INFORMATION REPORT

TO:	Chair and Members Public Works Committee
COMMITTEE DATE:	December 6, 2021
SUBJECT/REPORT NO:	Stormwater Gap Evaluation (PW21074) (City Wide) **(Outstanding Business List Item)**
WARD(S) AFFECTED:	City Wide
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COUNCIL DIRECTION

On November 23, 2020, the General Issues Committee approved the following motion:

"That Hamilton Water staff be directed to perform a comprehensive evaluation of all City of Hamilton (City) stormwater programs to identify existing gaps, immediate needs, risks to the City including risks from climate change and extreme weather, outline the levels of service that the City should strive to achieve, quantify funding requirements along with options for long term maintenance, second cycle replacements and financing alternatives and report back to Public Works Committee in the first quarter of 2021 with an information report."

INFORMATION

The purpose of this gap evaluation is to identify and analyze gaps in the City of Hamilton's (City) Stormwater Management Program (SWMP). The gap evaluation is a tool for the overall SWMP that will help to organize the City's current systems, processes, procedures, etc. so that the City is able to prioritize steps to close the identified gaps and outline a plan to move the SWMP forward.

The City provides stormwater management (SWM) services that protect property, livelihood, health and safety of residents, businesses and natural waterways, and plays

a significant role in the City's efforts to manage and adapt to the effects of climate change.

In the 2016 the City's stormwater asset inventory was valued at approximately $1.56B. This value corresponds to the City's 2016 stormwater asset inventory identified in Table 1 below. Updated asset inventories are being compiled as part of the City's Asset Management (AM) Plan initiative with the intent of compliance with AM Planning for Municipal Infrastructure, O. Reg 588/17. As a result of growth to the system and continued efforts to improve the inventory, it is expected that the updated inventory will reflect increases in the quantities of stormwater assets and overall value. To provide greater insight to the current state of the gaps, references have been made to the 2020-year end quantities for a portion of the existing gaps in this report.

Table 1 – 2016 City of Hamilton Stormwater Inventory

Asset Type	Asset (2016)	Quantity (2016)
Linear Stormwater Assets	Storm Sewers	1,149,441m
	Manholes	19,551 units
	Stormceptors (Oil and Grit Separators)	45 units
	Small Culverts	Inventory being developed
	Major Swales	190,000m
	Ditches	2,164,000m
	Major Culverts (3.0m diameter and larger)	191 units
Non-Linear Stormwater Assets	Storm Ponds	155 units
	Inlet/Outfall Structures	977 units

Notes to table above from 2016:
1. There is currently no inventory data available for small culverts.
2. Inventory for ditches estimate based on rural road lengths.
3. Storm ponds include 119 assumed and 36 unassumed (some of which have since been assumed).

For the purposes of this gap evaluation, gaps were identified through a process of reviewing existing documents, analyzing previous studies, and meeting and conferring with various stakeholders. HW, with the support of Planning Economic and Development (PED) and Public Works, have undertaken a comprehensive evaluation of all City SWMPs that fall within their respective portfolios. This report outlines the findings of the City-wide comprehensive review according to the following elements of the motion:

1. Existing gaps
2. Immediate needs and risks to the City
3. Risks from climate change and extreme weather
4. Levels of service that the City should strive to achieve and funding requirements

5. Financing alternatives

Appendix "A" to report PW21074 provides a tabulated summary of the findings and gaps that are explained in detail throughout the course of this report. Gaps include elements such as: incomplete processes, lack of modeling analysis, lack of standards or governance, urbanization and growth impacts, missing tools or documentation, overlapping processes, regulatory pressures, lack of staff resources, lack of funding, etc.

1. Existing Gaps

a) Low Impact Development (LID) Standards:

Low Impact Development (LID) is a planning and engineering design approach to managing stormwater runoff through on-site natural features.

The City currently retains a number of LIDs as part of its stormwater infrastructure and examples include, but are not limited to:

- Permeable pavements;
- Perforated pipe drainage channels;
- Rainwater harvesting gardens;
- Green roofs which utilize vegetation on roof tops to capture rainwater; and,
- Enhanced grass swales that convey, treat and attenuate stormwater.

A cross-divisional team within Public Works is currently reviewing asset ownership and responsibility for publicly owned LIDs. Issues related to complexity for each type of LID and required areas of expertise to effectively manage these assets through their lifecycle will be taken into consideration.

Currently, there is a lack of standards related to the implementation of LIDs which can result in varying degrees of functionality. The Ministry of the Environment, Conservation and Parks (MECP) is in the process of updating the development of a Low Impact Development Guidance Manual. The new manual will help to provide transparency and consistency for the MECP's expectations for LID standards.

b) Official Plan and Stormwater Management Features Adjacent to Parkland and Urbanization Impacts:

Stormwater features, such as SWM ponds, are generally compatible adjacent to parkland; however, the stormwater features should not impact the function of providing open space for use by residents which is a challenge in constrained areas of parkland. Parkland dedication requirements are based on the amount of programable parkland space required to serve the need of the surrounding community and cannot be used for

the acquisition of land for SWM purposes. If a SWM facility was constructed on a piece of land contiguous with parkland, the portion of land on which the SWM facility resides would need to be planned for and zoned appropriately. Consideration may be needed at a planning level to amend the Official Plan for larger parkland standards or identifying utility lands adjacent to parkland so that they can be integrated.

Regarding urbanization impacts, there are community pressures to urbanize rural and industrial road cross sections without sidewalks or ditches. Without enhanced infiltration of surface water that can be provided by ditches, additional run-off is added into the storm sewer or combined sewer systems. Additional capacity forced into a combined sewer can increase the volume of overflow from combined sewer overflow tanks during wet weather events.

c) Maintenance, Enforcement, Tracking and Awareness of Private Stormwater Infrastructure:

Private stormwater infrastructure, such as SWM ponds, mechanical quality control devices, and roof top storage have contributions to the City's stormwater system. Private stormwater infrastructure in post development conditions are typically not subject to a Site Plan Agreement that clearly outlines obligations and expectations of performance and maintenance. It should be noted that private SWM infrastructure on industrial, commercial and institutional lands require an Environmental Compliance Approval (ECA) from the MECP to which the property owner is obligated to operate and maintain their system per the ECA conditions. However, there is no assurance that the private infrastructure is performing as designed, or that infrastructure has not been altered or removed. Proper education regarding the importance of ensuring private SWM infrastructure functions as intended and the responsibility of property owners to maintain their private SWM would assist in ensuring that these systems continue to operate effectively.

The City has limited ability to track all privately-owned SWM infrastructure and the impacts these facilities have on the overall SWM system. AMANDA, an archiving software, is set up to track private SWM infrastructure; however, the information in this database is not available to all City departments. Furthermore, the City has no authority to inspect private SWM infrastructure other than as part of the site plan inspection process. To perform inspections of private facilities post-development poses a significant resourcing issue and would require authority in some form to access property to inspect, such as via easement or by-law. Other jurisdictions have implemented inspection programs for this type of infrastructure, and this would be a useful mechanism for the City to ensure that property owners are compliant with their obligations to maintain their private SWM infrastructure and to mitigate circumstances where private SWM infrastructure is negatively impacting public SWM infrastructure.

d) Lack of Resources and Governance for Management of Lot Level Controls:

Lot level controls, such as green roofs, on site storage and LIDs provide localized stormwater control for a particular property and are required to support intensification. However, inspection, maintenance and enforcement of the lot level controls is not established or resourced. The responsibility to manage City-owned lot level controls exists throughout various Divisions of Public Works, including Energy, Fleet, and Facilities Management (EFFM) and Environmental Services (ES) who maintain lot level controls for specific properties, such as building facilities, parkland, etc. The management of lot level controls are not part of the core responsibilities of EFFM and ES and takes resources away from their core programs.

e) Planning of Stormwater Mitigation in Parkland Assets:

Parkland is required to be well drained in order to facilitate recreation and manage the operations of the park. The watershed calculations within parkland assume a level of infiltration. If this level is not achieved, more pressure is put on the SWM infrastructure which was sized based on the assumed level of infiltration. New parks are not always draining sufficiently or comprised of good quality fill materials that allows for natural infiltration processes.

During development, parkland can become impacted as a result of staging or stockpiling which can lead to compacted soils and compromised infiltration. Areas of parkland with impacted infiltration from over-compaction of soils or substandard fill materials are challenged by changing weather patterns since increases in precipitation result in additional runoff. Under the City's Standard Form Subdivision Agreement (SFSA), parkland requirements and conditions, such as soil and drainage, are identified. The SFSA is currently under review and the anticipated updated version is intended to help mitigate such use of parkland during the development stage. For instance, if the updated SFSA insists on parks being in the first phase of development, this could cut down on this practice significantly.

Unless accounted for during design of developments, proper capital and operating budgets, and staffing resource levels cannot be established which impacts the level of service provided. Challenges to deliver the desired level of service are further compounded if as-built assets differ in performance from what was originally identified.

f) Developing Experience and Increasing Workloads in Unexpected Areas:

There are limited operational resources in HW that oversee the operation and maintenance (O&M) of SWM assets and other drainage related infrastructure:

- Project Manager/Drainage Superintendent: This position is challenged to balance many core duties and responsibilities:

  - Accountability for the O&M of $336M of assets which is a portion of the stormwater assets HW is responsible for.
  - Responsible for the O&M of 57km of municipal drains.
  - Relied upon heavily for the development and delivery of appropriate inspection, maintenance and rehabilitation programs, including training field staff.
  - Responsible to supervise and train three (3) Stormwater Technologists.
  - Oversees consultants that are actively running projects for HW in lieu of staff available to run the projects.
  - Relied upon as a resource by multiple City departments to review drainage issues brought forward by Council, members of the public and City staff.
- Three (3) Stormwater Technologists
- Wastewater and Stormwater Collection Operators
- Community Outreach Educator:
  - Liaison for all water, wastewater and SWM program inquiries from Council.
  - Since 2019, an increase of 15-20% in total inquiries received directly related to the SWMP. The increase in inquiry volumes related to the SWMP have delayed response times for other types of requests and impacted other core responsibilities.
- Water Information Systems (WIS) Business Unit:
  - Tasked with integrating, updating and maintaining SWM data and asset inventory database into HW's Geographic Information System (GIS) and computerized maintenance management system.

g) Major/Minor Stormwater Systems:

Major and minor storm drainage systems as defined in the City's Storm Drainage Policy:

- Minor Drainage System - Conveys urban drainage from relatively "minor" storms, typically having a frequency (return period) of between two (2) and ten (10) years in most southern Ontario municipalities. These works typically consist of storm sewers, inlet systems, catch basins, roadway gutters and swales, foundation drains and roof leaders. Their purpose is to prevent frequent flooding which may inconvenience motorists, home and business owners, and pedestrians.
- Major Drainage System - Inherently comprises the minor system, as well as the overland route followed by runoff not captured by the minor system either due to excessive flow or operational failures. Common elements of the major system include natural streams, valleys, swales, ponds, roadways, drainage channels, walkways and easements. The design storm usually applied to major system components ranges from a return period of 25 to 100 years, up to the Hurricane Hazel Regional Storm event.

Hydraulic modelling analysis is an essential process that provides valuable information that is required to ensure new or retrofitted assets are designed and constructed to the

most relevant conditions that could impact an asset. Until recently, HW has focused its hydraulic modelling and analysis efforts on the minor storm sewer system. Apart from SWM system design and hydraulic analysis that occurs during greenfield development, hydraulic analysis of the historical systems to bring them to current design standards is not completed on a City-wide scale, but rather completed in smaller areas of focus. It should be noted that with the implementation of the City's Stormwater Management Master Plan in 2006, all new greenfield development has been required to adhere to the standards laid out in the plan. However, for historical systems, the City is lacking hydraulic modelling analysis of major system drainage elements, such as stormwater management facilities, natural watercourses, open channel drains, overland flow channels, or major system drainage pipes. It is these major stormwater system elements that are relied on to transport surface water away from streets and neighbourhoods and towards local receiving waters during large precipitation events.

There are Divisions within PED and Public Works that are responsible for designing on-road flow management, culverts, and bridges associated with specific projects or specific development applications; however, there is no single entity that is actively assessing, modelling or planning overall stormwater flows intended to be conveyed by major systems. Public Works is not actively assessing major or minor stormwater system performance during extreme events and there is no Division currently responsible for establishing levels of service standards and strategic planning to mitigate major system flooding.

The City's Storm Drainage Policy and Development Engineering Guidelines outline impact assessment requirements under growth conditions, such as intensification. However, no single Division is delineated responsibility for studying or developing broad, neighbourhood-scale stormwater strategies. Implemented through, or as a result of, development applications, several area specific drainage studies have been completed, such as Ancaster Intensification Pilot Study and Leckie Neighbourhood Drainage Assessment. However, it is important to note that the City is generally not proactive in undertaking drainage studies outside of the development approvals process or in areas not experiencing significant development pressure. Additionally, when new development in existing neighbourhoods is proposed, while site-level stormwater impacts are assessed, broader studies to determine the benefits and performance of existing culverts and ditches in controlling stormwater in the broader area is generally out of scope for the development approval.

The City has a Storm Drain Policy, Grading Policy and best practices that are applied to individual development projects which lay out the requirements and dictate that a suitable outlet and grading must be established prior to approval. However, outside of the initial development approval, there is lack of control over future changes to private drainage systems in either recently developed or existing properties and private drainage issues are not analyzed when drainage studies are completed. Property

owners adjusting their property grades, filling in swales and paving backyards are a few examples that can result in localized flooding.

h) Asset Management (AM):

HW manages the condition assessment and capital replacement functions of an asset management (AM) program for vertical stormwater infrastructure facilities, such as pump stations. Engineering Services (ES) manages the same functions for linear stormwater assets, such as storm sewers, major culverts, bridges and outfalls/outlets. Outside of the previously noted Divisional responsibilities, there is no existing equivalent program for SWM facilities, watercourses, municipal drains or outfalls/shorelines. While general O&M, typically on a reactive basis, is performed on these assets, there is no proper AM program that identifies a capital inspection schedule, responsibility for the capital inspections or responsibility for the management of a repair that requires engineering design and construction. This is of particular concern for assets that need immediate work and don't align with the typical capital planning process of three (3) to five (5) years and as a result, infrastructure failures occur.

There are many unknowns about the SWM assets managed throughout the AM programs in ES and HW. To manage the SWMP portfolio in a sustainable manner, there is a significant amount of information that needs to be collected before gaps in the program can be analyzed including:

- Asset Ownership and/or Location – Many assets such as stormwater outfalls, easements, rear-yard catch basins and watercourse features are not currently catalogued or mapped.
- Asset Inventory Database - The asset inventory database is incomplete where components within SWM facilities are not captured, such as specific drains, outlet structures or number of bays. This challenges staff's ability to create an efficient and effective work order history that can support planning for future program needs.
- Asset Condition – Excluding storm sewers, as there is a good understanding of the condition of that SWM asset type, the current structural and operational condition of most of the SWM assets are either unknown or not documented. It has been noted that there are SWM assets currently existing in a poor state of repair.
- Potential Reclassification of Assets to HW – Culverts less than 3m in span are considered an element of road structures or bridges which are currently managed by Transportation Operations and Maintenance (TOM). This classification has been questioned as serving more a of SWM function given the assets purpose which is to mitigate stormwater impacts to road structures or bridges.

HW has responsibility for inventory, records and GIS management of minor system storm sewers and has well-developed systems in place for these assets. However, much of the major system drainage infrastructure network has not been incorporated into the City's information management systems. Inventory control for assets such as overland flow routes outside of the right of way, drainage channels and watercourses are the responsibility of HW, but existing resource levels are not adequate to complete this work.

HW operates and maintains a number of vertical SWM assets that are not captured under a formal AM process. As a result, these assets are not being assessed for condition, risk of failure, nor are they on an asset renewal schedule. The sub-components within vertical assets such as a stormwater pumping stations, or shoreline outlet structures are captured in varying degrees of completion throughout the City's AM software. This challenge is also experienced with the linear SWM assets maintained by ES linear stormwater AM plan. Under the current state, vertical and horizontal stormwater assets with a defined ownership within the City receive maintenance and repair according to the resources available, but their condition is gradually degrading without active oversight.

i) Regulatory Compliance:

SWM facilities are designed, built, and required to be maintained according to each facility's ECA. These compliance requirements typically dictate the maintenance schedule for each SWM facility and some LID features as they are the main driver behind activities, such as pond cleanouts. Based on a recent review of SWM facility documentation, the City has an incomplete inventory of SWM facility ECAs. For 34% of SWM facilities (2020 SWM facility inventory), as well as some LIDs, the City cannot locate an ECA. This is due to several factors, such as lost or missing documents from pre-amalgamation and no formal transfer processes set up at the time of amalgamation. HW is in the process of consolidating all stormwater approvals into one Consolidated Linear Infrastructure Environmental Compliance Approval (CLI-ECA) in which all historical ECAs and missing approvals will be combined into one approval with consistent conditions. SWMP staff will need to work through this information gap to ensure that the SWM facilities are monitored and operated within regulatory requirements.

SWM facilities located within regulated lands require permit applications for rehabilitation and maintenance work to be approved by regulatory bodies, such as conservation authorities (CAs) and the Department of Fisheries and Oceans. For capital works and planned maintenance this does not present an issue; however, for emergency works, no formal emergency works agreement exists with two (2) of the four (4) CAs, the Grand River Conservation Authority and Niagara Peninsula Conservation Authority. Emergency works agreements would mitigate the lengthy permitting process and allow the City to quickly attend to emergencies. While these agreements are

attainable, HW currently does not have the staffing resources to help initiate and implement these agreements.

j) Stormwater Management Facilities:

There has been a lack of proactive maintenance on the SWM ponds partially due to missing information, such as ECAs as mentioned in section i) Regulatory Compliance. Additionally, staffing and financial resources have not been sufficient to keep in compliance with the existing ECAs and complete preventative maintenance. Currently, major maintenance of SWM ponds, such as pond dredging, and disposal of accumulated sediments is undertaken based on priorities derived from monitoring of sediment accumulation and associated decrease in SWM facility performance rather than on a preventative or proactive approach.

Historically, the capital budget has been insufficient to support the maintenance of SWM ponds. As of the end of 2020, there were 143 assumed SWM facilities, with the projection that an additional 100 SWP facilities will come on-line over the next 20 years as a result of growth. Growth Management has forecasted 20 additional facilities will be assumed by the City by 2022 alone. An increase in the baseline level of service to establish a pond monitoring and inspection program and address repairs is required to keep up with growth. Additionally, the SWM facility capital budget and staffing resources to manage the maintenance and inspection programs will need to be increased to keep up with the growth of the system.

k) Watercourse Assessment, Natural Heritage System Enhancements, Erosion Risk Mitigation, Inspection, Maintenance and Inlet/Outlet Monitoring:

i) Erosion: The effects of natural erosion can impact the quality and resilience of the natural heritage system which is comprised of different natural areas that add to Hamilton's character and quality of life by providing biodiversity, long-term health and movement of wildlife and plants between habitats, such as healthy streams and wetland features. These natural assets are important buffers as they slow runoff, filter pollution and prevent soil erosion.

Responsibility for monitoring and managing erosion risk to City assets, public and private properties is shared with local CAs. The City is responsible to monitor the system wide performances and the CAs are responsible to monitor the cumulative impacts from the watershed perspective.

The City's efforts to conduct physical inspections of watercourses for erosion or inspection of assets located along watercourses is irregular and not undertaken as part of a formal program. Currently, ES has the technology to perform inspection and measurement of erosion to assist in mitigation and overall management, but limitations with data storage and management

capabilities, current staffing levels, and funding do not permit internal efforts to capture erosion patterns.

ii) Forecasting System Risk: Hydraulic modelling allows for predictive forecasting capability and the ability to run scenarios through the model in order to better understand potential outcomes. Under the Conservation Authority Act, CAs complete flood forecasting and issue warnings that help prepare local authorities in the event of a flood. However, as described in g) Major/Minor Stormwater Systems, major system hydraulic modelling of watercourse performance during wet weather events is not completed by the City on a consistent basis. As a result, the City is limited in its ability to rapidly conduct post flooding studies to identify and address any contributing factors to the flooding event. If completed consistently, this modelling would highlight potential hazards to infrastructure, including damage to stormwater outfall structures, damage to bridge structure elements and erosion along these watercourses.

iii) Inspections: There are irregular inspections and no proactive maintenance of the 191km of City-owned watercourse. Furthermore, inlets, outlets, culverts and headwalls along watercourses have historically only been inspected to ensure they are flowing and are not regularly inspected from a structural/condition perspective. A comprehensive inspection and maintenance program may have mitigated several 2019 and 2020 inlet/outlet failures in challenging locations to perform repairs. A regular inspection and maintenance program with associated capital funds for repairs can decrease the risk of costly failures.

l) Easements:

In 2019, the stewardship of the corporate easement GIS layer was transferred to HW. The easement layer does not contain up-to-date or complete information. Often, inquiries cannot be answered in a timely manner because historical records need to be pulled each time to verify GIS accuracy. A multi-phase project has commenced via consultant to retrieve easement documents from the Land Registry Office, add them to our asset management database, validate that all easements are captured and that they are illustrated correctly and are up to date, including all encroachments and the risks they pose.

The City lacks a holistic program that outlines a consistent inspection or maintenance schedule for drainage easements. As a result, inspection and maintenance of drainage easements are typically completed on a reactive basis. In some cases, drainage easements are obstructed by encroachments and cannot be accessed for works. For the time being, negotiating a resolution for easement encroachments falls on HW staff which diverts a great deal of staff resources and time.

m) Municipal Drains:

Under respective Drain Agreements established under the Drainage Act, the City is responsible for the maintenance of approximately 57 square kilometres of municipal drains which are located on private property and provide a drainage benefit to approximately 1,500 property owners. Municipal drains exist as a result of property owners petitioning their local municipality for a municipal drain project as a solution to their drainage issues. Most municipal drains are either ditches or closed systems, such as pipes or tiles buried in the ground. What makes municipal drains different from other forms of drainage systems is that they are municipal infrastructure on private property and the municipality is responsible for their construction, repair and management. Costs associated with the municipal drains are recovered through cost sharing from the benefitting property owners in accordance with the by-law.

Historically, the municipal drain program has been reactive with no preventative maintenance activities. The municipal drains need consistent inspections and maintenance to maintain the conveyance capacity. In failing to invest in the on-going need for erosion protection and restoration, bank failures could impact stormwater quality, channel capacity and private property, resulting in costly investments to deal with emergency repairs. Ultimately, the cost of future projects will be more expensive, with serviced property owners carrying the financial burden. Additionally, there is no formal process for chargebacks, which is a time-consuming and complex task by which Council must endorse each time.

n) Stormwater Water Quality Policy Development, Monitoring and Management:

Prior to amalgamation in 2001, the implementation of stormwater quality management strategies to protect the natural environment from stormwater contaminants was based on provincial guidance and standards. Each former municipality managed its own SWM drainage system generally in the same way, with differences related to physical setting and/or past development.

Responsibility within the City for policy development, monitoring and management of quality of stormwater, natural watercourses or the natural heritage system has not been clearly established. Acquired as part of the 2021 Rate Budget process, two (2) Stormwater Technologists will begin actively monitoring the effectiveness of the SWM facilities in attaining water quality objectives. Given that this program is in its infancy, the level of staffing requirements to monitor and manage the many different asset types across the City is unknown.

o) Stormwater Management Facility Capacity Tracking and Allocation for New Growth:

The City's ongoing Stormwater Master Plan update is focused on growth needs; it does not include performance review and planning for existing developed areas and existing SWM facilities unless the existing facility is being impacted by growth. Often, SWM facilities, such as SWM ponds, are constructed to control stormwater runoff from planned growth areas that are not fully developed until years or decades later. The actual form of development and runoff quantity can change significantly from design to when the growth areas are finally built out. Growth Management requires additional onsite SWM control if a proposed development exceeds the design assumption considered in the original design of the SWM system. All SWM pond rating curves proposed in greenfield development are generally verified by the sub-watershed or Master Drainage Plan model to confirm overall performance. However, there is no comprehensive tracking program that monitors the impacts on the existing downstream SWM facilities to ensure they are functioning as originally intended.

p) Administration:

There are several administrative activities in support of a progressive SWMP that are not being performed or being performed sporadically amongst various departments in the City. These activities include creation of consolidated stormwater standards, creation and operation of an environmental monitoring network, expansion and maintenance of a consolidated stormwater asset inventory, review of designs for LID features that are required for compliance with ECAs, and the establishment of internal and external stormwater committees. The City could benefit from a harmonized approach that clearly outlines the roles and responsibilities of each group to ensure that a holistic and consistent coordination of administrative activities is achieved.

2. Immediate Needs and Risks to the City

The following is a list of immediate needs and risks to the City from a review of the known gaps within the SWMP:

a) As of 2020-year end, the majority of the SWM ponds are regulated and have prescribed discharge water quality standards through ECAs. However, there are a number of ponds that have not been assessed for water quality performance since they were built and may not be performing as intended. There are several pre-amalgamation ponds that are difficult to access and maintain, which need capital upgrades to facilitate effective O&M to ensure compliance. The CLI-ECA will provide consistent conditions for the SWM ponds that are currently lacking ECAs but will also come with increased monitoring and reporting requirements that will have to be resourced.

b) As described in 1. g) Major/Minor Stormwater Systems, the City does not have all the hydraulic models necessary for predicting how the minor and major SWM systems function during extreme weather events. At the present time, there is no City-wide model that is fully connected between the minor and major systems. Without a comprehensive model that accurately captures both systems, the City cannot accurately predict overland flow and pipe flow during extreme storms. As a result, the City has insufficient visibility on where these systems are undersized and further, which streets or neighbourhoods are susceptible to flooding. In the absence of this information, the City cannot proactively implement operational changes to reduce the likelihood of flooding in these areas, nor can it plan for capital improvements to stormwater infrastructure (i.e. pumping stations, pipes, and stormwater ponds).

The City maintains several stormwater models including:

- Six (6) cities Stormwater model: Uncalibrated and only represents the trunk sewers (>525 mm).
- Dundas Stormwater model: Calibrated and represent all pipes within the respective drainage area.
- Stoney Creek Stormwater model: Calibrated and represent all pipes within the respective drainage area.
- Ancaster Dual Drainage model: All-pipes dual drainage representation of the Ancaster drainage area which has been calibrated and validated using 2018 flow monitoring data. The Ancaster model supports the identification of potential drainage and flooding issues, and the model can be used to address climate change and future development issues.

A wastewater flow monitoring study is underway to create a comprehensive program strategy for sanitary system flow monitoring to obtain data for detailed model calibration and a pilot project to determine if the City will continue with the current wastewater modelling software (Mike Urban) or move to a new software (Infoworks). Following this study, additional flow monitoring studies will be required to improve all SWM models to a level consistent with the Ancaster Dual Drainage model. There is a tentative plan to create a calibrated all-pipes dual drainage model for the Waterdown drainage area in parallel with further calibration of existing models.

c) As described in 1. h) Asset Management (AM), gaps in the SWMP cannot fully be analyzed and implemented into an AM plan because of missing information. For example, HW does not have complete information or assessments completed for two (2) stormwater pump stations acquired in 2019. These stations are operated by HW who perform preventative maintenance and repairs, but these assets are not captured under a formal AM program. As a result, the condition of these stations is not being recorded and tracked, leaving them susceptible to failure over time. These stormwater pump stations serve specific

purposes, such as flooding mitigation for bridge underpasses or specific areas, and failure of these assets could have immediate consequences.

d) There is an immediate need to define ownership and/or resources required for capital inspection programs to ensure that SWM assets are functioning as per original design. This is an important step that would support engineering and capital repair programs for stormwater/drainage assets such as watercourses, shoreline and outfalls.

e) Managing culverts less than 3.0m in diameter is a gap with unknown needs, which carries its own risk. Traditional like-for-like replacements is common practice completed through the TOM Division. This poses the challenge that improvements outlined in current design standards and needs identified by local stakeholders, such as CAs, are not captured. The consequence and cost of failure of these assets is related to the size and location of culverts. For example, small culverts that do not cross a roadway, have a smaller consequence of failure than larger culverts that are under or within a road structure.

3. Risks from Climate Change and Extreme Weather

Climate change is altering the intensity, overall duration, and frequency of climatic events and causing increases in precipitation volumes and patterns. Impacts of climate change and extreme weather patterns represent a critical challenge for City infrastructure. Whether analysed from a local, regional, national, or international perspective, the increasing vulnerability of climate systems has highlighted the urgent need to plan and prepare for the possible impacts. Addressing climate related threats requires targeted action, grounded in science, and focused on building resilient strategies capable of managing a future that is both unpredictable and unprecedented.

The potential changes in annual precipitation volumes and rates is a significant threat to urban areas. According to a 2014 Federal Government report titled “Canada in a Changing Climate: Sector Perspectives on Impacts and Adaptation” and outlined in the 2016 Local Governments for Sustainability report for climate changes in Hamilton, Canada has experienced a 13% increase in average precipitation over the past half century. This change, and the associated conditions in urban areas, has led to increased pressures on SWM infrastructure and has forced municipalities to adjust approaches to SWM.

In 2020, as part of a broader Climate Change Adaptation and Asset Management Pilot Project, Public Works completed a climate change event probability analysis to document potential climate events and thresholds in Hamilton:

- This analysis combined the results of 16 climate models to determine potential climate futures associated with storm events and high lake water

levels for Hamilton for the short term (2030s), mid-century (2050s), and long term (2080s). It should be noted that the uncertainty in climate change forecasts increases the further out into the future, with results forecasted in the 2080s being subject to the most uncertainty.

- Overall, the results of this ongoing assignment illustrate significant expected increases in extreme precipitation events, multi-day extreme precipitation events, multi-day dry conditions, and saturated ground conditions prior to extreme rainfall events in Hamilton.
- The results indicated that total days where precipitation exceeded 50mm of rainfall would rise from 0.2 events per year between 1981 and 2010 to over 0.44 events per year by the 2080s, doubling the frequency of this extreme weather event in Hamilton.
- Extreme rainfall events that produce over 150mm of rain over a two (2) day period could increase from a one (1) in 200-year frequency between 1981 and 2010 to a frequency of one (1) in a 67-year event by the 2080s.
- The percentage yearly chance of lake water levels exceeding the height of Hamilton's lowest outfall (not currently submerged) at 75.5m above sea level could rise from 18% in the 2030s to 100% by the 2050s. The forecast of this study projects that Hamilton could see the event per year occurrence rise from 0.3 events per year in the 2030s to 3.7 events per year in the 2080s.

Information gathered from the Climate Change Adaptation and Asset Management Pilot Project indicates that increased forecasts to changes in rainfall intensity, drought conditions, and extreme precipitation events as outlined above can lead to damage from flooding and/or washout of private and public infrastructure, such as stormwater pumping stations, basements, facilities, parkland, roads, culverts, catch basins, bridges, and lead to wastewater bypass events in the combined sewage system. Increased occurrences and size of storms are risks to existing assets that may be undersized, therefore leading to public and private infrastructure flooding. There is also a risk that major stormwater paths or systems do not exist in some parts of the City leaving streets and neighbourhoods vulnerable to flooding.

The forecasted changes in lake levels identified above will impact shoreline protection assets and the functionality of combined sewage outfalls potentially creating inflow of lake water into the combined sewer system which leads to capacity issues and impacts to the functionality of combined sewer overflow tanks. For instance, as a result of the record high lake levels in 2017 and 2019, many City shoreline assets were damaged, and outfalls became inoperable due to being submerged under water. Temporary control structures were placed in strategic locations to minimize water from entering the combined sewer system through outfalls. It is worth noting that most stormwater outlets located along watercourses have been designed to function during pre-defined storm events, such as 100-year storm or regional storms events. Should extreme weather events exceed these pre-defined events, a risk exists that watercourse banks and/or stormwater outlets could become unstable and washout.

Municipalities typically rely on Provincial or Federal governments to develop infrastructure design standards, but currently there are no universal predictive models, comprehensive guidelines or policies for managing climate change that are accepted across the board. In the absence of having reliable climate change forecasts, there is no decisive criteria to apply to infrastructure design. Without suitable design criteria reflecting climate change forecasts and the infrastructure to support climate change weather patterns, the risks to public and private infrastructure increases.

Currently, the MECP is working on a stormwater design guideline which may provide further guidance regarding climate change. At present, the City's current design standards follow a conservative approach with the intent that infrastructure is built with some capacity reserve. These reserves are intended to address changes that may occur between the time the assets are designed to when the service area is fully built out. These reserves were never intended to address the significant capacity increases that will be required to address extreme weather events resulting from climate change.

Under the Climate Change Adaptation and Asset Management Pilot project, the City has partnered with other municipalities to determine climate change event probability and analysis, risk assessment and adaptation strategies. The objective is to apply a climate change lens on the current AM strategies in place, then develop climate change adaptation strategies for two asset classes, wastewater sewers and pumping stations. The data will be input into an AM Decision Support System to determine the financial impact of climate change adaptation and impacts to customers.

4) Levels of Service that the City Should Strive to Achieve and Funding Requirements

The City's SWMP must strive to achieve the necessary quality and quantity controls for stormwater that protect private and public infrastructure, the natural environment, and maintain compliance with legislation. As SWMPs are not regulated by the provincial government to the same degree as drinking water systems, there is no current legislated minimum level of service for certain elements of a SWMP, such as proactive maintenance for shoreline assets and drainage easements. It should be noted that the phasing in of legislation, such as O. Reg. 588/17 Asset Management Planning for Municipal Infrastructure, will define a minimum threshold for the level of service to be provided for certain assets.

Funding requirements for the City's current SWMP requires consideration of capital reinvestment and O&M reinvestment. Capital reinvestment refers to the funding requirements required for capital rehabilitation or replacement projects aimed at maintaining existing infrastructure in a state of good repair. O&M reinvestment refers to the funding requirements to keep infrastructure functional during the operations phase of the asset life cycle. Both capital and O&M reinvestment have industry established targets that, if applied, will ensure the SWMP has sufficient financial resources to function as intended.

As per the latest assessment completed in 2016, the total SWM asset replacement value at that time was approximately $1.46B, which is composed of $1.35B for linear SWM infrastructure, and $106M for non-linear SWM infrastructure. As identified in **Error! Reference source not found.** below, the City should allocate between $16.6M/year to $20.7M/year toward capital reinvestment to maintain assets in a state of good repair. The capital reinvestment rates are 1-3% and vary for different asset types and are in accordance with:

- Lower and upper limits of the Canadian Infrastructure Reinvestment Rates outlined in the City of Hamilton's 2016 assessment, as well as,
- Capital reinvestment rates identified by an engineering consultant's review of the $336M of stormwater assets managed by HW.

Information regarding annual O&M reinvestment rates from HW's assignment was applied to the asset inventory valuation outlined in the 2016 assessment. These O&M annual reinvestment rates range from 1-3%. Once a level of service across all stormwater assets is defined, capital and O&M reinvestment rates will have to be revisited in accordance with the most current industry targets. As identified in Table 2, the industry standard for O&M reinvestment rates would require $15.5M/year applied to all stormwater assets across the City in 2016.

Table 2 - Annual Capital and O&M Reinvestment Rates Based on 2016 Assessment

City of Hamilton Annual Capital Reinvestment Rates	Linear Stormwater Infrastructure	Non-Linear Stormwater Infrastructure	Annual Capital Reinvestment Rates
Lower Capital Reinvestment Limit	$13.5M/year	$3.1M/year	$16.6M/year
Upper Capital Reinvestment Limit	$17.6M/year	$3.1M/year	$20.7M/year
City of Hamilton Annual Level of Service O&M Reinvestment Rates		Annual O&M Reinvestment Rates	
Industry Minimum Level of Service		$15.5M/year	

Notes to table above:
1. Does not account for inflation.

The combined total for capital and O&M funding to support industry standard reinvestment rates from the 2016 assessment totals $32.1M/year - $36.2M/year. From an analysis of the five (5) year average, from 2016 – 2020, for actual capital and O&M investments, the SWMP has been underfunded by at least $10M/year - $14M/year over that time period.

Considering the growth of the system alone since the 2016 assessment was completed the funding requirements are anticipated to be significantly higher in 2021. These values will continue to change annually based on growth of the system. Other factors that are not included in the funding requirements are:

- Inclusion of unknown assets into the City's AM plan as they are discovered.
- SWM assets not captured as part of the 2016 assessment (i.e. watercourses).
- Closure of known gaps.
- Implementing climate change mitigation and resiliency measures.
- Discovery and closure of new gaps currently not known.
- New stormwater capital construction to address problem areas with insufficient measures currently in place, or to meet a desired level of service

5) Financing Alternatives

Hamilton's stormwater program is currently funded through the Wastewater rates and to a much lesser extent by property taxes. However, there are three (3) viable alternatives for financing the SWMP, each of which is described below.

a) Currently, the City's SWMP is principally funded through the combined Water, Wastewater and Stormwater Rate Budget (Rate Budget). However, the Rate Budget practices have not historically collected enough revenue to fund all of the annual needs across the water, wastewater and stormwater programs. As a result, on an annual basis some stormwater needs have been deferred, and some water and wastewater capital needs have also been deferred in order to provide funding for the stormwater programs.

   In order to adequately fund the needs across all programs, water and wastewater rates could be increased more steeply than historically forecasted and additional debt could be issued to support the capital program. General Issues Committee Report FCS21088 (2022 Recommended Water, Wastewater and Stormwater Budget), was submitted based on this premise and the recommended debt financing plan and increases in water and wastewater rates contemplated fully funding the stormwater program based on existing levels of service. This will resolve the annual underfunding of the SWMP and the deferral of capital needs, but there will a backlog of capital projects that remain to be addressed over time.

b) A dedicated stormwater rate would alleviate the challenge of funding the stormwater program from rates collected to support the water and wastewater programs. In addition, implementing a dedicated stormwater rate would introduce an element of equitability in how the City financially supports the stormwater infrastructure and related programs.

Report PW19109 (Stormwater Rate Program) was provided to the General Issues Committee in December 2019 to follow up on previous discussions on the sustainability of the SWMP. The Report identified that:

"The City's current stormwater funding structure is a combination of Wastewater rates, development charges, direct developer contributions and property taxes. Most of the funding comes from the rate revenues which are based on the metered drinking water consumption of those connected users. Approximately 3,300 accounts within the City, such as parking lots, do not have a wastewater connection and therefore do not contribute to the stormwater program through their rates. Furthermore, there are properties such as large commercial plazas where the volume of water consumption is not proportional to the stormwater services they receive."

The Report also outlined the results of a municipal scan which showed that other Ontario municipalities, such as City of Ottawa, City of Mississauga, City of Guelph, City of London and Town of Newmarket, have shifted to a more equitable and robust stormwater structure by implementing a stormwater rate program. There is no single funding mechanism that is a "best-fit" for every jurisdiction but implementing the dedicated stormwater rate-based financial strategy has allowed for better management of funding associated with stormwater maintenance and system enhancement.

c) A third alternative that is employed by some municipalities would be to transfer more of the costs associated with the City's stormwater program to the Tax Supported Budget, or to fund the SWMP entirely from the Tax Support Budget. This would alleviate the stormwater pressure on the Water, Wastewater and Stormwater Rate Budget, and may resolve the concerns about the equitability of collecting revenue to support the stormwater program based on the volume of potable drinking water used at a specific property.

   Municipalities that finance their stormwater programs entirely from the Tax Supported Budget include Halton Region, Durham Region, the City of Brantford, City of Cambridge and City of St. Catharines.

APPENDICES AND SCHEDULES ATTACHED

Appendix "A" to report PW21074 – Findings Summary: Review of Stormwater Evaluation Report