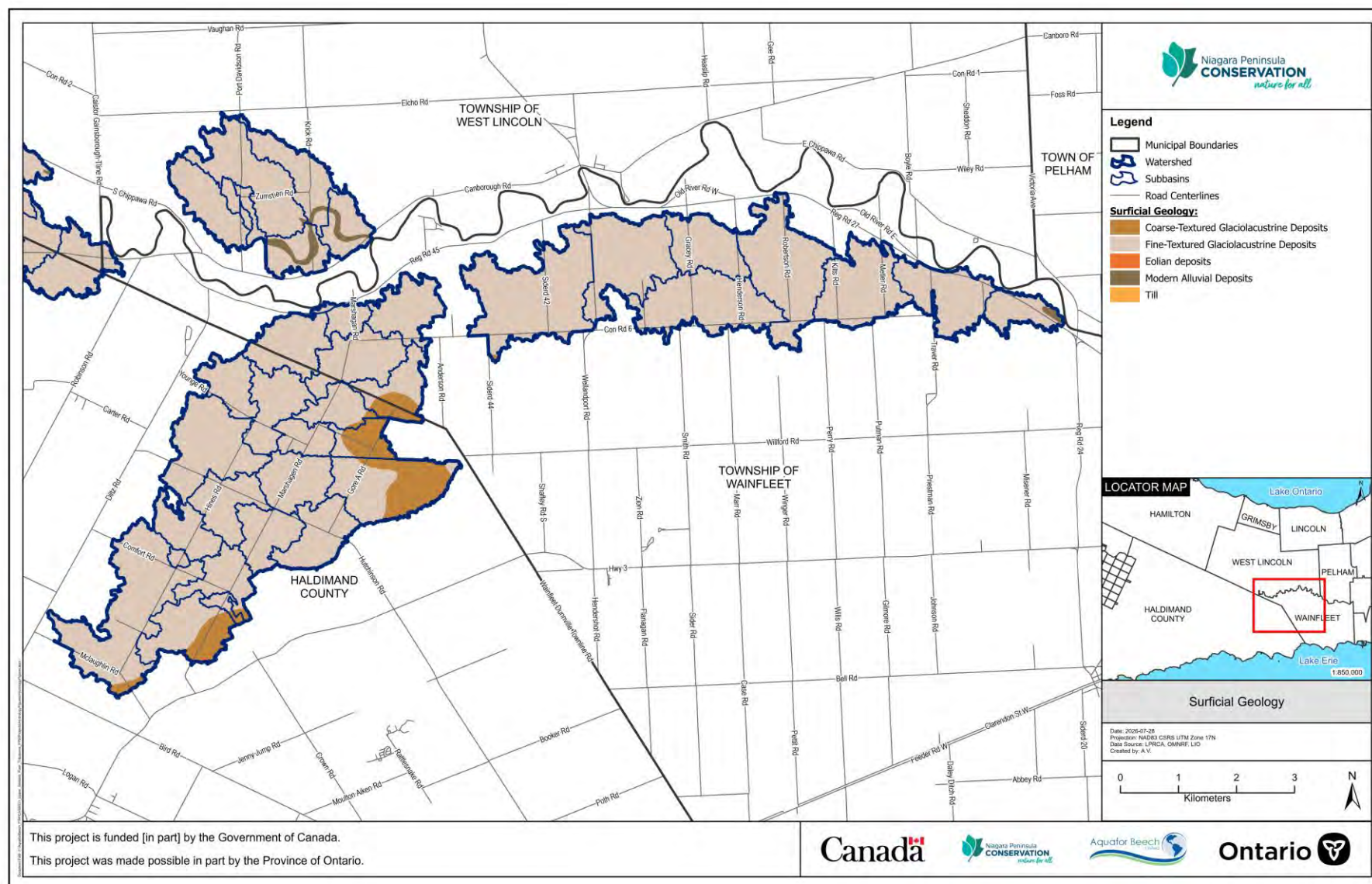


Figure 2-8: Surfacial Geology (Eastern Subwatersheds)

3 PREVIOUS STUDIES

The Welland River Floodplain Mapping Update (NPCA 2018) was previously undertaken to provide floodplain mapping along the Welland River from the Binbrook Dam to the Niagara River. A calibrated hydrologic model was created using Visual OTTHYMO, in which 37 subbasins were defined, including the Little Forks Creek, West Wolf Creek, Little Wolf Creek / Wolf Creek, Buckhorn Creek, Elsie Creek, Mill Creek / Moore's Creek, and Wilson Creek subwatersheds. Boundaries of all subcatchments that were included in this model are shown in **Figure 3-1**, and subcatchment IDs for subwatersheds that are pertinent to the present study and that were included as separate elements in the model (i.e., not merged with adjacent catchments) are provided in **Table 3-1**.

The 100-year regulatory storm event was defined by scaling a large historical event until peak flows from the calibrated model reached the 100-year peak flow return period, which was estimated based on a site frequency analysis for the Welland River below Caistor Corners streamflow gauge. The flows produced by the Visual OTTHYMO model under the regulatory storm event were then used as inputs to a MIKE 11 hydraulic model; this model was calibrated and subsequently used to determine water surface elevations and floodlines.

This model was used as a basis of comparison for evaluating results from Aquafor's model in **Section 5.1**.

Table 3-1: Subcatchment IDs for Pertinent Subwatersheds

Subwatershed Name	VO Subcatchment ID
Black Creek	16
Buckhorn Creek	5
Elsie Creek	7
Little Forks Creeks	24
Little Wolf Creek / Wolf Creek	9
Mill Creek / Moore's Creek	12
West Wolf Creek	2
Wilson Creek	14

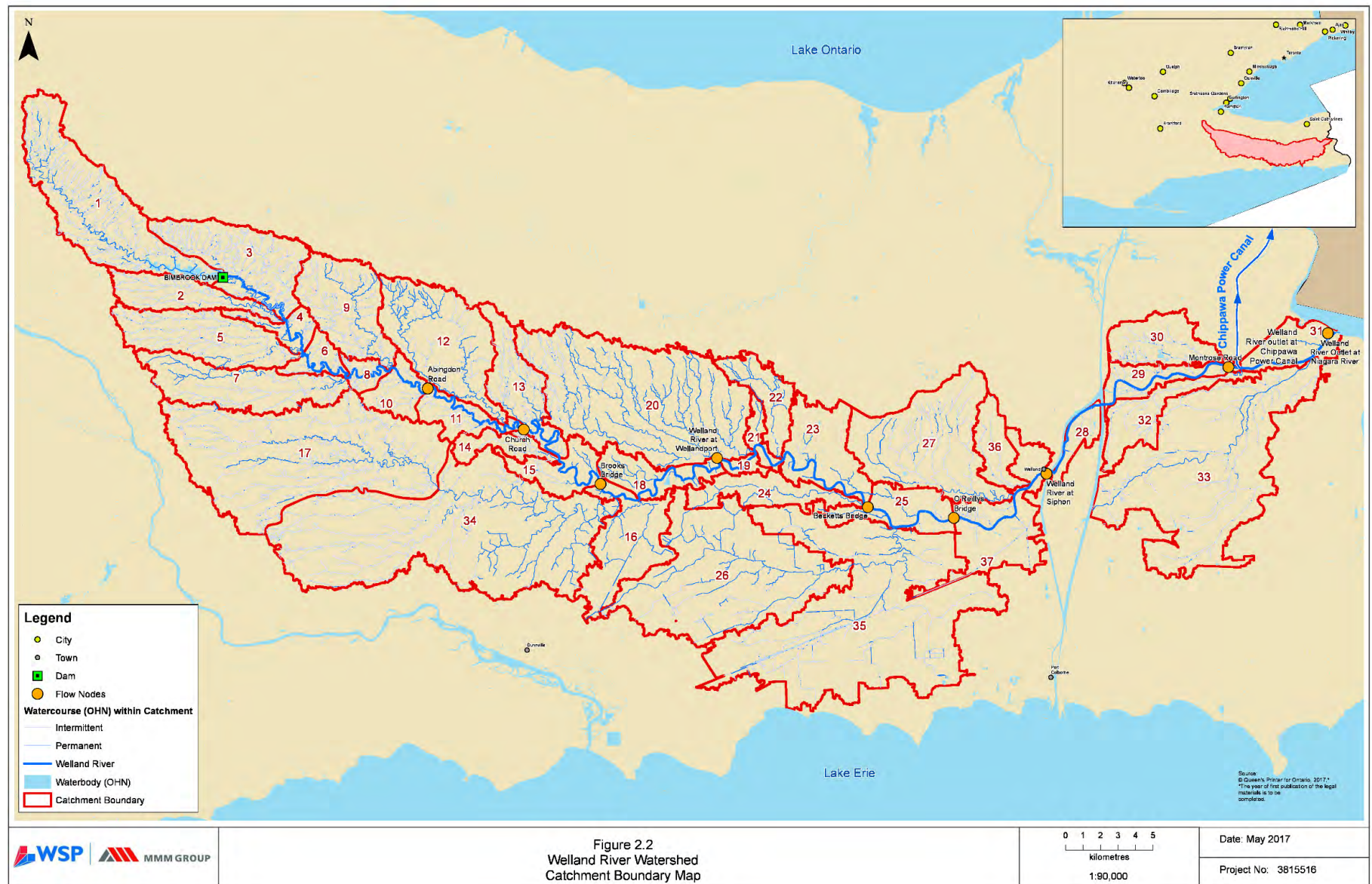


Figure 3-1: Subcatchments from the NPCA's 2018 Visual OTTHYMO Model

4 HYDROLOGIC MODEL

4.1 Model Selection and Setup

The hydrologic model was created using the US Army Corps of Engineers HEC-HMS software (Ver. 4.10). HEC-HMS was selected because it is publicly available and is widely used for floodplain mapping studies, incorporating a variety of loss, transform, and routing methods. An overview of the model setup is shown in **Figure 4-1**.

The model was set up using the NAD83 (CSRS) UTM Zone 17N horizontal coordinate system and the CGVD2013 vertical datum. All associated GIS files used the same coordinate system and vertical datum.

4.2 Digital Elevation Model

Two digital terrain models (DTM) derived from LiDAR elevation data and having a horizontal resolution of 0.5 m were available for the study area. Both DTMs are referenced to the CGVD2013 vertical datum. The first DTM covered the majority of the study area and was produced by Natural Resources Canada (NRCan) based on LiDAR data collected in 2021. The second DTM covered the southern and western edges of the study area and was produced by OMAFRA based on LiDAR data collected between 2016 and 2018. Local relief, along with the extents of each elevation data source, are shown in **Figure 4-2** and **Figure 4-3**.

The two DTMs were combined into a single raster covering the entire study area. The resulting DTM was used in the hydrologic study for discretizing the watershed into smaller subbasins, tracing longest flow paths, determining reach and longest flow path slopes, and extracting cross-section elevations used for channel routing.

4.3 Timestep

The model computation time step should be less than 1/5 of the smallest subbasin lag time, per the Technical Guidelines for Flood Hazard Mapping (TRCA et al., 2017). This represents a time step of 2 minutes for the study area, which was selected for the model's control specifications.

The time interval for Muskingum-Cunge routing is dependent on reach index flow, which was selected as the average between baseflow (assumed to be negligible for the study area) and the 100-year peak flow within each reach, based on guidance provided within the HEC-HMS Technical Reference Manual (US Army Corps of Engineers, 2000).

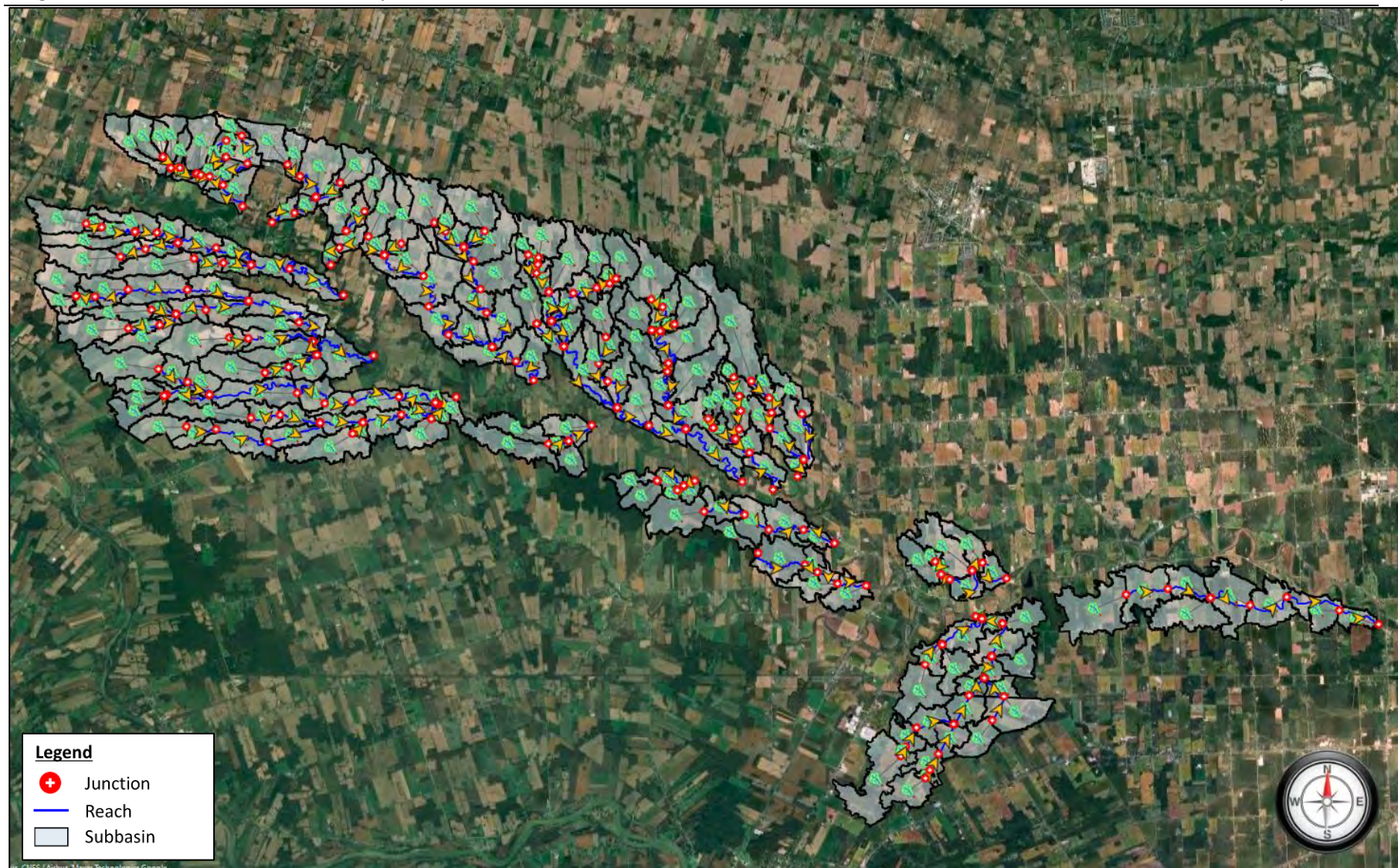


Figure 4-1: Overview of the HEC-HMS Model Setup

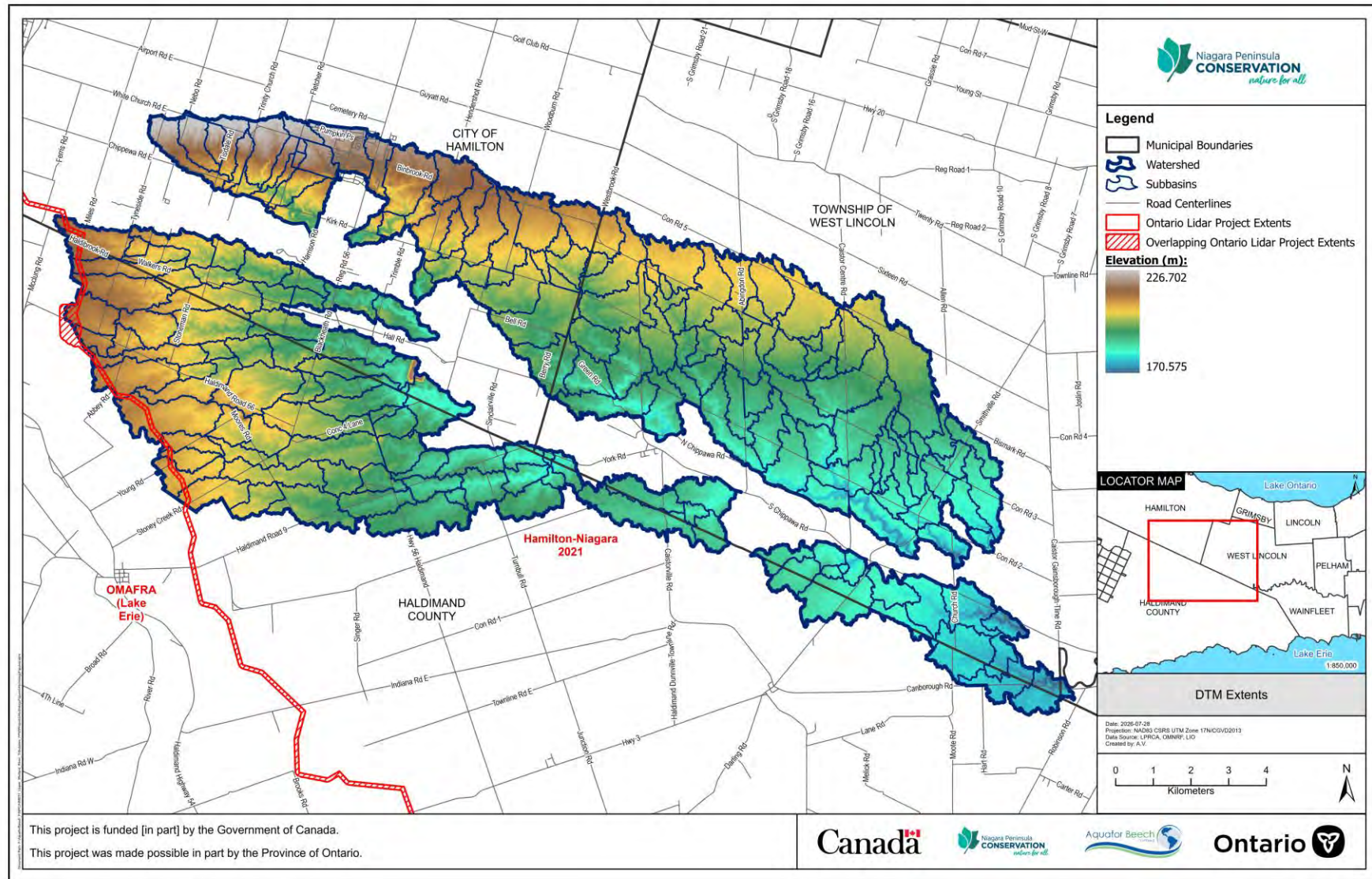


Figure 4-2: Local Relief and Extents of the Elevation Data Sources (Western Subwatersheds)

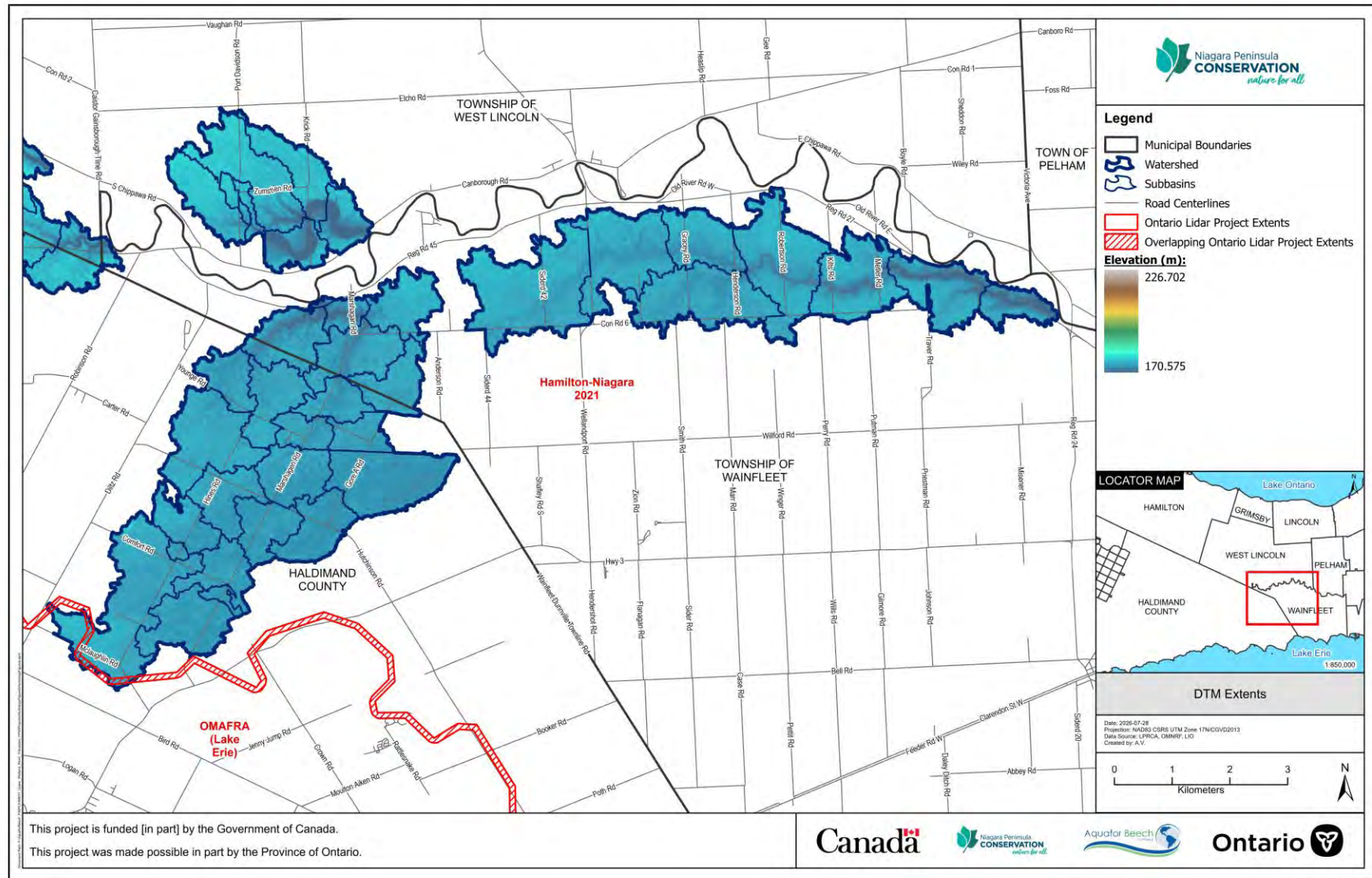
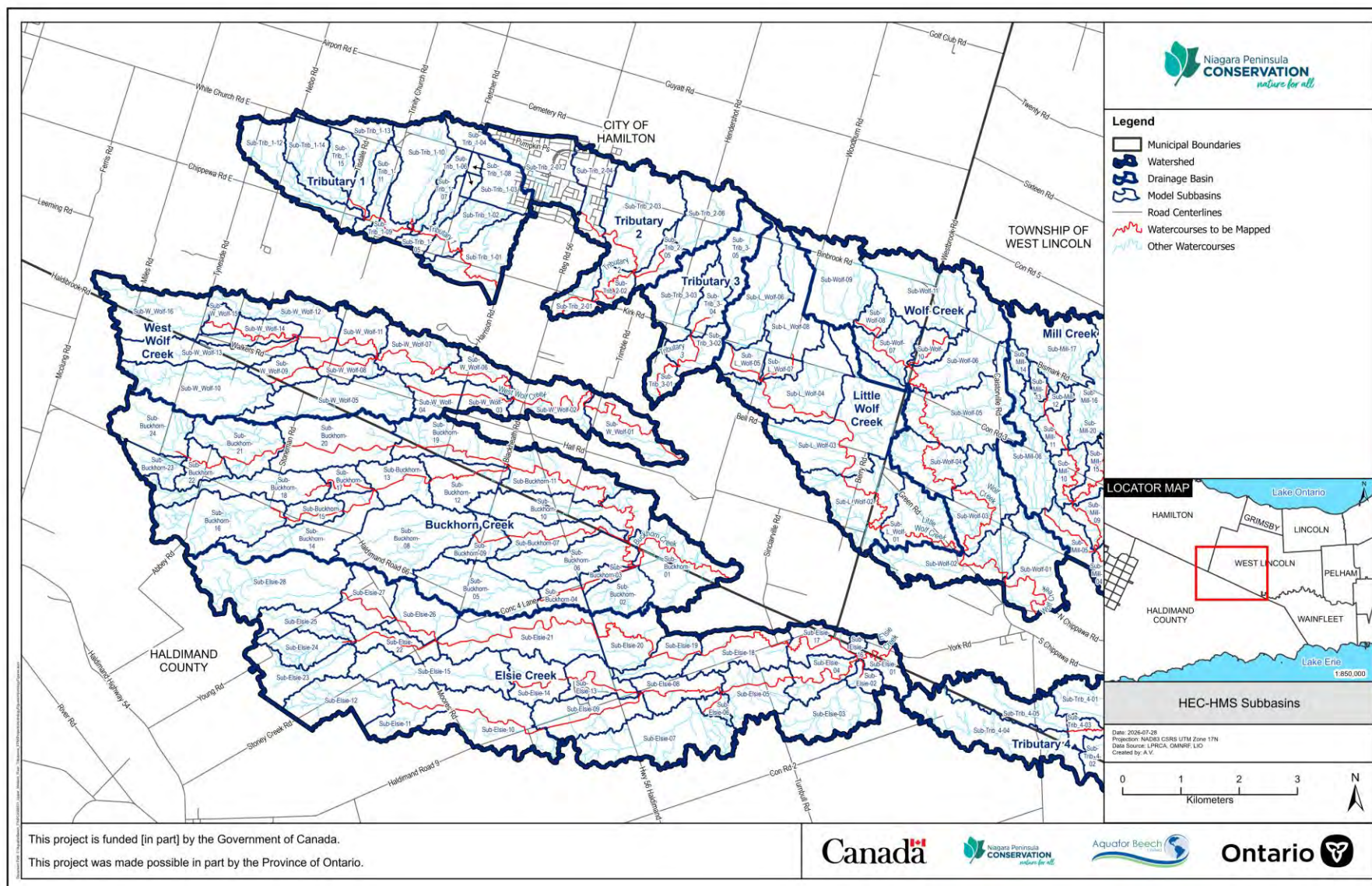


Figure 4-3: Local Relief and Extents of the Elevation Data Sources (Eastern Subwatersheds)

4.4 Subbasin Discretization

The study area was subdivided into 228 subbasins (**Figure 4-4 to Figure 4-6**) having relatively uniform land use and soil texture. Discretization was performed using the DTM and the watercourse GIS shapefile. Subbasin properties and model inputs are shown in **Appendix A**.

In order to ensure the accuracy of the delineated watershed and subbasin boundaries, Aquafor carefully reviewed the DTM, aerial imagery, and StreetView imagery and manually burned in culvert/bridge crossings accordingly. Watercourse GIS files typically only include significant watercourses and often omit smaller stream or drains. As such, many small hydraulic crossings under railways, roads, and private driveways are not taken into account during terrain reconditioning when relying solely on these watercourse GIS files. This often leads to inaccurate watershed delineation; manual intervention is therefore required to ensure that the drainage area boundary is adequately defined.



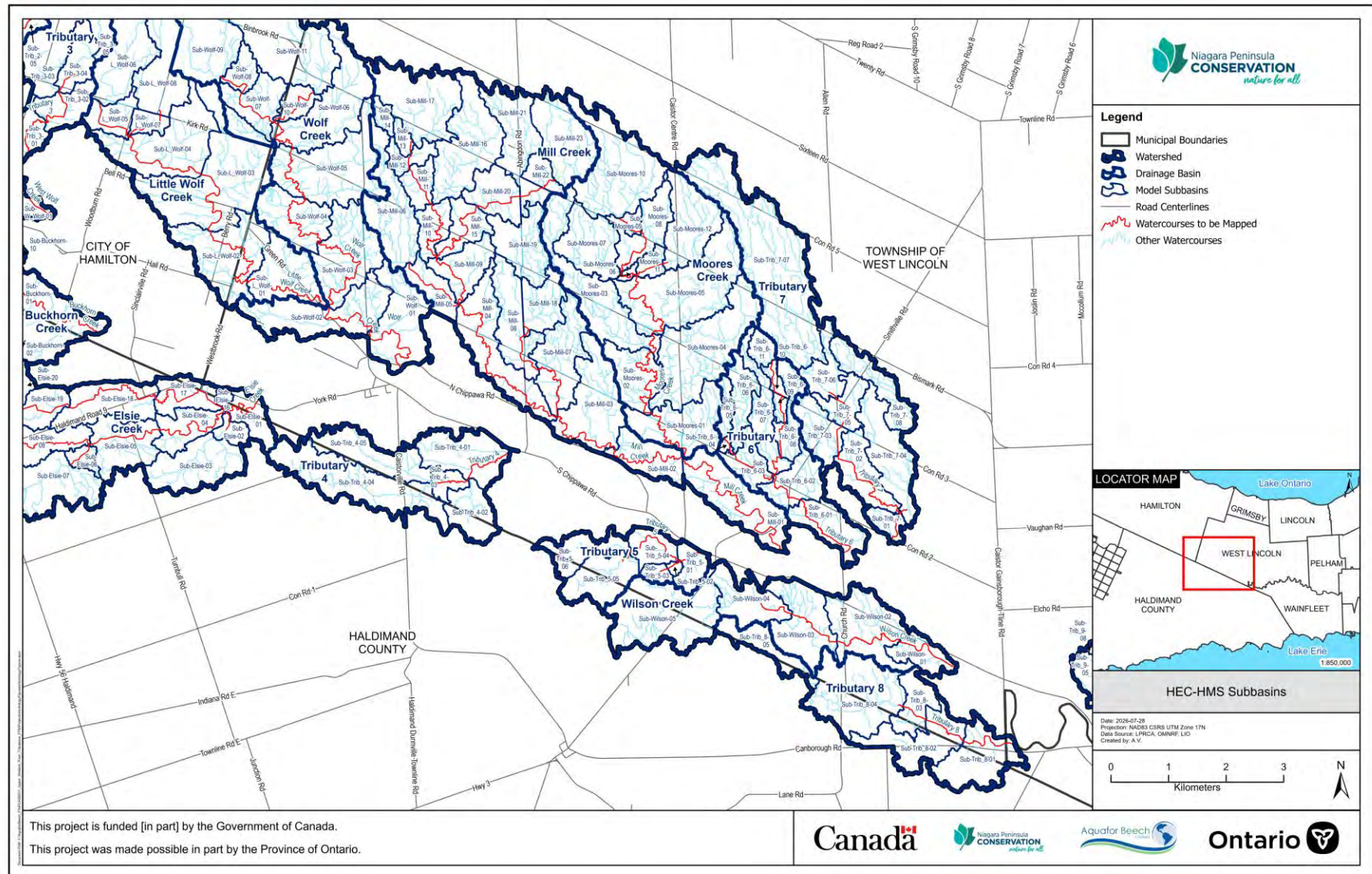


Figure 4-5: Delineated Subbasins (Central Subwatersheds)

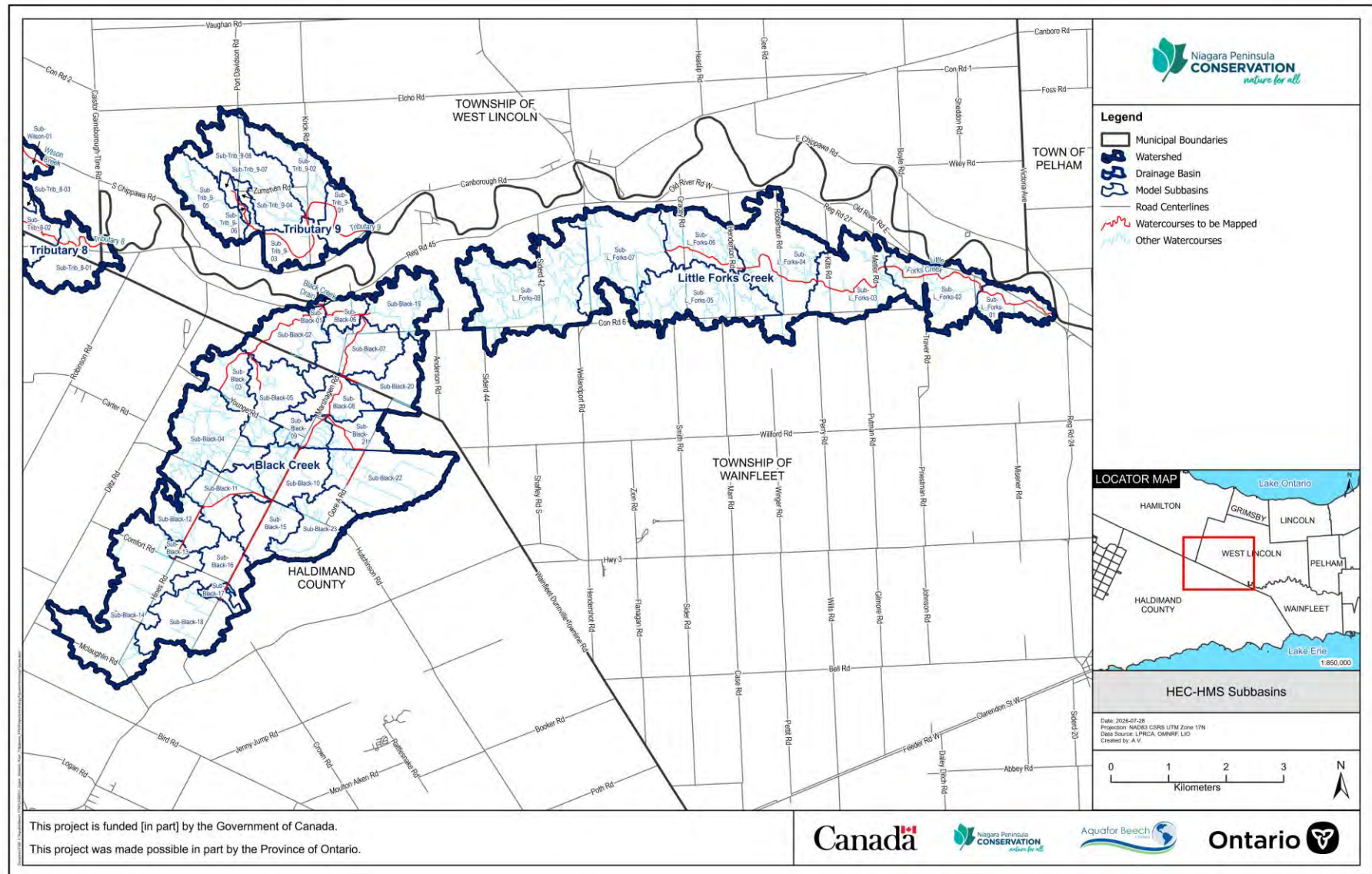


Figure 4-6: Delineated Subbasins (Eastern Subwatersheds)

4.5 Reach Routing

Reaches were defined using a watercourse layer that was developed by Aquafor as part of a separate study (Spatial Water Resources Data Framework) that was undertaken for the NCPA. Stream slopes were determined using the LiDAR-derived DTM.

A review of the DTM revealed that many reaches are characterised by wide floodplains. In addition, some of the reaches are characterized by low slopes (≤ 0.002 m/m). Based on these characteristics, the Muskingum-Cunge routing method was selected and was applied using representative 8-point cross-sections, which were defined for each reach using the DTM. This approach accounts for the effect of overbank flow on flood wave travel time and attenuation, and is appropriate for modelling flow in reaches with low slopes (US Army Corps of Engineers, 2000, 2022). Standard values of Manning's n for natural channels and overbanks were applied to the reaches (**Table 4-1**) based on a review of aerial imagery.

The locations of the model junctions and the reaches connecting them are shown in **Figure 4-7** to **Figure 4-9**. A summary of reach parameters is provided in **Appendix A**. The cross-section used for routing flows along R-Buckhorn-01 is shown as an example in **Figure A.1 (Appendix A)**.

Table 4-1: Standard Manning Roughness Coefficients for Open Channels (TRCA et al., 2017)

Land Cover	Standard 'n' Value
Natural Channel	0.035
Concrete	0.013
Woods (Overbank)	0.08
Meadows (Overbank)	0.055
Lawns (Overbank)	0.045
Cultivated (Overbank)*	0.04

*From the MTO Drainage Manual (MTO, 1997)

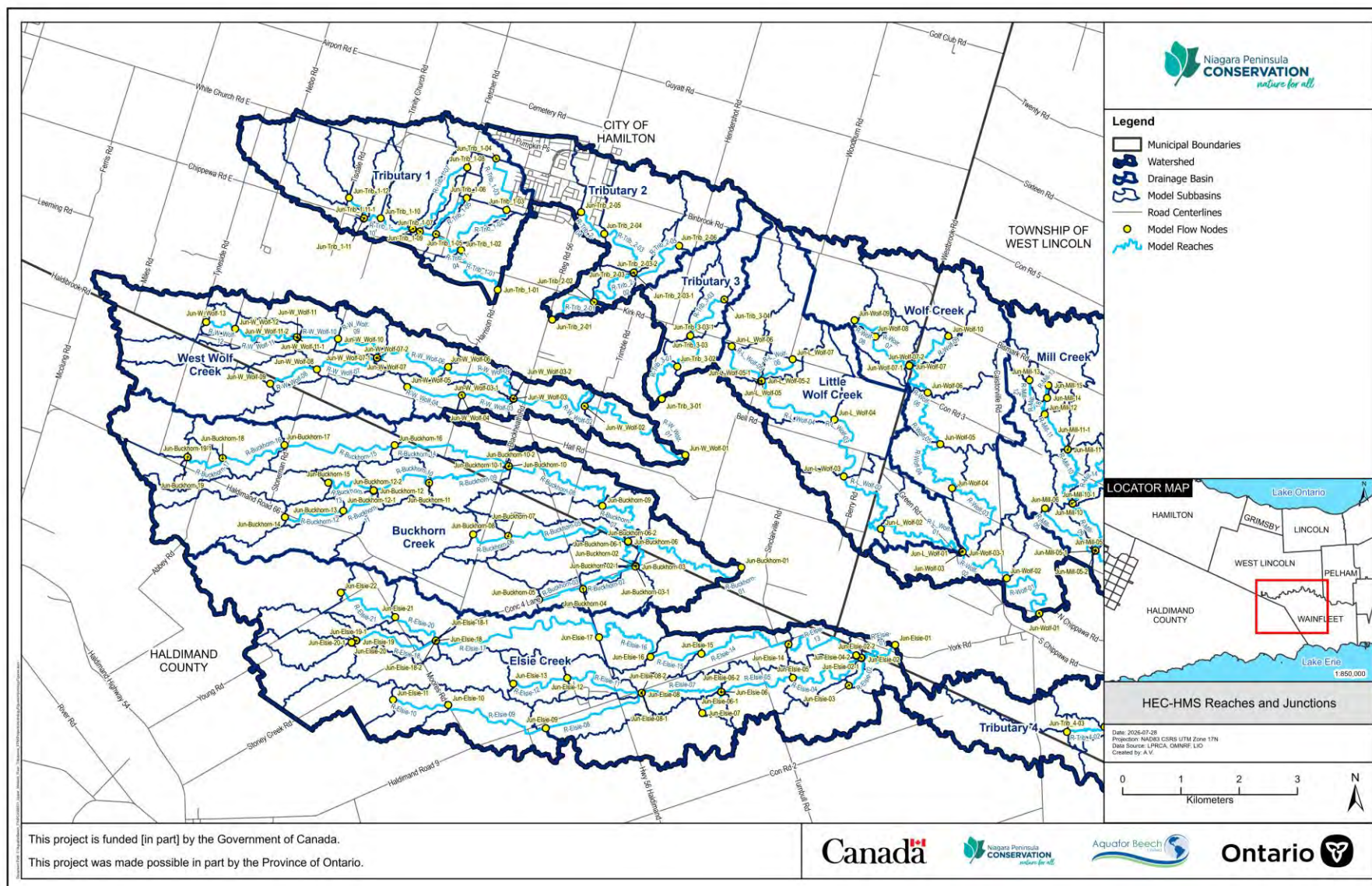


Figure 4-7: HEC-HMS Reaches and Junctions (Western Subwatersheds)

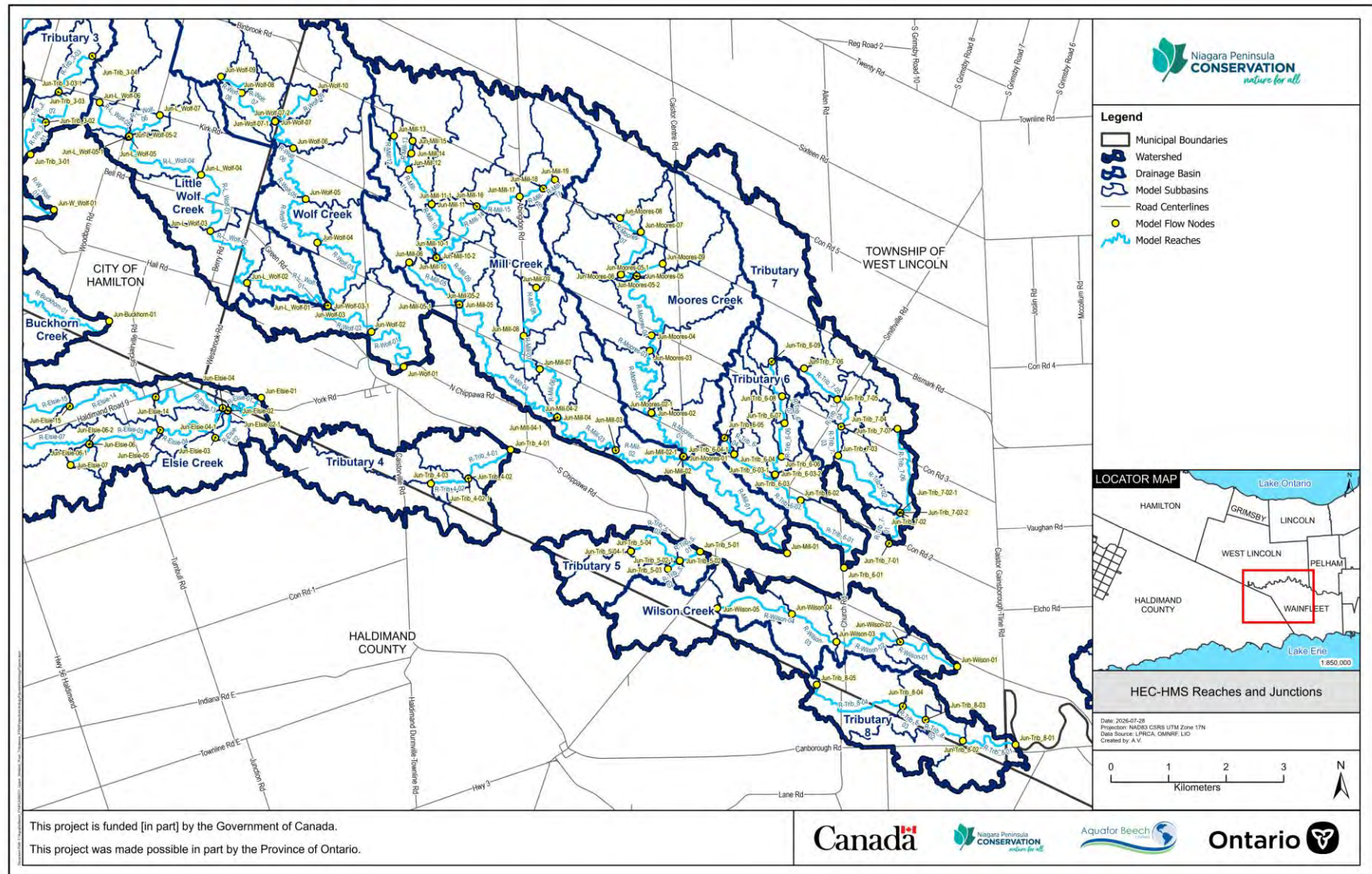


Figure 4-8: HEC-HMS Reaches and Junctions (Central Subwatersheds)

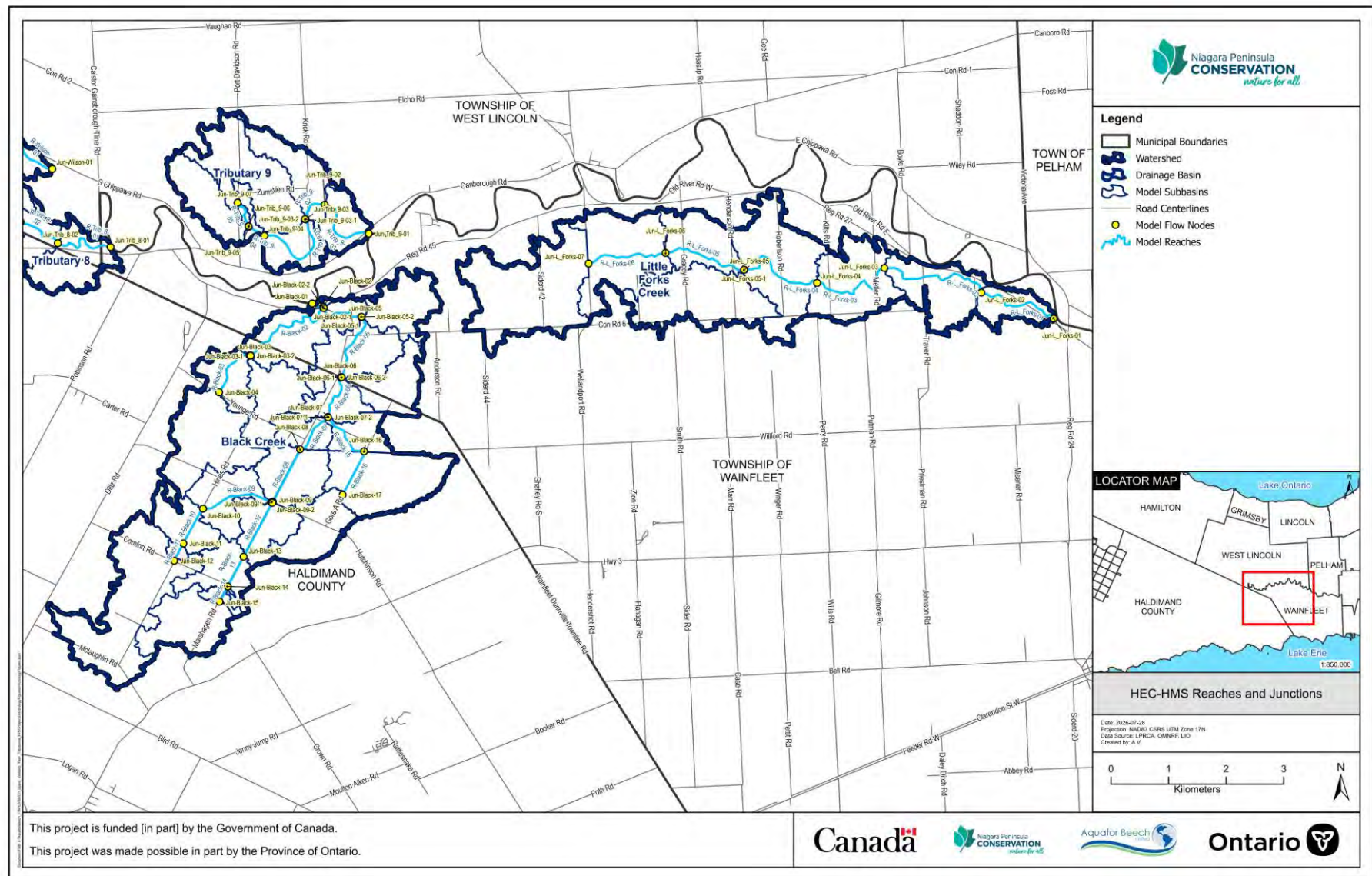


Figure 4-9: HEC-HMS Reaches and Junctions (Eastern Subwatersheds)

4.6 Transform Method and Lag Time

The SCS unit hydrograph transform method was selected, as per standard practice, and the standard peak rate factor of 484 was used in all subbasins except for those located within the Black Creek subwatershed. For this watershed, the peak rate factor was decreased to 250 for summer events (AMC II) since this area is very flat. However, the peak rate factor was not decreased for simulating rain-on-snowmelt since Aquafor has found through experience that the attenuation of peak flows in flat areas can be reduced during very wet antecedent conditions (i.e., when there is standing water).

Lag time, t_{lag} was calculated from time of concentration, t_c , using the equation:

$$t_{lag} = 0.6t_c$$

Time of concentration was calculated for each subbasin using a composite value of the 'C' runoff coefficient. Values 'C' corresponding to each land use type are listed in **Section 4.8** below. For subbasins having a composite 'C' value greater than 0.4, the Bransby-Williams equation was used to calculate time of concentration:

$$t_c = 0.057 \cdot L \cdot S_w^{-0.2} \cdot A^{-0.1}$$

where L [m] is length of the watershed's longest flowpath, S_w [%] is slope of the watershed's longest flowpath, and A [ha] is watershed area.

For subbasins having a composite 'C' value less than 0.4, the Airport equation (MTO, 1997) was used to calculate time of concentration:

$$t_c = 3.26 \cdot (1.1 - C) \cdot L^{0.5} \cdot S_w^{-0.33}$$

4.7 Infiltration Loss

The SCS curve number (CN) method for infiltration loss was adopted for estimating runoff, from which precipitation excess (equivalent to runoff in this case) can be calculated. HEC-HMS calculates precipitation excess, P_e [mm], as follows:

$$P_e = \frac{(P - I_a)^2}{P - I_a + \frac{(25400 - 254 \text{ CN})}{\text{CN}}}$$

where P [mm] is precipitation and I_a [mm] is initial abstraction. Values of CN under average antecedent moisture conditions (AMC II) and initial abstraction corresponding to each land use type are shown in **Table 4-2** in **Section 4.8** below. Composite (weighted average) values were calculated for each subbasin based on the area occupied by each land use type.

4.8 Land Use Parameters

Parameters for all land use types are recorded in **Table 4-2**. These values were subsequently used to calculate composite (weighted average) values for each subbasin.

Wetlands were assigned a high CN (98) to represent saturated conditions. Runoff from these areas was partially offset by high initial abstraction (25mm) and low C values (0.05) used to calculate time of concentration, per the guidelines and literature cited in **Table 4-2**. Attenuation of the hydrograph peak through storage routing was not modelled directly.

Table 4-2: Standard Land Use Hydrologic Parameters (based on TRCA et al., 2017)

Land use	CN under AMC II				I _a (mm)	‘C’ Coefficient	% Connected Impervious
	Hydrologic Soil Group						
	A	B	C	D			
Woods	32.0	60.0	73.0	79.0	10.0	0.30	0.0
Meadows	38.0	65.0	76.0	81.0	8.0	0.35	0.0
Cultivated	62.0	74.0	82.0	86.0	7.0	0.45	0.0
Lawns	49.0	69.0	79.0	84.0	5.0	0.15	0.0
Impervious Areas	–	–	–	–	2.0	0.95	100
Open Water	100.0	100.0	100.0	100.0	0.0	0.95	0.0
Gravel	76.0 ⁽¹⁾	85.0 ⁽¹⁾	89.0 ⁽¹⁾	91.0 ⁽¹⁾	4.0 ⁽²⁾	0.50 ⁽³⁾	0.0
Wetlands ⁽⁴⁾	98.0	98.0	98.0	98.0	25.0 ⁽⁵⁾	0.05	0.0
Built Up – Impervious – Rural ⁽⁶⁾	54.0	70.0	80.0	85.0	4.3	0.35	0.0
Built Up – Impervious – Urban ⁽⁶⁾	52.9	71.3	80.5	85.1	3.5	0.56	43.7
Built Up – Pervious (Lawns)	49.0	69.0	79.0	84.0	5.0	0.15	0.0
Transportation – Rural ⁽⁶⁾	57.0	73.8	82.1	86.3	4.0	0.41	0.0
Transportation – Urban ⁽⁶⁾	49.0	69.0	79.0	84.0	2.8	0.74	73.8

⁽¹⁾ From TR-55 Report (USDA, 1986)

⁽²⁾ Assumed

⁽³⁾ From the MTO Drainage Manual (MTO, 1997)

⁽⁴⁾ Assumed to be saturated

⁽⁵⁾ Derived from Watt et al. (1989)

⁽⁶⁾ Estimated through sampling

4.9 Rainfall and Rain-on-Snowmelt Design Storms

For the Upper Welland River tributaries, the regulatory event is defined as the 100-year storm, with the 200-year and 350-year storms serving as proxies for evaluating the regulatory storm under the effects of climate change, per MNR (2024) guidelines. Both rainfall design storms and rain-on-snowmelt design storm were evaluated, as described in the sections below.

4.9.1 Rainfall Events

The 12-hour 30% AES design storm was selected for the purposes of hydrologic modelling, which will be used to produce flows for subsequent hydraulic modelling and floodplain mapping. This design distribution / duration was selected because it was developed specifically for Southern Ontario and is consistent with pervious studies undertaken within the NPCA watershed, including the Coyle Creek and Draper's Creek Floodplain Mapping Study. Rainfall data for the 2-year to 350-year 12-hour AES design storms is provided in **Appendix B**.

Average equivalent rainfall depths, derived from IDF curves, were obtained from Environment and Climate Change Canada's Hamilton Airport station (#6153194) and are provided in **Table 4-3**. The IDF curves for this station were produced from 39 records spanning from 1971 to 2016.

The Welland-Pelham station (#6139449) was also considered but was not selected since only 15 records were available, spanning from 2006 to 2021, and rainfall volumes were less conservative for most return periods (including the 100-year return period). Rainfall recorded at the Welland-Pelham gauge between 2016 and 2021 was relatively moderate; as such, rainfall occurring during this period would not be expected to significantly skew IDF curves at the Hamilton Airport. IDF curves from the Hamilton Airport station were therefore deemed appropriate for simulating rainfall within the Upper Welland study area.

Table 4-3. Total Rainfall Depth at the Hamilton Airport Climate Station

Total Rainfall Depth (mm)						
Duration	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
5min	8.7	11.4	13.1	15.3	16.9	18.5
10min	12.6	16.8	19.5	23.0	25.6	28.2
15min	15.4	20.6	24.1	28.5	31.7	35.0
30min	20.6	27.5	32.0	37.8	42.1	46.4
1h	24.9	35.5	42.5	51.3	57.9	64.4
2h	30.0	43.3	52.1	63.3	71.6	79.8
6h	38.7	53.8	63.8	76.5	85.9	95.2
12h	44.6	61.0	71.8	85.4	95.5	105.6
24h	51.2	68.8	80.4	95.1	106.0	116.8

Since IDF curves were only defined up to the 100-year return period, rainfall depths under the 200-year and 350-year events were extrapolated by fitting a 2nd order polynomial distribution to logarithms of the 10-year to 100-year rainfall depths for the 12-hour duration; the fitted curve is shown in **Figure 4-10**. Equivalent precipitation depths for 200-year and 350-year return periods are 114.9 mm and 121.8 mm, respectively.

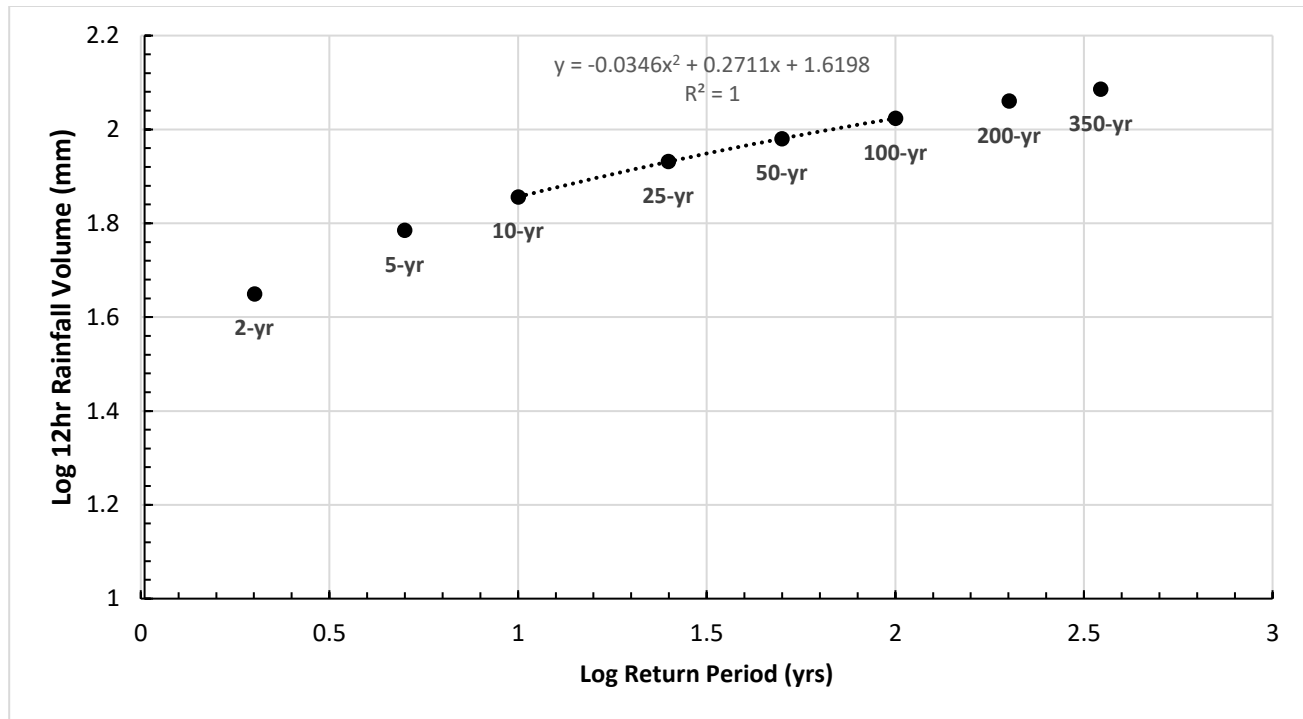


Figure 4-10. Log-Log Plot of 12-hour Rainfall Depths vs. Return Period, with the Fitted Polynomial Distribution

4.9.2 Rain-on-Snowmelt Event

A 100-year rain-on-snowmelt event was developed as part of the Welland River Floodplain Mapping Update (NPCA 2018), described in **Section 3** above, and was used for simulating regulatory flows along the main branch of the Welland River. Precipitation data for this design storm is provided in **Appendix B** of the present report.

Calibrated CN values within this 2018 study were very high (close to 100), which was attributed to saturated antecedent conditions during snowmelt periods. As such, when simulating the 100-year rain-on-snowmelt event, Aquafor applied CN values for AMC III (wet antecedent moisture conditions) to represent saturated conditions and frozen ground. The CN values for AMC III conditions were calculated from CN under average conditions (AMC II) using the empirical equations put forth by Chow (1988):

$$CN(III) = \frac{23 \text{ } CN(II)}{10 + 0.13 \text{ } CN(II)}$$

4.10 Areal Reduction Factors and Peak Flow Results

In order to avoid over-estimating the amount of rainfall that occurs throughout the subwatersheds, areal reduction factors (ARFs) were determined based on the ARF curves from the U.S. Weather Bureau's Technical Paper No. 29 (1960) and No. 40 (1961), as cited within the MNRF Technical Guide (2002). These ARF curves were

derived for geographically fixed areas and are appropriate for use in analyses of flood frequency. A second ARF source from the World Meteorological Organization is also cited within the MNRF Technical Guide (2002). However, these ARF curves are an inaccurate carbon copy of the ARF curves from the U.S. Weather Bureau's Technical Paper No. 38 (1960), which were themselves produced for storm-centred conditions and are better suited for Probable Maximum Flood studies, rather than studies of flooding frequency.

Technical Paper No. 29 (and No. 40) include ARF curves for storms having 24-hour, 6-hour, 3-hour, 1-hour, and 30-minute durations. Aquafor extracted a series of data points along each of the TP No. 29 curves using an online plot digitizer tool (~60 points per curve). The datasets were then linearly interpolated to obtain ARF values in increments of 1 mile (1.609 km). Aquafor also estimated the 12-hour ARF curve using a four-parameter logistic (4PL) distribution, which was found to best suited for creating a curve of best fit.

Finally, areas were converted from miles to kilometers for each storm duration. The resulting ARF data for 24-hour, 12-hour, 6-hour, 3-hour, 1-hour, and 30-minute storm durations is shown in **Figure 4-11** below.

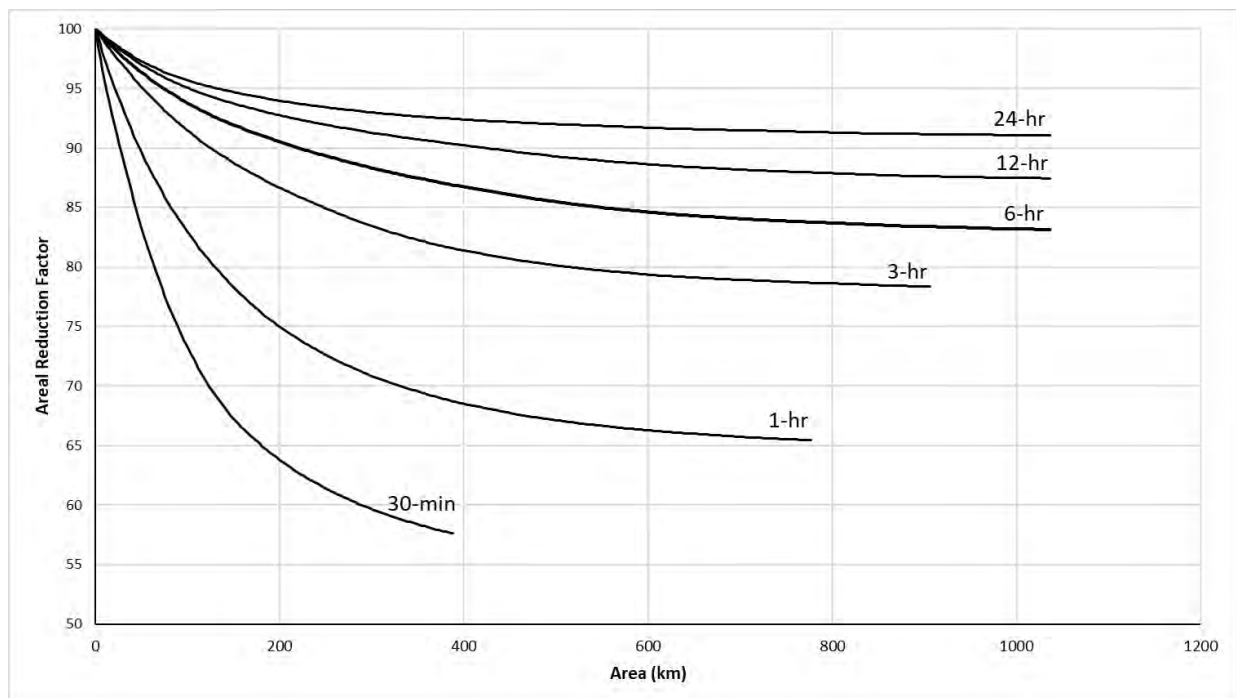


Figure 4-11: Areal Reductions Factors for 24-hour, 12-hour 6-hour, 3-hour, 1-hour, and 30-minute Storm Durations

A singular ARF was assigned to each subwatershed due to the relatively small size of the subwatersheds, i.e., ARF values were not varied to based on drainage area at points of interest throughout a given watershed. The ARFs used for each subwatershed are presented in **Table 4-4** below.

Table 4-4: Areal Reduction Factors Applied to Each Subwatershed

Watershed	ARF
Black Creek	0.9853
Buckhorn Creek	0.9840
Elsie Creek	0.9831
Little Forks Creek	0.9903
Wolf Creek / Little Wolf Creek	0.9843
Mill Creek / Moores Creek	0.9790
Tributary 1	0.9935
Tributary 2	0.9956
Tributary 3	0.9976
Tributary 4	0.9966
Tributary 5	0.9981
Tributary 6	0.9968
Tributary 7	0.9943
Tributary 8	0.9964
Tributary 9	0.9961
Wilson Creek	0.9959
West Wolf Creek	0.9905

The hydrologic model was run for the 2-year, 5-year, 10-year, 25-year, 50-year, 100-year, 200-year, and 350-year 12-hour AES events. Results are presented at key junctions in **Table 4-5** below; peak flows for all junctions are recorded in **Appendix C**. The 200-year and 350-year events, which serve as proxies for evaluating the 100-year (regulatory) event under the effects of climate change (MNR, 2024), produced substantially higher flows than the 100-year event. The locations of key junctions are shown in **Figure 4-12** and **Figure 4-13**.

Table 4-5: Peak Flows at Key Locations throughout the Upper Welland Tributaries Study Area, with ARFs

Junction ID	Location	Peak Flow (m ³ /s)							
		2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	200-yr	350-yr
Jun-Black-01	Black Creek Drain Subwatershed Outlet	11.35	20.21	26.10	34.34	40.21	46.61	52.52	56.80
Jun-Buckhorn-01	Buckhorn Creek Subwatershed Outlet	11.67	23.55	32.57	44.89	54.47	64.36	73.71	80.71
Jun-Elsie-01	Elsie Creek Subwatershed Outlet	10.20	20.63	28.98	40.31	49.34	58.83	67.88	74.69
Jun-L_Forks-01	Little Forks Creek Subwatershed Outlet	5.00	9.20	12.08	16.09	19.14	22.21	25.11	27.29
Jun-L_Wolf-01	Little Wolf Creek Subwatershed Outlet	6.47	12.25	16.11	21.00	25.37	29.87	34.09	37.24
Jun-Mill-02-1	Mill Creek, Immediately U/S of the Confluence with Moores Creek	9.34	18.03	25.03	34.54	41.99	49.67	56.89	62.26
Jun-Mill-01	Mill Creek Subwatershed Outlet	14.43	28.25	39.50	55.15	68.14	81.57	93.98	103.31
Jun-Moores-01	Moores Creek Subwatershed Outlet	7.53	14.47	19.52	26.19	31.32	36.57	41.49	45.24
Jun-W_Wolf-01	West Wolf Creek Subwatershed Outlet	7.03	13.15	18.08	25.09	30.71	36.54	42.04	46.17
Jun-Wilson-01	Wilson Creek Subwatershed Outlet	3.06	5.96	8.14	10.92	13.14	15.42	17.55	19.14
Jun-Wolf-03-1	Wolf Creek, Immediately U/S of the Confluence with Little Wolf Creek	7.47	13.49	18.04	24.26	29.06	33.95	38.53	41.93
Jun-Wolf-01	Wolf Creek Subwatershed Outlet	13.44	25.20	33.88	45.45	54.81	64.14	73.28	80.03
Jun-Trib_1-01	Tributary 1 Subwatershed Outlet	8.33	14.62	18.78	24.67	29.17	33.78	38.11	41.36
Jun-Trib_2-01	Tributary 2 Subwatershed Outlet	6.98	11.36	14.47	18.54	21.67	24.88	27.89	30.09
Jun-Trib_3-01	Tributary 3 Subwatershed Outlet	3.08	5.19	6.71	8.81	10.46	12.17	13.78	15.00
Jun-Trib_4-01	Tributary 4 Subwatershed Outlet	3.07	5.66	7.58	10.11	12.07	14.08	15.96	17.35
Jun-Trib_5-01	Tributary 5 Subwatershed Outlet	1.65	3.00	4.02	5.43	6.58	7.71	8.76	9.53
Jun-Trib_6-01	Tributary 6 Subwatershed Outlet	3.40	6.12	8.22	10.95	13.04	15.15	17.21	18.69
Jun-Trib_7-01	Tributary 7 Subwatershed Outlet	5.54	9.97	13.00	17.17	20.41	23.76	26.93	29.24
Jun-Trib_8-01	Tributary 8 Subwatershed Outlet	3.27	5.96	7.74	10.19	12.08	14.00	15.84	17.28
Jun-Trib_9-01	Tributary 9 Subwatershed Outlet	3.29	6.12	8.22	11.06	13.26	15.50	17.60	19.14

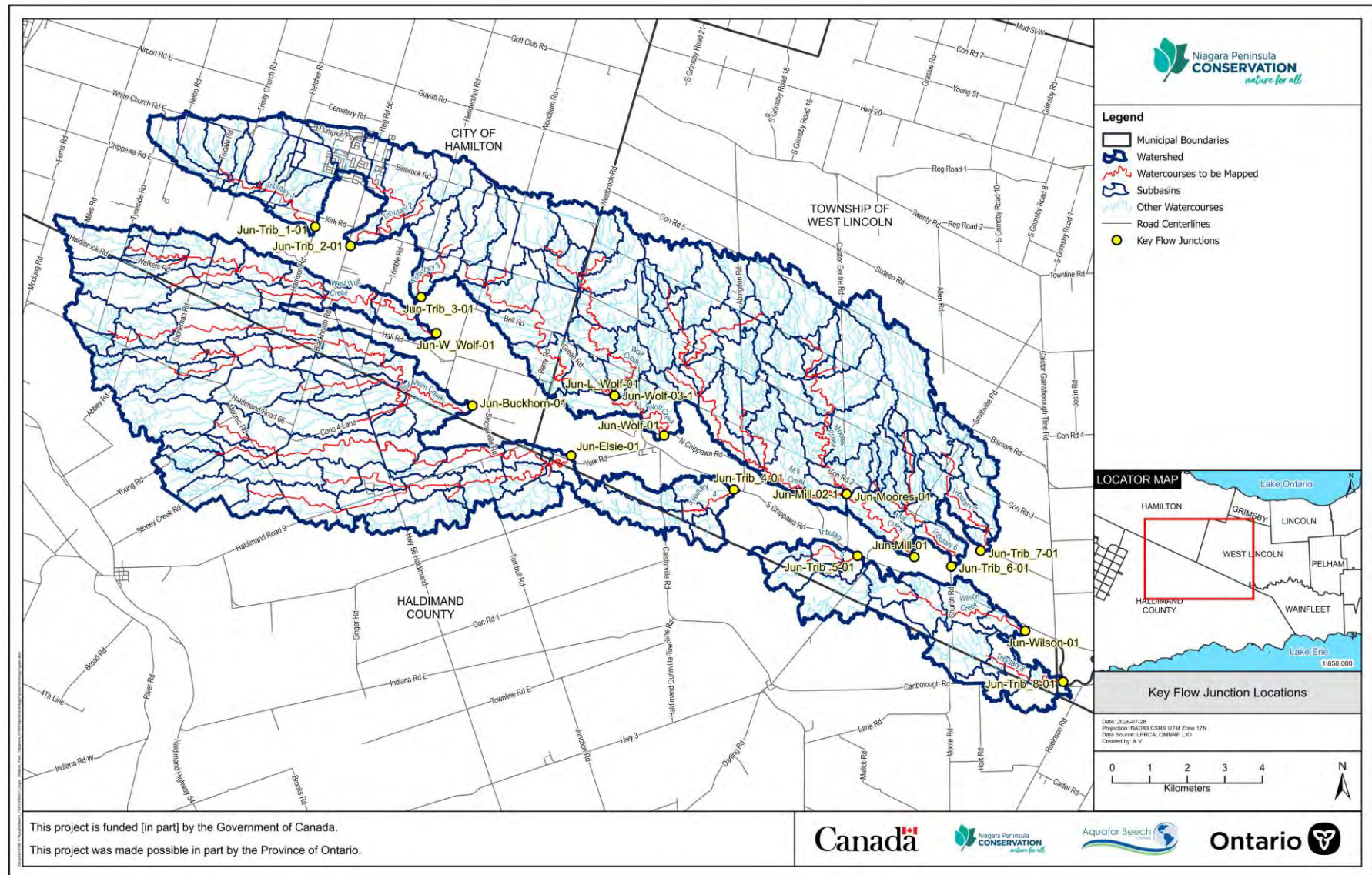


Figure 4-12: Locations of Key Junctions (Western Subwatersheds)

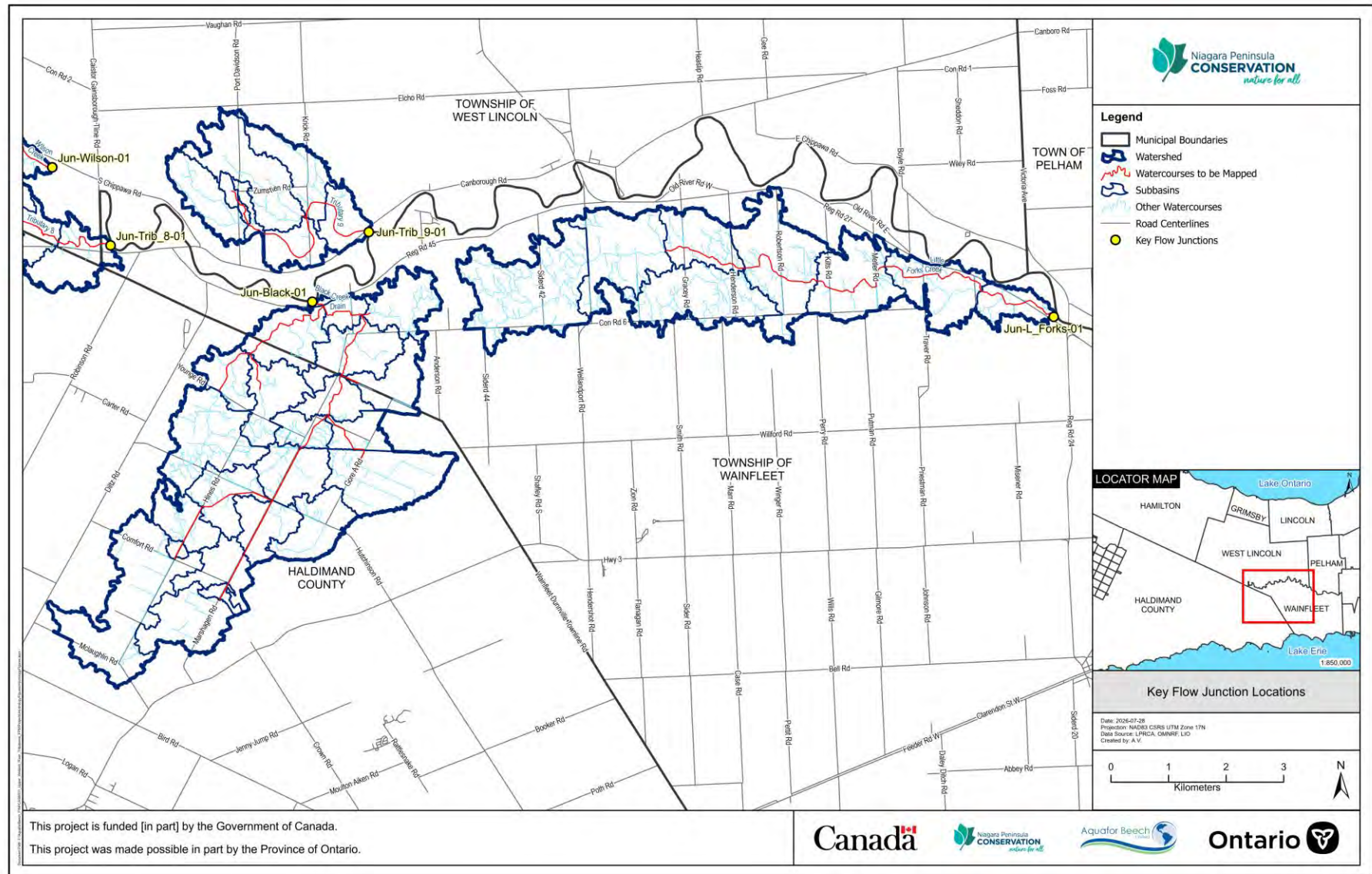


Figure 4-13: Locations of Key Junctions (Eastern Subwatersheds)

5 MODEL EVALUATION

5.1 Comparison with Previous Studies

Results from Aquafor's model for the rain-on-snowmelt event were compared against results from the NPCA (2018) Floodplain Mapping Update model at the most downstream junctions of each subwatershed where flow data was available. The NPCA (2018) hydrologic model was developed to support hydraulic modelling and floodplain mapping along the main branch of the Welland River. This hydrologic model was calibrated using a flow gauge along the Welland River below Caistor Corners and produced excellent validation results. The Welland River model was therefore selected as a basis of comparison for evaluating the results produced by Aquafor's model for tributaries included in the Upper Welland River Floodplain Mapping Study.

As shown in **Table 5-1**, the results from Aquafor's model were much higher than those predicted by the NPCA (2018) Floodplain Mapping Update. However, it should be noted that calibration of the NPCA (2018) hydrologic model was done for the entire Welland River watershed, in order to produce model results that were consistent with measured flow data from the flow gauge located along the Welland River below Caistor Corners. In the absence of hydrometric gauges along the various tributaries to the Upper Welland River, individual flows from each of the contributing subwatersheds – particularly those located downstream of the flow gauge – could not be individually calibrated and validated as part of the 2018 study, such that the accuracy of the 2018 flow estimates at the outlet of the individual catchments is not known. Furthermore, the NPCA (2018) study was conducted using Visual OTTHYMO (VO), while Aquafor's model was developed in HEC-HMS, which uses different modelling assumptions and subroutines than VO. Finally, lower degrees of discretization are known to produce lower peak flows in VO, which could partially explain why the NPCA (2018) flows were lower than Aquafor's estimates.

Table 5-1: Comparison with 100-year Peak Flows (m³/s) from the Welland River Floodplain Mapping Update (NPCA, 2018)

Junction	Aquafor Rain-on-Snow	NPCA (2018) Rain-on-Snow
Black Creek Drain Subwatershed Outlet (Jun-Black-01)	38.26	12.61
Buckhorn Creek Subwatershed Outlet (Jun-Buckhorn-01)	34.15	17.28
Elsie Creek Subwatershed Outlet (Jun-Elsie-01)	32.52	17.86
Little Forks Creek Subwatershed Outlet (Jun-L_Forks-01)	14.60	7.83
Mill Creek Subwatershed Outlet (Jun-Mill-01)	41.26	22.01
West Wolf Creek Subwatershed Outlet (Jun-W_Wolf-01)	20.24	10.31
Wilson Creek Subwatershed Outlet (Jun-Wilson-01)	10.29	5.39
Wolf Creek Subwatershed Outlet (Jun-Wolf-01)	38.16	16.78

5.2 Sensitivity Analysis

A sensitivity analysis was conducted to evaluate the effects of varying CN values, initial abstraction, impervious fraction, lag time, and computational timestep on 100-year peak flows at the watershed outlet. Sensitivity was evaluated by applying a range of factors for each parameter.

The results of the sensitivity analysis are recorded in **Table 5-2** to **Table 5-6**. It was found that the model had a high degree of sensitivity to values of CN and lag time, a moderate sensitivity to initial abstraction, and a low sensitivity to impervious fraction and computational timestep.

Table 5-2: Impact of Proportionally Varying CN on Peak Flows at the Watershed Outlets

Junction ID	Location	Multiplication Factor			
		0.8	0.9	1.1	1.2
Jun-Black-01	Black Creek Drain Subwatershed Outlet	-33.6	-18.9	22.9	41.0
Jun-Buckhorn-01	Buckhorn Creek Subwatershed Outlet	-37.9	-20.8	25.7	53.4
Jun-Elsie-01	Elsie Creek Subwatershed Outlet	-39.4	-21.9	27.9	55.9
Jun-L_Forks-01	Little Forks Creek Subwatershed Outlet	-35.9	-19.7	25.3	42.6
Jun-L_Wolf-01	Little Wolf Creek Subwatershed Outlet	-36.6	-20.2	24.5	54.5
Jun-Mill-02-1	Mill Creek, Immediately U/S of the Confluence with Moores Creek	-39.2	-21.7	27.2	47.3
Jun-Mill-01	Mill Creek Subwatershed Outlet	-41.2	-23.7	28.7	49.0
Jun-Moores-01	Moores Creek Subwatershed Outlet	-37.1	-20.5	26.2	41.5
Jun-W_Wolf-01	West Wolf Creek Subwatershed Outlet	-39.2	-21.6	26.8	57.2
Jun-Wilson-01	Wilson Creek Subwatershed Outlet	-37.0	-20.6	26.7	38.0
Jun-Wolf-03-1	Wolf Creek, Immediately U/S of the Confluence with Little Wolf Creek	-36.7	-20.2	25.1	49.0
Jun-Wolf-01	Wolf Creek Subwatershed Outlet	-36.7	-20.0	25.4	53.3
Jun-Trib_1-01	Tributary 1 Subwatershed Outlet	-32.7	-17.9	23.4	54.3
Jun-Trib_2-01	Tributary 2 Subwatershed Outlet	-27.2	-15.0	18.8	42.6
Jun-Trib_3-01	Tributary 3 Subwatershed Outlet	-34.3	-19.5	25.8	59.9
Jun-Trib_4-01	Tributary 4 Subwatershed Outlet	-35.3	-19.5	24.3	43.8
Jun-Trib_5-01	Tributary 5 Subwatershed Outlet	-37.2	-20.4	25.5	39.5
Jun-Trib_6-01	Tributary 6 Subwatershed Outlet	-36.4	-20.2	26.3	36.8
Jun-Trib_7-01	Tributary 7 Subwatershed Outlet	-35.5	-19.7	24.7	40.5
Jun-Trib_8-01	Tributary 8 Subwatershed Outlet	-34.0	-18.6	24.5	38.8
Jun-Trib_9-01	Tributary 9 Subwatershed Outlet	-36.8	-20.4	25.3	41.8

Table 5-3: Impact of Proportionally Varying Initial Abstraction on Peak Flows at the Watershed Outlets

Junction ID	Location	Multiplication Factor			
		0.8	0.9	1.1	1.2
Jun-Black-01	Black Creek Drain Subwatershed Outlet	2.3	1.2	-1.2	-2.4
Jun-Buckhorn-01	Buckhorn Creek Subwatershed Outlet	2.1	1.0	-1.0	-2.1
Jun-Elsie-01	Elsie Creek Subwatershed Outlet	2.6	1.3	-1.3	-2.6
Jun-L_Forks-01	Little Forks Creek Subwatershed Outlet	2.8	1.4	-1.4	-2.8
Jun-L_Wolf-01	Little Wolf Creek Subwatershed Outlet	1.9	0.9	-1.0	-1.9
Jun-Mill-02-1	Mill Creek, Immediately U/S of the Confluence with Moores Creek	2.5	1.3	-1.3	-2.5
Jun-Mill-01	Mill Creek Subwatershed Outlet	2.8	1.4	-1.4	-2.8
Jun-Moores-01	Moores Creek Subwatershed Outlet	2.6	1.3	-1.3	-2.6
Jun-W_Wolf-01	West Wolf Creek Subwatershed Outlet	2.1	1.1	-1.1	-2.1
Jun-Wilson-01	Wilson Creek Subwatershed Outlet	3.5	1.7	-1.7	-3.5
Jun-Wolf-03-1	Wolf Creek, Immediately U/S of the Confluence with Little Wolf Creek	2.0	1.0	-1.0	-2.0
Jun-Wolf-01	Wolf Creek Subwatershed Outlet	2.1	1.1	-1.1	-2.1
Jun-Trib_1-01	Tributary 1 Subwatershed Outlet	1.4	0.7	-0.7	-1.4
Jun-Trib_2-01	Tributary 2 Subwatershed Outlet	1.1	0.6	-0.6	-1.1
Jun-Trib_3-01	Tributary 3 Subwatershed Outlet	1.6	0.8	-0.8	-1.7
Jun-Trib_4-01	Tributary 4 Subwatershed Outlet	2.9	1.5	-1.5	-3.0
Jun-Trib_5-01	Tributary 5 Subwatershed Outlet	3.6	1.8	-1.8	-3.7
Jun-Trib_6-01	Tributary 6 Subwatershed Outlet	2.7	1.4	-1.4	-2.8
Jun-Trib_7-01	Tributary 7 Subwatershed Outlet	2.7	1.4	-1.4	-2.7
Jun-Trib_8-01	Tributary 8 Subwatershed Outlet	2.6	1.3	-1.2	-2.4
Jun-Trib_9-01	Tributary 9 Subwatershed Outlet	2.5	1.3	-1.3	-2.6

Table 5-4: Impact of Proportionally Varying Impervious Fraction on Peak Flows at the Watershed Outlets

Junction ID	Location	Multiplication Factor			
		0.8	0.9	1.1	1.2
Jun-Black-01	Black Creek Drain Subwatershed Outlet	0.0	0.0	0.0	0.0
Jun-Buckhorn-01	Buckhorn Creek Subwatershed Outlet	0.0	0.0	0.0	0.0
Jun-Elsie-01	Elsie Creek Subwatershed Outlet	0.0	0.0	0.0	0.0
Jun-L_Forks-01	Little Forks Creek Subwatershed Outlet	0.0	0.0	0.0	0.0
Jun-L_Wolf-01	Little Wolf Creek Subwatershed Outlet	0.0	0.0	0.0	0.0
Jun-Mill-02-1	Mill Creek, Immediately U/S of the Confluence with Moores Creek	0.0	0.0	0.0	0.0
Jun-Mill-01	Mill Creek Subwatershed Outlet	0.0	0.0	0.0	0.0
Jun-Moores-01	Moores Creek Subwatershed Outlet	0.0	0.0	0.0	0.0
Jun-W_Wolf-01	West Wolf Creek Subwatershed Outlet	0.0	0.0	0.0	0.0
Jun-Wilson-01	Wilson Creek Subwatershed Outlet	0.0	0.0	0.0	0.0
Jun-Wolf-03-1	Wolf Creek, Immediately U/S of the Confluence with Little Wolf Creek	0.0	0.0	0.0	0.0
Jun-Wolf-01	Wolf Creek Subwatershed Outlet	0.0	0.0	0.0	0.0
Jun-Trib_1-01	Tributary 1 Subwatershed Outlet	-0.4	-0.2	0.2	0.4
Jun-Trib_2-01	Tributary 2 Subwatershed Outlet	-1.9	-1.0	1.0	1.9
Jun-Trib_3-01	Tributary 3 Subwatershed Outlet	0.0	0.0	0.0	0.0
Jun-Trib_4-01	Tributary 4 Subwatershed Outlet	0.0	0.0	0.0	0.0
Jun-Trib_5-01	Tributary 5 Subwatershed Outlet	0.0	0.0	0.0	0.0
Jun-Trib_6-01	Tributary 6 Subwatershed Outlet	0.0	0.0	0.0	0.0
Jun-Trib_7-01	Tributary 7 Subwatershed Outlet	0.0	0.0	0.0	0.0
Jun-Trib_8-01	Tributary 8 Subwatershed Outlet	0.0	0.0	0.0	0.0
Jun-Trib_9-01	Tributary 9 Subwatershed Outlet	0.0	0.0	0.0	0.0

Table 5-5: Impact of Proportionally Varying Lag Time on Peak Flows at the Watershed Outlets

Junction ID	Location	Multiplication Factor			
		0.8	0.9	1.1	1.2
Jun-Black-01	Black Creek Drain Subwatershed Outlet	10.1	4.9	-4.5	-8.7
Jun-Buckhorn-01	Buckhorn Creek Subwatershed Outlet	1.9	1.0	-1.2	-2.4
Jun-Elsie-01	Elsie Creek Subwatershed Outlet	2.7	1.4	-1.4	-2.7
Jun-L_Forks-01	Little Forks Creek Subwatershed Outlet	7.5	3.6	-3.4	-6.5
Jun-L_Wolf-01	Little Wolf Creek Subwatershed Outlet	1.4	0.8	-0.9	-2.0
Jun-Mill-02-1	Mill Creek, Immediately U/S of the Confluence with Moores Creek	2.2	1.2	-1.3	-2.7
Jun-Mill-01	Mill Creek Subwatershed Outlet	1.6	0.9	-1.1	-2.4
Jun-Moores-01	Moores Creek Subwatershed Outlet	5.2	2.6	-2.6	-5.2
Jun-W_Wolf-01	West Wolf Creek Subwatershed Outlet	2.2	1.1	-1.2	-2.5
Jun-Wilson-01	Wilson Creek Subwatershed Outlet	9.2	4.4	-3.9	-7.5
Jun-Wolf-03-1	Wolf Creek, Immediately U/S of the Confluence with Little Wolf Creek	3.5	1.8	-1.8	-3.7
Jun-Wolf-01	Wolf Creek Subwatershed Outlet	1.5	0.8	-0.9	-1.9
Jun-Trib_1-01	Tributary 1 Subwatershed Outlet	2.9	1.4	-1.3	-2.6
Jun-Trib_2-01	Tributary 2 Subwatershed Outlet	3.2	1.6	-1.5	-3.0
Jun-Trib_3-01	Tributary 3 Subwatershed Outlet	3.2	1.6	-1.5	-2.8
Jun-Trib_4-01	Tributary 4 Subwatershed Outlet	10.5	5.2	-4.8	-9.1
Jun-Trib_5-01	Tributary 5 Subwatershed Outlet	9.8	5.1	-5.1	-10.0
Jun-Trib_6-01	Tributary 6 Subwatershed Outlet	5.8	2.9	-3.0	-6.0
Jun-Trib_7-01	Tributary 7 Subwatershed Outlet	10.1	5.1	-4.8	-9.0
Jun-Trib_8-01	Tributary 8 Subwatershed Outlet	7.6	3.7	-3.4	-6.6
Jun-Trib_9-01	Tributary 9 Subwatershed Outlet	6.1	3.1	-3.2	-6.2

Table 5-6: Impact of Varying Computational Timestep on Peak Flows at the Watershed Outlets

Junction ID	Location	Timestep	
		1 min	5 min
Jun-Black-01	Black Creek Drain Subwatershed Outlet	0.2	-0.4
Jun-Buckhorn-01	Buckhorn Creek Subwatershed Outlet	0.0	0.0
Jun-Elsie-01	Elsie Creek Subwatershed Outlet	-0.2	0.8
Jun-L_Forks-01	Little Forks Creek Subwatershed Outlet	-0.3	0.2
Jun-L_Wolf-01	Little Wolf Creek Subwatershed Outlet	0.0	-0.1
Jun-Mill-02-1	Mill Creek, Immediately U/S of the Confluence with Moores Creek	0.0	-0.1
Jun-Mill-01	Mill Creek Subwatershed Outlet	0.0	-0.1
Jun-Moores-01	Moores Creek Subwatershed Outlet	0.1	-0.2
Jun-W_Wolf-01	West Wolf Creek Subwatershed Outlet	0.1	0.1
Jun-Wilson-01	Wilson Creek Subwatershed Outlet	0.1	-0.2
Jun-Wolf-03-1	Wolf Creek, Immediately U/S of the Confluence with Little Wolf Creek	0.1	-0.2
Jun-Wolf-01	Wolf Creek Subwatershed Outlet	0.0	-0.1
Jun-Trib_1-01	Tributary 1 Subwatershed Outlet	0.1	-0.2
Jun-Trib_2-01	Tributary 2 Subwatershed Outlet	0.1	-0.3
Jun-Trib_3-01	Tributary 3 Subwatershed Outlet	0.1	-0.3
Jun-Trib_4-01	Tributary 4 Subwatershed Outlet	0.1	-0.3
Jun-Trib_5-01	Tributary 5 Subwatershed Outlet	0.1	-0.3
Jun-Trib_6-01	Tributary 6 Subwatershed Outlet	0.1	-0.3
Jun-Trib_7-01	Tributary 7 Subwatershed Outlet	0.1	-0.3
Jun-Trib_8-01	Tributary 8 Subwatershed Outlet	0.0	0.0
Jun-Trib_9-01	Tributary 9 Subwatershed Outlet	0.1	-0.1

6 CONCLUSION

As part of the hydrologic component of the Upper Welland River Tributaries Floodplain Mapping study, Aquafor developed a hydrologic model using the US Army Corps of Engineers HEC-HMS software (Ver. 4.10). The modelling approach was consistent with the HEC-HMS User and Technical Reference Manuals (US Army Corps of Engineers, 2000, 2022), the Federal Hydrologic and Hydraulic Procedures for Flood Hazard Delineation (NRCAN, 2023), the Technical Guide for River & Stream Systems: Flooding Hazard Limit (MNR, 2002), and the Flood Plain Management in Ontario: Technical Guidelines (MRN, 1986). Junctions were strategically placed throughout the watershed to ensure adequate discretization, as well as to provide flow inputs to the hydraulic model at key locations along the reaches included in the floodplain mapping study.

Aquafor's hydrologic model was run for the 2-year, 5-year, 10-year, 25-year, 50-year, 100-year, 200-year, and 350-year events, using the 12-hour AES 30% design storm for Southern Ontario. The peak flows estimated by the

hydrologic model for these return periods were subsequently used to complete the hydraulic modelling and floodplain mapping of the 19 tributaries included in this study.

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APPENDIX A – HYDROLOGIC MODEL PARAMETERS

Table A.1: Subbasin Parameters

Subbasin ID	Drainage Area (ha)	Initial Abstraction	CN, AMC II	CN, AMC III	Impervious Fraction (%)	Lag Time (min)	Peak Rate Factor
Sub-Black-01	4.20	7.01	83.90	92.20	0	15.15	250
Sub-Black-02	114.67	8.26	83.15	91.82	0	65.63	250
Sub-Black-03	72.63	7.29	82.48	91.49	0	45.92	250
Sub-Black-04	186.82	10.01	84.64	92.54	0	131.03	250
Sub-Black-05	105.83	10.88	85.46	92.94	0	128.12	250
Sub-Black-06	35.40	6.85	83.12	91.86	0	38.13	250
Sub-Black-07	123.71	9.00	85.61	93.12	0	98.31	250
Sub-Black-08	65.19	7.84	83.31	91.91	0	45.00	250
Sub-Black-09	53.45	8.33	84.23	92.41	0	122.56	250
Sub-Black-10	105.94	9.82	85.54	93.06	0	130.12	250
Sub-Black-11	98.52	8.73	84.59	92.58	0	119.62	250
Sub-Black-12	77.14	11.16	85.79	93.12	0	150.17	250
Sub-Black-13	9.47	7.89	81.28	90.84	0	23.77	250
Sub-Black-14	308.34	8.90	84.64	92.57	0	243.43	250
Sub-Black-15	87.94	6.90	83.97	92.33	0	58.27	250
Sub-Black-16	81.36	7.22	83.92	92.29	0	66.95	250
Sub-Black-17	15.44	7.03	83.23	91.93	0	30.11	250
Sub-Black-18	128.71	9.80	84.36	92.43	0	151.32	250
Sub-Black-19	103.91	13.86	88.24	94.34	0	146.21	250
Sub-Black-20	92.51	18.47	91.67	95.97	0	182.02	250
Sub-Black-21	56.18	7.70	83.59	92.10	0	57.77	250
Sub-Black-22	186.35	7.09	83.58	92.13	0	85.07	250
Sub-Black-23	105.52	9.26	85.97	93.30	0	147.12	250
Sub-Buckhorn-01	158.01	10.78	84.38	92.38	0	225.55	484
Sub-Buckhorn-02	63.99	6.96	82.63	91.61	0	42.09	484
Sub-Buckhorn-03	19.76	7.01	81.55	90.94	0	33.14	484
Sub-Buckhorn-04	34.41	6.81	83.60	92.11	0	31.39	484
Sub-Buckhorn-05	148.74	6.96	83.58	92.11	0	74.84	484
Sub-Buckhorn-06	128.41	7.42	83.07	91.82	0	93.56	484
Sub-Buckhorn-07	93.89	7.70	81.98	91.21	0	79.26	484
Sub-Buckhorn-08	210.72	7.23	82.93	91.75	0	71.54	484
Sub-Buckhorn-09	46.86	6.88	83.42	92.02	0	34.37	484
Sub-Buckhorn-10	146.13	7.35	82.66	91.60	0	141.09	484
Sub-Buckhorn-11	128.28	7.18	82.33	91.44	0	96.46	484
Sub-Buckhorn-12	91.13	7.41	83.27	91.93	0	54.57	484
Sub-Buckhorn-13	76.19	7.62	82.38	91.44	0	50.48	484
Sub-Buckhorn-14	130.90	7.59	83.41	91.99	0	95.93	484
Sub-Buckhorn-15	35.97	7.22	81.79	91.13	0	38.76	484
Sub-Buckhorn-16	167.71	9.04	84.42	92.49	0	104.58	484
Sub-Buckhorn-17	32.56	7.73	80.92	90.64	0	39.28	484
Sub-Buckhorn-18	112.88	7.00	83.66	92.15	0	111.55	484
Sub-Buckhorn-19	117.76	6.94	82.63	91.63	0	66.68	484
Sub-Buckhorn-20	173.30	7.03	82.40	91.50	0	70.81	484
Sub-Buckhorn-21	109.86	7.10	82.15	91.34	0	57.71	484
Sub-Buckhorn-22	46.70	6.85	83.82	92.25	0	35.29	484
Sub-Buckhorn-23	43.77	6.90	83.51	92.10	0	38.10	484
Sub-Buckhorn-24	108.72	6.93	83.76	92.23	0	56.62	484
Sub-Elsie-01	47.95	9.58	82.67	91.50	0	65.79	484
Sub-Elsie-02	22.38	8.11	80.76	90.55	0	40.75	484
Sub-Elsie-03	117.74	8.06	83.38	91.98	0	49.25	484
Sub-Elsie-04	62.43	8.97	82.54	91.46	0	101.19	484
Sub-Elsie-05	98.53	8.19	83.14	91.83	0	64.21	484
Sub-Elsie-06	19.53	7.46	83.46	92.06	0	21.19	484
Sub-Elsie-07	188.16	8.24	83.52	92.07	0	74.15	484
Sub-Elsie-08	70.24	7.04	83.52	92.11	0	63.38	484
Sub-Elsie-09	110.62	6.65	83.26	91.96	0	67.58	484
Sub-Elsie-10	163.93	7.13	83.28	91.95	0	76.79	484
Sub-Elsie-11	74.28	7.03	83.58	92.11	0	52.13	484
Sub-Elsie-12	117.31	7.15	84.19	92.44	0	59.42	484
Sub-Elsie-13	64.92	6.54	83.09	91.87	0	59.22	484
Sub-Elsie-14	77.26	7.22	83.01	91.82	0	50.48	484
Sub-Elsie-15	142.33	7.43	83.26	91.93	0	98.71	484
Sub-Elsie-16	8.56	8.51	83.65	92.12	0	35.50	484
Sub-Elsie-17	58.94	7.39	83.46	92.05	0	63.58	484

Subbasin ID	Drainage Area (ha)	Initial Abstraction	CN, AMC II	CN, AMC III	Impervious Fraction (%)	Lag Time (min)	Peak Rate Factor
Sub-Elsie-18	107.67	7.50	83.83	92.23	0	85.40	484
Sub-Elsie-19	59.70	7.01	83.39	92.01	0	57.90	484
Sub-Elsie-20	97.53	8.09	81.36	90.89	0	115.72	484
Sub-Elsie-21	197.14	8.08	83.90	92.24	0	112.18	484
Sub-Elsie-22	60.71	7.12	83.84	92.25	0	63.68	484
Sub-Elsie-23	93.00	13.59	87.06	93.72	0	140.25	484
Sub-Elsie-24	60.46	9.04	82.89	91.65	0	84.79	484
Sub-Elsie-25	62.46	7.09	83.00	91.80	0	72.79	484
Sub-Elsie-26	84.34	7.11	82.96	91.77	0	47.04	484
Sub-Elsie-27	77.90	6.86	83.20	91.91	0	54.37	484
Sub-Elsie-28	238.14	8.55	84.86	92.74	0	103.13	484
Sub-L_Forks-01	65.42	8.29	84.56	92.56	0	71.44	484
Sub-L_Forks-02	136.86	7.30	83.88	92.26	0	69.66	484
Sub-L_Forks-03	167.71	8.08	84.87	92.78	0	66.82	484
Sub-L_Forks-04	224.43	9.96	86.02	93.31	0	167.89	484
Sub-L_Forks-05	204.91	8.64	84.91	92.77	0	169.31	484
Sub-L_Forks-06	111.17	12.43	86.95	93.70	0	129.58	484
Sub-L_Forks-07	196.73	9.60	85.04	92.79	0	162.64	484
Sub-L_Forks-08	297.51	13.50	87.92	94.17	0	229.48	484
Sub-L_Wolf-01	105.15	9.66	84.48	92.50	0	121.72	484
Sub-L_Wolf-02	156.92	8.52	82.24	91.33	0	121.28	484
Sub-L_Wolf-03	262.49	7.27	82.97	91.79	0	94.12	484
Sub-L_Wolf-04	168.56	7.53	83.11	91.86	0	70.42	484
Sub-L_Wolf-05	46.82	6.80	82.54	91.58	0	33.64	484
Sub-L_Wolf-06	127.96	7.64	81.40	90.92	0	86.59	484
Sub-L_Wolf-07	23.25	6.92	82.69	91.66	0	32.52	484
Sub-L_Wolf-08	121.41	7.55	81.91	91.21	0	66.19	484
Sub-Mill-01	146.23	9.68	84.18	92.34	0	178.63	484
Sub-Mill-02	74.01	9.03	84.65	92.64	0	106.91	484
Sub-Mill-03	150.66	9.31	85.37	93.00	0	98.38	484
Sub-Mill-04	147.29	9.85	85.00	92.78	0	173.04	484
Sub-Mill-05	49.87	7.03	83.53	92.10	0	41.03	484
Sub-Mill-06	126.94	11.11	85.74	93.09	0	130.29	484
Sub-Mill-07	117.86	9.30	84.79	92.69	0	129.37	484
Sub-Mill-08	98.89	8.01	84.41	92.53	0	79.56	484
Sub-Mill-09	68.82	8.61	83.31	91.92	0	80.32	484
Sub-Mill-10	45.35	10.58	83.17	91.76	0	98.99	484
Sub-Mill-11	36.83	9.02	84.06	92.33	0	54.88	484
Sub-Mill-12	30.33	6.90	85.16	92.95	0	30.54	484
Sub-Mill-13	14.89	6.89	84.09	92.39	0	23.24	484
Sub-Mill-14	16.71	5.55	87.25	94.02	0	26.74	484
Sub-Mill-15	54.76	7.74	82.99	91.77	0	60.02	484
Sub-Mill-16	158.38	7.55	85.06	92.91	0	82.60	484
Sub-Mill-17	147.73	8.71	85.55	93.11	0	92.18	484
Sub-Mill-18	63.90	11.62	85.57	93.02	0	99.02	484
Sub-Mill-19	92.99	7.48	84.67	92.70	0	54.44	484
Sub-Mill-20	67.03	7.31	84.48	92.61	0	41.23	484
Sub-Mill-21	117.34	7.59	85.38	93.06	0	68.93	484
Sub-Mill-22	27.90	9.58	84.60	92.57	0	64.94	484
Sub-Mill-23	118.75	13.38	87.23	93.83	0	136.15	484
Sub-Moores-01	122.87	8.68	83.31	91.93	0	90.42	484
Sub-Moores-02	79.84	10.44	84.81	92.65	0	150.55	484
Sub-Moores-03	162.85	13.63	87.96	94.20	0	161.86	484
Sub-Moores-04	206.43	10.65	86.33	93.44	0	145.57	484
Sub-Moores-05	220.29	10.57	85.95	93.25	0	123.31	484
Sub-Moores-06	6.12	15.71	88.39	94.32	0	50.37	484
Sub-Moores-07	97.97	13.41	87.85	94.16	0	107.25	484
Sub-Moores-08	73.99	8.43	84.28	92.44	0	68.53	484
Sub-Moores-09	16.71	6.80	84.43	92.59	0	21.92	484
Sub-Moores-10	191.09	9.45	85.26	92.93	0	137.00	484
Sub-Moores-11	20.60	8.12	83.18	91.87	0	28.72	484
Sub-Moores-12	113.07	9.24	85.84	93.23	0	93.26	484
Sub-Trib_1-01	112.76	7.80	82.64	91.58	0.06	53.35	484
Sub-Trib_1-02	68.74	7.22	82.22	91.38	0	37.01	484
Sub-Trib_1-03	68.95	3.48	81.12	90.82	44.07	31.16	484
Sub-Trib_1-04	40.19	7.34	81.94	91.16	14.27	45.79	484
Sub-Trib_1-05	36.06	7.43	82.95	91.76	1.33	24.92	484
Sub-Trib_1-06	9.98	3.42	81.33	90.93	45.17	12.88	484
Sub-Trib_1-07	44.25	7.69	83.01	91.80	0.77	55.06	484

Subbasin ID	Drainage Area (ha)	Initial Abstraction	CN, AMC II	CN, AMC III	Impervious Fraction (%)	Lag Time (min)	Peak Rate Factor
Sub-Trib_1-08	7.63	3.41	80.45	90.47	45.65	10.99	484
Sub-Trib_1-09	26.19	6.94	82.59	91.59	0	33.24	484
Sub-Trib_1-10	139.80	7.01	81.84	91.18	0	60.41	484
Sub-Trib_1-11	47.51	6.03	82.32	91.44	0	38.92	484
Sub-Trib_1-12	117.79	6.81	82.46	91.53	0	86.59	484
Sub-Trib_1-13	79.63	7.01	82.16	91.34	0	71.08	484
Sub-Trib_1-14	91.79	7.09	82.42	91.50	0	55.36	484
Sub-Trib_1-15	43.45	6.96	82.88	91.76	0	40.37	484
Sub-Trib_2-01	47.02	7.76	81.87	91.16	0	37.27	484
Sub-Trib_2-02	37.19	10.03	81.41	90.79	0	72.33	484
Sub-Trib_2-03	192.56	6.87	82.21	91.39	1.23	75.20	484
Sub-Trib_2-04	79.21	3.77	80.93	90.64	43.37	55.82	484
Sub-Trib_2-05	41.05	7.02	82.99	91.82	0	37.40	484
Sub-Trib_2-06	106.54	6.85	82.21	91.41	0	61.50	484
Sub-Trib_2-07	134.34	3.98	79.42	89.83	44.17	69.09	484
Sub-Trib_3-01	39.64	8.47	82.39	91.40	0	35.72	484
Sub-Trib_3-02	56.94	7.11	82.76	91.69	0	40.34	484
Sub-Trib_3-03	107.49	7.23	81.73	91.12	0	64.01	484
Sub-Trib_3-04	53.95	7.40	81.14	90.77	0	50.81	484
Sub-Trib_3-05	75.42	7.06	82.00	91.29	0	63.55	484
Sub-Trib_4-01	108.18	7.08	83.78	92.24	0	54.73	484
Sub-Trib_4-02	67.28	14.07	85.50	92.84	0	89.70	484
Sub-Trib_4-03	25.22	7.12	82.91	91.75	0	32.68	484
Sub-Trib_4-04	186.03	12.03	84.61	92.45	0	165.52	484
Sub-Trib_4-05	100.38	11.80	84.62	92.48	0	158.91	484
Sub-Trib_5-01	36.86	7.01	83.07	91.88	0	28.49	484
Sub-Trib_5-02	5.33	7.00	83.94	92.36	0	9.97	484
Sub-Trib_5-03	15.31	7.00	83.73	92.23	0	20.34	484
Sub-Trib_5-04	45.18	7.00	83.30	91.99	0	43.97	484
Sub-Trib_5-05	87.52	15.29	85.72	92.90	0	147.60	484
Sub-Trib_5-06	62.76	14.14	87.58	93.96	0	121.11	484
Sub-Trib_6-01	78.80	7.44	82.92	91.75	0	54.80	484
Sub-Trib_6-02	70.57	6.98	84.43	92.57	0	33.67	484
Sub-Trib_6-03	50.61	9.68	84.76	92.66	0	77.88	484
Sub-Trib_6-04	5.46	6.99	83.71	92.22	0	18.92	484
Sub-Trib_6-05	22.78	16.58	89.67	95.01	0	103.63	484
Sub-Trib_6-06	51.52	12.44	87.17	93.83	0	125.27	484
Sub-Trib_6-07	71.66	12.58	88.08	94.31	0	131.71	484
Sub-Trib_6-08	53.94	10.84	85.99	93.25	0	99.36	484
Sub-Trib_6-09	10.73	16.97	88.39	94.30	0	82.29	484
Sub-Trib_6-10	13.04	10.30	85.97	93.28	0	63.45	484
Sub-Trib_6-11	23.21	15.27	88.84	94.61	0	94.99	484
Sub-Trib_7-01	27.97	7.32	83.42	92.05	0	24.17	484
Sub-Trib_7-02	77.51	8.67	82.78	91.63	0	102.68	484
Sub-Trib_7-03	68.22	8.49	85.20	92.92	0	54.01	484
Sub-Trib_7-04	117.02	9.58	84.63	92.59	0	111.99	484
Sub-Trib_7-05	47.33	6.91	84.24	92.48	0	30.87	484
Sub-Trib_7-06	53.06	10.38	85.02	92.76	0	94.72	484
Sub-Trib_7-07	354.18	11.41	86.23	93.37	0	174.09	484
Sub-Trib_7-08	77.81	8.99	84.67	92.65	0	118.36	484
Sub-Trib_8-01	114.85	7.26	81.90	91.18	0	63.09	484
Sub-Trib_8-02	106.25	7.23	83.27	91.93	0	62.69	484
Sub-Trib_8-03	57.73	11.72	85.90	93.16	0	80.25	484
Sub-Trib_8-04	179.18	12.35	86.07	93.23	0	160.71	484
Sub-Trib_8-05	59.56	18.47	89.43	94.76	0	220.19	484
Sub-Trib_9-01	67.52	7.04	83.36	92.01	0	48.30	484
Sub-Trib_9-02	104.93	9.34	85.32	92.97	0	110.00	484
Sub-Trib_9-03	69.07	8.78	83.61	92.06	0	135.34	484
Sub-Trib_9-04	19.74	8.25	83.84	92.21	0	40.37	484
Sub-Trib_9-05	102.25	14.74	89.39	94.92	0	158.98	484
Sub-Trib_9-06	5.20	10.78	81.93	91.07	0	45.97	484
Sub-Trib_9-07	12.88	8.08	84.72	92.71	0	24.43	484
Sub-Trib_9-08	177.84	9.21	85.01	92.80	0	135.67	484
Sub-Wilson-01	51.53	7.06	82.98	91.82	0	50.21	484
Sub-Wilson-02	135.29	9.09	84.32	92.43	0	96.92	484
Sub-Wilson-03	121.52	11.27	86.08	93.30	0	113.65	484
Sub-Wilson-04	83.20	9.76	84.67	92.61	0	114.81	484
Sub-Wilson-05	196.91	15.59	88.56	94.42	0	194.11	484
Sub-Wolf-01	130.14	8.73	82.55	91.50	0	116.09	484

Subbasin ID	Drainage Area (ha)	Initial Abstraction	CN, AMC II	CN, AMC III	Impervious Fraction (%)	Lag Time (min)	Peak Rate Factor
Sub-Wolf-02	156.66	8.75	83.87	92.21	0	112.81	484
Sub-Wolf-03	141.24	9.04	84.98	92.79	0	108.20	484
Sub-Wolf-04	99.75	7.91	83.67	92.15	0	66.98	484
Sub-Wolf-05	189.45	8.98	84.14	92.34	0	129.41	484
Sub-Wolf-06	186.33	9.69	85.06	92.81	0	129.95	484
Sub-Wolf-07	71.20	7.06	82.17	91.38	0	38.76	484
Sub-Wolf-08	32.34	7.00	82.67	91.65	0	30.64	484
Sub-Wolf-09	153.71	8.23	83.13	91.84	0	64.18	484
Sub-Wolf-10	32.37	8.67	83.93	92.25	0	65.99	484
Sub-Wolf-11	175.39	7.36	83.47	92.05	0	61.01	484
Sub-W_Wolf-01	99.69	8.84	84.05	92.30	0	91.91	484
Sub-W_Wolf-02	92.25	8.74	83.23	91.84	0	135.91	484
Sub-W_Wolf-03	37.30	7.04	82.44	91.53	0	35.19	484
Sub-W_Wolf-04	53.52	6.79	82.90	91.77	0	34.89	484
Sub-W_Wolf-05	166.73	7.15	82.18	91.36	0	102.80	484
Sub-W_Wolf-06	54.99	8.49	83.39	91.95	0	62.20	484
Sub-W_Wolf-07	89.44	7.82	82.50	91.50	0	58.04	484
Sub-W_Wolf-08	53.30	8.76	83.19	91.83	0	72.43	484
Sub-W_Wolf-09	47.78	6.89	82.44	91.53	0	42.52	484
Sub-W_Wolf-10	176.40	7.07	83.48	92.08	0	80.95	484
Sub-W_Wolf-11	62.40	9.22	83.53	92.01	0	72.80	484
Sub-W_Wolf-12	105.52	7.11	82.52	91.56	0	74.57	484
Sub-W_Wolf-13	111.07	7.12	82.87	91.74	0	96.89	484
Sub-W_Wolf-14	55.99	9.10	83.83	92.16	0	90.28	484
Sub-W_Wolf-15	23.53	7.00	82.66	91.64	0	23.57	484
Sub-W_Wolf-16	143.85	7.69	82.68	91.62	0	71.64	484

Table A.2: Reach Parameters

Reach	Routing Method	Length (m)	Channel Slope (m/m)	Channel Manning's n	Shape	Width (m)	Side Slope (m/m)	Left Manning's n	Right Manning's n
R-Black-01	Muskingum-Cunge	214.88	0.00099	0.035	Eight Point XS	–	–	0.08	0.08
R-Black-02	Muskingum-Cunge	1956.31	0.00168	0.035	Eight Point XS	–	–	0.04	0.04
R-Black-03	Muskingum-Cunge	946.52	0.00083	0.035	Eight Point XS	–	–	0.04	0.04
R-Black-04	Muskingum-Cunge	867.31	0.00099	0.035	Eight Point XS	–	–	0.04	0.04
R-Black-05	Muskingum-Cunge	1263.47	0.00170	0.035	Eight Point XS	–	–	0.04	0.04
R-Black-06	Muskingum-Cunge	821.98	0.00051	0.035	Eight Point XS	–	–	0.06	0.06
R-Black-07	Muskingum-Cunge	797.40	0.00088	0.035	Eight Point XS	–	–	0.06	0.06
R-Black-08	Muskingum-Cunge	1028.38	0.00025	0.035	Trapezoid	2.94	1.4	–	–
R-Black-09	Muskingum-Cunge	1279.26	0.00033	0.035	Eight Point XS	–	–	0.04	0.04
R-Black-10	Muskingum-Cunge	703.11	0.00027	0.035	Trapezoid	2.73	1.6	–	–
R-Black-11	Muskingum-Cunge	339.70	0.00059	0.035	Trapezoid	2.66	2.3	–	–
R-Black-12	Muskingum-Cunge	1062.98	0.00032	0.035	Trapezoid	2.13	1.7	–	–
R-Black-13	Muskingum-Cunge	585.18	0.00041	0.035	Trapezoid	2.72	1.5	–	–
R-Black-14	Muskingum-Cunge	298.97	0.00029	0.035	Trapezoid	1.84	2.2	–	–
R-Black-15	Muskingum-Cunge	956.62	0.00067	0.035	Eight Point XS	–	–	0.06	0.06
R-Black-16	Muskingum-Cunge	852.16	0.00034	0.035	Trapezoid	1.56	1.2	–	–
R-Buckhorn-01	Muskingum-Cunge	3433.30	0.00083	0.035	Eight Point XS	–	–	0.08	0.08
R-Buckhorn-02	Muskingum-Cunge	1143.11	0.00754	0.035	Eight Point XS	–	–	0.04	0.055
R-Buckhorn-03	Muskingum-Cunge	862.44	0.00270	0.035	Eight Point XS	–	–	0.04	0.04
R-Buckhorn-04	Muskingum-Cunge	954.84	0.00064	0.035	Eight Point XS	–	–	0.04	0.04
R-Buckhorn-05	Muskingum-Cunge	2661.04	0.00261	0.035	Eight Point XS	–	–	0.06	0.05
R-Buckhorn-06	Muskingum-Cunge	731.06	0.00320	0.035	Eight Point XS	–	–	0.04	0.04
R-Buckhorn-07	Muskingum-Cunge	1686.70	0.00110	0.035	Eight Point XS	–	–	0.08	0.08
R-Buckhorn-08	Muskingum-Cunge	2943.47	0.00078	0.035	Eight Point XS	–	–	0.06	0.06
R-Buckhorn-09	Muskingum-Cunge	1738.73	0.00210	0.035	Eight Point XS	–	–	0.04	0.04
R-Buckhorn-10	Muskingum-Cunge	1196.79	0.00123	0.035	Eight Point XS	–	–	0.04	0.04
R-Buckhorn-11	Muskingum-Cunge	795.52	0.00252	0.035	Eight Point XS	–	–	0.04	0.04
R-Buckhorn-12	Muskingum-Cunge	1171.88	0.00369	0.035	Eight Point XS	–	–	0.04	0.04
R-Buckhorn-13	Muskingum-Cunge	1183.51	0.00348	0.035	Eight Point XS	–	–	0.08	0.04
R-Buckhorn-14	Muskingum-Cunge	2316.10	0.00209	0.035	Eight Point XS	–	–	0.04	0.04
R-Buckhorn-15	Muskingum-Cunge	2191.56	0.00214	0.035	Eight Point XS	–	–	0.04	0.04
R-Buckhorn-16	Muskingum-Cunge	1346.68	0.00288	0.035	Eight Point XS	–	–	0.04	0.04
R-Buckhorn-17	Muskingum-Cunge	923.09	0.00281	0.035	Eight Point XS	–	–	0.04	0.04
R-Elsie-01	Muskingum-Cunge	1379.03	0.00084	0.035	Eight Point XS	–	–	0.08	0.08
R-Elsie-02	Muskingum-Cunge	693.44	0.00453	0.035	Eight Point XS	–	–	0.04	0.08
R-Elsie-03	Muskingum-Cunge	93.92	0.00084	0.035	Eight Point XS	–	–	0.08	0.08
R-Elsie-04	Muskingum-Cunge	2144.02	0.00102	0.035	Eight Point XS	–	–	0.08	0.08
R-Elsie-05	Muskingum-Cunge	1490.30	0.00115	0.035	Eight Point XS	–	–	0.04	0.04

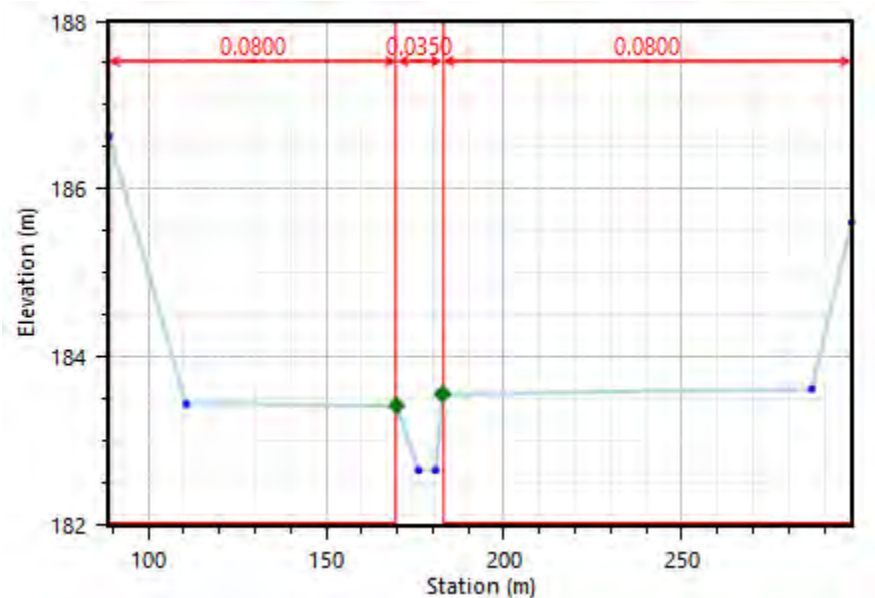
Reach	Routing Method	Length (m)	Channel Slope (m/m)	Channel Manning's n	Shape	Width (m)	Side Slope (m/m)	Left Manning's n	Right Manning's n
R-Elsie-06	Muskingum-Cunge	535.23	0.00374	0.035	Eight Point XS	–	–	0.04	0.04
R-Elsie-07	Muskingum-Cunge	1674.87	0.00106	0.035	Eight Point XS	–	–	0.04	0.04
R-Elsie-08	Muskingum-Cunge	1883.97	0.00207	0.035	Eight Point XS	–	–	0.04	0.04
R-Elsie-09	Muskingum-Cunge	2112.08	0.00178	0.035	Eight Point XS	–	–	0.04	0.04
R-Elsie-10	Muskingum-Cunge	1065.17	0.00301	0.035	Eight Point XS	–	–	0.04	0.04
R-Elsie-11	Muskingum-Cunge	1725.34	0.00283	0.035	Eight Point XS	–	–	0.04	0.045
R-Elsie-12	Muskingum-Cunge	1212.29	0.00157	0.035	Eight Point XS	–	–	0.04	0.04
R-Elsie-13	Muskingum-Cunge	1917.72	0.00129	0.035	Eight Point XS	–	–	0.04	0.04
R-Elsie-14	Muskingum-Cunge	2166.70	0.00115	0.035	Eight Point XS	–	–	0.04	0.04
R-Elsie-15	Muskingum-Cunge	1038.57	0.00163	0.035	Eight Point XS	–	–	0.04	0.04
R-Elsie-16	Muskingum-Cunge	2246.35	0.00121	0.035	Eight Point XS	–	–	0.08	0.08
R-Elsie-17	Muskingum-Cunge	3975.78	0.00138	0.035	Eight Point XS	–	–	0.06	0.06
R-Elsie-18	Muskingum-Cunge	1616.20	0.00239	0.035	Eight Point XS	–	–	0.04	0.04
R-Elsie-19	Muskingum-Cunge	83.57	0.00411	0.035	Eight Point XS	–	–	0.04	0.08
R-Elsie-20	Muskingum-Cunge	1064.71	0.00210	0.035	Eight Point XS	–	–	0.04	0.04
R-Elsie-21	Muskingum-Cunge	1270.45	0.00162	0.035	Eight Point XS	–	–	0.04	0.04
R-L_Forks-01	Muskingum-Cunge	1561.79	0.00008	0.035	Eight Point XS	–	–	0.06	0.06
R-L_Forks-02	Muskingum-Cunge	2072.75	0.00068	0.035	Eight Point XS	–	–	0.04	0.04
R-L_Forks-03	Muskingum-Cunge	1728.78	0.00056	0.035	Eight Point XS	–	–	0.04	0.04
R-L_Forks-04	Muskingum-Cunge	1737.62	0.00047	0.035	Eight Point XS	–	–	0.04	0.04
R-L_Forks-05	Muskingum-Cunge	1536.08	0.00043	0.035	Eight Point XS	–	–	0.06	0.06
R-L_Forks-06	Muskingum-Cunge	1446.72	0.00062	0.035	Eight Point XS	–	–	0.04	0.04
R-L_Wolf-01	Muskingum-Cunge	2389.48	0.00117	0.035	Eight Point XS	–	–	0.08	0.08
R-L_Wolf-02	Muskingum-Cunge	2408.61	0.00119	0.035	Eight Point XS	–	–	0.07	0.07
R-L_Wolf-03	Muskingum-Cunge	1871.61	0.00171	0.035	Eight Point XS	–	–	0.04	0.04
R-L_Wolf-04	Muskingum-Cunge	2033.88	0.00169	0.035	Eight Point XS	–	–	0.06	0.06
R-L_Wolf-05	Muskingum-Cunge	1054.85	0.00288	0.035	Eight Point XS	–	–	0.04	0.04
R-L_Wolf-06	Muskingum-Cunge	841.74	0.00269	0.035	Eight Point XS	–	–	0.04	0.04
R-Mill-01	Muskingum-Cunge	4476.21	0.00106	0.035	Eight Point XS	–	–	0.08	0.08
R-Mill-02	Muskingum-Cunge	2087.58	0.00091	0.035	Eight Point XS	–	–	0.08	0.04
R-Mill-03	Muskingum-Cunge	2047.07	0.00104	0.035	Eight Point XS	–	–	0.05	0.05
R-Mill-04	Muskingum-Cunge	4342.12	0.00105	0.035	Eight Point XS	–	–	0.08	0.08
R-Mill-05	Muskingum-Cunge	1341.54	0.00397	0.035	Eight Point XS	–	–	0.04	0.04
R-Mill-06	Muskingum-Cunge	1609.83	0.00191	0.035	Eight Point XS	–	–	0.08	0.08
R-Mill-07	Muskingum-Cunge	949.59	0.00249	0.035	Eight Point XS	–	–	0.06	0.04
R-Mill-08	Muskingum-Cunge	1265.35	0.00264	0.035	Eight Point XS	–	–	0.08	0.04
R-Mill-09	Muskingum-Cunge	1392.41	0.00157	0.035	Eight Point XS	–	–	0.05	0.05
R-Mill-10	Muskingum-Cunge	1932.05	0.00172	0.035	Eight Point XS	–	–	0.05	0.08
R-Mill-11	Muskingum-Cunge	832.58	0.00320	0.035	Eight Point XS	–	–	0.04	0.08
R-Mill-12	Muskingum-Cunge	962.14	0.00504	0.035	Trapezoid	7.42	2	–	–

Reach	Routing Method	Length (m)	Channel Slope (m/m)	Channel Manning's n	Shape	Width (m)	Side Slope (m/m)	Left Manning's n	Right Manning's n
R-Mill-13	Muskingum-Cunge	240.16	0.00685	0.035	Eight Point XS	–	–	0.04	0.04
R-Mill-14	Muskingum-Cunge	2009.17	0.00260	0.035	Eight Point XS	–	–	0.08	0.08
R-Mill-15	Muskingum-Cunge	979.64	0.00256	0.035	Eight Point XS	–	–	0.06	0.06
R-Mill-16	Muskingum-Cunge	498.78	0.00261	0.035	Eight Point XS	–	–	0.04	0.04
R-Mill-17	Muskingum-Cunge	350.29	0.00145	0.035	Eight Point XS	–	–	0.08	0.08
R-Mill-18	Muskingum-Cunge	300.39	0.00383	0.035	Eight Point XS	–	–	0.04	0.04
R-Moores-01	Muskingum-Cunge	1659.11	0.00130	0.035	Eight Point XS	–	–	0.08	0.08
R-Moores-02	Muskingum-Cunge	2957.88	0.00136	0.035	Eight Point XS	–	–	0.08	0.08
R-Moores-03	Muskingum-Cunge	612.78	0.00020	0.035	Eight Point XS	–	–	0.08	0.08
R-Moores-04	Muskingum-Cunge	2351.83	0.00215	0.035	Eight Point XS	–	–	0.06	0.06
R-Moores-05	Muskingum-Cunge	455.18	0.00161	0.035	Eight Point XS	–	–	0.08	0.08
R-Moores-06	Muskingum-Cunge	1308.60	0.00291	0.035	Eight Point XS	–	–	0.08	0.08
R-Moores-07	Muskingum-Cunge	512.58	0.00347	0.035	Eight Point XS	–	–	0.04	0.04
R-Moores-08	Muskingum-Cunge	570.66	0.00362	0.035	Eight Point XS	–	–	0.04	0.04
R-Trib_1-11	Muskingum-Cunge	1538.09	0.00165	0.035	Eight Point XS	–	–	0.08	0.08
R-Trib_1-01	Muskingum-Cunge	1634.54	0.00779	0.035	Eight Point XS	–	–	0.08	0.04
R-Trib_1-04	Muskingum-Cunge	1194.95	0.00885	0.035	Eight Point XS	–	–	0.055	0.055
R-Trib_1-08	Muskingum-Cunge	735.14	0.00287	0.035	Eight Point XS	–	–	0.04	0.04
R-Trib_1-09	Muskingum-Cunge	976.70	0.01518	0.035	Eight Point XS	–	–	0.06	0.06
R-Trib_1-10	Muskingum-Cunge	355.74	0.00234	0.035	Eight Point XS	–	–	0.06	0.06
R-Trib_1-02	Muskingum-Cunge	1958.15	0.01015	0.035	Eight Point XS	–	–	0.045	0.045
R-Trib_1-05	Muskingum-Cunge	159.07	0.00201	0.035	Eight Point XS	–	–	0.08	0.055
R-Trib_1-07	Muskingum-Cunge	813.37	0.00362	0.035	Eight Point XS	–	–	0.06	0.06
R-Trib_1-03	Muskingum-Cunge	359.21	0.00424	0.035	Eight Point XS	–	–	0.045	0.045
R-Trib_1-06	Muskingum-Cunge	520.35	0.00619	0.035	Eight Point XS	–	–	0.08	0.08
R-Trib_2-02	Muskingum-Cunge	1121.36	0.00596	0.035	Eight Point XS	–	–	0.06	0.06
R-Trib_2-01	Muskingum-Cunge	1707.88	0.00175	0.035	Eight Point XS	–	–	0.08	0.08
R-Trib_2-05	Muskingum-Cunge	1543.35	0.00312	0.035	Eight Point XS	–	–	0.06	0.06
R-Trib_2-04	Muskingum-Cunge	663.40	0.00497	0.035	Eight Point XS	–	–	0.045	0.045
R-Trib_2-03	Muskingum-Cunge	1250.97	0.00645	0.035	Eight Point XS	–	–	0.04	0.04
R-Trib_3-03	Muskingum-Cunge	1134.74	0.00532	0.035	Eight Point XS	–	–	0.08	0.08
R-Trib_3-01	Muskingum-Cunge	1070.13	0.00433	0.035	Eight Point XS	–	–	0.04	0.04
R-Trib_3-02	Muskingum-Cunge	1153.10	0.00638	0.035	Eight Point XS	–	–	0.06	0.06
R-Trib_4-02	Muskingum-Cunge	1156.67	0.00259	0.035	Eight Point XS	–	–	0.04	0.04
R-Trib_4-01	Muskingum-Cunge	825.21	0.00203	0.035	Eight Point XS	–	–	0.04	0.04
R-Trib_5-01	Muskingum-Cunge	534.50	0.00504	0.035	Eight Point XS	–	–	0.08	0.08
R-Trib_5-02	Muskingum-Cunge	279.31	0.01381	0.035	Eight Point XS	–	–	0.04	0.04
R-Trib_5-03	Muskingum-Cunge	1344.35	0.00392	0.035	Eight Point XS	–	–	0.04	0.04
R-Trib_6-01	Muskingum-Cunge	2015.81	0.00313	0.035	Eight Point XS	–	–	0.07	0.07
R-Trib_6-02	Muskingum-Cunge	896.80	0.00291	0.035	Eight Point XS	–	–	0.05	0.05

Reach	Routing Method	Length (m)	Channel Slope (m/m)	Channel Manning's n	Shape	Width (m)	Side Slope (m/m)	Left Manning's n	Right Manning's n
R-Trib_6-04	Muskingum-Cunge	1029.00	0.00340	0.035	Eight Point XS	–	–	0.04	0.045
R-Trib_6-05	Muskingum-Cunge	367.79	0.00231	0.035	Eight Point XS	–	–	0.07	0.07
R-Trib_6-06	Muskingum-Cunge	598.95	0.00492	0.035	Eight Point XS	–	–	0.07	0.07
R-Trib_6-03	Muskingum-Cunge	682.61	0.00361	0.035	Eight Point XS	–	–	0.04	0.04
R-Trib_6-08	Muskingum-Cunge	573.23	0.00250	0.035	Eight Point XS	–	–	0.08	0.08
R-Trib_6-07	Muskingum-Cunge	744.61	0.00181	0.035	Eight Point XS	–	–	0.04	0.04
R-Trib_7-01	Muskingum-Cunge	749.05	0.00530	0.035	Eight Point XS	–	–	0.08	0.08
R-Trib_7-02	Muskingum-Cunge	2270.53	0.00337	0.035	Eight Point XS	–	–	0.07	0.04
R-Trib_7-03	Muskingum-Cunge	544.84	0.00240	0.035	Eight Point XS	–	–	0.06	0.05
R-Trib_7-04	Muskingum-Cunge	625.80	0.00259	0.035	Eight Point XS	–	–	0.04	0.04
R-Trib_7-05	Muskingum-Cunge	862.16	0.00167	0.035	Eight Point XS	–	–	0.04	0.04
R-Trib_7-06	Muskingum-Cunge	1968.74	0.00485	0.035	Eight Point XS	–	–	0.04	0.05
R-Trib_8-04	Muskingum-Cunge	1281.50	0.00260	0.035	Eight Point XS	–	–	0.04	0.04
R-Trib_8-01	Muskingum-Cunge	861.64	0.00255	0.035	Eight Point XS	–	–	0.04	0.04
R-Trib_8-02	Muskingum-Cunge	500.49	0.00227	0.035	Eight Point XS	–	–	0.06	0.06
R-Trib_8-03	Muskingum-Cunge	2228.81	0.00152	0.035	Eight Point XS	–	–	0.08	0.08
R-Trib_9-02	Muskingum-Cunge	1256.95	0.00060	0.035	Eight Point XS	–	–	0.04	0.04
R-Trib_9-01	Muskingum-Cunge	525.39	0.00111	0.035	Eight Point XS	–	–	0.04	0.04
R-Trib_9-05	Muskingum-Cunge	1657.09	0.00015	0.035	Eight Point XS	–	–	0.04	0.04
R-Trib_9-04	Muskingum-Cunge	329.43	0.00520	0.035	Eight Point XS	–	–	0.04	0.04
R-Trib_9-03	Muskingum-Cunge	569.32	0.00701	0.035	Eight Point XS	–	–	0.06	0.06
R-Wilson-01	Muskingum-Cunge	1317.21	0.00209	0.035	Eight Point XS	–	–	0.04	0.04
R-Wilson-02	Muskingum-Cunge	1763.39	0.00224	0.035	Eight Point XS	–	–	0.06	0.06
R-Wilson-03	Muskingum-Cunge	1105.14	0.00255	0.035	Eight Point XS	–	–	0.04	0.06
R-Wilson-04	Muskingum-Cunge	1651.14	0.00171	0.035	Eight Point XS	–	–	0.04	0.06
R-Wolf-01	Muskingum-Cunge	2226.51	0.00159	0.035	Eight Point XS	–	–	0.08	0.08
R-Wolf-02	Muskingum-Cunge	1578.40	0.00070	0.035	Eight Point XS	–	–	0.08	0.08
R-Wolf-03	Muskingum-Cunge	2721.00	0.00144	0.035	Eight Point XS	–	–	0.08	0.08
R-Wolf-04	Muskingum-Cunge	2095.82	0.00113	0.035	Eight Point XS	–	–	0.08	0.08
R-Wolf-05	Muskingum-Cunge	1605.15	0.00152	0.035	Eight Point XS	–	–	0.08	0.08
R-Wolf-06	Muskingum-Cunge	1130.27	0.00159	0.035	Eight Point XS	–	–	0.07	0.06
R-Wolf-07	Muskingum-Cunge	1041.13	0.00388	0.035	Eight Point XS	–	–	0.04	0.04
R-Wolf-08	Muskingum-Cunge	715.61	0.00295	0.035	Eight Point XS	–	–	0.04	0.04
R-Wolf-09	Muskingum-Cunge	1194.18	0.00400	0.035	Eight Point XS	–	–	0.06	0.05
R-W_Wolf-01	Muskingum-Cunge	2986.68	0.00131	0.035	Eight Point XS	–	–	0.06	0.08
R-W_Wolf-02	Muskingum-Cunge	2438.00	0.00086	0.035	Eight Point XS	–	–	0.08	0.08
R-W_Wolf-03	Muskingum-Cunge	1031.09	0.00336	0.035	Eight Point XS	–	–	0.08	0.04
R-W_Wolf-04	Muskingum-Cunge	998.91	0.00209	0.035	Eight Point XS	–	–	0.04	0.04
R-W_Wolf-05	Muskingum-Cunge	1863.33	0.00116	0.035	Eight Point XS	–	–	0.06	0.06
R-W_Wolf-06	Muskingum-Cunge	1838.90	0.00133	0.035	Eight Point XS	–	–	0.08	0.04

Reach	Routing Method	Length (m)	Channel Slope (m/m)	Channel Manning's n	Shape	Width (m)	Side Slope (m/m)	Left Manning's n	Right Manning's n
R-W_Wolf-07	Muskingum-Cunge	1351.12	0.00252	0.035	Eight Point XS	–	–	0.04	0.04
R-W_Wolf-08	Muskingum-Cunge	952.12	0.00307	0.035	Eight Point XS	–	–	0.04	0.04
R-W_Wolf-09	Muskingum-Cunge	1391.25	0.00146	0.035	Eight Point XS	–	–	0.08	0.08
R-W_Wolf-10	Muskingum-Cunge	785.05	0.00229	0.035	Eight Point XS	–	–	0.04	0.04
R-W_Wolf-11	Muskingum-Cunge	1836.76	0.00217	0.035	Eight Point XS	–	–	0.04	0.08
R-W_Wolf-12	Muskingum-Cunge	659.34	0.00221	0.035	Eight Point XS	–	–	0.04	0.04

Figure A.1: Example Routing Cross-Section for R-Buckhorn-01



APPENDIX B – DESIGN STORM DATA

Table B.1: 12-hr AES Design Storm Rainfall for the 2-yr, 5-yr, 10-yr, 25-yr, 50-yr, 100-yr, 200-yr, and 350-yr Return Periods, Without Areal Reduction Factors

Time (hrs)	Rainfall Depth (mm)							
	2-year	5-year	10-year	25-year	50-year	100-year	200-year	350-year
1	5.798	7.930	9.334	11.102	12.415	13.728	14.937	15.828
2	11.596	15.860	18.668	22.204	24.830	27.456	29.874	31.655
3	8.920	12.200	14.360	17.080	19.100	21.120	22.980	24.350
4	6.690	9.150	10.770	12.810	14.325	15.840	17.235	18.263
5	6.244	8.540	10.052	11.956	13.370	14.784	16.086	17.045
6	3.568	4.880	5.744	6.832	7.640	8.448	9.192	9.740
7	1.338	1.830	2.154	2.562	2.865	3.168	3.447	3.653
8	0.446	0.610	0.718	0.854	0.955	1.056	1.149	1.218
9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
11	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
12	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table B.2: 100-yr Rain-on-Snow Precipitation (from NPCA, 2018)

Time (mins)	Combined Rainfall and Snowmelt (mm)
0	0
60	0
120	0
180	0
240	0
300	0
360	0
420	2.428
480	2.39
540	2.589
600	3.038
660	3.565
720	4.183
780	0.898
840	0
900	0
960	0
1020	0
1080	0
1140	0
1200	0
1260	0
1320	0
1380	0
1440	0
1500	0
1560	0
1620	0
1680	0
1740	0
1800	0
1860	3.8
1920	4.183
1980	4.532
2040	4.532
2100	4.532
2160	4.532
2220	4.492
2280	0

Time (mins)	Combined Rainfall and Snowmelt (mm)
2340	0
2400	0
2460	0
2520	0
2580	6.506
2640	0.525
2700	0.485
2760	0.668
2820	0.569
2880	0.569
2940	31.441
3000	0
3060	0
3120	0
3180	0
3240	0
3300	7.852
3360	0.352
3420	0.381
3480	0.381
3540	0.381
3600	0.381

APPENDIX C – HYDROLOGIC MODEL RESULTS

Table C.1: Peak Flows under the 2-yr , 5-yr , 10-yr , 25-yr , 50-yr , 100-yr , 200-yr, and 350-yr 12-hr AES Events

Junction ID	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	200-yr	350-yr
Jun-Black-01	11.35	20.21	26.10	34.34	40.21	46.61	52.52	56.80
Jun-Black-02	11.35	20.21	26.10	34.33	40.20	46.60	52.51	56.78
Jun-Black-02-1	2.91	5.09	6.67	8.82	10.48	12.16	13.73	14.90
Jun-Black-02-2	8.60	15.26	19.71	25.93	30.47	35.26	39.69	42.98
Jun-Black-03	2.12	3.80	4.99	6.57	7.77	9.00	10.14	10.99
Jun-Black-03-1	1.52	2.71	3.56	4.68	5.54	6.41	7.23	7.84
Jun-Black-03-2	0.61	1.10	1.45	1.90	2.25	2.61	2.94	3.19
Jun-Black-04	1.06	1.90	2.50	3.28	3.89	4.50	5.07	5.50
Jun-Black-05	8.50	15.07	19.53	25.63	30.18	34.88	39.25	42.52
Jun-Black-05-1	7.95	14.05	18.19	23.87	28.11	32.48	36.54	39.59
Jun-Black-05-2	0.55	1.02	1.35	1.78	2.11	2.44	2.75	2.98
Jun-Black-06	7.16	12.66	16.41	21.63	25.58	29.49	33.22	36.03
Jun-Black-06-1	6.78	11.89	15.37	20.24	23.93	27.57	31.06	33.69
Jun-Black-06-2	0.40	0.78	1.05	1.40	1.66	1.92	2.17	2.35
Jun-Black-07	6.54	11.67	15.36	20.24	23.77	27.22	30.59	33.11
Jun-Black-07-1	4.37	7.84	10.34	13.65	16.06	18.34	20.57	22.23
Jun-Black-07-2	2.33	4.06	5.28	6.90	8.13	9.39	10.56	11.43
Jun-Black-08	4.07	7.30	9.63	12.72	15.09	17.33	19.32	20.82
Jun-Black-09	3.62	6.49	8.55	11.28	13.38	15.40	17.09	18.34
Jun-Black-09-1	1.93	3.47	4.57	6.03	7.08	7.87	8.78	9.58
Jun-Black-09-2	1.96	3.44	4.49	5.88	6.95	8.04	9.07	9.83
Jun-Black-10	1.49	2.66	3.50	4.61	5.46	6.33	7.14	7.75
Jun-Black-11	1.15	2.04	2.68	3.53	4.17	4.83	5.45	5.91
Jun-Black-12	1.15	2.04	2.67	3.51	4.15	4.81	5.42	5.88
Jun-Black-13	1.33	2.34	3.06	4.01	4.74	5.48	6.17	6.69
Jun-Black-14	0.71	1.28	1.69	2.23	2.65	3.07	3.47	3.77
Jun-Black-15	0.66	1.18	1.56	2.05	2.43	2.82	3.18	3.45
Jun-Black-16	1.94	3.36	4.37	5.70	6.72	7.75	8.72	9.44
Jun-Black-17	0.61	1.06	1.39	1.81	2.13	2.46	2.77	3.00
Jun-Buckhorn-01	11.67	23.55	32.57	44.89	54.47	64.36	73.71	80.71
Jun-Buckhorn-02	12.25	24.51	33.62	45.99	55.53	65.29	74.56	81.85
Jun-Buckhorn-02-1	11.89	23.22	31.56	42.73	51.33	60.14	68.40	74.57
Jun-Buckhorn-03	2.49	4.23	5.43	7.02	8.27	9.53	10.74	11.63
Jun-Buckhorn-03-1	1.88	3.22	4.15	5.37	6.33	7.31	8.24	8.94
Jun-Buckhorn-04	1.71	2.92	3.76	4.88	5.75	6.66	7.50	8.14
Jun-Buckhorn-05	1.43	2.38	3.05	3.98	4.70	5.45	6.15	6.68
Jun-Buckhorn-06	11.88	22.89	30.87	41.47	49.59	57.90	65.68	71.49
Jun-Buckhorn-06-1	3.03	5.31	6.94	9.09	10.75	12.44	14.04	15.25
Jun-Buckhorn-06-2	10.21	19.38	25.87	34.53	41.17	47.92	54.24	58.97
Jun-Buckhorn-07	2.40	4.04	5.20	6.78	8.01	9.29	10.49	11.38

Jun-Buckhorn-08	1.97	3.30	4.24	5.54	6.57	7.63	8.63	9.37
Jun-Buckhorn-09	9.91	18.47	24.43	32.40	38.51	44.70	50.50	54.85
Jun-Buckhorn-10	10.02	18.03	23.50	30.88	36.56	42.24	47.55	51.54
Jun-Buckhorn-10-1	4.94	8.93	11.65	15.35	18.18	21.04	23.73	25.78
Jun-Buckhorn-10-2	5.44	9.26	12.08	15.81	18.73	21.75	24.59	26.71
Jun-Buckhorn-11	4.59	7.96	10.35	13.57	16.02	18.50	20.84	22.62
Jun-Buckhorn-12	4.09	7.02	9.13	11.92	14.05	16.21	18.25	19.78
Jun-Buckhorn-12-1	2.88	4.97	6.45	8.41	9.88	11.39	12.81	13.89
Jun-Buckhorn-12-2	1.22	2.07	2.68	3.52	4.17	4.83	5.44	5.90
Jun-Buckhorn-13	1.71	2.98	3.89	5.08	6.00	6.93	7.81	8.46
Jun-Buckhorn-14	1.48	2.54	3.28	4.27	5.02	5.80	6.52	7.05
Jun-Buckhorn-15	1.01	1.70	2.20	2.85	3.34	3.85	4.33	4.68
Jun-Buckhorn-16	4.50	7.60	9.87	12.89	15.26	17.75	20.09	21.84
Jun-Buckhorn-17	2.95	4.96	6.44	8.48	10.08	11.72	13.27	14.43
Jun-Buckhorn-18	1.96	3.26	4.26	5.61	6.66	7.74	8.76	9.51
Jun-Buckhorn-19	1.52	2.50	3.28	4.33	5.13	5.96	6.74	7.32
Jun-Buckhorn-19-1	1.08	1.78	2.33	3.07	3.64	4.22	4.77	5.19
Jun-Elsie-01	10.20	20.63	28.98	40.31	49.34	58.83	67.88	74.69
Jun-Elsie-02	10.50	21.08	29.70	41.26	50.50	60.20	69.49	76.45
Jun-Elsie-02-1	1.32	2.20	2.91	3.86	4.60	5.36	6.08	6.61
Jun-Elsie-02-2	10.50	21.04	29.55	40.85	49.85	59.27	68.24	74.99
Jun-Elsie-03	1.13	1.88	2.48	3.29	3.92	4.57	5.17	5.62
Jun-Elsie-04	10.51	21.06	29.58	40.88	49.88	59.31	68.28	75.03
Jun-Elsie-04-1	8.08	15.20	20.45	27.51	33.03	38.65	43.89	47.78
Jun-Elsie-04-2	6.09	11.77	16.01	21.72	26.21	30.86	35.25	38.55
Jun-Elsie-05	7.97	15.11	20.25	27.13	32.48	37.90	42.95	46.70
Jun-Elsie-06	7.70	14.40	19.16	25.51	30.41	35.34	39.93	43.35
Jun-Elsie-06-1	1.88	3.23	4.18	5.44	6.43	7.46	8.43	9.16
Jun-Elsie-06-2	6.45	11.80	15.56	20.66	24.58	28.55	32.25	35.00
Jun-Elsie-07	1.74	2.95	3.79	4.94	5.85	6.79	7.67	8.34
Jun-Elsie-08	6.24	11.19	14.64	19.37	22.94	26.55	29.92	32.44
Jun-Elsie-08-1	3.97	7.08	9.24	12.26	14.55	16.88	19.05	20.67
Jun-Elsie-08-2	2.44	4.22	5.48	7.13	8.39	9.68	10.88	11.77
Jun-Elsie-09	3.26	5.65	7.33	9.57	11.31	13.10	14.80	16.07
Jun-Elsie-10	1.88	3.13	4.06	5.32	6.31	7.33	8.28	9.00
Jun-Elsie-11	1.17	1.93	2.52	3.31	3.93	4.56	5.15	5.59
Jun-Elsie-12	1.87	3.25	4.23	5.51	6.49	7.48	8.42	9.11
Jun-Elsie-13	1.27	2.15	2.78	3.61	4.24	4.90	5.51	5.97
Jun-Elsie-14	6.15	11.86	16.09	21.79	26.23	30.82	35.16	38.41
Jun-Elsie-15	6.21	11.92	16.08	21.58	25.85	30.23	34.33	37.40
Jun-Elsie-16	6.22	11.86	15.94	21.31	25.45	29.69	33.66	36.61
Jun-Elsie-17	6.26	11.65	15.47	20.46	24.30	28.22	31.87	34.59
Jun-Elsie-18	5.40	9.61	12.62	16.56	19.60	22.69	25.56	27.69
Jun-Elsie-18-1	2.17	3.87	5.07	6.64	7.86	9.09	10.24	11.10
Jun-Elsie-18-2	3.23	5.74	7.55	9.94	11.76	13.61	15.33	16.60
Jun-Elsie-19	1.73	3.06	4.01	5.24	6.19	7.14	8.03	8.70
Jun-Elsie-19-1	1.19	2.13	2.80	3.68	4.35	5.03	5.66	6.13

Jun-Elsie-20	1.19	2.13	2.80	3.68	4.35	5.03	5.66	6.13
Jun-Elsie-20-1	0.52	0.90	1.17	1.52	1.79	2.08	2.35	2.55
Jun-Elsie-21	2.72	4.74	6.18	8.06	9.50	10.95	12.32	13.33
Jun-Elsie-22	2.17	3.69	4.77	6.18	7.26	8.37	9.40	10.17
Jun-L_Forks-01	5.00	9.20	12.08	16.09	19.14	22.21	25.11	27.29
Jun-L_Forks-02	6.59	11.58	14.97	19.65	23.21	26.76	30.05	32.50
Jun-L_Forks-03	6.69	11.54	14.83	19.41	22.78	26.09	29.13	31.39
Jun-L_Forks-04	6.45	11.32	14.50	18.96	22.06	25.03	27.74	29.76
Jun-L_Forks-05	5.07	9.25	12.09	15.38	17.43	19.41	21.24	22.69
Jun-L_Forks-05-1	3.59	6.64	8.63	10.79	12.04	13.23	14.54	15.81
Jun-L_Forks-06	3.08	5.64	7.15	9.05	10.59	12.26	13.86	15.07
Jun-L_Forks-07	1.88	3.44	4.54	5.98	7.07	8.18	9.21	9.98
Jun-L_Wolf-01	6.47	12.25	16.11	21.00	25.37	29.87	34.09	37.24
Jun-L_Wolf-02	6.22	11.95	15.43	20.19	24.50	28.77	32.73	35.66
Jun-L_Wolf-03	5.55	10.57	13.18	17.83	21.41	24.95	28.24	30.68
Jun-L_Wolf-04	3.66	6.87	9.12	12.05	14.28	16.55	18.68	20.26
Jun-L_Wolf-05	2.69	4.70	6.12	7.97	9.39	10.87	12.28	13.34
Jun-L_Wolf-05-1	1.40	2.51	3.28	4.30	5.07	5.86	6.60	7.15
Jun-L_Wolf-05-2	1.29	2.20	2.84	3.72	4.41	5.13	5.80	6.31
Jun-L_Wolf-06	1.08	1.85	2.41	3.13	3.70	4.29	4.84	5.26
Jun-L_Wolf-07	1.09	1.84	2.37	3.12	3.71	4.32	4.90	5.33
Jun-Mill-01	14.43	28.25	39.50	55.15	68.14	81.57	93.98	103.31
Jun-Mill-02	14.45	28.77	40.89	57.40	70.19	83.33	95.64	104.85
Jun-Mill-02-1	9.34	18.03	25.03	34.54	41.99	49.67	56.89	62.26
Jun-Mill-03	9.55	18.36	25.25	34.70	42.05	49.61	56.68	61.93
Jun-Mill-04	9.72	18.51	25.29	34.47	41.51	48.68	55.33	60.24
Jun-Mill-04-1	8.27	15.33	20.58	27.54	32.85	38.25	43.30	47.06
Jun-Mill-04-2	3.21	5.67	7.39	9.65	11.37	13.14	14.80	16.04
Jun-Mill-05	8.38	14.89	19.77	26.01	30.76	35.62	40.15	43.51
Jun-Mill-05-1	1.26	2.28	3.02	4.03	4.79	5.58	6.31	6.85
Jun-Mill-05-2	7.18	12.70	16.81	22.08	26.09	30.17	33.98	36.80
Jun-Mill-06	1.02	1.81	2.36	3.08	3.63	4.19	4.72	5.11
Jun-Mill-07	2.31	4.02	5.22	6.81	8.05	9.32	10.52	11.41
Jun-Mill-08	1.48	2.50	3.22	4.20	4.98	5.78	6.54	7.10
Jun-Mill-09	0.94	1.55	2.03	2.68	3.17	3.68	4.16	4.51
Jun-Mill-10	6.84	11.98	15.77	20.62	24.31	28.06	31.58	34.19
Jun-Mill-10-1	4.20	7.13	9.21	11.92	14.00	16.13	18.08	19.53
Jun-Mill-10-2	2.77	5.01	6.71	8.87	10.52	12.20	13.76	14.93
Jun-Mill-11	3.92	6.58	8.44	10.85	12.73	14.67	16.43	17.74
Jun-Mill-11-1	2.36	3.99	5.12	6.58	7.69	8.84	9.90	10.69
Jun-Mill-12	2.02	3.41	4.37	5.62	6.56	7.54	8.46	9.16
Jun-Mill-13	0.21	0.35	0.45	0.58	0.67	0.78	0.88	0.96
Jun-Mill-14	1.51	2.60	3.35	4.34	5.09	5.85	6.58	7.12
Jun-Mill-15	1.41	2.37	3.05	3.95	4.64	5.34	6.01	6.51
Jun-Mill-16	2.57	4.57	6.00	7.89	9.33	10.79	12.14	13.16
Jun-Mill-17	2.12	3.77	4.93	6.44	7.59	8.75	9.84	10.65
Jun-Mill-18	1.11	2.01	2.65	3.49	4.12	4.77	5.38	5.83

Jun-Mill-19	0.93	1.68	2.20	2.89	3.41	3.93	4.42	4.79
Jun-Moores-01	7.53	14.47	19.52	26.19	31.32	36.57	41.49	45.24
Jun-Moores-02	7.41	14.11	18.91	25.19	30.01	34.90	39.48	42.93
Jun-Moores-02-1	6.30	11.81	15.74	20.89	24.84	28.86	32.61	35.46
Jun-Moores-03	6.03	11.18	14.84	19.62	23.29	27.02	30.50	33.16
Jun-Moores-04	5.47	10.07	13.29	17.49	20.71	23.99	27.03	29.29
Jun-Moores-05	4.00	7.22	9.47	12.40	14.65	16.93	19.06	20.64
Jun-Moores-05-1	2.90	5.27	6.94	9.12	10.80	12.49	14.07	15.24
Jun-Moores-05-2	1.20	2.09	2.72	3.54	4.16	4.79	5.37	5.81
Jun-Moores-06	2.88	5.22	6.87	9.03	10.68	12.35	13.91	15.06
Jun-Moores-06-1	2.06	3.72	4.91	6.48	7.68	8.90	10.04	10.88
Jun-Moores-07	1.65	2.88	3.75	4.87	5.73	6.60	7.43	8.06
Jun-Moores-08	1.57	2.73	3.54	4.61	5.42	6.25	7.03	7.60
Jun-Moores-09	1.07	1.81	2.34	3.02	3.55	4.09	4.60	4.98
Jun-Trib_1-01	8.33	14.62	18.78	24.67	29.17	33.78	38.11	41.36
Jun-Trib_1-02	7.89	13.20	16.88	21.96	25.95	30.11	34.01	36.95
Jun-Trib_1-03	1.54	2.40	2.99	3.78	4.38	4.99	5.56	5.99
Jun-Trib_1-04	0.44	0.73	0.95	1.23	1.45	1.67	1.88	2.03
Jun-Trib_1-05	6.00	10.09	13.00	16.90	20.01	23.22	26.24	28.50
Jun-Trib_1-06	0.20	0.29	0.36	0.44	0.51	0.58	0.64	0.69
Jun-Trib_1-07	5.58	9.37	12.04	15.67	18.58	21.59	24.41	26.54
Jun-Trib_1-08	0.15	0.22	0.27	0.34	0.39	0.44	0.49	0.52
Jun-Trib_1-09	5.06	8.52	10.96	14.26	16.93	19.67	22.26	24.20
Jun-Trib_1-09-1	3.77	6.34	8.17	10.62	12.62	14.64	16.56	17.99
Jun-Trib_1-09-2	1.30	2.18	2.81	3.72	4.43	5.16	5.84	6.36
Jun-Trib_1-10	3.57	5.97	7.65	9.95	11.82	13.73	15.54	16.89
Jun-Trib_1-11	3.12	5.22	6.69	8.69	10.34	12.02	13.60	14.79
Jun-Trib_1-11-1	2.05	3.40	4.38	5.80	6.92	8.05	9.12	9.91
Jun-Trib_1-12	1.31	2.16	2.84	3.77	4.48	5.21	5.90	6.42
Jun-Trib_2-01	6.98	11.36	14.47	18.54	21.67	24.88	27.89	30.09
Jun-Trib_2-02	6.67	10.68	13.55	17.35	20.28	23.29	26.12	28.23
Jun-Trib_2-03	6.41	10.22	12.95	16.58	19.38	22.25	24.94	26.95
Jun-Trib_2-03-1	1.41	2.35	3.03	3.98	4.71	5.47	6.19	6.73
Jun-Trib_2-03-2	5.04	7.89	9.92	12.60	14.67	16.78	18.76	20.24
Jun-Trib_2-04	3.34	4.97	6.10	7.58	8.71	9.86	10.93	11.72
Jun-Trib_2-05	2.08	3.09	3.79	4.71	5.41	6.12	6.79	7.28
Jun-Trib_2-06	1.01	1.69	2.18	2.88	3.42	3.98	4.50	4.90
Jun-Trib_3-01	3.08	5.19	6.71	8.81	10.46	12.17	13.78	15.00
Jun-Trib_3-02	2.73	4.59	5.91	7.78	9.26	10.79	12.23	13.31
Jun-Trib_3-03	2.19	3.68	4.73	6.25	7.44	8.67	9.83	10.70
Jun-Trib_3-03-1	1.20	2.01	2.59	3.42	4.07	4.75	5.38	5.86
Jun-Trib_3-04	0.71	1.18	1.52	2.01	2.39	2.78	3.15	3.43
Jun-Trib_4-01	3.07	5.66	7.58	10.11	12.07	14.08	15.96	17.35
Jun-Trib_4-02	2.48	4.59	6.11	8.11	9.64	11.19	12.65	13.72
Jun-Trib_4-02-1	2.06	3.75	4.96	6.58	7.83	9.10	10.29	11.17
Jun-Trib_4-03	2.01	3.64	4.81	6.34	7.51	8.71	9.82	10.65
Jun-Trib_5-01	1.65	3.00	4.02	5.43	6.58	7.71	8.76	9.53

Jun-Trib_5-02	1.42	2.63	3.51	4.70	5.65	6.61	7.51	8.17
Jun-Trib_5-02-1	0.22	0.38	0.50	0.66	0.77	0.89	1.00	1.09
Jun-Trib_5-02-2	1.32	2.45	3.26	4.35	5.20	6.08	6.89	7.50
Jun-Trib_5-03	0.16	0.29	0.37	0.49	0.58	0.66	0.75	0.82
Jun-Trib_5-04	1.11	2.05	2.72	3.58	4.25	4.92	5.54	6.01
Jun-Trib_5-04-1	0.59	1.12	1.49	1.99	2.36	2.74	3.10	3.36
Jun-Trib_6-01	3.40	6.12	8.22	10.95	13.04	15.15	17.21	18.69
Jun-Trib_6-02	2.91	5.34	7.04	9.38	11.16	12.96	14.62	15.85
Jun-Trib_6-03	2.55	4.61	6.04	7.91	9.34	10.78	12.12	13.12
Jun-Trib_6-03-1	1.06	1.93	2.55	3.36	3.97	4.59	5.16	5.59
Jun-Trib_6-03-2	1.50	2.69	3.51	4.58	5.38	6.20	6.97	7.54
Jun-Trib_6-04	0.67	1.20	1.57	2.05	2.42	2.80	3.16	3.42
Jun-Trib_6-04-1	0.22	0.42	0.55	0.74	0.88	1.03	1.16	1.26
Jun-Trib_6-05	0.20	0.37	0.48	0.63	0.74	0.85	0.96	1.04
Jun-Trib_6-06	0.87	1.58	2.07	2.71	3.19	3.68	4.14	4.48
Jun-Trib_6-07	0.40	0.74	0.98	1.28	1.51	1.74	1.96	2.12
Jun-Trib_6-08	0.32	0.58	0.76	1.00	1.17	1.35	1.52	1.64
Jun-Trib_6-09	0.21	0.38	0.50	0.65	0.76	0.88	0.98	1.07
Jun-Trib_7-01	5.54	9.97	13.00	17.17	20.41	23.76	26.93	29.24
Jun-Trib_7-02	5.47	9.83	12.80	16.87	20.00	23.28	26.33	28.58
Jun-Trib_7-02-1	3.88	7.03	9.21	12.19	14.48	16.89	19.09	20.73
Jun-Trib_7-02-2	1.64	2.86	3.73	4.87	5.74	6.63	7.46	8.08
Jun-Trib_7-03	3.35	6.08	7.99	10.59	12.58	14.67	16.57	17.98
Jun-Trib_7-04	3.10	5.49	7.20	9.47	11.24	13.09	14.79	16.06
Jun-Trib_7-05	2.99	5.29	6.93	9.09	10.74	12.42	13.99	15.15
Jun-Trib_7-06	2.64	4.69	6.14	8.04	9.48	10.95	12.32	13.34
Jun-Trib_7-07	0.68	1.17	1.52	1.97	2.32	2.68	3.01	3.25
Jun-Trib_8-01	3.27	5.96	7.74	10.19	12.08	14.00	15.84	17.28
Jun-Trib_8-02	2.47	4.43	5.80	7.69	9.20	10.75	12.25	13.34
Jun-Trib_8-03	1.76	3.21	4.33	5.82	6.92	8.02	9.04	9.79
Jun-Trib_8-04	1.38	2.69	3.61	4.78	5.63	6.49	7.30	7.89
Jun-Trib_8-05	0.33	0.66	0.90	1.20	1.43	1.66	1.87	2.03
Jun-Trib_9-01	3.29	6.12	8.22	11.06	13.26	15.50	17.60	19.14
Jun-Trib_9-02	3.18	5.91	7.89	10.52	12.55	14.59	16.49	17.89
Jun-Trib_9-03	2.39	4.50	6.02	8.07	9.64	11.22	12.67	13.75
Jun-Trib_9-03-1	1.06	2.08	2.84	3.90	4.69	5.48	6.21	6.75
Jun-Trib_9-03-2	1.51	2.61	3.38	4.39	5.17	5.95	6.69	7.24
Jun-Trib_9-04	1.01	1.84	2.43	3.23	3.84	4.46	5.03	5.45
Jun-Trib_9-05	0.90	1.65	2.16	2.83	3.33	3.84	4.34	4.72
Jun-Trib_9-06	0.18	0.31	0.41	0.55	0.65	0.75	0.85	0.92
Jun-Trib_9-07	0.14	0.24	0.32	0.41	0.49	0.56	0.63	0.68
Jun-Wilson-01	3.06	5.96	8.14	10.92	13.14	15.42	17.55	19.14
Jun-Wilson-02	2.90	5.76	7.79	10.45	12.54	14.66	16.65	18.12
Jun-Wilson-03	2.32	4.53	6.04	8.10	9.67	11.27	12.76	13.87
Jun-Wilson-04	1.65	3.17	4.26	5.70	6.79	7.90	8.94	9.71
Jun-Wilson-05	1.31	2.45	3.26	4.30	5.10	5.90	6.65	7.20
Jun-Wolf-01	13.44	25.20	33.88	45.45	54.81	64.14	73.28	80.03

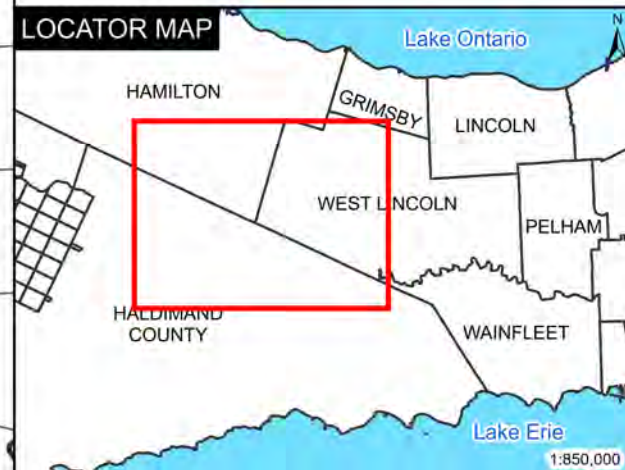
Jun-Wolf-02	13.41	25.09	33.62	44.94	54.08	63.54	72.47	79.14
Jun-Wolf-03	13.89	25.73	34.14	45.06	54.01	63.27	71.97	78.46
Jun-Wolf-03-1	7.47	13.49	18.04	24.26	29.06	33.95	38.53	41.93
Jun-Wolf-04	7.32	12.95	17.05	22.56	26.78	31.08	35.10	38.10
Jun-Wolf-05	7.21	12.52	16.29	21.25	25.03	28.89	32.51	35.21
Jun-Wolf-06	5.74	9.92	12.87	16.75	19.73	22.79	25.68	27.84
Jun-Wolf-07	4.25	7.29	9.44	12.38	14.68	17.04	19.27	20.94
Jun-Wolf-07-1	2.25	3.98	5.16	6.73	7.96	9.23	10.43	11.33
Jun-Wolf-07-2	2.00	3.32	4.31	5.67	6.73	7.82	8.85	9.62
Jun-Wolf-08	1.70	2.90	3.74	4.92	5.83	6.77	7.66	8.33
Jun-Wolf-09	1.43	2.41	3.09	4.08	4.85	5.65	6.40	6.96
Jun-Wolf-10	1.70	2.82	3.65	4.81	5.71	6.64	7.51	8.16
Jun-W_Wolf-01	7.03	13.15	18.08	25.09	30.71	36.54	42.04	46.17
Jun-W_Wolf-02	7.11	13.24	18.20	25.21	30.77	36.48	41.85	45.86
Jun-W_Wolf-03	7.48	13.27	18.40	25.49	31.05	36.73	42.00	45.90
Jun-W_Wolf-03-1	2.08	3.68	4.80	6.28	7.41	8.56	9.64	10.44
Jun-W_Wolf-03-2	6.07	11.31	15.46	21.07	25.40	29.82	33.95	37.03
Jun-W_Wolf-04	1.81	3.18	4.15	5.43	6.40	7.39	8.32	9.01
Jun-W_Wolf-05	1.44	2.45	3.18	4.13	4.87	5.62	6.33	6.86
Jun-W_Wolf-06	6.00	11.34	15.43	20.89	25.02	29.21	33.13	36.05
Jun-W_Wolf-07	5.76	11.12	14.89	19.77	23.45	27.18	30.66	33.26
Jun-W_Wolf-07-1	2.58	4.31	5.56	7.27	8.57	9.91	11.17	12.12
Jun-W_Wolf-07-2	3.79	7.10	9.52	12.64	15.01	17.42	19.67	21.34
Jun-W_Wolf-08	2.11	3.55	4.55	5.92	6.97	8.06	9.08	9.85
Jun-W_Wolf-09	1.68	2.82	3.62	4.69	5.53	6.40	7.22	7.84
Jun-W_Wolf-10	3.68	6.56	8.62	11.30	13.35	15.44	17.40	18.87
Jun-W_Wolf-11	2.85	5.07	6.61	8.64	10.20	11.80	13.31	14.44
Jun-W_Wolf-11-1	1.00	1.69	2.18	2.83	3.33	3.85	4.33	4.69
Jun-W_Wolf-11-2	1.92	3.40	4.44	5.81	6.87	7.96	8.98	9.75
Jun-W_Wolf-12	1.50	2.59	3.36	4.37	5.18	6.01	6.79	7.37
Jun-W_Wolf-13	1.33	2.24	2.89	3.77	4.47	5.19	5.88	6.39

APPENDIX D – HIGH-RESOLUTION FIGURES

Legend

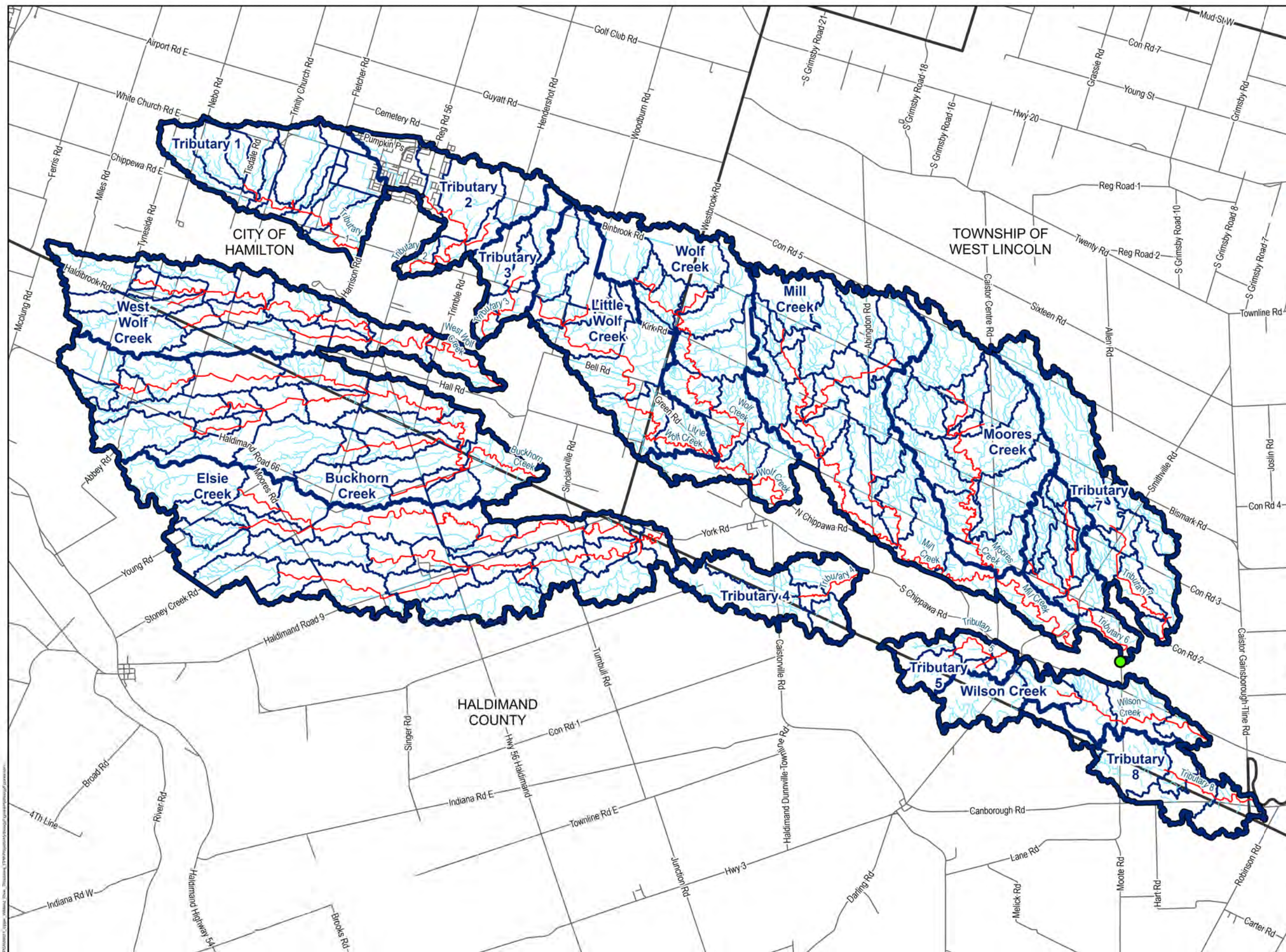
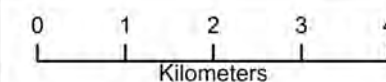
-  Municipal Boundaries
-  Watershed
-  Drainage Basin
-  Model Subbasins
-  Road Centerlines
-  Watercourses to be Mapped
-  Other Watercourses
-  WSC Flow Gauge

LOCATOR MAP



Drainage Network

Date: 2026-07-28
Projection: NAD83 CSRS UTM Zone 17N
Data Source: LPRCA, OMNRF, LIO
Created by: A.V.

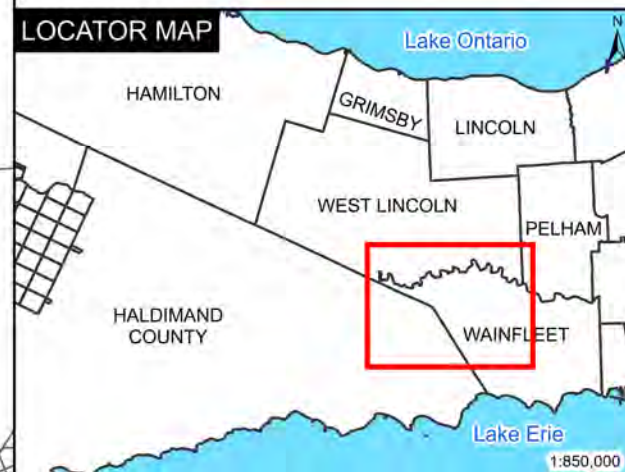


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Legend

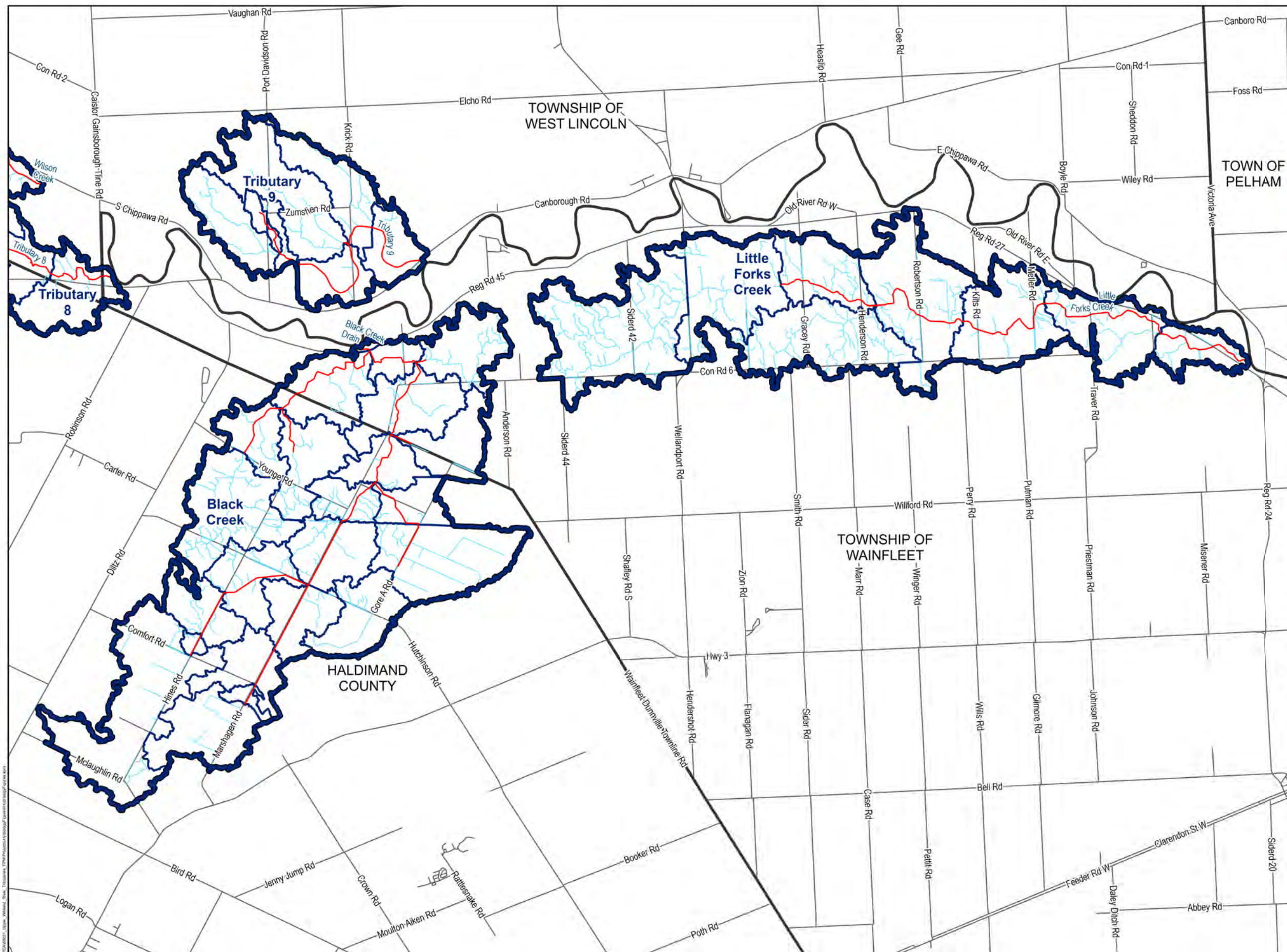
-  Municipal Boundaries
-  Watershed
-  Drainage Basin
-  Model Subbasins
-  Road Centerlines
-  Watercourses to be Mapped
-  Other Watercourses
-  WSC Flow Gauge

LOCATOR MAP



Drainage Network

Date: 2026-07-28
 Projection: NAD83 CSRS UTM Zone 17N
 Data Source: LPRCA, OMNRF, LIO
 Created by: A.V.

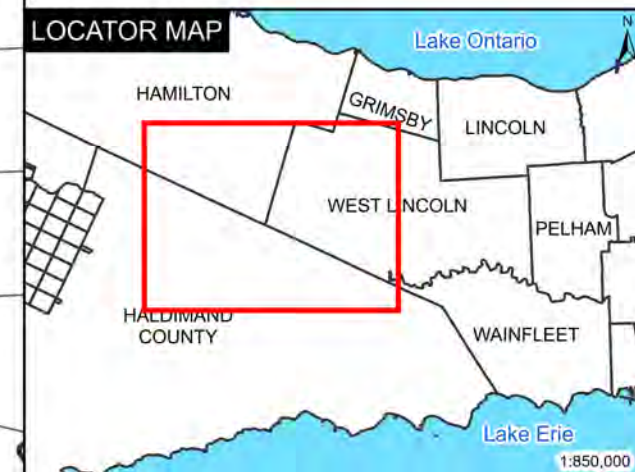


This project is funded [in part] by the Government of Canada.
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Legend

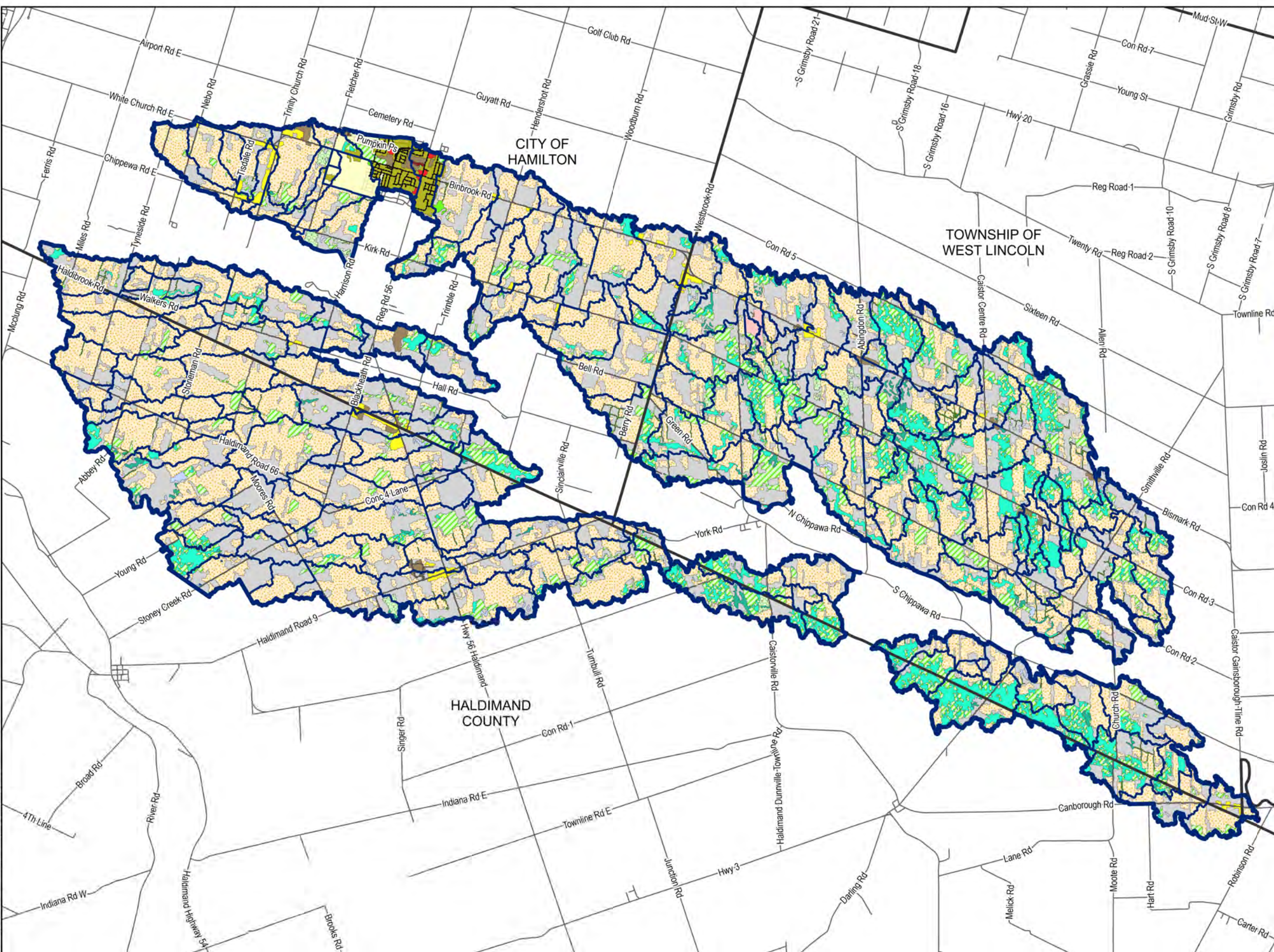
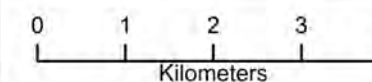
	Municipal Boundaries		Mixed Forest
	Watershed		Forest
	Subbasins		Meadow
	Road Centerlines		Hedge Rows
SOLRIS Land Use Classification:			
	Transportation - Urban		Gravel
	Transportation		Impervious Area - Connected
	Built-Up Area - Impervious - Urban		Impervious Area - Disconnected
	Built-Up Area - Impervious		Treed Swamp
	Built-Up Area - New Dev		Thicket Swamp
	Built-Up Area - Pervious		Marsh
	Coniferous Forest		Open Water
	Deciduous Forest		Plantations - Tree Cultivated
			Tilled
			Undifferentiated

LOCATOR MAP

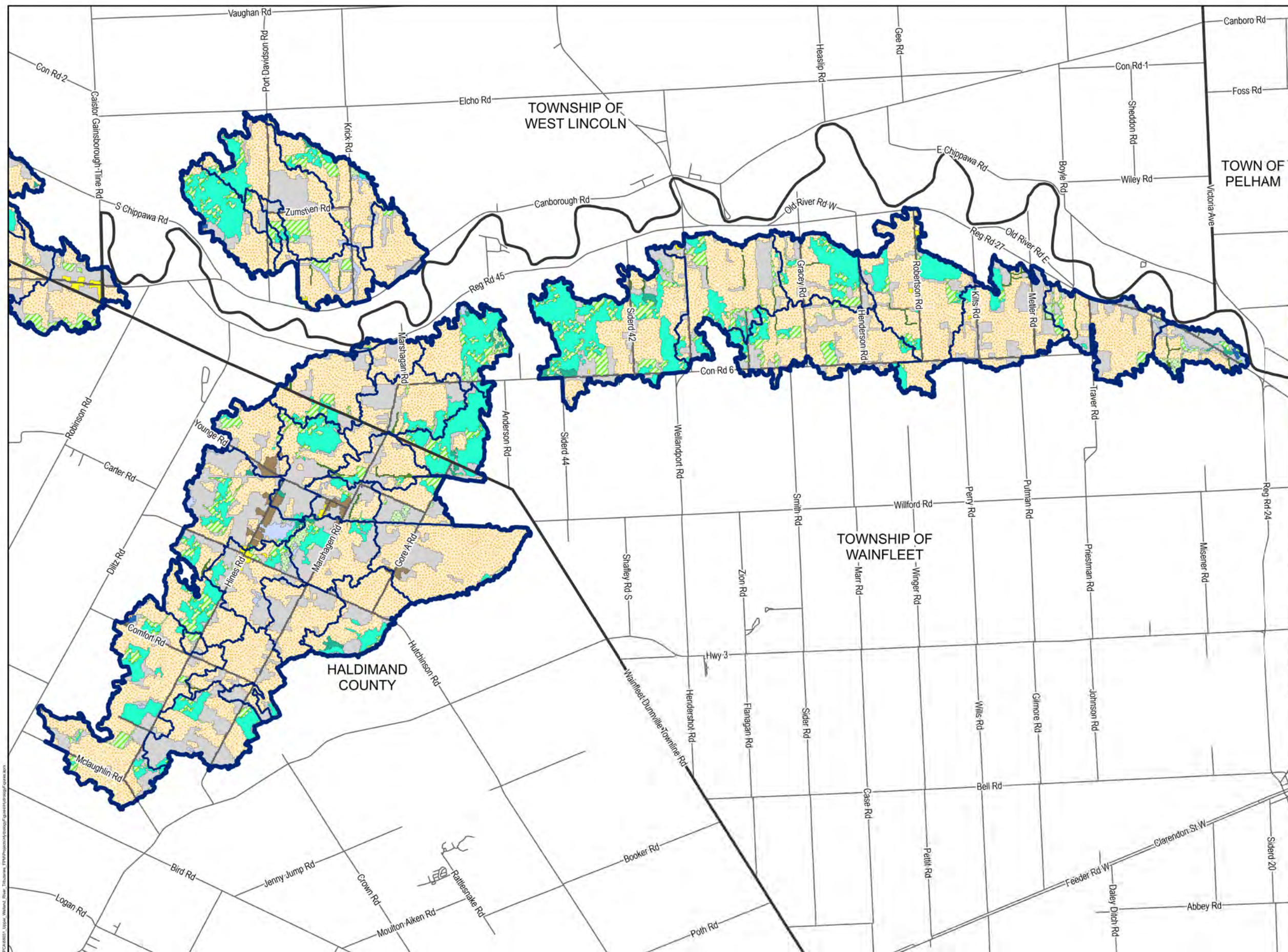


Future Land Use

Date: 2026-07-28
 Projection: NAD83 CSRS UTM Zone 17N
 Data Source: LPRCA, OMNRF, LIO
 Created by: A.V.

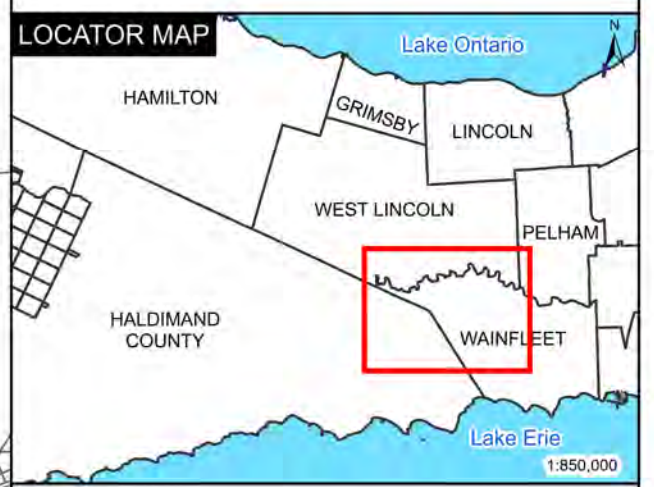


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Legend

Municipal Boundaries	Mixed Forest
Watershed	Forest
Subbasins	Meadow
Road Centerlines	Hedge Rows
SOLRIS Land Use Classification:	
Transportation - Urban	Gravel
Transportation	Impervious Area - Connected
Built-Up Area - Impervious - Urban	Impervious Area - Disconnected
Built-Up Area - Impervious	Treed Swamp
Built-Up Area - New Dev	Thicket Swamp
Built-Up Area - Pervious	Marsh
Coniferous Forest	Open Water
Deciduous Forest	Plantations - Tree Cultivated
	Tilled
	Undifferentiated



Future Land Use

Date: 2026-07-28
Projection: NAD83 CSRS UTM Zone 17N
Data Source: LPRCA, OMNRF, LIO
Created by: A.V.

0 1 2 3
Kilometers

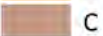
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Legend

-  Municipal Boundaries
-  Watershed
-  Subbasins
-  Road Centerlines

Hydrologic Soil Groups:

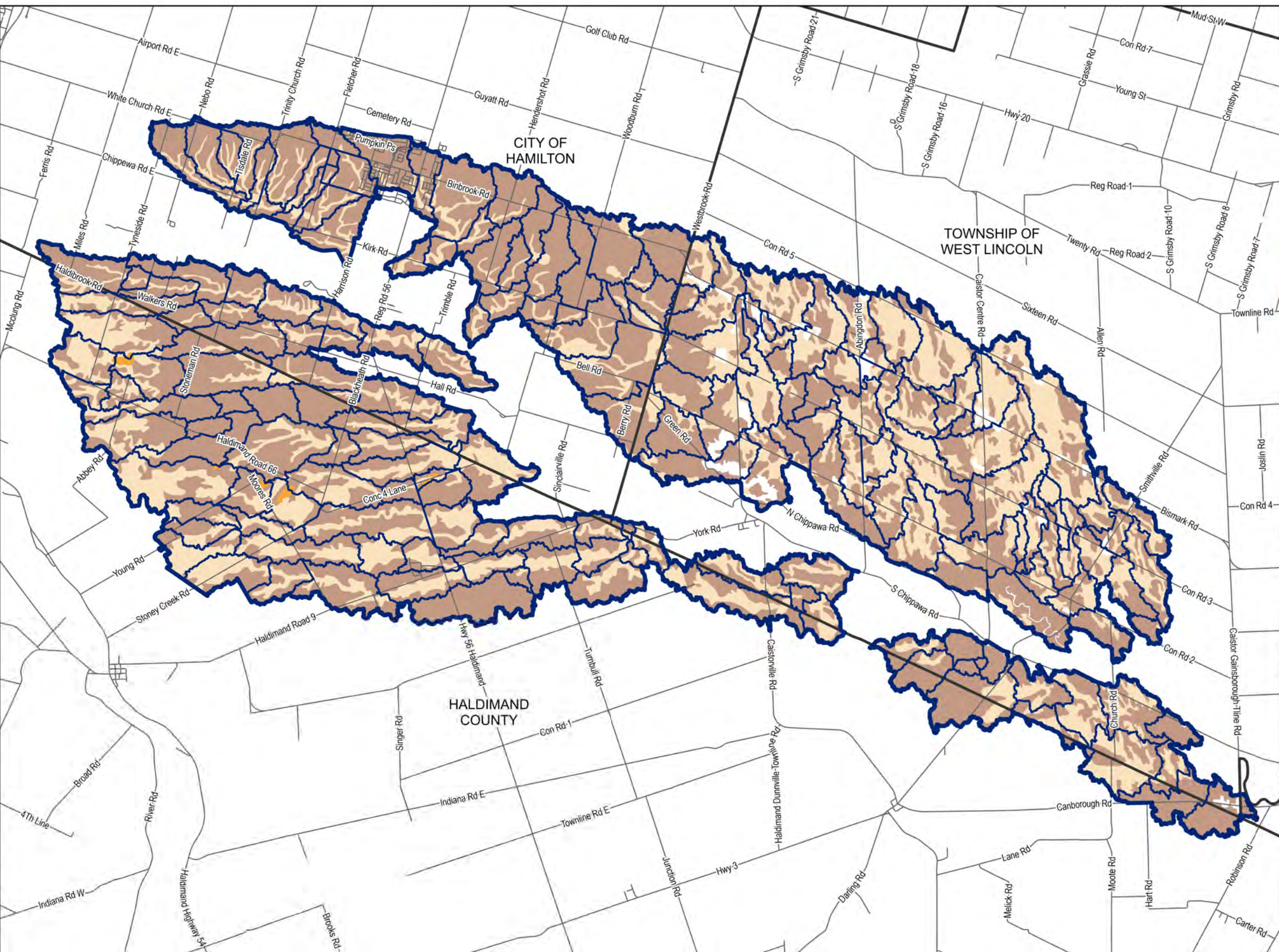
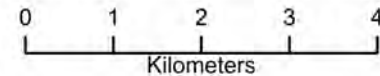
-  A
-  B
-  C
-  D

LOCATOR MAP



Distribution of Hydrologic Soil Groups

Date: 2026-07-28
 Projection: NAD83 CSRS UTM Zone 17N
 Data Source: LPRCA, OMNRF, LIO
 Created by: A.V.



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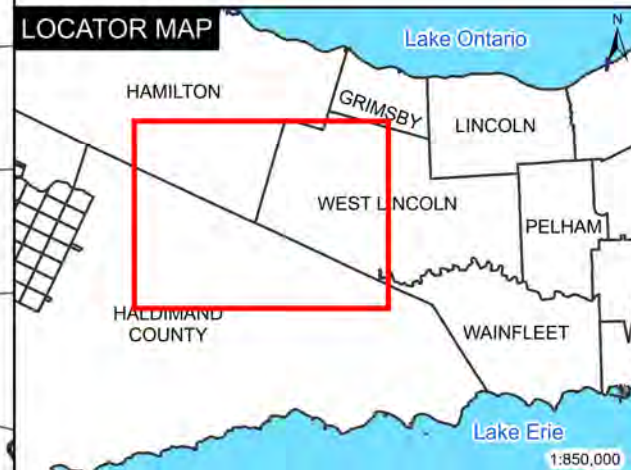
Legend

-  Municipal Boundaries
-  Watershed
-  Subbasins
-  Road Centerlines

Surficial Geology:

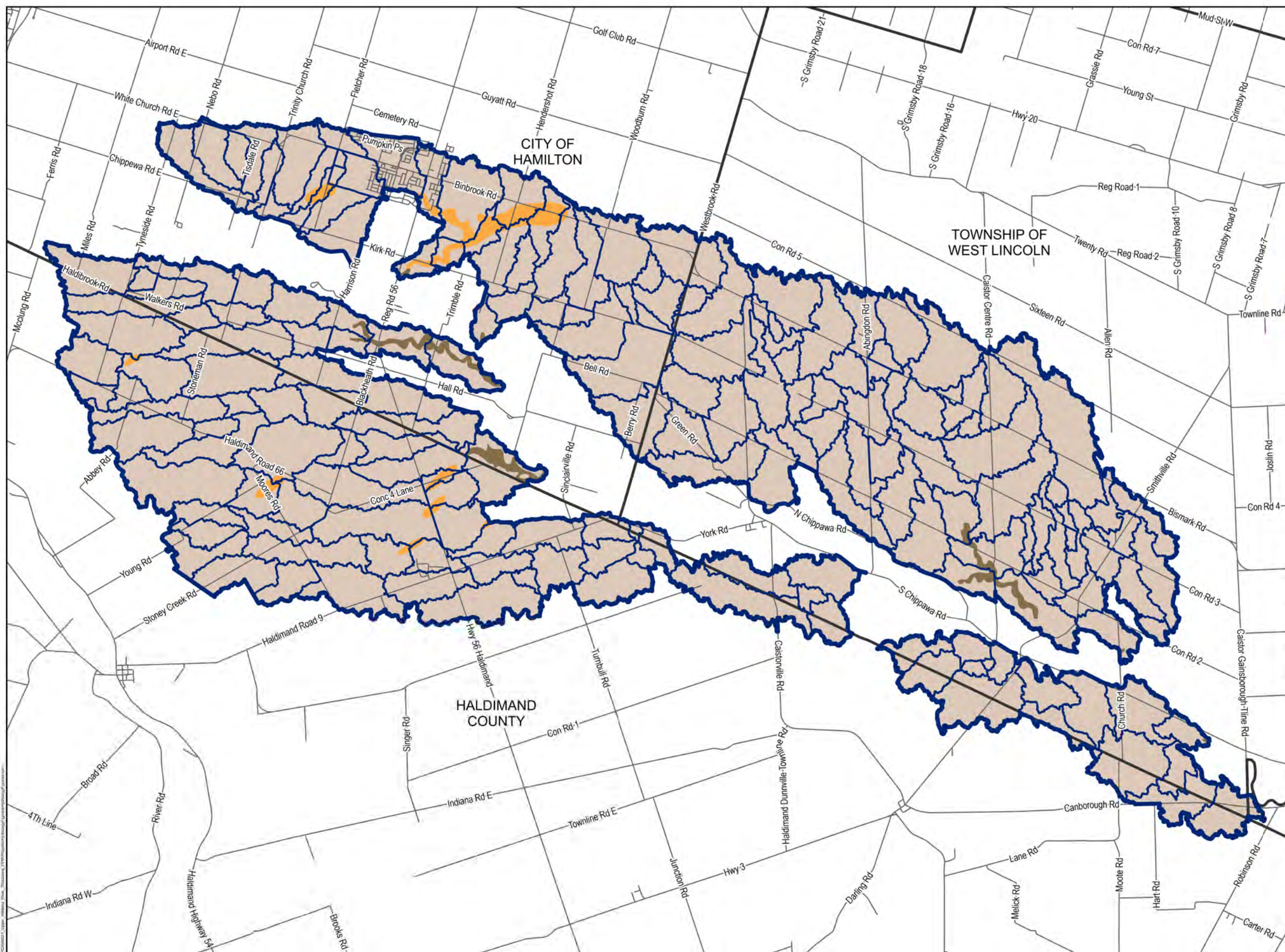
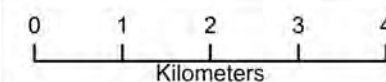
-  Coarse-Textured Glaciolacustrine Deposits
-  Fine-Textured Glaciolacustrine Deposits
-  Eolian deposits
-  Modern Alluvial Deposits
-  Till

LOCATOR MAP



Surficial Geology

Date: 2026-07-28
 Projection: NAD83 CSRS UTM Zone 17N
 Data Source: LPRCA, OMNRF, LIO
 Created by: A.V.



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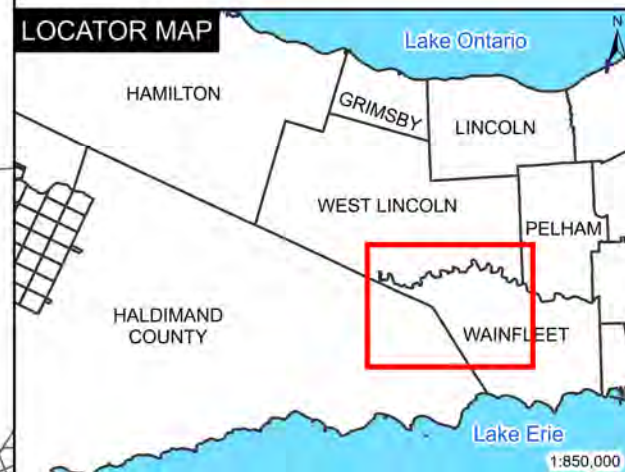
Legend

-  Municipal Boundaries
-  Watershed
-  Subbasins
-  Road Centerlines

Surficial Geology:

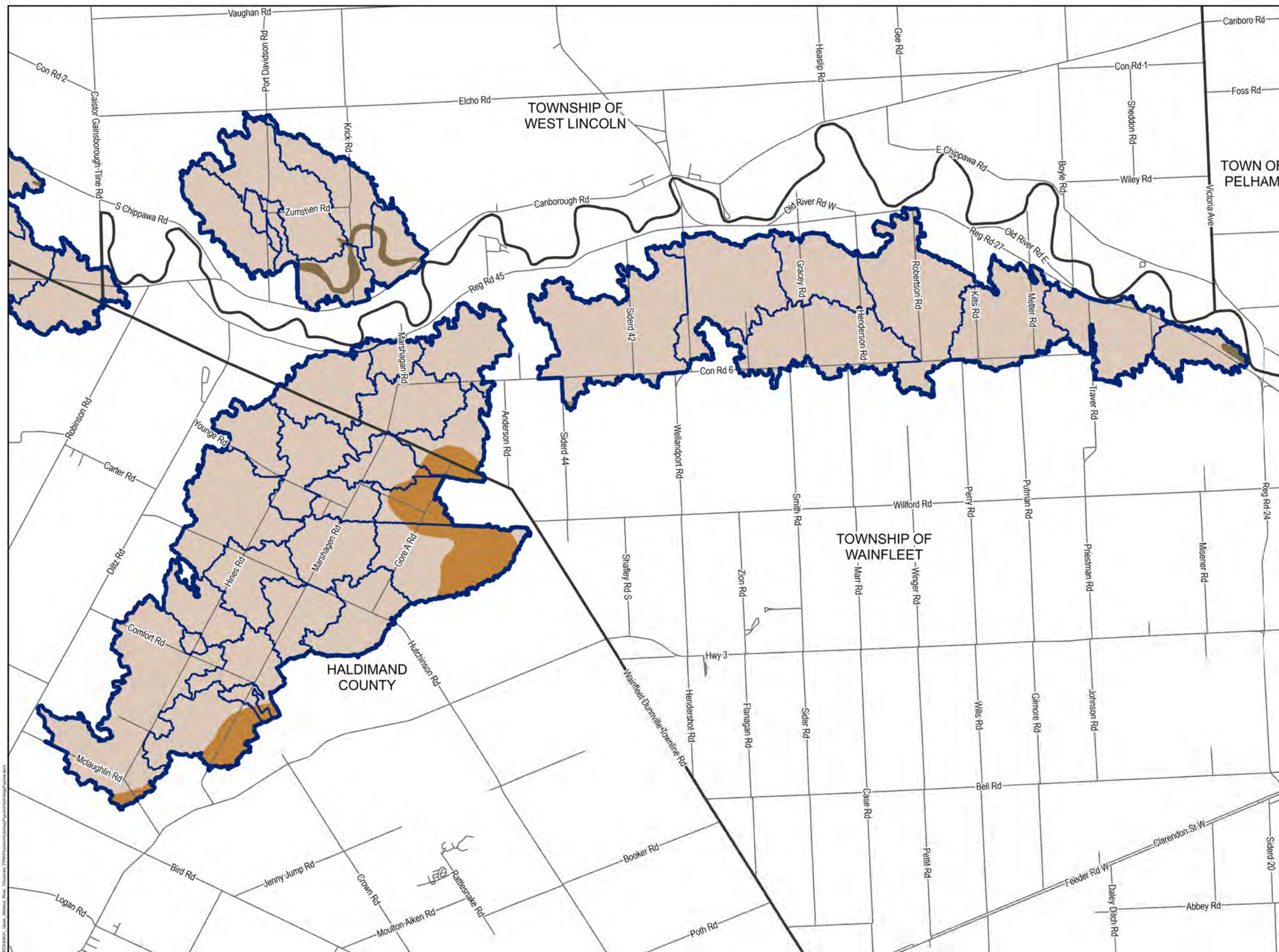
-  Coarse-Textured Glaciolacustrine Deposits
-  Fine-Textured Glaciolacustrine Deposits
-  Eolian deposits
-  Modern Alluvial Deposits
-  Till

LOCATOR MAP



Surficial Geology

Date: 2026-07-28
Projection: NAD83 CSRS UTM Zone 17N
Data Source: LPRCA, OMNRF, LIO
Created by: A.V.



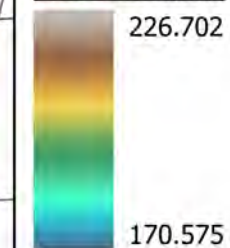
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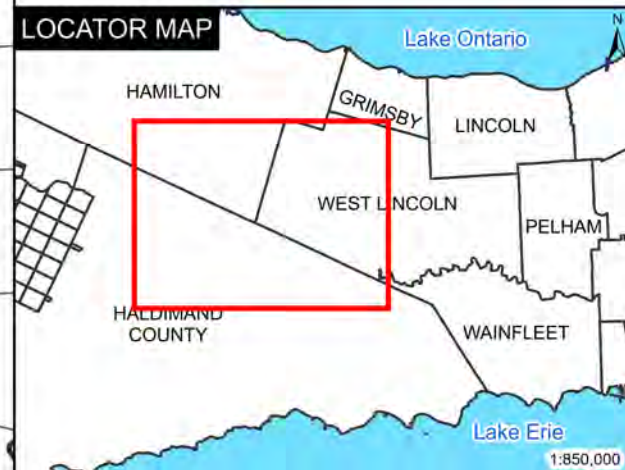
Legend

-  Municipal Boundaries
-  Watershed
-  Subbasins
-  Road Centerlines
-  Ontario Lidar Project Extents
-  Overlapping Ontario Lidar Project Extents

Elevation (m):

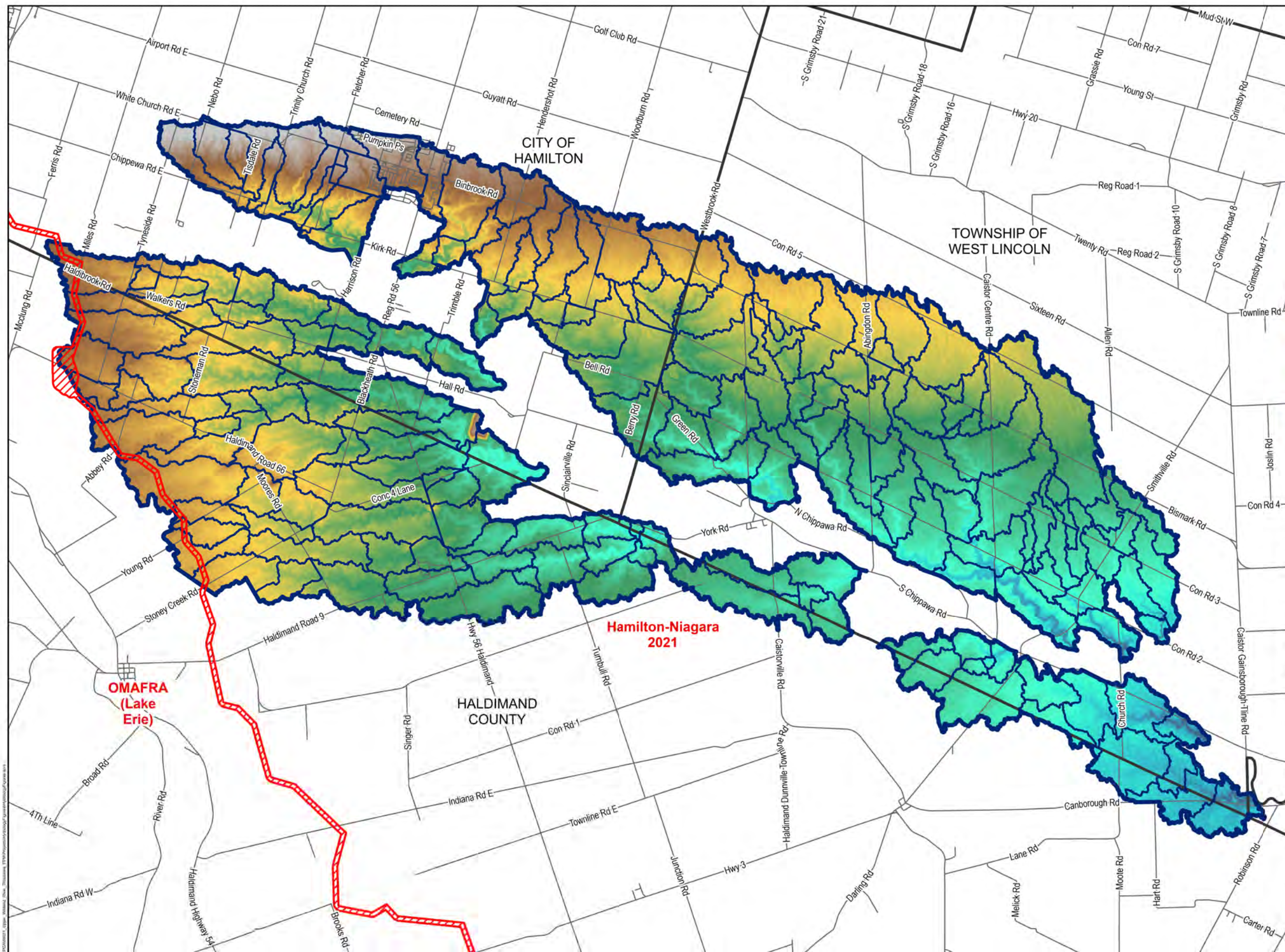
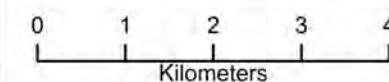


LOCATOR MAP



DTM Extents

Date: 2026-07-28
 Projection: NAD83 CSRS UTM Zone 17N/CGVD2013
 Data Source: LPRCA, OMNRF, LIO
 Created by: A.V.



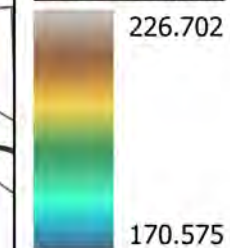
This project is funded [in part] by the Government of Canada.

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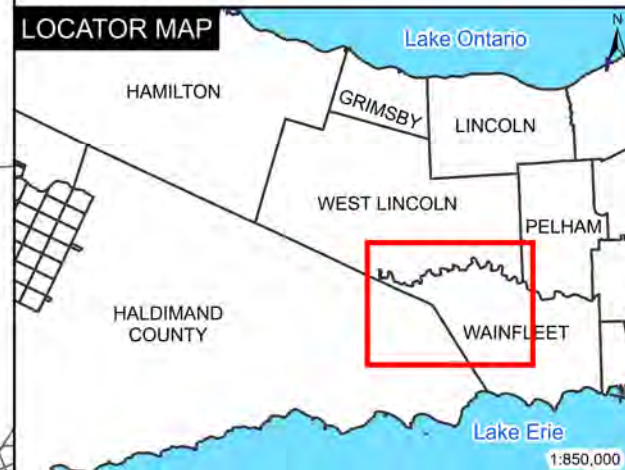
Legend

-  Municipal Boundaries
-  Watershed
-  Subbasins
-  Road Centerlines
-  Ontario Lidar Project Extents
-  Overlapping Ontario Lidar Project Extents

Elevation (m):

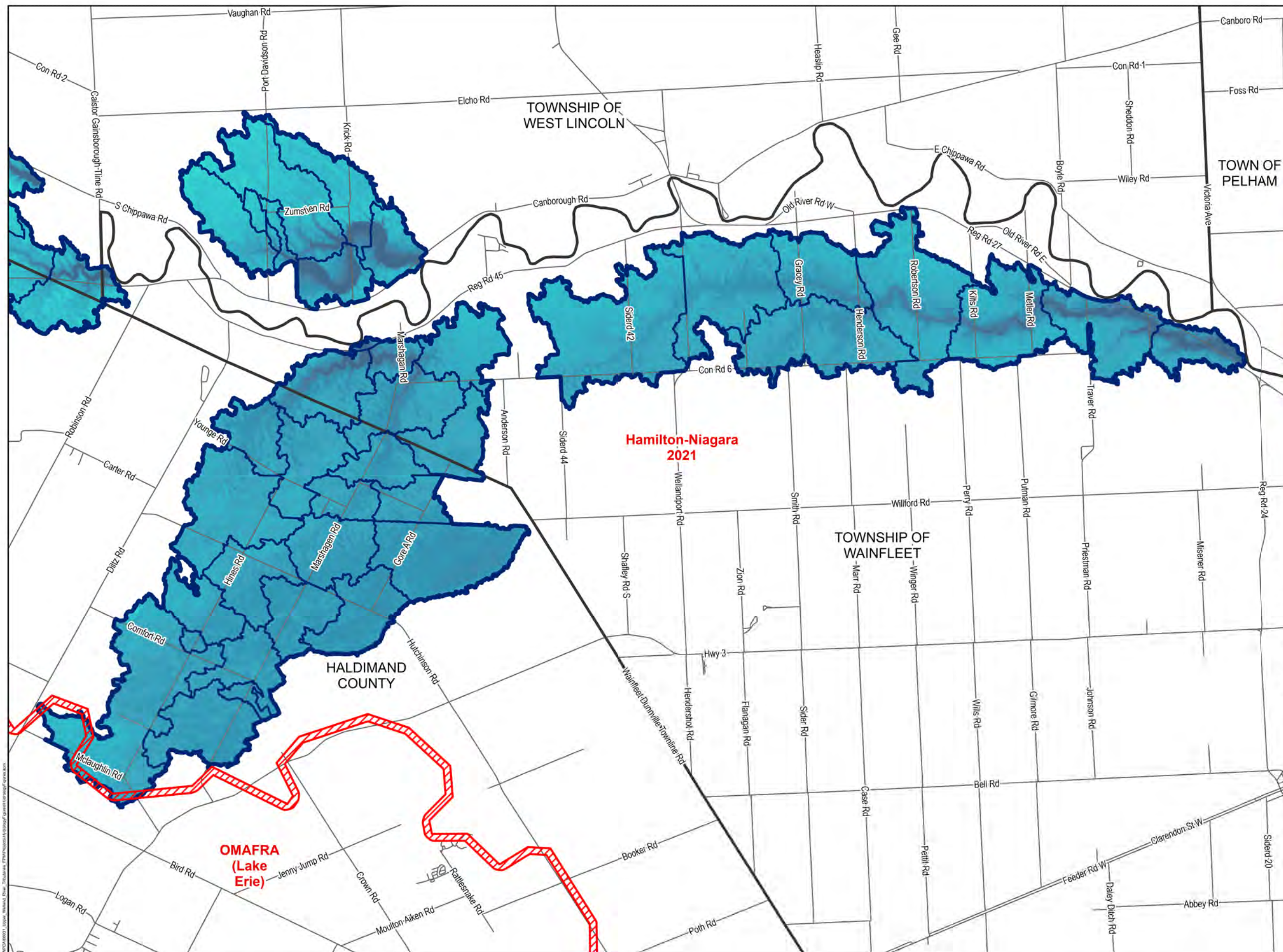


LOCATOR MAP



DTM Extents

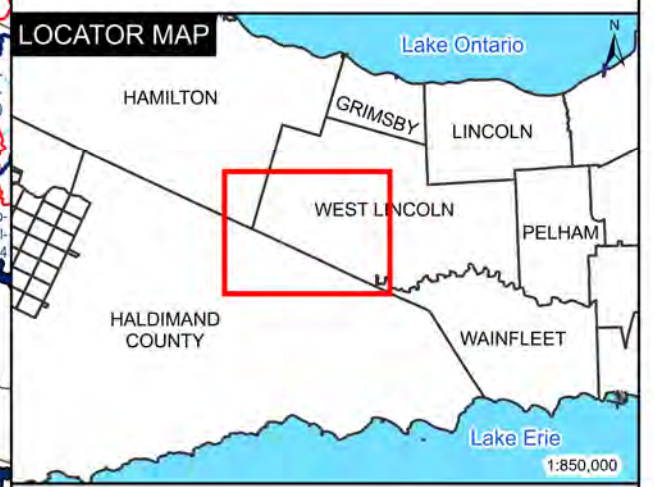
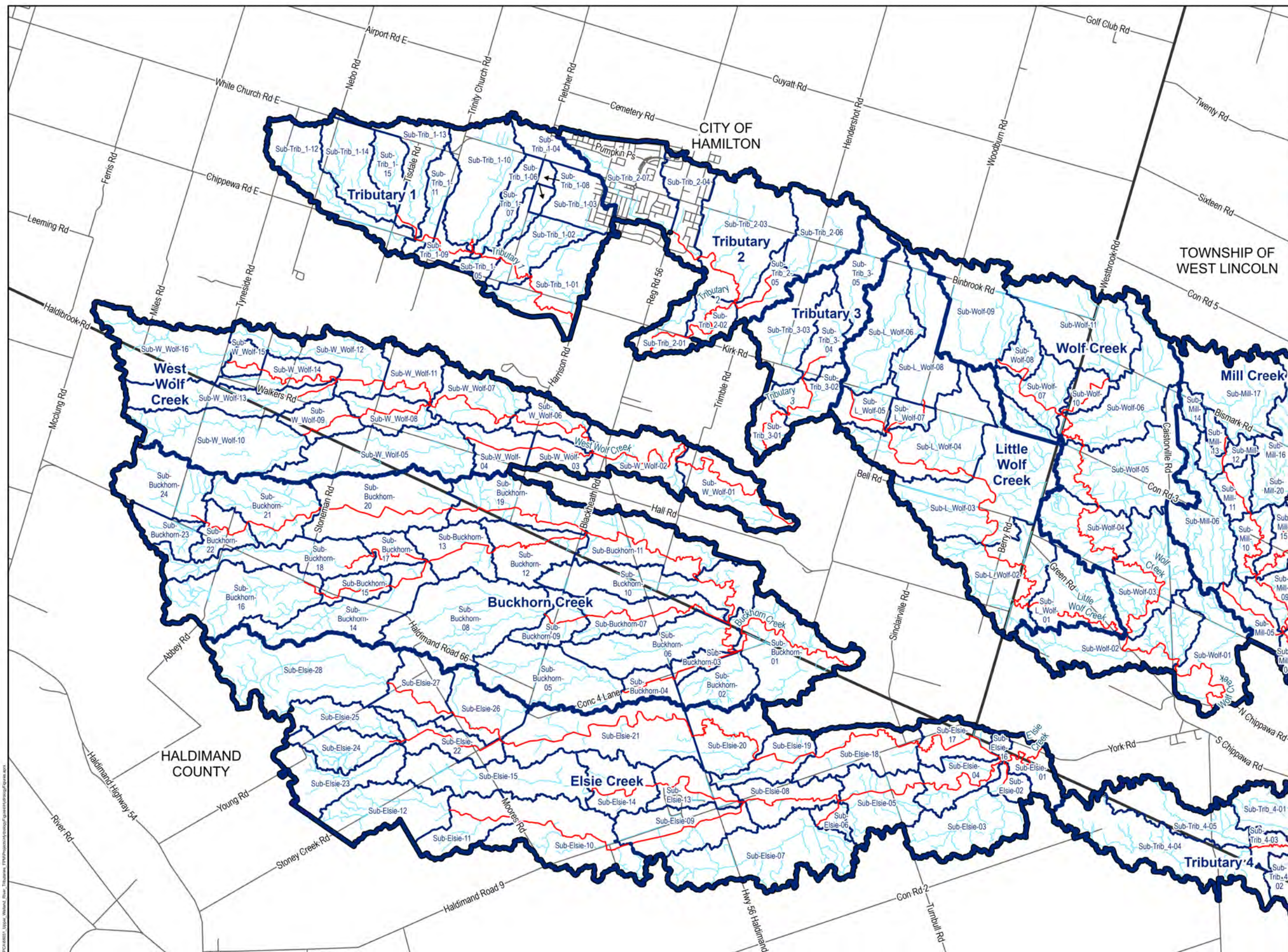
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 Data Source: LPRCA, OMNRF, LIO
 Created by: A.V.



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 This project was made possible in part by the Province of Ontario.

Legend

-  Municipal Boundaries
-  Watershed
-  Drainage Basin
-  Model Subbasins
-  Road Centerlines
-  Watercourses to be Mapped
-  Other Watercourses



HEC-HMS Subbasins

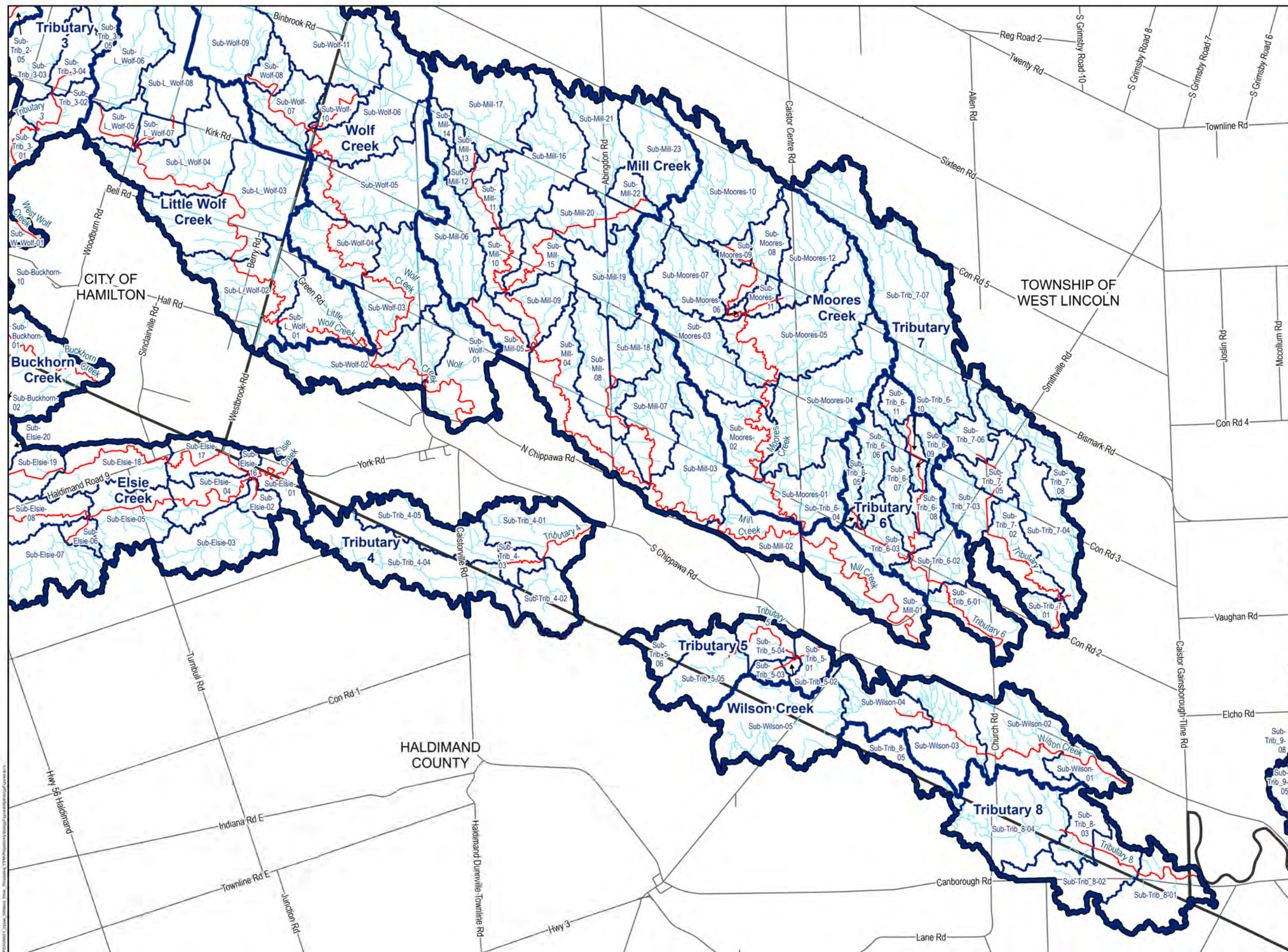
Date: 2026-07-28
 Projection: NAD83 CSRS UTM Zone 17N
 Data Source: LPRCA, OMNRF, LIO
 Created by: A.V.

0 1 2 3
 Kilometers

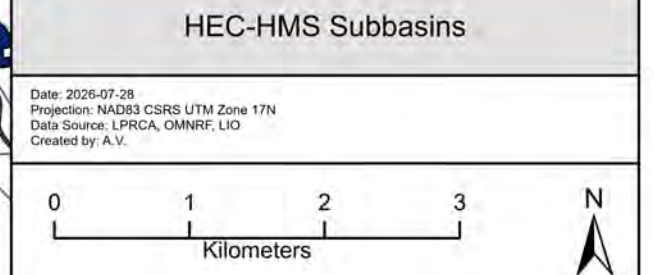
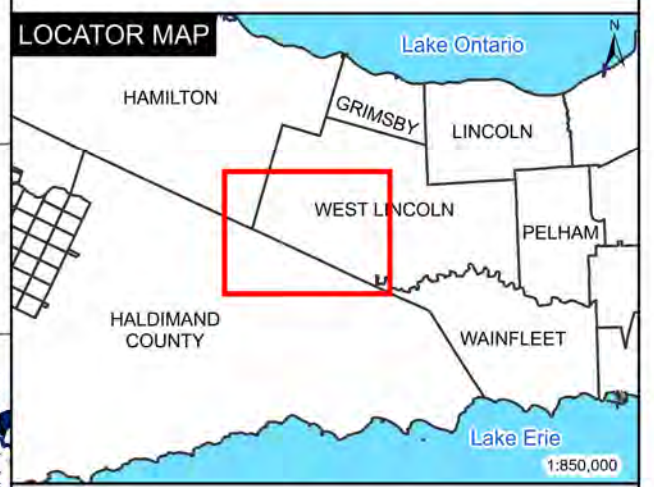
N

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- Legend**
- Municipal Boundaries
 - Watershed
 - Drainage Basin
 - Model Subbasins
 - Road Centerlines
 - Watercourses to be Mapped
 - Other Watercourses



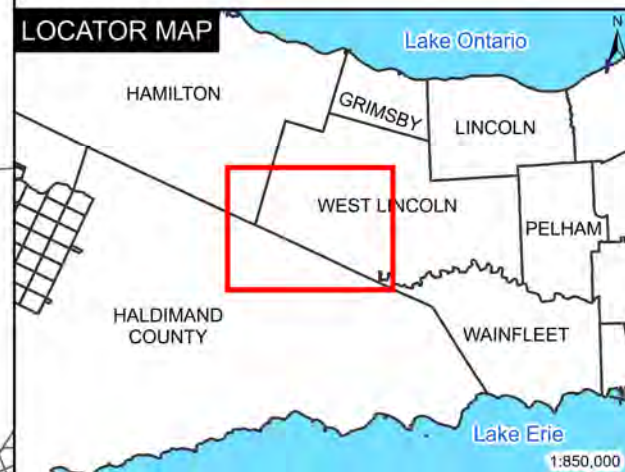
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Legend

-  Municipal Boundaries
-  Watershed
-  Drainage Basin
-  Model Subbasins
-  Road Centerlines
-  Watercourses to be Mapped
-  Other Watercourses

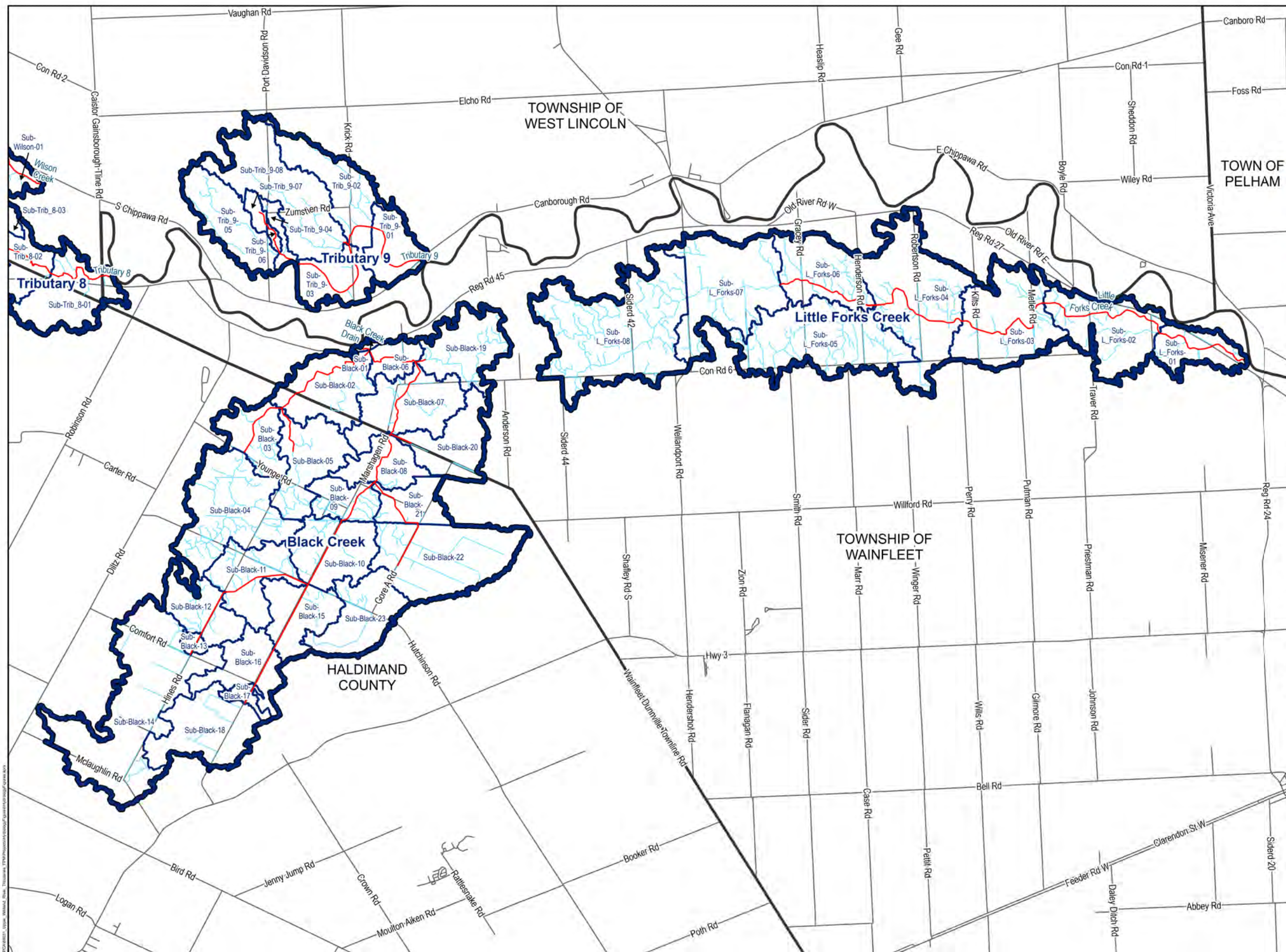
LOCATOR MAP



HEC-HMS Subbasins

Date: 2026-07-28
Projection: NAD83 CSRS UTM Zone 17N
Data Source: LPRCA, OMNRF, LIO
Created by: A.V.

0 1 2 3
Kilometers

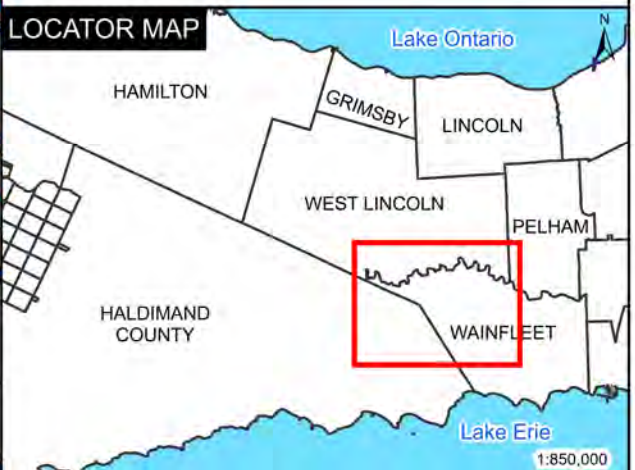


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Legend

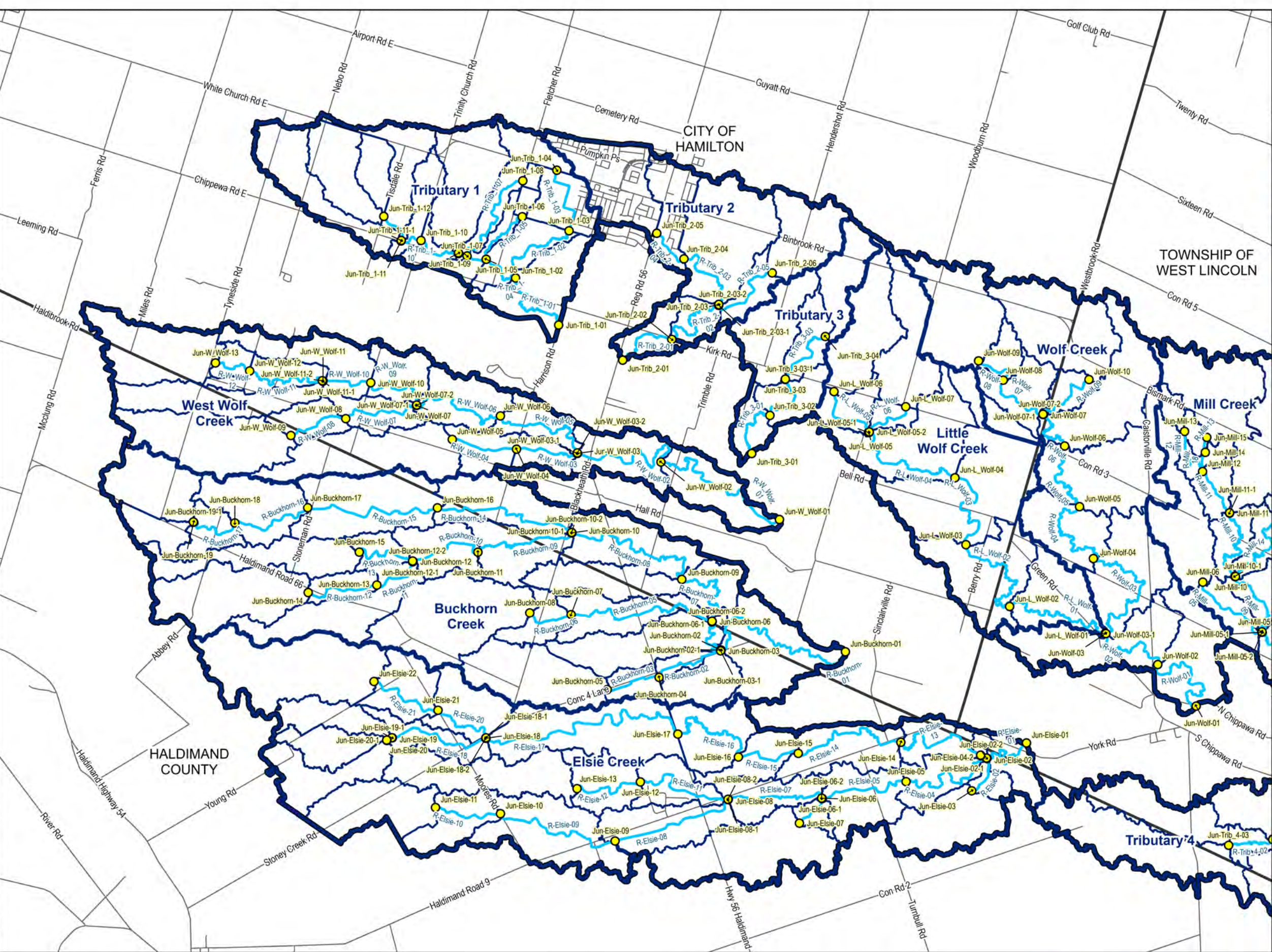
-  Municipal Boundaries
-  Watershed
-  Drainage Basin
-  Model Subbasins
-  Road Centerlines
-  Model Flow Nodes
-  Model Reaches

LOCATOR MAP

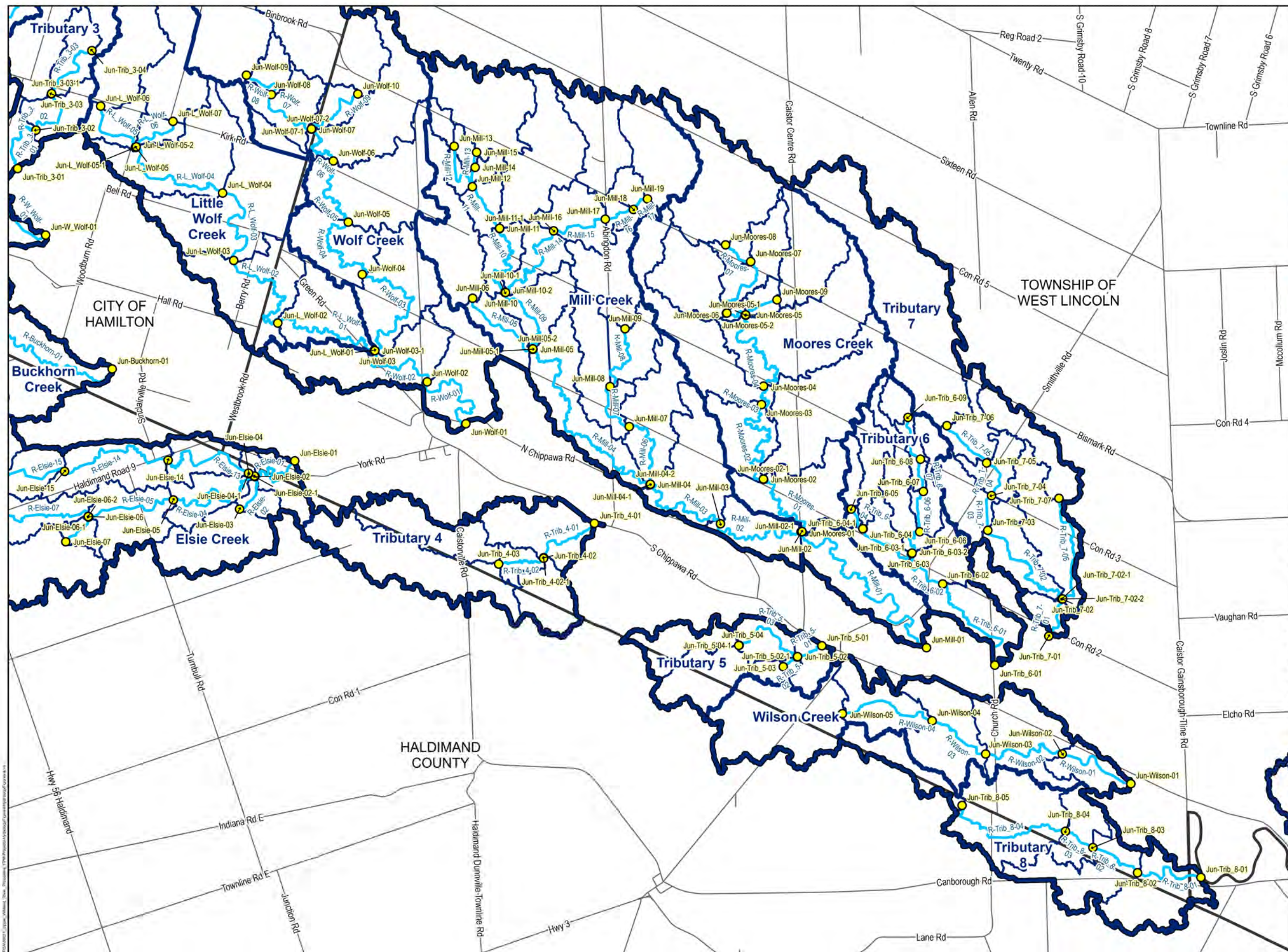


HEC-HMS Reaches and Junctions

Date: 2026-07-28
Projection: NAD83 CSRS UTM Zone 17N
Data Source: LPRCA, OMNRF, LIO
Created by: A.V.

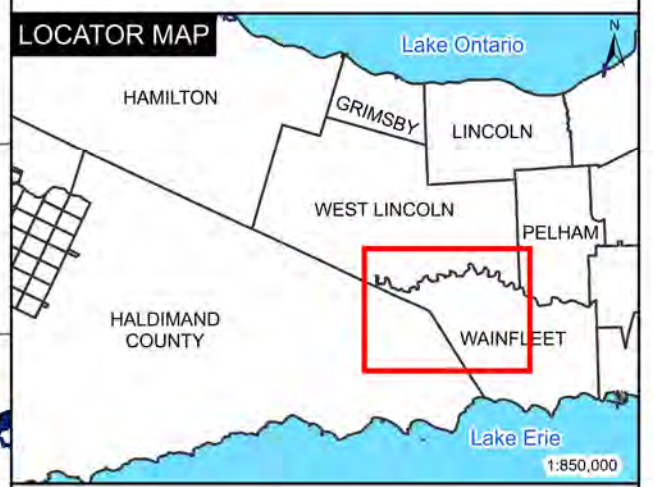


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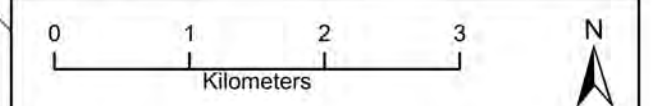
Legend

- Municipal Boundaries
- Watershed
- Drainage Basin
- Model Subbasins
- Road Centerlines
- Model Flow Nodes
- Model Reaches

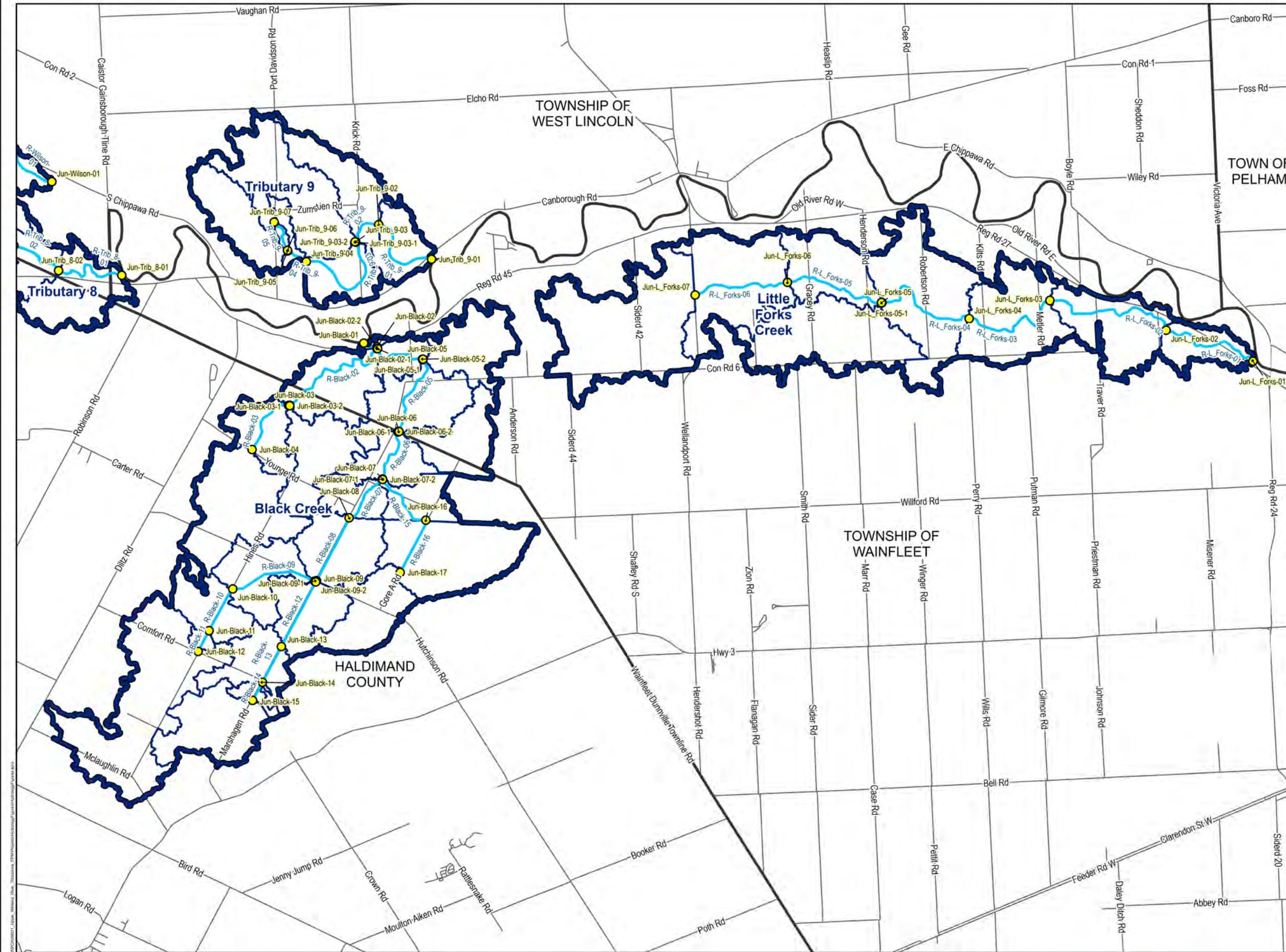


HEC-HMS Reaches and Junctions

Date: 2026-07-28
Projection: NAD83 CSRS UTM Zone 17N
Data Source: LPRCA, OMNRF, LIO
Created by: A.V.



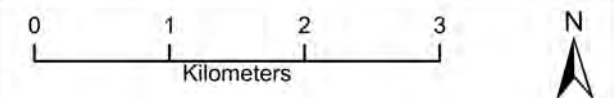
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- Municipal Boundaries
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Date: 2026-07-28
Projection: NAD83 CSRS UTM Zone 17N
Data Source: LPRCA, OMNRF, LIO
Created by: A.V.



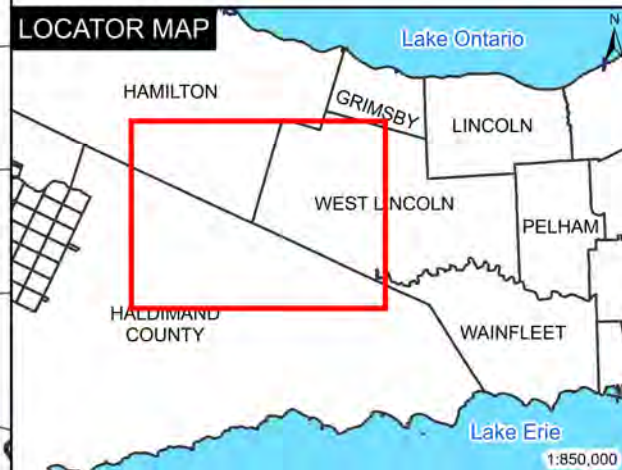
This project was made possible in part by the Province of Ontario.



Legend

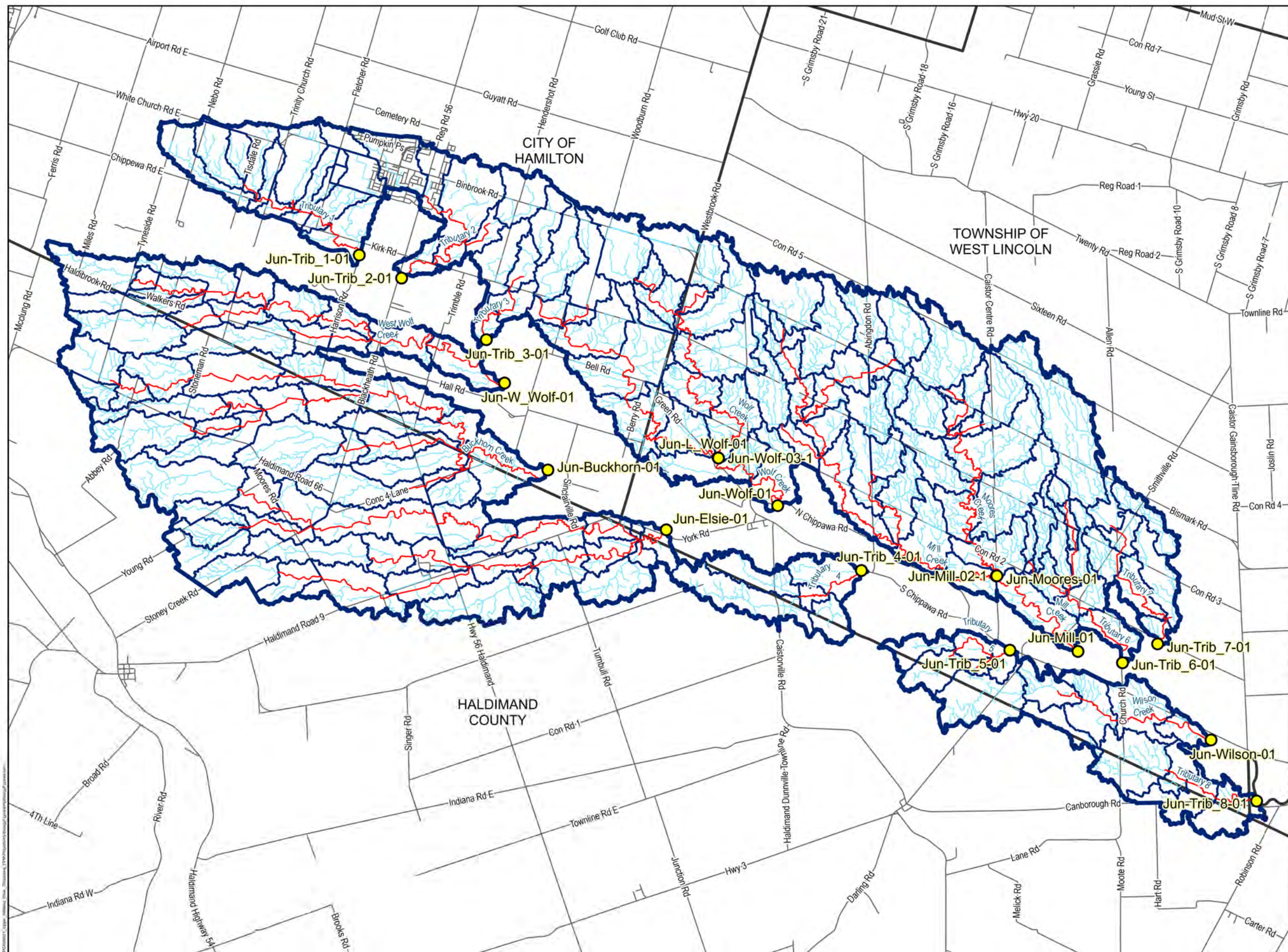
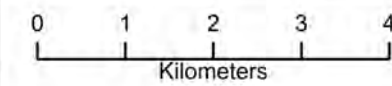
-  Municipal Boundaries
-  Watershed
-  Watercourses to be Mapped
-  Subbasins
-  Other Watercourses
-  Road Centerlines
-  Key Flow Junctions

LOCATOR MAP



Key Flow Junction Locations

Date: 2026-07-28
 Projection: NAD83 CSRS UTM Zone 17N
 Data Source: LPRCA, OMNRF, LIO
 Created by: A.V.

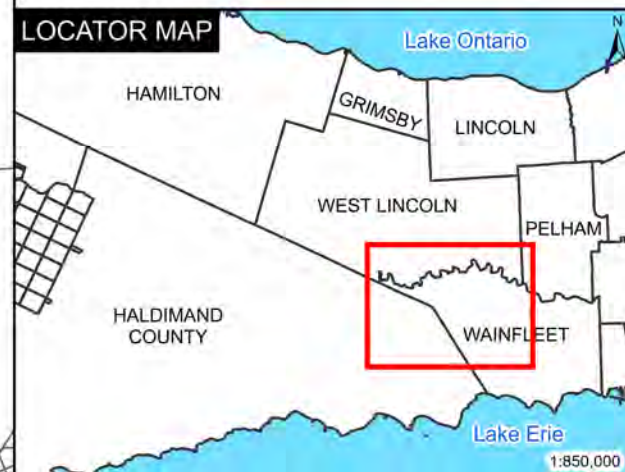


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Legend

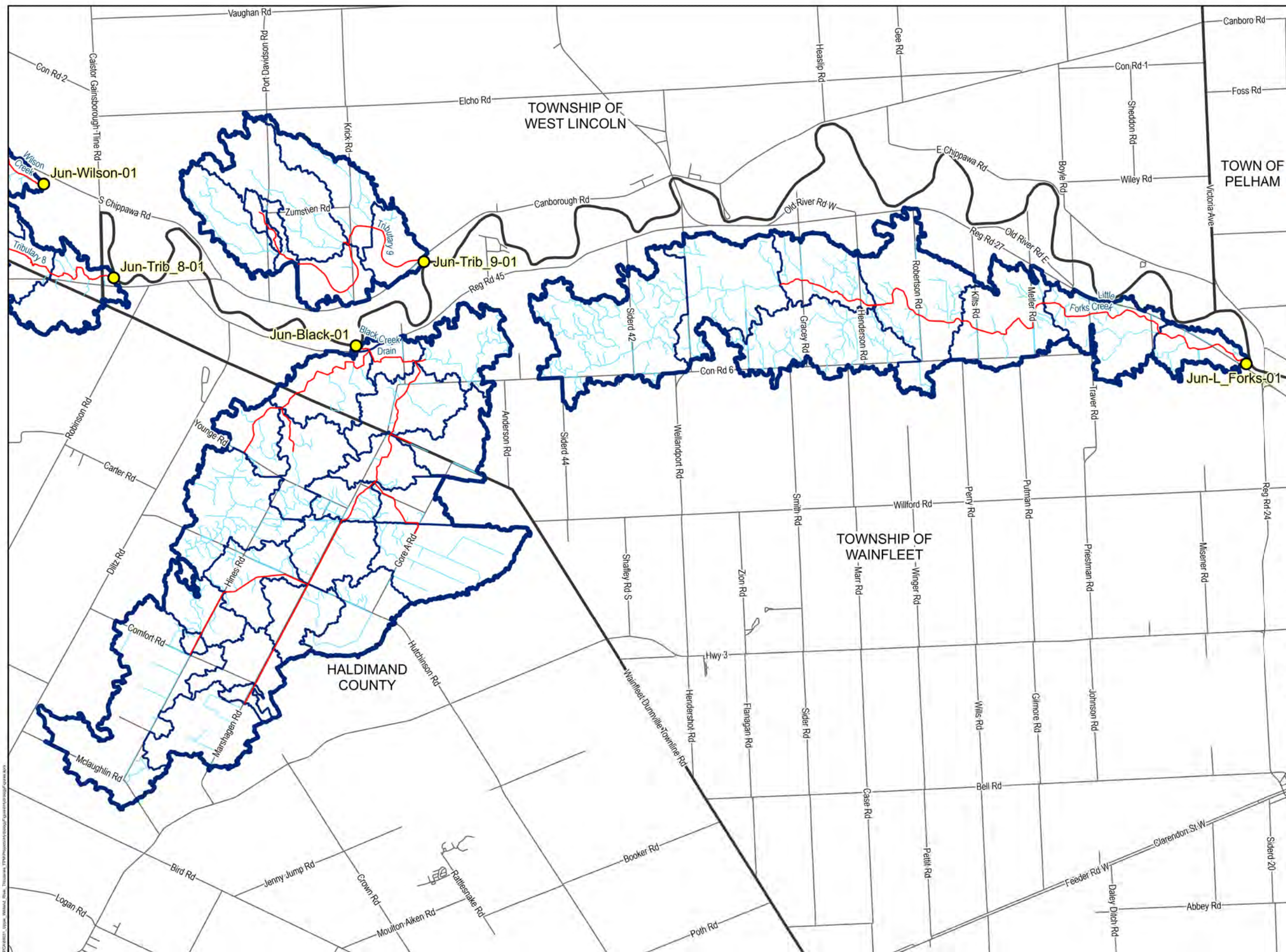
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