Appendix C
Stormwater Management and Drainage Report

Technical Report

October 6, 2017

City of Barrie

Transportation Improvements for Harvie Road, Essa Road and Bryne Drive Class EA

Drainage and Stormwater Management Report

ISSUE AND REVISION RECORD					
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1 Introduction

The City of Barrie has retained Hatch to complete a Schedule "C" Municipal Class Environmental Assessment (EA) for the proposed Transportation Improvements for Bryne Drive, Harvie Road and Essa Road which includes the widening for Harvie Road and Essa Road, as well as the extension of Bryne Drive northerly to Essa Road addressing both short and long term considerations for planned future growth up to 2031.

1.1 Project Background

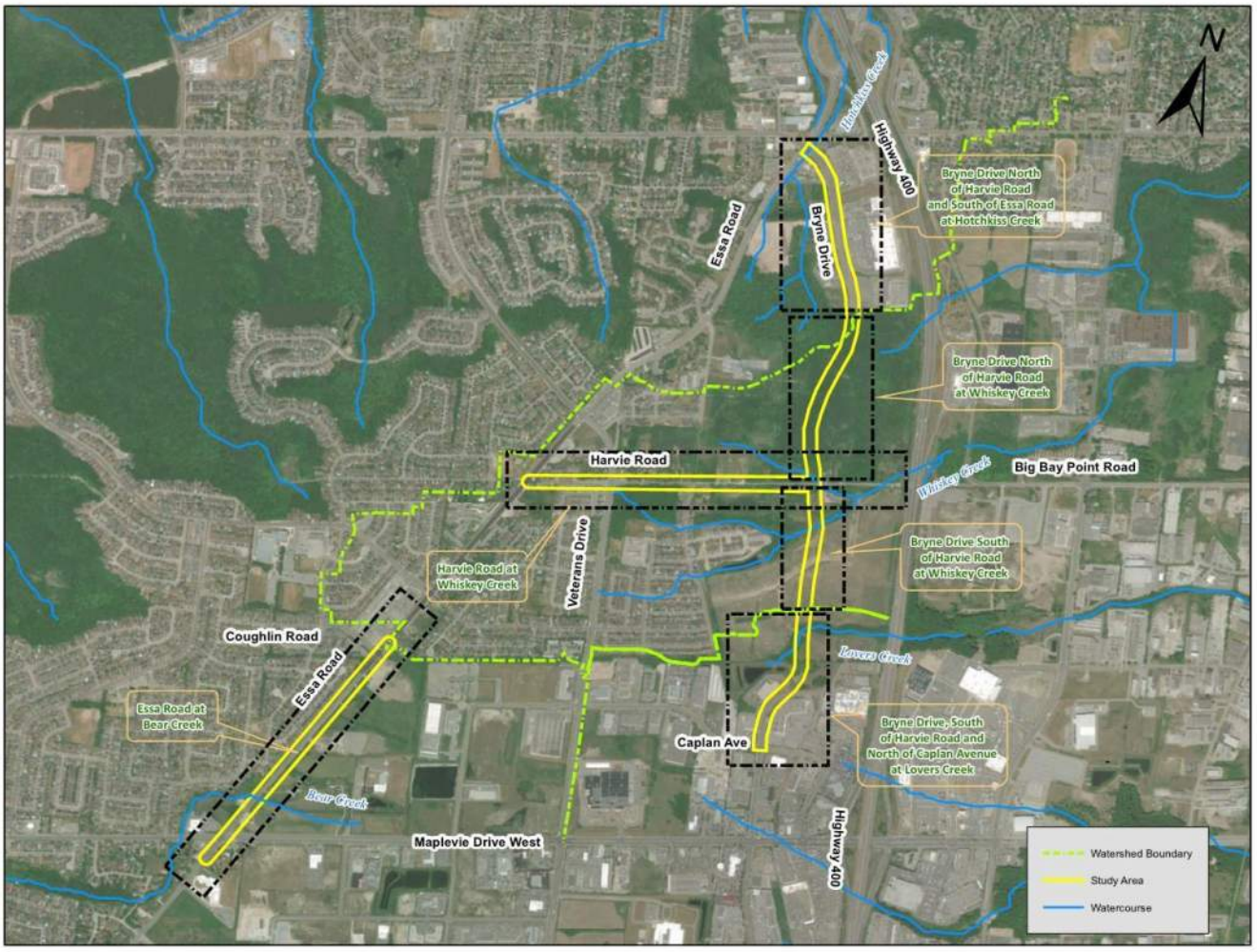
The Harvie Road, Essa Road and Bryne Drive (HEB) project study area will be divided into six (6) distinct drainage locations based on the subwatershed boundaries for Lover's Creek, Whiskey Creek, Hotchkiss Creek and Bear Creek. The following is the six (6) distinct study area locations:

- Harvie Road at Whiskey Creek
- Essa Road at Bear Creek
- Bryne Drive, South of Harvie Road and north of Caplan Avenue at Lovers Creek
- Bryne Drive, South of Harvie Road at Whiskey Creek
- Bryne Drive, North of Harvie Road at Whiskey Creek
- Bryne Drive, North of Harvie Road and South of Essa Road at Hotchkiss Creek

The proposed widening improvements are to be considered with the future development lands planned around the three identified roadways described above. This study has been formulated to recognize the impacts of the proposed widening while providing a comprehensive solution to integrate drainage and stormwater management from the road right-of-way (ROW) with the proposed SWM facilities or with the existing SWM facilities within the development lands. These elements are documented within the current study with reference to the R.G. Robinson and Associates (Barrie) Whiskey Creek Master Drainage Plan Update Environmental Assessment Document City of Barrie, September 2004.

At present, Harvie Road is an east-west arterial road with a 2-lane, mostly rural cross section on each side. Essa Road is a north-south arterial road which has a 2-lane rural cross-section. The existing Bryne Drive are separated into two sections, one intersects with existing Essa Road in the north, and the other section intersects Caplan Avenue in the south. The proposed extension of Bryne Drive will connect these two sections and cross Harvie Road through the large wooded area in the middle.

Exhibit 1-1 - Key Plan



1.2 Purpose

The purpose of this Drainage and Stormwater Management Report is to:

1. Review the background information obtained from the City of Barrie for the study area. Verify and adapt the background information within the study area to develop the drainage and stormwater management design.
2. Review and establish the drainage and SWM design criteria associated with the study area, which includes requirements for drainage features, water quantity, water quality, and erosion and sediment control.

3. Identify the drainage pattern and develop the existing conditions drainage mosaic within the study area. Document assumptions for existing soil conditions and drainage patterns. Update the drainage mosaics for proposed conditions.
4. Assess existing and future conditions hydrologic flows for all culverts and roadway catchments along the roadway alignment and conduct hydraulic capacity assessments for all road crossing culverts.
5. Prepare a stormwater management strategy for the proposed roadway extension and improvements as per City of Barrie's and corresponding conservation authorities' Storm Drainage and Stormwater Management Policies and Design Guidelines. Execute SWM sizing recognizing future development within the Whiskey Creek Watershed.
6. Document drainage conveyance features in the form of storm sewers, culvert crossings and ditches/water quality swales for the study area.
7. Identify property requirements for respective SWM facilities within the study area.
8. Highlight key next steps for the detailed design of the Stormwater Management and Drainage Design of the study area.

1.3 Reference Background Information and Data

As part of this HEB Drainage and Stormwater Management Report, there have been a series of standards, guidelines and background information utilized to develop the drainage and SWM analysis. The following listed information has been used and adapted for developing the Drainage and SWM Report:

Background Studies:

- Watson & Associates Economists Ltd., 2011. City of Barrie, ***Development Charge Background Study Whiskey Creek Stormwater Management Works and Downstream Conveyance Works Area-Specific Development Charge By-Law***. April.
    - The development Charge (DC) Background Study provides the area, runoff coefficients within the Whiskey Creek drainage areas, specifically documenting information pertaining to requirements and contributions to the existing Pond A.
- AECOM, 2009.City of Barrie, ***Whiskey Creek Master Drainage Plan Update Environmental Assessment Document***. October.
    - Master Drainage planning document for the Whiskey Creek watershed. The new crossing over Highway 400 is located within the Whiskey Creek watershed. The hydrologic model and proposed recommendations were adapted for the Harvie Road and Bryne Drive roadway drainage design. Parameters and catchments from this study were reviewed for use and updated as necessary.
- R.G. Robinson & Associates (Barrie) Ltd., 2004. City of Barrie, ***Whiskey Creek Master Drainage Plan Update Environmental Assessment Document***, September.
    - This study develops and establishes the basic hydrologic models for the Whiskey Creek HEB study area. Harvie Road/Big Bay Point Road/Hwy 400 Overpass (HBBP) project has incorporated the hydrologic model from this study into the existing and proposed hydrologic analysis.
- Cumming Cockburn Ltd., Charlesworth & Associates, 1995, ***LSRCA Lovers and Hewitts Creek Master Drainage Plans***, December.
    - The study provides basic information for the hydrology/hydraulics condition and erosion potentials at Lovers Creek subwatershed.
- City of Barrie, 2009. ***Lover's Creek Stormwater Management Pond (LV14) Retrofit Detailed Design Report***, September.

- The detailed design study of LV14 provides the key information pertaining to the pond facility. Items featured and reviewed from this study include, drainage areas, runoff coefficients, and the stage-storage-discharge relationship (operational performance) of the pond.

- The Jones Consulting Group Ltd., 2016, City of Barrie. ***300 Essa Road, Barrie, Ontario, Detailed Stormwater Management Report***, December.
  - The detail design Study of 300 Essa Road development area provides the information associated with the existing pond HT06 including total drainage area, runoff coefficients and the stage-storage-discharge relationship.

- C.C. Tatham & Associates Ltd., 2014, ***Messa Village Mapleview Drive West, Barrie, Functional Servicing and Preliminary Stormwater Management Report***, February.
  - This study provides the land use information, modelled runoff coefficients, and the catchment plan for the study area within the Bear Creek subwatershed. The Messa Village SWM Report also includes SWM facilities upstream of the Bear Creek culvert flow to Essa Road.

Municipal, Provincial and Conservation Authority Guide Documents and Standards:

- City of Barrie, 2017. **Infiltration LID Screening Process, Draft Final**. February.
  - LID screening document implementing infiltration LIDs within the City of Barrie. The document highlights information pertaining to potentially implementing LIDs within areas of Source Water Protection vulnerability.

- City of Barrie, 2009. **Storm Drainage and Stormwater Management Policies and Design Guidelines**. November.
  - Key standards and guidelines for design of drainage and stormwater infrastructure within the City of Barrie.

- City of Barrie, 2016. **Comprehensive Stormwater Management Master Plan.** November.
  - Standards, guidelines, and methodologies for drainage and stormwater infrastructure within the City of Barrie.

- Greater Golden Horseshoe and Region Conservation Authorities (GGHACA), 2008 **Urban Erosion and Sediment Control Guidelines**.
  - Guideline utilized to make recommendations for proposed erosion and sediment control protection for the HEB study Area.

- Lake Simcoe Region Conservation Authority (LSRCA), 2016. **LSRCA Technical Guidelines for Stormwater Management Submissions**. September.

  - Key guideline for the development of the SWM strategy. This guideline describes the requirements for water quantity, quality, and volume control requirements as part of a Linear Development.

- Ministry of the Environment (MOE), 2003. **Stormwater Management Planning and Design Manual**. March.
  - Standards for the water quantity and quality requirements for site development and will be used to provide guidance for targets and proposed BMP implementation.
- Ministry of Transportation (MTO), 1997. **MTO Drainage Management Manual**.
  - Drainage design standards and practices utilized to develop the hydrologic soil conditions and parameters for the modeling evaluation.

1.4 Reference Data

The stormwater management and drainage design analysis for the existing and proposed conditions within the HEB study area requires a variety of data in order to be properly executed. The following section documents the rainfall data, soil and land use, groundwater conditions, topographic and existing drainage infrastructure within the project area.

1.4.1 Rainfall Data

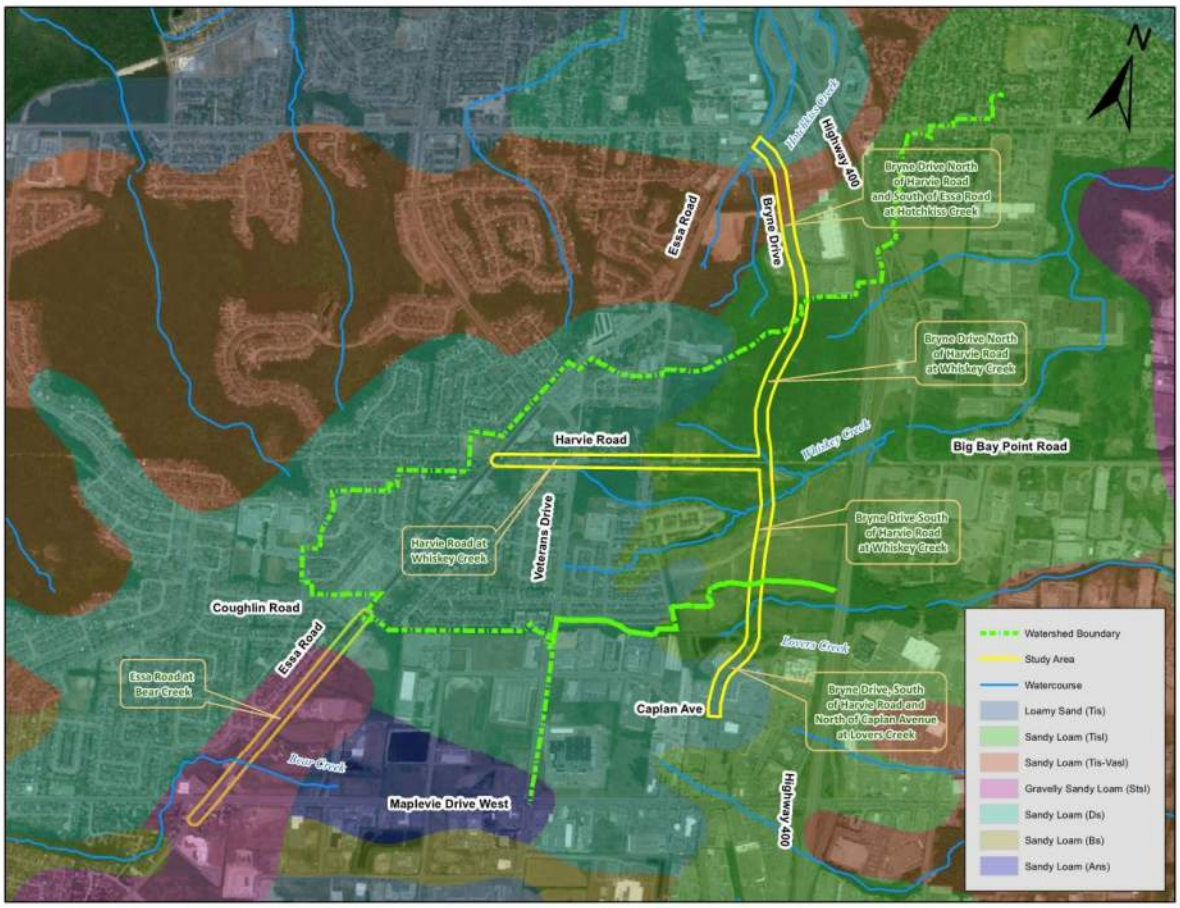
The rainfall data utilized for the project area taken from the City of Barrie IDF curve data within the storm drainage design standards form the City (Barrie, 2009).

1.4.2 Topographic, Soil Characteristics and Land Use Data

The topographic data utilized for the project area has been provided by the City of Barrie, LIDAR contours for the project study area.

A thorough review of the Simcoe County Soils Data has shown that the existing soils are typically sandy soils with some clay loams. The soils along Harvie Road, future Bryne Drive and Essa Road have been assumed to be a combination of sandy soils with the Hydrologic Group being “AB” for the site (Figure 1-2).

Exhibit 1-2 - Soil Map



The overall site is currently a combination of rural and subdivision developments surrounding arterial roadways. Following is the land use descriptions within each drainage study area:

- Harvie Road at Whiskey Creek
  - Mainly residential/commercial area located at the east end to Veterans Drive/Harvie Road Intersection;
  - Undeveloped land area between Veterans Drive and Highway 400.
- Essa Road at Bear Creek
  - The adjacent area on the west side of Essa Road is mainly for residential purpose, while the eastern area of the roadway was, until recently, an active farm, which comprised a small amount of impervious driveway and building area;

- Recent development was proposed at the north-east corner of Essa Road/Maplevie Drive West intersection (C.C. Tatham & Associates Ltd., 2014), which consists of a mixture of proposed commercial and residential buildings.

- Bryne Drive, south of Harvie Road and north of Caplan Avenue at Lovers Creek
  - Adjacent area of the existing Bryne Drive mainly consists of commercial and industrial area.
  - On the north side of existing Bryne Drive and existing SWM Pond LV14, the land is currently undeveloped.
- Bryne Drive, South of Harvie Road at Whiskey Creek
  - This area is currently remained undeveloped. According to the City of Barrie DC Background Study, this area will be developed as commercial and industrial land.
- Bryne Drive, North of Harvie Road at Whiskey Creek
  - This area is currently remained undeveloped. According to the City of Barrie DC Background Study, this area will be developed as industrial land.
- Bryne Drive, North of Harvie Road and South of Essa Road at Hotchkiss Creek
  - This area is currently mainly urbanized with large amount of impervious commercial and industrial areas, except a small amount of ROW area located at immediate south of existing Pond HT06 remained rural.

1.4.3 Existing Drainage Infrastructure Data

The existing drainage infrastructure data has been adopted from the following sources:

- For Bryne Drive at Lovers Creek Watershed:
  - Skelton Brumwell & Associates Inc. Consulting Engineers & Planners with City of Barrie, Barrieview Subdivision Plan and Profile, Bryne Drive ST. 0+367.47 To 0+600, Drawing No. 951268A-3, No. 951268A-4A, and No. 951268A-5A.
    - Provides information for the storm sewer plan and profile along existing Bryne Drive on the south near Caplan Avenue.
  - Skelton Brumwell & Associates Inc. Consulting Engineers & Planners with City of Barrie, Stormwater/Erosion Control Plan, Drawing No.: 001653-7.
    - Provides information for the existing wet pond LV14. This facility receives runoff from the existing Bryne Drive south section within Lover's Creek.

- Lovers Creek Stormwater Management Pond (LV14) Retrofit Storm Drainage Plan, Pond Grading Plan and Pond Detail, Contract 2010-007T
  - Provides information for the storm drainage retrofit catchment plans and design features for the existing SWM pond LV14.

- For Bryne Drive north at Hotchkiss Creek Watershed:
  - RG Robinson and Associates (Barrie) Ltd. Consulting Engineers, Markborough Properties Inc. Simcoe Centre with City of Barrie, General Storm Drainage Boundaries at Bryne Drive, 540-95079-21, Drawing No. P-1 to P-3, G-1.
    - Provides information for the existing storm sewer network plans and profiles and catchment plans along the existing Bryne Drive north road section near the Essa Road and Bryne Drive intersection.

- For Essa Road at Bear Creek Watershed:
  - City of Barrie, Essa Road Improvement Sta. 0+895 to Sta. 2+280, Drawing No. 93-06, Drawing No. 2015-004, Sheet No. PP1 to PP2.
    - Provides information for the existing storm sewer network plan and profile along Essa Road at Coughlin Road.
  - City of Barrie, Essa Road Reconstruction, Mapleview Dr. West to Harvie R. Sta. 0+000 to Sta. 0+900, Drawing No. 2005-06, Sheet No. PP1 to PP2.
    - Provides information for the existing storm sewer network plan and profile along existing Essa Road at Mapleview Drive.

2 Drainage Design Criteria and SWM Objectives

The stormwater management and drainage design requirements within the Harvie Essa Bryne Road EA study area are set by the Lake Simcoe Region Conservation Authority (LSRCA), Ministry of the Environment and Climate Change (MOECC) and the City of Barrie municipal design standards. The study design criteria can be divided into drainage and stormwater management criteria for water quantity, water quality, Low Impact Development (LID) requirements, erosion and sediment control and hydraulic conveyance for storm drainage infrastructure.

2.1 Stormwater Management Objectives

The following section documents the key guiding stormwater management targets for the Harvie, Essa, and Bryne Road study area. These key SWM criteria include water quantity, water quality, and erosion and sediment control.

2.1.1 Water Quantity

The water quantity targets for the study are, where feasible, to control post-development flows from the site, for design storms up to the 100-year event, to the pre-development conditions flow.

2.1.2 Water Quality

The proposed road design for the Harvie Road, Essa Road, and Bryne Drive study area will increase the impervious road area, which could potentially result in an increase in suspended solids loading. As this is anticipated to occur, the following objective is recommended:

- Consideration for providing Enhanced Level of treatment through the long-term removal of 80% Total Suspended Solids from all stormwater runoff prior to discharge, where feasible.

2.1.3 Low Impact Development (LID) Volume Control Requirements

As per the LSRCA technical guidelines, the current study falls under the *linear development* project for stormwater management requirements. The following are the LSRCA linear development volume control requirements, required for the LID/BMP treatment:

Linear developments shall capture and treat the larger of the following:

- Runoff from a 12.5 mm event from the fully reconstructed impervious surface and newly constructed impervious area, or,
- Runoff from a 25 mm runoff will be targeted for the net increase in impervious area.

2.1.4 Erosion and Sediment Control

The proposed drainage and SWM design should include design considerations for providing Erosion and Sediment Control requirements in accordance with the principles from the following design guideline:

- *Greater Golden Horseshoe Area Conservation Authorities (GGHACAs), Erosion & Sediment Control Guidelines for Urban Construction*, December 2006.

2.2 Drainage Design Criteria

Drainage design conveyance and control features shall be designed in accordance with the following criteria for both the preliminary and detailed design:

- The following is a summary of the *City of Barrie Storm Drainage and Stormwater Management Policies and Design Guidelines* (November 2009):
    - The ***minor system*** shall convey the 5-year storm event allowing connection of front and rear roof leaders and foundation drains.
    - The ***major system*** is to be designed to address flows larger than the minor system up to the greater of the 100-year storm or the Regulatory Storm event.
    - ***Culvert Hydraulics*** is to assessed using the 100-year storm (or Regional, if required by the City) conveyance for arterial roads, 50-year *storm* for collector and urban local roads.
- MTO Highway Drainage Design Standards (2008)
- MTO Drainage Management Manual (1997)
- MOE Stormwater Management Planning and Design Manual (2003)

3 Existing Conditions

The purpose of the following section is to identify and evaluate the current hydrologic and hydraulic conditions within the study area.

3.1 Overview and Study Approach

The Harvie, Essa, and Bryne (HEB) Drainage and SWM analysis for the baseline existing conditions was conducted in the following manner:

- Summarize the current site conditions, identify receiving watercourses, and catchment outlets.
- Inventory and document the existing stormwater management facilities onsite, and compile, review and integrate the existing data provided associated with the existing SWM facilities onsite.
- Perform hydrologic analysis for the existing drainage conditions, including documentation of the catchment areas, impervious coverage, soil characteristics and the outlet locations.
- Evaluate the existing hydraulics for all drainage structures within the study area, which includes the storm sewer networks and major culvert outlets.

3.2 Site Characterization and Receiving Watercourse

A site investigation of the study area was conducted by the Hatch drainage team on June 1, 2017 to confirm the existing drainage patterns and to inspect existing drainage features such as culverts, SWM facilities, ditches, etc. A Field Inspection Memo was prepared with a photographic inventory of the site featured within Appendix A.

There are four (4) major fluvial watercourses located within the study corridor boundaries, flowing across Harvie Road, Bryne Drive and Essa Road, and eventually discharge into:

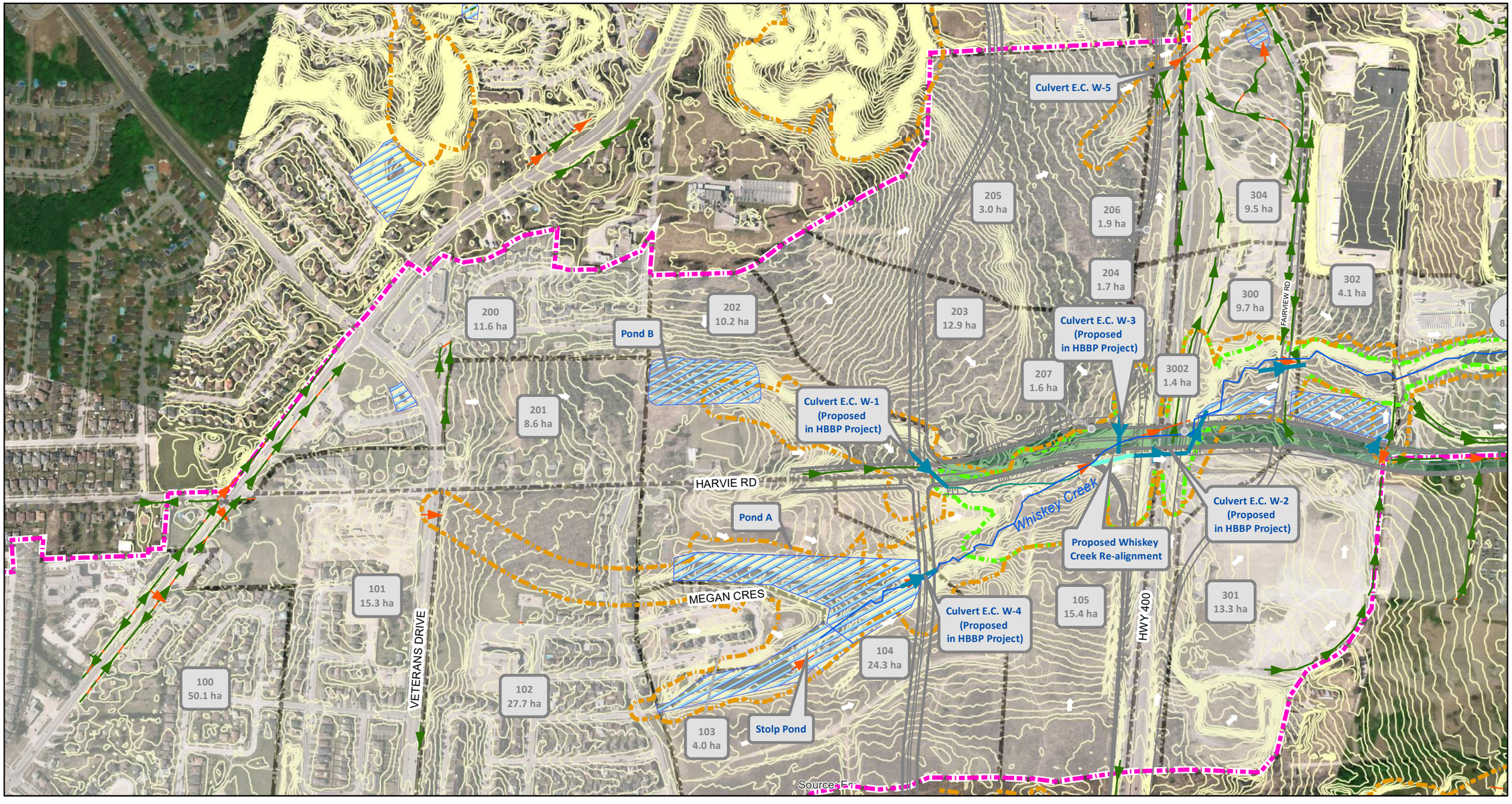
- Tributary of Lovers Creek
- Tributary of Bear Creek,
- Main branch of Whiskey Creek, and
- Tributary of the Hotchkiss Creek.

The study area (Exhibit 3-1, Exhibit 3-3, Exhibit 3-4, Exhibit 3-5, and Exhibit 3-6) is under the jurisdiction of the Lake Simcoe Region Conservation Authority (LSRCA), while the study area (Exhibit 3-2) is under the jurisdiction of the Nottawasaga Valley Conservation Authority (NVCA).

- Whiskey Creek subwatershed is a watershed with a tributary area of ±63.5 km^2 (AECOM, 2009), while approximate 2.21 km^2 of the watershed is situated within the project area. The watershed area falls under the jurisdiction of LSRCA. One section of Whiskey Creek (south of Harvie Road) is a cold-water fishery. The headwaters of

the creek is located just west of Highway 400, and the creek flows from the west to east for approximately 5,250 m before it outlets into Kempenfelt Bay (AECOM, 2009). The study area is located within the headwater area of the Whiskey Creek subwatershed. Refer Exhibits 3-1, 3-4 and 3-5

- Lovers Creek subwatershed is comprised of 58.20 km^2 and located south of the Whiskey Creek subwatershed (Cumming Cockburn Ltd., 1995). The watershed area falls under the jurisdiction of LSRCA. It has one main cold water tributary has a total combined length of 93.1 km. The headwaters of the creek are in high infiltration soils flowing down into silty clay loam that has slow infiltration rates. The land uses are relatively evenly split between agriculture, natural heritage, and urban areas. The study area is located at the northwest part of the study area and drains towards the north tributary of the watershed. Refer to Exhibit 3-3.
- Hotchkiss Creek subwatershed features 18.27 km^2 of drainage area that is located to the east of the project study area. The watershed area falls under the jurisdiction of LSRCA. The subwatershed is dominated by agricultural land uses with urban development within the lower reaches. The study area contains commercial and industrial land draining downstream towards Lake Simcoe to the north. Refer Exhibit 3-6.
- Bear Creek subwatershed is under the jurisdiction of the Nottawasaga Valley Conservation Authority (NVCA). Upstream of Essa Road, Bear Creek follows an almost straight path. The entire channel possesses emergent vegetation dominated by Broad-leaved Cattails with waters slowly flowing through. The branch of Bear Creek originates approximately 630 m upstream of a stormwater management pond with an overflow structure creating a warm water community. This portion of stream is considered warm water, while it contributes to a cold-water fishery on the downstream. Refer Exhibit 3-2.



Stormwater Management Facility
Existing Culvert
Existing Stormwater Linear Feature
Existing Stormwater Lateral
Watershed Boundary
LSRCA Floodplain Setback
LSRCA Regulation Limit
Culvert (Pr. in HBBP)
Existing Catchment
Hwy 400 Overpass Catchment

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0	FOR REVIEW	Init.	Init.	Init.	

HATCH

DESIGNED BY:	DRAWN BY: JZ
CHECKED BY: DJ	DISC. ENGR.
PROJ. DES. COORD.	PROJ. ENGR.

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HARVIE ESSA BRYNE PROJECT

Exhibit 3-1
Existing Condition - Harvie Road at Whiskey Creek

Stormwater Management Facility
Existing Culvert
Existing Stormwater Linear Feature
Existing Stormwater Lateral
Existing Stormwater Device
ROW Catchment
External Catchment
Watershed Boundary
LSRCA Floodplain Setback
LSRCA Regulation Limit

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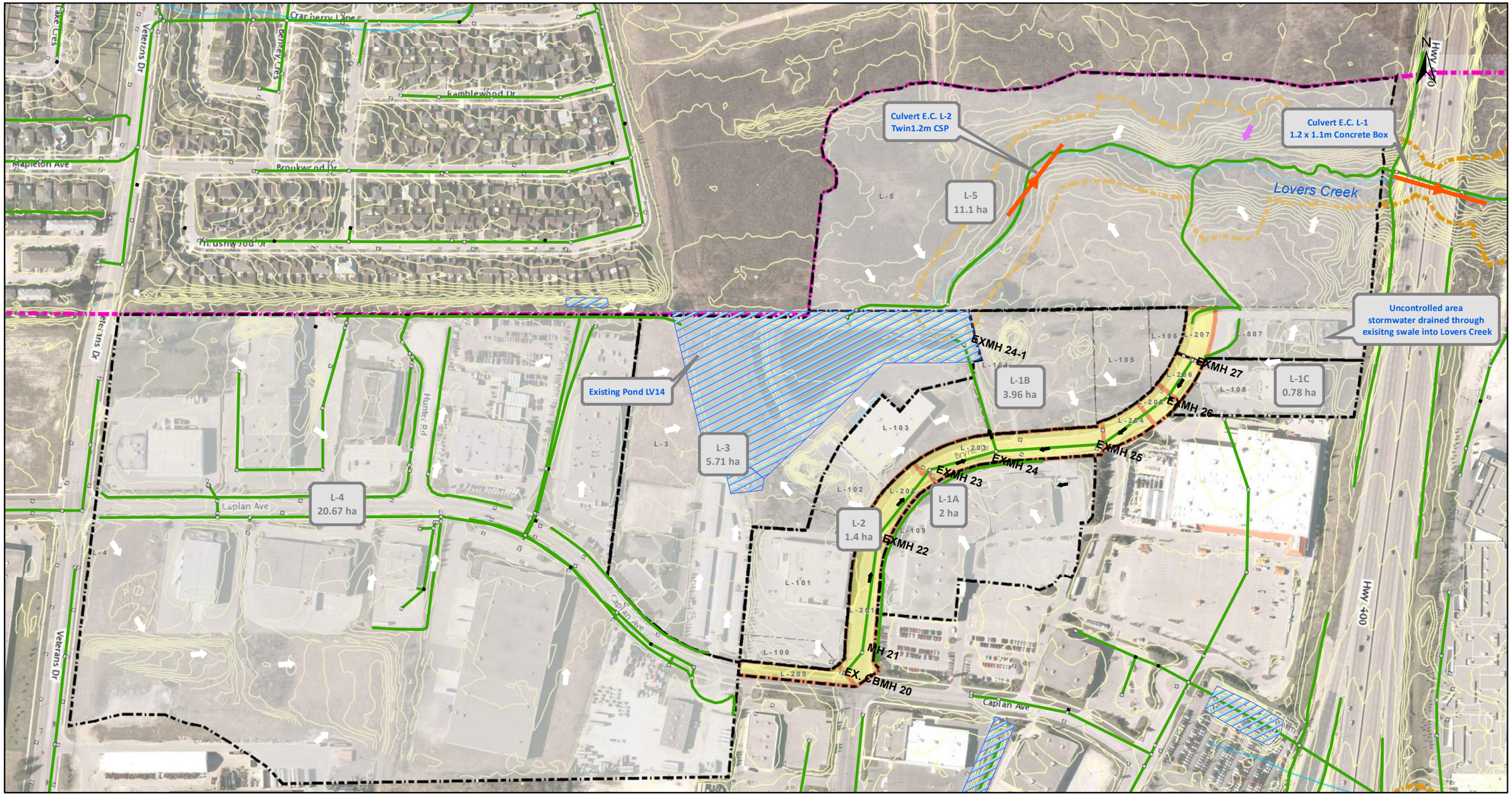
HARVIE ESSA BRYNE PROJECT

Exhibit 3-2
Existing Condition -
Essa Road at Bear Creek



- Stormwater Management Facility
- Existing Culvert
- Existing Stormwater Linear Feature
- Existing Stormwater Lateral
- Existing Stormwater Device
- ROW Sewershed Catchment
- External Catchment
- Watershed Boundary
- LSRCA Floodplain Setback
- LSRCA Regulation Limit
- Catchment Boundary

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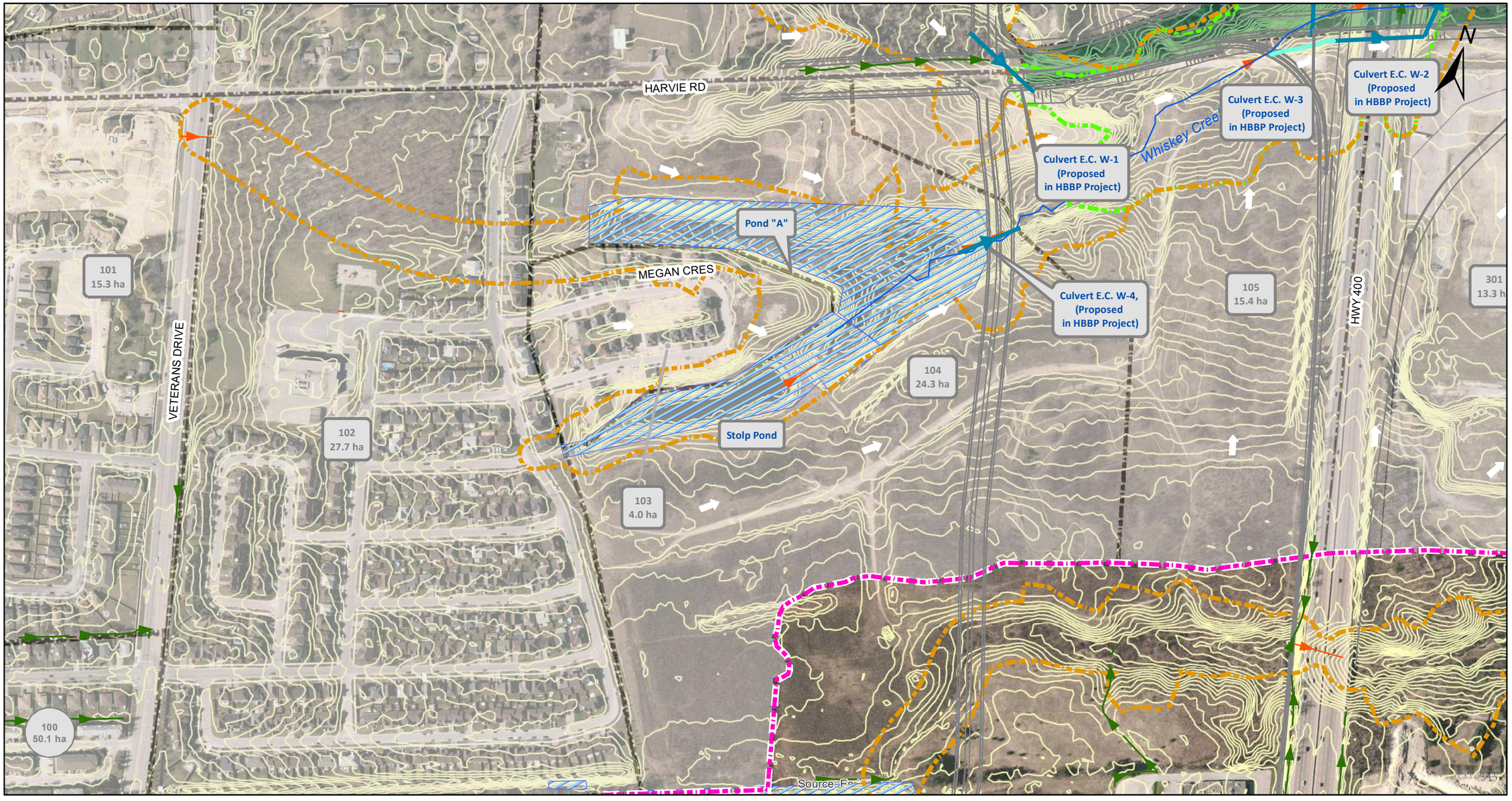
HARVIE ESSA BRYNE PROJECT

Exhibit 3-3
Exisitng Condition - Bryne Drive South of Harvie Road at Lovers Creek



Stormwater Management Facility
Existing Culvert
Existing Stormwater Linear Feature
Existing Stormwater Lateral
Watershed Boundary
LSRCA Floodplain Setback
LSRCA Regulation Limit
Culvert (Pr. in HBBP)
Existing Catchment
Hwy 400 Overpass Catchment

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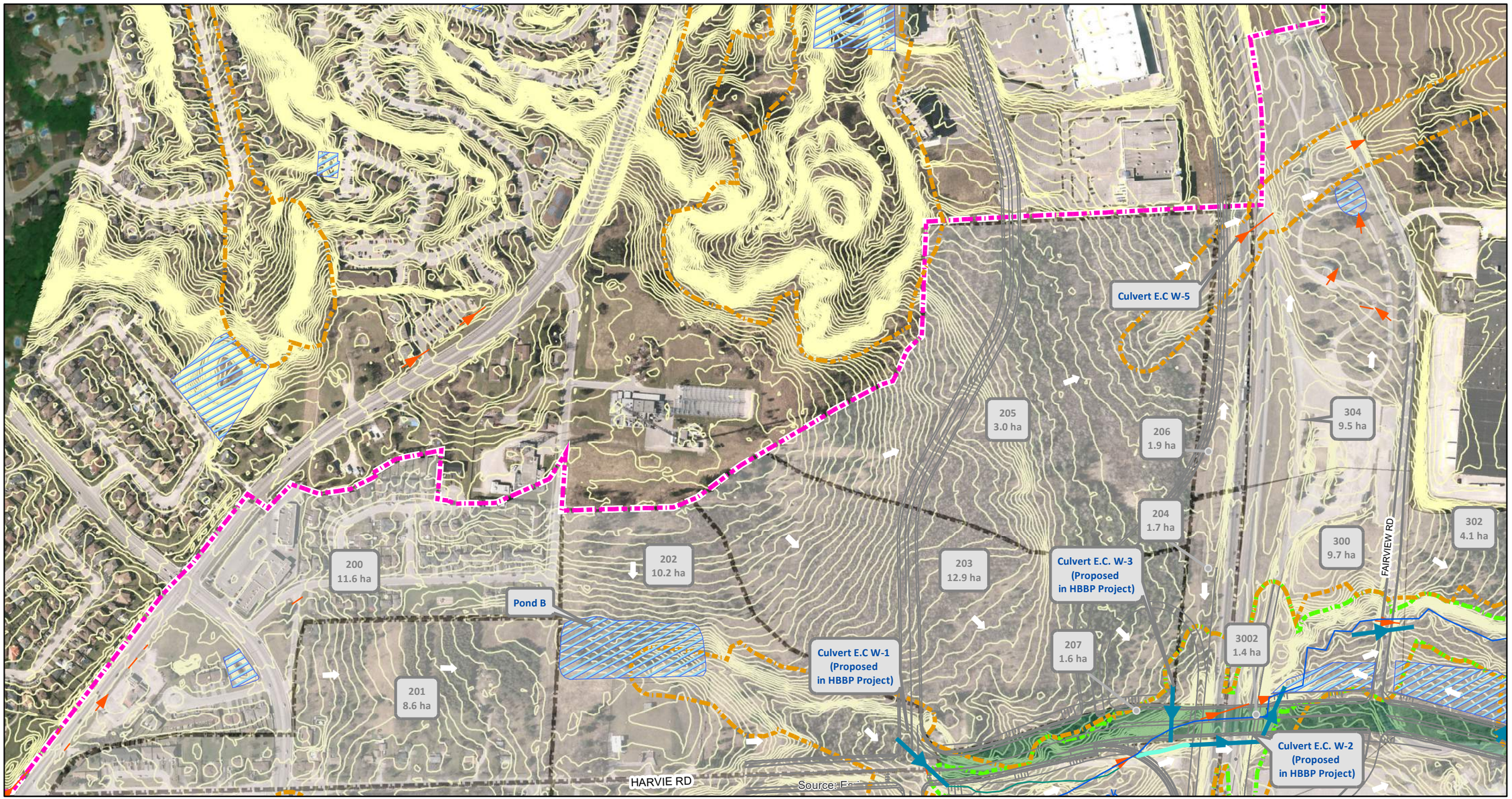
HARVIE ESSA BRYNE PROJECT

Exhibit 3-4
Existing Condition - Bryne Drive South to Harvie Road at Whiskey Creek



Stormwater Management Facility
Existing Culvert
Existing Stormwater Linear Feature
Existing Stormwater Lateral
Watershed Boundary
LSRCA Floodplain Setback
LSRCA Regulation Limit
Culvert (Pr. in HBBP)
Existing Catchment
Hwy 400 Overpass Catchment

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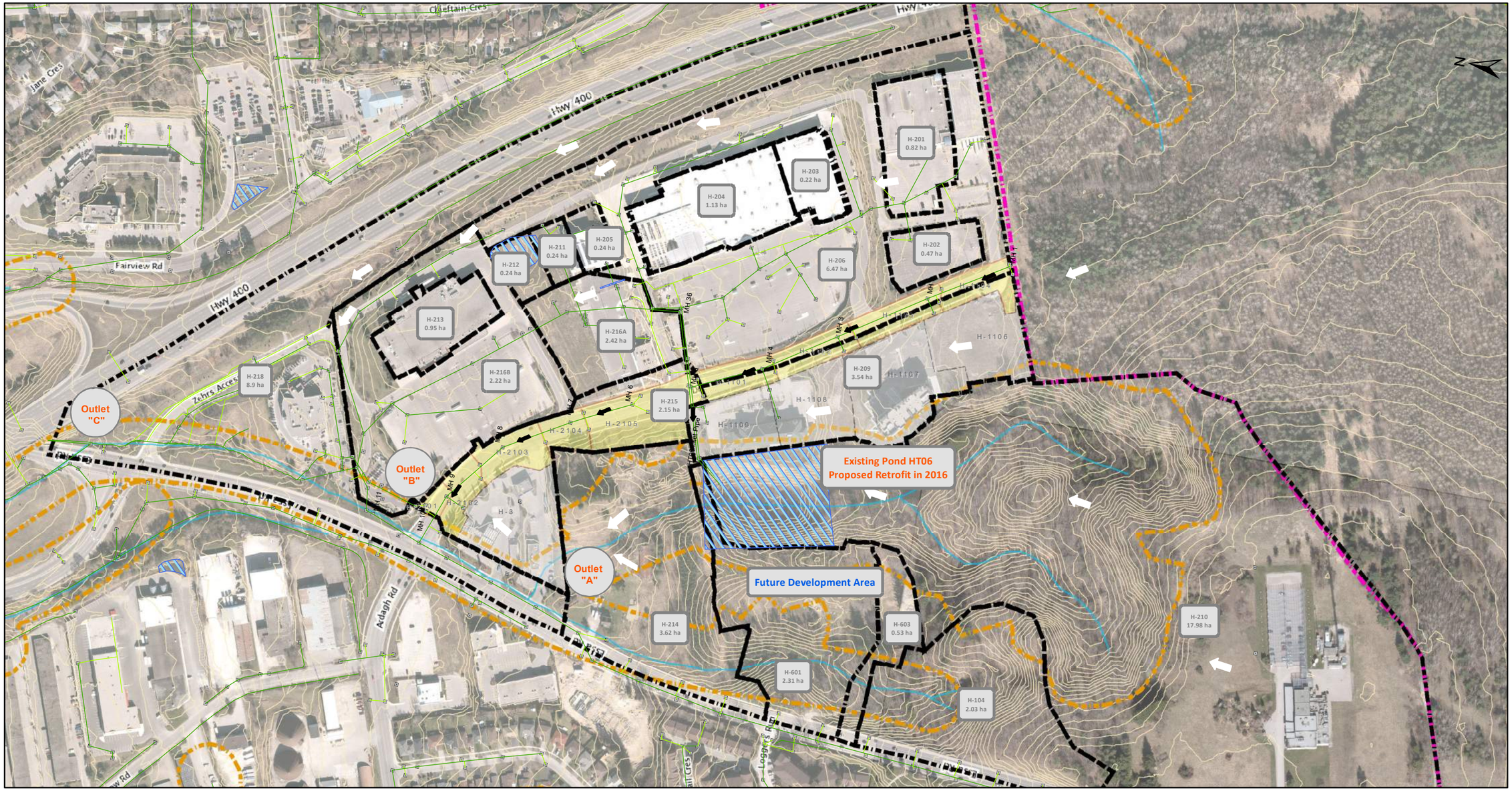
HARVIE ESSA BRYNE PROJECT

Exhibit 3-5
Existing Condition - Bryne Drive North to Harvie Road at Whiskey Creek



Stormwater Management Facility
Existing Culvert
Stormwater Linear Feature
Stormwater Lateral
Stormwater Device
ROW Sewer Catchment
External Sewer Catchment
Watershed Boundary
LSRCA Floodplain Setback
LSRCA Regulation Limit
Catchment Boundary

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HARVIE ESSA BRYNE PROJECT

Exhibit 3-6
Existing Condition - Bryne Drive North to Harvie Road at Hotchkiss Creek

3.3 Existing Conditions Drainage

The existing drainage system for the study corridor is depicted in Exhibit 3-1, Exhibit 3-2, Exhibit 3-3, Exhibit 3-4, Exhibit 3-5, and Exhibit 3-6 showing the general drainage patterns, delineated catchment boundaries (ROW and External), existing drainage structures and SWM facilities.

The following is a summary of documented conditions of the six (6) distinct study areas:

Study Area 1, 4 and 5: Harvie Road and Bryne Drive at Whiskey Creek Subwatershed (Exhibit 3-1, 3-4 and 3-5):

Under current conditions there are three (3) distinct drainage locations within the Whiskey Creek subwatershed, which are Area 1 – Harvie Road, Area 4 – Bryne Drive south of Harvie Road and Area 5 – Bryne Drive north of Harvie Road. All three (3) study areas are divided into three catchments series 100s, 200s, and 300s to be consistent with the Master Drainage Plan for the Whiskey Creek watershed.

- ***Catchments Series 100:*** On the south side of Harvie Road, contains six (6) catchments documented within the existing drainage mosaic.
    - The upstream Catchments 100 to 103 drain existing residential developments into a stormwater management facility (Pond A) to the east towards currently vacated lots (Catchments 104 and 105) at the west side of Highway 400.
    - The downstream Catchments 104 and 105 are the noted vacated pervious/vegetated lots that are to be developed for commercial and highway industrial (City of Barrie Land Use). Catchments 104 and 105 ultimately drain to Culvert E.C.W- 2 located at Highway 400 south of Harvie Road.
- ***Catchments Series 200:*** On the north side of Harvie Road features eight (8) catchments documented within the existing drainage mosaic.
    - The upstream Catchments 200, 201 and 202 drain existing residential areas and open, undeveloped fields via a combination of overland flow, open ditches, and storm sewers flowing to the existing culvert crossing at Harvie Road (E.C.W-1) flowing west to east of Harvie Road.
    - Catchments 203 and 204 drain an undeveloped woodlot to south of the proposed Harvie Road through the proposed Culvert E.C W-3 per HBBP Project, and eventually drains to the Culvert E.C.W-2 on Highway 400 proposed in HBBP Project. Catchment 204 features drainage from Highway 400, containing around 35% impervious area.

- Catchments 205 and 206 are featured within the Whiskey Creek subwatershed, but drain to the north branch of Whiskey Creek. These catchments drain a combination of open woodlots located west of Highway 400. Catchment 206 contains the Highway 400 right-of-way drainage flowing easterly to the Highway 400 culvert crossing E.C. W-5.
- Catchment 207 is the future Harvie/Big Bay Road Overpass ROW area, which has been featured in the HBBP Project. As per the HBBP drainage report, runoff of the ROW area from the high point of the new crossing structure of Highway 400 to the Bryne Drive intersection will be conveyed through a storm sewer network and discharged into Pond A located to the south of Harvie Road.

- ***Catchments Series 300:*** On the east side of Highway 400, contains five (5) catchments documented within this study and the existing drainage mosaic. These catchment areas are out of the current project scope.

Study Area 2: Essa Road at Bear Creek Subwatershed (Exhibit 3-2):

The areas surrounding Essa Road within the study limit are mainly comprised of residential and agricultural areas north of Mapleview Drive West. External areas located on the east side of the roadway drains toward the existing Bear Creek, which is a part of the Nottawasaga Valley watershed.

- ROW Catchments C501 and C502 drain towards Bear Creek, which flows southwest towards Mapleview Drive West. The portion of Essa Road from Mapleview Drive West to the south of Mapleton Avenue has a semi-urban cross section utilizing ROW ditches for local drainage.
- The upstream external drainage area of Catchment E501 is routed through the existing SWM Ponds BR-20 and BR-26. The outflow from BR-20 and BR-26 drains to Bear Creek east of the existing Culvert E.C. B-1.
- SWM Pond BR-P1 is a proposed wet pond for the future development within Messa Village area (Catchment E502), located at the north-east corner of the Essa Road and Mapleview Drive west. The preliminary design for the SWM Pond BR-P1 has been completed by *C.C. Tatham & Associates Ltd.,* according to the Functional Servicing and Preliminary Stormwater Management Report. The SWM Pond BR-P1 will eventually drain to Bear Creek east of the existing Culvert E.C. B-1.
- External area Catchment E503 with total drainage area of 6.38 ha drains to a dry Pond BR-27 located to the east side of Essa Road. There is an existing overflow swale extended from Pond BR-27, which conveyed the overflow from this pond to the Essa Road ROW ditch during major storm event. Under the proposed condition, the widening of Essa Road will affect the conveyance of the overflow swale.

- External area E504 is a catchment immediately upstream of the existing Culvert E.C. B-1. Under future development, this area will be developed as impervious parking areas serving the nearby Mapleview Industrial Park and Mapleview Community Church area. Currently, an underground parking area and Low Impact Development (LID) facilities are proposed as the major SWM strategy within this area.

Study Area 3: Bryne Drive, South of Harvie Road at Lovers Creek Subwatershed (Exhibit 3-3):

Bryne Drive south within Lovers Creek is mainly comprised of commercial and residential areas and a small portion of undeveloped rural/woodlot area to the west of Highway 400. The SWM Pond LV14 is the primary SWM facility providing the water quality and quantity control within this study area.

The Bryne Drive south within Lovers Creek area can be categorized into three distinct segments:

- Upstream Catchments L-3 and L-4: These upstream external catchments are mainly industrial and commercial areas, which contribute external flows collected by a trunk sewer along Caplan Avenue. The Caplan Avenue trunk sewer drains to the stormwater management facility Pond LV14 located within Catchment L-3 west of the existing Bryne Drive.
- Bryne Drive Commercial and Industrial Catchments L-1 (including L-1A, L-1B and L-1C) and L-2: The existing Bryne Drive ROW catchments are serviced by a storm sewer system flowing along Bryne Drive. Runoff from the external catchment areas are also serviced by the Bryne Drive storm sewer system. An existing 865 mm x 1345 mm elliptical storm sewer outfall conveys the flows from Bryne Drive to Pond LV14 draining to Lovers Creek.
- Catchment L-5: The outflow from Pond LV14 drains to a constructed channel forming the headwaters of Lovers Creek through Catchment L-5. The outlet channel draining into Lovers Creek also collects overland rural runoff from this catchment, which drains easterly to Culvert E.C. L-1 located at Highway 400.

Study Area 6: Bryne Drive, North of Harvie Road and south of Essa Road at Hotchkiss Creek Subwatershed (Exhibit 3-6):

The existing Bryne Drive, north of Whiskey Creek Subwatershed, falls within the subwatershed of Hotchkiss Creek flowing to the north. A stormwater management facility (HT06) is located west of Bryne Drive servicing a part of the existing roadway and commercial development areas.

- The existing Bryne Drive is an urban cross-section with minor system runoff conveyed via storm sewers.
- The major system runoff drains overland and is eventually captured by the ditch along Essa Road to the east of the existing Bryne Drive and Essa Road intersection.

- On the west side of Bryne Drive, the commercial center drains via storm sewers, which tie into the Bryne Drive sewer system to Pond HT-06. The Bryne Drive major system runoff drains overland towards the road low point which is eventually captured by catch basins and conveyed via the Bryne Drive storm sewer system.
- Stormwater management controls within the commercial lots have been documented. These commercial developments feature SWM controls through the implementation of roof top and underground storage facilities beneath the parking lot areas.
- On the east side of Bryne Drive, the existing woodlot areas contained within Catchments 601 and 603 are noted to be developed into residential areas. The future developments within these catchments will feature LID facilities and a retrofit of the HT-06 SWM facility in order to provide both quantity and quality control.
- The existing runoff on the site eventually drains to three (3) different Outlet, as shown in Exhibit 3-6:
    - Outlet A: this outlet located at immediately downstream of Pond HT06, which collects runoff from impervious area north of MH5 on Bryne Drive and adjacent commercial lots (Catchment H-201, H-202, H-203, H-204, H-206, and H-209) through existing minor system. It is recognized that future development will be taken place on the vacant rural area (Catchment H-601 and H-603), according to the *300 Essa Road, Barrie, Ontario, Detail Stormwater Management Report*, prepared by The Jones Consulting Group Ltd. in 2016. In addition, the uncontrolled flow from a small Catchment H-214 located south of Pond HT-06 drains to Outlet A.
    - Outlet B: this outlet located at the south end of existing Bryne Drive, which receive runoff from impervious area south of MH5 on Bryne Drive (Catchment H-215), adjacent commercial lots (Catchment H-211, H-212, H-213, H-216A, and H-216B), and the outflow from Pond HT06.
    - Outlet C: this outlet is the ultimate outlet of this site, which receive runoff from Outlets A and B, and ROW drainage from Essa Road and vacant area near Highway 400.

3.4 Hydrologic Assessments

For the purposes of this study, a multitude of hydrologic models have been developed to estimate flow under pre-development conditions. Overall, four (4) hydrologic analysis models were developed to study the existing drainage condition within this area:

A SWMHYMO hydrologic model adapted and updated from the Whiskey Creek Master Drainage Plan (consistent with the HBBP project) has been used to estimate the existing runoff for the following areas:

- ***Area 1: Harvie Road Study Area at Whiskey Creek****,*
- ***Area 4: Bryne Drive Study Area, south of Harvie Road at Whiskey Creek****, and,*
- ***Area 5: Bryne Drive Study Area, north of Harvie Road at Whiskey Creek.***

Based on the background information obtained from the City of Barrie, three (3) different SWMHYMO models were developed to evaluate the existing conditions runoff for the following areas:

- ***Area 6: Bryne Drive Study Area, north of Harvie Road at Hotchkiss Creek****, and,*
- ***Area 3: Bryne Drive Study Area, south of Harvie Road at Lovers Creek***
- ***Area 2: Essa Road at Bear Creek***.

The following is a summary of the key assumptions and parameters used for performing the hydrologic modeling.

(i) Whiskey Creek Subwatershed

The hydrologic and hydraulic conditions within the existing study area are analysed based on the proposed conditions in the previous approved study for *Harvie Road Big Bay Point Road New Crossing Over Highway 400* project (as “HBBP Project”). The proposed condition in HBBP project has incorporated with the future development, the overpass on Highway 400 and the SWM facilities designed within the HBBP Project.

The existing SWMHYMO model has been developed based on the HBBP Project to quantify the existing and proposed ROW conditions. The modeling has been developed to allow consistency and collaboration between the two (2) studies.

The followings are the key updates and assumptions for the hydrologic modelling updates:

- Contributing catchment area, flow length and slope were determined through ArcGIS analysis using the existing City of Barrie topographic and land use data;

- Site soil conditions were considered as Hydrologic Soil Group A/AB with CN ranging from 54 to 68 depending on the location and land use (Design Chart 1.09, MTO Drainage Manual, 1997);
- The time to peak for the rural catchments has been determined based on an averaged time to peak to prevent skewing of results based on a variety of methodologies (Airport, Bransby-Williams, and OTTHYMO methods);
- The initial abstraction (*Ia*) parameter for the NASHYD rural catchment modelling has been updated to reflect the existing rural field conditions; and,
- Pond A has been incorporated in both the existing conditions base model and proposed condition base model.

Table 3-1: Existing Catchment Parameter – Whiskey Creek

Catchment	Area (ha)	Impervious (%)
100	50.10	44.0
101	15.30	55.0
102	27.70	39.0
103	4.00	55.0
104	24.30	64.0
105	15.40	-
200	11.62	60.0
201	8.59	-
202	10.59	-
203	12.90	-
204	1.74	35.0
205	16.40	-
206	1.90	35.0

The hydrologic assessments are carried out by using the 24-hour SCS Type II storm distribution and the Chicago 4-hour storm distribution. It is recognized that the existing peak flow using 24-hour SCS storm distribution are higher than the Chicago 4-hour storm distribution, therefore, the results of 24-hour SCS storm distribution are summarized in Table 3-2. The table summarizes existing peak flows on Catchment Series 100 and 200. The Catchment series 300 are excluded because they are out of the project limit. Hurricane Hazel storm was used for the Regional Storm Analysis.

Table 3-2: Existing Peak Flows – Whiskey Creek

Catchment	Area [ha]	24-Hour SCS Type II Storm Peak Flow [m^3/s]						
		2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	Regional
100	50.10	2.22	3.81	4.83	6.79	8.00	9.25	5.96
101	15.30	1.11	1.83	2.30	2.93	3.66	4.20	2.01
102	27.70	1.65	2.64	3.31	4.62	5.42	6.24	3.44
103	4.00	0.30	0.47	0.59	0.79	0.92	1.06	0.50
104	24.30	2.60	3.76	4.53	5.66	6.45	7.25	3.13
105	15.40	0.09	0.25	0.40	0.61	0.78	0.97	1.27
200	11.62	0.89	1.46	1.82	2.31	2.68	3.28	1.55
201	8.59	0.05	0.14	0.21	0.32	0.42	0.52	0.70
202	10.60	0.06	0.18	0.28	0.43	0.56	0.69	0.88
203	12.90	0.08	0.22	0.34	0.52	0.67	0.82	1.07
204	1.74	0.06	0.13	0.18	0.25	0.31	0.36	0.21
205	16.40	0.12	0.33	0.52	0.79	1.01	1.25	1.41
206	1.90	0.07	0.14	0.20	0.27	0.33	0.40	0.23

(ii) Hotchkiss Creek Subwatershed, Bryne Drive between Harvie Road and Essa Road

The Hotchkiss Creek SWMHYMO hydrologic model for Bryne Drive, north of Harvie Road was developed to estimate runoff under the pre-development condition. The hydrologic modelling has been carried out using the 24-hour SCS Type II Storm distribution and Chicago 4-hour Storm Distribution. The higher among these two has been considered as the design flow. The Regional Storm flow will be calculated by using the Hurricane Hazel Storm.

The existing conditions Hotchkiss Creek hydrologic model was developed based on the previous OTTHYMO model output from the Markborough Properties Inc. Stormwater Report by R.G. Robinson and Associates Ltd. (dated May 9, 1997). The hydrologic model was later updated by The Jones Consulting Group Ltd. in 2016 for the 300 Essa Road residential areas, which incorporated the SWM retrofits within existing dry Pond HT06.

Drainage boundaries have been reviewed and adjusted accordingly, in order to be consistent with the drainage patterns identified within the previously completed studies.

It was noted that the existing conditions model in the previous OTTHYMO model has some discrepancies with the current condition. Therefore, the catchment areas have been adjusted based on the aerial images and field inspections.

The main updates to catchments and models are summarized as follows:

- The existing Catchment 217 used in Markborough Properties OTTHYMO model (dated May 9, 1997) will be eliminated due to the future development proposed in adjacent areas in 2016.

- The building roof top drainage areas in existing Catchment 201 and 202 will be adjusted as the final site layout has some discrepancy from the existing model.
- The parking lot drainage areas located immediately west of Catchments 211, 212 and 213, are adjusted and shown as Catchments 216A and 216B. In addition, the area within these two catchments has been modified to reflect the current condition.
- The total area of uncontrolled Catchment 214, which is located immediately north of existing Pond HT06, will be modified to account for external drainage area along Essa Road and future development of uncontrolled Catchment 602.
- The existing Catchment 218 was re-delineated and the total area was modified based on the updated contour obtained from the City of Barrie.

The following table (Table 3-3) summarizes the flows based on SCS 24-hour Storm distribution, drainage areas, catchment descriptions, and impervious level.

Table 3-3: Existing Peak Flows – Hotchkiss Creek Subwatershed

Catchment ID/HYD.	Description	Area (ha)	Total Imp %	2yr flow (m^3/s)	5yr flow (m^3/s)	10yr flow (m^3/s)	25yr flow (m^3/s)	50yr flow (m^3/s)	100yr flow (m^3/s)	Hazel Storm
H-104	300 Essa Road Project Post-Development Area	2.03	-	0.02	0.04	0.06	0.08	0.10	0.12	0.20
H-601		2.31	68	0.24	0.36	0.44	0.55	0.63	0.71	0.32
H-603		0.53	40	0.03	0.05	0.07	0.09	0.10	0.12	0.07
H-210	300 Essa Road Project External Drainage Area	17.98	-	0.69	1.22	1.62	2.17	2.59	3.04	2.46
H-201	Markborough Properties Project Post-development Area, adjusted building drainage areas, incorporating rooftop storage control.	2.11	-	0.35	0.48	0.57	0.68	0.76	0.84	0.31
H-202		0.82	99	-	-	-	-	0.01	0.01	0.02
H-203		0.47	99	-	-	-	-	-	-	0.01
H-204		0.22	99	-	-	-	-	-	-	-
H-205		1.13	99	-	-	0.01	0.01	0.01	0.02	0.03
H-206		0.24	99	-	-	-	-	-	-	-
H-209		6.47	87	0.94	1.31	1.55	1.87	2.10	2.33	0.91
404	Outflow from HT06	-	-	0.15	0.18	0.21	0.23	0.25	0.27	4.53

Catchment ID/HYD.	Description	Area (ha)	Total Imp %	2yr flow (m^3/s)	5yr flow (m^3/s)	10yr flow (m^3/s)	25yr flow (m^3/s)	50yr flow (m^3/s)	100yr flow (m^3/s)	Hazel Storm
H-212	Markborough Properties Project Post-development Area, adjusted building drainage areas incorporating rooftop storage control in buildings and lot control in parking lot areas.	3.54	92	0.55	0.76	0.90	1.08	1.21	1.35	0.51
H-211		0.24	99	-	-	-	-	-	-	-
H-213		0.24	99	-	-	-	-	-	-	-
H-215		0.95	99	-	-	-	0.01	0.01	0.01	0.02
H-216A1		2.15	74	0.27	0.38	0.45	0.54	0.61	0.68	0.30
H-216A2		1.12	99	0.10	0.14	0.16	0.20	0.22	0.25	0.15
H-216A3		0.49	82	0.07	0.10	0.11	0.14	0.15	0.17	0.07
H-216A4		0.39	99	-	0.01	0.01	0.02	0.02	0.02	0.03
H-216B		0.42	99	0.01	0.02	0.02	0.02	0.03	0.03	0.04
317	Outlet B	-	-	0.98	1.46	1.77	2.16	2.46	2.77	5.95
H-214	Markborough Properties Uncontrolled area, boundary adjusted per contour	2.22	82	0.31	0.43	0.51	0.61	0.69	0.77	0.31
H-218	Markborough Properties External Drainage Area, adjusted catchment boundary per contour	3.62	-	0.14	0.25	0.34	0.45	0.54	0.63	0.50
318	Outlet C	-	-	1.43	2.11	2.55	3.13	3.58	4.06	6.96

* Outflows lower than 0.01 cms are not documented. Low flows resulting from rooftop storage provided within these catchments

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(iii) Lovers Creek Subwatershed, Bryne Drive to the south of Harvie Road

The Lovers Creek SWMHYMO hydrologic model for Bryne Drive to the south of Harvie Road was developed to estimate the runoff under the pre-development condition. The hydrologic modelling will be carried out using 24-hour SCS Type II Storm distribution and Chicago 4-hour Storm Distribution. The higher among these two will be considered as the governing storm. The Regional Storm flow will be calculated by using the Hazel Storm.

Previous studies and analyses completed by City of Barrie and Skelton, Brumwell & Associates Inc. for the Lovers Creek Stormwater Management Pond LV14 Retrofit did not incorporate the catchment areas north of the existing Pond LV14. For analysing the impact of the proposed alignment of Bryne Drive within Lovers Creek subwatershed, the existing conditions hydrologic model was updated to incorporate the rural area Catchment L-5, as shown in Exhibit 3-3, located downstream of existing Pond LV14 and upstream of Culvert E.C. L-1 at Highway 400.

To accurately reflect the existing drainage patterns for the catchments influenced by the new Byrne Drive alignment, the drainage boundaries are adjusted from those used in previous studies. The followings are the key updates and assumptions for the hydrologic modelling:

- The revised catchments boundaries are based on the *General Storm Drainage Boundary Plan - Bryne Drive*, prepared by R.G. Robinson & Associated Ltd. for the design of storm sewer system in Barrie View Division (Markborough Properties Inc.).
- Site Soil Conditions were modelled as Hydrologic Soil Group A/AB with CN of 62 to reflect the location and land use on site (Design Chart 1.09, MTO Drainage Manual, 1997), which is consistent with previous studies.
- The slope used in the model is calculated based on the hydraulic length, highest and lowest elevation within each catchment.
- The initial abstraction (*Ia*) parameter for Catchment L-5 has been considered to reflect the existing rural catchment for the NASHYD modelling.
- An existing wet Pond LV14 has been incorporated into both the existing conditions and proposed conditions base models.
- Based on previous studies, a controlled release flow rate of 146 l/s/ha is considered from Catchment L-1 (combination of Catchments L-1A, L-1B and L-1C, total area 6.72 ha) to drain into Pond LV14. Therefore, a total of 0.98 m^3/s from Catchment L-1 was being directing to Pond LV-14 and remining flows was retained in the site using rooftop and parking lot storage. The DIVERT HYD routing command was used to split the hydrograph to direct controlled flow into the pond.
- It is recognized that the north end of the existing Bryne Drive is currently uncontrolled and is drained towards Lovers Creek through an existing swale. The area of existing catchment is included into Catchment L-5 for hydrologic analysis.

The following table summarizes the flow at key locations within the Lovers Creek subwatershed. It is recognized that the peak flow under 24-hour SCS Storm distribution are higher than the Chicago 4-hour distribution. Therefore, the 24-hour SCS Storm distribution peak flows are summarized in Table 3-4. Bryne Drive commercial and industrial catchments.

Table 3-4: Existing Peak Flows – Lovers Creek

Sewershed ID	Catchment ID	Imp %	C	Area [ha]	2yr flow (m^3/s)	5yr flow (m^3/s)	10yr flow (m^3/s)	25yr flow (m^3/s)	50yr flow (m^3/s)	100yr flow (m^3/s)	Hazel Storm
L-100[a]	L-1B	73%	0.74	0.19	0.03	0.04	0.05	0.06	0.07	0.07	0.96
L-101		83%	0.82	1.03	0.12	0.12	0.12	0.12	0.12	0.12	
L-102		88%	0.86	0.26	0.05	0.07	0.08	0.09	0.10	0.11	
L-103		55%	0.61	0.68	0.09	0.09	0.09	0.09	0.09	0.09	
L-104		85%	0.83	1.16	0.12	0.12	0.12	0.12	0.12	0.12	
L-105		85%	0.83	0.46	0.09	0.12	0.12	0.12	0.12	0.12	
L-106		85%	0.83	0.17	0.03	0.04	0.05	0.06	0.06	0.07	
L-108	L-1C	54%	0.59	0.78	0.07	0.09	0.09	0.09	0.09	0.09	
L-109	L-1A	89%	0.87	2.00	0.13	0.13	0.13	0.13	0.13	0.13	
L-200	L-2	74%	0.75	0.13	0.02	0.03	0.03	0.04	0.05	0.05	0.96
L-201		79%	0.78	0.35	0.06	0.08	0.10	0.11	0.13	0.14	
L-202		56%	0.61	0.20	0.03	0.04	0.04	0.05	0.06	0.06	
L-203		63%	0.66	0.43	0.07	0.09	0.10	0.12	0.13	0.14	
L-204		65%	0.68	0.11	0.02	0.02	0.03	0.03	0.03	0.04	
L-205		68%	0.70	0.07	0.01	0.02	0.02	0.02	0.02	0.03	
L-206		58%	0.62	0.10	0.01	0.02	0.02	0.03	0.03	0.03	
-[b]	L-3	60%	0.64	5.71	0.50	0.75	0.95	1.18	1.36	1.54	0.79
-	L-4	72%	0.73	20.67	1.77	2.63	3.31	4.10	4.70	5.64	2.86
-	L-5	0%	0.18	11.1	0.08	0.22	0.34	0.52	0.66	0.81	1.32

a. Draining into Bryne Drive Storm Sewer, calculated using Rational Method, except Hazel Storm
b. External Catchments calculated using the 24-hour SCS Storm distribution

(iv) Bear Creek Subwatershed, Essa Road

The SWMHYMO hydrologic model along Essa Road within Bear Creek subwatershed was developed to evaluate the runoff under pre-development condition from the roadway right-of-way (ROW) and external catchments, as well as assessing the conveyance capacity of existing Culvert E.C. B-1. The hydrologic modelling has been carried out using 24-hour SCS Type II Storm distribution and Chicago 4-hour Storm Distribution. The higher among these two has been considered as the governing flow. The Regional Storm flow has been calculated by using Timmins Storm, since the area located within Nottawasaga Valley falls within Zone 3 based on the Flood Hazard Criteria Map of the MNRF.

Previous analysis was completed by *C. C. Tatham & Associates Ltd.*(CCTA) in 2014 for the Messa Village site located at the north east corner of the intersection of Mapleview Drive

West and Essa Road. To accurately reflect the existing drainage patterns for the areas influenced by Essa Road widening, the drainage areas have been adjusted from those used in previous studies. The following are the key updates and assumptions for the hydrologic modelling:

- In the previous study, rural hydrograph NASHYD command was used to model catchments upstream of existing Culvert E.C.B-1 to (Catchments E501 and E503) assess the flow conveyed through the culvert, which may result in the under estimation of flow entering Culvert E.C. B-1.
- For the current study, the existing imperviousness level for Catchments E501 and E503, were calculated as 23% and 24%, respectively, necessitating the use of CALIB STANHYD being utilized to more accurately reflect the flow generated from the upstream catchment, as shown in Exhibit 3-6. The stage-storage information for the proposed SWM Pond BR-20 was included.
- Site soil conditions were considered as Hydrologic Soil Group A/AB with CN of 62 to reflect the location and land use on site (Design Chart 1.09, MTO Drainage Manual, 1997), which is consistent with the previous studies.
- The future developments within Catchments E502 and E504 was also incorporated: a total impervious level of 85% was assumed for both catchments; and the stage-storage information for the proposed SWM Pond BR-P1 was included.
- The slope used in the model was calculated based on the hydraulic length, highest and lowest elevation within each catchment in order to generate the slope and resulting time of concentration.

The following table (Table 3-5) summarizes the runoff generated from external areas under existing conditions based on 24-hour SCS Type II storm distribution, which generates flows higher than 4-hour Chicago Storm distribution.

Table 3-5: Existing Peak Flows – Bear Creek Subwatershed

Sewershed ID	Imp %	C	Area [ha]	2yr flow (m^3/s)	5yr flow (m^3/s)	10yr flow (m^3/s)	25yr flow (m^3/s)	50yr flow (m^3/s)	100yr flow (m^3/s)	Timmins Storm
E501[a]	24%	0.37	59.94	0.29	0.48	0.53	0.72	0.87	1.03	1.42
E502	85%	0.83	10.47	0.16	0.18	0.19	0.20	0.21	0.21	0.22
E503	23%	0.36	6.38	0.24	0.37	0.44	0.57	0.67	0.79	0.40
E504	85%	0.83	6.34	0.57	0.72	0.96	1.15	1.30	1.44	0.46
C501[b]	53%	0.87	1.29	0.17	0.23	0.27	0.31	0.35	0.38	0.14
C502	76%	0.87	0.55	0.10	0.13	0.15	0.17	0.19	0.21	0.05

a. External Catchments calculated using the 24-hour SCS storm distribution
b. Draining into Essa Road ROW, calculated using Rational Method, except Timmins Storm

For culvert capacity assessment, the existing flow conveyed through the existing Culvert E.C. B-1 were calculated based on the following assumptions:

- The flow discharged from Pond BR-27 has been excluded as the outflow from the pond is diverted to downstream of Culvert E.C. B-1 via existing Culvert E.C. B-2 and the ROW ditch.
- As the existing roadway corridor is a rural section, runoff from the roadway is conveyed by the roadside ditches located on both sides of the ROW. Therefore, 50% of the road runoff will be discharged to the upstream side of Culvert E.C. B-1.

Therefore, the 50-yr and 100-yr flow utilized for the evaluation of E.C. B-1 are ***2.65 m^3/s*** and ***2.98 m^3/s***, respectively.

3.4.2 Existing Crossing Structures

Based on the field inspection conducted by Hatch in June 2017, the current crossing structures have been identified and documented in Appendix A: Field Inspection Memo. Within the current project limit, three (3) existing culverts were identified and summarized.

The hydraulic performance of the existing culvert is summarized by material, size, and key flows, the 50-yr, 100-yr and Regional Storm events.

Table 3-6: Existing Culvert Summary

Roadway	Culvert ID	Material	Barrel	Span [m]	Rise [m]	50yr Flow [m3/s]	100yr Flow [m3/s]	Regional Flow [m3/s]
Essa Road	E.C. B-1	Concrete Box	1	1.80	0.60	2.65	2.98	2.51
Harvie Road	E.C. W-1	CSP Circular	1	1.05	1.05	3.30	4.06	3.77
Future Byrne Drive (Currently Undeveloped Land)	E.C. L-2	CSP Circular	2	1.20	1.20	-	-	-

*The flow upstream of E.C. L-2 is not summarized under existing condition. Due to the construction on Bryne Drive, the E.C. L-2 will be replaced, and the proposed flow at this crossing will be summarized for P.C. L-2. Due to the lack of information, no hydraulic assessment is conducted to E.C. L-2.

The existing structures identified within this study are consistent with the HBBP Project. Proposed culvert structures utilized within the Harvie Road section of the HBBP Project have been documented within the current study and considered as existing culvert structures.

The following are the summary of the sizes proposed under the HBBP Study:

- E.C. W-1 have been upsized to a ***1.65 m diameter circular concrete pipe*** and relocated at the intersection of Bryne Drive and Harvie Road.
- E.C. W-2 has been proposed as a ***2.1 m diameter circular concrete pipe*** at Highway 400 to convey the main branch of Whiskey Creek from west to east underneath the highway. This culvert is outside of the current project limit.
- E.C. W-3 have been proposed as a ***1.2 m diameter circular concrete pipe*** required to convey surface runoff from the north west quadrant of Highway 400 and proposed Harvie Road to drain a portion of Catchment 203 to discharge to the relocated main branch of Whiskey Creek south of proposed Harvie Road. This culvert is outside of the current project limit.

The Hydraulic performance of existing culverts structures are summarized in Section *4.3.2 Hydraulic Assessments of Culverts*.

3.4.3 Existing SWM Facilities

Multiple SWM Facilities are located on site. Brief description of each SWM facilities has been provided below:

- **SWM Pond A & Stolp Pond**

Pond A and Stolp Pond are located within Whiskey Creek subwatershed, south of Harvie Road, receiving runoff from a total drainage area of 121.65 ha.

The Pond A was proposed for the developments of Mapleview Residential subdivision and the Barrie 400 Industrial lands. In addition to the proposed construction of Pond A, the existing Stolp Pond was previously retrofitted to provide a wet cell facility for quality control. Pond A and Stolp Pond retrofits will also be utilized to provide quantity and quality control from the future Bryne Drive.

In this study, the existing storage capacity of the ponds have been quantified and confirmed if retrofit will be necessary to provide quality and quantity control for the proposed Bryne Drive. The stage-storage information for Pond A and Stolp Pond was provided by the City of Barrie.

- **SWM Pond B**

Pond B has not been constructed, however this facility was proposed in the City of Barrie Whiskey Creek Master Plan for the upstream development in the Whiskey Creek subwatershed. It is located north of Harvie Road, and immediately adjacent to the east side of future Beacon Road.

Currently the Pond B will be considered as an potential alternative for retrofit the additional runoff generating from the development area on Bryne Drive.

- **SWM Pond LV14**

Pond LV14 located at north-west of the Caplan Avenue and existing Bryne Drive intersection within Lovers Creek subwatershed, receiving runoff from a total drainage area of 43.60 ha.

The retrofit of Pond LV14 was carried out in 2010, to meet the desired quality and quantity control objectives. The retrofitted pond features two sediment forebays, each located at either side of the pond receiving runoff from the east and west inlets, and a main wet cell. In addition, an outlet channel was designed to convey the controlled 100-yr peak flow from the pond. Based on the field observation (conducted in May, 2017), the channel was constructed with a bottom width of approximately 3 m with 3:1 side slopes. Pond LV14 will be utilized to provide quantity and quality control for the future developments of Bryne Drive.

In this study, the existing storage of the pond has been quantified and confirmed if retrofit is necessary to provide quality and quantity control for the proposed Bryne Drive. The stage-storage information for the Pond LV14 was provided by the City of Barrie.

- **SWM Ponds BR-20, BR-26, BR-P1 and BR-27**

SWM facilities Pond BR-20, Br-26, BR-P1 and BR-27 are located with Bear Creek subwatershed north of Mapleview Drive West and east of Essa Road.

BR-20, BR-26 and BR-P1 are wet ponds located on the upstream of Bear Creek Culvert at Essa Road (E.C. B-1). BR-26 was designed to receive runoff from the Mapleview Community Church (total drainage area approx. 4.7 ha), and BR-20 was designed to receive and treat runoff from the Mapleview West Industrial park (total drainage area approx. 50.28 ha). BR-P1 is a proposed extended wet pond designed to provide water quality and quantity control for the Messa Village located at the north-east corner of Essa Road and Mapleview Drive West intersection.

In this study, the storage within these wet ponds will be considered in hydrologic modelling to determine the flow to assess the conveyance capacity of the existing downstream box concrete culvert located on Bear Creek, Culvert E.C. B-1and to identify if the replacement/rehabilitation is necessary for this existing culvert. The stage-storage information for Pond BR-P1 was provided by the City of Barrie, while the stage-storage relationship for Ponds BR-20 and BR-26 was estimated using geographic information system (GIS) tools and the existing engineering drawings provided by the City of Barrie.

BR-27 is a dry pond located at Holy Spirit Parish to the west of Essa Road, receiving runoff from a drainage area of approximately 6.38 ha. The pond features a main cell and an outlet swale serving the overflow under 100-yr storm event to the downstream roadside ditch of Essa Road. The overflow will be conveyed through a pipe to the west side of Essa Road which followed by the roadside ditch discharging to Bear Creek.

In this study, the storage within BR-27 was considered in the hydrologic modelling. The stage-storage relationship of Pond BR-27 was estimated using geographic information system (GIS) tools and the existing engineering drawings provided by the City of Barrie.

- **SWM Pond HT06**

HT06 is a dry pond located at west side of the existing Bryne Drive, south of Essa Road. The existing pond was originally designed to service the Cambridge Shopping Center and Bryne Drive ROW area, which was retrofitted into an improved Dry Pond in 2016 to provide treatment for 300 Essa Road development area.

In this study, the storage within HT06 was considered in the hydrologic modelling. The stage-storage relationship of Pond HT06 was provided by the City of Barrie.

3.4.4 *Existing Storm Sewers Capacity Assessment*

Within the HEB study area, there exists four (4) urbanized storm sewer networks that have been evaluated to determine their existing capacity. The following Table 3-7 demonstrates and documents the outlet locations, sewershed, watershed, and description of each drainage network.

Table 3-7: Existing Storm Sewer Information

Sewershed Area	Outlet	Watershed	Description
Bryne Drive, south of Harvie Road and north of Caplan Avenue	SWM Pond LV14	Lovers Creek	Outlets to the Pond LV14
Bryne Drive, just south of Essa Road	Essa Road Storm Sewer	Hotchkiss Creek	Tie-in to the existing storm sewer system along Essa Road at MH 11

To assess the storm sewer capacity, runoff estimation from the delineated sewershed was conducted using the Rational Method for the 5-year design storm. The Rational Method storm sewer capacity assessment is provided in Appendix D – Storm Sewer Sizing. The following assumptions were used for runoff estimation:

- City of Barrie's IDF curve data was used for design storms.
- An initial time of concentration is considered as 10 minutes as per City of Barrie design standards.
- Runoff coefficient (C) is assumed to be:
    - 0.90 for impervious area and 0.18 for non-impervious area as per City of Barrie's Storm Drainage and Storm Water Management Policies and Design Guidelines (2009).

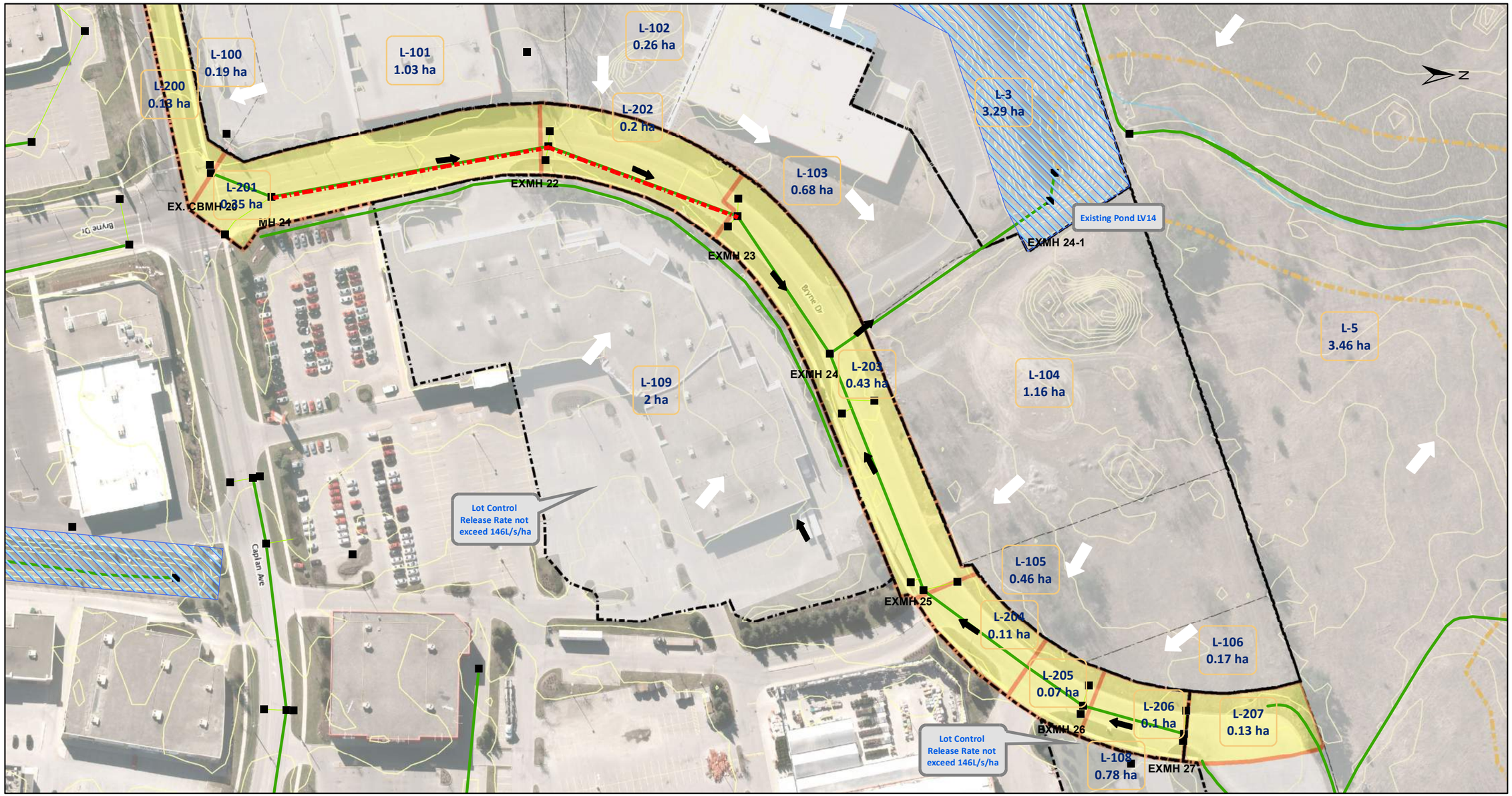
The following summary in Table 3-8 illustrates the results of the existing storm sewer capacity analysis.

Table 3-8: Existing Storm Sewer Capacity Evaluation

Location	Diameter Ranges (mm)	Existing Condition Sewer Capacity	Description
Bryne Drive, south of Harvie Road and north of Caplan Avenue, Outlet to Pond LV14	300 to 865 x 1345	Inadequate	Inadequate capacity between MH-21 to MH-23
Bryne Drive, just south of Essa Road, Outlet to Essa Road Storm Sewer System	300 to 1350	Adequate	Pipe Capacity ranged between 20 – 78%

As depicted in the storm sewer capacity assessment, storm sewers located in Bryne Drive, north of Caplan Avenue between MH-21 to MH-23 do not have sufficient capacity to convey the 5-year minor storm flow as per the City of Barrie standards.

The storm sewers in Bryne Drive just south of Essa Road are adequate to convey the 5-year flows under existing conditions.



Stormwater Management Facility
Existing Culvert
Existing Stormwater Linear Feature
Existing Stormwater Lateral
Existing Stormwater Device
ROW Sewershed Catchment
External Catchment
Watershed Boundary
LSRCA Floodplain Setback
LSRCA Regulation Limit
Catchment Boundary
Undersized Sewers

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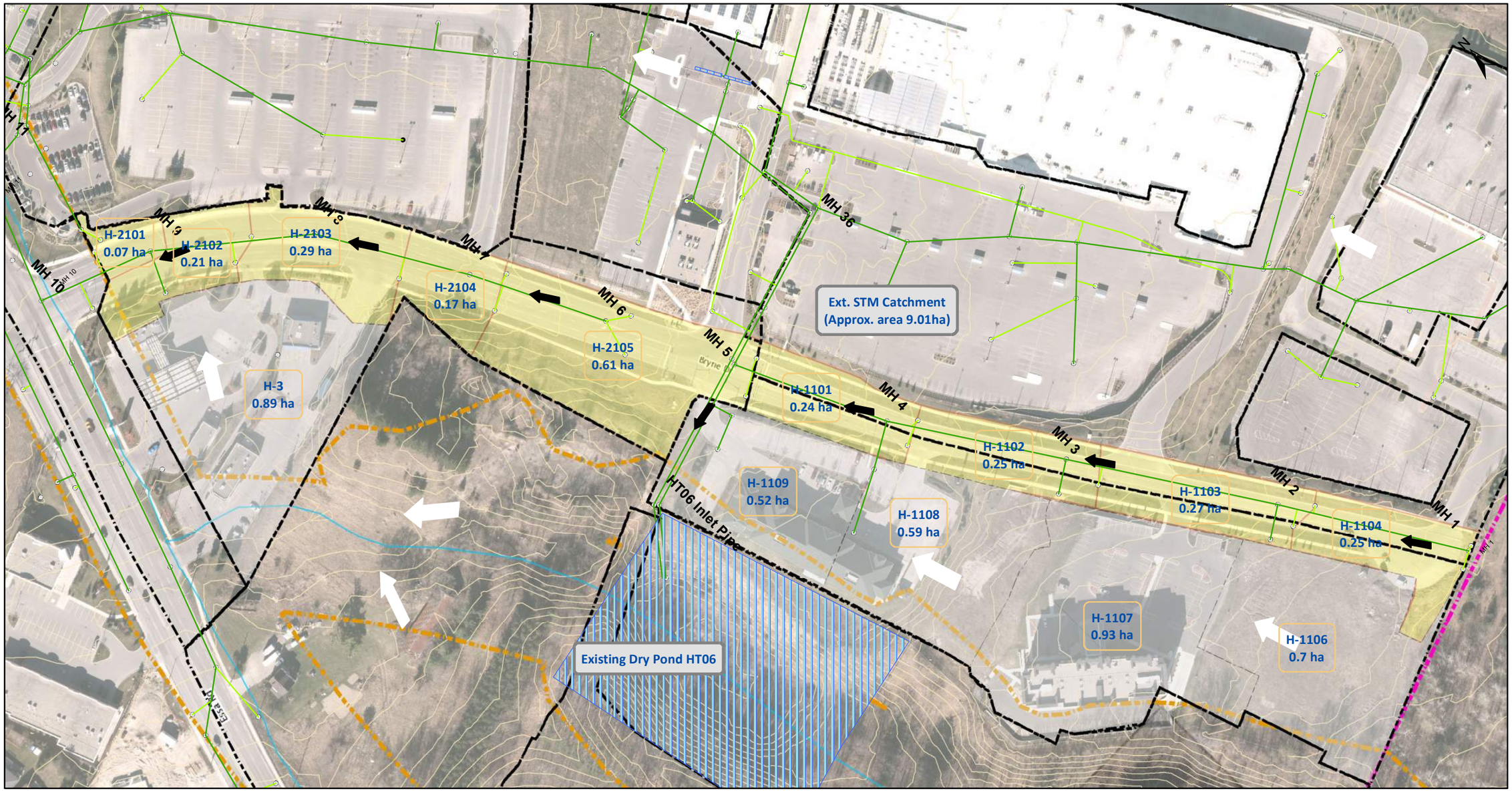
HARVIE ESSA BRYNE PROJECT

Exhibit 3-7 Exisitng Condition - Bryne Drive South of Harvie Road at Lovers Creek Sewer Capacity Assessment



Stormwater Management Facility
Existing Culvert
Stormwater Linear Feature
Stormwater Lateral
Stormwater Device
ROW Catchment
External Catchment
Watershed Boundary
LSRCA Floodplain Setback
LSRCA Regulation Limit
Catchment Boundary
Undersized Sewers

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HARVIE ESSA BRYNE PROJECT

Exhibit 3-8
Existing Sewershed - Bryne Drive North to Harvie Road at Hotchkiss Creek

4 Post-Development Conditions

The proposed roadway improvements to the Harvie Road, Essa Road, and Bryne Drive are anticipated to have an impact to the drainage conditions within these areas. The following section has been drafted to identify the proposed roadway configurations and to document the hydrologic and hydraulic impact of these proposed conditions.

Proposed Road Configurations:

The following road configurations are the proposed cross-section conditions under the preferred alternative:

- ***Harvie Road*** will be a 34.0 m ROW with an urban cross-section including 5 lanes of roadway, a 5.8 m wide pervious area (boulevard), one 2 m wide island, two 1.5 m wide bicycle lanes, and two 2.0 m wide sidewalks.
- ***Bryne Drive*** will be a 34.0 m ROW with an urban cross-section including 5 lanes of roadway, a 5.8 m wide pervious area (boulevard), two 1.5 m wide bike lanes, and two 2.0 m wide sidewalks.
- ***Essa Road*** will be a 30.0 m ROW with an urban cross-section including 5 lanes roadway, a 5.0 m wide boulevard (pervious) area, a 3.0 m wide multi-use trail and a 2.0 m wide sidewalk

The proposed conditions drainage mosaics are illustrated in Exhibits 4-1 to 4-6.

4.1 Proposed Conditions Drainage

In general, under proposed conditions, post-development runoff for road ROW catchments are expected to increase due to the added imperviousness of the roads, sidewalks, and multi-use trail. As a result, the improvement and/or implementation of both drainage conveyance features and stormwater management facilities are required to handle the additional runoff.

Area 1: Harvie Road at Whiskey Creek Subwatershed (Exhibit 4-1):

The proposed Harvie Road widening from Essa Road easterly to the intersection of proposed Bryne Drive will affect the imperviousness level in Catchments 200, 201, 202, 101, 102, and 104. Followings are the drainage plan for this stretch of the study area:

- Proposed storm sewer system along Harvie Road between Veterans Drive and Highway 400 will collect and convey runoff for the minor 5-year storm event towards the future Bryne Drive and ultimately to SWM Pond A for quantity and quality control.
- It is noted that in HBBP Project, Pond A expansion was proposed to treat the increase flow from the Harvie/Big Bay Point/Highway 400 Overpass, Harvie Road to the west and the southern stretch of Bryne Drive within the Whiskey Creek subwatershed. Major and minor flows will be routed into Pond A for water quality and quantity treatment.

- Through the HBBP project, in order to meet the LSRCA LID infiltration requirements, the proposed Pond A expansion is approximately 1,155 m^3. The expansion is positioned along the north side of the existing Pond A main cell and will be installed beneath the surface in the form of a soakaway pit facility.

Area 2: Essa Road at Bear Creek Subwatershed (Exhibit 4-2):

The proposed widening of Essa Road will increase the impervious level of the drainage catchments. The drainage strategy for the Essa Road section of the project includes:

- Proposed storm sewer system beneath Essa Road will collect and convey runoff from roadway Catchments C501 and C502 for the minor 5-year event. The storm sewer system will be pre-treated via an oil grit separator (OGS) unit and discharged to the proposed dry SWM facility Pond BR-P2. The pond will be overcontrolled to balance the flow conveyed from Catchment C502.
- An infiltration chamber IC-B1 will be installed adjacent to and beneath BR-P2 as an LID measure to meet the infiltration requirements for the Essa Road ROW catchments.
- The outflow from the proposed BR-P2 will be directed to the Bear Creek channel downstream of Culvert E.C. B-1 via a proposed water quality swale.
- The controlled outflow from existing Dry Pond BR-27 will be directed to the upstream end of existing Culvert E.C. B-1 through a proposed separated clean water storm sewer system (PMH8 to PMH9).
- Due to the proposed road cross-section, the existing Culvert E.C.B-2 will be removed and replaced in performance via the noted proposed clean water storm sewer system.

Area 3: Bryne Drive, South* of Harvie Road and *North of Caplan Avenue at Lovers Creek Subwatershed (Exhibit 4-3):

As part of this project, the existing Bryne Drive will be improved and realigned for the proposed extension of Bryne Drive within the Lovers Creek subwatershed. This improvement and extension of this roadway will affect the current drainage patterns, resulting in an increase to the impervious level within the ROW. The following drainage plan has been drafted to mitigate these drainage pattern impacts in terms of water quantity, quality, and overall runoff conveyance:

- The existing storm sewer system will be utilized to collect and convey runoff for the minor 5-year storm event from the proposed roadway area. Sections MH24 – MH23 to the outfall at LV14 will be upsized to meet the City of Barrie conveyance requirements. The storm sewer system has been designed to convey Catchments L-1, L-2, L-3 and L-4 to SWM Pond LV14, consistent with current drainage patterns.
- Runoff within this study area will be conveyed to LV14 in order to meet water quantity and quality requirements. In order to meet the infiltration requirements, an underground infiltration chamber is proposed at the southwest corner of the existing

pond LV14, to provide LID infiltration control volume for the net impervious increase on Bryne Drive. The 25mm storm flow will be diverted to the infiltration chamber for LID infiltration control through a proposed inlet pipe designed to convey the 25mm event from the LV14. The inlet pipe from the LV14 will be positioned above the 2 year elevation within the pond and below the 5 year storm elevation in order to provide infiltration capacity above the permeant pool level of the pond facility.

- Runoff from rural Catchment L-5A and the Pond LV14 outflow will be conveyed easterly via a re-aligned Lovers Creek channel through a proposed Culvert P.C.L-2 under the new roadway alignment of Bryne Drive.
- Linear bio swales are proposed on both the north and south side of the culvert as shown in Exhibit 4-3. Roadway runoff of Catchment L-5B will be conveyed to these swales through laterals for water quality treatment. CB-shields are recommended in catch basins for additional treatment. Granular infiltration galleries are proposed under these linear bio swales as a LID measure**.**

Area 4: Bryne Drive, South of Harvie Road at Whiskey Creek Subwatershed (Exhibit 4-4):

The future Bryne Drive alignment runs along Catchments 104 to the south of Harvie Road. Catchment 104 was updated to include a small portion of drainage area located at the south-west corner of Harvie Road and Bryne Drive intersection. Due to proposed roadway cross-section and new roadway construction within the currently undeveloped lands, imperviousness at Catchments 104 will increase. The following is the drainage plan for the Bryne Drive south at Harvie Road section, which focuses on conveyance and quality treatment prior to discharge to Pond A for quantity treatment:

- A proposed storm sewer system will collect and convey runoff for the minor 5-year storm event from the proposed Bryne Drive between Harvie Road, and Whiskey Creek and Lovers Creek subwatershed boundary. Runoff from the storm sewer will be directed to SWM Pond A for quantity and quality control.
    - The storm sewer outfall will be designed to accommodate the 100-year flow. Additional catch basins will be placed at the lowest point to capture and convey major storm runoff along the proposed roadway.
    - The section of Catchment 104 located east of Bryne Drive will be captured by a ditch inlet connected to the main storm sewer flowing to SWM Pond A.
- Outflow from Pond A will be conveyed to the east side of proposed Bryne Drive via an existing 2.0 m x 2.0 m concrete box culvert that will need to be extended. The outfall extension will convey runoff from Pond A to the Whiskey Creek main branch flowing to the Highway 400 culvert crossing.

Area 5: Bryne Drive, North of Harvie Road at Whiskey Creek Subwatershed (Exhibit 4-5):

The proposed Bryne Drive alignment runs northerly from Harvie Road through existing Catchments 203 and 205, which results in an increase to the imperviousness within these catchments. For the proposed conditions drainage assessments, these catchments are subdivided into Catchments 203.1, 203.2, 205.1, 205.2 and road ROW Catchments 208 and 209. The following is the drainage plan for the Bryne Drive north section, which focuses upon conveyance and SWM facility implementation:

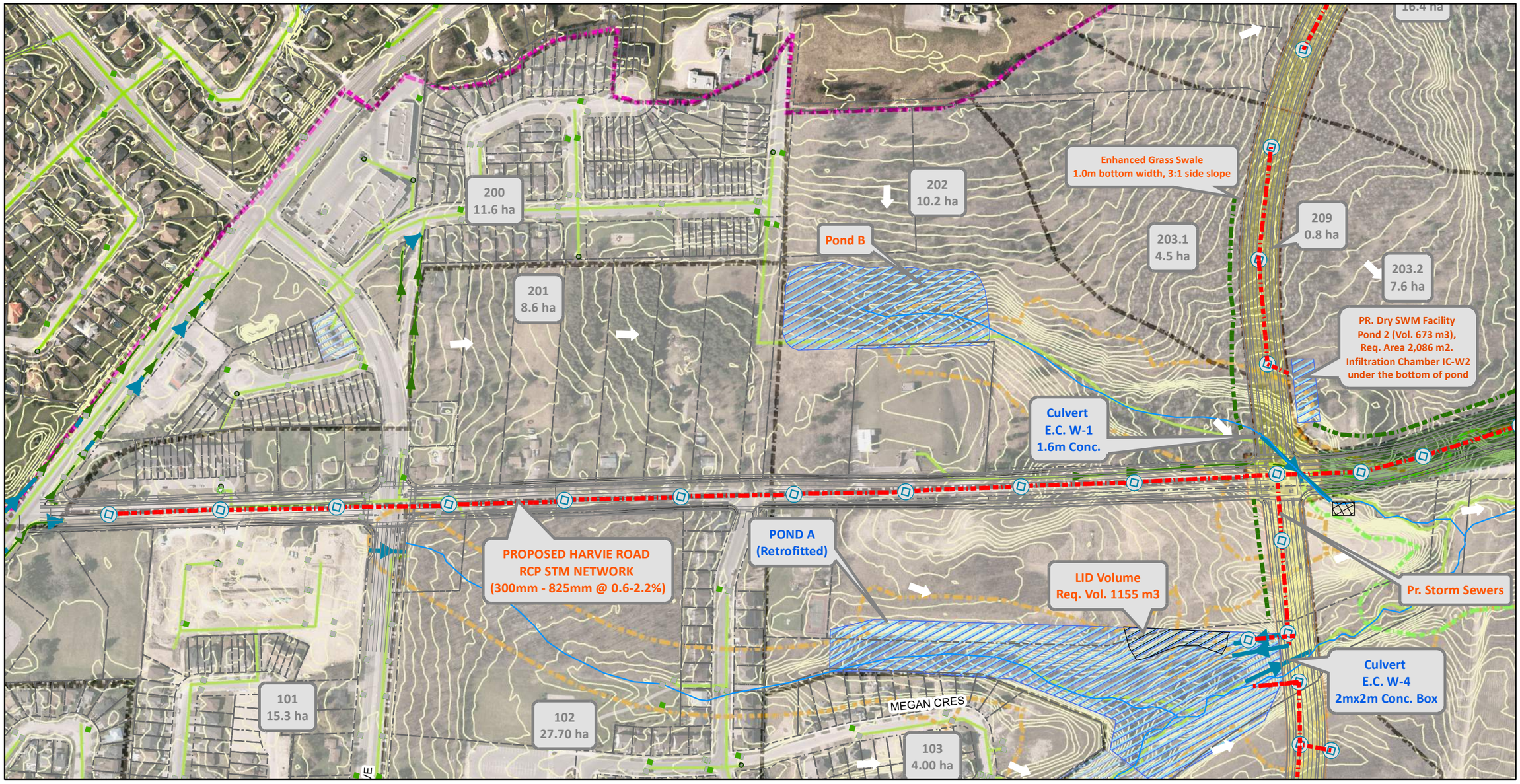
- Storm Sewer System will collect and convey runoff for the minor 5-year storm event from the roadway Catchments 208 and 209.
    - The storm sewer in Catchment 208 will be discharged to the proposed Linear Dry SWM Pond 1. This SWM facility will include an infiltration chamber IC-W1 at the bottom of the pond as a LID measure.
    - The outflow from Pond 1 will discharge to the proposed water quality swale D-W1, which eventually discharge to the Culvert E.C. W-5 at Highway 400.
    - The storm sewer in Catchment 209 will be discharged into the proposed Linear Dry SWM Pond 2. This facility will include an infiltration chamber IC-W2 at the bottom of the pond.
    - The outflow from Pond 2 will discharge to the proposed water quality swale D-W2, which eventually discharges to Culvert E.C. W-3 at Harvie road west Highway 400
    - Pre-treatment in the form of a pair of appropriately sized OGS units are recommended prior to discharging to the two (2) road ROW outfall locations.
- A culvert (P.C.W-1) is proposed at Bryne Drive within Catchment 208 to convey the runoff from Catchment 205.1 to the east of the proposed road in order to maintain the subwatershed catchment boundaries within Whiskey Creek and Hotchkiss Creek. The proposed culvert conveys runoff to the proposed swale D-W1.
- Runoff from Catchment 203.1 will be conveyed via a swale to the upstream of Culvert E.C.W-1 located at the intersection of Harvie Road and Bryne Drive. The culvert will convey the runoff to Whiskey Creek.
- As a potential option recommended from and consistent with the Whiskey Creek Master drainage plan, the consideration for Pond B has been reviewed. The design and construction of this facility could potentially provide compensation in terms of water quantity, quality and infiltration benefits within the Whiskey Creek subwatershed for the current project. However, it should be noted that a direct connection from the Bryne Drive ROW is not possible, the facility would need to be discussed with the LSRCA on a subwatershed basis to document benefits and

meeting target criteria. If this will be an agreeable alternative, the proposed Pond 2 located near the Bryne Drive and Harvie Road intersection can be removed.

Area 6: Bryne Drive, North of Harvie Road and South of Essa Road at Hotchkiss Creek Subwatershed (Exhibit 4-6):

Bryne Drive is proposed to be constructed with a widened urbanized cross-section featuring bike lanes and improved sidewalks. The proposed improvements will alter the catchment drainage conditions, increasing the imperviousness, which requires water quantity and quality treatment. The following is the drainage plan within the Bryne Drive section, which features the utilization of existing drainage and SWM infrastructure with additional quality and retrofit recommendations:

- The existing storm sewer system will collect runoff for the minor 5-year event from the roadway. Three (3) sections of the existing Bryne Drive storm sewer within this area require upsizing as a result of the roadway design and conveyance criteria requirements.
    - The Bryne Drive storm sewer from MH 1 to MH 5 has sufficient capacity to convey the proposed condition runoff. Runoff from this system ultimately discharges to SWM Pond HT06. Due to the documented high infiltration capacity of the soil at Pond HT06, this facility was considered to be a dry pond.
    - Due to hydraulic conveyance capacity concerns, an upsized storm sewer has been identified as a requirement for the section from MH 5 to SWM Pond HT06.
    - Storm sewers from MH 6 to MH 7 and from MH 8 to MH 9 have been identified as deficient in terms of meeting the conveyance criteria under the proposed condition. These two (2) noted sections will require replacement in order to meet the conveyance criteria.
    - Two (2) oil grit separator (OGS) units will be installed within this area. The first one will be installed prior to the outlet to HT06 at MH 5 in order to provide pre-treatment to contribute to meeting water quality requirements. The second unit will be located towards the Essa Road and Bryne Drive intersection at the downstream end of the system at MH 9 prior to discharging from the Bryne Drive ROW.
- The existing Dry Pond HT06 will be retrofitted to provide additional water quantity, quality, and LID infiltration volume in order to meet the proposed Bryne Drive ROW runoff impacts associated within the increase in impervious area. HT06 is currently slated to be retrofitted, however this facility will require an additional 682m^3. One key benefit identified for this facility is the high infiltration rate at this location, which has resulted in this facility being able to infiltrate all runoff events within 24 hours and form a dry pond facility.



Proposed MH
Proposed Sewers
Culvert
Catchment Boundary
HBBP Sewer Catchment
Bryne Drive Sewer Catchment
Catchment Boundary
Watershed Boundary
LSRCA Floodplain Setback
LSRCA Regulation Limit

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PROJ. DES. COORD.	PROJ. ENGR.

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HARVIE ESSA BRYNE PROJECT

Exhibit 4-1
Proposed Condition - Harvie Road at Whiskey Creek

Stormwater Management Facility
Culvert
Existing Stormwater Linear Feature
Existing Stormwater Lateral
Existing Stormwater Device
ROW Catchment
External Catchment
Watershed Boundary
LSRCA Floodplain Setback
LSRCA Regulation Limit
Proposed Sewers
Proposed Quality Swale

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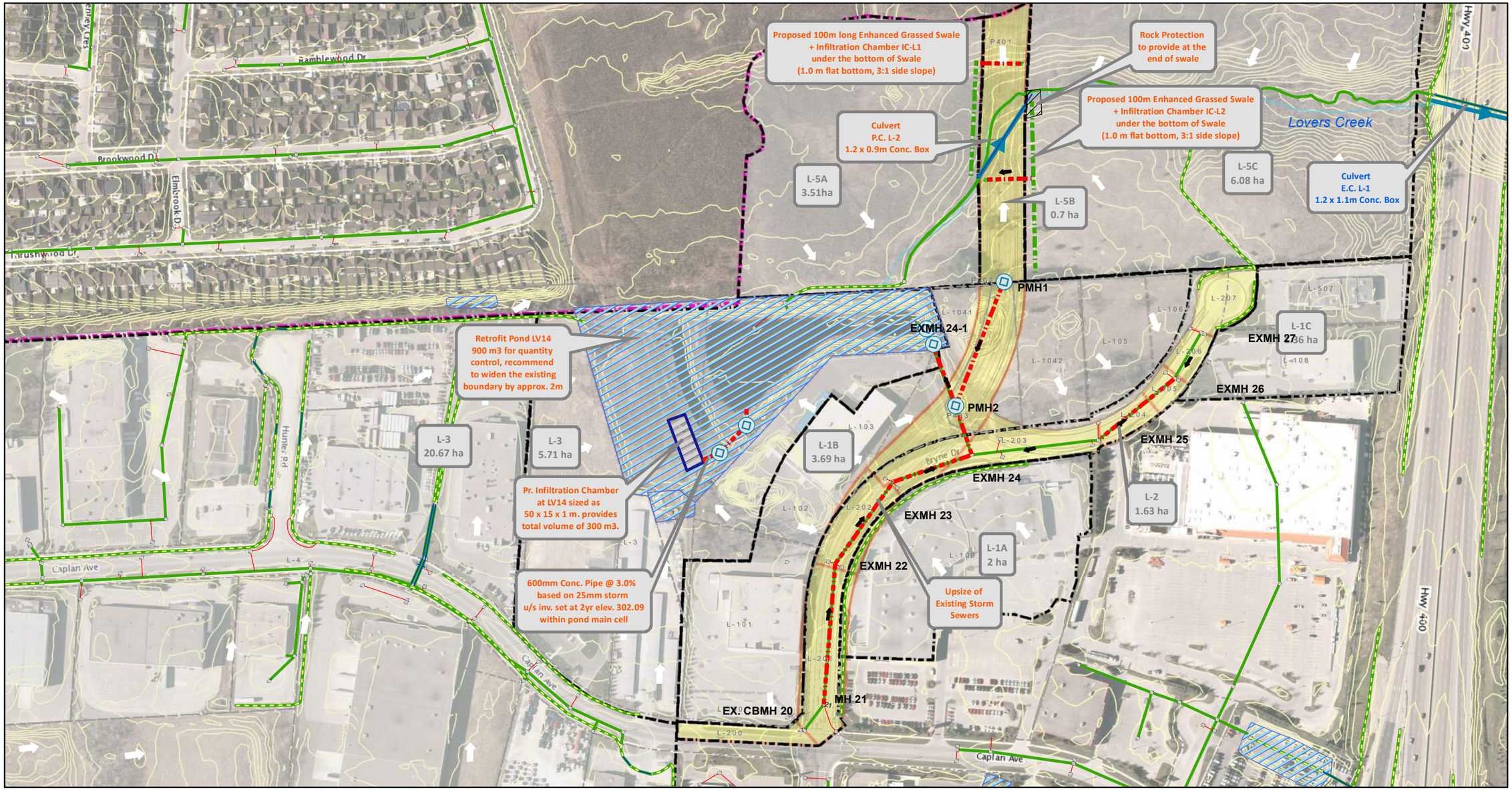
HARVIE ESSA BRYNE PROJECT

Exhibit 4-2
Proposed Condition -
Essa Road at Bear Creek



Stormwater Management Facility
Culvert
Existing Stormwater Linear Feature
Existing Stormwater Lateral
Existing Stormwater Device
ROW Sewershed Catchment
External Catchment
Watershed Boundary
LSRCA Floodplain Setback
LSRCA Regulation Limit
Catchment Boundary
Property Boundary

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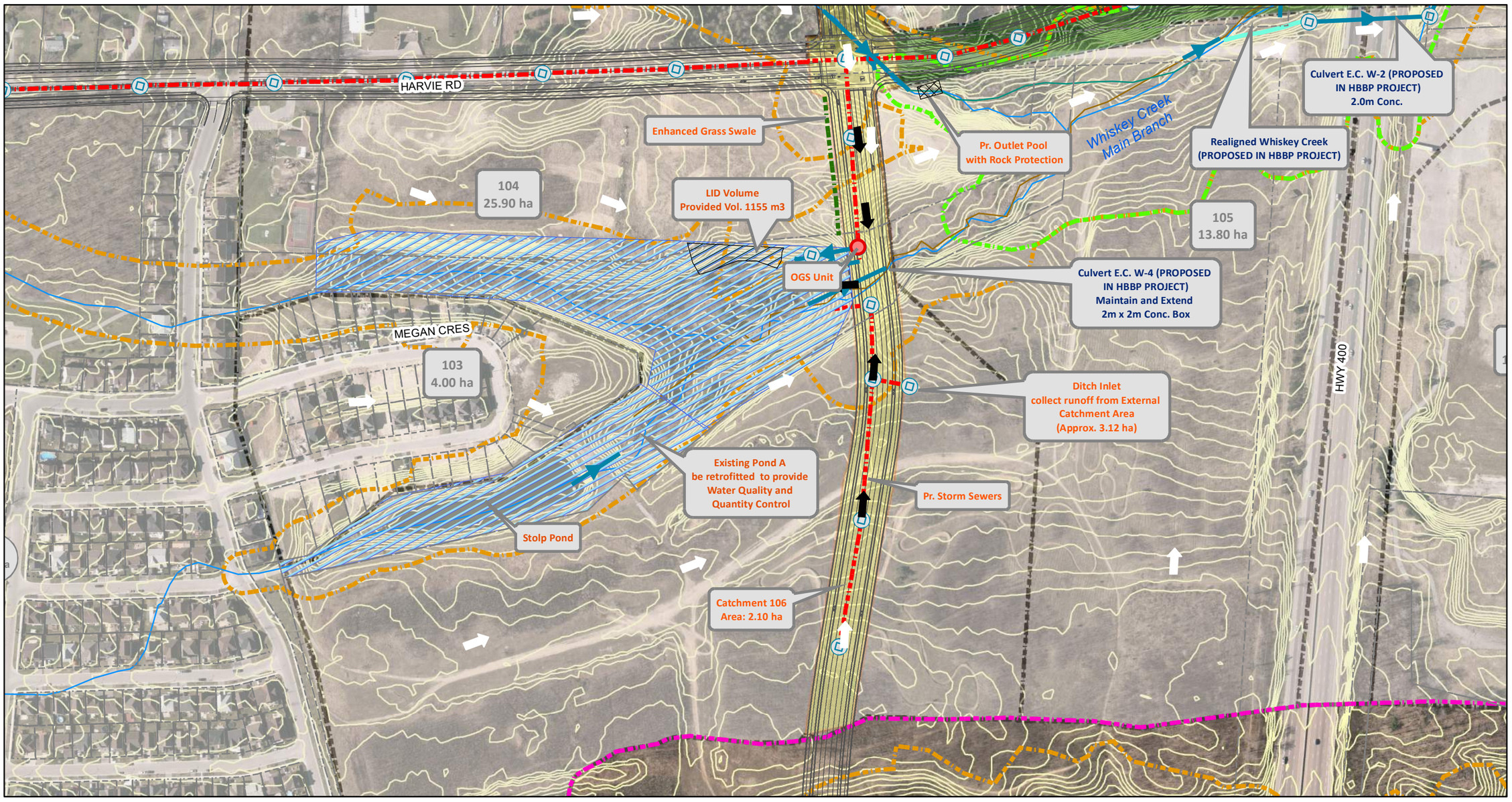
HARVIE ESSA BRYNE PROJECT

Exhibit 4-3
Proposed Conditions - Bryne Drive South to Harvie Road at Lovers Creek



Proposed OGS
Proposed MH
Proposed Sewers
Culvert
Catchment Boundary
HBBP Sewer Catchment
Bryne Drive Sewer Catchment
Property Boundary
Watershed Boundary
LSRCA Floodplain Setback
LSRCA Regulation Limit

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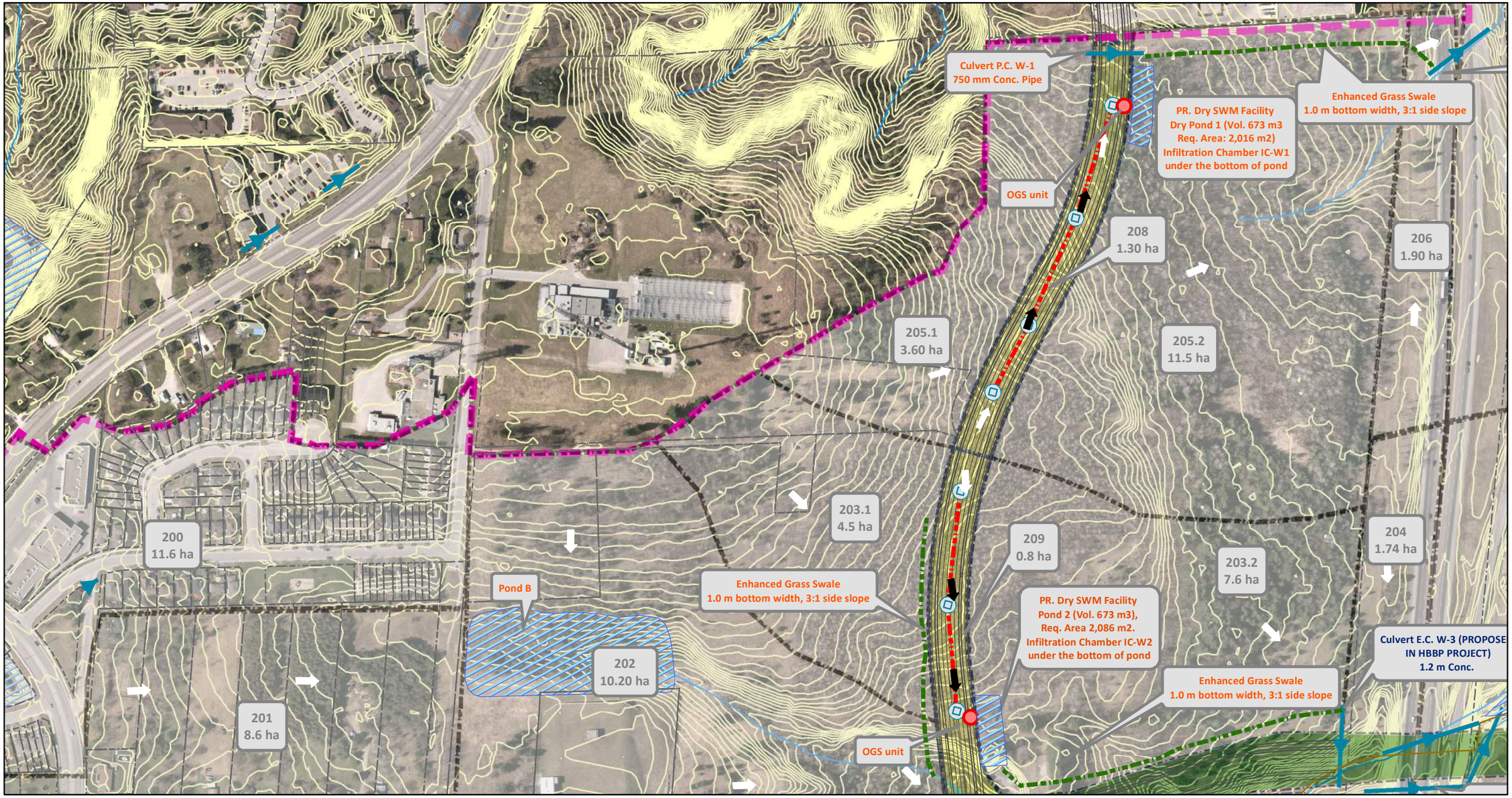
HARVIE ESSA BRYNE PROJECT

Exhibit 4-4
Proposed Condition - Bryne Drive South to Harvie Road at Whiskey Creek



Proposed OGS
Proposed MH
Proposed Sewers
Culvert
Catchment Boundary
HBBP Sewer Catchment
Bryne Drive Sewer Catchment
Property Boundary
Watershed Boundary
LSRCA Floodplain Setback
LSRCA Regulation Limit

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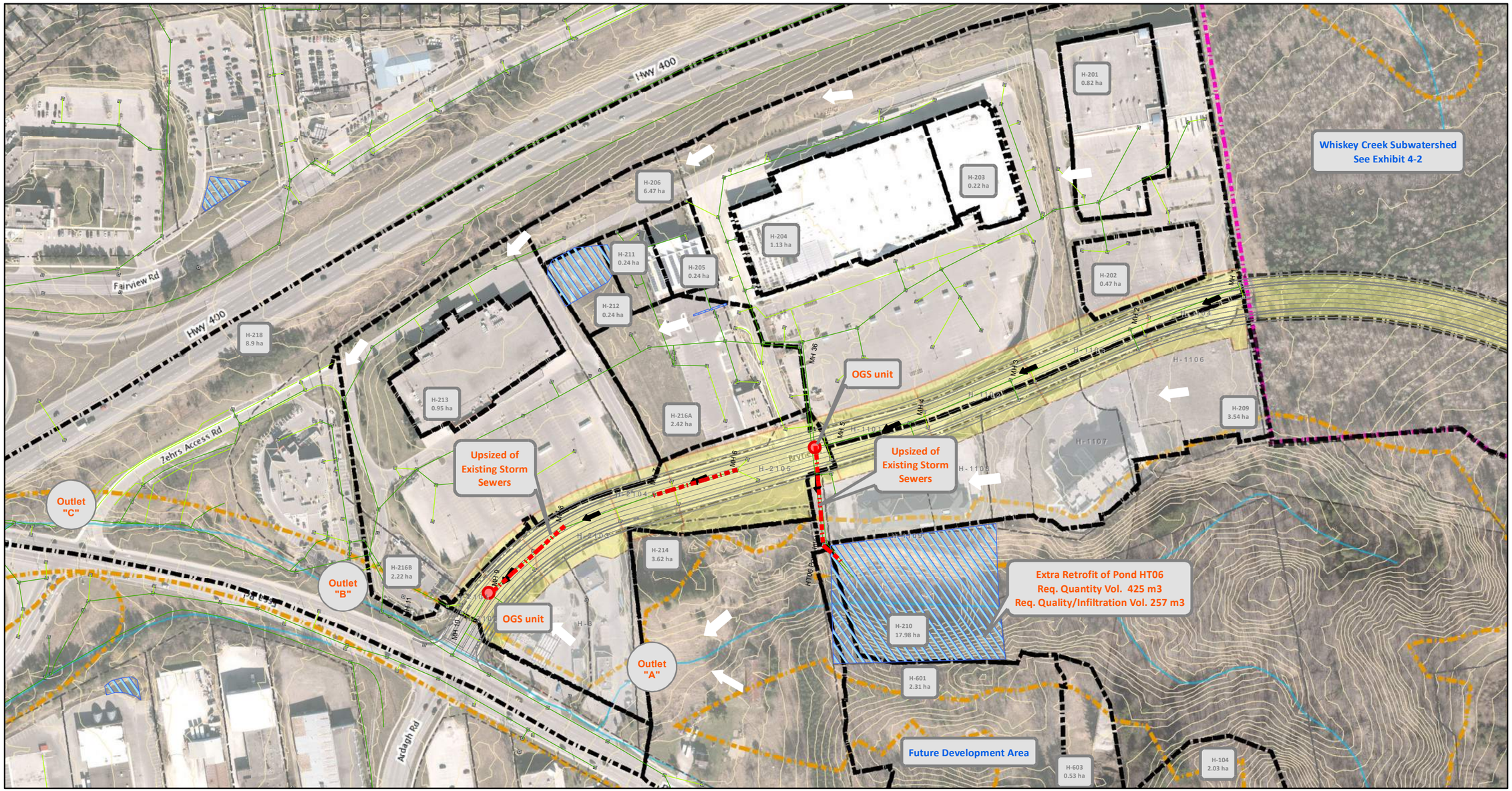
HARVIE ESSA BRYNE PROJECT

Exhibit 4-5
Proposed Condition - Bryne Drive North to Harvie Road at Whiskey Creek



Stormwater Management Facility
Culvert
Existing Stormwater Linear Feature
Existing Stormwater Device
ROW Sewer Catchment
External Sewer Catchment
Watershed Boundary
LSRCA Floodplain Setback
LSRCA Regulation Limit
Proposed OGS
Catchment Boundary
Property Boundary

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HARVIE ESSA BRYNE PROJECT

Exhibit 4-6
Proposed Condition - Bryne Drive North to Harvie Road of Hotchkiss Creek

4.2 Proposed Conditions Hydrology

Under the proposed conditions, the existing SWMHYMO models have been updated to reflect the preferred alternative road designs, which include the proposed and existing retrofitted SWM facilities. The following section documents these elements on a study area by study area basis for all catchments identifying impacts to the impervious condition and overall modelling within these areas.

(i) Whiskey Creek Subwatershed

The existing Whiskey Creek SWMHYMO model has been updated from the HBBP project design to reflect the proposed condition for the current study. The following is a summary of the key parameters altered and considered to effectively represent the proposed scenario:

- Imperviousness of roadway ROW catchments have been updated (approximately 90%) to reflect the proposed roadway development.
- Impervious levels on Catchment 104 have been updated to reflect the proposed Bryne Drive alignment.
- Catchment 203 have been divided into Catchments 203.1 and 203.2 due to the proposed Bryne Drive alignment.
- Catchment 205 have been divided into Catchments 205.1 and 205.2 due to the proposed Bryne Drive alignment.
- Stage-storage information for the proposed dry SWM facilities Pond 1 and Pond 2 as well as Pond A have been incorporated within the hydrologic model.

Table 4-1 illustrates the changes in catchment parameters for hydrologic runoff estimation within the Whiskey Creek subwatershed.

Table 4-1: Proposed Catchment Parameters – Whiskey Creek

Catchment	Area (ha)	Impervious (%)	Change
100	50.10	44.0	-
101	15.30	55.0	-
102	27.70	39.0	-
103	4.00	55.0	-
104	25.90	70.0	+6% (Catchment boundary change, account for impervious level increase in Catchment 106)

Catchment	Area (ha)	Impervious (%)	Change
105	13.80	-	Catchment boundary change
200	11.62	60.0	-
201	8.59	-	-
202	10.20	-	-
203.1	4.5	-	Catchment 203 Split in 3 parts
209	0.8	90.0	
203.2	7.6	-	
204	1.74	35.0	-
205.1	3.60	-	Catchment 205 Split into 3 parts: 205.1, 208 & 205.2
208	1.30	90.0	
205.2	11.50	-	
206	1.90	35.0	-

Table 4-2 presents a comparison between the existing and proposed conditions flows at key locations within Study Areas1, 4 and 5. The flows are summarized in Table 4-2 at four (4) key locations:

- Culvert E.C. W-5 at Highway 400 drains runoff of Catchments 205.1, 205.2, and 208. The post-development design and 100-year flows at the upstream of the culvert meet the post to pre development quantity control requirements with the implementation of proposed SWM facilities on site.
- Flow rate of Catchment 205.1 has been used to assess the conveyance of the proposed Culvert P.C. W-1 at Bryne Drive.
- Runoff from Catchments 200, 201, 202 and 203.1 will drain to the upstream of Culvert E.C. W-1. The resulting flow rate from these catchments has been utilized to assess the conveyance capacity of E.C.W-1. The proposed flow rate at Culvert E.C. W-1 is higher than the existing flow, due to the additional runoff Catchment 203.1 being directed to the upstream end of this culvert under proposed condition.
- Culvert E.C. W-4 has been designed and documented to convey the controlled outflow from Pond A.
- Culvert E.C. W-2 located at Highway 400 represents the major outlet of Whiskey Creek. With the implementation of proposed SWM facilities, the post-development

design and 100-year flows at the upstream of the culvert meet the post- to pre-requirements.

Table 4-2: Comparison Peak Flows at Key Locations

Key Location	Existing Flow (m^3/s)			Uncontrolled Proposed Flow (m^3/s)			Controlled Proposed Flow (m^3/s)		
	50-yr	100-yr	Hazel	50-yr	100-yr	Hazel	50-yr	100-yr	Hazel
Upstream of Culvert E.C. W-5 at Hwy 400	1.28	1.57	2.19	1.44	1.72	2.21	1.28	1.55	2.15
Downstream of Culvert P.C. W-1 at Future Bryne	-	-	-	0.61	0.70	0.61	0.35	0.41	0.55
Upstream of Culvert E.C. W-1 at future Bryne * & Harvie Road Intersection	3.30	4.06	3.77	3.49	4.31	4.29	3.49	4.31	4.29
Upstream of Culvert E.C.W-4 at Future Bryne Drive	1.36	1.40	14.44	1.36	1.41	14.69	1.36	1.41	14.69
Upstream of Culvert E.C. W-2 at Hwy 400 (105 to 301)	5.64	6.74	17.49	5.89	7.01	18.35	5.63	6.72	18.35

* The proposed flow rate at E.C. W-1 is higher than the existing flow, because additional drainage area of Catchment 203.1 is added under proposed condition.

As shown in Table 4-2, with the implementation of SWM facilities in the study area the floodplain within the Whiskey Creek area will be maintained and the 2-year to the 100-year storm events flows will not be increased under proposed conditions.

(ii) Hotchkiss Creek Subwatershed

The existing SWMHYMO model developed for Hotchkiss Creek Subwatershed has been updated to reflect the proposed conditions. Impervious areas of ROW Catchments are updated to reflect the increased imperviousness due to proposed road improvements, while the rest of the external catchments remain consistent with the current conditions.

Table 4.3 shows the changes in impervious levels in the Bryne Drive north catchments.

Table 4-3: Comparison of Imperviousness– Hotchkiss Creek Subwatershed

Catchment ID	Area (ha)	Imp % (Existing Condition)	Imp % (Proposed Condition)	Change
H-104	2.03	-	-	-
H-601	2.31	68	68	-
H-603	0.53	40	40	-
H-210	17.98	-	-	-
H-201	0.82	99	99	-
H-202	0.47	99	99	-
H-203	0.22	99	99	-
H-204	1.13	99	99	-
H-205	0.24	99	99	-
H-206	6.47	87	88	+1%
H-209	3.54	92	94	+2%
H-212	0.24	99	99	-
H-211	0.24	99	99	-
H-213	0.95	99	99	-
H-215	2.15	74	80	+6%
H-216A1	1.12	82	82	-
H-216A2	0.49	82	82	-
H-216A3	0.39	82	82	-
H-216A4	0.42	82	82	-
H-216B	2.22	82	82	-
H-214	3.62	-	-	-
H-218	8.90	38	38	-

Comparison of flows at three (3) key outlets, Outlet A, Outlet B and Outlet C, has been summarized in Table 4-4:

- Outlet A represents the outflow from Pond HT06 and the uncontrolled flow from Catchment 214 located immediately downstream of the pond.
- Outlet B receives the storm sewer flow from the commercial lot located east of Bryne Drive and the outflow from Pond HT06.
- Outlet C combines the flow from Outlet A and B and Catchment 218, which includes the ROW drainage areas of Highway 400. Outlet C is the downstream outlet of the overall study area, where flow rates are summarized to document that post to pre-development quantity control and peak flow requirements are met.

Table 4-4: Proposed Peak Flows at Key Locations – Hotchkiss Creek Subwatershed

Key Location	Existing Flow (m^3/s)			Uncontrolled Proposed Flow (m^3/s)			Controlled Proposed Flow (m^3/s)		
	50-yr	100-yr	Hazel	50-yr	100-yr	Hazel	50-yr	100-yr	Hazel
Outlet A	0.54	0.63	5.04	0.54	0.63	5.05	0.54	0.63	5.05
Outlet B	2.47	2.78	6.26	2.52	2.82	6.27	2.44	2.76	6.26
Outlet C	3.59	4.06	7.26	3.63	4.12	7.27	3.56	4.05	7.27

Overall the flow rate at Outlet C remained at the same level as the existing condition. It demonstrated that with the implementation of SWM facility (retrofit of Pond HT06), post to pre-flow control requirements are met and the floodplain condition in the overall study area remained the same.

(iii) Lovers Creek Subwatershed

The existing SWMHYMO model developed for Lovers Creek Subwatershed has been updated to reflect the proposed condition. The followings are the key parameters considered to for the proposed road design conditions:

- Imperviousness of roadway catchments have been updated (approximately 90%) to reflect the proposed development.
- The existing Bryne Drive roadway at Caplan Avenue will be altered to the proposed road cross-section, therefore imperviousness within the ROW catchments have been updated to demonstrate the increase.
- Stage-storage information based on retrofit of Pond LV14 has been included within the proposed hydrologic model.
- To account for the controlled release flow rate of 146 L/s/ha from Catchment L-1, the DIVERT HYD routing command was used in order to split the output hydrograph into two. The controlled flow with a maximum flow rate of 1.068 m^3/s (at a rate of

146 l/s/ha for area of 7.32 ha) has been directed to Pond LV14, while the remaining flow has been retained by the rooftop and parking lot storage in commercial lots.

- The drainage boundary of Catchment L-1C was updated to include a small portion of area on the north side of Bryne Drive and its imperviousness has been revised accordingly. A controlled flow at a rate of 146 l/s/ha from the north portion of L-1C area will also be directed to the Pond LV14.

Table 4-5 summarizes and compares the imperviousness in different catchments.

Table 4-5: Comparison of Imperviousness – Lovers Creek Subwatershed

Catchment ID	Area (ha)			Impervious (%)		
	Existing Condition	Proposed Condition	% Change	Existing Condition	Proposed Condition	% Change
L-1A	2.00	2.00	-	85%	85%	-
L-1B	3.96	3.96	-	85%	90%	+5%
L-1C	0.78	1.36	+43%	85%	85%	-
L-2	1.40	1.63	+14%	75%	90%	+15%
L-3	5.71	5.71	-	60%	60%	-
L-4	20.67	20.67	-	72%	72%	-
L-5A	11.1	3.51	Existing Catchment L-5 split into 3 catchments: L-5A, L-5B, and L-5C.	-	-	-
L-5B		0.70			90%	+90%
L-5C		6.08			-	-
Total	45.6	45.6	-	55.4%	58.8%	+3.4%

As shown in Table 4-5, the total drainage area for existing and proposed condition remained unchanged, while the total impervious area increased by approximately 3.4%. A Culvert P.C. L-2 is proposed on Bryne Drive to convey the Lovers Creek flow.

Table 4-6 summarizes the peak flow from ROW catchments and external catchments within this watershed.

Table 4-6: Proposed Peak Flows – Lovers Creek

Sewershed Catchment ID	Catchment ID	Imp %	C	Area [ha]	2yr flow (m^3/s)	5yr flow (m^3/s)	10yr flow (m^3/s)	25yr flow (m^3/s)	50yr flow (m^3/s)	100yr flow (m^3/s)	Hazel Storm
L-100[a]	L-1B	73%	0.74	0.19	0.03	0.04	0.05	0.06	0.07	0.07	1.15
L-101		78%	0.78	1.01	0.11	0.11	0.11	0.11	0.11	0.11	
L-102		84%	0.83	0.26	0.05	0.07	0.08	0.09	0.10	0.11	
L-103		63%	0.66	0.53	0.08	0.10	0.10	0.10	0.10	0.10	
L-1041		85%	0.83	0.73	0.03	0.04	0.05	0.05	0.06	0.07	
L-1042		85%	0.83	0.61	0.11	0.15	0.17	0.20	0.22	0.24	
L-105		85%	0.83	0.50	0.10	0.13	0.15	0.17	0.19	0.21	
L-106		85%	0.83	0.21	0.04	0.05	0.06	0.07	0.08	0.09	
L-507		78%	0.78	0.56	0.07	0.09	0.11	0.13	0.14	0.16	
P403		90%	0.91	0.67	0.14	0.18	0.21	0.25	0.28	0.31	
L-108	L-1C	54%	0.59	0.78	0.06	0.08	0.09	0.10	0.12	0.13	
L-109	L-1A	87%	0.85	1.92	0.12	0.12	0.12	0.12	0.12	0.12	
L-200	L-2	90%	0.91	0.13	0.03	0.04	0.04	0.05	0.06	0.06	2.39
L-201		90%	0.91	0.43	0.09	0.12	0.14	0.16	0.18	0.20	
L-202		90%	0.91	0.25	0.05	0.07	0.08	0.09	0.10	0.11	
L-203		90%	0.80	0.27	0.05	0.07	0.08	0.09	0.10	0.11	
L-204		90%	0.80	0.09	0.02	0.02	0.03	0.03	0.03	0.04	
L-205		90%	0.80	0.07	0.01	0.02	0.02	0.02	0.03	0.03	
L-206		90%	0.80	0.09	0.02	0.02	0.03	0.03	0.03	0.04	
L-207		90%	0.80	0.19	0.03	0.05	0.05	0.06	0.07	0.08	
P401	L-5B	90%	0.91	0.33	0.07	0.09	0.11	0.12	0.14	0.15	0.11
P402		90%	0.91	0.36	0.08	0.10	0.12	0.14	0.15	0.16	
-[b]	L-3	60%	0.64	3.29	0.50	0.75	0.95	1.18	1.36	1.54	0.50
-	L-4	72%	0.73	20.67	1.77	2.63	3.31	4.10	4.70	5.64	1.77
-	L-5A	-%	0.18	3.51	0.02	0.06	0.09	0.14	0.17	0.22	0.02
-	L-5C	-%	0.18	6.08	0.04	0.10	0.15	0.23	0.30	0.37	0.04

a. Draining into Bryne Drive Storm Sewer, calculated using Rational Method, except Hazel Storm
b. External Catchments calculated using the 24-hour SCS Storm distribution

The following Table 4-7 compares the flow rates of two (2) key locations:

- The flow at Culvert P.C. L-2 has been utilized to verify the hydraulic performance against the required conveyance capacity.
- Flow at the upstream end of Culvert E.C. L-1 represents the overall outflow rate within this watershed. The overall outflow rate has been utilized to evaluate the SWM design flow to meet quantity control requirements.

Table 4-7: Proposed Peak Flows at Key Locations– Lovers Creek

Key Location	Existing Flow (m^3/s)			Uncontrolled Proposed Flow (m^3/s)			Controlled Proposed Flow (m^3/s)		
	50-yr	100-yr	Hazel	50-yr	100-yr	Hazel	50-yr	100-yr	Hazel
Culvert P.C. L-2 at Bryne Drive	-	-	-	1.14	1.99	2.43	1.09	1.85	2.12
Upstream of Culvert E.C. L-1 at Highway 400	1.10	2.10	3.14	1.31	2.31	2.99	1.22	2.10	2.48

As shown in Table 4-7, with the retrofit of SWM Pond LV14, the total outflow to the upstream of Lovers Creek Outlet, i.e. Culvert E.C.L-1, will be maintained to pre-development levels under proposed conditions.

(iv) Bear Creek Subwatershed

To estimate the proposed conditions runoff, the Bear Creek SWMHYMO hydrologic model was updated under the following conditions:

- The imperviousness of the ROW catchments are updated to reflect the increased imperviousness (approximately 90%) under proposed conditions;
- The stage-storage information of dry Pond BR-P2 with retrofit will be incorporated into the model; and,
- The catchment slope used in the model was calculated based on the hydraulic length, highest and lowest elevation within each catchment.

As the external catchment areas and parameters remain consistent with existing conditions, the proposed condition runoff from the external catchments do not change. For completeness, the proposed hydrologic model included the external catchments to assess the conveyance capacity of the Culvert E.C. B-1 under proposed conditions. Table 4.8 summarizes the proposed conditions flows.

Table 4-8: Proposed Peak Flows– Bear Creek

Sewershed ID	Imp %	C	Area [ha]	2yr flow (m^3/s)	5yr flow (m^3/s)	10yr flow (m^3/s)	25yr flow (m^3/s)	50yr flow (m^3/s)	100yr flow (m^3/s)	Timmins Storm
E501[a]	24%	0.37	59.94	0.29	0.48	0.53	0.72	0.87	1.03	1.42
E502	85%	0.83	10.47	0.16	0.18	0.19	0.20	0.21	0.21	0.22
E503	23%	0.36	6.38	0.24	0.37	0.44	0.57	0.67	0.79	0.40
E504	85%	0.83	6.34	0.57	0.72	0.96	1.15	1.30	1.44	0.46
C501[b]	90%	0.87	1.29	0.26	0.34	0.40	0.46	0.51	0.56	0.15
C502	90%	0.87	0.55	0.11	0.15	0.17	0.20	0.22	0.24	0.06

a. External Catchments calculated using the 24-hour SCS Storm distribution
b. Draining into the Essa Road Storm Sewer, calculated using Rational Method, except the Timmins Storm

Table 4-9 summarizes the flow rates at three (3) key locations:

- The outflow rate from Pond BR-27 has been used to design the proposed clean water storm sewer draining to the upstream end of the Bear Creek Culvert E.C.B-1.
- The design flow at the upstream of Culvert E.C.B-1 includes the conveyed outflow from Pond BR-27. Runoff from C501 and C502 will not be included as these catchments drains to the downstream end of the Bear Creek culvert.
- Total flow at the downstream of Culvert E.C. B-1 represents the overall outflow rate within this watershed, which enables a location for verifying that the quantity control requirements are met under the proposed condition.

Table 4-9: Proposed Peak Flows at Key Locations – Bear Creek

Key Location	Existing Flow (m^3/s)			Uncontrolled Proposed Flow (m^3/s)			Controlled Proposed Flow (m^3/s)		
	50-yr	100-yr	Timmins	50-yr	100-yr	Timmins	50-yr	100-yr	Timmins
Pond BR-27 Outlet	0.67	0.79	0.40	0.67	0.79	0.40	0.67	0.79	0.40
Upstream of Culvert E.C.B-1	2.65	2.98	2.51	3.07	3.47	2.51	3.07	3.47	2.51
Downstream of Culvert E.C.B-1	3.07	3.48	2.28	3.18	3.59	2.28	3.07	3.47	2.28

Overall, the flow rate at the downstream of the Bear Creek Culvert E.C. B-1 remained at the same level as in the existing conditions. It demonstrated that, with the implementation of the proposed SWM strategy on site, the total outflow from the overall study area remained the same.

4.3 Hydraulic Assessments

The following section highlights the assessments of the conveyance capacity of culverts and storm sewers.

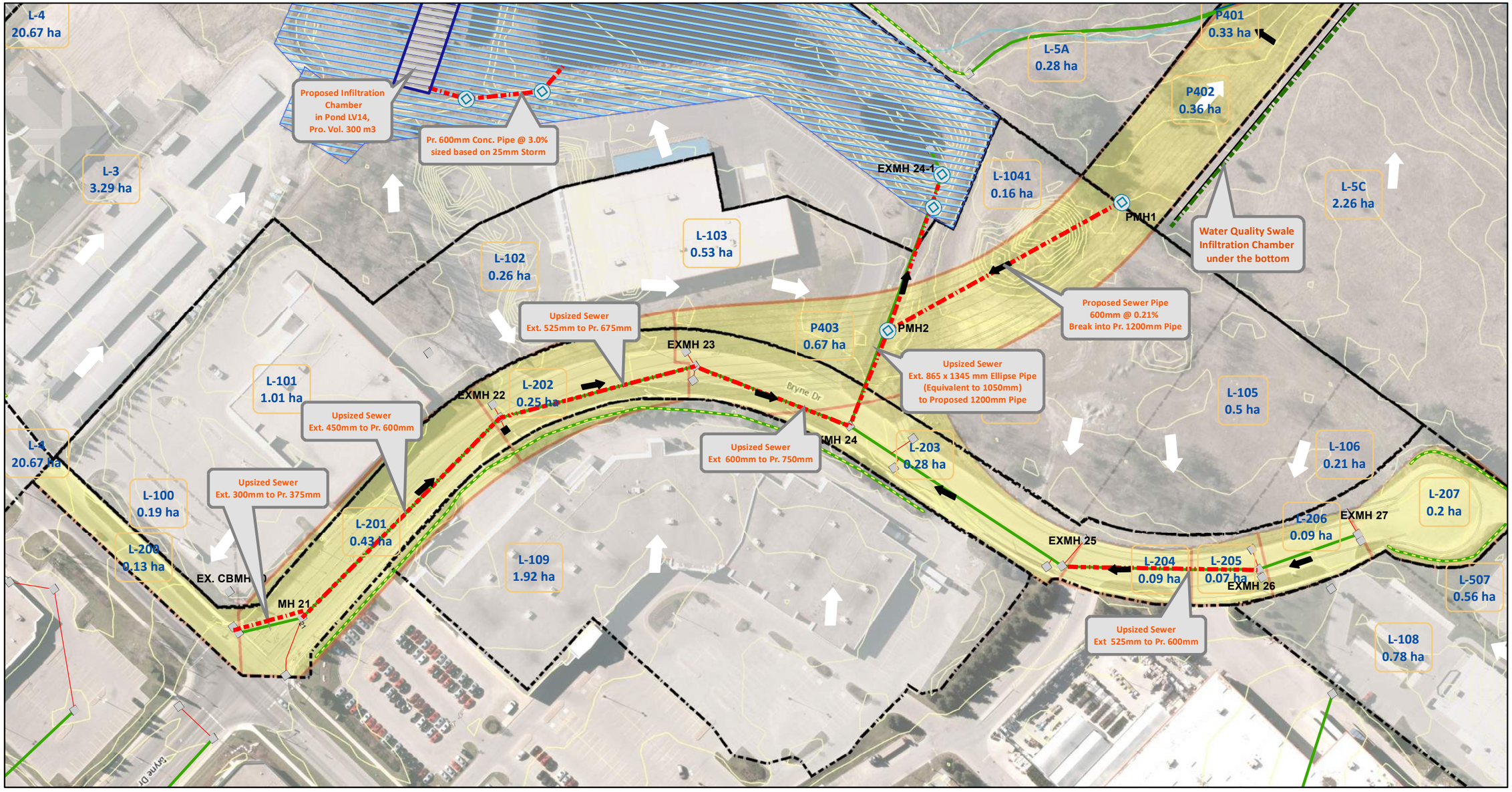
4.3.1 Storm Sewer Capacity Analysis and Sizing

The storm sewer analysis was completed using the Rational Method. As mentioned previously, there are existing storm sewers networks located within Study Area 3 and Study Area 6. The following table shows the minor system sewer capacity analysis with the diameters and associated drainage areas.

Table 4-10: Existing Storm Sewer Design Evaluation – Proposed Condition

Location	Diameters (mm)	Existing Condition Sewer Capacity
Storm Sewers at Bryne Drive near Caplan Avenue, Outlets to Pond LV14	300 to 865 x 1345	Inadequate
Storm Sewer at Bryne Drive, South of Essa Road	300 to 1350	Inadequate

The proposed drainage mosaic within these sewersheds are shown in Exhibit 4-7 and Exhibit 4-8. The highlighted sewers indicated that replacement is recommended to meet further conveyance requirements associated with the development within these two locations. Detailed calculations are included in Appendix D Storm Sewer Sizing.



Stormwater Management Facility
Existing Culvert
Existing Stormwater Linear Feature
Existing Stormwater Lateral
Existing Stormwater Device
ROW Sewershed Catchment
External Catchment
Watershed Boundary
LSRCA Floodplain Setback
LSRCA Regulation Limit
Catchment Boundary
Proposed/Upsized Storm Sewers

REV.	ISSUE FOR	BY	CHK'D	APP'D	DATE
0	FOR INFORMATION	Init.	Init.	Init.	

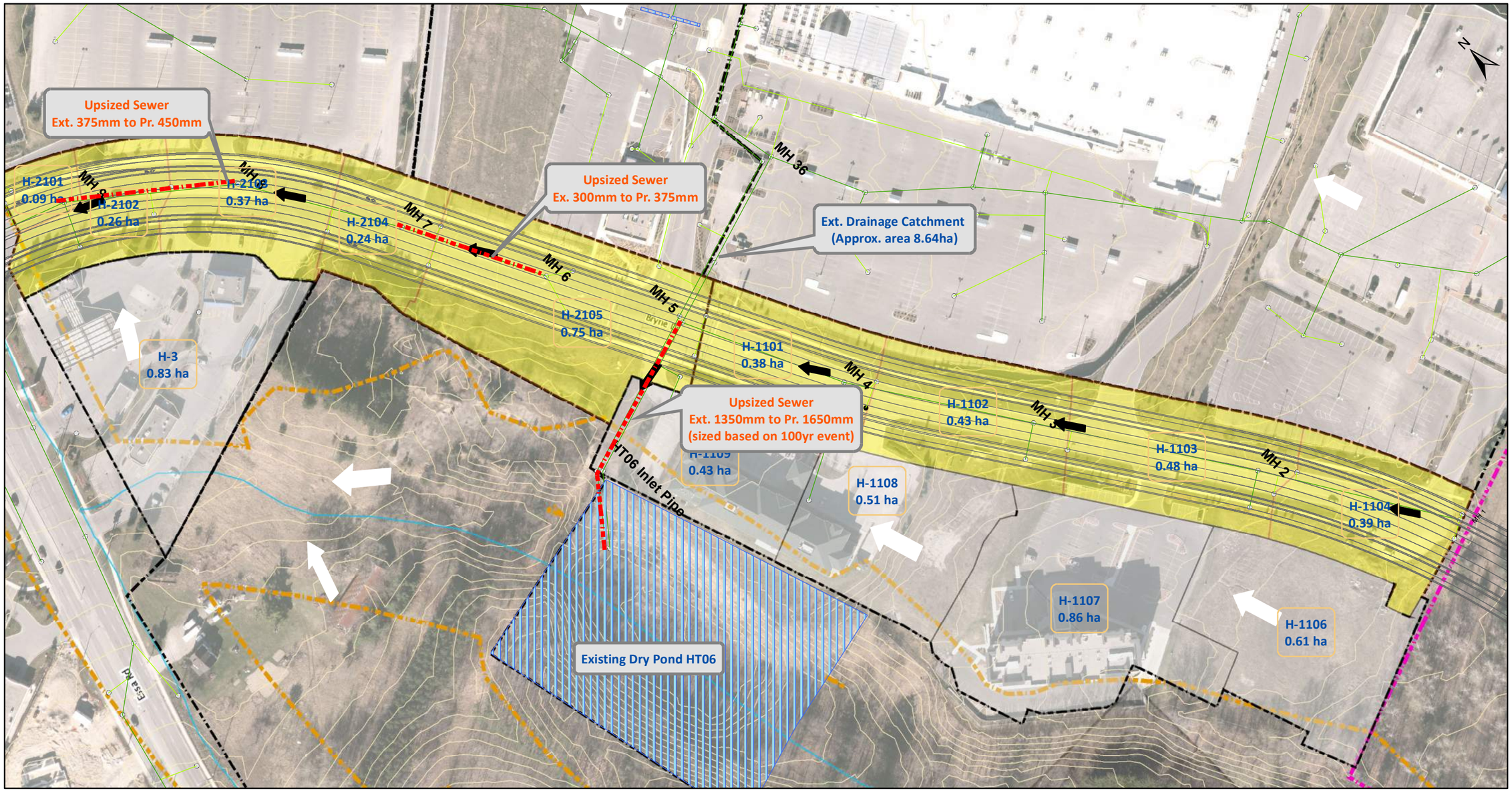
HATCH

DESIGNED BY:	DRAWN BY: JZ
CHECKED BY: DJ	DISC. ENGR.
PROJ. DES. COORD.	PROJ. ENGR.

1:1,500

HARVIE ESSA BRYNE PROJECT

Exhibit 4-7
Proposed Condition - Bryne Drive South at Lovers Creek Sewer Capacity Assesment



Stormwater Management Facility
Existing Culvert
Stormwater Linear Feature
Stormwater Lateral
Stormwater Device
External Catchment
ROW Catchment
Watershed Boundary
LSRCA Floodplain Setback
LSRCA Regulation Limit
Catchment Boundary
Undersized Sewers

REV.	ISSUE FOR	BY	CHK'D	APP'D	DATE
0	FOR INFORMATION	Init.	Init.	Init.	

HATCH

DESIGNED BY:	DRAWN BY: JZ
CHECKED BY: DJ	DISC. ENGR.
PROJ. DES. COORD.	PROJ. ENGR.

1:1,700

HARVIE ESSA BRYNE PROJECT

Exhibit 4-8
Proposed Condition - Bryne Drive North
at Hotchkiss Creek Sewer Capacity Assesment

In addition to the existing sewer networks within the Study Area 3 and Study Area 6, new sewer networks are proposed within the Study Area 1, Study Area 2, Study Area 4 and Study Area 5. The new storm sewer networks are shown in the proposed conditions drainage mosaic. A summary of the proposed sewer sizing for each study areas are listed as follows:

- Study Area 1 (Exhibit 4-1): Storm sewers are proposed with diameters ranges from 300 mm to 1050 mm @ 0.5% – 2.2 % slopes on Harvie Road.
- Study Area 2 (Exhibit 4-2): Storm sewers with diameters ranges from 375 to 675 mm @ 0.50 – 2.50 % are proposed on the north side of Culvert E.C.B-1 within Catchment C501. Another set of storm sewers with diameter of 450mm @ 0.5% are proposed on the south side of Culvert E.C. B-1 within Catchment C502. Storm sewer (750 mm @ 1.00%) has been proposed at the east side of Essa Road to convey the outflow from Pond BR-27 to discharge to Bear Creek.
- Study Area 4 (Exhibit 4-4): Storm sewers with diameter 1050 mm @ 0.5% are proposed on the north side of Culvert E.C W-4. The storm sewers network on Harvie Road and Hwy 400 Overpass ties into this section of storm sewer network. Storm sewers with diameters ranges from 450 to 800 mm @ 0.5 – 3.0 % are proposed on the south side of Culvert E.C W-4.
- Study Area 5 (Exhibit 4-5): Storm sewer with diameters ranges from 450 to 600 mm diameter @ 1.50% for Catchment 208, and storm sewer with diameters ranges from 375 to 600 mm diameter @ 0.50 - 1.50 % sewer for Catchment 209.

For detailed calculations and analysis, please refer to Appendix D Storm Sewer Sizing.

4.3.2 Hydraulic Assessment of Culverts

Proposed Culverts

Two (2) new culvert crossings are proposed on Bryne Drive to safely convey upstream overland runoff to the downstream watercourses and maintain existing subwatershed catchment boundaries.

- Culvert P.C. W-1 is proposed on Bryne Drive, north of Harvie Road at Whiskey Creek watercourse, as shown in Exhibit 4-1.
- Culvert P.C. L-2 is located on Bryne Drive, south of Harvie Road at Lovers Creek watercourse, as shown in Exhibit 4-3.

Table 4-11: Design of Proposed Culverts

Culvert ID	Proposed Size and Material	50-yr Flow [m3/s]	100yr Flow [m3/s]	Regional Flow [m3/s]	Edge of Roadway [m]	Pr. U/S Inv.	Pr. D/S Inv.
P.C. W-1	750 mm Diameter Concrete Pipe	0.21	0.26	0.42	291.75	290.25	290.10
P.C. L-2	1.2 x 0.9 m Concrete Box	1.09	1.85	2.12	301.95	300.00	299.60

Both proposed Culverts P.C.W-1 and P.C.L-2 meet the freeboard requirement for the 50-year design storm. Both culverts safely convey the100-yr and Regional Storm flows without overtopping the roadway and do not pose any impact on upstream lands. For Culvert P.C.L-2, rock protection will be provided on both upstream and downstream ends for erosion control.

Detailed output of hydraulic assessment has been provided in Appendix C Hydraulic Analysis.

Existing Culverts

Culvert E.C. W-1 of size 1050 mm diameter CSP pipe, is currently located at the Harvie Road and Bryne Drive Intersection. This culvert was redesigned in the HBBP Project, and a 1650mm diameter concrete pipe has been proposed to convey upstream runoff to the main branch of Whiskey Creek. Due to the proposed Bryne Drive alignment, runoff from additional drainage area was added upstream of this culvert. The hydraulic performance of Culvert E.C. W-1 has been further assessed under the existing and proposed condition documented in Table 4-12.

Table 4-12: Hydraulic Performance Assessment of Culvert E.C. W-1

	Structure Data	Existing Condition			Structure Data	Proposed Condition		
		50-yr Event	100-yr Event	Regional Storm		50-yr Event	100-yr Event	Regional Storm
Edge of Roadway (lowest point) [m]	293.00				297.63			
Upstream Invert [m] (Top of Streambed)	292.50				292.15			
Downstream Invert [m] (Top of Streambed)	290.50				290.80			
Flow Rate [m^3/s]		3.30	4.06	3.77		3.49	4.31	4.29
Water Level [m]		297.74	300.95	299.65		293.74	293.96	293.96
Freeboard [m]		Overtops Roadway Surface				3.89	-	-
Headwater: Depth Ratio (HW/D)		4.91	-	-		0.95	-	-
Velocity [m/s]		3.83	4.60	4.30		4.28	4.50	4.49

The hydraulic analysis results indicated that the existing structure E.C. W-1 (1050mm CSP Culvert) does not meet the City of Barrie guideline under existing conditions for both minimum freeboard and H/D ratio requirements. The existing structure overtops the existing roadway surface under design events including 50yr, 100yr and Regional Flow.

The hydraulic results for the proposed Culvert E.C.W-1 (1.65m circular Conc. Culvert) indicated that the proposed structure meets freeboard requirement for the 50-year design storm and H/D ratio requirements under proposed condition. The culvert safely conveys the100-yr and Regional Storm flows without overtopping the roadway.

Due to high velocity through the culvert structure, an outlet pool with rock protection is required at the downstream end of the culvert. Rock protection will also be provided at the inlet of culvert.

The culvert E.C.B-1, a 1.8 m x 0.60 m concrete box, is located under Essa Road at Bear Creek watershed. The conveyance capacity of Culvert E.C. B-1 was assessed under existing and proposed condition, and the results are summarized as follows:

Table 4-13: Hydraulic Performance Assessment of Culvert E.C. B-1

	Structure Data	Existing Condition			Proposed Condition		
		50-yr Event	100-yr Flow	Timmins Storm	50-yr Flow	100-yr Flow	Timmins Storm
Edge of Roadway (lowest point) [m]	306.17						
Upstream Invert [m] (Top of Streambed)	303.77						
Downstream Invert [m] (Top of Streambed)	303.41						
Flow Rate [m^3/s]		2.65	2.98	2.51	3.07	3.47	2.51
Water Level [m]		304.87	304.96	304.83	304.99	305.10	304.83
Freeboard [m]		1.30	-	-	1.18	-	-
Headwater: Depth Ratio (HW/D)		1.21	-	-	1.34	-	-
Velocity [m/s]		2.31	2.44	2.25	2.27	3.52	2.25

The results show that Culvert E.C.B-1 meets freeboard requirement for the 50-year design storm and H/D ratio requirements. The culvert safely conveys the100-yr and Regional Storm flows without overtopping the roadway. Rock protection is recommended at both inlet and outlet ends of the culvert in order to mitigate potential erosion within the downstream channel.

The existing culverts E.C. W-2, E.C. W-3, E.C. W-5 and E.C. L-1 are outside of the scope of the project. Flows at these culvert locations are maintained to existing conditions levels or less, capacity of these downstream culvert structures will not change or be analyzed.

5 Fluvial Geomorphological Assessment

The fluvial geomorphological assessments for the transportation improvements for Harvie Road, Essa Road and Bryne Drive (HEB) Class EA Project was completed by Water Edge Ltd. The report includes the assessments of two (2) crossings at Whiskey Creek, one crossing at Lovers Creek and one at Bear Creek. The following table summarizes the geomorphic parameters of existing crossings extracted from the Fluvial Geomorphological Assessments Report.

Table 5-1: Fluvial Geomorphological Assessment Summary

Crossing #	Crossing ID	Road	Watercourse	Average Bankfull Width (m)	Average Bankfull Depth (m)
1	E.C. W-1	Harvie Road	Whiskey Creek	1.41	0.35
2	E.C. W-4	Bryne Drive	Whiskey Creek	1.27	0.46
3	E.C. L-1	Bryne Drive	Lovers Creek	1.01	0.23
4	E.C. B-1	Essa Road	Bear Creek	n/a	n/a

The complete *Fluvial Geomorphological and Meander Belt Assessment Report* submitted by Water's Edge Ltd. has been included in Appendix E.

6 Stormwater Management

The future widening and extension of Harvie Road, Bryne Drive and Essa Road will increase the imperviousness thereby increasing the runoff from the roadway catchments. In order to mitigate these increases in runoff, a multitude of stormwater management techniques and strategies are required to be employed across the project study area. The following sections screen and evaluate alternatives and provide the recommended stormwater management strategy for the six (6) distinct study area locations.

6.1 Screening of Alternatives

A list of stormwater best management practices (BMPs) have been screened for use in the HEB project, with consideration of the general advantages and disadvantages, experience, and practical feasibility for the site-specific conditions.

It was determined at the start of the study that the “do nothing” alternative is not an acceptable course of action. The increase in pavement areas and the associated potential increase in pollutant loading to the receiving watercourses would result in negative effects such as reduced stream water quality, degraded aquatic habitat, flooding, and in-stream erosion, which necessitate provision of appropriate mitigation measures.

The MOECC, Conservation Authorities (CA), and City of Barrie have identified a broad range of stormwater management practices (SWMPs) that may be considered for the proposed roadway corridor. The recommended practices that can be implemented as part of this project are:

- Wet ponds providing quality treatment, quantity control and erosion control;
- Vegetative, dry linear facilities providing quantity control and a measure of quality treatment;
- Enhanced vegetated grassed swales providing quantity and quality benefits;
- Mechanical treatment facilities such as oil and grit separators (OGSs) to provide quality benefits; and
- LID measures such as bio-retention areas, bio-swales and infiltration galleries/trenches.

Storage SWMPs such as wet ponds, dry ponds, and linear SWM facilities, can be effective in providing combined quality treatment and/or quantity control where drainage areas are sufficient and land is available.

Vegetative SWMPs such as Enhanced grassed swales, bio-swales, etc. provide water quality treatment primarily by filtering out fine sediments and promoting infiltration, but can also be used to provide erosion control.

Enhanced grassed swales are primarily designed to provide water quality control by limiting flow velocities and increasing the wetted perimeter, and can include grassed berms to detain water during small events and/or wider flat bottoms to increase storage and flow contact.

Vegetative SWMPs can be readily applied to roads and highways, and are relatively inexpensive and particularly effective for small catchment areas. Infiltration measures such as bio-retention areas (bio-swales) and infiltration galleries/trenches are effective for water balance and low impact development (LID) measures.

To mitigate the quantity and quality impacts of the increased runoff from the road ROW, retrofit of existing SWM facilities as well as some new SWM facilities are proposed.

Following the principle and acceptable practices discussed above, the following SWM option evaluations have been completed:

Table 6-1: SWM Option Assessment Evaluation

SWM/LID Control Measures	Type of Control		Applicability to					
	Water Quantity	*Water Quality*	*Area 1: Harvie Road*	*Area 2: Essa Road*	*Area 3: Bryne Drive South at Lovers Creek*	*Area 4: Bryne Drive South at Whiskey Creek*	*Area 5: Bryne Drive North at Whiskey Creek*	*Area 5: Bryne Drive North at Hotchkiss Creek*
SWM Pond/Wetland	Most Effective Peak Flow Reduction	Most Effective Pollutant Removal	**Recommended** >> Connection to existing SWM Pond A, potential expansion is required for LID infiltration volume	**Recommended** >> Connection to Proposed BR-P2 for quantity control	**Recommended** >> Connection to existing SWM Pond LV14, potential expansion is required.	**Recommended** >> Connection to existing SWM Pond A, potential expansion is required for LID infiltration volume	**Recommended** >> connections to Proposed Dry Pond 1 and Dry Pond 2. Recognized the potential retrofit additional runoff volume within Pond B.	**Recommended** >> Connections to existing SWM Dry Pond HT06, potential to meet infiltration/quantity /quality requirement due to high soil infiltration capacity.
Oversized Storage Pipe	Runoff Reduction	N/A	Not applicable >> Due to the availability of alternative measures, site conditions, and constructability concerns (site roadway slopes).					
Oil-Grit Separator	N/A	Moderately Effective, Requires Treatment Train	**Recommended** at each storm sewer outlet					
Pervious Pavement, Porous Asphalt	Runoff Reduction	Moderate Pollutant Removal	Not recommended >> due to winter conditions, maintenance issues, and cost concerns by the City of Barrie.					
Enhanced Grassed Swales	Peak Flow Attenuation Only	Moderate Pollutant Removal	Not applicable >> Urban section	**Recommended** >>	**Recommended** >> Enhanced Grassed Swale to be implemented to	**Recommended** >>	**Recommended** >>	Not applicable >> Urban section

SWM/LID Control Measures	Type of Control		Applicability to					
	Water Quantity	*Water Quality*	*Area 1: Harvie Road*	*Area 2: Essa Road*	*Area 3: Bryne Drive South at Lovers Creek*	*Area 4: Bryne Drive South at Whiskey Creek*	*Area 5: Bryne Drive North at Whiskey Creek*	*Area 5: Bryne Drive North at Hotchkiss Creek*
				Outflow Swale at outlet of BR-P2	provide water quantity and quality benefits	Convey external rural area drainage	Convey external rural area drainage	
Filter Strips	N/A	Pretreatment Only	Limited feasibility >> Limited space availability within ROW					
Bioretention Swales and areas	Peak Flow and Volume Reduction	Effective Pollutant Removal	Not recommended >> due to the urban cross-section, maintenance and cost concerns by the City of Barrie.					
Infiltration Trench	Peak Flow and Volume Reduction	Somewhat Effective Pollutant Removal with Potential for GW Contamination	Limited feasibility >> Limited space availability within ROW					
Underground Detention (Infiltration Chambers, Schaeffer Design, perforated system)	Peak Flow and Volume Reduction	Effective Pollutant Removal	Recommended >> Infiltration chamber in the form of a soakaway pit facility has been provided within Pond A	Consider where feasible and required Under proposed Enhanced Grassed Swale and Dry Pond BR-P2	Consider where feasible and required Under proposed Enhanced Grassed swale on east and west side of L-5B and within Pond LV-14	Recommended >> Infiltration chamber in the form of a soakaway pit facility has been provided within Pond A	Consider where feasible and required Under proposed Dry Pond 1 and Pond 2	Recommended >> Proposed Retrofit in HT06 will provide sufficient infiltration

6.2 Proposed Stormwater Management Strategy

The following section introduces the Proposed Stormwater Management Strategy, which are recommended to be implemented for the quality and quantity control as well as the infiltration requirements. The discussion for recommended SWM measures will be categorized based on different study areas.

6.2.1 Study Area 1: Harvie Road at Whiskey Creek Subwatershed

The SWM strategy for this study area has been proposed within the HBBP Project. The following summarizes the proposed SWM strategy:

- Expansion of the existing Pond A is proposed to provide the infiltration requirements for the increase in impervious areas due to Harvie Road widening. Infiltration chambers will be provided on the northside of Pond A to meet the LSRCA infiltration requirements.
- A set of STM sewers are proposed along Harvie Road, which outlet to Pond A via Bryne Drive storm sewer.

6.2.2 Study Area 2: Essa Road at Bear Creek Subwatershed

SWM strategy for this study area has been summarized as follows:

- Runoff from Catchment C501 will be captured by catch basins and conveyed by storm sewer for the 5-year minor storm event and direct the flow to the proposed linear dry SWM Facility Pond BR-P2. Pond BR-P2 will provide quantity control of the runoff. This proposed pond will be over controlled to balance the uncontrolled runoff from Catchment C502. Using the SCS 24-hour storm distribution, the required volume of the proposed Dry Pond BR-P2 to maintain the quantity control requirement is 265 m^3, and the quality control requirement of 40 m^3 as per MOECC guideline. The provided volume within BR-P2 will be 732 m^3, which meets both the LSRCA and MOECC requirements.

Table 6-2: Dry SWM Facility – Study Area 6 in Bear Creek Subwatershed

Catchment ID	Facility ID	Required Water Quantity Volume [m^3]	Required Water Quality Volume [m^3]	Total	Max. Depth [m]	Min. Depth [m]	Max. Width [m]	Max. Length [m]	Required Surface Area [m^2]	Provided Volume[m^2]
C501 & C502	Dry Pond BR-P2	265	40	305	2.8	1.5	23	53	1,300	732

- An OGS will be provided for pre-treatment quality control prior to discharging to Pond BR-P2. Outflow from the proposed pond will be discharged to the Bear Creek at the downstream of Culvert E.C.B-1 via grassed swale. The combination of OGS, linear

dry SWM facility, underground infiltration chamber and grassed swale will provide the quality treatment of runoff following the treatment train approach.

- On the southside of Culvert E.C.B-1 (Catchment C502), Runoff will be captured by catch basins and conveyed by storm sewers for the 5-year minor storm flowing to downstream of the existing culvert E.C. B-1. An OGS will be provided prior to discharging to the watercourse for pre-treatment of the runoff.
- An infiltration chamber IC-B1 will be implemented below the bottom of Dry Pond BR-P2 and the adjacent Enhanced Grass Swale. The size of infiltration chamber has been based on the required LID volume for Catchment C501.

The preliminary design of the Infiltration Chambers IC-W1, were determined based on the LID volume requirements as per LSRCA SWM guidelines. The water quality control volume required for each catchment areas are summarized as follows:

Table 6-3: LID Infiltration Volume – Study Area 6 in Bear Creek Subwatershed

Catchment ID	Total Catchment Area [ha]	Catchment Length [m]	Net Impervious Area [ha]	LID Volume	Proposed Treatment Facility
C501	1.29	700.00	0.75	187	IC-B1
C502	0.55	230.00	0.25	61	
Total	-	-	-	***249***	-

Following table illustrates the details of provided LID infiltration design to meet the identified infiltration requirements.

Table 6-4: Infiltration Chamber Design – Study Area 6 in Bear Creek Subwatershed

Catchment ID	Facility ID	Location	Depth [m]	Width [m]	Length [m]	Provided Volume[m^2]
C501 & C502	IC-B1	Beneath Dry Pond BR-P2	2.5	6	40	240
		Beneath proposed swale	2.5	1.5	45	68
Total	-	-	-	-	-	308

Exhibit 6-1 shows the conceptual design of the Dry Pond and Infiltration Chamber Facility located on the ROW of Essa Road:

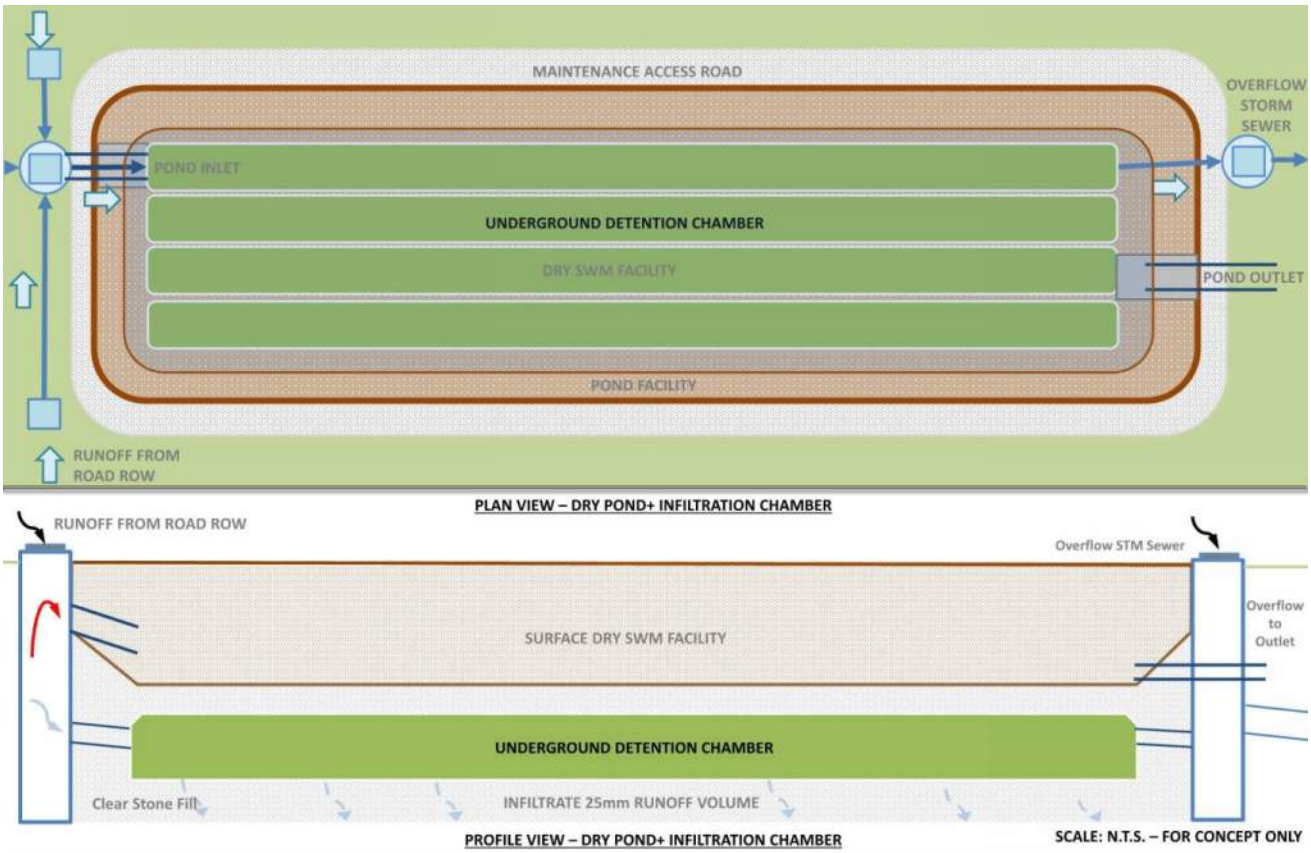


Exhibit 6-1 Infiltration Chamber Under Dry Pond

6.2.3 Study Area 3: Bryne Drive, South of Harvie Road and North Caplan Avenue at Lovers Creek Subwatershed

The SWM strategy for the Bryne Drive south within Lovers Creek study area has been summarized as follows:

- Roadway runoff will be captured by catch basins and conveyed by storm sewer for the 5-year minor storm event and directed to the wet SWM Facility Pond LV14. Pond LV14 will be retrofitted to meet the additional volume requirement for quantity and quality control.
- Using 24-hour SCS Storm distribution, approximately 810 m^3 of additional storage volume is required to retrofit Pond LV14 to maintain the water quantity control requirement. It is recommended to provide approximately 2m widening to the existing boundary of Pond LV14 to achieve the additional quantity requirement. It is estimated that an extra ***900 m^3*** can be provided from the expansion of the pond.
- Existing storm sewer system are recommended to upsize in some locations to convey the increased runoff due to widening of Bryne Drive. The summary of the proposed storm sewer sizing is summarized in Section 4.3.1.
- It is recommended to provide the water quality and quantity control through retrofitting the existing Pond LV14 for the overall roadway catchment drainage area. Over-control is required in Pond LV14 to balance the flow from Bryne Drive Catchment L-5B.
- An enhanced grass swale will be provided on the east side of Bryne Drive south of Culvert P.C.L-2. Roadway runoff will be directed to the bottom of the proposed enhanced grass swale through laterals. CB-shields will be installed within these catch basins. The combination of CB-shields and the enhanced grass swale will provide quality treatment of runoff.
- Similarly, another enhanced grass swale will be provided on the west side of Bryne Drive north of Culvert P.C.L-2. Roadway runoff will be directed to the bottom of the proposed enhance grass swale through laterals. CB-shields will be installed within these catch basins. The combination of CB-shields and the enhance grass swale will provide quality treatment of runoff.
- The enhanced grass swales are proposed to be 1 m flat bottom, trapezoidal channels with 3:1 side slopes. The schematic of the cross section of the swales are as follows:

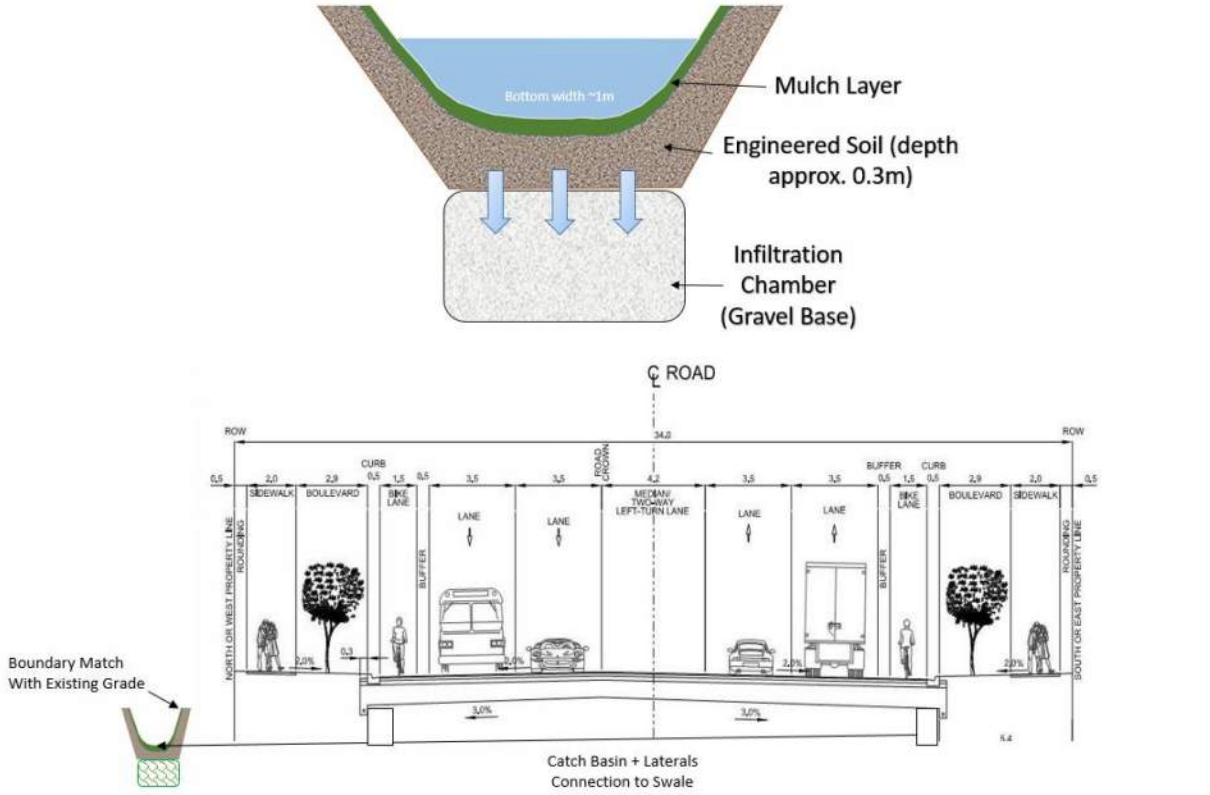


Exhibit 6-2 Infiltration Chamber Under Enhanced Grassed Swale

- Infiltration galleries (IC-L1 and IC-L2) will be provided in both enhanced grassed swales to maintain on on-site LID/ water balance requirement as per LSRCA SWM guidelines. Table 6-4 provides the summary of LID requirements.

Table 6-5: Water Quality/LID Volume – Study Area 5 in Lovers Creek

Catchment ID	Total Catchment Area [ha]	Catchment Length [m]	Net Impervious Area [ha]	Required Volume (m^3)			Proposed Treatment Facility	Provided Volume (m^3)
				Water Quality Volume	LID Volume	Total		
Existing Bryne Drive South of Catchment L-5B	33.40	-	0.98	Existing LV14 Pond provided sufficient WQ volume	245	***245***	Proposed LID Infiltration Chamber at south-west corner of LV-14	***245***
Total	-	-	-	-	245	***245***	-	***245***

Catchment ID	Total Catchment Area [ha]	Catchment Length [m]	Net Impervious Area [ha]	Required Volume (m^3)			Proposed Treatment Facility	Provided Volume (m^3)
				Water Quality Volume	LID Volume	Total		
(To LV14 Facility)								
Bryne Drive, part of Catchment L-5B on the north side	0.37	110	0.31	12	78	***90***	Proposed LID chamber at the bottom of proposed enhanced grassed swale	***90***
Bryne Drive, part of Catchment L-5B on the south side	0.34	100	0.28	11	71	***81***		***90***
Total	-	-	-	23	149	***171***	-	***180***

As per MOECC guidelines Table 3.2, quality control within existing pond LV14 is a function of total drainage area and imperviousness level. Due to the proposed roadway conditions, the impervious level in upstream drainage areas will increase from 72% to 73%.

Based on the MOE guidelines (Table 3.2), the required water quality volume for the wet pond LV14 providing “Enhanced Level” quality control, is as follows:

71% Imperviousness = 230 m^3/ha

Therefore, the total water quality volume is:

33.4 ha x 230 m^3/ha = 7,682 m^3

The existing LV14 provides the total water quality volume of 11,591 m^3, including 7,143 m^3 as Permanent pool and 4,448 m^3 as Extended Detention. Therefore, the existing LV14 pond provides sufficient water quality volume to accommodate the additional runoff from increased impervious area within the road ROW area.

As shown in Table 6-5, a total of 171 m^3 storage volume is required from Catchment L-5B for on-site control for water quality and LID infiltration control. A 90 m^3 of storage volume will be provided in each infiltration chamber (1.5 m wide and 1.5 m deep) provided within the enhanced grassed swale to meet the LID and quality requirements.

The existing Bryne Drive south Catchment L-5B requires 245 m^3 of additional LID storage volume, as per LSRCA LID guideline. This volume will be provided as the infiltration volume in the proposed underground infiltration chamber installed at the southwest corner of existing Pond LV14, as shown in Exhibit 4-3. A pipe structure will be designed to convey the 25mm quality storm to the proposed underground infiltration facility from the upstream LV14 main cell. The inlet elevation will be set between the 2 year and 5 year pond elevations, in order to convey 25mm storm to the infiltration chamber.

The proposed underground infiltration chamber in Pond LV14 is sized to be a 50 m long, 15m wide and 1m deep infiltration chamber, providing a total LID volume of ***300 m^3***.

6.2.4 Study Area 4: Bryne Drive, South of Harvie Road at Whiskey Creek Subwatershed

The SWM strategy for the Bryne Drive south at Whiskey Creek study area can be summarized as follows:

- Roadway runoff will be captured by catch basins and conveyed by storm sewers for the 5-year minor storm event and direct the flow to the Pond A SWM Facility.
- As per the HBBP Project drainage and stormwater management design, Pond A will be retrofitted to meet the quantity and quality control requirement resulting from the increased impervious area in Harvie Road widening to Veterans Drive, Harvie Road/Big Bay Road/Highway 400 Overpass, as well as a part of the future Bryne Drive south to Harvie Road.
- As a LID measure, approximately 982 m^3 of storage volume will be required for the roadway area of 3.93 ha (2.65 ha of Harvie Road/Hwy 400 Overpass and 1.28 ha of Bryne Drive) for the on-site control as a LID/water balance measure. As identified in HBBP project, an infiltration chamber will be provided on the north side of Pond A with a volume of 1155 m^3, which meets the requirements as per LSRCA SWM guidelines.
- One OGS will be provided for quality control of the storm runoff before the storm sewer located north side of Culvert E.C. W-4 discharges to Pond A.

6.2.5 Study Area 5: Bryne Drive, North of Harvie Road at Whiskey Creek Subwatershed

The proposed SWM strategy for the Bryne Drive north of Harvie Road within Whiskey Creek can be summarized as follows:

- Roadway runoff will be captured by catch basins and conveyed via storm sewers for the 5-year minor storm event (as per City of Barrie drainage design criteria) and directed to the proposed linear dry SWM Facility Pond 1 located in Catchment 205.2 and Pond 2 located in Catchment 203.2.
- Two (2) OGS will be provided for quality control of the storm runoff before the storm sewer discharges to the proposed pond facilities. Infiltration galleries (IC-W1, and IC-

W2) will be provided within these SWM facilities for the on-site retention as an LID measure.

- Outflow from Pond 1 will be conveyed to Culvert E.C.W-5 through a proposed enhanced grassed swale (1.5 m bottom width, 3H:1V side slope) for additional quantity and quality treatment.
- Outflow from Pond 2 will be conveyed to Culvert E.C.W-3 through a proposed enhanced grassed swale (1.5 m bottom width, 3H:1V side slope) for additional quantity and quality treatment.

Preliminary design of water quantity control was determined using the 24-hr SCS Type II Storm Distributions, which governs the design flow. Table 6-1 summarizes the requirement for runoff quantity control and Table 6-2 summarizes water quality and LID design volumes requirements, as per LSRCA SWM guidelines.

Table 6-6: Dry SWM Facilities – Study Area 2 in Whiskey Creek Subwatershed

Study Area	Facility ID	Required Quantity Volume (m^3)	Required Quality Volume (m^3)	Total	Min. Depth [m]	Max. Depth [m]	Max. Width [m]	Max. Length [m]	Provided Volume (m^3)	Required Surface Area (m^2)
208	Pond 1	570	44	614	1.0	2.2	19	90	673	2,016
209	Pond 2	561	28	589	1.0	2.5	20	91	673	2,086

Based on the post to pre-development quantity control volume requirements, the main cell of the proposed Pond 1 has been sized as 1m to 2.2 m deep with 3:1 side slope facility, providing a total storage volume of 673 m^3. Similarly, the main cell of the Pond 2 has been sized as 1 to 2.5 m deep with 3:1 side slope, providing a total storage volume of 673 m^3. The required surface area has considered the requirement for a 3m access road to be built surrounding the dry pond area.

Table 6-7: LID Infiltration Chambers – Study Area 2 in Whiskey Creek Subwatershed

Catchment ID	Total Catchment Area [ha]	Catchment Length [m]	Net Impervious Area [ha]	LID Volume (m^3)	Depth [m]	Length [m]	Width [m]	Proposed Treatment Facility	Provided Volume (m^3)
208	1.3	386.00	1.09	272	2	80	5	IC-W1	***320***
209	0.8	250.00	0.71	176	1.5	80	5	IC-W2	***240***
Total	-	-	-	448	-	-	-	-	***560***

Based on the MOECC volumetric water quality criteria, and the LSRCA LID Volume control requirements, two (2) infiltration chambers will be proposed and sized as follows:

- A 2.00 m deep infiltration chamber (IC-W1) is proposed within Pond 1 which provides a volume of 320 m^3 based on the void ratio of 0.4.
- A 1.50 m deep infiltration chamber (IC-W2) is proposed within Pond 2 which provides a volume of 240 m^3 based on the void ratio of 0.4.

For the conceptual design of the dry pond and infiltration, please refer to Exhibit 6-1.

It is recognized that there is a possibility to potentially construct Pond B, which has been previously proposed within the Whiskey Master Drainage Plan. The Pond B facility would be utilized to control and offset the additional runoff generated within Catchment 208 and the upstream rural area Catchment 203.1. Further confirmation with the City of Barrie and LSRCA is required to confirm if the construction of Pond B is feasible.

6.2.6 Study Area 6: Bryne Drive, North of Harvie Road and South of Essa Road at Hotchkiss Creek Subwatershed

The SWM strategy for the Bryne Drive north at Hotchkiss Creek study area can be summarized as follows:

- Roadway runoff will be captured by catch basins and conveyed via storm sewers for the 5-year minor storm event directed to the existing dry Pond HT06. Pond HT06 will be retrofitted to meet the additional volume requirements for quantity control. Over-control in HT06 will be required to accommodate the proposed widening of Bryne Drive on the north stretch towards Essa Road. As a result of the lack of downstream SWM facilities, this section will be treated for quality with LID and quantity controls being achieved upstream at HT06. Due to high infiltration capacity of Pond HT06, it cannot be designed as wet SWM facility.
- As previously noted, the existing storm sewer system is recommended to be upsized in some locations to avoid storm sewer surcharge. The summary of the proposed storm sewer sizing is summarized in Section 4.3.1.
- Water quality control will be maintained through two (2) OGS units installed at the downstream end of the storm sewer systems prior to discharge, as shown in Exhibit 4-4.
- The 24-hour SCS storm distribution provides higher storage volumes, which governs the design requirement. The required water quantity control volume to retrofit Pond HT06 is ***425 m^3***.

Table 6-3 summarizes the LID volume requirements for on-site control as per LSRCA SWM guidelines.

Table 6-8: Water Quantity/Quality/LID Volume – Study Area 4 in Hotchkiss Creek

Catchment ID	Total Catchment Area [ha]	Catchment Length [m]	Net Impervious Area [ha]	Required Volume (m^3)				Proposed Treatment Facility
				Water Quantity Volume	Water Quality Volume	LID Volume	Total	
Bryne Drive Draining into HT06	1.07	314.00	0.34	425	14	108	-	Retrofit within Pond HT06
Bryne Drive Draining into Outlet "B"	1.19	350.00	0.37		15	120	-	
Total	-	-	-	425	72	448	***682***	-

In order to meet the water quality and LID volume, the retrofit of Pond HT06 will incorporate the above volume, as per Exhibit 4-4.

Overall, the proposed retrofit of Pond HT06 will be provided at the south end of existing pond HT06, providing a total of ***682 m^3*** of storage volume for water quantity control and LID measure.

Based on the Soil Infiltration Assessment conducted in previous 300 Essa Road Project, it was recognized that the infiltration capacity of the native sand soil at and below the existing pond HT06 is very high, with hydraulic capacity ranged 2.5 - 2.6 x 10^{-2} cm/sec. Therefore, it is recommended to provide water quality control through the dry pond HT06 retrofit.

Pre-treatment in the form of a pair of appropriately sized OGS units are recommended prior to discharging to the two (2) road ROW outfall locations.

7 Conclusions and Recommendations

Based on the preceding assessments completed for the current study, the following conclusions can be made:

- The study includes an inventory of the background information provided by the City of Barrie and LSRCA for the project study area.
- The study area of Harvie Road, Essa Road and Bryne Drive falls within four (4) different subwatershed areas which are the main branch of the Whiskey Creek, tributary of Bear Creek, tributary of Lovers Creek, and tributary of the Hotchkiss Creek.
- The overall study area has been further divided into six (6) smaller study areas based on the watershed distribution. The existing site drainage patterns and outlets have been documented in detail for each study area. These six (6) study areas are:
    - Study Area 1: Harvie Road at Whiskey Creek Subwatershed
    - Study Area 2: Essa Road at Bear Creek Subwatershed
    - Study Area 3: Bryne Drive, south of Harvie Road and north of Caplan Avenue at Lovers creek Subwatershed
    - Study Area 4: Bryne Drive, south of Harvie Road at Whiskey Creek Subwatershed
    - Study Area 5: Bryne Drive, north of Harvie Road at Whiskey Creek Subwatershed
    - Study Area 6: Bryne Drive, north of Harvie Road and south of Essa Road at Hotchkiss Creek Subwatershed
- The future layout of the ultimate roadway condition was analysed and evaluated for the proposed hydrologic and hydraulic impacts. Hydrologic runoff updates for the existing and proposed conditions have been documented for the study area using SCS 24-hour Storm and Chicago 4-hour storm distributions. It is recognized that the peak flow using SCS 24-hour Storm distribution are higher than the Chicago 4-hour distribution, therefore, this design event has been used for the current preliminary design.
- Hydraulic assessments and design of two (2) new culverts P.C.W-1 and P.C.L-2 as well as hydraulic assessments of two (2) existing culverts E.C.W-1 and E.C.B-1 were completed. These culverts were evaluated and determined to satisfy the hydraulic requirements under the proposed condition.
- SWM layouts and concepts have been developed based on the proposed roadway cross sections while recognizing the future developments in adjacent external drainage areas.

- Drainage conveyance features in the form of storm sewers, culvert crossings and ditches/water quality swales for the proposed condition have been documented.
- Potential impacts due to future road widening and extensions are proposed to be mitigated through utilizing and retrofitting the existing SWM facilities including Pond LV14, Pond A and Pond HT06.
- New SWM facilities, LID measures (i.e. infiltration galleries and enhanced grassed swales), and OGS units are proposed at different locations for peak flow control, LID/water balance measures and quality control measures.

Based on the preceding assessments and conclusions, the following measures are recommended to support the Harvie Road, Essa Road and Bryne Drive detailed design stage:

- A 750 mm diameter Concrete Pipe Culvert be implemented for Culvert P.C.W-1 at Whiskey Creek Subwatershed area.
- A 1.2 m x 0.90 m Concrete Box Culvert be implemented for Culvert P.C.L-2 at Lovers Creek Subwatershed area.
- An outlet pool with rock protection will be provided as per HBBP Project at the outlet of Culvert E.C.W-1 for erosion control. Rock protection will be also provided on the upstream end of the culvert.
- Rock protection will be provided at the upstream and down stream ends of Culvert E.C.B-1 and Culvert P.C. L-2.
- Within Whiskey Creek Subwatershed:
    - Two (2) Linear Dry SWM facilities Pond 1 and Pond 2 be implemented for runoff quantity control.
    - Two (2) infiltration chambers (IC-W1 and IC-W2) be implemented at the bottom of the linear dry facilities.
    - Enhanced grassed swales are proposed to convey the outflow from SWM facilities.
    - Three (3) OGS units be implemented for runoff quality treatment.
    - Pond A be retrofitted to accommodate the infiltration requirements of Harvie Road and Bryne Drive south of Harvie Road. An infiltration chamber will be provided on the northside of Pond A to maintain the LID volume requirements.
    - Roadway runoff will be conveyed through the designed storm sewers.
- Within Hotchkiss Creek Subwatershed:

- Pond HT06 be retrofitted to provide water quantity and LID infiltration control due to the roadway cross-section alterations of existing Bryne Drive
- Two (2) OGS units be provided for runoff quality treatment.
- Documented storm sewers with proposed condition capacity deficiencies be upgraded to accommodate the required design flow.

- Within Lovers Creek Subwatershed:
  - Pond LV14 be retrofitted to accommodate additional quantity control volume due to the improvement and extension of existing Bryne Drive.
  - Based on MOECC water quality volume criteria (Table 3.2), the existing pond LV14 provides sufficient water quality control for overall drainage area under the proposed condition.
  - An infiltration chamber will be implemented at LV14 to satisfy the LID infiltration volume requirement for the increased net impervious area on Bryne Drive within the Lovers Creek subwatershed.
  - Enhanced grassed swales to be provided at two locations within the watershed.
  - Infiltration chambers (IC-L1 and IC-L2) be implemented within the proposed grassed swales to meet the LID volume requirements.
  - Documented storm sewers with proposed condition capacity deficiencies be upgraded to accommodate the required design flow.
- Within Bear Creek Subwatershed:
  - A Linear Dry SWM facilities Pond BR-P2 be implemented for runoff quantity control.
  - Roadway runoff will be conveyed through the designed storm sewers.
  - Enhanced grassed swale is proposed on the downstream of the dry SWM facility to convey the outflow to downstream of Culvert E.C.B-1.
  - Two (2) OGS units be implemented for runoff quality treatment.
  - One infiltration chamber IC-B1 be implemented within the linear dry SWM facility and adjacent enhanced grassed swale.
  - Outflow from existing dry Pond BR-27 be directed to Bear Creek with new set of clean water storm sewers on the east of Essa Road.

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Attachment(s)/Enclosure