Appendix D to PL-40-23

CITY OF BURLINGTON

FLOOD HAZARD AND SCOPED STORMWATER MANAGEMENT ASSESSMENT

ALDERSHOT GO MAJOR TRANSIT STATION AREA

JUNE 05, 2023

wsp

FLOOD HAZARD AND SCOPED STORMWATER MANAGEMENT ASSESSMENT

ALDERSHOT GO MAJOR TRANSIT STATION AREA

CITY OF BURLINGTON

PROJECT NO.: TPB178008
DATE: JUNE 05, 2023

WSP E&I CANADA LIMITED
3450 HARVESTER ROAD, SUITE 100
BURLINGTON, ON L7N 3W5

T: +1 905-335-2353

WSP.COM

QUALITY MANAGEMENT

ISSUE/REVISION	FIRST ISSUE	REVISION 1	REVISION 2
Remarks	Initial Technical Memorandum (as Amec Foster Wheeler)	Revised as per City and CH Comments (as Wood)	Revised as per City and CH Comments (as Wood)
Date	February 21, 2018	February 19, 2019	August 9, 2021
Prepared by	Matt Senior Mike Penney Ron Scheckenberger	Matt Senior Mike Penney Ron Scheckenberger Priyantha Hunkumbura Allison Zhang	Matt Senior Mike Penney Ron Scheckenberger Allison Zhang
Authorised by	Ron Scheckenberger	Ron Scheckenberger	Ron Scheckenberger
Project number	TPB178008	TPB178008	TPB178008

ISSUE/REVISION	REVISION 3		
Remarks	Revised as per CH Comments (as WSP)		
Date	June 5, 2023		
Prepared by	Matt Senior		
Authorised by	Matt Senior		
Project number	TPB178008		

SIGNATURES

APPROVED[1] BY *(must be reviewed for technical accuracy prior to approval)*

____

Per: Matt Senior, M.A.Sc., P.Eng.
Associate, Senior Water Resources Engineer
WSP E&I Canada Limited

WSP E&I Canada Limited prepared this report solely for the use of the intended recipient, City of Burlington, in accordance with the professional services agreement. The intended recipient is solely responsible for the disclosure of any information contained in this report. The content and opinions contained in the present report are based on the observations and/or information available to WSP E&I Canada Limited at the time of preparation. If a third party makes use of, relies on, or makes decisions in accordance with this report, said third party is solely responsible for such use, reliance or decisions. WSP E&I Canada Limited does not accept responsibility for damages, if any, suffered by any third party as a result of decisions made or actions taken by said third party based on this report. This limitations statement is considered an integral part of this report.

The original of this digital file will be conserved by WSP E&I Canada Limited for a period of not less than 10 years. As the digital file transmitted to the intended recipient is no longer under the control of WSP E&I Canada Limited, its integrity cannot be assured. As such, WSP E&I Canada Limited does not guarantee any modifications made to this digital file subsequent to its transmission to the intended recipient.

[1] Approval of this document is an administrative function indicating readiness for release and does not impart legal liability on to the Approver for any technical content contained herein. Technical accuracy and fit-for-purpose of this content is obtained through the review process. The Approver shall ensure the applicable review process has occurred prior to signing the document.

PRODUCTION TEAM

CITY OF BURLINGTON

Stormwater Engineer	Umar Malik, M.Eng., P.Eng.
Manager – Development and Stormwater Engineering	Cary Clark, P.Eng.
Manager – Policy and Community	Alison Enns, M.Pl., MCIP, RPP
Coordinator of Community Initiatives	Jenna Puletto, M.Pl., MCIP, RPP

WSP

Project Manager	Matt Senior, M.A.Sc., P.Eng.
Project Advisor	Ron Scheckenberger, M.Eng., P.Eng. (Scheckenberger & Associates Ltd.)

CONSERVATION HALTON

Manager, Environmental Engineering	Leah Smith, MCIP, RPP
Environmental Planner	Heather Dearlove, B.Sc.

TABLE OF CONTENTS

List of Drawings

List of Figures

List of Tables

List of Appendices

1 INTRODUCTION

The City of Burlington (City) is undertaking a land use planning study for three (3) Major Transit Station Areas (MTSAs), previously referred to as Mobility Hubs. These are areas as located around the City's GO stations including Appleby GO, Burlington GO, Aldershot GO, and also includes the Downtown area where re-development and intensification are expected.

A planning study was undertaken commening in 2017 (lead by Brook McIlroy Inc.). This work included the preparation of a series of Scoped Environmental Impact Studies (EIS) for each of the four (4) areas cited above. The purpose of the Scoped EIS is to document existing environmental conditions, and assess potential environmental impacts and mitigation strategies related to the expected development and re-development in these areas. Note that SGL Planning subsequently undertook a scoped review of the Downtown area ("Taking a Closer Look at the Downtown: Themes, Principles and Land Use Concepts", October 2019).

In support of this effort, WSP E&I Canada Limited (WSP; formerly Wood Environment & Infrastrucutre Solutions Canada Limited) prepared a series of flood hazard and scoped stormwater management assessments for each of these areas. Note that a combined report was prepared for the Burlington GO and Downtown area and assessed through a subsequent report update ("Major Transit Station Area (MTSA) Phase 2 Flood Hazard Assessmemnt, Burlington GO and Downtown" WSP, March 2023). Separate reporting was prepared for the Aldershot GO and Appleby GO MTSAs.

These documents aummarize existing flood hazards for areas of anticipated development, and to also develop preliminary stormwater management strategies, including consideraton for drainage infrastructure service capacity and associated improvements, where feasible and required.

The current report is focused specifically upon the Aldershot GO MTSA. Drawing 1 presents the boundaries of the MTSA study area along with the area watercourses.

Ultimately, the analyses documented within the current report are intended to provide context with respect to the overall flood risk to the Aldershot GO MTSA, and the potential implications to the proposed intensification development in these areas.

This report is intended to serve as a primary component of the overall Scoped EIS reporting. In addition, the current reporting also includes the Scoped Stormwater Management (SWM) criteria assessment

The current reporting was largely finalized in February, 2019. The current version of the reporting has been updated to include minor additional comments from Conservation Halton (CH), as per its comment summaries of April 16 and November 26, 2021. Since that time updated hydrologic and hydraulic modelling has been completed by CH specifically for the Grindstone Creek watershed ("Grindstone Creek Floodplain Mapping Update", Matrix, March 2020). Reference should be made to the most current flood hazard mapping as available from CH. It is also recognized that CH has deferred the requirements for some supplementary analyses to a future phase of work; reference is made to those comments accordingly (refer to Appendix B).

2 HYDROLOGY

2.1 AVAILABLE MODELLING

The Aldershot MTSA (Drawing 1) intersects a number of different watersheds (ref. Drawing 3). These watersheds and available sources of hydrologic modelling are summarized in Table 2.1 (as per Table B, Scoped EIS Work Plan (updated April 25, 2017).

Table 2.1. Available Hydrologic Modelling – Aldershot GO MTSA

WATERSHED	STUDY DATE AND REFERENCE	MODELLING PLATFORM
Grindstone Creek	Grindstone Creek Subwatershed Study (Cosburn Patterson Wardman Ltd, 1995)	GAWSER
Falcon Creek	Falcon Creek Hydrology and Hydraulics Study (Valdor, 2012)	GAWSER
West Aldershot Creek	Unavailable – new model to be created	PCSWMM
La Salle Creek Forest Glen Creek Teal Creek	Class EA for Aldershot Community Stormwater Master Plan (AMEC Environment & Infrastructure, 2013)	PCSMWM

The available modelling is a mixture of GAWSER and PCSWMM. It is noted that the Aldershot MTSA is primarily intersected by Grindstone Creek and West Aldershot Creek, and to a lesser degree, Teal Creek and Falcon Creek. Although included in the Scoped EIS Work Plan, based on updated drainage area analyses (Drawing 3), the other listed watersheds (La Salle Creek, and Forest Glen Creek) do not contribute flow to the Aldershot MTSA area and have therefore not been included in subsequent analyses.

Following the completion of the primary scope of work for this project (reporting dated February 19, 2019) Conservation Halton (CH) completed an updated Flood Hazard Mapping Study for the Grindstone Creek watershed (March 2020). This included the development of new hydrologic and hydraulic modelling. Given the timing of the current study, these results are not reflected in the reporting or analyses. Future studies should consider this updated modelling resources accordingly.

2.2 HYDROLOGIC MODELLING UPDATES

2.2.1 EXISTING LAND USE PARAMETERIZATION

In order to develop a consistent approach to the estimation of flows under existing land use conditions, a consistent land use layer has been employed for all hydrologic models.

The City of Burlington has provided two different sources of land use mapping (Official Plan Mapping and Zoning Bylaw mapping). These mapping data have been reviewed, and ultimately the Zoning Bylaw mapping has been considered to be most representative of current conditions, and more readily useable for hydrologic modelling purposes. This mapping has been updated as required, including merging certain land use classifications, and adding separate distinctions as required (in particular, differentiating between more recent and dense detached residential areas, as opposed to older, less dense residential areas). The resulting land use mapping is presented in Drawing 2.

Imperviousness for these land use areas has been estimated using current aerial photography, with spot checks for three (3) different sub-areas for each land use classification, in order to estimate an average value. For detached residential areas, directly and indirectly connected areas have been estimated based on rooftop downspout connectivity (as evident from Google EarthTM and field review). Table 2.2 presents the resulting land use classifications and associated estimated imperviousness values.

Table 2.2. Estimated Land Use Characterization and Parameterization for Aldershot GO MTSA

LAND USE CLASSIFICATION	TOTAL IMPERVIOUSNESS (%)	DIRECTLY CONNECTED IMPERVIOUSNESS (%)
Apartment Buildings	60%	60%
Low Density Detached	40%	20%
High Impervious	90%	90%
Institutional/Industrial	60%	60%
Park/Corridor	10%	10%
Semi Detached and Town Homes	60%	60%
Roadways	90%	90%
Forest	0%	0%
Other	20%	20%
Open Water	100%	100%

It should be noted that Table 2.2 includes two additional land use classifications not employed previously for other MTSAs. The classification of "other" refers to open space/unvegetated areas, primarily the industrial area north of Emery Avenue, and some of the area surrounding the Aldershot GO station. The estimated imperviousness (20%) reflects the value determined from current aerial photography. The classification of "forest" refers to the forested areas of the Aldershot MTSA which do not fit the estimated imperviousness of 10% which has been assigned to "Park/Corridor" in the more urbanized Burlington GO MTSA and Downtown Area.

Based on the above parameterization and estimated land use (Drawing 2), an average overall impervious coverage of 60% +/- results for the existing drainage areas within the Aldershot MTSA Limit. The modelling updates have resulted in an increase of the impervious coverage from the original modelling (which had an average impervious coverage of approximately 36%). This likely reflects the more conservative imperviousness assumptions in current engineering practice than in more dated modelling (the previous Cosburn Patterson Wardman Ltd. Study for Grindstone Creek was completed in 1995, some 23 years previous). In addition, there is some development within the study area which has occurred since the previous study, particularly around the Aldershot GO Station itself, including two parking lot areas, as well as the recent Masonry Court Development (which has been assumed to be fully built out (both Phases 1 and 2) under existing conditions, as per "Functional Servicing and Stormwater Management Report, Adi Development (Masonry) Inc., 101 Masonry Court" (Urbantech West, October 2017).

Drawing 3 presents the drainage area boundaries for the Aldershot MTSA area, and also depicts key hydrologic nodes (locations) of interest based on the flows generated from the updated hydrologic modelling.

It is noted that both GAWSER and PCSWMM are capable of undertaking continuous hydrologic simulation, as per item 6.1 c) from the Scoped EIS Work Plan (updated April 25, 2017). However, as outlined in that section, continuous simulation has not been included in the proposed work plan. As such, an event-based (design storm) approach has been employed for the current assessment, consistent with the approach employed for the other MTSAs.

Previously completed hydrologic assessments used the available IDF data of that time, which has since been superseded by more current/extensive datasets. As part of this assessment, the data from the 2004 IDF update completed by WSP (December 10, 2004) has been applied; refer to Appendix C for details. It should be noted however that the currently approved City IDF are those specified in the 1994 Storm Drainage Design Manual (based on data from 1964 to 1990). The 2004 values represent approximately a 5% increase in rainfall depths as compared to the 1994 values.

A number of different design storm distributions have been assessed to determine the most critical. Based on this analysis (completed for the Burlington GO MTSA and Downtown Area), the 24-Hour SCS Type II distribution has been selected based on the highest simulated flows within the receiving watercourse systems, and for consistency with the analyses completed for the other MTSAs. Sensitivity analysis results have been included in Appendix C.

As per CH's comments of April 16, 2021, it is undersood that as part of the Grindstone Creek Floodplain Mapping Study, the AES 12-hour design storm distribution was ultimately selected for the purposes of determining regulatory return period/frequency design flows. CH has indicated that any future calculations of return period flows within Grindstone Creek should use this distribution, and site-specific studies will be required to verify proposed SWM strategies accordingly. CH has further clarified (comments of November 26, 2021) that it encourages the evaluation of various design storm distributions when assessing SWM requirements and would support the use of a more critical storm (alternative distribution) if determined to govern for quantity control requirements. The AES 12-hour storm should be included regardless however as it should be the basis of regulatory flows.

2.2.2 GAWSER MODELLING (GRINDSTONE AND FALCON CREEKS)

The Guelph All-Weather Sequential-Events Runoff (GAWSER) modelling program has been applied historically in the Grindstone Creek and Falcon Creek watersheds. The GAWSER model has multiple methods for calculating subcatchment runoff, which apply variations of main channel and off channel routing of runoff through the subcatchment. The main channel section represents the overall hydraulic routing through the subcatchment, while the off channel represents the smaller drainage paths which lead to the main channel. The Cosburn Patterson Wardman Ltd (1995) model has applied the 'Model 2' approach which requires a reference channel section for both the main channel and the off channel. For the off channel, a generic section has been applied for all subcatchments. The main channel has been modelled with a representative cross section taken from the contours form the topographic mapping. This technique has been retained in the updated modelling. The main channel is defined as a representative cross section obtained from the 2015 DEM, while the off channel remains the same as in the Cosburn Patterson Wardman Ltd (1995) model. The reference flow for the main channel (QRMC) and off channel (QROC) has been set to 0.6 and 0.05, respectively, as applied in the original model.

The baseline GAWSER model used for the Aldershot GO MTSA is the 1995 future conditions land use model 'FU4100Q'. The model has been refined using the DEM supplied by the City of Burlington (Region of Halton, 2015) to further discretize the subcatchments between Highway #403 and the outlet to the Main Branch of Grindstone Creek. The subcatchments have been refined to allow for hydrologic input to facilitate a more discrete hydraulic modelling of structures around the Waterdown Road interchange upstream and downstream of the CN railway tracks. The schematic for the 1995 Study has been retained to the extent possible to aid in the review of the model, however due to the refinements, several flow nodes now represent different locations in the watershed. Additionally, several new areas have been added to the model including the previously unidentified Tributary 7 (subcatchment 701) and subcatchment 611 (Howard Road) which is located within the Aldershot GO MTSA boundary, and drains to the Main Branch of Grindstone Creek.

The 1995 Study modelled six tributaries to the Grindstone Creek numbered from east to west, with the 100 series subcatchments representing Tributary 1 (most easterly) and the 600 series subcatchments representing Tributary 6 (most westerly - refer to 1995 study for subcatchment boundaries). The 700 series of subcatchments added by WSP was not previously included in the hydrologic models for either the Grindstone Creek watershed or the Falcon Creek watershed and would lie to the east of Tributary 1. The runoff from subcatchment 701 is directed to a local drainage feature which travels along the east side of the Ippolito Group property and crosses Highway #403 through a culvert of unknown size, ultimately draining to the wetland feature in subcatchment 703. A review of drainage boundaries developed using the current DEM (Region of Halton, 2015) determined that subcatchments and 703 would drain towards the west to the ditch system along the CN railway tracks. Subcatchment 702 was previously included in the Falcon Creek watershed due to the presence of a berm to the northeast of the wetland feature in subcatchment 703. A review of current topographic data determined that the high point to the east of subcatchment 703 is higher than the berm and therefore the runoff from subcatchment 702 contributes to the wetland. It is noted that subcatchment 702 could potentially contribute to Falcon Creek rather than Grindstone Creek; a field verification would be necessary to confirm the drainage divide. However, the assumption that the 5.7 ha drainage area contributes to Grindstone Creek provides a more conservative estimate for the channelized area through the Aldershot GO MTSA. Reference is also made to Figure 3 in the 'Draft' version of the "Grindstone and Falcon Creek Headwater Wetland Complex OWES Evaluation" (MMM Group, March 2017) which indicates that the area around subcatchment 702 should be within the Grindstone Creek watershed boundary.

The estimated existing conditions land use for hydrologic modelling (ref. Drawing 2) has been updated assuming full build out of Phase 1 and Phase 2 of the 101 Masonry Court development (Urbantech West, October 2017). The Masonry Court development is located within subcatchment 307, which has been modelled as 47 % impervious based on the areal weighting of the land use map. The "Functional Servicing and Stormwater Management Report" (Urbantech West, October 2017) refers to an existing flood storage area located at the southwest corner of the Waterdown Road overpass of the CN railway tracks. The Urbantech Report specifies that this is not considered a stormwater management facility and has undertaken analyses on the existing conditions storage volume as well as the proposed conditions storage volume. The details of the analyses are located in Appendix C of the Urbantech Report, however there is no storage-discharge relationship provided. An inactive 'dummy' reservoir has been added to the model by WSP at the outlet of subcatchment 307 to represent the flood storage area which can be updated as required in both existing and future conditions land use modelling, should a suitable rating curve ultimately become available.

The GAWSER platform simulates subcatchment runoff by calculating the amount of available runoff from a rainfall event after losses due to depression storage and infiltration through the pervious component of the subcatchment. The infiltration routines for GAWSER are explicitly calculated through two soil layers (interflow layer and groundwater storage layer). The GAWSER model allows up to eight different soil types to be specified and each requires infiltration parameters to be explicitly defined (depression storage, hydraulic conductivity, seepage rate factor, percolation rate factor, etc.). The Cosburn Patterson Wardman study (1995) applied three different soil classifications in the 1995 model and the infiltration parameters provided for these soil classifications has been retained in the updated modelling.

The runoff procedures in GAWSER utilize a subcatchment discretization method which considers the impervious area as an alternative soil type. The Cosburn Patterson Wardman model divided the soils into hydrologic soil groups 'C', 'BC' and 'A' which is typical of the SCS methodology. A review of the soils determined that the current soil mapping (MNRF's Ontario Soil Survey Complex, 2012) differs from the soil mapping used for the 1995 Study. Current surficial soil mapping (MNRF, 2012) indicates that the Grindstone Creek portion of the Study Area consists of soils with Hydrologic Soil Groups of 'A', 'B', 'C' and approximately 40 % of the area as undefined. The Hydrologic Soil Group 'B' and the undefined soil areas have been assumed to be most representative of soil type 'BC' from the 1995 Study as it represents approximately the halfway point between soil groups 'A' and 'C' in the 1995 Study. The refined and new subcatchments in the GAWSER model have been updated with the MNRF 2012 soil mapping while the external subcatchments have retained their original soil distributions. The subcatchment parameterization for the 1995 model and the updated model is presented in Table 2.3.

Table 2.3. Subcatchment Parameterization – Grindstone Creek

SUBCATCHMENT	AREA (ha)	IMPERVIOUSNESS (%)	SOIL CLASS (% ADJUSTED FOR IMPERVIOUSNESS)		
			C	BC	A
Previous Modelling (Cosburn Paterrson Wardman Ltd, 1995)					
105	4.5	7	93	0	0
205	6.4	55	30	15	0
305	36.8	60	5	0	35
410	9.7	22	0	0	78
510	5.0	9	91	0	0
610	6.5	8	0	92	0
Total	**68.9**	**42.1**	**18.1**	**10.1**	**29.7**
Refined Subcatchment Delineation (WSP, 2018)					
GR105	5.6	27	0	73	0
GR205	3.0	40	6	54	0
GR305	2.7	51	23	26	0
GR306	5.3	70	0	17	13
GR307	12.8	47	0	1	52
GR308	9.5	51	0	1	48
GR309	3.7	21	0	79	0
GR410	5.5	39	8	53	0
GR411	4.6	26	0	74	0
GR510	2.3	31	0	59	10
GR511	1.1	10	0	90	0
GR512	0.7	68	0	32	0
GR610	4.9	31	0	69	0
Total	**61.8**	**41.5**	**2.1**	**44.0**	**12.4**
Additional Subcatchments (WSP, 2018)					
GR611[1.]	11.0	77	0	23	0
GR701	15.9	20	78	2	0
GR702	5.7	8	11	81	0
GR703	9.4	28	3	36	33
Total	**50.0**	**34.8**	**26.7**	**21.9**	**16.6**

Note: 1. Drains directly to the main branch of Grindstone Creek rather than to the tributary

The most recent hydrologic modelling (GAWSWER) for Falcon Creek (Valdor, 2012) divided the soils into hydrologic soil groups 'D' 'C', 'B' and 'A' which is typical of the SCS methodology. The soils have been further divided into low and high vegetative cover. A review of the soils determined that the current soil mapping (MNRF's Ontario Soil Survey Complex, 2012) is sufficiently similar to the soil mapping utilized in the 2012 Valdor Study that the parent catchment soil composition has been maintained, which also ensures consistency with the original modelling.

Given that Falcon Creek lies on the periphery of the Aldershot MTSA, only minor changes to the subcatchments in this area have been required. Minor boundary adjustments have been made to previous subcatchment 109, based on current topographic data. In addition, a new subcatchment (FL01) has been included on the south side of the railway tracks (north of Grove Park Drive); which, based on WSP's review, would drain easterly along the railway tracks towards Falcon Creek (ref. Drawing 3). Parameterization for the new subcatchment has been undertaken using the previously noted land use categorization, and the MNRF soil mapping (2012). The revised subcatchment parameterization for the updated hydrologic model is presented in Table 2.4.

Table 2.4. Subcatchment Parameterization – Falcon Creek

SUBCATCHMENT	AREA (ha)	IMPERVIOUS (%)	SOIL CLASS (% ADJUSTED FOR IMPERVIOUS)[1]			
			D	C	B	A
FL01	8.0	35.0	0 0	0 0	0 0	42.3 22.7
109	29.3	3.7	0 0	4.7 22.2	0 6.9	36.1 26.4

Note: 1. Soil group is separated into "High Vegetative Cover" (value above) and "Low Vegetative Cover" (value below)

2.2.3 PCSWMM MODELLING (WEST ALDERSHOT AND TEAL CREEKS)

2.2.3.1 WEST ALDERSHOT CREEK

As per Table 2.1 (and as per the Scoped EIS Work Plan), no existing hydrologic model is available for West Aldershot Creek. A new, integrated hydrologic and hydraulic model has been developed in PCSWMM accordingly.

Subcatchment boundaries have been developed on the basis of the trunk storm sewer network (as supplied by the City of Burlington), and topographic data supplied by the City of Burlington (2015 elevation data from the Region of Halton). A total of 61 subcatchments (147 ha) have been included for the PCSWMM model, with an average drainage area of 2.4 ha +/-. Given the limits of the current study area, a greater resolution has generally been achieved for those drainage areas within the study limits, with a relatively coarser level of refinement for those subcatchments further downstream (i.e. generally south of Fairwood Place). Subcatchment boundaries for the West Aldershot Creek area are presented in Drawing 3.

The proposed drainage boundaries for West Aldershot Creek differ slightly from those presented in previous reports (most recently "Class EA for Aldershot Community Stormwater Master Plan" (AMEC Environment & Infrastructure, 2013). To the north, the drainage boundary has been revised based on the updated Grindstone Creek boundary (which reflects the assumed full build-out of the 101 Masonry Court development). No significant boundary changes have resulted along La Salle Creek and Forest Glen Creek. However, the proposed drainage area revisions are such that neither of these creeks are expected to receive flows from the Aldershot GO MTSA study area. As such, no further modelling has been completed for these watersheds.

The developed subcatchment boundaries have been parameterized as per the land use described in Section 2.2.1 (Table 2.2). Based on a review of available soil mapping for the area, the majority of the West Aldershot Creek (particularly the portion within the study area) consists of Guelph Sandy Loam (SCS Soil Classification of "B"). A small portion at the north-eastern limits of the watershed consists of Winona Sandy Loam (SCS Soil Classification of "C"). A more pervious area of Springvale Sandy Loam (SCS Soil Classification of "A") is located to the north of the West Aldershot Creek watershed limits.

Selected geotechnical reports (borehole logs) available from the City of Burlington have also been reviewed to better assess area soils, as follows:

- City Report BH-156 (Fairwood Place West) – generally indicates presence of sandy silt and silty sand
- City Report BH-158 (Howard/Lemonville Road) – generally indicates presence of sand, sandy silt, and clayey silt
- City Report BH-287 (Plains Rd/Waterdown Road) – generally indicates presence of silty sand

Given the preceding overall soil mapping characterization (generally "B" soils with some "C"), and the presence of sandy silt and silty sands, a uniform SCS Soil Classification of "BC" has been more conservatively been assumed for the watershed, with SCS Curve Numbers developed accordingly for the simulation of infiltration. Notwithstanding, soil classifications should be re-visited for site specific SWM assessments, since more stringent targets should apply in areas with more permeable soils (i.e. Type "A" or "B").

As an integrated hydrologic/hydraulic model, PCSWMM also requires that routing and conveyance elements be included explicitly. Given the urbanized nature of the West Aldershot Creek watershed, this generally includes urban drainage components (i.e. storm sewers and roadways), as well as some riverine components (open channels/creeks – however these features are located downstream of the Aldershot MTSA study limit).

With respect to urban hydraulics, as per the approved April 25, 2017 Work Plan (and consistent with the approach employed for the Downtown Area), the modelling has focused upon "trunk" storm sewers, which have been considered to be those sewers with a diameter of 600 mm or greater. It should be noted that some smaller storm sewer segments have also been included in the modelling in certain locations as required to ensure a reasonable representation of drainage conditions. The storm sewer database supplied by the City of Burlington does not contain any invert elevation information. As such, a number of plan and profile drawings have been reviewed to extract the invert elevation data (and associated maintenance hole rim elevation) and transfer this information into the PCSWMM model. In some cases, plan and profile drawings (and associated elevation data) were not available; hence alternative techniques have been employed to estimate these data, including interpolation between known elevations, use of DEM data (for rim elevations), and in other cases, assumed depths (i.e. storm sewer 2.5 m +/- below surface). In general, the plan and profile drawings supplied by the City of Burlington have been sufficient to populate the majority of the required storm sewer system elevations. Ultimately, a total of 88 storm sewer segments have been incorporated into the PCSWMM model for the West Aldershot Creek modelling.

The dual drainage creator tool within PCSWMM has been used to develop a major flow conveyance system, parallel to the storm sewer system and based on those elevations (gutter elevation assumed to be equal to the maintenance hole rim elevation). The major system has used typical roadway right-of-way sections for conveyance (both a typical 2-lane and 4-lane roadway section). Additional major system conduits have been added to the modelling to link adjacent areas as required (i.e. parallel streets with unconnected storm sewers).

The minor (storm sewer) and major (roadway overland flow) systems have been linked through bottom draw orifices at junction nodes. The orifices have been sized based on the number of connected catchbasins being represented, with an assumed opening area of 0.125 m2 per catchbasin (consistent with OPSD details for catchbasin grates). Maintenance hole lids have also been included as required (i.e. junction node linkages where no catchbasins are present).

A limited number of open channel segments have also been included in the modelling to represent flow routing within West Aldershot Creek itself. Transects for the open channel section of the West Aldershot Creek have been generated using HEC-GeoRAS using the Region of Halton's DEM (2015 – as supplied by the City of Burlington) and imported into PCSWMM model to represent the hydraulic routing of the open channel segments. The storm sewer outfalls and major systems have been connected to the open channel segment of the West Aldershot Creek. No hydraulic structures have been included for this reach, and a coarser resolution has been applied in this area given that it is beyond the current study limit.

2.2.3.2 *TEAL CREEK*

A PCSWMM model of Teal Creek was previously developed as part of the aforementioned 2013 study. That model included a single large lumped subcatchment for areas upstream of Plains Road (32.61 ha), which is the focus of the current study. This drainage area has been split and refined accordingly into a total of five (5) subcatchments, ranging in area from 0.9 to 13.4 ha. The developed subcatchment boundaries have been parameterized as per the land use described in Section 2.1.2.1 (Table 2.2).

Consistent with the rationale outlined in Section 2.2.3.1 a SCS Soil Classification of "BC" has been assumed for the watershed, with SCS Curve Numbers developed accordingly for the simulation of infiltration. Notwithstanding, soil classifications should be re-visited for site specific SWM assessments, since more stringent targets should apply in areas with more permeable soils (i.e. Type "A" or "B").

It should be noted that the previous (2013) modelling employed Green-Ampt methodology for the simulation of infiltration; this has been updated to the use of SCS Curve Numbers in the current modelling.

Seven (7) storm sewer segments have been incorporated into the modelling to represent flow conveyance along Plains Road. Similar to the approach described for West Aldershot Creek, a dual drainage modelling approach (linked storm sewers and roadway segments) has been implemented accordingly.

2.3 HYDROLOGIC MODEL RESULTS

2.3.1 GAWSER MODELLING (GRINDSTONE AND FALCON CREEKS)

Updated simulated flows for key watercourse nodes along Grindstone Creek are presented in Tables 2.5 and 2.6 for the 100-year storm event and the Regional Storm respectively; refer to Drawing 3 for node locations. For comparison purposes, the results from the previous study (Cosburn Patterson Wardman Ltd, 1995) have been included at key nodes, for the (then) future land use condition as detailed in the preceding section.

Conservation Halton (CH) has noted (Comment 3b; April 20, 2018) that a discrepancy between the external drainage areas to nodes G815 and G804. CH's data indicates that G815 has an upstream drainage area of approximately 180 ha (modelled area of 96 ha) while node G804 has a drainage area of approximately 140 ha (modelled area of 220 ha). WSP has noted this, however, has not revised the modelling given that these areas are external to the study area and not being considered for redevelopment or intensification. CH indicated agreement with this approach in its comments, however noted that this should be considered as part of future studies. It should again be noted however that the GAWSER modelling is likely superseded by the updated hydrologic modelling completed as part of CH's Grindstone Creek Flood Hazard Mapping Study (March 2020).

The 1995 Grindstone Creek Study (Cosburn Patterson Wardman) used continuous simulation as well as the storm event recorded at Hamilton's Royal Botanical Garden rain gauge in August 1981 to determine the 100-year peak flows for the Grindstone Creek Tributaries. The 2012 Falcon Creek Study (Valdor) used continuous simulation as well as the 6 Hour SCS Type-II distribution for simulating the 2 to 100-year return periods. In order to maintain consistency with the previous work completed by WSP for the other MTSAs (and to be consistent with the Scoped EIS Work Plan) the updated Grindstone Creek and Falcon Creek models have been executed using the 24 Hour SCS Type II distribution for the 100-year return period.

The Regional Storm Event models from the 1995 Grindstone Creek Study (FU4CREG and 4QUANREG) have been reviewed to determine how the Regional Storm was modelled previously. It has been determined that the external storage facilities were active during the Regional Storm event and therefore have been allowed to remain active during a Regional Storm event for the current refined model. The SCS Curve number methodology does not apply for Grindstone Creek or Falcon Creek and therefore the soil conditions were maintained for the Regional Storm Event. A sensitivity test was performed to determine whether the 12-hour event using zero depression storage or the 48-hour event allowing depression storage produced the greater flow at the outlet. The results of the sensitivity test indicated that the 48 hours storm event produced the higher outflow and therefore the results from this scenario have been presented for both Grindstone Creek and Falcon Creek.

Simulated results for Grindstone Creek (Table 2.5) indicate that the difference in peak flows for the 100-year storm event vary from -1.47 m^3/s to +3.62 m^3/s. Minor flow decreases are indicated primarily for smaller tributaries, whereas the flow increases are generally indicated at the most downstream limits of Grindstone Creek. This likely reflects the relative contribution of updated drainage areas from the Aldershot MTSA, which would be highest at the downstream limits. In addition, it is noted that any additional drainage area (GR701 – 15.9 ha) is included in the updated modelling, which was not included in the previous (1995) modelling. Simulated results for Falcon Creek are +0.3 m^3/s +/- at the CN Railway tracks for the 100-year storm event, indicating only a nominal change in the modelling results (given the relative minor updates to the hydrology in this area).

Table 2.5. 100-Year Storm Event Flows – Grindstone Creek and Falcon Creek (GAWSER)

NODE	CURRENT DRAINAGE AREA[1] (ha)	LOCATION	100-YEAR STORM[3] PEAK FLOW (m^3/s)		
			ORIGINAL[4]	UPDATED[2] (WSP, 2019)	DIFFERENCE
Grindstone Creek					
701	15.90	Tributary 7 at Highway #403	-	1.06	-
702	5.70	Eastern inflow to Wetland	-	0.54	-
819	21.60	Wetland	-	1.59	-
820	31.00	Tributary 7 at CNR	-	2.04	-
101	69.60	Tributary 1 at Highway #403	1.89	1.89	0
801	75.20	Tributary 1 Outlet	2.32	2.34	+0.02
201	145.20	Tributary 2 at Highway #403	2.20	2.20	0
804	220.40	Confluence of Tributary 1 and Tributary 2	-	4.47	-
810	223.40	Tributary 2 Outlet	5.09	4.75	-0.34
815	96.10	Tributary 3 at CNR	3.36	1.89	-1.47
818	319.50	Confluence of Tributary 2 and Tributary 3	-	6.64	-
822	355.80	Tributary 3 Upstream of Waterdown Road	-	9.13	-
823	368.60	Tributary 3 at Waterdown Road	-	10.20	-
826	381.80	Tributary 3 Downstream of Waterdown Road	-	11.40	-
830	38.00	Tributary 4 at CNR	1.56	1.57	+0.01
831	42.60	Tributary 4 at Outlet	-	1.80	-
832	424.40	Confluence of Tributary 3 and Tributary 4	9.48	13.0	+3.62
845	86.00	Tributary 5 at CNR	3.25	3.01	-0.24
846	87.10	Tributary 5 at Outlet	-	3.06	-
860	76.10	Tributary 6 Outlet	1.74	1.71	-0.03
850	512.20	Howard Road	12.6	14.7	+2.2
865	588.30	Outlet to Grindstone Main Creek	13.9	15.9	+2.1
611	11.00	Subcatchment to Grindstone Main Creek	-	2.17	-
Falcon Creek					
809	227	Hwy 403	12.8	12.8	0.0
811	299	CNR	15.5	15.8	+0.3

Notes:
1. Based on updated (2018) subcatchment boundaries; may differ from previous modelling
2. Includes all current modelling updates noted
3. Based on the SCS Type-II 24-hour Design Storm
4. For Grindstone Creek (CPW, 1995) and for Falcon Creek (Valdor, 2012)

Table 2.6. Regional Storm Events – Grindstone Creek and Falcon Creek (GAWSER)

NODE	CURRENT DRAINAGE AREA[1] (ha)	LOCATION	REGIONAL STORM PEAK FLOW (m^3/s)		
			ORIGINAL[3]	UPDATED[2] (WSP, 2019)	DIFFERENCE
Grindstone Creek					
701	15.90	Tributary 7 at Highway #403	-	1.88	-
702	5.70	Eastern inflow to Wetland	-	0.79	-
819	21.60	Wetland	-	2.64	-
820	31.00	Tributary 7 at CNR	-	3.77	-
101	69.60	Tributary 1 at Highway #403	6.69	6.69	0
801	75.20	Tributary 1 Outlet	7.17	7.28	+0.11
201	145.20	Tributary 2 at Highway #403	11.5	11.5	0
804	220.40	Confluence of Tributary 1 and Tributary 2	-	18.7	-
810	223.40	Tributary 2 Outlet	19.2	19	-0.2
815	96.10	Tributary 3 at CNR	11.4	7.96	-3.44
818	319.50	Confluence of Tributary 2 and Tributary 3	-	26.9	-
822	355.80	Tributary 3 Upstream of Waterdown Road	-	30.9	-
823	368.60	Tributary 3 at Waterdown Road	-	32.2	-
826	381.80	Tributary 3 Downstream of Waterdown Road	-	33.5	-
830	38.00	Tributary 4 at CNR	4.5	4.08	-0.42
831	42.60	Tributary 4 at Outlet	-	4.57	-
832	424.40	Confluence of Tributary 3 and Tributary 4	35.1	38.1	3
845	86.00	Tributary 5 at CNR	10.3	9.99	-0.31
846	87.10	Tributary 5 at Outlet	-	10.1	-
860	76.10	Tributary 6 Outlet	9.52	9.33	-0.19
850	512.20	Howard Road	44.4	47.3	+2.9
865	588.30	Outlet to Grindstone Main Creek	53	56.2	+3.2
611	11.00	Subcatchment to Grindstone Main Creek	-	1.61	-
Falcon Creek					
809	227	Hwy 403	18.6	18.6	0.0
811	299	CNR	23.9	24.2	+0.3

Notes: 1 Based on updated (2018) subcatchment boundaries; may differ from previous modelling
2. Includes all current modelling updates noted
3. For Grindstone Creek (CPW, 1995) and for Falcon Creek (Valdor, 2012)

Simulated results for the Regional Storm Event (Table 2.6) indicate differences in peak flows from -3.44 m3/s to +3.20 m3/s, with similar trends to the 100-year storm event (i.e. largest flow increases are indicated towards the downstream limits, where the highest relative contribution of drainage from updated MTSA lands would result).

The largest simulated reduction in flow occurs at flow node 815. Under the revised modelling, this location has a notably reduced drainage area and revised location in the Tributary 3 watercourse. The flow node 815 was used in the 1995 Study to represent the outlet of Tributary 3 (approximately 100 m east of Howard Road). Under the updated hydrologic modelling, subcatchment 305 in the original (1995) model is now represented by subcatchments 305, 306, 307, 308 and 309. The flow node has been moved to represent the Tributary 3 flow upstream of the confluence with Tributaries 1 and 2. Thus the simulated difference is considered attributable to a refinement of drainage areas and revision to the reporting node location (i.e. further upstream).

As noted previously, only a small portion of the Falcon Creek watershed is located within the Aldershot GO MTSA boundary. One newly added area (FL01 – refer to Drawing 3) has been discretized and incorporated into the Falcon Creek modelling. The remaining potentially impacted area (sub-catchment 109 – refer to Drawing 3) would be minimally affected, with only 3.2 ha+/- of drainage area within the Aldershot MTSA boundary. The additional drainage area to Falcon Creek and updated hydrologic modelling results in an increase in flow at the CN Railway tracks of 0.3 m3/s +/- for both the 100-year storm event and Regional Storm Event.

Consideration is also required for the potential flow inputs to the Grindstone Creek System from an identified bi-lateral spill at Falcon Creek (spill towards both Indian Creek to the east, and Grindstone Creek to the west). This is discussed further as part of the review of hydraulic modelling for the study area (Section 3.2).

2.3.2 PCSWMM MODELLING (WEST ALDERSHOT AND TEAL CREEKS)

Updated simulated flows for key nodes within the West Aldershot and Teal Creek watersheds are presented in Tables 2.7 and 2.8 for the 100-year storm event and the Regional Storm respectively. Note that for simulation of the Regional Storm, Curve Numbers (CNs) have been updated to saturated (AMC-III) conditions to use the 12-hour version of Hurricane Hazel; depression storage values have also been set to zero.

The results presented in Table 2.7 indicate that the updated PCSWMM generates consistently lower peak flows for all locations for the 100-year storm event, despite a notable increase in overall imperviousness (approximately 64% for the areas within the study limit for the 2019 update, and 25% for the same area in the previous 2013 model). For the West Aldershot Creek watershed, this simulated reduction is generally considered attributable to the increased model refinement. The previous (2013) study utilized only three (3) subcatchments to the beginning of the open watercourse, whereas the updated model uses a total of 29 for the same area. The increased model refinement has also included additional conveyance elements (storm sewer and overland flow) which would tend to further attenuate flows, particularly peaky flows as would result from a design storm distribution of this magnitude. Further, it is noted that the locations presented in Table 2.7 do not precisely match due to the coarse level of discretization in the 2013 study, and that different infiltration routines were used for the two models (Green-Ampt in the original 2013 study, SCS Curve Number in the current update). This last point in particular is significant as there is a notable difference in the peak infiltration rate for the 100-year storm event. For Teal Creek as an example, the peak infiltration rate from the previous (2013) modelling using Green-Ampt is approximately 7 mm/hr, while for the current modelling (SCS Curve Number) it is approximately 26 mm/hr, which occurs coincidentally with peak rainfall, which would be expected to reduce peak flows.

Table 2.7. 100-Year Storm Event Flows – West Aldershot and Teak Creeks (PCSWMM)

WATERSHED	CURRENT DRAINAGE AREA[1] (ha)	LOCATION AND NODE	100-YEAR STORM EVENT PEAK FLOW (m^3/s)			
			ORIGINAL[3] 6H SCS (AMEC, 2013)	UPDATED[2] 6H SCS (WSP, 2019)	UPDATED[2] 24H SCS (WSP, 2019)	DIFFERENCE (6H SCS)
West Aldershot Creek	16.9	Plains Rd west of Emery Ave (4048)	4.54	3.35	3.32	-1.19
	25.1	Plains Rd at Waterdown Rd (4003)	10.86	4.57	4.45	-6.29
	50.2	South of Fairwood Pl and West of Aldershot School (J665.0624)	12.68	7.06	7.04	-5.62
Teal Creek	33.6	Plains Rd and Filmandale Rd (OF1 and OF3)	11.02	6.30	6.40	-4.62

Notes:
1. Based on updated (2018) subcatchment boundaries; this may differ slightly from previous modelling
2. Includes all current modelling updates noted
3. As per "Class EA for Aldershot Community Stormwater Master Plan" (AMEC Environment & Infrastructure, 2013)

Table 2.8. Regional Storm Event Flows – West Aldershot and Teak Creeks (PCSWMM)

WATERSHED	CURRENT DRAINAGE AREA[1] (ha)	LOCATION AND NODE	REGIONAL STORM EVENT PEAK FLOW (m^3/s)		
			ORIGINAL[3]	UPDATED[2]	DIFFERENCE
West Aldershot Creek	16.9	Plains Rd west of Emery Ave (4048)	2.44	1.83	-0.61
	25.1	Plains Rd at Waterdown Rd (4003)	4.95	2.28	-2.67
	50.2	South of Fairwood Pl and West of Aldershot School (J665.0624)	7.33	5.16	-2.17
Teal Creek	33.6	Plains Rd and Filmandale Rd (OF1 and OF3)	4.49	4.71	+0.22

Notes:
1. Based on updated (2018) subcatchment boundaries; this may differ slightly from previous modelling
2. Includes all current modelling updates noted. Uses 12-hour version of Hurricane Hazel and AMC-III (saturated) conditions with SCS Curve Number method for infiltration
3. Uses 48-hour version of Hurricane Hazel and AMC-II (normal) conditions due to Green-Ampt infiltration methodology.

The simulated difference in peak flows for Teal Creek is considered to be attributable to similar reasons; increased subcatchment resolution (five (5) subcatchments in the current modelling as compared to one (1) subcatchment in the 2013 modelling) and increased conveyance/routing elements, as well as the difference in infiltration methodology. For Teal Creek as an example, the peak infiltration rate from the previous (2013) modelling is approximately 7 mm/hr, while for the current modelling (SCS Curve Number) it is approximately 26 mm/hr, which occurs coincidentally with peak rainfall, which would be expected to reduce peak flows. As noted, additional hydraulic flow routing elements may also attenuate and reduce peaks.

For the Regional Storm Event (Table 2.8), simulated decreases in peak flows are again indicated throughout for West Aldershot Creek. It is considered that the reasons discussed previously with respect to the 100-year storm event would again apply. However, it is notable that a slight increase in the Regional Storm peak flow is indicated for the Teal Creek outlet. This may reflect the lower intensity (less peaked) rainfall and flow response for this storm event.

3 HYDRAULICS

3.1 AVAILABLE HYDRAULIC MODELLING

As noted previously, the Aldershot GO MTSA Area (Drawing 1) intersects a number of different watersheds (Drawing 3). Notwithstanding, only one (1) open creek system is directly within the Aldershot MTSA: Grindstone Creek. The other watersheds within the study area (West Aldershot Creek and Teal Creek) consist of urban conveyance systems (i.e. storm sewers and roadways). Sources of hydraulic modelling are summarized in Table 3.1 (as per the Scoped EIS Work Plan (updated April 25, 2017 – ref. Table C).

Table 3.1. Available Hydraulic Modelling – Aldershot GO MTSA

WATERSHED	STUDY DATE AND REFERENCE	MODELLING PLATFORM
Grindstone Creek	Grindstone Creek Subwatershed Study (Cosburn Patterson Wardman Ltd, 1995)	HEC-2
	Detailed Design of Waterdown Road/Highway 403 Interchange – Stormwater Management Design Brief (Philips Engineering Limited, October 2008)	HEC-RAS
	Functional Servicing and Stormwater Management Report – 101 Masonry Court (Urbantech West, October 2017)	HEC-RAS

Following the completion of the primary scope of work for this project (reporting dated February 19, 2019) Conservation Halton (CH) completed an updated Flood Hazard Mapping Study for the Grindstone Creek watershed (March 2020). This included the development of new hydrologic and hydraulic modelling. Given the timing of the current study, these results are not reflected in the reporting or analyses. Future studies should consider this updated modelling resources accordingly.

3.2 HYDRAULIC MODELLING UPDATES

3.2.1 HEC-RAS MODELLING (GRINDSTONE AND FALCON CREEK)

3.2.1.1 *GRINDSTONE CREEK*

As per the Scoped EIS Work Plan (updated April 25, 2017 – ref. Table C), a HEC-2 hydraulic model for the tributary branch which runs through the Aldershot GO MTSA was previously completed as part of the Grindstone Creek Subwatershed Study (Cosburn Patterson Wardman Ltd., 1995). An updated HEC-RAS model of the lower portion of Grindstone Creek (i.e. below Highway 403), was developed as part of previous studies; in particular, the Waterdown Road Interchange design work (Detailed design of Waterdown Road/Highway 403 Interchange Stormwater Management Design Brief, Philips Engineering Limited, October, 2008), and the recent residential development on Masonry Court (ref. Functional Servicing and Stormwater Management Report, ADI Development (Masonry) Inc., 101 Masonry Court – Urbantech West, October 2017). Based on WSP's review of the two (2) models, it was considered that the HEC-RAS modelling developed for the Waterdown Road interchange (and subsequently verified in May 2015 as part of the City-Wide Flooding study) was more current for the area upstream of the railway tracks than the HEC-RAS modelling for the 101 Masonry Court Development.

Therefore, as part of the current work, WSP has combined relevant updates from both models which reflects the most current portions of each (i.e. revised watercourse alignment from the Waterdown Road interchange work upstream, and revised watercourse alignment from the 101 Masonry Court development downstream). Through a review of the City's 2015 DEM it was determined that the cross sections between ID 0.50 and 0.32 in the received modeling for 101 Masonry Court (immediately upstream of the railway tracks) do not match the existing topography. The relevant sections have been extended and updated from the City's 2015 DEM. These updated hydraulic modelling cross-sections are presented on Drawings 4b and 4d.

The currently available HEC-RAS modelling cross-sections extend only slightly downstream of Waterdown Road; no cross-sections are available for the section between Waterdown Road and the confluence with the main branch of Grindstone Creek. Older hydraulic modelling and cross-sections are available from the original HEC-2 model (Cosburn Patterson Wardman Ltd, 1995). However, this modelling is not considered appropriate for the current study given the vintage of the topography data, and the spacing and locations of the hydraulic cross-sections, which are sparse in many locations, particularly between culvert crossings. As such, the Grindstone Creek tributaries west of Waterdown Road have been modeled as part of a new HEC-GeoRAS model, with new cross-sections which have been cut using the current DEM (Region of Halton, 2015). Hydraulic structure (culvert) details from the original HEC-2 modelling been incorporated accordingly into the new modelling. A suitable boundary condition for the main branch of Grindstone Creek has been determined by referring to the Flood Damage Reduction Program (FDRP) of the Main Branch of the Grindstone Creek prepared by Philips Planning + Engineering Limited (1982). The water surface elevation for the cross sections (1018 and 1019 in the FDRP) bounding the outlet of the Tributaries of Grindstone Creek to the Main Branch (near Lemonville Road) were applied in the hydraulic modelling. Cross Section 1019 has been utilized as the boundary condition since it produced the higher water surface elevation, and therefore the more conservative constraints, for both the 100-year storm event (91.22 m) and the Regional Storm Event (92.07 m).

In order to ensure continuity between the newly developed HEC-GeoRAS modelling to the west of Waterdown Road, and the updated HEC-RAS modelling to the east of Waterdown Road, the most downstream modelling (HEC-GeoRAS) has been run first. The resulting simulated water surface elevations at the downstream face of Waterdown Road have then been used as fixed water surface elevation boundary conditions within the second HEC-RAS model.

3.2.1.2 *BI-LATERAL SPILLS (FALCON CREEK)*

Previous studies have identified the existence of a bi-lateral spill from Falcon Creek towards both Indian Creek to the east and Grindstone Creek to the west. The Falcon Creek Hydrology and Hydraulic Study by Valdor Engineering (2012) identifies a bi-lateral spill at the CNR tracks, however the spill is not quantified. The King Road/CNR Grade Separation Drainage Works Design Brief prepared for the City of Burlington (Philips Engineering Limited, 2006) also identified a bi-lateral spill at the CNR tracks. The Philips Study quantified the spill to Indian Creek, however the spill to Grindstone Creek was not quantified as the focus of the study was on Indian Creek.

For the current assessment, the Valdor (2012) hydraulic model (HEC-RAS) has been modified to include a lateral structure to the west of the upstream face of the CNR Tracks at the estimated high point spill elevation of 103.08 m (based on current topography data – 2015 Region of Halton DEM) to simulate the spill from Falcon Creek into the CNR ditch system westerly towards Grindstone Creek. The spill occurs approximately 800 m to the west along the northside of the CNR tracks at the boundary between subcatchment 109 (Falcon Creek) and subcatchment GR702 (Grindstone Creek) as shown on Drawing 3.

It should be noted that the preceding ground elevation is based on the previously noted topographic data source, which was the best available at the time of the preparation of that report. More current topographic data (i.e. 2018 LiDAR data based DEM; or other most current dataset) should be used for any subsequent assessment or site-specific studies. Considerations for differences in vertical datums between datasets would also be required.

The current hydraulic model (HEC-RAS) has also been modified to include a lateral structure to the east of the upstream face of the CNR Tracks at the estimated high point spill elevation of 104.11 m (to Indian Creek). The spill occurs within 50 m of the CNR crossing of Falcon Creek. The spill is conveyed easterly along the CNR tracks to the Indian Creek crossing of King Road.

Additional cross sections (based on current topography data – 2015 Region of Halton DEM) have been added to the Valdor hydraulic model upstream of the CNR Tracks to represent the sections which spill to Grindstone Creek and to Indian Creek.

For comparison purposes, both the with and without flow optimization routines have been employed. Notwithstanding, the with flow optimization routine is considered the more realistic approach, as has been discussed and presented previously for the Burlington GO MTSA and Downtown area (with respect to spills from the Hager-Rambo Diversion Channel), namely that spills necessarily result in loss of flow and a corresponding reduction in water surface elevation within the main channel, and the use of a full flow main channel water surface elevation yields unrealistically high spill flows. As per comments from Conservation Halton (CH – Comment 4 c, April 20, 2018), it is understood that CH's primary concern with flow optimization is any removal of flows from the source watercourse, such that downstream capacity is preserved in the event the spills can be mitigated in the future. CH further indicated (comment 4 b, April 20, 2018) that they would potentially be supportive of spill flow optimization subject to the collection of more detailed topographic information, and CH review of the associated hydraulic modelling. Further topographic data collection is considered beyond the scope of the current study, thus the previously noted spill sections have been developed based on the best currently available date, namely the Region of Halton's 2015 DEM.

Table 3.2. Comparison of Estimated Falcon Creek Spill (HEC-RAS) – 100 Year Storm Event

SCENARIO	STUDY	DRAINAGE AREA (ha)	WSE[1] (m)	PEAK FLOW (m^3/s)					
				TOTAL FLOW U/S OF CNR	U/S OF CNR	D/S OF CNR	CNR WEIR FLOW	SPILL TO INDIAN CREEK	SPILL TO GRINDSTONE CREEK
No Flow Optimization	Philips (2006)[2]	271.4	103.71	17.30	17.30	17.70	7.29	59.92	-
	Valdor (2012)[3]	291.3	104.44	19.51	19.51	20.57	11.36	-	-
	WSP (2019)	292.9	105.24	15.80	15.80	15.80	5.78	8.33	7.97
Single Flow Optimization (Indian Creek)	Philips (2006)[2]	271.4	102.61	17.30	6.59	6.99	0	10.73	-
	WSP (2019)	292.9	105.05	15.80	10.39	10.26	0.31	5.50	6.36
Single Flow Optimization (Grindstone Creek)	WSP (2019)	292.9	104.98	15.80	9.98	9.98	0	4.63	5.80
Dual Flow Optimization	WSP (2019)	292.9	104.78	15.80	9.67	9.60	0	2.69	4.41

Notes:
1. Water Surface Elevation (WSE) is defined as the elevation at the CNR crossing.
2. Philips 2006 hydraulic model has been simulated using HEC-RAS model version 3.1.3 to maintain consistency with previous reporting
3. Valdor 2012 hydraulic model does not simulate spill flows although the reporting recognizes the existence of the spill condition

Table 3.3. Comparison of Estimated Falcon Creek Spill (HEC-RAS) – Regional Storm Event

Scenario	Study	Drainage Area (ha)	WSE[1] (m)	Peak Flow (m^3/s)					
				Total Flow U/S of CNR	U/S of CNR	D/S of CNR	CNR Weir Flow	Spill to Indian Creek	Spill to Grindstone Creek
No Flow Optimization	Philips (2006) [2.]	271.4	-	-	-	-	-	-	-
	Valdor (2012)[3.]	291.3	104.49	23.88	23.88	25.35	15.81	-	-
	WSP (2019)	292.9	105.35	24.20	24.20	24.20	14.04	10.31	8.99
Single Flow Optimization (Indian Creek)	Philips (2006) [2.]	271.4	-	-	-	-	-	-	-
	WSP (2019)	292.9	105.24	24.20	15.99	15.82	5.90	8.36	7.99
Single Flow Optimization (Grindstone Creek)	WSP (2019)	292.9	105.24	24.20	16.21	16.17	6.00	8.39	8.00
Dual Flow Optimization	WSP (2019)	292.9	105.11	24.20	11.15	11.00	1.03	6.28	6.83

Notes: 1. Water Surface Elevation (WSE) is defined as the elevation at the CNR crossing.
2. Philips 2006 hydraulic model has been simulated using HEC-RAS model version 3.1.3 to maintain consistency with previous reporting
3. Valdor 2012 hydraulic model does not simulate spill flows although the reporting recognizes the existence of the spill condition

The 2006 Philips Study determined that approximately 10.7 m^3/s of flow would spill towards Indian Creek at a water surface elevation of 102.61 m for the 100-year design event (using flow optimization). However, it should be noted that the 2006 Philips Study applied a 3-hour Chicago distribution. Furthermore, the 2006 Philips Study did not consider the Regional Storm Event. The unrealistic nature of the no flow optimization scenario is evident from the results presented in Table 3.2 for the Philips (2006) model for spills to Indian Creek.

The results of WSP's (2019) updated modelling are consistent with the Philips (2006) report text which indicates that the spill flow to Grindstone Creek is larger than the spill flow to Indian Creek. The lateral structures for the updated spill flow assessment have been modeled such that they terminate prior to the CNR culvert crossing and therefore reduce the flow which the culvert receives. The resulting spill flows with dual optimization (spills occurring both to Indian Creek and Grindstone Creek, as would realistically be expected to occur) reduce the water level such that the CNR crossing is not overtopped during a 100-year storm event.

The results presented in Table 3.3 and Tables 3.4 provide the peak flows from the dual optimization scenario (4.41 m3/s for 100-year storm event and 6.83 m3/s for the Regional Storm Event) which are considered the most realistic/representative spill flows given available information. These steady state flows have been incorporated into the HEC-RAS modelling for Grindstone Creek (refer to Section 3.3.1) through a direct peak flow addition upstream of Waterdown Road. It has been conservatively assumed that the spill from Falcon Creek would be conveyed westerly along or adjacent to the railside ditch north of the CNR Tracks. The spill flow would then enter a piped system between the existing Aldershot GO north parking lot and the CNR Tracks. The hydraulics of conveying the Falcon Creek spill flow to the Grindstone Creek tributaries has not been assessed in further detail. It is considered unlikely that the spill from Falcon Creek would have a coincident peak with the Grindstone Creek tributaries, therefore the addition of the peak flows to the Grindstone Creek flow nodes provides a level of conservatism to the resulting floodplains depicted on Drawings 4c and 4d.

As noted by CH in its comments of April 16, 2021, a more detailed spill assessment of the interaction between Falcon Creek and Grindstone Creek was completed as part of the Grindstone Creek Floodplain Mapping Study (March 2020). WSP has not been provided with a copy of the report, however CH has provided a summary of the outcomes from that study in its comments (refer to Appendix B). CH noted that upstream of the CNR tracks, that "…a spill from Falcon Creek to Grindstone Creek would not occur at or below the 1:100-year design flows, however… spill could occur under Regional Storm conditions". It was further noted that based on a subsequent analysis it was concluded that "…spill from Falcon Creek to Grindstone, would not occur when Regional Storm flows are occurring within both systems simultaneously". CH has noted that further hydrologic and hydraulic study will be required prior to site specific development proceeding for the lands located on the north side of the CNR tracks. For lands south of the CNR tracks, proponents can refine flood elevations further on their property by undertaking a more detailed assessment of the spill.

3.2.2 PCSWMM MODELLING (WEST ALDERSHOT AND TEAL CREEKS)

Only minor updates to the hydraulics within the existing Teal Creek modelling have been undertaken as part of the current assessment. Specifically, sections of trunk storm sewer along Plains Road have been incorporated into the modelling, along with a corresponding length of linked major system conduits. In addition, the major system linkages within the Teal Creek watershed modelling have been connected to those of the newly created West Aldershot Creek modelling, in the event of overflows or inter-watershed spills.

3.3 HYDRAULIC MODELLING RESULTS

3.3.1 GRINDSTONE CREEK (HEC-RAS)

Flood hazard limits generated by the previously noted HEC-RAS models are presented in Drawings 4a to 4d. As noted on those drawings, it should be understood that the flood hazard limits presented are based on the information available at the time of the study commencement (2017) and the preparation of the primary report (April 2019). Flood hazard limits have since been superseded by the information available in "Grindstone Flood Hazard Mapping Study" (Matrix, 2020). Reference should be made to current Flood Hazard Mapping as available from Conservation Halton. Notwithstanding, the results from the HEC-RAS modelling applied as part of the current study are detailed herein.

As noted in 2.3.1 (Tables 2.5 and 2.6), in general the 100-Year Storm and Regional Storm Event flows (without Falcon Creek spill flows) have increased slightly compared to the original modelling for the Grindstone Creek watershed through the study area. The simulated flooding extents for the 100-year storm event and the Regional Storm Event based on the updated hydrologic and hydraulic modelling (without spills) are depicted in Drawings 4a (west of Waterdown Road – Tributaries 6 to 4) and 4b (east of Waterdown Road – Tributaries 3 to 1 and Tributary 7).

In addition to the preceding, the simulated floodplain extents with the addition of spill flows from Falcon Creek are presented in Drawings 4c (west of Waterdown Road – Tributaries 6 to 4) and 4d (east of Waterdown Road –

Tributaries 3 to 1 and Tributary 7). Although discussed in further detail within this section, the floodplain mapping with the Falcon Creek spill condition depicted on Drawings 4c and 4d are generally consistent with the floodplains without the Falcon Creek spill. This is attributed to the high slopes within the valley system.

The floodplain mapping of Grindstone Creek west of Waterdown Road has identified several reaches with wide riverine floodplains during the Regional Storm Event. These areas are visible on Drawings 4a (without spills) and 4c (with spills), and are limited to:

— Between the Highway #403 and CNR tracks for Tributaries 4, 5 and 6

— Immediately upstream of Howard Road.

— 1160 Waterdown Road (Pro Concrete & Paving)

The culverts underneath the railway tracks for Tributaries 4, 5 and 6 are considered to be undersized for the Regional Storm Event, which causes a backwater area between Highway #403 and the railway tracks. The backwater from the railway culverts causes Tributaries 5 and 6 to spill into each other for a Regional Storm Event, i.e. each tributary spills towards the others and effectively creates one combined floodplain. During the 100-year design event only Tributaries 4 and 6 would spill towards Tributary 5, while Tributary 5 would be contained to the channel. It is anticipated that the 100-year floodplain for Tributary 5 would be wider if the resulting spill flows were considered. Ultimately, based on the preliminary concept plans for the Aldershot MTSA, there is no re-development proposed between Highway 403 and the railway tracks west of Waterdown Road. As such, flooding extents in this area would not be expected to impact development potential. The estimated floodplain for Tributary 5 downstream of the railway tracks (i.e. upstream of Howard Road) could potentially be underestimated due to the exclusion of the aforementioned spill flows, however based upon the steep slopes in the Tributary 5 valley it is considered unlikely that an increase in flow would significantly impact the extents of the floodplain. Further, the preliminary concept plans for this area do not indicate any re-development (proposed Hidden Valley Park land).

Based on the simulated results, the hydraulic structure (culvert) at Howard Road is overtopped during the 100-year design event and Regional Storm Event. Howard Road also would be overtopped by Tributary 5, which runs parallel to the road and would spill over the road during the Regional Storm Event.

The HEC-GeoRAS modelling simulates a slight encroachment onto the property of 1160 Waterdown Road during a Regional Storm Event (Drawing 4a), in particular the section furthest upstream, immediately downstream of Railway Road. This floodplain impact is worsened when spill flows from Falcon Creek are included (Drawing 4c) as would be expected. The identified floodplain limits would also occur at the driveway entrance to the property, which would limit safe ingress/egress from the site.

The property in question is slated for potential re-development ("Aldershot GO Central") on the Draft Precinct Plan for this area (May 2018 – refer to Appendix A). Based on CH policies, any development within the regulated area (plus a 15 m setback limit, given that Grindstone Creek and its tributaries are classified as a major valley system) would be precluded. Although the delineated floodplain is confined to the channel along the south limit (1140 Waterdown Road), this property would also be affected by the required 15 m setback limit.

Notwithstanding the preceding, the identified floodplain encroachment at 1160 Waterdown Road could be managed through channel widening and re-grading, including a cut/fill balance to ensure that there is no loss of floodplain storage and no impact to downstream areas. This would potentially permit safe ingress/egress to the site and increase the development potential of the site, while still ensuring CH requirements are met. It is recommended that further discussions with CH staff be arranged accordingly, to discuss the acceptability of this approach.

For the area east of Waterdown Road (Tributaries 3 to 1 and Tributary 7 - refer to Drawing 4b), the presented hydraulic modelling indicates an overtopping of the railway tracks immediately east of Waterdown Road during the Regional Storm Event. A review of current topographic data (2015 DEM) and simulated water surface elevations confirms that spill would likely occur across the tracks at this location. The full extents of the spill have not been delineated beyond this point; this spill would potentially impact the 101 Masonry Court development to the south, which is currently under construction. The spill, and the estimated floodplain through this area have not been delineated, as indicated on Drawing 4b. As this area is currently under construction, the current topography data (2015 DEM) would not be able to accurately present floodplain extents. Reference is rather made to the supporting analyses completed for that development (Urbantech, 2017). As part of the development, a flood storage facility is to be constructed between the railway tracks and Waterdown Road. Any potential spill across the railway tracks would therefore potentially be captured by the flood storage facility, and ultimately back to Grindstone Creek. A note has been added to Drawing 4b deferring floodplain mapping for the Masonry Court development to the supporting study for that development (Urbantech, 2017).

The 100-year design event and Regional Storm Event floodplain mapping for Tributaries 3 to 1 depicted on Drawing 4b (without spills) and 4d (with spills) demonstrate that the Grindstone Creek tributaries east of Waterdown Road are primarily contained to the channel block. The exceptions would be the area immediately upstream of the CNR, and the most easterly portion of the Grindstone Creek channel (Tributary 1).

Upstream of the CNR, the Regional Floodplain is generally consistent for the with and without Falcon Creek Spill flow scenarios and is bound by the Aldershot GO Parking area and roadway (with overtopping of the CNR tracks as noted previously). For the 100-year storm event floodplain, greater differences are noted, given that this location is where spill flows from Falcon Creek first enter the Grindstone Creek system.

The most easterly portion of the channel has a large floodplain, however based on discussions from the January 25, 2018 TAC meeting it is understood that no re-development of this area is being contemplated as part of the current study and that this area is subject to the outcomes of a separate study for that parcel of land (1200 King Road).

It should be again noted that the flow path of spill flows from Falcon Creek have not been assessed or delineated; this should be considered further in future studies or detailed assessment of upstream lands (potentially including 1200 King Road). Similarly, spill flows over the CNR (which would impact 101 Masonry Court and adjacent lands) have also not been assessed as part of the current study; further hydraulic modelling and review may be warranted as part of future land use planning for these lands.

3.3.2 WEST ALDERSHOT AND TEAL CREEKS (PCSWMM)

3.3.2.1 STORM SEWERS

The developed PCSWMM hydraulic modelling has been used to characterize the conveyance capacity of the existing trunk storm sewer system (i.e. those elements included in the modelling). The following characterization has been employed based on the simulated hydraulic gradeline (HGL – maximum expected water surface elevation) characterization for individual storm sewer segments:

- Unsurcharged - HGL is below pipe obverts at both upstream and downstream ends
- Surcharged – HGL is above pipe obvert at either or both of the upstream and downstream ends, but below the ground surface
- Flooded – HGL is above the ground surface at either or both of the upstream and downstream ends

Results have been generated for the 5-year storm event, as this is the City of Burlington's design standard for storm sewers. The 24-hour SCS Type-II Design Storm Distribution has been employed, consistent with the distribution employed for the assessment of the 100-year storm event. Results are presented graphically in Drawing 7.

The simulated results indicate variable results with respect to storm sewer capacity within the MTSA limit. Sections along Plains Road west of Emery Lane are indicated as being unsurcharged or slightly surcharged. A more constrained section is indicated east of Waterdown Road at Plains Road, including along Plains Road itself (indicated as flooded) and upstream along Cooke Boulevard. Storm sewer surcharging is also indicated at the eastern limits of the study area, generally east of White Oak Drive. Based on the preceding, the section in the vicinity of Waterdown Road/Plains Road appears to have the greatest constraint and simulated capacity deficiencies and may warrant further consideration and upsizing.

3.3.2.2 *OVERLAND FLOW (ROADWAYS)*

Hydraulic modelling results for the urban drainage area (i.e. roadway overland flow routes) within West Aldershot Creek and Teal Creek have also been assessed as part of the current summary. In order to characterize areas of higher overland flow depths, the following characterization has been employed:

— Maximum depth between 0.15 m and 0.30 m (i.e. above curb height, but within the roadway right-of-way)

— Greater than 0.30 m (i.e. outside the limits of the right-of-way)

Actual street cross-sections could be used to better refine the preceding generic assumptions on right-of-way depths. Notwithstanding, for the current assessment the preceding assumptions are considered reasonable.

The results have been generated for both the 100-year storm event (Drawing 5) as well as the Regional Storm Event (Drawing 6). Both drawings also indicate the locations of identified roadway sag points.

For the 100-year storm event, right-of-way flooding is indicated in several different locations within the Aldershot GO MTSA boundary:

— Waterdown Road and Plains Road, as well as Cooke Boulevard and Plains Road

— Clearview Avenue and Plains Road

— Plains Road (White Oak Drive to Flimandale Road)

The simulated results indicate potential overland flow depths well in excess of 0.30 m for the 100-year storm event (e.g. up to 1.1 m near Plains Road / Waterdown Road and up to 0.8 m for the eastern limits of Plains Road), which could impact emergency service access, as well as result in flooding of private properties (including potential re-development areas). As a major intersection, the simulated flooding in the vicinity of Waterdown Road and Plains Road (including Cooke Boulevard) is of particular note. This appears to be partially attributable to the number of roadway sag points in this area (i.e. lack of defined overland flow route). Simulated flooding at the sag point along Clearview Avenue is likely caused by a similar grading constraint.

Simulated flooding depths along Plains Road (White Oak Drive to Filmandale Road) may be somewhat overestimated, due to the omission of a potential overland spill relief path along Shadeland Avenue in the current modelling. Notwithstanding, simulated 100-year overland flow depths in this area are still well in excess of 0.30 m (e.g. 0.8 to 1.1 m as noted previously).

Given that the simulated overland flow depths exceed 0.30 m (and thus the limits of the public roadway right-of-way) potential spill pathways and depths cannot be further assessed in a 1-dimensional (1D) model. While a 2-dimensional (2D) model could potentially assess this further, this is beyond the scope of the current assessment. Notwithstanding, this should potentially be considered further as part of the overall SWM strategy for this area.

Simulated flooding depths and locations for the Regional Storm Event (Drawing 6) shows similar patterns to the 100-year results, albeit generally lower depths. Urban flooding in excess of 0.30 m continues to be indicated at the intersection of Waterdown Road and Plains Road (including Cooke Boulevard), as well as the sag point on Clearview Avenue. Simulated flooding depths along Plains Road east of White Oak Drive are however indicated as being contained within the roadway right-of-way (i.e. between 0.15 m and 0.30 m).

4 STORMWATER MANAGEMENT

4.1 PLANNED DEVELOPMENT

The currently proposed land use plans for the Aldershot GO MTSA are included in Appendix A. A precinct plan has been developed (May 2018), which separates the overall Aldershot GO MTSA into several sub-areas with common features. The majority of the proposed development areas are focused on residential land use types, along with some mixed commercial/residential along the "Aldershot Main Street" district (Plains Road East and Waterdown Road between Plains Road and Masonry Court), "Emery/Cooke Commons" precinct (generally located between Plains Road and Masonry Court), and the "Aldershot GO Central" precinct.

The preceding development would be expected to primarily alter land use to the west of Waterdown Road, given the existing industrial land use – primarily the paving/asphalt plant area, but other adjacent properties as well. These areas are proposed to be converted to residential and mixed commercial/residential uses. Other areas to the east would be expected to experience some intensification but remain primarily residential, with some associated commercial land usage. Notwithstanding, from a hydrologic perspective, significant changes to impervious coverage would not be expected; it is assumed that the paving/asphalt plant area is already highly impervious, although the existing ground coverage is difficult to verify given the site usage.

Figure 4.1 presents the identified remaining greenspace/undeveloped areas [(>0.5 ha +/-) within the Aldershot GO MTSA not including creek corridors and parks (Hidden Valley, Grove and Aldershot), which would not be expected to change based on the precinct plan]. The ongoing development at 101 Masonry Court has also been excluded from this area identification. Likewise, the lands forming 1200 King Road are understood to be under assessment through a separate study and are not considered as part of the current review.

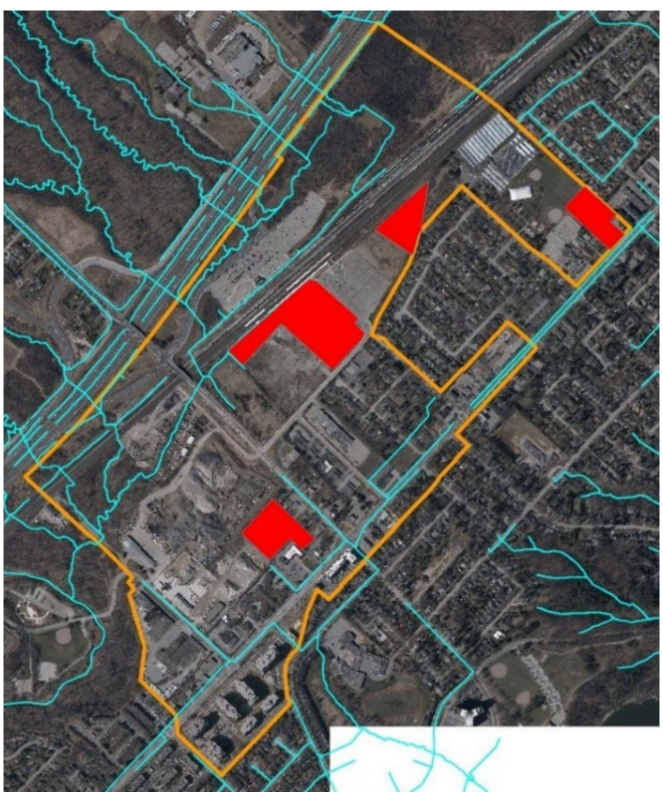

Figure 4.1. Aldershot GO MTSA and Existing Pervious Area

Based on the preceding, a total of 8.61 ha of such currently pervious/undeveloped areas has been identified (out of the total Aldershot GO Mobiity Hub area of 138.7 ha).

— 1021 Emery Avenue (1.68 ha)

— 121 Masonry Court (4.23 ha and 1.36 ha)

— 287 Plains Road East (1.34 ha)

The first parcel (1021 Emery Avenue) represents an undeveloped parcel of land. 121 Masonry Court appears to be owned by Metrolinx and would form part of the Aldershot GO Station property. Plans included with the Functional Servicing and Stormwater Management Report for 101 Masonry Court (Urbantech West, October 2017) indicate that the majority of the western area (4.23 ha) is planned for a future parking lot expansion, however the plans are indicated as conceptual only. The area to the east (1.36 ha) may be planned for a similar expansion, however this is unknown. The property at 287 Plains Road East is part of the Holy Rosary Catholic Church and Elementary school and is identified as "Public Service" in the proposed precinct plan.

From a hydrologic perspective, the identified areas represent only a small percentage of the total area, and as indicated, it is unclear how all of these areas may (or may not) develop. Further, as per Drawing 2, the areas at 1021 Emery Avenue and the western portion of 121 Masonry Court have been assessed at a higher rate of imperviousness ("Other" – 20%), while the pervious area at 287 Plains Road East has been considered as part of an overall institutional/industrial land use. The eastern portion of 121 Masonry Court (1.36 ha) is noted however as Park – Natural Corridor in Drawing 2.

It should be noted that the preceding has focused on existing undeveloped areas. As noted in CH's comments of April 16, 2021, there is also the potential for development of areas which have degree of development, but which may intensify in the future (including a greater degree of imperviousness). This would include areas classified as "Other" on Drawing 2 (i.e. primarily the area around the Aldershot GO Station and the industrial properties between Howard Road and Waterdown Road/Railway Road). Any proposed re-development of these properties would require further hydrologic assessment. It is assumed that existing City parklands will remain as is for the foreseeable future (i.e. assumed nominal imperviousness of 10% as per Table 2.2).

Overall, additional and updated hydrologic modelling are expected to be required through a future site-specific planning application should intensification increase impervious coverage beyond the limits of what has been considered as part of the current study. Additional hydrologic modelling and sizing of quantity controls would be required accordingly. Such modelling work would necessarily consider site specific soils and land use information. The potential need for Regional Storm controls should also be considered.

Future modelling work may also in turn require an additional review of hydraulic modelling and floodplain impacts, as discussed further in Section 4.2.

As per Section 2.2.1, CH has advised that return period analyses within the Grindstone Creek watershed will be required to use the AES 12-hour distribution, as per the recommendations of the March 2020 study. CH has further clarified (comments of November 26, 2021) that it encourages the evaluation of various design storm distributions when assessing SWM requirements and would support the use of a more critical storm (alternative distribution) if determined to govern for quantity control requirements. The AES 12-hour storm should be included regardless however as it should be the basis of regulatory flows.

Notwithstanding the preceding, expected changes in land coverage should be considered as part of the proposed stormwater management (SWM) strategy, as discussed further in Section 4.4.

4.2 FLOODPLAIN AND SPILL IMPACTS

Riverine Floodplain Limits for Grindstone Creek (based on the information used in this study) are presented in Drawings 4a – 4b (without spills) and 4c – 4d (with spills) respectively. Only one primary property (1160 Waterdown Road) has been identified which is slated for re-development (based on the understanding at the time of the original preparation of this report) but would have existing floodplain impacts (Section 3.3.1). As noted in Section 3.3.1, further discussion with CH staff is warranted to assess whether remedial channel modifications could be undertaken within the regulated area to increase channel capacity and adjust the associated floodplain limit to support future development.

A spill (overtopping) of the CNR tracks has been noted east of Waterdown Road. Similarly, spill flows from an adjacent watercourse (Falcon Creek) are expected to have an impact on the Grindstone Creek system (CH has separately noted the potential for bi-lateral spills between Grindstone and Falcon Creeks). Neither of these spills has been assessed in further detail as part of the current study; further hydraulic modelling and assessment of these areas may be warranted as part of future land use planning.

A distinction must be made between flood risk due to a riverine floodplain (i.e. floodplain directly along/adjacent to the watercourse) and due to spills (i.e. excess flow draining in an uncontrolled manner, potentially no longer following the path of the watercourse). The former (riverine floodplains) are regulated by Conservation Authorities and prevent any development within the floodplain limits (plus a 15 m buffer in the case of Grindstone Creek and its tributaries, given its classification as a Major Valley System), unless a Special Policy Area or other exception applies. Floodplain limits in these cases could potentially be reduced through infrastructure improvements (i.e. channel widening, re-grading, or more likely hydraulic structure (culvert) improvements where appropriate) to reduce floodplain extents, as discussed in Section 4.3. Beyond such measures, development would be restricted to the extents noted. It should also be re-iterated that any such works within a regulated area would require a permit and approval from CH.

Spills have not been historically regulated due to the inability to accurately map spills. Notwithstanding, in CH's "Policies and Guidelines for the Administration of Ontario Regulation 162/06" (Amended November 26, 2020), Section 2.29 (Spills), CH notes that spills are considered flood hazards and regulated as such; development or re-development may be considered on a case-by-case basis where the site is low risk. It is understood that CH is in the process of developing a formal spills policy. CH is currently operating under an interim spills policy; however the future formal policy may further elaborate on requirements. The two (2) spill areas noted previously have not been assessed further as part of the current study.

Generally, for locations subject to spill impacts (where other mitigation measures are not feasible), it is recommended that appropriate flood mitigation and management strategies be employed. This would primarily include floodproofing of buildings. Passive floodproofing (i.e. floodproofing that does not require human intervention) is preferred, which would be expected to focus on grading of both the site and building, to ensure that openings are greater than spill elevations (typically a 0.30 m freeboard is applied). Active floodproofing (measures that require human intervention) may be warranted in locations where passive floodproofing cannot reasonably be achieved. CH has clarified (comments of November 26, 2021) that it does not support active floodproofing for intensification of use, but is support for the protection of existing development, although passive measures are recommended.

In conjunction with the preceding, site grading should allow for the safe conveyance and routing of flood spill flows and consider the safe ingress and egress of vehicles from the site. Site grading in these locations should also work towards achieving a cut/fill balance, in order to avoid the potential for off-site impacts. This should be more strongly enforced for riverine floodplain areas, where a cut/fill can more easily be achieved. For re-developments in spill areas where filling is unavoidable, other compensatory measures may be warranted. Further hydraulic modelling (beyond the scope of the current study) is considered required to better assess and map spill flow impacts. Such hydraulic modelling could also be applied to better determine the potential impacts of any future developments and the most appropriate floodproofing/flood mitigation strategies.

It should again be noted that the hydrologic modelling applied for Grindstone Creek, while technically sound and appropriate, has not been calibrated (i.e. adjusted to reflect actual observed responses to storm events). Typically, uncalibrated hydrologic models are considered conservative (i.e. over-predict flows and volumes as compared to existing conditions). Thus, further study could potentially result in a reduction in the predicted flood risk. In the absence of such information, the results generated by the current study are considered to be the best available data at the time of the completion of this study.

Notwithstanding, it is noted that updated hydrologic modelling for the Grindstone Creek watershed is available as per the Grindstone Creek Floodplain Mapping Study (Matrix 2020) and should be applied as the basis for any subsequent watershed-based hydrologic assessments.

In addition to the preceding, it should be noted that the riverine (open channel) hydraulic modelling downstream of Waterdown Road has been developed using a digital elevation model (DEM) from the Region of Halton (2015). Hydraulic structures have been included based on elevations from this source, along with corrections from record drawings, and data from field observations/measurements. Notwithstanding, a further validation should be considered in the future using topographic survey data, to better confirm precise floodplain limits. It is expected that this may occur as specific sites (particularly those identified as being within the floodplain) re-develop and proponents design appropriate mitigation measures. As per CH's comments of April 16, 2021, additional detailed floodplain mapping may be required prior to proposed land use changes. The results generated by the current study are however still considered appropriate for the estimation of floodplain risk.

It should also be noted that the Region of Halton 2015 DEM was the best available dataset at the time of the preparation of that report. More current topographic data (i.e. 2018 LiDAR data based DEM; or other most current dataset) should be used for any subsequent assessment or site-specific studies. Considerations for differences in vertical datums between datasets would also be required.

Any future assessments should employ the most currently approved hydraulic modelling tools as available from Conservation Halton. For Grindstone Creek, this would be based on the work completed by the Grindstone Creek Floodplain Mapping Study (Matrix, 2020).

4.3 POTENTIAL INFRASTRUCTURE IMPROVEMENTS

As noted in Section 4.2, one potential strategy for areas with riverine floodplain impacts is to review the feasibility of infrastructure improvements, which would most likely take the form of hydraulic structure (culvert) improvements. Based on the results presented in Drawings 4a to 4d, hydraulic structure upgrades should be considered for the following locations:

- Grindstone Creek
  - CNR (existing 1950 mm diameter circular CSP)
  - Waterdown Road (existing 2100 mm diameter circular concrete and 1.84 m x 1.33 m rectangular concrete box culvert)
- Falcon Creek
  - CNR (existing 1800 mm diameter circular CSP)

With respect to Grindstone Creek, a spill/overtopping of the CNR has been identified for the Regional Storm Event, which could potentially impact downstream properties. As noted previously, the impacts of these spill flows have not been assessed further as part of the current study; reference is made to the ongoing development at 101 Masonry Court. The CNR hydraulic structure is notably smaller than the hydraulic structures at Waterdown Road. The capacity of these features has similarly not been assessed as part of the current study, thus the necessity of a hydraulic structure upgrade in this case is unknown. Based on the existing structure sizes however, the CNR crossing appears to have a greater deficiency.

With respect to Falcon Creek, a spill has been identified which has the potential to impact the Grindstone Creek watershed through the conveyance of these spill flows, as well as increased downstream floodplain limits (1160 Waterdown Road in particular). The CNR is also indicated as being overtopped at this location for the 100-year storm event (without flow optimization/spills) and for the Regional Storm event (both with and without flow optimization/spills). As such, a hydraulic structure upgrade in this location would benefit the current study area. In conjunction with such an upgrade, potential grading modifications to overbank areas to contain spill flows to the Falcon Creek system could also be considered.

In addition to the preceding, as noted in Section 4.2 and 3.3.1, there would be value in undertaking channel widening works for the section of Grindstone Creek immediately downstream of Railway Road, in order to reduce floodplain impacts to the property to the north (1160 Waterdown Road).

Future evaluation of potential hydraulic structure upgrades may also need to consider access and ingress/egress impacts for emergency services and the public, where appropriate.

It should again be noted that all of the preceding works would occur within CH Regulated areas, and thus would require a permit application and permission from CH prior to implementation.

Trunk storm sewer sections with deficient hydraulic capacity (i.e. less than the 5-year storm event) have been identified previously. These sections should therefore be considered for capacity upgrades where feasible, in conjunction with the City of Burlington's existing capital planning for road reconstructions.

4.4 STORMWATER MANAGEMENT STRATEGY

As discussed in Section 4.1, the proposed re-development within the study area is not expected to result in large overall changes in impervious coverage, given the existing urbanized/developed nature of the study area. Notwithstanding, some potential re-development sites do include larger sections of existing pervious land, and increased impervious coverage would potentially still be expected in some areas. As such, a general strategy for quantity control is still required.

Large park areas are currently proposed for Emery Avenue/Masonry Court and Cooke Boulevard north of Plains Road East. These areas could potentially be used to provide stormwater management (SWM) controls for adjacent developments, through the implementation of properly landscaped and designed features, including LID BMPs. Notwithstanding, given the complexities of shared-use agreements, on site controls for these areas may be preferred. None of the existing park areas (Hidden Valley, Grove, Aldershot) appear directly amenable to incorporating SWM measures for future development given their respective locations and nature.

The majority of the re-development areas in the Aldershot GO MTSA would be expected to discharge to adjacent storm sewer systems, with the exception of development north of the proposed Masonry Court extension and west of Waterdown Road, which may potentially outlet directly to Grindstone Creek. Consistent with current City practices for quantity control, it is recommended that requirements distinguish between these two types of outlets.

Where sites have an existing approved outfall directly to a watercourse system, post-development to pre-development peak flow for the 2 through 100-year storm events are generally considered sufficient. Given the relatively minor change in land use in the area, and the location (towards the downstream limits of the watershed) it is considered unlikely that further overcontrol to reduce any downstream riverine impacts would be of any benefit and may in fact result in an adverse synchronizing of peak flows.

It is recommended that the City of Burlington's current informal policy of over-control (100-year post-development peak flow controlled to the 5-year pre-development peak flow) be applied as a minimum criterion for those sites connecting to the City's storm sewer system unless the receiver can be demonstrated to have a greater capacity, in which case that identified capacity would govern. CH has noted in its comments of April 16, 2021 that post to pre peak flow control should still be required for the 2-year storm event in this case. In some areas the storm sewer system may have a capacity below the 5-year storm event; this reduced criterion should also govern in those areas. This policy ensures that discharges are adequately controlled to the conveyance capacity of the interim drainage system receiver (i.e. the storm sewer) and no overland flow impacts would result from the conversion of area land uses. Further, those areas outletting to trunk storm sewers with identified capacity constraints (refer to Drawing 7) should potentially require further over-control to the simulated capacity of the storm sewer receiver. The modelling tools developed as part of the current study may be applied to further assess and validate quantity control measures and storm sewer capacity in these areas.

As per CH's comments of April 16, 2021, SWM quantity control requirements should also be revisited as necessary as the result of any future updated hydrologic and hydraulic modelling analyses (potentially including CH's March 2020 updates to the Grindstone Creek watershed).

The necessity for on-site Regional Storm quantity controls has not been confirmed or assessed as part of the current study. Future assessments may be required as part of site plan development applications on a "case by case" basis. If Regional Storm controls are determined to be warranted, a further policy review will be required to confirm the necessary requirements to allow CH to support formal crediting, including consideration of ownership and operation and maintenance considerations.

Given the fragmented nature of the pervious areas within the study area, and the study areas location towards the downstream limits of watercourse systems, erosion control requirements are not considered as critical as in more undeveloped, greenfield areas. Notwithstanding, consistent with the City's current approach to site developments, erosion control should be implemented through the 24-hour extended detention of the 4-hour 25 mm storm event. This could potentially also be achieved through the provision of LID BMPs, as part of the overall site SWM strategy (including quality control). In cases where the proponent can demonstrate that the preceding requirement cannot be reasonably achieved for the site, further discussions with CH and City staff may be required.

As re-developments proceed within the study, area there is also an opportunity to holistically improve stormwater quality of discharges to the receiving system. The City of Burlington's current informal policy is to require "Enhanced" Water Quality treatment (80% average annual removal of Total Suspended Solids). This requirement accounts for the entire proposed impervious coverage, not only the "new" impervious coverage. It is recommended that this policy continue to be applied for re-developments within the study area, given the retroactive stormwater quality improvement to receivers.

It should be noted that over the course of this study, the City of Burlington updated its Stormwater Management Design Policies and Guidelines (these were finalized in May 2020), thus additional stormwater management requirements, particularly with respect to climate change, erosion control, and water balance/infiltration would result for future developments, beyond the basic quantity and quality requirements noted previously.

In addition to the preceding, the currently proposed land use plan for the Aldershot GO MTSA (Draft Precinct Plan – May 2018) indicates the use of "Green Streets" for area roadways. Green Streets provide the opportunity to incorporate Low Impact Development Best Management Practices (LID BMPs) as part of the overall streetscaping design, including surface features (bioswales and bioretention areas, soil retention cells/tree planters) and sub-surface features (exfiltration pipes and storage chambers). These measures would benefit both water quantity, quality, and water budget/infiltration/erosion.

5 CONCLUSIONS AND RECOMMENDATIONS

The land use plans prepared for the Aldershot GO MTSA indicate that re-development and intensification are expected in this area. This report has been prepared in support of this planning effort, in order to summarize the expected flood hazard limits for the MTSA. Existing hydrologic and hydraulic models have been refined in order to assess expected flood hazards, due to riverine floodplain extents, and potential spill areas.

Conventional 1-dimensional (1D) hydraulic modelling has been prepared for the area watercourses to confirm the riverine floodplain limits, and those locations where floodplain extents would limit any potential re-development.

As noted previously, since the completion of the primary report for this study (February 2019), Conservation Halton (CH) has completed a Floodplain Mapping Update Study for Grindstone Creek (March 2020). CH has advised that any future analyses within the Grindstone Creek watershed should use this updated hydrologic and hydraulic modelling accordingly.

A general floodplain management strategy has been proposed, which necessarily distinguishes between riverine floodplain extents (regulated by Conservation Halton) and spills (which are now considered to be regulated by CH and require assessment of re-development potential on a case-by-case basis). Recommendations for potential hydraulic structure and channel upgrades have been proposed in areas which may assist in reducing currently estimated floodplain extents. An overall stormwater management (SWM) strategy has also been proposed, including quantity, quality, and erosion control measures to mitigate the impacts of future development. A summary of the proposed measures for the Aldershot GO MTSA is outlined in Table 5.1.

The current study provides a basis for the estimation of existing flood hazards and a proposed SWM strategy for the Aldershot GO MTSA. As noted, further study may be warranted as future refined land use planning and development studies. The following additional recommendations are noted in this regard:

- Stormwater quantity control requirements should be revisited and refined if necessary as the result of future updated hydrologic and hydraulic modelling analyses (including potential consideration for Regional Storm controls).
- Further study of potential major system spills between watersheds may be required at future planning application stages.
- The City of Burlington may wish to consider undertaking further field monitoring and data collection efforts to support hydrologic model calibration, which will allow for a more informed estimate of flood risk. As noted previously, updated hydrologic modelling for Grindstone Creek was generated as part of CH's March 2020 study update, and should be used in future modelling work.
- Further field verification and topographic survey is also recommended in certain locations, including affected floodplain areas (1160 Waterdown Road), and spill locations (spill section from Falcon Creek to Grindstone Creek). As noted previously, a more detailed assessment of spills from Falcon Creek was completed as part of CH's Grindstone Creek Floodplain Mapping Update Study (March 2020); reference is made to that document accordingly. In addition, more current topographic data is now available (2018 CH LiDAR-based DEM) and should be applied for future studies (or more currently available data), notwithstanding consideration of vertical datum differences.

Table 5.1. Summary of Flood Hazard and SWM Strategies for Aldershot GO MTSA

MANAGEMENT AREA	CONSIDERATION	RECOMMENDATION
Development Area Flood Management	Riverine floodplain encroachment onto development sites	– No development can occur within 15 m buffer of identified floodplain extents (Grindstone Creek and its tributaries are identified as a Major Valley System) – Consider opportunities to reduce floodplain extents through hydraulic structure upgrades or channel improvements where feasible (1160 Waterdown Road) subject to CH approval
	Flood spills onto development sites	– Development may be able to proceed subject to suitable flood management strategy on affected development sites and confirmation based on current CH limits and policies. – Focus on passive floodproofing (re-grading of land and buildings to 0.30 m above identified flood level); consider active floodproofing (measures that require human intervention) where passive floodproofing not feasible, and where supported by CH (active floodproofing is not supported for intensification of use but supported for protection of existing development). Confirm safe ingress/egress from site. – Achievement of a cut/fill balance for flood storage volume to avoid off-site impacts. – Assess proposed site management strategies through application of developed modelling tools to confirm no off-site impacts and safe conveyance of spill flows.

Area Infrastructure Improvements	Hydraulic Structures (Culverts) and Channel Works	– Consider benefit of hydraulic structure upgrades to reduce spills to potential development lands (subject to CH permitting/approval):
		  – CNR (Grindstone Creek)
		  – CNR (Falcon Creek) – combine with potential grading modifications to prevent spill flows to Grindstone Creek
		– Consider channel widening and re-grading at 1160 Waterdown Road to reduce floodplain extents and ensure safe ingress/egress (subject to discussions with CH staff and permitting approval)

	Storm Sewers	– Consider capacity upgrades for identified deficient trunk storm sewers (those with surcharging or flooding for the 5-year storm event)
	Overland Flow Pathways	– Review opportunities for improvements in areas where 100-year and Regional Storm accumulation depths are > 0.30 m
	SWM Facilities	– Consider implementation of SWM facilities (for local or external lands) within proposed future park areas (Emery Ave/Masonry Court and Cooke Blvd) as part of future re-development plans, however these may not ultimately be feasible.

MANAGEMENT AREA	CONSIDERATION	RECOMMENDATION
Stormwater Management Criteria	Quantity Control	— Post to pre peak flow control (2-year through 100-year) for areas discharging directly to creek systems — Over-control (100-year post to 5-year pre or demonstrated capacity) of peak flows for areas connecting to storm sewers or where major system is constrained. Ensure post to pre peak flow control is still maintained for the 2-year event. Additional over-control may also be warranted where modelling results indicate storm sewer capacity is less than 5-year storm event standard. — Implement standard erosion control measures (24-hour extended detention of 4-hour 25 mm storm event), potentially in combination with LID BMPs for the overall SWM strategy. Where it can be demonstrated that the above cannot be reasonably be achieved, further discussion with CH and City staff may be required. — Requirements for Regional Storm control to be confirmed.
	Quality Control	— Enhanced (80% average annual TSS for all impervious areas — Review opportunities for synergies with other studies and road reconstruction projects in particular ("Green Streets")

The current study should also be considered in conjunction with other ongoing City of Burlington initiatives within the study area. For the MTSA assessed herein, updated direction from the City's revised Stormwater Management Policies and Design Guidelines should be taken into account in the development of future SWM strategies for re-developments.