Region of Waterloo

# Stage 2 ION LRT: Transit Project Assessment

## Preliminary Drainage and Stormwater Management Report

March 16, 2021 FINAL

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Region of Waterloo

FINAL

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WSP
582 Lancaster Street West
Kitchener, ON
Canada  N2K 1M3

T: +1 519 743-8778
wsp.com

# Revision History

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| Javeed Khan, Project Manager, Water Resources | Bryan Orendorff, Manager, Water Resources | Denise Morneau, Sr. Project Manager, Transportation Planning | | |
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| Javeed Khan, Project Manager, Water Resources | Bryan Orendorff, Manager, Water Resources | Denise Morneau, Sr. Project Manager, Transportation Planning | | |
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| Prepared by | Reviewed by | Approved By | | |
| Javeed Khan, Project Manager, Water Resources | Bryan Orendorff, Manager, Water Resources | Denise Morneau, Sr. Project Manager, Transportation Planning | | |

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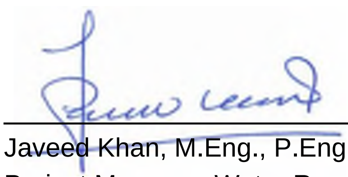
| Javeed Khan, Project Manager, Water Resources | Bryan Orendorff, Manager, Water Resources | Denise Morneau, Sr. Project Manager, Transportation Planning | | |

# Signatures

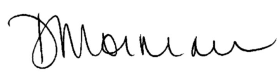
Prepared by



Javeed Khan, M.Eng., P.Eng., PMP
Project Manager, Water Resources

March 16, 2021
Date

Approved[1] by (must be reviewed for technical accuracy prior to approval)



Denise Morneau, P.Eng.
Senior Project Manager, Transportation Planning

March 16, 2021
Date

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# Contributors

Client

| | |
|---|---|
| Manager, Rapid Transit Coordination | Paula Sawicki |
| Senior Project Manager, Rapid Transit | Matthew O’Neil |

WSP

| | |
|---|---|
| Designer, Water Resources | Maria Vogiatzis, EIT |
| Sr. Engineer, Water Resources | Jeff Zhang, P.Eng. |
| Project Manager, Water Resources | Javeed Khan, P.Eng. |
| Manager, Water Resources | Bryan Orendorff, P.Eng. |
| Proof (non-technical / formatting) | Melinda Nowak |
| Sr. Engineer, Transportation Planning | Sarah Roberts, P.Eng. |
| Sr. Project Manager, Transportation Planning | Denise Morneau, P.Eng. |

Subconsultants

N/A

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# 1 INTRODUCTION

## 1.1 Introduction

WSP has been retained by the Region of Waterloo to undertake a route planning study, Transit Project Assessment (TPA) and functional design for Stage 2 of the ION Light Rail Transit (LRT). In June 2011, the Regional Council endorsed a staged approach to implementing LRT from Waterloo to Cambridge. Stage 1 ION consists of an LRT between Conestoga Mall in the City of Waterloo and Fairview Park Mall in the City of Kitchener for approximately 19 km, as well as Bus Rapid Transit (BRT) between Fairview Park Mall in the City of Kitchener and the Ainslie Street Terminal in the City of Cambridge for approximately 18 km. The TPA for Stage 1 was completed in 2012. BRT service in Stage 1 commenced operations in late 2015 and LRT in June 2019. Stage 2 will see the BRT service replaced with LRT on a route selected through the current study.

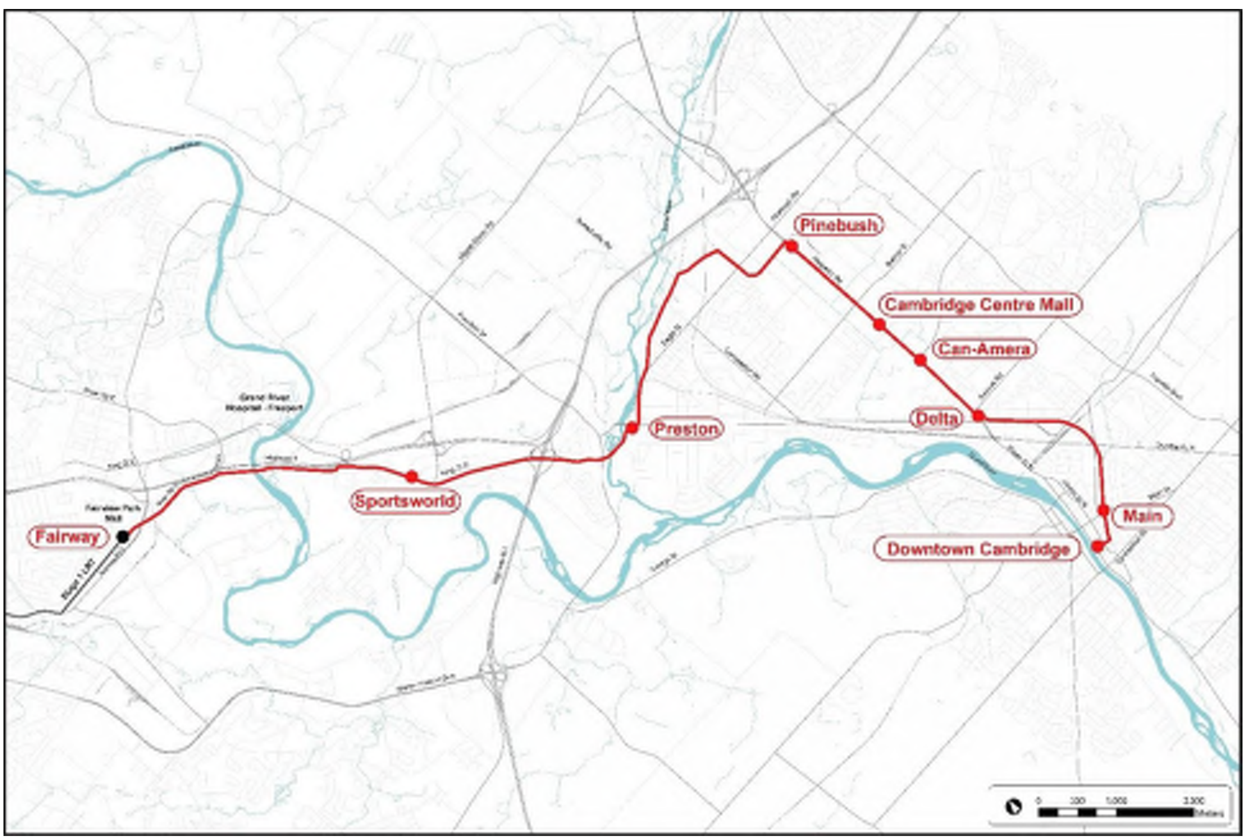


**Figure 1: Key Plan of Proposed LRT Route**

The following tasks were completed for the drainage and stormwater management assessment of the project:

- Input to the assessment of alternative routes during the route planning phase
- Assessment of existing drainage system along the preferred route
- Assessment of potential impacts of the proposed works on the existing surface drainage system, watercourse crossing structures and floodplains
- Hydraulic analysis of the main watercourse crossings
- Development of a conceptual drainage and stormwater management plan

This report provides an overview of the assessment of alternatives during the route planning phase and documents the existing drainage conditions of the preferred route, impact assessment of the proposed works and a drainage and stormwater management concept plan for the preferred route of the proposed Stage 2 ION LRT.

## 1.2 Study Methodology

WSP adopted the following study methodology for the drainage and stormwater assessment of the project:

- Collect and review background information from the Region, Cities of Kitchener and Cambridge and the Grand River Conservation Authority.
- Consult regulatory agencies to determine their requirements and drainage concerns for the Study Area.
- Conduct a site reconnaissance to confirm the location and sizes of existing watercourse crossing structures and the general drainage pattern.
- Assess the existing drainage system based on the existing drainage network and determine the major outlets. Storm sewer capacity assessment was not completed as part of this study.
- Assess the potential impacts through changes in imperviousness / drainage patterns at major outlets for the proposed system.
- Conduct hydraulic analysis for the proposed LRT corridor passing through the major watercourses to assess its impacts.
- Prepare a conceptual drainage and stormwater management plan for the proposed LRT corridor.

Throughout the course of this study, Grand River Conservation Authority staff have participated on the study's Technical Advisory Committee (TAC), which also includes representatives from the Region of Waterloo, Cities of Kitchener and Cambridge, and the Ministry of Transportation. The TAC has held 11 workshops / meetings to this point in the study to review work in progress and provide feedback, particularly regarding the development and assessment of route and station alternatives. During the conceptual design stage for the proposed LRT corridor, direct consultation with GRCA staff through meetings and informal communications (telephone and email) has been undertaken, focusing specifically on drainage and stormwater management.

## 1.3 Background Data

The following background information has been reviewed to prepare this report:

- Class EA River Road Extension from King St. to Manitou Drive, Stormwater Management Report, IBI, December 2013
- Flow Monitoring, Calibration and Hydrologic Study for New Secondary Plan (final Report), Hidden Valley Community, Wood, November 19, 2019
- City of Kitchener Integrated Stormwater Management Master Plan, Municipal Class EA, Aquafor Beech Ltd., May 2016
- City of Cambridge Stormwater Management Master Plan, Amec, August 2011
- Riverside Dam Class EA Environmental Study Report (ESR), Amec Foster, July 10, 2018
- Groff Mill Creek Two-Zone Floodplain Study, WSP, October 2016
- As-Built Drawings (Kerr St. Bridge and Galt Box Culvert) retrieved from the City of Cambridge's public OnPoint site: https://maps.cambridge.ca/Maps
- Hydraulic Models:
  - Grand River HEC-RAS (GRCA)
  - Freeport Creek HEC-RAS (GRCA)
  - Speed River HEC-2 Model (GRCA)
  - Speed River HEC-RAS Model (AMEC)
  - Groff Mill Creek HEC-RAS Model (GRCA)
  - Mill Creek HEC-RAS model (GRCA)
- Floodplain Maps (pdf version) provided by GRCA
- GIS data retrieved from GRCA website: https://maps.grandriver.ca/web-gis/public/?theme=General&bbox=407843,4715623,720099,4923899:
  - Floodplains
  - Topographic data
  - Hydraulic model cross-section location shape files

  - Watercourse alignments
  - Source Water Protection plans
- GIS data provided by the Region of Waterloo:
  - Storm sewer network and associated data
  - Topographic data
- Relevant design standards, guidelines:
  - Region of Waterloo and Area Municipalities Design Guidelines and Supplemental Specifications for Municipal Services (DGSSMS), Region of Waterloo, January 2018
  - City of Kitchener Development Manual, April 2015
  - City of Kitchener Stormwater Management Policy No: MUN-UTI-2003, November, 21, 2016
  - City of Cambridge, Engineering Standards and Development Manual, October 2013
  - Ontario Ministry of the Environment (MOE) Stormwater Management Planning and Design (SWMP) Manual (MOE, 2003)
  - Ontario Ministry of Transportation Highway Drainage Design Standards (HDSS) (MTO, 2008)
  - Ontario Ministry of Transportation Drainage Management Manual (MTO, 1997)
  - Canadian Highway Bridge Design Code (CSA, November 2006)
  - Low Impact Development Stormwater Management Planning and Design Guide (CVC, TRCA, 2010)
  - Region of Waterloo Asset Management Plan (Region of Waterloo, August 2020)
  - Policy Direction Paper on Climate Cahnge, Regional Official Plan Review, Regional Official Plan 2051 (Regional Municiplaity of Waterloo, January 2021)

# 2 PERFORMANCE STANDARDS

The proposed LRT route consists of roadway corridors with either embedded or ballasted tracks. The route includes on-street and off-street segments passing through the urban centres of Kitchener and Cambridge and the floodplains of the Grand River, Speed River, Groff Mill Creek and Mill Creek. The existing and proposed drainage systems consist of surface drainage systems (sewers and ditches) conveying storm runoff to either stormwater management facilities or directly discharged to the nearby rivers and creeks. For establishing drainage design criteria, the existing and proposed roadway and associated LRT tracks were assumed to be on an urban arterial roadway.

The proposed LRT passess through the City of Kitchener and Cambridge and would require consultation at the detailed design phase to implement the relevant performance standards and policies. The City of Kitchener has developed a Stormwater Management Policy (MUN-UTI-2003) that was approved by the council in 2016, (https://www.kitchener.ca/en/resourcesGeneral/Documents/DSD_ENG_MUN-UTI-2003_Stormwater-Management.pdf). This policy outlines various stormwater quality and quantity targets and should be reviewed and implemented at the next design phase where required.

The following summarizes the proposed design criteria for this study.

## 2.1 Surface Drainage System

The Region of Waterloo and Cities of Kitchener and Cambridge specify that all storm sewers shall, as a minimum, be designed to a 5-year storm event, unless otherwise indicated. Based on this criterion, it has been assumed that all existing storm sewers within the proposed LRT corridor are designed for a 5-year design storm event and over land flow routes are provided throughout the corridor to safely convey the major system flows. Based on the capacity and design criteria adopted by the Region and respective municipalities, the proposed roadway drainage infrastructure shall be designed to meet the following criteria:

- Minor system: 5-year
- Major System: 100-year

## 2.2 Hydraulic Criteria for Watercourse Crossings

The Region's DGSSMS does not provide any guidelines for watercourse crossings. However, the City of Kitchener Development Manual specifies that waterway opening, and bridge crossings shall be designed in accordance with the Ministry of Transportation (MTO) policies and guidelines.

Based on the above, the MTO HDSS hydraulic criteria for an urban arterial road is summarized below:

**Table 2-1: Hydraulic Design Criteria for Bridges and Culverts**

| Structure | Total Span ≤ 6.0 m | Total Span > 6.0 m |
|---|---|---|
| Design Flow (WC-1) | 50-Year | 100-Year |
| Check Flow for Scour[1] (WC-1) | 130 % of 100-Year | 130% of 100-year |
| Freeboard (WC-2, WC-7) | ≥ 1.0 m | ≥ 1.0 m |
| Clearance[2] (WC-2, WC-7) | ≥ 1.0 m (Bridges), ≥ 0.3.0 (Culverts) | ≥ 1.0 m (Bridges), ≥ 0.3.0 (Culverts) |
| Headwater / Diameter (HW/D)[3] | ≤1.5 (Culverts only) | ≤1.5 (Culverts only) |

Note:

1. The water level generated by the Check Flow shall not exceed the elevation of the edge of the travelled lane and is not subject to the Freeboard, Clearance and Flow Depth Criteria.
2. For Culverts, clearance requirements apply to open-footing culverts only and should be ≥ 0.3 m
3. Applies to Culverts only. The minimum headwater / diameter criterion for culverts with a rise or diameter of <3.0 m is ≤1.5, culverts with a rise or diameter of 3.0 m to 4.5 m is ≤ 4.5 and culverts with a rise or diameter of >4.5 m is ≤ 4.5.

In addition, the proposed LRT route traverses parallel along the Speed River, Groff Mill Creek and Mill Creek. The MTO HDSS suggests freeboard for Parallel Flow as:

- A freeboard of 0.3 m to the edge of the travel lane during the regulatory storm
- A freeboard of 0.5 m to the top of the subgrade during the 100-year storm event

The American Railway Engineering and Maintenance-of-way Association (AREMA) design criteria for culverts is:

- Pass the 25-year flood without static head at entrance (maximum headwater/depth (HW/D) ratio of 1.0)
- Pass the 100-year flood with a minimum freeboard of 2 ft (0.61 m) to the base of the rail, and with a maximum HW/D ratio of 1.5

Based on the MTO, AREMA and GRCA requirements, the following design criteria is recommended for the proposed LRT:

- The minor system will be designed for the 5-year storm and the major system will be designed for the greater of the 100-year or Regional storm event.

- All new bridges / centreline culvert crossings on regulatory watercourses will be designed for:
  - The Regional storm without overtopping and without increasing the existing flood elevations. An increase in flood elevation of ≤ 0.1 m is considered to be within the accuracy of the modelling.
  - The 100-year storm with a minimum of 1.0 m freeboard measured to the top of the rail.
  - The bridges will have a clearance of 1.0 m during the 100-year storm event and all centreline open footing culverts will have a clearance of 0.3 m.
- For the LRT segments along the regulatory watercourses, the MTO criteria for Parallel Flow should be adopted.

## 2.3 Floodplain Management Criteria

The proposed LRT corridor crosses the floodplain areas of the Grand River, Speed River, Groff Mill Creek and Mill Creek being managed by the GRCA. Under the Conservation Authorities Act, the GRCA within their jurisdiction regulate all prospective developments that have the potential to interfere with wetlands or alter shorelines and watercourses. The proposed works within and near the regulated features (i.e. wetlands, watercourses, floodplains, steep valley / erosion hazard slopes) will require a work permit from GRCA O.Reg. 150/06.

For watercourse crossing structures, the MTO HDDS WC-1 does not quantify a maximum increase in flood elevations, however, *"…any risk to public safety or potential damage to adjacent properties as a result of impact on the flood elevations associated with the Regulatory Flow …shall be determined in consultation with the Municipality, Conservation Authority or the Ministry of the Natural Resources given their responsibilities under the Conservation Authorities Act and Lakes and Rivers Improvement Act.*" In accordance with GRCA requirements, any increase in the upstream flood elevation resulting from the construction of a new or rehabilitated structure should be kept to a minimum (≤ 0.1 m) to prevent increased flood risk to upstream properties. An increase in flood elevation of ≤ 0.1 m is considered to be within the accuracy of the modelling.

## 2.4 Stormwater Management Criteria

The proposed LRT alignment consists of on-street and off-street sections. Both on-street (which involves widening of existing roadways) and off-street sections will increase the imperviousness of the existing corridor. This change in imperviousness and the proposed works could impact the stormwater characteristics in terms of quantity and quality and would require mitigation measures to reduce the flood risk and water quality impairment.

In consultation with the Region and the GRCA, the following stormwater management criteria is adopted:

- **Quantity Control:** An outlet based hydrologic and hydraulic assessment (under existing and proposed conditions) will be required to evaluate the requirement for quantity control. The following general criteria is recommended:
  - Discharge to existing sewer network: Control post-development peak flows to pre-development levels to avoid surcharging of the existing downstream sewer system.
  - Direct discharge to the Grand River and Speed River: No quantity control is required.
  - Direct discharge to Groff Mill Creek and Mill Creek: Assess impacts and provide quantity control, if required.
  - Hidden Valley Creek: The recent study (Wood, Nov 19, 2019) recommended quantity control in the form of North SWM Facility for a portion of the proposed LRT alignment.
  - Direct discharge to wetlands: Maintain existing hydrologic conditions.
- **Quality Control:** The quality control depends on the nature of receiving waters. The study area receiving waters consist of both warm and cold-water habitats. Both the Grand River and Speed River are warm water habitats while Mill Creek is a cold-water habitat. Depending on the receiving system, the following criteria are recommended:
  - Cold Water Habitat: Enhanced level of protection i.e. 80% Total Suspended Solids (TSS) on long-term basis.
  - Warm Water Habitat: Normal level of protection i.e. 70% Total Suspended Solids (TSS) on long-term basis.
  - Discharge to Wetlands: Enhanced level of protection i.e. 80% Total Suspended Solids (TSS) on long-term basis.
  - Maintain or improve the existing water quality control for the on-street sections, if opportunity exists.
- **Erosion Control:**
  - Avoid direct discharge to wetlands, otherwise provide additional erosion and sediment control measures.

  - For sites with SWM ponds, detain runoff generated from a 25 mm storm for 24 hours.
  - Prepare and implement a construction sediment and erosion control plan consistent with the prevailing guidelines.
- **Water Balance:**
  - Best efforts to maintain groundwater recharge and hydrologic regimes.
  - A feature-based water balance will be required for wetland features.

## 2.5 Level of Service

The different drainage elements of the transit corridor will be designed for applicable design storm events e.g. minor system (sewers) for the 5-year, major system (ditches / overland flow routes) for the 100-year and major bridges / culverts for the Regional storm event. However, the Region indicated that if the water level reaches the top of the tracks (designed 25-year flood elevation), then the LRT will not operate.

## 2.6 Climate Change

Climate Change poses a challenge to proper asset planning and management. Proper consideration of projected changes in climate ensures that infrastructure designed for today will still be resilient under uncertain future climatic conditions and provide the required level of service.

The Region of Waterloo developed an Asset Management (AM) Plan (Region of Waterloo, August 2020) to support the Region's stewardship of its assets. The AM Plan provides focus areas and strategic objectives for different factors that also include improving resilience to climate change and/or severe weather. The Regional Official Plan 2051, Policy Direction Paper on Climate Change (Regional Municipality of Waterloo, January 2021) is a key document for directing local action on climate change.

Drainage infrastructure will be designed for the collection, treatment and conveyance of future changing storm events and patterns (e.g. higher frequency and severity of storms occurring more frequently). The subsequent design phase shall employ best practices to design the proposed drainage infrastructure using the updated Intensity-Duration-Frequency (IDF) curves based on the Ontario Ministry of Transportation online IDF Lookup Tool *(*http://www.mto.gov.on.ca/IDF_Curves/terms.shtml*)*, and a future projection period that aligns with asset design life.

# 3 EVALUATION OF ALTERNATIVE ROUTES

The Stage 2 ION study area is located within the Regional Municipality of Waterloo, Ontario. In 2011, Regional Council endorsed a route and station locations for Stage 2 ION however several challenges were identified with the preferred route after more detailed study. In order to maximize the opportunity for transit-supportive development and create the most cost-effective solution (both in terms of construction and operating costs) this study was initiated to examine additional route alternatives.

Route and station alternatives were initially assessed at a screening level to identify those that:

- Offer the most direct connections to the proposed stops in order to improve travel times
- Have a reasonable right-of-way width to fit LRT
- Offer re-urbanization potential around the LRT stop areas
- Avoid constraints such as mature neighbourhoods or environmentally sensitive areas that would restrict opportunities to develop stop areas

From these, a short list was established, and these route and station alternatives were developed at a conceptual level to enable more detailed analysis and evaluation. The study area was divided into sections to enable comparison of route segments with common end points. Thirteen evaluation criteria were used in the comparison of the route segments within four categories: Transportation, Social / Cultural Environment, Natural Environment and Economic Environment. Within Natural Environment, the criteria included the potential impact on floodplains, measured as the area of floodplain crossed.

Based on input received from the study's Technical Advisory Committee and the public, the evaluation was undertaken in several steps with the incorporation of refinements in a number of areas. Following completion of this process and four rounds of public consultation, the preferred route for Stage 2 ION was endorsed by Regional Council in June 2019. The preferred route is shown in the **Figure 1** key plan.

Further details about the development, screening, evaluation and refinement of alternatives is provided in the Information Packages prepared for the four Public Consultation Centres (PCC):

- PCC No. 1, November 18 and 19, 2015: Study introduction and alternative routes / stations
- PCC No. 2, February 23 and 28, and March 1, 2017: Screening, refinement and evaluation of alternatives, presentation of the preliminary preferred route
- PCC No. 3, November 21 and 28, 2017 and January 16, 2018: Refinements and additional new alternatives
- PCC No. 4, May 8, 9 and 10, 2018: Evaluation of new alternatives and presentation of the preliminary proposed route
- PCC No. 4b, March 20, 2019: Refinements to the preliminary proposed route in North Cambridge

These Information Packages are available for download from the study's website at www.stage2ION.ca and will be included in the Environmental Project Report.

# 4 EXISTING DRAINAGE CONDITIONS

## 4.1 Study Area Watersheds

The entire length of the proposed LRT corridor (18 km) from Fairview Park Mall in Kitchener to Downtown Cambridge is located within the Grand River Watershed being managed by the Grand River Conservation Authority (GRCA). The proposed alignment crosses the tributaries of Hidden Valley Creek, Hofstetter Creek, the Grand River, Freeport Creek, Speed River, Groff Mill Creek and Mill Creek. The various tributaries of the Grand River crossing the proposed alignment are shown on **Exhibit 4.1** (attached at the end of this report) and briefly described below.

### 4.1.1 Hidden Valley Creek

The west portion of the proposed LRT route is located in the Hidden Valley Creek watershed. The main creek originates west of Wabanaki Drive and flows east to discharge into the Grand River. The north tributary originates near King Street East and collects runoff from Highway 8 and areas north of Highway 8. The runoff generated at Highway 8 and the E/W-S interchange entrance ramp is collected through the storm sewer network and crosses the Hidden Valley Road / proposed LRT route through Culvert C1. The north tributary crosses the Hidden Valley Road / proposed LRT route at Culvert C2 and joins the main creek within the Environmentally Sensitive Policy Area (ESPA). The proposed alignment through this watershed is located within the surface water Intake Protection Zone (IPZ) of Hidden Valley Intake.

### 4.1.2 Hofstetter Creek

Hofstetter Creek originates in the wetland located south of the existing Hidden Valley Road / proposed LRT route and flows northward crossing Highway 8, ultimately discharging into the Grand River on the north side of Highway 8. The creek lost about one third of its drainage area due to the construction of Highway 8 and the re-routing of Hidden Valley Road (IBI, 2013). Hofstetter Creek crosses the proposed alignment through Culvert C3 and then Highway 8 before it discharges into the Grand River. The proposed alignment through this watershed is located within the surface water Intake Protection Zone (IPZ) of Hidden Valley Intake.

### 4.1.3 Grand River

The Grand River starts in the Dufferin Highlands and flows south about 310 kilometres, discharging into Lake Erie at Port Maitland. The Grand River drains an area of

6,800 $km^2$ and is home to approximately one million people, mostly residing in the urban centres of Kitchener, Waterloo, Cambridge, Guelph and Brantford. The Grand River crosses the proposed LRT route immediately south of the existing Highway 8 Bridge. The floodplain at the proposed LRT crossing location is approximately 750 m wide and consists of the main channels of the Grand River, Freeport Creek and segments of wetlands. The entire floodplain and wetlands section will be crossed through the proposed LRT Bridge B1. The proposed crossing is in the surface water Intake Protection Zone (IPZ) of Hidden Valley Intake.

### 4.1.4 Freeport Creek

Freeport Creek originates at Fountain Street North and flows westward for about 3 km before it discharges into the Grand River downstream of the Highway 8 bridge. Freeport Creek drains an area of 4 $km^2$ and crosses Highway 8 through an existing box Culvert C4. The creek crosses the proposed LRT corridor immediately south of Highway 8 and will flow under the proposed Bridge B1 and no additional crossing structure will be required for this crossing. Freeport Creek is also located in the surface water Intake Protection Zone (IPZ) of Hidden Valley Intake.

### 4.1.5 Speed River

The Speed River is one of the main tributaries of the Grand River that originates at the southwest corner of Dufferin County and flows south for approximately 88 km before it discharges into the Grand River. The river drains an area of approximately 780 $km^2$ at the proposed LRT crossing south of King Street East. The proposed LRT route after crossing the Speed River traverses parallel to the Speed River northerly for approximately 3 km. The proposed LRT section in this area is at the southern limits of the floodplains along Eagle Street and an unused CP railway spur line. The proposed LRT will cross the Speed River through Bridge B2 located approximately 260 m south of the King Street East Bridge.

### 4.1.6 Groff Mill Creek

Groff Mill Creek watershed drains an area of 975 ha that includes highly urbanized commercial and industrial areas along Hespeler Road in the City of Cambridge. Groff Mill Creek begins at a storm sewer outlet at the northwest corner of the existing CN railway tracks and Hespeler Road. From this outlet, the creek is a man-made, straightened ditch that flows westward and then turns south to cross the proposed LRT route until it crosses Dunbar Road. South of Dunbar Road, the creek has a natural channel cross-section and is Terrafix-lined through Dumfries Conservation Area (WSP, 2016). Downstream of the Dumfries Conservation Area, the creek crosses the CP railway and Coronation Boulevard and flows through the Galt Country Club to its ultimate outlet into the Grand River. Groff Mill Creek receives storm runoff from the proposed LRT route along Hespeler Road through the storm sewer network outletting westward at Langs Drive and Bishop Street North. Groff Mill Creek crosses the proposed LRT route through an existing CSP Arch Culvert C7. A portion of the LRT and associated station is located within the floodplain of Groff Mill Creek, created by overtopping and spillage of floodwater at Langs Drive.

### 4.1.7 Mill Creek

Mill Creek drains an area of 104 $km^2$. Mill Creek headwaters originate in Puslinch Township, flows southwest to the Shades Mill Reservoir and Dam, ultimately discharging into the Grand River through a closed box Culvert C11 in downtown Cambridge. Within the Mill Creek Watershed, the proposed LRT route passes along the railway tracks, crosses Samuelson Street and Dundas Street and then traverses parallel along Beverly Street and Mill Creek before outletting into the 600 m long Box Culvert C11 (6.1 m x 3.05 m) at Main Street. The proposed LRT section from Kerr Street to Main Street is in the floodplain of Mill Creek caused by overtopping of Kerr Street Culverts.

## 4.2 Natural Heritage Features

A draft Natural Heritage Report was completed by LGL Limited in August 2019. The draft LGL report outlines potential impacts of the proposed LRT alignment on natural heritage features such as provincially significant wetlands (PSWs), environmentally sensitive policy areas (ESPAs), areas of natural and scientific interest (ANSIs) aquatic ecosystems, vegetation, wildlife, and species at risk. The following sub-sections summarizes some of the findings from the draft LGL Report. The final report will be included with the Environmental Project Report.

### 4.2.1 Aquatic Ecosystems

The Grand River, Freeport Creek, and the Speed River at Shantz Hill are habitat to warm and coolwater fish. Two fish species at risk were identified within the Grand River and the Speed River at Shantz Hill; Silver Shiner (Threatened) and Black Redhorse (Threatened). Two mussel species at risk were identified within the Grand River and Freeport Creek; Wavy-rayed Lampmussel (Threatened) and Rainbow Mussel (Endangered). The Wavy-rayed Lampmussel was also identified within the Speed River at Shantz Hill. The area is designated as ‘critical habitat’ for Rainbow Mussel at the proposed alignment within the Grand River. The endangered fish and mussels listed are regulated under the Endangered Species Act, 2007 (ESA).

Groff Mill Creek is habitat to warmwater fish species; however, fish were not observed at the time of the site visit, therefore, it is likely an indirect fish habitat. No species at risk were found within any other creeks and tributaries within the proposed LRT alignment and study area.

### 4.2.2 Vegetation

Vegetation communities within the study area include forest, wetland, and cultural communities. A total of 305 plant species were recorded within the study area. One species at risk was identified on the south side of Shantz Hill Road and Fountain Street South; Butternut. The Butternut is classified as Endangered and is regulated under the ESA.

### 4.2.3 Wildlife

A variety of wildlife were identified within the study area. A total of five species at risk were discovered from records within the last 10 years; Jefferson's Salamander, Snapping Turtle, Eastern Ribbonsnake, Queensnake, and Eastern Meadowlark. The MNRF in Guelph have records that indicate additional species at risk reside in the area; Bald Eagle, Common Nighthawk, and Chimney Swift. Three additional species at risk were documented during field surveys; Eastern Wood-Pewee, Barn Swallow, and Wood Thrush.

### 4.2.4 Provincially Significant Wetlands (PSW)

There are three PSWs that are located within the study area; Hidden Valley Wetland, Grandview Wetland, and Speed River Wetland. Culvert C2 discharges to Hidden Valley Wetland prior to its ultimate discharge point at the Grand River. Grandview Wetland is located to the east of the Grand River, just south of Highway 8. Culvert C3 discharges to Grandview Wetland prior to its ultimate discharge point at the Grand River. The Speed River Wetland is located just northwest of Eagle Street North and Russ Street intersection.

### 4.2.5 Environmentally Sensitive Policy Areas (ESPA)

Two ESPAs are located within the study area; ESPA #27 Hidden Valley located south of Highway 8 between Wabanaki Drive and the Grand River, and ESP #37 Grandview Woods located south of Highway 8 and east of the Grand River.

### 4.2.6 Conservation Areas

One conservation area (CA) is located within the study area in the City of Cambridge; Dumfries Conservation Area located on the west side of Hespeler Road at Dunbar Road. Groff Mill Creek runs through this area and ultimately discharges at the Grand River.

## 4.3 Surface Drainage

The proposed LRT corridor is 18 km long and consists of on-street (10 km) and off-street (8 km) sections. The on-street alignment passes through the heavily urbanized sections of Kitchener (King Street) and Cambridge (Eagle Street, Hespeler Road, Wellington Street, Bruce Street) and stormwater runoff is mainly collected through the existing underground storm sewer system. The storm sewer collects the minor system flows and discharges to either an existing sewer outlet or nearby watercourse crossing. The major system flows are conveyed through the existing roadways or roadside ditches to the respective outlets along the route.

WSP reviewed the Region’s GIS data for the existing storm sewer network along the proposed LRT route which is shown in **Exhibits 4.2** to **4.49** following this report. The sewershed boundary (within the proposed LRT corridor) for each outlet was delineated based on the GIS sewer network. The sewershed boundaries shown are approximate and further confirmation will be required at the next design phase. The majority of the storm sewer systems convey flow to sewer outfalls that directly discharge to the various tributaries of the Grand River along the alignment, except the two King Street outlets which discharge into an existing Stormwater Management Facility for treatment and attenuation, ultimately discharging into the Grand River.

The proposed LRT corridor is divided into nine sections for the purposes of this analysis, which coincide with the sections established for the evaluation process as described in Section 3. The existing drainage system in each section is summarized in **Table 4-1**. For comparison and as a ready reference, the proposed drainage system (**Section 5**) with potential impacts for each section are also summarized in **Table 4-1**. As summarized in **Table 4-1** and **Table 5-2**, the proposed LRT will add approximately 12 ha impervious area to the existing corridor. In addition, the proposed LRT will contribute salt, brake dust and hydraulic fluids from railway operations that will potentially affect the stormwater quality. Mitigation measures will be required to reduce the imapcts of the proposed works.

**Table 4-1: Summary of Existing Conditions, Proposed Conditions, and Potential Impacts / Mitigation Measures at each Proposed LRT Section**

| Section | Existing Drainage System | Proposed Drainage System | Potential Impacts and Mitigation Measures |
|---|---|---|---|
| **1. F2b**<br>Chainage: 10+000 – 11+740<br>Exhibits: 4.2 – 4.6<br>Route: Fairview Mall to Grand River along the approved River Road Extension (not yet constructed) and existing Hidden Valley Road, south of Highway 8, covering a distance of 1.75 km:<br>• Off-street length: 200 m<br>• On-street length: 1550 m<br>Main Drainage Features:<br>• Hidden Valley Creek<br>• Hofstetter Creek<br>• Hidden Valley Creek Provincially Significant Wetland (PSW)<br>• Culverts:<br>○ C1 (750 mm x 32 m CSP) - Hidden Valley Creek<br>○ C2 (1220 mm x 1220 mm x 95.58 m Box) – Hidden Valley Creek<br>○ C3 (1500 mm x 900 mm x 92.67 m Box) – Hofstetter Creek | Runoff from the west end of this section is collected through a network of storm sewers inside the Fairview Park Mall parking lot and conveyed across Fairway Road South through a 1200 mm trunk sewer, located east of Wabanaki Drive, discharges directly into Hidden Valley Creek (**Exhibit 4.3**) and ultimately into the Grand River. The existing storm sewers along Fairway Road South also discharge to the existing 1200 mm truck storm sewer.<br>Runoff from the existing Hidden Valley Road is collected through the road side ditches and discharged into Hidden Valley Creek (Culvert C1 and C2) and Hofstetter Creek (Culvert C3) and ultimately into the Grand River. Based on the visual observations, the condition of the existing culverts are as follows:<br>• C1 – Good condition<br>• C2 – The outlet of the culvert is scoured and perched due to erosion<br>• C3 – Good condition<br>The main drainage outlets in this section are:<br>Outlet 1: Fairview Park Mall sewer system<br>Outlet 2: Hidden Valley Creek (Culvert C1, C2)<br>Outlet 3: Hofstetter Creek (Culvert C3) | The proposed LRT in Section F2b consists of a bridge over Fairway Road South and an embedded track inside the urbanized section of the approved River Road Extension (existing Hidden Valley Road). The proposed drainage system consists of track trench drains collecting runoff from the LRT tracks and directing to the proposed sewer system along the River Road Extension (currently Hidden Valley Road). The existing drainage pattern will be generally maintained as per pre-development outlets:<br>• *Outlet 1 at Fairview Park Mall*: This outlet receives drainage from the proposed bridge and discharges to the existing storm sewer system inside the Fairview Mall parking lot after passing through an OGS unit for water quality treatment.<br>• *Outlet 2 at Hidden Valley Creek* (Culvert C1 and Culvert C2): This outlet will be receiving runoff from both the west and east sides of the proposed LRT and approved River Road Extension. Runoff from trackway and roadway will be collected, treated through OGS units and discharged to Culvert C1 and Culvert C2. Both culverts C1 and C2 will need to be extended under the proposed LRT corridor.<br>• *Outlet 3 at Hofstetter Creek* (Culvert C3): This outlet will not receive significant runoff from the proposed LRT due to the changes in vertical grades for the proposed River Road Extension over Highway 8 and Grand River Bridge crossing. Culvert C2 will require extension to convey the Hofstetter Creek flows beneath the proposed LRT corridor. | The proposed LRT and River Road Extension will add about 2 ha of impervious area, thereby changing the imperviousness of the corridor from 30% to 89%. Approximately 1.9 ha of additional impervious area will generate increased runoff volume and flows contributing to Outlet No. 2 and 3 (Hidden Valley Creek).<br>There will be no change in imperviousness of the Fairview Park Mall area, however about 1750 $m^2$ area of the bridge will be added to the Fairview Park Mall parking Lot drainage system. This storm sewer system will require a hydraulic capacity assessment at the next design phase to avoid any adverse impacts and propose mitigations measures if needed. If the Fairview Park Mall does not have enough capacity to accommodate the additional runoff from the bridge surface, then a separate storm sewer will be required to collect runoff from the west end of the structure and convey the flows across Fairway Road South to the existing 1200 mm trunk sewer, ultimately discharging to Hidden Valley Creek.<br>The area in this section discharges to Hidden Valley Creek and the PSW. Appropriate enhanced water quality control measures as well as erosion and sediment control (ESC) measures will be required. Water quality will be achieved through a treatment train approach i.e. a combination of grass swales and three OGS units; one at Fairview Park Mall, one at Culvert C1 (for the western section), and one at Culvert C2 (for the eastern section).<br>The recently completed Hydrologic Study for Hidden Valley Creek (Wood, Nov 19, 2019), recommended water quality controls in the form of LID BMPs along with a quantity control North SWM Facility which will receive runoff from the norhwest portion of the proposed LRT alignment. However, the increase in peak flows appears to be insignificant and no adverse impacts are anticipated at this stage. Further assessment and coordination will be required with the |

| Section | Existing Drainage System | Proposed Drainage System | Potential Impacts and Mitigation Measures |
|---|---|---|---|
| | | | City of Kitchener to implement appropriate quality and quanity controls for Outlet 1 and 2. Outlet 3 discharges to Hofstetter Creek and ultimately to the Grand River, where no quantity controls are required. |
| **2. K3b**<br>Chainage: 11+740 – 13+375<br>Exhibits: 4.6 – 4.11<br>Route: River Road / Hwy 8 to King St. / Highway 8, covering a distance of 1.7 km:<br>• On-street length: 700 m<br>• Off-street length: 1000 m<br>Main Drainage Features:<br>• Grand River<br>• Freeport Creek<br>• Grand River PSW<br>• Culverts:<br>○ C4 (1450 mm x 1140 mm x 98.64 m Box) – Freeport Creek<br>○ C5 (600 mm x 24.04m CSP) – Roadside Ditch<br>○ C6 (700 mm x 22.66 m CSP) – Roadside Ditch<br>○ Entrance culverts | The entire section is on an off-street alignment and crosses the Grand River, Freeport Creek, and associated wetlands. The proposed corridor area drains overland to the Grand River and Freeport Creek through natural swales and ditches. | The proposed LRT system in this section is mainly located on structure, including the crossing of the Grand River. The bridge is 1.46 km long and the sag point is located immediately downstream of the Freeport Creek Culvert (C4) outlet south of Highway 8.<br>Runoff from the east and west sides of the bridge will be directed through the proposed Bridge B1 curb / gutter or bridge deck drains (to be determined at the next design phase), discharged to an OGS unit, and then directed to an enhanced grass swale at Outlet 4 (**Exhibit 4.8**) to meet water quality criteria. | The proposed LRT corridor will add approximately 1.8 ha impervious area. The drainage from the proposed LRT corridor will be collected through the bridge curb / gutter or deck drainage system and discharged into or near the wetland. This concentration and transfer of flows at one point will potentially affect the existing drainage pattern and stormwater characteristics in terms of quantity and quality.<br>No quantity controls are required as the area discharges directly into the larger water body of the Grand River. The GRCA indicated that if discharge to wetlands cannot be avoided, then proper quality, sediment and erosion control measurements will be required.<br>A treatment train approach is recommended for enhanced water quality control, consisting of an OGS unit and approximately 50 m long flat bottom enhanced grass swale with gravel check dams before its ultimate discharge to the Freeport Creek channel.<br>The proposed bridge is above the Regional flood elevation and meets all applicable hydraulic design criteria.<br>The hydraulic analysis results indicate that the proposed bridge will cause an increase of 0.09 m in flood elevation and is within the GRCA prescribed limits (≤ 0.1). |
| **3. N**<br>Chainage: 13+375 – 16+775<br>Exhibits: 4.11 – 4.20<br>Route: King St. East and Shantz Hill Road from Highway 8 exit ramp to the Speed River at Fountain St. South, covering a distance of 3.5 km:<br>• All on-street alignment<br>Main Drainage Features: | The entire section has an urbanized cross-section and runs along existing municipal roadways. The proposed LRT corridor is an on-street alignment on King Street from Highway 8 to south of Highway 401, and Shantz Hill Road to Fountain Street. Stormwater runoff is collected through the existing storm sewer system and discharged through the following main outlet points:<br>Outlet 5: Overland flow to a ditch on the northern side of King St. | The existing drainage system will be maintained and collected runoff will be conveyed to the respective outlets 5 through 15. The existing swales along King St. will be converted into the widened LRT and major system flows will be conveyed through the roadway.<br>Overall, the existing drainage pattern is maintained and all catchments within the section will continue to drain to the same pre-development outlet points. However, the proposed LRT corridor involves widening the | An increase in peak flows is expected at all outlets and would require a detailed assessment at the next design phase. The change in imperviousness for Outlet 6 and 7 is minor (5% and 6% respectively). Both outlets discharge to an existing SWM Facility, which has a drainage area of 56.6 ha with 51% imperviousness. The proposed LRT will change the imperviousness of the SWM Pond drainage area from 51% to 51.28%. This change is insignificant and is not expected to affect the functionality of the existing pond. However, a |

| Section | Existing Drainage System | Proposed Drainage System | Potential Impacts and Mitigation Measures |
|---|---|---|---|
| • Sewer outlets with restricted capacities<br>• Stormwater Management Pond Facility | Outlet 6: Deer Ridge Drive (375 mm sewer).<br>Outlet 7: Sportsworld Crossing Road (600 mm), both Outlet 6 and 7 will discharge to a SWM Facility (Wet Pond / Wetland) at Pioneer Tower Road.<br>Outlet 8: Baxter Pl. (1050 mm), ultimately discharges to the Grand River near the River Ridge Golf Course.<br>Outlet 9: Opposite to Tulane Street (450 mm sewer) conveying flows into the Limerick Drive (1050 mm) storm sewer that ultimately discharges to the Grand River.<br>Outlet 10: 1050 mm storm sewer along Limerick Drive discharging into the Grand River.<br>Outlet 11: Existing ditch along the King St. / Highway 401 on-ramp, flowing west and eventually discharges into the Grand River.<br>Outlet 12: Existing ditch along the King St. / Highway 401 off-ramp, conveyed under the King St., and then into the 1200 mm storm sewer across Highway 401 and ultimately discharges into the Speed River.<br>Outlet 13: 1200 mm storm sewer that collects runoff from Highway 401, King St. / Highway 401 overpass (north side), and then conveyed across Highway 401 through a 1200 mm storm sewer and ultimately into the Speed River.<br>Outlet 14: 750 mm storm sewer that collects runoff from the King St. / Highway 401 overpass (south side) then discharging into the 1200 mm trunk sewer. Both Outlet 13 and 14 discharges into an existing 1200 mm trunk sewer eventually discharging into the Speed River. | existing roadway corridor. This will increase the imperviousness and may generate additional runoff that would need to be controlled. | capacity assessment of the outlet pipes will be required at the next design phase to assess the impact and determine whether they require upsizing.<br>Similarly, the increase in imperviousness for other outlets in this section ranges from 20% to 29% as shown in **Table 5-2**. This will cause an increase in peak flow rates and may surcharge the existing sewer outlet pipes. To avoid surcharging of the downstream system either quantity controls in the form of super pipes under the proposed LRT corridor or upsizing of the outlet pipes will be required. This will be developed in the next design phase.<br>For water quality improvement, installation of OGS units will be evaluated further at the existing outlet points from LRT corridor in the next design phase. |

| Section | Existing Drainage System | Proposed Drainage System | Potential Impacts and Mitigation Measures |
|---|---|---|---|
| | Outlet 15: Fountain St. South (825 mm) to Speed River. | | |
| **4. N3e**<br>Chainage: 16+775 – 18+375<br>Exhibits: 4.20 – 4.24<br>Route: The Speed River at Fountain St. South to Eagle St. North / Hedley St., covering a distance of 1.58 km:<br>• On-street Length: 915 m<br>• Off-street Length: 665 m<br>Main Drainage Features:<br>• Speed River Crossing<br>• Floodplain / Flood Fringe<br>• Preston Station<br>• CP Bridge Crossing | The off-street alignment area at the river crossing drains overland to the Speed River. The on-street alignment along Eagle Street is drained through an existing storm sewer that discharges at the following outlets:<br>Outlet 17: 900 mm dia. storm sewer along King St. discharging to Speed River.<br>Outlet 18: 450 mm dia. storm sewer opposite to William St., discharging to Speed River.<br>Outlet 19: 750 mm dia. Outfall to Speed River. | Runoff from the proposed Speed River Bridge (B2) will be collected at the sag point at Chopin Drive (Outlet #16). The stormwater will then pass through an OGS unit and be directed through an enhanced grass swale discharging to the Speed River. The existing drainage pattern along Eagle Street will be maintained and will continue to be drained at Outlet No. 17, 18, and 19 The proposed drainage infrastructure will consist of:<br>• Storm Sewers<br>• Potential replacement of existing outfalls<br>• OGS units<br>• Enhanced Grass Swale | The proposed bridge crossing will add additional impervious area, but no flood or water quantity impacts are anticipated as the flows are directly discharged to the Speed River. All other outlets in this section (17, 18, 19) also discharge to the Speed River, therefore no quantity controls will be required. However, capacity assessment of the existing sewer outfalls (No. 17, 18 and 19) is required in the next design phase to assess the surcharging of existing system.<br>For water quality of the Speed River crossing section, a treatment train approach is recommended. Runoff from the proposed bridge and station area will be collected through track drains at low point (Chopin Drive) and directed to an OGS unit and then through an enhanced grass swale or bioswale before its ultimate discharge to the Speed River.<br>The proposed alignment will disturb the existing storm sewer outfalls along Queenston Road (525 mm), King Street East (900 mm), opposite to William Street (450 mm), and at the intersection of the railway tracks and Eagle Street North (750 mm) and will require further investigation and replacement at the next design phase. If outfall replacements are necessary, the Region may consider the installation of OGS units at these outfalls to improve the water quality of storm runoff discharging to Speed River.<br>The proposed Speed River Bridge is well above the Regional flood line and meets all relevant hydraulic criteria (**Section 6.3**). The proposed ION station at Preston and LRT track along Eagle St. are in the flood fringe area but above the 100-year flood line and well above the 25-year Level of Service flood elevation. The hydraulic analysis indicates that the proposed LRT will not cause any significant increase in the existing Regional flood elevations. |
| **5. E2 / C1a** | The entire section is on ballasted tracks except at road crossing areas and the proposed ION station at | The entire alignment is on a ballasted track section. Enhanced grass swales with gravel check dams are | The proposed ballasted track will have a minor impact on the corridor imperviousness as ballast is considered |

| Section | Existing Drainage System | Proposed Drainage System | Potential Impacts and Mitigation Measures |
|---|---|---|---|
| Chainage: 18+375 – 21+180<br>Exhibits: 4.24 – 4.32<br>Route: Eagle St. North / Hedley St. to Hespeler Rd at Groff Mill Creek, covering a distance of 3.33 km:<br>• All off-street alignment<br>• Along unused railway spurline<br>• Tracks on ballast<br>Main Drainage Features:<br>• Speed River and associated floodplain<br>• Groff Mill Creek and associated floodplain<br>• PSW<br>• Culverts:<br>○ C7 (3.54 m 2.27 n x 14.5 m CSP Arch) – Groff Mill Creek | Pinebush. The proposed alignment is along the unused railway spurline and drains overland northwesterly to the Speed River. The area located on the southwest of the proposed tracks also drain towards the Speed River. There appears to be a few defined outlets / crossings, but the majority of this area drains overland towards the Speed River. The existing and potential outlets within this alignment are labelled as 20 through 25.<br>At Outlet 21, there is an existing sewer outfall (900 mm dia.), discharging to a defined channel and ultimately to the Speed River. A culvert under the abandoned railway tracks was found on the east side of Speedsville Road (Outlet 23). A section of the proposed LRT is in the Regional floodplain and passes along the PSWs located on the northwestern side.<br>At the east end, the proposed alignment crosses the Groff Mill Creek CSP Arch Culvert (C7). The proposed ION station at Pinebush and associated tracks are located within the Flood Fringe of Groff Mill Creek. | proposed to collect and convey the runoff. The swales generally drain westward along the proposed LRT tracks but five culverts crossings (No. 20 through 25) are proposed to convey the flows collected on the southeastern swales across the tracks to the northwestern swales and ultimately to the Speed River. The exact locations and sizes of proposed culverts will be determined at the next design phase. The grass swales will be flat bottom channels with gravel check dams.<br>The hydraulic analysis of the existing CSP Arch Culvert crossing the Groff Mill Creek Culvert (C7) shows the culvert meets the required hydraulic criteria. The proposed ION station at Pinebush and LRT tracks will not adversely impact the existing floodplain. | pervious and facilitates infiltration. The proposed track will not change the peak flows significantly and no quantity controls are required as it discharges to the Speed River. However, runoff from this section will discharge to a wetlands area and may impact the water quality. Enhanced grass swales on both sides of the tracks are proposed to treat, attenuate and convey the stormwater to the respective outlets.<br>The existing CSP Arch Culvert C7 (3.54 m x 2.27 m x 14.5 m) crossing the Groff Mill Creek meets applicable hydraulic criteria but will require further structural evaluation at the next design phase. No adverse impacts are anticipated to the floodplain of Speed River and Groff Mill Creek. |
| **6. C2**<br>Chainage: 21+180 – 24+460<br>Exhibits: 4.32 – 4.41<br>Route: Hespeler Rd. at Groff Mill Creek to Hespeler Rd. / Avenue Road, covering a distance of 3.47 km:<br>• All on-street alignment<br>Main Drainage Features:<br>• Groff Mill Creek<br>• Existing sewers<br>• Ditches<br>• Culverts:<br>○ C8 (~600 mm x 49.23 m CSP) – Hespeler Rd.<br>○ C9 (2.44 m x 1.2 m x 42.50 m Box) – Hespeler Rd. | The entire 3.22 km long section is an embedded track within the existing ROW of Hespeler Road. The proposed alignment passes through the heavily urbanized section of Cambridge. Storm runoff is collected through an existing sewer system and discharged to the following main outlets:<br>Outlet 26: 2100 mm dia. storm sewer along Langs Drive, discharging to Groff Mill Creek.<br>Outlet 27: 2440 mm dia. storm sewer along Bishop Street North, discharging to Groff Mill Creek.<br>Outlet 28: 1800 mm dia. storm sewer along Dunbar Road, discharging to Groff Mill Creek.<br>Outlet 29: 1500 mm dia. storm sewer along Hespeler Road (at CP Bridge), ultimately discharging to the Grand River outfall along Waterside Avenue (1650 mm dia.). | The existing drainage pattern will be maintained. The storm runoff will be collected through a storm sewer system and discharged to Outlet 26 through 29 as per the pre-development drainage system.<br>The proposed widening of Hespeler Road (to accommodate the LRT) will add approximately 2.4 ha impervious area in the entire section. The increase in impervious cover for individual outlets ranges from 3% to 26%. The change in imperviousness for Outlet 26 and 29 is 26% and 22% respectively and would cause significant increase in peak flow rates. For the other two outlets (No. 27 and 28) relevant change (3% and 5%) appears to be small and may not cause significant increase in flow rates.<br>No quantity controls are proposed at this stage and a dual drainage modelling assessment is recommended to be carried out in the next design phase to assess the capacity of the overall existing system and propose mitigation measures, if required.<br>No additional water quality measures are proposed at | The proposed works could potentially increase the peak flows and may affect the stormwater quality. Appropriate quanity and quality controls will be required.<br>Depending on the capacity assessment of the existing storm sewer system and receiving outlets (which will be conducted at the next design phase), the existing sewer system may require upsizing and would require quantity controls. Opportunities exist for the improvement of stormwater quality by providing OGS units at discharge points and should be further evaluated at the next design phase. For additional quality and quanity control, low impact development BMPs in the form of infiltration measures should be investigated in the next design phase. |

| Section | Existing Drainage System | Proposed Drainage System | Potential Impacts and Mitigation Measures |
|---|---|---|---|
| | Culvert C9 was 75% full of sediments, while C8 was in good condition. Both culverts flow southerly and convey the external drainage area runoff across Hespeler Road to Groff Mill Creek. | this stage; however, opportunity exists to improve the water quality by providing OGS units at existing sewer outlets (No. 26 through 29).<br>No extension / replacement is proposed for the existing culverts C8 and C9. Further hydraulic assessment and structural assessment will be required to assess its existing condition and recommend replacement / rehabilitation measures, if required. | |
| **7. S2a**<br>Chainage: 24+460 – 26+200<br>Exhibits: 4.41 – 4.45<br>Route: Hespeler Rd. / Avenue Rd. to Dundas St. North / Beverly St., covering a distance of 1.8 km:<br>• On-street length: 120 m<br>• Off-street length: 1680 m<br>• Track on ballast – existing railway<br>Main Drainage Features:<br>• Mill Creek<br>• Existing Sewers<br>• Overland flow (no existing culverts crossings, swales, or ditches along this alignment) | The proposed LRT corridor and ION station at Avenue (intersection of Norfolk Ave. and Brooklyn Rd.) discharges to the existing storm sewer network that discharges to the 1500 mm dia. trunk sewer (Outlet 29) crossing the CP Waterloo under Hespeler Road. Ultimately, these flows discharge into the Grand River outfall (1650 mm dia.) along Waterside Ave.<br>The rest of the proposed track runs easterly along the existing CP Waterloo railway tracks crossing Samuelson St. at grade and under the existing CPR Galt Yard towards the intersection of Beverly St. and Dundas St. North. No storm sewer exists along the CPR tracks except a 300 mm dia. sewer that flows northerly along Jarvis St. The majority of the storm runoff appears to dissipate into the ground or flows overland to the natural outlets. A portion of the corridor near the Beverly St. and Dundas St. intersection may drain to the existing sewers, eventually discharging to the 1050 mm trunk sewer along Dundas St. N (Outlet 30). | The existing drainage pattern for the west side of this section will be maintained and drainage from the proposed ION Avenue station and associated tracks will be directed to the existing storm sewer network at Outlet No. 29. A Ditch Inlet is also proposed to collect runoff from the enhanced grass swale for about 430 m of the proposed tracks (24+550 to 24+880) which will receive runoff from the ballasted tracks and conveying flows to the existing 1500 mm dia. trunk sewer under Hespeler Rd.<br>For the remaining ballasted tracks (from 24+880 to 26+070), the surface drainage will be collected through enhanced grass swales on both sides of the track and conveyed to the proposed ditch inlets at Dundas St. and Beverly St. intersection (Outlet No. 30A and 30B). These flows discharge into the existing sewer system along Dundas St. North (Outlet No. 30) and ultimately into Mill Creek. | The majority of the tracks are ballasted and no significant changes in the overall imperviousness and flows is anticipated. However, the proposed swales terminating at the intersection of Dundas St. North and Beverly St. are discharged to the existing storm sewer network. This will be an additional flow that would require further capacity assessment at the next design phase to avoid surcharging of the existing 1050 mm storm sewer along Dundas Street North. If the existing storm sewer is surcharged, then the system may require either an upsizing or overflow structure to spill over the additional flows to a new sewer along the tracks and conveyed into the Mill Creek.<br>Since the majority of the LRT in this section will be on ballasted tracks with enhanced grass swales on both sides, this will treat and convey the storm runoff, and therefore no additional quality treatment would be required. However, an OGS unit could be installed at the proposed ION station at Avenue to treat the storm runoff from the proposed LRT corridor and associated tracks before its discharge into the existing storm sewer network at Outlet No. 29. This will be assessed at the next design phase. |
| **8. S3d**<br>Chainage: 26+200 – 27+125<br>Exhibits: 4.45 – 4.47<br>Route: Dundas St. North / Beverly St. to Main St. / Wellington St., covering a distance of 930 km.<br>• On-street length: 55 m<br>• Off-street length: 875 m | This section (from Dundas St. N to Main St.) runs parallel along the Mill Creek. At Main St., the Mill Creek open channel discharges (Outlet No. 31) into a 600 m long closed box conduit (6.1 m x 3.05 m) that conveys the entire Mill Creek flows into the Grand River.<br>The proposed LRT corridor drains overland to the west bank of Mill Creek (assuming Mill Creek flows in a north-south direction).<br>The proposed route is crossed by three existing storm | The entire section (except the proposed ION station at Main and the Kerr St. crossing) is an off-street ballasted track. The proposed drainage system will consist of enhanced grass swales on both sides of the LRT tracks and crossing culverts to convey the track drainage to Mill Creek. | Due to the pervious nature of the ballasted tracks, the change in imperviousness is insignificant. No quantity controls are required, and quality control is provided in the form of enhanced grass swales with gravel check dams on both sides of the track.<br>The proposed ION station at Main and the LRT route south of Kerr Street is in the existing Regional floodplain caused by the spillage of floodwater at Kerr Street. However, the LRT tracks and associated station |

| Section | Existing Drainage System | Proposed Drainage System | Potential Impacts and Mitigation Measures |
|---|---|---|---|
| • Along Mill Creek<br>Main Drainage Features:<br>• Mill Creek and associated floodplains<br>• Floodplain<br>• Culverts:<br>○ C10 (Twin 4.88 m x 2.93 m x 14.73 m Concrete Box Culverts) – Kerr St. Culverts<br>○ C11 (6.1 m x 3.05 m x 600 m Concrete Box Culvert / Conduit) – Inlet at Main St., and discharges into the Grand River | sewer outfalls to Mill Creek, as shown in **Exhibits 4.46 and 4.47**. These outfalls convey drainage from residential areas located on the west side of the proposed route.<br>The LRT alignment is above the Regional and 100-year flood elevation within the Mill Creek channel. However, due to limited conveyance capacity of the culverts at Kerr St. (C10), flood water spills over to the west side of Mill Creek inundating the proposed LRT route and Main Station. | | is well above the 25-Year Flood (Level of Service) and no adverse impacts are anticipated. The spillage of floodwater at Kerr St. could be avoided, if the existing twin culverts are replaced with a large single span bridge. This would be a separate undertaking and not part of the ION project and would require further assessment as part of a separate study. |
| **9. T2**<br>Chainage: 27+125 – 27+540<br>Exhibits: 4.47 – 4.49<br>Route: Main St. / Wellington St. to Bruce St. / Water St., covering a distance of 530 m:<br>• All on-street alignment<br>Main Drainage Features:<br>• Mill Creek<br>• Grand River Floodplain and Galt City Centre Special Policy Area<br>• Culverts and Outfalls:<br>○ C11 (6.1 m x 3.05 m x 600 m Box) – Inlet at Main St., outlets into the Grand River north of Bruce St.<br>○ 600 mm storm outfall to the Grand River along Bruce St. | The entire section is proposed to be an on-street embedded track and drained through the existing storm sewer system that discharges at the following main outlets:<br>Outlet 32: 450 mm storm sewer along Ainslie St., ultimately discharging to the Grand River along Walnut St.<br>Outlet 33: 600 mm storm sewer outfall along Bruce St., discharging into the Grand River.<br>The proposed LRT corridor along Wellington St. South is drained into the existing storm sewer system, discharging along Ainslie St. (Outlet No. 32) and ultimately into the Grand River through a 900 mm dia. storm sewer outfall along Walnut St.<br>The proposed ION Downtown Cambridge station at Bruce Street and associated LRT corridor along Bruce St. drain overland westerly to Water St. South, where runoff is collected through an existing storm sewer network and discharges into the Grand River through a 600 mm sewer outfall (Outlet No. 33). The Region's GIS sewer data shows that this outfall was installed in 1972 and remains in operation. Further confirmation is required in the next design phase. | The existing drainage network along Wellington St. South will be maintained.<br>The Bruce St. LRT corridor and associated ION Downtown Cambridge station will be drained through the existing storm sewer system along Water St. South. However, the 600 mm Bruce St. outfall will be submerged due to flood elevations within the Grand River during storm events ≥10-year. This will cause back water flows thereby inundating the terminal area. A new storm sewer system with a new outfall with a flow preventer valve / flap gate is recommended to avoid back-water flows and inundation of the terminal area. | The increase in impervious area draining to Outlet 32 (20%) and 33 (24%) could be significant and requires further assessment as part of the next design phase to avoid surcharging of the storm sewer system.<br>To avoid backwater flows from the Grand River (during large storm events), a new storm sewer network connected to the Walnut St. outfall could be considered. The flood elevations within the Grand River at Walnut St. are a few centimeters lower than the existing 600 mm Bruce St. outfall. However, this will not avoid the back-water flows and the station will be flooded during the storm events ≥ 10-year. The 10-year flood elevation within the Grand River near Walnut St. is 264.83 m while the proposed ION station is located at an elevation of 264.5 m. The 10-year flood elevation within the Grand River (near Bruce St.) is approximately 265 m.<br>Alternatively, a backflow preventer valve can be installed within the existing Outlet 33, or a new outfall in this location, to avoid back-water flows and reduce the flood risks for the proposed ION station area in the 10 through 100-year storm events and is therefore recommended.<br>The proposed ION station area is located within the GRCA floodplain regulated and Galt City Centre Special Policy Area and is under water during the Regional storm event due to spillage of flood water from the Grand River at Park Hill Rd. Bridge. A 2D hydrodynamic flood study should be carried out for this |

| Section | Existing Drainage System | Proposed Drainage System | Potential Impacts and Mitigation Measures |
|---|---|---|---|
| | | | area during the next design phase to assess the back-water impacts and flood risks during various design storm events. |

## 4.4 Existing Drainage Infrastructure

The existing drainage infrastructure along the proposed LRT on-street alignment consists of a curb and gutter system and network of storm sewers along the existing roadways to collect and convey the minor and major system flows. Some sections of the roads have swales at various locations being used to collect and convey the major system flows spilled over from the roadway or external areas draining towards the road. Storm runoff collected from the roadway surfaces is discharged either to the storm sewer outlets or adjacent watercourses along the road.

### 4.4.1 Existing Storm Sewers

Based on the GIS data provided by the Region, the approximate length and sizes (range) of the existing storm sewer network along the proposed LRT route in each section is summarized in **Table 4-2**. As indicated in **Table 4-2**, the proposed LRT will potentially impact approximately 7.4 km storm sewers with associated catch basins and manholes along the route.

**Table 4-2: Existing Storm Sewers**

| No. | Section | Roads | Length (m) | Size Range (mm) | | |
|---|---|---|---|---|---|---|
| 1 | F2b | Fairview Mall | 167 | 900 | to | 1200 |
| | | Hidden Valley Road | --- | --- | to | --- |
| 2 | K3b | King St. E | --- | --- | to | --- |
| 3 | N | King St. E | 2302 | 250 | to | 750 |
| | N3e | King St. E | 278 | 250 | to | 975 |
| 4 | N3e | Eagle Street N | 170 | 300 | to | 375 |
| 5 | E2 | --- | --- | --- | to | --- |
| 6 | C2 | Hespeler Rd | 3390 | 300 | to | 1350 |
| 7 | S2a | Hespeler Rd | 137 | 1200 | to | 1500 |
| 8 | S3d | Wellington St | 190 | 250 | to | 375 |
| 9 | T2 | Bruce St | 150 | 300 | to | 600 |
| | | **Total / Average:** | **7360** | **250** | **to** | **1500** |

Note: There are no existing storm sewers on the section of Hidden Valley Road in segment F2b, or on the section of King Street in segment K3b. Segment E2 is an off-street section.

### 4.4.2 Existing Watercourse Crossing Structures

The watercourse crossing structures along the proposed LRT route were visually inspected and are summarized in **Table 4-3**. A photo inventory of the existing watercourse crossings is included in **Appendix A.** Some of the structures are not directly under the LRT corridor but were evaluated either because of their proximity to the LRT, or because they are impacted by the existing floodplain. The assessment is based on a visual inspection and no hydrologic and hydraulic assessment was carried out as part of this study. Further investigation will be required at the next design phase.

### 4.4.3 Existing Stormwater Management Facilities

Storm runoff from the LRT corridor along King St. E (from 3+700 to 4+350) is discharged into the Deer Ridge Drive (Outlet No. 6 – 375 mm) and Sportsworld Crossing Road (Outlet No. 7 – 600 mm) storm sewer outlets which are ultimately conveyed into an existing Stormwater Management Facility located at Pioneer Tower Road. The facility, labelled as No. 54 in the in the City of Kitchener Integrated Master Drainage Plan (Aquafor Beech, 2016), was constructed in 2009. The facility has been designed as a wet pond and receives runoff from a drainage area of 56.6 ha with an imperviousness of 51%. The existing wet pond provides both quality (normal level of protection) and quantity control with a Permanent Pool Volume of 7,457 $m^3$ and Extended Detention Volume of 6,482 $m^3$.

The LRT corridor area that will be drained to the existing SWM facility through the two outlets is approximately 2.57 ha with an overall existing imperviousness of 94%. Under proposed conditions, the imperviousness of the proposed LRT corridor (for these two outlets) will increase from 94% to 100%, thereby, adding an impervious area of 0.16 ha. This 0.16 ha additional impervious area will change the overall imperviousness of the SWM Facility drainage area from 51% to 51.28%. This appears to be an insignificant change and no adverse impacts are anticipated on the functionality of the existing SWM Facility regarding the quality and quantity controls.

**Table 4-3: Summary of Culvert Inspection Observations**

| Culvert / Bridge ID | Watercourse | Road Name | Chainage | Crossing Type | Crossing Span (mm) | Crossing Rise (mm) | Crossing Length (m) | Comments |
|---|---|---|---|---|---|---|---|---|
| C1 | Hidden Valley Creek | Hidden Valley Road | 11±160 | CSP Circ. | --- | 750 | 32.0 | Good condition, ~300 mm sediment deposit downstream, cleaning required. |
| C2 | Hidden Valley Creek | Hidden Valley Road | 11±180 | Conc. Box | 1220 | 1220 | 95.6 | Outlet scoured and perched, require immediate repairs. |
| C3 | Hofstetter Creek | Hidden Valley Road | 11±675 | Conc. Box | 1500 | 900 | 92.7 | Good condition, there may be deposits as the rise was measured as 700 mm – could potentially be a 900 mm rise. |
| C4 | Freeport Creek | Highway 8 | 12±430 | Conc. Box | 1450 | 1140 | 98.6 | Good condition, riverstone at bottom of culvert, not impacted by LRT. |
| C5 | Ditch / Swale | N-E Ramp to King St. E | 13±100 | CSP Circ. | --- | 600 | 24.0 | Good condition, not impacted by LRT. |
| C6 | Ditch / Swale | N-E Ramp to King St. E | 13±330 | CSP Circ. | --- | 700 | 22.7 | Fair condition, top of U/S and D/S end is deformed / dented, not impacted by LRT. |
| C7 | Groff Mill Creek | CN Rail Spur line | 20±960 | CSP Arch | 3540 | 2270 | 14.5 | Good condition, upstream lined concrete channel. |
| C8 | Ditch / Swale | Hespeler Road | 22±090 | Conc. Box | 2240 | 1200 | 49.2 | Good condition. |
| C9 | Ditch / Swale | Hespeler Road | 23±075 | CSP | --- | ± 600 | 42.5 | Fair condition, ~3/4 full of sediment on D/S end, no apparent blockage on U/S end. |
| C10 | Mill Creek | Kerr St. | 26±625 | Twin Conc. Box | 4877 | 2930 | 14.7 | Good condition, some debris caught in between twin culverts, not under LRT but evaluated as part of flood impact assessment. |
| C11 | Mill Creek | Main St., Wellington St., Ainslie St. and along Bruce St. | 27±000 | Conc. Box | 6100 | 3050 | 600 | Good condition but may require replacement in parts under the LRT for structural integrity reasons. |

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# 5 PROPOSED DRAINAGE CONDITIONS

## 5.1 Proposed Drainage System

The existing drainage pattern is maintained, and a conceptual drainage plan is prepared and shown on **Exhibits 4.1** to **4.49**. The proposed drainage system and potential impacts are summarized for each section in **Table 4-1.**

Runoff from the on-street alignments of the LRT trackway will be collected through Trench Track Drains and connected to the existing sewer systems and drainage outlets. A typical cross-section of the proposed drainage system is shown on **Exhibit 5.1** and **5.2**.

The off-street alignments are mostly on ballasted tracks. In these locations, runoff will be collected and conveyed through side ditches on either side of the tracks. A typical cross-section of the ballasted track drainage system is shown in **Exhibit 5.3**. These ditches will be designed as enhanced grass swales with gravel check dams to treat, attenuate, and convey the storm runoff to the nearby outlets.

The proposed LRT alignment consists of two major river crossings, the Grand River and Speed River. Runoff from these bridge sections will be collected and conveyed to a sag point where it discharges to the respective outlets. The stormwater will be passed through an OGS unit for water quality enhancement prior to discharging through each respective outlet.

The capacity assessment of existing sewer system or sizing of proposed sewer system will be carried out as part of the next design phase. To qualitatively assess the potential impacts of the proposed works, the change in impervious cover for each section was determined and summarized in **Table 5-1**. Similarly, the LRT corridor area was delineated into 33 catchments based on the existing sewer system outlets and topography. The impervious cover for each outlet (within the LRT corridor) under existing and proposed conditions was determined and summarized in **Table 5-2**. As shown in **Table 5-1**, the proposed LRT corridor occupies a total area of 46 ha with an existing impervious area of 28.6 ha with an overall imperviousness of 62%. The proposed works will add another 11.9 ha impervious area, thereby, increasing the corridor overall imperviousness to 88%.

Out of 33 total outlets, 21 outlets discharge to existing sewer systems and 18 outlets discharge to swales or nearby watercourses. The change in impervious cover for each outlet was also determined and shown in **Table 5-2**. The change in impervious cover for each outlet varies and ranges from 1% to 29%. Quantity controls in the from of superpipes or upsizing of existing sewer outfalls will be required to avoid surcharging of the downstream system.

Dual drainage modelling is recommended at the next design phase to accurately assess the existing systems and to ensure that the proposed systems keep the LRT tracks free of flooding at the required Level of Service (25-year).

## 5.2 Proposed Drainage Infrastructure

The proposed drainage infrastructure will include track drains and its connection to the existing drainage system. Two major river crossings are proposed at the Grand River and Speed River. The key drainage infrastructure will include but not be limited to:

**Storm Sewers**: Replacement, relocation and adjustment of the existing 7.4 km long storm sewers with associated catchbasins and manholes will be required. In addition, approximately 2 km long new storm sewers will be required along River Road, which will be provided under the Region of Waterloo’s River Road Extension project.

**Ditches and Swales**: Approximately 9.5 km long enhanced grass swales are proposed on both sides of the proposed ballasted tracks to collect, treat and convey the storm runoff.

**Watercourse Crossing Structures**: The existing Culverts C1, C2, and C3 will require extension to accommodate the proposed LRT. About five new crossing culverts will be required under the proposed LRT along the railway spurline to convey drainage across the tracks to the Speed River. Similarly, about two new crossing culverts will be required under the proposed LRT along Mill Creek to convey flows across the tracks to Mill Creek.

**Oil Grit Separator Units**: Five OGS units are proposed at this stage to treat the storm runoff. Additional units at the existing sewer outfalls may be considered at the next design phase to enhance water quality, with the applicable design standards to be confirmed with the Cities of Kitchener and Cambridge.

**Table 5-1: Existing and Proposed Imperviousness Areas in Each Section of LRT Corridor**

| Section | Approx. Chainage (From) | Approx. Chainage (To) | Exhibit No. | Roadway Corridor Drainage Area[1] (ha) | Existing Impervious Area (ha) | Existing Imperviousness (%) | Proposed Impervious Area (ha) | Proposed Ballast Area[2] (ha) | Proposed Imperviousness (%) | Difference in Area (ha) | Difference in Imperviousness (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| F2b | 10+000 | 11+740 | 4.2 - 4.6 | 3.67 | 1.09 | 30 | 3.27 | 0 | 89 | 2.18 | 59 |
| K3b | 11+740 | 13+375 | 4.6 - 4.11 | 2.03 | 0.02 | 1 | 1.94 | 0 | 95 | 1.92 | 94 |
| N | 13+375 | 16+775 | 4.11 - 4.20 | 12.93 | 10.46 | 81 | 12.93 | 0 | 100 | 2.47 | 19 |
| N3e | 16+775 | 18+375 | 4.20 - 4.24 | 4.25 | 2.31 | 54 | 3.50 | 0.23 | 83 | 1.22 | 29 |
| E2 | 18+375 | 21+180 | 4.24 - 4.32 | 3.23 | 1.01 | 31 | 1.41 | 1.70 | 51 | 0.65 | 20 |
| C2 | 21+180 | 24+460 | 4.24 - 4.41 | 14.43 | 11.11 | 77 | 13.57 | 0 | 94 | 2.46 | 17 |
| S2a | 24+460 | 26+200 | 4.41 - 4.45 | 2.26 | 0.60 | 27 | 0.62 | 1.67 | 38 | 0.27 | 12 |
| S3d | 26+200 | 27+125 | 4.45 - 4.47 | 1.33 | 0.52 | 39 | 0.85 | 0.71 | 72 | 0.43 | 33 |
| T2 | 27+125 | 27+540 | 4.47 - 4.49 | 1.88 | 1.46 | 78 | 1.88 | 0 | 100 | 0.42 | 22 |
| | | | **TOTAL:** | **46.02** | **28.58** | **62** | **39.95** | **4.31** | **88** | **12.01** | **26** |

[1] Areas are approximate and do not include contributing areas outside the road corridor. Detailed analysis required in the next design phase.

[2] The ballasted tracks are assumed to have a runoff coefficient of 0.3 (approximately 15% imperviousness)

**Table 5-2: Main Drainage Outlets - Existing and Proposed Impervious Areas**

| Outlet ID | Location | Approx. Chainage | Section | Exhibit No. | Existing Outlet Type | Existing Sewer Outlet Size (mm) | Roadway Corridor Drainage Area[1] (ha) | Existing Impervious Area (ha) | Existing Imperviousness (%) | Proposed Impervious Area (ha) | Proposed Ballast Area[2] (ha) | Proposed Imperviousness (%) | Diff. Area (ha) | Diff. Imperviousness (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Fairview Park Mall | 10±175 | F2b | 4.2 | Sewer | Unknown | 0.61 | 0.44 | 72 | 0.61 | --- | 100 | 0.17 | 28 |
| 2 | Hidden Valley Creek | 11±180 | F2b | 4.5 | Culverts C1 and C2 | --- | 2.59 | 0.46 | 18 | 2.24 | --- | 86 | 1.78 | 69 |
| 3 | Hofstetter Creek | 11±675 | F2b | 4.6 | Culvert C3 | --- | 0.26 | 0.09 | 35 | 0.22 | --- | 85 | 0.13 | 50 |
| 4 | Freeport Creek | 12±430 | K3b | 4.8 | Creek | --- | 1.98 | 0.03 | 2 | 1.87 | --- | 94 | 1.84 | 93 |
| 5 | King St. / Highway 8 | 13±600 | N | 4.11 | Swale | --- | 1.26 | 1.06 | 84 | 1.26 | --- | 100 | 0.20 | 16 |
| 6 | Deer Ridge Drive | 13±875 | N | 4.12 | Sewer | 375 | 0.38 | 0.36 | 95 | 0.38 | --- | 100 | 0.02 | 5 |
| 7 | Sportsworld Crossing Road | 14±080 | N | 4.12 | Sewer | 600 | 2.19 | 2.05 | 94 | 2.19 | --- | 100 | 0.14 | 6 |
| 8[3] | Baxter Creek | 14±475 | N | 4.14 | Sewer | 1050 | 1.69 | 1.36 | 80 | 1.69 | --- | 100 | 0.33 | 20 |
| 9 | near Tulane Street | 15±040 | N | 4.15 | Sewer | 450 | 1.07 | 0.82 | 77 | 1.07 | --- | 100 | 0.25 | 23 |
| 10 | Limerick Drive | 15±275 | N | 4.16 | Sewer | 1050 | 0.15 | 0.15 | 99 | 0.15 | --- | 100 | 0.00 | 1 |
| 11 | 401 west on ramp | 15±650 | N | 4.17 | Swale | --- | 1.29 | 0.94 | 73 | 1.29 | --- | 100 | 0.35 | 27 |
| 12 | 401 west off ramp | 15±650 | N | 4.17 | Swale | --- | 0.73 | 0.53 | 73 | 0.73 | --- | 100 | 0.20 | 27 |
| 13 | 401 underpass - north side | 15±860 | N | 4.17 | Sewer | 1200 | 0.38 | 0.27 | 71 | 0.38 | --- | 100 | 0.11 | 29 |
| 14 | 401 underpass - south side | 15±950 | N | 4.17 | Sewer | 750 | 1.76 | 1.41 | 80 | 1.76 | --- | 100 | 0.35 | 20 |
| 15 | Fountain Street South | 16±680 | N | 4.19 - 4.20 | Sewer | 825 | 1.99 | 1.56 | 78 | 1.99 | --- | 100 | 0.43 | 22 |
| 16 | Chopin Drive | 17±190 | N3e | 4.21 | Swale / Speed River | --- | 1.96 | 0.94 | 48 | 1.96 | --- | 100 | 1.02 | 52 |
| 17 | King St. East | 17±350 | N3e | 4.21 | Sewer | 900 | 1.05 | 0.95 | 90 | 1.05 | --- | 100 | 0.10 | 10 |
| 18 | Opposite William St. | 17±560 | N3e | 4.22 | Sewer / Speed River | 450 | 0.58 | 0.58 | 100 | 0.58 | --- | 100 | --- | 0 |
| 19 | Railway Spurline | 17±820 | N3e | 4.23 | Sewer | 750 | 0.23 | 0.01 | 6 | 0 | 0.23 | 15 | 0.02 | 9 |
| 20 | Railway Spurline | 18±350 | E2 | 4.24 | Swale / Speed River | --- | 0.71 | 0.01 | 1 | 0 | 0.71 | 15 | 0.10 | 14 |
| 21 | Railway Spurline | 18±560 | E2 | 4.25 | Swale / Speed River | --- | 0.53 | --- | --- | 0 | 0.53 | 15 | 0.08 | 15 |
| 22 | Railway Spurline | 18±980 | E2 | 4.26 | Swale / Speed River | --- | 0.04 | 0.01 | 35 | 0.01 | 0.04 | 40 | 0.00 | 5 |

| Outlet ID | Location | Approx. Chainage | Section | Exhibit No. | Existing Outlet Type | Existing Sewer Outlet Size (mm) | Roadway Corridor Drainage Area[1] (ha) | Existing Impervious Area (ha) | Existing Imperviousness (%) | Proposed Impervious Area (ha) | Proposed Ballast Area[2] (ha) | Proposed Imperviousness (%) | Diff. Area (ha) | Diff. Imperviousness (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 23 | Speedville Road | 19±020 | E2 | 4.26 | Sewer | 750 | 0.42 | --- | --- | --- | 0.42 | 15 | 0.06 | 15 |
| 24 | Railway Spurline | 19±370 | E2 | 4.28 | Swale / Speed River | --- | 0.53 | --- | --- | 0.53 | --- | 100 | 0.53 | 100 |
| 25 | Railway Spurline | 20±030 | E2 | 4.29 | Swale / Speed River | --- | 0.63 | 0.00 | 0 | 0.63 | --- | 100 | 0.63 | 100 |
| 26 | Langs Drive / Groff Mill Creek | 21±600 | C2 | 4.33 | Sewer | 2100 | 4.81 | 3.14 | 65 | 4.39 | --- | 91 | 1.25 | 26 |
| 27 | Bishop Street North / Groff Mill Creek | 22±325 | C2 | 4.35 | Sewer | 2440 | 3.79 | 3.23 | 85 | 3.35 | --- | 88 | 0.12 | 3 |
| 28 | Dunbar Road / Groff Mill Creek | 22±850 | C2 | 4.36 | Sewer | 1800 | 3.7 | 3.06 | 83 | 3.24 | --- | 88 | 0.18 | 5 |
| 29 | Hespeler Road / Water Side Ave (1600 mm-Grand River) | 24±525 | C2/S2a | 4.41 | Sewer | 1500 | 3.92 | 2.99 | 76 | 3.85 | --- | 98 | 0.86 | 22 |
| 30 | Dundas St. / Beverley St. Intersection / Mill Creek | 26±100 | S2a/S3d | 4.45 | Sewer | 1050 | 1.64 | 0.05 | 3 | 0.11 | 1.65 | 22 | 0.31 | 19 |
| 31 | Main Street / Mill Creek / Grand River | 27±000 | T2 | 4.47 | Mill Creek Galt Box Culvert | 6.1 m x 3.1 m x 600 m | 1.51 | 0.78 | 52 | 0.78 | 0.78 | 59 | 0.11 | 7 |
| 32 | Ainslie Street / Bruce Street | 27±430 | T2 | 4.48 | Sewer | 450 | 1.30 | 1.04 | 80 | 1.30 | --- | 100 | 0.26 | 20 |
| 33 | Water St. South / Bruce St. | 27±550 | T2 | 4.48-4.49 | Sewer | 600 | 0.34 | 0.26 | 76 | 0.34 | --- | 100 | 0.08 | 24 |
| | | | | | | **TOTAL / AVERAGE:** | **46.02** | **28.58** | **62** | **39.85** | **4.31** | **88** | **12.01** | **26** |

[1] Areas are approximate and do not include contributing areas outside the road corridor. Detailed analysis required in the next design phase.

[2] The ballasted tracks are assumed to have a runoff coefficient of 0.3 (approximately 15% imperviousness)

[3] This outlet was investigated in 2012 by the City of Kitchener. The outlet was built originally as a twin storm sewer, one sewer belonging to the City, the other one to the Region of Waterloo. Both sewers are in poor condition and would require further assessment and replacement at the next design phase.

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# 6 FLOODPLAIN MANAGEMENT

## 6.1 Floodplains

The proposed LRT route passes through the floodplains of the Grand River, Speed River, Groff Mill Creek, Mill Creek and Downtown Cambridge Galt City Centre Special Policy Area. The approved regulatory floodline extents are provided by the GRCA and shown in **Exhibits 6.1** through **6.9**. Within the project limits, the floodplain is based on the greater of the Regional storm (Hurricane Hazel) or the 100-year storm as established by the GRCA.

The Speed River and Groff Mill Creek floodplain areas have been delineated into two-zones of Flood Fringe and Floodway. In a past meeting, the GRCA indicated that a portion of Mill Creek is identified as a candidate for the two-zone flood approach and may be delineated in a future study if required and pursued by the City of Cambridge. During a flood event, Flood Fringe areas will have lower velocities and shallower depths while Floodway areas will have higher velocities and higher depths.

The proposed development works consist of two new bridge crossing structures, the Grand River Bridge and Speed River Bridge. In addition to the two bridge crossing structures, the proposed works associated with the LRT are within the regulated floodplains of Groff Mill Creek and Mill Creek. These works will require a GRCA work permit under O.Reg. 150/06. The proposed works should not adversely impact the regulated floodplain areas and any increase in the upstream flood elevation resulting from the construction of a new or rehabilitated structure or associated works should be kept to a minimum (≤ 0.1 m) to prevent increased flood risk to upstream properties. An increase in flood elevation of ≤ 0.1 m is considered to be within the accuracy of the modelling.

## 6.2 Historical Flooding

### 6.2.1 City of Kitchener

The Integrated Stormwater Management Master Plan (Aquafor Beech, 2016) for the City of Kitchener was reviewed to determine historical flooding and inundation within the study area. It is noted within the Aquafor Beech report that there were three historical storm events that surcharged the sewer system which caused "…over 100 reports of basement flooding due to backup of water through the floor drains or plumbing, etc." These storm events occurred on August 4, 2009 (3 hours, 36.1 mm of rainfall, 70.1 mm/hr peak intensity), October 23, 2010 (data not available), and June 28, 2013 (12 hours, 53.6 mm of rainfall, 12.2 mm/hr peak intensity). Areas within or near to the study limits that were reported being impacted by the June 28, 2013 storm events include:

- Fairway Road South and Wabanaki Drive
- Fairway Road South and Wilson Avenue (west of Wabanaki Drive)
- Hidden Valley Drive and Hidden Valley Creek (near the Grand River outfall point)

Other areas impacted by one or more of these significant storm events fall further outside of the study limits, therefore it is not expected that the proposed works will be impacted by these areas or vice versa. The proposed LRT route is located in close proximity to the Fairway Road South and Wabanaki Drive intersection, however it is elevated on a bridge structure crossing Fairway Road. A portion of stormwater flows from the LRT tracks are ultimately directed into the trunk storm sewer at this intersection, therefore it will be imperative to perform a capacity analysis on this system at the next design phase to ensure sizing is adequate to convey the required flows and avoid surcharging and inundation of the storm sewer system and proposed LRT system during major storm events.

No previous flooding events were identified along King St. East.

### 6.2.2 City of Cambridge

The Stormwater Management Master Plan (Amec, 2011) for the City of Cambridge was reviewed to determine historical flooding and inundation within the study area. Drawing 1, "Historic Flooding Location Plan" within the Amec report identifies 108 sites within Cambridge where flooding was observed and documented historically. These locations are categorized by the type of flooding that was experienced and whether the flooding occurred in 2008 or prior to this year. The proposed LRT track alignment was superimposed with Drawing 1 to identify potential problem areas within or very near to the study limits. These areas were extracted and are summarized below:

**Basement Flooding:**

- In the subdivision east of Hespeler Road at Munch Avenue (Node 79, 2008). A section of the proposed LRT track is located west of this area. The storm sewer along Munch Ave. is connected to the Hespeler Rd. storm sewer system.

**Surcharging:**

- There were no areas with flooding due to surcharging within the study limits.

**Street Flooding:**

- In the area of Elmwood Avenue, Norfolk Avenue, and Jarvis Street (Node 92, 2008). A section of the proposed LRT track is located just northeast of this area. A 300 mm diameter storm sewer takes drainage from the existing CP railway tracks to the Jarvis St. storm sewer system.
- At the Beverly Street and Kerr Street intersection (Node 105, 2008). A section of the proposed LRT tracks is located in this area. A 600 mm storm sewer conveys stormwater from the Beverly St. and Kerr St. area and discharges to Mill Creek.

**Private Property Surface Flooding:**

- In the subdivision at Eagle Street South and Queenston Road (Node 31, Pre-2008). The proposed ION Preston station is proposed within this area.

**Miscellaneous Flooding:**

- In the area of Chopin Drive, a portion of Hamilton Street, and the Speed River (Node 55, Pre-2008). The proposed Speed River bridge crossing and ION Preston station are located east of this area.
- Along Water Street and a portion of Warnock Street, near to Bruce Street (Node 48, Pre-2008). The proposed ION Downtown Cambridge station at Bruce Street is just south of this area.

A capacity analysis of the problem areas that fall within the study limits will be conducted during the next design phase to ensure sizing is adequate to convey the required flows and avoid surcharging and inundation of the storm sewer system and proposed LRT system during major storm events.

## 6.3 Hydraulic Analysis

To assess the impacts of the proposed works on the existing floodplains, a hydraulic analysis was conducted for the Grand River, Speed River, Groff Mill Creek and Mill Creek. Hydraulic models for these watercourses were provided by the GRCA. WSP reviewed and updated the existing hydraulic models to reflect the proposed ION alignment and stations. The various data sources used to update the existing models are shown in **Exhibit 6.1**. It should be noted that bathymetric or field surveys were not conducted for these watercourses. Channel geometries as per original GRCA models were utilized in the analyses. If additional cross-sections were required along the watercourse, channel geometry was interpolated from the existing model for that cross-section. Further confirmation is required through field and bathymetric surveys in the next design phase.

The impacts of the proposed works were assessed, and mitigation measures were proposed to reduce the flood risk. The floodplain hydraulic assessment for each area is discussed separately in the following sections.

All digital modelling files will be provided to GRCA along with this report.

### 6.3.1 Grand River

The proposed LRT route crosses the Grand River immediately downstream of the existing Highway 8 bridge. Freeport Creek crosses under Highway 8 approximately 250 m south of the existing Highway 8 bridge through a concrete box culvert C4 (1.45 m x 1.14 m). The regulatory floodplain at the proposed crossing location is approximately 750 m wide and covers the provincially significant wetlands (PSW).

Different alternative designs were evaluated for the proposed LRT Bridge B1 crossing. Based on cost effectiveness and minimal impact to the environment, a 1.46 km long bridge is proposed. The proposed bridge spans the main channel and crosses the entire valley. The preliminary General Arrangement (GA) drawings of the proposed bridge are included in **Appendix B-1**.

A HEC-RAS hydraulic model was provided by the GRCA covering the proposed crossing area. Additional cross-sections were added to depict the existing conditions and the proposed bridge was incorporated in the model. The results of the hydraulic analysis are summarized in **Table 6-1**. The existing and proposed floodplains are shown in **Exhibit 6.2** and detailed modelling output and graphs are provided in **Appendix B-2**.

The results indicate that the proposed bridge will not be overtopped during the Regional storm event and will have a freeboard and clearance of >1.0 m during the 100-year storm event, therefore meeting the applicable hydraulic criteria. The proposed bridge will cause an increase in the Regional flood elevation by 0.09 m immediately upstream of the proposed bridge. However, this rise in elevation diminishes upstream of the King Street Bridge at Freeport. The increase in flood elevation is within the prescribed GRCA limits (≤0.1 m) and no adverse impacts are anticipated.

**Table 6-1: Grand River Crossing – Existing and Proposed Flood Elevations**

| River Station | Plan | WSE Ex. (m) | WSE Ex. (m) | WSE Prop. (m) | WSE Prop. (m) | Difference in WSE (m) (Prop – Ex.) | Difference in WSE (m) (Prop – Ex.) |
|---|---|---|---|---|---|---|---|
| | Structure | 100-Year | Regional | 100-Year | Regional | 100-Year | Regional |
| 43 | | 288.01 | 288.82 | 288.03 | 288.82 | 0.02 | - |
| 42.5 | Railway Bridge at Freeport | | | | | | |
| 42 | | 287.94 | 288.76 | 287.96 | 288.76 | 0.02 | - |
| 41 | | 287.97 | 288.8 | 287.99 | 288.8 | 0.02 | - |
| 40 | | 287.85 | 288.66 | 287.87 | 288.66 | 0.02 | - |
| 39.5 | King St. Bridge at Freeport | | | | | | |
| 39 | | 287.82 | 288.2 | 287.84 | 288.23 | 0.02 | 0.03 |
| 38 | | 287.81 | 288.19 | 287.83 | 288.22 | 0.02 | 0.03 |
| 37 | | 286.8 | 287.12 | 286.85 | 287.18 | 0.05 | 0.06 |
| 34.5 | Bridge – Hwy. 8 | | | | | | |
| 34 | | 286.46 | 286.72 | 286.54 | 286.81 | 0.08 | 0.09 |
| 33.6 | | 286.49 | 286.76 | 286.57 | 286.85 | 0.08 | 0.09 |
| 33.5 | Prop. LRT Bridge | | | | | | |
| 33.4 | | 286.46 | 286.73 | 286.5 | 286.77 | 0.04 | 0.04 |
| 33.3 | | 286.52 | 286.8 | 286.52 | 286.8 | - | - |
| 33.2 | | 286.36 | 286.62 | 286.36 | 286.62 | - | - |
| 33 | | 286 | 286.24 | 286 | 286.24 | - | - |

### 6.3.2 Speed River

The section of the Speed River within this study area has unique hydraulic characteristics. The flow in the Speed River is historically conveyed through three parallel channels including the Speed River (main channel), the Dover Flour mill race channel and Sulphur / Silver Creek from east to west. The mill creek race channel which was used for hydropower is no longer in operation. The main channel passes through a series of three main hydraulic structures from north to south: Riverside Dam, the CP Railway Bridge and the King Street East Bridge. The Sulphur / Silver Creek originates from the Toyota Motor Manufacturing Canada property on the north of Highway 401 and flows through Riverside Park. The creek picks up the split flow from the Speed River within Riverside Park and flows for approximately 650 m before the confluence of Silver Creek and the Speed River.

The original HEC-2 model provided by GRCA was converted to HEC-RAS and some cross-sections were updated according to the 0.5 m interval contours and the proposed LRT grading surface. A few cross-sections (No. 1050, 830, 740 and 728) were added to properly represent the proposed bridge. Cross-sections No. 3242 through 754 were updated using the 3D surface generated from the proposed LRT profile. It should be noted here that field or bathymetric surveys were not conducted at this stage and the river channel geometry as per original model was used or interpolated.

In the HEC-RAS model, the Speed River (main channel) upstream from King Street East is coded as River 1 Reach 1 and the Speed River downstream from King Street East is coded as River 1 Reach 2. The Silver Creek channel is coded as River 2 and the mill race channel is coded as River 3. The three channels merge at Cross-Section No. 906 and the proposed LRT bridge is located between two bounding Cross-Sections 754 and 728.

For the divided flows, rating curves were developed in the 1992 Floodline Mapping Study report by Paragon Engineering Limited and in the HEC-RAS model. The elevations of the rating curves range from 270 m to 276 m and cover all flood elevations of the 2, 5, 10, 20, 50, 100-year and the Regional Storm.

The proposed LRT route crosses the Speed River south of existing King St. E bridge and then runs easterly and parallel along the Speed River for about 3 km. The proposed bridge crossing and LRT alignment along Eagle St. N and the unused railway spurline are located within the GRCA regulated floodplain. The Speed River floodplain near King St. E is divided into two-zones, Floodway and Flood Fringe. The proposed ION Preston station and a segment of the LRT route along Eagle St. N is in the Flood Fringe zone as shown on **Exhibit 6.3.** The LRT alignment along the unused railway spurline is in the one-zone floodplain area as shown in **Exhibit 6.4**.

The proposed LRT Bridge crosses the Speed River and associated floodplain on the southern side diagonally. The traditional modelling approach with cross-sections aligned at the upstream and downstream faces of the bridge does not represent the flood elevations properly. Therefore, in consultation with GRCA, existing cross-sections (986 and 754) were removed and new cross-sections (1012 through 1016 and 801 through 811) were drawn perpendicular to the stream lines / contours as shown on **Figure 6.3**. The channel bottom geometry was interpolated from existing GRCA model as no bathymetric survey was conducted as part of this study. The cross-sections were spaced in such a way that each pier of the bridge is intersected and modelled as blocked obstruction. The bridge deck is above the Regional water surface elevation and was not coded as bridge structure in the model.

The hydraulic analysis results are summarized in **Table 6-2**. The results indicate that the proposed bridge will cause an increase of 0.02 m in the Regional flood elevation immediately upstream of the bridge and is within the GRCA acceptable limits (≤ 0.1 m). However, this would require further detailed assessment through 2D hydraulic modelling to assess the impact on the existing properties.

**Table 6-2: Speed River Crossing – Existing and Proposed Flood Elevations**

| | Plan | Ex. WSE (m) | Ex. WSE (m) | Prop. WSE (m) | Prop. WSE (m) | Difference in WSE (m) (Prop – Ex.) | Difference in WSE (m) (Prop – Ex.) |
|---|---|---|---|---|---|---|---|
| **River Station** | **Structure** | **100-Year** | **Regional** | **100-Year** | **Regional** | **100-Year** | **Regional** |
| 3242 | | 277.26 | 278.37 | 277.26 | 278.37 | 0 | 0 |
| 3086 | | 277.15 | 278.3 | 277.15 | 278.3 | 0 | 0 |
| 3046 | | 276.87 | 278.12 | 276.87 | 278.12 | 0 | 0 |
| 3044 | | 276.6 | 278.08 | 276.6 | 278.08 | 0 | 0 |
| 3034.5 | Speedsville Road Bridge | | | | | | |
| 3034 | | 276.45 | 277.4 | 276.45 | 277.4 | 0 | 0 |
| 3032 | | 276.52 | 277.4 | 276.52 | 277.4 | 0 | 0 |
| 2912 | | 276.04 | 276.62 | 276.04 | 276.62 | 0 | 0 |
| 2662 | | 275.17 | 276.18 | 275.17 | 276.18 | 0 | 0 |
| 2422 | | 274.89 | 275.99 | 274.88 | 275.99 | -0.01 | 0 |
| 2132 | | 274.23 | 275.42 | 274.23 | 275.41 | 0 | -0.01 |
| 1898 | | 273.88 | 275.23 | 273.86 | 275.2 | -0.02 | -0.03 |
| 1552 | | 273.74 | 275.19 | 273.71 | 275.17 | -0.03 | -0.02 |
| 1304 | | 273.71 | 275.16 | 273.7 | 275.15 | -0.01 | -0.01 |
| 1161 | | 273.63 | 274.95 | 273.63 | 274.95 | 0 | 0 |
| 1151.5 | Inl Struct (Riverside Dam) | | | | | | |
| 1151 | | 272.47 | 274.53 | 272.48 | 274.53 | 0.01 | 0 |
| 1145 | | 272.37 | 274.39 | 272.39 | 274.39 | 0.02 | 0 |
| 1144 | | 272.31 | 274.36 | 272.32 | 274.36 | 0.01 | 0 |

| River Station | Plan | Ex. WSE (m) | Ex. WSE (m) | Prop. WSE (m) | Prop. WSE (m) | Difference in WSE (m) (Prop – Ex.) | Difference in WSE (m) (Prop – Ex.) |
|---|---|---|---|---|---|---|---|
| | **Structure** | **100-Year** | **Regional** | **100-Year** | **Regional** | **100-Year** | **Regional** |
| 1140.5 | CP Railway Bridge | | | | | | |
| 1140 | | 272.24 | 273.8 | 272.25 | 273.82 | 0.01 | 0.02 |
| 1139 | | 272.26 | 273.82 | 272.27 | 273.84 | 0.01 | 0.02 |
| 1133 | | 272.26 | 273.83 | 272.28 | 273.85 | 0.02 | 0.02 |
| 1132 | | 272.26 | 273.81 | 272.27 | 273.82 | 0.01 | 0.01 |
| 1115.5 | King St. E Bridge | | | | | | |
| 1115 | | 272.26 | 273.4 | 272.27 | 273.42 | 0.01 | 0.02 |
| 1114 | | 272.29 | 273.49 | 272.3 | 273.5 | 0.01 | 0.01 |
| 1016 | | 272.24 | 273.4 | 272.25 | 273.41 | 0.01 | 0.01 |
| 1015 | | 272.17 | 273.33 | 272.18 | 273.35 | 0.01 | 0.02 |
| 1014 | | 272.05 | 273.11 | 272.06 | 273.15 | 0.01 | 0.04 |
| 1013 | | 272.01 | 272.99 | 272.03 | 273.03 | 0.02 | 0.04 |
| 1012 | | 272.12 | 273.21 | 272.13 | 273.25 | 0.01 | 0.04 |
| 906 | | 272.08 | 273.16 | 272.09 | 273.2 | 0.01 | 0.04 |
| 811 | | 272.09 | 273.16 | 272.1 | 273.19 | 0.01 | 0.03 |
| 810 | | 272.07 | 273.12 | 272.08 | 273.16 | 0.01 | 0.04 |
| 809 | | 272.07 | 273.12 | 272.08 | 273.15 | 0.01 | 0.03 |
| 808 | | 272.03 | 273.05 | 272.05 | 273.08 | 0.02 | 0.03 |
| 807 | | 272 | 273 | 272.01 | 273.01 | 0.01 | 0.01 |
| 806 | | 272 | 273.01 | 272.02 | 273.03 | 0.02 | 0.02 |
| 805 | | 271.96 | 272.95 | 271.97 | 272.97 | 0.01 | 0.02 |
| 804 | | 271.85 | 272.79 | 271.85 | 272.81 | 0 | 0.02 |
| 803 | | 271.8 | 272.7 | 271.79 | 272.69 | -0.01 | -0.01 |
| 802 | | 271.81 | 272.74 | 271.81 | 272.74 | 0 | 0 |
| 801 | | 271.79 | 272.72 | 271.79 | 272.72 | 0 | 0 |
| 516 | | 271.71 | 272.62 | 271.71 | 272.62 | 0 | 0 |
| 0.1 | | 270.55 | 271.51 | 270.55 | 271.51 | 0 | 0 |

The preliminary General Arrangement drawings for the proposed LRT crossing of the Speed River are included in **Appendix C-1**. The HEC-RAS modelling output files and graphs are included in **Appendix C-2**.

### 6.3.3 Groff Mill Creek

The LRT route crosses Groff Mill Creek that flows between Industrial Road and Hespeler Road, parallel to the two streets. The GRCA provided the Floodplain mapping and the Regulation Limits for the creek. In 2016, WSP conducted a study to assess the applicability of creating a two-zone floodplain policy area between Eagle Street and Dunbar Road. As a result, the Floodway and Flood Fringe were re-defined. The route was evaluated against the newly defined floodplain mapping.

The proposed LRT route first enters the Groff Mill Creek Floodway, the creek itself, and the Flood Fringe in the southwest quadrant of the existing CN spurline and Hespeler Road intersection. It then leaves the floodplain area for a short distance before merging with Hespeler Road and re-entering the Flood Fringe. After Hespeler Road and Sheldon Drive, the LRT route stays out of the floodplain area of Groff Mill Creek.

As a result, some cross-sections on the north side of Sheldon Drive were updated according to the 0.5 m interval contours and the proposed LRT grading surface. Cross-sections 4970 through 4667 were updated using a 3D surface generated for the proposed LRT profile. All other cross-sections in the HEC-RAS model remain unchanged.

There is an existing CSP arch culvert under the proposed LRT at the creek. The structure is at River Station 4775 between two bounding Cross-section 4782 and 4767. The centreline station of the structure was adjusted according to the bounding cross-sections.

Cross-section 4782 immediately upstream of the LRT crossing culvert was checked against the MTO design criteria (freeboard and HW/D). There is no clearance requirement for the closed-footing CSP arch culvert. The 50-year water surface elevation at the cross-section is 292.13 m. The upstream invert of the CSP culvert is 290.08 m and the rise is 2.27 m. The culvert is not overtopped during the Regional and 100-year storm events. The freeboard to the low-point is 1.63 m, which is greater than 1.0 m. The HW/D is 0.82, which is less than 1.5 as the design criteria. Therefore, the culvert meets both the freeboard and HW/D criteria.

Note that the 2D model during the Groff Mill Creek two-zone floodplain study (WSP, 2016) shows that the Regional storm inundate the proposed LRT station (at Cross-section 4889) with the flood depths up to 0.5 m. This is caused by the limited culvert capacity at Langs Drive, located downstream of the cross-section, resulting in backwater flows to the area. According to the HEC-RAS model, the 25 and 100-year flood elevations are 292.45 m and 292.99 m, which are below the proposed ION Pinebush station profile (approximately 293.00 m).

A summary of the results of the hydraulic analysis for the culverts is included in **Table** 6-3 below. Refer to **Exhibits 6.5** and **6.6** following this report for the cross-section locations and floodplain mapping.

**Table 6-3: Groff Mill Creek – Existing and Proposed Flood Elevations**

| River Station | Plan | Ex. WSE (m) | Ex. WSE (m) | Prop. WSE (m) | Prop. WSE (m) | Difference in WSE (m) (Prop – Ex.) | Difference in WSE (m) (Prop – Ex.) |
|---|---|---|---|---|---|---|---|
| | **Structure** | **100-Year** | **Regional** | **100-Year** | **Regional** | **100-Year** | **Regional** |
| 4970 | | 293.04 | 293.37 | 293.02 | 293.36 | -0.02 | -0.01 |
| 4889 | | 293.01 | 293.35 | 292.99 | 293.34 | -0.02 | -0.01 |
| 4816 | | 292.86 | 293.22 | 292.84 | 293.20 | -0.02 | -0.02 |
| 4805 | Culvert (upstream of Railway) | | | | | | |
| 4800 | | 292.46 | 292.70 | 292.44 | 292.68 | -0.02 | -0.02 |
| 4782 | | 292.44 | 292.69 | 292.42 | 292.67 | -0.02 | -0.02 |
| 4775 | Railway / LRT Culvert | | | | | | |
| 4767 | | 291.99 | 292.18 | 291.96 | 292.16 | -0.03 | -0.02 |
| 4667 | | 291.99 | 292.19 | 291.98 | 292.19 | -0.01 | 0 |

The HEC-RAS modelling output files and graphs are included in **Appendix D**.

### 6.3.4 Mill Creek

Within the study area, Mill Creek has an open channel (Dundas Street to Main Street) and a 600 m long and 6.1 m x 3.05 m underground box culvert (C11) from Main Street to the Grand River. The existing HEC-RAS model (provided by the GRCA) appears to be based on the 1992 HEC-2 model and converted to HEC-RAS in 2002. The 600 m long box culvert was modelled as an open channel. WSP reviewed the model and the following changes were made to the existing model in consultation with the GRCA:

— The 600 m box culvert was modelled separately in a PCSWMM hydrodynamic model as a closed conduit and the resultant head water elevations were used as downstream boundary conditions (known water surface elevations) for the Mill Creek HEC-RAS model at the Main Street cross-section.

- To assess the impact of the proposed LRT route located on the northwestern side of the creek and the proposed relocation of the Multi-use Path (MUP) to the southeastern side of the creek, the existing cross-sections were extended on both sides of the creek. It should be noted that field or bathymetric surveys were not conducted as part of this study and the channel geometry was maintained or interpolated as per original GRCA models. Further confirmation of the channel geometry and adjacent areas will be required in the next design phase.

The following sections summarize the hydraulic analysis of the Box Culvert and Mill Creek open channel. The HEC-RAS modelling output files and graphs are included in **Appendix E.**

#### 6.3.4.1 Hydraulic Analysis of Box Culvert – Main St. to Grand River

The as-built drawings of the Galt Box Culvert (C11) were obtained from the City of Cambridge and reviewed. The Galt Box Culvert consists of three main segments:

- Segment 1: 330 m long section at a slope of 0.66% under Wellington Street
- Segment 2: 38 m long section at a steep slope of about 12% - curved segment from Wellington St. to a private property
- Segment 3: 228 m long section at an average slope of 0.6% - from curved segment to the Grand River

A separate hydraulic model was developed using the PCSWMM modelling software package based on the existing HEC-RAS model and as-built drawings. Hydraulic simulations were conducted, and the results indicate that the last section (Segment 3) remains submerged during the 100-year and Regional storm event. This segment will be under pressure (due to high water levels in the Grand River) during the larger storm events, flood water will be flowing out (if there exists any CB or sewer connection) inundating the surrounding area of the proposed station. However, during the 5-year storm event, Segment 3 is not flowing under pressure and can accept minor flows from the surrounding area of the proposed LRT route and station.

Based on the preceding analysis, the existing culvert has enough capacity to convey the Regional and 100-year storm flows.

#### 6.3.4.2 Open Channel – Dundas St. to Main St.

This section consists of an open channel with three bridge / culvert crossings under Dundas St., Shade St. and Kerr St. The existing model shows that:

- Dundas St. is not overtopped during the Regional and 100-year storm events

- Shade St. is overtopped during the Regional and 100-year storm events
- Kerr St. is overtopped during the Regional storm event only
- The floodwater spills over Kerr St. and inundates the area on the northwestern bank (proposed location for the ION Main station area) as shown on **Exhibit 6.7** and **6.8**
- Flood water during the Regional storm is generally contained within the channel

The proposed works (LRT and MUP) were incorporated in the hydraulic model. The head water elevations (at the inlet of the existing Box Culvert) obtained from PCSWMM hydraulic analysis were used as boundary conditions for the HEC-RAS model. Hydraulic simulations were conducted to assess the impacts of the proposed works on the existing floodplain and the results are summarized in **Table 6-4**. The results indicate that the proposed works will not cause an increase in the Regional flood elevation. To reduce or avoid flooding of the proposed LRT station and associated tracks during the Regional storm, additional hydraulic analysis was conducted and briefly described below.

**Table 6-4: Mill Creek Water Surface Elevations**

| River Station | Ex. WSE (m) | Ex. WSE (m) | Prop. LRT WSE (m) | Prop. LRT WSE (m) | WSE Kerr St. Culverts Replaced by 9.76 m x 3.05 m Bridge | WSE Kerr St. Culverts Replaced by 9.76 m x 3.05 m Bridge | Diff. in WSE Prop. LRT (m) | Diff. in WSE Prop. LRT (m) | Diff. in WSE Prop. Kerr St. Bridge (m) | Diff. in WSE Prop. Kerr St. Bridge (m) |
|---|---|---|---|---|---|---|---|---|---|---|
| | 100-Year | Regional | 100-Year | Regional | 100-Year | Regional | 100-Year | Regional | 100-Year | Regional |
| 53 | 275.71 | 275.08 | 275.71 | 275.08 | 275.71 | 275.08 | 0 | 0 | 0 | 0 |
| 52 | 275.75 | 276.13 | 275.75 | 276.13 | 275.75 | 276.13 | 0 | 0 | 0 | 0 |
| 51 | 275.75 | 276.12 | 275.75 | 276.12 | 275.75 | 276.12 | 0 | 0 | 0 | 0 |
| 50 | 275.64 | 275.88 | 275.64 | 275.88 | 275.64 | 275.88 | 0 | 0 | 0 | 0 |
| 49.5 | Shade St. Culvert | | | | | | | | | |
| 48 | 275.19 | 275.67 | 275.19 | 275.67 | 275.19 | 275.67 | 0 | 0 | 0 | 0 |
| 47 | 273.48 | 275.71 | 273.48 | 275.69 | 273.48 | 275.45 | 0 | -0.02 | 0 | -0.26 |
| 46 | 274.34 | 275.70 | 274.34 | 275.68 | 274.34 | 275.42 | 0 | -0.02 | 0 | -0.28 |
| 45 | 274.11 | 275.63 | 274.11 | 275.61 | 274.11 | 275.22 | 0 | -0.02 | 0 | -0.41 |
| 44 | 274.16 | 275.62 | 274.16 | 275.59 | 274.16 | 275.22 | 0 | -0.03 | 0 | -0.4 |

| River Station | Ex. WSE (m) | Ex. WSE (m) | Prop. LRT WSE (m) | Prop. LRT WSE (m) | WSE Kerr St. Culverts Replaced by 9.76 m x 3.05 m Bridge | WSE Kerr St. Culverts Replaced by 9.76 m x 3.05 m Bridge | Diff. in WSE Prop. LRT (m) | Diff. in WSE Prop. LRT (m) | Diff. in WSE Prop. Kerr St. Bridge (m) | Diff. in WSE Prop. Kerr St. Bridge (m) |
|---|---|---|---|---|---|---|---|---|---|---|
| | 100-Year | Regional | 100-Year | Regional | 100-Year | Regional | 100-Year | Regional | 100-Year | Regional |
| 43 | 274.11 | 275.58 | 274.11 | 275.56 | 274.12 | 275.17 | 0 | -0.02 | 0.01 | -0.41 |
| 42 | 274.01 | 275.59 | 274.01 | 275.57 | 274.01 | 275.05 | 0 | -0.02 | 0 | -0.54 |
| 41 | 273.92 | 275.49 | 273.92 | 275.46 | 273.92 | 274.93 | 0 | -0.03 | 0 | -0.56 |
| 40 | 273.61 | 275.44 | 273.61 | 275.41 | 273.61 | 274.73 | 0 | -0.03 | 0 | -0.71 |
| 39 | 273.39 | 275.42 | 273.39 | 275.39 | 273.40 | 274.64 | 0 | -0.03 | 0.01 | -0.78 |
| 38 | 273.37 | 275.43 | 273.37 | 275.39 | 273.38 | 274.65 | 0 | -0.04 | 0.01 | -0.78 |
| 37 | 273.36 | 275.42 | 273.36 | 275.39 | 273.37 | 274.65 | 0 | -0.03 | 0.01 | -0.77 |
| 36 | 273.32 | 275.42 | 273.32 | 275.38 | 273.33 | 274.62 | 0 | -0.04 | 0.01 | -0.8 |
| 35 | 273.28 | 275.41 | 273.28 | 275.37 | 273.29 | 274.60 | 0 | -0.04 | 0.01 | -0.81 |
| 34 | 273.24 | 275.40 | 273.24 | 275.36 | 273.25 | 274.57 | 0 | -0.04 | 0.01 | -0.83 |
| 33 | 273.15 | 275.28 | 273.15 | 275.24 | 273.16 | 274.36 | 0 | -0.04 | 0.01 | -0.92 |
| 32 | 273.14 | 275.23 | 273.14 | 275.19 | 273.15 | 274.27 | 0 | -0.04 | 0.01 | -0.96 |
| 31.5 | Kerr St. Culvert S | | | | | | | | | |
| 31 | 273.14 | 274.24 | 273.14 | 274.24 | 273.12 | 274.22 | 0 | 0 | -0.02 | -0.02 |
| 30 | 273.10 | 274.21 | 273.10 | 274.21 | 273.10 | 274.21 | 0 | 0 | 0 | 0 |
| 29 | 272.89 | 273.96 | 272.89 | 273.96 | 272.89 | 273.96 | 0 | 0 | 0 | 0 |
| 28 | 272.56 | 273.60 | 272.56 | 273.60 | 272.56 | 273.60 | 0 | 0 | 0 | 0 |
| 27 | 272.49 | 273.55 | 272.49 | 273.55 | 272.49 | 273.55 | 0 | 0 | 0 | 0 |
| 26 | 272.39 | 273.46 | 272.39 | 273.46 | 272.39 | 273.46 | 0 | 0 | 0 | 0 |
| 25 | 272.02 | 273.04 | 272.02 | 273.04 | 272.02 | 273.04 | 0 | 0 | 0 | 0 |
| 24 | 271.54 | 272.50 | 271.54 | 272.50 | 271.54 | 272.50 | 0 | 0 | 0 | 0 |
| 23 | 271.67 | 272.70 | 271.67 | 272.70 | 271.67 | 272.70 | 0 | 0 | 0 | 0 |
| 22 | 271.35 | 272.35 | 271.35 | 272.35 | 271.35 | 272.35 | 0 | 0 | 0 | 0 |
| 21 | 270.82 | 272.37 | 270.82 | 272.37 | 270.82 | 272.37 | 0 | 0 | 0 | 0 |
| 20 | 270.32 | 272.40 | 270.32 | 272.40 | 270.32 | 272.40 | 0 | 0 | 0 | 0 |

* Under Ground Galt Box Culvert (Section 10 to 0.1) – Modelled in PCSWMM

#### 6.3.4.3 Kerr Street Bridge Replacement Options

The water surface profile and floodplain maps show that the proposed tracks and ION Main station will be flooded during the Regional storm event due to overtopping of the Kerr Street Bridge. The Kerr Street Bridge obstructs the flow and spills over to the northwestern side of the creek inundating the proposed LRT route and station area. The existing Kerr Street Bridge consists of twin box culverts built in 1979. To avoid overtopping of the bridge and inundation of tracks and station during the Regional storm, the following alternatives were evaluated:

- 10.98 m x 3.66 m Bridge
- 10.98 m x 3.05 m Bridge
- 9.76 m x 3.05 m Bridge

The hydraulic analysis results show that replacing the existing structure with the above single span bridges will avoid the overtopping of Kerr St. during the Regional storm event. This will eliminate the spilling of flood water, containing it within the main channel.

The LRT route and ION Main station (between Kerr St. and Main St.) is in the Regional floodplain but is well above the Level of Service (25-year flood) adopted by the Region for the system operation. The Kerr St. culverts were constructed about 40 years ago and appear to be in good condition. Replacement at this stage is not required to accommodate the proposed LRT project. However, if the Region considers its replacement for structural integrity / end of service life, then a single span bridge is recommended to avoid inundation of the proposed LRT route and station area.

### 6.3.5 ION Downtown Cambridge Station Area

The proposed ION Downtown Cambridge station is the southern terminal station, located on Bruce Street and the western bank of the Grand River. This area is in the regulatory storm floodplain area and is designated as a Galt City Centre Special Policy Area by the GRCA. Water up to and including the Regional storm is contained within the Grand River through the 3 m high embankments to avoid spill into the downtown and surrounding areas. However, this area appears to be flooded due to an upstream spill over from the Park Hill Road Bridge at the Grand River. A closer look at the Grand River HEC-RAS model shows that:

- Ground elevation at the proposed ION Downtown Cambridge station is 264.5 m and the top of the Grand River western embankment is 267.24 m
- The Reginal storm flood elevation near the ION Downton Cambridge station (cross-section 77) is approximately 266.96 m

- The 100-year flood elevation within the Grand River (cross-section 77): 266.62 m
- The 50-year flood elevation within the Grand River (cross-section 77): 266.16 m
- The 10-year flood elevation within the Grand River (cross-section 77): 265.03 m
- The 5-year flood elevation within the Grand River (cross-section 77): 264.32 m

The proposed ION station and surrounding area is serviced by a storm sewer network which collects storm runoff and directly discharges into the Grand River. Based on the existing hydraulic model and storm sewer network, in the absence of backflow preventer valves, the area will be flooded due to storm sewer back up from the Grand River even during the 10-year storm event (265.03 m). This requires further confirmation with the City of Cambridge / GRCA and detailed 2D hydraulic modelling at the next design phase. A summary of the water surface elevations at each bridge and downstream river stations are included in **Table 6-5** below. The water surface profiles are included in **Appendix F** for reference.

### Table 6-5: Water Surface Elevation in Grand River near Downtown Cambridge

| River Sta | RReg (2180) | N100 (2023) | N50 (1823) | N20 (1562) | MaxObs (1557) | N10 (1333) | N5 (1044) | GTOcap (580) | 10ffa | 100ffa | Jan-2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 80.15 | Main Street Bridge | | | | | | | | | | |
| 80 | 267.05 | 266.72 | 266.28 | 265.71 | 265.7 | 265.17 | 264.45 | 263.05 | 263.77 | 265.12 | 264.78 |
| 79 | 266.93 | 266.61 | 266.18 | 265.62 | 265.61 | 265.1 | 264.39 | 263.02 | 263.73 | 265.04 | 264.72 |
| 78 | 266.89 | 266.56 | 266.13 | 265.56 | 265.55 | 265.04 | 264.33 | 262.97 | 263.67 | 264.98 | 264.66 |
| 77* | 266.96 | 266.62 | 266.16 | 265.57 | 265.56 | 265.03 | 264.32 | 262.95 | 263.65 | 264.98 | 264.64 |
| 76* | 266.92 | 266.57 | 266.11 | 265.53 | 265.51 | 264.99 | 264.28 | 262.92 | 263.62 | 264.93 | 264.6 |
| 75 | 266.92 | 266.57 | 266.12 | 265.54 | 265.53 | 265 | 264.29 | 262.92 | 263.63 | 264.94 | 264.61 |
| 74 | 266.86 | 266.51 | 266.07 | 265.49 | 265.48 | 264.96 | 264.26 | 262.9 | 263.6 | 264.9 | 264.57 |
| 73 | 266.85 | 266.51 | 266.06 | 265.48 | 265.47 | 264.95 | 264.25 | 262.9 | 263.59 | 264.9 | 264.57 |
| 72 | 266.88 | 266.53 | 266.08 | 265.5 | 265.49 | 264.97 | 264.27 | 262.91 | 263.61 | 264.91 | 264.58 |
| 71 | 266.67 | 266.34 | 265.9 | 265.35 | 265.34 | 264.83 | 264.16 | 262.85 | 263.52 | 264.78 | 264.46 |
| 70 | 266.6 | 266.26 | 265.82 | 265.27 | 265.26 | 264.76 | 264.1 | 262.81 | 263.47 | 264.7 | 264.39 |
| 69 | 266.57 | 266.23 | 265.79 | 265.23 | 265.22 | 264.72 | 264.06 | 262.78 | 263.44 | 264.67 | 264.36 |
| 68.3 | 266.58 | 266.24 | 265.8 | 265.25 | 265.24 | 264.74 | 264.08 | 262.79 | 263.45 | 264.68 | 264.37 |
| 68.15 | Concession Street Bridge | | | | | | | | | | |
| 68 | 266.04 | 265.81 | 265.5 | 265.07 | 265.06 | 264.65 | 264.04 | 262.77 | 263.43 | 264.6 | 264.33 |
| 67 | 265.99 | 265.75 | 265.44 | 265.01 | 265.01 | 264.59 | 264 | 262.75 | 263.4 | 264.55 | 264.28 |
| 66 | 265.74 | 265.52 | 265.25 | 264.86 | 264.85 | 264.47 | 263.91 | 262.7 | 263.32 | 264.42 | 264.17 |

*The proposed ION Downtown Cambridge station at Bruce St. is located between cross-sections 77 and 76.

# 7 STORMWATER MANAGEMENT

Within the project limits, the proposed LRT corridor occupies an area of approximately 46 ha. Under existing conditions, the corridor has 28.6 ha of impervious cover in the form of paved road surfaces and concrete sidewalks, with an overall imperviousness of 62%. The proposed LRT works and associated corridor widening will add another 12.5 ha impervious area, thereby increasing the corridor overall imperviousness to 88%.

The proposed works could impact the stormwater characteristics in terms of erosion, water quality and quantity, and would require appropriate mitigation measures. The following stormwater management strategy is proposed to reduce the potential impacts on erosion, stormwater quality and quantity (flooding).

## 7.1 Stormwater Management Strategy

To reduce the potential impacts of the proposed works, a treatment train approach is recommended that utilizes a combination of source, conveyance, and end-of-pipe practices. As discussed earlier, the majority of the on-street alignment have an existing sewer system that collects runoff and conveys it to the nearby outfalls except the Deer Ridge Drive and Sportsworld Crossing Road outlets that discharge to an existing SWM pond. This pond provides quality and quantity control. Due to the restricted road corridor, no additional ponds are proposed, and stormwater management is provided through the following measures.

## 7.2 Water Quantity Controls

Per the applicable stormwater management criteria, no quantity controls are required when stormwater is directly discharged into the Grand River and Speed River. However, quantity controls are required where corridor runoff is discharged to an existing outlet with restricted capacity to avoid surcharging of the system. Since detailed capacity assessment of the existing system will be carried out during the next design phase, a qualitative assessment methodology is used to evaluate the requirements for quantity controls.

As summarized in **Table 5-1**, the majority of the additional impervious area is added in the following sections:

- River Road, existing Hidden Valley Road (Section F2b) – 2.2 ha
- Grand River Crossing (Section K3b) - 1.9 ha
- King Street / Shantz Hill Road (Section N) – 2.5 ha

- Speed River Crossing (Section N3e) – 1.2 ha
- Hespeler Road (Section C2) - 2.5 ha
- Mill Creek Area (Section S2a & S3d) – 0.7 ha

Since River Road (F2b), the Grand River crossing (K3b), and the Speed River crossing (N3e) directly discharge into larger water bodies, no water quantity controls are required. The remaining LRT sections with potential quantity control requirements are discussed in the following sections. It should be noted that the following recommendations assume no additional drainage area is added to the existing storm sewer system due to the proposed LRT works and would require further confirmation at the next design phase.

### 7.2.1 King Street (Section N)

The entire section discharges to the existing sewer or ditch outfalls along King St. as summarized in **Table 4.1**. These outlets are numbered from Outlet 6 through Outlet 15. The corresponding change in imperviousness for each outlet is provided in **Table 5-2** and required quantity controls are briefly discussed below:

**Outlet 6 and 7:** Both outlets discharge to an existing SWM pond where quality and quantity controls are provided. The change in imperviousness for both outlets (5 to 6%) is minimal and no adverse impacts are anticipated for the existing SWM pond. However, capacity assessment of the existing sewers along Deer Ridge Drive and Sportsworld Crossing Road is required in the next design phase to assess its capacity under the proposed conditions.

**Outlet 9, 10, 13, 14 and 15:** All these outlets discharge to existing sewers and the corresponding change in impervious ranges from 20% to 29%. This may cause increase in peak flow rates that existing outlet sewers may not be able to accommodate. Depending on the capacity assessment to be undertaken in the next design phase of existing outlets under proposed conditions, quantity controls can be provided in the form of super pipes under the proposed LRT corridor. If space limitations and utility conflicts prove to be an issue and under ground storage pipes cannot be provided, then upsizing of the outlet sewers should be considered to avoid surcharging of the existing downstream system.

**Outlet 10 and 11:** The change in imperviousness for Outlet 10 appears to be insignificant (1%) and the existing 1050 mm dia. storm sewer along Limerick Drive may have the capacity to accommodate this additional flow. Outlet 11 (with 27% increase in imperviousness) discharges to an existing swale along the Highway 401 westbound lanes that ultimately discharges to the Grand River. Based on the assumption that the existing swale would have enough capacity to accommodate the additional flows without any adverse impacts, no quantity controls will be required.

### 7.2.2 Hespeler Road (Section C2)

The proposed LRT in this section is on-street alignment along the urbanized section of Hespeler Road. Storm runoff in this section is collected through the existing sewer system and discharged to Outlet 26 through 29. With the exception of Outlet 29, these outlets discharge into the Groff Mill Creek watercourse. The relevant change in imperviousness for Outlets 27 (Bishop Street North) and 28 ranges from 3 to 5% and associated increase in peak flows is considered minimal. For Outlet 26 (Langs Drive), approximately 1.25 ha of impervious area is added resulting in a 26% change in the overall imperviousness of the sewershed. This will increase peak flow rates and will require either quantity controls under the proposed LRT corridor or upsizing of the existing sewer system (2100 mm dia.) along Langs Drive. Similarly, for Outlet 29 (Hespeler Road and ultimately along Waterside Ave.), the change in imperviousness is 22%, which will cause a significant increase in peak flows and would require quality controls, if the existing system cannot accommodate the flows under proposed conditions.

### 7.2.3 Mill Creek Area (Section S3d)

The corridor in this section mainly consists of off-street alignment on ballasted tracks. The proposed drainage system consists of enhanced grass swales that will collect, treat and convey the storm runoff from the LRT trackway to Outlet 30 (Dundas St. N / Beverley St. Intersection) and Outlet 31 (Main St.). Due to ballasted tracks, the increase in imperviousness range from 19% (Outlet 30) to 7% (Outlet 31). Both outlets discharge to Mill Creek and no overall impacts are anticipated. However, as a result of the proposed concept drainage plan, Outlet 30 will receive additional runoff from the proposed LRT tracks through the new swales at the Dundas St. N and Beverly St. intersection. This may cause an increase in peak flow rates for the existing 1050 mm dia. storm sewer along Dundas St. N. This will require either quantity controls or an overflow structure to spill over the additional flows to avoid surcharging of the existing Dundas St. N sewer. The spill over flows could be conveyed through a new sewer or swale along the proposed LRT tracks and discharged into the Mill Creek.

## 7.3 Water Quality Controls

The proposed LRT works, and associated widening of existing roadway will increase the overall imperiousness of the corridor, and proposed works will potentially affect the storm runoff quality requiring mitigation measures. These mitigation measures include but are not limited to catchbasin inserts, oil grit separators (OGS) and low impact development best management practices. These measures should be further evaluated at the next design phase for site specific conditions and requirements.

### 7.3.1 Catchbasin Inserts

Catchbasin inserts are available in different forms and can be installed in new or existing (retrofit) structures. No such inserts are proposed at this stage but could be considered at the next design phase to enhance the water quality.

Depending on the type of catchbasin inserts, they may consist of simple screens or additional filtration media, to capture a wide variety of pollutants such as sediments, trash, debris, heavy metals and hydrocarbons. These inserts require regular maintenance as per manufacturer’s guidelines. The inserts used for capturing trash, debris and sediments can be cleaned out and reused. The inserts with filtration media would require routine replacement as per manufacture’s specifications.

### 7.3.2 Oil Grit Separators

Oil grit separators (OGS) capture litter, suspended sediment, free oils and greases (hydrocarbons), floatables and other pollutants attached to the particles. Removing fine particles from runoff ensures that the majority of the pollutants, such as hydrocarbons and heavy metals that adhere to particles, are captured and removed.

At the current design stage OGS units are proposed at the following locations, where new drainage outlets are introduced along the proposed route:

- Outlet 1: To treat runoff from the bridge crossing Fairway Road South and CP Rail
- Outlet 2: Hidden Valley Creek Outlet, this may require two units, one for the east and one for the west section
- Outlet 4: An OGS unit in combination with an enhanced grass swale to treat runoff from the 1.4 km long Grand River Bridge crossing, may require a single or two units (to be determined) at the next design phase
- Outlet 16: To treat runoff from the Speed River crossing and associated Preston station, in combination with an enhanced grass swale

In addition to the above new outlets, OGS units are recommended at the existing sewer outlets and should be considered in the next design phase to improve the water quality.

### 7.3.3 Low Impact Development Measures

A combination of Low Impact Development (LID) measures are proposed for the proposed LRT corridor to manage stormwater runoff as close to its source as possible. These measures include various LID Best Management Practices (BMPs) briefly described below.

#### 7.3.3.1 Permeable Sidewalks

Permeable sidewalks consist of pervious paving material underlain by a uniformly graded stone reservoir. The pervious surface may consist of pervious asphalt, permeable concrete, permeable interlocking concrete pavers, concrete grid pavers, or plastic grid pavers (CVC, TRCA, 2010). The openings in the interlocking concrete pavers, concrete and plastic grid pavers are filled with pea gravel, sand or top soil and grass to facilitate the infiltration of rainfall into the stone reservoir and ultimately into the underlying soil.

The proposed LRT corridor consists of sidewalks along the on-street alignment of River Road, King St. and Hespeler Road. The use of permeable sidewalk (where feasible along the route) will reduce the impervious cover, resulting in flow and runoff volume reduction and water quality enhancement.

#### 7.3.3.2 Enhanced Grass Swale

Enhanced grass swales or vegetated swales are vegetated open channels designed to convey, treat, attenuate and convey stormwater runoff to respective outlets. Check dams and vegetation in the swale reduces the flow velocity to allow sedimentation, filtration, evapotranspiration and infiltration into the underlying native soil (CVC, TRCA, 2010).

Enhanced Grass Swales with gravel check dams are proposed either stand alone or in combination with OGS units as a treatment train approach to collect, treat and convey the runoff. The proposed grass swales will have a flat bottom (0.5 m to 1 m) with a maximum 1V: 2H side slope or as per site specific conditions to suit the proposed grading and space requirements. At the current design stage swales are proposed at the following locations and would require further refinement at the next design phase:

- Outlet 4: Approximately 50 m long swale in combination with an OGS unit, to convey the bridge runoff to Freeport Creek
- Outlet 16: Approximately 80 m long swale, in combination with an OGS unit, to treat runoff from the Speed River crossing and associated ION Preston station
- Unused Railway Spurline: Approximately 2500 m long swales on both sides (total 5000 m long) of proposed ballasted track

- CP Railway / Mill Creek: Approximately 2200 m long swales on both sides (total 400 m long) of proposed ballasted track.

Based on the above, approximately 9.5 km long grass swales will be incorporated into the proposed LRT corridor for water quality treatment and conveyance of storm runoff.

#### 7.3.3.3 Bioretention

Bioretention is a stormwater filter and infiltration BMP which temporarily stores, treats and infiltrates runoff. Depending on the underlying soil infiltration characteristics and site-specific conditions, bioretention facilities may be designed for full infiltration (without an underdrain), partial infiltration (with an underdrain) and for filtration only (with an impermeable liner and underdrain). A typical bioretention facility consists of a filter bed (mixture of sand, fines and organic material), mulch ground cover and plants. The bioretention facilities are designed to capture small storm events to meet the water quality storage requirement and an overflow or bypass flow paths are provided to pass large storm events (CVC, TRCA, 2010). Bioretention may be provided in the form of bioretention cells, rain gardens, stormwater planters, extended tree pits and curb extensions.

The above forms of bioretention facilities could be provided under the sidewalks, landscaped zones, traffic islands and multiuse pathways. Runoff from the roadway will be collected through curb inlets and directed towards the bioretention areas and either conveyed to the sewer system through an underdrain pipe or infiltrated. Since the LRT trackway have its own segregated runoff collection and conveyance system flows cannot be directly discharged to such facilities. However, the roadway runoff can be collected through curb inlets and directed towards the bioretention areas and either conveyed to the sewer system through an underdrain pipe or infiltrated into the ground.

No such facilities are proposed at this stage for the proposed LRT corridor, however, opportunities along the corridor exist and should be further explored in the next design phase after conducting detailed investigations of existing underlying native soils, water table depth and underground utilities.

#### 7.3.3.4 Perforated Pipe Systems

Perforated pipe systems can be used in place of conventional storm sewer pipes, where topography, water table depth, and runoff quality conditions are suitable (CVC, 2010). Perforated pipes are underground stormwater conveyance systems designed as linear infiltration trenches or soakaways to convey and infiltrate stormwater runoff. The perforated pipe systems facilitate infiltration while conveying flows, attenuate runoff volumes and reduce pollutant loads to the receiving waters. Perforated pipes should be located below shoulders of roadways, pervious boulevards or grass swales for maintenance purposes. Depending on further investigations in the next design phase, perforated pipe systems could be considered for the new sewer pipes located under the landscaped zones or sidewalks in the proposed LRT corridor.

## 7.4 Water Balance Management

The proposed LRT works, and associated widening of existing roadway will increase the impervious cover of the LRT corridor and potentially impact the existing water balance. The LRT corridor pre-development water balance can be preserved by capturing and managing the rainfall at site though a combination of stormwater management measures including infiltration, evapotranspiration, landscaping and low impact development BMPs. The following components of the proposed SWM Plan may be used to maintain the corridor pre-development water balance:

- **Enhanced Grass Swales:** Approximately 9 km enhanced grass swales are proposed along the proposed LRT corridor which facilitate infiltration and evapotranspiration to maintain the corridor water balance.
- **Landscaped Zones:** Landscaped zones are being considered along Hespeler Road, River Road and other corridor areas which will facilitate infiltration and evapotranspiration, thereby retaining rainfall at source to enhance corridor water balance.
- **Bioretention Facilities:** LID BMPs (in the form of bioretention cells, rain gardens, stormwater planters, extended tree pits and curb extensions) could be considered to facilitate infiltration, evapotranspiration and retention of rainfall at site to main corridor water balance.

## 7.5 Sediment and Erosion Control Measures

Sediment and erosion control (ESC) measures will be implemented during all phases of construction, clean-up, and restoration to prevent sediment-laden runoff from entering any of the watercourses directly from the construction zone. The measures will include management of any residual flow or potential for flow in the watercourses where fish habitat was confirmed.

Uncontrolled erosion and sedimentation occurring during construction can result in a loss of topsoil, a disruption of nearby watercourses, and a degradation of downstream water quality. During construction, erosion and sedimentation control measures will be implemented to prevent the migration of soils from the site. The construction sediment and erosion control plan will be developed as part of the final design phase prior to construction, considering the following measures:

**Vegetative:**

- All areas not subject to active construction 30 days after area grading should be top soiled and seeded immediately after completion of such grading.
- Immediately following seed application, a straw erosion control blanket should be installed on any exposed slopes adjacent to sensitive features.

**Structural:**

- As construction proceeds, diversion swales should be graded where needed along the right-of-way boundaries to intercept drainage from external areas and direct it away from exposed surfaces.
- Temporary silt fencing and sedimentation traps should be placed around inlets and outlets from existing culverts in the drainage system.
- All culvert work should be conducted “in the dry”.
- Temporary silt fencing should be installed:
  - Around sensitive vegetative features
  - Approximately 2.0 m from the final toe-of-slope for any roadway embankment widening areas.
- Straw bale flow and rock checks should be provided in roadside ditches.
- Additional erosion control works may be required during the course of construction. These may consist of silt fences, swales, and/or diversion berms. The location and need for these works will be established in the field.
- The availability of mobile treatment units should also be considered at construction sites to handle sediment-laden water, if the proposed planned sediment and erosion control measures (silt fence/haybales etc.) become overwhelmed due to heavey storm events or otherwise.  This is especially important in the environmentally sensitive areas of Freeport and Hidden Valley where sediment deposition could be more detrimental and more difficult to restore.

The integration of these measures will minimize the impacts of erosion and sedimentation during construction.

# 8 CONCLUSIONS

This Preliminary Drainage and Stormwater Management Report is prepared in support of the proposed Stage 2 ION LRT from Kitchener to Cambridge, a distance of approximately 18 km. Field investigations and desktop assessment were completed to assess the existing and proposed drainage conditions of the LRT corridor. The impacts were evaluated, and a conceptual drainage plan was prepared as part of the proposed works. Based on the preceding analysis, the following conclusions and recommendations are made.

## 8.1 Surface Drainage

- The proposed LRT corridor consists of approximately 10 km on-street alignment and 8 km off-street alignment.
- The on-street alignment runs mainly along River Road and King St. E in the City of Kitchener, and Eagle St. N, Hespeler Road, Wellington Street and Bruce Street in the City of Cambridge.
- The off-street alignment mainly consists of the Grand River Crossing, the Speed River Crossing, along a currently unused CP railway spurline and a CN spurline, adjacent to an active CP railway line, and along an existing multi-use trail adjacent to Mill Creek.
- Under existing conditions, runoff from the existing road corridors is collected through a combination of sewers and ditches and then conveyed to different drainage outlets along the proposed LRT route. These outlets either discharge to existing sewer outfalls or nearby watercourses.
- The proposed LRT will add approximately 12.0 ha impervious cover, thereby increasing the corridor imperviousness from 62% to 88%.
- The existing drainage pattern is generally maintained except the two major river crossings (Grand River and Speed River) where runoff will be collected at bridge sag points, treated and conveyed to the respective rivers.
- Out of 33 drainage outlets, 21 drainage outlets discharge to existing sewer systems.
- Two outlets (Outlet 6- Deer Ridge Drive and Outlet 7 – Sportsworld Crossing Road) discharge to an existing SWM pond at Pioneer Road, no adverse impacts are anticipated to affect the functionality of the existing pond.
- Capacity assessment of the existing system was not conducted as part of this study and will be carried out in the next design phase. In addition, dual-drainage or 2D modelling is recommended for the LRT surface drainage system to determine

floodwater depths along the LRT tracks and roadway, and appropriately assess the capacity of the receiving system.

## 8.2 Watercourse Crossings

The proposed LRT corridor crosses various watercourses and requires:

- A new Grand River Bridge crossing
- A new Speed River Bridge crossing
- Crossing culverts under the currently unused Railway Spurline (Section E2) to convey flows across the tracks to Speed River. Sizes and location will be determined at the next design phase.
- Crossing culverts under ballasted tracks along Mill Creek (Section S3d) to convey drainage flows to Mill Creek, along Mill Creek to convey flows across the LRT tracks. Sizes and location will be determined at the next design phase.
- Extension of existing Culvert C1, C2, C3
- No extension required for culverts at Groff Mill Creek (C7), C8 and C9 under Hespeler Road

Hydrologic and hydraulic capacity assessment of the existing culverts (C1, C2, C3, C8 and C9) was not conducted at this stage and will require further assessment at the next design phase.

## 8.3 Floodplain Management

The proposed LRT route passes through the floodplains of the Grand River, Speed River, Groff Mill Creek, Mill Creek and Downtown Cambridge Galt City Centre Special Policy Area. To assess the impacts of the proposed LRT and associated works, hydraulic analysis was conducted as part of this study. The GRCA provided hydraulic models for the existing conditions and these were reviewed and updated. However, no field or bathymetric survey was conducted as part of this study. The results indicate:

### 8.3.1 Grand River

The proposed 1.46 km long bridge, crossing the entire valley including the wetlands and Freeport Creek, will have minimal impact on the existing floodplain. The proposed bridge will not be overtopped during the Regional storm and increase in flood elevation is within the prescribed GRCA limits (≤0.1 m). The proposed bridge will have a freeboard and clearance of >1.0 m during the 100-year storm event, therefore meeting the applicable hydraulic criteria. No separate culvert crossing is required for the Freeport Creek and will flow under the proposed bridge.

### 8.3.2 Speed River

The proposed LRT crosses the Speed River south of the existing King St. E bridge and then runs easterly and parallel along the Speed River for about 3 km. The Speed River floodplain has two-zones, Floodway and Flood Fringe. A 2D hydraulic model is recommended for the Speed River and associated floodplains in the next design phase. The main components of the proposed works within the Speed River floodplain are:

- **Bridge Crossing:** The hydraulic analysis indicates that the proposed bridge will not be overtopped during the Regional storm event and increase in Regional flood elevation is within the prescribed GRCA limits (≤0.1 m). However, further detailed assessment is required through 2D hydraulic modelling in the next design phase to assess the impact on existing properties. The proposed bridge will have a freeboard and clearance of >1.0 m during the 100-year storm event and meets applicable hydraulic criteria.
- **Proposed ION Preston Station Area:** The ION Preston station area is located within the Speed River Flood Fringe extents. This area is inundated from the spillage of flood water at the King St. E bridge crossing. The proposed ION Preston station and associated works do not cause an increase in Regional flood elevations. The proposed station is above the 100-year flood elevation and well above the 25-year flood elevation (Level of Service).
- **LRT route along Eagle St. N and unused Railway Spurline:** A portion of the proposed LRT route along Eagle St. N is located at the southern extents of the existing flood fringe (King St. E to CP Railway crossing). However, the proposed works will not cause an increase in existing flood elevations. The LRT route (275.6 m) is above the 100-year flood elevation (273.71 m) and well above the 25-year flood elevation.

  Similarly, the LRT route along the unused CP railway spurline will not impact the existing flood elevations. The LRT route from 18+300 to 19+200 is located at the southern limits of the Regional floodplain. The LRT route top elevation in this area ranges from 276.5 m to 278 m, while the Regional flood elevation ranges from 275.41 m (Cross sec. 2132) to 278.3 m (Cross sec. 3086), therefore it will not be under water during the Regional storm. It will be well above the 100-year flood elevation (274.23 to 277.16 m) and Level of Service flood elevation (25-year).

### 8.3.3 Groff Mill Creek

The proposed LRT route crosses Groff Mill Creek (Culvert C7) along the existing railway tracks. A portion of the LRT route and ION Pinebush station is located within the floodplain of Groff Mill Creek. The hydraulic analysis results indicate that the proposed works will not cause an increase in the existing flood elevations. The hydraulic model shows that floodwater within the vicinity of the LRT tracks and station is contained within the channel. However, due to limited capacities of Langs Drive and Bishop Street culverts, floodwater overtops these culverts and spills over to the adjacent areas. The Langs Drive culvert (located approximately 400 m south of the LRT station) is overtopped during the storm events equal to and exceeding the 10-year design storms. A review of the Groff Mill Creek two-zone floodplain study (WSP, 2016) shows that the Regional storm flood depths around the proposed ION Pinebush station and Hespeler Road ranges from 0 to 0.5 m. The study further recommended that if opportunities for the reconstruction arise, consideration be given to upgrading the existing culverts under Langs Drive and Bishop Street.

### 8.3.4 Mill Creek

The proposed LRT route runs parallel along Mill Creek from Dundas St. to Main St. where it becomes a closed conduit and discharges into the Grand River north of Bruce St. The proposed LRT works will not cause an increase in the existing flood elevations. A portion of the LRT route and proposed ION Main station area is in the GRCA regulated floodplain, created through the overtopping of Kerr St. culverts. However, floodwater is generally contained within the channel and the LRT route and ION Main station is well above the Level of Service (25-year flood) adopted by the Region for the system operation. The existing floodplain could be eliminated through the replacement of the existing Kerr St. Culverts with a single span bridge, if required, however this would be an undertaken separately from the LRT project.

### 8.3.5 ION Downtown Cambridge Station Area

The ION Downtown Cambridge station at Bruce St. is in the regulatory storm floodplain area and is designated as a Galt City Centre Special Policy Area by the GRCA. Although flood water within the Grand River (up to and including the Regional storm) is contained within the Grand River, this area is inundated due to potential spill over from the Park Hill Road Bridge at the Grand River. This area may also be flooded due to potential back water flows from the Grand River through the existing sewer system catchbasins. These backwater flows could be avoided through the installation of backflow preventer valves at the existing or new outfalls. This requires further confirmation with the City of Cambridge / GRCA and detailed 2D hydraulic modelling at the next design phase.

## 8.4 Stormwater Management

The proposed LRT works will increase the imperviousness of the existing corridor creating the potential to adversely impact the quality of stormwater runoff and increase the potential for erosion and flooding downstream. A stormwater management strategy has been developed to mitigate these potential impacts as summarized below:

### 8.4.1 Quantity Controls

No quantity controls are required for the outlets that discharge directly to the Grand River and Speed River. However, quantity controls will be required for the areas which discharge into an existing sewer with restricted capacity. Capacity assessment has not been conducted at this stage, and no quantity controls are proposed. This will require further review during the next design phase, and if required, quantity controls could be provided in the form of underground superpipes to provide peak flow attenuation.

### 8.4.2 Quality Controls

A treatment train approach has been adopted including an OGS unit and an enhanced grassed swale at the Grand River (Outlet 4) and Speed River (Outlet 15) crossing outlets. Due to site specific constraints, only OGS units are proposed at Outlet 1, 2 and 3 where enhanced grassed swales cannot be provided. Approximately 9.5 km long enhanced swales are proposed along the proposed ballasted tracks on both sides to treat the storm runoff. The proposed grassed swales will facilitate infiltration, evapotranspiration and enhance stormwater quality. Additional water quality measures such as OGS units at existing sewer outfalls, catchbasin inserts, low impact development BMPs such as permeable pavements, perforated pipe systems and bioretention areas should be further evaluated and considered at the next design phase.

## 8.5 Permits and Approvals

It is anticipated that the following permits and approvals will be required from the respective regulatory agencies to complete the work:

- A work permit will be required from the GRCA for all proposed works within the regulated areas under O. Reg. 150 / 06.

- An Environmental Compliance Approval (ECA) from the Ministry of Environment, Conservation and Parks (MECP) will be required for all storm sewers, OGS units, and stormwater treatment BMPs.
- At the permitting stage, a detailed site-specifc assessment of hydrologic impacts on regulated watercourse and wetland features will be required.