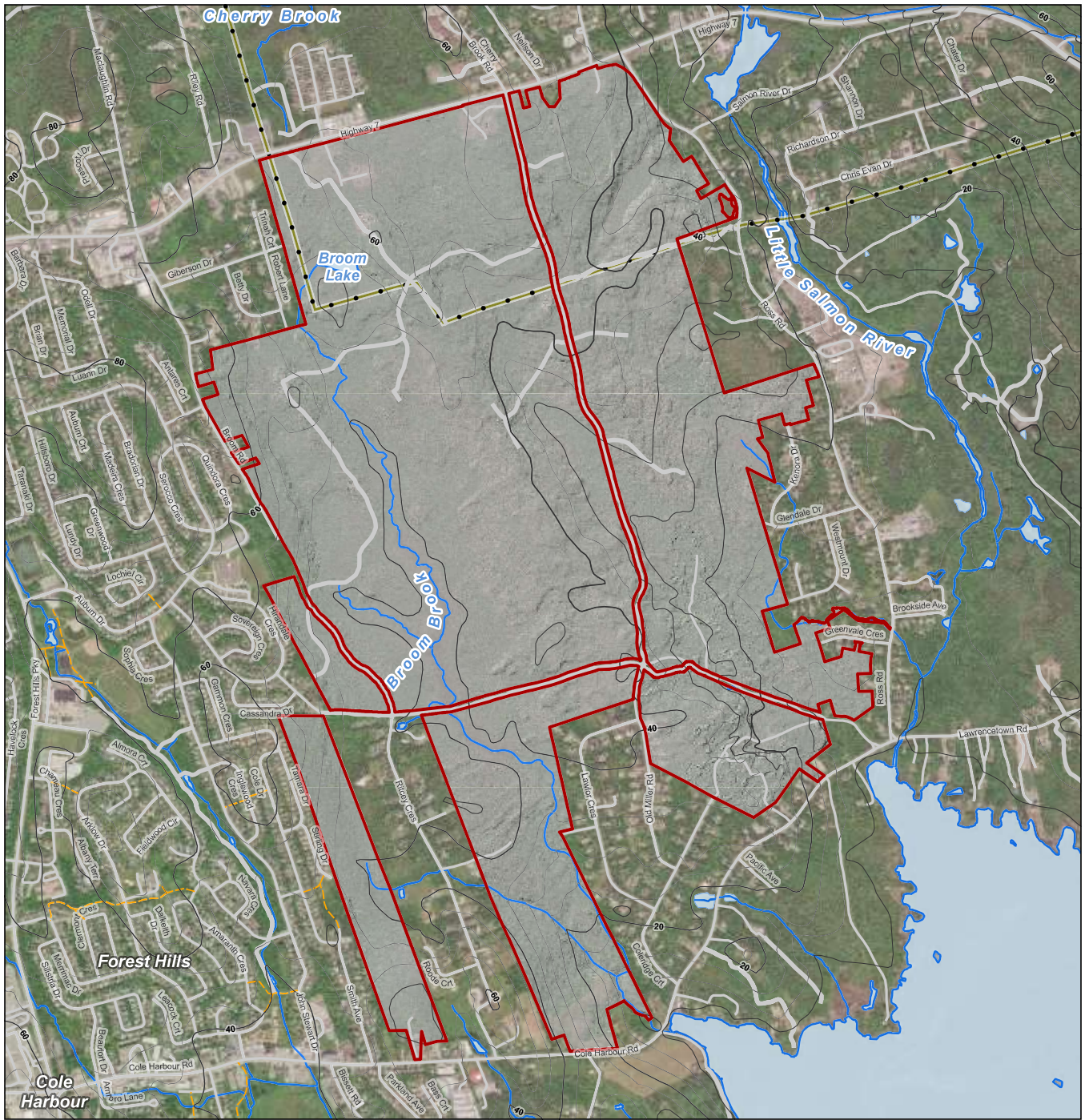




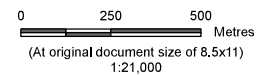
- Study Area
- Contour (5 m)

Transportation

- Trail
- Highway
- Other Road

Utilities

- Transmission Line
- Waterway
- Waterbody



Project Location
Halifax Regional Municipality,
Nova Scotia

Prepared by NW on 2024-10-06
QR by SW on 2024-10-07

Client/Project
Halifax Regional Municipality
Future Serviced Communities
Background Studies

Fig ID: 160410459_014a

Figure No.
8.3

Title
Elevation Contours - Westphal

Notes
1. Coordinate System: NAD 1983 CSRS UTM Zone 20N
2. Data Sources: Government of Nova Scotia, Department of Service Nova Scotia and Internal Services
3. Background: ESRI, Government of Nova Scotia, Department of Service Nova Scotia and Internal Services

8.4 Soil Conditions

Soil conditions for the Westphal Study Area were obtained from the “Nova Scotia Soil Survey Report #13 – Halifax County 1963”. As depicted in **Figure 8.4**, the soil type is generally classified as Halifax (Hx), which corresponds to a sandy loam soil with good to excessive drainage. There are also small areas classified as Aspotogan (As), Hantsport (Ha), Wolfville (Wv) and Peat (P). As corresponds to sandy loam with poor drainage, Ha corresponds to sandy loam to sandy clay loam with imperfect drainage, Wv corresponds to brown loam to sandy clay loam with good drainage, and P corresponds to semi-decomposed fibrous material with poor drainage. Consequently, the classification scheme has been used to categorize the general native soils as Hydrologic Soil Group C.

Additionally, the bedrock beneath the site predominantly belongs to the Taylors Head and Beaverbank Formations.

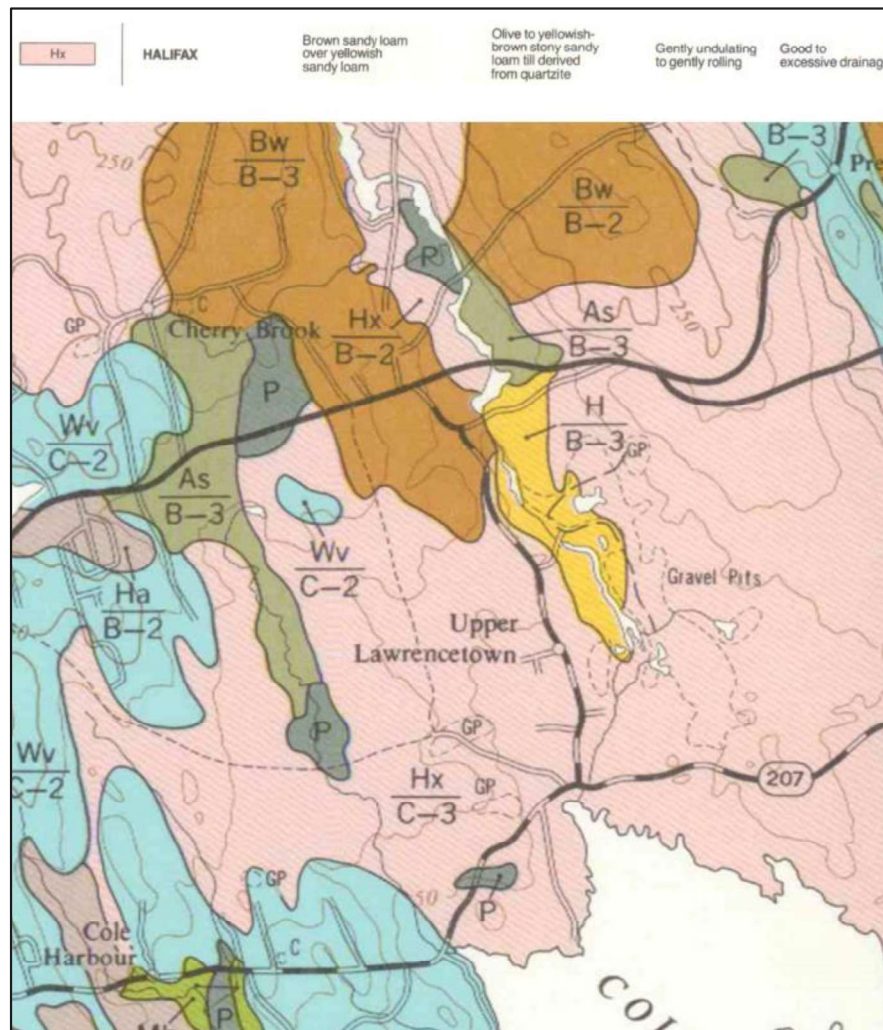


Figure 8.4 Soil Type (Nova Scotia Soil Survey Report #13 – Halifax County 1963)



8.5 Watercourses and Waterbodies

The data for wetlands and waterbodies were sourced from the Nova Scotia Open Data, complemented with the information presented in Stantec's 2024 Land Suitability Analysis and Watershed Study for the Westphal Study Area (WSA).

Nineteen (19) wetlands were identified and evaluated within the WSA. While none of the evaluated wetlands in the WSA were determined to be Wetlands of Special Significance (WSS), there are multiple factors that can result in a wetland being considered a WSS and further work and/or consultation with regulators may result in any of the wetlands within the SLSA being considered a WSS. Stantec's land suitability analysis recommended to engage with Nova Scotia Environment and Climate Change (NSECC) as early as possible to discuss potential wetland impacts (direct or indirect), the permitting process, and compensation requirements (e.g., potential opportunities for wetland restoration, enhancement, or creation).

Watercourse mapping was obtained from Nova Scotia Open Data complemented with Stantec's Land Suitability Analysis, which identified three mapped watercourses, and one mapped waterbody. Broom Brook that runs from Broom Lake south to Cole Harbour, a tributary to the west that intersects Broom Brook at the south end, and a tributary to the Little Salmon River running north to south on the eastern side of the site. Water quality monitoring along the watercourses was completed as part of the field study and the results were complemented with a desktop study using historical water quality reports.

As outlined in Stantec's Land Suitability Analysis for the WSA, riparian zones which are areas adjacent to watercourses were considered in the analysis, in addition to the bed and banks of the watercourse. Riparian zones provide a buffer that protects the watercourse from the impacts of adjacent development and also reduce the severity of flooding on adjacent lands. This resulted in the creation of watercourse setbacks and buffers as established in the Cole Harbour/Westphal Land Use By-Laws (Halifax Regional Municipality 2024) as the minimum criteria.

The PCSWMM software was used to create an existing drainage condition model composed of subcatchments, junctions, and conduits, which were partially parameterized based on features from the Digital Elevation Model (DEM).

The Watershed Delineation Tool (WDT) in PCSWMM was used to establish drainage patterns and channels, from which, the main channels were retained and transformed into ditches using the Transect Creator Tool. This tool utilizes the DEM to gather elevation data at each station along the transects. This comprehensive approach improves accuracy and efficiency when modelling watercourses.

8.6 Existing Drainage Areas

Existing drainage areas were delineated using LiDAR data (2019) sourced from the HRM Open Data portal, specifically the HRM 1044650063400_201901_CHM.tif file.

The Watershed Delineation Tool (WDT) was used to determine the tributary subcatchments to the Westphal Area. The flow lengths of these subcatchments were generated from the furthest point along



the boundary to the outlet, following the direction of flow. The width was then computed from the total area divided by the flow length. Along the flow length, the average surface slope for the subcatchments was determined using the DEM and the Slope from DEM tool in PCSWMM.

The imperviousness for the existing area was estimated based on actual impervious areas within the existing subcatchments. The areas of existing buildings and the road centerline, provided in Shapefile format, were included in this calculation. A 10 m buffer was applied to the road centerline for the total impervious area. Furthermore, an additional 25% of the residential area was added to account for existing parking lots. The commercial and industrial areas were also reviewed to incorporate larger parking lots into the imperviousness calculation.

The hydrologic parameters, which are integral to the functioning of the drainage system's subcatchments, are detailed in **Table 8.1**.

Table 8.1 Global Hydrologic Parameter for Subcatchments

Global Hydrologic Parameter	Value
Infiltration Method Subcatchments	NRCS
Conductivity (mm/hr)	0.5
Drying Time (days)	7
Curve Number for Pasture / Open Grass Area	74
Curve Number for Wetland	98
Manning's Roughness	
Impervious Surface (-)	0.013
Pervious Surface – Woodlot Area (-)	0.80
Pervious Surface – Urban Area (-)	0.25 - 0.35
Depression Storage	
Impervious Surface (mm)	1.88
Pervious Surface (mm)	3.75
Zero Imperviousness (%)	0

The USDA Natural Resources Conservation Service (NRCS) method was selected in PCSWMM to estimate infiltration. Average Curve Number (CN) values were determined based on weighted areas for each land use within the pervious portion of the subcatchment. This approach is used to estimate the site's ability to absorb rainfall, which is primarily influenced by the pervious surfaces.

Depression storage refers to the capacity of a specific land area to retain water in its pits and depressions, thereby preventing it from flowing. The PCSWMM online help manual offers a range of values suitable for defining the depression storage for both pervious and impervious surfaces. Average values within the provided ranges were selected.

The existing storm drainage plan presented in **Drawing EXSD-1** in **Appendix B** illustrates the existing storm drainage patterns, showcasing the watercourses and the delineated subcatchments.



8.7 Boundary Conditions

The water elevations in Cole Harbour were obtained from the preliminary floodlines (i.e., subject to change) for the 5-year, 20-year, 100-year, and 200-year scenarios for both current climate conditions and projected climate conditions in the year 2100 provided by HRM as part of the on-going Regional Flood Mapping Delineation project being completed by CBCL. These floodlines were derived from a high-level hydrologic and hydraulic analysis of flooding risks in the entire Halifax Regional Municipality and are based on a series of assumptions regarding seasonal land cover, initial conditions at lakes, dam operation, coastal water elevations, rainfall distribution (Chicago distribution – 24-hour, 5-min interval), and soil conditions.

The preliminary floodlines have been used to estimate the water levels at the discharge location during various return periods. These estimated 100-year water levels have been applied as fixed water elevations, also known as boundary conditions, at the Westphal outfalls within the hydrologic/hydraulic PCSWMM model for the 100-year storm event scenarios. As illustrated in **Figure 8.5**, there is one stormwater outfall that discharges into the Little Salmon River, and two stormwater outfalls that discharge into Cole Harbour. The water elevation at each of these outfalls is based on the topographic contours for both the current and climate change flood extent. For all other return periods, the normal flow depth within the outletting conduit or watercourse transect was used as a boundary condition at these locations. The 20-year and 100-year floodlines are also shown in **Drawing EXSD-1** in **Appendix B**.

8.8 Existing Culverts

As illustrated in **Figure 8.5**, the Study Area includes two (2) existing culvert crossings, as identified from the HRM Open data source. Existing Culvert 19 is located along Broom Brook, crossing Cole Harbour Road, while existing Culvert 20 is located along the Little Salmon River tributary, crossing Ross Road. Each of these culverts were surveyed, and the gathered data was incorporated into the existing hydraulic model. The existing culvert dimensions and 100-year headwater to diameter ratios are presented in **Table 8.2** Error! Reference source not found.below.

As the following table presents, existing Culvert 19 appears to be undersized based on the NSE's requirement of a $H_w/D \leq 1$ in the 100-year design storm event. Based on the results, Culvert 19 will need to be upgraded; however, without finalizing development plans or calibrating the hydrologic/hydraulic model to confirm design water levels and peak flows, upsizing of this culvert will not be completed as part of this conceptual design. Since the downstream invert of Culvert 19 is within the tidal range of Cole Harbour, the sizing of this culvert will likely be governed by tidal flows as opposed to upstream peak flows. As such, it is recommended that further hydraulic analyses be completed at the detailed design stage of this culvert upgrade, if this upgrade is considered prudent, to assess flooding impacts downstream. It is important to note that culvert upgrades will result in peak flow increases downstream, during low tide conditions, but will likely reduce the flooding risk of Cole Harbour Rd. in the vicinity of the culvert. Culvert sizing as a whole should be confirmed during later stages of this project.



Table 8.2 Existing Culverts

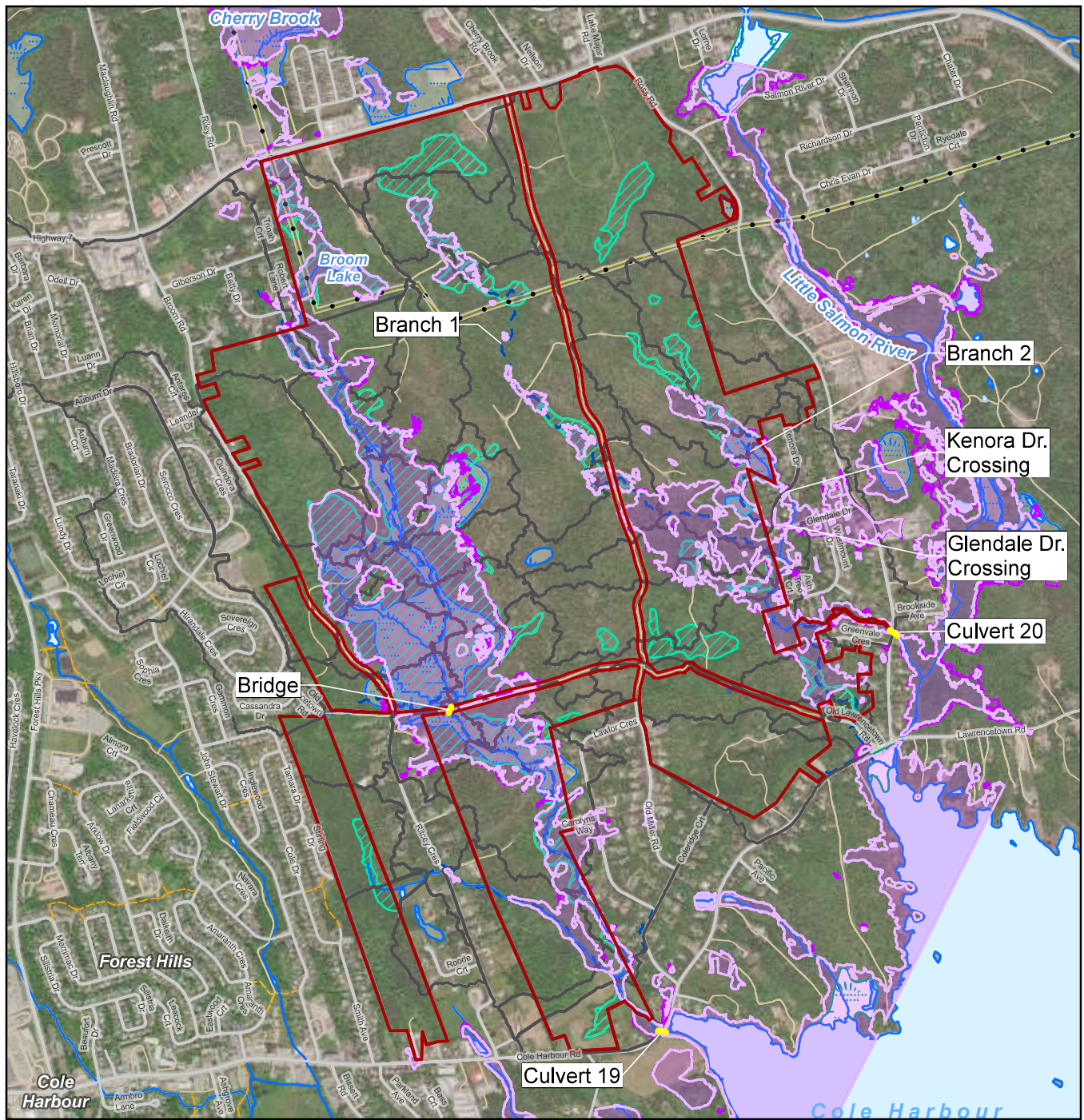
Culvert ID	Existing				
	Shape	Barrels	Width (m)	Height (m)	100-yr Design Storm Hw/D
Existing Culvert 19	Rectangular	1	2.5	1.0	3
Existing Culvert 20	Rectangular	2	2.0	1.5	1

Based on the aerial image of the study area, there is an existing bridge within the study area, as shown in **Figure 8.5**. However, no specific information on this structure was provided, thus it has been modeled with dimensions sufficient to ensure that the flow is not restricted.

Based on Open Data and the PCSWMM Watershed Delineation Tool, there are two (2) small tributaries to the Little Salmon River that run south from the wetland area east of Broom Lake and converge near the southern end of the site, near Glendale Dr, upstream of Culvert 20 as shown in **Figure 8.5**. The western-most tributary, identified as Branch 1 in **Figure 8.5**, was included in the model since it is the largest one and crosses the proposed site. The eastern-most tributary, identified as Branch 2 in **Figure 8.5**, was not directly modelled as it falls primarily outside the WSA boundary. However, the runoff contribution from Branch 2, from the existing rural residential development along Westmount Dr and Glendale Dr, was allocated in the model and added downstream within the overall tributary, at the convergence point of Branch 1 and Branch 2.

It should be noted that there are at least two (2) existing culvert structures along Branch 2, outside the WSA boundary, crossing Kenora Dr and Glendale Dr that convey flow through the existing rural residential development. The conveyance capacity of these culverts should be assessed at the detailed design stage.

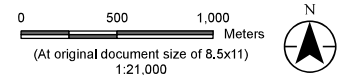




Notes
 1. Coordinate System: NAD 1983 CSRS UTM Zone 20N
 2. Data Sources: Stantec; Government of Nova Scotia, Department of Service Nova Scotia and Internal Services; Government of Nova Scotia Environment and Climate Change
 3. Background: ESRI; Government of Nova Scotia, Department of Service Nova Scotia and Internal Services.

- Legend**
- Study Area
 - Culvert
 - Existing Subcatchment
 - 20yr Flood Extent (Draft, HRM 2023)
 - 100yr Flood Extent (Draft, HRM 2023)

- Built Infrastructure**
- Transmission Line
 - Highway
 - Road
 - Resource / Seasonal Road
 - Trail
- Wetlands and Waterways**
- Waterway
 - Waterway (Stantec, LiDAR-delineated)
 - Waterbody
 - Designated Wetland of Special Significance
 - Wetland
 - Wetlands (Stantec, 2023)



Project Location
 Halifax Regional Municipality,
 Nova Scotia

Prepared by HB on 2024-02-13
Revised by AC on 2024-10-23

Client/Project
 Halifax Regional Municipality
 Future Serviced Communities
 Westphal Stormwater Management Plan

160410459

Figure No.
8.5

Title
**Existing Conditions Preliminary
 Floodplain Extents**

9 Post Development Conditions

Stantec's planning team has engaged landowners to help establish a potential development scenario for the Westphal Study Area and built on that scenario to provide lower and higher density scenarios. However, it is noted that these scenarios are subject to change based on recommendations from this study.

For the purpose of this stormwater management assessment, the high-density scenario, which results in larger impermeable surfaces, has been selected given that it is the worst-case scenario and provides a comprehensive understanding of the most conservative conditions. It should be noted that the current development plan is conceptual and subject to change based on results of further analysis and studies within the WSA and to adhere to the recommendations made in Stantec's 2024 Land Suitability Analysis for the Westphal Study Area (WSA). Refer to **Figure 9.1** for proposed development conditions.

Moreover, it is anticipated that the stormwater management strategies for the high-density scenario will also be applicable and effective for both the low and medium density scenarios.

The subsequent subsections detail the various characteristics of the post-development conditions. Additionally, the post-development storm drainage plan is presented in **Drawing SD-1** in **Appendix B**.

9.1 Site Grading & Land Use

The high-density development scenario has been used to create a master grading plan designed to follow existing drainage patterns as much as possible, provide sufficient cover over trunk sewers, provide an overland flow outlet, take into account sufficient cover over future culvert crossings and incorporate bottom and high-water elevations at end-of-pipe SWM facilities.

The proposed development plan consists of a diverse mix of land uses that encompasses low-density residential areas, high-density residential areas, institutional areas, commercial areas, as well as green space areas. **Figure 9.1** presents the proposed development areas.

9.2 Proposed Subcatchments

The general hydrologic parameters applied to the post-development drainage areas are consistent with those used in the existing conditions model, as detailed in **Section 8.6**. The proposed subcatchments and their corresponding runoff coefficients are illustrated in **Drawing SD-1** in **Appendix B**.

Given that the concept plans are preliminary and subject to change and do not provide details on location and width of driveways and sidewalks, a representative runoff coefficient based on proposed land use was used. Average runoff coefficients based on the proposed conceptual land use were obtained from the help file for ICM SWMM, ICM InfoWorks and SWMM5 software. The average runoff coefficients (C) based on the various land uses are as follows:

- Low-Density Residential: 0.65



- High-Density Residential: 0.75
- Commercial: 0.85
- Institutional: 0.70
- Green Space: 0.20
- Community Park: 0.40

In the PCSWMM model, the imperviousness parameters for the proposed subcatchments were obtained using the following equation, where C corresponds to the runoff coefficient:

$$\text{Percent Impervious} = \frac{(C - 0.2)}{0.7} \times 100$$

Additionally, the flow length of each subcatchment was calculated based on the proposed grading and layout. The slope of the proposed areas is estimated to be 2% for the hydraulic assessment. Additionally, for the pervious areas within the proposed subcatchments, a CN value of 74 was used.

There are four (4) drainage areas (UNC-1, UNC-2, UNC-3, and UNC-5) that are identified for future build-out during subsequent phases of this development. Existing conditions parameters were maintained in the proposed conditions model for these areas due to the lack of information available at this time. It is anticipated that stormwater management for these areas will be established separately from the current phase.

9.3 Boundary Conditions

For the post-development hydrologic/hydraulic PCSWMM model, the boundary conditions remain consistent with the existing conditions. Refer to **Section 8.7** for detailed information about boundary conditions.

9.4 Proposed Crossing Structures

The conceptual storm drainage plan presented in **Drawing SD-1** in **Appendix B** shows the high-density development plan for the Westphal Study Area, which includes proposed road crossings at the existing watercourses. These crossing locations have been identified, however at this stage, there is insufficient data available to validate the watercourse peak flows and water levels associated with the proposed development area and therefore only high-level conceptual sizing of these structures has been completed based on unrestricted conveyance. It is recommended that the sizing of these structures be reviewed once flow monitoring and model calibration are completed for the existing watercourses. **Table 9.1** presents the conceptual sizing of the proposed culverts within the study area. **Figure 9.1** shows the approximate culvert locations.



Table 9.1 Existing and Proposed Culverts

Culvert ID	Shape	Barrels	Width (m)	Height (m)	100-yr Design Storm Hw/D
Existing Culvert 19	Rectangular	1	2.5	1.0	2.6
Existing Culvert 20	Rectangular	2	2.0	1.5	0.8
Proposed Culvert 1	Rectangular	1	2.5	2.0	0.5
Proposed Culvert 2	Rectangular	1	1.5	1.0	0.5

While existing Culvert 19's Hw/D ratio is slightly improved from existing conditions, it does not meet the design criteria outlined by NSE of $Hw/D \leq 1$ in the 100-year design event under proposed conditions. Due to the conceptual nature of this analysis, no upgrades have been recommended for this culvert at this stage. Since the downstream invert of Culvert 19 is within the tidal range of Cole Harbour, the sizing of this culvert will likely be governed by tidal flows as opposed to upstream peak flows. As such, it is recommended that further hydraulic analyses be completed at the detailed design stage of this culvert upgrade, if this upgrade is considered prudent, to assess flooding impacts downstream. It is important to note that culvert upgrades will result in peak flow increases downstream, during low tide conditions, but will likely reduce the flooding risk of Cole Harbour Rd. in the vicinity of the culvert. All other culverts meet NSE requirements under proposed conditions.

Proposed Culvert 2 is located along the western-most (modelled) tributary to Little Salmon River and should be further confirmed in later design phases. The eastern-most tributary running through the existing rural residential development was not modelled but does cross Kenora Dr and Glendale Dr through existing crossing structures.

Additionally, portions of the proposed development plan are shown through existing watercourses and the delineated floodplain, as identified on the **Drawing SD-1 in Appendix B**. These watercourses need to maintain dedicated connectivity to their receiving waterbodies unless otherwise specified in future environmental assessments. It is recommended that the development plan be revised to accommodate existing wetlands and watercourses. It is noted that throughout the site, the 1 in 100-year flood delineation is close to the wetland extent. Therefore, it is also recommended to maintain any development outside of the delineated 1 in 100-year floodplain.

