

Subject: Urban Flood Information Report

File Number: ACS2024-IWS-WL-0003

**Report to Environment and Climate Change Committee on 19 March 2024
and Council 3 April 2024**

**Submitted on March 8, 2024 by Susan Johns, Director, Asset Management
Services**

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Ward: Citywide

Objet : Rapport d'information sur les inondations en milieu urbain

Numéro de dossier : ACS2024-IWS-WL-0003

Rapport présenté au Comité de l'environnement du changement climatique

Rapport soumis le 19 mars 2024

et au Conseil le 3 avril 2024

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Quartier : À l'échelle de la ville

REPORT RECOMMENDATION(S)

That Environment and Climate Change Committee recommend that Council receive this report for information.

RECOMMANDATION(S) DU RAPPORT

Que le Comité de l'environnement et du changement climatique recommande au Conseil de prendre connaissance du présent rapport.

EXECUTIVE SUMMARY

Urban flooding may occur in the City of Ottawa during extreme rainfall events. Where and how frequent urban flooding occurs depends on a number of factors, such as the amount of rain that falls over a period of time, topography, the historical drainage systems, and the size of the storm and sewer pipes. Climate change and the growing number of extreme weather events also significantly impacts the city. The Infrastructure and Water Services Department (IWSD) is committed to ensuring the infrastructure is safe and reliant and is continuously working to improve the City's sewer and stormwater systems and implement innovative measures in response to previous floods and severe weather events in the city.

The City has invested and continues to invest in critical infrastructure. The purpose of this report is to outline the City's long-standing efforts to increase resilience to urban flooding. This report details the existing integrated systems, services and programs, continuous improvement measures and highlights key investments made by Council. These key investments total \$337.8 million to support flood mitigation and climate resilience efforts.

RÉSUMÉ

Des inondations urbaines peuvent se produire dans la Ville d'Ottawa pendant des épisodes de précipitations extrêmes. L'endroit et la fréquence des inondations urbaines dépendent d'un certain nombre de facteurs comme la quantité de pluie qui tombe pendant une période donnée, la topographie, le réseau d'évacuation historique et la taille des conduites d'égouts pluviaux et sanitaires. Les changements climatiques et le nombre grandissant d'épisodes météorologiques extrêmes ont aussi des répercussions importantes sur la ville. La Direction générale des services d'infrastructure et d'eau (DGSIE) est déterminée à faire en sorte que les infrastructures soient sécuritaires et fiables; elle s'efforce continuellement d'améliorer les systèmes d'égouts et de gestion des eaux pluviales de la Ville, et de mettre en place des mesures novatrices en réponse aux inondations et aux épisodes météorologiques violents antérieurs.

La Ville a investi et continue d'investir dans ses infrastructures essentielles. Le présent rapport vise à décrire les efforts qu'elle déploie depuis longtemps pour augmenter la résilience aux inondations urbaines. Ce rapport détaille les systèmes, services et programmes intégrés existants, et les mesures en place pour améliorer continuellement les choses. Il met également en évidence les investissements essentiels effectués par

le Conseil, d'un montant total de 337,8 millions de dollars, consacrés aux efforts d'atténuation des inondations et de résilience climatique.

BACKGROUND

On October 25, 2023, Council carried a [motion](#) directing staff to review initiatives and programs the City undertakes to prepare for and mitigate the impact of urban flooding. During the discussion on the motion, the Infrastructure and Water Service's General Manager offered to present an information report at Committee to further outline how the City prepares for, responds to, and mitigates the impacts of urban flooding. There is no single solution for protecting communities from floods, but this report details the existing integrated systems, services and programs, the measures in place for continuous improvement and highlights the key investments made by Council.

Ottawa faces two common types of flooding which are urban flooding and riverine flooding. Urban flooding includes:

- Runoff flows over the surfaces like streets, ditches, yards (also referred to as overland flooding) during a significant rainfall event
- Homes connected to the storm, sanitary or combined systems that surcharge (exceed capacity) during an event, resulting in stormwater or sewage back-ups into the basement.

The second type of flooding is riverine flooding which occurs when rivers overflow into the surrounding areas. This report speaks specifically to urban flooding from significant rainfall events, and not related to riverine flooding.

Similarly, though many stormwater solutions can have one or multiple objectives (such as reducing flooding impacts, improving water quality, etc.) this report primarily discusses solutions that aid in increasing urban flooding resilience.

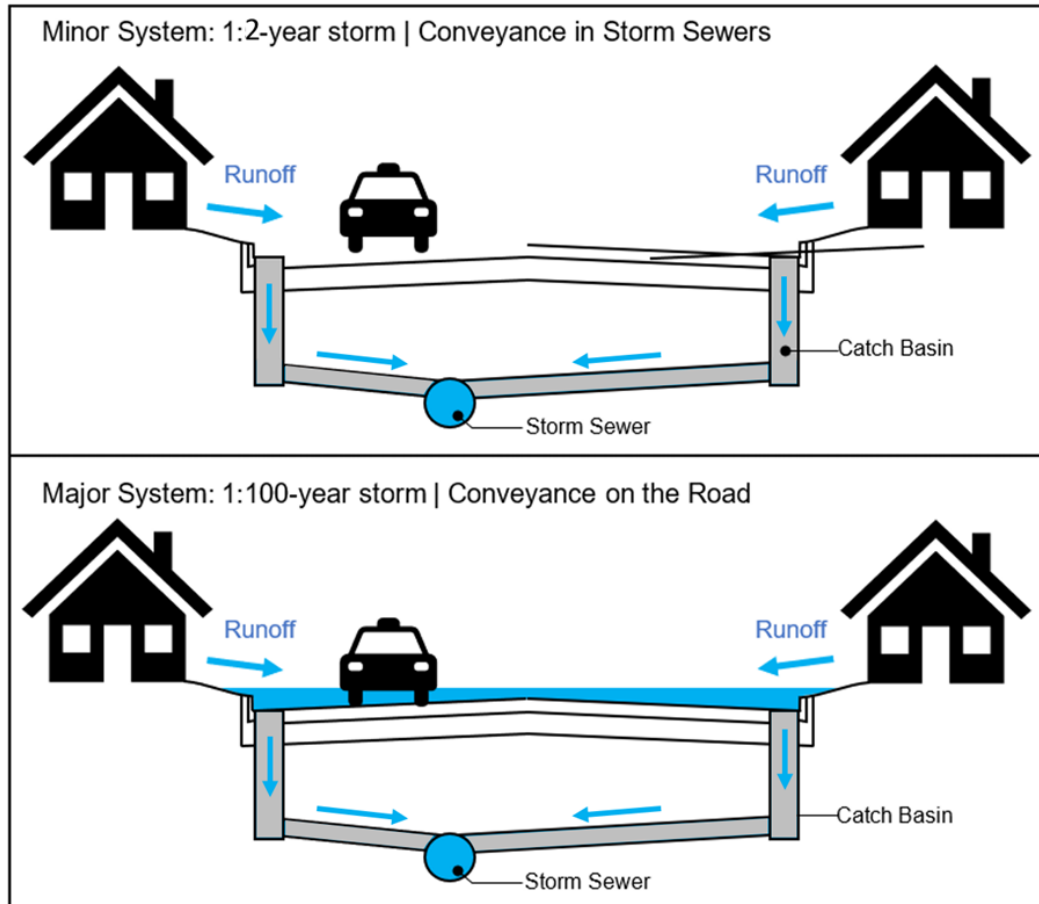
IWSD is responsible for \$72 billion in assets which include a complex inventory of [stormwater and wastewater collection assets](#). These assets include approximately 3,000 kilometres of storm sewers, 3,000 kilometres of wastewater (sanitary) sewers, 55 wastewater pump stations, 14 stormwater pump stations, nearly 1,700 outfalls, up to 6,000 kilometres of roadside ditches, three wastewater storage tanks, one combined sewage storage tunnel, 167 stormwater ponds, and 95 other stormwater facilities. These assets exist as measures to protect the public from flooding and protect the quality of our creeks and rivers.

Stormwater Drainage System

Figure 1 shows how the surface (the overland flow system) and underground drainage system work together to store and convey runoff in small and large events. The figure depicts a common type of drainage system in urban areas with curbs, catch basins, and storm sewers.

Figure 1 also demonstrates how large rain events, like August 10, 2023, involve complex interactions where many parts of the system can be overwhelmed at once and one type of flooding can trigger others.

Figure 1: Major Systems: 1:100-year storm



Storm sewers, ditches, and drainage on the surface work together as a system to drain the road. In large events, this system stores runoff in the road until it eventually reaches a creek, stream, or river. Newer neighbourhoods have careful design of house elevations, driveway slopes, storage, and conveyance on the road so that runoff from extreme events can reach a creek, stream, or river without causing flooding.

Older neighbourhoods were designed to the standards of their time, stormwater management is a relatively new field of design used today for newer neighbourhoods. All neighbourhoods, however, share one thing in common: there is no stormwater system (sewer, ditch, overland, and private property drainage) that will have capacity for every extreme event. It is impracticable to achieve or exceed the current design standard as our topography could not accommodate the pipe size required, and the associated cost in doing so would increase development charges, the cost of new home construction, and capital renewal budgets.

Capital Investments

Urban flood mitigation has a long history in Ottawa. Considerable capital investments in flood-prone areas over the past four decades have strengthened the infrastructure, ensuring enhanced resilience and preparedness for the future.

The City strives to improve the efficiency of our stormwater system through the annual capital renewal program. As a result of historical and recent urban flooding strategic investments, amounting to millions, many special projects have been completed. Some examples include the [Combined Sewage Storage Tunnel](#) (CSST) (\$232 million), Sandy Hill Storage Tank (\$19.8 million), Preston Combined Sewer System (\$25 million), West End Flood Mitigation (\$38 million), and Orleans Flood Mitigation (\$23 million). This investment totals \$337.8 million. The projects are outlined in further detail in Document 1.

Making improvements to the storm water and wastewater systems continues to be a focus. The City of Ottawa has a dedicated team of experts who are industry leaders in urban flooding, which positions Ottawa at the forefront of best practices and knowledge in managing and adapting to the challenges posed by climate change. Through complex and integrated measures and systems, the City continues to protect critical assets and residents' properties. The goal is to make infrastructure more resilient but also improve community resilience.

DISCUSSION

The current processes, practices, and solutions that the City of Ottawa employs to reduce the risk of urban flooding and increase resilience of properties, homes, and businesses involve multiple aspects of community design, infrastructure management, planning, risk assessment, and flood response. The discussion section of this report details the existing integrated systems, services and programs, and the measures in place for continuous improvement.

The following section outlines ongoing practices, programs and assessments used to address urban flooding and build resiliency within communities through:

1. Planning and Strategy
2. Community Design
3. Operations and Maintenance
4. Risk Assessment and Mitigation Programming
5. Preparation for and Response to Rainfall Events
6. Renewal of Infrastructure, Buildings, and Properties

1. Planning and Strategy

The City has a number of key plans, guidelines, standards, and strategies that address aspects of flood resilience related to growth and housing, lifecycle management of assets, and long-term system improvements.

The plans outlined in this section work together to address and provide guidance for flood resilience through design, lifecycle maintenance, and renewal and retrofit. The plans outlined include the Infrastructure Master Plan, the Asset Management Plans, the Climate Change Master Plan, and Various Wet Weather Plans.

Infrastructure Master Plan (IMP):

A goal of the Infrastructure Master Plan is to address climate-related impacts triggered by growth, while aligning with other city climate change actions and strategies. The IMP, along with the other strategic documents listed below, provide direction on how climate change is to be considered in follow-up work, such as infrastructure studies, design guideline reviews and capital upgrades.

The IMP generally considers climate change impacts triggered by growth under four broad categories including Infrastructure System Planning, Riverine Flood Risks, Community Resilience and Implementation and Operation.

Asset Management Plans (AMPs):

The Asset Management Plans are strategic City documents that provide a snapshot of current conditions and programs and establish a basis for future asset management planning and decision making. Though their focus is primarily the management of infrastructure assets, asset management plans provide the basis for understanding the levels of service that the assets provide and strategies for addressing current and future challenges including climate change.

Flood remediation and infrastructure renewal projects are planned under the City's asset management programs and are designed with consideration of extreme weather events that are projected for the future.

By July 1, 2025, Council must approve updates to the Asset Management Plans with a future focus that incorporates climate change considerations and other policies and goals to determine service levels, priorities, and financial forecasts. This review will allow Council to adjust service priorities or service levels in response to climate change, if endorsed and affordable.

Importantly, Asset Management Plans form the basis of updates to Long Range Financial Plans which will enable sufficient revenue to meet Council-approved targets.

Climate Change Master Plan:

The Climate Change Master Plan is the City's overarching framework to reduce greenhouse gas emissions and respond to the current and future effects of climate

change. Increasing resilience to extreme weather and climate change is a strategic objective of the [2023-2026 Term of Council](#).

As part of the City's efforts to prepare for climate change, the [Climate Projections Study \(2020\)](#) (ACS2020-PIE-EDP-0014) was developed in partnership with the National Capital Commission and Environment and Climate Change Canada. It uses advanced climate science modeling to predict changes in temperature, precipitation, wind, and extreme weather until the year 2100. Total rainfall will increase over the next decades, with heavy rainfall projected to increase by 15 per cent by the 2050s.

The City undertook a [Climate Vulnerability and Risk Assessment \(2022\)](#) to identify the top climate risks facing Ottawa. Flooding was identified as a top risk, including riverine flooding, overland flooding, and basement flooding. A more detailed [Climate Change Vulnerability and Risk Assessment \(2022\)](#) report (ACS2022-PIE-EDP-0019) was prepared specifically for the City's three water services (drinking water, stormwater, and wastewater) and for drinking water and wastewater plants to inform the Infrastructure Master Plan and future updates to the City's Asset Management Plans.

The Climate Resiliency Strategy is currently being developed. It is a long-term strategy that will contribute to the vision of the Climate Change Master Plan. The strategy will include actions at all stages of prevention, mitigation, preparedness, response, and recovery. To mitigate flooding risks, it identifies actions to build resiliency of City stormwater infrastructure to cope with future rainfall, support homeowners to reduce the risks of flooding, and strengthen flood planning and response. The draft strategy is currently available on [Engage Ottawa](#) and is expected to be brought to Council later in 2024.

Various Wet Weather Plans:

The [Ottawa River Action Plan \(ORAP\)](#) is a Council-approved plan consisting of 17 individual projects aimed at protecting Ottawa's water environment and ensuring the health of the Ottawa River.

A key ORAP project that has contributed to flood resilience is the Wet Weather Infrastructure Management Plan (WWIMP).

The WWIMP, adopted in 2013, manages wet weather flows and mitigates the adverse effects on our wastewater and stormwater collection systems. Additional issues addressed in this plan included basement and surface flooding, environmental protection, system operation and maintenance, and capacity for intensification. There are six sub-programs to the WWIMP, with the flood control program, sewer separation, extraneous flow management and capacity management programs being more directly connected to urban flood resilience.

The Flood Control Program proactively assesses flood-prone areas in order to determine root-causes of the flooding and provide solutions to mitigate against further flooding. Through this program, City of Ottawa water resources engineers developed

innovation in computer modelling of stormwater and wastewater systems, implementation of inlet control devices, and the creation of the City-Wide Flood Risk Profile.

The City also continues to achieve sewer separation, where topography allows, by replacing and/or rehabilitation of combined sewers with separate sanitary and storm sewers.

Since Council approved the plan in 2010, staff have leveraged multiple benefits from the WWIMP and integrated that 'wet weather lens' into many other master plans and programming, such as:

- The city-wide Flood Risk Profile
- Dual drainage studies and subsequent infrastructure retrofits
- Sanitary flood studies and subsequent infrastructure retrofits
- The Stormwater Asset Management Plan
- The Climate Change Risk and Vulnerability Assessment
- The Infrastructure Master Plan - Capacity Management Program, Onsite Stormwater Management Program
- Sewer separation completed through integrated renewal
- Combined sewer flood control studies and subsequent infrastructure retrofits

2. Community Design

What we have learned from older neighbourhoods is that the way we build communities matters. The planning and design process set critical components on the system and are difficult, or impossible, to change after construction (e.g., house elevations). Such components are considered in the sewer design guidelines for new communities, which specifically account for flood resilience and climate change. New communities also benefit from higher level studies such as sub-watershed studies and master servicing studies that help to guide the subsequent design process for flood resilience and other objectives.

3. Operations and Maintenance

The ongoing maintenance of the City's sanitary, storm and combined infrastructure is critical as it ensures the city's stormwater system is operating in optimal state and prevents additional flood risks. The City has an ongoing proactive maintenance program to inspect, clean and repair sanitary, storm and combined infrastructure.

There is an extensive inspection program for all sewers to ensure regular inspection and correction of any discovered issues. The inspections are completed on a five-year

cycle as not all sewers can be inspected every year. If an issue is identified from an inspection, the severity and risk are considered and appropriate action is taken. This could mean immediate action or action at a future date. The asset management program uses these condition assessments to plan future rehabilitations or renewal projects.

4. Risk Assessment and Mitigation Programming

The City completes risk assessments for infrastructure and neighbourhoods to help plan and design mitigation solutions for ditches, storm sewer flooding, sanitary sewer flooding, and overland flooding. Risk assessments help the City to identify and quantify risks, and develop, prioritize, and implement mitigation measures. Mitigation measures can be implemented through various means.

Several improvements, for example, have been accomplished by integrating flood mitigation into mature asset management and replacement programs. Sewer renewal and integrated road-sewer-watermain renewal can provide opportunities to upgrade infrastructure to manage and convey runoff for very little additional cost above base renewal costs. This benefit only exists when the asset (e.g., pipe) is already at the end of its structural life and must be replaced.

Some of these renewal opportunities are simple modifications to sewers, such as upsizing old sewers to today's minimum pipe sizes or separating sewage and stormwater piping in combined sewer areas.

Further improvements have been made by assessing dual drainage capacity. Dual drainage refers to the phenomenon that rainfall in urban areas is conveyed on the surface (i.e. driveways, roads, ditches, and so on) and in the underground infrastructure (i.e. storm sewers and sanitary sewers). Dual drainage studies have been completed to develop mitigation plans that can include inlet control devices, inlet capacity modifications, and storm pipe upgrades. Dual drainage studies have also been used to identify surface flow management improvements, such as diversions, storage, and driveway humps. The studies allow for analysis to assess the impact of modifications underground to the performance of the above-ground system. This way solutions do not solve one problem only to create another.

Increasing flood resilience requires larger projects and many smaller, local scale projects. Staff have completed many more small, local scale projects such as local pipe upgrades, installation of inlet control devices, sewer lateral repair, maintenance hole rehabilitation, and catch basin upgrades.

5. Preparation and Response to Rainfall Events

Response to Rainfall Events:

Depending on the severity of the rainfall event, IWSD deploys resources to coordinate response efforts to provide intervention and public assistance. IWSD is responsible for the development of plans and procedures to coordinate the prioritization, protection, and resumption of the City's critical infrastructure. Also, in conjunction with other partners,

IWSD is responsible to protect and sustain the natural resources and environment. For extreme events, IWSD will support the City's response to situations through the Emergency Operations Centre, as per the Municipal Emergency Management Plan.

After a flooding event, Asset Management Services in IWSD conducts a thorough analysis and data review using modelling tools to understand the cause of the flood. After an initial analysis, staff develop next steps and proceed with further investigations, analysis, and conduct follow-up studies. These analyses support future decision making for asset management planning and renewal.

IWSD will continue to provide Councillors and residents with information and resources that will help prevent flooding, but also support those in the event of an emergency. IWSD, in working with Emergency Protective Services (EPS), has reviewed, updated, and consolidated all flood information on Ottawa.ca and has relocated the information to a centralized location.

Staff are continually seeking opportunities to improve the City's flood response activities to find ways to better and more efficient ways to inform and support residents before, during and after a flooding event.

Preparation for Rainfall Events:

As described in Section 4 (Risk Assessment and Mitigation Programming), the City has many strategies to prevent urban flooding of public infrastructure. However, rainfall can affect private properties if there are deficiencies in private infrastructure. The following outlines programs that are intended to aid homeowners prepare for rainfall events:

Residential Protective Plumbing Program:

The [Residential Protective Plumbing Program](#) (RPPP) provides financial assistance to qualified City of Ottawa property owners for the installation of protective plumbing devices, such as sump pumps and storm and sanitary backwater valves to prevent water and sewage from flooding homes as a result of increased water level (surcharging) in the City's sewer system. Even the newest neighbourhoods with the most modern design standards may require protective plumbing devices to achieve flood resiliency.

While the program has been successful, staff will be reviewing program eligibility criteria, the program application process, and evaluating the program to determine how it can best be used to support properties that are affected by flooding.

As per the motion carried at Council on October 25, 2023, staff will report back in Fall 2024 with proposed revisions to the Residential Protective Plumbing By-law and program.

Rain Ready Ottawa:

[Rain Ready Ottawa](#) is a pilot program that offers home assessments to help property owners find ways to better manage rainwater on the property. Rebates up to \$5,000

may be available to help install rainwater management projects (i.e. downspouts, permeable pavements, rain gardens). Though this is not an urban flood control program, improvement of drainage on private property does contribute to resilience in small events.

After an extreme rainfall event has occurred, the City has programs and activities to provide support in flood recovery.

The pilot program is currently being reviewed with a report to Committee and Council expected in spring 2024.

Compassionate Grant Program:

Residents affected by flooding three or more times could be eligible for a grant of up to \$1,000 under the [Residential Compassionate Grant](#) policy for sewer backups.

In response to a rainfall event, the City has many emergency plans and response teams who are activated. The City has a team available to the public 24/7 to respond to water and wastewater emergencies.

In coordination with the review of Residential and Protective Plumbing Program, staff will return to Committee and Council in Fall 2024 with recommendations for both programs.

6. Renewal of Infrastructure, Buildings and Properties

With the information collected through extreme events, studies, and condition assessments, the City is continuously planning and implementing integrated road, sewer and water projects, and standalone drainage projects which contain flood protection components. These street-by-street improvements form part of broader, long-term strategies to reduce flooding. This is an important component to implement flood resilience measures. The City is working on improving standards so that flood resilience can also increase through smart re-development of buildings and properties.

Current practices for re-development typically include application of modern grading standards, disconnection of foundation drains from sanitary sewers, and complete replacement of storm and sanitary service laterals. All these measures act as a conduit to keep water away from homes to reduce the risk of flooding.

Council has invested in various renewal projects to improve flood resilience. Some of the key Council investments totaling \$337.8 million have been highlighted in Document 1 of this report.

Conclusion

As this report has outlined, the City has many effective processes and programs in place that all contribute to flood mitigation efforts. Infrastructure sustainability, protecting the natural environment, and public safety remain top strategic priorities for IWSD. For decades, IWSD has had a forward-thinking approach and the efforts made over the

years have reduced the impact of extreme rainfall events. Each rainfall event is unique it provides opportunities to evolve the stormwater system and mitigate the impacts of climate change.

FINANCIAL IMPLICATIONS

There are no financial implications associated with this information report.

LEGAL IMPLICATIONS

There are no legal impediments associated with Committee and Council's receipt of this report for information.

COMMENTS BY THE WARD COUNCILLOR(S)

This is a city-wide report.

CONSULTATION

This report is for information only; therefore, no consultation is required.

ACCESSIBILITY IMPACTS

All actions taken by the City of Ottawa in response to urban flooding will follow the City's accessibility legislative framework including the requirements of the *Accessibility for Ontarians with Disabilities Act (2005)* and the *Integrated Accessibility Standards Regulation, 191/11*, as well as meet the City of Ottawa's Accessibility Design Standards to the greatest extent possible.

Staff recognize that while everyone in Ottawa is impacted by climate change, including flooding, people with disabilities are disproportionately impacted due to increased exposure to climate hazards. Additional impacts can be experienced through reduced physical and mental health, financial pressures due to property damage, and food insecurity. Impacts can also be experienced through reduced safety, comfort and convenience, and increased barriers to opportunities, and resources. As such, staff will continue to work with those in Emergency and Protective Services and Ottawa Public Health to ensure information, resources and supports, including financial supports as outlined in this report, are in place for people with disabilities impacted by urban flooding.

Finally, all public information regarding the City's flood response, including emergency information and available resources, shall be available in accessible formats and with communication supports, upon request, and that all web content posted on ottawa.ca will conform with the Web Content Accessibility Guidelines, level 2.0 AA.

ASSET MANAGEMENT IMPLICATIONS

The report describes existing practices and upcoming plans that are part of (and feed into) the City's Comprehensive Asset Management Program, which support the guiding principles in the Comprehensive Asset Management Policy. Since this report only

describes the current state of urban flood mitigation in Ottawa, it does not have an impact on the City's physical assets.

CLIMATE IMPLICATIONS

Rainfall and flooding are expected to be strongly influenced by climate change. Intense rainfall is projected to increase by 15 per cent by the 2050s (as per the Climate Projections for the National Capital Region). Urban flooding was identified as a top risk to communities in the City's Climate Vulnerability and Risk Assessment (2022). The City of Ottawa has incorporated climate change into design standards such as the Sewer Design Guidelines for a long time. Future rainfall is also routinely included in computer modelling used to assess risks and plan flood mitigation and retrofits. Additional initiatives to prepare for flooding, and reduce the impacts where possible, are being considered in the City's Climate Resiliency Strategy and associated initiatives.

ENVIRONMENTAL IMPLICATIONS

This is an information report and, as such, there are no report recommendations. Urban flooding has impacts on public health through exposure to sources of disease (sanitary basement flooding), and the socioeconomic pressures, and negative mental health outcomes.

TERM OF COUNCIL PRIORITIES

The programs, services and assessments outlined in this report support the

2023-2026 Term of Council Priorities of:

- A city that has affordable housing and is more liveable for all;
- A city that is green and resilient

SUPPORTING DOCUMENTATION

Document 1 - Description of Capital Investment Projects

DISPOSITION

The Infrastructure and Water Services Department will implement any direction arising from consideration of this information report, in consultation with other departments, as appropriate.

Document 1 – Description of Capital Investment Projects

Combined Sewage Storage Tunnel (CSST) - \$232 million:

The CSST functions as an underground storage system for surface runoff water and wastewater (combined sewage) until it may be treated at the Robert O. Pickard Environmental Centre (ROPEC) and returned safely to the Ottawa River. During a rain event, the CSST has significantly reduced the volume of combined sewage overflows ([CSOs](#)) to the Ottawa River by approximately 18 Olympic-sized swimming pool and has reduced the risk of basement flooding for approximately 7,000 residential properties in the Glebe and Centretown.

Sandy Hill Storage Tank - \$19.8 million:

The Sandy Hill Storage Tank project, completed in 2009, is an award-winning system that consists of a 12,000 meters³ underground combined sewage storage tank topped with a 4,000 meters³ dry pond for managing excess stormwater runoff. This system has protected our rivers from combined sewage overflow during rain events, has directed runoff water to the storage tank which has prevented basement flooding in the area, and finally, has enhanced the local community parkland with natural landscapes.

Preston Street Combined Sewer System – \$25 million:

During rainfall events that exceed the piped system's capacity, excess water surcharged the sewers and drained overland to other outlet locations (Dow's Lake, Brown's Inlet) and accumulated in low lying areas becoming a flooding hazard to adjacent properties. The solution was upgrading the Preston Street trunk sewer along Preston Street, creating a storm water management facility in Plouffe Park, implementing storm water management in the entire drainage area to limit the runoff entering the combined sewer system, and installing new storm sewers at key locations to convey excess runoff to surface outlets. This solution was challenging since new storm drainage to the Rideau Canal System was not permitted and the area had to remain combined. Construction was undertaken in the late 2000's, providing a level of service greater than 50 years in most locations.

West End Flood Mitigation - \$38 million:

On July 24, 2009, parts of the City experienced a significant rainfall (over 100 millimeters of rain in a 24 hour period) that resulted in nearly 1,500 flooded basements. Studies found that several factors contributed to widespread occurrences of flooding and sewer backups. After a large-scale investigation in Kanata South, Kanata North, Stittsville and Carp, numerous solutions have been implemented in the years following:

- Inlet control devices were installed in catch basins to limit the flow entering the storm sewer system and reduce surcharging.
- Storm sewers were upgraded in areas where bottlenecks were identified. In some cases, new sewers were constructed to promote efficiency in the system.

- The Glen Cairn Storm Management Facility was isolated from the Carp River using valves and the facility was expanded to reduce its water level during critical events.
- Sanitary maintenance hole covers were replaced with watertight covers.
- An overflow system was constructed at the Hazeldean sanitary pumping station to protect basements in the Glamorgan Drive area.
- Sanitary sewer pipes were upgraded at areas where bottlenecks were identified or where efficiencies could be achieved.
- A protective plumbing program was implemented in the affected areas.
- Berms along Cattail Creek were constructed to protect yards backing onto the creek. Ditches were rehabilitated in the Katimavik area.

Orleans Flood Mitigation - \$23 million:

On July 3, 2006, and subsequently August 2, 2006, part of the Orleans area was hit with significant rainfall events. During both events, ponding occurred on some City streets as well as on private property, but most of the flooding reports were due to a surcharging storm sewer system that backed up water around weeping tiles and entered homes via cracks and joints. Solutions were implemented by late 2000's that reduced sewer surcharge and managed excess surface runoff, so much so that in 2011 a similar storm hit the area with no basement floods reported. Additional solutions included:

- Inlet control devices were installed in catch basins to control the inflow to the storm sewer and thus reduce surcharging.
- High level storm sewers were constructed to drain low lying areas.
- Surface modifications in the form of street grading and park storage were also implemented to manage surface runoff.