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Appendix H: Drainage and Stormwater Management Brief

Bradford Street Municipal Class Environmental Assessment Study

Drainage and Stormwater Management Brief

April 5, 2023

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City of Barrie

Bradford Street
Municipal Class Environmental Assessment Study

Drainage and Stormwater Management Brief

PREPARED BY: **Madhav Baral** **April 5, 2023**

Name **Date**

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1. Introduction

1.1. Proposed Description

CIMA+ was retained by the City of Barrie (City) to conduct a Municipal Class Environmental Assessment (Class EA) Study to identify transportation improvements required on Bradford Street to address transportation needs to support growth and incorporate streetscape improvements with active transportation infrastructure within the study area between Tiffin Street and Dunlop Street. Existing land use along Bradford Street is transitioning from low density residential and commercial to future intensification corridor. The study area can be seen on Error! Reference source not found. below. The entire study area is within the jurisdiction of Lake Simcoe Region Conservation Authority (LSRCA).

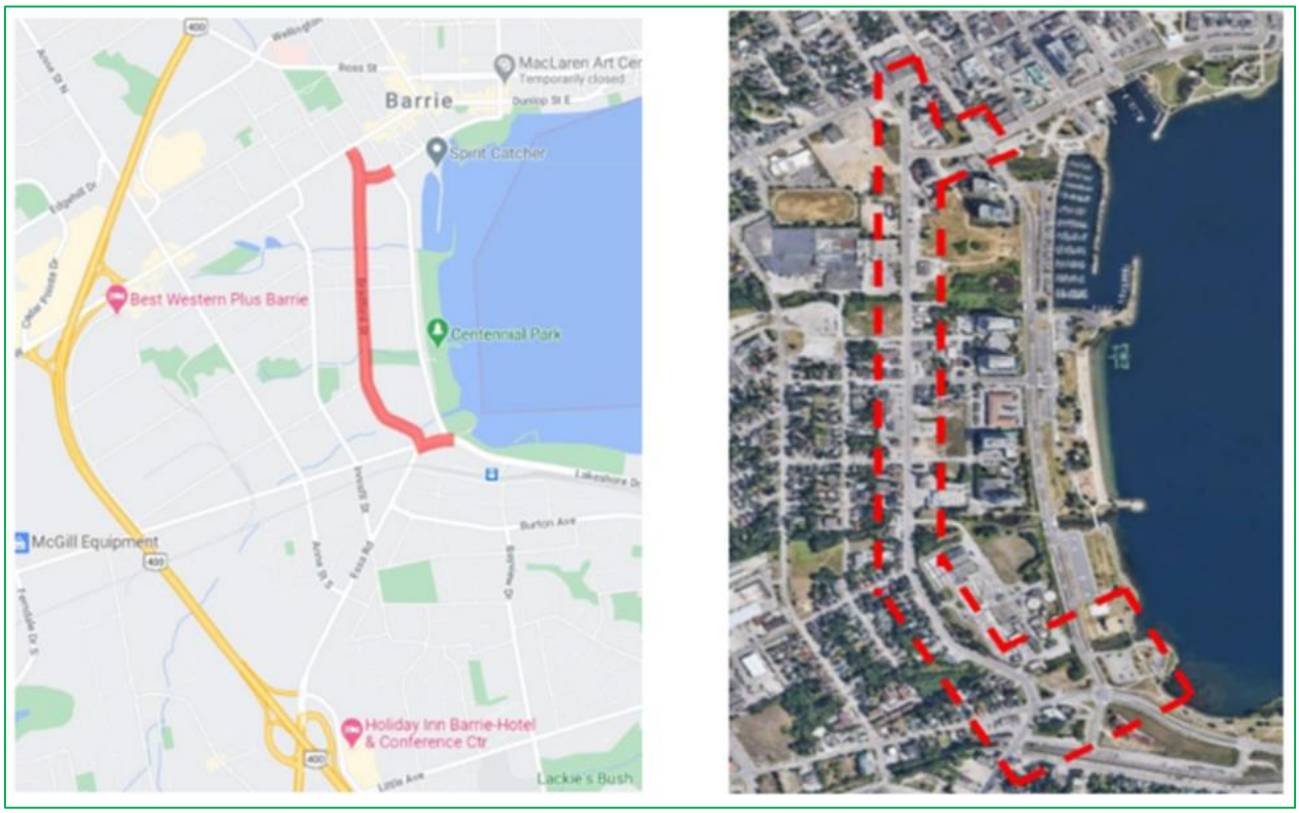


Figure 1: Study Area Location Map Sample

1.2. Study Purpose

This Drainage and Stormwater Management study usually identifies the relevant characteristics of the existing and proposed drainage systems, documents the hydrologic assessments to determine the flow for the culverts and flow related to

stormwater management design, hydraulic assessments of culverts, reconfiguration of existing drainage features as well as design of new drainage features to accommodate the proposed improvements.

However, given that the proposed Bradford Street corridor improvements will take place in the long term (i.e. beyond the 10-year timeline), the approach to drainage and stormwater management review for the Bradford Street MCEA Study includes a high level review of the existing drainage system and identify commitments for the necessary work to be completed during the detailed design phase; findings are documented in this report.

1.3. Potential Drainage Impacts

Road improvement projects can affect drainage patterns and watercourse characteristics due to increased impervious areas, culvert extensions, culvert replacements, and other roadway works. Some potential impacts include:

- Increased runoff (affecting peak flow rate and the erosion potential of the receiving watercourse)
- Increased pollutant and sediment loading within stormwater and meltwater runoff
- Physical changes to watercourse morphology (i.e., base flows, flooding levels, and water quality)
- Physical changes to drainage boundaries
- Physical changes to hydrologically significant features (i.e., existing ponding areas, dams, zones of infiltration, etc.)

2. Background Information and Site Description

2.1. Background Information Review

The following documents have been reviewed as a part of the study:

- Highway *Drainage Design Standards,* Ontario Ministry of Transportation (MTO), 2008
- Storm Drainage and Stormwater Management Policies and Design Guidelines, City of Barrie, May 2022
- Low Impact Development Interim Guidance, City of Barrie, 2019
- LSRCA Technical Guidelines for Stormwater Management Submission, Lake Simcoe Region Conservation Authority, September 2016
- Erosion and Sediment Control Guide for Urban Construction, TRCA, 2019
- MECP (former MOE) Stormwater Management Planning and Design Manual, 2003
- Contract Drawings for Bunkers Creek – Bradford Street Culvert and Upstream Channel Improvements, prepared by Aquafer Beech Limited, October 2022
- IFC drawings for Dunlop Street West Reconstruction and Kidds Creek Culvert Replacement, Contract # FIN2019-145T, prepared by R. J. Burnside & Associates Limited, January 2020
- New Construction CAD Drawing of Dyments Creek Channel and Culvert Improvements, Bradford Street and Sanford Street, prepared by the City of Barrie, September 2021
- As-built drawing of Bradford Street Reconstruction at High Street, Drawing # 2003-02, January 2003.
- As-built drawings of Bradford Street Corridor Reconstruction, 2003
- Drainage Master Plan, Appendix B: Hydrologic and Hydraulic Modelling Technical Memorandum, Prepared by Tatham Engineering, March 2019

2.2. Site Description

The project site consists of improvement of Bradford Street from Dunlop Street to Tiffin Street in the City of Barrie. In addition to this, improvements to small section connecting roads to Bradford Street such as, High Street, Simcoe Street, and Tiffin Street from Bradford Street to Lakeshore Drive are also the part of the project. There are four major

watercourses that crosses Bradford Street within the study area which are Hotchkiss Creek, Dyments Creek, Bunkers Creek and Kidds Creek. According to Master Drainage Plan, Hydrologic & Hydraulic Modelling Technical Memorandum:

- Hotchkiss Creek crosses Bradford Street between Tiffin Street and Brock Street. It has a total drainage area of 483 ha.
- Dyments Creeks crosses Bradford Street between Brock Street and John Street. It has a total drainage area of 580 ha.
- Bunkers Creeks crosses Bradford Street from the north of Vespra Street. This watercourse has a total drainage area of 361 ha.
- Kidds Creek crosses Bradford Street at High Street intersection. This watercourse has a total drainage area of 488 ha.

All these four watercourses ultimately drain to Kempenfelt Bay of Lake Simcoe at approximately 300 m east of Bradford Street.

3. Design Standards and Criteria

This section provides an overview of the SWM design criteria for the study area. These criteria are based on the City of Barrie Storm Drainage and Stormwater Management Policies and Design Guidelines, LSRCA Technical Guidelines for Stormwater Management Submission, Ministry of the Environment, Conservation and Parks (MECP), Low Impact Development Interim Guidance of the City of Barrie and MTO Highway Drainage Design Standards, 2008.

3.1. City of Barrie SWM Requirements

This section describes the stormwater management policies and design guidelines regarding environmental protection and flood and erosion control. According to the City of Barrie SWM Policies and Design Guidelines.

a) **Water Quality and Erosion Control:**

As per Ontario Regulation 219/09 regarding water quality and phosphorus loading to Lake Simcoe, all new SWM facilities shall provide as a minimum the Enhanced level of protection as specified in the *Stormwater Management Planning and Design Manual* (MOE, 2003).

b) **Quantity Control (Flood Protection)**

Post-to-pre quantity control shall be provided unless otherwise directed by the City or Conservation Authority, or unless otherwise indicated in an approved master drainage plan or watershed plan. Under certain circumstances where the proposed development is located in close proximity to Lake Simcoe and where there are no downstream landowners, the post-to-pre peak flow control requirements may be waived subject to approval by the LSRCA.

c) Water Balance

All new developments with a contributing drainage area > 5 ha shall provide post-to-pre infiltration on-site where soils permit and unless otherwise established at the secondary plan stage. The water balance requirements apply to the property limit of the development and do not necessarily need to be achieved on a lot-by-lot basis. Sites ≤ 5 ha shall minimize any anticipated changes in the water balance between pre-development and post-development conditions and shall provide a minimum infiltration equivalent to the first 5 mm of any given rainfall event.

3.2. LSRCA Requirements

a) Peak Flow Control Requirement

In order to minimize these risks, the SWM Quantity Control requirements for linear development projects are as follows:

- The post-development peak flow rates are not to exceed the corresponding pre-development peak flow rates for the 2-year to the 100-year storm events unless specified otherwise by a subwatershed study or fluvial geomorphic analysis.
- Every effort must be made to maintain existing watershed boundaries and drainage patterns. Pre-consultation is mandatory for any proposed change in drainage boundaries.
- Quantity control is not required if the site is directly adjacent to Lake Simcoe with a sufficient outlet or connection to a municipal system that is designed to discharge uncontrolled flows from the site directly to Lake Simcoe.

b) Stormwater Volume Control Requirements

Any works that meet the major development definition outlined in the Lake Simcoe Protection Plan or that results in site disturbance that creates 0.5 ha of new impervious surface or fully reconstructs 0.5 ha or more of impervious surface, should meet the following control requirements.

- Linear development on sites without restrictions that create 0.5 ha or greater of new and/or fully reconstructed impervious surfaces, shall capture and retain / treat on site, the larger of the following:
    i. The runoff from a 12.5 mm event from the fully reconstructed impervious surface and newly constructed impervious area.
    ii. The runoff from a 25 mm event from the net increase in impervious area on the site.

c) Major-Minor System Conveyance

The minor system conveys the frequent runoff events up to the design frequency of the system (typically 1 in 5 year design storm) while the major system conveys the runoff from infrequent storm events (typically 1 in 100 year design storm) that exceed the minor system capacity. The minor system includes the lot drainage components i.e. lot grades, ditches, swales, street gutters, catch basins and the storm sewer system. The major system may include overland flow routes, roadways, artificial channels, streams, and valleys.

The major and minor systems are to be designed to safely convey stormwater flows to a sufficient outlet, without negative impacts on adjacent properties. All minor system and major overland flow routes are to be secured by an appropriate easement as per municipal requirements.

d) Quality Control Requirement

Contaminants, such as oil, grease, metals, pesticides, fertilizers, winter salt and sediment tend to build up on surfaces in urbanized areas. These contaminants come from sources such as pavement deterioration, tire and brake pad wear, vehicle emissions, spills, construction and road maintenance.

- Suspended Solids: The required suspended solids removal treatment is MECP Enhanced Protection Level (Level 1). This corresponds to a long-term average removal of 80% of suspended solids. For linear development, an OGS may be considered as a standalone control device, if the use of other quality control measures is not feasible. The LSRCA is to be pre-consulted in these circumstances.
- Phosphorus: An application for major development shall be accompanied by a stormwater management plan that demonstrates through an evaluation of anticipated changes in phosphorus loadings, between pre-development and post-development, how the loadings from the proposed development shall be minimized. An area load method kilogram per hectare per year (kg/ha/yr) is to be utilized to compare existing load under pre-development conditions versus the total post-development load with / without quality controls. In addition, the removal of 80% of the annual Total Phosphorus (TP) load from all major development areas will be required.

e) Erosion Control

For sites less than 2 hectares, erosion control is normally not required. For larger areas, where an erosion control study is not specified, LSRCA will require that the runoff from a 25 mm design storm (4 hour, Chicago distribution) be detained and released over a period of at least 24 hours. LSRCA must be consulted about the need for an Erosion Study.

f) Water Balance

Every attempt should be made to match post development infiltration volumes and recharge quality to pre-development levels on an annual basis. It is common practice and an accepted method to provide estimates of surplus using a Thornthwaite and Mather approach where surplus is estimated based on precipitation minus evapotranspiration. Pre-development and post-development

water balances may have different catchments depending on the change in drainage patterns, grading, soil and vegetation as a result of the proposed site works.

Infiltration targets may be achieved through the incorporation of a variety of stormwater management practices including reduced lot grading, roof leaders discharging to ponding areas or soak away pits, infiltration trenches, and grassed swales / enhanced grassed swales.

3.3. MECP Design Requirements

a) Water Quality and Quantity

- Quality and quantity control measures to treat stormwater runoff should be considered for all new impervious areas and, where possible, existing surfaces.
- According to the MECP SWM Planning and Design Manual (2003), the highest level of water quality treatment is the Enhanced level. Runoff from the road ROW shall be treated to the Enhanced level of treatment.
- A Stormwater Management Plan should be prepared in accordance with the MECP Stormwater Management Planning and Design Manual, May 2003.

b) Runoff Volume Control Targets

The MECP developed Runoff Volume Control targets (RFC_T) for Ontario for linear infrastructure and retrofits to provide guidance for the implementation of low impact development. The report titled Runoff Volume Control Targets for Ontario was prepared by Aquafor Beech in October 2016 for MECP and recommends the following:

- For New Linear Projects, the recommended Runoff Volume Control targets (RVC_T) for Ontario is to capture and retain the 90^{th} percentile event (infiltrate 90% of the annual rainfall runoff) for all new impervious surfaces. This recommendation is founded on the principles of maintaining the pre-development water balance to ensure the ecosystem function and natural quality and hydrological characteristics of natural features in including aquatic habitat, baseflow, and water quality.
- For Linear Reconstruction Projects, which are primarily mill, overland and other resurfacing activities the recommendation is to achieve volume control to the Maximum Extent Possible (MEP) using all known, available and reasonable methods, given the site restrictions to achieve the maximum volume control.

3.4. MTO Hydraulic Design Standards

The MTO's *Highway Drainage Design Standards* prescribe standards for designing Surface Drainage Systems (SD) and Water Crossings (WC). The standards that are relevant to this study are as follows:

a) **SD-1 Design Flows for Surface Drainage Systems:** This standard identifies the minimum design flows that should be used for the sizing of road surface drainage systems.

b) **SD-12 Freeboard above Adjacent Watercourse or Water Bodies:** This standard identifies the minimum required freeboard for roadways that are constructed adjacent to watercourses or waterbodies.

c) **WC-1 Design Flows (bridges and culverts):** This standard identifies the minimum design flows for the sizing of bridges and culverts for flow conveyance on regulated and non-regulated watercourses. It stipulates that an urban arterial road with a watercourse crossing and span of less than or equal to 6.0 m should be designed to convey the flow generated during a 50-year design storm. For spans greater than 6.0 m the watercourse crossing should be designed to convey the flow generated during a 100-year design storm.

d) **WC-7 Culvert Crossings on a Watercourse:** This standard identifies freeboard, minimum clearance and the maximum flood depth at culvert crossings.

- *Minimum Freeboard* of 1.0 m measured vertically from the High Water Level for the design flow to the edge of the travelled lane at the low point.
- *Minimum Clearance* of 1.0 m measured vertically from the High Water Level for the design flow to the minimum soffit elevation of the bridge or the average soffit elevation of an arch culvert.
- The *Flood Depth to Rise Ratio (HW/D)* at culverts with a rise less than 3.0 m should not exceed 1.5 times the diameter or rise of the culvert at the upstream face. For culverts with a rise between 3.0 m and 4.5 m the flood depth to rise ratio at the upstream face must not exceed 4.5 m. This standard applies to closed footing culverts and open footing culverts with non-erodible bottoms.
- In addition to these design standards, the culverts within the study limits will be analyzed for overtopping during the 100-year and Regional Storm events.

e) **WC-13 Relief Flow:** This standard WC-13 of the HDDS addresses the control of flood flows conveyed over the roadway as Relief Flow at water crossings and

identifies the maximum depth and the maximum velocity of flow over the roadway. As such the following parameters shall not be exceeded at the cross section of the road for the regulatory flow:

- The maximum depth of flow on the roadway shall not exceed 0.3 m.
- The product of the velocity and depth on the roadway shall not exceed 0.8 m^2/s.

3.5. Rainfall IDF and Storm Distribution

Intensity-Duration-Frequency (IDF) parameters for City of Barrie for the Barrie WPCC Station #6110557. The parameters are summarized in **Table 1** along with the 12-hour and 24-hour rainfall depths. The IDF intensity values for Barrie WPCC Station were increased by 15% before calculating a, b, c values to account for climate change.

In order to determine the critical design storms, hyetographs for the SCS Type II (6-Hour, 12-hour and 24-hour durations) and the 4-hour Chicago storm distributions are generated and generally used for the City of Barrie. The storm duration which results in the highest peak flows and runoff volumes will be used for the study. To estimate flows during a Regional Storm event, either the Timmins storm or Hurricane Hazel shall be used as the Regional storm within the respective jurisdictions of the NVCA and the LSRCA for the preparation of floodplain mapping where applicable.

City approved design storm hyetographs for computer modeling (adjusted to account for climate change) are provided in Appendix B of the City of Barrie Storm Drainage and SWM Policies and Design Guidelines.

Table 1: Rainfall IDF Information

Parameters	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
A	675.586	843.019	976.898	1133.123	1251.473	1383.628
B	4.681	4.582	4.745	4.734	4.847	4.905
C	0.780	0.763	0.760	0.756	0.753	0.754
12-Hr Rainfall Depth (mm)	47.6	66.5	78.6	93.6	105.4	115.8
24-Hr Rainfall Depth (mm	55.6	78.6	93.0	111.1	125.4	137.6

3.6. Design Approach

The linear nature of the roadway project presented challenges in addressing drainage and stormwater management impacts associated with the roadway rehabilitation. of the significant challenges include land availability, utility conflicts, and operations & maintenance. Due to the characteristics of the subject area and proposed roadway resurfacing, the stormwater management assessment will have the following approach:

- Documentation of existing conditions including identification of outlets, existing culverts, drainage topography, soils, land use, flood limits and other relevant drainage features and constraints.
- Evaluation of the existing and proposed hydrology flows and associated impacts to the receiving watercourse due to the proposed roadway improvement.
- Conduct hydraulic assessment of culvert for existing and proposed conditions in relation to applicable design criteria.
- Identifying potential opportunities to implement Low Impact Development features.

4. Drainage Assessments

4.1. Existing Conditions Drainage

Bradford Street is an arterial road corridor running in a north-south direction parallel to Lakeshore Drive, with a four-lane urban cross-section within the study area. The posted speed limit is 50 km/h within the study area. There are no separate left turn lanes except at Tiffin Street intersection. Sidewalk exists on both side of the road.

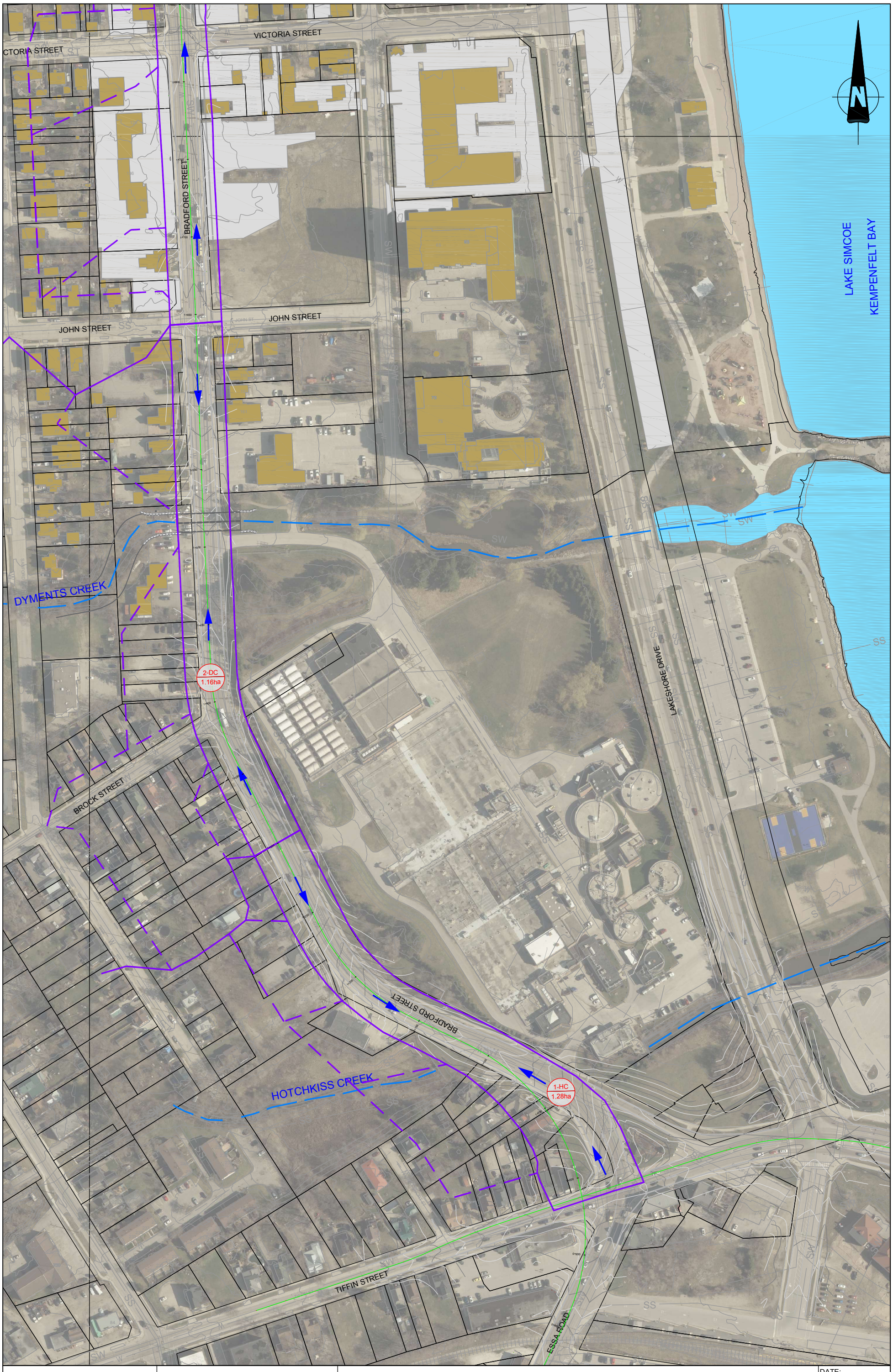
Existing conditions drainage mosaics for the roadway area is shown in **Figure 2** and **Figure 3**. These figures also show the boundary of external drainage catchments (shown in dash line) draining toward the roadway. These external catchments boundary lines match with the drainage plan prepared in 2003 for Bradford Street reconstruction. However, this drainage discussion is focused only on the changes in the drainage condition within the roadway area. The roadway area of Bradford Street is divided into four subcatchments depending upon the watershed boundary of watercourses.

Under existing conditions, roadway runoff from Catchment 1-HC (drainage area 1.28 ha) drains to Hotchkiss Creek. It covers approximately 300 m road stretch of Bradford Street from Tiffin Street to the south of Brock Street. Road runoff is conveyed by existing storm sewers and discharge to Hotchkiss Creek. Road low point is located near Hotchkiss Creek culvert. Major storm flow drains overland toward road low point and ultimately discharged to Hotchkiss Creek.

Roadway Catchment 2-DC (drainage area 1.16 ha) falls under the watershed of Dyments Creek. It covers approximately 350 m length of Bradford Street from the south of Brock Street to John Street. Minor storm road runoff is conveyed by storm sewers and discharge to Dyments Creek. Major storm flow drains overland toward road point which is located near Dyments Creek culvert and ultimately discharged to the creek.

Approximately 700 m length of Bradford Street from John Street northerly to Simcoe Street falls under the watershed of Bunkers Creek, Catchment 3-BC. This catchment has a drainage area of 2.36 ha. Minor storm runoff is conveyed by storm sewers and major storm flow drains overland toward Bunkers Creek culvert and ultimately both major and minor storm flow drains to Bunkers creek.

Approximately 0.55 ha of drainage area (Catchment 4-KC) falls under the watershed of Kidds Creek. This catchment includes approximately 165 m stretch of Bradford Street. Minor storm runoff is conveyed by storm sewers and major storm flow drains overland toward Kidds Creek culvert. Kidds Creek runs entirely underground specifically on the downstream of Bradford Street and is not visible from the Bradford Street right-of-way.



CITY OF BARRIE, BRADFORD STREET EA

EXISTING CONDITIONS DRAINAGE MOSAIC

DATE: MAR 2023

DRAWING NO. FIGURE 1

DWG SHEET: 1 of 2

HIGH STREET
DUNLOP STREET W
TORONTO STREET
SIMCOE STREET
KIDDS CREEK
4-KC
0.55ha
BRADFORD STREET
3-BC
2.36ha
BUNKERS CREEK
ECO PARK
EXISTING STORM OUTLET CHANNEL
VESPRA STREET
LAKESHORE DRIVE
VICTORIA STREET
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CITY OF BARRIE, BRADFORD STREET EA

EXISTING CONDITIONS DRAINAGE MOSAIC

DATE: MAR 2023

DRAWING NO. FIGURE 2

DWG SHEET: 2 of 2

4.2. Proposed Conditions Drainage

Under proposed conditions Bradford Street will be a four-lane urban section with following major improvements:

- Two dedicated left tun lanes from Bradford Street to Tiffin Street.
- Dedicated left turning lanes will be added on Bradford Street at the intersection with Brock Street, John Street, Victoria Street, Vespra Street, Simcoe Street and Dunlop Street.
- A conceptual 4.2 m wide median has been proposed through out the study area. The width of medians is reduced at the left turning lane locations. The proposed medians are conceptual and subject to future development application and access management approval.
- A 2 m sidewalk and a 2 m bicycle track on both sides of the roadway.
- A 2.5 m wide boulevard is proposed on both sides of the road which separates the cycle track with driving lanes (may potentially be used for planting / vegetation or for utilities).

Figure 4 and **Figure 5** show the proposed conditions drainage mosaic. These figures also illustrate the external drainage boundary (shown in dash line). It is expected that the drainage conditions of external areas will remain same for the pre- and post development of Bradford Street Improvement during the time of implementation. Therefore, this report is mostly focussed on the changes in the drainage condition of Bradford Street between pre- and post-development conditions due to increase in impervious surface. During the detailed design phase, the external area will need to be included in the analysis for the sizing of conveyance system i.e., sizing of storm sewer.

As in existing conditions, the roadway area of Bradford Street is divided into four subcatchments depending upon the watershed boundary of watercourses. There will be no change in the drainage pattern and boundary from the existing condition; however, due to the proposed improvements, imperviousness will be increased in each subcatchment, which will be discussed in **Section 5** for the necessary runoff peak flow and quality control requirements.

4.3. Hydrologic Assessments

The time horizon for the construction of proposed improvements on Bradford Street is not certain yet. Therefore, hydrologic assessments for the roadway corridor have not been completed and deemed not required in this stage. When the City is ready to

proceed with the proposed improvement of the roadway in the future, followings will be carried out during that time:

- Existing and proposed conditions hydrologic assessment for the roadway corridor and comparison of the flow between pre- and post development scenarios. Necessary peak flow control measure will be reviewed during that time.
- Flow for the culverts will be based on external catchments and will be obtained from the LSRCA.

4.4. Hydraulics Assessments

There are four watercourse crossing structures on Bradford Street which are:

- Hotchkiss Creek Culvert, 9.75 m x 2.04 m Concrete Box Culvert[1], located approximately 110 m north of Tiffin Street. The culvert conveys the Regional storm flow.
- Dyments Creek Culvert, two cell 5.4 m x 2.4 m size concrete Box Culvert[2], located approximately 125 m north of Brock Street. The culvert will convey the Regional storm flow.
- Bunkers Creek Culvert, twin 8.29 m x 2.98 m CSP Arch Culvert[3], located approximately 105 m north of Vesra Street. The culverts will convey the Regional storm flow.
- Kidds Crek Culvert, twin cell 3.0 m x 1.50 m Concrete Box Culvert[4], located approximately 65 m north of Simcoe Street. The culvert has the capacity to convey the 100-year flow.

Out of these four culverts, Hotchkiss Creek culvert and Kidds Creek culvert are existing culverts, whereas Dyments Creek and Bunkers Creek culverts are new culverts and are proposed for construction in the near future by the City (outside of the scope of the Bradford Street MCEA Study).

Foot Note:

1. Hydrologic and hydraulic Modelling Technical Memorandum, Prepared by Tatham Engineering, March 2019
2. Dyments Creek, Channel and Culvert Improvement Drawing, Drawing # 6, Sheet PP-2, City of Barrie, Sept 2021.
3. Bunkers Creek Culvert Replacement and Water Course Improvements, Prepared by Aquafor Beech Limited, October 2022
4. Bradford Street Reconstruction As-built drawing, City of Barrie, Drawing # 2003-002-004, Sheet PP1, May 2003.

It is not expected that the proposed Bradford Street improvement will impact the culverts at Hotchkiss Creek, Dyments Creek and Bulkers Creek. However, some extension on Kidd Creek Culvert may require on the upstream side if the combination of other design measures (e.g., headwall / wingwall, slope measures, adjustments to sidewalk / cycle track / boulevard etc.) are not enough to avoid impact. This will be further reviewed in the next phase of study.

The hydraulic analysis will also be carried out in the next phase of study for the culverts where the culvert extension is required. LSRCA requires that the culvert extensions must demonstrate no negative impact to flood elevations upstream and downstream of crossings and demonstrate no increase in over bank velocity.

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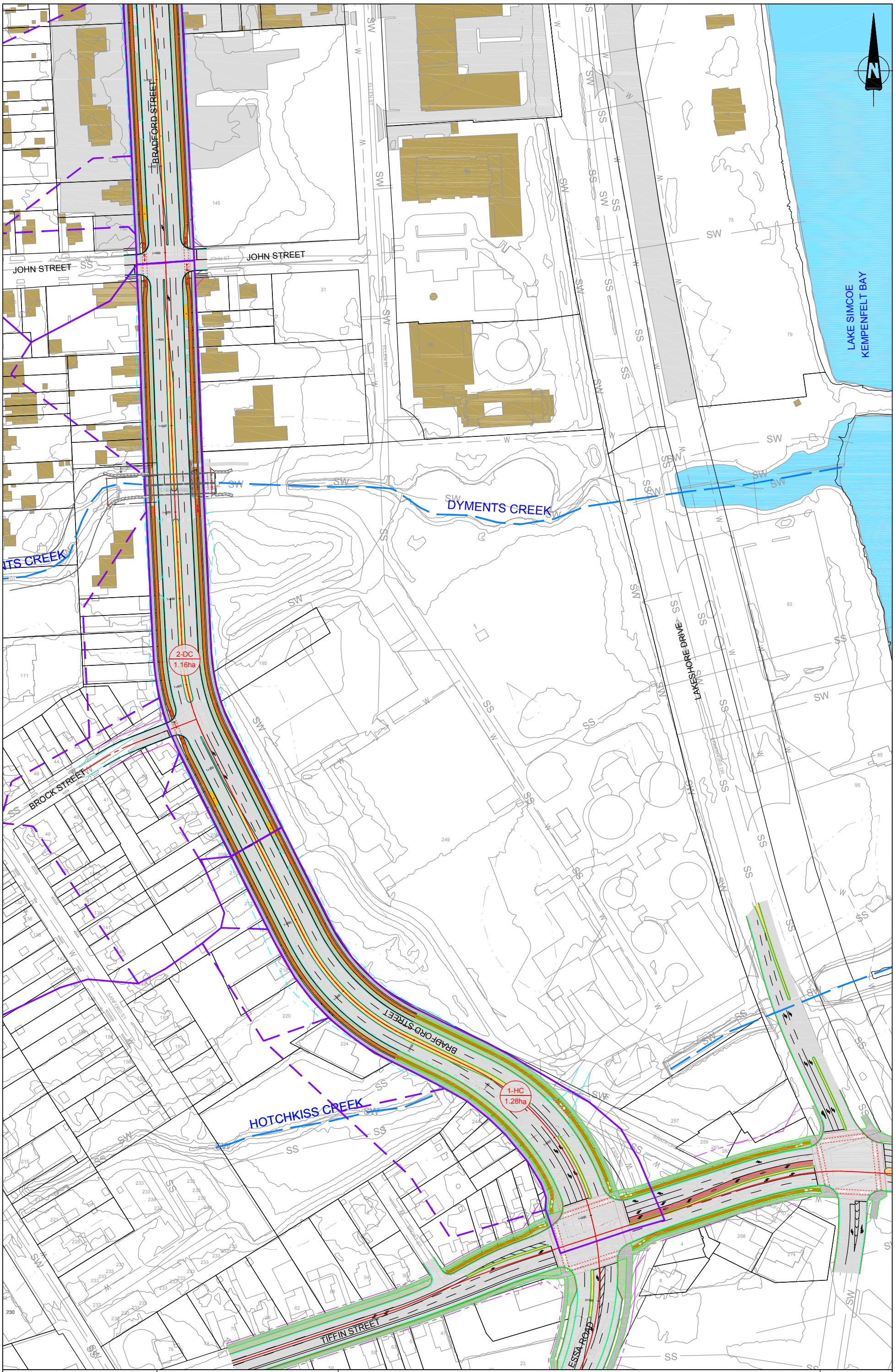


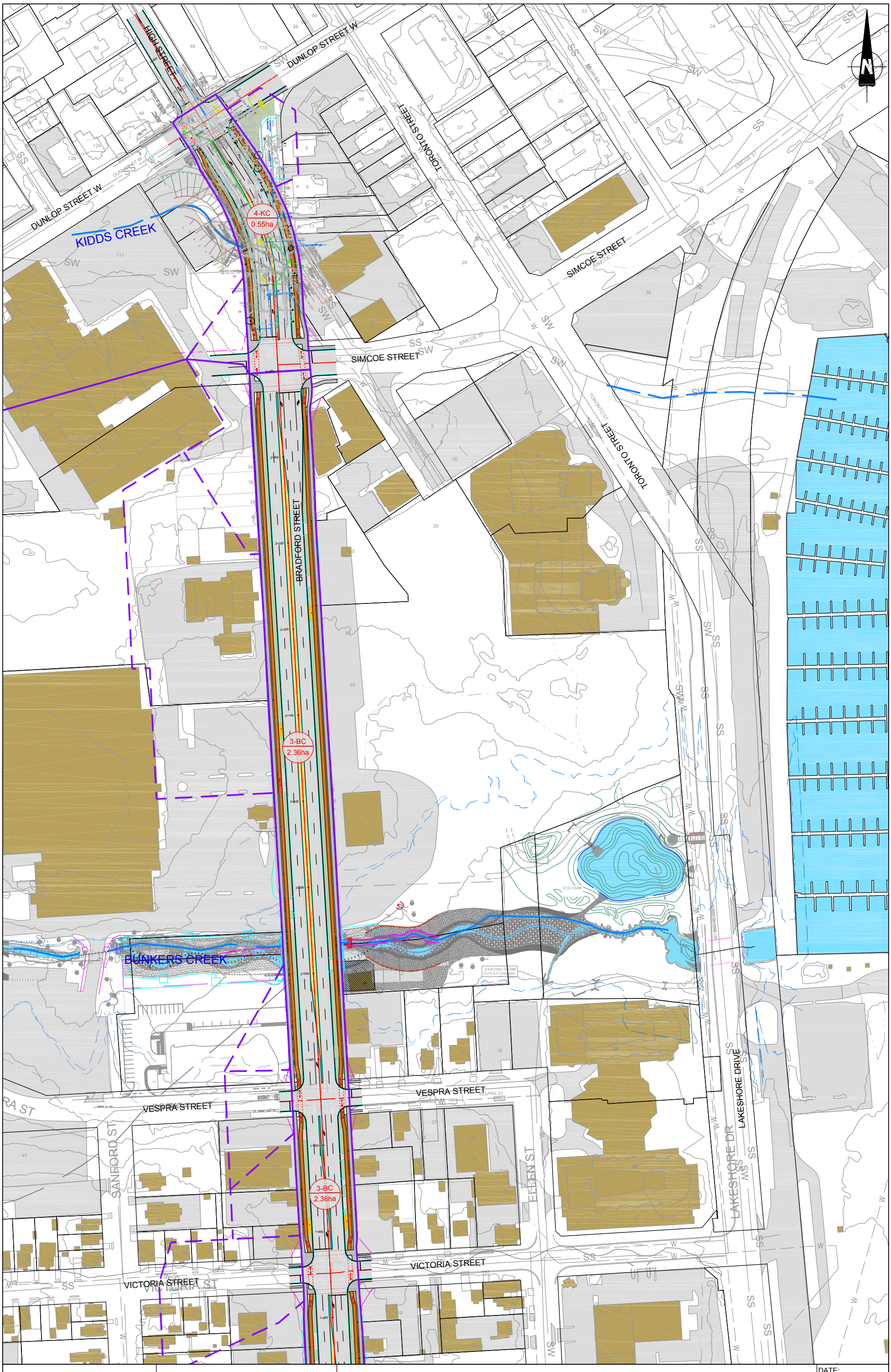
CITY OF BARRIE, BRADFORD STREET EA

PROPOSED CONDITIONS DRAINAGE MOSAIC

DATE: MAR 2023

DRAWING NO. FIGURE 3

DWG SHEET: 1 of 2



CITY OF BARRIE, BRADFORD STREET EA

PROPOSED CONDITIONS DRAINAGE MOSAIC

DATE: MAR 2023

DRAWING NO. FIGURE 4

DWG SHEET: 2 of 2

5. Stormwater Management

5.1. General Overview

Under existing conditions, minor storm runoff from Bradford Street is conveyed by storm sewers and major storm drains overland toward road low point and ultimately discharged to respective watercourses, which ultimately discharged to Kempenfelt Bay of Lake Simcoe. There are no runoff quality and quantity control measures currently in place.

The Drainage Master Plan, Appendix B Hydrologic and Hydraulic Modelling Technical Memorandum, prepared by Tatham Engineering dated March 2019, has identified minor system deficiency for the minor system drainage along Bradford Street. The minor system deficiency map can be found in Appendix B of Drainage Master Plan.

The proposed improvement of Bradford Street will result in an increase in impervious area compared to the existing land use. Increased imperviousness as a result of the road improvement may need to address by stormwater quality and quantity control measures.

5.2. Impact of the Proposed Road Improvement

The proposed road improvement of Bradford Street will increase the imperviousness which may lead some increase in peak flow. **Table 2** provides a comparison of impervious area under existing and proposed conditions.

Table 2: Comparison of Impervious Area Pre- and Post-development

Catchment ID	Drainage Area	Existing Condition		Proposed Condition with Median as Green Area		Proposed Condition with Median as Impervious Area	
		Imp. Area (ha)	Imp. %	Imp. Area (ha)	Imp. %	Imp. Area (ha)	Imp. %
1-HC	1.28	0.95	74.0%	1.04	81.3%	1.13	88.3%
2-DC	1.16	0.93	80.2%	0.94	81.1%	1.02	88.2%
3-BC	2.36	2.00	84.9%	2.02	85.6%	2.14	90.6%
4-KC	0.55	0.41	74.9%	0.48	87.3%	0.50	90.5%
Total	**5.35**	**4.29**	**80.2%**	**4.48**	**83.8%**	**4.79**	**89.5%**

It is intended that opportunities for streetscape plantings / landscape areas be fully explored to reduce imperviousness and contribute to stormwater management, where possible through the use of low impact development (LID) measures. In the future, There may be opportunity for the proposed median to function as a landscaped median, reducing overall impervious area. The proposed medians in the road improvements plan are conceptual only and will be subject to future development application and access management approvals.

As per the results provided in **Table 2**, imperviousness for the proposed road improvement depends on the future land use plan of the road. Increase in the major and minor storm flows along the roadway will be determined when the City decides to go for the construction of Bradford Street. Some stormwater management measures may need to be implemented depending on the increase in flow.

5.3. Stormwater Management Strategy

Bradford Street Improvement is a linear infrastructure improvement project with mostly developed surrounding areas, therefore there are limitations to implement stormwater management measure fully due to the property and various utility constraints. It should also be noted that limited stormwater infrastructure opportunities are available due to the elevation of Bradford Street relative to receiving watercourses / Lake Simcoe. However, every attempt will be made to meet the latest City of Barrie requirements and the LSRCA requirements identified in **Section 3.1** and **0,** respectively, to the maximum extent possible.

Depending on the runoff peak flow control and quality control requirements, potential of implementing following stormwater management measures will be reviewed further in the next phase of the study.

- Potential of implementing super pipe (storage pipe system) for peak flow control.
- Infiltration galleries within the 2.5 m wide boulevards located between the driveway lane and bicycle track to augment storage requirements, water balance and infiltration, as required.
- Potential infiltration galleries and rain gardens with Silva Cells within medians. This will help reduce to the peak flow control required as well able to meet the requirements for infiltration, water balance and erosion control requirement.
- Improvement of storm sewer system to convey the post-development minor storm flows as the existing system has some deficiency. Review the potential

of capturing 10-year storm flow as a minor storm flow for the long term planning.

- Potential of implementing oil-grit separator for the quality control of roadway drainage. It has been noted that there is no quality control measure under existing conditions. CB-shield can be implemented where the catch basins are directly connected to infiltration galleries.

6. Conclusions

Construction timeline of the proposed Bradford Street Improvement is to be confirmed and is expected to be beyond the 10-year timeframe. More detail drainage and stormwater management study will be carried out in during detailed design based on the most current design standards and guidelines at that time.

For the purpose of the Bradford Street MCEA Study a review of relevant background information, design standards as well as a qualitative review of the existing and proposed drainage and stormwater management assessment was completed.

The following tasks associated with drainage and stormwater management will be completed during detailed design:

- Analysis of pre- and post development flow to confirm the peak flow control requirements.
- Review the potential of capturing 10-year storm flow as a minor storm flow for the long term planning.
- Review the potential of eliminating minor system deficiency in the future design and plan watercourse upgrade as required according to the Master Drainage Plan of the City of Barrie.
- Complete stormwater management design to meet the latest applicable design criteria of the City of Barrie as well as the Lake Simcoe Conservation Authority in term of runoff peak flow control, quality control and erosion control.
- Review the potential of implementing LID measures such as infiltration galleries, raingardens, etc. to meet the requirements of infiltration and water balance.
- Carry out hydraulic analysis for the culverts where the culvert extension is required. LSRCA requires that the culvert extensions must demonstrate no negative impact to flood elevations upstream and downstream of crossings and demonstrate no increase in over bank velocity.

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