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CSO Master Plan

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CSO Master Plan

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Executive Summary

Technical Background

This document presents the final submission for the City of Winnipeg's (City's) Combined Sewer Overflow (CSO) Master Plan. The CSO Master Plan started as a three-phased study in 2013. The first two phases were completed and reported on in the CSO Master Plan Preliminary Proposal (Preliminary Proposal). The first phase identified and developed potential plans for five alternative CSO control limits. The benefits and costs of each alternative were evaluated and ranked through a scoring process in the second phase with "Control Option No. 1 – 85 Percent Capture in a Representative Year" being ranked the highest. A Preliminary Proposal based on the first two phases was submitted to Manitoba Sustainable Development (MSD) before the December 31, 2015, submission date, with a recommendation to proceed with Control Option No. 1.

Following its review and further clarifications, the Preliminary Proposal was approved by MSD on November 24, 2017. This initiated the third phase of the CSO Master Plan, requiring submission of a CSO Master Plan by August 31, 2019, and completion of the program implementation by December 31, 2045.

The November 24, 2017 response from MSD included additional conditions for phasing in Control Option No. 2 – Four Overflows in a Representative Year. This will have significant impacts on the overall program in the future. Migration to Control Option No. 2 was included in this CSO Master Plan submission as a high-level descriptive review.

Technical Approach

The CSO Master Plan will provide a road map for implementation of a long-term program to reduce CSOs. As a planning document, it provides initial concepts and high-level costing. It is intended to be a living document that will be revised with updated planning information and more detailed engineering evaluations as the program proceeds. The district engineering plans (DEPs) meet the intent of the detailed engineering plans requested in the Environment Act Licence No. 3042 (EA No. 3042) and are included as Part 3B. The DEPs are considered planning level from an engineering and cost estimating perspective.

Design Basis

The CSO Master Plan is designed to take the current sewer system from an estimated 74 percent capture rate to an 85 percent capture rate based on the 1992 Representative Year. This has been modelled to be equal to an additional 2.3 million cubic meters of combined sewage being captured and treated based the 1992 Representative Year. The major considerations in the design of a CSO Master Plan that meets the requirements of EA No. 3042 are identified in the following subsections.

Baseline Conditions

The CSO Master Plan was developed with 2013 as the baseline year. This included existing hydraulic models and relevant reports. The hydraulic model was initially developed as part of the Preliminary Proposal with this 2013 baseline data. Updates were made to the hydraulic model for the CSO Master Plan development to correct errors in the data sets that were made available.

Planning Projections

Planning projections account for population growth that may affect the future performance of the CSO program. The use of combined sewers in new developments has been prohibited for over half a century, so no growth or enlargement of the contributing combined sewer area is anticipated. Growth that will impact the CSO program comes from densification and redevelopment within the combined sewer districts, and from outside the combined sewer area that affects the shared capacity of Winnipeg's three sewage treatment plants.

Planning projections for the CSO Master Plan were adopted from studies applied to the most recent sewage treatment plant upgrade projects. The available projections considered growth to 2037 and general allowances for a longer-term design horizon to 2067. The increased capture associated with the CSO Master Plan utilizes additional treatment capacity that may have been used to accommodate growth in the separated areas. The CSO Master Plan utilizes controls that provide temporary storage and controlled dewatering rates to mitigate this decrease in capacity at the treatment plants.

Clause 8 of EA No. 3042 requires no increase in the frequency or volume of CSOs in any combined sewer area due to new and upgraded land development. The City reviews all proposed new developments and proposed redevelopments in the combined sewer (CS) system to ensure that post-development peak wet weather flows (PWWF) are equal to or less than pre-development PWWF, in order to demonstrate compliance with Clause 8. In consider of this, while growth is expected to occur in combined sewer areas, there will be no impact on the flows received on CSOs. As a result, for hydraulic modelling purposes the planning projections were not applied to increase flows generated from combined sewer districts. The planning projections were instead applied to project the increase in sewage flow from the separate sewer areas alone, as they do not have these flow restrictions.

CSO Control Technologies

There are two broad classes of technologies used for CSO control—grey and green infrastructure. Grey infrastructure refers to the conventional infrastructure projects such as sewer pipes or storage tanks. Green infrastructure (GI) refers to those that use natural hydrologic processes to keep rainwater out of the sewer systems entirely. The CSO Master Plan focuses on traditional and well established grey infrastructure. The Master Plan also includes opportunities for green infrastructure, specifically to provide resiliency on potential impacts of climate change on the long term precipitation trends.

Technologies were evaluated for each combined sewer district and proposed based on CSO volume reduction and cost.

Performance Target

Control Option No. 1 – 85 Percent Capture in the Representative Year was the highest ranked of the five control options considered in the first phase and was recommended and approved by MSD for implementation. Upon implementation, it will increase the percent capture in the representative year from the current level of 74 percent to 85 percent. The parameters for Control Option No. 1 provide the basis for how the CSO projects are identified and developed into a program for long-term implementation.

Control Option No. 1 requires that 85 percent capture be achieved for a representative year on a system-wide basis. It does not set limits for the number of overflows or volume of discharge from individual districts, only that the 85 percent capture performance target be met.

Representative Year

The representative year provides the foundation for the technical evaluations, planning, design, and future compliance reporting, and it is fixed for the program duration. The long-term records of annual precipitation were reviewed during the first phase, with the year 1992 selected as the representative year. No further investigations or modifications to the representative year were made for this submission. River flows were also reviewed and 1992 was found to be within the normal range and suitable for use as the representative year river level.

The representative year is applied uniformly on a system-wide basis for the evaluations and design. This assumes uniform rainfall occurs on all districts at the same time. The representative year provides a useful analytical approach; however, because this exact pattern of precipitation will not happen in nature.

The performance of the combined sewer system in comparison to the representative year cannot be measured directly by site monitoring, and the methods for tracking and reporting compliance must be established accordingly.

The representative year rainfall is applied within the InfoWorks software for drainage system modelling. The CSO volumes have been estimated for the existing conditions by simulating the runoff from the representative year precipitation. Future performance is estimated by adding the CSO program updates to the configured model. Since actual rainfall and CSO events are not used in the analysis, or defined in the metrics, compliance with the program is tracked by the degree of project implementation. The impacts of climate change on the continued use of 1992 representative year will be evaluated through the CSO Master Plan implementation.

The river level used for evaluation of the control options was based on the normal summer water (NSWL), typically used in the design and evaluation of sewers in Winnipeg. Results from the modeling exercise using the NSWL are similar to the results using the 1992 river levels. As such, the NSWL levels were used in the evaluation of compliance with EA No. 3042.

Percent Capture Calculation

Percent capture is the key metric for the program design and compliance. Percent capture is calculated as the volume of wet weather flow (WWF) treated in comparison to the total volume of WWF collected. The calculation incorporates the definitions as stated in EA No. 3042 and as agreed to with MSD during development of the CSO Master Plan. In general, the calculation can be applied as shown in Figure ES-1.

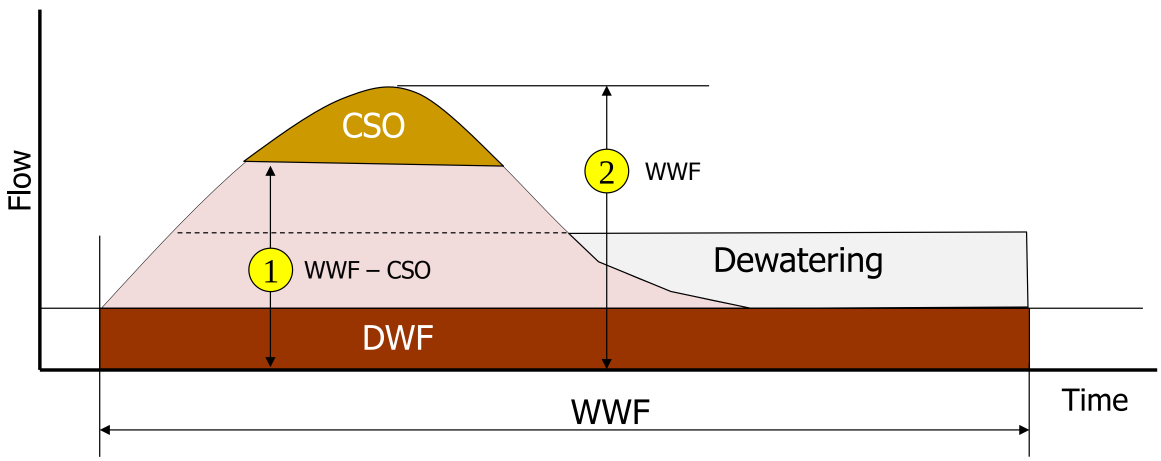

Figure ES-1. Percent Capture Representation

The concept is for the volume represented in Item 1 to be divided by the total volume represented in Item 2 of the figure, with the results represented on a percentage basis.

It should be noted that the percent capture is for WWF specifically, and not for CSO capture alone. WWF is defined as the runoff collected from precipitation along with the dry weather flow (DWF) generated over the wet weather period. CSO is the only component not treated and provides the final factor for the calculation.

The duration of the WWF event was included in the clarification and affects the volume of DWF used in the calculation. The DWF contribution begins upon the start of WWF and terminates at the end of the captured combined sewage dewatering period or WWF treatment period.

Dewatering Strategy

The CSO Master Plan will significantly change the amount and methods by which combined sewage is captured when fully implemented. The current use of diversion weirs installed in Combined Sewer (CS) trunks will be replaced by control gates and temporary storage to capture larger volumes. After the rainfall event, the captured combined sewage will be gradually released back into the interceptors and directed to the sewage treatment plants (STP). This release process is referred to as dewatering. This will be off-set by the sewer separation of select districts, where the WWF flow within the street sections of the district will be removed from the combined sewage and thus reducing the captured combined sewage volume in the corresponding interceptors and treatment systems.

Dewatering rates were determined for each district based on the CSO control options selected and the requirement for dewatering to be completed within 24 hours after a rainfall event has stopped, as required by EA No. 3042. The analysis indicated that the existing pumping stations will meet the dewatering capacity requirements. Even though there will be a larger volume pumped for some rainfall events, the maximum rate of pumping required is less than or approximately equal to what currently exists. The existing pumps will then be required to run for longer durations at a constant rate. The analysis also indicated that the gravity discharge districts meet the dewatering capacity requirements.

Collection System Modelling

The technical approach for the CSO Master Plan made extensive use of computer simulation modelling of the collection systems. This included creating representative models for the entire collection system using InfoWorks CS software. Two sewer system models were developed covering the entire CS and separate sanitary sewage collection systems. These were the Global and Regional models. The Global model included all pipes, while the Regional model is a more streamlined representation of the sewer system for modeling and analysis purposes.

The Regional model developed for Control Option No. 1 of the Preliminary Proposal formed the basis of the evaluation completed for this phase of the CSO Master Plan. The model was updated to incorporate changes the City had made to its version of the Preliminary Proposal model between 2013 and 2019. An increased level of detail was added for the control options in the hydraulic model. Additionally, minor changes identified during the control solution model evaluation and DEP development were added as appropriate.

Project Development

A project is considered an individual control option, such as an off-line tank or control gate construction, that has been proposed to increase the level of CSO capture. An evaluation was completed within the hydraulic model for each CS district to identify suitable control options. An individual district model was used for this assessment. The control options proposed for the individual districts were added to the Regional model to assess the system-wide performance. The system-wide evaluation lead to further refinements at the district level. Once the project selections were confirmed and the system-wide performance achieved 85 percent capture in the 1992 representative year, the final projects were recommended for each combined sewer district.

Control Option Selection Summary

A summary of the project selection is as follows:

- **Sewer Separation:** The sewer separation projects initiated or underway as part of the CSO and basement flood relief (BFR) program have been recommended to continue. These projects have tangible benefits, and the separation option will provide the added benefit of CSO mitigation over and above the BFR objectives. These projects encompass a large component of the total capital costs for the CSO Master Plan program. Previously committed sewer separation projects will continue in the following 5 sewer districts:

  - Cockburn
  - Ferry Road
  - Riverbend
  - Parkside
  - Jefferson East
- **Additional Separation:** The evaluation recommended 10 additional districts where the benefit/cost ratio of sewer separation was greater than that for alterative means using grey infrastructure to achieve the same level of volume capture. The additional separation has a higher initial capital cost but will have lower long-term O&M costs when structured such that a district is completely separated.
- **In-line Storage:** In-line storage accesses the storage volume already available in the existing combined sewers. It is maximized by installing a control gate that increases the interception weir height temporarily, to store additional combined sewage during rainfall events. The in-line storage control gate lowers the interception weir height to the levels currently provided during particularly high rainfall events, to avoid increasing the risk of basement flooding. The evaluation recommended 22 districts for in-line storage via control gate construction. In-line storage will use the existing pump stations where available. For the 10 districts that do not have sewage lift stations, gravity flow controllers are recommended to control gravity discharges to the interceptor.
- **Floatables Screening:** The approach used for floatables screening was to include an off-line screening facility at every primary outfall when hydraulic and operational considerations would allow for it**.** This off-line screening approach for first-flush screening has been recommended for 25 districts.
- **Latent Storage:** The storage volume currently available in relief sewers with separate outfalls is referred to as latent storage and, in most cases, can cost effectively be accessed with the addition of a lift station. The lift station will then convey the combined sewage temporarily stored in these relief sewers back to the combined sewer system. Latent storage has been recommended for 14 districts.
- **Off-line Storage:** Off-line storage is considered as new sewer infrastructure that adds additional temporary storage capacity to the system. Both off-line tank and tunnel storage were considered in the evaluations. Tunnel storage was identified as the preferred option for use where additional storage was required to reach the 85 percent capture metric. Off-line tunnel storage may be used interchangeably with off-line tank storage but has the advantages of being easier to locate and having lower O&M costs. Off-line tunnel storage was recommended for 1 district.

Program Cost Estimating

The proposed control options for each sewer district form the basis of the overall capital cost and operation and maintenance (O&M) cost estimates. Cost estimating followed the same approach as in the Preliminary Proposal, including use of a parametric estimation tool. The Program Alternative Cost Calculator (PACC) tool provided planning level costing information of commonly used CSO control technologies based on other similar completed projects. Refinements were made to the control solution cost curves and the baseline year was adjusted to 2019. The cost estimation process is further described in the Basis of Estimate Technical Memorandum included as Appendix C.

The estimates are considered to be Class 5 in accordance with the Association for the Advancement of Cost Engineering (AACE) International estimating standards. The classification is based on the level of project definition, with the CSO Master Plan being a program with multiple projects, with low levels of definition for each project.

The estimates for each control solution were based on the following general principles:

- Local costs were applied where local estimates were readily available for items such as sewer and chamber installations.
- Standard unit rates from Winnipeg experience were used to estimate and quantify the sewer separation work.

- A parametric cost estimation tool was used for generating costs for other technologies that have not been previously applied in Winnipeg. This tool utilized projects completed in other cities and applied correction factors to adjust to expected Winnipeg conditions.
- The estimate capital costs then include capital cost mark-ups of 53 percent. Program management costs are included within the construction cost markup values.
- A 10% allowance was then applied to these estimated capital costs, to provide funding for future green infrastructure projects.
- Finally, the upper range of Class 5 conceptual estimates of +100% was applied to the estimated capital costs for the program implementation planning and budget evaluations. This also provides an allowance for unknown capital costs, such as potential land acquisition, consequential works, and costs associated with risks not directly identifiable at the conceptual planning stage.

O&M costs were also estimated for the proposed control options for each sewer district. O&M costs were used for lifecycle evaluations and comparisons of different control option selections.

Program Cost Overview

The capital cost estimate for the CSO Master Plan is summarized in terms of 2019 dollar values in Table ES-1:

Table ES-1. CSO Master Plan Capital Estimate

Item	2019 Capital Cost Estimate
Class 5 Estimated Capital Costs	$1,045,800,000
Green Infrastructure Allowance/ Climate Change Resiliency	$104,600,000
Subtotal – Capital Cost Estimate	**$1,150,400,000**
Class 5 Estimate Range of Accuracy: -50% to +100%	$575,200,000 to $2,300,800,000
Total Capital Cost for Budgeting Purposes	**$2,300,800,000**

The total capital cost estimate in terms of 2019 dollar values with all markups and the GI allowance included comes to $1,150,400,000.

The expected accuracy range for a Class 5 estimate is from a low of minus 50 percent to a high of plus 100 percent. This results in the range of estimates as shown in Table ES-2.

Table ES-2. CSO Master Plan - Expected Range of Capital Costs (2019 dollar values)

Estimate	Minimum (-50%)	Maximum (+100%)
$1,150,400,000	$575,200,000	$2,300,800,000

Program costs do not include the following:

Capital investments within the CSO and BFR program committed following the Preliminary Proposal submission, and prior to the submission of this CSO Master Plan.

WWF treatment upgrades ongoing or planned at the sewage treatment plants within the City of Winnipeg.

O&M costs, except as used for net present value comparisons. O&M costs are to be budgeted separately in the City's operating budgets.

The CSO program does not include replacement or rehabilitation of the existing combined sewer infrastructure. A long-term program will be required to continue in parallel with the CSO program for it to be maintained in a condition suitable for it to function with the CSO program upgrades.

District Engineering Plans

The District Engineering Plans (DEPs) are intended to provide a summary of existing sewer district information and describe the proposed CSO Master Plan projects. The DEPs are developed to a conceptual level of detail and will provide the basis for defining the scope of work for future upgrades. It is expected that each project will undergo preliminary and detailed design prior to construction. The DEPs have been prepared as individual reports for each district, and are meant to be living documents, which will be maintained and updated throughout the program as CSO projects are completed and district information changes.

Project Data Collection and Documentation

Project information was collected, developed, and tracked from the Preliminary Proposal through to the third phase of the CSO Master Plan. Technical information has been compiled and transferred to the City in digital format including the InfoWorks model database.

Program Development

Program development is the process of defining the CSO Master Plan program details. It begins after project development, with projects meeting the performance requirements having been identified and evaluated, and capital and operational cost estimates prepared for each project. Program development considers the project sequencing approach for the long-term implementation.

Program Criteria and Constraints

The following criteria and conditions have been identified through the CSO master planning process as having a direct impact on the scenario definitions, their evaluation, and how they impact the program:

- **Regulatory Requirements:** The primary objective of the CSO Master Plan is to achieve compliance with the regulatory requirements, with the two key requirements being CSO capture and implementation schedule.
- **Water Quality:** Since all the scenarios will achieve the same water quality improvements, there is little differentiation between the scenarios. The main consideration is that the extended implementation schedule due to lower funding levels means there will be a delay in achieving the projected water quality improvements.
- **Affordability:** The City's Water and Waste Department finances its capital and operating budgets for the sewer utility on a user-pay basis through water and sewer rates. The City takes a long-term view of rates to provide stability for its rate-payers. The rates have steadily been rising for several years and are expected to continue to rise because of major obligations for sewage treatment plant upgrades, and replacement and refurbishment of aging infrastructure. However continuous increases in rates to support these capital projects are not sustainable. The City has determined that the upper threshold for the CSO program funding should be no more than $30 million per year in order to maintain affordability of water and sewer rates. This has therefore been set as a funding constraint for the CSO Master Plan program.
- **Funding:** Timeframes to achieve completion of the program are directly related to the level of funding committed. The Clean Environment Commission hearings (CEC, 2003) recommended one-third equal shared funding among the three levels of government for upgrading the City's wastewater collection and treatment systems in order to complete the work in a reasonable amount of time. Therefore, the CSO Master Plan implementation period has been evaluated with three funding scenarios representing funding commitments from either one or both of the senior levels of

government. A third scenario considering no funding from either level of government is also considered.

- **Committed Sewer Separation Projects:** Several major projects have been initiated or are well underway in CS districts for upgrading of the level of basement flooding protection with the use of sewer separation, which also reduces CSOs. These projects were part of a previously approved program and align with the CSO Master Plan.
- **Technology Validation:** The CSO program has identified several cost-effective control technologies using grey infrastructure, however many of these technologies have not yet been utilized in the City of Winnipeg. The City plans to carry out investigations and testing of these new technologies on local conditions prior to full scale commitment. They will be programmed later in the CSO Master Plan.
- **Operations and Maintenance:** The new CSO control technologies include mechanical equipment that is more labour-intensive, and with a shorter service-life than what currently exists. The City requires that this be recognized in the evaluation, with major mechanical equipment having a service life of less than the period under evaluation for life cycle comparison purposes be accounted for with periodic replacement costs.
- **Startup:** The City recognizes the potential for delays in regulatory approvals and provincial and federal funding commitments. Accordingly, the schedule has assumed a two year delay in receipt of the final regulatory licence, to allow time for a major alteration of the CSO licence and a further two year delay for the commitment of long-term provincial and federal funding. During this time all committed sewer separation projects as part of the existing CSO and BFR programs will continue to be funded and implemented by the City.
- **Integrated Benefits:** The CSO and BFR programs are to be combined into a single integrated program once the CSO Master Plan is implemented.
- **Beneficial Uses:** The river systems within Winnipeg are not recommended for recreational use in which sustained contact with the water occurs. It is not expected that improvements in percent capture with implementation of the CSO program will improve the river water quality to change these recommendations.
- **Stakeholder Expectations:** The public has been engaged during the Preliminary Proposal phase at the public events held between 2013 and 2015. Further public communications work will continue as elements of the CSO Master Plan are initiated.
- **Risks and Opportunities:** Longer implementation periods would tend to reduce many of the risks inherit to a capital program of this scale. The longer implementation period however would result in an escalation in construction costs due to inflation.

Program Scenarios

The purpose of multiple program scenarios is to provide a structure for evaluation of a broad range of program alternatives. In practice, however, the final range of scenarios was limited, because the projects were pre-selected, and the application of the criteria and constraints limited the number of variables to be considered. The program scenarios therefore specifically address different sources and levels of funding.

The program scenarios are as follows:

- **Scenario 1 – Shared Tri-Level Funding:** A tri-level funding agreement between the Government of Canada, Manitoba Government and the City of Winnipeg. The City has an expectation that the program will be equally funded through a cost-sharing arrangement with the federal and provincial governments, at one-third equal funding contributions from each level of government. This scenario places a limit of $30 million per year on funding from each of the three levels of government, totally $90 million per year.
- **Scenario 2 – Shared Bi-level Funding:** A bi-level funding agreement between the City of Winnipeg and either the Government of Canada or the Manitoba Government. As a compromise to three-way funding, the second scenario assumes that one of the two senior levels of government will not

participate in the funding arrangement. This has the effect of maintaining the same $30 million per year level of funding per year from two of the three levels of government, totally $60 million per year maximum. The reduced funding will ultimately extend the timeline for the program implementation.

- **Scenario 3 –City-only Funding:** This scenario assumes the two senior levels of government will not participate in shared funding, with the program being fully funded by the City at a limit of $30 million per year. The schedule would be extended as necessary at this fixed rate of funding to complete the program.

Program Implementation Strategy

In addition to the program criteria in the previous section, a strategy has been defined to balance risks and costs of the projects through the implementation period. Additionally, projects were scheduled to maintain a relatively uniform level of expenditure within the approximate implementation period based on the three funding scenarios.

Program sequencing was carried out for each funding scenario based on the following:

1) Start-up:

Funding for the first four years was limited to the City's contribution cap. The delay accounts for a two year period to allow a major alteration to the Licence and a further two year period for the other levels of government to arrange for their funding commitments.

2) Committed Sewer Separation Projects:

Committed projects will be carried out to completion. The City's legacy CSO and BFR program is well advanced and has contributed greatly to basement flooding reductions. Several CS districts have been identified for relief, with the preferred method of relief being sewer separation, which provides the dual benefit of flooding reduction and CSO mitigation.

3) Additional Separation Projects:

Sewer separation was identified for several sewer districts during the project selection process. The additional separation locations are not currently committed. It is therefore assumed they can be implemented at any time, unless noted otherwise.

4) Partial Sewer Separation Projects:

The partial sewer separation projects are recommended for a variety of reasons, generally because of their connection to another project:

- Ash: There is potential opportunistic separation as part the Route 90 – Kenaston corridor upgrade.
- Jessie: Southeast Jessie to be separated as part of the Cockburn CSO and BFR project.

5) In-Line Storage, Gravity Flow Control and Latent Storage Projects:

In-line storage, gravity flow control and latent storage generally provide the highest cost-effectiveness but concerns with operation and the reliability of the technologies must be resolved prior to their use. Because of their high cost-effectiveness, these projects are sequenced to be implemented shortly after evaluation and acceptance of the technologies.

Control gates are an integral part of floatables screening and real time control (RTC), and coordination of their implementation with in-line storage projects is required.

6) Tunnel and Off-Line Storage Projects:

Tunnel and off-line storage are considered similar to each other from a project sequencing perspective, with neither taking a priority over the other.

Neither tunnel nor off-line storage are being applied for basement flooding improvements, and control gates are integrated into both to maximize their performance. The implementation of these solutions will follow with the implementation of the high cost effective in-line storage, latent storage and gravity flow control projects.

7) Program Support Services:

The CSO program will require a wide range of engineering and administrative services throughout its completion to support overall program management. They are expected to include the following:

- Technology Evaluation and Pilot Studies:
    - Control Gates
    - Screens
    - Flap Gate Control
    - Green Infrastructure
    - Real Time Control
- Alternative Floatables Management Demonstration Project and Pilot Study
- In-Situ Flow Monitoring Of Districts Before and After Control Options Implemented
- RTC Instrumentation Upgrades (as required) and SCADA Integration
- 2030 CSO Master Plan Update

Project support services will include one-off investigations as well as continual annual activities. The details will be established once the program is initiated. A cost allowance for these works has not been included in the CSO Master Plan.

The City intends to complete the main technology evaluations and pilot studies within the first ten years. At that time the level of effort for support services will reduce, and recommendations from the work will be incorporated into the already budgeted capital projects. Some level of support services will continue but has not been accounted for in the CSO Master Plan estimates.

8) Green Infrastructure Projects and Climate Change Resiliency:

Green infrastructure (GI) has been addressed separately from the other control options. It has not been included in the base solutions because of unknowns and uncertainty with its application. It is recommended that the analysis of the main technology evaluations and pilot studies are completed within the first ten years. This will provide confirmation that these proposed options are appropriate and suitable for the Winnipeg sewerage system. The GI projects will provide the necessary additional performance improvements to mitigate any detrimental impacts from Climate Change on future precipitation trends An allowance of 10 percent of the total CSO Master Plan capital cost estimates has been included for its future implementation.

Scenario Evaluations

The program scenarios were evaluated with the programming workbook tool. Projects were scheduled according to the criteria and constraints identified, maintaining constant annual budget amounts in terms of 2019 dollar values. Table ES-3 provides a high level summary of the program under each funding scenario.

Table ES-3. CSO Master Plan Funding Scenario Evaluation Results (2019 Dollars)

Program Scenario	Description	Funding by	Annual Budget	Timeline
Scenario 1	3 Levels of Funding 3 x $30 Million	Tri-level Government of Canada, Manitoba Government and the City of Winnipeg	$90 Million	27 years (2047)
Scenario 2	2 Levels of Funding 2 x $30 Million	Bi-Level City of Winnipeg and either the Government of Canada or the Manitoba Government	$60 Million	39 years (2059)
Scenario 3	1 Level of Funding 1 x $30 Million	One Level City Only	$30 Million	75 years (2095)

Only Scenario 1 would allow the CSO Master Plan to be completed near the 2045 deadline, as requested by MSD. In contrast, Scenario 3 is estimated to be complete by 2095 (75 years). Scenarios 2 and 3 are intended as guides to illustrate the impact of reduced funding arrangements.

The City will proceed under the assumption that funding will be as described with Scenario 1, with three-way shared funding with the two senior levels of government. The CSO implementation plan will comply with EA No. 3042, meeting Control Option No. 1 – 85 Percent Capture in a Representative Year and be completed by December 31, 2047. Included in this time frame are two years for a major alteration of the Licence and two years for arranging funding commitments. If combined Licence alteration/approval and funding commitments are achieved in less or more than four years, then the implementation timeline will correspondingly change.

The implementation plan details for this recommendation are summarized in Part 3A of this report, and the corresponding DEPs are included in Part 3B.

Migration to Control Option No. 2

The MSD response to the Preliminary Proposal of December 24, 2017, included a condition that Control Option No. 1 - 85 Percent Capture in a Representative Year be implemented in such a way that Control Option No. 2 - Four Overflows in a Representative Year may be eventually phased in. This condition will have further financial and planning impacts.

The City raised concerns that the migration approach is not cost-effective, primarily due to the change in the metric by which performance is measured. Control Option No. 1 considers the percent capture as the metric used to measure and track performance. Control Option No. 2 moves away from the percent capture metric, and instead relies on the number of overflows at each outfall across the city as the performance tracking metric. There are several master planning impacts associated with upgrading to Control Option No. 2 and changing the performance metric during the implementation in this manner. Each of these impacts are stated further below:

- The performance metric would essentially change from a city-wide limit to a district-based limit. Under Control Option No. 2 each district would be required to meet a four overflow limit for the representative year. To achieve this the configuration of projects changes, such that only the work necessary to reduce the overflows from the district to four or less would be practical to complete. Even in the case where to continue work in a particular district to remove all overflows is the most cost effective solution at that time, it would not be completed under Control Option No. 2 as there would be no further benefit provided in completing this work to meet Control Option No. 2. With Control Option No. 1 and utilizing a volume percent capture metric across the City of Winnipeg, this is not the case. With the percent capture metric to completely remove overflows from a particular district, where it is most cost-effective to do so, continues to provide performance improvements to towards meeting the target. This reconfiguration to meet the Control Option No. 2 target and associated performance metric is not directly aligned with the project configuration currently provided for Control Option No. 1. Projects completed as part of meeting 85 percent capture would not necessarily be useful in meeting the Control Option No. 2 target, as currently defined.

- Utilizing a district based overflow metric will require that some amount of partial work would need to be completed in every district to achieve a CSO frequency of 4 or less per year. This would include work in several districts where it is not as cost-effective to complete this work compared to other districts. Utilizing a percent capture metric allows for the maximization of work available within a single district where it is cost effective to do so, in order to reduce the burden on other sewer districts where it may not be as cost-effective to have construction projects implemented.

For these reasons the City has engaged MSD as part of the Master Plan development, to discuss the issues mentioned, and to propose continuing with a volume percent capture metric. The City would continue to prepare the CSO Master Plan and the CSO Master Plan update such that the future target would be Control Option No. 2, however it would be evaluated based on an *equivalent volume percent capture target* which would provide equal or better performance. From this analysis it has initially been found that a level of volume capture of approximately 98 percent as compared to 85 percent for Control Option No. 1, would provide the same benefits on the receiving water bodies as Control Option No. 2. The exact equivalent percent capture target requires further water quality testing to confirm it meets the equivalent water quality bacterial performance reduction of Control Option No. 2 presented in the Preliminary Proposal. This level of water quality evaluation is beyond the scope of work for this CSO Master Plan submission, and would ultimately delay submission beyond the August 31, 2019 deadline if included. As part of the engagement regarding this with MSD, it was agreed that this water quality evaluation would instead be completed as part of the 2030 CSO Master Plan update submission, to determine the exact equivalent percent capture target to Control Option No. 2. This increased percent capture target would then be recommended to MSD to be applied as the future control target in which the 2030 CSO Master Plan update is evaluated. By doing so the plan continues with the percent capture metric while meeting MSD's overall goals on water quality improvements.

Monitoring and Reporting

Monitoring and reporting is a requirement of EA No. 3042 and is required during the development and implementation of the CSO Master Plan. The specific clauses listed in the Licence include the following:

- **Clause 9: Public Education Plan:** A public education program plan documenting how information on combined sewer overflows will be made available to the public
- **Clause: 10: Public Notification System:** A plan regarding the development and implementation of an internet-based public notification system for all discharges from combined sewer overflow points, including an assessment of making this notification available on a real time basis.
- **Clause 13: Annual Progress Reporting:** Upon approval of the CSO Master Plan, provide annual submissions with an indication of progress. This is to include monitoring results and the work plan for the next year.
- **Clause 14: Reporting (Director Notification):** A notification plan acceptable to the Director for each overflow event
- **Clause 15: Interim Monitoring:** A plan for water quality monitoring between May 1, 2014 and the date upon which the master plan is approved.
- **Clause 16: Record Keeping:** Maintain annual records of water quality testing results and CSO dates

Clause 9, 10, 14 and 15 will be complete and in place prior to the start of implementation. Clauses 13 and 16 relate to the annual reporting and record keeping during implementation.

The City has liaised with MSD and developed reporting protocols for the public notification system and interim water quality monitoring. Transition to the CSO Master Plan implementation will require that updated protocols be established for progress and performance monitoring and compliance reporting for the implementation program.

The reporting approach for implementation of Control Option No. 1 is dictated by use of the percent capture performance metric. Progress reporting will be based on project completion in comparison to the work scheduled in the CSO Master Plan. Annual reporting will identify construction progress in comparison to the current version of the CSO Master Plan and the work plan for the subsequent year.

Risks and Opportunities

The program planning process identified a number of potential risks with significant potential consequences. Consideration of risks and opportunities was part of the CSO Master Plan development. Individual risk responses and contingency allowances were not directly identified, but recognition and general allowance for risk is included in the upper end of the range of cost estimates which is included as part of the budget estimates. The following risks and opportunities are being highlighted as having potential impacts on the CSO program.

Risks

Risks to the successful completion of the CSO Master Plan were identified throughout the planning process. Where possible mitigation measures have been identified and are described in the following subsections.

- **Program Implementation:** The City has identified the program costs as being unsustainable to rate payers while meeting the 2045 target date. Support from both senior levels of government will be requested, with a fallback position of extending the implementation timeframe to fit with funding availability. Large capital programs are always at risk of cost uncertainty and increases. Cost monitoring as part of the program management process will be used to track market trends and adjust the program for better results. Large scale infrastructure projects take a long time from initiation to completion with the potential for delay risks. Budget restrictions and shortages of engineering and contracting capacity may also limit the rate of progress to implement the program. Program management tracking and project selections will be carried out to coordinate types of work and timing with availability of resources.
- **Migration to Control Option No. 2:** The risk of moving to a different performance metric during the implementation of the program can be reduced by demonstrating how the volume percent capture metric can be maintained. The additional cost to complete the migration is significant and must be better defined prior to the 2030 CSO Master Plan update.
- **Climate Change:** The potential for more severe weather from climate change may affect the relative performance of the CSO mitigation works. The control options will continue to capture WWF, but their performance will depend on the nature of the change. They will capture greater volumes with an increase in the number of precipitation events.
- **Program Feasibility and Sustainability:** In order to complete the program cost effectively and to minimize the risks, a number of initial studies and evaluations must be completed in the early stages to gain confidence in new technologies. This program will compete with multiple other large infrastructure projects needed in the City that will be drawing from the same pool of resources. The capacity of local industry in terms of engineering and construction services will have to adapt to the scale of the program.
- **Basement Flooding:** A major objective of the CSO Master Plan is to avoid compromising basement flooding protection or system operability through the modification of infrastructure, or installation and operation of new equipment. These risks can be mitigated by identification of alternative technologies for control gates, latent storage, screening and RTC, followed by completing pilot studies to prove and validate the installations prior to implementing across several districts.

Opportunities

The CSO Master Plan has been developed using grey infrastructure projects and has not incorporated GI and RTC optimization. These additional control options are included in the CSO Master Plan as potential program opportunities. These opportunities will provide additional capacity to meet more stringent control targets, provide resiliency to impacts from changes in precipitation patterns based on climate change, or provide a cost-effective measure to off-set the cost of grey infrastructure projects currently recommended.

Specific opportunities where there is potential for savings and added CSO volume reduction have been identified as follows:

- **Engineering Refinements:** Value engineering provides a structured method for reviewing the costs and benefits of conceptual plans, from the perspective of adding value. Value engineering exercises should be carried out early in the conceptual design stage to achieve best value for money in the projects. The DEPs for each of the combined sewer districts has been developed to a conceptual level and will be further developed through value management, additional studies and through design to construction. The timeframe of the program will require new and innovative technology be reviewed and incorporated into the program as applicable.
- **Public Education:** The public's perceived success of the program can best be managed through a structured communication program. Communicating what is going on in neighbourhoods and why, as well as managing expectations, are essential to the success of the CSO Master Plan.
- **Stakeholder Collaboration:** Working together with other stakeholders including industry and community groups will provide partnership opportunities that may provide additional benefit to the CSO Master Plan.
- **Real Time Control:** RTC provides a method of increasing system performance by improving the operation of the system by increasing the use of existing infrastructure. The topography in Winnipeg is relatively flat and allows for a potentially higher than typical utilization rate. RTC can adapt and balance the system for real precipitation events that are spatially and temporally distributed. Flow monitoring and sensing equipment will be incorporated throughout the system to provide an increased understanding of operation. These controls will provide a basis for a future system that links the sensing and control elements together with the control infrastructure. This will allow for better control on a real time basis and an optimization of flows in the system and to the treatment plants.
- **Green Infrastructure:** EA No. 3042 requires that GI be used in the design and operation of all new and upgraded storm and wastewater infrastructure. GI is applicable to both private and public property. However, the application of GI in Winnipeg must be evaluated to confirm the potential long term benefits to CSO reduction and the evaluations should be completed in the early stages of implementation. Future use of GI is most cost effective when installed as part of other capital projects including community enhancements and street work. The CSO Master Plan has included a budgetary allowance to incorporate GI in the future.
- **Floatables Management Approach:** The CSO Master Plan includes implementation of 25 screening facilities where hydraulics permit. The installation and operation of the screens will be difficult because of the limited space for construction, difficulty in access, and high O&M requirements. Screens tend to clog and increase the risk of basement flooding; therefore, they must be continually monitored and maintained.

  For these reasons the City has identified source control as a potential alternative to screen installation to provide the floatables management requirement. The investigation of source control alternatives will proceed in the early stages of the program. Districts that have been identified as being difficult to install screens are likely candidates for this evaluation as pilot projects. The comparative evaluation will be presented for replacing the screens with the program once the approach has been fully investigated and confirmed.

Next Steps and Future Considerations

The CSO Master Plan sets out a path forward to reduce the volume of combined sewer overflows by 2,300,000 m^3. Acceptance of the CSO Master Plan by MSD will require the City to adopt a long-term program impacting approximately one third of the serviced sewer area across Winnipeg. Upon completion, the estimated level of combined sewage capture will increase from 74 to 85 percent and a Control Option No. 1 target of the CSO Master Plan will be achieved.

A delayed start of 4 years has been included in the implementation to account for a startup period that would include time for regulatory acceptance of the plan and to secure program funding. In the early stages of implementation, the lower risk previously committed sewer separation projects will continue, and pilot studies and evaluations of new technologies will occur. During the first ten years, the City will further evaluate the options in moving towards the higher level of regulatory compliance established as Control Option No. 2. The evaluations for meeting the increased level of compliance and the new technologies will take place in collaboration with the regulator and will be documented as part of the 2030 CSO Master Plan update.

It is certain that future conditions and influences will change over the implementation of the program. The CSO Master Plan is able to adapt to continue achieving progress towards meeting the environment regulations set out in EA No. 3042 and accommodate future changes. A consistent approach to the monitoring and reporting of progress is necessary for a cost effective approach during implementation. A plan that balances the impact on all stakeholders through a well-managed program based on proven technologies will guide the City towards achieving compliance.

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Acronyms and Abbreviations

AACE	Association for the Advancement of Cost Engineering
ADWF	average dry weather flow
BFR	basement flood relief
$CBOD_5$	5-day carbonaceous biochemical oxygen demand
CCME	Canadian Council of Ministers of the Environment
CEC	Clean Environment Commission
CEPA	*Canadian Environmental Protection Act*, 1999
City	City of Winnipeg
CO1MP	Control Option No. 1 – Master Plan
CS	combined sewer
CSO	combined sewer overflow
DBB	design bid build
DEP	district engineering plan
DO	dissolved oxygen
DWF	dry weather flow
EA No. 3042	Environment Act Licence Number 3042
FPS	flood pumping station
GI	green infrastructure
GIM	ground infiltration module
GIS	geographical information system
HGL	hydraulic grade line
ICI	industrial/commercial/institutional
LDS	land drainage sewer
LS	lift station
MMWE	*Management of Municipal Wastewater Effluent*
MPN	most probable number
MSD	Manitoba Sustainable Development
MRST	Manitoba Retail Sales Tax
MWQSOG	Manitoba Water Quality Standards, Objectives and Guidelines
NEWPCC	North End Sewage Treatment Plant
NPRI	National Pollutant Release Inventory
NPS	national performance standards
NPV	net present value
NSWL	normal summer river water level
O&M	operations and maintenance
PACC	Program Alternative Cost Calculator
Preliminary Proposal	CSO Master Plan Preliminary Proposal
Province	Province of Manitoba
POC	pollutant of concern

PWWF	peak wet weather flow
RDII	Rainfall Derived Inflow and Infiltration
RI	Residential Indicator
RLC	Regulatory Liaison Committee
RM	Rural Municipality
RTC	real time control
RTU	remote terminal unit
RWC	Regulatory Working Committee
SCADA	supervisory control and data acquisition
STP	Sewage Treatment Plant
SEWPCC	South End Sewage Treatment Plant
SRS	storm relief sewer
TMP	transportation master plan
TSS	total suspended solids
WEWPCC	West End Sewage Treatment Plant
WSER	Wastewater Systems Effluent Regulations
WSTP	Winnipeg Sewage Treatment Program
WWF	wet weather flow
WWS	wastewater sewer

1. Introduction

1.1 Study Background

The City of Winnipeg (City) is required to develop a Combined Sewer Overflow (CSO) Master Plan to comply with the Province of Manitoba's (Province's) *Environment Act Licence Number 3042* (EA No. 3042) (Manitoba Conservation And Water Stewardship, 2013). EA No. 3042 requires the evaluation of alternative regulatory control limits to select the best approach to developing the CSO Master Plan. Control limits establish the method of measurement used to assess the performance of the CSO Master Plan. The CSO Master Plan provides the City with a long-term roadmap for CSO mitigation.

"Control option" was the original term used in the Preliminary Proposal to describe the type of technology that may be constructed to reduce CSOs. A dual definition for the term arose through the licensing process, with control option used to describe the level of performance, such as "Control Option No. 1 – 85 Percent Capture in a Representative Year." The technology reference is occasionally replaced with the term "solution" but remains in use and can be differentiated by the context of the discussion.

The CSO Master Plan assignment commenced in February 2013 with a work plan structured into a progressive three-phase approach:

1. **Phase 1: Study phase:** This phase developed a series of potential Master Plan configurations for each of the alternative control limits identified in EA No. 3042.
2. **Phase 2: Visioning and decision-making phase:** This phase focused on control limits through evaluation and rating of the merits of the potential plans developed in the first phase.
3. **Phase 3: Long-term Master Plan phase:** This phase developed a Master Plan to meet the selected control limits, which serve as an implementation roadmap and identify a series of projects that will meet the intent of the Master Plan.

The first two phases led to the development of the CSO Master Plan Preliminary Proposal (Preliminary Proposal; CH2M., 2015). The Preliminary Proposal provided a recommended approach to Manitoba Sustainable Development (MSD) for review and acceptance. The Preliminary Proposal evaluated five potential control options, described the process for the control option evaluation, and recommended the most advantageous option considering Winnipeg-specific performance measures and value criteria.

The Preliminary Proposal was submitted to MSD on December 18, 2015, with a formal response received from MSD on November 24, 2017, in which Control Option No. 1 - 85 Percent Capture in a Representative Year was accepted. A condition was added, stating that Control Option No. 1 be implemented in a way such that Control Option No. 2 (four overflows in a Representative Year) may be phased in and the implementation end date for the Master Plan was changed from 2030 to 2045 or an alternative date subject to approval by the Director of MSD.

The entirety of this CSO Master Plan document development occurred during the third phase. This CSO Master Plan is based on MSD's approval of Control Option No. 1 and includes District Engineering Plans (DEPs) for each sewer district and an overall program implementation plan.

1.2 Purpose

This Part 2 Technical Report is part of the third phase work, and documents the approach for development of the recommended CSO Master Plan and its implementation. It provides the analysis of potential control options for each sewer district used to form the Master Plan. The Part 2 report also describes the process for the evaluation and recommendation of the overall program. It also summarizes the updated program cost estimates and performance targets.

1.3 Scope

The scope of this third phase is to develop an implementation plan for Control Option No. 1, with the services as documented in Scope Change 11, CSO Master Plan – Phase 3 Updated Work Plan, approved by the City on June 20, 2018. The scope includes a descriptive evaluation of the impacts of migration from Control Option No. 1 to Control Option No. 2 but does not include a detailed evaluation and recommendations for phase in of Control Option No. 2, or for the 2030 CSO Update.

The work plan includes project development, program development and preparation of DEPs for all 43 Combined Sewer (CS) districts in order to meet the regulatory requirements for Control Option No. 1. Descriptive assessments for migration to Control Option No. 2, and descriptive assessment of opportunities such as the use of Green Infrastructure (GI) and Real Time Control (RTC), and an alternative floatables management approach are included. The opportunities will be further developed as the CSO Master Plan is implemented.

This Part 2: Technical Report is organized into the following major sections:

Section 2, Technical Background: Provides an overview of the current situation, the licensing process, and information relevant to developing the DEPs and program implementation.

Section 3, Technical Approach: Provides an overview of the approach and technical methodology used to assess existing conditions, evaluate control options, develop the DEPs and develop the overall Master Plan.

Section 4, Program Development: Describes the approach used to develop the CSO Master Plan program including decision criteria and identifying the funding scenarios being considered. It also provides a description of anticipated program management, monitoring and reporting requirements.

Section 5, Risk and Opportunities: Provides an overview of the risks and opportunities identified during the plan development. This includes GI for climate change resilience, RTC and the alternatives floatable management approach.

Section 6, Next Steps and Future Considerations: Provides an overview of the next stages and considerations for the implementation of the CSO Master Plan.

Section 7, References: Provides a summary of source documents.

2. Technical Background

This section provides an overview of the technical background for the CSO Master Plan. This includes a description of the City's collection and treatment systems, CSO regulatory history, water quality considerations, and current CSO programs, as well as an overview of the first phase of the CSO Master Plan development.

2.1 Master Plan Key Drivers

The key drivers are a major consideration in the evaluation and selection of the preferred CSO Control Option and development of the CSO Master Plan. The Master Plan takes a balanced approach to addressing the key drivers. The key drivers used for assessing the development and implementation of a Master Plan in Winnipeg are as follows:

Public Health

It is understood that the bacteria in CSOs poses a risk to human health. Infection may be possible through direct contact and ingestion of contaminated sources. The representative contribution that CSOs have in increasing this risk has been reviewed as part of the water quality analysis completed. CSOs represent only one of many contributing sources of bacteria to receiving water courses. A reduction in the volume of CSOs entering the watercourse will not eliminate this risk.

Aesthetics

The appearance of floatable material creates a negative experience for people using the river walks and those that commonly use the rivers for recreation. However, a reduction in the volume of CSOs will not materially change the appearance of the rivers in Winnipeg or the amount of visible floatable material.

Nutrients

Nitrogen and phosphorus loading to the rivers can influence the river system and the life within it. Nutrient loading from CSO discharge and the influence of these loadings on the river systems is a consideration in the development of the CSO Master Plan. The health of Lake Winnipeg is a major concern. The water quality study completed in development of the CSO Master Plan indicated that CSO discharge does not contribute significantly to phosphorus and nitrogen nutrient loading to Lake Winnipeg. For existing conditions, less than 0.3 percent of the total load of both nitrogen and phosphorus to Lake Winnipeg is from CSOs.

Aquatic Life

CSOs can change river conditions and influence its ability to sustain life. Dissolved oxygen (DO) and ammonia content are the two most important criteria for aquatic life, which may be affected by CSOs. The water quality analysis completed indicated that CSOs depress the DO level slightly, but not to a level that would impact aquatic life. Ammonia contribution from CSOs is also negligible in terms of river loading. The contribution of ammonia from dry weather flows at the sewage treatment plants (STPs) has a much greater impact than CSOs.

Public Perception

It must be understood that CSOs represent a minor impact to the overall aesthetic and health of the lakes and rivers. It is therefore, fundamentally important to continue to educate the public on the impact of CSO discharges.

Regulatory Requirements

EA No. 3042 was issued to assist the City in developing a mitigation strategy for CSOs. All options must be assessed in terms of meeting the requirements of EA No. 3042. The regulatory environment is constantly changing and a program that balances the potential changes is required.

2.2 Regulatory Background

The regulatory perspective for wastewater discharges in Manitoba has evolved significantly over the years. Treatment plant licensing has evolved to include lower effluent limits, CSO discharges are licenced and there has been an increased focus on protecting water quality.

MSD is the regulatory body that is responsible for the licensing and enforcement of the provincial *Environment Act* (Government Of Manitoba, 1988) and subsequent EA No. 3042 outlining the regulatory requirements for CSOs. The regulatory background and current perspective are described in the following section.

2.2.1 CSO Licensing History

Prior to 1988, the City had responsibility for protection of river water quality within Winnipeg and provincial licensing was not required. After proclamation of the Environment Act on March 31, 1988, responsibility was transferred from the City of Winnipeg to the Province of Manitoba. Prior this point, the City continued to make major investments in wastewater treatment.

In 1989, the Minister of Conservation instructed the Clean Environment Commission (CEC) to hold public hearings and provide a report with recommendations on water quality objectives for the Red and Assiniboine Rivers within and downstream of Winnipeg to sustain beneficial uses of the rivers.

After completion of hearings in 1992, the CEC submitted a report with 14 recommendations (CEC, 1992). With respect to CSOs, the CEC concluded there was insufficient information to advocate for CSO regulation and recommended that site-specific studies be undertaken to determine the water quality impacts and formulate remedial measures.

The CSO study undertaken by the City that followed was a comprehensive multi-year study that commenced in 1994 and was finalized in 2002; it is now referred to as the *2002 CSO Study* (Wardrop, 2002). It was undertaken in four phases, which included identification of the current situation, the effects of overflows on river water quality and river use, the potential control options and their costs and benefits, and development of an illustrative CSO control program. The study's final report was presented at CEC public hearings in 2003.

The 2003 CEC public hearings were called following a sewage spill at the City's North End Sewage Treatment Plant (NEWPCC) on September 16, 2002. The spill of 427 million L of untreated sewage into the Red River had extensive media coverage and resulted in the Minister of Conservation instructing the CEC to include both the collection and treatment systems in the public hearings.

The CEC conducted the hearings over a 9-day period between January and April of 2003, and submitted its *Report on Public Hearings. City of Winnipeg Wastewater Collection and Treatment Systems* (CEC, 2003) which includes advice and recommendations. The recommendations include:

- Nutrient Management Strategy
  - Recommendation 5 – "The City of Winnipeg should be directed to plan for the removal of nitrogen and phosphorus from its municipal wastewaters, and to take immediate steps in support of the nutrient reduction targets established for Lake Winnipeg. The City's nutrient removal plan should be a key element of a licence review hearing to be scheduled within two years."
- Combined Sewer Overflow Reduction
  - Recommendation 7 – "The City of Winnipeg should be directed to shorten the timeframe to complete its combined sewer overflow plan from the proposed 50 years to a 20 to 25-year period."
  - Recommendation 8 – "The City of Winnipeg should be directed to take immediate action to reduce combined sewer overflows by instrumenting outfalls, adjusting weirs, accelerating

combined sewer replacement, advancing the pilot retention project and undertaking other reasonable measures to reduce combined sewer overflows within two years."

- Public Notification System
  - Recommendation 9 – "The City of Winnipeg should be directed to develop and implement a notification system to inform the public whenever there is a release of raw sewage from any source into the Red and/or Assiniboine Rivers. This public notification system should be operational by the beginning of the 2004 summer recreation season."
- Financial Support
  - Recommendation 15 – "The City of Winnipeg should be directly assisted by the Province of Manitoba in efforts to secure financial support under existing and future infrastructure programs for upgrades to its wastewater collection and treatment systems."
  - "The Commission believes that the senior levels of government should assist with the cost of achieving improved nutrient management and other water quality enhancement measures. Ideally, the funding formula of one-third municipal, one-third provincial and one-third federal should be used."
- Public Education
  - Recommendation 17 – "The City of Winnipeg should be strongly encouraged to develop and implement a permanent public education program to improve awareness of Winnipeg's wastewater collection and treatment systems, and to foster public involvement in activities focusing on water conservation and pollution prevention at source."
- Public Consultation
  - Recommendation 18 – "The City of Winnipeg should be directed to prepare a public consultation plan for Winnipeg's wastewater collection and treatment systems for approval by Manitoba Conservation by April 2004."

Other findings by the CEC related to CSOs were identified in the body of the report but not included as recommendations. These were as follows:

- "However, based on concerns, consideration of the impacts only as they may relate to recreational season is insufficient. Combined sewer overflows should therefore be managed on an annual basis and not just during the summer months."
- "The Commission notes that the target of four combined sewer overflow events per year may not result in significant improvement over the present situations."

The recommendations were received and reviewed by MSD, and in response to this Environment Act Licence No. 3042 (EA No. 3042) was issued on September 4, 2013.

2.2.2 Manitoba Water Quality Standards, Objectives, and Guidelines

The 1988 Manitoba Surface Water Quality Objectives referenced in the 2002 CSO Study were replaced with the *Manitoba Water Quality Standards, Objectives and Guidelines* (MWQSOG) by the Province on November 28, 2011. Changes that impacted the CSO program were the fecal coliform standard for bacterial has been replaced with *E. coli*, and the secondary recreation river use category has been removed, with only a primary recreation standard remaining.

The 2002 CSO Study examined a wide range of pollutant types to identify pollutants of concern (POCs). Based on these analyses, fecal coliform was identified as the sole POC from the standpoint of managing CSO discharges. In the intervening years, a great deal of attention was directed towards the eutrophication of Lake Winnipeg through excessive nutrient inputs. EA No. 3042 specifies requirements for treated CSO discharges and for ambient water quality monitoring parameters, which also need to be considered when establishing POCs. The POCs identified and used in the CSO Master Plan development are described in Section 2.3.3.

2.2.3 Federal Regulations

Under federal law, Environment Canada administers two acts concerning environmental protection of surface waters: the *Canadian Environmental Protection Act* (*CEPA*) (Canada, 1999) and the *Fisheries Act* (Canada, 1985).

CEPA governs the release of toxic substances and nutrients into the environment from a broad range of contributing areas. The *Fisheries Act* protects against deleterious substances being put into water with fish populations and the destruction of fish habitat.

The Was*tewater Systems Effluent Regulations* (WSER) (Environment Canada, 2012) is under the authority of the Fisheries Act and is based on the recommendations of the Canadian Council of Ministers of the Environment's (CCME's) *Canada-wide Strategy for the Management of Municipal Wastewater Effluent* (MMWE) (CCME, 2009). The WSER requirements are further detailed in Section 2.2.4.1 below.

2.2.4 Canada-wide Strategy for the Management of Municipal Wastewater Effluent

The CCME developed the Canada-wide Strategy for the MMWE. The strategy is based on a collective agreement reached by the 14 ministers of the environment in Canada to verify that wastewater facility owners have regulatory clarity in managing municipal wastewater effluent. The strategy provides recommendations for minimum National Performance Standards (NPS) and manage site-specific effluent discharge objectives.

The recommended national standards for CSOs regarding combined and sanitary wastewater collection systems are as follows:

- No increase in CSO frequency caused by development or redevelopment, unless it occurs as part of an approved CSO management plan
- No CSO discharge during dry weather, except during spring thaw and emergencies
- Removal of floatable materials where feasible
- The NPS are consistent with EA No. 3042 (Appendix A) Clause 7, Clause 8, and Clause 12, which reads as follows:
  - Clause 7 – "The Licencee shall operate the combined sewer system and wastewater collection system such that there are no combined sewer overflows except during wet weather."
  - Clause 8 – "The Licencee shall not increase the frequency or volume of combined sewer overflows in any sewershed due to new and upgraded land development activities and shall use green technology and innovative practices in the design and operation of all new and upgraded storm and wastewater infrastructures."
  - Clause 12 – "The Licencee shall demonstrate, in the Master Plan submitted pursuant to Clause 11, the prevention of floatable materials, and that the quality of the CSO effluent will be equivalent to that specified for primary treatment to 85 percent or more of the wastewater collected in the CSO system during wet weather periods."

2.2.4.1 Wastewater Systems Effluent Regulations

The WSER is a national wastewater standard under the federal *Fisheries Act* that came into effect in June 2012. In its current form, it requires an annual report on the number of days that CSOs occur for each month and the volume of CSO discharged from each overflow point. The first annual report was submitted by the City in February 2013 in compliance with WSER, and has continued on an annual basis.

2.2.5 Provincial Regulations

2.2.5.1 Winnipeg Sewage Treatment Plant Licensing

Winnipeg's sewage treatment plants (STPs), formerly known as the water pollution control centres, are all licensed under the *Environment Act*. The majority of the CS districts contribute flows to the NEWPCC. In consideration of this, the CSO Master Plan must be developed and managed to account for the STP capacities and licence requirements. The most current versions of the STP licences are as follows:

- North End Sewage Treatment Plant (NEWPCC): Licence No. 2684 RRR, issued June 19, 2009
- South End Sewage Treatment Plant (SEWPCC): Licence No. 2716 RR, issued April 18, 2012
- West End Sewage Treatment Plant (WEWPCC): Licence No. 2669 E RR, issued June 19, 2009

An upgrading plan for the NEWPCC was submitted to MSD as required under the *Save Lake Winnipeg Act* (Government Of Manitoba, 2011). The plan was approved on June 19, 2011, under the condition that the upgrade meets the required effluent quality criteria. Criteria include the proposed new effluent quality parameters for the NEWPCC as issued on October 2, 2012. It is intended that the effluent limits form the basis of the next revision to the NEWPCC licence.

2.2.6 Environment Act Licence Number 3042

EA No. 3042 for CSOs was issued on September 4, 2013 and is the main driver for the development of the CSO Master Plan. A copy of EA No. 3042 is included in Appendix A. EA No. 3042 clauses are specific to various components of the CSO Master Plan and are defined and discussed in each of the relevant sections of this report. The licence has adopted recommendations received from the CEC following the 2003 hearings. It is structured to accommodate development of a Master Plan, and includes the following:

- It allows for the identification and evaluation of alternative control limits.
- Although the CSO Master Plan implementation is intended to be complete by 2030, it allows for an alternative implementation time period based on the study findings at the discretion of the MSD Director. This was since updated to 2045 or otherwise as approved by the Director as part of the Preliminary Proposal response from MSD.
- It expands the compliance period from the recreational season to year-round.

There are 16 individual clauses within EA No. 3042, 10 of which are specific conditions required for the CSO Master Plan. The 10 clauses specific to CSO control and the CSO Master Plan are highlighted below.

2.2.6.1 Clause 7: Avoid CSOs

> *The Licencee shall operate the combined sewer system and wastewater collection system such that there are no combined sewer overflows except during wet weather periods.*

The City operates its collection system to collect all flows during dry weather (DWF). Only during emergency situations should an overflow occur from a CSO location during DWF.

2.2.6.2 Clause 8: New or Upgraded Developments

> *The Licencee shall not increase the frequency or volume of combined sewer overflows in any sewershed due to new and upgraded land development activities and shall use green technology and innovative practices in the design and operation of all new and upgraded storm and wastewater infrastructures.*

The City reviews development on a case-by-case basis and does not allow an increase of peak wet weather flow (PWWF) to the CS system in order to demonstrate compliance with Clause 8. In districts where CS separation takes place as part of this CSO Master Plan, the remaining wet weather flow response in the CS system will be assessed by flow monitoring. If no major wet weather responses resulting in a risk of future CSOs are found, then the standard City of Winnipeg wastewater and land drainage requirements will apply to evaluation of all future infill development for the district. At this point Clause 8 will no longer apply to developments within this district.

GI will be evaluated for applicability for each project carried out under the CSO Master Plan. An allowance for its evaluation and construction has been included.

2.2.6.3 Clause 9: Public Education Plan

A public education plan is required as noted in EA No. 3042 Clause 9 and states:

> *The Licencee shall, on or before December 31, 2013, submit to the Director, a public education program plan documenting how information on combined sewer overflows will be made available to the public.*

The City completed this plan and submitted it prior to the required date.

2.2.6.4 Clause 10: Public Notification System

A public notification system is required as noted in EA No. 3042 Clause 10 and states:

> *The Licencee shall, on or before December 31, 2015, submit to the Director for approval, a plan regarding the development and implementation of an internet-based public notification system for all discharges from combined sewer overflow points, including an assessment of making this notification available on a real time basis.*

The City initiated a public notification system in 2004, which identifies the likelihood that an overflow is occurring based on in-system levels. This notification is manually updated and provided on the City's website.

The City is updating this system and developing a tool which will link with the hydraulic model for the City of Winnipeg CS system, and the permanent instrumentation at each of the 39 primary outfalls. This tool will provide a real-time indication of an overflow occurring and forecasted overflows. This notification system will indicate to the public that a CSO is occurring or is predicted to occur.

2.2.6.5 Clause 11: CSO Master Plan

The CSO Master Plan and the associated Preliminary Proposal are requirements of EA No. 3042 Clause 11 which reads as follows:

> *The Licencee shall, on or before December 31, 2015, submit a preliminary proposal for approval by the Director, pursuant to Section 14(3) of The Environment Act, for the combined sewer overflow system.*
>
> *The plan proposed above would consist of an evaluation of a minimum of the following CSO control alternatives:*
>
> - *A maximum of four overflow events per year;*
> - *zero combined sewer overflows; and*
> - *a minimum of 85 percent capture of wet weather flow from the combined sewer system and the reduction of combined sewer overflows to a maximum of four overflow events per year.*
>
> *The Licencee shall, on or before December 31, 2017, file a final Master Plan, including the detailed engineering plans, proposed monitoring plan, and implementation schedule for the approved design identified in the preliminary plan above. The Master Plan is to be filed for*

> *approval by the Director. The Licencee shall implement the plan by December 31, 2030, unless otherwise approved by the Director.*

The City submitted the Preliminary Proposal prior to the required date and received approval from MSD to proceed on the CSO Master Plan in November of 2017. The final Master Plan submission day was revised to August 2013 to reflect the revised Preliminary Proposal approval date. The implementation date was also updated to December 31, 2045 or otherwise as approved by the Director to reflect the Preliminary Proposal approval commentary.

2.2.6.6 Clause 12: Effluent Quality Limits

> *The Licencee shall demonstrate, in the Master Plan submitted pursuant to Clause 11, the prevention of floatable materials, and that the quality of the CSO effluent will be equivalent to that specified for primary treatment to 85% or more of the wastewater collected in the CSO system during wet weather periods. The following effluent quality limits summarize what is expected from primary treatment:*

- *five day biochemical oxygen demand (BOD_5) not to exceed 50 mg/l;*
- *total suspended solids not to exceed 50 mg/l;*
- *total phosphorus not to exceed 1 mg/l; and*
- *E. coli not to exceed 1000 per 100 ml.*

Currently, all CSO collected in the system will be conveyed to the sewage treatment plants and as such is regulated under the plant licence. This Clause also includes a requirement for the prevention of floatable materials. The CSO Master Plan incorporates floatable management through the use of screening and by including an alternative approach to floatable management. This alternative approach is described in Section 5.2.3.2.

2.2.6.7 Clause 13: Annual Progress Reporting

> *The Licencee shall, upon approval of the Master Plan submitted pursuant to Clause 11 of this Licence, implement the plan such that progress towards meeting the required level of treatment is demonstrated annually by submission of an annual report, due March 31 of each year for the preceding calendar year. Annual submissions shall include the progress made on the plan pursuant to Clause 11 including monitoring results and the work plan for the subsequent calendar year.*

This component of the reporting will be initiated upon acceptance of the CSO Master Plan and will continue through implementation.

2.2.6.8 Clause 14: Reporting

A notification plan for each overflow event is required as noted in EA No. 3042 Clause 14 and states:

> *The Licencee shall, prior to December 31, 2013, develop a notification plan acceptable to the Director for each overflow event.*

The City completed this plan and submitted it prior to the required date.

2.2.6.9 Clause 15: Interim Monitoring

As part of the compliance monitoring requirements noted in EA No. 3042, Clause 15, an Interim Monitoring Plan (City of Winnipeg, 2014a) was developed and carried out. Clause 15 of the licence reads as follows:

The Licencee shall by January 31, 2014 submit a plan to the Director for approval of an interim combined sewer overflow monitoring program for implementation between May 1, 2014 and the date upon which the final master plan is approved by the Director. The plan shall identify locations to be sampled, rationale for these locations, and sampling frequency. The plan also shall identify constituents to be monitored including, but not limited to:

- *organic content as indicated by the five-day biochemical oxygen demand (BOD5) and expressed as milligrams per litre;*
- *total suspended solids as expressed as milligrams per litre;*
- *total phosphorus content as expressed as milligrams per litre;*
- *total nitrogen content as expressed as milligrams per litre;*
- *total ammonia content as expressed as milligrams per litre;*
- *pH; and*
- *E.coli content as indicated by the MPN index and expressed as MPN per 100 millilitres of sample.*

This monitoring plan and the data collected serves as a basis for the water quality component of the CSO Master Plan study phase and was used to develop water quality performance for each alternative potential plan. The monitoring data provided an updated characterization of collection system discharge quality and allowed for the assessment of the impact of these discharges on receiving stream water quality. This assessment was fully reported on as part of the Preliminary Proposal submission. (CH2M, 2015).

2.2.6.10 Clause 16: Record Keeping

The City is required to maintain records for CSOs as noted in EA No. 3042 Clause 16 which states:

The Licencee shall:

a) during each year maintain records of:

i. grab sample dates and locations;

ii. summaries of laboratory analytical results of the grab samples; and

iii. combined sewer overflow dates;

b) make the records being maintained pursuant to sub-Clause 16 a) of this Licence available to an Environment Officer upon request and, within three months of the end of each year, post the results on the public notification site required by Clause 10 of this Licence.

The City currently maintains this information on record and posts the results on its website.

2.2.6.11 Licence Clarification And Outcome

Consultation between MSD and the City took place throughout the study and development phases of the CSO Master Plan. Several licence clarifications that impact the overall Master Plan were addressed. This included the selection of the representative year, the calculation process for reporting percent capture performance, and additional consideration for regulatory conformance at the time of the Master Plan update in 2030. Details of how these clarifications apply to the implementation phase of the CSO Master Plan are described throughout this report.

The Preliminary Proposal was submitted to MSD on December 18, 2015 with a recommendation for using Control Option No. 1 – 85 Percent Capture in a Representative Year. MSD issued a formal response to the Preliminary Proposal on November 24, 2017. The response from MSD stated that the Preliminary Proposal submission met the intent of Clause 11 of EA No. 3042, and that Control Option No. 1 –

85 Percent Capture in a Representative Year, is to be implemented by December 31, 2045 or otherwise as approved by the Director, in such a way that Control Option No. 2 may eventually be phased in. The CSO Master Plan was further developed on this basis.

2.3 Water Quality

Major waterbodies impacted by the CSO Master Plan include the Red and Assiniboine Rivers and Lake Winnipeg. These surface waters are extremely important to the economical and cultural identity of Manitoba. As such, they play a pivotal role in the development of the CSO Master Plan. Figure 2-1 provides an overview of the Lake Winnipeg watershed.

Figure 2-1. Map of the Lake Winnipeg Watershed
Source: www.ec.gc.ca, accessed April 10, 2019

The waterbodies and their relation to CSOs in Winnipeg are described in the following subsections.

2.3.1 Red River and Assiniboine River Watersheds

The Red and Assiniboine Rivers drain a watershed of over 270,000 km^2, including the prairie regions of southern Manitoba, southeastern Saskatchewan, North Dakota, northern South Dakota, and northwestern Minnesota.

The rivers carry large volumes of suspended solids, which gives them their natural murky appearance. The rivers cross intensively used agricultural lands and collect nutrients and other pollutants during their natural flow towards Lake Winnipeg. Many cities, towns, and agricultural livestock operations contribute pollutant and nutrient loadings to the rivers before they reach Winnipeg.

2.3.2 Lake Winnipeg

Lake Winnipeg is suffering from an overabundance of nutrients, and the Global Nature Fund (a non-profit, private, independent international foundation for the protection of environment and nature) recognized Lake Winnipeg as the world's most "Threatened Lake of the Year" for 2013. The Preliminary Proposal details several initiatives related to the health and protection of Lake Winnipeg.

The lake provides a valuable amenity and supports a wide variety of beneficial uses. It is a popular recreational area with public beaches, water recreation, and many vacation properties. It supports a wide variety of wildlife and active sport and commercial fisheries and warrants consideration in the CSO evaluation process.

The Preliminary Proposal's water quality analysis found that CSOs contribute 0.26 percent of the total phosphorus and 0.14 percent of the total nitrogen of the overall nutrient loading to Lake Winnipeg. Although CSOs are not considered the primary contributor for nutrient loadings to Lake Winnipeg, it is prudent to include discussion of the lake in the current CSO Master Plan because of its distressed nature and the public and regulatory attention it has generated.

2.3.3 Water Quality Pollutants of Concern

POCs were identified during the Preliminary Proposal development. The identified POCs form the basis for defining the discharge controls required for compliance. In general, the POCs are focused on the water quality requirements to protect river uses and have been previously identified in the 2002 CSO Study. Additionally, specific compliance requirements listed in the MWQSOG and EA No. 3042 have been considered. For the Master Plan, the POCs are identified as follows:

- **Dissolved oxygen (DO):** CSOs were found to slightly depress DO levels in the rivers, but not to the point where the levels would fall below those required to sustain healthy aquatic life. DO depression of only about 1 mg/L was observed with significant CSO events. Therefore, DO is not considered to be a CSO issue.
- **Total Suspended Solids (TSS):** The rivers have always carried large volumes of suspended solids, which gives them their characteristic murky brown appearance, typical of prairie rivers. CSOs have little impact on the existing TSS conditions and, accordingly the TSS loadings are not considered to be a CSO issue.
- **Ammonia:** The contribution of ammonia from CSOs is minor compared to that from dry weather discharges and STPs and is not a significant CSO issue.
- **Toxic substances**: While it was recognized that there is potential for release of toxic substances, monitoring of the CSOs under the 2002 CSO Study indicated that it was not a significant CSO issue.
- **Nutrients**: CSO discharges play a minor role in nitrogen and phosphorus loads to the rivers. Analysis completed during the Preliminary Proposal found that CSOs make up approximately 0.26 percent of total phosphorus and 0.14 percent of the total nitrogen load to Lake Winnipeg. The STP discharge licences and EA No. 3042 have limits for phosphorus and nitrogen.
- **Bacteria:** CSOs are known to be a major source of bacterial contamination of the rivers under wet weather conditions, and this is a main POC for the Master Plan. *E. coli* was the main bacteriological indicator assessed for the CSO Master Plan development. The Preliminary Proposal included an analysis of the level of bacteria that could be expected at Lake Winnipeg. The analysis showed densities of about 100 to 1,000 MPN /100 mL based on average velocities and anticipated travel times in the river. The results are conservative and do not include factors for in-stream dispersion or others that may be relevant, but is considered to be a conservative approach to estimating this value. No additional studies were completed for bacteria decay as part of the Master Plan.

The Master Plan study phase included a multi-year water quality monitoring program to collect and update river and CSO water quality data. The 2014-2015 data were compared to the 2002 data to reassess and update the POCs identified previously. The data gathered during the 2014-2015 water quality program were used as the baseline for the water quality modelling and loading assessments used in the potential plan evaluations. The results of both data sets provided similar estimations of the values for each constituent. The analysis and results of the CSO Master Plan water quality monitoring work are documented in the Preliminary Proposal.

Additional information is available of the condition of Lake Winnipeg through MSD. MSD periodically publishes state of the Lake reports describing the nutrient loadings and contributing sources. Typically, these reports are issued every five years with the latest report available online. The most recent publication is *Lake Winnipeg: Nutrient and Loads, A Status Report*. (MSD, 2019).

2.3.4 River Uses and CSO Impacts

River uses are identified to determine additional upgrading requirements and potential project benefits. A detailed review of river uses were carried out under the 2002 CSO Study and, in several cases, site-specific surveys were completed. The same level of investigation was not repeated for the CSO Master Plan, since there are no indications that river uses have substantially changed since that time. Therefore, the previous studies provide a good reference for river uses, with the one exception that year-round CSO control also needs to be considered, since it has been included in EA No. 3042.

The river uses to be protected have been defined as the following:

- **Aquatic life and wildlife**: In their natural state, rivers support aquatic plants and animals. Discharging treated and untreated wastewater can change conditions in the rivers and affect the rivers' ability to support aquatic life. DO and ammonia content are two of the most important criteria for aquatic life, which are affected by CSOs. Generally, conditions that support a healthy fish population indicate good conditions for other aquatic life. Aquatic life is not considered to be significantly impacted, since the Red and Assiniboine Rivers support a highly valued sports fishery.
- **Recreational use**: The water quality objectives at the time of the 2002 CSO Study included protection of both primary and secondary recreation, with the secondary recreation use now eliminated from the MWQSOG. Primary recreation involves direct contact activities such as swimming and waterskiing where immersion is probable. Secondary recreation includes activities like fishing and boating, where immersion would be incidental or accidental. While the rivers support secondary recreational uses, the Red and Assiniboine Rivers are unsuited and have few occurrences of primary recreation. Swimming and other primary recreational activities are naturally limited because of the rivers' murky waters, dangerous currents, and steep, muddy banks.
- **Aesthetic public amenity**: The aesthetics of the rivers are adversely affected by floatable materials and oil and grease discharges from CSOs under wet weather conditions.
- **Source of irrigation water:** Prior surveys identified a number of greenhouses that use river water for irrigation, which could be adversely impacted by CSOs, and irrigation is considered as a beneficial use to be protected.
- **Domestic and industrial water consumption**: The rivers will be restricted for use as sources of consumption, but this is not a CSO control issue. Any use of river water for potable purposes would require complete treatment, even if CSOs were eliminated.

2.3.5 Current Water Quality Monitoring Procedures

Currently the City of Winnipeg maintains bi-weekly river and stream water quality monitoring for the water quality POC mentioned in Section 2.3.3. The results from this monitoring work is reported on the City of Winnipeg webpage. This process is to continue during the CSO Master Plan implementation.

2.4 Winnipeg Sewer System

Wastewater is collected and conveyed to the three STPs by three primary sewer systems: combined, sanitary, and interceptor sewers. The combined and sanitary sewers collect wastewater from the various homes and businesses across the city and convey it to the interceptor sewer system. The interceptor sewers collect the wastewater from the individual sewer districts and convey it to the STPs.

2.4.1 Sewage Treatment Plants

Winnipeg is divided into three treatment areas and serviced by three STPs; NEWPCC, SEWPCC, and WEWPCC as shown on Figure 2-2. Since construction of NEWPCC in the mid-1930s, the City has continuously increased and upgraded the treatment capacity to the present levels. The STPs all provide a minimum of secondary treatment prior to discharge to either the Red or Assiniboine Rivers.

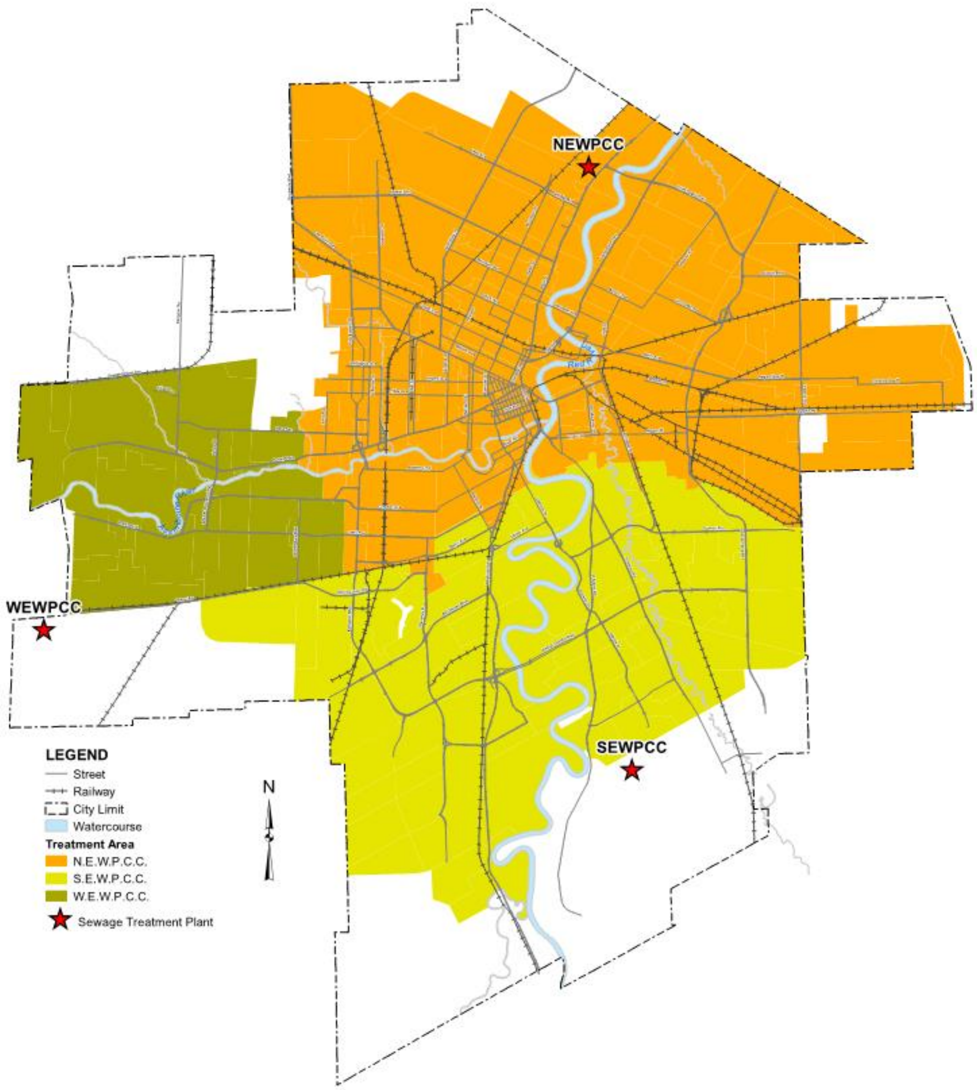

Figure 2-2. Sewage Treatment Plant Service Areas

Winnipeg's three STPs were upgraded just prior to or in parallel with the 2002 CSO Study, and the following additional upgrades have been implemented since that time:

- Ultraviolet light disinfection was added to NEWPCC in July 2006, followed by phosphorus and ammonia removal from the centrate side stream in 2008. A major upgrade for nutrient removal is in the planning phase.
- Ultraviolet light disinfection was added to SEWPCC in July 1999. A capacity expansion and upgrade for nutrient removal is currently in progress.

- The WEWPCC mechanical plant was constructed in the early 1990s and subsequently upgraded to nutrient removal in 2008. The former lagoons were retained to serve as polishing ponds and provide natural disinfection.

General information regarding the processes, capacities and other relevant STP details are summarized in Table 2-1.

Table 2-1. Sewage Treatment Plant Details

Sewage Treatment Plant	Capacities Full Treatment (2019)	Average Daily Flow	Existing Processes	Future Processes	EA Licence No.
NEWPCC	Primary: 675 MLD Secondary: 380 MLD	195 MLD	Conventional activated sludge plant Total Phosphorus & Ammonia removal from centrate side stream Dewatering UV Disinfection	Biological Nutrient removal WWF Treatment	2684 RRR, issued June 19, 2009
SEWPCC	Primary: 174 MLD Secondary: 100 MLD	58 MLD	UV Disinfection Activated sludge plant Odour Control	Biological Nutrient removal WWF Treatment	2716 RR, issued April 18, 2012
WEWPCC	Primary: 112 MLD Secondary: 54 MLD (Restricted to 40 MLD)	20 MLD	Biological Nutrient Removal Activated sludge plant	N/A	2669 E RR, issued June 19, 2009

During heavy rainfalls and high spring runoff, flows may exceed the hydraulic capacity of the biological processes and other downstream processes. The excess flow only receives primary treatment, which is blended with the plant effluent receiving secondary and tertiary treatment before being discharged to the rivers. Current plans for the SEWPCC and NEWPCC upgrades include use of high rate clarification to provide the necessary level of treatment for wet weather flows to meet regulatory limits.

2.4.2 Sewage Collection System

Within each treatment service area, the collection system consists of both combined and separate sewer areas, as shown on Figure 2-3.

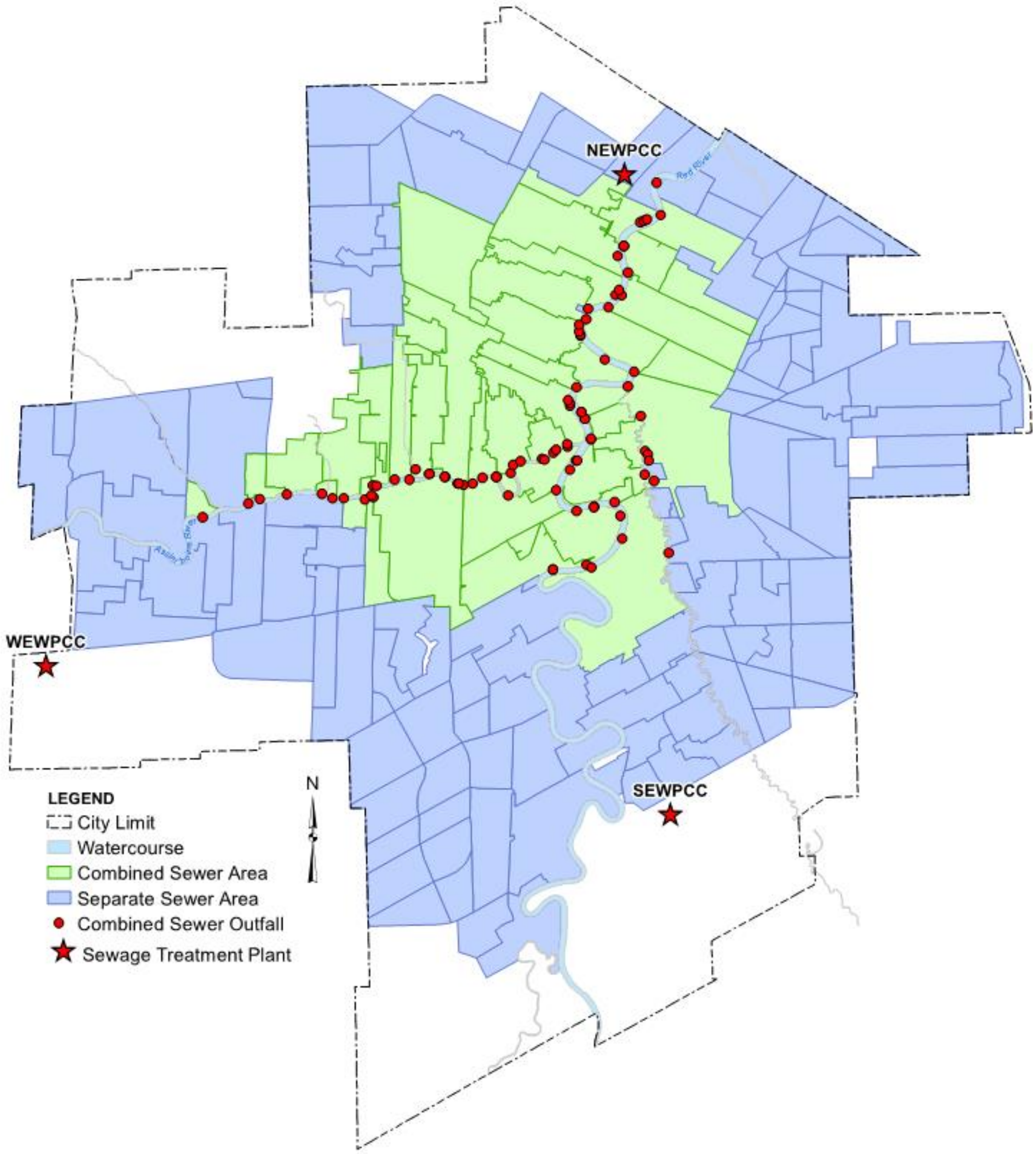

Figure 2-3. Combined and Separate Sewer Areas

The original design of combined sewers in Winnipeg was to convey both the wastewater and surface runoff flows directly to the Red, Assiniboine, and Seine Rivers. In the 1930s, interceptor sewers were built, along with associated diversion weirs and pumping stations, to intercept a portion of the wastewater and surface runoff flows discharging to the rivers and convey it to the newly constructed NEWPCC. The interceptors were designed to intercept approximately 2.75 times the Average Dry Weather Flow (ADWF), which included a nominal amount of wet weather flow (WWF). The 2.75 interception rate was consistent with general practice at the time. Combined sewers were installed in Winnipeg up to the 1960s, when separate wastewater sewer (WWS) and land drainage sewer (LDS) systems were required. As such, all new developments in the City have been serviced by these two types of sewers since the 1960s, and are considered separate sewer systems. In general, separate systems consist of the following:

- WWS systems that collect domestic, commercial, and industrial wastewater and convey it to the STPs for treatment. WWSs connect into the interceptor sewer system.

- LDS systems that collect surface runoff from rainfall or snowmelt and conveys it either directly to the rivers or to stormwater retention basins, where the water is held and then slowly released to the rivers.

2.4.3 Interceptor Systems

The interceptor systems continue to operate under the same principles today, although the interception rate at each outfall may deviate from the 2.75 times ADWF. During dry weather, all flow is captured and conveyed to the STPs. For larger wet weather events, the CS flows may exceed the interception capacity and cause the excess flow to overtop the primary weir and discharge as a CSO to the river. On average, CSOs occur approximately 22 times a year, although the numbers vary for individual districts. Discharge from one or more outfalls in a district is considered a CSO and the number of overflows for the entire area is the average of all the districts.

The interceptors are key in the ability of the system to transfer collected sewage and runoff from the sewer districts to the STPs. Sewage and runoff captured behind the diversion weirs in each sewer district flows through an off-take pipe to either a lift station wet well or directly to the interceptor. The Main, Northeast, and Northwest Interceptor systems flow to the NEWPCC, while the SEWPCC and WEWPCC each have their own independent interceptor system. These form the five major interceptor sewer systems throughout the collection system, which are shown on Figure 2-4 and are described in the following subsections.

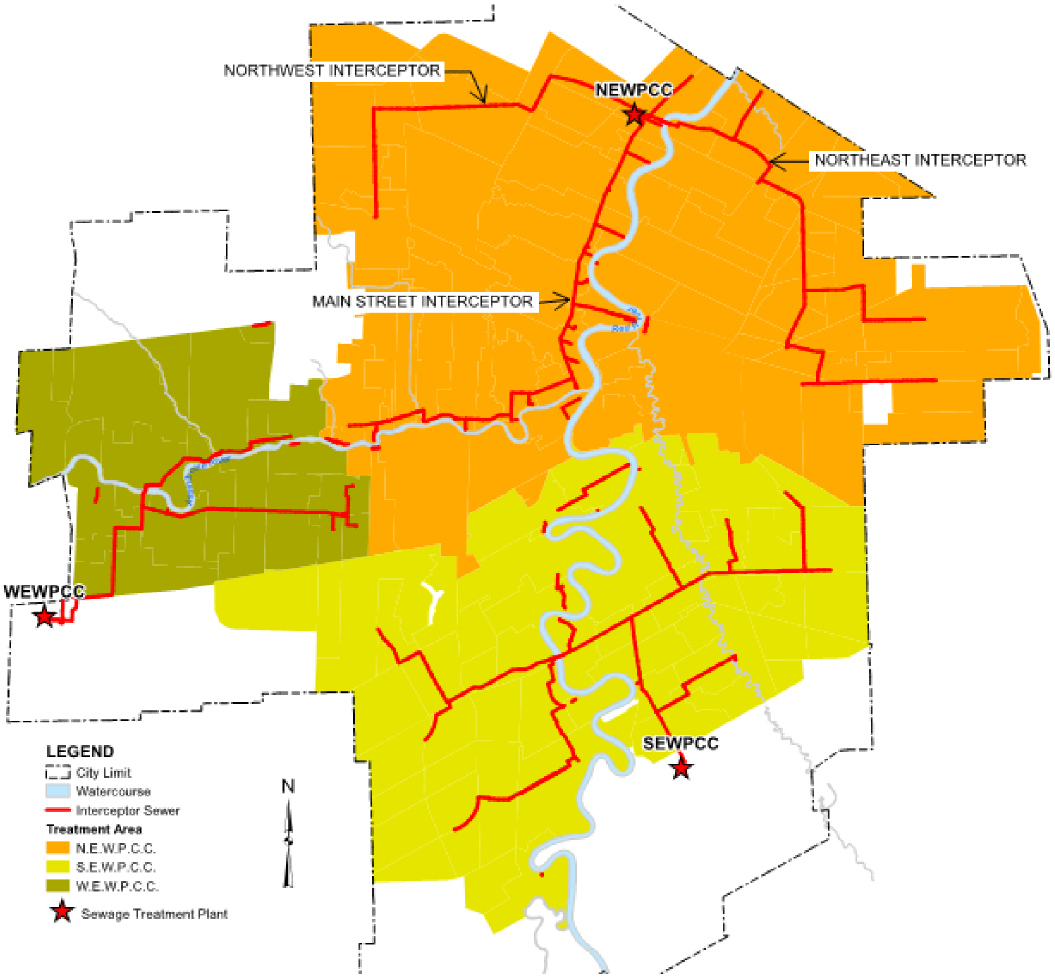

Figure 2-4. Interceptor Sewer Network

There is a wide range of flow intensities that can enter the interceptors from the individual districts during wet weather events. For interceptors with lift stations (LSs), flow is consistent based on their pumping capacity; for those with gravity diversions, the flow depends on the local conditions and can increase significantly when the levels rise in the sewers.

2.4.3.1 North End Interceptors

The Main Street Interceptor, with its north-south leg located under Main Street in parallel to the Red River, serves the older part of the City and only receives flows from CS districts and CS districts which have been separated over time. It collects flows from 35 of the 43 CS districts representing approximately 7,540 ha of the total 8,320 ha CS area in the City of Winnipeg (± 91 percent on an area basis). The interceptor has capacity beyond what is required for DWF, approximately 4 to 5 times DWF, and can convey flows from minor storm events.

The Northeast Interceptor conveys wastewater from the North Kildonan and Transcona areas in the City's northeast and east, and the Northwest Interceptor conveys wastewater from the Brooklands and Maples areas in the City's northwest to the NEWPCC. Flow received from these areas are received entirely from separate sewer districts. Flow in these interceptors are important to the CSO program evaluation process, because both the Northeast and Northwest Interceptors combine with the Main Street Interceptor prior to reaching the NEWPCC. Hence, flows from one of the interceptors will affect the flows and levels in the others, and all three of them contribute to the flows delivered to the NEWPCC and share the treatment capacity.

Two of the 76 CSO discharge locations have the functionality to allow overflows directly from the Main Street Interceptor to the Red River, located in the St. John's and Polson districts. These overflows discharge by gravity when the levels in the Main Street interceptor are excessively high and the river level is low.

2.4.3.2 South End and West End Interceptors

The South End and West End interceptor sewers convey flows from mostly separate sewer districts, with smaller fractions of CS contributions as follows:

- The South End interceptor collects separate wastewater from the Fort Garry, St. Norbert, St. Vital, and St. Boniface areas, as well as combined sewage from Cockburn/Calrossie, Baltimore, Mager, and Metcalfe CS districts.
- The West End interceptor collects separate wastewater flows from the St. James and Charleswood areas and combined sewage from Woodhaven, Moorgate, and Strathmillan CS districts.

2.4.4 Combined Sewer Districts

The City's CS area is split into a number of individual areas known as CS districts. A CS district is an area of the City that is serviced by a network of primarily CSs that convey collected sewage and runoff to the plants for treatment. CS districts have a history of basement flooding that occurs during intense summer rainfall events as the combined sewage received from the CS system in these districts fills sewer capacity and begins to back up in the system, eventually reaching homes and properties connected to the system. The City has carried out extensive work to study and alleviate basement flooding. The work to date is through use of sewer relief piping, outfall abandonment, and sewer separation on a strategic and opportunistic basis.

There are currently 43 CS districts within the City. The total area of the City of Winnipeg serviced by combined sewer systems is 8,320 ha, and the number of CSO discharge points via outfall pipes to the Red, Assiniboine, and Seine Rivers is 76. This includes 41 primary and 35 secondary outfalls. Primary outfalls are the main discharge within a sewer district and typically represent the low point of the sewer within the district. Secondary outfalls are additional outfalls within a district which are in place to relieve the CS system during high flow events. The secondary outfalls typically service only a portion of the CS district area.

The service area includes an estimated 1,000 ha reduction for greenspace areas that are not typically serviced by either combined or separate sewer systems, and an estimated 1,500 ha reduction for any areas that have been partially separated. Therefore, the total area serviced by combined sewer systems including the greenspace and partially separated combined areas is approximately 11,000 ha. There are an additional 10 outfall discharge points at Flood Pumping Stations (FPSs) in several combined sewer districts. The FPS's provide outfall capacity to relieve the system when high river levels hydraulically prevent CSO outfalls from discharging, which causes the sewer system to surcharge. These 10 discharge points with dual pipes are reported as a single outflow discharge point for this report. These outfalls are as follows:

- ID80 – Aubrey FPS
- ID81 – Clifton FPS
- ID82 – Cornish FPS
- ID83 – Despins FPS
- ID84 – Dumoulin FPS
- ID85 – Marion FPS
- ID86 – La Verendrye FPS
- ID87 – Cockburn FPS
- ID88 – Linden FPS
- ID89 – Ash FPS

In total, 41 of the districts have what is considered a primary outfall discharge that receives the majority of the combined sewage for that district, and intercepts a portion of it via the primary weir and off-take pipe at the diversion structure, with the remainder discharged to the receiving streams. The remaining 35 discharge points are secondary outfalls within the CS districts, which only discharge CS collected from a portion of the district at overflow points to provide localized basement flood relief.

The CS districts evaluated as part of CSO Master Plan are identified on Figure 2-5.

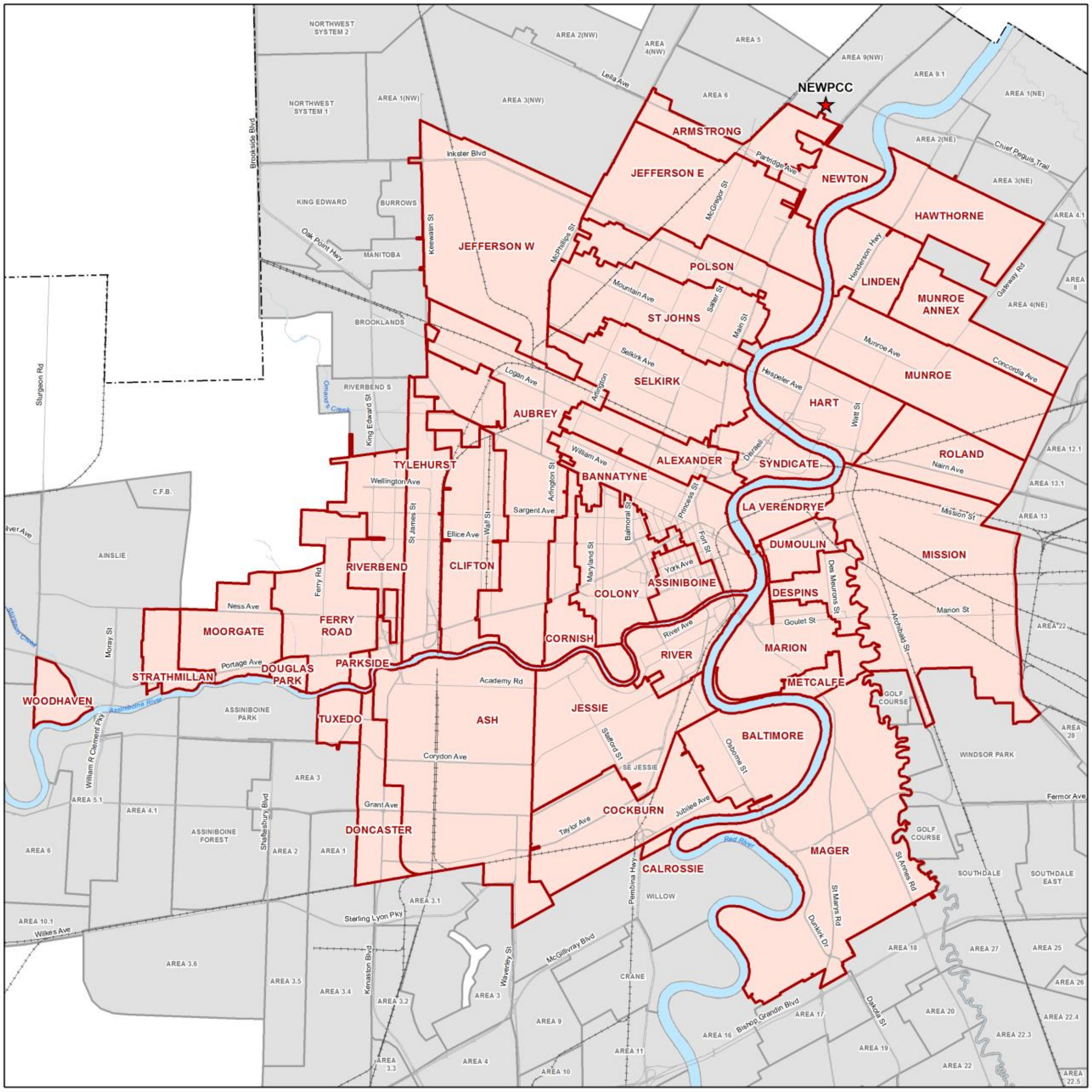

Figure 2-5. Combined Sewer Districts

DEPs have been developed for each of the combined sewer districts documenting the planned approach in that specific district to meet the CSO Master Plan regulatory requirements. The DEPs have been developed to a conceptual level of design that will require further analysis prior to implementation. It is expected that the proposed solutions will be further refined through the preliminary and detailed design phases. The Master Plan will be updated to reflect any changes required from the additional analysis. The DEPs are included in Part 3B of the Master Plan.

2.5 Current Sewer Programs

The City has progressed with improvements to its collection system through several ongoing programs. These programs are described in the following subsections.

2.5.1 Basement Flooding and Sewer Relief

Beginning in the 1960s, the City implemented a program to reduce the frequency of basement flooding in the hardest hit neighbourhoods. The program has included replacement of some smaller sewers, construction of relief sewers, and selective separation where economically feasible. The relief sewers are termed storm relief sewers (SRSs) and have been installed in many of the CS districts to increase hydraulic capacity.

Work in the program has been prioritized based on first scheduling those projects with the highest benefit/cost ratio. The program generally provides upgrading to a minimum of a 1 in 5-year level of basement flooding protection through the use of relief piping, with a longer term goal of achieving a 1 in 10-year level through supplemental measures. This means that when the CS district is subjected to a storm equal or less than a 1 in 5-year event in rainfall intensity, there should be no risk of basement flooding occurring within the homes and properties in the district. Sewer separation has been used selectively where it has been demonstrated to be cost competitive, recognizing the increased benefits to the level of basement flooding protection and to CSO mitigation.

The City has invested well over $400 million on sewer relief since 2002, with another $140 million budgeted for future investment. The districts where work is currently planned, committed and underway for the near term include the Cockburn West, Ferry Road, Riverbend, Parkside, Douglas Park, Jefferson East, Mission, and Armstrong sewer districts. A summary of the existing sewer relief work in progress is provided in Table 2-2.

Table 2-2. Current Sewer Relief Projects

Sewer District	Sewer Relief Work	Status	Dates of Construction
Cockburn West	Sewer Separation	Design and Construction	2014 – Present
Ferry Road / Riverbend	Sewer Separation	Design and Construction	2013 – Present
Parkside / Douglas Park	Sewer Separation	Design and Construction	2013 – Present
Jefferson East	Sewer Separation	Design and Construction	2012 – Present
Mission	Sewer Separation	Conceptual Design	
Armstrong	Sewer Separation	Conceptual Design	

The Basement Flood Relief (BFR) program has been underway for several decades, and most CS districts have now been provided with additional relief through both the construction of relief sewers and sewer separation in various combinations. There will be major upgrades, focusing on sewer separation, continuing for the next several years in at least three of the combined sewer districts, which will be integrated in the project sequencing recommended in this CSO Master Plan. These districts include Cockburn, Ferry Road, and Jefferson East.

2.5.2 Outfall Monitoring

The City's outfall monitoring program began in 2009 with the installation of monitoring instrumentation at the CS primary outfall points. There are presently 39 locations with permanent outfall monitoring instrumentation installed. The City collects level, flow and flap gate inclination data for the sewers to indicate if a CSO is occurring or has occurred. This data is analyzed and compared to a simulated event with the sewer system hydraulic model. The hydraulic model is continually improved based on the latest information and utilization of this outfall monitoring data. This further improves how CSOs are simulated and quantified, and improves the validation process of when CSOs have occurred and the volume of discharge.

2.5.3 Sewer Flow Monitoring

An annual sewer flow monitoring program is conducted to collect data from the collection system. Temporary flow monitors are installed at various locations in winter and summer throughout the system. The locations are targeted based on districts that are scheduled for future work. Monitors are installed prior to analysis and design of various sewer infrastructure projects within a sewer district to better understand system flows. The data collected also provides further data for calibration and validation of the hydraulic model to improve its accuracy as a tool for the planning and management of the Master Plan.

2.5.4 River Monitoring

A river water quality sampling program takes place during open river months each year. This data provides an understanding of the water quality influences impacting the Assiniboine River and Red River. Sampling occurs every second week and frequency does not change on account of the occurrence of rainfall or runoff events that may cause overflows and impact the sampled river water quality. The monitoring completed as part of the Preliminary Proposal was used to develop a profile of river water quality during dry weather (no overflows) and during wet weather (overflow recently occurred).

2.6 Preliminary Proposal

The Preliminary Proposal was submitted to MSD on December 17, 2015, with the City's recommended approach for a target level of control for the CSO Master Plan. The City recommended Control Option No. 1, 85 percent capture in a representative year as the preferred control limit. This control limit provides a higher level of performance than the existing approach and allows for continued improvement in the future if a more restrictive control limit was to be implemented. MSD accepted the City's recommendation with the added requirement to move towards the water quality performance criteria provided by Control Option No.2, four overflows in a representative year as the four overflow control option provides a further reduction to both nutrient loading and bacteria exceedance days.

The basis for the development of this CSO Master Plan is 85 percent capture in a representative year control limit and it has been developed to allow the program to adapt to meet a higher level of water quality performance in the future.

2.6.1 Preliminary Proposal Control Option Alternatives

The potential plans developed during the first two phases of the Master Plan provided the basis for evaluation of the control limits. Potential plans were developed using various CSO control technologies to meet the identified control limit. The three control limits from Clause 11 of EA No. 3042 were included, along with additional City developed control limits used elsewhere to broaden the perspective and allowed under the Clause 11 description.

The current approach to CSO control is also included (as outlined in Section 2.5.1), thereby providing coverage for the full range of possibilities from the current situation to complete separation of the combined districts. The potential plans and control limits are listed and described in Table 2-3. .

Table 2-3. Preliminary Proposal Control Option Alternatives Evaluated

Control Option Alternative	Description
Current Approach	Elimination of dry weather overflows and protection against basement flooding, with a greater focus more recently on monitoring, measuring, and controlling CSOs

85 Percent Capture in a Representative Year	85 percent volume capture for the 1992 representative year. U.S. Environmental Protection Agency presumptive approach.
Four-overflows in a representative year	A maximum of four overflows for the 1992 representative year, uniformly distributed across the CS area; this means that the fifth largest event for that year must be fully captured
Zero Overflows in a representative year	No overflows for the largest event for the 1992 representative year, uniformly distributed across the CS area
No More Than Four Overflows per year	Maximum number of overflows in any year over the long-term is limited to four; spatial distribution of rainfall is accounted for over the long-term record
Complete Sewer Separation	CSs are eliminated and, therefore, could not produce CSOs

An evaluation and decision process followed the solution development and resulted in the selection and subsequent recommendation of 85 percent capture in a representative year. This selection was carried forward in the Preliminary Proposal submitted to MSD on December 17, 2015.

The Preliminary Proposal Control Option No. 1 alternative was conceptual and is not to be considered as refined or optimized. The goal was to develop a plan that could be practically completed if selected. This approach avoids unproven technologies and unreasonable assumptions. The overall level of detail included in the Preliminary Proposal was appropriate for a planning level study. Improvements and efficiencies have taken place in the development of the final selected control limit and plan. The further development and refinement of Control Option No. 1 is described in detail throughout the following sections of this document.

2.7 Regulatory Engagement

Regulatory collaboration between the City and MSD was a large component of the CSO Master Plan. The regulatory program was included to allow for communication between the City project team and MSD. This included a regulatory liaison committee (RLC), comprising senior managers and a regulatory working committee (RWC), made up of key individuals from each group. The project timeline indicating the major milestones in the CSO Master Plan including regulatory aspects is illustrated in Figure 2-6.

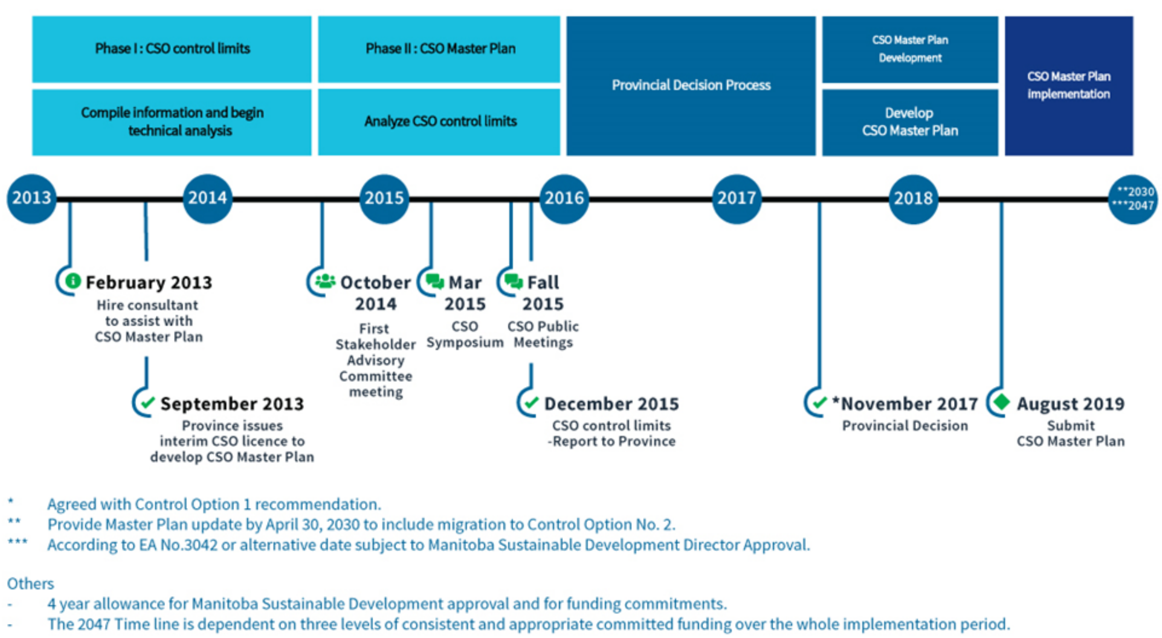

Figure 2-6. CSO Master Plan Timeline

2.7.1 Regulatory Liaison Committee

The purpose of the RLC was to facilitate a communication link between the study team and MSD. It provided an opportunity for each group to provide their perspective and understanding of the current situation and their expectations for the application of EA No. 3042. Six meetings were held during the project with five occurring during the first two phases and one during the final CSO Master Plan development phase. These meetings served to provide a summary of ongoing work and discussions with the RLC.

2.7.2 Regulatory Working Committee

The purpose of the RWC was to establish a smaller technical working group to meet on the project level items pertinent to EA No. 3042 and to discuss ongoing progress and planning. Nine meeting were held over the course of the project with five occurring in the first two phases and four during the final CSO Master Plan development phase.

2.7.3 Outcome of Regulatory Collaboration

The two groups met on several occasions to report on progress and discuss issues or clarifications necessary as part of the CSO Master Plan development. Specific requirements of EA No. 3042 were reviewed and addressed through these meetings and through supplemental submissions. Some of these additional items included a public education plan, interim monitoring plan, notification plan and annual reporting. Some of the key clarifications addressed in the first two phases include definitions for Representative Year, Overflow, and Percent Capture Calculation. EA No. 3042 and additional clarifications are included as Appendix A and B. Additional related submissions can be found on the MSD website.

The acceptance of the Preliminary Proposal in November 2017 marked the beginning of the final phase in the CSO Master Plan development. The main areas discussed during the RWC meetings held in the third phase are described below.

2.7.3.1 District Engineering Plans

EA No. 3042 required detailed engineering plans to be developed for each of the combined sewer districts. These plans, as described in Section 3.7, provide the conceptual design detail for each of the sewer districts that will be required to achieve the control target.

Due to conceptual level of detail expected in these plans as part of the CSO Master Plan submission, it was identified and agreed with MSD that these plans no longer be referred to as "detailed engineering plans" as detailed design of the solutions has not taken place. Going forward these plans were referred to as "district engineering plans" (DEPs), and this same naming convention was used through the CSO Master Plan document, where applicable. This was clarified during RWC Meeting No. 6 on June 15, 2018.

A template for the DEPs was also prepared and provided during RWC Meeting No. 6. The DEP template was accepted as appropriate by MSD and was used to develop the plan for each sewer district.

2.7.3.2 Migration Approach To Control Option No. 2

The November 27, 2017 decision letter from MSD included an additional requirement not included in EA No. 3042. It reads as follows:

> *I am hereby approving the CSO Master Plan Preliminary Proposal dated December 18, 2015 and additional information submitted on July 22, 2016 with the condition that Control Option No. 1 be implemented in such a way so that Control Option No. 2 may eventually be phased in.*

This additional requirement was included in the first RWC meeting of Phase 3, RWC Meeting No. 6 held on June 15, 2018. It was identified as a potential issue due to the different performance metric used for each of the Control Options. The City proposed a program that maintains percent capture as the performance metric in order for the program to maintain expandability and eliminate inefficiencies in the migration approach. MSD agreed in principle and requested a formal clarification from the City.

The City submitted this clarification on July 25, 2018 and MSD responded on August 26, 2018 requesting further information to demonstrate equivalence of the 98 percent capture target proposed in terms of the water quality estimated with Control Option No. 2 in the Preliminary Proposal. Supplementary information was then provided by the City to MSD as part of RWC No. 7 on September 13, 2018, providing further background on the reasoning for volume percent capture as the target metric. The City indicated that a 98 percent capture control target would not necessarily meet the same water quality performance. Nutrient loading will improve, but the number of non-compliance days for bacteria may not be the same. A response was provided by MSD in regards to this additional information on October 3, 2018. The response from MSD stated that as there are no studies or information available to demonstrate that 98 percent capture will provide equivalent water quality as Control Option No. 2, that the Department is not in a position to alter the Control Option No. 2 target.

This topic was subsequently raised at RWC Meeting No. 8 held on November 26, 2018. At this meeting MSD identified that the performance shown for Control Option No. 2 in the Preliminary Proposal is the long term goal with bacteria non-conformance as the primary driver. It was agreed that a percent capture value that has been verified to provide the same or improved reduction in the bacterial non-compliance days would be required before MSD would be in a position to alter the requirements of Control Option No. 2. This verification would need to be completed using water quality testing, and was beyond the scope of work for the CSO Master Plan submission for August 31, 2019. It was then agreed by both parties that the work necessary to demonstrate the water quality equivalence of Control Option No. 2 in terms of a percent capture approach would be completed prior to the 2030 CSO Master Plan update. At that time as part of the 2030 CSO Master Plan update future discussions on the modifications of Control Option No. 2 to maintain a percent capture approach would occur.

For further details on this approach for Migration to Control Option No. 2, please see Section 4.6 of this Part 2 Technical Report.

2.7.3.3 Opportunities

Several system wide opportunities were identified to improve the CSO Master Plan and assist in meeting the requirements of EA No. 3042. A number of the opportunities are directly linked to regulatory clauses in EA No. 3042. This includes green infrastructure (GI), real time control (RTC) and floatables management. Each of these topics was discussed with the RWC group as part of RWC Meeting No. 7 on September 13, 2018.

Green infrastructure is required for new or upgraded developments as identified in Clause 8 of EA No. 3042. GI is incorporated in the CSO Master Plan through a 10 percent capital cost allowance which is allocated to review and implement GI. The City will complete an evaluation of existing and potential GI to determine the suitability and performance in CSO control. This is further described in Section 5.2.1.

Real time control provides the City with an opportunity to reduce CSOs without added new sewer infrastructure. The City is in the beginning phases of implementing such a control program and has the potential to impact the proposed projects and reduce overall program cost. This is further described in Section 5.2.2.

The prevention of floatable materials is identified in Clause 12 of EA No. 3042. The Preliminary Proposal included an approach that would incorporate physical screens at each of the primary CSO locations. The CSO Master Plan continues with the recommendation of physical screens to ensure compliance with Clause 12. The Master Plan also includes an alternative floatables management approach where a focused floatable source control will be evaluated to prevent floatable material from entering the rivers. The ultimate goal will be to demonstrate equivalent floatable reduction performance of this alternative approach, meeting Clause 12. This would result in the physical screen facilities being recommended across the City being replaced with adopting this alterative floatable source control program. This alternative floatables management approach is described further in Section 5.2.3.

Each of these opportunities represents innovation in achieving the performance target and was well received during discussion with MSD during RWC Meeting No. 7.

2.8 City Investments Towards CSO Mitigation To Date

The CSO Master Plan development has not stopped the City from continuing with ongoing efforts to replace and upgrade infrastructure or increasing the level of understanding of the collection systems. The City's current programs are highlighted in Section 2.5.

The City has invested over $90 million since the beginning of the Master Plan project in 2013 with another $140 million committed for future investment. Prior to 2013, it is estimated that over $300 million has been spent on sewer relief work. The districts where work is currently planned, committed and underway for the near term includes the Jefferson, Ferry Road, Douglas Park, Parkside, Riverbend, Cockburn, Mission, and Armstrong sewer districts. This section provides further detail on the level of investment the City has implemented within the CS collection area since EA No. 3042 was issued in 2013.

- CSO Master Plan study and development - $5.4 million
- Interceptor Flow Monitoring - $1.0 million
- Sewer District Flow Monitoring - $2.5 million
- Sewer Instrumentation - $0.5 million
- InfoWorks ICMLive Software Purchase For Hydraulic Modeling- $0.4 million
- Sewer Relief Work - $74.0 million
    - Cockburn / Calrossie / Jessie- $53.0 million LDS separation
    - Ferry Road / Riverbend / Parkside / Douglas Park - $13.0 million LDS separation including the elimination of one CSO outfall in Douglas Park
    - Jefferson - $8.0 million LDS separation
- Latent Storage Dewatering Stations - $5.0 million
    - Bannatyne – McDermot SRS - $2.5 million
    - River – Fort Rouge SRS - $2.5 million
- Sewer Cleaning (outside of annual program)
    - Mission - $0.9 million
- Green Infrastructure
    - Bannatyne – North East Exchange Sustainable Drainage System - $0.5 million
- Decommissioning of secondary CS outfalls no longer required or in use

Additional work has been completed outside of the CS area that also benefits the long term goals of the CSO Master Plan. This work has included:

- Upgrading the Northeast Interceptor river crossing to include a redundant crossing
- Installation of a relief sewer in the separate sewer districts surrounding the Transcona neighborhood
- Elimination of 20 cross connections between the WWS and LDS systems

3. Technical Approach

This section of the report describes the technical approach used for project selection and development of cost estimates for Control Option No. 1.

It follows on from the Preliminary Proposal which reviewed five control options, and its ultimate recommendation of Control Option No. 1 as the basis for the CSO Master Plan. Much of the information presented in the Preliminary Proposal remains relevant to the technical approach for the CSO Master Plan. The emphasis is now on the further development of the potential plan described in the Preliminary Proposal into the Control Option No. 1 implementation plan and document this as part of this CSO Master Plan.

3.1 Design Basis

3.1.1 Planning Projections

The construction of combined sewers for new developments has been prohibited since the 1960s, so continued growth of the total area of the City of Winnipeg serviced by combined sewers will not occur. Although it is acknowledged that population and related sanitary flow may increase within the CS districts, the regulatory requirements of EA No. 3042 require that there be no increase in CSOs from any infill or re-developments in CS districts. In order to achieve this regulatory requirement, the City restricts any infill or re-developments in combined sewer districts to the pre-development flows.

For all existing CS districts that will be separated as part of Control Option No. 1, no additional infill has been accounted for as the wastewater generated from infills should remain at pre-redevelopment flows. There will be the ability of the existing combined sewers to receive more wastewater flows due to the removal of a significant WWF component. However, any increase in potential re-development wastewater flows will have to be assessed to ensure the static primary weir level is sufficient to fully contain this flow increase and does not contribute to an increase in CSOs. A detailed overview of the planning projections attributed to the modelling assessment has been provided in Section 3.4.1.

Significant growth outside of the mature CS areas is expected. As these areas are serviced by separate sewer districts, the growth in these areas do not have to meet the flow restrictions dictated by EA No. 3042. Development in these areas only must meet servicing capacities of the sewage conveyance and treatment systems. Several areas outside of the CS districts have been identified and prioritized as areas of growth within the Our Winnipeg planning guidelines as shown on Figure 3-1.

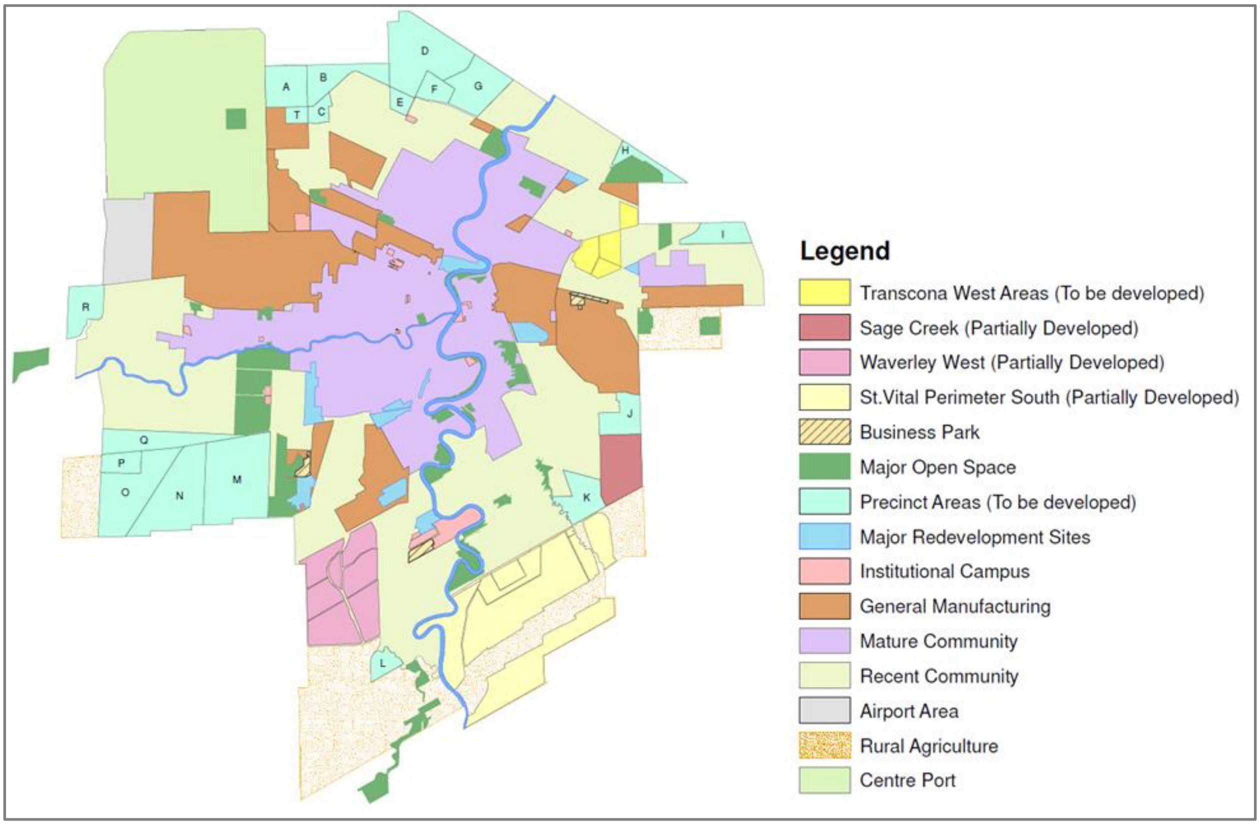

Figure 3-1. Potential Land Development or Redevelopment Areas

There is a critical link between the city-wide growth expected and CSO control options through the sewage treatment process. Combined sewage from CS districts and wastewater from separate sewer districts all flow to one of the three STPs, and essentially compete for sewage treatment capacity. This is especially important for CSO control options, where increased flow from the separate sewer areas will leave less capacity for treatment of flow from the CS districts. The growth projections are most important for the NEWPCC, since it has the largest CS area, but also applies in principle to the SEWPCC and WEWPCC.

All the combined sewage that is captured and temporarily stored must be sent to treatment facilities and treated to regulatory limits. The increased flow that reaches treatment as a result of these events is called wet weather flow (WWF) and will require treatment at an existing STP. The upgrades to the wet weather flow treatment capacity at the sewage treatment plants, to accommodate future growth and increased combined sewage capture is therefore essential to ensure this aspect of the CSO Master Plan is met.

3.1.1.1 NEWPCC Service Area Growth Projections

Future development and flow estimates for use in the CSO Master Plan were adopted from a recent study produced by the Winnipeg Sewage Treatment Program (WSTP), *North End Facility Flows and Loads* (WSTP, 2014).

The estimated 2015 population for the NEWPCC service area was 435,437, with a projected increase to 550,000 by 2037. The growth accounts for routing of Windsor Park flows to the NEWPCC and added servicing for the adjacent municipalities.

The study estimated a population of 684,000 in the year 2067, based on a continuation of the growth rate at 0.75 percent per year.

The study also included wastewater flow rate and quality projections for the NEWPCC.

CentrePort is a large development located to the northwest of Winnipeg, and was also represented in this WSTP report. This development was assigned a daily flow of 15ML/d for both the 2037 and 2067 future development scenarios, as an alternative to reporting a population figure.

3.1.1.2 SEWPCC Service Area Growth Projections

The SEWPCC Service Area is the second largest in Winnipeg. Future flow estimates for the SEWPCC Service Area were adopted from the *SEWPCC Upgrading/Expansion Preliminary Design Report* (Stantec et al., 2008). The report selected a 2031 design year and established an average annual growth rate of 0.7 percent per year. The population is expected to grow to between 229,800 and 281,000 by 2031. According to the report, DWF is expected to increase from a current flow of approximately 45 ML/day to 68.4 ML/day by 2031 (including the Windsor Park District).

3.1.1.3 WEWPCC Service Area Growth Projections

The WEWPCC Service Area is the smallest in Winnipeg. As shown in Figure 3-1, several new residential areas are expected to be developed in the near future within the WEWPCC Service Area that will increase DWF. The CS districts are at the upstream limit of the treatment area and are fully developed areas. As such, no growth within these CS districts is expected.

No future reports have been noted on development within the WEWPCC catchment area. It was therefore assumed that a growth rate similar to the SEWPCC catchment growth rate would be adopted. This results in a 2037 population estimate of 116,700.

3.1.2 Asset Information

Asset information used in the development of the hydraulic model and the CSO Master Plan was initially based on 2013 data transferred from the City. The City provided their sewer system asset data from their Land-Based Information System (LBIS) database. Additionally, all relevant reports and hydraulic models were made available.

3.1.3 Sewer System Critical Data

The technical evaluations required collection of system information and a sound understanding of the existing sewer system and its operation. A set of data was identified from the existing asset information that is critical to the selection, functioning, and design of the control option technologies under consideration.

A schematic of the critical points is shown on Figure 3-2.

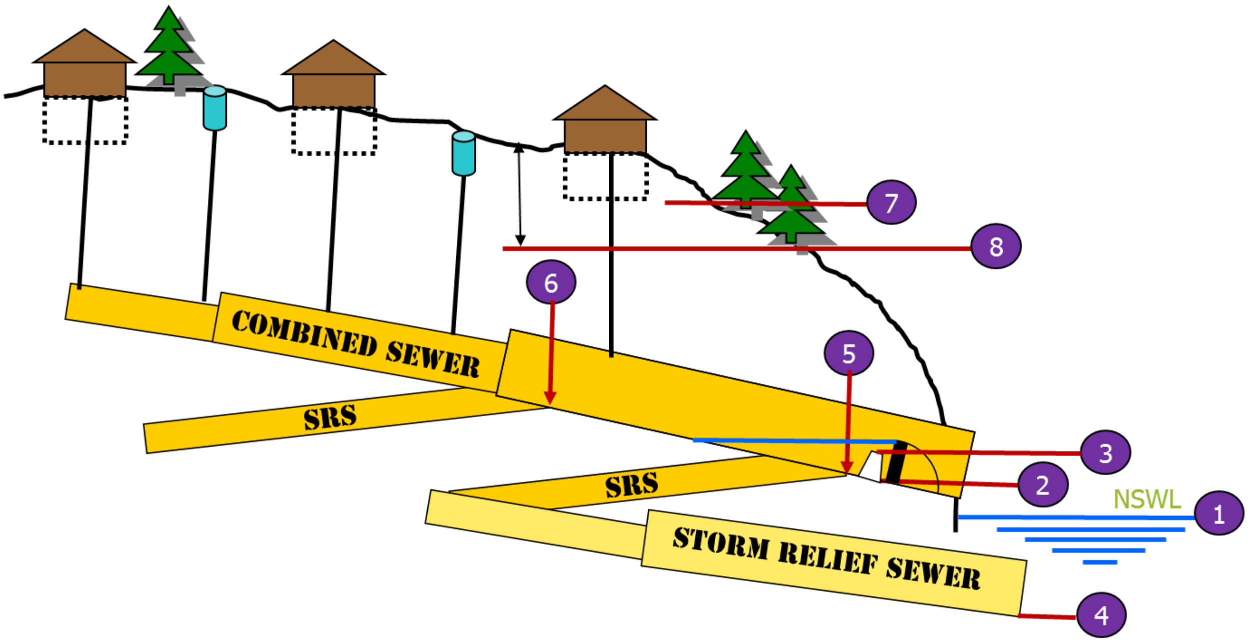

Figure 3-2. Sewer District Critical Data Points

The numbers in Figure 3-2 relate to the critical data points identified in Table 3-1.

Table 3-1. Sewer System Critical Data Points

Identification Number	Name	Description
1	NSWL Elevation	Long term average summer river levels at each CS outfall location. Considered a minimum level during the recreational season. Will vary spatially along the Red, Assiniboine and Seine Rivers.
2	Invert Elevation at Off-Take	Invert elevation of pipe diverting flow from diversion weir towards Interceptor pipe (via pump or gravity).
3	Diversion Weir Crest Elevation	Elevation of existing static weir in each district to contain up to 2.75 x ADWF prior to overflowing.
4	SRS Outfall Invert Elevation	Invert elevation immediately upstream of SRS flap gate.
5	Low SRS Interconnection Elevation	Lowest elevation level where surcharged in-line storage in the CS system would flow into the interconnected SRS system.
6	Low SRS Interconnection to alternative discharge point	Lowest elevation level where surcharged in-line storage would discharge to a secondary overflow or to an adjacent combined sewer district.
7	Low Basement Elevation	Lowest basement floor elevation in the district – considered for risk analysis to basement flooding.
8	Basement Flood Protection Elevation	Typically calculated as 3 m (10 feet) below lowest CS manhole rim elevation, but under no circumstances can be above the low basement elevation.

3.1.4 Standard Details

Standard details for each CSO control option technology selected as part of the CSO Master Plan provide a common description and basis for sizing and costing technologies used in multiple districts. Standard details apply to the control options selected in each sewer district and are discussed in each engineering plan in Part 3B. The proposed control options were initially selected because they have a proven record of operation within combined sewers. The details were updated and further refined during this phase of the CSO Master Plan. Part 3C includes a summary of the standard details used in the CSO Master Plan development. Part 3C also discusses each of control technologies in terms of design considerations and operations and maintenance (O&M).

3.1.5 Control Option No. 1 Target

As discussed in Section 2.6, potential plans were developed as part of the Preliminary Proposal to define and evaluate each of the five alternative control limits. The highest rated alternative, which best balanced the key drivers for long-term CSO control in Winnipeg, was identified as Control Option No. 1 - 85 Percent Capture in a Representative Year (CO1).

An official response from MSD was received on November 24, 2017, via a letter that states that the Preliminary Proposal met the intent of Clause 11 of EA No. 3042, and that Control Option No. 1 – 85 Percent Capture in a Representative Year, is to be implemented by December 31, 2045 or otherwise as approved by the Director, in such a way that Control Option No. 2 may also eventually be phased in.

This will require a major investment in combined sewer infrastructure. Control Option No. 1 as included in the Preliminary Proposal included a combination of the following CSO controls:

- Control gates and in-line storage
- Screens for floatables capture
- Latent storage
- Off-line storage
- Sewer separation of combined sewer districts where BFR is required
- Wet weather treatment as provided under the Winnipeg Sewage Treatment Program

Control Option No. 1 will meet the City's vision of "doing our part" to address CSOs within the City of Winnipeg. CO1 was the preferred choice from among the alternatives for the following reasons:

- It will achieve 85 percent capture, which was set by the U.S. Environmental Protection Agency for the presumption approach, thereby meeting a recognised benchmark for CSO control programs.
- The number of overflows and the amount of floatable material will be reduced in the majority of the combined sewer districts.
- It can incorporate GI and is adaptable to opportunities based on new technologies or aspects of this CSO Master Plan that require further evaluation, such as RTC.
- Although it has the lowest cost of the five alternatives it represents a significant investment from the City in CSO management, will be the most affordable for ratepayers, and have the least impact on competing programs when compared to the other alternatives.
- It will provide environmental improvements and protect river uses to a level similar to the other alternatives.
- The reduced amount of construction in comparison to the other alternatives will limit the potential disruptive impacts on neighborhoods and businesses.
- It integrates with the current CSO and BFR program implemented by the City.
- It can be expanded in the future if climate change or regulatory standards require further mitigation of CSOs.

3.1.6 Representative Year

A representative year is a single year of historic climate data for the City of Winnipeg selected from the long-term historical dataset, that best defines a typical year and was used to establish the performance of the alternative control options in the Preliminary Proposal. A defined representative year provides a reference data set on which alternative control options can be evaluated and progress can be measured. The selection included a review of annual precipitation (rain and snow) and river flow, inclusive of the recreation and non-recreation seasons. For the prior 2002 CSO study, 1992 was selected as the representative year for CSO control alternative assessment purposes. After further review using an increased dataset, 1992 was again selected as the representative year for the CSO Master Plan, as documented in the Preliminary Proposal.

The evaluation found 1992 to be a representative year for both precipitation and river flows. River flows are important for both collection system discharge calculations and river water quality evaluation purposes. The 1992 river flows were used extensively to assess the impacts of CSOs on river water quality, as reported in the Preliminary Proposal. Because the CSO Master Plan is proceeding with a percent capture regulation as per Control Option 1, the use of a representative year for river water quality evaluations was not required for this portion of the CSO Master Plan study.

3.1.7 Percent Capture Calculation

Percent capture is the main component in determining the performance of the program. The percent capture calculation is derived from the definitions in EA No. 3042, stated as follows:

> ***Environment Act Licence No. 3042 definition:*** *"percent capture" means the volume of wet weather flow treated in comparison to the volume of wet weather flow collected on a percentage basis. In other words: "percent capture' expressed as % = [(total wet weather flow collected – combined sewer overflow) / total wet weather flow collected] x 100*

A clarification was issued and confirmed with MSD in October 2015 as part of the Preliminary Proposal development, to define the measurement periods and is included in Appendix B of this Part 2 Technical Report for reference. The updated definition of percent capture is identified as follows:

> ***Approved Clarification:*** *"percent capture" means the volume of wet weather flow treated in comparison to the volume of wet weather flow collected on a percentage basis; as measured from the start of the precipitation event until the CSO controls return to dry weather conditions, determined by the completion of the dewatering process and the ending of wet weather treatment.*

As illustrated on Figure 3-3, the percentage capture calculation incorporates a combination of DWF, captured WWF, and CSO. A simplified approach for determining percent capture was used for the Preliminary Proposal and has been continued for the final submission.

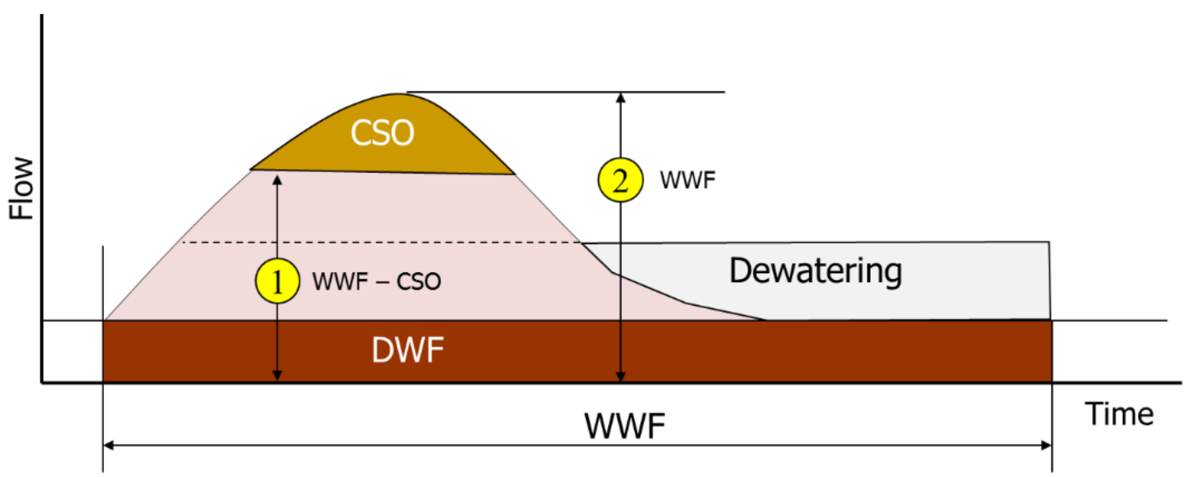

Figure 3-3. Illustration of Percent Capture Calculation

Percent capture is determined in the illustration as volume 1 divided by volume 2, including the dewatering time and is reported as a percentage estimated using the hydraulic model. Volume No 2 in the diagram was determined with volume No. 1 which is generated by the hydraulic model, plus the combined sewer overflow volume generated by the model.

3.1.8 Existing System Performance

The baseline conditions for the CSO Master Plan were established as the year 2013 as part of the original Preliminary Proposal development process. The baseline conditions are a snapshot in time and provide the basis for tracking progress for the CSO program. As the program proceeds, any changes to percent capture will be tracked and reported. The baseline conditions were established using an InfoWorks CS hydraulic model which replicated the sewer system conditions as of 2013. The 1992 representative year for precipitation and river level conditions was applied to the sewer system and utilized to report the model's performance in the Preliminary Proposal. The baseline modelled conditions were subsequently modified based on additional information and corrections in the sewer system asset data in 2018. This is considered the "updated 2013 baseline" model.

The CSO volume for the full representative year, based on the updated 2013 baseline sewer system conditions, was determined to be 5,170,000 m^3. The capture rate for the baseline conditions is 74 percent.

The CSO volumes for the updated 2013 baseline system configuration for the 1992 representative year are shown on Figure 3-4 for each of the 41 CS districts with primary outfalls. The Jefferson West and Munroe Annex districts do not have an outfall that flows directly to the Red River and are therefore not included in the reporting throughout this section.

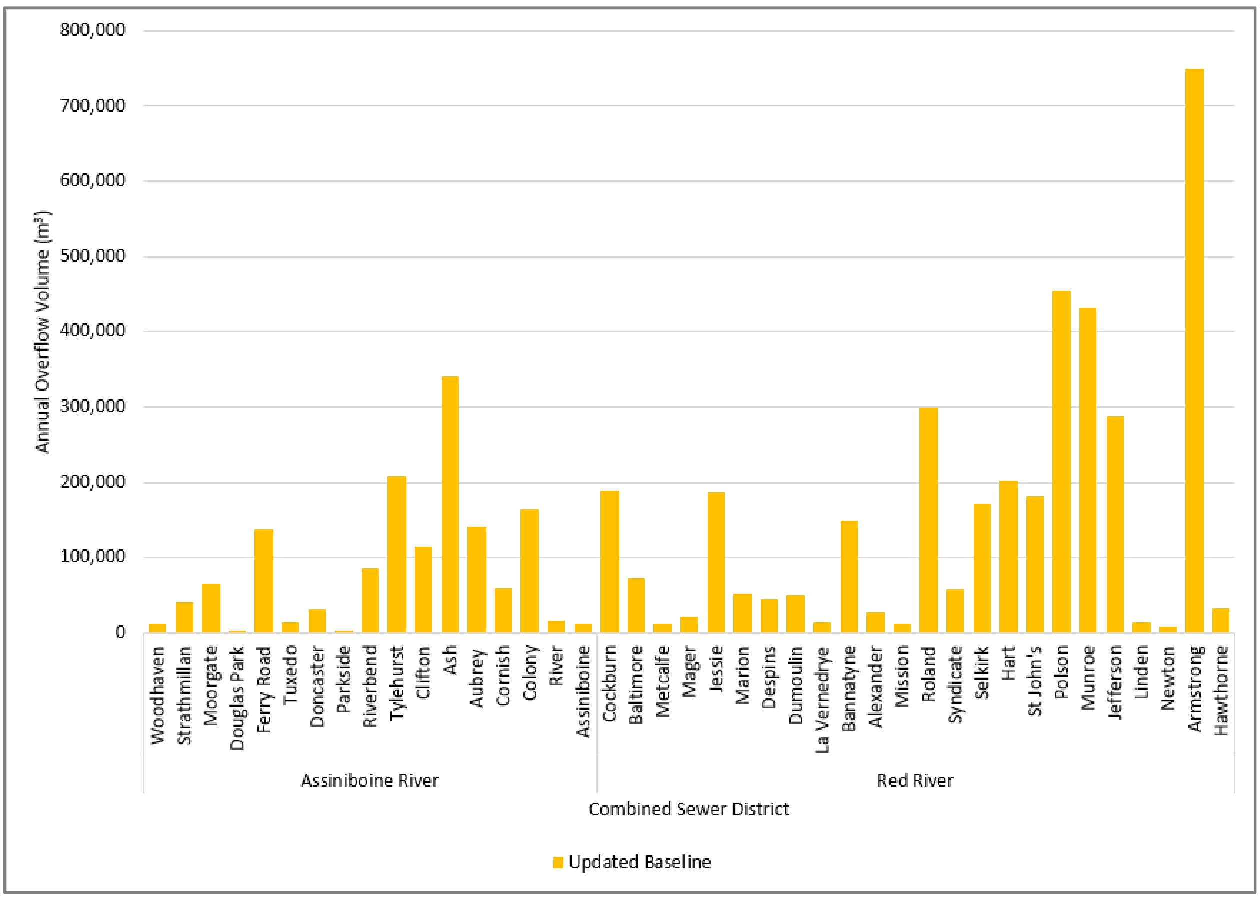

Figure 3-4. Updated Baseline Number of District CSO Volumes – 1992 Representative Year

3.2 Dewatering Strategy

The CSO Master Plan will significantly change the amount and methods by which combined sewage is captured when fully implemented. The current use of diversion weirs installed in CS trunks will predominately be replaced by control gates and temporary storage measures to capture larger runoff volumes from rainfall events. The captured combined sewage will then be gradually released back into the interceptors and treatment systems, as would occur during normal dry weather flow operation. This release process is referred to as dewatering. This will be off-set via the separation of selected districts, where the runoff collected from the streets within the district will be removed from the combined sewage reducing the captured combined sewerage in the corresponding interceptor and treatment systems.

The dewatering strategy ultimately will make better use of the existing separate and combined sewer systems to improve the sewage volume capture and treatment performance. A typical sewer district has a proposed arrangement in place to capture flow when levels within the system increase. The captured flow/volume increases incrementally as the level of in-line storage is increased through the addition of an in-line control gate. The variable flow rates received by the interceptor system following the implementation of these in-line control gates, latent storage and off-line storage arrangements result in suboptimal use of the interceptor system. The CSO Master Plan assessment was completed on a system wide rainfall event distribution. Future dewatering studies will have to evaluate the impact of spatial rainfall event distributions.

As part of an overall dewatering strategy improvements will be made that result in controlled discharge from each in-line storage/latent storage/off-line storage facility, at known and measured discharge rates. The interceptor and STPs would be able to run for longer durations at peak capacity through these controlled dewatering rates from the sewer districts. An overall dewatering strategy will maintain a more constant flow rate to the STPs and avoid uncontrolled system back-ups or CSO events.

3.2.1 Dewatering Strategy Approach

The future CSO control works, interceptor system and STPs must function as an integrated system. Discharges from CSO storage facilities must not overload the interceptors and the interceptors must not overload the STPs. If the STP are overloaded, the interceptor system will begin to surcharge, and the additional combined sewage volume captured cannot enter the interceptor system. At this point, the CSO event will simply be relocated, compromising the program performance. The planning and management of these components will be carried out through the dewatering strategy.

There is a direct trade-off between storage volumes and dewatering rates, with higher dewatering rates reducing the temporary storage requirements. The dewatering rates are limited by constraints within the existing sewer system. Interceptor, conveyance and sewage treatment have limits that are generally more difficult and costlier to change beyond a practical limit. A further limitation for increasing CSO dewatering rates is the reduction in STP effluent quality produced by wet weather treatment facilities due to the facilities being overloaded. This will further detriment the ability for the blended effluent from the STPs to meet the final plant effluent water quality limits.

The dewatering strategy approach requires that dewatering rates be developed for each CS district, and operate within the interceptor and sewage treatment plant constraints. The strategy must accommodate future growth for the entire STP service area. However as discussed in Section 3.1.1, future growth was only evaluated in the separate sewer districts. It was assumed there would be no growth in WWF in CS districts beyond that resulting from the control options recommended in the CSO Master Plan, as any further growth in WWF due to densification could result in further CSOs and would violate Clause 8 of EA No. 3042.

The dewatering strategy was established for the NEWPCC as part of the Preliminary Proposal. The NEWPCC services the largest CS area; therefore, the general approach and concepts have been applied to the smaller SEWPCC and WEWPCC interceptor and treatment systems.

3.2.2 Wet Weather Flow Treatment Capacity Considerations

Two WWF treatment scenarios were considered for the NEWPCC as part of the Preliminary Proposal. Both scenarios considered a peak WWF treatment rate of 705 ML/d, based on the design requirements for the future NEWPCC upgrade.

This sets the dewatering rate for combined and separate area inflows for the entire NEWPCC service area. The NEWPCC wet weather treatment facility will be designed for a peak rate of 325 ML/d, which is the difference between the plant peak flow rate of 705 ML/d and the biological nutrient removal plant flow capacity of 380 ML/d.

DWF and Rainfall Derived Inflow and Infiltration (RDII) from separate sewer districts will continue to be received and treated without interruption. CS dewatering will be set as a secondary treatment priority if the combination of combined sewage flow in CS districts and DWF plus RDII from separate sewer districts being conveyed to the NEWPCC exceeds 705 ML/d. CS dewatering has been set as a secondary priority, as the addition CS stored as part of the solutions recommended in this Master Plan can be held in the temporary storage facilities while peak flows generated from the separate sewer areas are conveyed and treated as soon as they are received.

3.2.3 Interceptor Capacity Considerations

The NEWPCC interceptor was assessed for dewatering rates using the InfoWorks model and found to have sufficient capacity to support the 705 ML/d WWF treatment rate. As a result, the primary limiting factor to be considered in the dewatering strategy is the NEWPCC treatment capacity, and not the interceptor system.

3.2.4 Combined Sewer District Dewatering Rates

Dewatering rates were determined for each district based on the CSO control options selected and the requirement for dewatering to be completed within 24 hours after a rainfall event has stopped, as required by EA No. 3042. The analysis indicated that the existing pumping stations will meet these dewatering requirements. Even though there will be a larger volume pumped for some rainfall events, the maximum rate of pumping required to meet the 24 hour dewatering period is less than or approximately equal to what currently exists. All that will be modified is the existing pumps will be required to run for longer durations at a constant rate. Several sewer districts do not have pumping stations and drain by gravity to the interceptors. The analysis also indicated that these gravity discharge districts meet the dewatering capacity requirements. The existing offtake pipes within these gravity discharge districts are sufficiently sized currently to accommodate dewatering of the 1992 representative year rainfall events.

An important caveat of the dewatering strategy capacity evaluation completed is that it assumes a control system will be in place, and utilized to adjust pumping rates for each district to match available conveyance and treatment capacity. This will require the installation of flow monitoring and pumping rate controls within each district. Pumping rates will range from diurnal dry weather low flows to the peak dewatering rates. For the gravity discharge districts, gravity flow controllers are to be installed to provide similar flow monitoring and control to modulate discharges to the interceptor sewer system.

This ability to monitor and control discharge rates from each combined sewage district is intimately tied with the implementation of the RTC program opportunity. Full RTC implementation would be particularly effective for dealing with variable spatial rainfall distributions, where districts receiving higher rainfall could dewater faster than those with low or no rainfalls. Flow could be retained in the districts with minimal rainfall to allow the affected districts to dewater faster. Refer to Section 5.2.2 for further details on how an RTC arrangement with the City's combined sewer system would function.

3.3 CSO Control Technology Descriptions

The CSO program requires that control options be identified, evaluated, selected, and designed for each location. A single control option or combination of options may be required to achieve the required level of performance.

This section provides a description of each control option used in the CSO Master Plan. Specific details of the control options proposed for each sewer district as part of the recommended CSO Master Plan can be found in Part 3A and 3B.

Part 3C describes the technology and/or products selected as representative for each control option. The representative control option products are then used for the performance analysis and cost estimating. The design and O&M considerations for each representative product are also included and explained in more detail in Part 3C.

3.3.1 Sewer Separation

In separate sewer systems, stormwater is conveyed in a LDS system to its own dedicated outfall for discharge directly into the receiving water, whereas sanitary sewage is collected by a WWS system and, conveyed to treatment where it is fully treated before discharge. Sewer separation projects under the CSO program modify the existing CS systems and build an adjacent WWS or LDS system to achieve the same outcome.

Sewer separation involves the installation of additional conveyance capacity to achieve independent sewers for each of the WWS and LDS flows. As such, sewer separation projects greatly reduce the volume of surface runoff entering the CS system. This reduces or eliminates the number of CSOs that occur in a sewer district when separation is completed.

The City has proceeded with sewer separation in CS districts under the previous CSO and BFR program when conditions warranted. Various levels of separation have been completed within some of the sewer districts, with large investments in sewer separation projects currently underway and projected to continue under the CSO Master Plan.

There are several methods for achieving sewer separation that may be applicable to the CSO program. The terminology used for the methods and types of sewer separation recommended throughout this Master Plan are summarized in Table 3-2.

Table 3-2. Types of Sewer Separation

Type of Separation	Features
Complete Separation*	All wet weather flow is collected by an LDS system. All wastewater flows are collected and conveyed by a WWS system.
Partial Separation “Separation Ready”	Complete separation of selected regions within a sewer district to achieve a desired level of basement flooding protection or CSO relief. The entire CS district is not separated. Small separate areas within the district may be referred to as Separation-Ready: typically, where the area can be connected to an existing LDS.
LDS Separation	A new land drainage sewer (LDS) system is constructed in which catch basins in the CS district are reconnected to the new LDS system. The existing CS system is then converted to WWS system.
WWS Separation	A new wastewater sewer (WWS) system is installed to collect domestic sewage. The existing CS system is then converted to a LDS system.

*As part of complete separation all surface runoff from roads within the CS district are removed from the CS system, by reconnecting all catch basins to the LDS system. Private foundation drains, sump pumps, and roof drain connections from older properties built prior to 1990 however may remain connected to the CS system that is being used as part of the WWS system. A wet weather flow (WWF) response is likely to remain in this WWS system as a result.

The type of separation most commonly recommended as part of this CSO Master Plan is complete separation for a district. Even after complete separation for a district has taken place, WWF in the wastewater system from foundation drainage will still require management. Flows will be monitored following separation of the district to determine if further work, such as weir height increases, are required. Where the WWF remains significant, additional consideration will be given to incorporating a sump pump and backwater valve subsidy program to divert roof and weeping tile flows from the WWS collection system.

A benefit from the remaining flows from foundation, sump pump and roof leader connections that must also be considered is that they will continue to provide a flushing flow to the CS system during wet weather to facilitate self-cleaning velocities. This must be balanced with the necessary removal of WWF to remove CSO events from the CS districts where complete separation is recommended.

An added benefit for completely separating a district is the increased level of basement flooding protection. LDS systems are not connected to building service lines and, therefore, may surcharge to street level without backing up into basements. However, all LDS systems will be designed to prevent conditions for surcharging to street level beyond extreme wet weather events, to meet the City of Winnipeg's design requirements for LDS systems.

Sewer separation is complex to implement and comes with a high cost and increased time required to implement the separation work and achieve the water quality benefits. Large pipes must be installed on every street in existing developed areas, with potential alignment conflicts with the existing combined sewers and other utility services. The level of disruption to traffic and local businesses may be significant and occur for an extended period while construction is ongoing. As identified in Table 2-2, some sewer separation projects within Winnipeg have been ongoing for many years, causing various levels of disruption to the area.

3.3.2 In-line Storage

In-line storage refers to the storage volume accessed within a CS system with the installation of a control gate. In most sewer districts, the CS pipes are large and only fill completely during very large runoff events. The use of weirs or gates to prevent discharge results in the sewers surcharging, with sewer levels rising to a known and controlled level within the pipe; this flow volume is referred to as in-line storage. In-line storage includes any point in which DWF or WWF is restricted by a weir or gate and is allowed to surcharge. The surcharged volume of CS is prevented from overflowing and is eventually dewatered to the interceptor system utilizing the existing pumping and gravity discharge infrastructure.

The existing CS districts use a diversion weir, known as the primary weir, which has a set elevation to intercept all DWF from the district but does not optimize CS capture. These primary diversion weirs are generally set at a design height capable of intercepting 2.75 times the ADWF rate, to ensure all DWF events and minor WWF events are intercepted and sent to treatment. The volume of in-line storage can be temporarily increased by installing a control gate adjacent to this primary weir. This will increase the maximum elevation under which DWF and WWF is intercepted, as illustrated on Figure 3-5. The increase in the maximum intercepted elevation ultimately results in a higher volume capture. This additional volume captured is referred to as in-line storage volume. Figure 3-5 shows a typical arrangement with the primary weir and control gate at the same location. In some cases, the control gate may be located nearby due to system constraints. There are many methods for temporarily increasing the control elevation, but the method must avoid compromising the hydraulic capacity of the CS system and not increase the risk of basement flooding caused by increasing surcharge levels within the sewer.

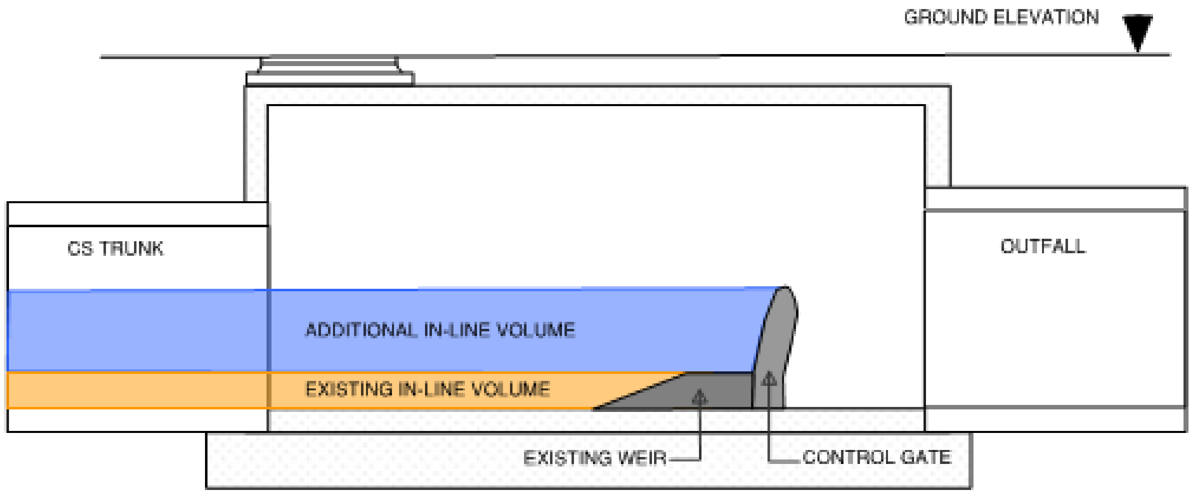

Figure 3-5. Proposed Typical In-line Storage Schematic

The CSO Master Plan proposes the use of a control gate with a height restriction for this application. This type of control gate hinges from the bottom like a drawbridge and is generally placed immediately downstream of the primary weir, as shown in Figure 3-5.

During DWF conditions, the control gate would remain in an upright raised position and all DWF would be diverted to the interceptor via the existing pumping or gravity discharge infrastructure. During WWF, the control gate in its raised position would allow the in-line storage within the CS system to increase. Flows captured behind the gate would be continually dewatered through the existing gravity discharge or lift station to the interceptor. If the in-line level continues to increase to a previously established critical height, as may occur under larger WWF events, the control gate would drop into its lowered position. This critical height will be based on ensuring the same level of basement flooding protection remains in the district. The interception height when the control gate is in the lowered position would match that of the existing primary diversion weir; therefore, having a minimal impact on head losses under these high flow conditions. At this point with such significant WWF events, a CSO from this outfall would occur, in order to protect homes in the area from basement flooding. Once levels in the combined sewers decrease, the gate would activate again and gradually rise to allow in-line storage levels within the CS system to build. This operating method is intended to maximize the volume of CSO capture by capturing all WWF from smaller events and capture the receding rainfall runoff response near the end of the medium to larger events.

The control gate would operate to fail in the lowered position in emergency situations or where the control gate is malfunctioning. Therefore, under these conditions the control gate would not provide any restriction of the CS outfall pipe during extreme WWF events. This is known as a fail open condition and is essential for the control gate product selected to ensure operational issues do not increase the risks of basement flooding. As part of the conceptual design of the in-line storage arrangements for CS districts, the control gate has been evaluated with a maximum height of approximately half the main CS incoming trunk diameter for the CS district in question. This may be modified as part of the preliminary and detailed design of the in-line storage control gate for specific CS districts.

The existing primary weir would continue to function as it currently does and continue to divert flows to the interceptor system. The difference in height between the top of the control gate and the existing weir represents an increased volume of in-line storage.

It is proposed that a rectangular concrete control gate chamber would be constructed to contain the control gate system. A typical arrangement would have the control gate chamber centered on the existing outfall pipe in the vicinity of the existing weir. The width of the proposed chamber is directly related to the width of the existing sewer trunk and the length is related to the amount of space required for hydraulics and gate operation. There will be locations where reconfiguration of the existing CS sewers, diversion structures or intercepting off-take pipe will be required to accommodate this installation. This chamber may be constructed to be stand alone or to operate with an adjacent off-line screen.

Further details of the in-line storage design considerations are provided in Part 3C.

3.3.3 Screening

Screening can be used to reduce the volume of floatables entering the receiving water course. For the CSO Master Plan, floatables screening has been proposed as a control option at each primary outfall where the system hydraulics allow. Screening operation typically requires an increase to the existing weir height or the supplemental installation of an in-line control gate to generate sufficient hydraulic head differential to allow for proper screening operation. This also provides additional in-line storage CSO volume capture. Screened flow is diverted back through the existing outfall and to the receiving stream downstream of the control gate. Screenings would be diverted back to the off-take or CS lift station for transport to the STP for removal. A schematic of a typical screening – control gate installation is provided in Figure 3-6.

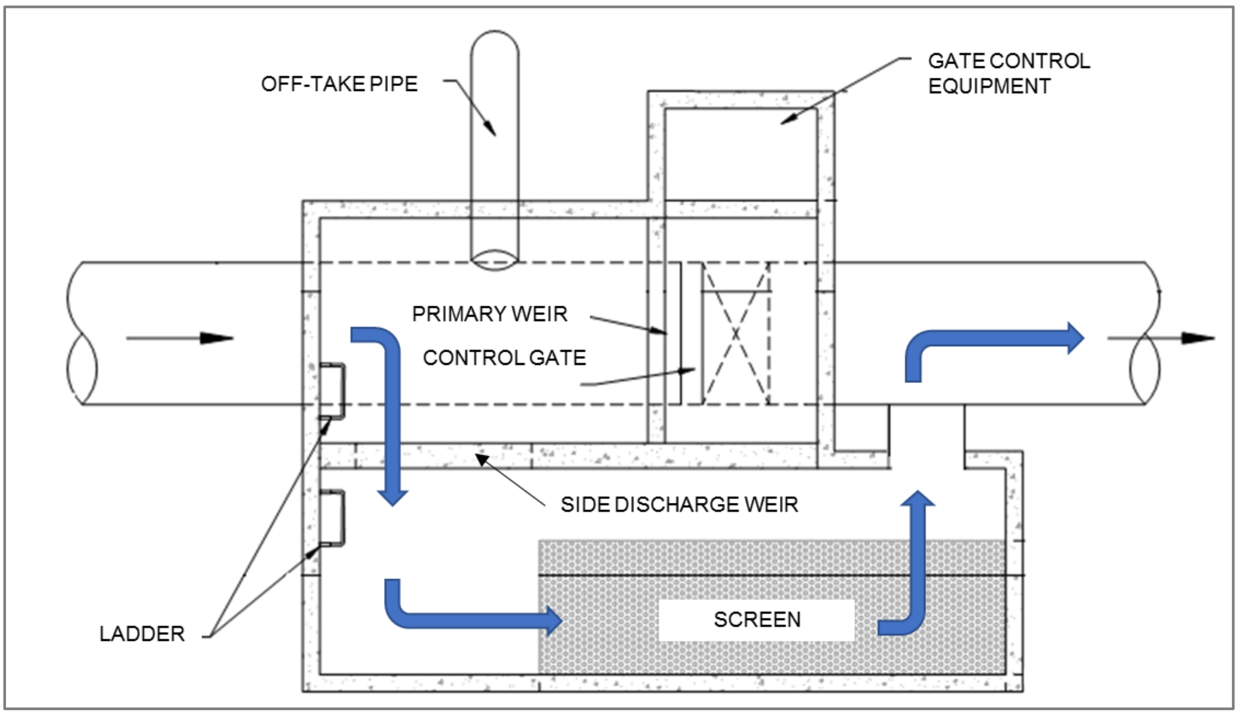

Figure 3-6. Proposed Typical Off-Line Screening Arrangement

Proposed screening facilities would typically be installed in combination with a control gate. The control gate would capture all sewage, including floatables, up to the design capacity based on the control gate height. Once the combined sewage reaches the crest of a side-discharge weir, the combined sewage would flow through the screens and capture floatables. The screening operation would continue in this manner until the combined sewage level receded below the side-discharge weir height or increased to the point where the control gate drops to its lowered position. When the control gate drops to its lowered position, there would be no further screening operation, as all combined sewage is allowed to overflow directly to the river, preserving the level of basement flooding protection. As the screening facilities are not connected to the main collection pipework in the CS system, and instead are only activated once sufficient levels in the CS system are reached, the screening facilities are considered off-line facilities.

It is proposed that a rectangular concrete structure would be constructed to contain the screening system. A typical arrangement would have the control gate chamber centered on the existing outfall pipe in the vicinity of the existing weir and the screen chamber would be located adjacent to this. The width and length of the screening chamber is related to the hydraulics at the installation location. Locations with a higher level of hydraulic head available would require a smaller screen to operate. There will be locations where reconfiguration of the existing CS sewers, diversion structures or intercepting off-take pipe will be required to accommodate this installation. This chamber would be accessed through an above grade manhole or access hatches.

The captured screening material will be pushed and retained in the storage area adjacent to the mechanical screen itself. Where there is available head and space, the screenings can be returned to the main trunk under gravity after the rainfall event has ended and the control gate has returned to its raised position. Where there are space or head constraints, a pumping system is required to remove these screenings and return them to the main CS trunk for interception and final routing to the sewage treatment plant/s. These will be assessed on an individual basis, given the unique arrangements at many of the CS outfalls.

3.3.4 Latent Storage

Latent storage refers to the existing storage available in the SRS system. Each SRS system includes dedicated outfalls and are protected from high river levels backing up into the SRS system by a flap gate. This flap gate allows one-way flow only; it allows SRS collected to be relieved from the CS system during WWF events by discharge by gravity towards the river. A sluice gate is also provided which is manually engaged for maintenance purposes.

The flap gate does not allow the river to flow backwards into the outfall pipe. Under high river level conditions, the river exerts a backpressure on the flap gate. This backpressure forces the flap gate shut and in turn does not allow the SRS system to discharge to the river under WWF events. Only until the hydraulic level in the SRS system exceeds the river level at that time does it forces the flap gate to open and allow discharge of the combined sewage within the SRS system until the SRS and river levels on each side of the flap gate equalize. This is further illustrated in Figure 3-7 below. While this is a risk which is managed now in the CS and SRS systems, it can be taken advantage of and monitored to provide additional temporary storage of WWF that can then be returned to the primary CS system during DWF conditions for conveyance and treatment.

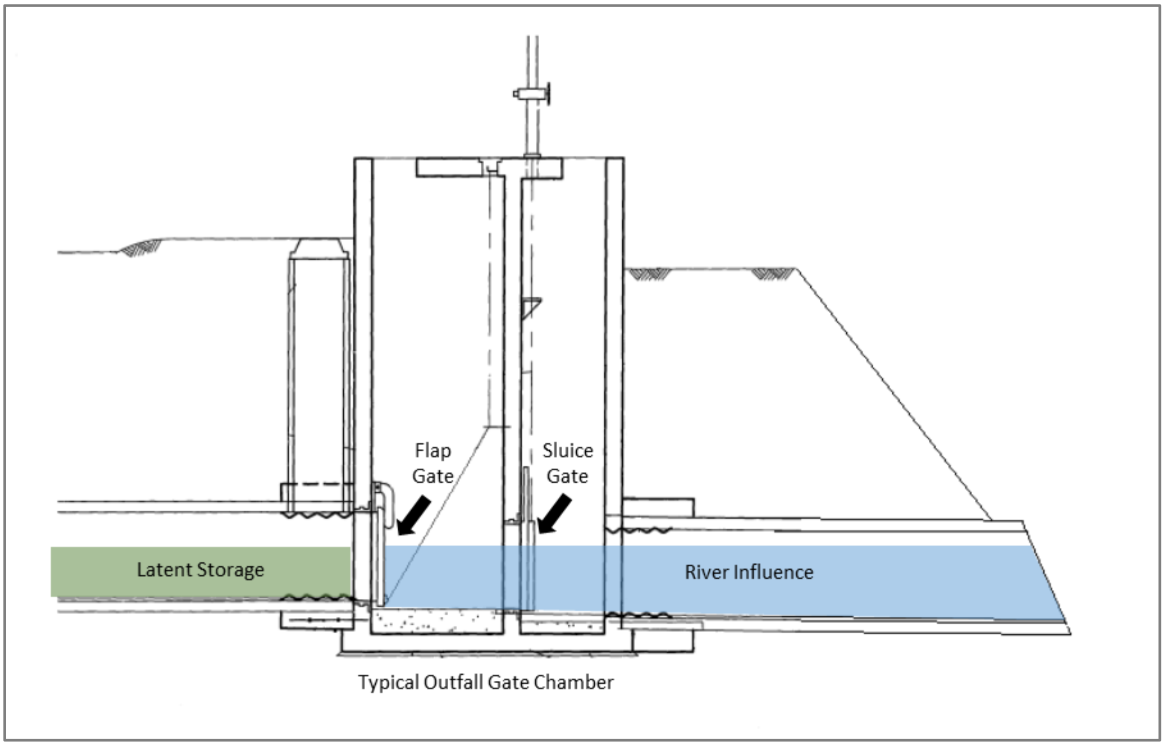

Figure 3-7. Proposed Latent Storage Schematic

This control option requires the installation of a pumping station to dewater the latent storage contained behind the flap gate following a WWF event. This option has the advantage of accessing existing storage for CSO control, off-setting the construction of more costly storage alternatives such as off-line tanks or tunnels.

The implementation of latent storage can only be completed with the installation of a pumping station and force main on the SRS outfall pipe, where the additional CS volume will be temporarily stored. The force main would provide a connection back into the existing CS system, where any combined sewage stored in the SRS system during a WWF event would be redirected to the CS, and ultimately to the STP for treatment as part of the dewatering process. Although the pumps may be installed along the SRS outfall pipe, care must be taken not to impede the discharge capacity of the SRS system. The CSO Master Plan has assumed the use of off-line latent storage pumping station (LSPS) with an off-take from the SRS immediately upstream of the flap gate.

A typical arrangement would have the off-line LSPS installed near the SRS flap gate chamber to maximize the volume that would be dewatered. An offtake pipe would connect the LSPS and the SRS trunk. A force main would then connect from the LSPS back to the CS system at the most convenient location. These installations would not require significant space for installation, or operation and maintenance needs. Typically, this would require a single manhole converted to a pump station.

The latent storage option is only applicable to sewer districts with an SRS system with a dedicated SRS outfall with a flap gate installed. The available latent storage volume has been assessed based on the NSWL at the various SRS outfalls and the amount that can be stored in the SRS at that particular elevation. In districts where the SRS system share a common outfall with the CS system, it is proposed to isolate the systems via the inclusion of a flap gate on the SRS system to control the latent storage discharge. To meet the design under the 1992 representative year requirement stated in the Preliminary Proposal, the performance of the latent storage facilities used the NSWL level for the full year and this was continued for the CSO Master Plan assessment. The 1992 representative year river level profile, including the chronological river level changes throughout 1992 should also be evaluated in the future. This will further refine the performance expectations for the latent storage control option. For further detail on the river levels used and their impact on latent storage facilities see Section 3.4.4 of this Part 2 Technical Report.

There are also situations where it has been found that the latent storage volume required to meet the Control Option No. 1 target required storage volume above the river NSWL design condition. Under these conditions a more automated control of the SRS outfall flap gate is required, which forces the flap gate closed regardless of the river level backpressure exerted. This is known as flap gate control and has been recommended as part of the latent storage design in specific districts in Part 3B. Flap gate control is also required where the level of storage volume in the primary trunk projected to be used for in-line storage is high enough to backflow through the SRS flap gate, and therefore must also be contained in the SRS system to be considered.

A key aspect of latent storage design is that the SRS system protect basements from flooding by relieving the CS system. This key function of the SRS system must not be compromised by implementing latent storage. Therefore, any flap gate control measures recommended must have a low risk of failure. A latching device that maintains the flap gate closed until a system level set-point is reached, at which point the latching mechanism disengages and allows the flap gate to naturally swing open, was selected as the preferred product for flap gate control. This is discussed further in Part 3C, Standard Details.

3.3.5 Gravity Flow Control

Gravity flow control is required for combined sewer districts that dewater by gravity to the sewer interceptor, instead of by lift station pumps. There is currently no ability to control the flow to the interceptor through these types of connections, beyond the discharge pipes reaching their maximum flow capacity and providing a restriction at this point. Gravity flow controllers will continue to allow gravity discharge but will monitor and restrict the flow rate to a predetermined dewatering flow rate, which in many cases would be below the maximum flow capacity of the gravity pipes. This is a control measure which is also intimately tied to the RTC program opportunity.

The installation of new flow monitoring and control systems would provide the control necessary to manage in-line storage to the same degree as districts which rely on pumping stations for conveying intercepted sewage. A typical gravity flow controller arrangement is shown on Figure 3-8. This is typically installed in two chambers, one located on the existing gravity pipe and a second ‘dry’ chamber that houses the controls and instrumentation and can be housed above ground where space allows.

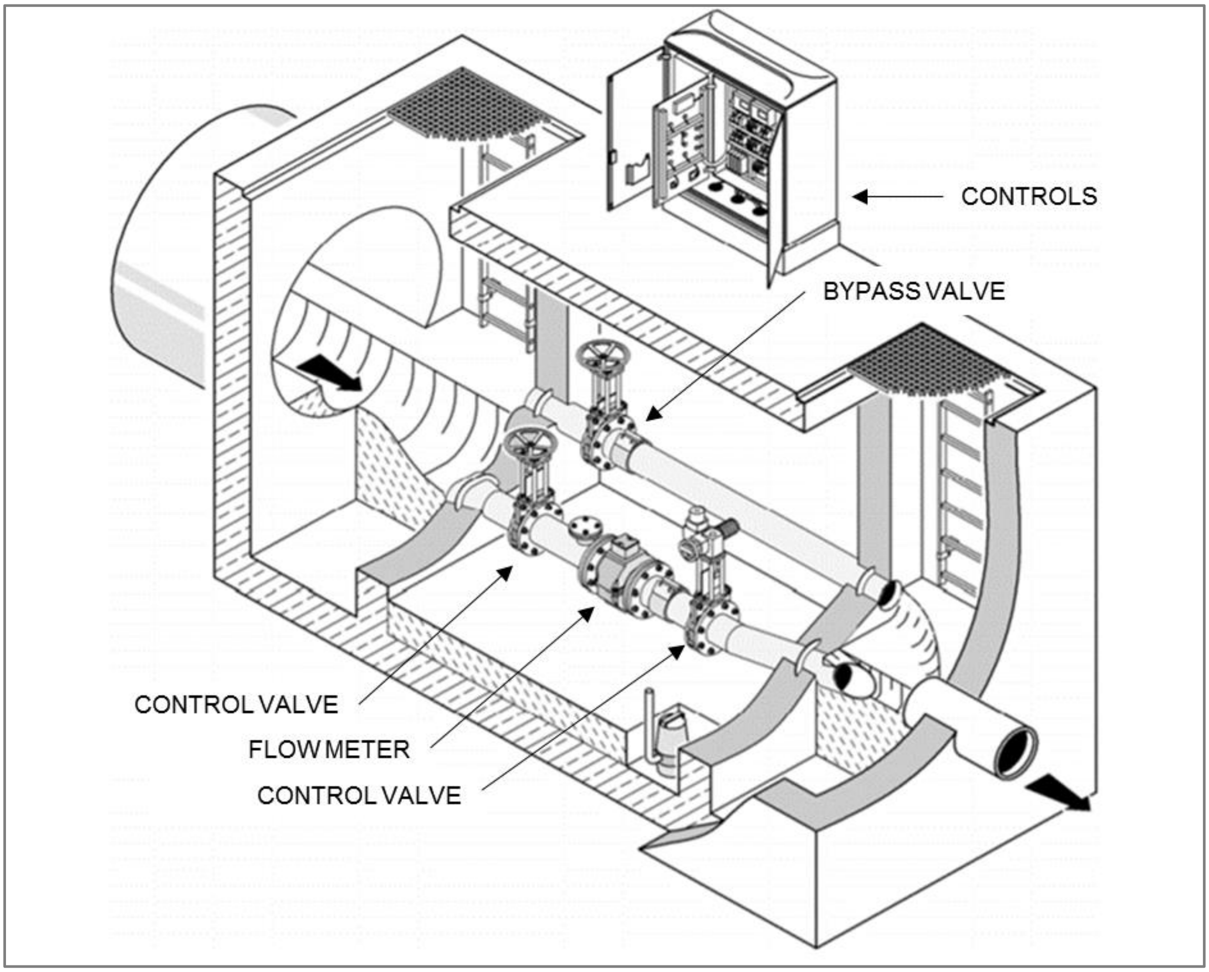

Figure 3-8. Proposed Gravity Flow Controller
(Picture credit: Veolia Water Technologies)

3.3.6 Off-Line Storage

Off-line storage refers to any storage element that does not receive flow from the existing combined sewer system under normal DWF conditions. Only excessive combined sewage flows which exceed a specific elevation are diverted to the off-line storage facilities. These elements instead rely on off-take overflow pipes or side weir arrangements, many of which are then connected to pumping systems, which will divert surcharging combined sewage during WWF events. Off-line storage is used to provide temporary storage of combined sewage where supplemental storage is required to meet the performance targets. Common types of off-line storage include underground tanks and storage tunnels.

3.3.6.1 Off-Line Storage Tanks

Storage tanks may be either near surface or deep. A near surface tank is installed with the top of tank near the ground surface and requires large transfer pumps to lift the combined sewage from the existing CS system into these tanks. Deep tanks are constructed low enough to fill by gravity from the CS sewer system after being diverted via an off-take pipe or side weir arrangement, which requires the top of tank to be below the primary sewer maximum storage level. Figure 3-9 provides a schematic for deep tanks.

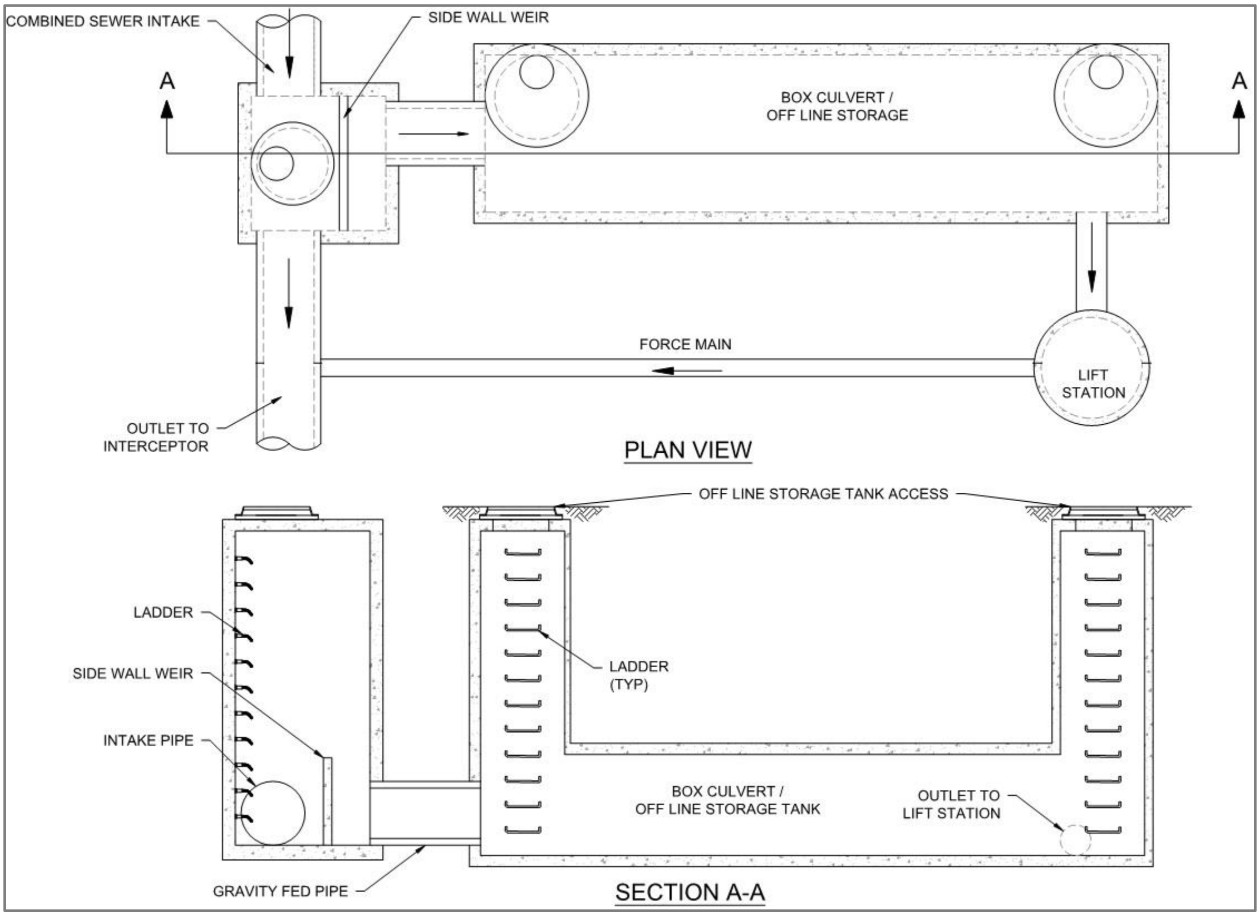

Figure 3-9. Proposed Off-line Deep Storage Tank Schematic

The deep tank would be empty and sit idle during DWF. During WWF, the levels in the sewer rise to an elevation above the side overflow weir, allowing flow to enter the tank. With enough inflow, the tank would continue to fill until it reaches maximum volume, or the downstream control gate (if applicable) opens to reduce the risk of basement flooding. The dewatering system for the tank would operate to completely dewater the tank prior to the next WWF event.

Figure 3-10 provides a schematic for near surface tanks.

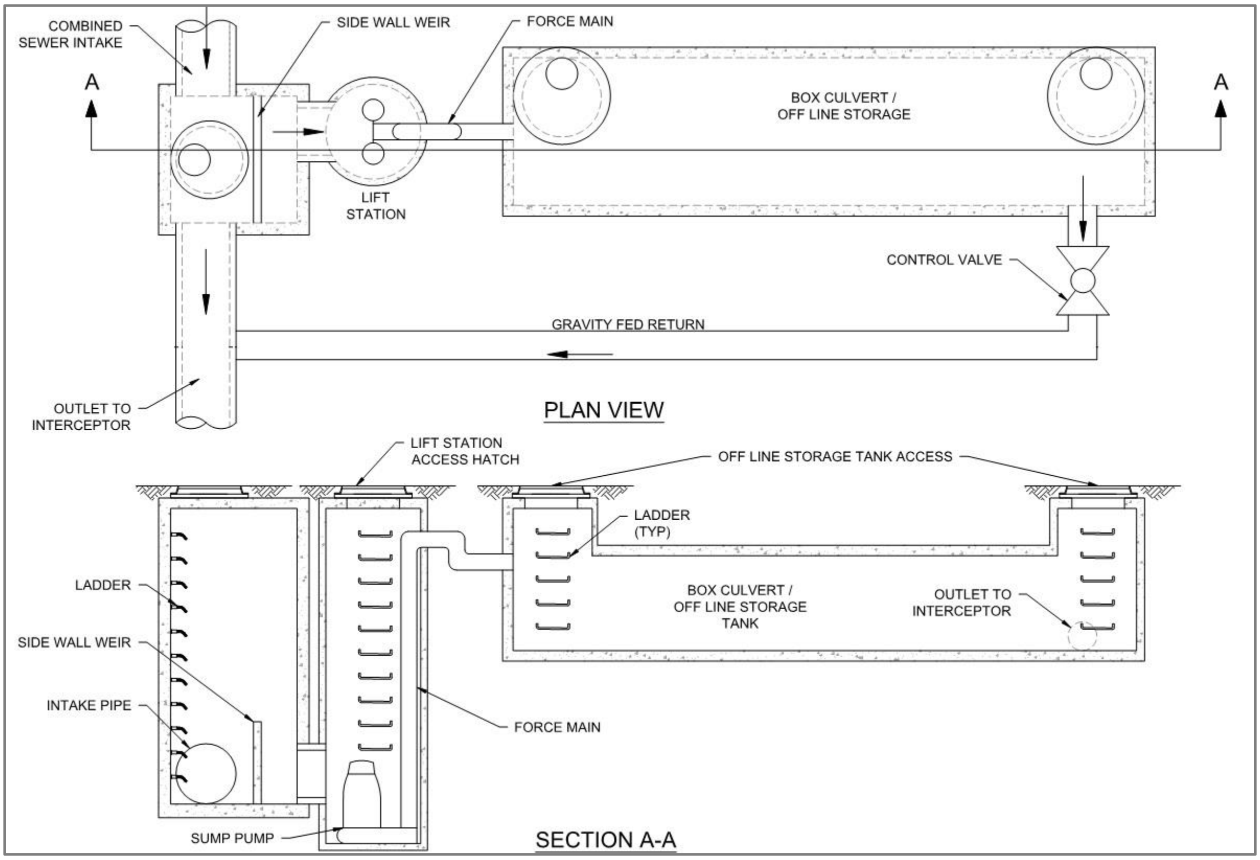

Figure 3-10. Proposed Off-line Near Surface Storage Tank Schematic

The near surface tank would be empty and sit idle during DWF. During WWF, a lift station that is connected to the CS trunk would activate and pump flow from the CS system to the off-line tank. The pumps would continue to operate until the tank is full or the level in the CS system drops below the pump operating level. Flow from the off-line tank back to the CS system would occur once levels within the CS system drop and capacity is available. The tank could be dewatered by gravity or through a pumping system. This will depend on the location and the level of control required. The dewatering system for the tank would operate to completely dewater the tank prior to the next WWF event.

There are pros and cons with each type of tank. The drawback with deep tanks is in the difficulty to construct them to such a depth, particularly when in close proximity to riverbanks due to the associated geotechnical and groundwater infiltration challenges. These challenges are significantly reduced with near surface tanks, but they introduce other challenges. Large capacity low-lift pumps would be required to fill near surface tanks, but the combined sewage may be stored high enough to drain by gravity.

The off-line storage tanks are generally large and require special considerations for selection of the final location and approvals prior to construction. The cost and implementation challenges may both be limiting factors for this control option. Consideration must be made for land availability and its acquisition, electrical and mechanical components, flushing, grit management, odour control, permitted use and riverbank by-laws, environmental and construction permits, and public acceptance.

3.3.6.2 Off-line Tunnel Storage

Tunnels are an alternative to off-line tanks for temporary storage. Unlike storage tanks, tunnels are easier to locate as they are placed under the public roadway right of way and may have multiple connections to the sewer system at strategic locations.

Off-line storage tunnels have several advantages, including the following:

- Storage tunnels can convey combined sewage over short distances as well as temporarily store combined sewage, providing increased capacity for basement flooding relief, and minor supplementation of force main or interceptor sewers for transport of wastewater to the treatment facility.
- Tunnel storage locations and sizes are much more flexible than for tanks, and engineering evaluations are likely to develop solutions that are cost competitive with storage tanks.
- Construction techniques make it possible to design tunnels at nearly any depth and alignment, making it possible to both fill and dewater the tunnel by gravity drainage rather than high-rate pumping.
- Current tunneling technology makes it possible to construct tunnels in nearly any ground condition, for long drive lengths with minimal surface disruption.

Conversely, the construction of tunnels have disadvantages, including the following:

- Storage tunnels will require flushing/cleaning after each operation, increasing the O&M requirements on the City of Winnipeg sewer system.
- Off-line tunnels may encounter odour issues and may require the construction of an extensive odour control facility.
- Storage tunnel launch and receiving shafts for large diameter tunnels can be extensive such that local streets may have to be entirely closed temporarily during construction activities, causing disruptions to the local residents.

3.4 Collection System Modelling Approach

The technical approach for the CSO Master Plan made extensive use of computer simulation modelling of the collection systems. This included creating representative InfoWorks models for the entire collection system. This section describes the main design considerations used for the model updates and refinements carried out during Phase 3 of the CSO Master Plan. Additional details regarding the initial hydraulic model development were reported in the Preliminary Proposal.

Two sewer system models covering the entire CS and separate sanitary sewage collection systems were developed using InfoWorks CS for the CSO Master Plan. These were the Global and Regional models; the Global model included all pipes, while the Regional model was a more streamlined representation. A schematic of the Regional model is shown in Figure 3-11.

Figure 3-11. Regional Hydraulic Model Schematic

The model build, calibration, and verification were primarily completed with datasets and information provided from the City in 2012 and 2013. These models are referred to as the 2013 baseline model and the regional 2013 baseline model. These 2013 baseline models were used for the creation of the five alternative plans identified in the Preliminary Proposal.

The model created for the 85 percent capture in a representative year alternative plan as identified in the Preliminary Proposal was used as the basis for further refinements during CSO Master Plan assessments. The full Regional model required several days to complete the simulation of the entire 1992 representative year event. Due to this time constraint, during Phase 3 individual district models were created based on the Regional model to evaluate the control option alternatives more efficiently. These smaller models did not represent the full interaction with adjacent sewer districts but did provide an initial indication of the performance to evaluate proposed control options. This served as the basis of Step One: Initial Control Option Selection. The specifics of this process are as described in detail in Section 3.5.3. Step Two: Control Option Refinements included recreation of the combined hydraulic model using the solutions recommended in Step One to determine the overall system performance and assisted to identify additional refinement opportunities. The specifics of this process are as described in detail in Section 3.5.4.

The following sections present the hydraulic modelling approach utilized to support the control option evaluations, project development, and program development processes.

3.4.1 Population and Growth

The future population and growth included in the hydraulic model evaluations were determined during model development in the first two phases. For future growth, the CS districts will include in-fill development/population density increase, although this is highly subjective, the exact locations are unknown and liable to change. However, any in-fill development within the CS districts must adhere to Clause 8 of the EA No. 3042 that shall not increase the frequency or volume of combined sewer overflows due to new and upgraded land development activities. This would occur with additional population added to the model for a CS district. As a result, while it is expected that further densification and population growth in these CS districts will occur over time, there should be no impact on CSOs or impact on the work planned for the CSO Master Plan. This is because there should be no change in the flow generated in these CS districts even though population growth has occurred, in order to comply with Clause 8. Therefore, for the purposes of the hydraulic modeling for the CSO Master Plan, no population change was assumed for the CS districts over time as the CS control options are installed. Within the hydraulic model the population is directly related to the sewage flow generated, and therefore it must be kept constant.

Separate sewer districts on the other hand do not have this limitation in flow rate increases as a result of densification, beyond the pipe/treatment capacity constraints typical to all development within the City of Winnipeg. These areas will be subject to similar growth to that expected to be encountered in the CS districts; however, the increase in flows from these areas must be accounted for in the hydraulic model. The level of growth expected in these separate sewer districts has been defined as part of previous land development studies, and this information was utilised to estimate the increase in flows generated by these districts. This will ultimately impact the interceptor sewer system shared by both the CS and separate sewer districts, which will impact the dewatering strategy. This is explained in further detail in Section 3.2.1 and Section 3.4.6.

The following sub-sections provide a summary of the main sources of data utilized to project the future population growth and how this was attributed to the future hydraulic model.

3.4.1.1 NEWPCC Collection Area Population Estimation

The population and growth forecasts for the NEWPCC Service Area are as defined in the *North End Facility Flows and Loads* (WSTP, 2014) report. The report identifies a 2011 population of 405,274 and a 2037 population of 550,000. An additional population of 33,500 is identified for the four outlying Rural Municipalities (RMs) of East St Paul, Rosser, West St. Paul and St Andrews. The CSO Master Plan has used the population data identified within this report for the NEWPCC Service Area as summarized in Table 3-3.

Table 3-3. NEWPCC Population used in Hydraulic Model

Contribution Area Within Hydraulic Model	2011	2037	Population Change
CS Area	255,600	255,600 [a]	0 [a]
Transcona	33,700	42,100	8,400
Rural Municipalities	0	33,500	33,500
CentrePort	0	0 [b]	0 [b]
Northeast (NE) Interceptor (excluding Transcona)	45,100 [c]	70,200 [c]	25,100
Northwest (NW) Interceptor	48,600	148,600	100,000
NEWPCC Total Population Changes	**383,000**	**550,000**	**167,000**

Notes:

[a] – No change to future 2037 CS area population as from wastewater perspective. The population generating all future wastewater flows will be the same due to Clause 8 being in effect for the CS districts.

[b] – Future CentrePort flows from development added to model as a set daily flow rate of 15ML/d and was not attributed to a specific population within the hydraulic model.

The baseline hydraulic model was updated to include the 2037 population of 550,000 to match the WSTP 2037 future population. Overall the population is projected to increase by 167,000 between 2011 and 2037.

The next step was to determine the appropriate allocation of this 167,000 population growth among the separate sewer districts. First previous assessments of the Transcona catchment related to recent sewer work was specifically evaluated based on the North Transcona Sewer f design study (AECOM, 2012) This report indicated a population increase of 8,400 was projected to occur by 2037. This Transcona catchment is upstream of the Northeast (NE) Interceptor, and so this population growth was removed from the population growth allocated overall to the NE Interceptor.

The future population growth of 33,500 peoples was included as a result of future tie-ins and subsequent growth from rural municipalities. This is a summation of the future population growth projected in the WSTP report of four separate RMs. The specific growth assigned to each of these RMs in the WSTP report is listed below:

- East St Paul (10,953);
- Rosser (1,763);
- West St Paul (14,468); and,
- St Andrews (6,369).

Each of the RMs were added to the model as single subcatchment areas draining to the closest manhole with future population as stated as above.

At this point of the 167,000 population growth expected, 8,400 and 33,500 was allocated to the Transcona catchment and RM tie in points respectively. This resulted in a remaining 125,100 population growth to be distributed to the new development areas upstream of both the Northeast and Northwest Interceptors. It was assumed for simplicity at this point to assign the remaining population growth specifically to largely undeveloped areas which would be subject to future growth. It is understood that a portion of the projected growth will occur within existing sewer districts as a result of in-fill development. For the purposes of this evaluation however, the primary impact of the allocation of this population growth is to assess impacts on the interceptor system, and how this may impact dewatering of the CS districts using the solutions recommended in this Master Plan. Therefore, the population growth remaining was conservatively assumed to be entirely allocated in these undeveloped lands, which have been identified for future development. This same approach was also utilized to assign the projected population growth within the SEWPCC and WEWPCC Service Areas (see Section 3.1.1.2 and Section 3.1.1.3).

For the identification of new development areas, further review of the WTSP report was completed. The WTSP report states that its population projection methodology is based on the Transportation Master Plan (TMP). The TMP uses the City of Winnipeg internal land-use planning model, called PLUM (Winnipeg Planning and Land Use Model). Economic and demographic forecasts, land use strategies, and OurWinnipeg are ultimately built from PLUM. The PLUM catchment model identified six areas draining to the NEWPCC (not including the four RMs) that would be suitable for allocating the additional 2037 population of 125,100. Following this an assumed average rate of density was assumed within the new sub-catchments based on City design standards for residential, commercial and industrial land uses. This density rate was applied to the area assigned to these new catchments within plum, to determine the appropriate population to be assigned to these catchments to result in the total 125,100 growth.

The CentrePort development is a large industrial/commercial/institutional (ICI) development to the northwest of Winnipeg and noted to produce a daily flow of 15ML/d for the 2037 future growth figure. A continuous inflow to match the daily flow rate was added to the model draining to the Northwest Interceptor sewer, but no associated population increase was applied.

3.4.1.2 SEWPCC Collection Area Population Estimation

According to the Technical Memorandum of Population and Flow Projections for the South End Water Pollution Control Centre Upgrading/Expansion project (Stantec, June 2006), the future population the Service Area for 2030 is projected to be 253,300. Next the population growth rate previously utilized from the WSTP report for the NEWPCC Service area was applied to the 2030 population. This further projected the future population growth, and indicated that a 2037 future population of 266,500 should be adopted. The CSO Master Plan has used the population data identified within this report for the SEWPCC collection area.

The baseline hydraulic model had a 2011 population of 185,000 for the SEWPCC, and therefore an additional 81,500 population was required achieve the 2037 future growth forecast. Here once more the PLUM catchment area evaluation was utilized to indicate the areas for development in the future. This indicated a single catchment draining to the SEWPCC was identified for future growth. Refer to Figure 3-12 below for the specific location within the SEWPCC Service Area in which this additional population growth was assigned. The typical population density figures adopted for the NEWPCC evaluation were used to determine that the area was sufficient to accommodate the entire 2037 future growth projection for the SEWPCC service area.

3.4.1.3 WEWPCC Collection Area Population Estimation

No information or previous reports have been noted on the projections for the WEWPCC. An estimate of future population using the typical rates of population growth as per the SEWPCC assessment was adopted. This resulted in a WEWPCC 2037 population estimate to be 116,700.

The hydraulic model has a 2011 population of 79,394 for the WEWPCC and an additional 37,306 population growth was included to achieve the 2037 future growth forecast. This population growth within the model was once more allocated based on the PLUM catchment areas to areas focused for future development. Ultimately four additional catchments draining to the WEWPCC were identified from the PLUM catchment areas, and the same area weighted approach was utilized to determine the portion of the 37,306 additional population to be assigned to each of these catchments. Refer to Figure 3-12 for highlighted locations within the WEWPCC service where modelled subcatchments were created and this 37,306 population growth was allocated.

3.4.1.4 Development Areas Allocated For Population Growth

All known future developments that were added to the future hydraulic model within the NEWPCC, SEWPCC, and WEWPCC Service Areas are illustrated in Figure 3-12.

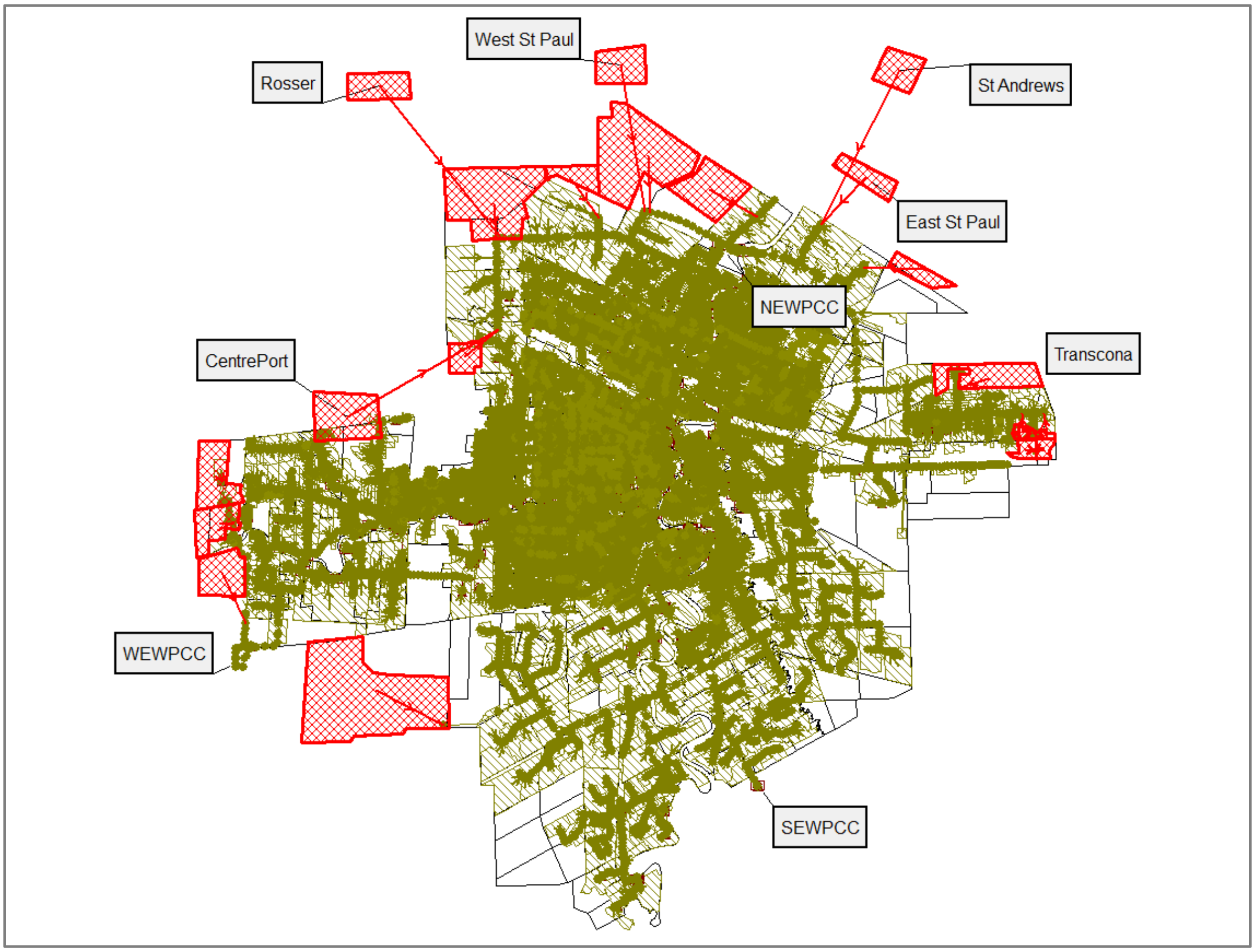

Figure 3-12 Future Development Areas (2037 Population Growth)

3.4.1.5 Wet Weather Contribution From New Sub-catchments

Each of the future growth areas have been noted in the separated districts within the outlying areas of the main Winnipeg sewerage system. As such, minimal WWF inflow should be generated by each of these new subcatchment areas. However, from monitoring and model assessment it is noted that rain derived inflow and infiltration (RDII) is generated by the separated districts. To ensure an accurate assessment for separated districts, each of the new subcatchment areas assigned for population growth were also assigned similar ground infiltration parameters as the adjacent existing separated districts. This allows realistic RDII to be included and accounted for in the interceptor system from these new sub-catchments.

3.4.2 2013 Baseline Model Findings

The Preliminary Proposal 2013 baseline model assessment concluded that the Winnipeg CS system had an overflow volume of 5,260,000 m^3 for the full 1992 representative year rainfall event. This is equivalent to a 74 percent capture rate. The overflow reduction assessment of the 2013 baseline model found that to achieve Control Option No. 1: 85 percent capture target in a representative year, required a reduction of 2,300,000 m^3 in CSO overflow volume.

3.4.3 Model Updates

The regional model was updated to include:

- Revised assumptions based on district sewer system reviews,
- Asset dataset revisions

- Updates to the sewer system based on work completed by the City of Winnipeg between 2013 and 2019.

The City provided the extent of future development and population growth expected for the City to the 2037-year planning horizon. The timeframe and estimates were not changed with the modelled growth development, and all projections remaining at the 2037 growth level. Refer to Section 3.4.1 for further details.

The City reviewed and updated the critical asset datasets within each of the sewer district engineering plans (Part 3B), and these alterations were assessed and added as appropriate to the Control Option No. 1 model. The City's updates included pumping capacities at several of the lift stations resulting from further assessment of the City's Supervisory Control And Data Acquisition (SCADA) data, and elevations of existing weirs obtained from recent survey work. The inclusion of the updated information does not remove the modelling limitations that were identified during the previous phase model build and calibration exercise. The City is committed to continuing to maintain and update the hydraulic model during the execution of the CSO Master Plan.

3.4.4 River Levels

The river levels for the 1992 representative year were not uniformly applied for drainage modelling as was done for precipitation. Instead, the NSWL at the James Avenue station on the Red River, 1.98 metres (6.5 feet) above James Avenue Datum (223.74 m geodetic elevation) was used and extrapolated along the river reaches to each outfall. River levels within Winnipeg are highly variable during spring runoff but remain relatively constant during the summer and winter seasons. The summer levels are controlled by a set of locks downstream of the City that maintains a minimum level for watercraft navigation. A comparison of the NSWL to the historic 1992 river levels, both taken at the James Avenue station, is shown on Figure 3-13.

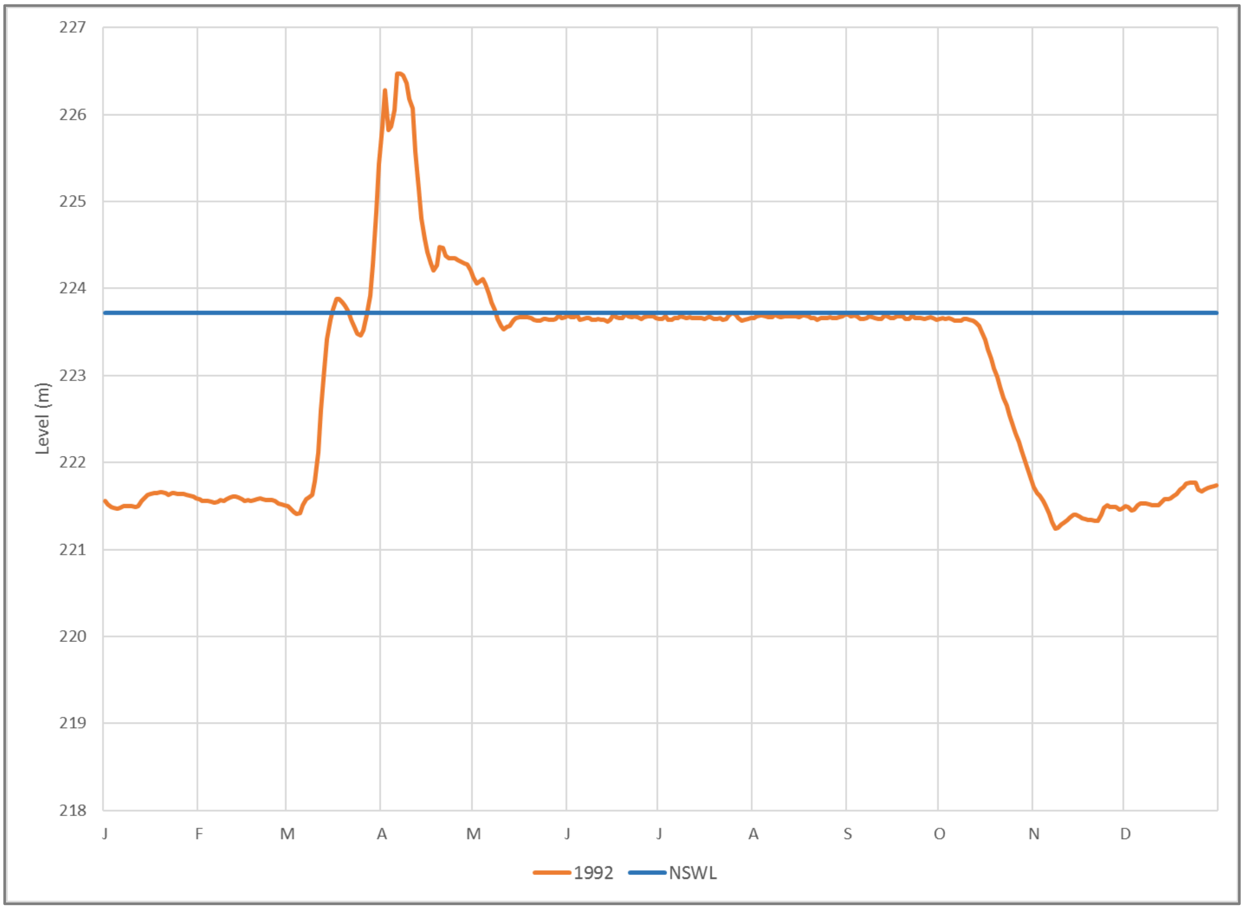

Figure 3-13. 1992 Representative Year and NSWL River Levels at James Avenue Station

Lowering of the locks that control the river elevation in the city occurs in late fall each year after the navigation season is over, with the levels remaining low until spring runoff. The lowering of the river levels coincides with reduced rainfalls and the transition to precipitation as snowfall. The lower rates of runoff during the winter season are largely captured within the combined sewers and are infrequently at rates that would overflow to the latent storage facilities, which require higher river levels to be utilized. Section 3.3.2 and Section 3.3.4 provide further details on how the use of various river level conditions impact the in-line storage and latent storage control options.

A continuous river level at this NSWL elevation was assumed at each of the outfalls for the modelling assessment. The NSWL was used in the Preliminary Proposal evaluations and maintained for the CSO Master Plan. There are notable differences in using the NSWL versus the 1992 river level. The NSWL does not fluctuate the same way as the actual 1992 river level. Using the NSWL in the model does not show improved performance during the spring snow melt period of April and May. This would be expected from the increase in available system storage volumes that occur during high river levels. The interaction between the CS and SRS system as described in Section 3.4.7 will also change the latent storage operation and requirement for flap gate control. An assessment with the 1992 recorded river level on the baseline model will need to be completed to confirm the actual variance in performance.

Use of this NSWL for CSO evaluation provides a comparative approach, since (in 1992 representative year or any other year) the river levels can only be higher during the period of the year in which CSOs are encountered. Higher river levels would benefit the performance of the in-line and latent storage solutions recommended in the CSO program. Therefore, the utilization of the NSWL provides a conservative baseline to evaluate the performance of these solutions.

3.4.5 Precipitation Events

Runoff from rainfall is the main cause of CSOs and it is therefore important to be accurately represented in the analyses. Rainfalls must be considered on a continuous rather than single event basis because of their variability, which affects runoff rates and runoff volume captured. Rainfall events are inherently variable in terms of when they occur and where they occur, within any year and from year-to-year. Long-term rainfall records were used in the evaluation to establish a representative rainfall year. It provides a common basis for control system sizing and regulatory compliance that is not affected by annual variations in precipitation. The 1992 rainfall year was identified as the representative year during the Preliminary Proposal study phase. The representative year is used by applying the annual 1992 precipitation events in the hydraulic model uniformly across the entire combined sewer area. The 1992 representative year had a total of 41 rainfalls above a minimum 1 millimetre (mm) threshold. The total depth of each of these 41 rainfall events and is shown in Figure 3-14 below, arranged in the order of depth for each event.

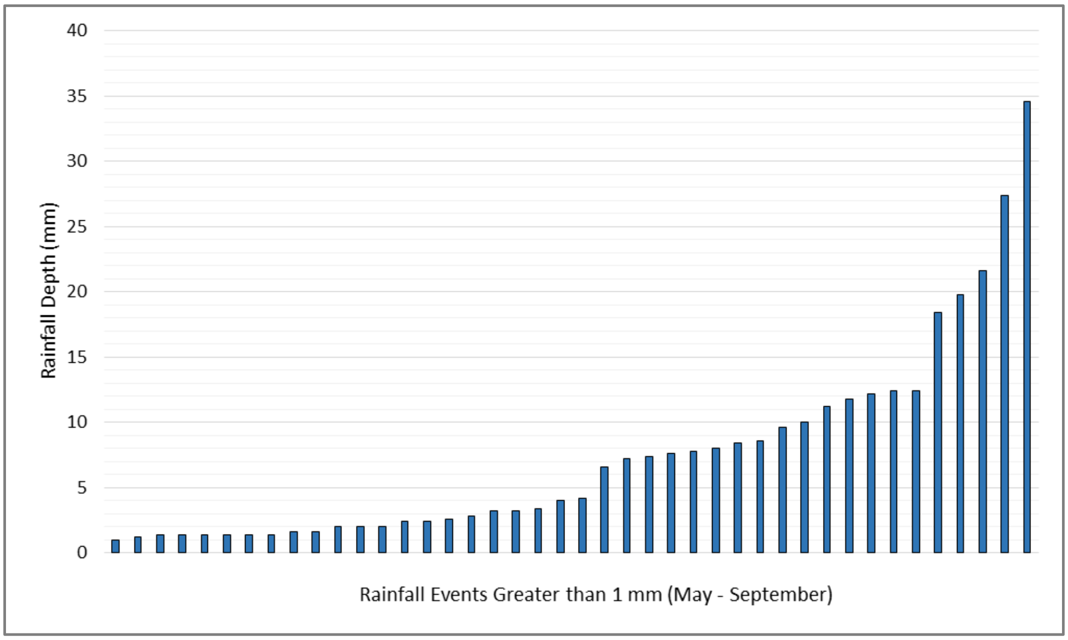

Figure 3-14. 1992 Representative Year Rainfall Depths (May – September)

The assessment of sewer system performance for the baseline and proposed control options was based on the year-round precipitation events for the 1992 representative year. To verify that the full year was accurately replicated, the snowmelt events were converted to equivalent rainfall intensities and added to the full event for the evaluations. The rainfall events were included in 60-minute increments and modelled for the entire 1992 representative year.

3.4.6 Dewatering Strategy

The purpose of the dewatering strategy is to establish target pumping rates from each of the sewer districts in balance with the interceptor and treatment capacities. The initial pumping rates from the Preliminary Proposal were established based on the requirement for the system to dewater and return levels to those experience during DWF conditions within 24 hours after the end of a rainfall event. All existing pumps and their operation conditions were simulated with InfoWorks, as well as the interceptor hydraulic capacity and WWF treatment rates at each STP. All new pumps recommended as part of the latent storage and offline storage control options were sized as part of the dewatering strategy. To verify that the stored flows within the system were not transferred to the CS and then overflowed at the main CS outfall, all latent/offline storage pumps were set to not operate when the local CS system is overflowing or when the control gate is in the lowered position.

The assessment was completed for each of the existing lift stations, interceptor, and treatment plants. The existing infrastructure was found to operate satisfactorily for Control Option No. 1, with only minor adjustments, and not needing any major changes or upgrades to lift station pump capacity.

The future dewatering strategy and potential interaction with a future RTC arrangements is beyond of the scope of this CSO Master Plan submission, and was therefore not included in the hydraulic model. RTC is included in the CSO Master Plan as part of future opportunities (see Section 5.2.2).

3.4.7 System Interconnections

There are many different types of interconnections within the modelled sewer system. Each of these are listed in detail in the individual district plans within Part 3B. Important interconnections for the CSO program are those between the CS and SRS systems. These allow overflow relief to the CS system, diverting excessive combined sewage collected to the SRS to reduce the risk of basement flooding. In cases where latent storage is to be used, these interconnections provide the source of flow into the latent storage facilities; therefore, the interconnection's hydraulic capacity and the frequency of CS-SRS interconnections will impact the performance of latent storage.

All CS-SRS interconnections within the City of Winnipeg sewer network are designed to contain all DWF in the CS system and not overflow into the SRS under DWF conditions. The models were set up with the best available data, which identified pipe invert elevations for the interconnections in numerous cases, but no weir or critical interconnection elevations. If the interconnection SRS pipe invert elevation is the same as the CS pipe, this would result in DWF entering the SRS system and ultimately discharging to the river in DWF conditions. This is known to not be the case based on how the SRS system is design, and is an issue with the way pipes are represented in the City's Geographical Information System (GIS) data. These discrepancies in the City's GIS data is continuously being investigated and improved utilizing field surveys of specific areas of the sewer network. For the purposes of the CSO Master Plan model development however, assumptions were needed to be made for these interconnections with unknown elevations. The assumption utilized in development of the model was to assume a fixed weir, stoplog, or brick wall constructed within the interconnection manhole to prevent DWF overflows. This led to numerous weir structures being added to the model and the associated weir levels being based on assumptions agreed with the City. The standard assumption used for any missing weir information for the CS-SRS interconnections was to place a weir with a height of half the pipe diameter in which the weir is placed. There are approximately 208 interconnections modified in this manner within the hydraulic model. This resulted in the hydraulic model performing as the real life sewer conditions perform now, with no overflows to the SRS system under DWF conditions. The interconnection modelling assumptions to be gradually refined and updated based on ongoing site survey work completed by the City of Winnipeg.

The controlling interconnection elevation is not a major concern to basement flooding flow simulations because of the high flow rates encountered during basement flooding conditions would necessitate full utilization of the SRS and CS systems. The interconnection heights however are critical for latent storage volume evaluation, where smaller storms provide the source of combined sewage ultimately stored in the latent storage system.

These details result in a degree of uncertainty in the performance of latent storage. Physical modifications to these interconnections are relatively easy and straight forward and can be dealt with during program implementation. This is a risk which must be considered when furthering the design and analysis of the latent storage solutions recommended for specific districts as part of the CSO Master Plan. When in-line storage and latent storage projects are to be pursued in a specific district, all CS-SRS interconnections within that district should be verified and surveyed prior to furthering any design work. Based on the actual interconnection elevations found, the potential in-line storage and latent storage volume capture performance can be re-evaluated and compared to the performance originally estimated in the DEPs based on these modelling assumptions.

3.4.8 Latent Storage

The latent storage control option does not require any pipe infrastructure to be constructed as it will utilize the existing SRS pipe system and interconnections from the CS to the SRS systems. A latent storage lift station is proposed to be installed adjacent to the existing flap gate chambers to allow the latent storage to be dewatered.

At present, some of the SRS outfalls have only a positive gate. To implement latent storage control, a flap gate is needed to separate the SRS system WWF flow from the river under sufficiently high river level conditions. The City is undertaking work to replace these single positive gates with a new flap gate and positive gate chamber. Replacement work has been completed at the McDermot SRS outfall, and work is planned or underway at the Ruby SRS and Aubrey SRS gate chambers. This work includes the installation of a submersible pumping system to allow the latent storage of the SRS system to be dewatered. No force main to accommodate the dewatering process is proposed with the replacement gate chamber work.

In the case of these recently constructed SRS flap gate chamber and dewatering pumping systems, the latest details as to the design of these facilities was represented in the hydraulic model. Specific details as to the design of these systems can be found in the specific DEPs where this has occurred.

3.4.9 Latent Storage Flap Gate Control

Flap gate control has been recommended for specific districts where latent storage is recommended, when the level of latent storage at the dedicated SRS outfall is above the design NSWL. Flap Gate Control provides a mechanism where the flap gate can be set to stay in a closed position, regardless of the river elevations. Under normal flap gate operation without flap gate control, the flap gate can only be in a closed position and store WWF when river levels are sufficently higher than the flap gate invert creating sufficiently high hydraulic back pressure on the flap gate to keep it closed.

The installation of flap gate control on the SRS system has been proposed for the following locations:

- Clifton – Strathcona SRS system
- Ash – Renfrew SRS system

The majority of SRS systems are partially below the NSWL levels and can rely on the normal hydraulic pressures exerted by the river to provide the required volume capture. For example, the Spence SRS system within the Colony district is 90 percent full when assessed against the NSWL level, while the Strathcona SRS outfall within the Clifton district is only 10 percent full. In the case of the Strathcona SRS outfall however, a 2700 mm diameter pipe is in place, and significantly more latent storage volume capture could be achieved by implementing flap gate control arrangement. Implementing flap gate control in a situation such as this would be for a minimal capital expenditure when compared to alternative method to capture an equivalent additional volume, such as by constructing an off-line storage tank of similar volume. As well in the case of the Strathcona SRS system, the relatively high elevations of the SRS system compared to the CS system result in overflow one of the CS to SRS interconnections prior to control gate operation with the in-line storage facilities also recommended for the Clifton district. In situation such as this as well flap gate control is also needed.

Where flap gate control is proposed, the flap gate control is to be set to open when the in-line control gate on the CS system is in its lowered position. This allows the SRS and CS systems to be relieved concurrently to protect homes from basement flooding.

In the hydraulic model all flap gate control arrangements, where recommended, are represented as a variable crest weir. The weir is initially set at the full height of the SRS pipe, representing the closed flap gate. The lowering of the in-line control gate at the primary outfall signals the flap gate control to open, and in the hydraulic model this causes the variable crest weir height to reduce to zero with no restriction. This represents a fully open flap gate, allowing the SRS to discharge.

3.4.10 In-line Storage Control Gates

The control gates have a dual purpose within the hydraulic model. First, they increase the depth for in-line storage capacity. Secondly, they provide sufficient head for the screens to operate successfully.

These gates were modelled as variable crest weirs, where the crest level can be adjusted by the InfoWorks software using modelling parameters that continually assess the levels in the system for the 1992 representative year rainfall/runoff conditions. The level in the upstream system determines when the gate, modelled as a weir, drops to the lowered position after the upstream levels has reached an entered set point. At this point the variable crest weir would have an elevation matching the weir crest for the existing primary weir. As the levels in the system are lowered, the variable crest weir would begin to rise until it reaches a maximum height, matching the design height for the control gate. This variable crest weir modeling approach for control gates was developed in the Control Option No. 1 Preliminary Proposal models for the representation of the gates at the required overflow locations.

The control gate is modelled in conjunction with the side overflow bypass weir for the screening chamber.

3.4.11 Floatables Screening

The screens were modelled downstream of the side overflow bypass weir and given a standard design within the model as explained in Section 3.4.11.1 below. Any blockage or partial blinding of the screen will cause the hydraulic grade line (HGL) to increase, which then will result in the control gate dropping to the lowered position, restoring the discharge capacity in the CS trunk outlet to those currently provided by the primary weir for each district.

Screens were designed as a first flush tool, where only the initial runoff from rainfall events is screened. The model evaluations indicated that for a portion of the rainfall events during the 1992 representative year all the event overflow volume is passed through the screening chamber in specific districts.

The amount of hydraulic head available for screen operation is critical to proper screening operation and was therefore reviewed for each location using the hydraulic model. This was also necessary to avoid recommending screens with excessive dimensions for construction. The typical screen width was based on the head and peak flow rate as defined in Part 3C. For a low hydraulic head available, the proposed screen width would be too large to be practical. This modelling assessment highlighted that not all districts had suitable available hydraulic head and would result in impractical screen size recommendations. The districts of Despins, Marion, and Metcalfe have negative hydraulic head due to the NSWL being above the proposed weir elevation. The districts of Jessie and Polson have limited hydraulic head available. As a result, screening is not proposed as part of the solutions recommended for these specific districts and supplementary evaluation work to determine alternative control options was required as discussed in Section 3.5.4.1.

In addition, a bypass pipe was modelled to convey all screened overflow volumes from the screening chamber back to the main outfall. This allows the full overflow volume, screened and not screened, to be assessed at each outfall location.

3.4.11.1 Side Overflow Bypass Weir

The screening arrangement recommended includes a screening chamber in parallel to the existing CS trunk. Further detail on this arrangement can be found in Section 3.3.3. A side overflow weir is included to allow flows from the CS trunk to overflow into the screening chamber. The side overflow bypass weir acts as the first overflow location within the CS district, where flow is diverted to a screening chamber.

In the model a standard weir was used to represent this bypass weir. The weir elevation is set by the constraints of the control gate height, basement flood critical level and screen performance. These controls were added as new elements in the model since the 203 basement line, and were part of the detailed individual sewer district model assessments completed as part of Master Plan development.

3.4.12 Gravity Flow Control

Gravity flow control is proposed for districts that utilize gravity discharge to convey the intercepted CS to the interceptor system. Gravity flow control is required to enable both flow control for assessment of the future RTC controls within the entire sewer network.

Gravity flow controllers however were not included in the model. This was because the controllers were specifically identified as beneficial for future RTC assessments. As part of future RTC assessments it is recommended that gravity flow controllers to align with the design criteria established in this Master Plan be added to the sewer system hydraulic model. The application of gravity flow controllers is described in more detail within each DEP. It is expected that the future RTC will allow the system to be controlled and the gravity flow controllers will provide monitoring to ensure the flows arriving at the control points during spatial rainfall events are known. This will allow RTC controls to be implemented to dewater a district experiencing rainfall event quicker than one which has DWF conditions at that same moment.

3.4.13 Foundation Drainage

A model representation of foundation drainage within a newly separated district was completed was completed in all alternative models completed for the Preliminary Proposal assessment. This modelling approach was continued and improved upon for the CSO Master Plan assessments and is described below.

A runoff area assumption with the Ground Infiltration Module (GIM) allows an RDII inflow to enter the system which allowed a replication of the potential WWF flows entering the system from foundation drains, on a district wide basis.

The sewer separation control option recommended in the Master Plan was primarily achieved by installation of a new separate LDS system in a CS area, with the existing CS being repurposed as a separate wastewater system. This is known as LDS Separation and this approach has been previously completed by the City in a number of districts. Only the catch basins are reconnected to the new LDS system, which then collects all road drainage. The sewer service lines, which carry sanitary sewage and foundation drainage from the connected buildings, remain connected to the original CS. In the past, homes were allowed to connect their foundation drainage to the CS and would often have the roof gutters connected into the CS instead of discharging at grade. Beginning in the 1990s these practices were no longer allowed, and all newly constructed homes have the foundation drainage and roof drains separate from the CS and WWS systems. Note that this foundation drainage contribution is primarily from residential homes. Industrial/commercial/institutional (ICI) areas generally do not have these same foundation drain connections to the CS system, primarily due to the lack of a basement. The amount of foundation drainage from the residential properties in the older CS districts can be quite large and needs to be considered in the CSO program.

The modelling approach for the CSO Master Plan Control Option No. 1 assessment, included specific modelling of a known representation of the district foundation drains for the complete separation control option. Foundation drains were represented in the hydraulic model as an update to the Preliminary Proposal subcatchment area, which is connected directly to the original CS system. The existing pre-separation subcatchment draining to the modelled manhole would typically include runoff area parameters (that allow the InfoWorks hydraulic modelling software to represent WWF inflows) for the road and permeable areas within the subcatchment boundary (these were defined as part of the Preliminary Proposal model build and calibration exercise). This updated subcatchment area does not affect the sanitary, industrial/commercial/institutional (ICI), or base inflow and infiltration component generated flows based on the baseline model. An update to the values within the subcatchment runoff areas was completed and the rainfall on the updated subcatchment area is still collected and routed directly to the original CS system representing the foundation drainage WWF inflow. The new areas are theoretical representations within the model, and the area values do not reflect real life conditions. The foundation drainage representation should not be mistaken as an increase to the drainage area.

The modelled representative of the foundation drainage runoff rates was based on local results developed in a study by Wardrop Engineering in 1978. The study developed typical runoff curves for a range of house lot grading types (varying from Good to Unsatisfactory) for the 10-year MacLaren design rainfall event. The Type C grading curve was used and assumed for all homes for the Master Plan, representing a poorly graded lot for all residential properties within the completely separated districts. The flow-grading curves as part of this 1978 Wardrop study are shown on Figure 3-15.

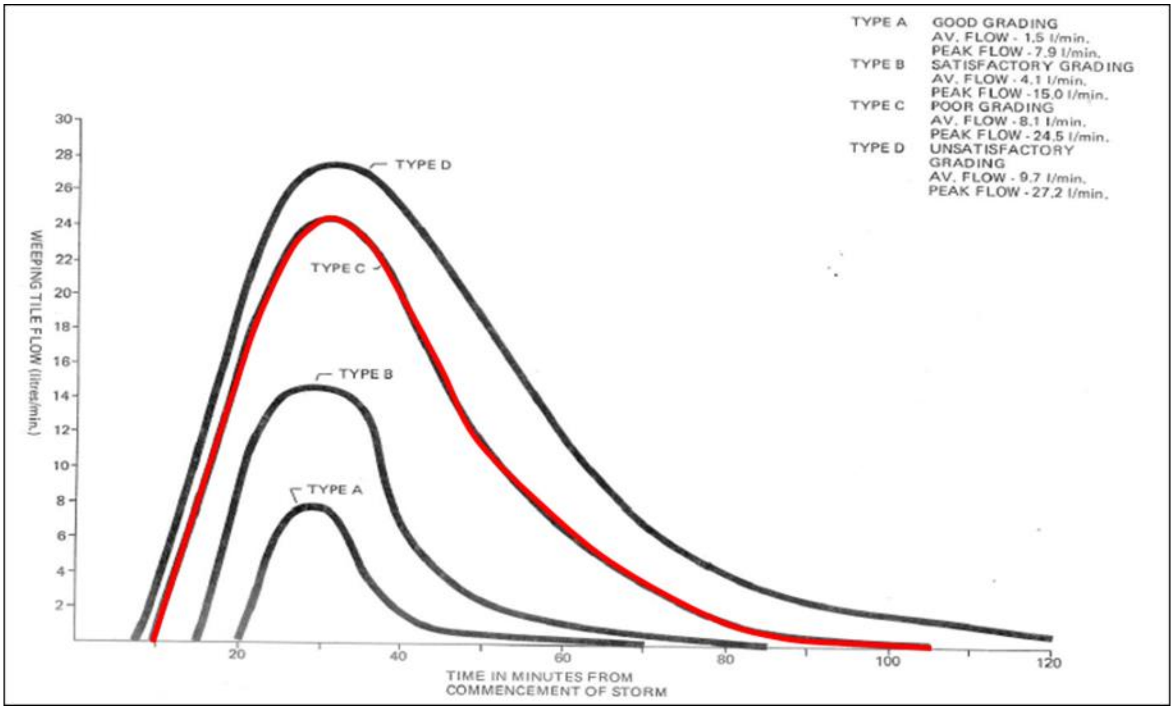

Figure 3-15. Foundation Drain Grading Curve Inflow Hydrographs (Wardrop, 1978)

Within each of the districts prioritized for partial or complete separation as per the current CSO and BFR Program (Douglas Park. Ferry Road, Riverbend, Parkside, and Cockburn), the houses identified as built prior to 1990 were provided an equivalent Type C poor grading inflow hydrograph (shown as the orange hydrograph on Figure 3-16) converted to a modelling parameter that represented this inflow as an equivalent area within the InfoWorks model runoff surfaces per house. This allowed the generation of flows within each of the separate district areas to more accurately replicate the foundation drain flows found from the real life study. This approach was extended to those districts identified as additional separation areas. 1990 was selected as this year established all new homes constructed to have weeping tiles disconnected from the sewage system. Instead weeping tiles in these newer constructed homes connect to a central sump pit, with the flow from the weeping tile system discharged overland from the property via a sump pump system.

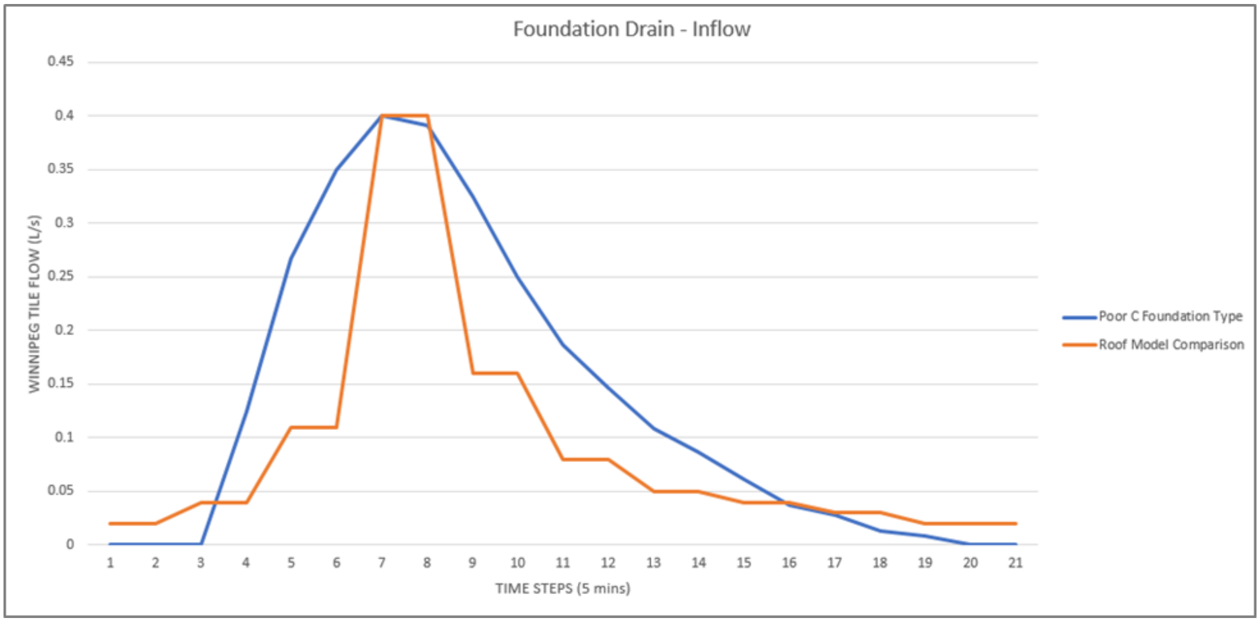

Figure 3-16. Modelled Foundation Drain Representation Inflow Hydrograph (Single property)

The infograph produced in Figure 3-16 from a single property lot, in line with the Type C grading produced in the 1978 Wardrop report, was found to occur by generating a contributing area of 0.04 ha per single family dwelling within the subcatchment. The next step based on this information was to estimate the number of such single family dwellings within the catchment. This was completed by reviewing aerial photography of the City of Winnipeg and notating all single family dwellings within the GIS dataset for the CS districts recommended to be separated. These notated single family dwellings GIS locations was then imported into InfoWorks, the sub-catchment area take-off function within InfoWorks was utilized to produce a count of such properties previously identified within each subcatchment. A dynamic formula was then established within the sub-catchment properties, such that this area-take off value, multiplied by 0.04 ha/home, would then be entered as the contributing area for that subcatchment.

This updated modelling technique provides a more accurate representation of the foundation drains within these CS districts. When considered with the district's dewatering rate, this technique can be used to provide an early indication if all existing WWF remaining from foundation drains under a 10 year MacLaren design event is captured by the primary weir of the CS district, or if the weir needs to be permanently raised. For example, this assessment was completed on the Ferry Road district following complete separation, and indicated that the existing primary weir should be raised to fully contain the separated WWF. For each CS district where complete separation occurs, the City will also conduct flow monitoring of the actual WWF response to confirm if any primary weir modifications within the district are required.

The actual WWF response from the existing foundation drain connections within a proposed separated district will determine if the system can be reclassified as a separate sewer district. The City may continue to target these areas for the sump pump and backwater valve subsidy program that has been completed in other district areas. This program removes the roof area and foundation drain WWF flows to be redirected outside the property and away from the CS system, as is done now for all homes constructed after 1990. This will provide flexibility to further improve the district's WWF performance in order to reclassify the district as a separate sewer district.

Additional notes and assumptions with the foundation drain modelling technique utilized are as follows:

- The inflow hydrograph is produced for the 10-year design rainfall event; larger or smaller runoff rates will be generated for larger or smaller events.

- Overflows for separate sewer districts are prohibited; therefore, the volume capture provided by the primary weir of the district must be able to handle a 10-year or larger foundation drainage contribution.
- Each residential housing parcel has been attributed a 'poor lot grade'. The actual grading of homes in these districts will vary, but this approach provides a conservative estimate to represent foundation drain impacts.
- This does not account for the City's previous sump pump replacement work and work to disconnect existing properties foundation drains from the CS system that has been completed throughout several districts. This also does not account for any homes built after 1990, in which the foundation drains are not allowed to be connected to the CS system are therefore assumed to have no contribution. The City of Winnipeg intends to review this work and update the model when specific locations where this foundation drain disconnection work has been completed are identified.
- Both the Tylehurst and Mission districts have been identified with large ICI areas and did not have significant residential areas. The previous Preliminary Proposal assumptions to represent foundation drains therefore remained in the hydraulic models for these areas. This assumes that there is not a significant foundation drain or roof drain component tying into the CS system in these ICI areas. The previous phase assumed a permeable runoff area (15 percent of total area) and Ground Infiltration Module (GIM) to provide a small inflow to the separated districts for foundation drain representation.

It is recommended that a flow monitoring program specific to each newly separated district be completed to confirm that these assumptions used to model the foundation drainage within both residential and primarily ICI districts.

3.4.14 Basement Flooding Evaluation

One of the requirements in selection of CSO control options was that they not be detrimental to the existing level of basement flooding protection. Therefore, the selection process included considerations for maintaining the current levels of service and carrying out additional modelling as a basement flood risk evaluation for each district.

For these evaluations, the individual district models (or combination of district models) were used to assess the impact of the proposed control options. The InfoWorks model was updated with the infrastructure proposed for each control solution, as detailed in Part 3B. The HGL produced by the model before and after the updates to the model to add the control solutions was then reviewed to determine any basement flooding protection impacts. For example, the control gate, bypass weir, and screen structures were assessed for the HGL against the baseline modelled HGL results.

Further details of this individual district basement flood protection evaluation are detailed below:

- The flood design event selected was based on no predicted surface flooding for the existing baseline model HGL results, and these were matched, within a plus 10 mm modeling tolerance, for the updated Control Option No. 1 models.
- Any predicted increases in HGL levels were noted, and the Control Option No. 1 model was altered by reducing the gate or bypass weir level or extending the bypass weir width as necessary, or both, to achieve the same HGL levels as the baseline, within a plus 10 mm modeling tolerance.
- Both design rainfall event (varying depending on surface flooding) and 5-year design river level hydrographs were simulated with the models for these HGL evaluations.

3.4.15 Percent Capture Calculation

The percent capture calculation considers the CSO volume in relation to the total of all flows collected in the system. A clarification process was undertaken with MSD during the Preliminary Proposal development, to redefine the components included in the original calculation. This clarification process is described further in Section 3.1.7. The components of flow used in this calculation were derived from the InfoWorks model assessment.

In general, the starting point for the calculation of flows collected in the system during wet weather conditions was established as:

- The beginning of a precipitation event, and
- the end point as when the system returns to DWF conditions, being either the end of dewatering or end of WWF treatment at the STP.

The approach to the calculation used for the development of the CSO Master Plan control options was based the following assumptions:

- The WWF volumes were derived from the InfoWorks model evaluations for the 1992 representative year.
- The DWF volume used in the calculation was based on the average flow calculated from recorded values at the STPs for the WWF period. The DWF duration was calculated from the beginning of the precipitation event to the end of dewatering, which was assumed to extend for an average of ten hours for all precipitation events. The dewatering time represents an average from a wide range of events, which may be from one to two hours for a small rainfall to a maximum of 24 hours.
- A City-wide DWF rate was used in the calculation and includes all combined and separate sewer district contributions.

This approach was maintained for both the Preliminary Proposal and the CSO Master Plan to allow comparisons.

3.4.16 Updated CSO Master Plan Model Findings

The WWF volume used for the CSO Master Plan calculation was updated to reflect the 2018 revised baseline model WWF volume and overflow volume. Overall the CS Master Plan refined model assessment concluded that the Winnipeg CS system had an overflow volume of 5,170,000 m^3 for the full 1992 representative year rainfall event This is equivalent to a 74 percent capture rate, and matches the percent capture rate determined with the 2013 baseline model. The overflow reduction assessment of the CSO Master Plan refined model found that to achieve Control Option No. 1: 85 percent capture target in a representative year, required a reduction of 2,270,000 m^3 in CSO overflow volume was required. Ultimately this resulted in a slight decrease in the volume required to reach the 85 percent capture target compared to the 2,300,000 m^3 value reported in the Preliminary Proposal. Ultimately by rounding this refined value the same 2,300,000 m^3 value is produced, and remains the target reduction in order to meet Control Option 1.

3.5 Project Development

Project development is the process of selecting specific control option projects for each district to meet the system-wide level of performance. At this stage, the planning projections and district-specific dewatering rates have been established and potential projects can be identified and grouped to meet the remaining constraints. The solutions under consideration for each district in the hydraulic model are then evaluated to achieve the performance requirements, which for the CSO Master Plan is Control Option No. 1 – 85 Percent Capture in a Representative Year. The term ‘project’ or ‘solution’ refers to the implementation of an individual control option as identified and discussed in Section 3.3.

The project selections proposed as part of the Preliminary Proposal form the basis of the refinements completed during this final phase of the CSO Master Plan. The basic approach to plan development for the Preliminary Proposal was as follows:

- The CSO and BFR program was leveraged to identify sewer districts that have a high cost benefit for implementing relief and corresponding higher priority for completion. Several districts with ongoing sewer relief work and recently completed planning and study work were identified for sewer separation. These districts were not evaluated any further as to alternative solutions to address the CSO Master Plan Control Option No. 1.

- Early actions were identified through the initial evaluations where large reductions could be achieved if work were to be prioritized. The Armstrong sewer district was identified for complete separation through this process.
- Maximizing the use of existing infrastructure using alternative technologies was the next consideration. In line and latent storage were considered readily accessible and evaluated first. The evaluation included consideration for the incremental benefits and increasing risks of progressively raising the levels of storage in the combined sewers. In-line and latent storage were optimized to maximize the operation storage while not allowing any increase to the risk for basement flooding to the various combined sewer districts.
- Off-line screening was considered necessary and included at each primary outfall in conjunction with the in-line storage control gate. In select districts the in-line storage control gate was a recommended project for the district specifically to accommodate off-line screening, and not for additional volume capture benefits.
- Off-line storage including both tanks and tunnel storage were considered following the optimized use of existing infrastructure through in line and latent storage. Typically, the off-line storage would be applied in districts that required a large volume reduction following the optimization of existing infrastructure with in-line or latent storage solutions.

3.5.1 Project Selection Process Limitations

The project selection process is limited to the selection and application of the control options that are used in the hydraulic model evaluations. The initial location of control options is based on the hydraulics of the sewer system and is verified with The City's GIS database. This typically means that an in-line gate or latent storage lift station in the model is located close to the diversion weir or flap gate. No consideration for land availability was made through the model development.

The DEP development included a conceptual level review of the constructability of each control option within a sewer district. The proposed locations of the selected control options are within available public lands where possible. This may be within an existing right-of-way or outfall easement. Adjustments to locations proposed in the model may have been made to account for property lines. This typically meant a control option would be moved further upstream along the trunk sewer or a lift station location would be moved away from the flap gate chamber. The locations of City owned land to potentially be utilized for construction of the selected control options is based on the City's GIS dataset. No consideration was made for other underground utilities such as water mains, communications or power. Further evaluation and consideration of constructability in relation to property lines, traffic impacts and utilities will have to be assessed at the preliminary design stage.

Other CSO Master Plan elements such as GI and RTC were not included in the project selection process. These are considered opportunities for future considerations to provide climate change resiliency or adapting to meet changing regulatory requirements. Additional details on these opportunities can be found in Sections 5.2.1 and 5.2.2.

3.5.2 Control Option Selection

A two-step process was used for control option project selection within a sewer district.

Step One: Initial Control Option Selection - The initial control option selection process identified district specific projects and estimated their performance using the individual district hydraulic models. Control options considered included in-line storage and latent storage primarily. Sewer separation was also considered if it was identified as a previously committed City project with the CSO and BFR program. This step continued until projects were defined for all specific districts, or 85 percent capture had been achieved. Section 3.5.3 describes the results of Step One.

The evaluation included in Step One can be summarized as follows:

a) Committed projects were considered first. The majority of these were sewer separation projects identified by the City to achieve BFR objectives, such as the Cockburn and Calrossie sewer districts where partial separation is currently prioritized to meet BFR objectives. The Armstrong district, although not a BFR directed project, was included as a committed project for complete sewer separation because some the results of initial evaluations show there is a large potential for CSO reduction.

b) The second stage within Step One was to identify in-line and latent storage opportunities to align with the marginal analysis. In-line storage is applicable to all but the completely separated districts. Latent storage can only be used in districts that have an SRS system with a dedicated SRS outfall. Identification of potential gravity flow control locations within sewer districts that drain to the interceptor by gravity was also included.

c) The third stage of Step One was the refinement and removal of latent storage within specific districts which have the necessary SRS infrastructure, but was not deemed cost effective based on the marginal analysis.

d) The final stage within Step One for district-specific projects was to include floatables screening for every primary outfall, where hydraulic conditions permitted. The screens are typically installed in combination with the control gates to provide the hydraulic conditions necessary for adequate screening performance.

Step Two: Control Option Refinements – This process identified additional projects required to achieve the system-wide goal of 85 percent capture, that was not achieved in Step One.

Projects evaluated with Step Two included additional latent storage, off-line tank storage, off-line tunnel storage or additional separation. Unlike the first step, these projects were not restricted to any specific districts with the requirement only to meet the system-wide performance goal. Section 3.5.4.1 describes the results of Step Two.

The evaluation included in Step Two can be summarized as follows:

a) The first stage of Step Two included refinements made to the projects selected for districts where off-line screening was determined to not be feasible due to hydraulic constraints within the CS system. This included recommendation of complete separation to remove the necessity for screening, or adoption of alternative floatables management pilot studies in these locations.

b) The second stage of Step Two included further evaluation of districts where in-line and/or latent storage arrangements previously recommended, in comparison to complete separation. Estimated capital cost differences and overall changes in O&M costs between each option considered, and resulted in additional areas of complete separation for a district recommended.

c) The third stage of Step Two included selection of partial separation of specific districts where opportunistic separation work was available. This opportunistic separation work would align with proposed major infrastructure projects in the future.

d) The fourth stage of Step Two included refinements made to latent storage arrangements in specific districts to provide the additional volume capture to meet the 85 percent target. Refinements included flap gate control upgrades, the addition of interconnections to the CS and SRS systems, and upgrades to combined CS/SRS shared outfalls.

e) The final stage of Step two included removal of off-line tunnel or off-line tank storage facilities previously recommended in the Preliminary Proposal from specific districts to meet the 85 percent volume capture target.

3.5.3 Step One: Initial Control Option Selection Process

The challenge with selecting projects when there are multiple choices is to identify those that are the most beneficial ones. This was dealt with using marginal analysis as part of Step One.

Note that this marginal analysis did not apply to the following districts in which complete separation was previously recommended to align with committed or planned projects within the existing CSO and BFR program:

- Douglas Park
- Ferry Road
- Parkside
- Riverbend
- Mission
- Armstrong

The marginal analysis completed as part of Step One compares the incremental cost of choosing one option versus another. Using this technique, a single or combination of options were selected to maximize cost-effectiveness. The marginal cost curves for the capital cost (not including O&M) of CSO mitigation for a range of options are shown in Figure 3-17.

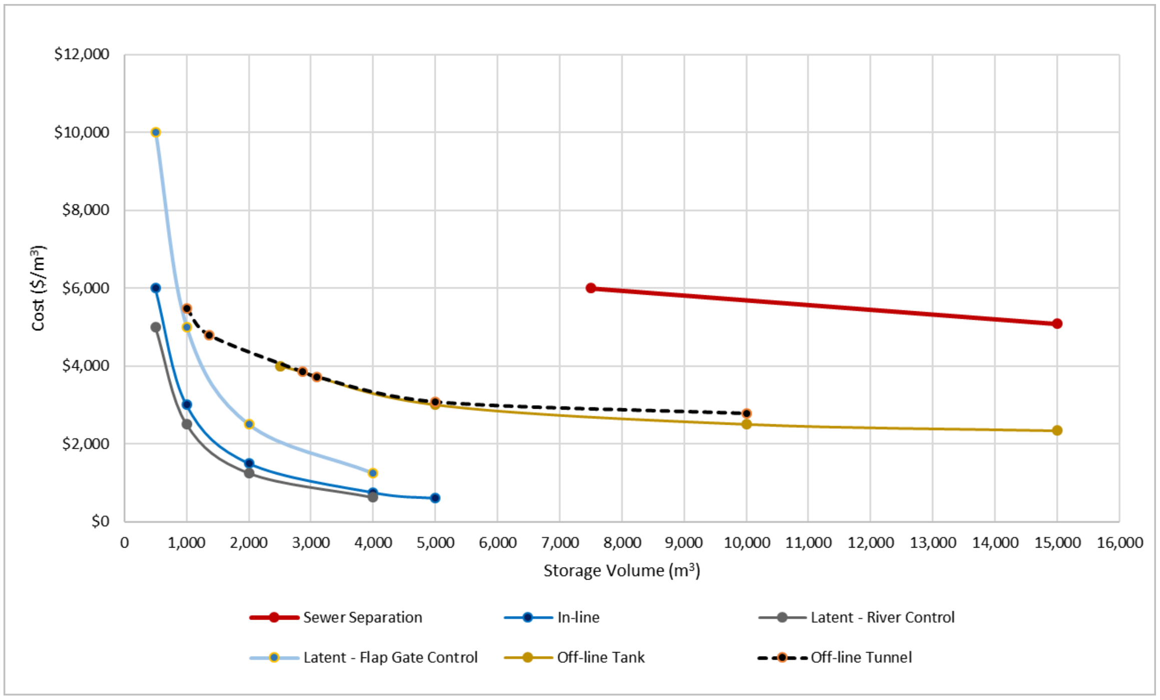

Figure 3-17. Marginal Cost of CSO Control Options (Capital Costs)

Several terms are used in the marginal cost illustration shown in Figure 3-17 which are further described below:

- Sewer Separation: represents the relative costs for separation of small area with 7,500 m^3 to a large area with up to 15,000 m^3 of CSO volume eliminated.

- In-line: represents the cost to install an in-line storage gate control.
- Latent – River Control: represents the cost to install latent storage without flap gate control.
- Latent – Flap Gate Control: represents the cost to install latent storage with flap gate control.
- Off-line Tank: represents the cost to install an off-line storage tank.
- Off-line Tunnel: represents the cost to install an off-line storage tunnel.

The marginal analysis process indicated the following:

- In-line and latent storage projects are generally cost-effective for volumes greater than 1,000 m^3 and always warrant first consideration. In cases where screens are used, in-line storage gate control may be required regardless of cost-effectiveness, in order to provide the required hydraulic conditions for screen operation. As a result of this in-line storage and latent storage was recommended for the majority of the districts, where complete separation was not recommended, and the necessary infrastructure for in-line and latent storage implementation was in place.
- If it was found that the existing weir heights within the district was sufficient to provide the equivalent of the in-line storage arrangements recommended, then no work towards in-line storage via control gate construction was recommended. This was found to be the case in the following districts:
    - Bannatyne
    - River
    - Assiniboine
- The off-line tank and off-line tunnel storage options were found to be highly variable in cost but, because they are largely interchangeable, the most cost-effective option can be picked at time of final selection. Recent bid prices from the Cockburn BFR project for mid-size tunnels, suitable for storage, varied by about a factor of two between bids from different contractors.
- Cost for separation of an entire district is always high because the unit costs are applied to the full area of separation. Sewer separation projects do not use storage, and therefore an amount of equivalent storage was substituted for the marginal analysis comparison purposes. This equivalent storage was equal to the predicted overflow volume needed to reduce the number of overflows from the district to zero. A smaller area of separation would require less sewer pipe to be installed and would equate to less equivalent storage volume.

As part of the marginal review in Step One, a more focused review of the SRS latent storage was completed. The latent storage volumes less than the 1,000 m^3 threshold were deemed to be not cost effective. This resulted in the removal of the latent storage originally recommended during Step One in the following districts:

- Baltimore District, within the Hay SRS and Osborne SRS dedicated outfalls.
- Jessie District within the Grosvenor SRS.

The marginal analysis completed in Step One provided the initial control option selections. The Step One control option selection process achieved a capture rate of 84 percent. Additional refinements as part of Step Two were required to meet the regulatory requirements and achieve the 85 percent capture target.

3.5.4 Step Two: Control Option Refinements Process

Identified as Step Two of the Control Option assessment, additional evaluations were required following Step One to assess unique circumstances and make final refinements to the proposed configuration of control options. This included a review of sewer districts on an opportunistic basis for additional complete or partial sewer separation, the addition of flap gate control or additional interconnection to the SRS latent storage arrangement recommended, and the addition of off-line storage including both tunnels and tanks. These refinements are described in the following subsections.

3.5.4.1 Floatables Screening Refinements

Floatables screening has been considered for all primary outfalls that are not completely separated. Implementation of the off-line screening facilities in these districts was found to be inoperable at some sites however because of physical constraints.

The off-line screening installations require that there be sufficient positive hydraulic head available for gravity screening operation, higher combined sewage levels than NSWL at the screening chamber. The extent of positive head was assumed to be part of the typical screen installation requirement. Refer to Part 3C Section 5.4 for further detail as to the interaction between the screen length requirements and hydraulic head applied to the screening facilities. As part of the Preliminary Proposal assessment, it was recommended and agreed with the City that the control gates would be at a maximum elevation that is equivalent to the half pipe level of the incoming trunk sewer. Increasing the control gate level above the half pipe level to provide adequate screen head in the districts where sufficient head was not available was discounted as not appropriate, given the increased risks of basement flooding associated with this. The installation of control gates artificially raises the operating levels, but at some locations this is still not sufficient to raise the level above the NSWL river level, as shown on Figure 3-18.

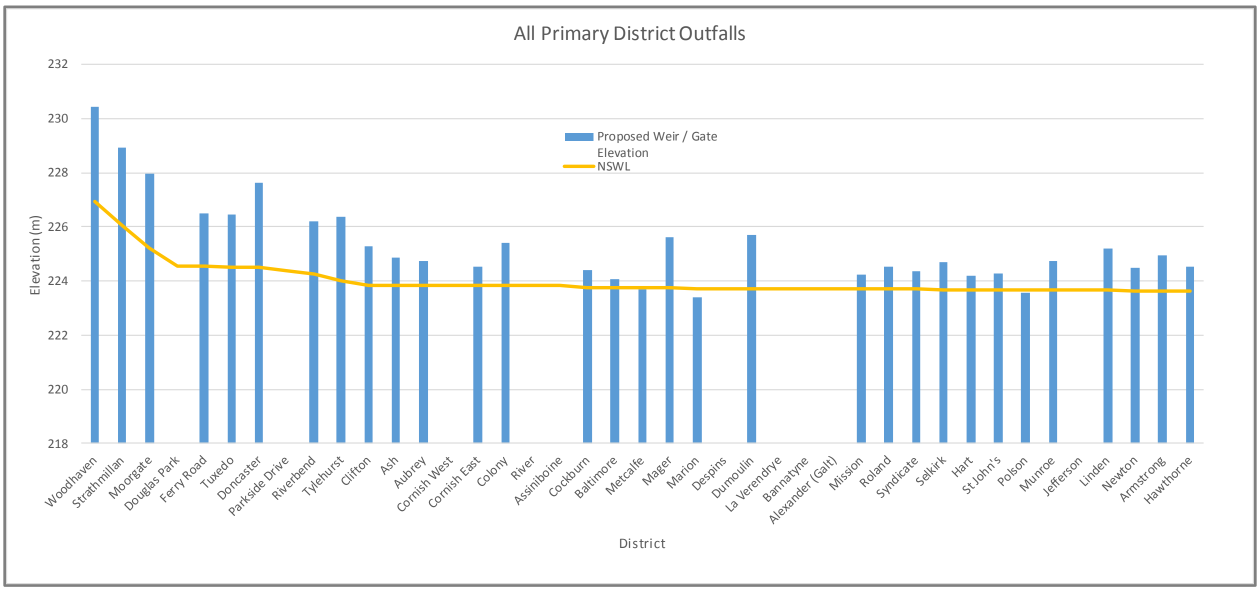

Figure 3-18. Proposed Screen Operating Height versus Normal Summer River Level (NSWL)

The selection of the standard screening chamber as described in Part 3C provides an indication of expected screening head requirements. Where negative head is noted between the screen operating height and the NSWL river level, the district was not considered for typical gravity off-line screening facilities. In addition, those districts where the slight positive head would require an excessive screen length (> 8 m) or positive head below 0.1 m were also not considered for off-line screening.

It should also be noted that the selection of the NSWL river elevation was completed as this river level is that at which the river is primarily controlled to during the majority of the months when rainfall events occur. The high spring river levels may not allow any positive head to be established between the gate/weir level and the river level and under these conditions the off-line screening facilities currently recommended would not operate.

It was concluded during the assessment that the off-line gravity screening facilities could not operate and, therefore, would not be recommended in the following districts:

- Metcalfe
- Despins
- Jessie
- Marion
- Polson

The approach to address the floatables management requirements for these districts was unique. Initially an assessment was completed to determine the feasibility of implementing control options which would remove the requirement for screening entirely. An assessment of utilizing either complete sewer separation or additional off-line storage (via off-line tank or off-line tunnel facilities) for these five districts then completed. From this assessment the recommendation for complete sewer separation based on the elimination of the screening requirement was revised for the following districts:

- Metcalfe
- Despins

It should be noted that the initial marginal analysis and lifecycle cost evaluation completed as described in Section 3.5.4.2 below both found the selection in-line storage and screening options previously recommended to be most cost effective. If the alternative floatables management approach (see Section 5.2.3.2) is utilized in the future within these districts, the recommendation of complete sewer separation in the Metcalfe and Despins districts should be reevaluated.

Additional off-line storage was then assessed in the remaining three districts where off-line screening facilities could not be accommodated, to ensure full capture of the fifth largest overflow event. By capturing the fifth largest overflow event the requirements for floatables management within the district would be met. The provision of the off-line storage to capture this volume of CSO would provide collection of the equivalent first flush flows within each of the four largest overflow events and be similar to the annual performance that would meet four overflows per representative year. The model was used to identify and optimize the infrastructure required to achieve the storage of the fifth largest event. This infrastructure would provide an increase in the capture within each of these districts and provide an improvement to floatables capture and overflow frequency although will not eliminate overflows from these districts. From this evaluation no other districts were found to be sufficiently cost effective to utilize off-line storage facilities to off-set the requirements for screening.

For the remaining three districts the approach to address the floatables management requirements involved selecting these districts for piloting of an alternative floatables management approach. This is explained in more detail in Section 5.2.3.2. If this alternative approach can be demonstrated successful by piloting in these districts, it will remove the requirement to construct an off-line screening facility to meet the floatables management requirements dictated in Environment Act Licence No. 3042.

The piloting of the alternative floatables management approach was therefore recommended for the following districts:

- Jessie
- Marion
- Polson

3.5.4.2 Sewer Separation Refinements

A lifecycle evaluation showed that several smaller sewer districts, or districts in which the majority of the area had been previously separation, could be have complete separated implemented at a comparable cost to in-line storage with screening. Sewer separation is the only control option which would eliminate the need for control gates and screens within a district. Sewer separation can also result in future decommissioning of a FPS associated with the district, potentially providing long term operations and maintenance cost savings for the district after separation is finished. Separation (either partial or complete) will also reduce the volume of flow pumped by an existing LS, reducing both operations and maintenance costs, resulting in an increase to the lifespan of existing infrastructure as well as reducing the replacement cost of existing infrastructure (e.g. smaller pumps required at lift stations for future upgrades).

The addition of the long-term O&M costs to the evaluation of in-line storage with screening increases the lifecycle costs. Conversely, the reduction of district WWF also would reduce the operation of the LS and FPS (where applicable), which would reduce the lifecycle costs. This option refinement required sewer separation to convert the district to a separate sewer district and would eliminate the need for control gates and screening.

The recommendation for complete sewer separation based on this lifecycle analysis was found to apply to the following districts:

- Linden
- Tuxedo
- Doncaster
- La Verendrye

Dumoulin may be considered as a district for complete sewer separation in the future as well. The assessment found that the life cycle costs of complete sewer separation was slightly above the life cycle costs for implementing the other control options. The control options currently recommended for this district should be revaluated prior to proceeding with preliminary design.

The potential benefit from the opportunity to reduce or eliminate FPS requirements was only reviewed at a high level as part of this analysis, and should be investigated further. This may be evaluated in more detail during the CSO Master Plan implementation and may result in other districts having revised recommendations for complete sewer separation instead of the measures currently recommended.

3.5.4.3 Partial District Sewer Separation Refinements

Partial district sewer separation can be considered on an opportunistic basis. These opportunities may arise from further technical analysis and model evaluations or as a result of unrelated redevelopments or construction activity within the district. This approach was applied to the following district:

- Ash: Redevelopment of the Kenaston – Route 90 corridor provides the opportunity for partial separation along the western edge of the district. Sewer separation has been included along parts of the roadway where Route 90 crosses into the Ash district.

3.5.4.4 Latent Storage Refinements

The initial design concept for latent storage was to fully integrate latent and in-line storage. The detailed sewer district evaluations showed that many of the interconnections between the CS and SRS systems are too high to transfer sufficient flows into the relief pipes to take full advantage of the latent storage.

In addition, many of the interconnection levels are not fully documented and further refinement of these assumed levels may not provide the level of interaction that would occur when the interconnection levels are determined as part of future data collection work. This is a potential opportunity for further refinement through model maintenance during the implementation of the CSO Master Plan.

From these evaluations the Aubrey SRS system specifically indicated that a relatively large latent storage volume is not fully utilized. Modifications to the sewer interconnections between the CS and SRS systems are required to access this storage volume. Modifications proposed for Aubrey sewer district are as follows:

- Aubrey – CS to SRS interconnections have been added for both the Aubrey SRS and Ruby SRS systems.

The feasibility and final routing of these interconnections are proposed to be investigated during future model maintenance and as part of the preliminary design for the solutions within the Aubrey district.

Of the 12 potential locations selected for latent storage, 10 are sufficiently controlled by the river NSWL to allow the latent storage to be utilized for each rainfall event. Sewer districts with high SRS outfall pipes in relation to the river NSWL require additional control measures to maximize the latent storage volume. Flap gate control has been applied at these locations to increase the active latent control storage volume.

From this evaluation the following districts were recommended to have the latent storage arrangement refined to have flap gate control as a proposed control option:

- Clifton
- Ash

For the Clifton district, the in-line storage gate allows the interaction between the CS and SRS systems to follow the original design concept. Flap gate control is required to contain the district flow above the NWSL level.

Each flap gate control would be controlled in conjunction with the in-line storage control gate at the primary outfall. Lowering of the in-line storage control gate would trigger the release of the lock controlled SRS flap gate to maintain the level of basement flooding protection.

In two sewer districts, the CS and SRS systems also share a common outfall pipe. The interaction between the two systems creates unnecessary upstream impacts. A new gate chamber including new flap gates and a lift station to dewater the SRS system are proposed to reduce the potential for interactions and separate the SRS and CS outfalls.

These modifications to the SRS outfalls as part of the latent storage refinements are proposed for the following sewer districts:

- Roland
- St John's

This will permit isolation of the SRS storage to optimize the latent storages within these districts.

3.5.4.5 Off-line Tunnel and Tank Storage Refinements

The system-wide assessment of the 85 percent target was achieved via the control options detailed above. Proposals for off-line tank and tunnel storage requirements put forward in the Preliminary Proposal were found to not be necessary to achieve the 85 percent volume capture target for the Master Plan. The increased capture via latent storage, additional sewer separation districts and the hydraulic model upgrades from more recent data sets has resulted in these control options not being required for Control Option No. 1.

However, it was noted that the complete separation of the La Verendrye district did not fully eliminate the overflows at this site. The La Verendrye district is a gravity discharge district flowing to the adjacent Dumoulin district. A combination of the under capacity pass forward pipe, high WWF flows arriving at the Dumoulin LS, and high-level gravity bypass pipe results in overflows at La Verendrye for the separated district modelling assessment. The inclusion of an off-line tunnel and flap gate to isolate the La Verendrye and Dumoulin districts eliminate overflows from the La Verendrye district and would eliminate the requirement for screening facilities. This is not ideal as any improvements to the Dumoulin district for future control options would result in flow reduction in the Dumoulin district that would allow the La Verendrye district to operate within the requirement of the off-line tunnel.

3.5.5 Final Control Option Selection

The final assessment of the control options involved the review of the overflow performance of each district based on the recommendations from Step One and Step Two. The individual district solution models were combined to form the Regional model and the 1992 representative year was simulated. The results of the combined district solutions achieved a system wide performance of 85 percent capture.

The Master Plan final assessment concluded that off-line storage, utilized in the Preliminary Proposal assessment was not required (other than for the La Verendrye district as mentioned above). The additional sewer separation districts, improvements to the modelled infrastructure and latent storage improvements replaced these off-line storage facilities and aligned better with potential future regulatory changes. . The control option selection results as identified in Step One and Step Two for the CSO Master Plan are shown in Table 3-4.

Table 3-4. Control Option Selection for the CSO Master Plan

District	Step One – Initial Control Option Selection						Step Two – Control Option Refinements					
	Complete Sewer Separation	Partial Sewer Separation	In-Line Storage (with Control Gate)	Screens	Gravity Flow Control	Latent Storage (River Control)	Latent Storage (Flap Gate Control)	Latent Storage (Interconnection Upgrades)	Additional Complete Sewer Separation	Additional Partial Sewer Separation	Off-Line Storage Tanks	Off-line Tunnel Storage
Woodhaven			Yes **	Yes								
Strathmillan			Yes **	Yes								
Moorgate			Yes	Yes								
Douglas Park *	Yes											
Ferry Road **	Yes											
Tuxedo									Yes			
Doncaster									Yes			
Parkside *	Yes											
Riverbend *	Yes											
Tylehurst									Yes			
Clifton			Yes	Yes		Yes	Yes					
Ash			Yes	Yes		Yes	Yes			Yes		
Aubrey			Yes	Yes		Yes		Yes				
Cornish			Yes **	Yes		Yes						
Colony			Yes	Yes	Yes	Yes						

Table 3-4. Control Option Selection for the CSO Master Plan

	Step One – Initial Control Option Selection						Step Two – Control Option Refinements					
District	Complete Sewer Separation	Partial Sewer Separation	In-Line Storage (with Control Gate)	Screens	Gravity Flow Control	Latent Storage (River Control)	Latent Storage (Flap Gate Control)	Latent Storage (Interconnection Upgrades)	Additional Complete Sewer Separation	Additional Partial Sewer Separation	Off-Line Storage Tanks	Off-line Tunnel Storage
River				Yes		Yes						
Assiniboine				Yes	Yes	Yes						
Cockburn *		Yes	Yes	Yes								
Baltimore			Yes	Yes		Yes						
Metcalfe									Yes			
Mager			Yes	Yes								
Jessie		Yes	Yes									
Marion						Yes						
Despins									Yes			
Dumoulin			Yes	Yes								
La Verendrye									Yes			Yes
Bannatyne				Yes	Yes	Yes						
Alexander				Yes	Yes							
Mission *	Yes											
Roland			Yes	Yes		Yes						

Table 3-4. Control Option Selection for the CSO Master Plan

	Step One – Initial Control Option Selection						Step Two – Control Option Refinements					
District	Complete Sewer Separation	Partial Sewer Separation	In-Line Storage (with Control Gate)	Screens	Gravity Flow Control	Latent Storage (River Control)	Latent Storage (Flap Gate Control)	Latent Storage (Interconnection Upgrades)	Additional Complete Sewer Separation	Additional Partial Sewer Separation	Off-Line Storage Tanks	Off-line Tunnel Storage
Syndicate			Yes	Yes								
Selkirk			Yes	Yes	Yes	Yes						
Hart			Yes	Yes								
St John's			Yes	Yes	Yes							
Polson			Yes		Yes	Yes						
Munroe			Yes	Yes	Yes							
Jefferson *		Yes	Yes	Yes	Yes							
Linden									Yes			
Newton			Yes	Yes	Yes							
Armstrong *	Yes											
Hawthorne			Yes	Yes								

* denotes a Committed Project with the CSO and BFR Program

** In-Line Storage Control Gate recommended for this district primarily to provide hydraulic head for screen operation. This solution does not provide sufficient additional volume capture to be cost-effective based on performance alone. Should screens no longer be required for this district, In-Line Storage Control Gate recommendation should be reassessed.

3.6 Cost Estimation

The following section presents the approach to estimating the costs to implement the CSO Master Plan. Sewer district level estimates are used in the subsequent programming process to develop annual estimates and the overall program budget.

For the CSO Master Plan, cost estimates were developed for each combined sewer district based on the proposed control options and totaled for the overall program. The district level estimates include the capital costs and allowances for O&M costs. The overall program is based on capital costs only, however the O&M costs and their potential impact on implementing the CSO Master Plan have also been evaluated. Estimating details are provided within the DEPs and in the Basis of Estimate Technical Memorandum included as Appendix C to this Part 2 Technical Report.

3.6.1 Capital Cost Summary

Capital costs in 2019 dollars are calculated based on the estimated construction costs and are shown, including the estimating range, in Table 3-5. The upper range of the confidence limits has been used for the budget assessment of the CSO Master Plan.

Table 3-5. CSO Master Plan Capital Cost Estimates (2019 Dollar Values)

Item	2019 Capital Cost Estimate
AACE Class 5 Estimated Capital Costs	$1,045,800,000
Green Infrastructure Allowance	$104,600,000
Subtotal – Capital Cost Estimate	**$1,150,400,000**
AACE Class 5 Estimate Range of Accuracy: -50% to +100%	$575,200,000 to +$2,300,800,000
Total Capital Cost for Budgeting Purposes	**$2,300,800,000**

The capital cost estimate breakdown is provided in further detail in the Part 3 report. The confidence limits for AACE Class 5 estimates are -50% to +100% and the expectation is that the final cost will fall within this range. The cost estimates presented in Table 3-5 do not include the future operations and maintenance (O&M) costs for CSO program upgrades. The future O&M costs have been estimated separately and further detail can be found in Section 3.6.5 and Section 4.

It is important to note that there were a number of changes incorporated since the original 2015 Preliminary Proposal was submitted. Comparison of the current capital cost estimate to the Preliminary Proposal is listed in Table 3-6. The values are adjusted to have the same cost components.

Table 3-6. Capital Cost Estimate Comparison

Estimate	Preliminary Proposal Capital Cost Estimate (2014 dollars)	Preliminary Proposal Capital Cost Inflated (2019 dollars)	2019 Capital Cost Estimate (2019 dollars)
Base Cost	$830,000,000	$962,000,000	$1,150,400,000
Base Cost + 100%	$1,659,000,000	$1,924,000,000	$2,300,800,000

Notes:

Includes 2014 to 2019 inflation of 3%
Includes full cost of current BFR projects
Includes GI allowance of 10%
Excludes O&M budgets

As agreed with the City, the upper range of the Class 5 estimate (+100%) is to be used for budgeting purposes giving a total capital cost of $2.300 Billion. In the Preliminary Proposal, a different approach was used whereby the total capital cost was reported as $1.245 Billion using +50% of the base estimate. Using the same approach of applying the full +100% estimating range to the Preliminary Proposal capital cost estimates would equate to $1.726 Billion dollars in 2014 dollars. Considering this the overall change in capital costs based on CSO Master Plan refinements is approximately 40 percent higher than that reported for the Preliminary Proposal.

This increase of CSO Master Plan total capital costs in comparison to previous estimates is attributed to the following:

- A change in City's use of the classification range of accuracy for cost estimating. For the Preliminary Proposal, plus 50 percent of capital cost was used to represent the budget estimating amount. In 2015, the City moved to the AACE classification system and the top end of the accuracy range was increased to plus 100 percent of capital cost.
- GI was applied as an allowance to the capital cost estimate of 10 percent for the CSO Master Plan but was not included in the Preliminary Proposal.
- Construction cost escalation from 2014 to 2019 equating to about 16 percent.
- An increase in the amount of sewer separation projects selected as control options for specific districts. This resulted in higher capital costs, but lower long term operation and maintenance costs for those districts.

The capital costs of each of the recommended projects for each of the districts detailed in Part 3B. Over time as the CSO Master Plan is implemented, it is intended that any modification to the CSO Master Plan be updated and reported in Part 3. Part 2 will remain as the supporting technical document to explain the estimating process.

3.6.2 Capital Cost Basis

Conceptual level AACE Class 5 estimates were developed for the proposed control solutions for each sewer district. The estimate for each control solution was based on the following:

- Cost estimation for the CSO Master Plan followed the same approach as was used for the Preliminary Proposal. This included the use of the Program Alternative Cost Calculator (PACC) parametric estimating tool for generating costs for other technologies that have not been previously applied in the City.
  - The PACC tool provided planning level costing information for commonly used CSO control technologies based on other similar completed projects, which can readily be updated to local conditions.
  - Unit costs are provided and represented by parametric curves for each of the units making up the control options. The unit costs are applied to each control option for each district and totaled for the entire CSO Master Plan. Refinements were made to the control solution cost curves and the baseline year was adjusted to 2019.
- Local costs were applied where local estimates from previously tendered work were readily available. This was typically utilized for items such as sewer and chamber installations.
- Standard unit rates from Winnipeg experience were used to estimate and quantify the sewer separation work.
- The CSO Master Plan assumes construction projects will be completed using the design-bid-build (DBB) approach, as has traditionally been used for conveyance projects in Winnipeg. With the DBB approach, the consultant designs the work, the contractor provides a bid price for the tendered project and is responsible for means and methods of construction. The bid price includes all components necessary to complete the construction work.

Further details for the estimation methodology of each control solution technology are included in the Basis of Estimate technical memorandum, included as Appendix C.

3.6.3 Class of Estimation

The CSO Master Plan is a planning level document that deals with strategic planning for a large and complex issue. Therefore, the projects are defined and estimated at a high level, which is suitable for feasibility evaluations, comparative evaluations, and planning, but which is not to be relied upon where a greater deal of accuracy is required.

The CSO Master Plan estimates are reported as a Class 5 level as defined by *Association for the Advancement of Cost Engineering (AACE) International Cost Estimate Classification System – As Applied In Engineering, Procurement, and Construction for the Process Industries* (AACE, 1997). Class 5 estimates have an accuracy range from minus 50 to plus 100 percent and are based on a project definition of between zero and two percent. The AACE Class 5 estimate accuracy range is utilized to project the potential range of total program cost estimate changes. This is based on the understanding that each of the projects included in the program will be refined and potentially modified as the Master Plan is implemented. As a result of this the upper range of an AACE Class 5 estimate (+100%) is to be used for program evaluation and budgeting purposes.

3.6.4 Capital Cost Assumptions

The total capital costs are estimated by adding markups to the expected construction costs to arrive at the total capital cost for the project. The following percentage markups are included in the capital estimates:

- Engineering – 13 percent
- Project Design Contingencies – 30 percent
- Program Management – 2 percent
- Manitoba Retail Sales Tax (MRST) – 8 percent, applies to tangible personal property and has been applied to all projects. It is expected to be applicable to some projects or parts of projects, or both, and not to others, which is subject to interpretation and may require tax department clarification at the time of construction.
- MRST was reduced to 7 percent in July 2019; however, this change was not applied to the estimates due to the timing of when the estimates were created.

In total each of the percentage markup factors above, a cumulative markup of 53 percent is applied to the base construction costs developed from the CSO unit costs.

Specific capital costs based on previous estimates or parametric cost curves are included for each capital project, except for GI. GI is considered an opportunity, with the costs and performance accounted for separately from the other control options. It has been accounted for with a separate cost allowance of 10 percent assigned to the capital costs for all the districts.

There are additional cost markups that may be applicable to portions of the CSO Master Plan but were not included. These are listed as follows:

- Federal Goods and Services Tax (GST) – normally 5 percent, but not included because of potential municipal exemptions.
- Finance and Administration – normally 3.25 percent, but not applied for the CSO Master Plan

3.6.5 Operations and Maintenance Cost Assumptions

Each of the projects will require some level of O&M throughout their life. The CSO Master Plan addresses the need for reporting the O&M costs by two means, the lifecycle 35 year O&M costs, and the program

O&M costs. The lifecycle O&M costs are identifying them as separate line items within each DEP, while combining them together for scenario evaluations. The cumulative O&M program costs and impacts based on the project sequencing and timelines can be found in Section 4 of this Part 2 Technical Report.

O&M costs accrue after capital projects are completed and continue while the project is in service. O&M costs include routine labour and expenses for servicing (such as energy, materials, and chemicals) and labour and expenses for periodic refurbishment or replacement. The O&M estimates were developed based on the PACC tool approach, as described in Appendix C: Basis of Estimate Technical Memorandum. The O&M costs consider the annual maintenance and operation based on the expected number of times operated and a periodic replacement cost.

O&M evaluations were first completed for the lifecycle cost analysis as part of the initial project selection and for the program scenario evaluations. The lifecycle costs were based on the hypothetical assumption each project would be implemented in 2019, and were based on 35 years of O&M costs. The 35 years timeframe was used in alignment with the City's business case process used for planning and project comparisons. This information will be utilized further as part of comparing solutions selected amongst different districts as the solutions recommended in the districts are taken forward to preliminary design.

Next the O&M evaluations were completed to determine the program additional O&M costs. O&M costs were assumed to initiate following the completion of a control option based on the project sequencing and funding scenario, and continue for the life of the infrastructure. In the evaluation of the various budget scenarios, the O&M costs were evaluated based on a projection to the year 2100. It includes routine costs at a constant annual rate in 2019 dollar values, inflated to the year of expenditure, as well as the periodic costs:

- Routine O&M costs were initially estimated in 2019 dollar values and are extended to the year 2100.
- Periodic maintenance costs were applied as a factor of the capital cost at 10, 20 and 30 years.
- The cost estimate for each sewer district includes the net present value (NPV) of the combined routine and periodic O&M costs, which are used in the Master Plan programming and budget estimates.

3.6.6 Estimating Allowances

An estimating allowance was included for the CSO Master Plan. The estimating allowance is calculated as 100 percent of the base capital cost estimate. Note that this estimating allowance is a separate consideration from the AACE Class 5 estimate accuracy range. This allowance is applied to the final cost figures to account for unknowns and provide the necessary contingency allowance for budget projections.

The estimating allowance accounts for program unknowns and uncertainty beyond the risks normally encountered on a project basis. Examples of potential cost increases are as follows:

- **Proof of Concept:** The CSO Master Plan includes a ten year period for technology evaluations and pilot studies, intended to validate and gain comfort in the control option selections. This implies that there is a possibility of rejection, which may lead to the need for more costly substitutes.
- **Consequential Upgrades:** The project development process for the CSO Master Plan assumed the works would be carried out independent of existing or other asset condition or upgrading needs. In practice, there may be needs or pressures to integrate indirect upgrades, such as LS upgrades, water mains, integration of other BFR works, street repairs, or rehabilitation of existing sewers to support the CSO program upgrades.
- **Market Demand Price Changes:** The rapid growth in work and the long-term implementation period increase the risk of construction cost increases. The engineering and contracting resources are currently not in place to deal with the volume of work projected in the Master Plan. The usual market response to increased demand results in increased costs, which may be exacerbated because of the need for specialized skills and limited resources for much of the work.

- **Program Support Services:** The capital cost estimates include a line item for project support services. The budget is intended for field services by internal resources, consulting services, and contracts for carrying out or supporting the engineering evaluations, pilot testing, and RTC works in support of program management.
- **Constructability Issues:** Several issues in relation to the process to construct some of the solutions recommended as part of the CSO Master Plan could result in escalating costs. This could include logistical issues related to existing underground infrastructure, high water table and groundwater infiltration concerns impacting unground construction, or items relating to unforeseen ground conditions during construction.

3.6.7 Cost Estimate Exclusions

Section 3.6.6 identifies items outside of what is included in the cost estimates, but which are assumed to be covered as part of the estimating contingency and allowances. There are other items that may impact the overall cost of the CSO Master Plan but are not included within the cost estimates provided. These items are described as follows:

- **FPS Usage Reduction:** FPSs are present in number of sewer districts that have been identified for work as part of the CSO Master Plan. There is the potential that the requirements for the FPS could be reduced or eliminated if the basement flooding issues are mitigated by other means. There would be long term operational savings attributed to this reduced service.
- **BFR Projects:** Current projects initiated under the BFR projects are underway and include works associated with CSO mitigation. The value of the constructed works directly related to CSO and BFR is approximately $440,000,000 to date. All future work of this nature is included in the CSO program. This will need to be reviewed and will result in minor reductions to the total capital cost estimate provided at this time.
- **Sewage Treatment Plant Upgrades:** Combined sewage captured under the CSO program will be routed to STPs for WWF treatment. Allowances have been committed for WWF treatment at the SEWPCC and WEWPCC. The future NEWPCC project is to include upgrading an independent treatment facility for WWF, which will be used by the CSO program. The capital and operating costs of all WWF treatment is included with the STP upgrade budgets as part of the Winnipeg Sewage Treatment Program (WSTP) and has not been allocated to the CSO program estimates.
- **Land Acquisition:** The base estimates do not include land acquisition costs, if required.

3.7 District Engineering Plans

EA No. 3042 required the development of district engineering plans (DEPs) as part of the CSO Master Plan. As such, DEPs were developed for each of the combined sewer districts. Each DEP documents the existing relevant sewer data and the solutions proposed to meet regulatory requirements. This process incorporates the use of a standard template to streamline the creation of the plans. This template will be maintained and used for future sewer planning efforts in the City.

The DEPs have been developed to a conceptual level of design that will require further analysis prior to implementation. It is expected that the proposed solutions will be further refined through the preliminary and detailed design phases. The CSO Master Plan will be updated to reflect any changes required from the additional analysis. The DEPs are included with Part 3B.

3.8 Project Data Collection Documentation

The development of the CSO Master Plan required a detailed review of the City's sewer system and the creation and updates to the sewer system hydraulic models. The review and analysis undertaken to complete these tasks required the use and creation of a large set of data. The CSO Master Plan study began in 2013 and the Preliminary Proposal was based on the data set collected during the initial stages of the project at that time. The CSO Master Plan included a more detailed review of the City's data, model updates identified as a result of the review of the district engineering plans, and the creation of an updated baseline and preferred solution for the Master Plan.

A data tracking and review plan was put in place to record the changes that have taken place between the submission of the Preliminary Proposal to the submission of the CSO Master Plan. The main components of the data tracking and review plan are described in the following subsections.

3.8.1 Data Sheets

Data sheets were created during the detailed plan development and implementation to track changes to the asset data, hydraulic model, control options, and costs. Data are tracked in a spreadsheet for each sewer district to identify the changes between the baseline and the CSO Master Plan versions of the model. This includes the identification of critical elevations used in selection of the CSO controls for the CSO Master Plan. The content of these datasheets is ultimately included within each of the DEPs.

3.8.2 Hydraulic Models

Hydraulic models were created in InfoWorks CS for the City's sewer collection system during the study phases of the CSO Master Plan project. A baseline model representing the year 2013 was created based on available data at the start of the project. This included a global, all-pipes model and a skeletonized CS system model. Preliminary Master Plan alternative models were created for each of the control limits requested by MSD and others added by the study team. A hydraulic river model was created with the Water Quality Analysis Simulation Program and used in the study phase to estimate the loading and dynamic water quality impacts. These planning models were finalized and included in the submission of the 2015 Preliminary Proposal.

A new baseline and CSO Master Plan model were created based on new information available at the beginning of the implementation phase in 2018. Additional updates were included resulting from a detailed review and development of the DEPs. The Master Plan model and associated modelling files are included with the CSO Master Plan submission to the City of Winnipeg.

4. Program Development

Program development is the process of defining the CSO Master Plan program details. It begins after project development, with projects meeting the performance requirements having been identified and evaluated, and capital and operational cost estimates prepared for each project.

Program development considers the project sequencing for the long-term implementation. The program will include multiple projects, resulting in many variations to the potential programs. The wide range of variations warrants a methodical approach for program development.

Program development is ultimately used to produce the CSO Master Plan submission. The Master Plan will include a project listing, project descriptions, the year of implementation, and capital and operating costs for each project. Both of these costs are directly impacted by the sequencing of the projects during program development, due to the impacts from inflation. The project sequencing alternatives presented below form the CSO Master Plan and will be reviewed by MSD for compliance with EA No. 3042. It will then be used in the City's capital budgeting process and followed for program implementation and performance tracking.

The following section describes the program development process. It includes review of scenarios, with the recommended implementation plan presented in Part 3A. As the program evolves, it is intended that the program updates will be documented through changes to Part 3A, without the need for updates to the technical sections of this Part 2 report.

The project development process is summarized on Figure 4-1 and its application is described in the following sections.

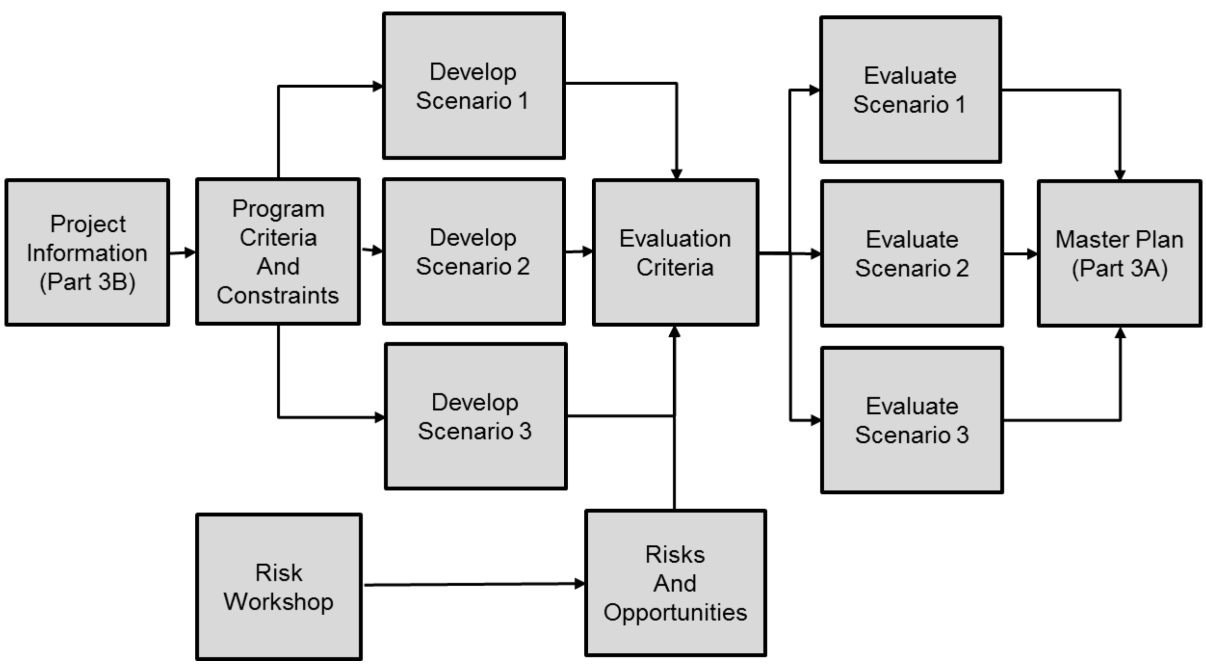

Figure 4-1. Program Development Process

4.1 Program Criteria and Constraints

Several criteria and constraints have been identified through the CSO master planning process as having a direct impact on the scenario definitions, their evaluation, and how they impact the program. Each of these criteria are defined below as follows:

- **Regulatory Requirements:** The primary objective of the CSO Master Plan is to achieve compliance with the regulatory requirements, with the two key requirements being CSO capture and implementation schedule.

  Ideally all scenarios would meet the regulatory requirements, but in fact the high costs may be too onerous on the ratepayers, with an extension to the time frame for implementation being required. An extension may be approved by the Director of MSD, as stated in EA No. 3042.

- **Water Quality:** Since all the scenarios will achieve the same water quality improvements, there is little differentiation between the scenarios. The main consideration is that the extended implementation schedule due to lower funding levels means there will be a delay in achieving the projected water quality improvements.

- **Affordability:** The City's Water and Waste Department finances its capital and operating budgets for the sewer utility on a user-pay basis through water and sewer rates. The City takes a longer-term view of rates to provide stability for its rate-payers. The rates have steadily been rising for several years and are expected to continue to rise because of major obligations for wastewater treatment plant upgrading and replacement and refurbishment of aging infrastructure. However, continuous increases in water and sewer rates to fund these obligations are not sustainable. The City has determined that the upper threshold for the CSO program funding specifically should be no more than $30 million per year and has set this as a funding constraint. There are additional resources available to guide municipalities such as the EPA's *Guidance for Financial Capability Assessment and Schedule Development* (EPA, 1997). The approach assesses the average cost of the program per household in comparison to the median household income. This produces a numerical factor called the Residential Indicator (RI). In general, an RI of 2 percent or greater is considered a "large economic impact" on residents. In Winnipeg, most of the CS areas are within lower income neighbourhoods and this factor is already above the indicator which means any additional costs from the CSO Master Plan will impact this further.

- **2003 CEC Recommendation:** Timeframes to achieve the completion of the program are directly related to the level of funding committed. The CEC hearings (CEC, 2003) recommended shared costs for upgrading the City's wastewater collection and treatment systems in order to complete the work in a reasonable amount of time. The program development phase has therefore been evaluated based on shared funding from municipal, provincial and federal levels of government.

- **Committed Projects:** Several sewer separation projects have been initiated and are underway. These projects were part of a previously approved program and align with the objectives of the CSO Master Plan. There will be no changes made to the project sequencing of these specific projects within the program development.

- **Technology Validation:** The CSO program has identified several cost-effective control technologies which have not yet been applied in the City. The City plans to carry out investigations and testing of these new technologies under local conditions prior to full scale commitment.

- **Operations and Maintenance:** The new CSO control technologies include mechanical equipment that is more labour-intensive, and with a potentially shorter service-life than what the current infrastructure would have. The O&M assessment includes the estimated annual O&M costs and an allowance for the periodic equipment replacement costs as they occur.

- **Startup:** The City is currently working on projects previously approved as part of the CSO and BFR program. These projects are similar to the CSO projects as they are based on sewer separation and will be well positioned for initiation of other separation work, but the City still recognizes the time required for approvals and provincial and federal funding commitments. Accordingly, the schedule has assumed two years for Provincial Approval and a further two year delay for the commitment of long-term provincial and federal funding before initial implementation of the projects developed in the CSO Master Plan using the project sequencing provided.

- **Beneficial Uses:** The rivers running through Winnipeg are not recommended for recreational use in which sustained contact with the water occurs. It is not expected that the improvements in percent capture with implementation of the CSO program will improve the river water quality to change these recommendations.
- **Stakeholder Expectations:** The public has been engaged during the Preliminary Proposal phase at the public events held between 2013 and 2015. Further public communications work will continue as elements of the CSO Master Plan are initiated. Throughout this process it will be important to restate the improvements and existing issues surrounding CSOs as they occur, to educate the public of the improvements the CSO Master Plan will provide. It has been stated to the public in the past as part of these events that the complete removal of CSOs will not provide the level of bacteria removal necessary to recommend swimming in the river system. The complete removal of CSOs will also not impact the lack of clarity in the waters of rivers in Winnipeg. Large amounts of suspended soils inherit in the river system give the rivers their natural murky brown appearance. The removal of CSOs will also not significantly impact the nutrient loadings to the Lake Winnipeg watershed to prevent algae blooms. The primary contributors to nutrient loadings to Lake Winnipeg are from the Red River excluding the City Of Winnipeg, the Winnipeg River, and the Saskatchewan River systems.
- **Risks and Opportunities:** Longer implementation periods would tend to reduce many of the risks inherit to a capital program of this scale. The longer implementation period however would result in an escalation in market pricing due to inflation.

4.2 Program Scenarios

The purpose of multiple program scenarios is to provide a structure for evaluation of a broad range of program alternatives. In practice, however, the final range of scenarios was quite limited, because the projects were pre-selected and the application of the criteria and constraints limited the number of variables to be considered. The different program scenarios were therefore selected to specifically address different sources and levels of funding. This was found to be the primary criteria subject to large variations.

The program scenarios are as follows:

- **Scenario 1 – Shared Tri-Level Funding:** Tri-level funding agreement between the Government of Canada, Government of Manitoba and the City of Winnipeg, based on previous recommendations from the CEC Hearings (CEC, 2003). Under this scenario the City has an expectation that the entire program will be equally funded through a cost-sharing arrangement with the provincial and federal governments, at one-third equal funding contributions from each level of government. This scenario places a cap of $30 million per year on funding from each of the three levels of government ($90 million per year total), based on the City’s $30 million affordability limit to support the CSO program.
- **Scenario 2 – Shared Bi-level Funding:** Bi-level funding agreement between the City of Winnipeg and either the Government of Manitoba or the Government of Canada. As a compromise to three-way sharing, the second scenario assumes that either one of the two senior levels of government will not participate in the funding arrangement. This has the effect of maintaining the same $30 million per year level of funding per year from two of the three levels of government ($60 million per year total) and extending the program until its completion.
- **Scenario 3 – City-only Funding:** This scenario assumes the two senior levels of government will not participate in shared funding, with the program being fully funded by the City at a limit of $30 million per year. The schedule would be extended as necessary at the fixed rate of funding to complete the program.

It should be noted that there are other multiple possible variances of scenarios such as delays in committed funding from other sources or they are partial and or inconsistent, which will impact schedules. There are risks associated with changes of government and associated policies and available funding. There are also risks associated with City committed funding as it is based on annual capital budget approval by council. The scenarios above however are considered to cover a broad range of possible scenarios.

A workbook tool was developed to assist in the development of the scenarios. A descriptive overview of this workbook is provided in Appendix D. Detailed figures from each of the scenario workbooks is provided in Appendix E. The scenarios are created to include four main components; the project details, O&M cost summary, capital cost summary, and a budget schedule. Further details on each of these components is described as follows:

Project Details

The project details include the following:

- Three control option categories are listed for each district (i.e., separation, in-line storage/latent storage/screening, and off-line storage). The percentage of separation and use of a control gate for in-line storage, latent storage, and screening is identified.
- Individual capital costs for the three types of control options are listed in 2019 dollar values.
- Performance estimates are individually listed for each control option in terms of annual capture volumes for the 1992 representative year.

Operations and Maintenance

The O&M summary includes the following:

- Annual O&M cost estimates are provided for each control option for each district where they apply.
- The annual O&M cost is based on the 2019 O&M estimate inflated to the year in which the control option is completed and operational.
- NPVs for O&M are provided for the projects, beginning after the project is complete and sequenced to continue over the implementation period.
- A budget summary of the O&M values is provided for the year in which the work takes place.

Capital Cost Summary

The capital cost and budget summary include the following:

- Capital cost totals in 2019 values for each control option for each district are provided, which includes the 53 percent markup on construction cost for engineering, burdens, and contingency.
- The CSO Master Plan includes a minus 50 percent to plus 100 percent range on the total capital cost, based on a Class 5 level of estimate.
- NPV for the projects, as sequenced over the implementation period.
- A budget summary of project values in their year of construction is provided.

Budget Schedule

The budget schedule is specific to each worksheet and includes the following:

- A timeline for project implementation and the respective project budgets for capital projects is included.
- A timeline for the annual additional O&M expenditure in the year in which each recommended solution is to be completed is included.
- A summary of annual project and O&M costs is included for all projects to illustrate the annual expenditures.

4.3 Implementation Considerations

The main objective of programming is to sequence and schedule the projects into an implementation plan that meets the program criteria and constraints. It also provides the opportunity to maximize or optimize the program for other considerations, such as cost-effectiveness or CSO capture performance.

The high-level scheduling considerations are as follows:

- The projects as part of the CSO and BFR program are a high priority. The City has committed projects at various stages of delivery based on previous benefit-cost analyses and these were approved and underway prior to issuance of EA No. 3042. The projects as part of this program provide demonstrated tangible benefits to residents, and a change to the sequence of these projects to accommodate CSO projects is not warranted.
- Opportunities such as GI and RTC also offer potentially low costs for CSO reduction, but these technologies also require research and validation prior to a commitment for full scale implementation. For this reason, the exact sequencing of these works as part of the program development was not considered.
- The use of NPV for project evaluation favours deferral of large expenditures and extended program durations. While this is true for the CSO program, there is little opportunity for adjustments because of the constant annual budgeting approach and duration being dictated by the rate of funding and funding scenario ultimately implemented.

Projects were selected to maintain a relatively uniform level of expenditure within the approximate implementation period based on the three funding scenarios identified in Section 4.2. Capital project sequencing was identified for the scenarios based on the following:

9) **Start-up**:

   Funding for the first four years of the program was limited to the City's contribution limit of $30 million. The delay accounts for a two year period to allow alterations to EA No. 3042 and a further two year period for the senior levels of government to arrange for their funding commitments necessary for the program.

10) **Committed Projects**:

   According to the criteria and constraints, the first priority is to complete the committed projects from the CSO and BFR program.

   Several CS districts have been identified for relief as part of this program, with the preferred method of relief being sewer separation, which provides the dual benefit of flooding reduction and CSO mitigation. Specific details for each of these committed projects are listed below:

   - Cockburn and Calrossie: Conceptual engineering has been completed and detailed design and construction is underway. Cockburn West is in the process of being completely separated, and completion of the project is required to leverage its full benefits.

     The Cockburn project is unique in that the project consultants have identified the use of in-line storage for Cockburn East. This will achieve the CSO program objectives without the need for its complete separation. The need for separation of Cockburn East to achieve BFR benefits was not part of the CSO project scope. In-line storage proposed for Cockburn East was evaluated to ensure it would not be detrimental to the existing level of basement flooding protection.
   - Ferry Road, Riverbend, Douglas Park and Parkside: These districts are bundled together for the CSO and BFR program, with works well underway. The design approach is for complete separation, which will continue for this scenario.
   - Jefferson East: This project is well underway. The design approach is for partial separation, which will continue under all scenarios for the CSO Master Plan.

- Armstrong: This district has also been considered a committed project with the CSO and BFR program because of its high cost-effectiveness in meeting CSO reduction. Some preliminary evaluations have taken place within the district.
- Mission: As a sewer district with a high level of industrial land use, there is an expectation that the water quality impacts would be significant relative to a residential or commercial area. An extensive sewer cleaning project and flow monitoring has been completed in this district. No sewer separation work under the CSO and BFR program is currently underway in this district, but has been prioritized to occur following the completion of other projects in the program.

The CSO study has not dealt with specific details for sequencing of the committed projects. Each of these has or will have a conceptual study to assess the exiting conditions and detailed upgrading requirements for establishing an implementation plan. It is common for the detailed plans to change as work progresses, and this degree of flexibility should be retained in the CSO program.

The sequencing and phasing assumptions for these separation projects was to prioritize based on the CSO volume which would be removed a result of the separation work. The large volume of work can most readily be achieved by assigning manageable size projects to multiple locations.

11) Additional Separation Projects:

Additional evaluations made to the initial project selections concluded that sewer separation should also be selected for several districts. These projects however are not committed to the CSO and BFR program.

These projects will be sequenced following the committed projects, as it has been identified that all sewer separation projects be sequenced before all new technologies being recommended. This will allow for sufficient time for these new technologies to be piloted and their performance evaluated. The additional sewer separation projects to be sequenced after the committed projects are listed below:

- Tuxedo: As a small distrct with partial separation, the cost of extending separation to the full district and avoiding use of in-line storage and sceening is cost-effective.
- Doncaster: Widening of the Route 90 - Kenaston Boulevard transportation corridor and the redevelopment of the Kapyong Barracks within the Doncaster district provides opportunites for complete separation. The CSO study has not investigated this redevelopment work in detail. This district should be further reviewed during the CSO Master Plan implementation to determine the feasibility to align with the expected future development schedule.
- Metcalfe, La Verendrye and Despins: These districts are each small in area in which partial separation has already occurred. As well in the case of the Metcalfe and Despins districts the primary outfalls cannot be screened due to hydraulic constraints, providing further incentive to complete the separation of these districts. Therefore, the cost of extending separation to the full district and avoiding use of in-line storage and sceening only has a small cost premium for these districts.
- Linden: The existing level of separation in the Linden district is approximately 87 percent by area . This results in separation being a cost-effective option, as compared to in-line storage previously recommended for the district.
- Tylehurst: This district was identified as a potential sewer separation candidate in the Preliminary Proposal. It was listed in the top ten priority districts to be relieved in the 1986 BFR report, but sewer relief has yet to be implemented. No sewer separation work under the BFR program is currently proposed in this district. As such this sewer separation will be programmed as the last of all separation projects to be completed.

The sequencing and phasing assumptions for these additional separation projects was to prioritize based on the CSO volume which would be removed a result of the separation work. These sequencing and phasing assumptions will be refined by staff within the City of Winnipeg as the CSO Master Plan is implemented and is subject to change.

12) Partial Separation Projects:

The partial separation projects are recommended for a variety of reasons, generally because of their connection to another project:

- Ash: To be completed on the Route 90 – Kenaston corridor upgrading schedule
- Jessie: Southeast Jessie is to be separated as part of the Cockburn BFR project.

The sequencing and phasing assumptions for these partial separation projects was to prioritize based on the CSO volume which would be removed a result of the separation work. These sequencing and phasing assumptions will be refined by staff within the City of Winnipeg as the CSO Master Plan is implemented and is subject to change.

13) In-Line Storage, Gravity Flow Control and Latent Storage Projects:

In-line storage, gravity flow control and latent storage generally provide the highest cost-effectiveness but concerns with operations and the reliability of the technologies must be resolved prior to their use. Because of their high cost-effectiveness, these projects are sequenced to be implemented after the committed projects, additional separation projects, and partial separation project are completed. At this point the evaluation and acceptance of the technologies will also have been completed.

Control gates are also an integral part of floatables screening and RTC.

The sequencing and phasing assumptions for these projects was to prioritize based on the CSO volume which would be removed a result of the separation work. These sequencing and phasing assumptions will be refined by staff within the City of Winnipeg as the CSO Master Plan is implemented and is subject to change.

14) Tunnel and Off-Line Storage Projects:

Tunnel and off-line storage are considered similar to each other from a project sequencing perspective, with neither taking a priority over the other.

Neither tunnel nor off-line storage are being applied for basement flooding improvements, and control gates are integrated into both to maximize their performance. The implementation of these solutions will follow with the implementation of the high cost effective in-line storage, latent storage and gravity flow control projects.

15) Program Support Services:

The CSO program will require a wide range of engineering and administrative services throughout its completion to support overall program management as described in the Section 4.5. They are expected to include the following:

- Technology Evaluation and Pilot Studies:
  - Control Gates
  - Screens
  - Flap Gate Control
  - Green Infrastructure
  - Real Time Control
- Alternative Floatables Management Demonstration Project and Pilot Study
- In-Situ Flow Monitoring Of Districts Before and After Control Options Implemented
- RTC Instrumentation Upgrades (as required) and SCADA Integration
- 2030 CSO Master Plan Update

Project support services will include one-off investigations as well as continual annual activities. The details will be established once the program is initiated. Cost allowances for these works have been included in the CSO Master Plan.

It is recommended that the analysis of the main technology evaluations and pilot studies are completed within the first ten years. This will provide confirmation that these proposed options are appropriate and suitable for the Winnipeg sewerage system. After this time the level of effort for support services is expected to reduce, and recommendations from the work will be incorporated into the already budgeted capital projects. Some level of support services will continue but has not been accounted for in the CSO Master Plan estimates.

16) **Green Infrastructure/Climate Change Resiliency Projects:**

GI has been addressed separately from the other control options. It has not been included in the base solutions because of unknowns and uncertainty with its application. The GI projects will provide the necessary additional performance improvements to mitigate any detrimental impacts from Climate Change on future precipitation trends. Further details on the approach to GI implementation can be found in Section 5.2.1 of this Part 2 Technical Report.

Review and evaluation of GI is included in the ten year technology investigations phase and is anticipated to be implemented from that point forward. An allowance of ten percent of the Master Plan capital costs has been included for its implementation.

17) **Unbudgeted Projects:**

The implementation strategy does not include capital or O&M allowances for wet weather flow treatment. This is assumed to be included as part of the WSTP.

The implementation strategy also does not consider any work required for the future migration to Control Option 2. The costs for this work will be considered in further detail as part of the 2030 CSO Master Plan update. This is detailed in further in Section 4.6 of this Part 2 Technical Report.

18) **Budgeting Allowance:**

A 100 percent budgeting allowance has been applied the estimated capital cost, and is included in the CSO Master Plan estimates for budgeting purposes.

4.4 Program Scenario Evaluation

The three scenarios were compared in the overall program format to determine the timeline and costs to complete. The comparisons took place after the proposed solutions were identified, and in adherence with the criteria and constraints listed in Section 4.2 and defined below. Each scenario incorporates the same projects, with the only material difference being the rate of funding and resulting project sequencing, and ultimately the length of implementation period. This process simplifies the comparative evaluation to assess the differences.

4.4.1 Scenario Budget Summary

All three scenarios will meet the intention of EA No. 3042 to capture 85 percent of CSOs for the 1992 representative year. The program is dependent on the level of funding received to complete this work. It can be completed under any of the funding scenarios identified, but the timeframe is extended as the level of funding decreases. $2.3 Billion was used as the total capital budget for assessment of each of the scenarios, and is explained in further detail in Section 3.6.1. A comparison of the implementation timeline and budget expenditures is shown in Table 4-1.

Table 4-1. Program Scenario Implementation Time Comparison

Program Scenario	Description	Funding by	Annual Budget	Total Capital Expenditure	Timeline
Scenario 1	3 Levels of Funding 3 x $30 Million	Tri-level Government of Canada, Manitoba Government and the City of Winnipeg	$90 Million	$3,667,000,000	27 years (2047)

Table 4-1. Program Scenario Implementation Time Comparison

Program Scenario	Description	Funding by	Annual Budget	Total Capital Expenditure	Timeline
Scenario 2	2 Levels of Funding 2 x $30 Million	Bi-Level City of Winnipeg and either the Manitoba Government or the Government of Canada	$60 Million	$4,482,000,000	39 years (2059)
Scenario 3	1 Level of Funding 1 x $30 Million	One Level City of Winnipeg Only	$30 Million	$8,285,000,000	75 years (2095)

The total capital expenditure demonstrates how the same $2.3 Billion capital budget, if projected over a longer period of time, results in a much larger cumulative dollar total. This is due to the impacts of construction inflation from delaying planned work further into the future. The effect of time extensions is to increase the annual budgets in the year of expenditure but reduce the NPV overall. All values are inflated to the year they are planned to take place. This is further illustrated in Table 4-2.

Table 4-2. Program Scenario NPV Capital and O&M Cost Comparison

Scenario	Capital Expenditure	NPV of Capital Expenditures	Total of Additional O&M Costs (Extended Until 2100)	NPV of Total Additional O&M Costs (Extended Until 2100)	Total NPV Of Capital Expenditures + O&M Extended to 2100
Scenario 1	$3,667,000,000	$1,534,000,000	$1,367,000,000	$61,000,000	$1,595,000,000
Scenario 2	$4,482,000,000	$1,336,000,000	$1,246,000,000	$42,000,000	$1,378,000,000
Scenario 3	$8,285,000,000	$936,000,000	$543,000,000	$11,000,000	$947,000,000

Each of the scenarios has a specific net present value (NPV), which accounts for capital costs, operation and maintenance costs and their year of expenditure. Each scenario has a specific timeline including the year all control solutions are in operation, with Scenario 1 being the earliest due to the increased level of funding.

The total and NPV for the additional O&M costs anticipated are shown for each scenario, and also reflects the implementation timeline. The O&M costs associated with each project are extended to the year 2100 in order to compare the scenarios with all projects complete. All additional O&M cost estimates extend from the year after project completion to the year 2100. In reality, these O&M costs will continue for the life of the infrastructure.

Table 4-3 illustrates the average additional annual O&M costs for each scenario in the year following the completion of all projects. Any changes to the project sequencing will change the projections shown for Capital and O&M costs. This provides an estimate of overall impact on year to year operations as a result of implementation of the solutions recommended to meet Control Option No. 1.

Table 4-3. Additional Annual O&M Costs For Each Program Scenario

Scenario	Year all Control Options are in Operation (CO Completion Year)	Additional Annual O&M Costs After CO Completion Year	Additional Annual O&M Costs after CO Completion Year in 2019 Dollars
Scenario 1	2048	$10,600,000	$4,500,000
Scenario 2	2060	$15,100,000	$4,500,000
Scenario 3	2096	$44,000,000	$4,500,000

All O&M costs shown in the above evaluation are specific to the CSO Master Plan projects and do not include additional O&M costs for existing infrastructure.

4.4.1.1 Definition of Scenario Cost Terms

Each of the scenarios will have a specific NPV, which accounts for capital costs, operation and maintenance costs and their year of expenditure. NPV is commonly used to compare engineering projects, with the lowest NPV being one of the key evaluation criteria. The effect of time extensions is to increase the annual budgets due to inflation to the year of expenditure but reduce the NPV overall.

1) **Inflation:** Annual inflation has a major impact on annual budgets. The evaluation adds the fixed percentage of inflation to the capital and O&M costs and determines the costs in terms of the actual year the project is sequenced to occur.

   The average annual inflation rate fluctuates over time, with recent inflation rates for consumer goods being less than two percent. For the CSO program construction inflation is more relevant and has historically exceeded the consumer rate of inflation. An average annual inflation rate of three percent has been selected for the evaluation of capital costs and O&M budgets.

2) **Discount Rate:** A simple definition of the discount rate is; the rate of return required on a project when inflation is removed. For public projects, this is referred to as the social discount rate, and a fixed value of three to four percent is commonly used. In theory, if the rate of return associated with a project is lower than this amount, other competing projects will have more benefits and be of higher priority for approval. An average annual discount rate of three percent has been selected for the evaluation of capital costs and O&M budgets.

3) **Net Present Value:** Present value converts the future capital and O&M costs to a single equivalent amount. The term NPV is used instead of PV only to maintain consistency with the naming convention within the workbook tool. NPV is established as rate of annual inflation plus the discount rate (for example, three percent inflation plus three percent discount rate produces a six percent NPV rate). For the CSO program, the year 2019 is used as the base year for present value comparisons. An average annual NPV rate of six percent has been selected for the evaluation of capital costs and O&M budgets, based on the previously selection inflation and discount rates.

4.4.2 Scenario 1 – Tri-Level Funding

The shared funding scenario assumes three-way sharing of funding between the three levels of government, with the upper limit being an annual funding level of $30 million per year from each level of government, totaling $90 million per year capital funding.

4.4.2.1 Scenario 1 Capital Budgets

Scenario 1 is based on equally shared cost by the three levels of government for a total of $90 million per year. The programming goal was to develop relatively uniform annual budgets in 2019-dollar values after accounting for the initial funding gap for the startup period.

The 2019-dollar value annual budgets are shown in Figure 4-2. As can be seen in the figure a near constant funding of $90 million dollars is maintained.

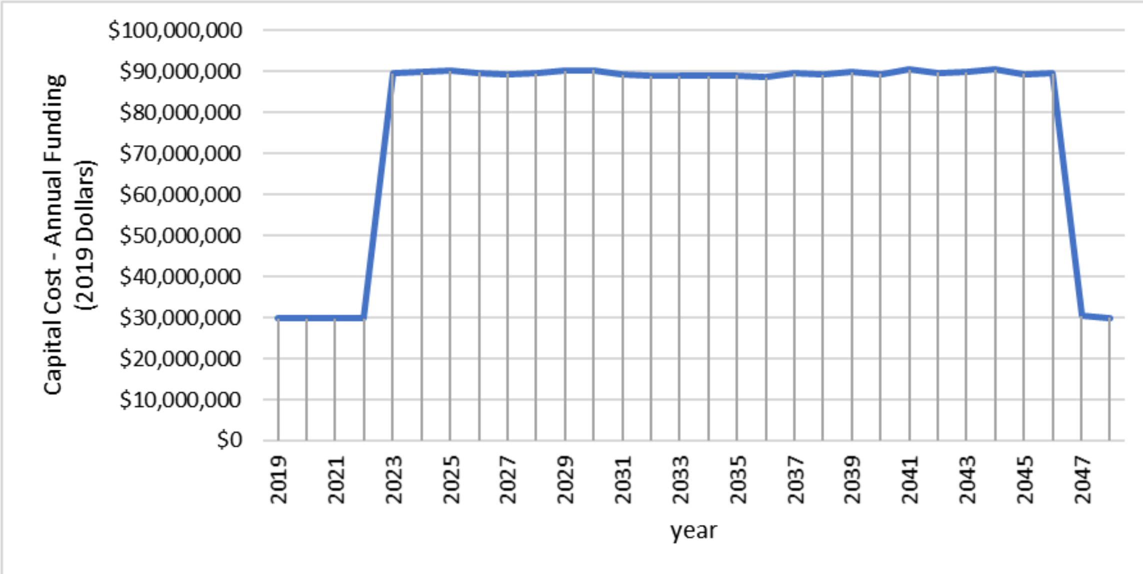

Figure 4-2. Scenario 1 Annual Capital Budget (2019-dollar value)

Figure 4-2 shows the annual budget varying slightly from year to year which is a result of discrete project costs that cannot readily be smoothed out to accommodate uniform budgeting. The overall budget is approximately $90 million in 2019 dollars. The implementation costs are not allowed to exceed the budget for each year of the program.

The annual capital budget values inflated at three percent per year are shown in Figure 4-3. The inflated values show the increase to the annual budget over the implementation time period. The maximum annual capital budget shared by the three levels of government in the second last year in 2046 is $199,000,000.

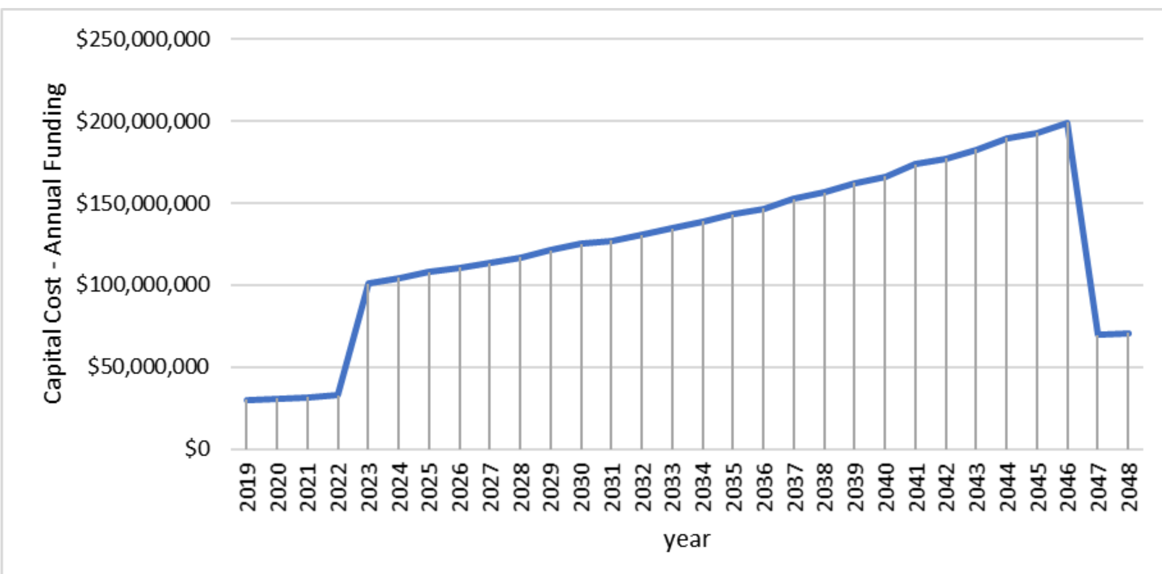

Figure 4-3. Scenario 1 Capital Budget Inflated at Three Percent Annually

The Scenario 1 budget in 2019-dollar values plotted on a cumulative basis is shown in Figure 4-4. The projects are sequenced by year in the budget schedule, per the project sequence determined during the program development, and they show the budget value for the year of construction. Based on an escalation of three percent per year, the total for the future budget amounts is $3,667,000,000.

The NPV for Scenario 1 is $1,534,000,000 based on a six percent discount rate.

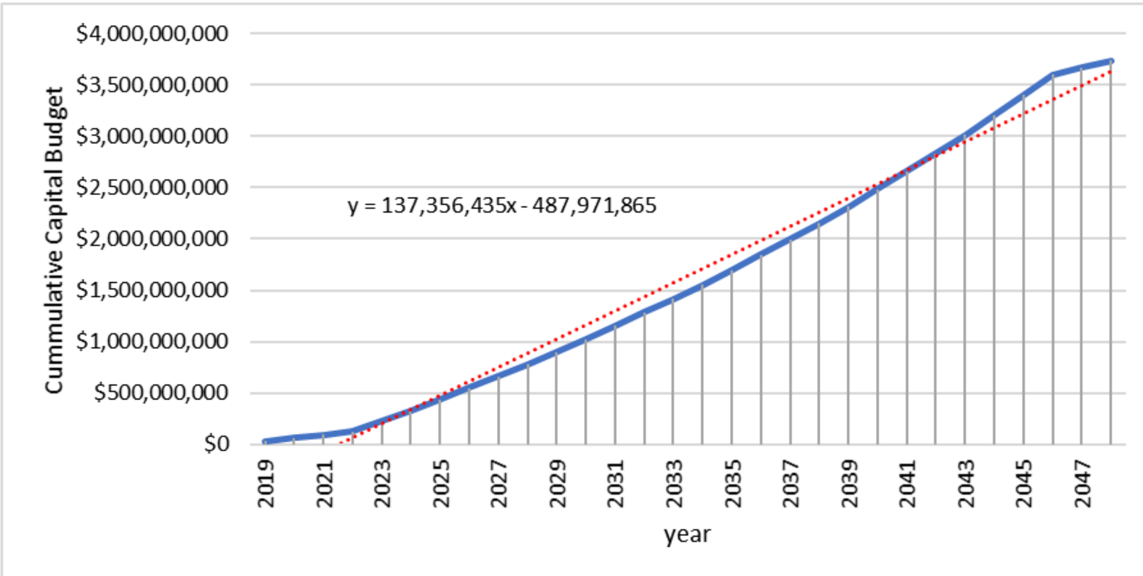

Figure 4-4. Scenario 1 Cumulative Capital Budget with Three Percent Inflation

Figure 4-2 shows that the implementation of Scenario 1 can be completed within 27 years with an annual budget of approximately $90,000,000, with provision for delayed full commencement due to license approval and funding confirmation periods. The annual costs under the assumption of three-way capital cost sharing between the three levels of government will be within the $30,000,000 affordability limit identified by the City.

4.4.2.2 Scenario 1 Operations and Maintenance Budget

The operating and maintenance costs are considered separate from the capital cost budget. There is no target budget value for O&M similar to the $30 million capital budget, as operation and maintenance costs are a function of the control technologies selected. The annual budgets in terms of 2019 dollar values are shown in Figure 4-5.

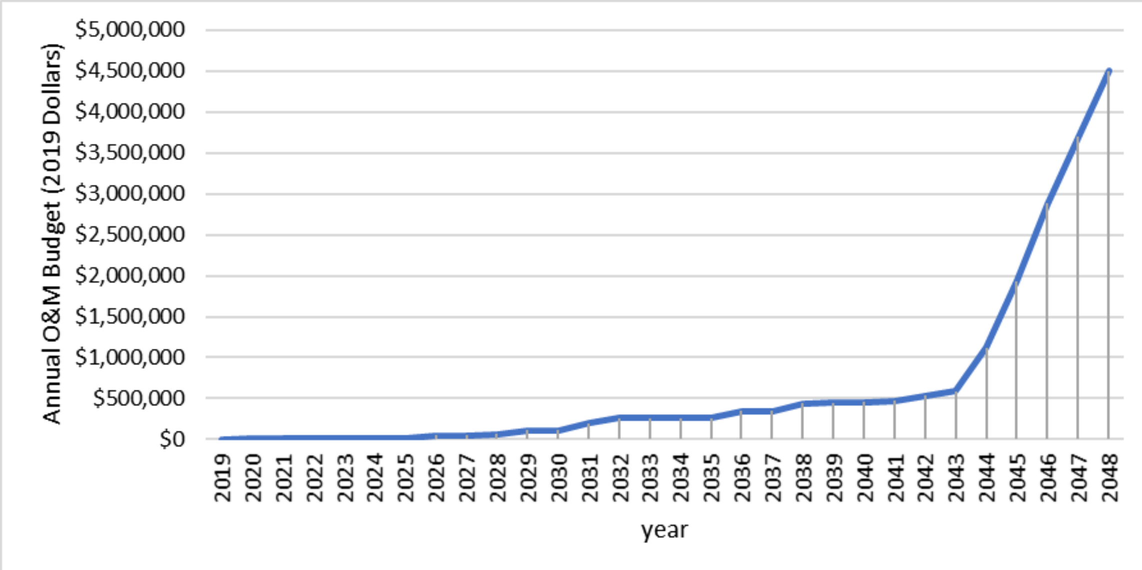

Figure 4-5. Scenario 1 Annual O&M Budget (2019-dollar value)

Projects with higher O&M requirements have been scheduled to take place later in the program, which is reflected in the figure. The steep rise in the operating budget results from the cumulative effect of having to operate and maintain new infrastructure with the more O&M intensive projects scheduled later in the program. The completion of the program will result in an additional annual O&M cost of $4,500,000 per year in 2019 dollars by the year 2048 in which all projects are complete and operational.

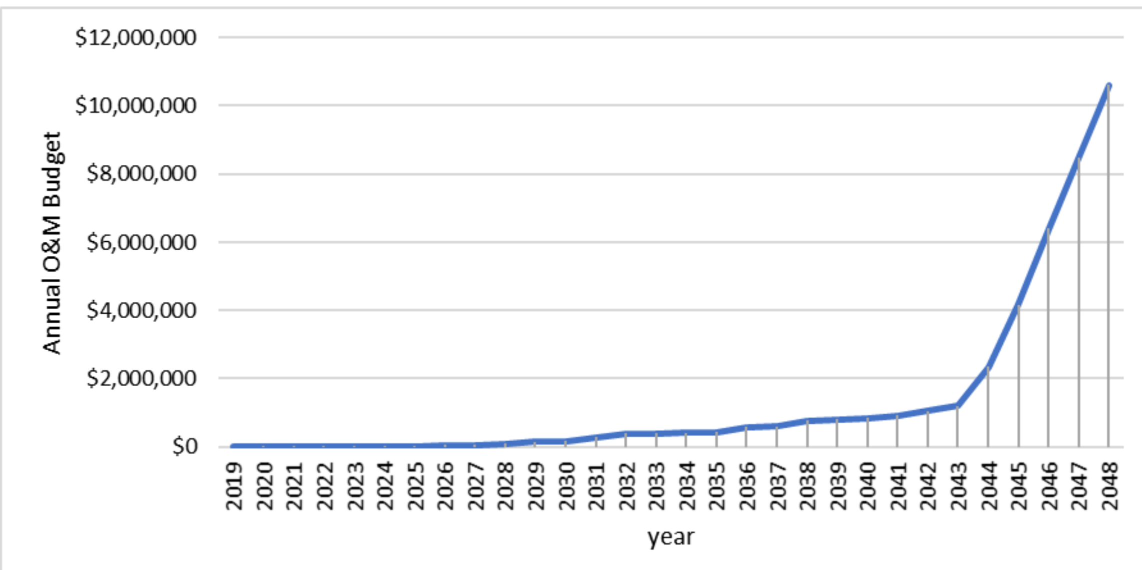

Figure 4-6. Scenario 1 O&M Budget Inflated at Three Percent Annually

The estimated O&M costs shown in Figure 4-6 have been inflated to the year of expenditure at three percent annual escalation. The inflated annual cost of O&M, at the end of the implementation period, with all the works in place and operational is estimated to be approximately $10,600,000 per year in 2048 dollar values.

4.4.2.3 Scenario 1 Performance

The reduction in CSOs is relatable to the implementation period for Scenario 1 and the reductions are assumed to occur as the projects are completed. This reduction in the annual CSO volume is shown in Figure 4-7. This shows that the 85 percent capture target will be met in the year 2047.

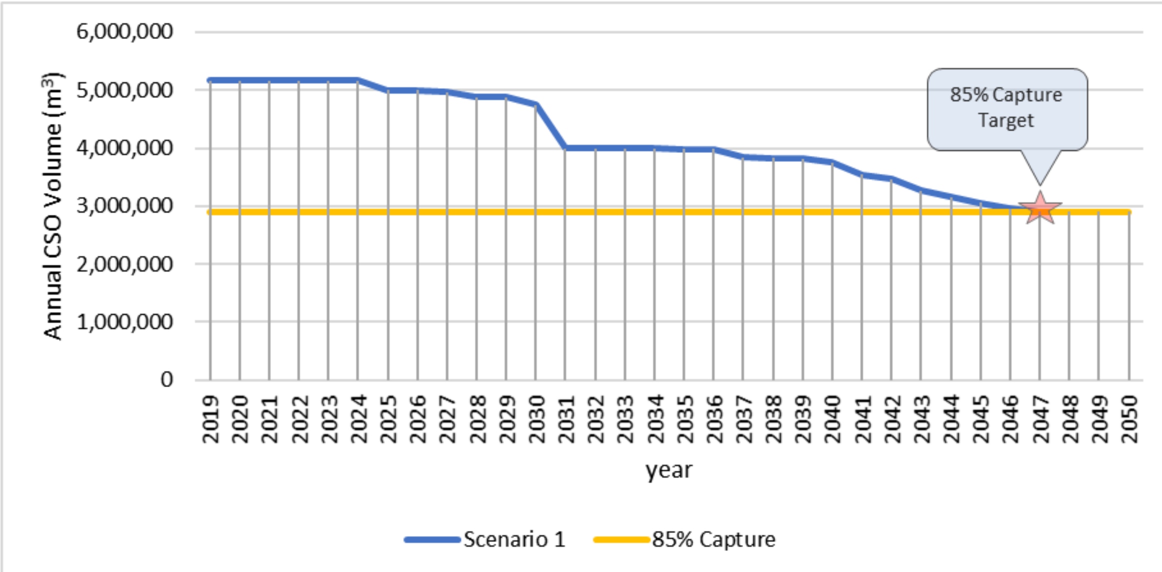

Figure 4-7. Scenario 1 Annual CSO Discharges

4.4.3 Scenario 2 – Bi-level Funding

Funding for this scenario will be by the City and one of either the provincial or federal governments at $30 million per year each. The net effect is to extend the implementation period beyond the December 31, 2045, date listed in EA No. 3042.

4.4.3.1 Scenario 2 Capital Budgets

The Scenario 2 program is based on equally shared cost by the two levels of government for a total of $60 million / year. The programming goal was to develop relatively uniform annual budgets in 2019-dollar values after accounting for the initial funding gap for the startup period.

The 2019-dollar value annual budgets are shown in Figure 4-8. As can be seen in the figure a near constant funding of $60 million dollars is maintained.

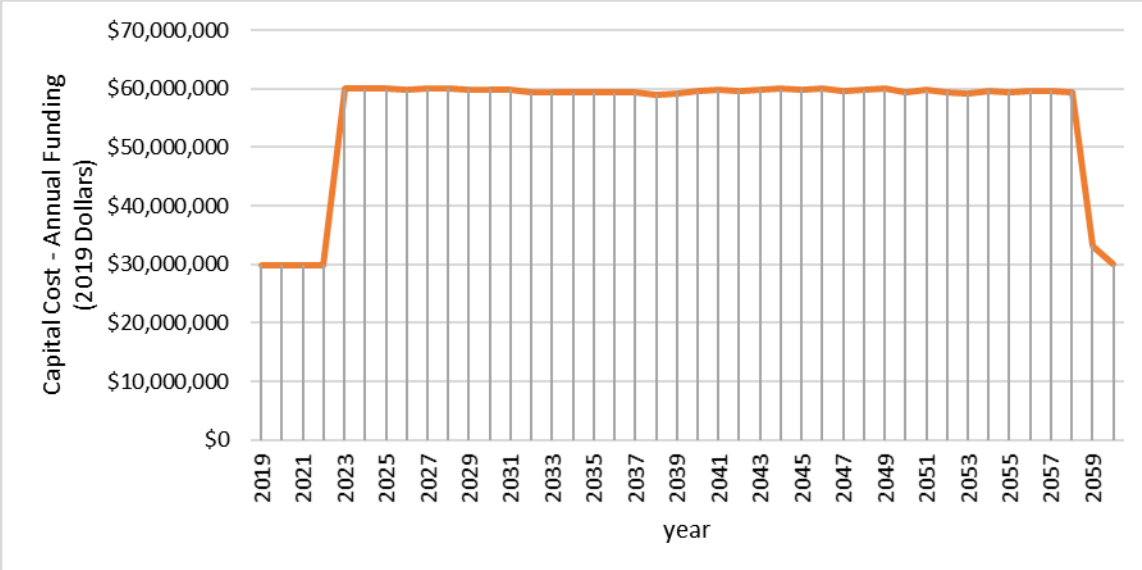

Figure 4-8. Scenario 2 Annual Capital Budget (2019-dollar value)

Figure 4-8 shows the annual budget varying slightly from year to year which is a result of discrete project costs that cannot readily be smoothed out to accommodate uniform budgeting. The overall budget is approximately $60 million in 2019 dollars. The implementation costs are not allowed to exceed the budget for each year of the program.

The annual capital budget values inflated at three percent per year are shown in Figure 4-9. The inflated values show the increase to the annual budget over the implementation time period. The maximum annual capital budget shared by the two levels of government in 2058 is estimated at $188,500,000.

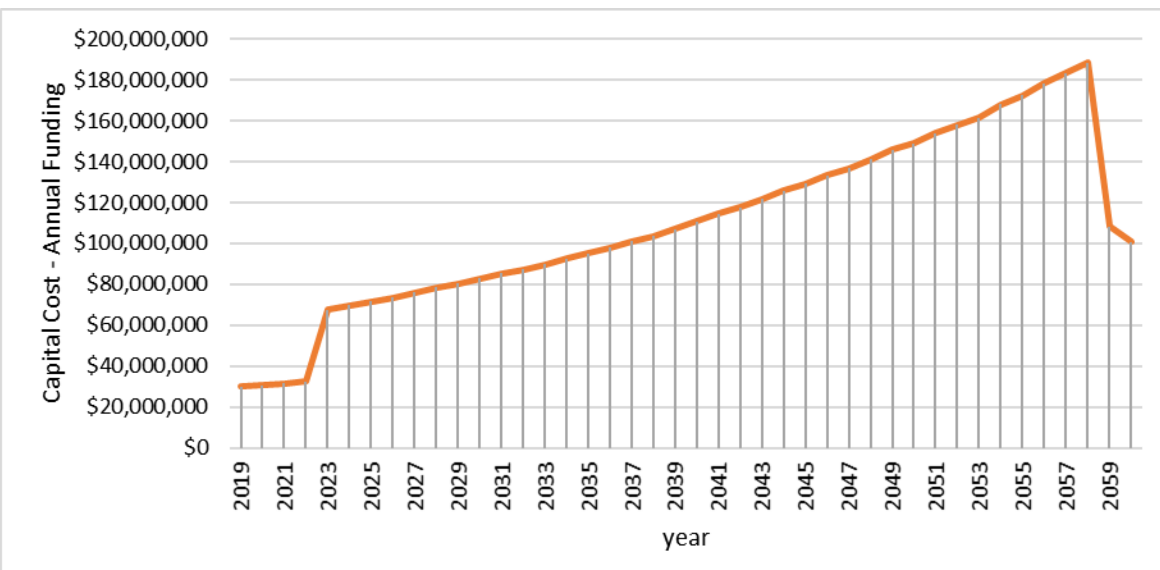

Figure 4-9. Scenario 2 Capital Budget Inflated at Three Percent Annually

The Scenario 2 budget in 2019-dollar values is plotted on a cumulative basis shown in Figure 4-10. The projects are sequenced by year in the budget schedule, per the project sequence determined during the program development, and they show the budget value for the year of construction. Based on an escalation of three percent per year, the total for the future budget amounts is $4,482,000,000 in the year 2059.

The NPV for Scenario 2 is $1,336,000,000 based on a six percent discount rate.

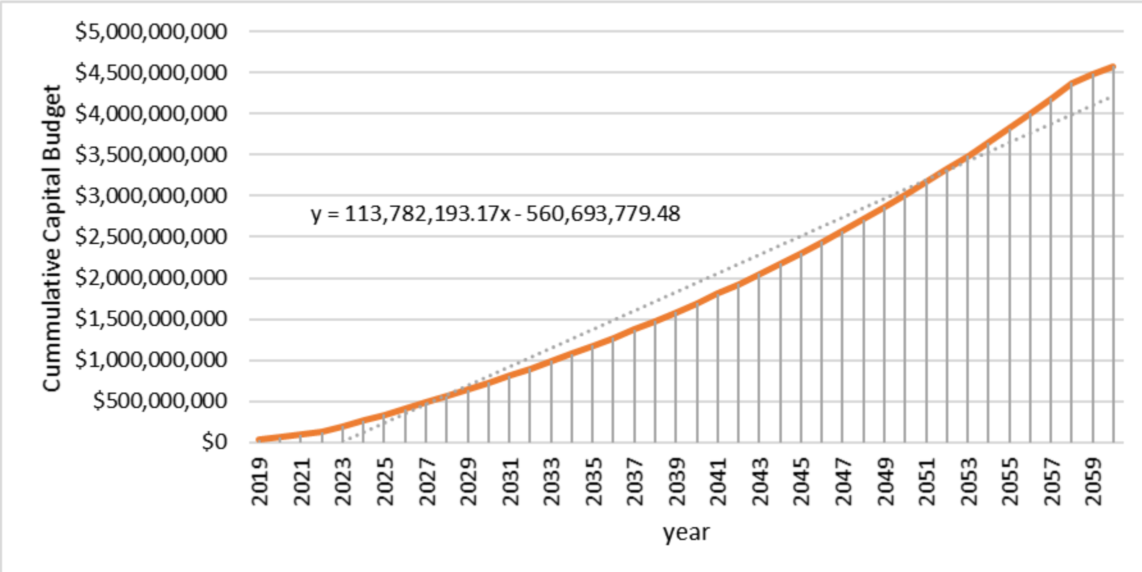

Figure 4-10. Scenario 2 Cumulative Capital Budget with Three Percent Inflation

Figure 4-8 shows that the implementation of the CSO Master Plan can be completed within 38 years with an annual budget of approximately $60,000,000, with provision for delayed full funding commencement due to license approval and funding confirmation periods. The annual costs under the assumption of two-way capital cost sharing between two levels of government will be within the $30,000,000 affordability limit identified by the City.

4.4.3.2 Scenario 2 Operations and Maintenance Budget

The operating and maintenance costs are considered separate from the capital cost budget. There is no target budget value for O&M similar to the $30 million capital budget, as operation and maintenance costs are a function of the control technologies selected. The annual budgets in terms of 2019 dollar values are shown in Figure 4-11.

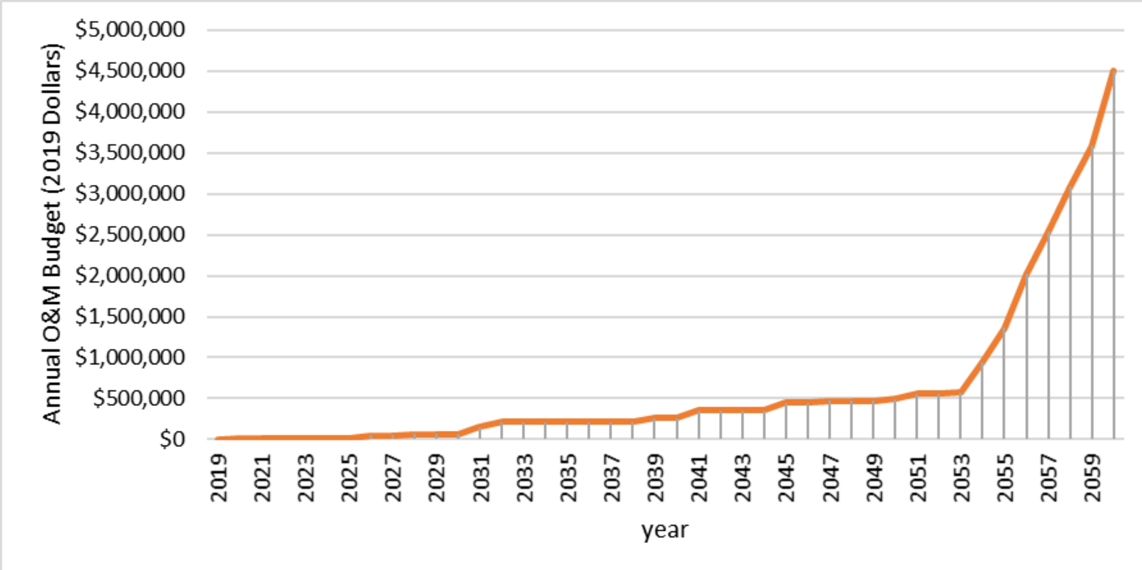

Figure 4-11. Scenario 2 Annual O&M Budget (2019-dollar value)

Projects with higher O&M requirements have been scheduled to take place later in the program, which is reflected in the figure. The steep rise in the operating budget results from the cumulative effect of having to operate and maintain new infrastructure with the more O&M intensive projects scheduled later in the program. The completion of the program will result in an additional annual O&M cost of $4,500,000 per year in 2019 dollars by the year 2060 in which all projects are complete and operational.

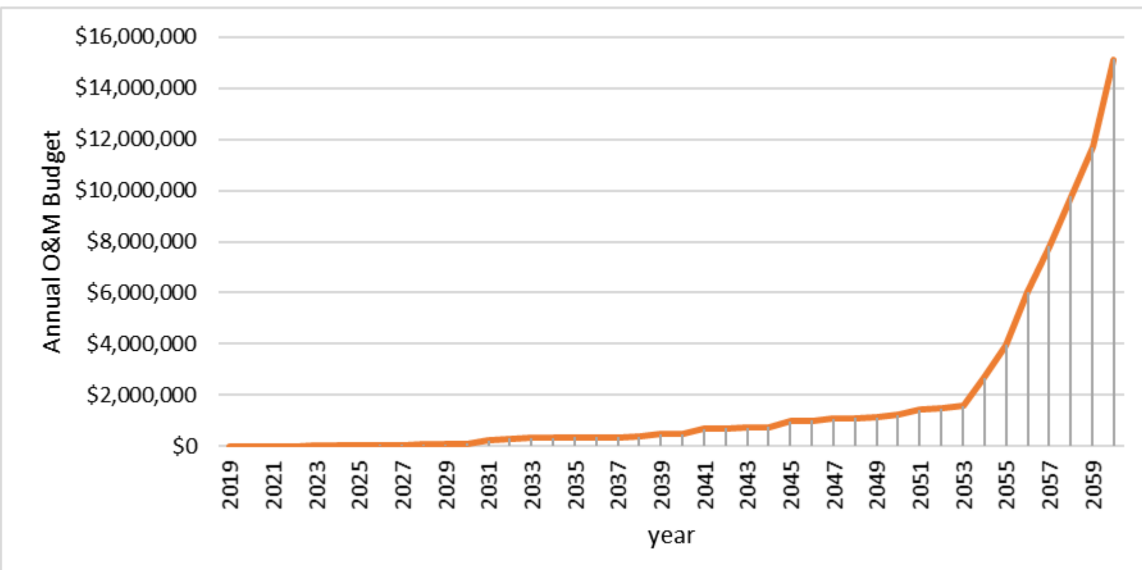

Figure 4-12. Scenario 2 O&M Budget Inflated at Three Percent Annually

The estimated O&M costs shown in Figure 4-12 have been inflated to the year of expenditure at three percent annual escalation. The inflated annual cost of O&M, at the end of the implementation period, with all the works in place is estimated to be approximately $15,100,000 per year in 2060 dollar values.

4.4.3.3 Scenario 2 Performance

The reduction in CSOs is relatable to the implementation period for Scenario 2 and the reductions assumed to occur as the projects are completed. This reduction in the annual CSO volume is shown in Figure 4-13. This shows that the 85 percent capture target will be met in the year 2059.

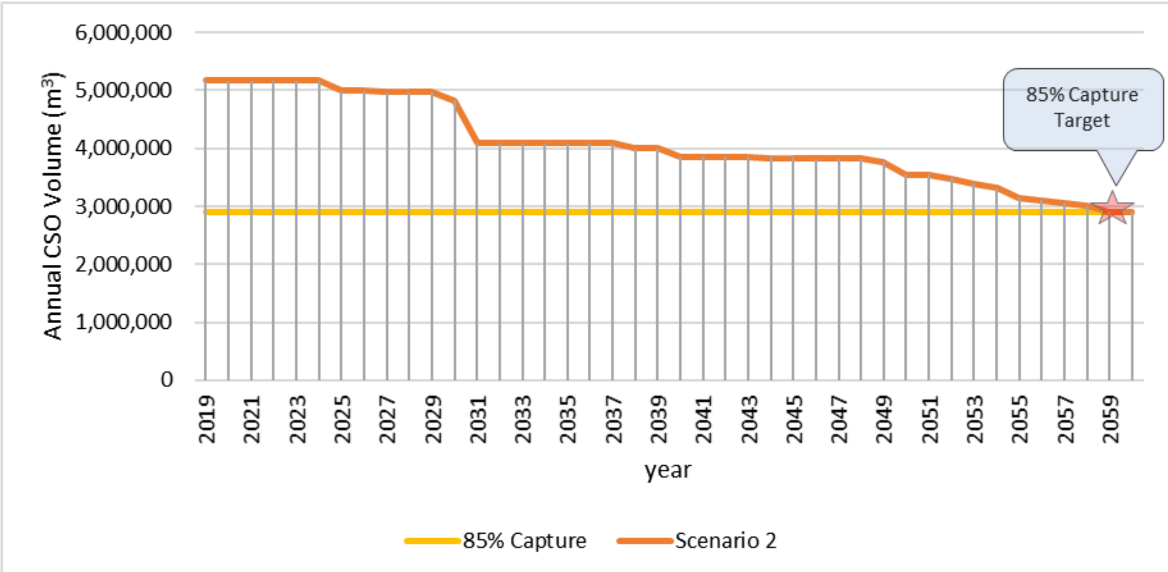

Figure 4-13. Scenario 2 Annual CSO Discharges

4.4.4 Scenario 3 – City-only Funding

The City would be the sole source of funding for this scenario at $30 million per year. The net effect is to further extend the implementation period beyond December 31, 2045, as listed in EA No. 3042.

4.4.4.1 Scenario 3 Capital Budgets

The Scenario 3 program is based on City funding only for a total of $30 million / year. The programming goal was to develop relatively uniform annual budgets in 2019-dollar values after accounting for the initial funding gap for the startup period.

The 2019-dollar value annual budgets are shown in Figure 4-14. As can be seen in the figure a near constant funding of $30 million dollars is maintained.

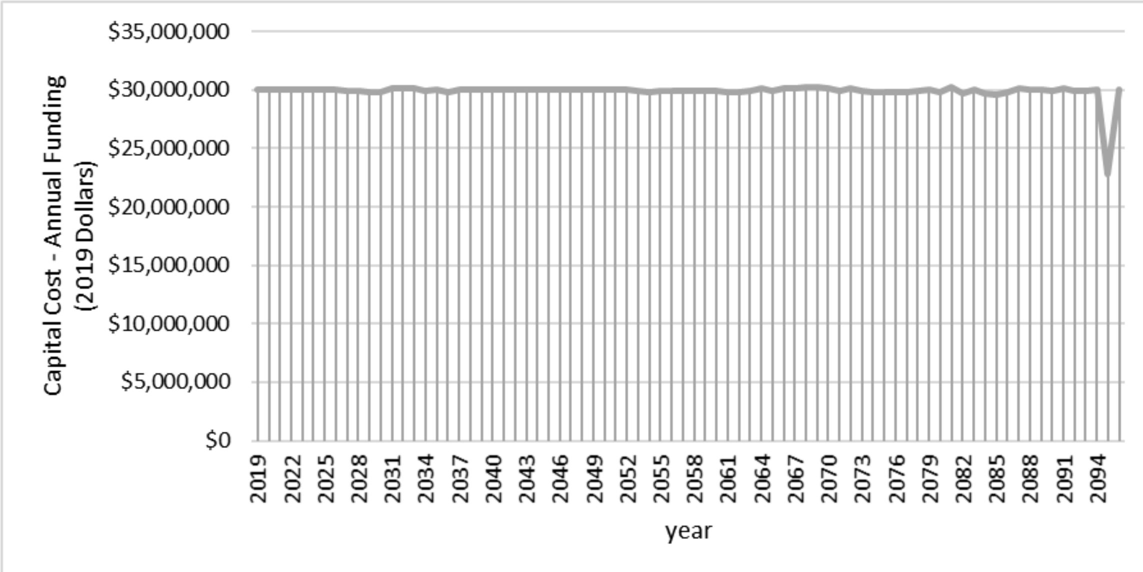

Figure 4-14. Scenario 3 Annual Capital Budget (2019-dollar value)

Figure 4-14 shows the annual budget varying slightly from year to year which is a result of discrete project costs that cannot readily be smoothed out to accommodate uniform budgeting. The overall budget is approximately $30 million in 2019 dollars. The implementation costs are not allowed to exceed the budget for each year of the program.

The annual capital budget values inflated at 3 percent per year are shown in Figure 4-15. The inflated values show the increase to the annual budget over the implementation time period. The annual capital budget in 2094 is $275,800,000.

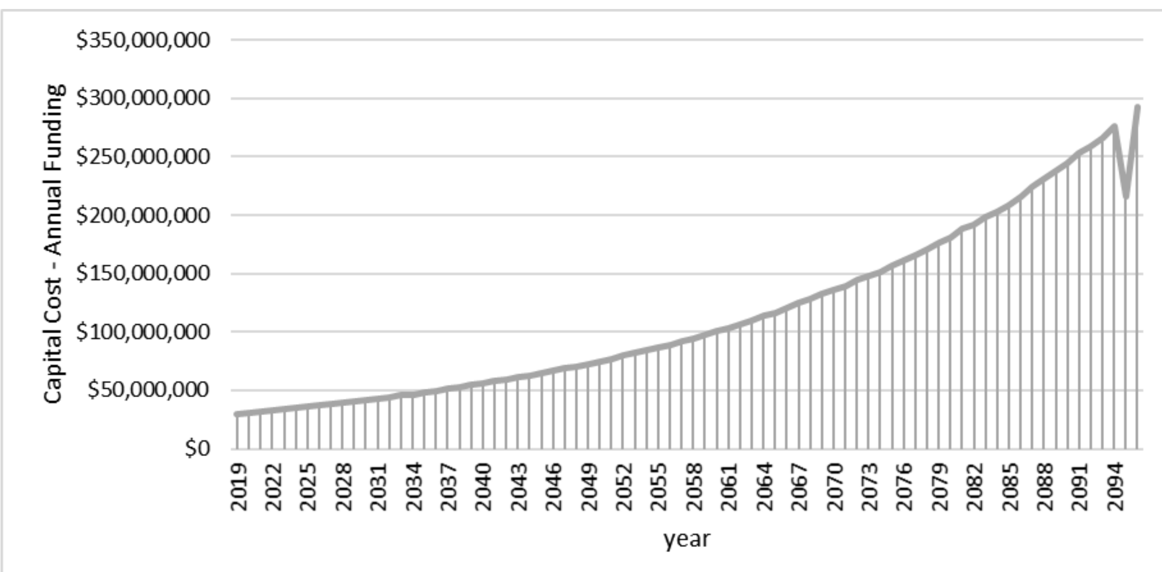

Figure 4-15. Scenario 3 Capital Budget Inflated at Three Percent Annually

The Scenario 3 budget in 2019-dollar values plotted on a cumulative basis is shown in Figure 4-16. The projects are sequenced by year in the budget schedule, per the project sequence determined during the program development, and they show the budget value for the year of construction. Based on an escalation of three percent per year, the total for the future budget amounts is $8,285,000,000.

The NPV for Scenario 3 is $936,000,000 based on a six percent discount rate.

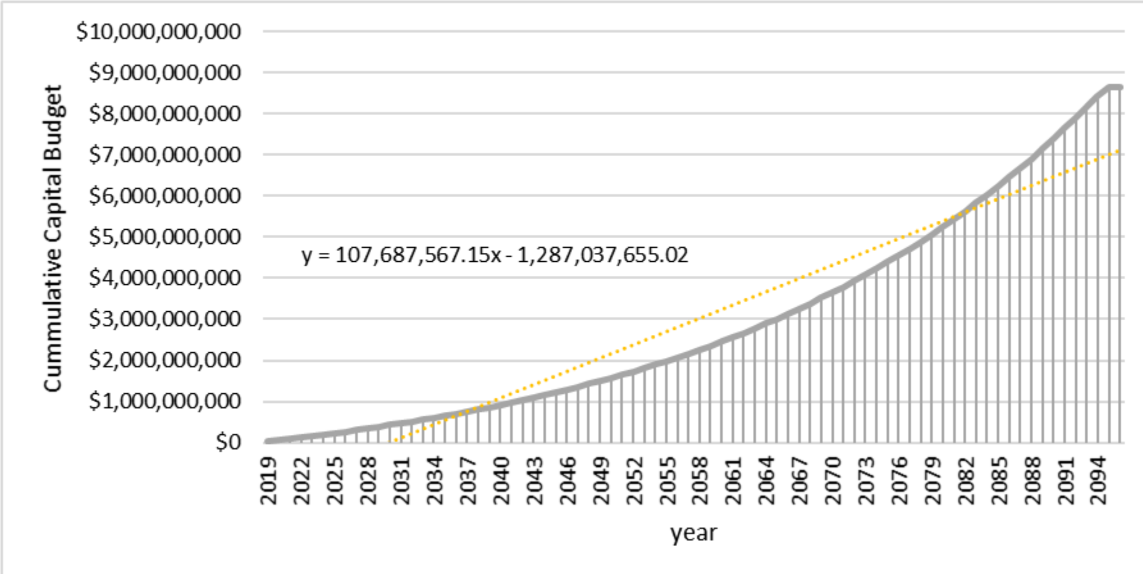

Figure 4-16. Scenario 3 Cumulative Capital Budget with Three Percent Inflation

Figure 4-14 shows that the implementation of Scenario 3 can be completed within 73 years with an annual budget of approximately $30,000,000. The City of Winnipeg funding remains at $30,000,000 per year with no cost sharing.

4.4.4.2 Scenario 3 Operations and Maintenance Budget

The operating and maintenance costs are considered separate from the capital cost budget. There is no target budget value for O&M similar to the $30 million capital budget, as operation and maintenance costs are a function of the control technologies selected. The annual budgets in terms of 2019 dollar values are shown in Figure 4-17.

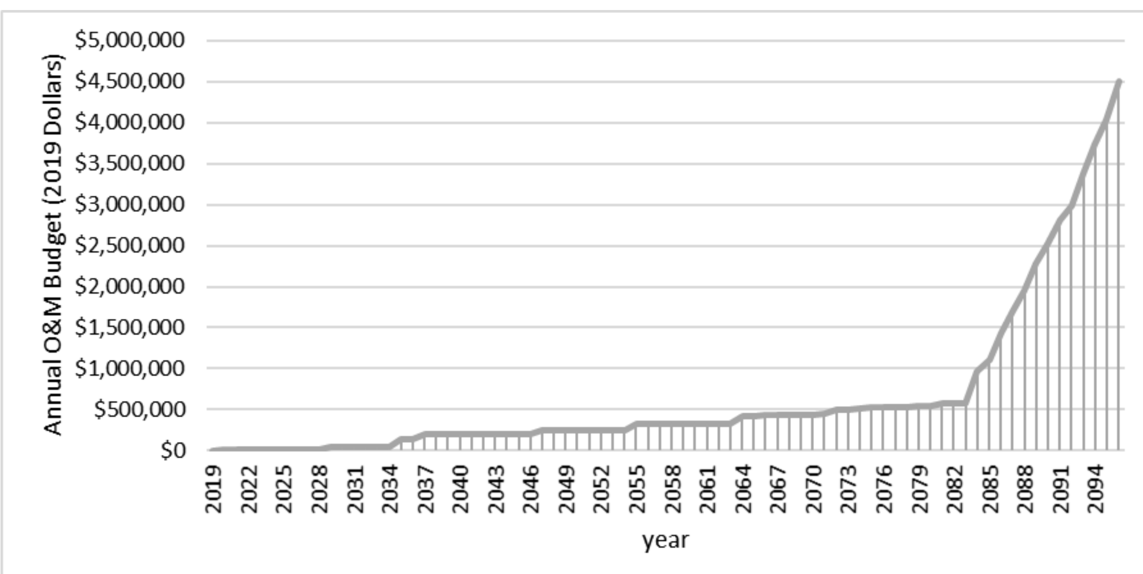

Figure 4-17. Scenario 3 Annual O&M Budget (2019-dollar value)

Projects with higher O&M requirements have been scheduled to take place later in the program, which is reflected in the figure. The steep rise in the operating budget results from the cumulative effect of having to operate and maintain new infrastructure with the more O&M intensive projects scheduled later in the program. The completion of the program will result in an additional annual O&M cost of $4,500,000 per year in 2019 dollars by the year 2096 in which all projects are complete and operational.

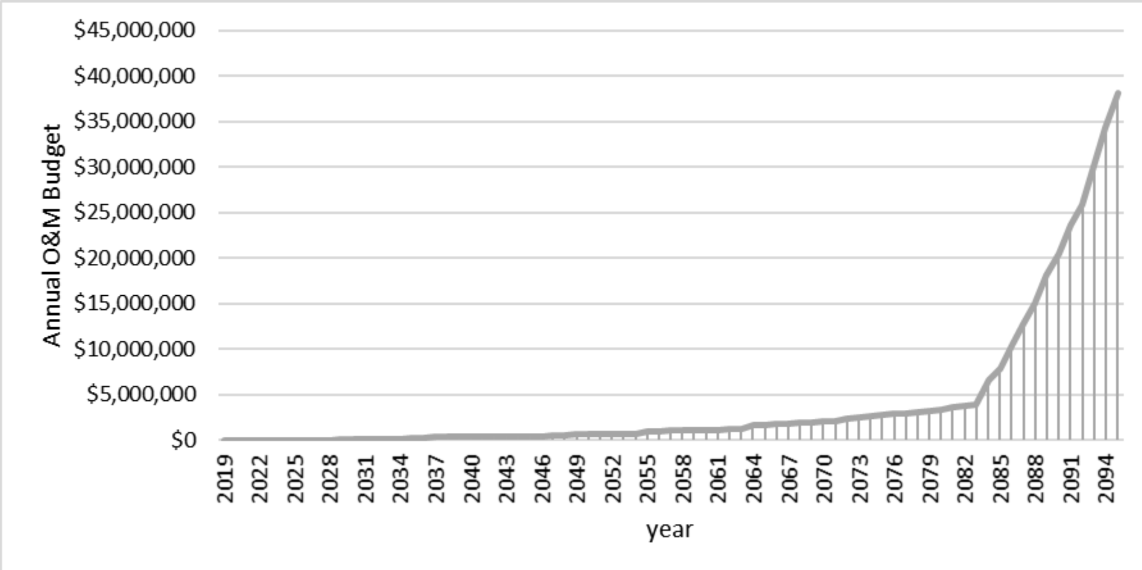

Figure 4-18. Scenario 3 O&M Budget Inflated at Three Percent Annually

The estimated O&M costs shown in Figure 4-18 have been inflated to the year of expenditure at three percent annual escalation. The inflated annual cost of O&M, at the end of the implementation period, with all the works in place and operational is estimated to be approximately $43,700,000 per year in 2096 dollar values.

4.4.4.3 Scenario 3 Performance

The reduction in CSO is relatable to the implementation period for Scenario 3 and the reductions assumed to occur as the projects are completed. This reduction in the annual CSO volume is shown in Figure 4-19. This shows that the 85 percent capture target will be met in the year 2095.

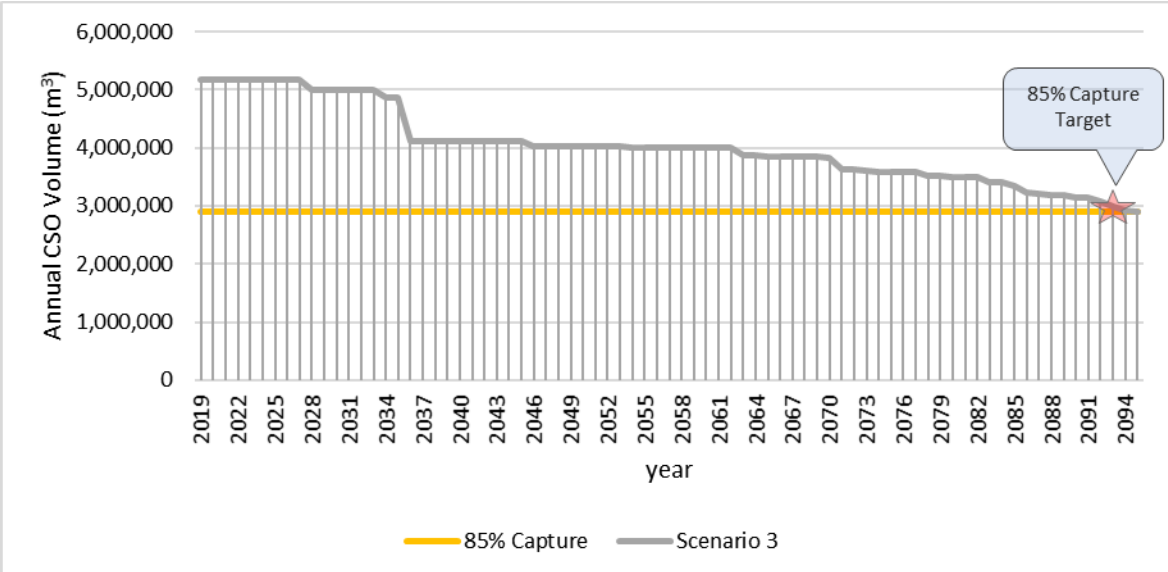

Figure 4-19. Scenario 3 Annual CSO Discharges

4.5 Program Management

Once the CSO Master Plan is initiated, the City will take on responsibility for the implementation of a large-scale, long-term program. Programs of this size and complexity typically require dedicated resources, either with internal staff or by engaging external program management support.

Since program management is a required component of implementation it should be accounted for in the CSO Master Plan. This has been done by allocating a two percent allowance of the estimated construction costs within the capital projects estimates. The City will be responsible for defining the scope and assigning responsibilities prior to the services being required.

A general review of the program management tasks and responsibilities is provided below to support this future activity, with many of these tasks being dependent on future decisions:

- **Administration:** The CSO program will require a high level of administration for budgeting, accounting and reporting of routine activities.
- **Engineering Investigations:** The CSO Master Plan project implementation schedule includes assumptions that the review and acceptance of new technologies associated with some of the control solutions be completed within the implementation phase prior to some projects commencing. These include review of control gates, flap gate control, screens, floatables management approach, RTC and GI. Each of these will be smaller side-stream projects within the program and may require pilot testing or demonstration projects for each new technology.
- **Planning:** A continual process will be required to identify and account for changes to service areas, technologies, standards and expectations, and prepare for project implementation. Land acquisition and preliminary studies may need to take place several years before actual construction can begin. Additionally, public information has to be rolled out to ensure all stakeholders involved are properly informed. The planning projections used as part of this study will need to be continually re-evaluated to ensure they are consistent with actual growth.
- **Coordination:** The CSO Master Plan program will impact and be impacted by other programs and services ongoing within the City of Winnipeg Water and Waste Department. By integration of the projects within the CSO and BFR program, the parameters for project prioritization and selection are affected. Additionally, large scale developments can impact option selection and implementation scheduling. Coordination of the CSO Master Plan works must also occur with the upgrades to the STPs to confirm that customer billing rates are consistent and remain affordable. Projects related to the CSO

Master Plan should be coordinated with street works to realize synergies and cost savings where possible.

- **Project Delivery:** Alternative methods of project delivery may need to be considered for the large capital project investments projected in this CSO Master Plan program. This includes how supplemental studies related to specific projects in this CSO Master Plan are carried out and by whom. The DEPs, as part of this CSO Master Plan, will be heavily relied upon to educate Consultants and Contractors of the overall vision for CSO mitigation in a particular district. These plans will be further updated as conceptual and preliminary design of these solutions is pursued.
- **Risk Management:** As with any large program there are multiple risks and opportunities to be considered and dealt with. These will require careful management of risk responses and contingency budgets.
- **Regulatory Liaison:** The City has a responsibility for reporting and responding to MSD on all matters related to EA No. 3042. Documentation of the benefits each project contributes in terms of percent capture will be essential to keep MSD informed on progress over time.
- **Public Engagement:** It will be important to provide public notifications for large scale construction works related to the CSO Master Plan projects, which affect infrastructure the public readily uses, such as major transportation routes.
- **Master Plan Maintenance:** The CSO Master Plan is intended to be a living document. Information will be updated as projects are completed, and new developments or redevelopments within districts occur. Periodic reprioritization of projects may be necessary to address new developments or redevelopments.
- **Master Plan Update:** A formal update of the CSO Master Plan to demonstrate the process to migrate to Control Option No. 2 is required under EA No. 3042 by April 30, 2030. The scope and level of effort has yet to be established and will be a future phase of the CSO Master Plan.

4.6 Control Option No. 2 Migration

MSD completed its review of the City's CSO Master Plan Preliminary Proposal submitted in December 2015, with a letter response dated November 24, 2017. The response indicated that the document and additional information prepared subsequent to its submission met the intent of Clause 11 of EA No. 3042. The letter provided the Director's approval for the Preliminary Proposal recommendations, with the condition that "Control Option No. 1 be implemented in such a way so that Control Option No. 2 may be eventually phase in." The letter required that the final CSO Master Plan for Control Option No.1 - 85 Percent Capture In A Representative Year be submitted by August 31, 2019, and by April 30, 2030 for Control Option No. 2: Four Overflows In A Representative Year.

- **Control Option No. 1 – 85 Percent Capture in a Representative Year:** This system-wide performance measure aligns with the City's current plans to continue with sewer separation in CS districts. It also accommodates selection of the most cost-effective projects in other districts. The plan proposes that every one of the 41 combined sewer districts will have at least some level of CSO control, but it will result in a wide range of performance. If it were most cost effective to have all CSO control within only a portion of the districts, this would be allowed with the percent capture performance measure.
- **Control Option No. 2 – Four Overflows in a Representative Year:** This option requires a maximum of four overflows in a representative year for each district. Projects completed in districts to achieve the Control Option No. 1 performance may have to be further upgraded to meet the increased performance target. Projects in districts that are shown to have a low cost benefit may have to be completed.

Migration from Control Option No. 1 to Control Option No. 2 is now a requirement of the CSO Master Plan program. The City has reviewed this additional requirement and has discussed and documented the potential impacts with MSD. The CSO program will have to adapt to meet the additional requirements associated with the water quality performance of this option as identified in the Preliminary Proposal.

The City raised concerns that the migration approach is not cost-effective, and not in keeping with the aspiration goal of eliminating all CSOs in the long term. Potential impacts associated with upgrading to Control Option No. 2 are as follows:

- The performance metric changes from a system-wide to a district-based limit, meaning that each district would be required to meet a four overflow limit for the representative year. To achieve this, the configuration of projects changes for Control Option No. 2. This reconfiguration to meet the Control Option No. 2 performance target is not directly aligned with the project configuration for Control Option No. 1 and projects completed as part of meeting 85 percent capture would not necessarily be useful in meeting the long term water quality objective.
- It would require a higher level of control, increasing to an equivalent level of capture of approximately 98 percent as compared to 85 percent for Control Option No. 1. The exact percentage needs to be confirmed and agreed with MSD prior to the 2030 submission and needs to meet the equivalent water quality bacterial performance reduction as Control Option No. 2 presented in the Preliminary Proposal

A compromise approach of migrating to a 98 percent capture value, and maintaining a percent capture target approach was proposed. This has been reviewed based on the data available from the Preliminary Proposal and is expected to provide similar overall CSO performance to Control Option No. 2. This would then avoid throw-away costs by allowing for contiguous projects following the same performance metric and establish a path for complete separation.

MSD requires equivalent river water quality performance with regards to bacteria for any control alternative in order to demonstrate compliance. It is possible that a percent capture target above 98 percent capture could be required for compliance. The City understands that the future expandability of the program is important to meet future regulatory requirements; therefore, the City has chosen to move ahead with a plan that will maintain percent capture as the performance measure.

4.6.1 Master Plan Approach to Migration

Changing to a higher level of control during the implementation of the CSO Master Plan creates additional risk for the master planning process. Risks are mainly associated with the types of control option projects completed and the ability of those projects to adapt and continue to contribute effectively to the overall percent capture targets. The approach taken in the CSO Master Plan is to maintain an expandable percent capture program. In order to most effectively apply this approach, the initial projects identified for completion during the CSO Master Plan implementation are sewer separation which is considered lower risk when considering an increasing percent capture target. The contributing benefit from sewer separation does not change if the level of control increases. Sewer separation projects are aligned with the City’s percent capture approach to achieving the higher control limit required for Control Option No. 2 – Four Overflows in a Representative Year.

In order to maintain an expandable percent capture program, the City of Winnipeg is required to demonstrate compliance with the increased water quality performance of Control Option No. 2. This process will align with the 2030 Master Plan Update.

Specific details of the next steps to address migration to a future performance target are summarized as follows:

1) Submit the CSO Master Plan by August 31, 2019, in accordance with EA No. 3042 with the performance target based on Control Option No. 1 – 85 Percent Capture in a Representative Year.
2) Complete the sewer separation projects identified in the CSO Master Plan through the initial period of implementation while the water quality performance evaluations and pilot studies are being completed. Determine the percent capture required to meet the water quality performance identified for Control Option No. 2 in the Preliminary Proposal.
3) Collaborate with MSD regarding any changes necessary to the CSO Master Plan or EA No. 3042 in order to meet the required performance.

4) Submit the updated CSO Master Plan before April 30, 2030, in accordance with EA No. 3042. The update will incorporate any agreed changes required to achieve Control Option No. 2 water quality performance equivalence.
5) Continued implementation of the updated CSO Master Plan following acceptance by MSD.

4.7 Monitoring and Reporting

Monitoring and reporting on a regular basis is a requirement of Clause 13 of EA No. 3042 and is required during the implementation of the CSO Master Plan. Section 2.2.6 identifies the specific requirements of this clause. As part of the reporting process, progress will also be communicated to the public at large, as explained in the Public Education Plan previously submitted to MSD.

This section provides an indication of the existing and planned approach to meet these requirements.

4.7.1 Public Notification System

The City initiated a public notification system in 2004, which identifies the likelihood that an overflow is occurring based on levels recorded by instruments in the CS System. This notification is manually updated and provided on the City's website.

The City is updating this system and developing a tool which will link in with the hydraulic model for the City of Winnipeg CS system, and the permanent instrumentation at each of the 39 primary outfalls, to provide a real-time indication of an overflow occurring and forecasted overflows. This notification system will indicate to the public that based on the hydraulic model and permanent instruction conditions at that time, a CSO is occurring or is predicted to occur.

4.7.2 Interim Monitoring

The City has continued water quality sampling and testing through their bi-weekly water quality program as described in Section 2.5.4. This water quality sampling will continue during the implementation of the CSO Master Plan.

The City plans to undertake further water quality analysis and review the prioritization of districts to include the consideration of reducing the number of river water quality failings as a result of bacteria exceedances.

4.7.3 Current CSO Reporting

The City currently completes quarterly and annual CSO reporting to track variations and trends in system performance. This reporting is based on actual rainfall received as measured by permanent rain gauges installed across the city and includes recorded and calculated CSOs and volume capture. Outfall monitoring instrumentation in combination with the hydraulic model is used to calculate the volume and frequency of CSOs at each primary and secondary outfall within the city.

Reports of these CSO volume and frequency trends are submitted to MSD for compliance and are provided to the Federal Government as required by the Wastewater System Effluent Regulation (WSER) with the total pollutant loading required to comply with the National Pollutant Release Inventory (NPRI) requirements. The City also reports to MSD upon the occurrence of significant events. A significant event is defined by the occurrence of a 10 year rainfall event within the City limits.

4.7.4 CSO Master Plan Implementation Reporting

Progress reporting for implementation of Control Option No. 1 will be based on project completion in comparison to the CSO Master Plan. Annual reporting will identify construction progress in comparison to the current version of the CSO Master Plan and the work plan for the subsequent year.

The reporting approach is dictated by selection of the percent capture performance metric. Each project of the Master Plan will contribute to the percent capture which is directly related to its implementation with no improvement shown until a project is complete. Each project's performance in terms of improvement in percent capture will be recorded and tracked as part of a benefits register. This will be included as part of the annual progress reports. The City will also conduct flow monitoring within CS districts where projects have been completed to verify the benefits provided.

5. Risks and Opportunities

The program planning process identified a number of potential risks with significant consequences. Consideration of risks and opportunities was part of the CSO Master Plan development. Individual risk responses and contingency allowances were not directly identified, but recognition and general allowance for risk is included in the upper end of the range of cost estimates (i.e. +100 percent AACE estimating contingency).

The following risks and opportunities are being highlighted as having potential impacts on the CSO program.

5.1 Risks

The CSO Master Plan assignment included a broad risk management approach to address project delivery and program risks, with a risk workshop conducted with key stakeholders within the City Of Winnipeg and Jacobs Engineering, focused primarily on program risks. The project delivery risks have been dealt and closed on an ongoing basis, while the program risks are to be transferred to the program implementation phase. Risk management will continue through the implementation of the Master Plan and is a component of every project.

Risks to the successful completion of the CSO Master Plan were identified throughout the planning process. Where possible, mitigation measures have been identified and are described in the following subsections.

5.1.1 Program Feasibility and Sustainability

Aside from the funding requirements and affordability risks, there is a number of other factors to be considered regarding the feasibility of completing this work in the implementation period of 27 years. The 27 year implementation period is the minimum timeframe necessary to meet the deadline as set out in Environment Act Licence No. 3042. These considerations are described as follows:

- Proof of Concept: A period of time for technology evaluations and pilot studies, intended to validate and gain comfort in the control option selections. This implies that there is a possibility of rejection, which may lead to the need for more costly substitutes.
- Project Overlap: There are multiple competing infrastructure needs within the City to consider (e.g. STP upgrades) as well as the possibility of additional requirements in the future that cannot be forecast.
- Construction Capacity: The local construction industry is committed to assisting the City with its objectives. While it is assumed that the industry will add resources to meet the City's needs, it is expected that there would be a delay in the ability of the industry to adjust to the additional number and types of projects.
- City Capacity: To meet the 2047 implementation timeline the City would have to triple the size of its current capital delivery program from $30 million to $90 million with increased work associated with implementing key aspects of the CSO Master Plan. To achieve this would require additional resources and time to expand.
- Operations and Maintenance: New infrastructure will be added that will require additional O&M staff and resources. Some of this infrastructure will be new to the City and will require additional training and supplier support.
- Public Impact: Sewer separation projects are planned throughout the combined sewer system and will encompass large sections of the sewer districts. Each of these will include large programs that will each take several years to complete, resulting in extended periods of impact on residents and businesses.

- City Impact: Coordination with other City services will be needed to minimize impacts and identify planning overlap. Services that will be impacted include Transit, Public Works, Fire Paramedic and Police Services. Aligning with street renewals will be difficult but necessary, new streets have an expected lifespan that may be reduced if sewer work is required in the same right of way.
- Affordability: The City's Water and Waste Department finances its capital and operating budgets for the sewer utility on a user-pay basis through sewer rates. The City takes a longer-term view of rates to provide stability for its rate payers. The rates have steadily been rising for several years and are expected to continue to rise because of wastewater treatment plant upgrade works and replacement and refurbishment of aging infrastructure. However, continuous rate increases are not sustainable.

5.1.2 Program Implementation

A number of significant factors associated with funding and scheduling during implementation must be considered as follows:

- Funding Risks: The expectation is that funding assistance will be provided by senior levels of government. There is a risk that the shared funding will not be available over the life of the program. To mitigate this risk, the City will continue to request funding from both the Federal and Provincial Governments, with the fallback position of extending the program completion date in accordance with the actual sustainable funding levels.

- Cost Risks: There are many sources of cost risks. For example, many of the technologies are new, with little local market information on which to base cost estimates, and vulnerability to cost increases because of the increased work load. To mitigate this risk, the City will take advantage of experience and resources from other locations. This could include reaching out to the design and construction industries beyond the local markets to inform them of the opportunities planned for Winnipeg. By notifying those with experience in design or construction in the proposed technologies, more realistic costs of the work involved can potentially be received. Unavoidable changes in costs may have to be accepted and managed through a risk contingency allowance.

- Schedule Risks: There are many sources of schedule risks. Major delays may result from funding shortages or high bid costs. Shortages of engineering and construction capacity or project approvals may cause delays to implementation plans. Risk mitigation includes providing early notice to the design and construction industry for the work to be implemented as part of the CSO Master Plan, and stream-lining bidding techniques.

5.1.3 Migration to Control Option No. 2

The regulatory requirement to migrate from Control Option No. 1 to Control Option No. 2 represents a significant change to the program. Section 4.6 addresses this topic in detail. In general, this risk can be reduced though further technical analysis and continued liaison with MSD.

Changing to a higher level of control during the implementation of the CSO Master Plan creates additional risks for the master planning process. Risks are mainly associated with the types of control option projects completed and the ability of those projects to adapt and continue to contribute effectively to the overall percent capture. The approach taken in the CSO Master Plan is to maintain an expandable percent capture program. In order to most effectively apply this approach, the initial projects identified for completion during the CSO Master Plan implementation are sewer separation which is considered lower risk when considering future performance targets. The contributing benefit from sewer separation does not change if the level of control increases.

5.1.4 Climate Change

Precipitation trends across the globe are expected to change over time because of the effects of greenhouse gases on our climate. Climate change is linked to less frequent, but larger rainfall events which could have a negative effect on the CSO program. Larger rainfall events will increase the rate and volume of runoff that must be managed by the CSO controls. This increase in extreme weather events is a potential risk to the performance of the CSO program. The program is based on a 1992 Representative Year, which would become less representative of the City of Winnipeg precipitation trends, if the average rainfall event intensities increase over time. Increased rainfall totals would not change the 1992 performance estimates, but the frequency of actual overflows could gradually increase and not meet desired outcomes.

The historic climate information for the City of Winnipeg gathered and reported in the Preliminary Proposal showed an increase in the frequency of small rainfalls, but a consistent trend for the larger ones. Because the CSO control system will capture the smaller events, this trend would not be detrimental to the program performance. However, there is a high degree of uncertainty in the long-term trends, and the opposite effect would occur if the frequency of large events increases over time.

The long-term precipitation records were reviewed to identify any climate change trends that may already be in progress. The rainfall categories used for the recreational season (May to September) assessment are useful for this evaluation since it compares not only the total annual and event rainfalls, but the number of rainfalls of varying sizes.

The review for long-term trends indicated the following:

- There was no increasing trend observed for annual rainfall accumulations.
- There was no increasing trend observed for any of the larger increments of rainfall.
- The 0 to 5 mm increments of rainfall showed an increased frequency in the more recent years, but this would not be significant in terms of the CSO program.

Examples of the long-term historical trends for the number of events for the 0 to 5 mm, 10 to 15 mm, 15 to 20 mm, and greater than 25 mm incremental ranges are shown on Figure 5-1.

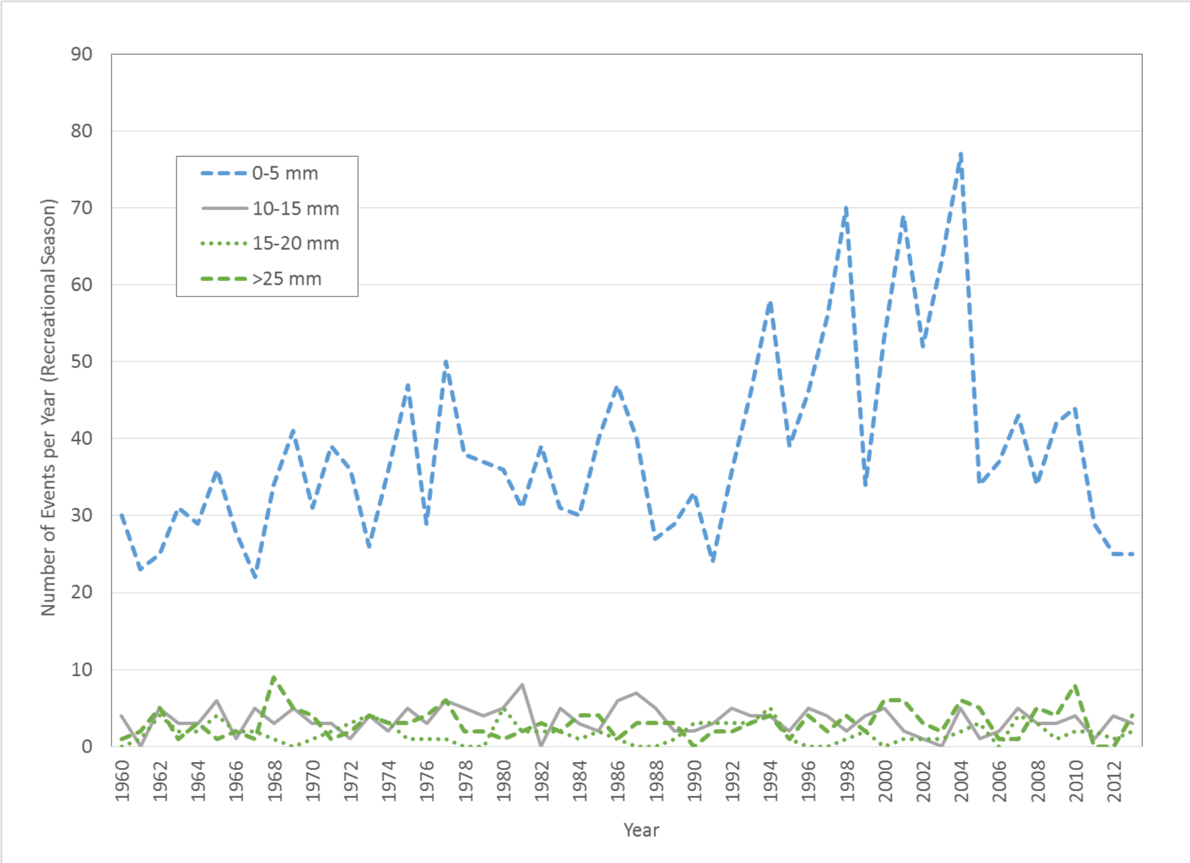

Figure 5-1. Long-term rainfall trends for select accumulated rainfall increments

The impact and rate of change associated with climate change means future trends are uncertain, and consideration should be made for how to respond if conditions worsen. For the CSO program, GI and RTC have been identified as opportunities improving the performance levels achievable through the CSO program. The implementation strategy also prioritizes sewer separation work upfront which makes the program more resilient to climate change as any additional runoff generated from climate change impacts will primarily be directed to land drainage sewers. Additionally, the City will be monitoring and tracking weather patterns to assess any impact to the CSO Master Plan including the use of 1992 as the representative year.

5.2 Opportunities

Opportunities to improve or enhance the CSO Master Plan were identified during its development. These can be realized through a number of different ways and are described in the following subsections.

5.2.1 Green Infrastructure

GI is included in the program to reduce CSO volume by preventing or delaying runoff entry into the CS system. Additionally, GI has the potential to offset any impacts associated with climate change, and will provide climate change resiliency.

There is a number of specific local issues that are unlike those in other large jurisdictions that should be evaluated prior to adopting GI for the CSO Master Plan, such as:

- **Infiltration rates:** Some GI options rely on infiltration, and the clay soils found locally have very low rates that would affect the storage recovery time.

- **Year-round performance:** The effectiveness of GI would decline in the winter months, because of frozen soils and a slowdown in natural soil infiltration processes, limiting their performance for snowmelt.
- **Freeze-thaw conditions:** Roadway designs attempt to avoid water being captured below streets because of the damaging effects of freeze-thaw cycles, which may be at odds with use of permeable pavements.
- **Street maintenance:** The use of sand and salt on streets in the winter may have a detrimental effect on GI operation, maintenance and discharge water quality. Snow plowing may be damaging to the facilities.
- **Maintenance requirements:** The factors listed above which could impact GI use will be assessed in terms of additional maintenance required to maintain GI operation. The scale of increased operations and maintenance costs for implementation of GI is needed to be assessed.

The uncertainty with local conditions suggests that it is premature to make definitive recommendations on GI application or identify specific projects. Therefore, in response to Clause 8 of Environment Act Licence No. 3042, a GI approach must await further analysis to determine specific applications and make performance assessments. There are a number of tasks that may be initiated prior to the full-scale implementation of GI.

The following general principles are recommended for review to enable for GI integration into the CSO Master Plan:

- Identify existing GI assets and create a database.
- Prepare a screening procedure to identify suitable locations to apply GI and those locations that may act as pilot sites.
- Pilot studies should be undertaken to evaluate the unknowns and assess the use of GI technologies.
- Functional sizing should be based on proven and sustainable technologies and practices. GI is to initially be considered as a supplementary upgrade for CSO controls, until the GI technology has been tested and proven.
- GI technologies that can be applied opportunistically and economically should proceed. These include rain gardens and bioswales where land is readily available, surface grading is suitable, and costs are competitive.
- GI technologies should be encouraged or promoted for use on private properties, such as rain barrels and rain gardens.
- Policy and guidelines should be developed for GI implementation once the effectiveness and costs have been better established, recognizing that there is likely to be an investment premium for use of these technologies, even with the off-setting benefits of grey infrastructure implementation. This may include the creation and updating of Stormwater and GI design standards and guidelines.

Along with being a requirement under EA No. 3042, the GI program will provide a visible indication of environmentally consciousness and tangible actions by the City.

5.2.2 Real Time Control

The City is working towards system wide RTC optimization of the combined sewer network. This work has the potential to reduce CSO volumes by managing sewer flows with existing sewer system infrastructure. This in turn reduces the amount of sewer separation and other works required. As this work requires a high level of control of the sewer system in combination with permanent monitoring at key locations in the sewer system, it will take time to implement a fully functional RTC system. The City is planning to complete its RTC network in four consecutive phases as follows:

- **Phase 1 (2009-2019):** Flow monitoring, sewer modeling, ICMLive forecasting, Remote Terminal Unit (RTU) panel upgrading

- **Phase 2 (~7-9 years):** Desktop engineering, permanent instrumentation, complete RTU panel upgrades, data collection and validation
- **Phase 3 (~7-10 years):** Asset management replacement plan, static optimization, data collection and validation
- **Phase 4 (>15 years):** Mechanical optimization

5.2.2.1 RTC Implementation

The implemented CSO control options will capture and convey the combined sewage to treatment as described in the dewatering strategy in Section 3.2. This will require flow control and monitoring systems that include pumping, gates, valves, instrumentation, and an automation system to manage them. Refinement of the automation system and its level of sophistication is the premise behind RTC implementation and will depend on the types of control options selected and how the system is intended to be used. Initial planning of the automation system needs to at minimum incorporate the dewatering strategy for the orderly transfer of the additional captured combined sewage to treatment. The use of more sophisticated RTC systems will further manage, improve, and optimize the in-system operations and allow for additional combined sewage to be captured with little to no impact on interceptor or treatment capacity constraints.

The CSO Master Plan includes recommendations for gravity flow controllers for districts utilizing gravity flow collection to the interceptor system, and installation of flow monitors and pumping controls on all LSs. This will permit every sewer district's discharge rate to the interceptor to be monitored and altered dynamically during a WWF event. The dewatering strategy is intended to provide a constant rate of flow into the interceptor during the dewatering period, sized to the peak capacity of either WWF or the interceptor capacity, whichever is limiting. The SCADA system will be relied on for RTC implementation, to collect data and control pumping rates and gravity discharge rates. The RTC system will provide the logic function and automation in which these discharge rates are dynamically changed during WWF events.

The proposed control system will maximize operation of the existing system for uniform rainfalls. The main benefit provided by RTC program opportunity is by expanding to a global system that can respond to spatially distributed rainfalls, and potentially to rainfall prediction.

A well thought out strategy will be necessary for implementation of a successful RTC system. RTC is closely tied to the day to day collection system monitoring completed by SCADA operators at this time. Implementation must account for risks of failure on operation of the collection system, and allow for appropriate manual overrides. Not all collection systems will benefit from the most complex implementation, depending on requirements, organizational structure, and physical aspects of the collection system.

Advanced RTC may extend to global predictive controls with storm tracking or rainfall measurements used in real time data to calculate future storm flows to be generated in the collections system. The use of these highly complex RTC systems have not been considered at this stage of the CSO Master Plan, but have been prioritized to be studied in the future as an opportunity to the current CSO Master Plan approach.

5.2.3 Floatables Management

Combined sewage discharges are a known source of floatables. They contain street litter captured by storm inlets and sanitary matter disposed of with sanitary sewage, which can make its way to the rivers during CSOs.

The floatables issue was investigated in detail under the 2002 CSO Study. Floatables were captured successively for 20 rainfall events from the Alexander, Bannatyne, Mission, and Cockburn CS districts primary outfalls through use of a boom placed on the river. The investigation also included Lot 16 Drain, which is a separate stormwater discharge. The captured floatables were then quantified, classified, and categorized for the series of 20 rainfall events. The amounts of floatables captured are shown in Figure 5-2.

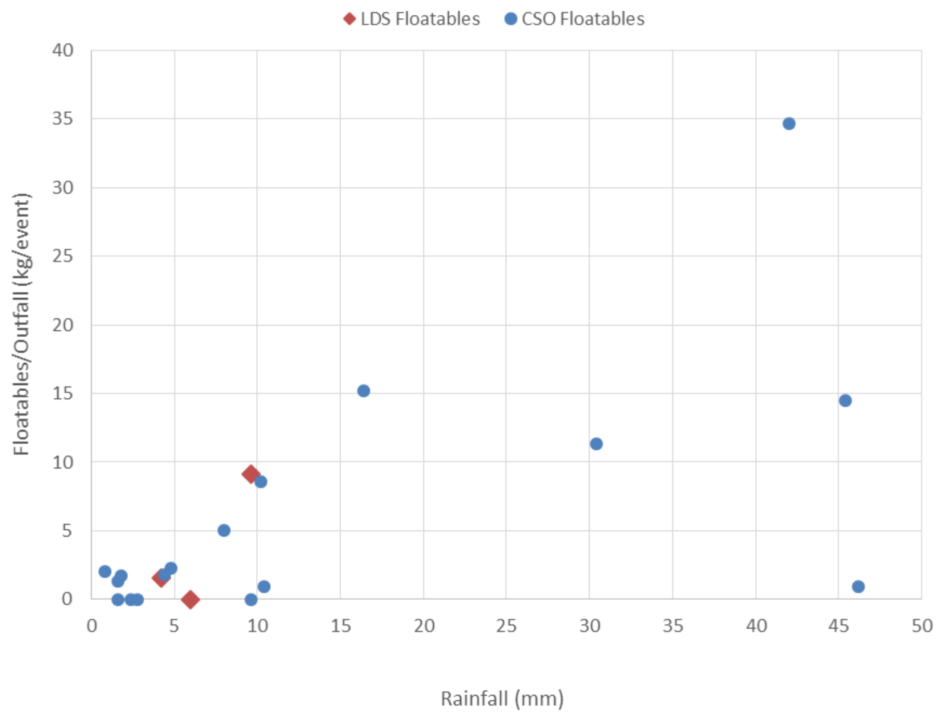

Figure 5-2. Floatables Collected from Primary Outfalls During 1996/1997 Rainfall Events

The highest loadings from each district is about 15 kg per event, with the exception of one event that had a total of 34.7 kg. The study did not report on the size of individual materials or provide a volume for the floatables captured. It did identify a spread flat area, being the area that the floatables covered when spread on the ground, which was about 6 m^2 for the 15 kg captures, and 19.5 m^2 for the 34.7 kg capture.

The study also found the following:

- The amount of floatables was highly variable for each district.
- The floatables loading rate averaged 0.13 kg per 1,000 m^3 for the five locations tested and was highest for the Alexander district at 0.4 kg per 1,000 m^3 of overflow.
- The major components were found to be natural debris (49 percent), followed by surface films (grease and scum), plastics (16 percent), paper products (8 percent), hygienic products (4 percent), and a small amount of other material.
- About 74 percent of the floatables were attributed to street litter and 26 percent from sanitary sewage.

The study only collected floatables from the primary outfalls, and not from the secondary or relief outfalls that may also be located in the districts.

Overall, the 2002 CSO Study concluded that floatable discharges were not a system-wide problem and improved floatable control could be achieved through selective targeting of CS outfalls. Another recommendation of the study was that source control should be the primary route of controlling floatables before more permanent end-of-pipe measures are implemented at the outfalls.

5.2.3.1 Master Plan Screening Approach

Control Option No. 1 includes off-line screening in each sewer district where it was determined to be operable and hydraulically feasible, and where sewer separation would not be implemented. In each applicable case, the primary outfall has a proposed off-line screen installed that would capture floatables from the first flush of an overflow. The off-line approach is necessary to avoid placing screens on the direct discharge line which may blind off and increase the risk of basement flooding. The technical approach is described in Section 3.3.3 and the type of screens and the screening installation arrangement is described in more detail in Part 3C.

There are many challenges associated with the use of screens. Common challenges are listed below:

- Limited space available at the outfall locations for screening infrastructure.
- Issues with land use for screens.
- Odour concerns where screens neighbor residential communities.
- Public acceptance and approvals.
- Relative short operating life of screens and require frequent replacement. Capital cost intensive over time.
- Difficulty in construction, and disruption to neighboring areas.
- O&M intensive; build up of screenings and screening removal systems mandatory.
- Health and Safety risks for O&M staff working in confined spaces within screening chambers.
- Implementation of screening at all outfalls will transport screenings within CS system and interceptor system to the headworks at STPs. Significant increase in screenings received at each plant would occur, likely requiring headworks upgrades at each STP.

5.2.3.2 Alternative Floatables Management Approach

The City has identified source control as a potential alternative to the off-line, end-of-pipe screening for floatables management. It is expected to achieve similar results while eliminating the end-of-pipe screening and avoid the high capital and long-term O&M costs and other risks associated with screening facilities. The City intends to carry out investigations and a demonstration project to evaluate its performance.

The approach will be similar to the ongoing approach being undertaken by the City of Ottawa. Source control techniques will include more frequent street cleaning, catch-basin cleaning to remove floatable material from surface runoff before it enters the sewer system, and public education to reduce the sanitary components from entering the plumbing systems.

The floatables management plan will include a trial period to evaluate the alternative within a 10 year testing timeframe, to better define the benefits and costs associated with source control floatables management as compared to screening floatables management:

- Site-specific testing would be carried out on trial districts to quantify the existing “as-is” conditions, with end-of-pipe floatables captured and quantified during storm events of various intensities, similar to the approach used in the 2002 CSO Study.
- Source control in terms of increased street and catch basin cleaning would be applied to the trial districts, with end-of-pipe floatables again being captured and quantified for comparison to the “as-is” situation.
- Observation would be made of the rivers and riverbanks to identify floatables from CSO sources and assess the river use impairment, and potential program benefits.

- The source control actions taken would be monitored and documented, to better understand the level of effort, costs, and efficacy of the various techniques.
- The level of improvement would be evaluated and compared to the expected performance of the first-flush end-of-pipe screening approach as currently recommended for the CSO Master Plan.
- An evaluation report would be prepared to document the performance, ease of implementation, sustainability, operation, level of effort, and costs.

This assessment will lead to a better understanding of system floatables and determine the best long-term approach to dealing with floatables as part of the CSO Master Plan. As discussed within Section 3.5, the districts of Jessie, Marion and Polson do not allow the installation of the typical screening facility due to hydraulic constraints. These districts will be ideal to allow pilot study demonstration projects to be implemented. An allowance has been included in the cost estimates for these districts, equivalent to the capital costs required for a similar level of in-line storage implementation. This allowance will be utilized to pilot this alternative floatables management approach.

5.2.4 Project Innovation

The CSO Master Plan was completed at a planning level for project optimization and cost-effectiveness evaluations. A stated objective of the assignment was to use tried and true technologies and approaches and avoid riskier options that may have potential cost savings. It is essential as part of finding opportunities for innovation and cost-effectiveness evaluations, that the program prioritization be revisited as new information becomes available during the implementation of the CSO Master Plan.

5.2.5 Engineering Refinements

Value engineering provides a structured method for reviewing the costs and benefits of conceptual plans, from the perspective of adding value. Value engineering exercises should be carried out early in the conceptual design stage to achieve best value for money in the projects.

The DEPs for each of the combined sewer districts has been developed to a conceptual level. As shown in Figure 5-3, the solutions recommended in the DEP for each district will be further developed through the value management and additional studies through design to construction.

Figure 5-3. Key Stages For Solutions In District Engineering Plans

5.2.6 Public Engagement

The CSO Master Plan will impact all residents directly through an increase in sewer rates, and from traffic disruptions related to the CSO mitigation construction work. Implementation of the Scenario 1 program will result in triple the annual sewer separation work currently undertaken by the City of Winnipeg. The public's opinion and buy-in is important to the actual and perceived success of the program and can best be managed through a structured communication program. Communicating what is going on in specific neighborhoods and why, and managing expectations is essential to the success of the CSO Master Plan.

5.2.7 Industry and Community Collaboration

A program of this scope will create opportunities for partnerships and collaboration with industry and community groups to create mutually positive benefits. Industry is intent in promoting green aspects of their organizations through environmentally positive initiatives and may be willing to invest in technologies that could benefit the CSO Master Plan through storm water reduction or other site specific means.

There are existing community groups such as Save Our Seine that are aware of the environmental benefits of such programs and are already promoting the ideas and benefits of green technology. The City will continue to work with these groups to promote and educate all stakeholders about the CSO Master Plan.

5.2.8 Aspirational Goal

The City's Preliminary Proposal recognized that future goals may be established to exceed the 85 percent capture limit and identified this as the aspiration goal. The City's intended approach for achieving increased volume capture was through progressively higher amounts of sewer separation. The relevant metric for this approach was identified in the document as percent capture. The methodology would be similar to that adopted by Ottawa, in which the ultimate goal could be to achieve 100 percent capture, in which case combined sewers would eventually be completely eliminated and replaced with a separated two-pipe system.

6. Next Steps and Future Considerations

The CSO Master Plan sets out a path forward to reduce the volume of combined sewer overflows by 2,300,000 m^3. Acceptance of the CSO Master Plan will require the City to adopt this large and costly long-term program impacting about one third of the serviced sewer area in the City.

Once complete, the CSO program will increase the estimated level of capture of combined sewage from 74 to 85 percent. The program will demonstrate environmental stewardship and achieve a level of control in compliance with EA No. 3042, and recognized by the U.S. Environmental Protection Agency for the protection of rivers and lakes.

While the program objective is to improve water quality, the program is defined by overflow volumes and is not based on water quality metrics. Reducing the volume of overflow has a corresponding reduction in water quality detriment caused by CSOs. The program will reduce the amount of diluted sanitary sewage discharged to the Red and Assiniboine Rivers, improving the rate of compliance with bacterial limits and providing a reduction of floatable material. There will also be a minimal reduction in nutrient loading to the rivers as CSOs are reduced.

6.1 Next Steps

Following the submission of this report the City will initiate the CSO program which includes the continuation of committed projects identified within the CSO and BFR program. The City will then begin annual reporting as required by EA No. 3042.

6.1.1 Implementation

The program implementation has assumed a startup period of four years following submission of this CSO Master Plan. During this startup period the City will continue with its ongoing committed projects and initiate pilot studies and water quality assessments to prepare for the 2030 update.

6.1.2 Secure Funding

The City has assessed the program costs and has determined that carrying out the CSO program concurrent with its other commitments is unaffordable to its utility rate payers. Assistance from the senior levels of government will be required to complete the program based on Control Option No. 1 in accordance with EA No. 3042. Funding and cost sharing arrangements should be reassessed following selection of the implementation period. Consideration of the CEC recommendation for one-third shared funding from each level of government will be required.

An increased future commitment for migration to Control Option No. 2 may require further affordability assessments, and increased commitments from the senior levels of government. This will be evaluated as part of the 2030 CSO Master Plan Update.

The Water and Waste Department will transition from the master planning phase to program management for the implementation phase following acceptance by MSD of the CSO Master Plan recommendations and confirmation of funding commitments. If the City is directed to proceed with the CSO Master Plan without any funding assistance or with reduced funding commitments from the senior levels of governments, the City will comply however the program completion timeline will be based on the City's current maximum affordability cap of $30 million per year.

6.1.3 Pilot Studies

Floatable materials control and GI pilot studies and evaluations will be completed to better understand their suitability and benefit to the CSO reduction objectives. These pilot studies will be initiated once the

CSO Master Plan is approved by MSD. Pilot projects will also be carried out for each control option technology that has not been installed in the City prior to full scale implementation.

6.1.4 Regulatory Liaison

Continued collaboration between the City and MSD will help to maintain direction towards the regulatory objectives while balancing the degree of change required by the City to meet its obligations. Updates regarding CSO reporting and improvements towards 85 percent capture target, pilot studies underway and their findings, and internal works to improve the CSO Master Plan implementation will be provided to MSD are part of regular update meetings.

6.1.5 2030 CSO Master Plan Update

The CSO Master Plan update, scheduled for 2030 may substantially increase the program requirements. Close collaboration with MSD on regulatory issues will be required throughout the evaluation period to arrive at a manageable and practicable solution. The update will report on the continued system analysis and the results of the program since the submission of the CSO Master Plan in 2019. This update is expected to include the following:

- Update on results to date: volume of CSO, number of events, money invested.
- Discussion on path forward to meet the Control Option No. 2 water quality target.
- Conceptual cost estimate to move an increased capture rate beyond 85 percent.
- New timeline and implementation schedule for this migration.
- Assessment of potential Climate Change impacts since 2019 Master Plan submission.
- Update on pilot studies, alternative floatables management, RTC and GI work.

6.1.6 Annual Progress Reporting

Clause 13 of EA No. 3042 triggers annual progress reporting to begin after the MSD has accepted the proposed CSO Master Plan. This includes a summary of planned and completed projects and an estimate of the system performance utilizing the 1992 Representative Year.

6.2 Future Considerations

A major benefit of the CSO Master Plan is a reduction in bacteria entering the rivers from the CS system. However, the contribution of the CS system in comparison to other sources is small. Other mutually beneficial initiatives will need to be reviewed and undertaken to maintain the balance between environmental benefit and affordability. There are a number of items that will need to be considered during the implementation of the program.

6.2.1 Watershed Approach

A holistic watershed approach for the reduction of nutrient and bacteria loadings, both to the City of Winnipeg and to the Lake Winnipeg Watershed, would provide additional benefits to the water quality objectives of EA No. 3042. Watershed based solutions could lead to additional reductions in a more cost effective way reducing the cost burden. Further steps toward building the watershed approach might logically involve expanding the stakeholder program beyond the City of Winnipeg, explicitly involving more stakeholders from the Lake Friendly Stewards Alliance, and Provincial/State authorities from the upper reaches of the watersheds.

6.2.2 Incentives

Incentives may be considered for homeowners and business owners that voluntarily disconnect or reduce their contribution to the CS system. This could be in the form of rebates or discounts for incorporating stormwater reduction technology on a property. The City of Winnipeg previously implemented a subsidy that encouraged the disconnection of foundation drains through the installation of a sump pump system. This may be implemented once more in an effort to further reduce the WWF entering the collection system.

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Appendix A
Environment Act Licence No. 3042

Appendix B
Licence Clarifications

Appendix C
Basis of Estimate Technical Memorandum

Appendix D
Scenario Workbook Description

Appendix E
Scenario Figures