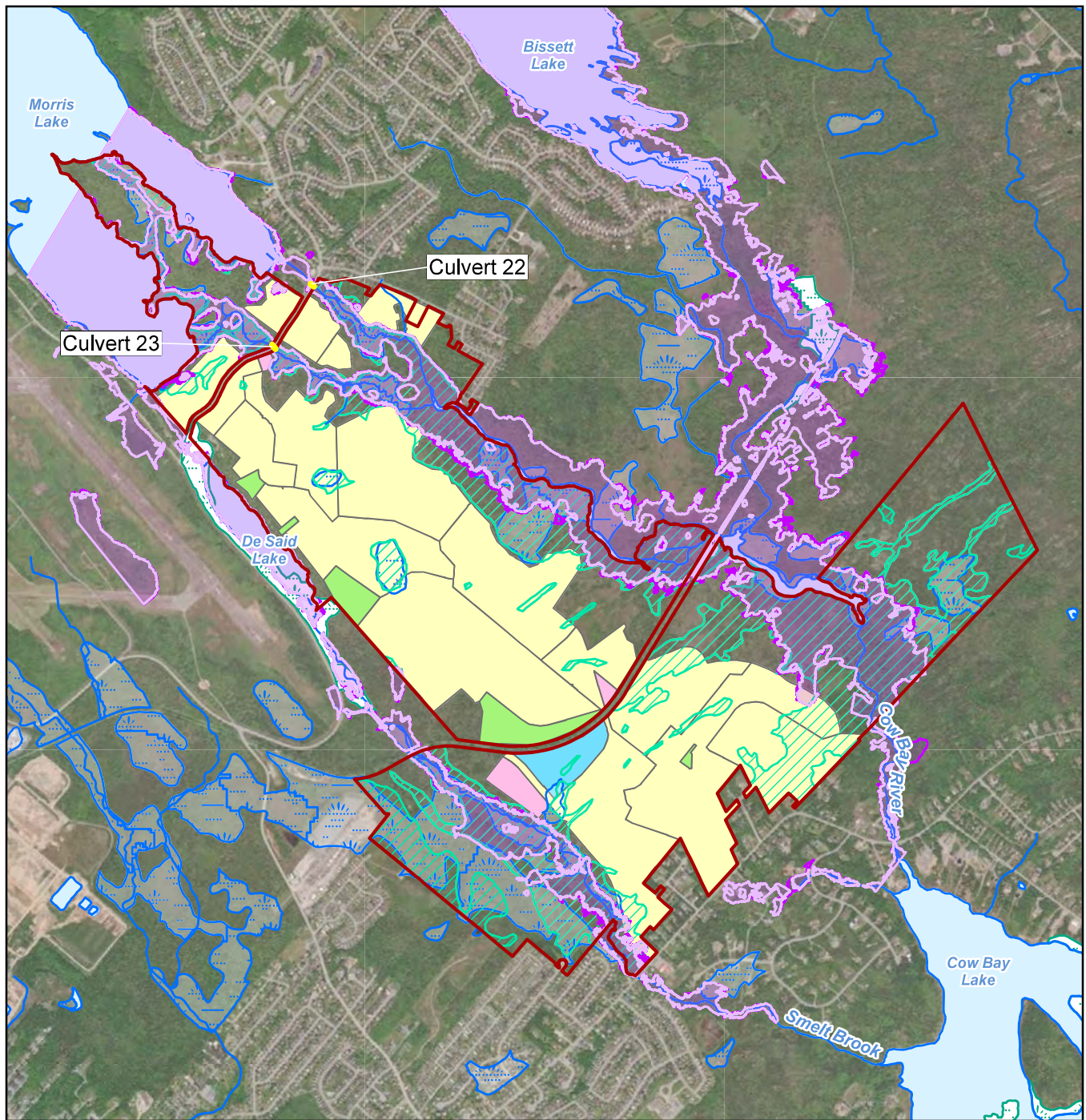
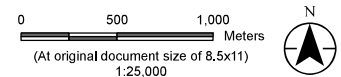


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Notes
1. Coordinate System: NAD 1983 CSRS UTM Zone 20N
2. Data Sources: Stantec; Government of Nova Scotia, Department of Service Nova Scotia and Internal Services; Government of Nova Scotia Environment and Climate Change
3. Background: ESRI; Government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

- Legend**
- Study Area
 - Culvert
 - 20yr Flood Extent (Draft, HRM 2023)
 - 100yr Flood Extent (Draft, HRM 2023)
 - Land Use**
 - Institutional
 - Low Residential
 - Mixed Commercial
 - Green Space
 - Wetlands and Waterways**
 - Waterway
 - 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 2024-10-29

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

160410459

Figure No.
9.1

Title
Conceptual Development and Culvert
Locations

Disclaimer: This document has been prepared based on information provided by others as cited in the Notes section. Stantec has not verified the accuracy and/or completeness of this information and shall not be responsible for any errors or omissions which may be incorporated herein as a result. Stantec assumes no responsibility for data supplied in electronic format, and the recipient accepts full responsibility for verifying the accuracy and completeness of the data.

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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 on **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

In the PCSWMM model, imperviousness values 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.

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.

Lake storage and outlet weir length for Bissett Lake and Morris Lake were revised iteratively in the existing condition PCSWMM model to obtain lake water levels that reflected the values estimated from the preliminary flood lines for the different return periods as described in **Section 8.7.1**. Significant deviations were observed in the lakes' outflow and water level results in the post development PCSWMM model when using the same lake storage and outlet weir length for the same storm events as per the existing condition model. As a result, for consistency, upstream hydrographs at Bissett and Morris Lake outlets were brought in from the existing condition model into the post development condition model for the different storm events.



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9.4 Proposed Crossing Structures

No additional watercourse crossings, as a result of proposed developed, have been identified therefore there are no proposed crossing structures recommended at this time.

9.5 Stormwater Management Strategy

Urbanization inevitably leads to changes in the landscape and as such, in order to successfully implement development plans that result in balanced and environmentally sustainable development, it is key to devise an effective management strategy. This section provides a general description of stormwater management measures which, when combined, form a comprehensive approach to stormwater management in order to meet established SWM criteria and protect the surrounding natural environment.

Following discussions with HRM and HW, it was agreed that quantity control measures would be implemented to limit post-development peak flows to pre-development levels up to the 100-year storm. It is therefore recommended that quantity control measures in the form of end-of-pipe stormwater management (SWM) dry ponds be implemented at key locations within the proposed development area to mitigate post development peak flows to pre-development levels.

The current SWM pond locations are conceptual (i.e., not an approved plan) and subject to change based on results of more detailed analysis as the development plan progresses. The SWM ponds should be located outside of the floodplain based on existing topography and proposed grading to restrict post development peak flows to existing conditions levels.

Urbanization typically alters the water balance, leading to increased runoff and decreased infiltration, primarily due to increased impervious surfaces associated with urban development. In addition, urbanization usually results in increased sediment and phosphorus loading in receiving watercourses. Retaining native and existing ground cover should be prioritized where possible to preserve ecosystem service function, reduce volume of runoff discharged into watercourses, promote infiltration and provide an opportunity for evapotranspiration. Where retaining native cover is not possible, it is recommended that a treatment train approach consisting of lot level best management practices (BMPs), such as directing residential roof runoff to vegetated surfaces, introducing vegetated swales, and low impact development (LID) measures such as infiltration trenches, bioswales, etc., be investigated at the detailed design stage to provide quality control of runoff prior to discharging into the receiving watercourses and to promote infiltration.

Please refer to **Section 6** for mitigation recommendations to reduce phosphorus (P) loading, *E. coli* loading, and sediment loading from the Morris Lake Study Area and achieve contaminant loads of existing conditions.

To reduce annual Total P load to the watershed, future development scenarios must consider implementing a combination of measures such as a street maintenance program to remove sediment-associated P from roadways and catch basins, along with the implementation of Low Impact Development (LID) measures to reduce loading.



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The implementation of LID measures within the future developments would also aid in the removal of fecal coliform through sedimentation.

Erosion and sedimentation control measures are recommended during construction of all future developments to mitigate sediment loadings into the receiving water bodies.

Table 9.1, taken from the Credit Valley Conservation Low Impact Development Stormwater Management Planning and Design Guide (CVC, 2010, Table 3.4.1), provides a comparison of site constraints for a variety of structural LID SWM practices.

Table 9.1 Comparison of Site Constraints for a Range of Structural LID SWM Practices

LID Stormwater Management Practice	Depth to high water table or bedrock ¹ (m)	Typical Ratio of Impervious Drainage Area to Treatment Facility Area	Native Soil Infiltration Rate (mm/hr) ³	Head ⁴ (m)	Space ⁵ %	Slope ⁶ %	Pollution Hot Spots ⁷	Setbacks ⁸
Rain barrel	Not applicable	[5 to 50 m ²] ²	Not applicable	1	0	NA	Yes	None
Cistern	1	[50 to 3000 m ²] ²	Not applicable	1 to 2	0 to 1	NA	Yes	U, T
Green roof	Not applicable	1:1	Not applicable	0	0	0	Yes	None
Roof downspout disconnection	Not applicable	[5 to 100 m ²] ²	Amend if < 15 mm/hr ⁹	0.5	5 to 20	1 to 5	Yes	B
Soakaway, infiltration trench or chamber	1	5:1 to 20:1	Not a constraint	1 to 2	0 to 1	< 15%	No	B, U, T, W
Bioretention	1	5:1 to 15:1	Underdrain required if < 15 mm/hr	1 to 2	5 to 10	0 to 2	No	B, U, W
Biofilter (filtration only Bioretention design)	Not applicable	5:1	Not applicable	1 to 2	2 to 5	0 to 2	Yes	B, T



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LID Stormwater Management Practice	Depth to high water table or bedrock ¹ (m)	Typical Ratio of Impervious Drainage Area to Treatment Facility Area	Native Soil Infiltration Rate (mm/hr) ³	Head ⁴ (m)	Space ⁵ %	Slope ⁶ %	Pollution Hot Spots ⁷	Setbacks ⁸
Vegetated filter strip	1	5:1	Amend if < 15 mm/hr ⁹	0 to 1	15 to 20	1 to 5	No	None
Permeable pavement	1	1:1 to 1.2:1	Underdrain required if < 15 mm/hr	0.5 to 1	0	1 to 5	No	U, W
Enhanced grass swale	1	5:1 to 10:1	Not applicable	1 to 3	5 to 15	0.5 to 6	No	B, U
Dry swale	1	5:1 to 15:1	Underdrain required if < 15 mm/hr	1 to 3	5 to 10	0.5 to 6	No	B, U, W
Perforated pipe system	1	5:1 to 10:1	Not a constraint	1 to 3	0	< 15%	No	B, U, T, W

Notes:

1. Minimum depth between the base of the facility and the elevation of the seasonally high water table or top of bedrock.
2. Values for rain barrels, cisterns and roof downspout disconnection represent typical ranges for impervious drainage area treated.
3. Infiltration rate estimates based on measurements of hydraulic conductivity under field saturated conditions at the proposed location and depth of the practice.
4. Vertical distance between the inlet and outlet of the LID practice.
5. Percent of open pervious land on the site that is required for the LID practice.
6. Slope at the LID practice location.
7. Suitable in pollution hot spots or runoff source areas where land uses or activities have the potential to generate highly contaminated runoff (e.g., vehicle fueling, servicing or demolition areas, outdoor storage or handling areas for hazardous materials and some heavy industry sites).
8. Setback codes: B = Building foundation; U = Underground utilities; T = Trees; W = drinking water wellhead protection areas.
9. Native soils should be tilled and amended with compost to improve infiltration rate, moisture retention capacity and fertility.

For the Morris Lake Study Area, which is underlain by the Taylors Head Formation of the Meguma Supergroup, several LIDs are worth considering:

- Bioretention Cells and Rain Gardens are designed to imitate natural water cycles and are effective in removing various contaminants from runoff, while also reducing its volume and intensity;



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- Permeable Pavements allow stormwater to seep through into a stone reservoir for temporary storage or infiltration;
- Vegetated Filter Strips and Swales are designed to process and reduce runoff from nearby impervious surfaces; and,
- Tree Plantings and Native Plantings can help absorb stormwater, decrease runoff, and enhance water quality.

However, the specific selection, design, and location of these LIDs should be further investigated during the detailed design stage. The assessment should take into account factors such as the infiltration capability of the native soils, the depth to bedrock, the depth to groundwater table, and local regulations. It should also be noted that LID measures that impact the overall drainage plan should be located within the right of way owned by the Municipality, since practices located at the lot level could be modified by property owners impacting the performance of the overall storm drainage plan.



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10 Hydrologic and Hydraulic Modelling

The following sections provide a comprehensive overview of the conceptual stormwater management plan for the Morris Lake Study Area developer-proposed concept plan, including outlining measures required to restrict post-development peak flows to pre-development values, identifying flood risk areas, and summarizing the limitations associated with the modelling process.

This section provides a high-level estimate of the storage volume required to reduce post-development peak flows to pre-development conditions. While the proposed development concept plan serves as the basis for these calculations, it is understood that the final location and size of the SWM ponds may change based on recommendations from the various assessments that make up this project. These calculations are provided to aid in evaluating the feasibility of mitigating post-development impacts in the Study Area and do not represent firm conceptual designs.

10.1 Floodplain Identification

Based on the preliminary flood lines obtained from HRM, minor portions of the proposed development lie within the floodplain. A minor portion of subcatchments C131A, C141A, C304A, C410A, C504A, and C601A are within the preliminary floodplain. In order to minimize the risk of flooding and ensure the proposed roads are safe for traffic during emergency conditions, it is recommended that the concept plan be revised to move proposed roads outside of the floodplain as much as possible, and as a last resort, that the proposed roads be raised above 100-year floodline. Similarly, it is recommended that future development be restricted within the 100-year floodplain in consistency with municipal by-laws and the Nova Scotia Statement of Provincial Interest Regarding Flood Risk Areas.

10.2 Model Validation

As described in **Section 8.7.1**, a preliminary validation exercise was completed in the existing condition model to estimate the lake volumes and outflows for Morris Lake and Bissett Lake at the upstream end of the drainage system to obtain lake water levels that approximately reflected the estimated values from the preliminary HRM floodlines for all return periods. The objective of this preliminary validation of the stormwater management model is to improve the model's consistency with the preliminary floodlines obtained from HRM. However, it is recommended that lake water level monitoring and flow monitoring at the outlet of Morris, Bissett, and De Said Lakes be completed to calibrate the hydrologic/hydraulic model to confirm the floodplain extents and the location and sizing of the required SWM measures.

The validation process was conducted using the existing condition model and simulated for different storm events. The volumes in Morris Lake and Bissett Lake were adjusted iteratively until the model's simulated water elevations for the lakes closely matched the estimated values, as per HRM's preliminary floodlines. In addition, for each storm event, an initial depth was added to the lakes (Morris and Bissett) and iteratively adjusted to match the estimated lake water levels from HRM's preliminary floodlines.



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For the 100-year model, a hotstart file was used to simulate backwater conditions from the storm outfalls and to establish an initial depth scenario at the upstream lakes (Bissett and Morris Lake). Fixed boundary conditions, based on HRM's preliminary flood lines, were applied at the storm outfalls, for all other storm events.

The validated lake volumes and peak outflows for Morris Lake and Bissett Lake resulted in observed instabilities in the post development condition model due to the significant length of the outlet weir at Morris Lake. This instability led to varying peak flows from Morris Lake under post-development conditions, even though there were no changes to Morris Lake runoff contributions and/or stage-storage-discharge relationship from the existing condition model. To address this, outflow hydrographs from Morris Lake and Bissett Lake were exported from the existing condition model for all storm events and imported as timeseries at the upstream end of the system in the post-development condition model for all return periods.

10.2.1 VALIDATION RESULTS

The modeled water levels in Morris Lake and Bissett Lake, based on HRM's preliminary floodlines, show minimal variation during the 5, 20, and 100-year storms. The lake water levels and the initial depth obtained from the existing condition model are shown in **Table 10.1**.

Table 10.1 Modeled Water Levels and Initial Depths at Morris Lake and Bissett Lake

Storm Event	Morris Lake		Bissett Lake	
	Water Level (m)	Initial Depth	Water Level (m)	Initial Depth
2-year	28.45	25.50	32.29	2.40
5-year	28.55	23.50	32.29	2.20
10-year	25.58	21.80	32.44	2.20
25-year	25.58	19.85	32.47	2.05
50-year	28.59	18.40	32.50	1.93
100-year ¹	28.60	2.70	32.57	0.50
Note: ¹ The 100-year scenario is run using an hotstart file.				

The lake water levels at Morris Lake and Bissett Lake govern the peak flows conveyed through downstream watercourses (i.e., Cow Bay River). Since the lake water levels do not change substantially across return periods, the peak flows at different locations in the downstream watercourses also change very little across return periods.



May 29, 2025

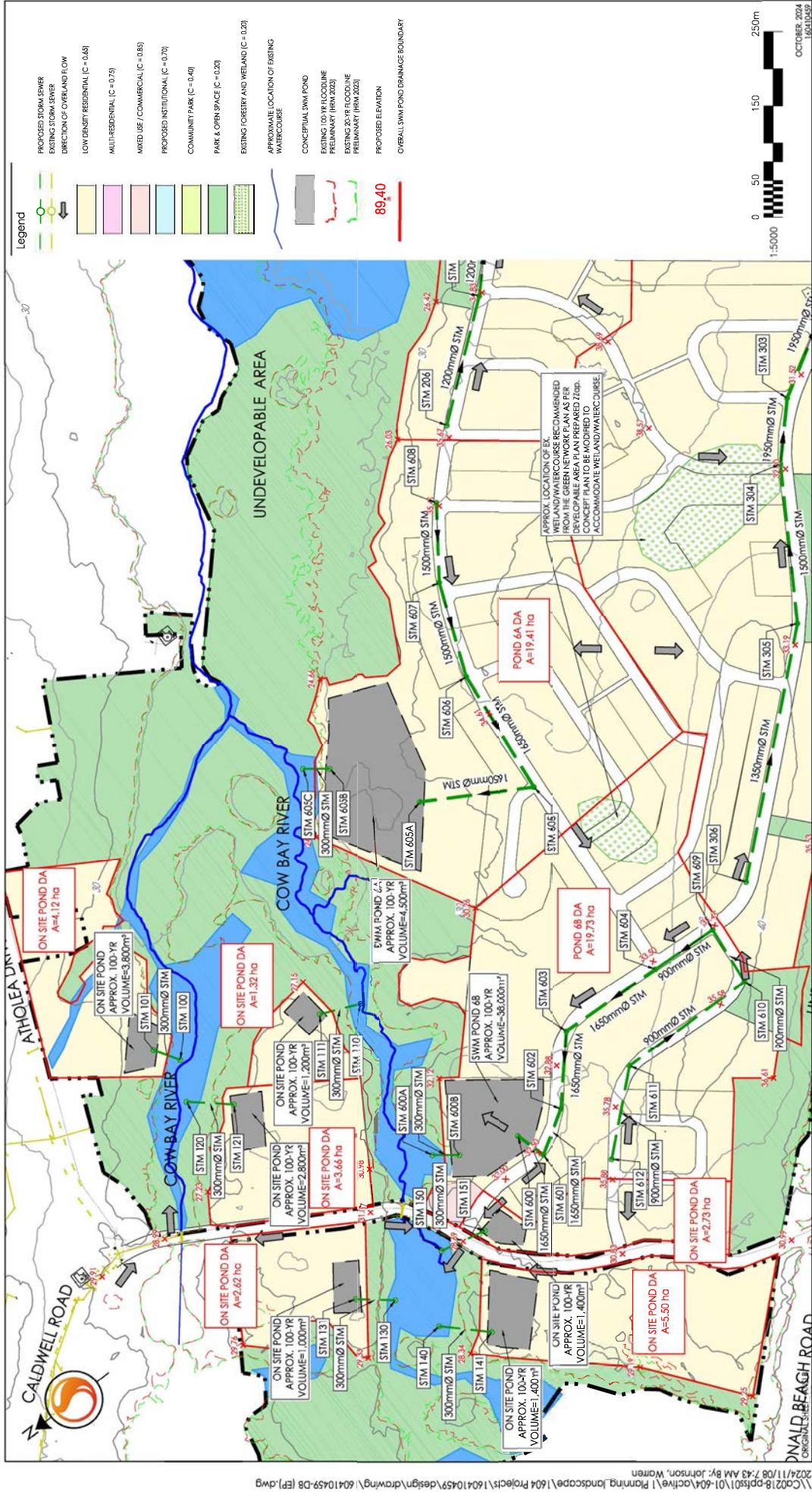
10.3 Stormwater Management Dry Ponds

The location and sizing of dry ponds presented in this study provide an estimate of storage volumes required to mitigate post development peak flows, based on the information available at the time. However, these locations are in very close proximity to the estimated floodplain extents and will require revision to avoid flooding risks and backwater effects in the ponds and associated stormwater infrastructure.

As presented on **Drawing SD-1 in Appendix B**, the proposed development area would be serviced through storm sewers that would be sized to convey the 5-year runoff under free flow conditions to the proposed end of pipe SWM dry ponds for quantity control prior to discharging into the receiving watercourses. During major storm events, higher than the 5-year storm, peak overflows would be routed overland to the proposed SWM dry ponds.

A total of thirteen SWM dry ponds have been proposed for stormwater management based on existing drainage patterns and the conceptual development plan to mitigate post development peak flows to pre-development levels for all storms from the 2-year up to the 100-year storm event. The final number, location and size of the SWM dry ponds is to be confirmed based on best engineering principles and detailed floodplain mapping for the area, including flow monitoring and model calibration. The conceptual location and overall drainage area of the SWM ponds are shown in **Figure 10.1, Figure 10.2, Figure 10.3, and Figure 10.4.**





Notes

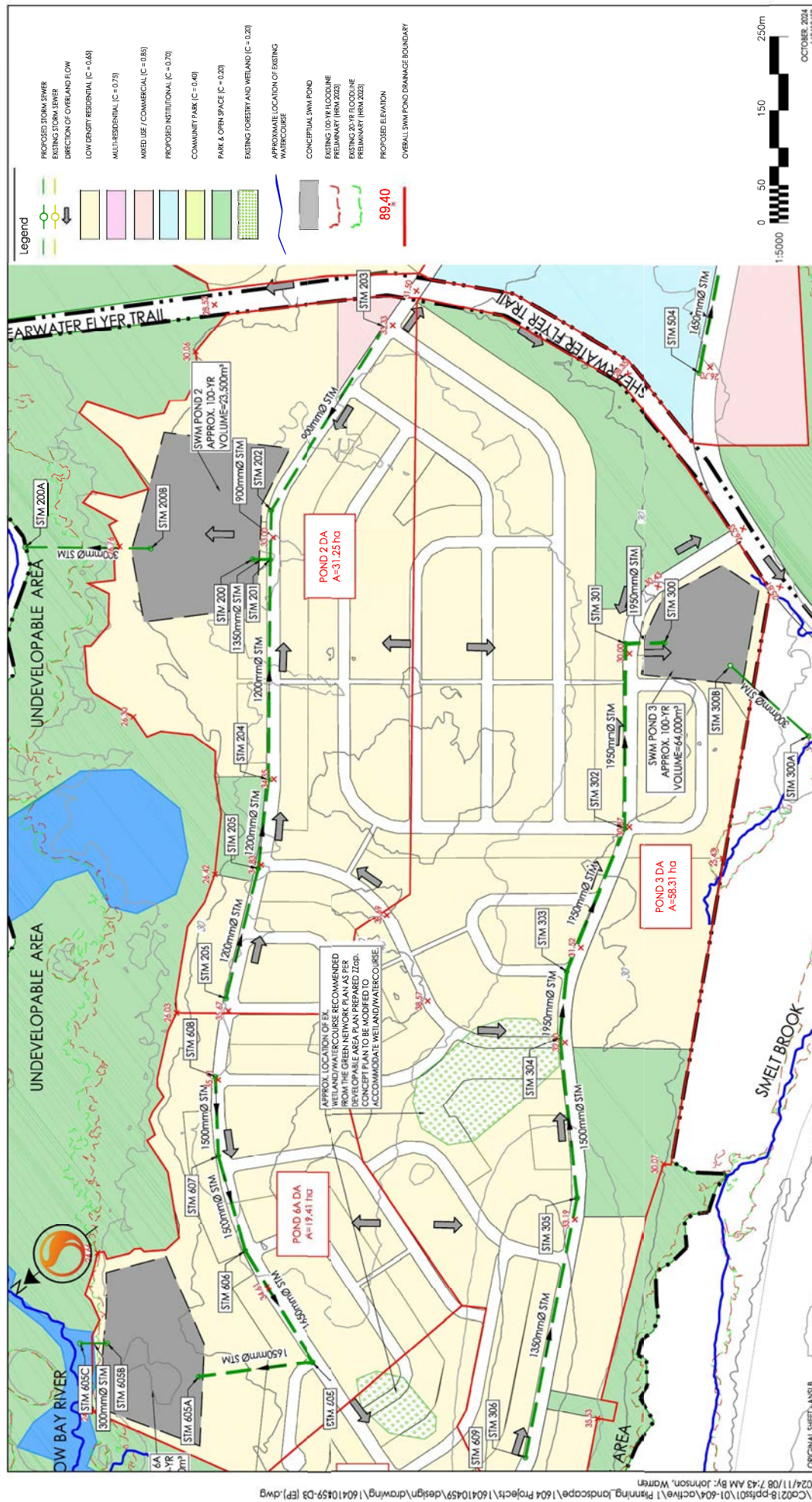
Stantec
 Stantec Consulting Ltd.
 400 - 1331 Clyde Avenue
 Ottawa, ON
 Tel. 613.722.4420
 www.stantec.com

HRM
 FUTURE SERVICED COMMUNITIES
 STORMWATER MANAGEMENT

Figure No.
 10.1

Title
 OVERALL DRAINAGE AREA
 TO SWM POND 6A AND SWM POND 6B

OCTOBER 2024
 160410459



Notes

HRM
FUTURE SERVICED COMMUNITIES
STORMWATER MANAGEMENT

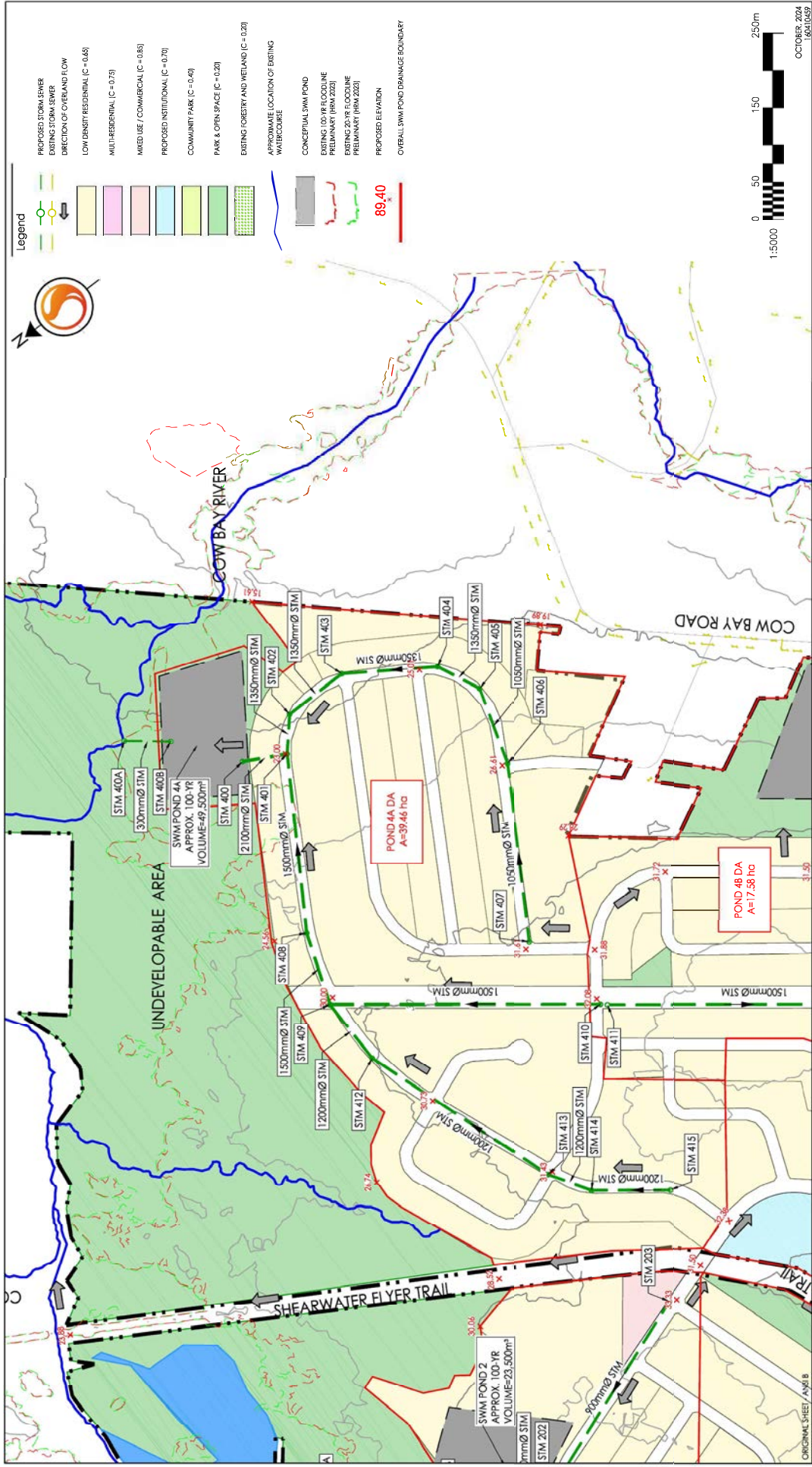
FIGURE NO. 100

Title	10.2
-------	------

OVERALL DRAINAGE AREA
TO SWM POND 2 AND SWM POND 3



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Notes

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HRM
FUTURE SERVICED COMMUNITIES
STORMWATER MANAGEMENT

Figure No.
10.4
Title

OVERALL DRAINAGE AREA
TO SWM POND 4A

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The drainage areas and approximate 100-year volume requirements for the proposed SWM dry ponds are summarized in **Table 10.2**.

Table 10.2 Proposed Pond 100-Year Volume

Pond ID	Drainage Area (ha)	100-yr Volume (m ³)
Pond 2	31.3	23,500
Pond 3	87.9	64,000
Pond 4 A	55.2	49,500
Pond 4 B	26.9	14,800
Pond 5	31.4	30,800
Pond 6 A	19.2	4,500
Pond 6 B	39.1	38,000
Pond C131A ¹	2.6	1,000
Pond C141A ¹	5.7	1,400
Pond UNC-1 ¹	2.8	1,400
Pond C121A ¹	3.6	2,800
Pond F101A ¹	4.2	3,800
Pond F111A ¹	1.3	1,200
Note: ¹ On site dry pond, located within associated subcatchment		

Although the SWM ponds are generally outside of the HRM-provided 100-year floodline, this floodline is based on a high-level model and it is subject to change based on more detailed analysis that could result in the SWM ponds being within the 100-year floodplain, especially for SWM Pond 5. In general, it is recommended that the proposed development plans for the Study Area be revised to avoid residential, commercial and institutional land uses within the 100-year floodplain and to ensure that appropriately sized blocks are allocated for the SWM Ponds outside of the confirmed 100-year floodplain. In the further stages of planning and development of the site, the development plan should be revised to relocate residential development and ponds that are currently close to or within the potential floodline. By pulling back the development, and potentially adding density to the remaining, the population/development yield of the site could remain similar, and it could reduce the potential risks associated with flooding. The Land Suitability Report outlines that areas within 30 m of a watercourse have low suitability for development, so setback areas from watercourses have to be studied on a site-specific basis during subsequent area planning to determine suitability..

The conceptual stormwater management plan shown on **Drawing SD-1** includes trunk storm sewers at key locations such as watercourse crossings and SWM pond inlets. These trunk sewers have been sized to convey the 5-year storm under free flow conditions. However, pipe sizes and SWM pond locations will be confirmed at the detailed design stage. **Table 10.3** shows preliminary trunk storm sewer characteristics.



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Table 10.3 Storm Sewer Characteristics

U/S MH ID	D/S MH ID	U/S Invert Elevation (m)	D/S Invert Elevation (m)	Diameter (mm)
612	611	21.72	20.61	900
611	610	20.59	19.22	900
610	609	19.21	18.55	900
609	604	18.49	18.30	900
608	607	30.53	28.76	1500
607	606	28.61	27.52	1500
606	605	27.07	26.63	1500
605	604	26.61	25.58	1500
604	603	25.56	24.32	1650
603	602	24.26	24.00	1650
602	601	30.26	27.37	1650
601	600	27.34	25.68	1650
504	503	26.23	25.77	1650
503	502	27.99	23.14	1650
502	501	23.08	20.93	1650
501	500	20.63	20.38	1650
415	414	30.53	28.76	1200
414	413	28.61	27.52	1200
413	412	27.07	26.63	1200
412	409	26.61	25.58	1200
411	410	30.44	29.86	1500
410	409	29.80	29.15	1500
409	408	28.54	28.01	1500
408	401	27.99	27.68	1500
407	406	25.56	24.32	1050
406	405	24.26	24.00	1050
405	404	30.26	27.37	1350
404	403	27.34	25.68	1350
403	402	32.77	31.87	1350
402	401	31.84	30.50	1350
401	400	27.67	26.25	2100
306	305	20.35	19.83	1350
305	304	19.80	19.44	1500
304	303	19.41	19.20	1950
303	302	28.62	27.00	1950
302	301	26.99	25.53	1950
301	300	25.47	23.94	1950
206	205	21.72	20.61	1200
205	204	20.59	19.22	1200
204	201	19.21	18.55	1200
203	202	23.90	19.05	900



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U/S MH ID	D/S MH ID	U/S Invert Elevation (m)	D/S Invert Elevation (m)	Diameter (mm)
202	201	18.45	18.30	900
201	200	18.49	18.30	1350

10.4 Quantity Control Results

As shown on **Drawing SD-1**, flow points have been established along the existing watercourses at proposed crossings, watercourse intersections and at SWM pond outlet locations to compare pre-development and post-development peak flows. The stage-storage-discharge relationship of the proposed SWM ponds was iterated in PCSWMM in order to restrict post development peak flows close to pre-development levels for the 2, 5, 10, 25, 50, and 100-year design storms. **Table 10.4** presents the post to pre-development peak flow comparison at the different flow points along the watercourses for the 2-year, 5-year, and 100-year design storm events. Refer to **Appendix C** for a table showing peak flow results for all storm events.

Table 10.4 Post to Pre-Development Peak Flow Comparison

Flow Point ID	2-year, 24hr Chicago Peak Flow (m ³ /s)		5-year, 24hr Chicago Peak Flow (m ³ /s)		100-year, 24hr Chicago Peak Flow (m ³ /s)	
	Existing	Proposed	Existing	Proposed	Existing	Proposed
FP_1	5.930	5.580	6.343	5.947	8.094	7.533
FP_2	1.773	1.781	1.952	1.903	2.042	1.940
FP_3	1.773	1.790	1.951	1.913	2.042	1.951
FP_4	6.059	6.061	8.501	8.467	10.265	10.189
FP_5	8.140	8.055	10.833	10.594	12.802	12.271
FP_6	7.289	7.324	7.586	7.576	7.555	7.544
FP_7	0.947	0.826	1.687	1.282	3.375	2.865
FP_8	2.101	1.842	3.756	2.949	8.808	7.721
FP_9	8.586	8.476	9.143	9.009	9.999	9.844
FP_10	8.603	8.475	9.161	9.009	10.171	9.871
FP_11	8.742	8.621	9.349	9.252	11.189	11.284
FP_12	1.761	1.507	2.550	2.171	5.260	4.473

As can be seen in the above table, post development peak flows slightly exceed the existing condition levels at some locations along the watercourses during smaller rainfall events (i.e., 2-year). It is expected that these exceedances will be substantially reduced once best management practices and LIDs designed to promote infiltration are incorporated at the detailed design stage.

Post development peak flows are lower than existing condition levels for major storm events (i.e., higher than 5-year storm) at all flow point locations with the exception of FP_6 and FP_11, where minor exceedances are observed. Final sizing and location of the SWM ponds should be confirmed at the detailed design stage, pending flow monitoring, model calibration and detailed floodplain mapping for the



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area to ensure that post development peak flows along the watercourses are balanced within 10% (+ or -) of pre-development levels.

10.5 Modelling Limitations

The following are some of the limitations associated with the current modelling approach:

- **Boundary Conditions:** The hydrologic/hydraulic PCSWMM models for the Morris Lake Study Area used fixed water levels at the Cow Bay Lake outfalls as boundary conditions. These fixed water levels were estimated from the preliminary flood lines obtained from HRM from their on-going Regional Flood Risk Mapping project.
- **Calibration:** Flow monitoring data for the Bissett Lake and Morris Lake watersheds is not available at this time and as such, the hydrologic/hydraulic PCSWMM model has not been fully calibrated. Hydrologic and hydraulic parameters used in this modeling exercise have been selected as discussed in this report based on available information. However, these parameters have not been calibrated to reflect the actual runoff response from the watershed, which includes significant external rural and urban catchments with watercourses and natural depressions and wetlands. Without calibration, the model's predictions are based solely on theoretical calculations and assumptions, which may not accurately reflect real-world conditions. It is recommended that lake water level monitoring and flow monitoring at the outlet of Morris, Bissett and De Said Lakes be completed to calibrate the hydrologic/hydraulic model to confirm the extent of floodplain and the location and sizing of the required SWM measures.
- The model was not designed to assess site-specific flooding risks. This report primarily relies on floodlines provided by HRM, which were generated using a high-level regional model that may underestimate flooding along smaller streams. A detailed floodline delineation is necessary to accurately evaluate flooding risks along the watercourses abutting the site.



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11 Floodplain & Sustainable Development

Planning and development decisions should be guided by best practices in both floodplain management and sustainable development. This process should integrate the principles of resilience to climate change and commitment to environmental conservation at each planning stage.

To guide the HRM in planning, development and refinement of sustainable future development plans for the Morris Lake Study Area, it is recommended to develop a high level map outlining opportunities to protect and improve the natural environment and associated limitations and constraints. It is important to note that most development constraints which include meander belt widths and regulatory floodplains, greatly impact the environment and hence should not be altered. However other constraints such as modification to drainage may be permitted if carried out as part of an integrated planning approach such as a subwatershed study. Should there be a need to alter/affect development constraints, detailed investigation must be performed to evaluate the impact on natural features and downstream properties and infrastructure, and to establish corresponding measures to eliminate/compensate for the adverse impacts. Development constraint mapping for the Study Area has been provided in the Land Suitability Assessment (Stantec, 2024), as well as in this report. However, these studies do not quantify the impacts on stormwater/flooding resulting from any alterations that may be proposed as part of the development concept plans.

Wetlands effectively aid in reducing the negative impacts of frequent heavy rainfall events by collecting runoff in their naturally low-lying areas, allowing it to be slowly released into receiving watercourses, infiltrated into the soil to recharge groundwater systems, or absorbed by wetland vegetation. As a result, wetlands represent an important constraint for any development in Nova Scotia. Conservation of wetlands in the province is guided by the Nova Scotia Wetland Conservation Policy and supported by regulation under the provincial Environment Act and Activities Designation Regulations. The goals of the policy are to have no loss of Wetlands of Special Significance (WSS) and to prevent net loss in area and function for other wetlands.

As stated in the Statement of Provincial Interest Regarding Flood Risk Areas, within the *Floodway*, development must be restricted to uses such as roads, open space uses, utility and service corridors, parking lots and temporary uses, and the placement of off-site fill must be prohibited. Within the *Floodway Fringe*, flood proofed development may be allowed except for residential institutions where flooding could pose a significant threat to the safety of residents if evacuation became necessary, and in any use associated with the warehousing or the production of hazardous materials. Additionally, the placement of off-site fill within the *Floodway Fringe* must be limited to that needed for flood proofing or flood risk management.

Development contrary to the Statement of Provincial Interest Regarding Flood Risk Areas may be allowed provided a hydrotechnical study, carried out by a qualified person, shows that the proposed development will not contribute to upstream or downstream flooding or result in a change to flood water flow patterns.

Based on the above, it is recommended that no active development be permitted within the limits of the 100-year regulatory floodplain. Some reduced risk uses may be considered in agreement with HRM by-



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laws and the Nova Scotia Statement of Provincial Interest Regarding Flood Risk Areas. This is subject to design considerations that effectively mitigate and/or minimize the impact of such development on the floodplain and protect the riparian corridor functions. It is further recommended that future development phasing start in higher areas outside of the identified preliminary floodplain and that detailed floodplain mapping be completed to confirm floodplain extents and development setbacks.

Moreover, any proposed development should adhere to the constraints identified in the Land Suitability Assessment constraint mapping for the Morris Lake Study Area (Stantec, 2024). This includes areas of significant wildlife habitat, wetlands, steep slopes, and other environmentally sensitive areas. In areas where development is proposed within or in proximity to the identified floodplain, suitable mitigation measures should be implemented.

In addition, the promotion of green space creation or naturally forested park areas greatly reduce volume of runoff and pollutant loading discharged into receiving watercourses and as such, it is recommended that green space be promoted within future development plans.



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12 Stormwater Management Conclusions and Recommendations

The following lists the key points concluded from the stormwater analysis:

- The stormwater management plan for the Morris Lake Study Area includes storm sewers sized for the 5-year storm at 80% full flow pipe capacity, overland flow routing to end-of-pipe SWM facilities and thirteen (13) SWM dry ponds designed to restrict post-development peak flows to existing watercourses to pre-development levels for up to and including the 100-year storm. However, the analysis has identified important limitations and vulnerabilities in the layout provided by the developer. Although this layout was used to assess the feasibility of controlling post-development peak flows, it requires further consideration of key elements. The proposed development layout and associated stormwater management requires a thorough revision based on further analysis of the land use distribution and the siting of SWM ponds, as well as detailed hydraulic modeling, to confidently mitigate risks of flooding and reduce risks of degradation to the natural assets within the Study Area. High density land uses can potentially reduce the footprint of development and help to maintain development and stormwater management infrastructure away from flooding risk areas.
- Quality control for the Study Area is to be provided through best management practices, along with the use of LID measures to provide filtration and promote infiltration within public areas. Loading reduction tracking as a result of mitigation measures can be achieved through monthly grab samples at select monitoring locations during the summer months.
- No proposed watercourse crossings have been identified.
- Small portions of the current development plans infringe on the preliminary 100-year floodplain extents. It is recommended that proposed development plans be updated such that all proposed development falls outside the 100-year floodplain.

Based on the discussion provided in this report, the following is a summary of recommendations:

- An existing watercourse crossing under the TransCanada trail was not included in the HRM Open data source and was not included in the model. This crossing should be included in future hydraulic analysis of the area to assess flood risk mapping and required culvert upgrades.
- The conceptual development plan be revised to accommodate existing wetlands, unless otherwise specified in future environmental assessments.
- Flow monitoring in the watercourses and lakes, followed by model calibration be completed to determine lake water levels, confirm regulatory floodplain limits, determine culvert sizing, and proposed pond sizes and locations.



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- No active development be permitted within the limits of the 100-year regulatory floodplain. Some reduced risk uses may be considered in agreement with HRM by-laws and the Nova Scotia Statement of Provincial Interest Regarding Flood Risk Areas. This is subject to design considerations that effectively mitigate and/or minimize the impact of such development on the floodplain and protect the riparian corridor functions.
- A detailed geotechnical investigation is recommended to be completed at the detailed design stage. Geotechnical recommendations should be provided for the proposed Stormwater Management (SWM) ponds, grade-raise restrictions, and the feasibility of Low Impact Developments (LIDs) in the area.
- A revision of land use distribution to increase high-density uses, reduce development footprint and allow the location of the proposed ponds is advised to inform the design of an effective and sustainable stormwater management plan.
- The development concept plan be revisited to ensure SWM Ponds are located outside of the confirmed 100-year floodplain and/or delineated wetlands, to maximize the use of natural areas considering the recommendations of the Land Suitability Assessment, to consider high-density land uses that reduce sprawl to achieve this purpose, and to inform the revision of the proposed development layout and stormwater management plan to reduce risk of flooding and degradation to natural assets in the Study Area. The current layout includes SWM ponds located in or close to areas under risks of flooding.
- Future development phasing start in higher areas outside of the identified preliminary floodplain and detailed floodplain mapping be completed to confirm floodplain extents and associated development setbacks.
- In future stages of planning and development of the site, the development plan should be revised to relocate residential development and SWM ponds that are currently close to or within the potential floodplain. By pulling back the development, and potentially adding density to the remaining area, the population/development yield of the site could remain similar, and it could reduce the potential risks associated with flooding. The Land Suitability Report outlines that areas within 30 m of a watercourse have low suitability for development. Minimum setbacks to the watercourses in excess of the 30 m identified in the Land Suitability Report and as specified in the draft Regional Plan must be studied on a site-specific basis during subsequent area planning.
- Retaining native and existing ground cover be prioritized where possible to preserve ecosystem service function, reduce volume of runoff discharged into watercourses/waterbodies, promote infiltration and provide an opportunity for evapotranspiration.
- Implementing structural LID measures within public property to reduce contaminant loads for the development area to achieve contaminant loads of existing conditions.
- Implementing erosion and sedimentation control measures to mitigate effects from development during construction, as well as implementing construction sequencing to minimize the quantity of soil exposed at any given time to prevent erosion.



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13 References

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APPENDICES



Appendix A Water Quality Results



Bureau Veritas ID	VPL983	VWO844	WDN003	WKL382	WRG984	XAK410	XIU388	XPK316	VPL984	VWO845	WDN004	WKL383
Sampling Date	2023/04/20 15:05	5/23/2023 10:35	2023/06/19 13:02	2023/07/18 06:30	2023/08/14 10:30	2023/09/19 10:00	2023/10/20 09:55	2023/11/15 11:15	2023/04/20 15:39	5/23/2023 10:26	2023/06/19 12:50	2023/07/18 06:45
COC Number	N/A	N/A	938243-02-01	943092-01-01	948311-01-01	954353-01-01	CH958824-01-01	CH963439-01-01	N/A	N/A	938243-02-01	943092-01-01
UNITS	SW-10	SW-10	SW-10	SW-10	SW-10	SW-10	SW-10	SW-10	SW-11	SW-11	SW-11	SW-11
Microbiological												
Escherichia coli	<10	<10	100	110	30	80	<100	<100	<10	<10	160	140
Total Coliforms	300	190	870	1500	290	1300	600	600	210	1400	1300	360
Inorganics												
Dissolved Chloride (Cl-)	90	89	84	68	58	44	47	40	91	91	75	78
Colour	20	44	14	47	37	64	47	100	12	13	34	11
Total Suspended Solids	1.6	<1.0	1.2	4.4	<1.0	2.4 (1)	12	<1.0	<1.0	<1.0	<1.0	1
Turbidity	1	0.67	1.9	5.9	1.1	1.4	3.8	2.3	0.56	0.62	1.2	1.8
Total Phosphorous			0.0065	<0.004	0.01	0.009	<0.020	0.012		<0.004	<0.004	<0.004

Bureau Veritas ID	WRG985	XAK411	XIU389	XPK317	VPL985	VWO846	WDN005	WKL384	WRG986	XAK412	XIU390	XPK318
Sampling Date	2023/08/14 10:40	2023/09/19 10:05	2023/10/20 09:35	2023/11/15 11:10	2023/04/20 16:02	5/23/2023 10:15	2023/06/19 14:35	2023/07/18 06:50	2023/08/14 10:50	2023/09/19 10:15	2023/10/20 09:45	2023/11/15 11:20
COC Number	948311-01-01	954353-01-01	CH958824-01-01	CH963439-01-01	N/A	N/A	938243-02-01	943092-01-01	948311-01-01	954353-01-01	CH958824-01-01	CH963439-01-01
UNITS	SW-11	SW-11	SW-11	SW-11	SW-12	SW-12	SW-12	SW-12	SW-12	SW-12	SW-12	SW-12
Microbiological												
Escherichia coli	>2500	>2500	300	<100	10	10	170	90	180	680	<100	<100
Total Coliforms	>2500	>2500	2100	1000	590	520	800	900	700	1600	800	600
Inorganics												
Dissolved Chloride (Cl-)	60	48	52	51	88	89	7.5	77	60	46	50	52
Colour	21	26	16	15	14	13	410	14	41	42	18	16
Total Suspended Solids	2	<2.0 (1)	<1.0	2.4	2.6	2.0	<1.0	1.2	<1.0	1	1	<2.0
Turbidity	3.6	3.7	1	0.95	1.7	0.62	2	0.46	1	1.1	2.1	0.62
Total Phosphorous	0.008	0.023	<0.020	0.006		<0.004	0.012	0.008	0.006	0.012	<0.020	<0.004

Bureau Veritas ID	VPL986	VWO847	WDN006	WKL385	WRG987	XAK413	XIU391	XPK319	VPL987	VWO848	WDN007	WKL386
Sampling Date	2023/04/20 13:43	5/23/2023 11:42	2023/06/19 15:18	2023/07/18 07:40	2023/08/14 10:00	2023/09/19 09:25	2023/10/20 11:25	2023/11/15 11:55	2023/04/20 14:45	5/23/2023 12:34	2023/06/19 14:00	2023/07/18 06:00
COC Number	N/A	N/A	938243-02-01	943092-01-01	948311-01-01	954353-01-01	CH958824-01-01	CH963439-01-01	N/A	N/A	938243-02-01	943092-01-01
UNITS	SW-13	SW-13	SW-13	SW-13	SW-13	SW-13	SW-13	SW-13	SW-14	SW-14	SW-14	SW-14
Microbiological												
Escherichia coli	20	10	460	<10	>2500	1100	<100	<100	20	50	220	410
Total Coliforms	530	560	2500	980	>2500	1700	800	1200	520	790	920	1200
Inorganics												
Dissolved Chloride (Cl-)	45	56	21	35	13	18	21	23	54	60	61	36
Colour	120	84	250	120	240	200	95	100	110	64	100	100
Total Suspended Solids	3.6	2	<1.0	1.2	<1.3	4.4 (1)	<1.0	2	<1.0	<1.0	<1.0	1
Turbidity	2.3	1.6	1.7	3.1	2.9	4	2.4	2.4	0.81	0.36	1.1	1
Total Phosphorous		0.01	0.015	0.009	0.012	0.015	<0.020	0.01		<0.004	0.007	0.015

Bureau Veritas ID	WRG988	XAK414	XIU392	XPX320	VPL988	VW0849	WDN008	WKL387	WRG989
Sampling Date	2023/08/14 09:40	2023/09/19 09:00	2023/10/20 10:05	2023/11/15 12:15	2023/04/20 13:15	5/23/2023 11:16	2023/06/19 15:40	2023/07/18 07:50	2023/08/14 10:15
COC Number	948311-01-01	954353-01-01	CH958824-01-01	CH963439-01-01	N/A	N/A	938243-02-01	943092-01-01	948311-01-01
	SW-14	SW-14	SW-14	SW-14	SW-15	SW-15	SW-16	SW-15	SW-15
Microbiological									
Escherichia coli	>2500	1500	200	<100	10	60	180	290	430
Total Coliforms	>2500	5100	1500	500	580	380	750	960	900
Inorganics									
Dissolved Chloride (Cl-)	26	24	30	28	84	86	56	77	53
Colour	250	210	76	57	29	17	150	21	56
Total Suspended Solids	2	660	<1.0	1	<1.0	1.4	<1.0	<1.0	<1.0
Turbidity	2.7	33	1.5	2	0.82	0.4	1.5	0.72	0.93
Total Phosphorous	0.016	0.023	0.022	0.006		<0.004	0.009	0.01	0.004

Bureau Veritas ID	XAK415	XIU393	XPX321	
Sampling Date	2023/09/19 09:30	2023/10/20 11:20	2023/11/15 11:45	
COC Number	954353-01-01	CH958824-01-01	CH963439-01-01	
	SW-15	SW-15	SW-15	
Microbiological				
Escherichia coli	150	<100	<100	
Total Coliforms	650	1000	300	
Inorganics				
Dissolved Chloride (Cl-)	47	50	49	
Colour	63	26	27	
Total Suspended Solids	<2.0 (1)	<1.0	<1.0	
Turbidity	0.49	1.3	1.3	
Total Phosphorous	0.008	<0.020	0.004	

Appendix B Storm Drainage Drawings





Item	Description	Quantity	Unit
1	Manhole	1	Each
2	Catch Basin	1	Each
3	Storm Pipe	1	Each
4	Storm Pipe	1	Each
5	Storm Pipe	1	Each
6	Storm Pipe	1	Each
7	Storm Pipe	1	Each
8	Storm Pipe	1	Each
9	Storm Pipe	1	Each
10	Storm Pipe	1	Each
11	Storm Pipe	1	Each
12	Storm Pipe	1	Each
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97	Storm Pipe	1	Each
98	Storm Pipe	1	Each
99	Storm Pipe	1	Each
100	Storm Pipe	1	Each

Client: HANOVER REGIONAL MUNICIPALITY
Project: Future Serviced Communities
Location: Morris Lake
Drawing No.: EXSD-1

Project No.: 1041049
Drawing No.: EXSD-1

Scale: 1" = 100'
Sheet: 4 of 5
Revision: 2

