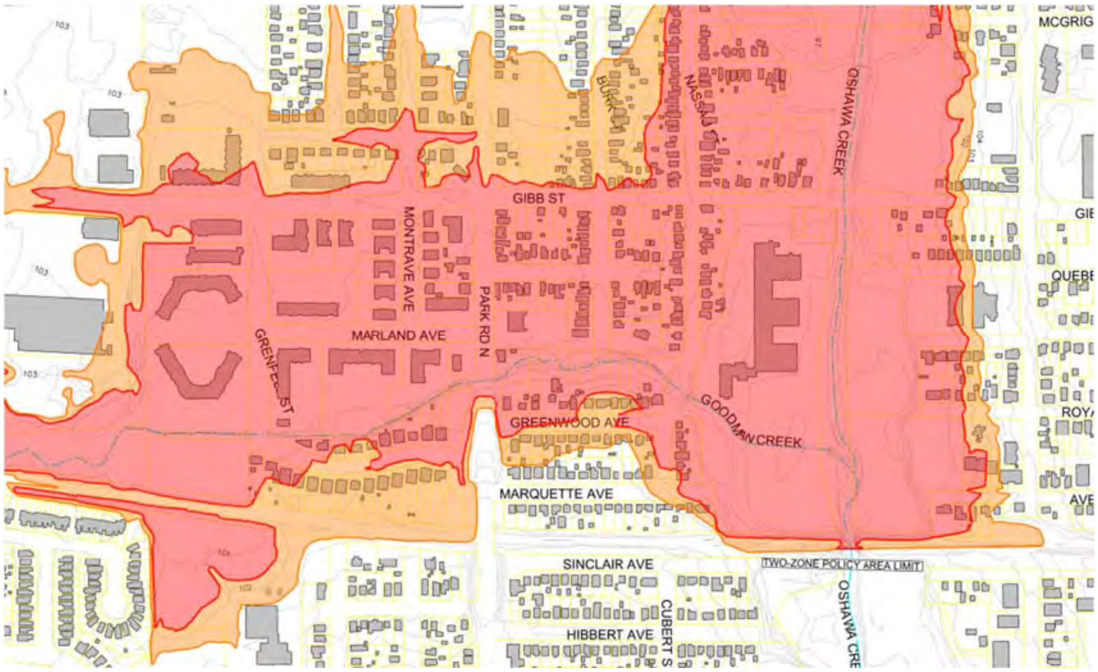
TWO-ZONE FLOODPLAIN MAPPING AND FLOOD MITIGATION STUDY

OSHAWA AND GOODMAN CREEKS

APRIL 22, 2021
PROJECT 18-543



PREPARED BY
Greck and Associates Limited
5770 Highway 7, Unit 3
Woodbridge, ON
L4L 1T8

PREPARED FOR
Central Lake Ontario Conservation Authority
100 Whiting Avenue
Oshawa, Ontario
L1H 3T3

City of Oshawa
50 Centre Street South
Oshawa, Ontario
L1H 3Z7

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Prepared by

LICENSED PROFESSIONAL ENGINEER
April 22,2021
S. M. SEXTON
100216608
PROVINCE OF ONTARIO

SIGNATURE

Scott Sexton, P.Eng

Reviewed and Approved by

LICENSED PROFESSIONAL ENGINEER
B. GRECK
17095407
April 22,2021
PROVINCE OF ONTARIO

B. Greck

SIGNATURE

Brian Greck, P.Eng

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EXECUTIVE SUMMARY

In the City of Oshawa significant flood hazards are known to exist along Oshawa Creek and Goodman Creek upstream of the Canadian Pacific Railway (CPR) embankment. The nature of the flood hazard in this area has been known for many years, and as such since 1997 the Central Lake Ontario Conservation Authority (CLOCA) has utilized a Two-Zone Flood Hazard Policy to regulate the flood risks in this area. As part of a Watershed Flood-Risk Assessment, completed in 2017 by CLOCA, the number of homes and businesses and the significance of this flooding was assessed in comparison to other known flood hazard areas. This flood hazard area was considered to be one of the most significant within CLOCA jurisdiction. The severity of flooding within this area is largely attributed to the limited flow capacity provided by the bridge and CPR embankment crossing downstream of the confluence of Goodman Creek with Oshawa Creek.

The goals of this study were to:

1. Update the delineation of the Two-Zone flood hazard area based on the latest hydrologic and hydraulic modelling for the Oshawa Creek watershed,
2. Assess the possible impacts associated with future land use and climate changes, and
3. Identify possible floodplain reduction solutions.

To define the flood fringe area (the area between the floodplain limit and the floodway) the limits of the floodway were examined using a variety of criteria. The floodway was delineated within the study area based on the limits of the 100-year floodplain, and provincial standards for safe flood depths, velocities, and depth-velocity product. It was determined that the majority of the study area's floodway can be defined by the depth of flooding. Due to severe backwater effects caused by the limited flow capacity at the CPR bridge, most of the floodplain has flow depths exceeding 1m with low velocities during the Regional storm event.

This study identified 712 buildings or structures at risk of flooding within the Two-Zone Policy area, of which 326 of the flooded buildings can be attributed to the limited flow capacity and obstruction to floodplain flow caused by the CPR bridge and embankment, respectively. The remaining 386 buildings are located within the natural floodplains of Oshawa and Goodman Creeks.

Most roads within the study area have limited safe ingress-egress, as flood depths are greater than 0.4m in almost all instances, especially west of the Oshawa Mall and south of John Street. The need for safe ingress and egress is particularly important in locations such as the Village Union Public School, located at Gibb Street and Nassau Street. Limited safe ingress/egress also exists along Goodman Creek upstream of Stevenson Road. However, the flooding situation in this part of the study area is more favorable compared to the Oshawa Branch (such as the Oshawa Centre) because alternative routes are available with only minor pockets of flood depths greater than 0.4m.

Unlike a One Zone Flood Hazard Policy, a Two Zone Flood Hazard Policy is not as strict, and some encroachment may be permitted into the flood fringe area. The potential for encroachment associated by development or redevelopment of the lands within the flood fringe was assessed by examining the effects on flood flow conveyance and storage. Encroachment within the entire flood fringe was found to have little impact on flood elevations or flood flows due to a loss in storage, except for a small area through Goodman Creek, north of Montcalm Avenue. The flood fringe area represents approximately 48 ha of existing developed land.

The effects of climate change were assessed to determine the extents of the expected 100-year floodplain in the future. It was determined that future 100-year floodplains will have no impact on the overall regulatory floodplain, however, will have minor impacts on the floodway through the Goodman Creek upstream of Gibb Street, as the floodway is often defined here by the 100-year floodline.

The effects of continued development of the Whitebelt area (3A land use Scenario) were investigated. The flooding impacts through the study area due to development of the Whitebelt lands were noted to be relatively minor, generally resulting in a maximum 8cm increase in flood elevations. Even though this increase may be relatively minor, due to the current severity of flood hazards in this area, CLOCA cannot accept any level of additional increase in flood risks.

To mitigate the potential impacts associated with flood increase caused by development of the Whitebelt area, two relief culvert structure scenarios were investigated at the CPR Embankment. The analyses concluded that either a 3.6m span by 3.0m rise box culvert or twin 2.7m diameter pipe culverts would offset the 8cm flood increase. These works however would not offer any flood relief to existing flood susceptible areas within the Two-Zone Policy Area. The estimated cost for these flood relief works is $1.08 and $1.10 million, respectively.

A stormwater management alternative for flood mitigation was also investigated in effort to reduce peak flows through the study area due to the development of the Whitebelt Area. Both the additional quantity storage volume and the area required to mitigate peak runoff from the 100-year to the Regional storm event was assessed through hydrologic modelling. An additional estimated cost of $7.7 million would be required for the Regional stormwater management works over the cost required for normal stormwater management works for typical storm events (i.e. 1-year to 100-year return period). This cost would only offset the 8cm increase associated with development of the Whitebelt lands and would have no additional benefits to the Two-Zone Policy area.

To reduce the existing level of flood hazard within the Two Zone Policy area, several flood reduction solutions were assessed, primarily by examining the benefits of a much larger secondary bridge opening through the CPR embankment. The resulting hydraulic and benefit-cost analysis concluded that a 30m span relief structure, located in the floodplain west of the existing opening, would be the optimum flood reduction solution. It was estimated that the 30m span structure would cost approximately $6.90 million and would remove 298 buildings from the floodplain. It is also noted that 386 buildings will remain within the natural floodplain of the valley. The flood reduction benefits offered by improvements to the CPR embankment are limited to reducing the Regional floodplain to the downstream side of Stevenson Road on Goodman Creek and the downstream side of John Street on Oshawa Creek.

Other flood reduction solutions considered included improvements downstream of the CPR Embankment, and upgrades to the Montcalm Avenue, Stevenson Road, Gibb Street and Cartier Street structures. The results demonstrated that Montcalm Avenue, Stevenson Road, Gibb Street, John Street and Cartier Street improvements would have little to no benefits to reducing the regulatory floodplain.

All flood reduction strategies were compared, and it was concluded that a second, large 30m span opening is the most effective flood reduction alternative, as it provides the highest level of benefit to cost ratio in comparison to other alternatives. While smaller flood relief structures result in lower overall capital costs, their overall benefits are minor as their main function is to bring 3A flood levels back to 2A conditions. These works only address a 8cm decrease in flood elevation and as such, only a few buildings become removed from the floodplain.

It was concluded that in lieu of providing Regional stormwater management through the Whitebelt Area, the costs for the flood prevention works during the Regional storm would be more appropriately spent on improvements at the CPR crossing of Oshawa Creek. These works would provide benefits to reducing existing flood risks in the Two zone policy area and offset the increases in flood hazard associated with development of the Whitebelt area lands.

The key recommendations offered by this study are as follows:

1. CLOCA and the City of Oshawa adopt the floodway and fringe areas defined by this study into an update of the current Two-Zone Policy for this area.

2. When the opportunity arises, the flow conveyance be increased at the CPR Embankment by adding a second 30m span bridge adjacent to the existing bridge to reduce the number of homes in the floodplain due to the CPR Embankment by ~90% and improve the overall ingress/egress viability for properties located within the Two Zone Policy Area.

3. The City should consider financial contributions from the development community to support CPR Embankment Improvements, as the benefit-costs for implementing Regional stormwater management control are not as cost effective in the Two-Zone Policy area for reducing the impacts caused by development of the Whitebelt Area. Potential increases in flooding within the Two-Zone study area associated with development of the 3A Scenario can be offset with flow conveyance improvements at the CPR Embankment.

    3.1. If there is an opportunity to improve the CPR Embankment, Regional Stormwater Management Control would not be required within the Whitebelt Area.

    3.2. If no CPR Embankment opportunities arise, Regional Stormwater Management should be imposed within the Whitebelt to ensure no adverse flood impacts occur to downstream Flood Damage Centers.

4. Any application to fill (encroach) within the flood fringe area must be accompanied by a hydraulic analysis to ensure no flood impacts occur to adjacent properties.

5. The Canadian Pacific Railway (CPR) and associated authorities (Metrolinx et al) should be advised of the importance of improving flood conveyance at this location. Opportunities to improve the crossing should be investigated in cooperation with the City of Oshawa, with all expansion, replacement, and improvement projects through this railway segment.

6. The City should investigate additional flood reduction strategies once the CPR Embankment improvements have been implemented. Such floodplain reduction strategies include, but not limited to improvements to bridges crossing Oshawa Creek on Gibb Street and John Street Bridge.

7. With respect to the Two-Zone area only, there should be no tolerance for increases in flood hazards caused by upstream development (Whitebelt Lands). This recommendation has no bearings on impacts due to peak flows outside of the Two-Zone Area.

TWO-ZONE FLOODPLAIN MAPPING AND FLOOD MITIGATION STUDY OSHAWA AND GOODMAN CREEKS

1.0 INTRODUCTION

In 2017, the Central Lake Ontario Conservation Authority (CLOCA) conducted a Watershed Flood Risk Assessment (WFRA) to determine the most at-risk to flood hazard watersheds within their jurisdiction. The WFRA study concluded that a significant number of homes and businesses are located within the regulatory flood hazard limit of the Oshawa and Goodman Creeks located upstream of the Canadian Pacific Railway (CPR) crossing of Oshawa Creek. More than 400 structures within the study area were identified in the WFRA study. The floodplain study area along Oshawa and Goodman Creeks are currently regulated by CLOCA using a Two-Zone flood hazard policy. This policy recognized the concepts of a floodway and flood fringe. The potential impacts of flooding in this area include the loss of public property, public safety concerns, and social and economic hardship for the property owners within this area.

Establishing policies for managing regulatory floodlines is an essential mandate by Conservation Authorities. Municipalities are generally delegated with the responsibility of identifying flood hazard lands and developing management plans to limit the public from the associated flood risks. As such, CLOCA and the City of Oshawa are undertaking this study with the goal of updating the delineation of the Two-Zone flood study area, identifying possible floodplain reduction solutions and assessing possible impacts associated with future land use and climate changes in the watershed.

Greck and Associates Limited (Greck) were retained to conduct the technical analyses required, prepare updated floodplain mapping and facilitate the public consultation process.

1.1 STUDY AREA

The study area is generally defined as the lands and watercourse located within the currently defined Two-Zone Policy Area, with the exception of additional lands on Oshawa Creek (from John Street to King Street West), see **Figure 1.1**. This study area includes land and watercourses within the regulatory floodplain:

- On Goodman Creek downstream of the online stormwater management pond upstream of King Street West to the confluence with Oshawa Creek; and
- On Oshawa Creek downstream of King Street West to the upstream side of the CPR embankment.

The current limit of the Two-Zone policy area on Oshawa Creek is located downstream of King Street West and closer to John Street West.

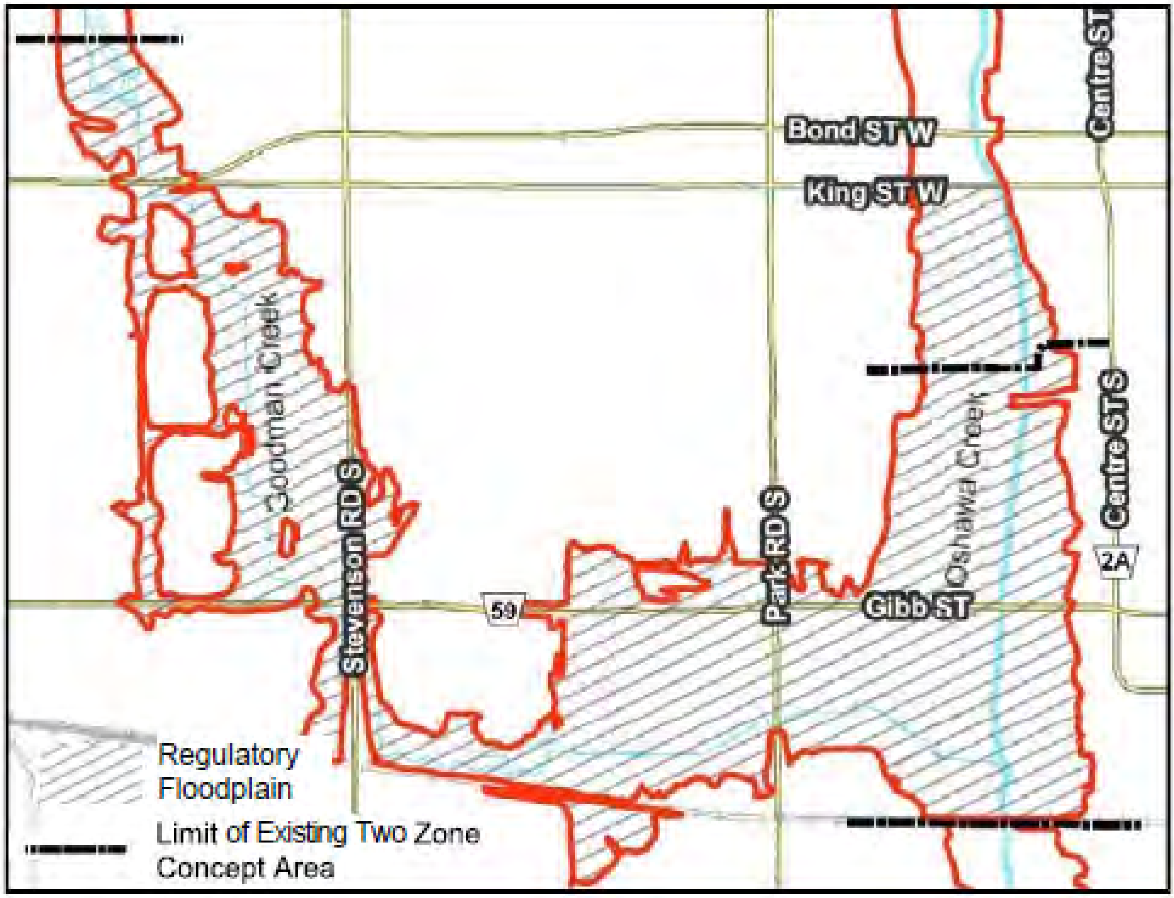

FIGURE 1.1: TWO-ZONE STUDY LIMIT

2.0 BACKGROUND INFORMATION

The development of flood management policy and the assessment of flood reduction solutions for the study area has evolved over time. The following study highlight key relevant background studies.

Preliminary Engineering Study, Oshawa Creek, Totten Sims Hubicki Associates Limited, May 1977

In 1979, a floodplain management policy was implemented to address the flooding concerns within the study area. This policy was based on increasing the opening through the CPR embankment which was believed to be the primary cause for the extensive floodplain area. A 100-year design storm bridge opening (100') was recommended to replace the existing CPR opening, however, the enlargement of the opening was never implemented due to significant cost constraints.

Two-Zone Flood Plain Study for a Reach of the Goodman Creek – Background Technical Document and Policy Recommendation, Rand Engineering Corporation, 1997

In 1997, a Two-Zone floodplain study was completed for a portion of the study area, located within the Goodman Creek regulatory floodplain, located upstream of the Grenfell Street watercourse crossing.

Two-Zone Flood Plain Study for Portions of the Goodman and Oshawa Creeks Immediately Upstream of the St. Lawrence and Hudson / CP Railway Embankment, Greck and Associates Limited, July 2005

In 2005, Greck and Associates Limited completed Phase 2 to the 1997 Rand Engineering study, to provide Two-Zone floodplain mapping and policy recommendations of the remaining study area, located downstream of Stevenson Road, Upstream of the CPR crossing and downstream of John Street.

Oshawa Creek Hydrologic and Hydraulic Modeling, CLOCA, August 2014

In 2014, CLOCA updated the regulatory floodplain mapping of the Oshawa Creek Watershed to determine official regulatory floodplain limits due to anticipated land-use changes within the City of Oshawa, Ontario. This study included updating hydrologic and hydraulic analyses of the overall watershed based on the future land-use changes proposed in the 2010 City of Oshawa Official Plan (OP), referred as the Future Conditions 2A: Full OP Build out (2A Scenario).

An additional scenario was completed to estimate the peak regulatory flows within the watershed due to the Future Conditions 3A: Full OP Buildout Plus White Belt Buildout

(3A Scenario). The 3A Scenario assumed the 2010 City of Oshawa Official Plan land-use, in addition to going beyond the foreseeable development limits within the Whitebelt Area (primarily agricultural land between the urban boundary and the Green Belt & Oak Ridges Moraine). The results of the study concluded a smaller flood hazard area in comparison to historical mapping.

Watershed Flood-Risk Assessment, CLOCA, April 2017.

The risk assessment identifies the Goodman Creek Flood Damage Center as the largest damage center in the CLOCA jurisdiction with more than 400 homes, businesses, and apartment complexes within the regulatory floodplain. This flood damage centre (FDC) has the greatest flood risk of all 92 FDCs in the CLOCA watershed. The potential depth and extent of flooding within this area would cause extensive structural damage to buildings, pose significant threat to public safety, and have high economic and social impacts.

2.1 DEFINITION OF TERMS

The fundamental concept of a Two-Zone floodplain policy is based on the nature of how watercourses flood within their floodplain area. A number of terms are used in this report which deal with these basic concepts. These terms are defined below. The definitions provided are those provided in the 2020 Provincial Policy Statement by the Ministry of Municipal Affairs and Housing (MMAH, 2020) and the Ontario Ministry of Natural Resources – Technical Guide – River and Stream Systems: Flooding Hazard Limit (MNR, 2002).

Floodplain: for a river stream, and small inland lake systems, means the area, usually lowlands adjoining a watercourse, which has been or may be subject to flooding hazards.

Flooding Hazard: means the inundation, under the conditions specified below, of areas adjacent to a shoreline or a river or stream system and not ordinarily covered by water. Along river, stream and small inland lake systems, the flooding hazard limit is the greater of:

1. The flood resulting from the rainfall actually experienced during a major storm such as the Hurricane Hazel storm (1954) or the Timmins storm (1961), transposed over a specific watershed and combined with the local conditions, where evidence suggests that the storm event could have potentially occurred over watersheds in the general area;
2. The 100-year flood; and
3. A flood which is greater than 1. or 2. which was experienced in a particular watershed or portion thereof as a result of ice jams and which has been

approved as the standard for that specific area by the Minister of Natural Resources and Forestry.

The exception is where the use of the 100-year flood or the experienced event has been approved by the Minister of Natural Resources and Forestry as the standard for a specific watershed (where the history of flooding supports the lowering of the standard).

One Zone Concept: is used by planning authorities to determine the flood hazards limit based on the 100-year flood or major storm-centered event and prohibits all development or site alteration within these boundaries. This is the most effective way of minimizing threats to public health or safety, or property damage. The one-zone concept is the preferred approach for the management of flooding hazards within river and stream systems as it provides the most cost-effective means of minimizing potential threats to life and risks of property damage and social disruption. Where the one zone concept is applied, the entire floodplain or flooding hazard limit defines the floodway. An example of the one zone concept is provided in **Figure 2.1**.

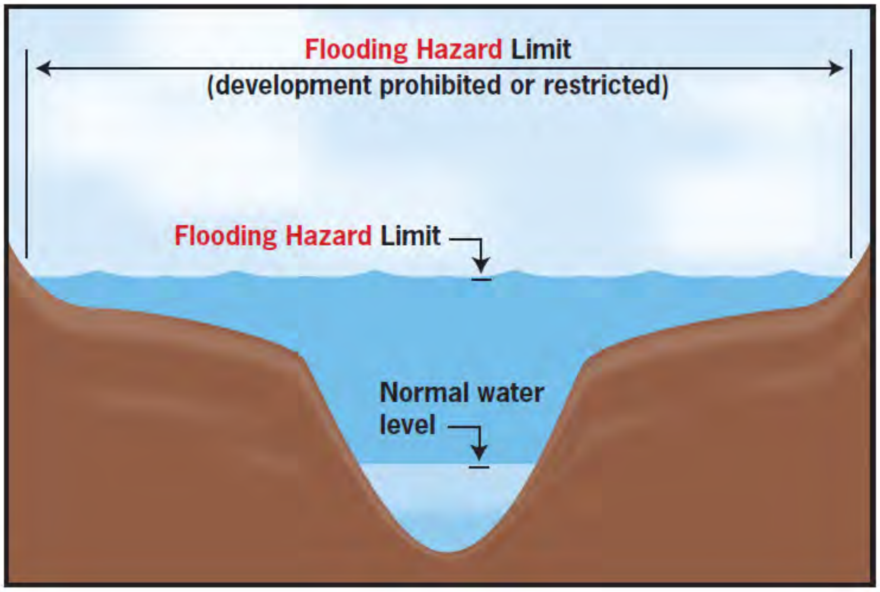

FIGURE 2.1: ONE ZONE FLOODPLAIN CONCEPT (MNRF, 2002)

Two-Zone Concept: Identifies the floodway and flood fringe. This concept is less restrictive than the One Zone Concept and allows some development and alterations to be considered within the overall floodplain. An example of the Two-Zone concept is provided in **Figure 2.2**.

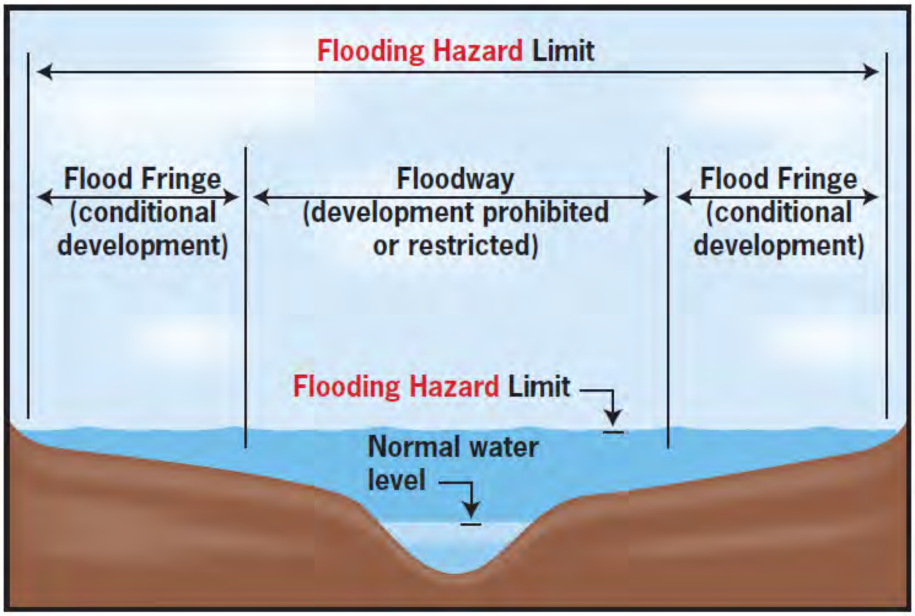

FIGURE 2.2: TWO-ZONE FLOODWAY-FLOOD FRINGE CONCEPT (MNRF, 2002)

Floodway: for river, stream and small inland lake systems, means the portion of the floodplain where development and site alteration would cause a danger to public health and safety or property damage.

Where the One-Zone concept is applied, the floodway is the entire contiguous floodplain.

Where the Two-Zone concept is applied, the floodway is the contiguous inner portion of the floodplain, representing that area required for the safe passage of flood flow and/or that area where flood depths and/or velocities are considered to be such that they pose a potential threat to life and/or property damage. Where the Two-Zone concept applies, the outer portion of the flood plain is called the flood fringe.

Flood Fringe: for river, stream and small inland lake systems, means the outer portion of the flood plain between the floodway and the flooding hazard limit. Depths and velocities of flooding are generally less severe in the flood fringe than those experienced in the floodway.

Ingress/Egress: in this study, these terms refer to the safe entry and exit to a building or property by a municipal roadway. Generally, if the flow depth exceeds 0.4 m then safe access by a private vehicle may not be possible. Emergency vehicles typically have an allowable flow depth of up to 1.0 m (MNRF, 2002).

3.0 SCOPE OF WORK

The following presents an overview of the scope of work completed in this study. In general, the accuracy and quality of the products prepared by this assignment are very important, as they update or redefine the limits for application of Ontario Regulation 42/06 within the Two-Zone Floodplain Management Policy area. This requires the use of detailed technical analyses to adequately update the limits of the flood hazard area. Public Consultation was also a critical component of this study and was done via a Public Information Centre (PIC), held on September 25th, 2019. Details of the public consultation are provided in **Appendix A.**

The purpose of this study is to achieve the goals of:

1. Update the delineation of the Two-Zone flood hazard area based on the latest hydrologic and hydraulic modelling for the Oshawa Creek watershed,
2. Assess the possible impacts associated with future land use and climate changes, and
3. Identify possible floodplain reduction solutions,

The study was completed as a three-phase work plan. The phases of the work plan are described below:

Phase 1: Two-Zone Floodway and Flood Fringe Analysis. Update the limits of the Two-Zone flood hazard area.

Phase 2: Future Impact Assessment. Assess potential impacts associated with anticipated increased in peak flows due to climate change and development of lands within the Whitebelt Area*.

Phase 3: Flood Reduction Solutions. Assess flood reduction solutions associated with downstream, undersized watercourse crossings.

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*The Whitebelt Area is referred to the lands located between the outer edges of the existing urban settlement boundary and the Greenbelt area. This area is currently subject to policies of the Growth Plan, 2019. As this area has been shown in white on provincial Greenbelt maps it has become known as the Whitebelt.

3.1 PHASE 1: TWO-ZONE FLOODWAY AND FLOOD FRINGE ANALYSIS

In Phase 1, the primary goal was to provide information to support update of the existing Two-Zone flood policy, as outlined below:

1. Review Existing Background Information

The initial study tasks consisted of reviewing existing information including the following:

- Existing hydrologic and hydraulic computer models.
- Existing digital floodline mapping.
- Digital base mapping with respect to 2014 and 2017 aerial photography.
- Existing Two-Zone Policy document; and
- Review existing available municipal drawings.

2. Delineate the Floodway and Flood Fringe

Based on existing hydraulic modelling completed by CLOCA, the floodway and flood fringe areas were determined and mapped. The flood fringe was defined using specific flow depth, flow velocity, flow depth-velocity relationships and the 100-year floodline. The floodway was identified as the area of floodplain not associated with the flood fringe.

3. Encroachment Analyses

Using the hydraulic model developed for the study, encroachment analyses were completed. The purpose of these analyses was to examine the benefits and opportunities for reducing flood risks associated within the flood fringe area through the placement of fill. The placement of fill within the flood fringe may be permitted provided no adverse impacts occur upstream or downstream of the fill location.

4. Access Allowance

During times of flood flow, it is critical that a passage for safe access to and from the flood fringe is achieved. This is particularly important along roadways and pedestrian trails such that the public can leave the flood fringe area, and for emergency vehicles to access the flood fringe area. To address the issue of ingress and egress to and from the flood fringe area, flow depths and velocities were examined along all roads within the floodplain area.

5. Floodplain Mapping

Based on the analyses completed above, a final set of updated Two-Zone floodline maps were prepared.

3.2 PHASE 2: FUTURE IMPACT ASSESSMENT

Several future condition scenarios were evaluated to determine the effects they might have on the Two-Zone study area.

1. Climate Change Hydrologic Modeling

It is anticipated that due to climate change, the intensity of rainfalls will likely increase. Future rainfall IDF Curves were provided by CLOCA and incorporated into the hydrologic and hydraulic modeling to determine how the Two-Zone study area may be affected by climate change.

2. Climate Change Floodplain Mapping

As per the climate change hydrologic modelling, floodplain mapping was produced to demonstrate how the 100-year floodline changes over time due to climate change, and how it compares to the existing regulatory floodplain within the Two-Zone study area.

3. Hydraulic Analysis – Future Land-use Scenario

A future land-use scenario, referred to as the 3A scenario was incorporated within the hydraulic modelling. The 3A scenario involves further development (intensification) within the Whitebelt Area and therefore may cause an increase in regulatory peak flows. An assessment of the structure at the CPR embankment was completed to determine the required structure/opening size, such that there is no increase in the regulatory flood limits within the Two Zone Policy Area (in comparison to the existing regulatory 2A Scenario floodline).

A rating curve was developed to assess the potential flood elevations increase due to intensification of the Whitebelt Area. A relationship between regulatory flood elevation and the level of development within the Whitebelt Area can therefore be established to determine the optimal level of intensification within the Whitebelt Area. This analysis is preliminary in nature, as further work will be required to determine the effects.

3.3 PHASE 3: FLOOD REDUCTION SOLUTIONS

In Phase 3, the primary goal was to review flood reduction solutions within the Two-Zone study area in effort to reduce (minimize) the flood hazard limit within the Two-Zone study area.

1. Reconfirm Technical and Non-Technical Alternatives

All previous studies associated with flooding relief within the study area were reviewed. Bridges and culverts improvements within the study area were examined to assess their impact with respect to regulatory flood conditions.

2. Assess Alternative Solutions

Alternative solutions were examined within the hydraulic modelling to determine the effectiveness of flood reduction strategies. A benefit-cost analysis was completed in effort to evaluate each flood reduction solution.

3. Recommendation of the Preferred Alternative(s)

Based on the benefit-cost analysis, a recommended alternative was prepared.

4.0 TECHNICAL ANALYSES AND RESULTS

This section provides description of the technical analyses completed and the results obtained. The focus of this work includes a description of the analytical methodology and results for the hydrologic and hydraulic analyses completed.

4.1 PHASE 1: TWO-ZONE FLOODWAY AND FLOOD FRINGE ANALYSIS

4.1.1 DELINEATE THE FLOODWAY / FLOOD FRINGE

To be consistent with previous floodway and flood fringe analysis and provincial standards, the criteria of the current CLOCA policy were applied and summarized below. These parameters were originally based on the MNRF 2002 Technical Guidelines for delineating the floodway and flood fringe. The four (4) criteria for delineating the floodway are:

- Velocity equal or greater than 1.5 m/s;
- Depth equal or greater than 1.0 m;
- Depth-velocity product equal or greater than 0.4 m^2/s; and
- 100-year floodplain.

Velocities equal or greater than 1.5 m/s has been defined as flow velocity where individuals would likely get swept off their feet (MNRF, 2002). Flood depths of 0.98 m would be sufficient to float young school children, while also potentially causing flooding concerns for emergency vehicles (MNRF, 2002).

The product-velocity rule is typically a more appropriate method of determining forces on pedestrians, as it accounts for the upward buoyant forces, lateral force due to moving water, unbalanced hydrostatic forces and the shear force of friction acting on the weight of one person. The MNRF Guidelines provide several velocity-depth recommendations, however for conservative purposes and to be consistent with existing policies, a depth-velocity of 0.4 m^2/s was used to define a high-risk area for individuals.

Depth, velocity and depth velocity floodway was determined using HEC-RAS Mapper (RAS Mapper – a built in GIS application through HEC-RAS software. A digital elevation model (DEM) provided by CLOCA/the City of Oshawa was imported into RAS Mapper. The regulatory floodplain is then plotted, and depths can be determined throughout the model based on the difference between the regulatory flood elevation and the underlying DEM elevation. The DEM provided is based on a 10 m grid to generate 1 m contours. The DEM was imported to RAS-Mapper and interpolated to a 0.5 m cell size.

4.1.1.1 EXISTING REGULATORY FLOODPLAIN

As part of the 2014 CLOCA Floodplain Mapping of the Oshawa Creek Watershed, significant changes in the regulatory floodplain were identified, specifically at the CPR Embankment. Previous hydraulic analyses from the Greck 2005 study concluded a flood elevation of 102.97 m upstream of the CPR Embankment, where a peak flow of 935.3 m^3/s is conveyed through the embankment during the Regional Storm Event. The updated hydrologic analysis used in the 2014 CLOCA Floodplain mapping concluded that the peak flow entering the CPR Embankment is 768 m^3/s, resulting in a Regional Flood Elevation of 101.93 m at the CPR Embankment, or no overtopping the CPR embankment.

In comparison to the historical floodplain mapping studies, peak flows were reduced due to the development of a new model and updated methods for calculating Time to Peak from the 2014 Floodplain Mapping, specifically within the Oshawa 1 Main Branch, where Regional peak flows decreased from 866 m^3/s to 768 m^3/s (at the location of the CPR Embankment, Node 38). It should be noted that in the 2005 analyses, the attenuation of flows upstream of the CPR Embankment were considered – where the CPR Embankment was modelled as a Route Reservoir, thus acting as a dam that would provide inline quantity controls. As part of the updated Two-Zone Flood Study, all storage considerations upstream of the CPR Embankment were no longer considered.

The level of peak flow reduction due to the CPR embankment storage/attenuation was considered minor, and the CPR Embankment was not constructed as a formal dam/flow attenuating structure. Regional peak flow attenuation would not be considered appropriate as per discussions with CLOCA and the City. Updates in the channel routing lengths were applied, resulting in a peak flow of 769.5/s (increase in 1.5m^3/s) in comparison to the 2014 CLOCA study.

Within the Goodman Reach, the Regional Flood Hazard increases towards several local road networks, where flood depths are relatively shallow. The majority of Waverly Street, Durham Street and Stevenson Road are under flooded conditions north of Gibb Street and south of King Street West. Within the Lower Goodman Reach (downstream of Stevenson Road) and in the Oshawa Branch, the majority of Gibb Street is flooded, with depths exceeding 1.0m throughout the majority of Gibb Street, east of the Oshawa Mall and west of Centre Street.

4.1.1.2 HEC-RAS MODELING MODIFICATIONS

To undertake the hydraulic analyses necessary to quantify velocities and depths through the study area, modifications were required to the existing hydraulic model. Several cross sections were removed or realigned within the confluence area of Oshawa and Goodman Creek, in effort to graphically illustrate the depth, velocity and depth-velocity products. Furthermore, under major flood events the cross sections in Goodman Creek were removed as the flow velocities, depth and depth-velocity characteristics would be more representative of flood flows through Oshawa Creek rather than the Goodman Creek. The following cross sections were removed:

- 539, 542, 507, 405, 381, 270, 253, 237, 140, 41

The following cross sections within the Oshawa Creek reach were then realigned such that they were perpendicular to contours, as per standard HEC-RAS modeling procedures:

- 6403, 6394, 6384, 6283, 6150, 5997, 5987, 5977, 5850, 5720, 5620.

The cross sections immediately upstream and downstream of the CPR crossing were also recut to ensure the embankment is not captured. The current regulatory model applied a process used in the historical HEC2 modelling software which is inconsistent with the methodologies used with HEC-RAS software. The bridge modelling methodology was revised from Energy Only (Standards Step) methodology to a combination of Energy (during low flow) and Pressure/Weir Flow (during higher flows) as it is standard practice in hydraulic modelling. A figure outlining the updates to the hydraulic modelling cross section alignment is provided in the Appendix B.

A summary of flood elevations at key locations throughout the study area are provided below in **Table 4.1**.

TABLE 4.1: 2A REGULATORY FLOOD ELEVATION – EXISTING VS UPDATED

Reach	Location	HEC-RAS Section	Existing Flood Elevation (m)	Updated Flood Elevation (m)	Change in Flood Elevation (m)
Oshawa-2	Upstream of CPR Embankment	5620	101.93	102.63	0.70
Oshawa-1	Gibb Street	5997	101.95	102.64	0.69
Oshawa-1	John Street	6403	102.03	102.71	0.68
Oshawa-1	King Street	6832	102.63	102.99	0.36
Goodman	Grenfell Street	828	102.02	102.64	0.62
Goodman	Stevenson Road	1566	102.83	102.87	0.04
Goodman	Gibb Street	1852	103.66	103.64	-0.02
Goodman	Cartier Avenue	2251	104.74	104.75	0.01
Goodman	Montcalm Avenue	2581	106.03	106.03	0.00
Goodman	King Street	2899	106.90	106.90	0.00

As demonstrated above, most significant changes in the flood elevation occur immediately upstream of the CPR Embankment. This was due to the removal of the storage/attenuation component within the hydrologic model, reorienting the upstream cross section 5447, revising the bridge modelling methodology, and re-alignment of several cross sections throughout the study area.

The updated analyses concluded a flood elevation at the CPR embankment of 102.60m, or approximately 48cm of flow depth overtopping the railway, with a flood elevation of 102.63m at the confluence of the Goodman and Oshawa Creek.

4.1.1.3 VELOCITY FLOODWAY RESULTS

Velocities are determined based on the HEC-RAS “interpolation surface” function. A velocity is determined across each individual cross section at a finite number of “bands”. Velocities are then interpolated between each cross section. A velocity is then assigned for each 0.5m grid within the regulatory floodplain. Provided in **Figure 4.1** is the velocity mapping of the study area. All these analyses were completed using the Regional storm event (2A scenario).

These results indicate that for most of the floodplain area, flood flow velocities are less than the 1.5m/s criteria used to define a floodway. Throughout the study area, velocities are typically very low (less than 1m/s), except for areas around culverts and bridges that experience concentrated flows. Velocities are low primarily due to the subject area being in a backwater condition. The backwater effects caused by the CPR crossing result in very low kinetic flow energy causing flows to approach near stagnant conditions. Where the backwater effects caused by the CPR cease to have an effect (near Stevenson Road South) the flood flow velocities increase slightly.

Figure 4.1: Velocity Mapping

Oshawa-Goodman Creek
2 Zone Flood Study
Project No. 18-543

0 250 500 m

NAD 1983 UTM Zone 17N

Legend

Velocity

- ▭ <= 1m/s
- ▭ 1 - 2m/s
- ▭ 2 - 3m/s
- ▭ 3 - 4m/s
- ▭ 4 - 5m/s
- ▭ 5 - 6m/s
- ▭ 6 - 7m/s
- ▭ > 7m/s
- ▭ Velocity Floodway

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June 2020

Basemap Image Google Maps 2019

Raster grid developed with HEC-RAS RAS Software by Greck and Associates Limited, March 2020

4.1.1.4 DEPTH FLOODWAY RESULTS

The depth of flooding throughout the study reach was determined using the RAS-Mapper GIS application. Depths were determined by the difference between the flood elevation and the ground surface elevation (derived from the DEM). Overall mapping of the regulatory flooding depth within the study area is provided in **Figure 4.2**. On this map, the boundary of the area which meets or exceeds the 1m depth criteria for a floodway is highlighted.

The results indicate that for the portion of Goodman Creek upstream of Stevenson Road South, flow depths are considered very shallow (less than 0.5m). This occurs, as Goodman Creek through this portion of the study area runs through a channelized reach through several private rear yards. While the channel can spill its banks frequently, flooding occurs over a very wide area resulting very shallow flow depth. For most of this area this depth of flooding is less than the 1m criteria used to define the floodway.

The flood depths along Goodman Creek downstream of Stevenson Road South to the confluence with Oshawa Creek are significantly greater, typically 2m to 3m and as high as 8m.

The flood depths are also very high along the Oshawa Creek reach. The flood depths are typically 5m and as high as 10 m immediately upstream of the CPR crossing. The greater depths are attributed to the deeper defined valley lands within Rotary Park, south of John Street and north of the CPR crossing.

This depth of flooding has much of the area exceeding the 1m criteria used to define the floodway. It should be noted that the Village Union Public School, located at the intersection of Gibb Street and Nassau Street lies entirely within an area with flood depths greater than 1m, and considered an area of high risk due to a high concentration of school children in the area.

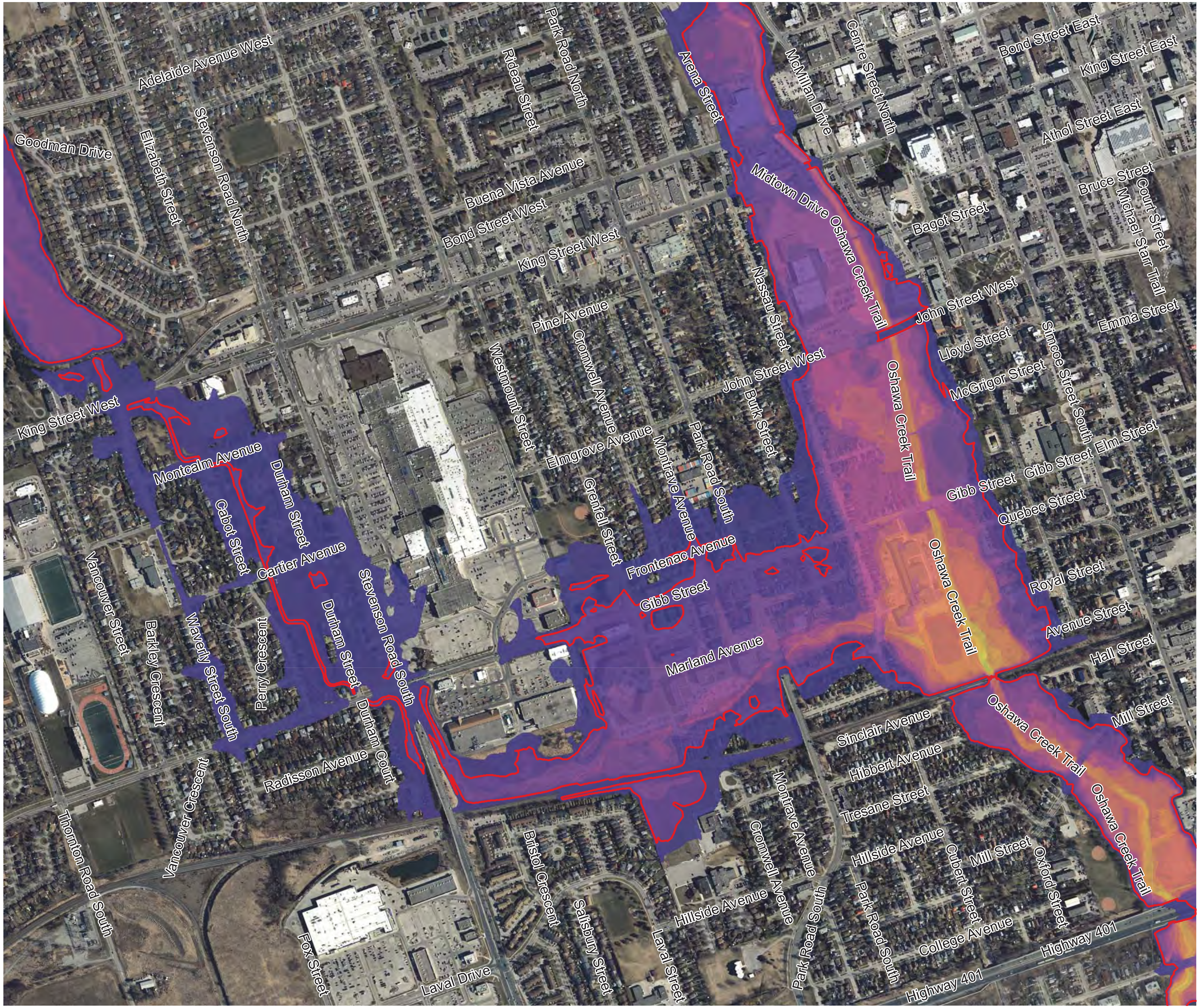

Figure 4.2: Depth Mapping

Oshawa-Goodman Creek
2 Zone Flood Study
Project No. 18-543

0 250 500 m

NAD 1983 UTM Zone 17N

Legend

Depth
- ■ <= 1m
- ■ 1 - 2m
- ■ 2 - 3m
- ■ 3 - 4m
- ■ 4 - 5m
- ■ 5 - 6m
- ■ 6 - 7m
- ■ 7 - 8m
- ■ 8 - 9m
- ■ 9 - 10m
- ■ > 10m
- □ Depth Floodway

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June 2020

Basemap Image Google Maps 2019

Raster grid developed with HEC-RAS RAS Software by Greck and Associates Limited, March 2020

4.1.1.5 DEPTH-VELOCITY PRODUCT FLOODWAY RESULTS

The depth-velocity product was calculated as the product of the depth and velocity at each cell of the 0.5m grid. The results are provided below in **Figure 4.3**. The mapped results are generally similar to the depth contour mapping of the area. The greatest risks occur in areas of high depth-velocity located within the defined valley lands along Oshawa Creek and centralized along the watercourse. In this area the depth-velocity results are typically 2.0m^2/s to 4.0m^2/s. This exceeds the 0.4m^2/s criteria used to define the floodway.

Along Goodman Creek the depth-velocity criteria tend to be more significant than either the depth or velocity criteria, resulting in several locations where the depth-velocity values of 1.0 m^2/s and 2.0 m^2/s exceed the 0.4 m^2 /s criteria.

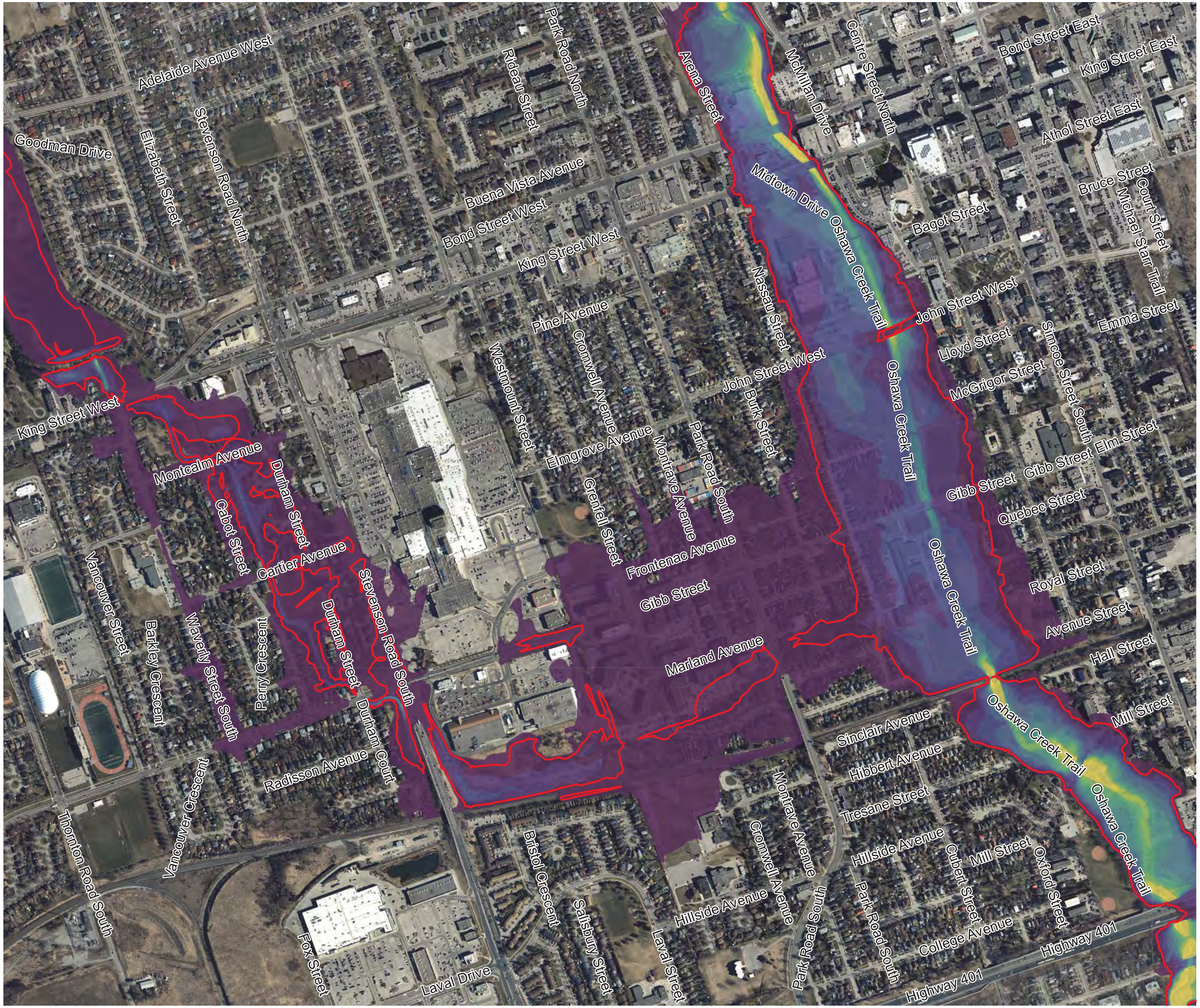

Figure 4.3: Depth-Velocity Product Mapping

Oshawa-Goodman Creek
2 Zone Flood Study
Project No. 18-543

0 250 500 m

NAD 1983 UTM Zone 17N

Legend

Depth-Velocity Product

- 🟪 <= 1m2/s
- 🟪 1 - 2m2/s
- 🟦 2 - 3m2/s
- 🟦 3 - 4m2/s
- 🟦 4 - 5m2/s
- 🟩 5 - 6m2/s
- 🟩 6 - 7m2/s
- 🟩 7 - 8m2/s
- 🟩 8 - 9m2/s
- 🟨 9 - 10m2/s
- 🟨 > 10m2/s
- ☐ Depth-Velocity Floodway Threshold (0.4m2/s)

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June 2020

Basemap Image Google Maps 2019

Raster grid developed with HEC-RAS RAS Software by Greck and Associates Limited, March 2020

4.1.1.6 100-YEAR STORM EVENT UPDATE

The existing 100-year floodline was generated from a 12-hour Chicago Storm distribution. Greck updated the hydrologic model with a second scenario to include the 12-hour SCS Type II storm distribution. The resulting analyses concluded that the SCS storm distribution provides a slightly more conservative peak flow through the study area. This is due to the fact that the upstream catchment areas are generally rural in nature, where an SCS storm distribution is more applicable.

4.1.1.7 OVERALL FLOODWAY RESUTLS

MNRF guidelines also recommend that the 100-year return frequency floodplain be considered in defining the floodway, as this flood represents a sufficiently extreme event to identify the river that carries most of the flow.

The floodway was therefore defined from the combination of the criteria provided above. Examples of how this was determined are illustrated in typical cross section outlining the floodway criteria throughout the study area. In all instances, the floodway is delineated based on the worst-case scenario of the four criteria: velocity, depth, depth-velocity and 100-year floodline. A sample of the floodway delineation is provided below in **Figure 4.4** which represents how the floodway is typically defined through the Oshawa Reach (South of Bond Street and North of the CPR Embankment).

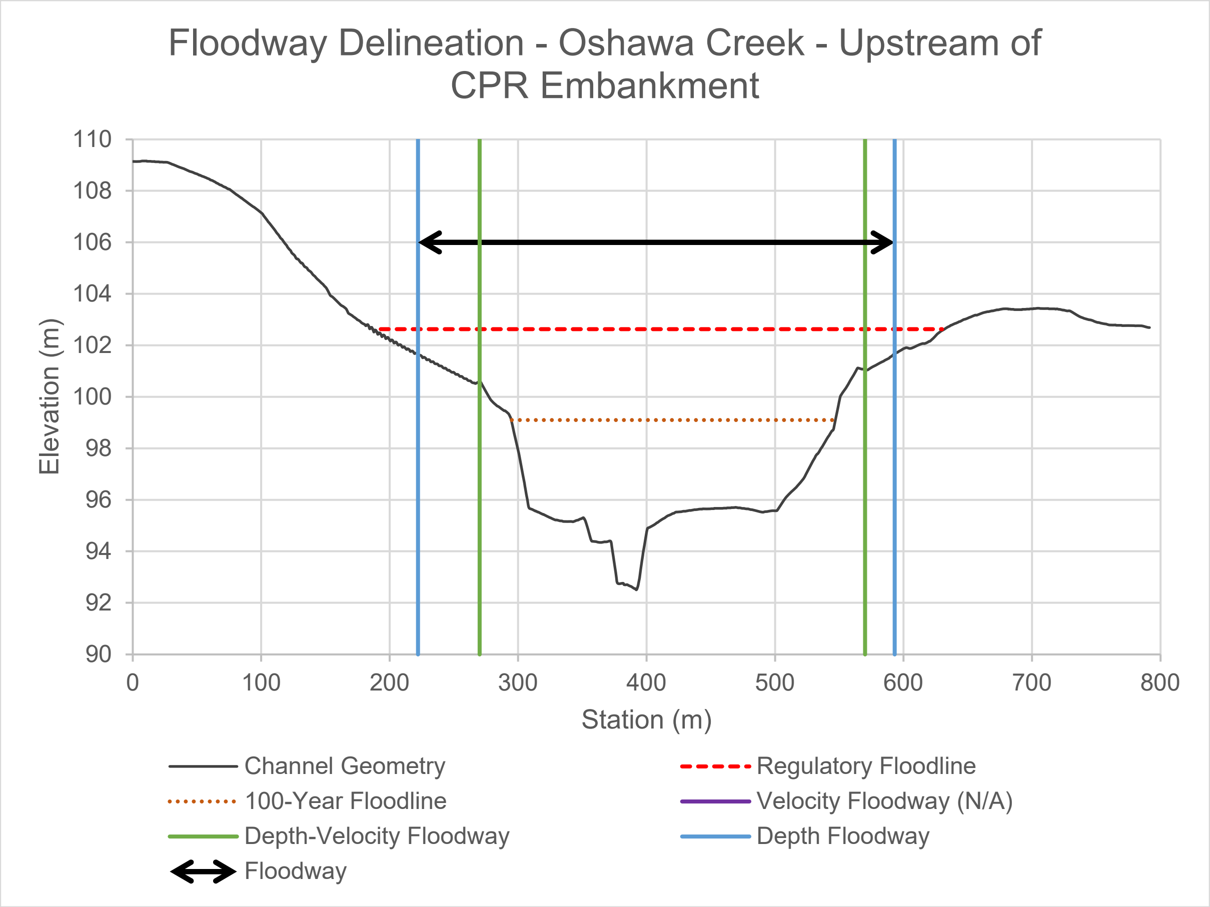

FIGURE 4.4: TYPICAL SECTION OF DELINEATED FLOODWAY – OSHAWA CREEK UPSTREAM OF CPR EMBANKMENT

Throughout the Oshawa Main Branch, the dominant factor in establishing the floodway/flood fringe is the depth within the Oshawa Main Branch and Goodman Branch downstream of Stevenson Road. Flooding within the above area is due to the high backwater effect caused by the CPR Embankment, and therefore velocities are relatively low due to this backwater effect.

Provided in **Figure 4.5** is the typical floodway/flood fringe delineation through Goodman Creek, downstream of Stevenson Road.

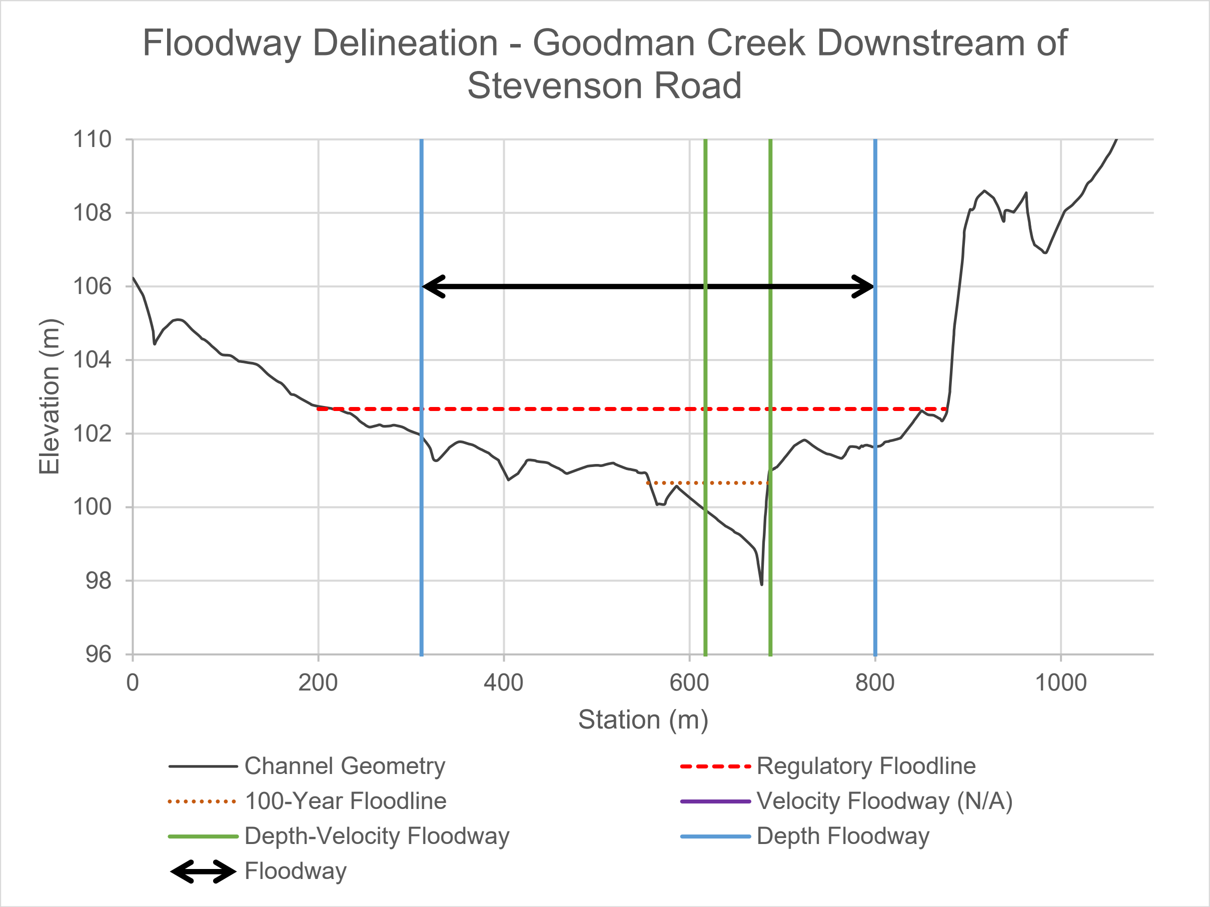

FIGURE 4.5: TYPICAL SECTION OF DELINEATED FLOODWAY – GOODMAN CREEK UPSTREAM OF CPR EMBANKMENT

Similar to Oshawa Main Branch, the dominant factor in establishing the floodway/flood fringe is the depth due to the backwater effect from the CPR Embankment.

Provided in **Figure 4.6** is the typical floodway/flood fringe delineation through Goodman Creek, upstream of Gibb Street.

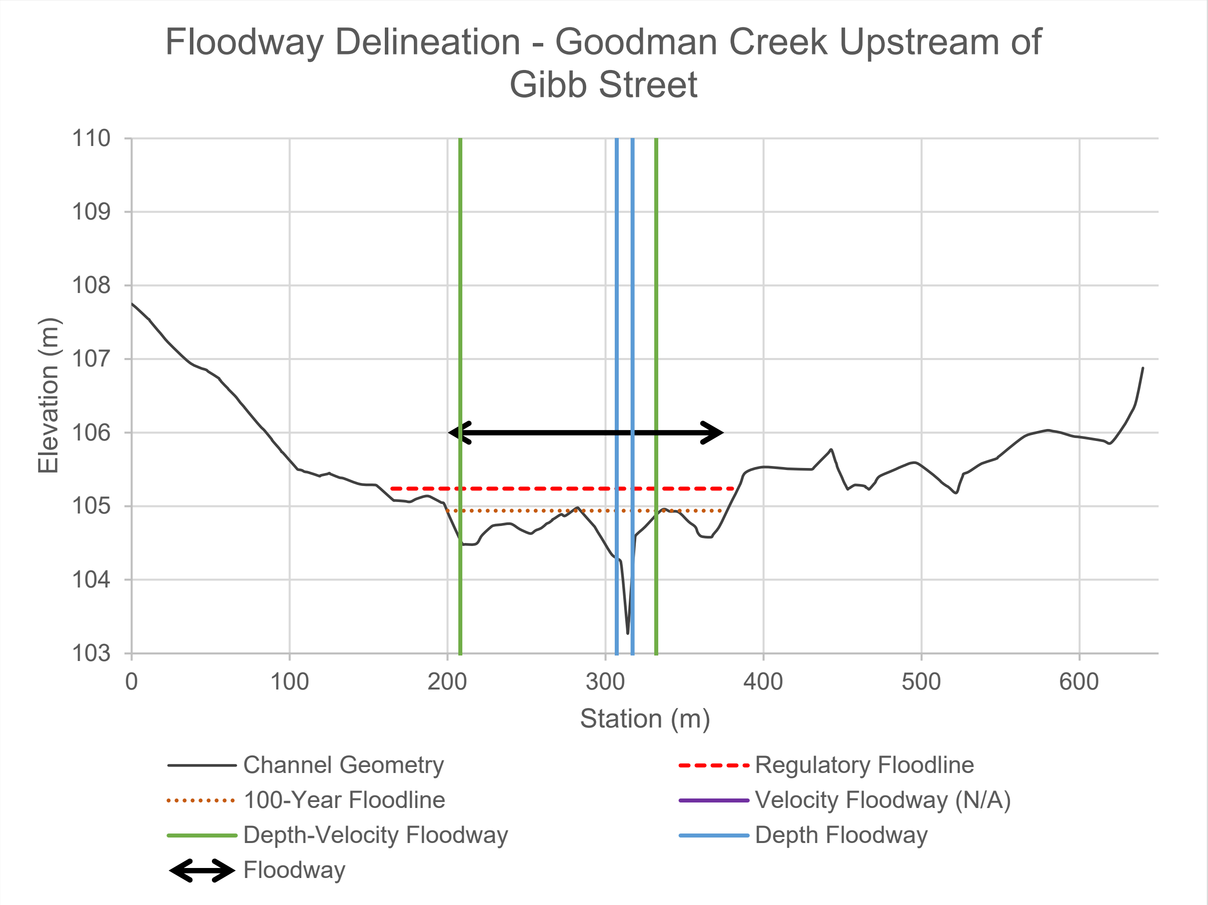

FIGURE 4.6: TYPICAL SECTION OF DELINEATED FLOODWAY – GOODMAN CREEK UPSTREAM OF GIBB STREET

Upstream of Stevenson Road and Gibb Street, the floodway is dominated by the 100-year flood elevation, primarily due the lack of a well-defined valley with limited floodplain access. Flood hazards within this area are generally shallow with minimal velocities.

The overall floodway/flood fringe delineation is provided below in **Figure 4.7**. In comparison to the previously delineated floodway, the overall floodplain has decreased, as flood elevations upstream of the CPR have decreased from 102.97m to 102.63m in comparison to the previous Two-Zone flood study. As such, the overall flood fringe and floodway has generally decreased.

Figure 4.7: Overall Floodway/Flood Fringe

Oshawa-Goodman Creek
2 Zone Flood Study
Project No. 18-543

0 250 500 m

NAD 1983 UTM Zone 17N

Legend

- 🟧 Flood Way
- 🟦 Flood Fringe

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June 2020

Basemap Image Google Maps 2019

Raster grid developed with HEC-RAS RAS Software by Greck and Associates Limited, March 2020

4.1.2 ACCESS ALLOWANCE – INGRESS/EGRESS

All roads within the regulatory flood hazard limit were assessed to determine if they could be safely used during a flood event. This is particularly important to ensure that during a flood event, people could have adequate ingress or egress to and from the flood hazard area.

The limit for safe vehicular ingress was defined by roads where during the regulatory storm event, flood depths were equal or greater than 0.4m. As per MNRF guidelines, a flood depth of 0.4m or less allows for passage of private vehicles. Emergency vehicles such as firetrucks or ambulances typically can drive through flood depths of 1.0m.

Road networks where flood depths were equal or greater than 0.4m have been provided in **Figure 4.8.** Any properties adjacent to these roads do not have safe access, therefore any new or redevelopment within these parcels will not be permitted.

The majority of roads within the study area have limited safe ingress-egress, as flood depths are greater than 0.4m in almost all instances, especially west of the Oshawa Centre Mall and south of John Street. Special attention should be made to areas of concern such as the Village Union Public School, located at Gibb Street and Nassau Street.

Limited safe ingress/egress exists in the Goodman Reach, upstream of Stevenson Road. However, the flooding situation in this part of the study area is more favorable compared to the Oshawa Branch (such as the Oshawa Centre Mall) because alternative routes are available with only minor pockets of flood depths greater than 0.4m.

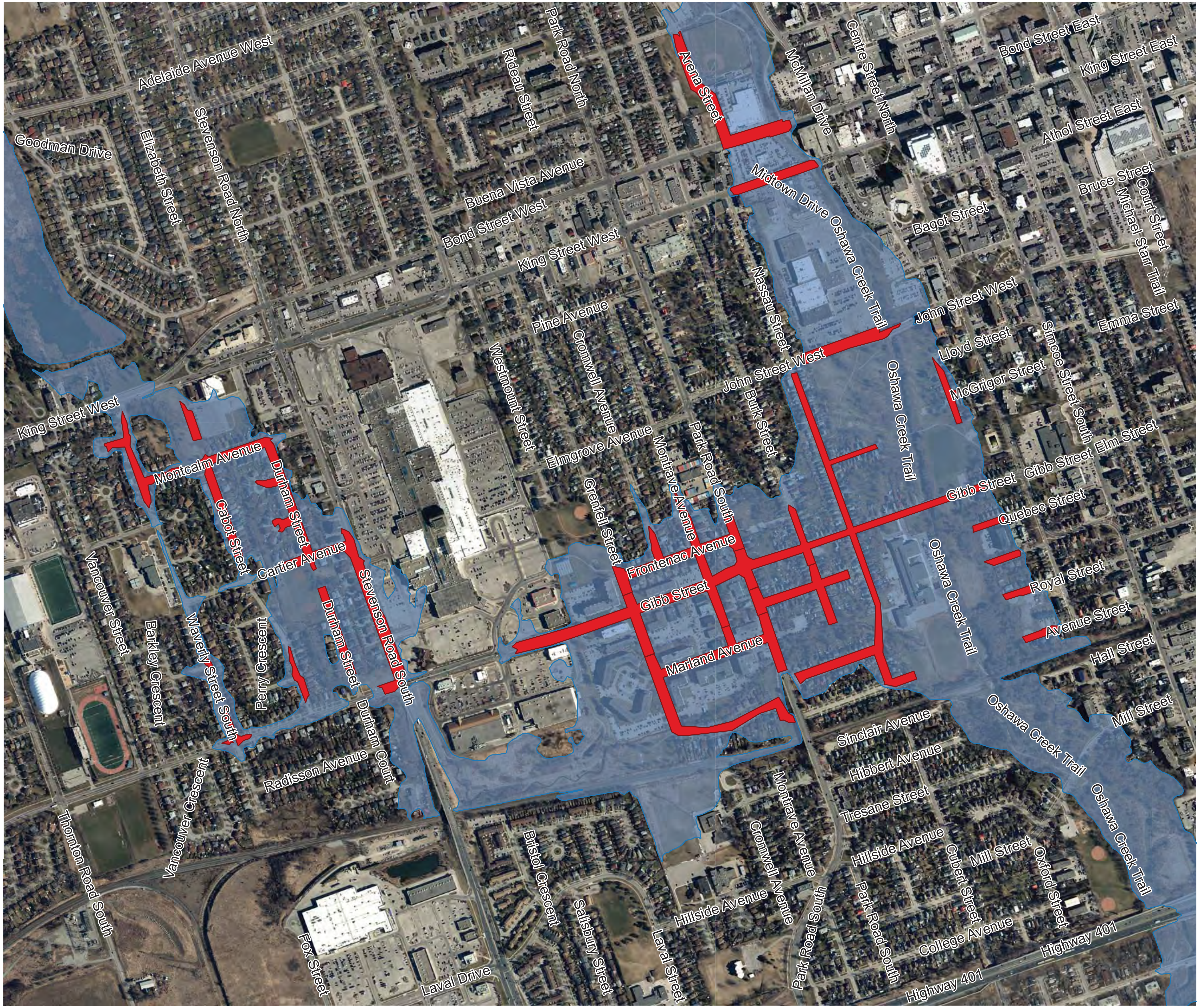

Figure 4.8: Safe Ingress/Egress Through Floodplain

Oshawa-Goodman Creek
2 Zone Flood Study
Project No. 18-543

0 250 500 m

NAD 1983 UTM Zone 17N

Legend

- 🟦 2A Regulatory Floodplain
- 🟥 Depths Greater than 0.4m through Roadway

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June 2020

Basemap Image Google Maps 2019

Raster grid developed with HEC-RAS RAS Software by Greck and Associates Limited, March 2020

4.1.3 ENCROACHMENT ANALYSIS

Given the extent of the flood fringe area and the significant differences, at some locations, between the flood fringe and 100-year floodline, the impact of encroachment within the flood fringe area was completed. Encroachment refers to the altering of the floodplain through the placement of fill, regrading of the land, or placement of structures. Encroachment may be permissible within the flood fringe, provided the encroachment does not increase flood elevations or downstream flood flow rates. This analysis is to examine the maximum achievable development within the flood fringe without altering the overall floodway.

Upon delineating the floodway/flood fringe, the potential for encroachment was assessed with the HEC-RAS model. The effects of encroachment were investigated by the placement of ineffective flow areas within the Flood Fringe. This simulates the placement of fill within the floodplain by losing the effective flow area within the flood fringe. A first attempt was made by assuming full encroachment within the flood fringe throughout the entire study area. Three (3) separate reaches were assessed based on their conveyance characteristic.

The effects of encroachment through the Oshawa Branch (from the CPR to Bond Street) is provided below in **Table 4.2**. It should be noted that encroachment was only applied up to John Street, as there is little to no flood fringe area upstream of John Street.

TABLE 4.2: OSHAWA CREEK ENCROACHMENT ANALYSIS – FROM CPR CROSSING TO BOND STREET

HEC-RAS Cross Section	2A Regulatory Flood Elevation (m)	Encroachment Regulatory Flood Elevation (m)	Increase in Flood Elevation (m)	2A Regulatory Velocity (m/s)	Encroachment Regulatory Velocity (m/s)	Increase in Velocity (m/s)
5720.403	102.63	102.63	0.00	0.35	0.35	0.00
5850	102.64	102.64	0.00	0.31	0.31	0.00
5976.971	102.64	102.64	0.00	0.71	0.71	0.00
Gibb Street						
5997.008	102.64	102.64	0.00	0.70	0.70	0.00
6150	102.65	102.65	0.00	0.59	0.54	-0.05
6282.752	102.66	102.66	0.00	0.47	0.47	0.00
6384.608	102.67	102.67	0.00	1.48	1.48	0.00
John Street						
6403.231	102.71	102.71	0.00	1.33	1.33	0.00
6503.613	102.78	102.78	0.00	1.12	1.13	0.01
6600	102.83	102.83	0.00	1.14	1.14	0.00
6705.93	102.91	102.91	0.00	1.21	1.21	0.00
6809.793	102.96	102.96	0.00	2.54	2.54	0.00
King Street						
6832.49	102.98	103.00	0.02	2.55	2.54	-0.01
6884.784	102.89	102.91	0.02	4.58	4.53	-0.05
6924.769	103.34	103.34	0.00	3.61	3.62	0.01
Bond Street						
6946.907	103.52	103.51	-0.01	3.16	3.17	0.01
7034.698	103.81	103.81	0.00	5.13	5.13	0.00

It is demonstrated that placement of fill within the flood fringe between John Street and the CPR crossing has little to no impact on the regulatory flood elevation. Flood elevations through this section are defined by backwater effect due to the CPR crossing, as such, the valley lands provide little to no conveyance through this reach. Flood elevations were noted to increase slightly immediately upstream of King Street; however, these increases are minimal.

Changes in velocities were noted to be minimal and would have no effect on the floodway/flood fringe delineation.

The effects of encroachment through the Goodman Creek Reach, from Park Road to Stevenson Road, is provided below in **Table 4.3.**

TABLE 4.3: GOODMAN CREEK ENCROACHMENT ANALYSIS – FROM PARK ROAD TO STEVENSON ROAD

HEC-RAS Cross Section	2A Regulatory Flood Elevation (m)	Encroachment Regulatory Flood Elevation (m)	Increase in Flood Elevation (m)	2A Regulatory Velocity (m/s)	Encroachment Regulatory Velocity (m/s)	Increase in Velocity (m/s)
651.4663	102.64	102.64	0.00	0.20	0.20	0.00
708.8131	102.64	102.64	0.00	0.19	0.20	0.01
808.6823	102.64	102.64	0.00	0.17	0.19	0.02
Grenfell Street						
827.5217	102.65	102.65	0.00	0.19	0.20	0.01
932.2719	102.65	102.65	0.00	0.08	0.08	0.00
1050	102.65	102.65	0.00	0.43	0.41	-0.02
1200	102.66	102.66	0.00	0.64	0.68	0.04
1420.552	102.71	102.72	0.01	1.16	1.15	-0.01
1523.7	102.77	102.77	0.00	0.98	0.97	-0.01
Stevenson Road						

It is demonstrated that placement of fill within the flood fringe within the Goodman Creek reach, upstream of Park Road and downstream of Stevenson Road has minimal effect on the regulatory flood elevation, as the flood elevation through this reach is governed primarily by the backwater effect of the CPR crossing.

The effects of encroachment through the Goodman Creek Reach, from Gibb Street to King Street, west of Stevenson Road, is provided below in **Table 4.4**.

TABLE 4.4: GOODMAN CREEK ENCROACHMENT ANALYSIS – FROM GIBB STREET ROAD TO KING STREET CROSSING TO BOND STREET

HEC-RAS Cross Section	2A Regulatory Flood Elevation (m)	Encroachment Regulatory Flood Elevation (m)	Increase in Flood Elevation (m)	2A Regulatory Velocity (m/s)	Encroachment Regulatory Velocity (m/s)	Increase in Velocity (m/s)
1851.839	103.65	103.65	0.00	0.59	0.59	0.00
1910.567	103.80	103.80	0.00	1.84	2.06	0.22
1950	104.04	104.07	0.03	0.89	0.87	-0.02
2100	104.36	104.38	0.02	1.26	1.29	0.03
2135.661	104.42	104.44	0.02	1.6	1.55	-0.05
2237.844	104.72	104.73	0.01	1.04	1.03	-0.01
Cartier Avenue						
2250.846	104.75	104.74	-0.01	1.01	1.02	0.01
2351.543	105.24	105.24	0.00	1.47	1.47	0.00
2417.174	105.63	105.63	0.00	1.86	1.87	0.01
2545.492	106.05	106.05	0.00	0.82	0.82	0.00
Montcalm Avenue						
2581.456	106.03	106.03	0.00	1.31	1.31	0.00
2714.286	106.37	106.4	0.03	0.97	1.29	0.32
2735.24	106.45	106.53	0.08	1.47	1.46	-0.01
2836.864	106.69	106.76	0.07	0.69	0.62	-0.07
King Street						

Encroachment within the Flood Fringe between Gibb Street and Montcalm Avenue would result in a negligible increase in flood elevation. However, encroachment within the Flood Fringe between Montcalm Avenue and King Street is not recommended, as this encroachment would increase flooding significantly. Based on the above encroachment analyses, areas where encroachment might occur such that no adverse upstream flood impacts is illustrated below in **Figure 4.9**. In all instances, these areas should be dry flood proofed and only be allowed to develop where there is safe ingress/egress. Included in **Appendix C** is an overall 2 Zone Limit, which includes areas within the flood fringe that are considered non-developable due to impacts of encroachment.

Figure 4.9: Encroachment Limits

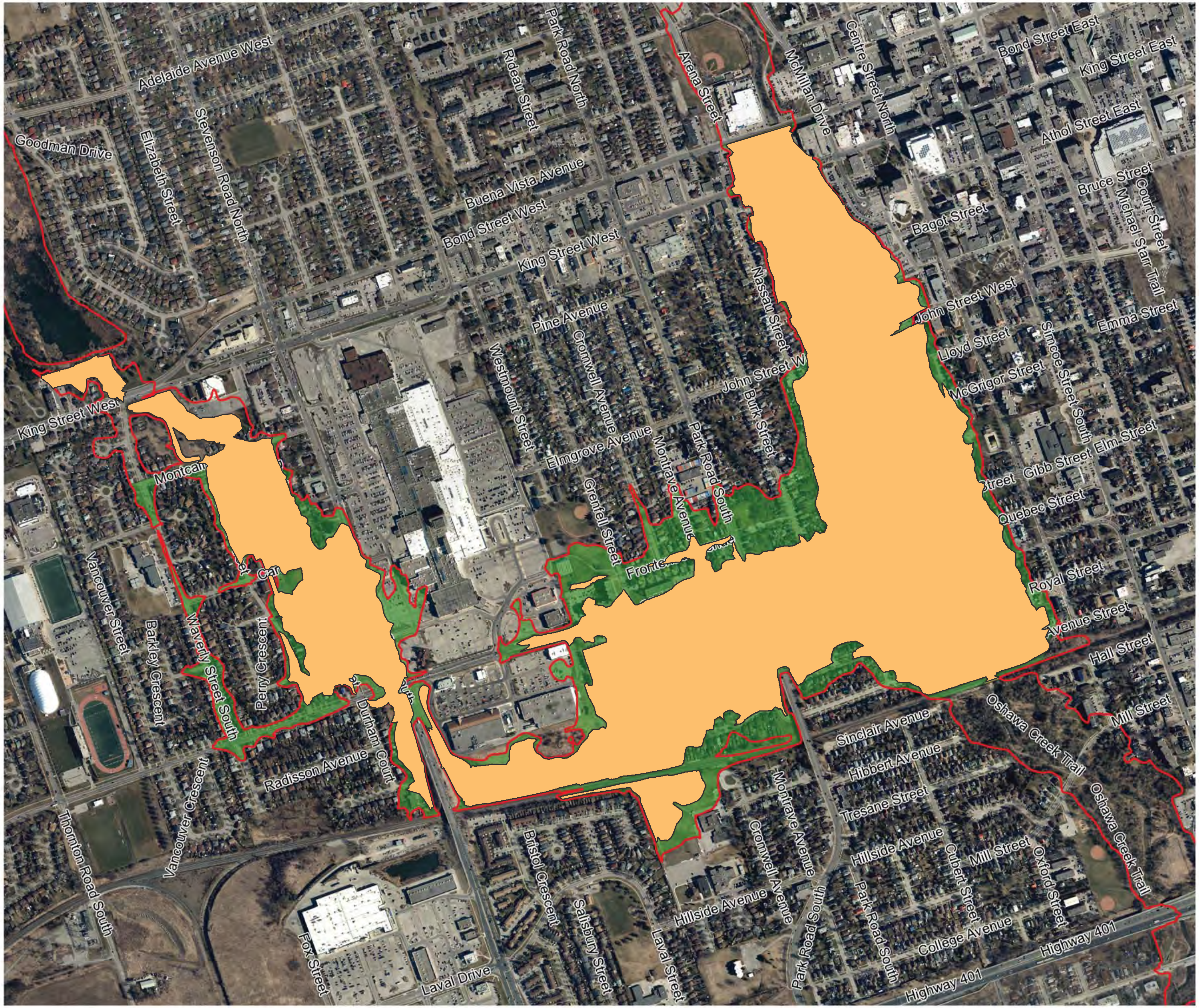
Oshawa-Goodman Creek
2 Zone Flood Study
Project No. 18-543

0 250 500 m

NAD 1983 UTM Zone 17N

Legend

- 🟧 Flood Way
- 🟥 2A Regulatory Floodplain
- 🟩 Permissible Encroachment Limit



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June 2020

Basemap Image Google Maps 2019

Raster grid developed with HEC-RAS RAS Software by Greck and Associates Limited, March 2020

4.1.3.1 IMPACTS OF ENCROACHMENT ON CHANNEL ROUTING

Impacts due to the loss of floodplain storage due to encroachment were investigated. Within the hydrologic model of the Oshawa Creek Watershed, channel flow routing is prevalent within the study area. Channel routing accounts for storage of flows as they are conveyed within them in channel and floodplain. Accounting for the storage of the unsteady flows along the channel is referred to as channel flow routing. Channel flow routing results in the attenuation (lowering) and a delay (lag) in peak flows. A reduction in flood storage could therefore result in an increase in downstream flood flow.

A review of the hydrologic model revealed the overall width of the channel routing element within the hydrologic model was generally small (between 210 m and 220 m wide within the Goodman Reach, and 250 m wide within the Oshawa Main Branch). Floodplain widths within the study area were determined to be greater than 400 m wide within both reaches.

Encroachment is not proposed in the floodway, where the floodway does not exceed 400 m within the lower Goodman Portion (downstream of Stevenson) and 250 m within the Oshawa Creek (downstream of King Street). As such, no updates to the hydrologic modelling were required to evaluate impacts that encroaching may have towards channel routing. Therefore, encroaching within the flood fringe would have no effect on the attenuation or lag of regulatory storm flows of Oshawa Creek.

4.2 PHASE 2: FUTURE IMPACT ASSESSMENT

A number of future condition scenarios were evaluated to determine the effects they might have on the Two-Zone study area.

4.2.1 CLIMATE CHANGE

It is anticipated that due to climate change, the intensity of rainfalls will likely increase. Future rainfall events were provided by CLOCA and incorporated into the hydrologic and hydraulic modelling to determine how the Two-Zone study area may be affected by climate change.

Stormwater management systems within southern Ontario rely on Intensity-Duration Frequency (IDF) curves to determine peak flows when developing hydrologic models to characterize peak runoff within a watershed. In southern Ontario, there has been an upward trend in the maximum daily precipitation due to climate change (Fadhel et al, 2017). Therefore, the existing peak flows of the future condition scenario within the Oshawa Creek watershed may not be applicable during future land use scenarios.

As such, the future rainfall IDF curves were provided by CLOCA in effort to demonstrate how the 100-year floodline changes over time due to climate change, and how it compares to the existing regulatory floodplain (or floodway) within the Two-Zone study area.

Three (3) IDF curve scenarios were incorporated within the hydrologic modelling and in turn, the hydraulic modelling to delineate anticipated flood hazards due to climate change. IDF curves were determined from the worse-case scenario based on the Oshawa WPCP weather station (Climate ID 6155878), or the Toronto City Weather Station (Climate ID 618355). In all instances, the SCS 12-hour storm distribution was simulated as it provides the most conservative level of assessment (generating the highest peak flow). Rainfall volumes provided in **Table 4.5** were generated from the IDF Climate Change Tool 4.0 via the University of Western Ontario. All results applied the Representative Concentration Pathway (RCP) 8.5 to represent the most conservative estimate. Climate change IDF information is provided in Appendix F.

TABLE 4.5: CLIMATE CHANGE IMPLICATIONS – 12 SCS RAINFALL VOLUMES

Scenario	100-year 12 Hour Rainfall Volume (mm)
Existing	112.40
Year 2030-2050	117.00
Year 2050-2070	123.24
Year 2070-2100	153.04

A summary of the peak flows at key locations within the watershed are summarized below in **Table 4.6**

TABLE 4.6: 100 YEAR PEAK FLOW COMPARISON - CLIMATE CHANGE (2A LANDUSE SCENARIO)

Reach **(Street)** **[Flow Node]**	**Peak Flows (m^3/s)**				
	100 Year	100 Year (2030-2050)	100 Year (2050-2070)	100 Year (2070-2100)	Regional
Goodman **(King Street)** **[2000]**	10.96	11.32	11.77	17.61	69.21
Goodman **(Gibb/Stevenson Road)** **[45]**	30.95	32.49	34.61	45.12	80.42
Goodman **(Nassau Street)** **[46]**	62.38	65.64	70.18	92.52	98.65
Oshawa **(King Street)** **[36]**	255.83	268.49	292.76	412.49	673.15
Oshawa **(CPR)** **[38]**	265.55	282.99	307.99	433.51	769.54

100-year floodline based on climate change considerations are provided below in **Figure 4.10**. As a result of climate change, the 100-year storm is not expected to increase the Regulatory Floodplain, however, has some minor impacts on the floodway through the Goodman Creek upstream of Gibb Street.

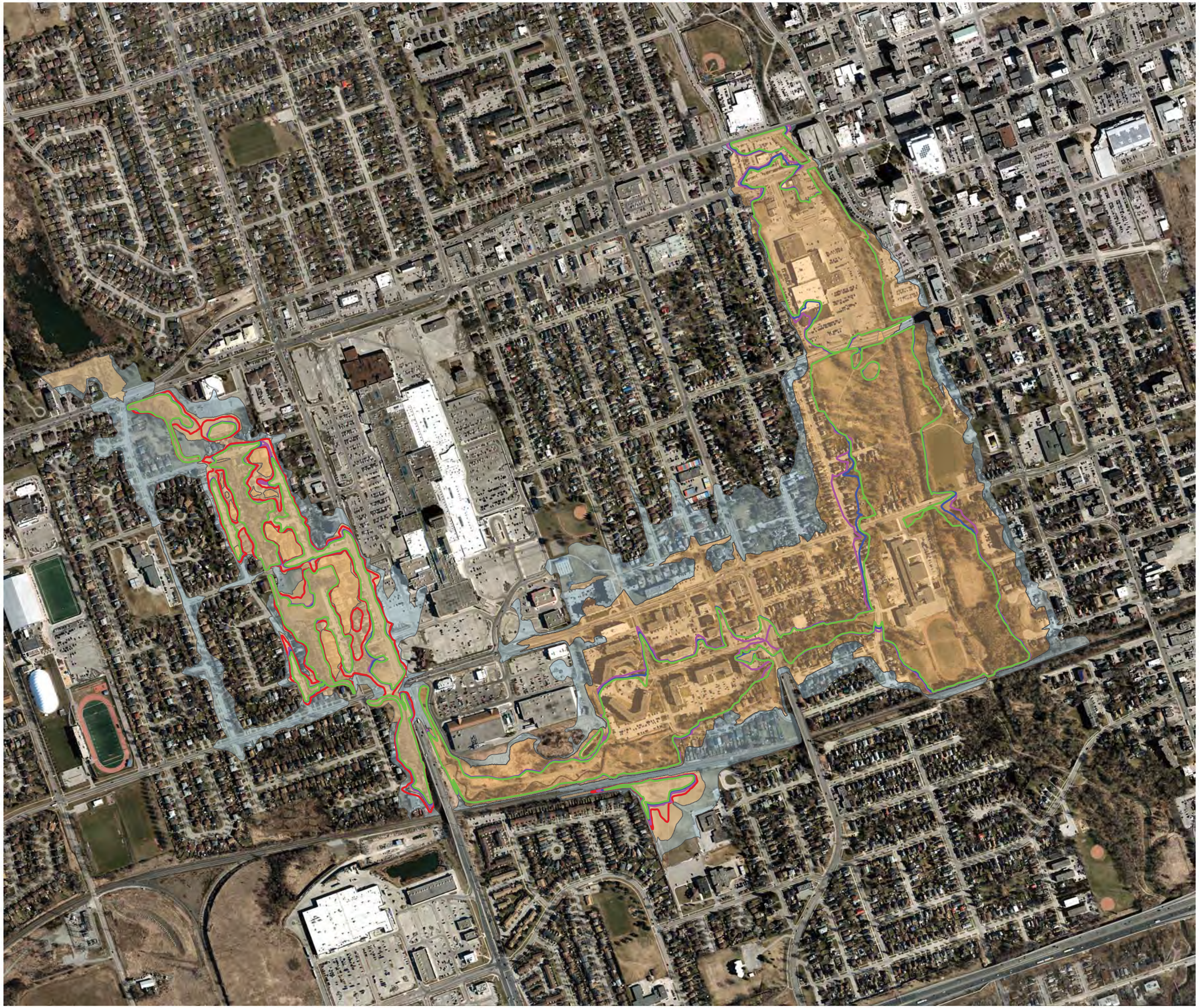

Figure 4.10: Climate Change Impacts - 100-year Floodline

Oshawa-Goodman Creek
2 Zone Flood Study
Project No. 18-543

0 250 500 m

NAD 1983 UTM Zone 17N

Legend

- 🟩 100-Year Floodline (Existing)
- 🟦 100-Year Floodline (2030-2050)
- 🟪 100-Year Floodline (2050-2070)
- 🟥 100-Year Floodline (2070-2100)
- 🟧 2A Flood Way
- ⬜ 2A Flood Fringe

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August 2020

Basemap Image Google Maps 2019

Raster grid developed with HEC-RAS RAS Software by Greck and Associates Limited, March 2020

4.2.2 WHITEBELT DEVELOPMENT IMPACTS

As part of the 2014 CLOCA floodplain mapping of Oshawa Creek, a future land-use scenario which involves development of the Whitebelt area, referred to as the 3A scenario, was incorporated within the hydraulic modelling. The 3A scenario involves further development (intensification) and therefore, causes an increase in regulatory peak flows. All the following hydrologic analyses did not credit any stormwater management facilities that currently exist or may be developed in the future. The change in land-use from the 2A to the 3A scenario is provided in the Appendix E.

Table 4.7 is a comparison of flood elevations between the 2A and 3A scenarios at various points within the study area.

TABLE 4.7: 2A VS 3A REGULATORY FLOOD ELEVATION (M)

Reach	Location	HEC-RAS Section	2A Flood Elevation (m)	3A Flood Elevation (m)	Change in Flood Elevation (m)
Oshawa-1	Upstream of CPR Embankment	5620	102.63	102.69	+0.06
Oshawa-2	Gibb Street	5997	102.64	102.70	+0.06
Oshawa-2	John Street	6403	102.71	102.77	+0.06
Oshawa-2	King Street	6832	102.99	103.07	+0.08
Goodman	Grenfell Street	828	102.64	102.70	+0.06
Goodman	Stevenson Road	1566	102.87	102.88	+0.01
Goodman	Gibb Street	1852	103.64	103.66	+0.02
Goodman	Cartier Avenue	2251	104.75	104.75	0.00
Goodman	Montcalm Avenue	2581	106.03	106.03	0.00
Goodman	King Street	2899	106.90	106.90	0.00

As outlined in **Table 4.7** development of the Whitebelt area has a minimal effect on the flood elevations throughout the study area, as flood elevations increase by a maximum of 8cm through the study area, with no reduction of buildings/dwellings within the regulatory floodplain. The 3A scenario does however results in an increase of accessory buildings (garages/sheds) within the floodplain, however was not considered as part of this study as these buildings are considered low risk in comparison to dwellings with permanent residents.

Under the existing condition (2A Scenario), a rating curve was developed to determine how much flood elevations increase due to intensification of the Whitebelt Area. As previously mentioned, the 3A scenario assumes that 100% of the Whitebelt developable area is developed fully. Three (3) additional scenarios were incorporated within the hydrologic model in effort to estimate the level of impact that the development of the Whitebelt may have through the study area. These three scenarios include:

- 25% of the Whitebelt is developed;
- 50% of the Whitebelt is developed; and
- 75% of the Whitebelt is developed.

It should be noted that the level of imperviousness is assumed to be distributed uniformly across the watershed for all three scenarios.

Peak flows were inserted into the hydraulic model to determine the increase in flood elevations, specifically at section 5620, as it represents the elevation upstream of the CPR crossing. A rating curve was then developed to determine a relationship between percent developed and flood levels upstream of the CPR Embankment (**Figure 4.11a).** 0% represents the 2A scenario, while 100% represents the 3A scenario (full development within the Whitebelt). Provided in **Figure 4.11b** is a rating curve showing the overall percent impervious of the Whitebelt only vs flood elevation and peak discharge at the CPR Embankment.

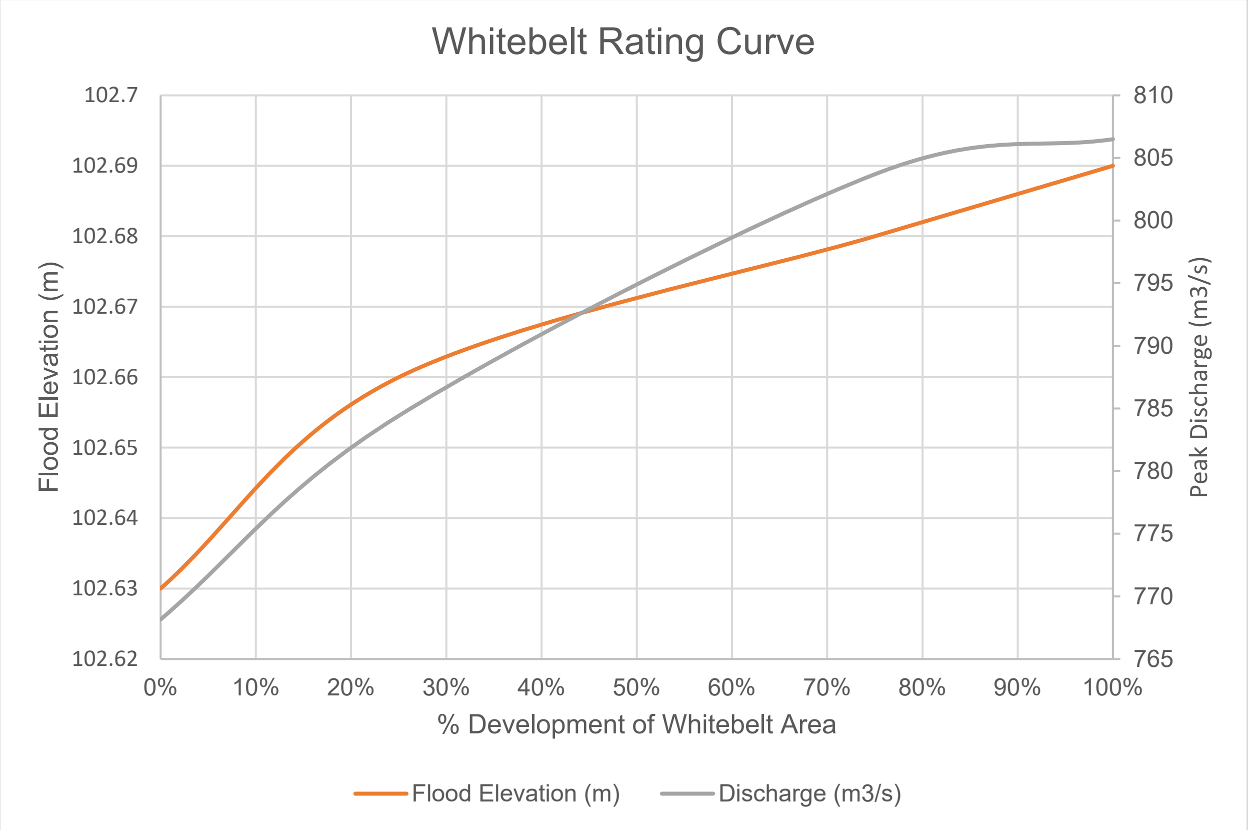

FIGURE 4.11A: WHITEBELT RATING CURVE FOR THE CPR BRIDGE

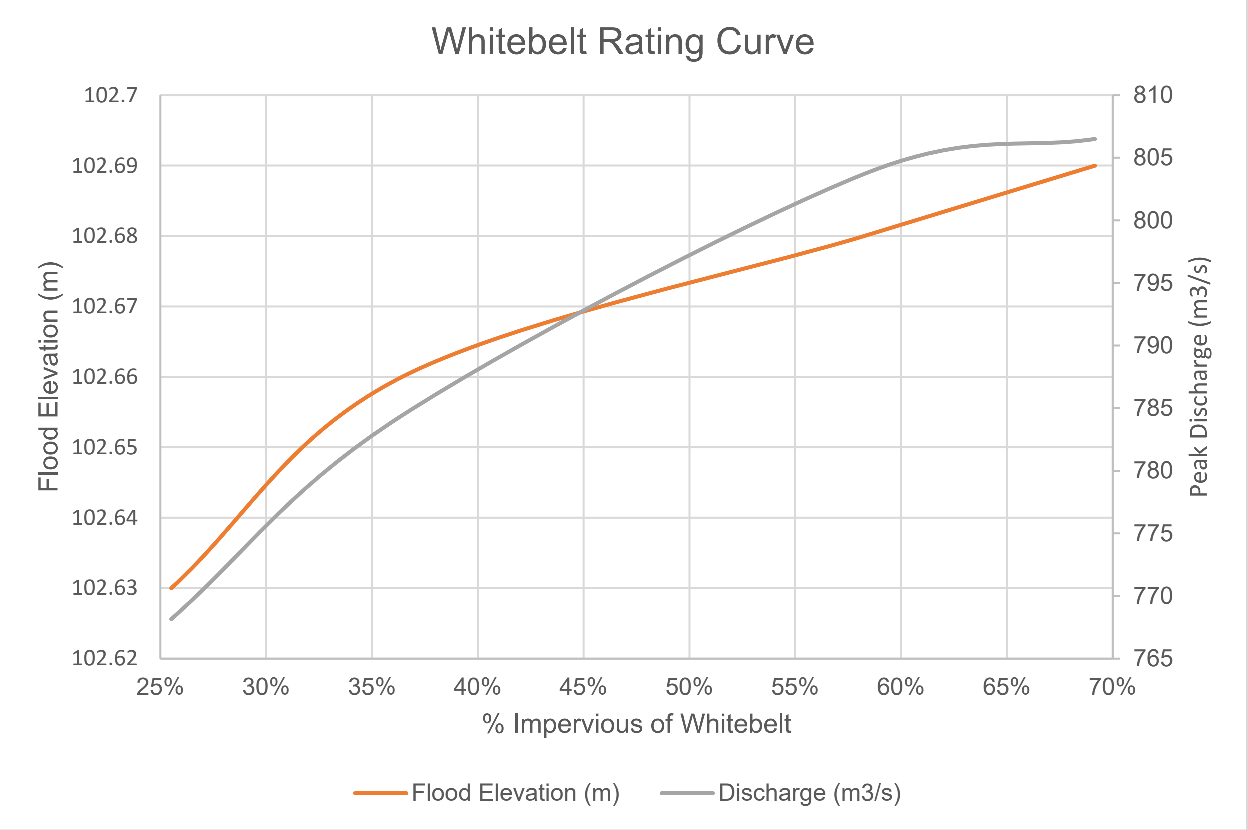

FIGURE 4.11 B: WHITEBELT RATING CURVE FOR THE CPR BRIDGE

From **Figure 4.11b**, the increase in flood elevation is directly proportional to the increase in impervious area within the Whitebelt area. The rate of increase in flood elevation is slightly greater for the initial increases in imperviousness. This may have future implications with respect to funding for mitigative works to offset these increases as funding to implement mitigative works may not be proportional for the level of development within the Whitebelt area.

Peak flows through the Goodman reach remain unaffected, as there are no Whitebelt designated lands through the Goodman Watershed; however, flood elevation increases in Oshawa Creek will impact the lower Goodman Creek simply due to the backwater effect at the CPR Embankment.

4.3 PHASE 3: FLOOD REDUCTION SOLUTIONS

The potential for flood reduction within the study area was investigated. It is noted that the CPR crossing induces a significant backwater effect throughout the area and is the primary contributor to flooding within the study limits. The second most contributing factor is that development of lands within the natural floodplain of Oshawa Creek and Goodman Creek, as defined by the regulatory storm event.

Several solutions were considered to reduce the extent of flooding during the 2A scenario and to offset the potential increases due to future development of the Whitebelt area. It should be noted that these solutions are conceptual only and do not consider several factors such as constructability and compliance with external authorities (i.e. Go Transit, CPR etc.). Discussion of the alternatives examined is provided below.

4.3.1 IMPROVEMENT TO DOWNSTREAM STRUCTURES

Prior to examining an option to improve the conveyance at the CPR embankment, improvements to bridge structures downstream of the CPR were investigated. The analyses were intended to examine if a reduction in the tailwater elevation would reduce flood elevations upstream of the CPR embankment. If these improvements were to substantially lower flood elevations, they potentially could be more cost effective and easier for the municipality to implement. The improvements examined included:

- Improvements to the CN crossing and Mill Street and/or Bloor Street Bridge crossing; and
- Localized grading improvements to improve flood flow conveyance.

The maximum potential benefits of downstream improvements were assessed by simply removing the Mill Street, Bloor Street and CN crossings from the hydraulic model. The removal of such structures would reflect the best-case scenario, where the man-made crossing is replaced by valley lands entirely. While these types of work may be infeasible, as the road and rail crossings are essential to the economy and daily transportation within the City of Oshawa, it does allow one to understand the significance and impact on flooding.

With the removal of the CN, Mill Street and Bloor Street crossings, there was no change in the flood elevation upstream of the CPR crossing as summarized in **Table 4.8**. Therefore, it can be established that downstream improvements would not provide flood reduction within the study area.

TABLE 4.8: 2A REGIONAL FLOOD ELEVATION – DOWNSTREAM IMPROVEMENTS

Reach	Location	HEC-RAS Section	Regional Flood Elevation (m)	With Downstream Improvements Regional Flood Elevation (m)	Change in Flood Elevation (m)
Oshawa-2	Upstream of CPR Embankment	5620	102.63	102.63	0.00
Oshawa-1	Gibb Street	5997	102.64	102.64	0.00
Oshawa-1	John Street	6403	102.71	102.71	0.00
Oshawa-1	King Street	6832	102.99	102.99	0.00
Goodman	Grenfell Street	828	102.64	102.64	0.00
Goodman	Stevenson Road	1566	102.87	102.87	0.00
Goodman	Gibb Street	1852	103.64	103.64	0.00
Goodman	Cartier Avenue	2251	104.75	104.75	0.01
Goodman	Montcalm Avenue	2581	106.03	106.03	0.00
Goodman	King Street	2899	106.90	106.90	0.00

4.3.2 INCREASED FLOW CONVEYANCE

Two alternatives to increase in flow conveyance at the CPR Embankment alternative structure types and sizes were considered. These alternatives were examined to reduce the current level of flooding and to reduce the potential impacts associated with the development of the Whitebelt area.

4.3.3 CPR EMBANKMENT IMPROVEMENTS

The initial strategy was to open the CPR crossing, simply by increasing the width of the existing 15m span bridge. Consultation with structural engineers indicated that a more cost-effective approach would be to construct a secondary relief opening to the west, rather than widening the existing opening. If a second truss style bridge was built adjacent to the existing bridge there could be advantages of reduced costs associated with removing the existing abutments: reduced closure of the railway, reduced risks for impacts to the existing watercourse and utilization of the existing embankment to temporarily support the structure during construction.

For each opening width scenario examined, the relief structures obvert remained the same as the existing structure, however the invert of the relief structure was elevated to that of the natural floodplain (the approximate elevation of the existing pedestrian path through the area). Minor grading was assumed to ensure a more flat, consistent floodplain. This relief structure would only be active during significant storm events and the form and function of the watercourse would remain unchanged.

A total of nine (9) scenarios were investigated by incrementally increasing the opening span. The nine scenarios were then used to establish a rating curve, based on increase in span versus flood elevation. In addition to the nine scenarios, the CPR crossing was removed entirely to determine the best-case scenario. A summary of the CPR crossing widening and their respective upstream flood elevation (at HEC-RAS Section 5620) is provided below in **Table 4.9**. Selected HEC-RAS modelling outputs are provided in **Appendix D.**

TABLE 4.9: CPR EMBANKMENT IMPROVEMENT FLOOD IMPACTS

Scenario	Total Span (m)	Regulatory Flood Elevation (m)	Decrease in Flood Elevation (m)
Existing	15 m	102.63	0.00
2m Spanned Relief Structure	17 m	102.53	0.10
4m Spanned Relief Structure	19 m	102.41	0.22
6m Spanned Relief Structure	21 m	102.3	0.33
8m Spanned Relief Structure	23 m	102.15	0.48
10m Spanned Relief Structure	25 m	102.13	0.51
15m Spanned Relief Structure	30 m	101.68	0.91
20m Spanned Relief Structure	35 m	101.37	1.18
30m Spanned Relief Structure	45 m	100.37	1.52
40m Spanned Relief Structure	55 m	100.21	1.65
Best Case Scenario	Full Valley	99.67	2.96

A rating curve demonstrating the increase in span vs flood elevation is provided below in **Figure 4.12**, with floodplain mapping extents provided in **Figure 4.13**.

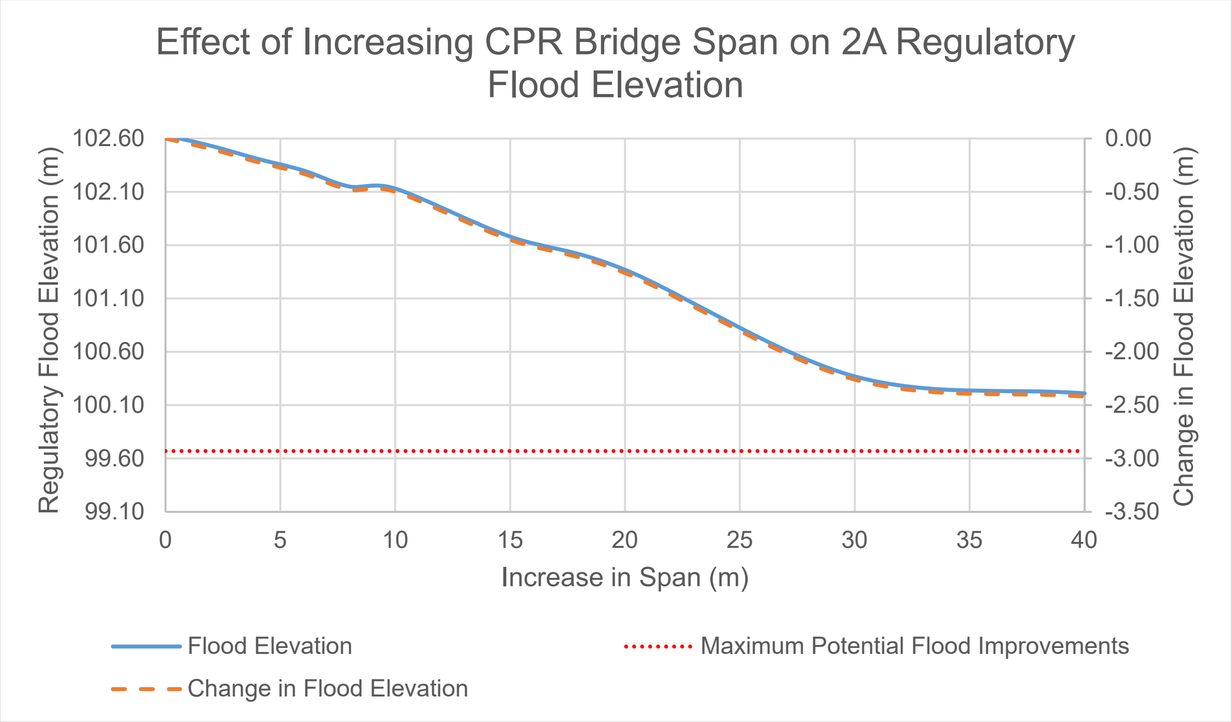

FIGURE 4.12: CPR SPAN INCREASE VS FLOOD ELEVATION RATING CURVE

The widening of the CPR bridge presents very interesting results. The most significant finding is that existing development of lands lies within the natural floodplains of Oshawa Creek and Goodman Creek. More specifically,

- Increasing the opening has its greatest benefits on the floodplain associated with Goodman Creek from Stevenson Road South to the confluence with the Oshawa Creek Flood plain.
- Increasing and/or removing the bridge entirely has no benefits to the Two-Zone policy flood hazard area upstream of Stevenson Road South.
- Increasing and/or removing the bridge entirely has very limited benefits by way of flood reduction upstream of John Street West.
- Places such as the Midtown Mall (north of John Street), Village Union Public School remain within the regulatory floodplain even with the complete removal of the CPR crossing.

Figure 4.13: CPR Improvements Flood Results

Oshawa-Goodman Creek
2 Zone Flood Study
Project No. 18-543

0 250 500 m

NAD 1983 UTM Zone 17N

Legend

- ▭ 2A Regulatory Floodplain
- ▭ 2m Spanned Relief Opening
- ▭ 4m Spanned Relief Opening
- ▭ 6m Spanned Relief Opening
- ▭ 8m Spanned Relief Opening
- ▭ 10m Spanned Relief Opening
- ▭ 15m Spanned Relief Opening
- ▭ 20m Spanned Relief Opening
- ▭ 30m Spanned Relief Opening
- ▭ 40m Spanned Relief Opening
- 🟩 Maximum Flood Improvements

Greck

June 2020

Basemap Image Google Maps 2019

Raster grid developed with HEC-RAS RAS Software by Greck and Associates Limited, March 2020

4.3.3.1 RELIEF CULVERT

A scenario of providing small relief culvert(s) was considered. The relief culvert is proposed in effort to ensure that the 3A Regulatory Flood Elevation upstream of the CPR crossing does not exceed the 2A Regulatory Flood Elevation (102.63m at HEC-RAS Section 5620).

A hypothetical relief culvert was anticipated to be placed immediately west of the CPR Embankment, where construction access is possible. Two (2) culvert options were provided with the parameters provided in **Table 4.10.** The results presented in **Table 4.10** are for the 3A development scenario.

TABLE 4.10: CPR CROSSING – 3A RELIEF CULVERT

	Option A	**Option B**
Culvert Type	Concrete Box	Twin Circular Concrete Pipe
Span (m)	3.6	2.70
Rise (m)	3.0	2.70
Length (m)	10.0	10
Upstream Invert (m)	96.3	96.3
Downstream Invert (m)	96.2	96.2
Flood Elevation (m)	102.63	102.62

The results show that the relief culverts/culvert could be used to offset the small increase in flooding due to increases associated with development of lands in the Whitebelt area. The analyses also concluded that the effectiveness of relief culverts for the greater level of flooding is severely limited. This is primarily due to the small conveyance area of a box or pipe.

4.3.4 CPR EMBANKMENT BENEFIT COST ANALYSIS

The approach to building the secondary opening and to maximize its potential for operation would be to construct the second opening as a truss bridge. It may be possible to utilize the existing west abutment to support the second span thereby providing some cost savings. Rough order of magnitude cost estimates were prepared for relief structures with spans greater than 10m.

The flood reduction benefits were evaluated based on two criteria: the flood elevation upstream of the CPR Embankment and the number of buildings removed from the floodplain. It should be noted that even with the complete removal of the CPR Embankment, a total of 386 buildings remain in the floodplain (under the 2A scenario). As such, the effectiveness of the floodplain reduction is based on the percentage of total buildings removed from the floodplain due to impacts by the CPR Embankment. The number of buildings within the regulatory floodplain for each bridge alternative scenario (**Figure 4.13**) was counted using building inventory information provided by the City of Oshawa. Costs associated with flood damages were based on a unit rate of $10,000 per building as recommended by CLOCA and the City of Oshawa. It should be noted that this is a ballpark estimate only and costs may be lower or higher per building depending on several factors – as some buildings may be subject to more flooding than others, while others may have finished or unfinished basements.

All sheds/garages were removed from this assessment, therefore only dwellings and any commercial buildings were considered in this analysis.

Additional flood damage costs are likely due to a number of additional factors such as:

- Road washout
- Loss of public lands
- Loss of public infrastructure

Both the 2A and 3A land use scenarios were assessed. A summary of the benefit-cost analysis is provided below in **Table 4.11**.

A profile view of the results has been provided in **Figure 4.14** and **Figure 4.15.** The profile view illustrates that improvements at the CPR Embankment can result in a significant reduction on upstream flood elevations, however, the effectiveness is diminished at Stevenson Road through the Goodman Creek reach, and at Bond Street through the Oshawa Branch.

TABLE 4.11: BENEFIT COST ANALYSIS OF FLOOD REDUCTION ALTERNATIVES

Scenario	Opening Area (m^2)	Bridge Construction Cost (millions)	2A Scenario								3A Scenario						
			Regulatory Flood Elevation (m)	Change in Flood Elevation from 2A	Total # Buildings in Floodplain	# Buildings Removed due to Improved Structure	% of Buildings Removed due to Improved Structure	Flood Damage Reduction Costs (millions)	Net Cost - Bridge less Flood Damage Reduction Costs (millions)	Regulatory Flood Elevation (m)	Change in Flood Elevation from 2 A	# Buildings in Floodplain	# Buildings Removed due to Improved Structure	% of Buildings Removed due to Improvements from 2A	Flood Damage Reduction Costs (millions)	Net Cost - Bridge less Flood Damage Reduction Costs (millions)
Existing	114.71	$0.00	102.63	0	712					102.69	0.06	712				
10m Increase in Span	168.71	$4.85	102.13	-0.5	638	74	23%	$0.74	$4.11	102.21	-0.42	650	62	19%	$0.62	$4.23
15m Increase in Span	195.71	$5.34	101.68	-0.95	581	131	40%	$1.31	$4.03	101.84	-0.79	598	114	36%	$1.14	$4.20
20m Increase in Span	222.71	$5.84	101.37	-1.26	531	181	56%	$1.81	$4.03	101.48	-1.15	553	159	50%	$1.59	$4.25
30m Increase in Span	276.7	$6.90	100.37	-2.26	414	298	91%	$2.98	$3.92	100.54	-2.09	433	279	87%	$2.79	$4.11
40m Increase in Span	328.21	$8.03	100.21	-2.42	406	306	94%	$3.06	$4.97	100.37	-2.26	413	299	93%	$2.99	$5.04
Best Case Scenario (CPR Removed)		N/A	99.67	-2.96	386	326	100%	$3.26	NA	99.8	-2.83	391	321	100%	$3.21	NA

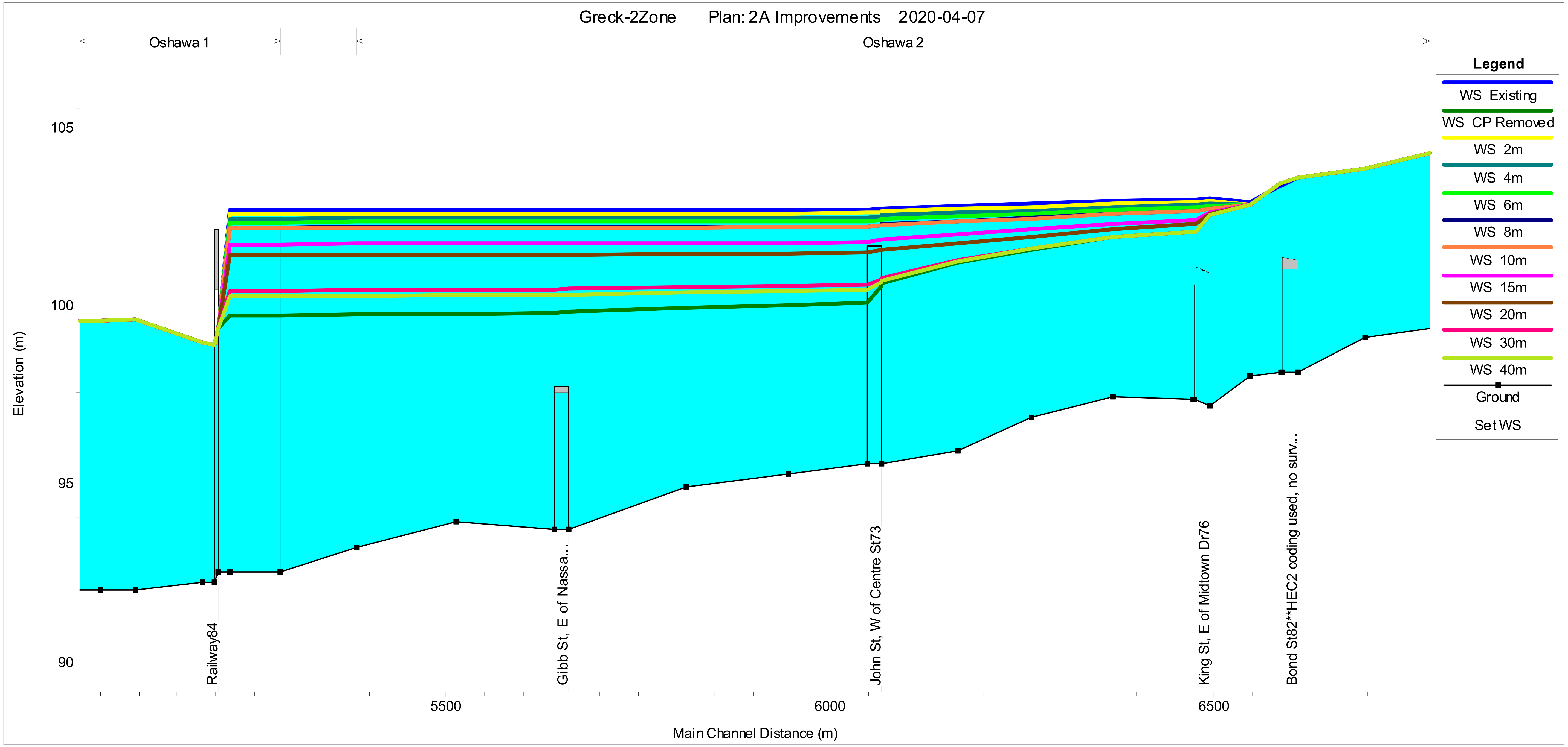

FIGURE 4.14: CPR EMBANKMENT IMPROVEMENTS - OSHAWA CREEK PROFILE

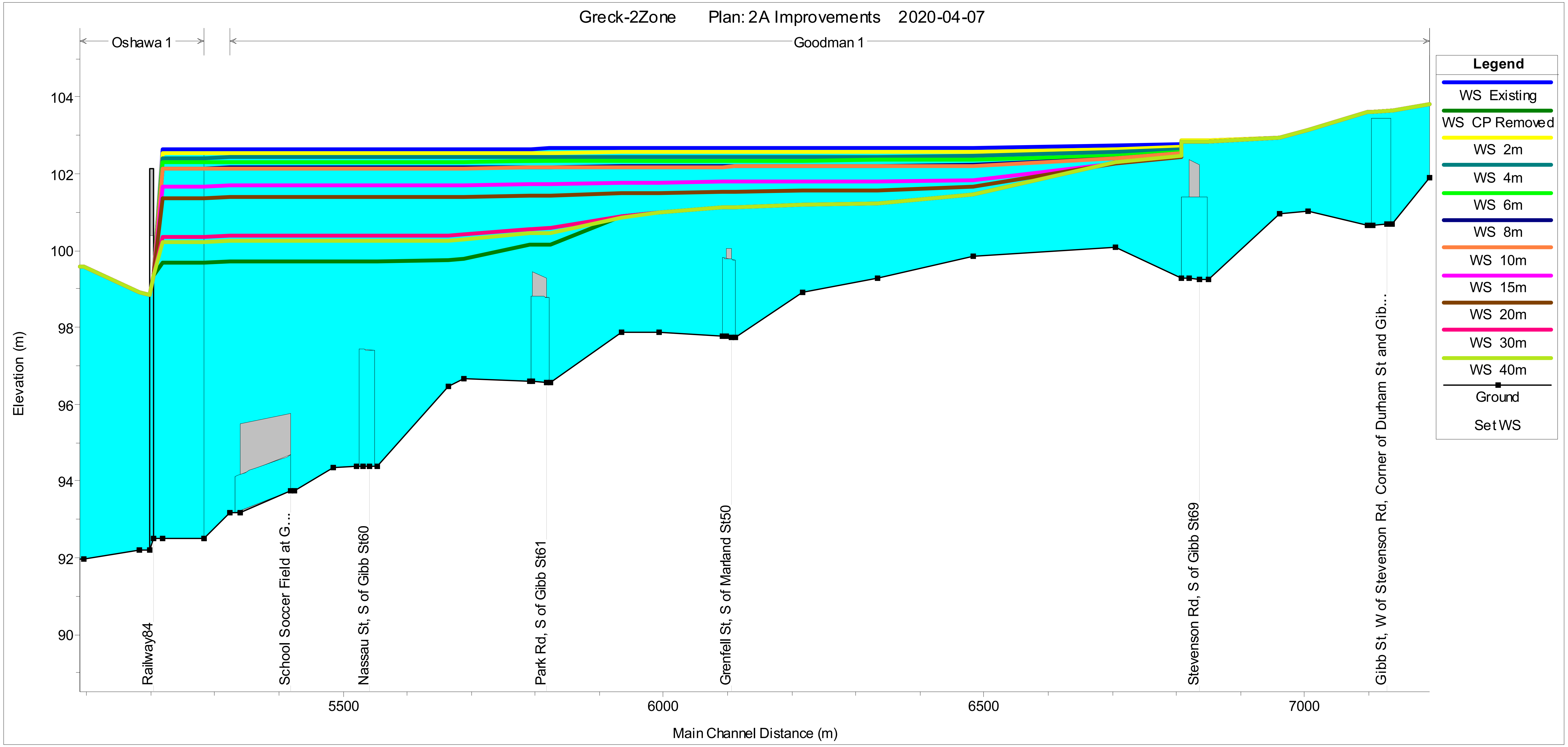

Figure 4.15: CPR Embankment Improvements - Goodman Creek Profile

Several rating curves have been developed to evaluate the effectiveness of CPR Embankment improvement strategies in **Figure 4.16** and **Figure 4.17**.

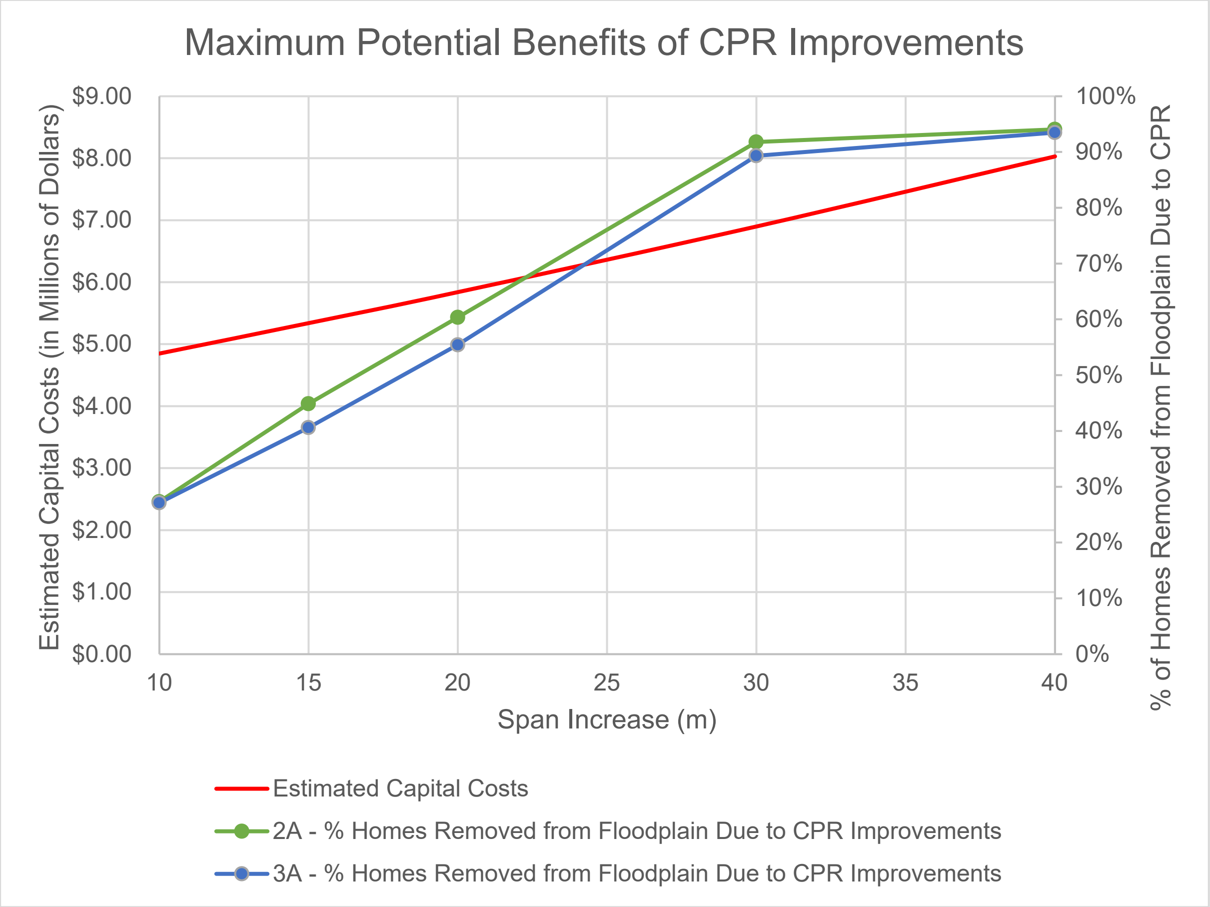

FIGURE 4.16: CPR EMBANKMENT IMPROVEMENTS: BUILDINGS REMOVED & CAPITAL COST VS SPAN INCREASE

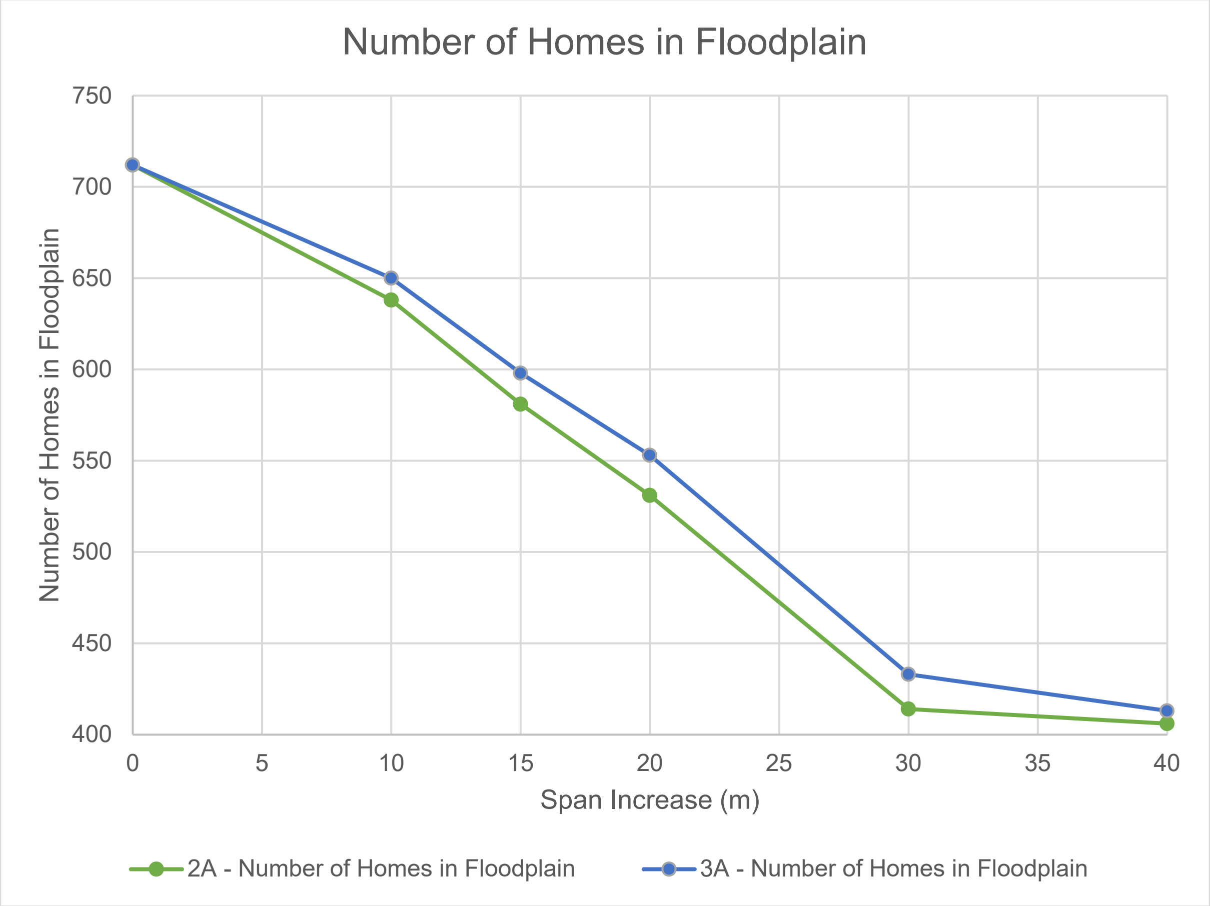

FIGURE 4.17: CPR EMBANKMENT IMPROVEMENTS: SPAN INCREASE VS NUMBER OF BUILDINGS IN FLOODPLAIN

Figure 4.16 and **Figure 4.17** demonstrate that both the benefits of flood elevation reduction and number of buildings removed from the floodplain begins to diminish for a relief structure larger than 30m.

In regard to ingress/egress, it is noted that much of Gibb Street is removed from the floodplain for relief openings over 30m, as outlined in **Figure 4.13**. Since Gibb Street is an arterial road, this is of significant value during times of severe flooding. During these scenarios, Gibb Street is flooded only directly over the watercourse crossings at Oshawa Creek and Gibb Street, leaving Gibb Street dry from the Oshawa Mall to Burk Street.

Should a 30m or greater span structure be implemented, the practicality of managing the study area as a Two-Zone policy area would likely diminish, as flood waters through Goodman Creek to Burk Street are less influenced by backwater conditions and result in significantly shallower flooding depths throughout the area. Should CPR Embankment strategies be implemented, it is recommended that the flood fringe and floodway through this area be reviewed to reassess the validity of using a Two-Zone policy though the study area.

Additional anticipated flood costs would be noticed through the study area for each building type removed from the floodplain. The type of buildings removed from the floodplain vary though the study area, ranging from commercial and residential buildings with garages and sheds. However, this information was not considered in this exercise. The benefit-costs associated with a reduced level of flooding associated for each building remaining within the floodplain was also not completed as part of this study.

4.3.5 GOODMAN CREEK GIBB STREET /STEVENSON ROAD IMPROVEMENTS

Flood improvements at Stevenson Road and Gibb Street along Goodman Creek were considered. Like the analysis completed on the downstream impacts, several watercourse crossings were removed to determine the maximum potential flood benefits due to culvert/bridge improvements:

- Gibb Street
- Stevenson Road
- Cartier Avenue; and
- Montcalm Avenue

A secondary analysis was completed by removing the CPR embankment, to determine if the CPR crossing has any backwater effect on the Upper Goodman Reach (upstream of Gibb Street).

A summary outlining the flood elevations through this reach are provided below in **Table 4.12.** Increases in flood elevation are likely associated with model instability and would be considered negligible.

TABLE 4.12: POTENTIAL CULVERT/BRIDGE IMPROVEMENT BENEFITS – GIBB STREET, STEVENSON ROAD, CARTIER AVENUE AND MONTCALM AVENUE

HEC-RAS Cross Section	2A Regulatory Flood Elevation (m)	Montcalm, Cartier, Gibb & Stevenson Culvert Removal Flood Elevation (m)	Change in Flood Elevation (m)
Gibb Street			
1851.839	103.65	103.66	+0.01
1910.567	103.8	103.79	-0.01
1950	104.04	104.04	0.00
2100	104.36	104.36	0.00
2135.661	104.42	104.42	0.00
2237.844	104.72	104.72	0.00
2250.846	104.75	104.78	+0.03
Cartier Avenue			
2351.543	105.24	105.22	-0.02
2417.174	105.63	105.63	0.00
2545.492	106.05	106.05	0.00
2581.456	106.03	106.09	+0.06
Montcalm Avenue			
2714.286	106.37	106.38	+0.01
2735.24	106.45	106.45	0.00
2836.864	106.69	106.04	-0.65

The resulting analysis concluded that the culverts within this reach have minimal impact to the regulatory flood elevation. Most of the creek through this reach traverses through residential rear yards. Most of the homes are located within the natural floodplain, with others located in a poorly-defined valley corridor. The removal of all structures will not be effective to improve the flooding through Goodman Creek, as these structures are almost entirely submerged during the Regional storm event.

As mentioned in Section 4.1.1.1, most Regional storm flow is conveyed overtop Gibb Street / Stevenson Road. To mitigate the flooding upstream of Gibb Street, significant channel improvements would be required to improve the conveyance capacity of the watercourse in effort to contain flows within valley lands, in addition to upsizing the culvert structures at Gibb Street and Stevenson Road. This scenario was not investigated, as it would require significant transfer or expropriation of lands adjacent to Goodman Creek to the City. The improvement of all structures is not an effective strategy due to the level of submergence of the bridges during the Regional Storm event.

4.3.6 OSHAWA CREEK – GIBB STREET / JOHN STREET IMPROVEMENTS

Flood improvements at Gibb Street and John Street along Oshawa Creek were not considered for during this study, as these two structures are entirely submerged during the 2A Regulatory Storm event. Provided below in Figure 4.18 is the current 2A Regulatory flood profile, and the flood profile should the CPR Embankment become entirely removed (representing the maximum potential flood benefits from CPR Embankment Improvements).

As such, any upgrades to these structures would have little to no impact on upstream flood elevations.

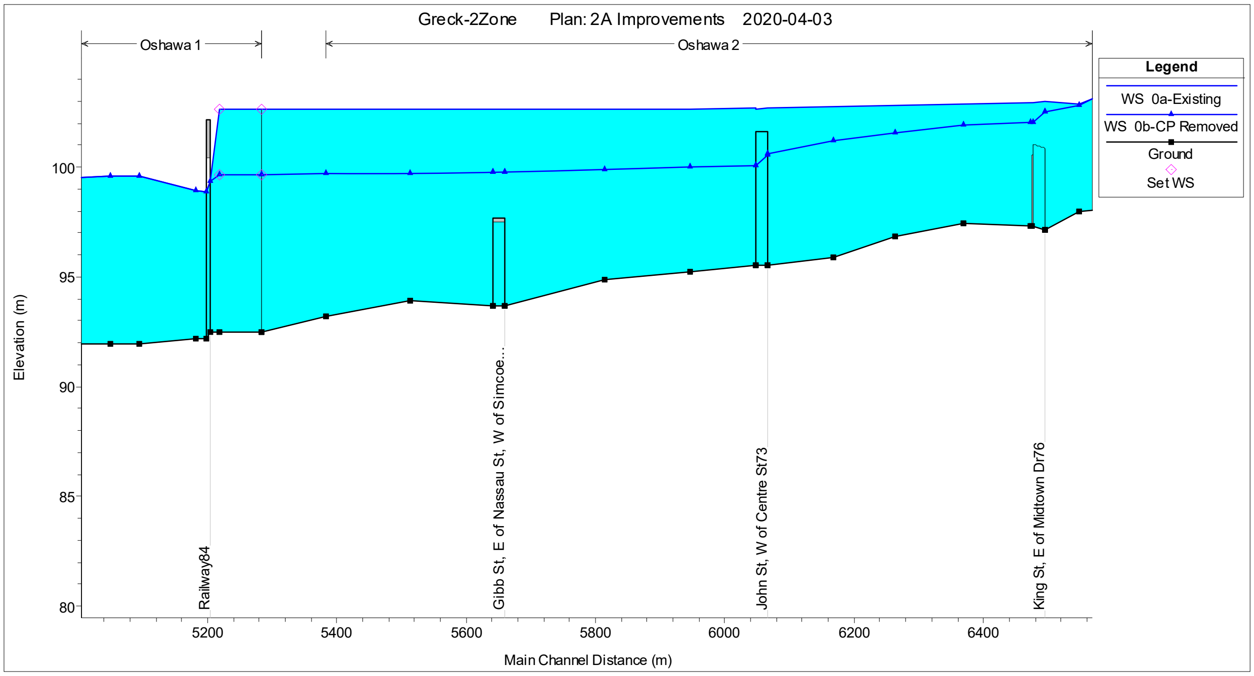

FIGURE 4.18: REGULATORY FLOOD PROFILE THROUGH GIBB STREET AND JOHN STREET

Even with substantial CPR Embankment improvements, further improvements to the Gibb Street Crossing would provide no upstream flood benefits, as the structure remains entirely submerged during the 2A Regional storm event, due to downstream backwater effects.

Improvements to the John Street crossing would have little to no benefits, as flood waters generally follow normal depth conditions through this portion of Oshawa Creek. To determine any potential flood improvements at John Street, it is recommended to explore John Street bridge improvements only once CPR Embankment improvements are made.

4.3.7 REGIONAL STORMWATER MANAGEMENT CONTROLS

A conceptual stormwater management scenario was investigated to evaluate the cost implications of providing upstream stormwater management controls through the Whitebelt Area. In the City of Oshawa, stormwater management facilities typically ensure post development discharge from each individual development is reduced to pre-development conditions for the 2-year through 100-year storm events. It may be possible to control the impacts of increased flood hazard caused by the Regional storm if stormwater management (SWM) facilities were designed to control this event.

When defining the regulatory flood plain limits SWM facilities are typically not credited for their effects during the Regional storm event, as per MNRF provincial standards (MNRF, 2002). The rationale for this is these facilities are not typically designed to withstand a Regional Storm event. If adequately designed following requirements of the Lakes and Rivers Improvement Act (LRIA), it may be possible to credit such facilities.

A hydrologic analysis was completed to evaluate the amount of storage required to provide post to pre-development quantity controls within the Whitebelt Area, both for the 2-year to 100-year storm events and the Regional storm event. This allowed for the estimation of the additional volume that would be required to go from a typical 100-year SWM facility, to a Regional SWM facility. This analysis was completed only for catchments within the Whitebelt Area, and assumed that a single, theoretical SWM facility applies to an entire catchment – as such, each facility is treated as an online facility. It is acknowledged that this has limitations, as stormwater management would occur throughout each catchment on a site by site basis, rather than as a single SWM facility.

Cost estimates associated with the facility were based on two criteria: additional volume and approximate additional land required for the facility. Costs associated with additional volume were based on an estimate of $100 per cubic meter of storage volume to account for the typical costs of earth moving, landscaping, berm reinforcement etc. The pond footprint area was estimated based on typical length to width ratios of SWM facilities and maximum allowable storage depths. The land area costs were based on an estimated land value of $200,000 per hectare of undeveloped land. A summary of the anticipated capital costs of Regional SWM facilities within the Whitebelt Area of Oshawa Creek is provided in **Table 4.13**.

TABLE 4.13: REGIONAL STORMWATER MANAGEMENT FACILITY – ROUGH ORDER OF MAGNITUDE CAPITAL COST ESTIMATES

Subcatchment	NYD	Drainage Area (ha)	Whitebelt Area (ha)	% Impervious		Regional Peak Flow			Required Storage Volume (m^3)				Required Area (m^2)				Note
				Existing	3A	Existing	3A Uncontrolled	3A Controlled	100-year	Regional	Delta	Additional Storage Cost*	100-year	Regional	Delta	Additional Footprint Cost*	
E1	101	269	177	3%	40%	24.1	35.4	24.1	9161	17576	8415	$ 841	8038	8788	750	$ 15	
E11	111	299	58	2%	8%	24.3	24.7	24.3	1889	3600	1711	$ 171	1500	1800	299	$ 6	
E12	112	280	96	2%	18%	23.7	25.4	23.7	3243	6760	3517	$ 352	2902	3380	478	$ 10	
E4	104	245	160	2%	48%	23.7	33.5	23.7	10610	17784	7173	$ 717	8259	8892	632	$ 13	
E5	105	328	77	3%	15%	25.8	24.8					-				-	3A reduces regional peak flows
E6	106	84	2	1%	2%	8.4	8.5	8.4	345	**570**	225	$ 23	214	285	71	$ 1	
K11	411	293	104	2%	51%	26.2	38.6	26.2	11113	20186	9073	$ 907	9335	10093	758	$ 15	
K12	412	102	64	2%	70%	11.4	14.4	11.4	4311	5437	1126	$ 113	1681	2719	1037	$ 21	
K6	406	179	133	2%	63%	15.7	25.4	15.7	8805	14988	6183	$ 618	8805	14988	6183	$ 124	
K8	408	55	38	1%	72%	5.7	7.8	5.7	2729	3797	1068	$ 107	1724	1898	175	$ 3	
R1	701	113	47	3%	16%	10.9	10.6					-				-	3A reduces regional peak flows
R13	713	104	65	2%	25%	9.7	14.4	9.6	3266	6907	3641	$ 364	2963	3454	491	$ 10	
R2	702	36	20	2%	17%	4.2	3.9					-				-	3A reduces regional peak flows
R5	705	299	158	2%	28%	25.8	39.3	25.8	9723	19610	9887	$ 989	8965	9805	840	$ 17	
R6	706	331	13	2%	3%	24.0	24.0	24.0	550	900	350	$ 35	352	450	98	$ 2	
R7	707	348	1	6%	6%	27.3	27.3	27.2	1465	1500	35	$ 4				-	Negligible increase in area
W4	804	406	181	8%	60%	29.7	55.7	29.5	20432	39840	19408	$ 1,941	5795	19920	14125	$ 282	
Total		3772	1395	3%	30%						71812	**$7,181**			25937	$ 519	
															Grand Total	$7,700	

Cost per ha of developable Whitebelt Land				
	Storage	$ 5,149	Cost per m^3 of additional storage	$ 100
	Additional Footprint	$ 372	Estimated cost per Hectare of land	$ 200,000
	Total	$ 5,520	Cost per m^2 of land	$ 20

***thousands of dollars**

While the above analyses are conceptual in nature, it is demonstrated that the level of required stormwater management varies significantly from catchment to catchment, as some areas within the Whitebelt undergo more intensification than others.

The resulting analyses and cost estimates conclude that the difference in capital costs between a 100-year SWMF to a Regional SWMF within the Whitebelt area would be approximately $7.7 million dollars. Assuming this provides sufficient peak flow reduction through the study area, and that 2A conditions are met, this results in only an 8cm decrease in flood elevation upstream of the CPR Embankment. This equates to that of no buildings being removed from the Regulatory Floodplain, as there are a total of 712 total buildings within the 3A and 2A regulatory floodplain.

Therefore, it would be much more economical to pursue CPR Embankment improvements, rather than providing Regional Stormwater management controls. Provided in **Figure 4.19** is an updated graphic from **Figure 4.16**. It can be demonstrated a lesser amount of money (~$7,000,000) can provide considerably much better flood improvements through the study area by constructing a 30m relief opening through the CPR Embankment. This would reduce the number of buildings within the 3A regulatory floodplain by approximately 300 buildings, while Regional stormwater management would eliminate no buildings from the floodplain. This provides further benefits by eliminating much of Gibb Street from the regulatory floodplain, providing further benefits to ingress/egress through the study area. This cannot be achieved through Regional stormwater management.

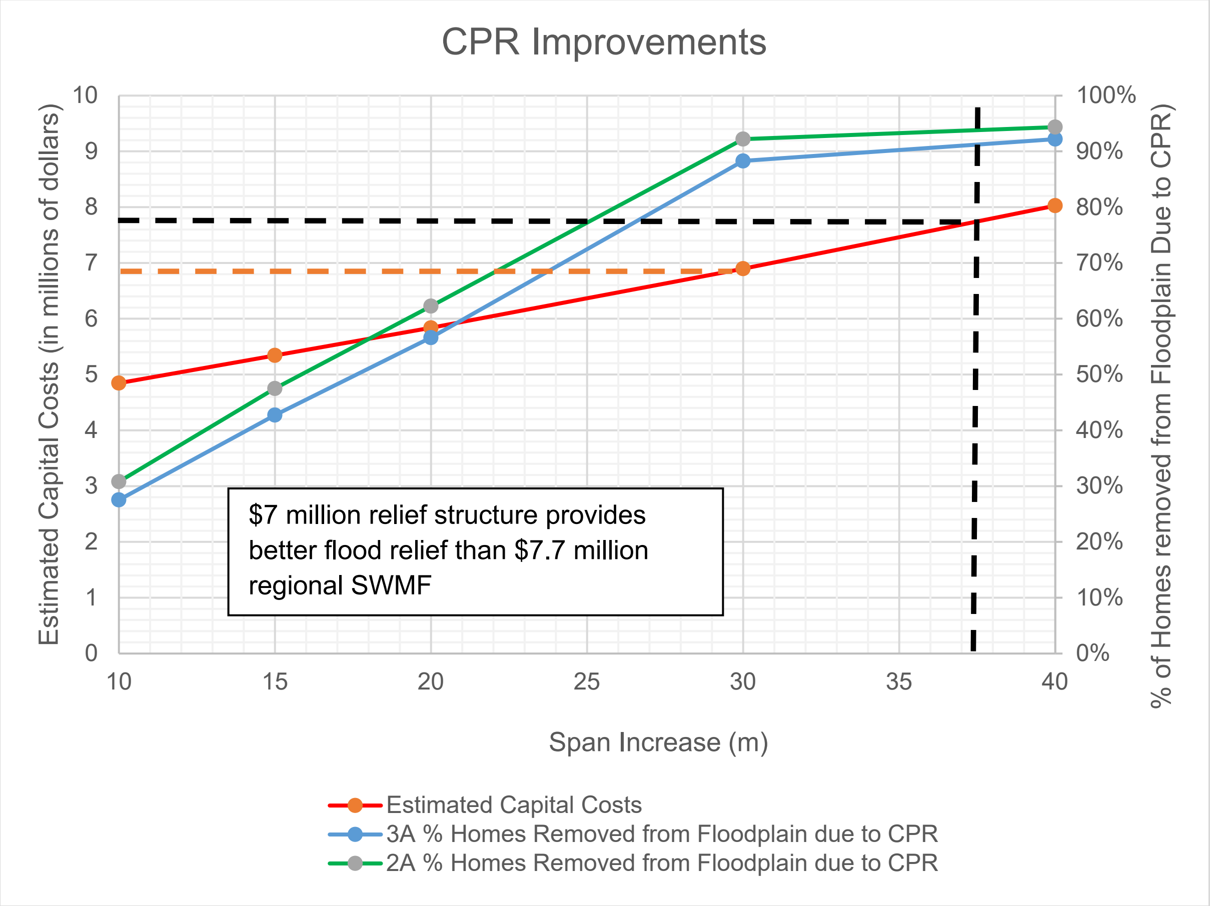

FIGURE 4.19: CPR EMBANKMENT IMPROVEMENTS VS REGIONAL SWMF

4.3.8 COMPARISON OF ALTERNATIVES

A summary of all flood reduction strategies is provided below in **Table 4.14**. The summary includes capital and flood reduction savings costs only for the Regulatory storm event. All fees associated with flood damage savings are in comparison to the existing conditions only. Fees provided below are based on the 3A scenario only.

TABLE 4.14: EVALUATION OF ALTERNATIVES

Scenario	Capital Costs (millions)	Flood Damage Savings (millions)	Net Cost - Capital Costs Less Flood Damage Savings (millions)	Benefit Cost Ratio
Existing	$0.00	$0.00	$0.00	NA
10m Increase in Span	$4.85	$0.62	$4.23	0.13
15m Increase in Span	$5.34	$1.14	$4.20	0.21
20m Increase in Span	$5.84	$1.59	$4.25	0.27
30m Increase in Span	$6.90	$2.79	$4.11	0.40
40m Increase in Span	$8.03	$2.99	$5.04	0.37
Relief Culvert A: 3.6mx3.0m Box Culvert*	*$1.08*	*$0.00*	*$1.08*	*NA**
Relief Culvert B: Twin 2700mm Circular Concrete Pipes*	*$1.10*	*$0.00*	*$1.10*	*NA**
Stormwater Management Controls*	*$7.70*	*$0.00*	*$7.70*	*NA**

**Function of these alternatives is to bring 3A flood conditions to 2A flood conditions and provides little benefit to the overall flood mitigation within the study area, as number of total dwellings remain the same comparing the 2A and 3A scenarios.*

Costs associated with relief culverts include capital costs, construction set up associated with tunneling / boring through a railway embankment. It should be noted that all above capital costs are a rough estimate only, and may have limitations due to their impact on structural integrity of the embankment, or may impose risks due to vibrations associated with tunneling / boring.

All the above items provide some level of flood benefits, however, the relief culverts and stormwater management controls main purpose is to reduce 3A flood conditions to 2A conditions and as such, have limited to no flood reduction benefits. As implied in Section 4.3.4, the optimum flood mitigation strategy would be to provide a second 30m span at the CPR Embankment, as it provides a higher level of benefit-to-cost ratio and substantially reduces the number of buildings within overall floodplain.

5.0 CONCLUSIONS

Greck and Associates Limited conducted hydrologic and hydraulic analyses to delineate an updated floodway and flood fringe through the Goodman Creek and Oshawa Creek, located south of King Street and north of the CPR Embankment within the study area.

The analyses concluded the following:

1. The floodway and flood fringe was defined by the greater of velocity, depth, depth-velocity product and the 100-year floodline criteria. In most cases the floodway and flood fringe is defined by the flood depth within the Oshawa Creek Branch, and by the 100-year floodplain through Goodman Creek.
2. The flood fringe was noticeably small through the Oshawa Creek, and more significant through the Goodman Reach, upstream of Stevenson Road. as Regional floodwaters through the Goodman Reach are typically shallow and with low velocities.
3. Most roads through the study area do not provide safe ingress/egress. Roads without safe ingress/egress were identified based on flood depths greater than 0.4m. This was particularly important for Gibb Street which is an arterial roadway through the study area.
4. Without considerations for Climate Change impacts, encroachment within the flood fringe area is generally feasible through the study area as it would have little to no impact on flood elevation except for the area of Goodman Creek between Montcalm Avenue and King Street. There would also be no impacts downstream brought about by an increase in peak flow due to lost flood storage.
    - 4.1. Encroachment is not feasible once climate change considerations are incorporated, as the floodway increases significantly due to the overall increase in the 100-year floodplain
5. The effects of climate change on the 100-year floodline was simulated via hydrologic and hydraulic analyses and concludes that in the future, the 100-year floodline will not exceed the Regional floodplain, however, will have impact on the floodway within the Goodman Reach due to an increase in 100-year floodplain through the area.
6. The impacts of future development within the Whitebelt area could result in up to an 8 cm increase in flood elevations through the study area. While considered to be a relatively small increase, there is less tolerance for this increase by CLOCA as the area is already a significant flood risk area and efforts are required to prioritize reductions in flood hazards.

A variety of flood mitigation strategies were investigated, and following conclusions have been prepared:

7. Improving the conveyance of flood flows at structures downstream (south) of the CPR Embankment have no benefits on reducing flood elevations through the study area.
8. Increasing the opening has its greatest benefits on the floodplain associated with the Goodman Creek from Stevenson Road South to the confluence with the Oshawa Creek floodplain
9. Increasing and/or removing the bridge entirely has no benefits to the Two-Zone policy flood hazard area upstream of Stevenson Road South
10. Increasing and/or removing the bridge entirely has very limited benefits by way of flood reduction upstream of John Street West
11. Places such as Midtown Mall (north of John Street), Village Union Public School remain within the regulatory floodplain even with complete removal of the CPR Crossing.
12. A variety of CPR Embankment flood relief structures were investigated and concluded that a second 30m span bridge be added to the west of the existing opening would provide the optimum level of flood benefits through the area.
13. Other structural improvements, such as a smaller flood relief culvert were noted to have little to no benefits within the study area, as existing flood elevations are typically governed by the backwater effect of the CPR Embankment. At most, these structures could only offset the 8 cm increase in flooding caused by development of the Whitebelt area. Structure improvements through the Goodman Reach (upstream of Gibb Street) have little value due to the hydraulics of the valley lands
14. Structural Improvements along the Goodman Creek, upstream of Stevenson Road were shown to have little to no impact on flood elevations through the area due to their level of submergence and limited capacity during the Regional storm event
15. Regional stormwater management facilities were investigated in effort to mitigate flood elevation increases due to Whitebelt Development. The analyses concluded that the benefit-costs associated with these facilities would be substantially less than the benefit-costs associated with the construction of a large flood relief structure at the CPR Embankment.

16. If an opportunity to improve the CPR opening occurs, prior to development of the Whitebelt area, it would be desirable from a benefit-cost perspective for the City of Oshawa to consider enlarging the opening to accommodate 3A development scenario (Whitebelt areas). Should this occur, Regional Stormwater Management Control requirement would not be required for any future developments in the Whitebelt area.

17. In the event if there is no opportunity for improving the CPR opening, but the Whitebelt area is to be considered for development, the Regional Stormwater Management Control should be imposed on the lands to the satisfaction of both CLOCA and the City to ensure that there is no significant adverse impact to the existing Goodman/Oshawa Creeks Flood Damage Center located immediate upstream of the CPR structure.

18. A net benefit-cost value has been estimated for each of the flood mitigation strategies outlined in this report. This benefit-cost exercise considers capital costs for construction and flood damages to basements only and has concluded that the optimum solution is an additional 30m spanned structure through the CPR Embankment

6.0 RECOMMENDATIONS

As a result of the above study, Greck and Associates Limited provides the following recommendations:

1. CLOCA and the City of Oshawa adopt the floodway and fringe areas defined by this study into an update of the current Two-Zone Policy for this area.

2. When the opportunity arises, the flow conveyance be increased at the CPR Embankment by adding a second 30 m span bridge adjacent to the existing bridge to reduce the number of homes in the floodplain due to the CPR Embankment by ~90 % and improve the overall ingress/egress viability for properties located within the Two Zone Policy area.

3. The City should consider financial contributions from the development community to support CPR Embankment Improvements, as the benefit-costs for implementing Regional stormwater management control are not as cost effective in the Two-Zone Policy area for reducing the impacts caused by development of the Whitebelt Area. Potential increases in flooding within the Two-Zone study area associated with development of the 3A Scenario can be offset with flow conveyance improvements at the CPR Embankment.

    3.1. If there is an opportunity to improve the CPR Embankment, Regional Stormwater Management Control would not be required within the Whitebelt Area.

    3.2. If no CPR Embankment opportunities arise, Regional Stormwater Management should be imposed within the Whitebelt to ensure no adverse flood impacts occur to downstream Flood Damage Centers.

4. Any application to fill (encroach) within the flood fringe area must be accompanied by a hydraulic analysis to ensure no flood impacts occur to adjacent properties.

5. The Canadian Pacific Railway (CPR) and associated authorities (Metrolinx et al) should be advised of the importance of improving flood conveyance at this location. Opportunities to improve the crossing should be investigated in cooperation with the City of Oshawa, with all expansion, replacement, and improvement projects through this railway segment.

6. The City should investigate additional flood reduction strategies once the CPR Embankment improvements have been implemented. Such floodplain reduction strategies include, but not limited to improvements to bridges crossing Oshawa Creek on Gibb Street and John Street Bridge.

7. With respect to the Two-Zone area only, there should be no tolerance for increases in flood hazards caused by upstream development (Whitebelt Lands). This recommendation has no bearings on impacts due to peak flows outside of the Two-Zone Area.

APPENDIX A

Public Consultation

Two Zone Floodplain Mapping and Flood Mitigation Update Study
Oshawa Goodman Creeks

Name (Please Print)	Email Address	Do you want to be on the direct contact list for future notification?
[redacted]	[redacted]	Yes No
[redacted]	[redacted]	Yes No
[redacted]	[redacted]	Yes No
[redacted]	[redacted]	Yes No
[redacted]	[redacted]	Yes No
[redacted]	[redacted]	[✓ Yes] No
[redacted]	[redacted]	[✓ Yes] No
[redacted]	[redacted]	[✓ Yes] No
[redacted]	[redacted]	Yes No
[redacted]	[redacted]	[✓ Yes] No
[redacted]	[redacted]	[✓ Yes] No
[redacted]	[redacted]	[✓ Yes] No
[redacted]	[redacted]	[✓ Yes] No
[redacted]	[redacted]	Yes No
[redacted]	[redacted]	[✓ Yes] No
[redacted]	[redacted]	[✓ Yes] No
[redacted]	[redacted]	[✓ Yes] No
[redacted]	[redacted]	[✓ Yes] No
[redacted]	[redacted]	Yes No
[redacted]	[redacted]	[✓ Yes] No
[redacted]	[redacted]	Yes [✓ No]
[redacted]	[redacted]	[✓ Yes] No
[redacted]	[redacted]	~~[✓ Yes]~~ [✓ No]
[redacted]	[redacted]	Yes No
[redacted]	[redacted]	Yes No

Central Lake Ontario Conservation

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Greck

Two Zone Floodplain Mapping and Flood Mitigation Update Study
Oshawa Goodman Creeks

Attendance Sheet – Public Information Centre
September 25, 2019

Name (Please Print)	Email Address	Do you want to be on the direct contact list for future notification?
[redacted]	[redacted]	Yes No
[redacted]	[redacted]	Yes No
[redacted]	[redacted]	Yes No
[redacted]	[redacted]	Yes No
[redacted]	[redacted]	[✓ Yes] No
[redacted]	[redacted]	[✓ Yes] No
[redacted]	[redacted]	[✓ Yes] No
[redacted]	[redacted]	[✓ Yes] No
[redacted]	[redacted]	Yes No
[redacted]	[redacted]	[✓ Yes] No
[redacted]	[redacted]	[✓ Yes] No
[redacted]	[redacted]	[✓ Yes] No
[redacted]	[redacted]	[✓ Yes] No
[redacted]	[redacted]	Yes No
[redacted]	[redacted]	[✓ Yes] No
[redacted]	[redacted]	[✓ Yes] No
[redacted]	[redacted]	[✓ Yes] No
[redacted]	[redacted]	[✓ Yes] No
[redacted]	[redacted]	Yes [✓ No]
[redacted]	[redacted]	[✓ Yes] No
[redacted]	[redacted]	[✓ Yes] No
[redacted]	[redacted]	[✓ Yes] No

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Two Zone Floodplain Mapping and Flood Mitigation Update Study
Oshawa Goodman Creeks

Question Form

1. Do you understand the basic concepts of the two-zone floodplain policy? Yes No
2. Do you live within the proposed two-zone floodplain policy area? [✓ Yes] No
3. Do you have any specific concerns regarding the area to be zoned as a two-zone floodplain policy area? If so, please describe below

Do I need cloca approval to work on my house.
re: permits ? cost if any
will my insurance (house) go up. ?

Please fill in the section below with any comments or questions you may have regarding this study.

if the rail embankment was put in for the good of the country and now to the detriment of those living north of it... let the rail company or the government which okayed it. rectify the problem. call me
289 423 9767

Nam[redacted]	Email Address: [redacted]

[redacted]

We would greatly appreciate your co-operation if you can hand in the Comment Sheet before you leave tonight, or send it in by October 9, 2019 to:

Lucy Benham, P.Eng.
Water Resources Engineer
Central Lake Ontario Conservation Authority
100 Whiting Ave.
Oshawa, ON L1H 3T3
Tel: 905 579 0411 ext 106
e-mail: lbenham@cloca.com

Central Lake Ontario Conservation

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Oshawa Goodman Creeks

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Please fill in the section below with any comments or questions you may have regarding this study.

OPEN UP THE FLOW AT THE RAILWAY BRIDGE?

Name: [redacted]	Email Address: [redacted]

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Oshawa Goodman Creeks

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How can I prepare for a severe event

Please fill in the section below with any comments or questions you may have regarding this study.

~~[illegible]~~ A more formal presentation would be better for my understanding. Reading the boards did not help my understanding.

The person I spoke with was very helpful

Name: [redacted]	Email Address: [redacted]

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Oshawa Goodman Creeks

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Email Address:

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any effects on homeowners insurance?

Please fill in the section below with any comments or questions you may have regarding this study.

Name: [redacted]	Email Address: [redacted]

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2. Do you live within the proposed two-zone floodplain policy area? [✓ Yes] No
3. Do you have any specific concerns regarding the area to be zoned as a two-zone floodplain policy area? If so, please describe below

try and ~~import~~ change our area from the water

Please fill in the section below with any comments or questions you may have regarding this study.

Well there is not to much you can do about water coming (flood)

Name [redacted]	Email Address: [redacted]

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Information contained on this form is collected pursuant to Municipal Freedom of Information and Protection of Privacy legislation and will be used for the purpose of responding to your request. Questions about this collection should be directed to CLOCA's Director of Corporate Services

Two Zone Floodplain Mapping and Flood Mitigation Update Study
Oshawa Goodman Creeks

Question Form

1. Do you understand the basic concepts of the two-zone floodplain policy? [✓ Yes] No
2. Do you live within the proposed two-zone floodplain policy area? [✓ Yes] No
3. Do you have any specific concerns regarding the area to be zoned as a two-zone floodplain policy area? If so, please describe below

Are there any plans in the works for additional forms of ~~flood~~ reducing potential flood damage such as dykes along the 2 main creeks.

Please fill in the section below with any comments or questions you may have regarding this study.

A

Name: [redacted]	Email Address: [redacted]

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Two Zone Floodplain Mapping and Flood Mitigation Update Study
Oshawa Goodman Creeks

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Oshawa, ON L1H 3T3
Tel: 905 579 0411 ext 106
e-mail: lbenham@cloca.com

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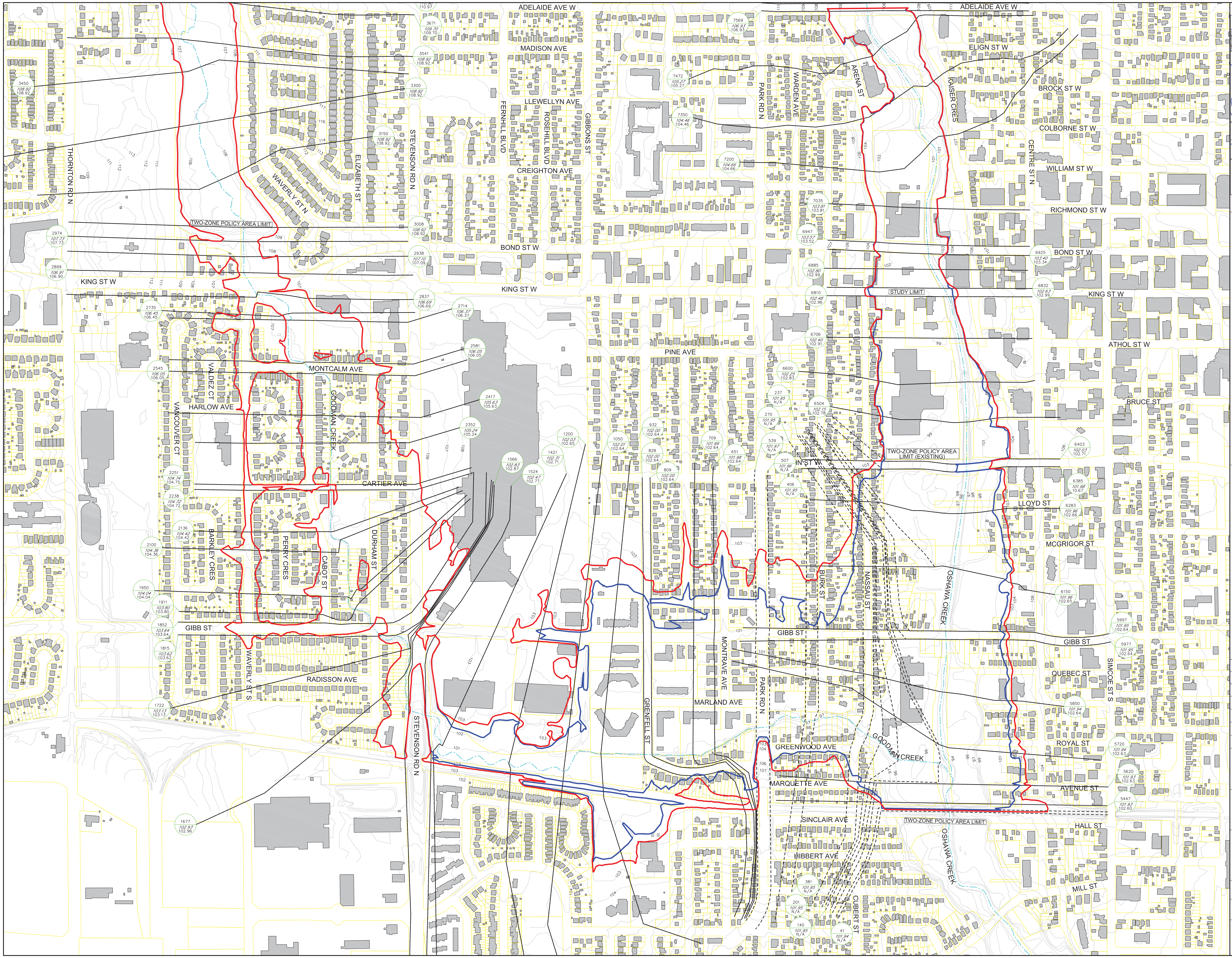
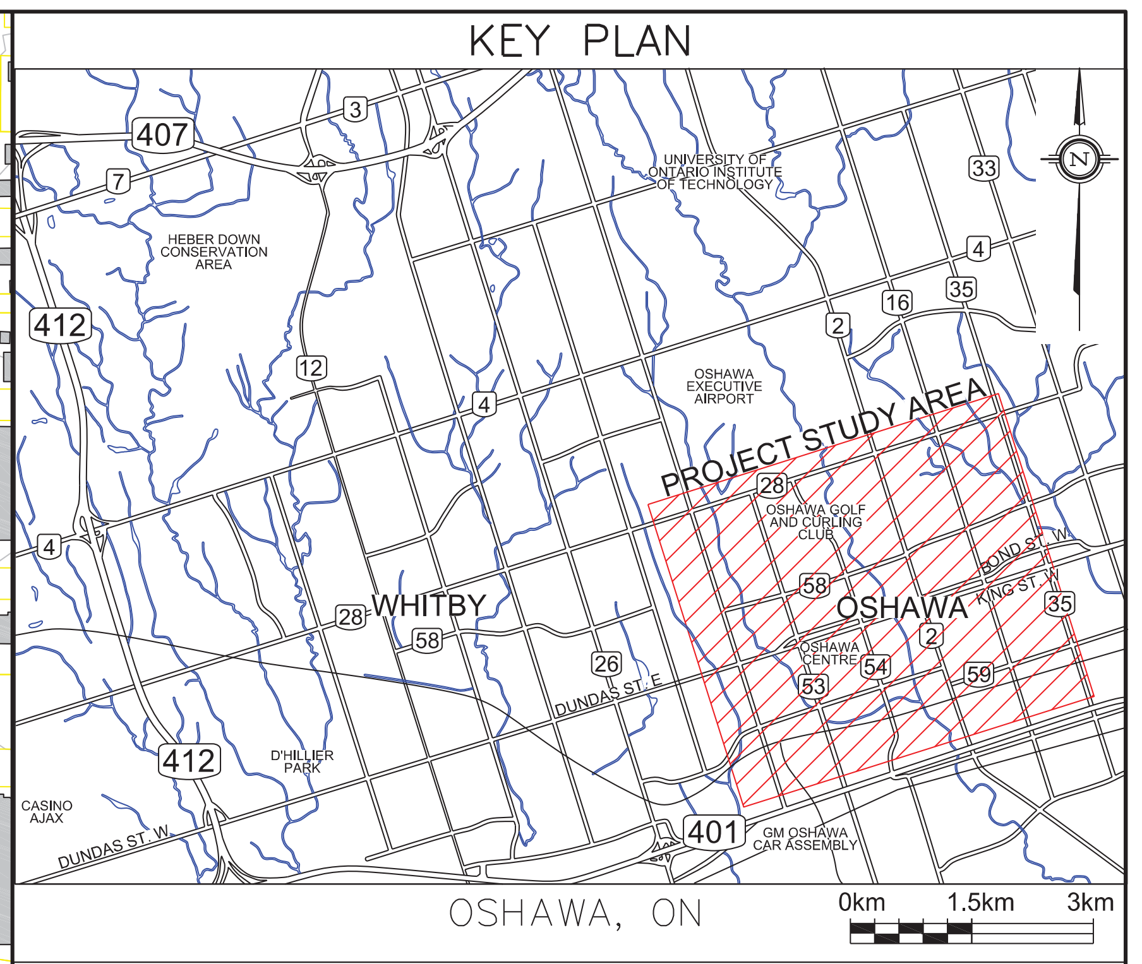
APPENDIX B

Hydraulic Modelling Modifications





LEGEND

101	CONTOUR 1m INTERVALS
— · — · —	CHANNEL CENTRE LINE
▨	EXISTING BUILDING
——	PARCEL BOUNDARY
- - - - - -	EXISTING HEC RAS CROSS SECTION
——	UPDATED HEC RAS CROSS SECTION
——	EXISTING FLOODLINE
——	UPDATED FLOODLINE
XXXX.XXX	STATION NUMBER
~~XXX.X~~	EXISTING REGIONAL FLOOD ELEVATION
XXX.X	UPDATED REGIONAL FLOOD ELEVATION

DATE	REVISION	BY
27/MAR/2020	FINAL SUBMISSION	S.S.

Greck
5770 Highway 7, Unit 3, Woodbridge, Ontario, L4L 1T8

Oshawa
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OSHAWA AND GOODMAN CREEK

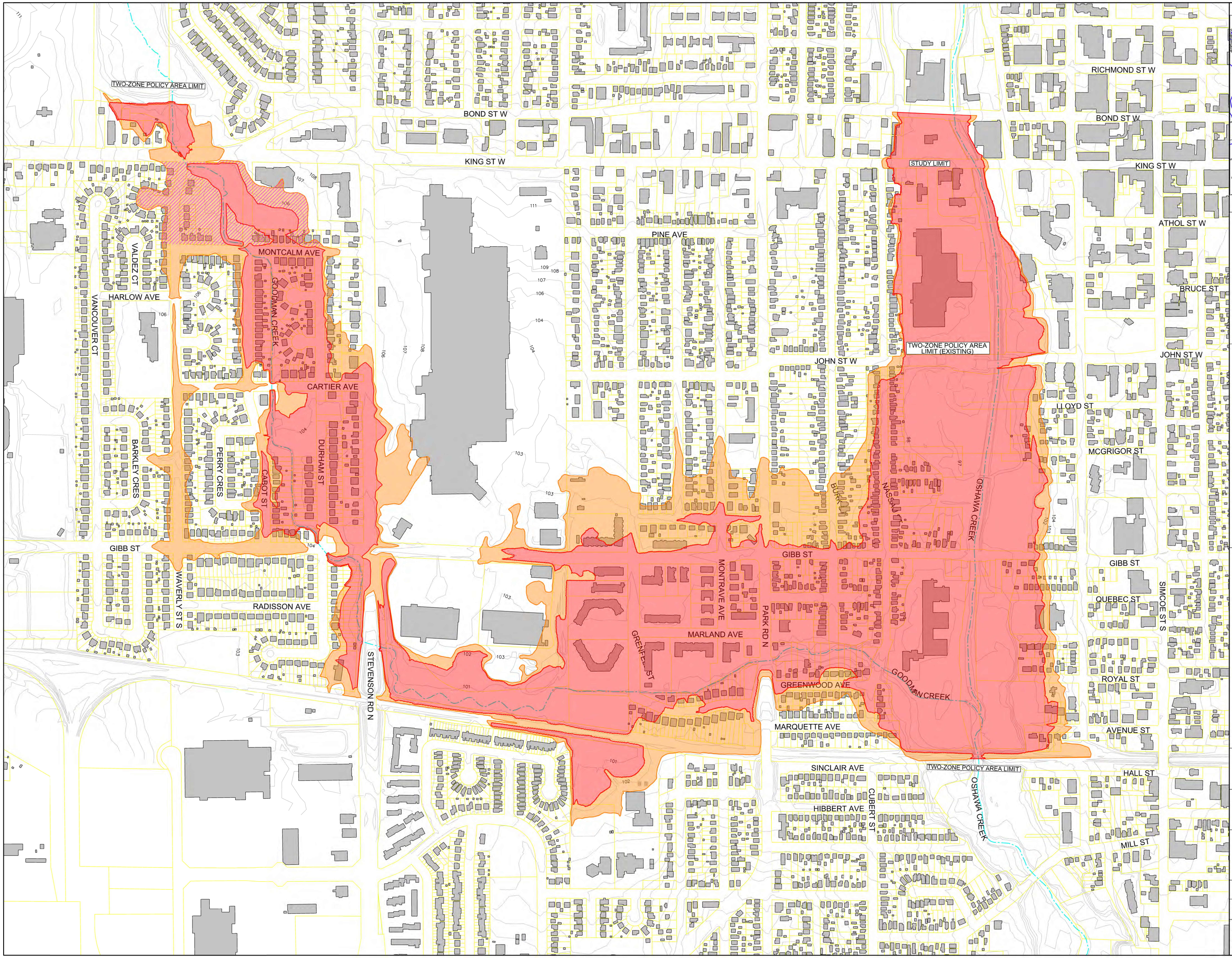
TWO-ZONE FLOODPLAIN MAPPING AND FLOOD MITIGATION STUDY

UPDATED FLOODLINE

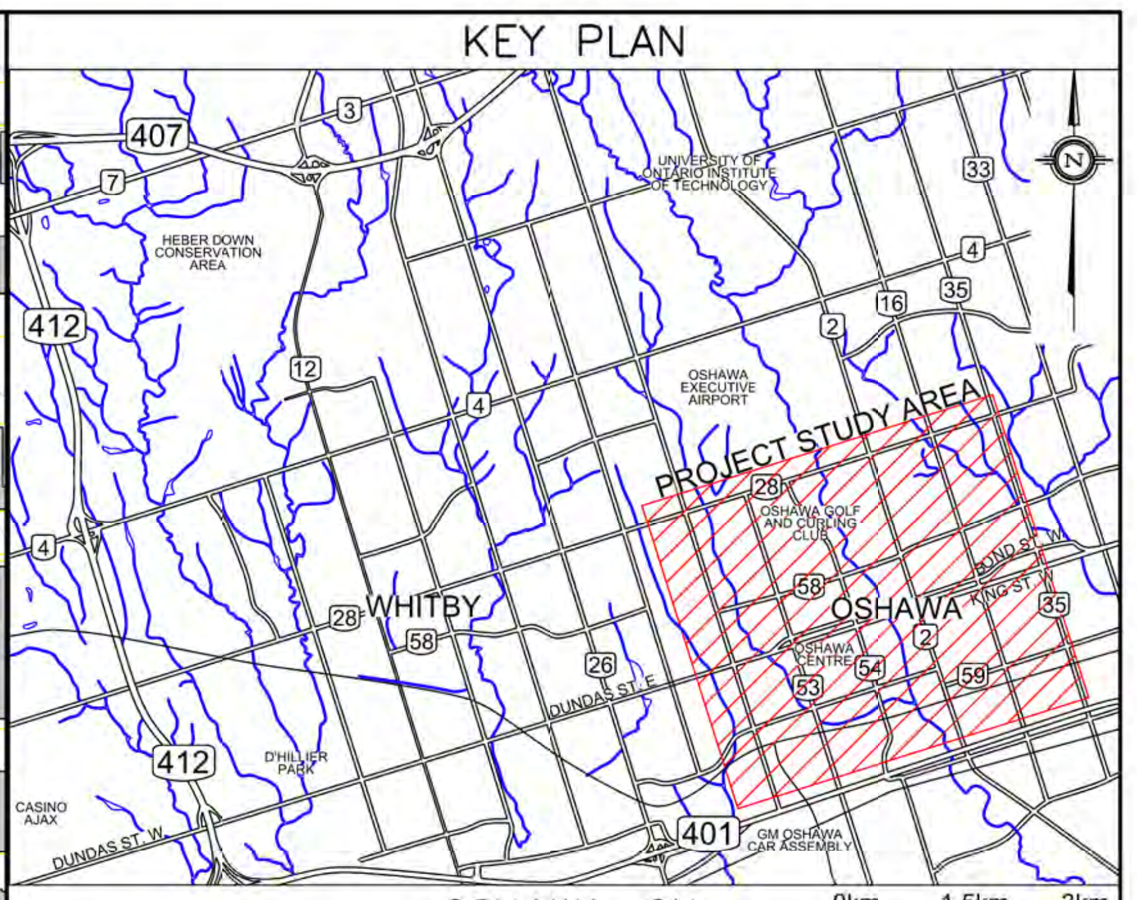
DATE: MARCH 2020	DESIGN BY B.G. & S.S.	DWG. BY P.G.	APPD. BY B.G.
SCALE: 1:4000	PROJECT NO. 18–543		
100m 0m 100m	SHEET NO. 1		

APPENDIX C

Floodway/Flood Fringe Delineation



KEY PLAN



OSHAWA, ON

0km 1.5km 3km

LEGEND

—	CONTOUR 1m INTERVALS
■	EXISTING BUILDING
—	PARCEL BOUNDARY
—·—	CHANNEL CENTRE LINE
🟥	PROPOSED FLOODWAY
🟧	PROPOSED FLOOD FRINGE
▨	MODIFIED FLOODWAY DUE TO ENCROACHMENT SENSITIVITY

Greck
5770 Highway 7, Unit 3, Woodbridge, Ontario, L4L 1T8

Oshawa
Prepare To Be Amazed

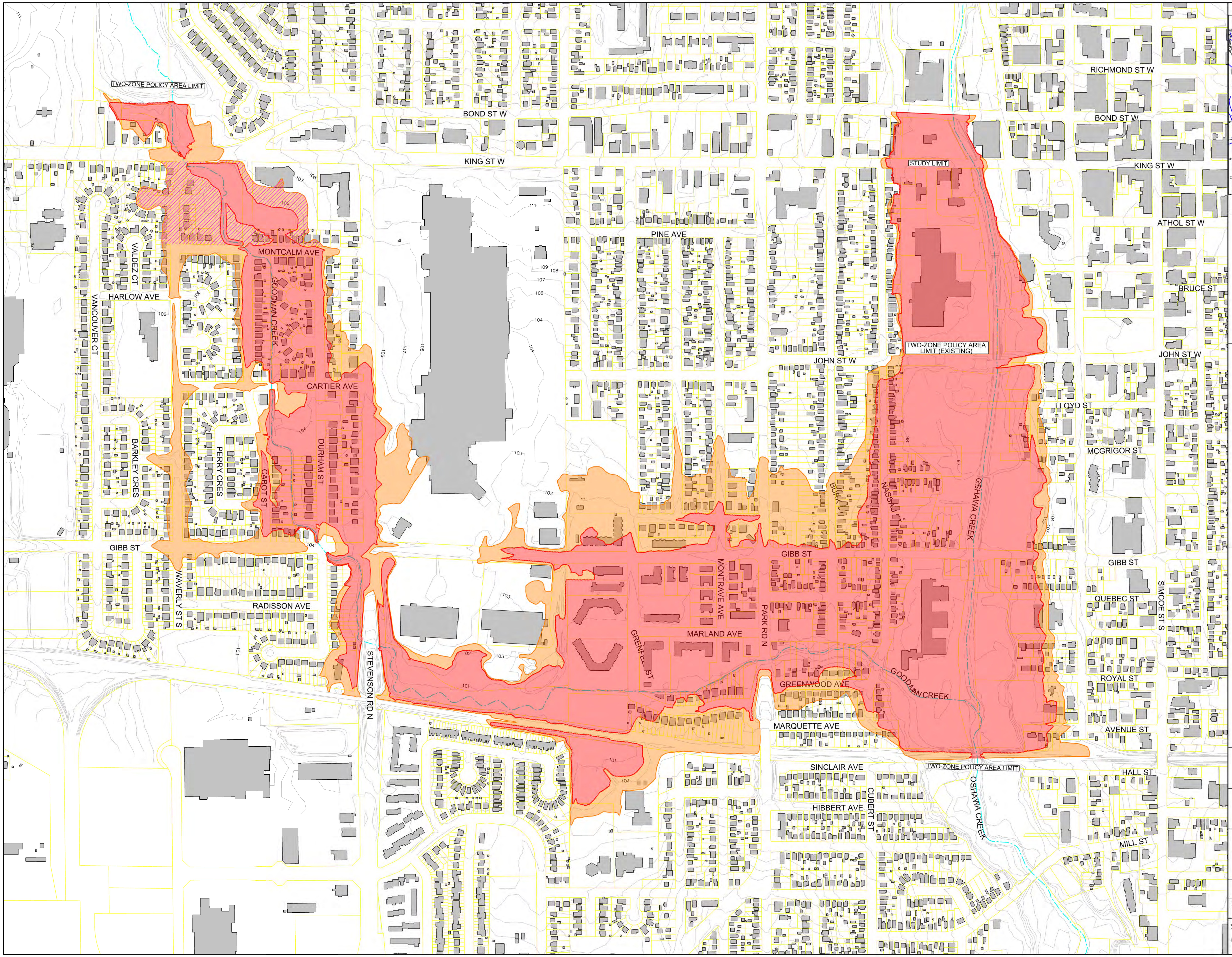
Central Lake Ontario Conservation

OSHAWA AND GOODMAN CREEK

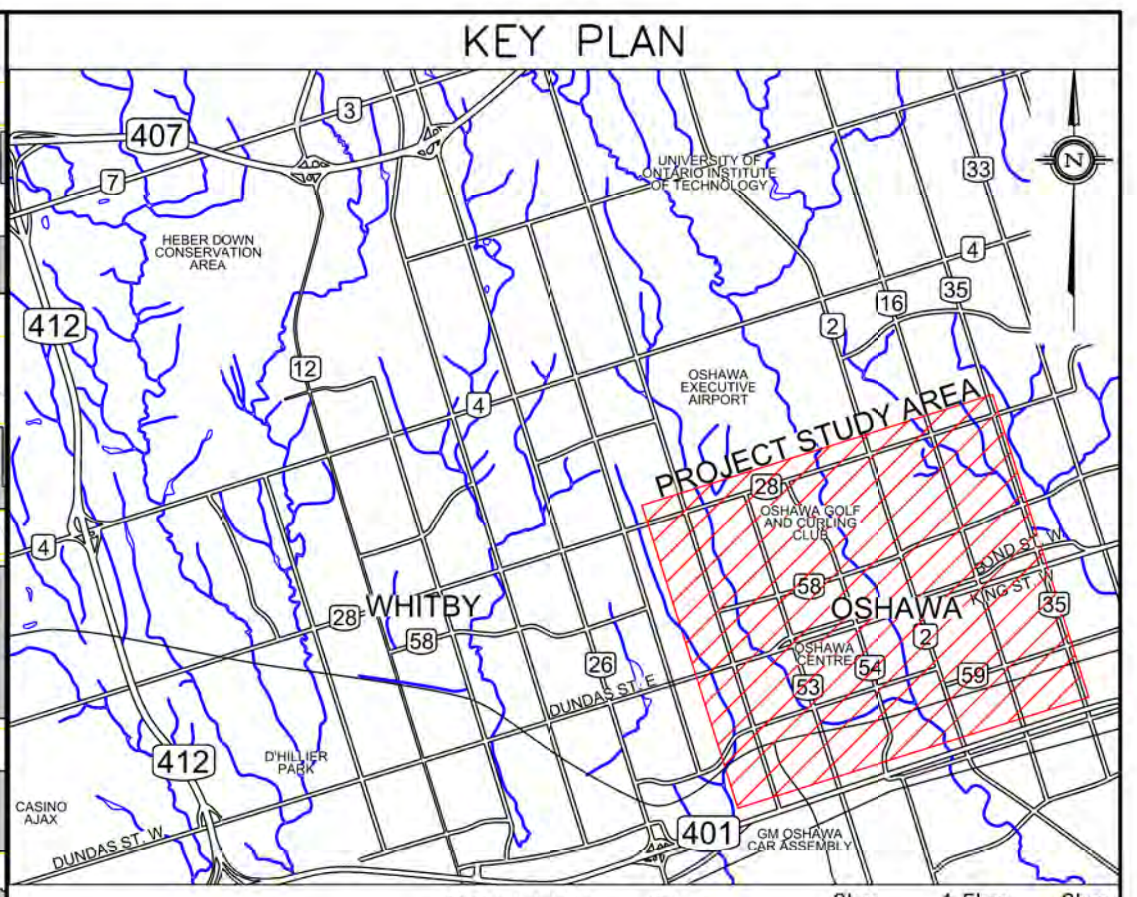
TWO-ZONE FLOODPLAIN AND FLOOD FRINGE STUDY

2 ZONE POLICY LIMIT

DATE: DEC 2020
DESIGN BY B.G. & S.S.
DWG. BY P.G.
APPD. BY B.G.
SCALE: 1:3500
100m 0m 100m
PROJECT NO. 18-543
SHEET NO. 1



KEY PLAN



OSHAWA, ON

0km 1.5km 3km

LEGEND

—	CONTOUR 1m INTERVALS
▭	EXISTING BUILDING
—	PARCEL BOUNDARY
- -	CHANNEL CENTRE LINE
🟥	PROPOSED FLOODWAY
🟧	PROPOSED FLOOD FRINGE
▨	MODIFIED FLOODWAY DUE TO ENCROACHMENT SENSITIVITY

N

Greck

5770 Highway 7, Unit 3, Woodbridge, Ontario, L4L 1T8

Oshawa
Prepare To Be Amazed

Central
Lake Ontario
Conservation

OSHAWA AND GOODMAN CREEK

TWO-ZONE FLOODPLAIN AND FLOOD FRINGE STUDY

2 ZONE POLICY LIMIT

DATE: DEC 2020	DESIGN BY B.G. & S.S.	DWG. BY P.G.	APPD. BY B.G.
SCALE: 1:3500 100m 0m 100m	PROJECT NO. 18-543 SHEET NO. 1		

APPENDIX D

Selected HEC RAS Hydraulic Modelling Summaries

HEC-RAS Plan: 2AImprovements Locations: User Defined

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Oshawa	2	7034.698	Existing	673.15	99.06	103.81	103.81	104.43	0.018311	5.13	231.55	153.90	0.76
Oshawa	2	7034.698	CP Removed	673.15	99.06	103.81	103.81	104.43	0.018311	5.13	231.55	153.90	0.76
Oshawa	2	7034.698	2m	673.15	99.06	103.81	103.81	104.43	0.018311	5.13	231.55	153.90	0.76
Oshawa	2	7034.698	4m	673.15	99.06	103.81	103.81	104.43	0.018311	5.13	231.55	153.90	0.76
Oshawa	2	7034.698	6m	673.15	99.06	103.81	103.81	104.43	0.018311	5.13	231.55	153.90	0.76
Oshawa	2	7034.698	8m	673.15	99.06	103.81	103.81	104.43	0.018311	5.13	231.55	153.90	0.76
Oshawa	2	7034.698	10m	673.15	99.06	103.81	103.81	104.43	0.018311	5.13	231.55	153.90	0.76
Oshawa	2	7034.698	15m	673.15	99.06	103.81	103.81	104.43	0.018311	5.13	231.55	153.90	0.76
Oshawa	2	7034.698	20m	673.15	99.06	103.81	103.81	104.43	0.018311	5.13	231.55	153.90	0.76
Oshawa	2	7034.698	30m	673.15	99.06	103.81	103.81	104.43	0.018311	5.13	231.55	153.90	0.76
Oshawa	2	7034.698	40m	673.15	99.06	103.81	103.81	104.43	0.018311	5.13	231.55	153.90	0.76
Oshawa	2	6946.907	Existing	673.15	98.10	103.54	102.81	103.84	0.002246	3.12	328.48	172.11	0.43
Oshawa	2	6946.907	CP Removed	673.15	98.10	103.57	102.81	103.85	0.002167	3.07	332.93	172.81	0.42
Oshawa	2	6946.907	2m	673.15	98.10	103.57	102.81	103.85	0.002167	3.07	332.93	172.81	0.42
Oshawa	2	6946.907	4m	673.15	98.10	103.57	102.81	103.85	0.002167	3.07	332.93	172.81	0.42
Oshawa	2	6946.907	6m	673.15	98.10	103.57	102.81	103.85	0.002167	3.07	332.93	172.81	0.42
Oshawa	2	6946.907	8m	673.15	98.10	103.57	102.81	103.85	0.002167	3.07	332.93	172.81	0.42
Oshawa	2	6946.907	10m	673.15	98.10	103.57	102.81	103.85	0.002167	3.07	332.93	172.81	0.42
Oshawa	2	6946.907	15m	673.15	98.10	103.57	102.81	103.85	0.002167	3.07	332.93	172.81	0.42
Oshawa	2	6946.907	20m	673.15	98.10	103.57	102.81	103.85	0.002167	3.07	332.93	172.81	0.42
Oshawa	2	6946.907	30m	673.15	98.10	103.57	102.81	103.85	0.002167	3.07	332.93	172.81	0.42
Oshawa	2	6946.907	40m	673.15	98.10	103.57	102.81	103.85	0.002167	3.07	332.93	172.81	0.42
Oshawa	2	6935.837		Culvert									
Oshawa	2	6924.769	Existing	673.15	98.10	103.35	102.92	103.75	0.003016	3.59	291.65	166.83	0.50
Oshawa	2	6924.769	CP Removed	673.15	98.10	103.40	102.92	103.77	0.002836	3.50	299.25	169.12	0.49
Oshawa	2	6924.769	2m	673.15	98.10	103.40	102.92	103.77	0.002836	3.50	299.25	169.12	0.49
Oshawa	2	6924.769	4m	673.15	98.10	103.40	102.92	103.77	0.002836	3.50	299.25	169.12	0.49
Oshawa	2	6924.769	6m	673.15	98.10	103.40	102.92	103.77	0.002836	3.50	299.25	169.12	0.49
Oshawa	2	6924.769	8m	673.15	98.10	103.40	102.92	103.77	0.002836	3.50	299.25	169.12	0.49
Oshawa	2	6924.769	10m	673.15	98.10	103.40	102.92	103.77	0.002836	3.50	299.25	169.12	0.49
Oshawa	2	6924.769	15m	673.15	98.10	103.40	102.92	103.77	0.002836	3.50	299.25	169.12	0.49
Oshawa	2	6924.769	20m	673.15	98.10	103.40	102.92	103.77	0.002836	3.50	299.25	169.12	0.49
Oshawa	2	6924.769	30m	673.15	98.10	103.40	102.92	103.77	0.002836	3.50	299.25	169.12	0.49
Oshawa	2	6924.769	40m	673.15	98.10	103.40	102.92	103.77	0.002836	3.50	299.25	169.12	0.49
Oshawa	2	6884.784	Existing	673.15	98.00	102.87	102.80	103.45	0.015104	4.63	248.68	155.68	0.68
Oshawa	2	6884.784	CP Removed	673.15	98.00	102.80	102.80	103.45	0.017022	4.87	237.51	155.32	0.72
Oshawa	2	6884.784	2m	673.15	98.00	102.80	102.80	103.45	0.017022	4.87	237.51	155.32	0.72
Oshawa	2	6884.784	4m	673.15	98.00	102.80	102.80	103.45	0.017022	4.87	237.51	155.32	0.72
Oshawa	2	6884.784	6m	673.15	98.00	102.80	102.80	103.45	0.017022	4.87	237.51	155.32	0.72
Oshawa	2	6884.784	8m	673.15	98.00	102.80	102.80	103.45	0.017022	4.87	237.51	155.32	0.72
Oshawa	2	6884.784	10m	673.15	98.00	102.80	102.80	103.45	0.017022	4.87	237.51	155.32	0.72
Oshawa	2	6884.784	15m	673.15	98.00	102.80	102.80	103.45	0.017022	4.87	237.51	155.32	0.72
Oshawa	2	6884.784	20m	673.15	98.00	102.80	102.80	103.45	0.017022	4.87	237.51	155.32	0.72
Oshawa	2	6884.784	30m	673.15	98.00	102.80	102.80	103.45	0.017022	4.87	237.51	155.32	0.72
Oshawa	2	6884.784	40m	673.15	98.00	102.80	102.80	103.45	0.017022	4.87	237.51	155.32	0.72
Oshawa	2	6832.49	Existing	673.15	97.16	102.97	102.17	103.16	0.001458	2.57	414.64	212.55	0.34
Oshawa	2	6832.49	CP Removed	673.15	97.16	102.51	102.17	102.85	0.002777	3.36	320.88	189.86	0.46
Oshawa	2	6832.49	2m	673.15	97.16	102.90	102.17	103.10	0.001608	2.68	399.56	209.50	0.36
Oshawa	2	6832.49	4m	673.15	97.16	102.81	102.17	103.04	0.001813	2.82	381.71	205.53	0.38
Oshawa	2	6832.49	6m	673.15	97.16	102.75	102.17	103.00	0.001985	2.92	368.62	202.71	0.39
Oshawa	2	6832.49	8m	673.15	97.16	102.69	102.17	102.96	0.002172	3.04	355.97	200.04	0.41
Oshawa	2	6832.49	10m	673.15	97.16	102.68	102.17	102.95	0.002189	3.05	354.90	199.81	0.41
Oshawa	2	6832.49	15m	673.15	97.16	102.57	102.17	102.89	0.002555	3.25	333.70	194.77	0.45
Oshawa	2	6832.49	20m	673.15	97.16	102.55	102.17	102.87	0.002647	3.29	327.96	191.94	0.45
Oshawa	2	6832.49	30m	673.15	97.16	102.51	102.17	102.85	0.002769	3.35	321.26	189.90	0.46
Oshawa	2	6832.49	40m	673.15	97.16	102.50	102.17	102.84	0.002794	3.37	320.15	189.80	0.47
Oshawa	2	6821.114		Culvert									
Oshawa	2	6809.793	Existing	673.15	97.34	102.94	101.97	103.10	0.001170	2.57	451.37	217.05	0.35
Oshawa	2	6809.793	CP Removed	673.15	97.34	102.03	101.97	102.55	0.004164	4.31	272.43	186.40	0.64
Oshawa	2	6809.793	2m	673.15	97.34	102.87	101.97	103.04	0.001257	2.64	435.93	209.98	0.36
Oshawa	2	6809.793	4m	673.15	97.34	102.78	101.97	102.97	0.001390	2.75	418.46	205.86	0.38
Oshawa	2	6809.793	6m	673.15	97.34	102.71	101.97	102.91	0.001513	2.84	403.01	201.74	0.39
Oshawa	2	6809.793	8m	673.15	97.34	102.61	101.97	102.83	0.001728	3.00	383.43	199.24	0.42
Oshawa	2	6809.793	10m	673.15	97.34	102.60	101.97	102.83	0.001757	3.02	380.98	198.91	0.42
Oshawa	2	6809.793	15m	673.15	97.34	102.36	101.97	102.67	0.002473	3.47	333.79	192.58	0.49
Oshawa	2	6809.793	20m	673.15	97.34	102.23	101.97	102.61	0.002998	3.76	309.86	189.68	0.54
Oshawa	2	6809.793	30m	673.15	97.34	102.05	101.97	102.55	0.004055	4.26	275.30	186.57	0.63
Oshawa	2	6809.793	40m	673.15	97.34	102.04	101.97	102.55	0.004109	4.29	273.88	186.48	0.63
Oshawa	2	6705.93	Existing	673.15	97.41	102.89		102.93	0.000900	1.22	728.73	221.84	0.17
Oshawa	2	6705.93	CP Removed	673.15	97.41	101.89		101.98	0.002799	1.87	509.39	217.08	0.29
Oshawa	2	6705.93	2m	673.15	97.41	102.81		102.86	0.000968	1.25	711.85	220.49	0.17
Oshawa	2	6705.93	4m	673.15	97.41	102.72		102.77	0.001058	1.29	692.24	220.18	0.18
Oshawa	2	6705.93	6m	673.15	97.41	102.64		102.70	0.001149	1.33	674.58	219.90	0.19
Oshawa	2	6705.93	8m	673.15	97.41	102.54		102.60	0.001284	1.39	651.56	219.51	0.20
Oshawa	2	6705.93	10m	673.15	97.41	102.53		102.58	0.001302	1.40	648.64	219.46	0.20
Oshawa	2	6705.93	15m	673.15	97.41	102.26		102.33	0.001751	1.56	590.94	218.48	0.23
Oshawa	2	6705.93	20m	673.15	97.41	102.12		102.20	0.002075	1.67	560.12	217.95	0.25
Oshawa	2	6705.93	30m	673.15	97.41	101.91		102.00	0.002733	1.85	513.27	217.15	0.28
Oshawa	2	6705.93	40m	673.15	97.41	101.90		101.99	0.002767	1.86	511.27	217.11	0.28

HEC-RAS Plan: 2AImprovements Locations: User Defined (Continued)

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Oshawa	2	6600	Existing	673.15	96.83	102.81	100.59	102.85	0.000690	1.15	792.22	262.05	0.15
Oshawa	2	6600	CP Removed	673.15	96.83	101.54	100.59	101.66	0.003307	2.15	475.19	239.25	0.32
Oshawa	2	6600	2m	673.15	96.83	102.73	100.59	102.77	0.000753	1.19	770.39	260.87	0.16
Oshawa	2	6600	4m	673.15	96.83	102.63	100.59	102.67	0.000838	1.24	744.77	259.46	0.17
Oshawa	2	6600	6m	673.15	96.83	102.54	100.59	102.58	0.000926	1.29	721.49	257.41	0.17
Oshawa	2	6600	8m	673.15	96.83	102.42	100.59	102.47	0.001061	1.37	690.86	254.40	0.18
Oshawa	2	6600	10m	673.15	96.83	102.40	100.59	102.45	0.001079	1.38	686.97	254.01	0.19
Oshawa	2	6600	15m	673.15	96.83	102.09	100.59	102.15	0.001568	1.59	607.72	247.54	0.22
Oshawa	2	6600	20m	673.15	96.83	101.90	100.59	101.98	0.001987	1.75	562.34	244.54	0.25
Oshawa	2	6600	30m	673.15	96.83	101.57	100.59	101.68	0.003153	2.11	482.81	239.69	0.31
Oshawa	2	6600	40m	673.15	96.83	101.56	100.59	101.67	0.003231	2.13	478.91	239.47	0.31
Oshawa	2	6503.613	Existing	673.15	95.88	102.75	100.20	102.79	0.000557	1.14	853.94	282.79	0.14
Oshawa	2	6503.613	CP Removed	673.15	95.88	101.18	100.20	101.31	0.003764	2.48	451.94	234.24	0.34
Oshawa	2	6503.613	2m	673.15	95.88	102.67	100.20	102.70	0.000607	1.18	828.95	279.62	0.14
Oshawa	2	6503.613	4m	673.15	95.88	102.56	100.20	102.60	0.000674	1.23	799.62	275.85	0.15
Oshawa	2	6503.613	6m	673.15	95.88	102.46	100.20	102.50	0.000745	1.28	772.87	272.36	0.16
Oshawa	2	6503.613	8m	673.15	95.88	102.33	100.20	102.38	0.000856	1.35	737.37	268.30	0.17
Oshawa	2	6503.613	10m	673.15	95.88	102.31	100.20	102.36	0.000871	1.36	732.82	267.96	0.17
Oshawa	2	6503.613	15m	673.15	95.88	101.95	100.20	102.01	0.001312	1.60	638.08	255.91	0.21
Oshawa	2	6503.613	20m	673.15	95.88	101.72	100.20	101.80	0.001735	1.80	581.24	241.73	0.24
Oshawa	2	6503.613	30m	673.15	95.88	101.24	100.20	101.36	0.003422	2.38	466.26	234.66	0.33
Oshawa	2	6503.613	40m	673.15	95.88	101.21	100.20	101.34	0.003589	2.43	459.08	234.43	0.34
Oshawa	2	6403.231	Existing	673.15	95.53	102.69	99.84	102.73	0.000578	1.22	882.35	277.66	0.15
Oshawa	2	6403.231	CP Removed	673.15	95.53	100.58	99.84	100.81	0.006445	3.24	362.84	197.97	0.46
Oshawa	2	6403.231	2m	673.15	95.53	102.60	99.84	102.64	0.000633	1.27	856.68	276.75	0.15
Oshawa	2	6403.231	4m	673.15	95.53	102.49	99.84	102.53	0.000709	1.33	825.93	273.02	0.16
Oshawa	2	6403.231	6m	673.15	95.53	102.38	99.84	102.42	0.000790	1.39	797.26	271.67	0.17
Oshawa	2	6403.231	8m	673.15	95.53	102.24	99.84	102.29	0.000921	1.48	758.26	269.41	0.18
Oshawa	2	6403.231	10m	673.15	95.53	102.22	99.84	102.27	0.000940	1.49	753.19	269.10	0.18
Oshawa	2	6403.231	15m	673.15	95.53	101.80	99.84	101.87	0.001458	1.78	643.24	263.57	0.23
Oshawa	2	6403.231	20m	673.15	95.53	101.52	99.84	101.61	0.001967	2.00	572.49	247.29	0.26
Oshawa	2	6403.231	30m	673.15	95.53	100.74	99.84	100.94	0.005192	2.97	395.10	208.33	0.42
Oshawa	2	6403.231	40m	673.15	95.53	100.67	99.84	100.88	0.005642	3.07	381.08	202.53	0.43
Oshawa	2	6393.918		Bridge									
Oshawa	2	6384.608	Existing	673.15	95.53	102.66	99.84	102.69	0.000626	1.27	874.48	277.53	0.15
Oshawa	2	6384.608	CP Removed	673.15	95.53	100.06	99.84	100.52	0.014418	4.50	264.07	177.68	0.68
Oshawa	2	6384.608	2m	673.15	95.53	102.56	99.84	102.60	0.000673	1.30	847.27	275.43	0.16
Oshawa	2	6384.608	4m	673.15	95.53	102.44	99.84	102.48	0.000752	1.36	815.09	272.21	0.17
Oshawa	2	6384.608	6m	673.15	95.53	102.34	99.84	102.38	0.000840	1.43	785.89	271.00	0.17
Oshawa	2	6384.608	8m	673.15	95.53	102.19	99.84	102.24	0.000971	1.51	745.44	268.63	0.19
Oshawa	2	6384.608	10m	673.15	95.53	102.17	99.84	102.22	0.000992	1.52	740.21	268.31	0.19
Oshawa	2	6384.608	15m	673.15	95.53	101.73	99.84	101.81	0.001555	1.82	625.45	257.60	0.23
Oshawa	2	6384.608	20m	673.15	95.53	101.44	99.84	101.54	0.002164	2.08	551.99	243.06	0.27
Oshawa	2	6384.608	30m	673.15	95.53	100.55	99.84	100.79	0.006769	3.30	356.31	196.98	0.47
Oshawa	2	6384.608	40m	673.15	95.53	100.42	99.84	100.70	0.008155	3.56	331.60	192.53	0.51
Oshawa	2	6282.752	Existing	677.24	95.22	102.65		102.66	0.000086	0.47	1466.94	383.82	0.06
Oshawa	2	6282.752	CP Removed	677.24	95.22	99.98		100.05	0.001127	1.26	615.66	272.79	0.19
Oshawa	2	6282.752	2m	677.24	95.22	102.55		102.57	0.000093	0.48	1429.37	378.72	0.06
Oshawa	2	6282.752	4m	677.24	95.22	102.43		102.45	0.000101	0.50	1384.96	372.51	0.06
Oshawa	2	6282.752	6m	677.24	95.22	102.33		102.34	0.000110	0.52	1345.00	366.75	0.06
Oshawa	2	6282.752	8m	677.24	95.22	102.18		102.19	0.000123	0.54	1291.58	359.25	0.07
Oshawa	2	6282.752	10m	677.24	95.22	102.16		102.17	0.000125	0.54	1284.51	358.28	0.07
Oshawa	2	6282.752	15m	677.24	95.22	101.72		101.74	0.000179	0.62	1133.49	333.52	0.08
Oshawa	2	6282.752	20m	677.24	95.22	101.42		101.45	0.000231	0.68	1036.27	317.08	0.09
Oshawa	2	6282.752	30m	677.24	95.22	100.51		100.55	0.000582	0.97	762.50	285.20	0.14
Oshawa	2	6282.752	40m	677.24	95.22	100.37		100.42	0.000681	1.04	724.65	281.88	0.15
Oshawa	2	6150	Existing	677.24	94.87	102.65		102.65	0.000042	0.32	1907.51	481.04	0.04
Oshawa	2	6150	CP Removed	677.24	94.87	99.89		99.93	0.000603	0.89	753.36	339.51	0.13
Oshawa	2	6150	2m	677.24	94.87	102.55		102.56	0.000045	0.33	1860.11	476.99	0.04
Oshawa	2	6150	4m	677.24	94.87	102.43		102.44	0.000049	0.34	1803.75	472.13	0.04
Oshawa	2	6150	6m	677.24	94.87	102.32		102.33	0.000053	0.35	1752.73	466.36	0.04
Oshawa	2	6150	8m	677.24	94.87	102.17		102.18	0.000059	0.37	1684.84	453.21	0.04
Oshawa	2	6150	10m	677.24	94.87	102.15		102.16	0.000060	0.37	1675.86	452.53	0.05
Oshawa	2	6150	15m	677.24	94.87	101.71		101.72	0.000087	0.42	1479.18	438.55	0.05
Oshawa	2	6150	20m	677.24	94.87	101.41		101.42	0.000114	0.47	1348.02	429.86	0.06
Oshawa	2	6150	30m	677.24	94.87	100.46		100.49	0.000300	0.68	962.14	380.83	0.10
Oshawa	2	6150	40m	677.24	94.87	100.32		100.35	0.000354	0.72	908.51	374.93	0.10
Oshawa	2	5997.008	Existing	677.24	93.70	102.64	98.80	102.65	0.000023	0.54	2433.34	634.48	0.06
Oshawa	2	5997.008	CP Removed	677.24	93.70	99.78	98.80	99.85	0.000450	1.78	830.81	492.47	0.25
Oshawa	2	5997.008	2m	677.24	93.70	102.54	98.80	102.55	0.000025	0.56	2370.52	630.93	0.06
Oshawa	2	5997.008	4m	677.24	93.70	102.43	98.80	102.43	0.000027	0.57	2295.67	624.80	0.07
Oshawa	2	5997.008	6m	677.24	93.70	102.32	98.80	102.32	0.000030	0.59	2227.83	618.19	0.07
Oshawa	2	5997.008	8m	677.24	93.70	102.17	98.80	102.17	0.000033	0.62	2136.65	608.65	0.07
Oshawa	2	5997.008	10m	677.24	93.70	102.15	98.80	102.15	0.000034	0.62	2124.52	607.40	0.07
Oshawa	2	5997.008	15m	677.24	93.70	101.70	98.80	101.71	0.000049	0.72	1859.39	585.72	0.09
Oshawa	2	5997.008	20m	677.24	93.70	101.40	98.80	101.41	0.000065	0.81	1682.58	573.13	0.10
Oshawa	2	5997.008	30m	677.24	93.70	100.43	98.80	100.45	0.000184	1.23	1152.25	510.19	0.16
Oshawa	2	5997.008	40m	677.24	93.70	100.27	98.80	100.31	0.000223	1.33	1075.46	503.35	0.18

HEC-RAS Plan: 2AImprovements Locations: User Defined (Continued)

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Oshawa	2	5986.99		Bridge									
Oshawa	2	5976.971	Existing	677.24	93.70	102.64	98.80	102.65	0.000023	0.54	2432.62	634.44	0.06
Oshawa	2	5976.971	CP Removed	677.24	93.70	99.74	98.80	99.81	0.000479	1.82	810.75	490.28	0.26
Oshawa	2	5976.971	2m	677.24	93.70	102.54	98.80	102.55	0.000025	0.56	2369.74	630.87	0.06
Oshawa	2	5976.971	4m	677.24	93.70	102.42	98.80	102.43	0.000027	0.57	2294.82	624.73	0.07
Oshawa	2	5976.971	6m	677.24	93.70	102.31	98.80	102.32	0.000030	0.59	2226.91	618.09	0.07
Oshawa	2	5976.971	8m	677.24	93.70	102.17	98.80	102.17	0.000033	0.62	2135.62	608.55	0.07
Oshawa	2	5976.971	10m	677.24	93.70	102.15	98.80	102.15	0.000034	0.62	2123.49	607.29	0.07
Oshawa	2	5976.971	15m	677.24	93.70	101.70	98.80	101.71	0.000049	0.72	1857.87	585.60	0.09
Oshawa	2	5976.971	20m	677.24	93.70	101.39	98.80	101.41	0.000065	0.81	1680.53	573.01	0.10
Oshawa	2	5976.971	30m	677.24	93.70	100.41	98.80	100.44	0.000187	1.23	1146.02	509.77	0.16
Oshawa	2	5976.971	40m	677.24	93.70	100.26	98.80	100.29	0.000228	1.34	1067.60	502.63	0.18
Oshawa	2	5850	Existing	677.24	93.91	102.64		102.64	0.000021	0.25	3174.25	735.06	0.03
Oshawa	2	5850	CP Removed	677.24	93.91	99.72		99.74	0.000269	0.68	1261.53	541.94	0.09
Oshawa	2	5850	2m	677.24	93.91	102.54		102.54	0.000022	0.26	3101.24	731.80	0.03
Oshawa	2	5850	4m	677.24	93.91	102.42		102.42	0.000024	0.27	3014.20	725.38	0.03
Oshawa	2	5850	6m	677.24	93.91	102.31		102.32	0.000026	0.27	2935.11	720.02	0.03
Oshawa	2	5850	8m	677.24	93.91	102.16		102.17	0.000029	0.29	2828.40	711.50	0.03
Oshawa	2	5850	10m	677.24	93.91	102.14		102.15	0.000029	0.29	2814.19	710.36	0.03
Oshawa	2	5850	15m	677.24	93.91	101.70		101.70	0.000041	0.33	2502.70	685.32	0.04
Oshawa	2	5850	20m	677.24	93.91	101.39		101.39	0.000052	0.36	2293.96	674.40	0.04
Oshawa	2	5850	30m	677.24	93.91	100.40		100.41	0.000128	0.51	1649.96	612.73	0.06
Oshawa	2	5850	40m	677.24	93.91	100.25		100.26	0.000150	0.54	1555.66	593.62	0.07
Oshawa	2	5720.403	Existing	677.24	93.19	102.64		102.64	0.000011	0.30	3902.00	860.11	0.03
Oshawa	2	5720.403	CP Removed	677.24	93.19	99.71		99.72	0.000109	0.72	1687.59	644.66	0.09
Oshawa	2	5720.403	2m	677.24	93.19	102.54		102.54	0.000012	0.31	3816.60	854.30	0.03
Oshawa	2	5720.403	4m	677.24	93.19	102.42		102.42	0.000013	0.31	3714.90	846.04	0.03
Oshawa	2	5720.403	6m	677.24	93.19	102.31		102.31	0.000014	0.32	3622.60	838.30	0.03
Oshawa	2	5720.403	8m	677.24	93.19	102.16		102.16	0.000015	0.33	3498.35	826.27	0.04
Oshawa	2	5720.403	10m	677.24	93.19	102.14		102.14	0.000016	0.34	3481.83	824.46	0.04
Oshawa	2	5720.403	15m	677.24	93.19	101.69		101.70	0.000021	0.38	3122.67	786.01	0.04
Oshawa	2	5720.403	20m	677.24	93.19	101.39		101.39	0.000026	0.41	2882.97	770.92	0.05
Oshawa	2	5720.403	30m	677.24	93.19	100.40		100.40	0.000057	0.56	2149.33	692.44	0.07
Oshawa	2	5720.403	40m	677.24	93.19	100.24		100.24	0.000066	0.59	2040.79	684.05	0.07
Oshawa	1	5620.121	Existing	768.16	92.50	102.63		102.64	0.000030	0.44	2025.90	409.48	0.05
Oshawa	1	5620.121	CP Removed	768.16	92.50	99.67		99.70	0.000191	0.87	1046.32	266.05	0.11
Oshawa	1	5620.121	2m	768.16	92.50	102.53		102.54	0.000031	0.44	1985.17	405.36	0.05
Oshawa	1	5620.121	4m	768.16	92.50	102.41		102.42	0.000033	0.46	1936.78	400.55	0.05
Oshawa	1	5620.121	6m	768.16	92.50	102.30		102.31	0.000035	0.47	1893.03	394.61	0.05
Oshawa	1	5620.121	8m	768.16	92.50	102.15		102.16	0.000038	0.48	1834.46	386.60	0.05
Oshawa	1	5620.121	10m	768.16	92.50	102.13		102.14	0.000039	0.48	1826.70	385.44	0.05
Oshawa	1	5620.121	15m	768.16	92.50	101.68		101.69	0.000050	0.53	1658.98	360.41	0.06
Oshawa	1	5620.121	20m	768.16	92.50	101.37		101.38	0.000060	0.56	1549.99	342.52	0.06
Oshawa	1	5620.121	30m	768.16	92.50	100.37		100.39	0.000113	0.72	1238.24	282.38	0.08
Oshawa	1	5620.121	40m	768.16	92.50	100.21		100.23	0.000127	0.75	1193.37	278.31	0.09
Oshawa	1	5554.72	Existing	768.16	92.50	102.63	97.77	102.65	0.000058	0.98	1874.17	403.54	0.10
Oshawa	1	5554.72	CP Removed	768.16	92.50	99.67	97.77	100.37	0.001818	4.32	251.06	261.76	0.52
Oshawa	1	5554.72	2m	768.16	92.50	102.53	97.77	102.54	0.000055	0.94	1834.50	379.17	0.10
Oshawa	1	5554.72	4m	768.16	92.50	102.41	97.77	102.43	0.000057	0.96	1791.29	334.69	0.10
Oshawa	1	5554.72	6m	768.16	92.50	102.30	97.77	102.32	0.000061	0.98	1754.66	331.10	0.10
Oshawa	1	5554.72	8m	768.16	92.50	102.15	97.77	102.17	0.000065	1.00	1705.46	323.77	0.10
Oshawa	1	5554.72	10m	768.16	92.50	102.13	97.77	102.15	0.000065	1.00	1698.96	323.00	0.10
Oshawa	1	5554.72	15m	768.16	92.50	101.68	97.77	102.04	0.000684	3.14	344.57	307.90	0.34
Oshawa	1	5554.72	20m	768.16	92.50	101.37	97.77	101.76	0.000782	3.28	330.15	299.82	0.36
Oshawa	1	5554.72	30m	768.16	92.50	100.37	97.77	100.91	0.001252	3.82	283.63	274.38	0.44
Oshawa	1	5554.72	40m	768.16	92.50	100.21	97.77	100.78	0.001359	3.92	276.18	271.62	0.46
Oshawa	1	5549.677		Bridge									
Goodman	1	4500	Existing	64.36	110.85	112.44		112.66	0.029345	2.91	33.87	52.06	0.77
Goodman	1	4500	CP Removed	64.36	110.85	112.44		112.66	0.029345	2.91	33.87	52.06	0.77
Goodman	1	4500	2m	64.36	110.85	112.44		112.66	0.029345	2.91	33.87	52.06	0.77
Goodman	1	4500	4m	64.36	110.85	112.44		112.66	0.029345	2.91	33.87	52.06	0.77
Goodman	1	4500	6m	64.36	110.85	112.44		112.66	0.029345	2.91	33.87	52.06	0.77
Goodman	1	4500	8m	64.36	110.85	112.44		112.66	0.029345	2.91	33.87	52.06	0.77
Goodman	1	4500	10m	64.36	110.85	112.44		112.66	0.029345	2.91	33.87	52.06	0.77
Goodman	1	4500	15m	64.36	110.85	112.44		112.66	0.029345	2.91	33.87	52.06	0.77
Goodman	1	4500	20m	64.36	110.85	112.44		112.66	0.029345	2.91	33.87	52.06	0.77
Goodman	1	4500	30m	64.36	110.85	112.44		112.66	0.029345	2.91	33.87	52.06	0.77
Goodman	1	4500	40m	64.36	110.85	112.44		112.66	0.029345	2.91	33.87	52.06	0.77
Goodman	1	4350	Existing	64.36	109.32	111.52		111.56	0.003035	1.23	74.10	61.41	0.27
Goodman	1	4350	CP Removed	64.36	109.32	111.52		111.56	0.003035	1.23	74.10	61.41	0.27
Goodman	1	4350	2m	64.36	109.32	111.52		111.56	0.003035	1.23	74.10	61.41	0.27
Goodman	1	4350	4m	64.36	109.32	111.52		111.56	0.003035	1.23	74.10	61.41	0.27
Goodman	1	4350	6m	64.36	109.32	111.52		111.56	0.003035	1.23	74.10	61.41	0.27
Goodman	1	4350	8m	64.36	109.32	111.52		111.56	0.003035	1.23	74.10	61.41	0.27
Goodman	1	4350	10m	64.36	109.32	111.52		111.56	0.003035	1.23	74.10	61.41	0.27
Goodman	1	4350	15m	64.36	109.32	111.52		111.56	0.003035	1.23	74.10	61.41	0.27
Goodman	1	4350	20m	64.36	109.32	111.52		111.56	0.003035	1.23	74.10	61.41	0.27
Goodman	1	4350	30m	64.36	109.32	111.52		111.56	0.003035	1.23	74.10	61.41	0.27
Goodman	1	4350	40m	64.36	109.32	111.52		111.56	0.003035	1.23	74.10	61.41	0.27

HEC-RAS Plan: 2AImprovements Locations: User Defined (Continued)

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Goodman	1	4200	Existing	64.36	109.24	111.17		111.19	0.002000	0.70	97.13	139.12	0.19
Goodman	1	4200	CP Removed	64.36	109.24	111.17		111.19	0.002000	0.70	97.13	139.12	0.19
Goodman	1	4200	2m	64.36	109.24	111.17		111.19	0.002000	0.70	97.13	139.12	0.19
Goodman	1	4200	4m	64.36	109.24	111.17		111.19	0.002000	0.70	97.13	139.12	0.19
Goodman	1	4200	6m	64.36	109.24	111.17		111.19	0.002000	0.70	97.13	139.12	0.19
Goodman	1	4200	8m	64.36	109.24	111.17		111.19	0.002000	0.70	97.13	139.12	0.19
Goodman	1	4200	10m	64.36	109.24	111.17		111.19	0.002000	0.70	97.13	139.12	0.19
Goodman	1	4200	15m	64.36	109.24	111.17		111.19	0.002000	0.70	97.13	139.12	0.19
Goodman	1	4200	20m	64.36	109.24	111.17		111.19	0.002000	0.70	97.13	139.12	0.19
Goodman	1	4200	30m	64.36	109.24	111.17		111.19	0.002000	0.70	97.13	139.12	0.19
Goodman	1	4200	40m	64.36	109.24	111.17		111.19	0.002000	0.70	97.13	139.12	0.19
Goodman	1	4050	Existing	64.36	109.35	111.04		111.06	0.000475	0.63	112.88	108.45	0.18
Goodman	1	4050	CP Removed	64.36	109.35	111.04		111.06	0.000475	0.63	112.88	108.45	0.18
Goodman	1	4050	2m	64.36	109.35	111.04		111.06	0.000475	0.63	112.88	108.45	0.18
Goodman	1	4050	4m	64.36	109.35	111.04		111.06	0.000475	0.63	112.88	108.45	0.18
Goodman	1	4050	6m	64.36	109.35	111.04		111.06	0.000475	0.63	112.88	108.45	0.18
Goodman	1	4050	8m	64.36	109.35	111.04		111.06	0.000475	0.63	112.88	108.45	0.18
Goodman	1	4050	10m	64.36	109.35	111.04		111.06	0.000475	0.63	112.88	108.45	0.18
Goodman	1	4050	15m	64.36	109.35	111.04		111.06	0.000475	0.63	112.88	108.45	0.18
Goodman	1	4050	20m	64.36	109.35	111.04		111.06	0.000475	0.63	112.88	108.45	0.18
Goodman	1	4050	30m	64.36	109.35	111.04		111.06	0.000475	0.63	112.88	108.45	0.18
Goodman	1	4050	40m	64.36	109.35	111.04		111.06	0.000475	0.63	112.88	108.45	0.18
Goodman	1	3900	Existing	64.36	108.47	111.01		111.02	0.000179	0.59	154.43	153.39	0.13
Goodman	1	3900	CP Removed	64.36	108.47	111.01		111.02	0.000179	0.59	154.43	153.39	0.13
Goodman	1	3900	2m	64.36	108.47	111.01		111.02	0.000179	0.59	154.43	153.39	0.13
Goodman	1	3900	4m	64.36	108.47	111.01		111.02	0.000179	0.59	154.43	153.39	0.13
Goodman	1	3900	6m	64.36	108.47	111.01		111.02	0.000179	0.59	154.43	153.39	0.13
Goodman	1	3900	8m	64.36	108.47	111.01		111.02	0.000179	0.59	154.43	153.39	0.13
Goodman	1	3900	10m	64.36	108.47	111.01		111.02	0.000179	0.59	154.43	153.39	0.13
Goodman	1	3900	15m	64.36	108.47	111.01		111.02	0.000179	0.59	154.43	153.39	0.13
Goodman	1	3900	20m	64.36	108.47	111.01		111.02	0.000179	0.59	154.43	153.39	0.13
Goodman	1	3900	30m	64.36	108.47	111.01		111.02	0.000179	0.59	154.43	153.39	0.13
Goodman	1	3900	40m	64.36	108.47	111.01		111.02	0.000179	0.59	154.43	153.39	0.13
Goodman	1	3810.334	Existing	64.36	108.33	111.01		111.01	0.000051	0.32	273.82	236.63	0.07
Goodman	1	3810.334	CP Removed	64.36	108.33	111.01		111.01	0.000051	0.32	273.82	236.63	0.07
Goodman	1	3810.334	2m	64.36	108.33	111.01		111.01	0.000051	0.32	273.82	236.63	0.07
Goodman	1	3810.334	4m	64.36	108.33	111.01		111.01	0.000051	0.32	273.82	236.63	0.07
Goodman	1	3810.334	6m	64.36	108.33	111.01		111.01	0.000051	0.32	273.82	236.63	0.07
Goodman	1	3810.334	8m	64.36	108.33	111.01		111.01	0.000051	0.32	273.82	236.63	0.07
Goodman	1	3810.334	10m	64.36	108.33	111.01		111.01	0.000051	0.32	273.82	236.63	0.07
Goodman	1	3810.334	15m	64.36	108.33	111.01		111.01	0.000051	0.32	273.82	236.63	0.07
Goodman	1	3810.334	20m	64.36	108.33	111.01		111.01	0.000051	0.32	273.82	236.63	0.07
Goodman	1	3810.334	30m	64.36	108.33	111.01		111.01	0.000051	0.32	273.82	236.63	0.07
Goodman	1	3810.334	40m	64.36	108.33	111.01		111.01	0.000051	0.32	273.82	236.63	0.07
Goodman	1	3706.602	Existing	64.36	107.59	110.98	110.49	111.00	0.000323	0.76	157.99	201.42	0.13
Goodman	1	3706.602	CP Removed	64.36	107.59	110.98	110.49	111.00	0.000323	0.76	157.99	201.42	0.13
Goodman	1	3706.602	2m	64.36	107.59	110.98	110.49	111.00	0.000323	0.76	157.99	201.42	0.13
Goodman	1	3706.602	4m	64.36	107.59	110.98	110.49	111.00	0.000323	0.76	157.99	201.42	0.13
Goodman	1	3706.602	6m	64.36	107.59	110.98	110.49	111.00	0.000323	0.76	157.99	201.42	0.13
Goodman	1	3706.602	8m	64.36	107.59	110.98	110.49	111.00	0.000323	0.76	157.99	201.42	0.13
Goodman	1	3706.602	10m	64.36	107.59	110.98	110.49	111.00	0.000323	0.76	157.99	201.42	0.13
Goodman	1	3706.602	15m	64.36	107.59	110.98	110.49	111.00	0.000323	0.76	157.99	201.42	0.13
Goodman	1	3706.602	20m	64.36	107.59	110.98	110.49	111.00	0.000323	0.76	157.99	201.42	0.13
Goodman	1	3706.602	30m	64.36	107.59	110.98	110.49	111.00	0.000323	0.76	157.99	201.42	0.13
Goodman	1	3706.602	40m	64.36	107.59	110.98	110.49	111.00	0.000323	0.76	157.99	201.42	0.13
Goodman	1	3690.354		Culvert									
Goodman	1	3671.383	Existing	64.36	107.46	109.70	109.70	110.82	0.019618	4.69	13.72	94.03	1.00
Goodman	1	3671.383	CP Removed	64.36	107.46	109.70	109.70	110.82	0.019618	4.69	13.72	94.03	1.00
Goodman	1	3671.383	2m	64.36	107.46	109.70	109.70	110.82	0.019618	4.69	13.72	94.03	1.00
Goodman	1	3671.383	4m	64.36	107.46	109.70	109.70	110.82	0.019618	4.69	13.72	94.03	1.00
Goodman	1	3671.383	6m	64.36	107.46	109.70	109.70	110.82	0.019618	4.69	13.72	94.03	1.00
Goodman	1	3671.383	8m	64.36	107.46	109.70	109.70	110.82	0.019618	4.69	13.72	94.03	1.00
Goodman	1	3671.383	10m	64.36	107.46	109.70	109.70	110.82	0.019618	4.69	13.72	94.03	1.00
Goodman	1	3671.383	15m	64.36	107.46	109.70	109.70	110.82	0.019618	4.69	13.72	94.03	1.00
Goodman	1	3671.383	20m	64.36	107.46	109.70	109.70	110.82	0.019618	4.69	13.72	94.03	1.00
Goodman	1	3671.383	30m	64.36	107.46	109.70	109.70	110.82	0.019618	4.69	13.72	94.03	1.00
Goodman	1	3671.383	40m	64.36	107.46	109.70	109.70	110.82	0.019618	4.69	13.72	94.03	1.00
Goodman	1	3541.114	Existing	64.36	106.60	108.92		108.93	0.000023	0.24	307.17	159.65	0.05
Goodman	1	3541.114	CP Removed	64.36	106.60	108.92		108.93	0.000023	0.24	307.17	159.65	0.05
Goodman	1	3541.114	2m	64.36	106.60	108.92		108.93	0.000023	0.24	307.17	159.65	0.05
Goodman	1	3541.114	4m	64.36	106.60	108.92		108.93	0.000023	0.24	307.17	159.65	0.05
Goodman	1	3541.114	6m	64.36	106.60	108.92		108.93	0.000023	0.24	307.17	159.65	0.05
Goodman	1	3541.114	8m	64.36	106.60	108.92		108.93	0.000023	0.24	307.17	159.65	0.05
Goodman	1	3541.114	10m	64.36	106.60	108.92		108.93	0.000023	0.24	307.17	159.65	0.05
Goodman	1	3541.114	15m	64.36	106.60	108.92		108.93	0.000023	0.24	307.17	159.65	0.05
Goodman	1	3541.114	20m	64.36	106.60	108.92		108.93	0.000023	0.24	307.17	159.65	0.05
Goodman	1	3541.114	30m	64.36	106.60	108.92		108.93	0.000023	0.24	307.17	159.65	0.05
Goodman	1	3541.114	40m	64.36	106.60	108.92		108.93	0.000023	0.24	307.17	159.65	0.05

HEC-RAS Plan: 2AImprovements Locations: User Defined (Continued)

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Goodman	1	3450	Existing	64.36	106.45	108.92		108.92	0.000033	0.27	271.69	138.07	0.06
Goodman	1	3450	CP Removed	64.36	106.45	108.92		108.92	0.000033	0.27	271.69	138.07	0.06
Goodman	1	3450	2m	64.36	106.45	108.92		108.92	0.000033	0.27	271.69	138.07	0.06
Goodman	1	3450	4m	64.36	106.45	108.92		108.92	0.000033	0.27	271.69	138.07	0.06
Goodman	1	3450	6m	64.36	106.45	108.92		108.92	0.000033	0.27	271.69	138.07	0.06
Goodman	1	3450	8m	64.36	106.45	108.92		108.92	0.000033	0.27	271.69	138.07	0.06
Goodman	1	3450	10m	64.36	106.45	108.92		108.92	0.000033	0.27	271.69	138.07	0.06
Goodman	1	3450	15m	64.36	106.45	108.92		108.92	0.000033	0.27	271.69	138.07	0.06
Goodman	1	3450	20m	64.36	106.45	108.92		108.92	0.000033	0.27	271.69	138.07	0.06
Goodman	1	3450	30m	64.36	106.45	108.92		108.92	0.000033	0.27	271.69	138.07	0.06
Goodman	1	3450	40m	64.36	106.45	108.92		108.92	0.000033	0.27	271.69	138.07	0.06
Goodman	1	3300	Existing	70.11	105.84	108.92	106.48	108.92	0.000017	0.24	337.26	134.42	0.04
Goodman	1	3300	CP Removed	70.11	105.84	108.92	106.48	108.92	0.000017	0.24	337.26	134.42	0.04
Goodman	1	3300	2m	70.11	105.84	108.92	106.48	108.92	0.000017	0.24	337.26	134.42	0.04
Goodman	1	3300	4m	70.11	105.84	108.92	106.48	108.92	0.000017	0.24	337.26	134.42	0.04
Goodman	1	3300	6m	70.11	105.84	108.92	106.48	108.92	0.000017	0.24	337.26	134.42	0.04
Goodman	1	3300	8m	70.11	105.84	108.92	106.48	108.92	0.000017	0.24	337.26	134.42	0.04
Goodman	1	3300	10m	70.11	105.84	108.92	106.48	108.92	0.000017	0.24	337.26	134.42	0.04
Goodman	1	3300	15m	70.11	105.84	108.92	106.48	108.92	0.000017	0.24	337.26	134.42	0.04
Goodman	1	3300	20m	70.11	105.84	108.92	106.48	108.92	0.000017	0.24	337.26	134.42	0.04
Goodman	1	3300	30m	70.11	105.84	108.92	106.48	108.92	0.000017	0.24	337.26	134.42	0.04
Goodman	1	3300	40m	70.11	105.84	108.92	106.48	108.92	0.000017	0.24	337.26	134.42	0.04
Goodman	1	3150	Existing	70.11	105.31	108.92	105.88	108.92	0.000009	0.19	410.53	153.74	0.03
Goodman	1	3150	CP Removed	70.11	105.31	108.92	105.88	108.92	0.000009	0.19	410.53	153.74	0.03
Goodman	1	3150	2m	70.11	105.31	108.92	105.88	108.92	0.000009	0.19	410.53	153.74	0.03
Goodman	1	3150	4m	70.11	105.31	108.92	105.88	108.92	0.000009	0.19	410.53	153.74	0.03
Goodman	1	3150	6m	70.11	105.31	108.92	105.88	108.92	0.000009	0.19	410.53	153.74	0.03
Goodman	1	3150	8m	70.11	105.31	108.92	105.88	108.92	0.000009	0.19	410.53	153.74	0.03
Goodman	1	3150	10m	70.11	105.31	108.92	105.88	108.92	0.000009	0.19	410.53	153.74	0.03
Goodman	1	3150	15m	70.11	105.31	108.92	105.88	108.92	0.000009	0.19	410.53	153.74	0.03
Goodman	1	3150	20m	70.11	105.31	108.92	105.88	108.92	0.000009	0.19	410.53	153.74	0.03
Goodman	1	3150	30m	70.11	105.31	108.92	105.88	108.92	0.000009	0.19	410.53	153.74	0.03
Goodman	1	3150	40m	70.11	105.31	108.92	105.88	108.92	0.000009	0.19	410.53	153.74	0.03
Goodman	1	3007.703	Existing	70.11	104.18	108.92	108.42	108.92	0.000010	0.13	559.00	217.91	0.02
Goodman	1	3007.703	CP Removed	70.11	104.18	108.92	108.42	108.92	0.000010	0.13	559.00	217.91	0.02
Goodman	1	3007.703	2m	70.11	104.18	108.92	108.42	108.92	0.000010	0.13	559.00	217.91	0.02
Goodman	1	3007.703	4m	70.11	104.18	108.92	108.42	108.92	0.000010	0.13	559.00	217.91	0.02
Goodman	1	3007.703	6m	70.11	104.18	108.92	108.42	108.92	0.000010	0.13	559.00	217.91	0.02
Goodman	1	3007.703	8m	70.11	104.18	108.92	108.42	108.92	0.000010	0.13	559.00	217.91	0.02
Goodman	1	3007.703	10m	70.11	104.18	108.92	108.42	108.92	0.000010	0.13	559.00	217.91	0.02
Goodman	1	3007.703	15m	70.11	104.18	108.92	108.42	108.92	0.000010	0.13	559.00	217.91	0.02
Goodman	1	3007.703	20m	70.11	104.18	108.92	108.42	108.92	0.000010	0.13	559.00	217.91	0.02
Goodman	1	3007.703	30m	70.11	104.18	108.92	108.42	108.92	0.000010	0.13	559.00	217.91	0.02
Goodman	1	3007.703	40m	70.11	104.18	108.92	108.42	108.92	0.000010	0.13	559.00	217.91	0.02
Goodman	1	2987.697		Culvert									
Goodman	1	2973.565	Existing	70.11	104.07	107.73	107.73	107.98	0.004023	3.77	52.70	85.06	0.63
Goodman	1	2973.565	CP Removed	70.11	104.07	107.73	107.73	107.98	0.004023	3.77	52.70	85.06	0.63
Goodman	1	2973.565	2m	70.11	104.07	107.73	107.73	107.98	0.004023	3.77	52.70	85.06	0.63
Goodman	1	2973.565	4m	70.11	104.07	107.73	107.73	107.98	0.004023	3.77	52.70	85.06	0.63
Goodman	1	2973.565	6m	70.11	104.07	107.73	107.73	107.98	0.004023	3.77	52.70	85.06	0.63
Goodman	1	2973.565	8m	70.11	104.07	107.73	107.73	107.98	0.004023	3.77	52.70	85.06	0.63
Goodman	1	2973.565	10m	70.11	104.07	107.73	107.73	107.98	0.004023	3.77	52.70	85.06	0.63
Goodman	1	2973.565	15m	70.11	104.07	107.73	107.73	107.98	0.004023	3.77	52.70	85.06	0.63
Goodman	1	2973.565	20m	70.11	104.07	107.73	107.73	107.98	0.004023	3.77	52.70	85.06	0.63
Goodman	1	2973.565	30m	70.11	104.07	107.73	107.73	107.98	0.004023	3.77	52.70	85.06	0.63
Goodman	1	2973.565	40m	70.11	104.07	107.73	107.73	107.98	0.004023	3.77	52.70	85.06	0.63
Goodman	1	2937.506	Existing	69.21	104.47	107.10		107.15	0.001986	2.05	96.14	157.48	0.41
Goodman	1	2937.506	CP Removed	69.21	104.47	107.10		107.15	0.001986	2.05	96.14	157.48	0.41
Goodman	1	2937.506	2m	69.21	104.47	107.10		107.15	0.001986	2.05	96.14	157.48	0.41
Goodman	1	2937.506	4m	69.21	104.47	107.10		107.15	0.001986	2.05	96.14	157.48	0.41
Goodman	1	2937.506	6m	69.21	104.47	107.10		107.15	0.001986	2.05	96.14	157.48	0.41
Goodman	1	2937.506	8m	69.21	104.47	107.10		107.15	0.001986	2.05	96.14	157.48	0.41
Goodman	1	2937.506	10m	69.21	104.47	107.10		107.15	0.001986	2.05	96.14	157.48	0.41
Goodman	1	2937.506	15m	69.21	104.47	107.10		107.15	0.001986	2.05	96.14	157.48	0.41
Goodman	1	2937.506	20m	69.21	104.47	107.10		107.15	0.001986	2.05	96.14	157.48	0.41
Goodman	1	2937.506	30m	69.21	104.47	107.10		107.15	0.001986	2.05	96.14	157.48	0.41
Goodman	1	2937.506	40m	69.21	104.47	107.10		107.15	0.001986	2.05	96.14	157.48	0.41
Goodman	1	2899.247	Existing	69.21	103.78	106.91	106.79	107.04	0.003345	2.34	58.23	103.32	0.42
Goodman	1	2899.247	CP Removed	69.21	103.78	106.91	106.79	107.04	0.003345	2.34	58.23	103.32	0.42
Goodman	1	2899.247	2m	69.21	103.78	106.91	106.79	107.04	0.003345	2.34	58.23	103.32	0.42
Goodman	1	2899.247	4m	69.21	103.78	106.91	106.79	107.04	0.003345	2.34	58.23	103.32	0.42
Goodman	1	2899.247	6m	69.21	103.78	106.91	106.79	107.04	0.003345	2.34	58.23	103.32	0.42
Goodman	1	2899.247	8m	69.21	103.78	106.91	106.79	107.04	0.003345	2.34	58.23	103.32	0.42
Goodman	1	2899.247	10m	69.21	103.78	106.91	106.79	107.04	0.003345	2.34	58.23	103.32	0.42
Goodman	1	2899.247	15m	69.21	103.78	106.91	106.79	107.04	0.003345	2.34	58.23	103.32	0.42
Goodman	1	2899.247	20m	69.21	103.78	106.91	106.79	107.04	0.003345	2.34	58.23	103.32	0.42
Goodman	1	2899.247	30m	69.21	103.78	106.91	106.79	107.04	0.003345	2.34	58.23	103.32	0.42
Goodman	1	2899.247	40m	69.21	103.78	106.91	106.79	107.04	0.003345	2.34	58.23	103.32	0.42
Goodman	1	2864.743		Culvert									

HEC-RAS Plan: 2AImprovements Locations: User Defined (Continued)

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Goodman	1	2836.864	Existing	69.21	102.99	106.69	106.04	106.70	0.001159	0.69	137.04	177.68	0.11
Goodman	1	2836.864	CP Removed	69.21	102.99	106.69	106.04	106.70	0.001159	0.69	137.04	177.68	0.11
Goodman	1	2836.864	2m	69.21	102.99	106.69	106.04	106.70	0.001159	0.69	137.04	177.68	0.11
Goodman	1	2836.864	4m	69.21	102.99	106.69	106.04	106.70	0.001159	0.69	137.04	177.68	0.11
Goodman	1	2836.864	6m	69.21	102.99	106.69	106.04	106.70	0.001159	0.69	137.04	177.68	0.11
Goodman	1	2836.864	8m	69.21	102.99	106.69	106.04	106.70	0.001159	0.69	137.04	177.68	0.11
Goodman	1	2836.864	10m	69.21	102.99	106.69	106.04	106.70	0.001159	0.69	137.04	177.68	0.11
Goodman	1	2836.864	15m	69.21	102.99	106.69	106.04	106.70	0.001159	0.69	137.04	177.68	0.11
Goodman	1	2836.864	20m	69.21	102.99	106.69	106.04	106.70	0.001159	0.69	137.04	177.68	0.11
Goodman	1	2836.864	30m	69.21	102.99	106.69	106.04	106.70	0.001159	0.69	137.04	177.68	0.11
Goodman	1	2836.864	40m	69.21	102.99	106.69	106.04	106.70	0.001159	0.69	137.04	177.68	0.11
Goodman	1	2735.24	Existing	69.21	104.16	106.45		106.49	0.004443	1.47	82.18	169.91	0.32
Goodman	1	2735.24	CP Removed	69.21	104.16	106.45		106.49	0.004443	1.47	82.18	169.91	0.32
Goodman	1	2735.24	2m	69.21	104.16	106.45		106.49	0.004443	1.47	82.18	169.91	0.32
Goodman	1	2735.24	4m	69.21	104.16	106.45		106.49	0.004443	1.47	82.18	169.91	0.32
Goodman	1	2735.24	6m	69.21	104.16	106.45		106.49	0.004443	1.47	82.18	169.91	0.32
Goodman	1	2735.24	8m	69.21	104.16	106.45		106.49	0.004443	1.47	82.18	169.91	0.32
Goodman	1	2735.24	10m	69.21	104.16	106.45		106.49	0.004443	1.47	82.18	169.91	0.32
Goodman	1	2735.24	15m	69.21	104.16	106.45		106.49	0.004443	1.47	82.18	169.91	0.32
Goodman	1	2735.24	20m	69.21	104.16	106.45		106.49	0.004443	1.47	82.18	169.91	0.32
Goodman	1	2735.24	30m	69.21	104.16	106.45		106.49	0.004443	1.47	82.18	169.91	0.32
Goodman	1	2735.24	40m	69.21	104.16	106.45		106.49	0.004443	1.47	82.18	169.91	0.32
Goodman	1	2714.286	Existing	69.21	104.69	106.37		106.39	0.004014	0.97	109.87	272.50	0.27
Goodman	1	2714.286	CP Removed	69.21	104.69	106.37		106.39	0.004014	0.97	109.87	272.50	0.27
Goodman	1	2714.286	2m	69.21	104.69	106.37		106.39	0.004014	0.97	109.87	272.50	0.27
Goodman	1	2714.286	4m	69.21	104.69	106.37		106.39	0.004014	0.97	109.87	272.50	0.27
Goodman	1	2714.286	6m	69.21	104.69	106.37		106.39	0.004014	0.97	109.87	272.50	0.27
Goodman	1	2714.286	8m	69.21	104.69	106.37		106.39	0.004014	0.97	109.87	272.50	0.27
Goodman	1	2714.286	10m	69.21	104.69	106.37		106.39	0.004014	0.97	109.87	272.50	0.27
Goodman	1	2714.286	15m	69.21	104.69	106.37		106.39	0.004014	0.97	109.87	272.50	0.27
Goodman	1	2714.286	20m	69.21	104.69	106.37		106.39	0.004014	0.97	109.87	272.50	0.27
Goodman	1	2714.286	30m	69.21	104.69	106.37		106.39	0.004014	0.97	109.87	272.50	0.27
Goodman	1	2714.286	40m	69.21	104.69	106.37		106.39	0.004014	0.97	109.87	272.50	0.27
Goodman	1	2581.456	Existing	69.21	102.22	106.03	105.67	106.07	0.001578	1.31	135.21	306.39	0.23
Goodman	1	2581.456	CP Removed	69.21	102.22	106.03	105.67	106.07	0.001578	1.31	135.21	306.39	0.23
Goodman	1	2581.456	2m	69.21	102.22	106.03	105.67	106.07	0.001578	1.31	135.21	306.39	0.23
Goodman	1	2581.456	4m	69.21	102.22	106.03	105.67	106.07	0.001578	1.31	135.21	306.39	0.23
Goodman	1	2581.456	6m	69.21	102.22	106.03	105.67	106.07	0.001578	1.31	135.21	306.39	0.23
Goodman	1	2581.456	8m	69.21	102.22	106.03	105.67	106.07	0.001578	1.31	135.21	306.39	0.23
Goodman	1	2581.456	10m	69.21	102.22	106.03	105.67	106.07	0.001578	1.31	135.21	306.39	0.23
Goodman	1	2581.456	15m	69.21	102.22	106.03	105.67	106.07	0.001578	1.31	135.21	306.39	0.23
Goodman	1	2581.456	20m	69.21	102.22	106.03	105.67	106.07	0.001578	1.31	135.21	306.39	0.23
Goodman	1	2581.456	30m	69.21	102.22	106.03	105.67	106.07	0.001578	1.31	135.21	306.39	0.23
Goodman	1	2581.456	40m	69.21	102.22	106.03	105.67	106.07	0.001578	1.31	135.21	306.39	0.23
Goodman	1	2564.198		Culvert									
Goodman	1	2545.492	Existing	69.21	102.12	106.05	105.55	106.06	0.001584	0.83	162.45	279.10	0.13
Goodman	1	2545.492	CP Removed	69.21	102.12	106.05	105.55	106.06	0.001584	0.83	162.45	279.10	0.13
Goodman	1	2545.492	2m	69.21	102.12	106.05	105.55	106.06	0.001584	0.83	162.45	279.10	0.13
Goodman	1	2545.492	4m	69.21	102.12	106.05	105.55	106.06	0.001584	0.83	162.45	279.10	0.13
Goodman	1	2545.492	6m	69.21	102.12	106.05	105.55	106.06	0.001584	0.83	162.45	279.10	0.13
Goodman	1	2545.492	8m	69.21	102.12	106.05	105.55	106.06	0.001584	0.83	162.45	279.10	0.13
Goodman	1	2545.492	10m	69.21	102.12	106.05	105.55	106.06	0.001584	0.83	162.45	279.10	0.13
Goodman	1	2545.492	15m	69.21	102.12	106.05	105.55	106.06	0.001584	0.83	162.45	279.10	0.13
Goodman	1	2545.492	20m	69.21	102.12	106.05	105.55	106.06	0.001584	0.83	162.45	279.10	0.13
Goodman	1	2545.492	30m	69.21	102.12	106.05	105.55	106.06	0.001584	0.83	162.45	279.10	0.13
Goodman	1	2545.492	40m	69.21	102.12	106.05	105.55	106.06	0.001584	0.83	162.45	279.10	0.13
Goodman	1	2417.174	Existing	69.21	103.48	105.63		105.67	0.007438	1.86	88.10	187.41	0.42
Goodman	1	2417.174	CP Removed	69.21	103.48	105.63		105.67	0.007438	1.86	88.10	187.41	0.42
Goodman	1	2417.174	2m	69.21	103.48	105.63		105.67	0.007438	1.86	88.10	187.41	0.42
Goodman	1	2417.174	4m	69.21	103.48	105.63		105.67	0.007438	1.86	88.10	187.41	0.42
Goodman	1	2417.174	6m	69.21	103.48	105.63		105.67	0.007438	1.86	88.10	187.41	0.42
Goodman	1	2417.174	8m	69.21	103.48	105.63		105.67	0.007438	1.86	88.10	187.41	0.42
Goodman	1	2417.174	10m	69.21	103.48	105.63		105.67	0.007438	1.86	88.10	187.41	0.42
Goodman	1	2417.174	15m	69.21	103.48	105.63		105.67	0.007438	1.86	88.10	187.41	0.42
Goodman	1	2417.174	20m	69.21	103.48	105.63		105.67	0.007438	1.86	88.10	187.41	0.42
Goodman	1	2417.174	30m	69.21	103.48	105.63		105.67	0.007438	1.86	88.10	187.41	0.42
Goodman	1	2417.174	40m	69.21	103.48	105.63		105.67	0.007438	1.86	88.10	187.41	0.42
Goodman	1	2351.543	Existing	69.21	103.27	105.24		105.26	0.005175	1.46	107.13	232.02	0.34
Goodman	1	2351.543	CP Removed	69.21	103.27	105.24		105.26	0.005175	1.46	107.13	232.02	0.34
Goodman	1	2351.543	2m	69.21	103.27	105.24		105.26	0.005175	1.46	107.13	232.02	0.34
Goodman	1	2351.543	4m	69.21	103.27	105.24		105.26	0.005175	1.46	107.13	232.02	0.34
Goodman	1	2351.543	6m	69.21	103.27	105.24		105.26	0.005175	1.46	107.13	232.02	0.34
Goodman	1	2351.543	8m	69.21	103.27	105.24		105.26	0.005175	1.46	107.13	232.02	0.34
Goodman	1	2351.543	10m	69.21	103.27	105.24		105.26	0.005175	1.46	107.13	232.02	0.34
Goodman	1	2351.543	15m	69.21	103.27	105.24		105.26	0.005175	1.46	107.13	232.02	0.34
Goodman	1	2351.543	20m	69.21	103.27	105.24		105.26	0.005175	1.46	107.13	232.02	0.34
Goodman	1	2351.543	30m	69.21	103.27	105.24		105.26	0.005175	1.46	107.13	232.02	0.34
Goodman	1	2351.543	40m	69.21	103.27	105.24		105.26	0.005175	1.46	107.13	232.02	0.34

HEC-RAS Plan: 2AImprovements Locations: User Defined (Continued)

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Goodman	1	2250.846	Existing	76.11	102.11	104.74	104.51	104.76	0.004632	1.03	116.92	264.97	0.23
Goodman	1	2250.846	CP Removed	76.11	102.11	104.74	104.51	104.76	0.004632	1.03	116.92	264.97	0.23
Goodman	1	2250.846	2m	76.11	102.11	104.74	104.51	104.76	0.004632	1.03	116.92	264.97	0.23
Goodman	1	2250.846	4m	76.11	102.11	104.74	104.51	104.76	0.004632	1.03	116.92	264.97	0.23
Goodman	1	2250.846	6m	76.11	102.11	104.74	104.51	104.76	0.004632	1.03	116.92	264.97	0.23
Goodman	1	2250.846	8m	76.11	102.11	104.74	104.51	104.76	0.004632	1.03	116.92	264.97	0.23
Goodman	1	2250.846	10m	76.11	102.11	104.74	104.51	104.76	0.004632	1.03	116.92	264.97	0.23
Goodman	1	2250.846	15m	76.11	102.11	104.74	104.51	104.76	0.004632	1.03	116.92	264.97	0.23
Goodman	1	2250.846	20m	76.11	102.11	104.74	104.51	104.76	0.004632	1.03	116.92	264.97	0.23
Goodman	1	2250.846	30m	76.11	102.11	104.74	104.51	104.76	0.004632	1.03	116.92	264.97	0.23
Goodman	1	2250.846	40m	76.11	102.11	104.74	104.51	104.76	0.004632	1.03	116.92	264.97	0.23
Goodman	1	2244.345		Culvert									
Goodman	1	2237.844	Existing	76.11	102.07	104.72	104.52	104.75	0.004382	1.04	108.67	292.05	0.20
Goodman	1	2237.844	CP Removed	76.11	102.07	104.72	104.52	104.75	0.004382	1.04	108.67	292.05	0.20
Goodman	1	2237.844	2m	76.11	102.07	104.72	104.52	104.75	0.004382	1.04	108.67	292.05	0.20
Goodman	1	2237.844	4m	76.11	102.07	104.72	104.52	104.75	0.004382	1.04	108.67	292.05	0.20
Goodman	1	2237.844	6m	76.11	102.07	104.72	104.52	104.75	0.004382	1.04	108.67	292.05	0.20
Goodman	1	2237.844	8m	76.11	102.07	104.72	104.52	104.75	0.004382	1.04	108.67	292.05	0.20
Goodman	1	2237.844	10m	76.11	102.07	104.72	104.52	104.75	0.004382	1.04	108.67	292.05	0.20
Goodman	1	2237.844	15m	76.11	102.07	104.72	104.52	104.75	0.004382	1.04	108.67	292.05	0.20
Goodman	1	2237.844	20m	76.11	102.07	104.72	104.52	104.75	0.004382	1.04	108.67	292.05	0.20
Goodman	1	2237.844	30m	76.11	102.07	104.72	104.52	104.75	0.004382	1.04	108.67	292.05	0.20
Goodman	1	2237.844	40m	76.11	102.07	104.72	104.52	104.75	0.004382	1.04	108.67	292.05	0.20
Goodman	1	2135.661	Existing	76.11	102.64	104.42		104.44	0.002094	1.60	122.76	283.68	0.39
Goodman	1	2135.661	CP Removed	76.11	102.64	104.42		104.44	0.002094	1.60	122.77	283.68	0.39
Goodman	1	2135.661	2m	76.11	102.64	104.42		104.44	0.002094	1.60	122.76	283.68	0.39
Goodman	1	2135.661	4m	76.11	102.64	104.42		104.44	0.002094	1.60	122.77	283.68	0.39
Goodman	1	2135.661	6m	76.11	102.64	104.42		104.44	0.002094	1.60	122.77	283.68	0.39
Goodman	1	2135.661	8m	76.11	102.64	104.42		104.44	0.002094	1.60	122.77	283.68	0.39
Goodman	1	2135.661	10m	76.11	102.64	104.42		104.44	0.002094	1.60	122.77	283.68	0.39
Goodman	1	2135.661	15m	76.11	102.64	104.42		104.44	0.002094	1.60	122.76	283.68	0.39
Goodman	1	2135.661	20m	76.11	102.64	104.42		104.44	0.002094	1.60	122.76	283.68	0.39
Goodman	1	2135.661	30m	76.11	102.64	104.42		104.44	0.002094	1.60	122.77	283.68	0.39
Goodman	1	2135.661	40m	76.11	102.64	104.42		104.44	0.002094	1.60	122.77	283.68	0.39
Goodman	1	2100	Existing	76.11	102.66	104.36		104.38	0.001363	1.26	159.28	391.98	0.32
Goodman	1	2100	CP Removed	76.11	102.66	104.36		104.38	0.001363	1.26	159.28	391.98	0.32
Goodman	1	2100	2m	76.11	102.66	104.36		104.38	0.001363	1.26	159.28	391.98	0.32
Goodman	1	2100	4m	76.11	102.66	104.36		104.38	0.001363	1.26	159.28	391.98	0.32
Goodman	1	2100	6m	76.11	102.66	104.36		104.38	0.001363	1.26	159.28	391.98	0.32
Goodman	1	2100	8m	76.11	102.66	104.36		104.38	0.001363	1.26	159.28	391.98	0.32
Goodman	1	2100	10m	76.11	102.66	104.36		104.38	0.001363	1.26	159.28	391.98	0.32
Goodman	1	2100	15m	76.11	102.66	104.36		104.38	0.001363	1.26	159.28	391.98	0.32
Goodman	1	2100	20m	76.11	102.66	104.36		104.38	0.001363	1.26	159.28	391.98	0.32
Goodman	1	2100	30m	76.11	102.66	104.36		104.38	0.001363	1.26	159.28	391.98	0.32
Goodman	1	2100	40m	76.11	102.66	104.36		104.38	0.001363	1.26	159.28	391.98	0.32
Goodman	1	1950	Existing	76.11	102.68	104.04		104.06	0.003675	0.89	145.48	403.59	0.26
Goodman	1	1950	CP Removed	76.11	102.68	104.04		104.06	0.003672	0.89	145.52	403.66	0.26
Goodman	1	1950	2m	76.11	102.68	104.04		104.06	0.003676	0.89	145.48	403.59	0.26
Goodman	1	1950	4m	76.11	102.68	104.04		104.06	0.003672	0.89	145.53	403.68	0.26
Goodman	1	1950	6m	76.11	102.68	104.04		104.06	0.003677	0.89	145.46	403.56	0.26
Goodman	1	1950	8m	76.11	102.68	104.04		104.06	0.003677	0.89	145.46	403.56	0.26
Goodman	1	1950	10m	76.11	102.68	104.04		104.06	0.003672	0.89	145.52	403.66	0.26
Goodman	1	1950	15m	76.11	102.68	104.04		104.06	0.003676	0.89	145.47	403.58	0.26
Goodman	1	1950	20m	76.11	102.68	104.04		104.06	0.003676	0.89	145.47	403.58	0.26
Goodman	1	1950	30m	76.11	102.68	104.04		104.06	0.003672	0.89	145.52	403.66	0.26
Goodman	1	1950	40m	76.11	102.68	104.04		104.06	0.003672	0.89	145.52	403.66	0.26
Goodman	1	1910.567	Existing	76.11	101.90	103.80		103.84	0.009713	1.84	103.23	404.22	0.44
Goodman	1	1910.567	CP Removed	76.11	101.90	103.80		103.84	0.009854	1.85	102.65	402.81	0.45
Goodman	1	1910.567	2m	76.11	101.90	103.80		103.84	0.009708	1.84	103.26	404.28	0.44
Goodman	1	1910.567	4m	76.11	101.90	103.80		103.84	0.009866	1.85	102.60	402.70	0.45
Goodman	1	1910.567	6m	76.11	101.90	103.80		103.84	0.009648	1.83	103.51	404.88	0.44
Goodman	1	1910.567	8m	76.11	101.90	103.80		103.84	0.009648	1.83	103.51	404.88	0.44
Goodman	1	1910.567	10m	76.11	101.90	103.80		103.84	0.009854	1.85	102.65	402.81	0.45
Goodman	1	1910.567	15m	76.11	101.90	103.80		103.84	0.009691	1.83	103.33	404.45	0.44
Goodman	1	1910.567	20m	76.11	101.90	103.80		103.84	0.009691	1.83	103.33	404.45	0.44
Goodman	1	1910.567	30m	76.11	101.90	103.80		103.84	0.009854	1.85	102.65	402.81	0.45
Goodman	1	1910.567	40m	76.11	101.90	103.80		103.84	0.009854	1.85	102.65	402.81	0.45
Goodman	1	1851.839	Existing	76.11	100.68	103.65	103.07	103.67	0.001255	0.58	121.15	398.99	0.11
Goodman	1	1851.839	CP Removed	76.11	100.68	103.64	103.07	103.66	0.001274	0.59	120.30	395.71	0.11
Goodman	1	1851.839	2m	76.11	100.68	103.65	103.07	103.67	0.001254	0.58	121.19	399.12	0.11
Goodman	1	1851.839	4m	76.11	100.68	103.64	103.07	103.66	0.001275	0.59	120.23	395.45	0.11
Goodman	1	1851.839	6m	76.11	100.68	103.65	103.07	103.67	0.001246	0.58	121.55	400.49	0.11
Goodman	1	1851.839	8m	76.11	100.68	103.65	103.07	103.67	0.001246	0.58	121.55	400.49	0.11
Goodman	1	1851.839	10m	76.11	100.68	103.64	103.07	103.66	0.001274	0.59	120.30	395.71	0.11
Goodman	1	1851.839	15m	76.11	100.68	103.65	103.07	103.67	0.001252	0.58	121.29	399.51	0.11
Goodman	1	1851.839	20m	76.11	100.68	103.65	103.07	103.67	0.001252	0.58	121.29	399.51	0.11
Goodman	1	1851.839	30m	76.11	100.68	103.64	103.07	103.66	0.001274	0.59	120.30	395.71	0.11
Goodman	1	1851.839	40m	76.11	100.68	103.64	103.07	103.66	0.001274	0.59	120.30	395.71	0.11
Goodman	1	1832.469		Culvert									

HEC-RAS Plan: 2AImprovements Locations: User Defined (Continued)

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Goodman	1	1814.996	Existing	76.11	100.67	103.62	103.23	103.65	0.001484	1.29	111.46	358.99	0.24
Goodman	1	1814.996	CP Removed	76.11	100.67	103.62	103.23	103.65	0.001475	1.29	111.80	361.05	0.24
Goodman	1	1814.996	2m	76.11	100.67	103.62	103.23	103.65	0.001483	1.29	111.48	359.12	0.24
Goodman	1	1814.996	4m	76.11	100.67	103.62	103.23	103.65	0.001483	1.29	111.50	359.22	0.24
Goodman	1	1814.996	6m	76.11	100.67	103.62	103.23	103.65	0.001475	1.29	111.80	361.07	0.24
Goodman	1	1814.996	8m	76.11	100.67	103.62	103.23	103.65	0.001475	1.29	111.80	361.07	0.24
Goodman	1	1814.996	10m	76.11	100.67	103.62	103.23	103.65	0.001475	1.29	111.80	361.05	0.24
Goodman	1	1814.996	15m	76.11	100.67	103.62	103.23	103.65	0.001475	1.29	111.80	361.04	0.24
Goodman	1	1814.996	20m	76.11	100.67	103.62	103.23	103.65	0.001475	1.29	111.80	361.04	0.24
Goodman	1	1814.996	30m	76.11	100.67	103.62	103.23	103.65	0.001475	1.29	111.80	361.05	0.24
Goodman	1	1814.996	40m	76.11	100.67	103.62	103.23	103.65	0.001475	1.29	111.80	361.05	0.24
Goodman	1	1722.472	Existing	76.11	101.04	103.13	103.13	103.32	0.008563	3.12	51.35	115.38	0.77
Goodman	1	1722.472	CP Removed	76.11	101.04	103.13	103.13	103.32	0.008563	3.12	51.35	115.38	0.77
Goodman	1	1722.472	2m	76.11	101.04	103.13	103.13	103.32	0.008563	3.12	51.35	115.38	0.77
Goodman	1	1722.472	4m	76.11	101.04	103.13	103.13	103.32	0.008563	3.12	51.35	115.38	0.77
Goodman	1	1722.472	6m	76.11	101.04	103.13	103.13	103.32	0.008563	3.12	51.35	115.38	0.77
Goodman	1	1722.472	8m	76.11	101.04	103.13	103.13	103.32	0.008563	3.12	51.35	115.38	0.77
Goodman	1	1722.472	10m	76.11	101.04	103.13	103.13	103.32	0.008563	3.12	51.35	115.38	0.77
Goodman	1	1722.472	15m	76.11	101.04	103.13	103.13	103.32	0.008563	3.12	51.35	115.38	0.77
Goodman	1	1722.472	20m	76.11	101.04	103.13	103.13	103.32	0.008563	3.12	51.35	115.38	0.77
Goodman	1	1722.472	30m	76.11	101.04	103.13	103.13	103.32	0.008563	3.12	51.35	115.38	0.77
Goodman	1	1722.472	40m	76.11	101.04	103.13	103.13	103.32	0.008563	3.12	51.35	115.38	0.77
Goodman	1	1676.609	Existing	76.11	100.96	102.96		102.98	0.001443	0.75	126.40	244.42	0.18
Goodman	1	1676.609	CP Removed	76.11	100.96	102.93		102.96	0.001621	0.79	120.60	241.83	0.19
Goodman	1	1676.609	2m	76.11	100.96	102.95		102.97	0.001497	0.77	124.57	243.61	0.18
Goodman	1	1676.609	4m	76.11	100.96	102.94		102.97	0.001538	0.77	123.20	243.00	0.18
Goodman	1	1676.609	6m	76.11	100.96	102.94		102.96	0.001589	0.79	121.58	242.27	0.19
Goodman	1	1676.609	8m	76.11	100.96	102.94		102.96	0.001578	0.78	121.93	242.43	0.19
Goodman	1	1676.609	10m	76.11	100.96	102.94		102.96	0.001592	0.79	121.49	242.23	0.19
Goodman	1	1676.609	15m	76.11	100.96	102.93		102.96	0.001627	0.79	120.44	241.76	0.19
Goodman	1	1676.609	20m	76.11	100.96	102.93		102.95	0.001641	0.80	120.00	241.57	0.19
Goodman	1	1676.609	30m	76.11	100.96	102.93		102.96	0.001620	0.79	120.64	241.85	0.19
Goodman	1	1676.609	40m	76.11	100.96	102.94		102.96	0.001595	0.79	121.41	242.20	0.19
Goodman	1	1566.215	Existing	80.42	99.26	102.87	102.38	102.88	0.000563	0.74	260.02	559.78	0.12
Goodman	1	1566.215	CP Removed	80.42	99.26	102.83	102.38	102.84	0.000694	0.81	237.08	534.38	0.14
Goodman	1	1566.215	2m	80.42	99.26	102.86	102.38	102.87	0.000599	0.76	253.16	556.32	0.13
Goodman	1	1566.215	4m	80.42	99.26	102.85	102.38	102.86	0.000629	0.78	247.81	550.62	0.13
Goodman	1	1566.215	6m	80.42	99.26	102.84	102.38	102.85	0.000668	0.80	241.13	542.31	0.14
Goodman	1	1566.215	8m	80.42	99.26	102.84	102.38	102.85	0.000661	0.80	242.42	544.81	0.13
Goodman	1	1566.215	10m	80.42	99.26	102.84	102.38	102.85	0.000670	0.80	240.76	541.58	0.14
Goodman	1	1566.215	15m	80.42	99.26	102.83	102.38	102.84	0.000699	0.82	236.40	533.54	0.14
Goodman	1	1566.215	20m	80.42	99.26	102.83	102.38	102.84	0.000711	0.82	234.57	531.41	0.14
Goodman	1	1566.215	30m	80.42	99.26	102.83	102.38	102.84	0.000693	0.81	237.25	534.73	0.14
Goodman	1	1566.215	40m	80.42	99.26	102.84	102.38	102.85	0.000672	0.80	240.45	540.98	0.14
Goodman	1	1544.957		Culvert									
Goodman	1	1523.7	Existing	80.42	99.27	102.78	102.05	102.80	0.000272	0.95	223.39	283.93	0.16
Goodman	1	1523.7	CP Removed	80.42	99.27	102.47	102.05	102.51	0.000801	1.53	140.25	217.43	0.27
Goodman	1	1523.7	2m	80.42	99.27	102.72	102.05	102.73	0.000347	1.06	204.30	274.44	0.18
Goodman	1	1523.7	4m	80.42	99.27	102.64	102.05	102.66	0.000456	1.20	184.18	265.35	0.21
Goodman	1	1523.7	6m	80.42	99.27	102.59	102.05	102.62	0.000562	1.32	170.21	259.09	0.23
Goodman	1	1523.7	8m	80.42	99.27	102.53	102.05	102.56	0.000671	1.42	155.31	246.13	0.25
Goodman	1	1523.7	10m	80.42	99.27	102.53	102.05	102.56	0.000683	1.44	154.12	244.48	0.25
Goodman	1	1523.7	15m	80.42	99.27	102.44	102.05	102.49	0.000873	1.59	134.86	209.48	0.29
Goodman	1	1523.7	20m	80.42	99.27	102.44	102.05	102.49	0.000873	1.59	134.80	209.39	0.29
Goodman	1	1523.7	30m	80.42	99.27	102.46	102.05	102.51	0.000801	1.54	140.21	217.38	0.27
Goodman	1	1523.7	40m	80.42	99.27	102.47	102.05	102.51	0.000800	1.53	140.28	217.48	0.27
Goodman	1	1420.552	Existing	80.42	100.09	102.73		102.75	0.000615	1.13	130.13	152.04	0.23
Goodman	1	1420.552	CP Removed	80.42	100.09	102.30		102.36	0.002399	1.97	75.65	104.61	0.44
Goodman	1	1420.552	2m	80.42	100.09	102.65		102.68	0.000782	1.25	118.73	133.29	0.26
Goodman	1	1420.552	4m	80.42	100.09	102.56		102.59	0.001049	1.41	106.67	127.11	0.29
Goodman	1	1420.552	6m	80.42	100.09	102.49		102.53	0.001336	1.56	97.69	122.56	0.33
Goodman	1	1420.552	8m	80.42	100.09	102.40		102.45	0.001832	1.78	87.15	117.28	0.38
Goodman	1	1420.552	10m	80.42	100.09	102.39		102.44	0.001888	1.80	86.21	116.81	0.39
Goodman	1	1420.552	15m	80.42	100.09	102.26		102.33	0.002457	1.97	71.66	97.97	0.44
Goodman	1	1420.552	20m	80.42	100.09	102.26		102.33	0.002462	1.97	71.60	97.74	0.44
Goodman	1	1420.552	30m	80.42	100.09	102.30		102.36	0.002401	1.97	75.62	104.56	0.44
Goodman	1	1420.552	40m	80.42	100.09	102.30		102.36	0.002396	1.97	75.68	104.65	0.44
Goodman	1	1200	Existing	80.42	99.84	102.68		102.69	0.000163	0.62	202.75	266.02	0.12
Goodman	1	1200	CP Removed	80.42	99.84	101.48		101.63	0.004806	2.31	51.02	67.47	0.59
Goodman	1	1200	2m	80.42	99.84	102.58		102.59	0.000203	0.68	180.91	189.09	0.13
Goodman	1	1200	4m	80.42	99.84	102.47		102.48	0.000268	0.76	160.34	163.36	0.15
Goodman	1	1200	6m	80.42	99.84	102.37		102.39	0.000343	0.84	144.92	151.46	0.17
Goodman	1	1200	8m	80.42	99.84	102.23		102.25	0.000498	0.97	124.52	137.66	0.20
Goodman	1	1200	10m	80.42	99.84	102.21		102.24	0.000518	0.98	122.49	136.67	0.21
Goodman	1	1200	15m	80.42	99.84	101.85		101.91	0.001523	1.50	81.32	91.63	0.35
Goodman	1	1200	20m	80.42	99.84	101.66		101.76	0.002726	1.88	64.58	80.82	0.45
Goodman	1	1200	30m	80.42	99.84	101.48		101.63	0.004782	2.31	51.12	67.57	0.59
Goodman	1	1200	40m	80.42	99.84	101.47		101.62	0.004833	2.32	50.91	67.36	0.59

HEC-RAS Plan: 2AImprovements Locations: User Defined (Continued)

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Goodman	1	1050	Existing	80.42	99.28	102.67		102.67	0.000058	0.42	405.12	427.33	0.07
Goodman	1	1050	CP Removed	80.42	99.28	101.22		101.27	0.001251	1.32	91.19	105.87	0.31
Goodman	1	1050	2m	80.42	99.28	102.57		102.57	0.000079	0.48	363.31	414.95	0.09
Goodman	1	1050	4m	80.42	99.28	102.45		102.46	0.000081	0.47	318.89	336.02	0.09
Goodman	1	1050	6m	80.42	99.28	102.35		102.36	0.000091	0.49	288.22	283.94	0.09
Goodman	1	1050	8m	80.42	99.28	102.21		102.21	0.000116	0.53	251.75	218.06	0.10
Goodman	1	1050	10m	80.42	99.28	102.19		102.20	0.000120	0.54	248.42	213.00	0.10
Goodman	1	1050	15m	80.42	99.28	101.80		101.81	0.000268	0.73	174.09	168.89	0.15
Goodman	1	1050	20m	80.42	99.28	101.58		101.59	0.000464	0.90	138.49	149.90	0.19
Goodman	1	1050	30m	80.42	99.28	101.23		101.27	0.001231	1.31	91.79	106.53	0.31
Goodman	1	1050	40m	80.42	99.28	101.22		101.26	0.001274	1.33	90.52	105.13	0.31
Goodman	1	932.2719	Existing	80.42	98.93	102.67		102.67	0.000006	0.08	1170.61	737.81	0.01
Goodman	1	932.2719	CP Removed	80.42	98.93	101.19		101.20	0.000231	0.35	291.66	358.48	0.08
Goodman	1	932.2719	2m	80.42	98.93	102.57		102.57	0.000007	0.08	1098.63	721.29	0.01
Goodman	1	932.2719	4m	80.42	98.93	102.45		102.45	0.000009	0.09	1016.01	699.88	0.02
Goodman	1	932.2719	6m	80.42	98.93	102.35		102.35	0.000011	0.10	946.35	689.00	0.02
Goodman	1	932.2719	8m	80.42	98.93	102.21		102.21	0.000015	0.11	847.96	664.73	0.02
Goodman	1	932.2719	10m	80.42	98.93	102.19		102.19	0.000015	0.12	837.63	662.59	0.02
Goodman	1	932.2719	15m	80.42	98.93	101.80		101.80	0.000041	0.17	585.81	608.30	0.03
Goodman	1	932.2719	20m	80.42	98.93	101.57		101.57	0.000074	0.22	459.23	488.56	0.04
Goodman	1	932.2719	30m	80.42	98.93	101.20		101.20	0.000226	0.34	293.95	359.95	0.07
Goodman	1	932.2719	40m	80.42	98.93	101.19		101.19	0.000236	0.35	289.09	356.82	0.08
Goodman	1	827.5217	Existing	98.65	97.74	102.67	100.47	102.67	0.000022	0.19	1032.61	738.85	0.03
Goodman	1	827.5217	CP Removed	98.65	97.74	101.13	100.47	101.15	0.001044	1.00	216.42	301.37	0.17
Goodman	1	827.5217	2m	98.65	97.74	102.57	100.47	102.57	0.000027	0.20	960.38	721.55	0.03
Goodman	1	827.5217	4m	98.65	97.74	102.45	100.47	102.45	0.000035	0.23	877.18	703.49	0.03
Goodman	1	827.5217	6m	98.65	97.74	102.35	100.47	102.35	0.000044	0.25	807.03	686.89	0.04
Goodman	1	827.5217	8m	98.65	97.74	102.20	100.47	102.21	0.000058	0.28	709.20	626.65	0.04
Goodman	1	827.5217	10m	98.65	97.74	102.19	100.47	102.19	0.000060	0.29	699.42	618.09	0.04
Goodman	1	827.5217	15m	98.65	97.74	101.79	100.47	101.79	0.000162	0.44	472.26	490.00	0.07
Goodman	1	827.5217	20m	98.65	97.74	101.55	100.47	101.55	0.000311	0.59	368.85	402.21	0.10
Goodman	1	827.5217	30m	98.65	97.74	101.13	100.47	101.15	0.001019	0.99	218.82	303.63	0.17
Goodman	1	827.5217	40m	98.65	97.74	101.12	100.47	101.14	0.001074	1.01	213.69	298.98	0.18
Goodman	1	818.1213		Culvert									
Goodman	1	808.6823	Existing	98.65	97.79	102.66	100.46	102.67	0.000026	0.17	999.88	742.03	0.02
Goodman	1	808.6823	CP Removed	98.65	97.79	101.12	100.46	101.14	0.001234	0.92	209.51	260.80	0.16
Goodman	1	808.6823	2m	98.65	97.79	102.56	100.46	102.56	0.000031	0.19	925.00	719.81	0.03
Goodman	1	808.6823	4m	98.65	97.79	102.44	100.46	102.44	0.000041	0.21	841.70	689.00	0.03
Goodman	1	808.6823	6m	98.65	97.79	102.35	100.46	102.35	0.000051	0.23	774.41	671.99	0.03
Goodman	1	808.6823	8m	98.65	97.79	102.20	100.46	102.20	0.000073	0.27	679.40	644.78	0.04
Goodman	1	808.6823	10m	98.65	97.79	102.18	100.46	102.18	0.000076	0.27	666.85	641.14	0.04
Goodman	1	808.6823	15m	98.65	97.79	101.79	100.46	101.79	0.000208	0.43	440.31	505.68	0.07
Goodman	1	808.6823	20m	98.65	97.79	101.55	100.46	101.55	0.000377	0.55	335.98	351.45	0.09
Goodman	1	808.6823	30m	98.65	97.79	101.13	100.46	101.15	0.001210	0.91	211.31	262.04	0.16
Goodman	1	808.6823	40m	98.65	97.79	101.11	100.46	101.13	0.001263	0.93	207.40	259.32	0.16
Goodman	1	708.8131	Existing	98.65	97.89	102.66		102.66	0.000026	0.19	957.24	694.64	0.03
Goodman	1	708.8131	CP Removed	98.65	97.89	101.00		101.01	0.001313	1.01	198.68	203.10	0.19
Goodman	1	708.8131	2m	98.65	97.89	102.56		102.56	0.000031	0.21	886.00	683.27	0.03
Goodman	1	708.8131	4m	98.65	97.89	102.44		102.44	0.000040	0.23	805.81	657.07	0.03
Goodman	1	708.8131	6m	98.65	97.89	102.34		102.34	0.000049	0.25	742.59	605.69	0.04
Goodman	1	708.8131	8m	98.65	97.89	102.20		102.20	0.000069	0.29	657.91	568.95	0.04
Goodman	1	708.8131	10m	98.65	97.89	102.18		102.18	0.000072	0.29	646.62	566.15	0.05
Goodman	1	708.8131	15m	98.65	97.89	101.77		101.77	0.000205	0.46	430.98	451.70	0.08
Goodman	1	708.8131	20m	98.65	97.89	101.51		101.52	0.000349	0.58	330.35	327.86	0.10
Goodman	1	708.8131	30m	98.65	97.89	101.01		101.02	0.001282	1.00	200.64	204.34	0.18
Goodman	1	708.8131	40m	98.65	97.89	100.99		101.00	0.001353	1.02	196.37	201.70	0.19
Goodman	1	651.4663	Existing	98.65	97.89	102.66		102.66	0.000027	0.19	926.48	655.09	0.03
Goodman	1	651.4663	CP Removed	98.65	97.89	100.89		100.91	0.002049	1.18	145.37	143.05	0.23
Goodman	1	651.4663	2m	98.65	97.89	102.56		102.56	0.000033	0.21	859.45	638.04	0.03
Goodman	1	651.4663	4m	98.65	97.89	102.44		102.44	0.000043	0.23	784.89	610.49	0.04
Goodman	1	651.4663	6m	98.65	97.89	102.34		102.34	0.000053	0.25	724.45	596.55	0.04
Goodman	1	651.4663	8m	98.65	97.89	102.19		102.19	0.000074	0.29	638.67	551.55	0.05
Goodman	1	651.4663	10m	98.65	97.89	102.17		102.17	0.000078	0.30	627.67	545.06	0.05
Goodman	1	651.4663	15m	98.65	97.89	101.75		101.76	0.000236	0.48	410.16	475.75	0.08
Goodman	1	651.4663	20m	98.65	97.89	101.48		101.49	0.000540	0.69	300.51	362.60	0.12
Goodman	1	651.4663	30m	98.65	97.89	100.90		100.93	0.001976	1.16	147.23	144.30	0.23
Goodman	1	651.4663	40m	98.65	97.89	100.87		100.90	0.002141	1.20	143.15	141.53	0.23
Goodman	1	539.0491	Existing	98.65	96.56	102.66	100.17	102.66	0.000028	0.17	778.90	530.98	0.02
Goodman	1	539.0491	CP Removed	98.65	96.56	100.17	100.17	100.41	0.013847	2.70	64.95	119.42	0.45
Goodman	1	539.0491	2m	98.65	96.56	102.55	100.17	102.55	0.000033	0.19	725.49	495.04	0.02
Goodman	1	539.0491	4m	98.65	96.56	102.43	100.17	102.43	0.000042	0.21	668.51	458.48	0.03
Goodman	1	539.0491	6m	98.65	96.56	102.33	100.17	102.33	0.000051	0.22	623.23	436.67	0.03
Goodman	1	539.0491	8m	98.65	96.56	102.18	100.17	102.18	0.000067	0.25	560.63	393.69	0.03
Goodman	1	539.0491	10m	98.65	96.56	102.16	100.17	102.16	0.000070	0.26	552.60	392.30	0.03
Goodman	1	539.0491	15m	98.65	96.56	101.73	100.17	101.73	0.000173	0.38	392.80	341.32	0.05
Goodman	1	539.0491	20m	98.65	96.56	101.44	100.17	101.44	0.000333	0.51	305.50	273.66	0.07
Goodman	1	539.0491	30m	98.65	96.56	100.58	100.17	100.64	0.003406	1.44	120.07	159.79	0.23
Goodman	1	539.0491	40m	98.65	96.56	100.47	100.17	100.55	0.004910	1.70	103.22	148.04	0.27
Goodman	1	524.2396		Culvert									

HEC-RAS Plan: 2AImprovements Locations: User Defined (Continued)

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Goodman	1	507.365	Existing	98.65	96.59	102.65	100.05	102.65	0.000034	0.20	745.33	509.51	0.03
Goodman	1	507.365	CP Removed	98.65	96.59	100.15	100.05	100.34	0.010355	2.46	69.42	101.18	0.42
Goodman	1	507.365	2m	98.65	96.59	102.55	100.05	102.55	0.000040	0.22	694.78	495.21	0.03
Goodman	1	507.365	4m	98.65	96.59	102.43	100.05	102.43	0.000050	0.24	638.20	460.72	0.03
Goodman	1	507.365	6m	98.65	96.59	102.33	100.05	102.33	0.000061	0.26	590.57	444.61	0.03
Goodman	1	507.365	8m	98.65	96.59	102.18	100.05	102.18	0.000080	0.29	529.65	379.23	0.04
Goodman	1	507.365	10m	98.65	96.59	102.16	100.05	102.16	0.000083	0.30	522.05	378.08	0.04
Goodman	1	507.365	15m	98.65	96.59	101.72	100.05	101.73	0.000204	0.44	372.57	312.09	0.06
Goodman	1	507.365	20m	98.65	96.59	101.43	100.05	101.43	0.000398	0.59	284.73	284.42	0.09
Goodman	1	507.365	30m	98.65	96.59	100.56	100.05	100.61	0.003087	1.45	119.12	149.24	0.23
Goodman	1	507.365	40m	98.65	96.59	100.45	100.05	100.52	0.004243	1.66	103.15	131.04	0.27
Goodman	1	405.7738	Existing	98.65	96.68	102.65		102.65	0.000031	0.23	741.13	461.86	0.03
Goodman	1	405.7738	CP Removed	98.65	96.68	99.80		99.84	0.002271	1.27	103.74	67.34	0.24
Goodman	1	405.7738	2m	98.65	96.68	102.55		102.55	0.000036	0.25	695.24	444.02	0.03
Goodman	1	405.7738	4m	98.65	96.68	102.43		102.43	0.000043	0.27	642.93	423.75	0.04
Goodman	1	405.7738	6m	98.65	96.68	102.32		102.32	0.000051	0.29	599.10	403.16	0.04
Goodman	1	405.7738	8m	98.65	96.68	102.17		102.17	0.000065	0.32	540.27	378.18	0.05
Goodman	1	405.7738	10m	98.65	96.68	102.15		102.15	0.000067	0.33	532.62	374.98	0.05
Goodman	1	405.7738	15m	98.65	96.68	101.70		101.71	0.000146	0.45	386.89	298.75	0.07
Goodman	1	405.7738	20m	98.65	96.68	101.40		101.40	0.000242	0.56	301.39	229.67	0.08
Goodman	1	405.7738	30m	98.65	96.68	100.43		100.45	0.000873	0.90	156.19	102.99	0.15
Goodman	1	405.7738	40m	98.65	96.68	100.28		100.30	0.001094	0.98	141.24	93.06	0.17
Goodman	1	381.0593	Existing	98.65	96.48	102.65		102.65	0.000034	0.25	703.09	455.85	0.03
Goodman	1	381.0593	CP Removed	98.65	96.48	99.75		99.79	0.001773	1.17	105.62	62.13	0.21
Goodman	1	381.0593	2m	98.65	96.48	102.55		102.55	0.000040	0.27	657.55	443.14	0.04
Goodman	1	381.0593	4m	98.65	96.48	102.42		102.43	0.000049	0.30	605.07	425.35	0.04
Goodman	1	381.0593	6m	98.65	96.48	102.32		102.32	0.000058	0.32	560.78	407.27	0.04
Goodman	1	381.0593	8m	98.65	96.48	102.17		102.17	0.000074	0.35	501.09	378.75	0.05
Goodman	1	381.0593	10m	98.65	96.48	102.15		102.15	0.000077	0.36	493.47	367.51	0.05
Goodman	1	381.0593	15m	98.65	96.48	101.70		101.70	0.000159	0.49	349.90	285.30	0.07
Goodman	1	381.0593	20m	98.65	96.48	101.39		101.40	0.000213	0.54	279.27	169.79	0.08
Goodman	1	381.0593	30m	98.65	96.48	100.41		100.43	0.000728	0.86	155.92	97.13	0.14
Goodman	1	381.0593	40m	98.65	96.48	100.25		100.28	0.000890	0.92	141.48	89.29	0.16
Goodman	1	270.4464	Existing	98.65	94.38	102.65	97.69	102.65	0.000003	0.07	1796.90	631.55	0.01
Goodman	1	270.4464	CP Removed	98.65	94.38	99.71	97.69	99.72	0.000284	0.49	313.88	323.14	0.07
Goodman	1	270.4464	2m	98.65	94.38	102.54	97.69	102.55	0.000003	0.07	1733.04	626.58	0.01
Goodman	1	270.4464	4m	98.65	94.38	102.42	97.69	102.42	0.000004	0.08	1657.82	619.91	0.01
Goodman	1	270.4464	6m	98.65	94.38	102.32	97.69	102.32	0.000004	0.08	1592.51	607.27	0.01
Goodman	1	270.4464	8m	98.65	94.38	102.17	97.69	102.17	0.000005	0.09	1502.39	585.73	0.01
Goodman	1	270.4464	10m	98.65	94.38	102.15	97.69	102.15	0.000005	0.09	1490.47	583.76	0.01
Goodman	1	270.4464	15m	98.65	94.38	101.70	97.69	101.70	0.000009	0.11	1237.22	550.18	0.01
Goodman	1	270.4464	20m	98.65	94.38	101.39	97.69	101.39	0.000014	0.13	1070.24	529.80	0.02
Goodman	1	270.4464	30m	98.65	94.38	100.40	97.69	100.40	0.000071	0.27	578.49	437.40	0.03
Goodman	1	270.4464	40m	98.65	94.38	100.25	97.69	100.25	0.000095	0.30	511.74	412.55	0.04
Goodman	1	252.6487		Culvert									
Goodman	1	236.9849	Existing	98.65	94.40	102.64	97.49	102.64	0.000001	0.05	2415.27	694.08	0.01
Goodman	1	236.9849	CP Removed	98.65	94.40	99.71	97.49	99.71	0.000043	0.21	727.22	470.34	0.03
Goodman	1	236.9849	2m	98.65	94.40	102.54	97.49	102.54	0.000001	0.05	2346.41	689.92	0.01
Goodman	1	236.9849	4m	98.65	94.40	102.42	97.49	102.42	0.000002	0.05	2264.43	681.66	0.01
Goodman	1	236.9849	6m	98.65	94.40	102.31	97.49	102.31	0.000002	0.05	2190.30	672.02	0.01
Goodman	1	236.9849	8m	98.65	94.40	102.17	97.49	102.17	0.000002	0.06	2090.91	661.98	0.01
Goodman	1	236.9849	10m	98.65	94.40	102.15	97.49	102.15	0.000002	0.06	2077.67	660.92	0.01
Goodman	1	236.9849	15m	98.65	94.40	101.70	97.49	101.70	0.000003	0.07	1792.27	614.86	0.01
Goodman	1	236.9849	20m	98.65	94.40	101.39	97.49	101.39	0.000004	0.08	1607.79	574.24	0.01
Goodman	1	236.9849	30m	98.65	94.40	100.40	97.49	100.40	0.000014	0.13	1070.14	522.59	0.02
Goodman	1	236.9849	40m	98.65	94.40	100.24	97.49	100.24	0.000018	0.14	988.25	514.61	0.02
Goodman	1	201.2231	Existing	98.65	94.35	102.64		102.64	0.000001	0.05	2788.79	714.23	0.01
Goodman	1	201.2231	CP Removed	98.65	94.35	99.71		99.71	0.000018	0.16	960.99	532.81	0.02
Goodman	1	201.2231	2m	98.65	94.35	102.54		102.54	0.000001	0.05	2717.92	709.96	0.01
Goodman	1	201.2231	4m	98.65	94.35	102.42		102.42	0.000001	0.05	2633.54	699.67	0.01
Goodman	1	201.2231	6m	98.65	94.35	102.31		102.31	0.000001	0.05	2557.40	692.08	0.01
Goodman	1	201.2231	8m	98.65	94.35	102.17		102.17	0.000001	0.05	2455.01	680.05	0.01
Goodman	1	201.2231	10m	98.65	94.35	102.15		102.15	0.000001	0.06	2441.42	678.66	0.01
Goodman	1	201.2231	15m	98.65	94.35	101.70		101.70	0.000002	0.06	2142.63	658.45	0.01
Goodman	1	201.2231	20m	98.65	94.35	101.39		101.39	0.000002	0.07	1941.86	642.28	0.01
Goodman	1	201.2231	30m	98.65	94.35	100.40		100.40	0.000007	0.11	1343.65	580.92	0.01
Goodman	1	201.2231	40m	98.65	94.35	100.24		100.24	0.000009	0.12	1253.03	568.55	0.02
Goodman	1	140.4352	Existing	98.65	93.74	102.64	96.09	102.64	0.000001	0.03	3319.64	755.34	0.00
Goodman	1	140.4352	CP Removed	98.65	93.74	99.71	96.09	99.71	0.000007	0.09	1344.68	595.37	0.01
Goodman	1	140.4352	2m	98.65	93.74	102.54	96.09	102.54	0.000001	0.03	3244.68	751.12	0.00
Goodman	1	140.4352	4m	98.65	93.74	102.42	96.09	102.42	0.000001	0.04	3155.35	740.54	0.00
Goodman	1	140.4352	6m	98.65	93.74	102.31	96.09	102.31	0.000001	0.04	3074.75	731.75	0.00
Goodman	1	140.4352	8m	98.65	93.74	102.17	96.09	102.17	0.000001	0.04	2966.36	722.21	0.00
Goodman	1	140.4352	10m	98.65	93.74	102.15	96.09	102.15	0.000001	0.04	2951.92	720.53	0.00
Goodman	1	140.4352	15m	98.65	93.74	101.70	96.09	101.70	0.000001	0.04	2635.14	698.24	0.00
Goodman	1	140.4352	20m	98.65	93.74	101.39	96.09	101.39	0.000001	0.05	2421.88	687.99	0.01
Goodman	1	140.4352	30m	98.65	93.74	100.40	96.09	100.40	0.000003	0.07	1766.17	637.46	0.01
Goodman	1	140.4352	40m	98.65	93.74	100.24	96.09	100.24	0.000004	0.07	1666.60	624.88	0.01

HEC-RAS Plan: 2AImprovements Locations: User Defined (Continued)

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Goodman	1	94.22269		Culvert									
Goodman	1	40.51218	Existing	98.65	93.19	102.64	95.11	102.64	0.000000	0.03	4735.59	939.47	0.00
Goodman	1	40.51218	CP Removed	98.65	93.19	99.71	95.11	99.71	0.000001	0.07	2243.33	765.73	0.01
Goodman	1	40.51218	2m	98.65	93.19	102.54	95.11	102.54	0.000000	0.03	4642.31	934.29	0.00
Goodman	1	40.51218	4m	98.65	93.19	102.42	95.11	102.42	0.000000	0.03	4531.19	924.83	0.00
Goodman	1	40.51218	6m	98.65	93.19	102.31	95.11	102.31	0.000000	0.03	4430.47	915.17	0.00
Goodman	1	40.51218	8m	98.65	93.19	102.16	95.11	102.16	0.000000	0.03	4294.94	901.86	0.00
Goodman	1	40.51218	10m	98.65	93.19	102.14	95.11	102.14	0.000000	0.03	4276.92	900.09	0.00
Goodman	1	40.51218	15m	98.65	93.19	101.70	95.11	101.70	0.000000	0.04	3880.31	876.81	0.00
Goodman	1	40.51218	20m	98.65	93.19	101.39	95.11	101.39	0.000000	0.04	3612.47	863.90	0.00
Goodman	1	40.51218	30m	98.65	93.19	100.40	95.11	100.40	0.000001	0.05	2782.09	809.45	0.01
Goodman	1	40.51218	40m	98.65	93.19	100.24	95.11	100.24	0.000001	0.06	2655.07	800.26	0.01

APPENDIX E

2A & 3A Landuse

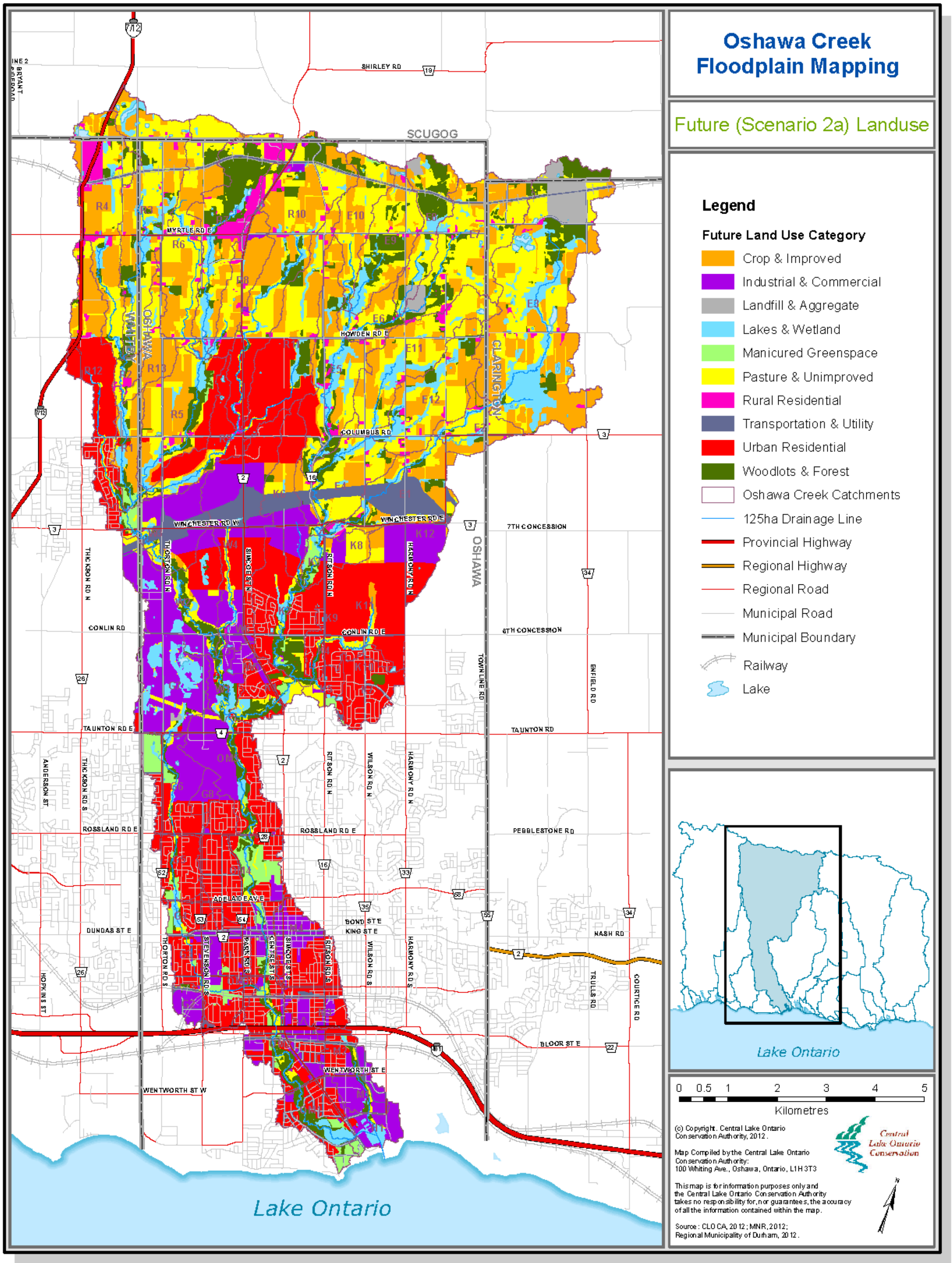


FIGURE 4 - FUTURE LAND USE 2A: FULL OP BUILDOUT

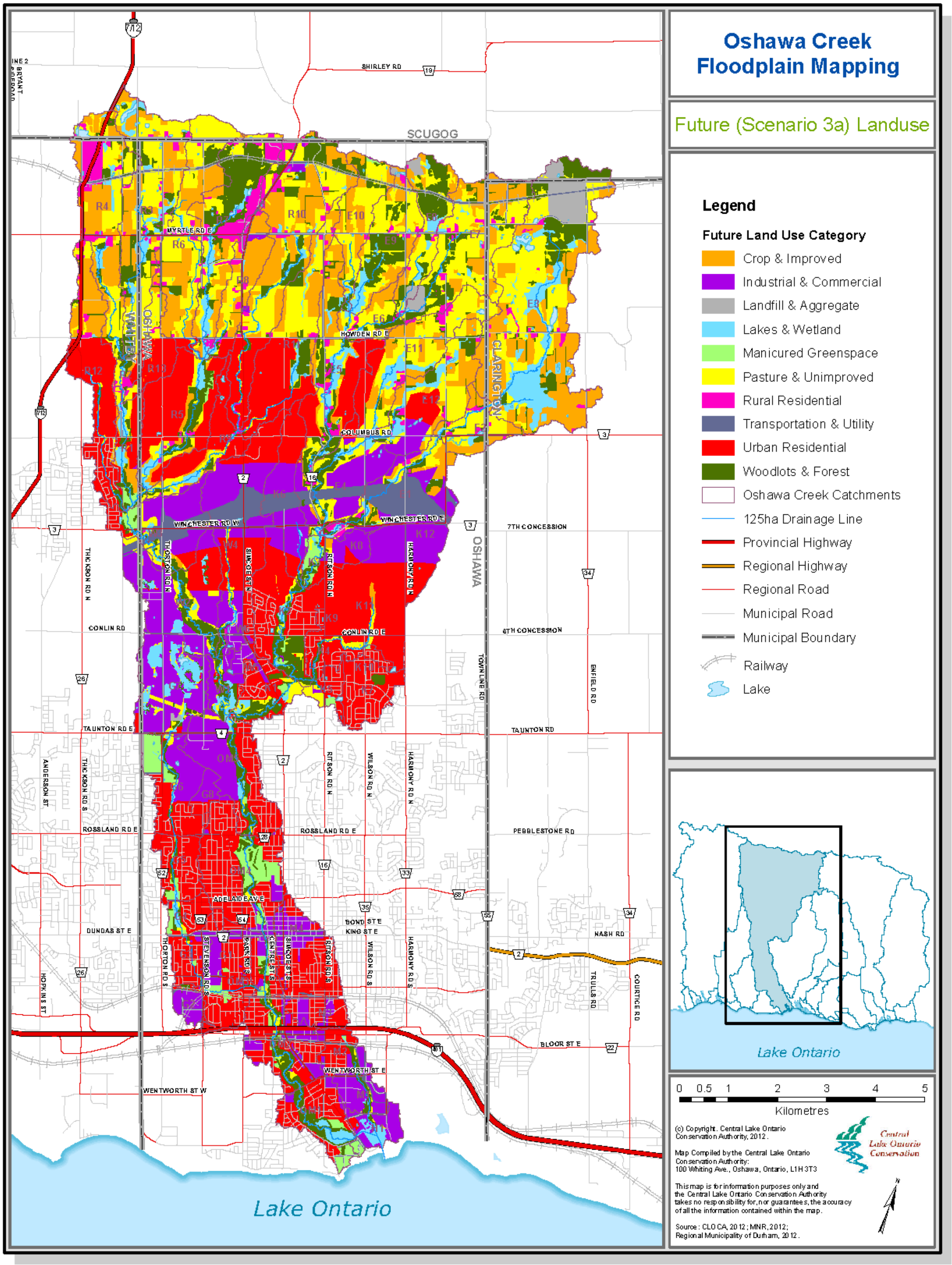


FIGURE 5 - FUTURE LAND USE 3A: FULL OP BUILDOUT + WHITEBELT BUILDOUT

APPENDIX F

Climate Change IDF Information

Oshawa WPCP
IDF Under Climate Change Scenario RCP 8.5

2070 - 2100

Total PPT (mm)

T (years)	2	5	10	25	50	100
5 min	10.62	13.44	15.31	17.67	19.43	21.16
10 min	15.06	19.04	21.68	25.01	27.48	29.93
15 min	18.18	23.02	26.22	30.26	33.26	36.24
30 min	23.63	29.76	33.81	38.94	42.74	46.51
1 h	29.9	38.09	43.51	50.36	55.44	60.49
2 h	37.17	47.39	54.15	62.7	69.04	75.33
6 h	48.27	60.65	68.85	79.21	86.9	94.53
12 h	66.73	89.9	105.24	124.62	139	153.27
24 h	71.42	93.29	107.77	126.06	139.63	153.1

2070 - 2100

Intensity Rates (mm/hr)

T (years)	2	5	10	25	50	100
5 min	127.45	161.32	183.75	212.08	233.1	253.97
10 min	90.35	114.24	130.05	150.04	164.87	179.58
15 min	72.73	92.07	104.87	121.04	133.04	144.95
30 min	47.26	59.51	67.62	77.87	85.48	93.03
1 h	29.9	38.09	43.51	50.36	55.44	60.49
2 h	18.58	23.69	27.08	31.35	34.52	37.67
6 h	8.04	10.11	11.47	13.2	14.48	15.75
12 h	5.56	7.49	8.77	10.39	11.58	12.77
24 h	2.98	3.89	4.49	5.25	5.82	6.38

T (years)	Coefficient A	Coefficient B	Coefficient t_0
2	31.2	-0.727	0.062
5	39.3	-0.715	0.056
10	44.6	-0.71	0.053
25	51.4	-0.705	0.051
50	56.5	-0.703	0.049
100	61.5	-0.7	0.048

The table below provides the coefficients for the interpolated equations fitted to the average IDF for future scenario RCP 8.5

Use the coefficients provided in the table above with the following equation:

$$i(mmh)=A\cdot(t+t_0)_B$$

Where:
i is the precipitation intensity rate in mmh
A, B and t0, are the coefficients for each return period (T) in years
t, the time (duration) of the precipitation event in hours (h)

2050 - 2070

Total PPT (mm)

T (years)	2	5	10	25	50	100
5 min	8.38	11.32	13.26	15.72	17.55	19.36
10 min	11.9	16.05	18.8	22.27	24.84	27.4
15 min	14.45	19.41	22.69	26.84	29.92	32.98
30 min	18.97	24.93	28.88	33.87	37.57	41.24
1 h	23.06	30.62	35.62	41.94	46.63	51.28
2 h	28.15	37.21	43.2	50.77	56.39	61.97
6 h	37.32	48.66	56.16	65.64	72.67	79.66
12 h	45.6	66.39	80.15	97.55	110.44	123.24
24 h	52.16	71.57	84.43	100.67	112.71	124.67

Intensity Rates (mm/hr)

T (years)	2	5	10	25	50	100
5 min	100.57	135.83	159.18	188.68	210.56	232.29
10 min	71.39	96.29	112.78	133.63	149.07	164.41
15 min	57.78	77.63	90.76	107.37	119.68	131.9
30 min	37.95	49.87	57.76	67.73	75.13	82.48
1 h	23.06	30.62	35.62	41.94	46.63	51.28
2 h	14.08	18.6	21.6	25.39	28.2	30.99
6 h	6.22	8.11	9.36	10.94	12.11	13.28
12 h	3.8	5.53	6.68	8.13	9.2	10.27
24 h	2.17	2.98	3.52	4.19	4.7	5.19

T (years)	Coefficient A	Coefficient B	Coefficient t_0
2	24.5	-0.758	0.073
5	32	-0.739	0.057
10	37	-0.732	0.051
25	43.4	-0.725	0.046
50	48.1	-0.722	0.044
100	52.8	-0.72	0.042

2030 - 2050

Total PPT (mm)

T (years)	2	5	10	25	50	100
5 min	8.72	11.32	13.13	15.41	17.11	18.79
10 min	12.39	16.04	18.59	21.81	24.2	26.57
15 min	15.03	19.4	22.45	26.3	29.16	31.99
30 min	19.75	24.89	28.51	33.07	36.46	39.82
1 h	24.15	30.53	35.06	40.77	45.02	49.23
2 h	29.53	37.08	42.46	49.27	54.31	59.32
6 h	39.07	48.49	55.22	63.73	70.03	76.3
12 h	48.93	66.13	78.45	94.02	105.57	117.03
24 h	55.05	71.27	82.82	97.42	108.25	119

Intensity Rates (mm/hr)

T (years)	2	5	10	25	50	100
5 min	104.67	135.82	157.52	184.94	205.28	225.47
10 min	74.33	96.25	111.55	130.87	145.2	159.43
15 min	60.12	77.6	89.79	105.2	116.63	127.97
30 min	39.49	49.78	57.01	66.15	72.92	79.65
1 h	24.15	30.53	35.06	40.77	45.02	49.23
2 h	14.77	18.54	21.23	24.63	27.16	29.66
6 h	6.51	8.08	9.2	10.62	11.67	12.72
12 h	4.08	5.51	6.54	7.84	8.8	9.75
24 h	2.29	2.97	3.45	4.06	4.51	4.96

T (years)	Coefficient A	Coefficient B	Coefficient t_0
2	25.6	-0.752	0.072
5	32	-0.739	0.057
10	36.5	-0.733	0.051
25	42.2	-0.728	0.046
50	46.5	-0.725	0.043
100	50.7	-0.723	0.041

Toronto City
IDF Under Climate Change   Scenario RCP 8.5

2070 - 2100

Total PPT (mm)

T (years)	2	5	10	25	50	100
5 min	9.75	13.97	16.83	20.42	23.07	25.7
10 min	13.56	18.69	22.16	26.53	29.75	32.94
15 min	16.69	23.94	28.84	35.01	39.56	44.08
30 min	21.15	30.66	37.1	45.19	51.16	57.09
1 h	25.35	36.42	43.9	53.33	60.27	67.17
2 h	29.3	40.87	48.7	58.56	65.83	73.05
6 h	35.78	49.77	59.23	71.18	79.97	88.7
12 h	42.53	57.43	67.51	80.23	89.59	98.89
24 h	47.14	63.14	73.96	87.64	97.7	107.68

Intensity Rates (mm/hr)

T (years)	2	5	10	25	50	100
5 min	117.04	167.66	201.92	245.04	276.83	308.38
10 min	81.34	112.12	132.96	159.16	178.48	197.67
15 min	66.75	95.76	115.37	140.05	158.26	176.33
30 min	42.31	61.33	74.19	90.38	102.32	114.17
1 h	25.35	36.42	43.9	53.33	60.27	67.17
2 h	14.65	20.44	24.35	29.28	32.92	36.52
6 h	5.96	8.3	9.87	11.86	13.33	14.78
12 h	3.54	4.79	5.63	6.69	7.47	8.24
24 h	1.96	2.63	3.08	3.65	4.07	4.49

T (years)	Coefficient A	Coefficient B	Coefficient t_0
2	27	-0.823	0.086
5	38.8	-0.845	0.1
10	46.9	-0.855	0.106
25	57.1	-0.863	0.111
50	64.6	-0.868	0.114
100	72.1	-0.872	0.117

The table below provides the coefficients for the interpolated equations fitted to the average IDF for future scenario RCP 8.5

Use the coefficients provided in the table above with the following equation:

$$i(mmh)=A\cdot(t+t_0)_B$$

Where:

i is the precipitation intensity rate in mmh

A, B and t0, are the coefficients for each return period (T) in years

t, the time (duration) of the precipitation event in hours (h)

2050 - 2070

Total PPT (mm)

T (years)	2	5	10	25	50	100
5 min	9.74	13.76	16.42	19.78	22.28	24.74
10 min	13.4	18.25	21.47	25.53	28.54	31.52
15 min	16.44	23.24	27.74	33.42	37.64	41.81
30 min	20.76	29.6	35.45	42.84	48.32	53.75
1 h	24.88	35.17	41.99	50.6	56.99	63.33
2 h	28.95	39.87	47.1	56.24	63.01	69.74
6 h	35.53	48.44	56.99	67.79	75.8	83.76
12 h	41.83	55.66	64.82	76.38	84.97	93.49
24 h	46.69	61.31	70.98	83.21	92.28	101.28

Intensity Rates (mm/hr)

T (years)	2	5	10	25	50	100
5 min	116.87	165.11	197.04	237.4	267.33	296.83
10 min	80.38	109.51	128.8	153.16	171.24	189.1
15 min	65.76	92.95	110.95	133.69	150.57	167.23
30 min	41.52	59.19	70.89	85.68	96.64	107.51
1 h	24.88	35.17	41.99	50.6	56.99	63.33
2 h	14.48	19.94	23.55	28.12	31.51	34.87
6 h	5.92	8.07	9.5	11.3	12.63	13.96
12 h	3.49	4.64	5.4	6.37	7.08	7.79
24 h	1.95	2.55	2.96	3.47	3.84	4.22

T (years)	Coefficient A	Coefficient B	Coefficient t_0
2	26.4	-0.819	0.081
5	37.4	-0.842	0.095
10	44.8	-0.853	0.101
25	54.1	-0.862	0.106
50	61	-0.867	0.11
100	67.9	-0.871	0.112

2030 - 2050

Total PPT (mm)

T (years)	2	5	10	25	50	100
5 min	10.03	13.83	16.4	19.63	22.04	24.42
10 min	13.75	18.34	21.44	25.36	28.26	31.15
15 min	16.92	23.36	27.71	33.2	37.27	41.31
30 min	21.4	29.76	35.41	42.54	47.82	53.07
1 h	25.6	35.38	41.97	50.29	56.47	62.6
2 h	29.72	40.09	47.09	55.92	62.48	68.98
6 h	36.47	48.71	56.98	67.41	75.16	82.84
12 h	42.84	55.96	64.82	76.01	84.31	92.54
24 h	47.77	61.62	70.98	82.8	91.57	100.27

Intensity Rates (mm/hr)

T (years)	2	5	10	25	50	100
5 min	120.41	165.99	196.75	235.62	264.45	293.07
10 min	82.49	110.05	128.65	152.14	169.57	186.87
15 min	67.68	93.45	110.83	132.78	149.07	165.23
30 min	42.8	59.53	70.81	85.07	95.65	106.15
1 h	25.6	35.38	41.97	50.29	56.47	62.6
2 h	14.86	20.05	23.54	27.96	31.24	34.49
6 h	6.08	8.12	9.5	11.24	12.53	13.81
12 h	3.57	4.66	5.4	6.33	7.03	7.71
24 h	1.99	2.57	2.96	3.45	3.82	4.18

T (years)	Coefficient A	Coefficient B	Coefficient t_0
2	27.2	-0.82	0.082
5	37.7	-0.843	0.095
10	44.8	-0.852	0.101
25	53.8	-0.861	0.106
50	60.5	-0.867	0.11
100	67.1	-0.871	0.112