Winnipeg

Water and Waste Department • Service des eaux et des déchets

December 18, 2015

Client File No: 3205.00
Our File Nos.: S-734
020-17-08-11-00
020-17-08-11-0N

Manitoba Conservation and Water Stewardship
Climate Change and Environmental Protection Division
Environmental Approvals Branch
Suite 160 – 123 Main Street (Box 80)
Winnipeg, MB R3C 1A5

Attention: Ms. Tracey Braun, M.Sc., Director

Dear Ms. Braun:

RE: ENVIRONMENT ACT LICENCE NO. 3042

This is in response to the requirements within Environment Act Licence 3042, submitted to the City of Winnipeg September 4, 2013.

Specifically, we are submitting for your review and approval, our CSO Master Plan Preliminary Proposal, as per Clause 11 of the Licence.

Should you have any questions on this report please contact Mr. Duane Griffin, P.Eng. at 204-986-4483 or by email at dgriffin@winnipeg.ca.

Yours truly,

Chris Carroll, P. Eng., MBA
Manager of Wastewater Services Division

Attachment

PC/je

c: D. Sacher, P.Eng., Water and Waste Department (email)
G. Patton, P.Eng., Water and Waste Department (email)
R. Grosselle, Water and Waste Department (email)
D. Griffin, P.Eng., Water and Waste Department (email)
S. Lambert, P.Eng., Water and Waste Department (email)

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December 17, 2015

City of Winnipeg
Water and Waste Department
110-1199 Pacific Ave.
Winnipeg, MB R3E 3S8

Subject: CSO Master Plan Preliminary Proposal

Dear Patrick Coote:

CH2M and the other members of our project team are pleased to submit the attached Preliminary Report and Decision Making Report for the CSO Master Plan project. This submission completes the first two phases of our services for the assignment made to us on February 8, 2013. We have provided assessments for a range of alternative CSO controls that allowed the City of Winnipeg, stakeholder advisory committee and the public to review and select the most appropriate CSO control alternative for management of CSOs in the City of Winnipeg.

The CSO Master Plan will set the long term direction for stewardship of the local rivers, and will require a significant financial commitment from the City of Winnipeg. Included in our submission is the Preliminary Report, which describes five alternative approaches to CSO control and the Decision Making Report which describes how the alternatives were then evaluated using a triple bottom line approach. An Executive Summary has also been included to provide an overview of both the technical study and decision making phases and describes the rationale behind the recommended CSO control alternative.

We appreciate the opportunity to provide these services, and look forward to continuing to work with the City of Winnipeg through the next phase of the CSO Master Plan.

Please do not hesitate to contact me at 204.488.2214 ext. 73058, if you have questions regarding our submission.

Sincerely,

CH2M HILL Canada Limited

Ed Sharp, P. Eng. — Project Manager

John Herbert — Vice-President

PROVINCE OF MANITOBA
E.J. SHARP
Dec 17, 2015
REGISTERED PROFESSIONAL ENGINEER

APEGM
Certificate of Authorization
CH2M HILL Canada Ltd.
No. 1441 Date: Dec 17, 2015

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Winnipeg

Water and Waste Department • Service des eaux et des déchets

CSO Master Plan Preliminary Proposal

Environment Act Licence No. 3042
Clause 11

XCG ch2m DILLON CONSULTING

Prepared for
Manitoba Conservation and Water Stewardship

December 2015

PRELIMINARY PROPOSAL

Water and Waste Department • Service des eaux et des déchets

CSO Master Plan Preliminary Proposal

Environment Act Licence No. 3042
Clause 11

Prepared for
Manitoba Conservation and Water Stewardship

December 2015

Contents

Acronyms and Abbreviations

CEC	Clean Environment Commission
City	City of Winnipeg
cfu	Colony-Forming Unit(s)
CSO	Combined Sewer Overflow
EA No. 3042	Environment Act Licence No. 3042
GI	Green Infrastructure
IAP2	International Association for Public Participation
MCWS	Manitoba Conservation and Water Stewardship
mg/L	Milligram(s) per Litre
mL	Millilitre(s)
MPN	Most Probable Number
N/A	Not Applicable
NEWPCC	North End Water Pollution Control Centre
Province	Province of Manitoba
SAC	Stakeholder Advisory Committee
STP	Sewage Treatment Plant
TN	Total Nitrogen
TP	Total Phosphorus

SECTION 1

Overview

The City of Winnipeg (City) recognizes that our local rivers and lakes are valuable natural amenities that contribute to the vibrancy of our city and need to be protected for the generations to come. As a result, the City is proceeding with the Combined Sewer Overflow (CSO) Master Plan as per Environment Act Licence No. 3042 (EA No. 3042). Clause 11 of EA No. 3042 requires a preliminary proposal be submitted to Manitoba Conservation and Water Stewardship (MCWS) by December 31, 2015.

The City has complied with this requirement by evaluating five viable alternatives. The evaluations were completed through a high-level comprehensive review of the combined sewer system operation, the impacts of combined sewer discharges, an evaluation of upgrading alternatives and an assessment of the alternative performance improvements. Each of the alternatives would require implementation of a major CSO program, with the difference between them being in their cost, complexity and extent of infrastructure development required.

During the evaluation process, the City worked with key stakeholders to get their input on how to make choices and decisions about CSOs. Stakeholders suggested that any decision on CSO Limits must meet licence requirements, and help us achieve the outcomes and future we want together.

The City recommends the implementation of a CSO control limit defined as 85% Capture in a Representative Year, (as explained in Section 3, *Alternative Levels of CSO Control*, of this submission). It balances environmental, economic and social values and will provide a responsible and realistic recommendation for moving forward with this challenging regulatory issue.

Implementing this program will mean a reduction to the amount of CSO discharged, and that floatables control will be installed in each of the existing 43 combined sewer districts. An overview of the treatment areas for each sewage treatment plant and the combined sewer districts is shown in Figure 1-1.

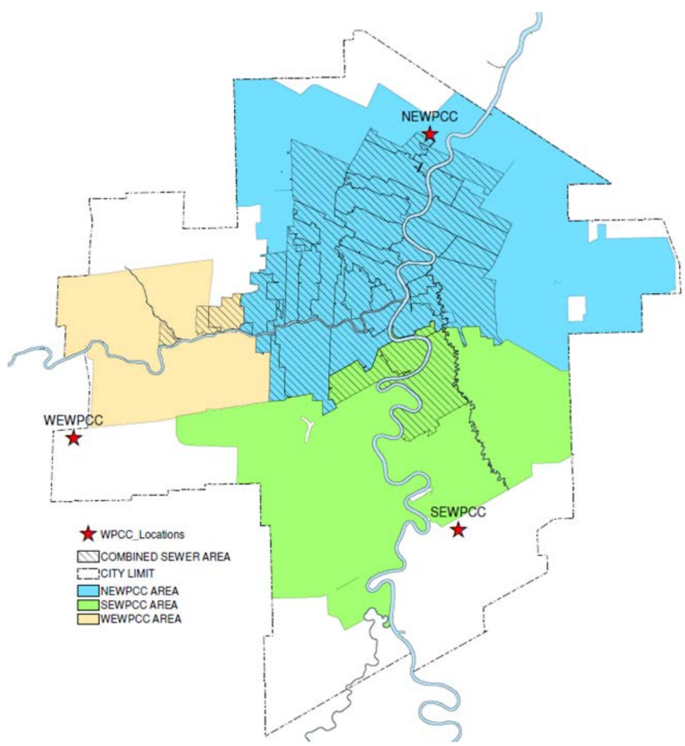


Figure 1-1. Sewer Areas of the City of Winnipeg

SECTION 2

Our Submission

Clause 11 of EA No. 3042 defines the requirements for two submissions, this Preliminary Proposal, which is to be submitted by December 31, 2015, and a final Master Plan to be submitted by December 31, 2017. The Preliminary Proposal provides the basis for selection of a control limit, and thereby defines the long term goal for CSO control. The Master Plan to be submitted in the second phase will identify location specific plans for each of the 43 combined sewer districts based on the decision made from the first submission.

This preliminary proposal provides an overview of the alternatives, technical evaluations, performance assessments and the rationale for the recommendation. More detailed information is included in the attached documents, which are organized as follows:

- Executive Summary – provides a more comprehensive summary of the technical content included in the Preliminary Report and Decision Report.
- Preliminary Report – contains the study detail, as well as descriptions for the monitoring program, public engagement and regulatory clarifications.
- Decision Making Report – describes the process used for the alternative evaluation, and the final results.

CSO Background

Combined sewer systems are a legacy from early city development. They were the standard design practice until the 1960s when it changed to a two-pipe separated system. The combined sewers provided an essential service by draining water from the streets and an effective way for disposing of sanitary sewage before sewage treatment plants were built. They played a major role in urbanization and protection of public health by removing contaminants from populated areas.

The City of Winnipeg, was one of the early adopters of sewage treatment, with the construction of the North End Sewage Treatment Plant (NEWPCC) in the mid-1930s. Most of the combined sewers were already in place by that time and they were modified to intercept and transport flows to the NEWPCC. Only the dry weather flow, along with a minimal amount of wet weather flow, was intercepted and treated. The higher flows from larger rainfalls and snowmelt overflowed directly to the rivers. The combined sewers still operate this way.

Winnipeg Sewage Treatment Program

South End Sewage Treatment Plant (SEWPCC)

The City of Winnipeg operates three sewage treatment plants (STP) under Environment Act Licences issued by Manitoba Conservation and Water Stewardship. The licence requirements have become more stringent and now require year-round disinfection and the removal of nitrogen and phosphorus.

The West End STP has already been upgraded, while the South End is under construction and the North End is in the early stages of being upgraded. The cost of the upgrading program will approach $1 billion.

The City has 8,320 hectares served by combined sewers, which is about one-third of the City's developed land. There are 43 combined sewer districts with 41 primary outfalls to the river (the two remaining combined districts flow into another an adjacent district). Relief sewers with outfalls and high-level overflows from the combined system have been added over the years to increase the combined sewer hydraulic capacity, and reduce basement flooding. As a result, most districts have more than one discharge point, resulting in a total of 79 discharge points for the entire combined sewer area. The combined sewer districts are located therefore not practical as the costs for piping and treatment would be astronomical.

in the older city neighborhoods, which are mostly in the NEWPCC service area.

Runoff from rainfall or snowmelt only occurs occasionally, but the flow rates in the combined sewers are much higher than for sanitary sewers, which makes controlling CSOs particularly difficult. There are about 40 rainfalls in a typical year, with about 22 of them large enough to cause CSOs. The rate of runoff from only one of the combined sewer districts can easily exceed the maximum capacity of the NEWPCC. The complete collection and transportation of all CSOs to treatment is

A number of other control options are available that could be used for the Winnipeg CSO program, which are discussed in the preliminary report.

Combined sewer areas are also susceptible to sewer backups. The problem results from the direct pathway from street inlets to buildings through the sewers to the sanitary service connections. High rates of runoff that cannot be handled by the combined sewers can flood basements. The City has made many upgrades to reduce basement flooding in recent decades. This includes the installation of relief sewers with extra capacity or through sewer separation where it is cost competitive. The combined sewer service area has been reduced by over 1,000 hectares through the basement flooding relief program.

CSOs have been an issue in Winnipeg for many years. After the enactment of the Manitoba Environment Act in 1988, the Province requested the Clean Environment Commission (CEC) to hold hearings on the rivers and make recommendations for dealing with CSOs. These hearings were completed in 1992 with the CEC concluding that there was insufficient site-specific information to reach conclusions, and recommended a CSO study be undertaken. The City then carried out its first major CSO study (2002 CSO Study), and reported back to the CEC at another set of hearings in 2003.

There has been an increasing awareness and concern over the health of Lake Winnipeg since that time, and the environmental focus has been placed on sewage treatment plant upgrading. With the treatment plant upgrading now in progress, combined sewer operations are now being reviewed. This has corresponded to the issuance of EA No. 3042 for combined sewers on September 4, 2013.

Aubrey Sewer District Outfall Pipe

Images from inside the trunk sewer near the outfall; left image shows the weir and flap gate with water trapped in between: right image shows the weir and off-take pipe that diverts dry weather flows to treatment, note the difference in sizes between the off-take and trunk sewer

Alternative Levels of CSO Control

Clause 11 of EA No. 3042 requires that a minimum of three control limits must be evaluated. This also permits the City to include additional control limits it considers viable.

Selection of a control limit is the most important decision for the CSO program. It will set the performance standard and provide the basis for a long term commitment to a major capital program. The approach taken by the Province of Manitoba (Province) for allowing the City to add alternative control limits provides the City with a unique opportunity to fully investigate a complete range of alternatives.

The final alternative control limits included in the evaluation are described in Table 4-1.

Table 4-1. Alternative Control Limits
City of Winnipeg CSO Master Plan Preliminary Proposal

EA No. 3042 Control Limits to be Evaluated	Alternative Control Limits	
	Representative Year	**Not to Exceed**
Additional control limits defined by City	1) 85% Capture in a representative year	N/A
A maximum of four overflow events per year	2) Four overflows in a representative year	4) No more than four overflows per year
A minimum of 85% capture and a maximum of four overflow events per year	Achieved with the four overflow alternative	Achieved with the no more than four overflows per year alternative
Zero combined sewer overflows	3) Zero overflows in a representative year	5) Complete sewer separation

N/A = not applicable

Representative years are commonly used for CSO alternative evaluations, setting of regulatory limits and have been included in the definition of alternative control limits listed in Table 3-1. It was important to include use of a representative year, since it was used in the 2002 CSO Study and reported on by the CEC, and also important to evaluate the not-to-exceed approach. Representative years are considered industry standard practice and have been used for similar CSO programs carried out in Edmonton, Ottawa and Omaha, as confirmed under the master plan peer review process.

The representative year is applied much like an average year or a design event, but uses actual precipitation and river flows from a specific year. It provides the advantage of defining specific conditions, and avoids the complications with interpretation and evaluation and use of extensive data records.

Use of a representative year was an early issue identified under the regulatory liaison process. This led to the decision to proceed with both approaches as shown in the table. The not-to-exceed basis sets a much more stringent limit than use of a representative year.

The technical evaluations also determined that the four overflow criteria would capture more than 85% of the combined sewer flows during wet weather events, and therefore the control limit requiring both four overflows and 85% minimum capture was already met. The City therefore identified a new control limit consisting of only the 85% capture in a representative year alternative.

The final list of alternative control limits for evaluation, in ascending order of expected performance, level of infrastructure requirements and costs was therefore defined as follows:

1. 85% Capture in a Representative Year
2. Four Overflows in a Representative Year
3. Zero Overflows in a Representative Year
4. No More than Four Overflows per Year
5. Complete Sewer Separation

The range of control limits meets the requirements of Clause 11, and includes the additions that the City believes to be important for the evaluations. EA No. 3042 also defined effluent quality limits in Clause 12. These limits are for prevention of floatables and treatment of the wastewater collected in the CSO system during wet weather. The licence does not allow for the City to add alternatives as is the case for overflows.

The City elected not to include a do-nothing alternative. These types of baseline evaluations are commonly included in engineering projects for justification of investments, but by not including it the City has demonstrated its commitment to “doing its part.” As a result selection of any one of the alternatives will require investment in a major CSO program, with the differences being in the cost and complexity of the alternatives and the incremental value between them.

Regulatory Engagement

The CSO Master Plan will be reviewed, decided upon and regulated by MCWS, and therefore a regulatory engagement program was setup and followed. Regulatory liaison meetings were held with senior managers to provide updates and review progress, and a regulatory working group was created to deal with technical issues.

The City met with the two groups on several occasions, and successfully reported on progress and discussed issues. A clarification document was prepared to document the issues and resolutions. Some of the key additional clarifications are as follows:

- The control limits must apply on a year-round basis
- Only the captured portion of combined sewage is to be treated, the overflows permitted in accordance with the control limit will remain to be discharged as CSOs.
- The effluent quality limits referred to under Clause 12 apply only to CSO treatment facilities located off-site from the currently licensed sewage treatment plants, as would be the case for end-of-pipe treatment or satellite treatment. Combined sewage that is collected and routed to existing sewage treatment plants is to be blended with sewage treatment plant (STP) effluent and meet the STP licence effluent limits.
- The Clause 12 requirement for never exceeding a limit of 1.0 milligrams per litre (mg/L) for total phosphorus is of concern, and the City has advised the regulatory working committee that a request to change this to an averaging approach would be required if end-of-pipe or satellite treatment is to be pursued.
- The requirement for prevention of floatable materials has been assumed to be required for a minimum of 85% of the combined sewage captured, to be consistent with the treatment volumes.

The peers, strongly recommended working collaboratively with the regulator.

Peer Reviewers

SECTION 6

Technical Evaluations

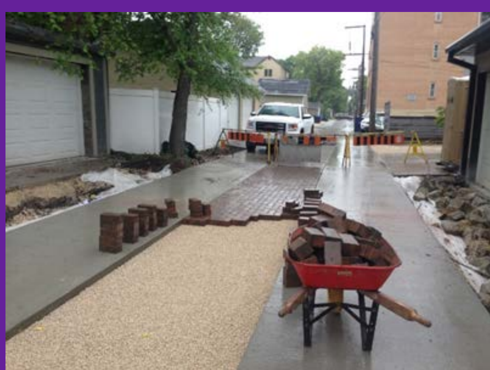
The study phase of the master plan included extensive work developing a city-wide hydraulic computer simulation model of the sewer systems. The model provided the capability to evaluate the current situation and develop potential plans for each alternative control limit.

To ensure that each alternative had an equal chance of being selected, the technical evaluations in the study phase were limited to objective evaluations, with the goal being to provide accurate comparative information for the subsequent visioning and decision-making process.

6.1 Potential Plans

The evaluation required that potential plans first be developed for each alternative control limit. The potential plans, as the name implies, were based on selection and sizing of control options that could be used to meet the alternative control limits, and provide a reasonable representation of the capital works for each.

The study identified a complete list of control options and reviewed their practicality for use in the Winnipeg program. The two general control option categories were grey infrastructure and green infrastructure (GI).



City of Winnipeg Green Back Lane Project Photo

Green Infrastructure (GI) uses natural systems, such as infiltration and evaporation, to reduce runoff and improve water quality. There are several GI technologies that could be implemented, such as porous or permeable pavements, bio-swales, rain gardens and green roofs. GI was not included in the master plan alternatives, since it was determined to be too early to make recommendations for its use. There are several issues still to be resolved relating to its design standards, performance under cold climates and cost effectiveness. GI will be considered in the next phase of the master plan and will incorporated into the future program as required under EA No. 3042.

Grey infrastructure includes the traditional heavy construction options used for building sewers and treatment facilities. The control options considered were in-line storage, off-line storage, tunnel storage, storage/transport tunnels, sewer separation and treatment facilities.

GI is a requirement for use in all new and upgraded storm and wastewater infrastructure under Clause 8 of EA No. 3042. The development of the potential plans recognized the need for use of GI, but did not define specific works at this stage. There are several issues to be investigated and decisions required before GI can be fully incorporated.

EA No. 3042 clause 12 also requires the prevention of floatable material. Floatables capture was therefore included with each of the alternatives except for complete sewer separation alternative which eliminates CSOs.

The floatables will be captured to a minimum of 85% along with the combined sewage, and partially screened for any additional CSO.

The potential plans provided a rational basis to compare the alternatives. Standard estimating methods were used to identify the costs for each alternative, which are shown on Figure 6-1.

The cost estimates are planning level and are considered Class 5 estimates, having an accuracy range from -50% to +100%. The estimates are for capital costs and are shown along with the accuracy ranges. The wide range in accuracy is a result of the alternatives only being developed to a planning study level of detail, to be used to compare alternatives, and not for budgeting. More detailed program costing will be developed for the master plan submission after final selection of the alternative control limit.

The figure also shows the costs increased by 50%. This increase would account for escalation over the program duration and provides an allowance for uncertainty that is common with these types of projects. The increased cost estimate was used for the storyboards and presentation material for the public engagement program (see Section 8, Public Engagement).

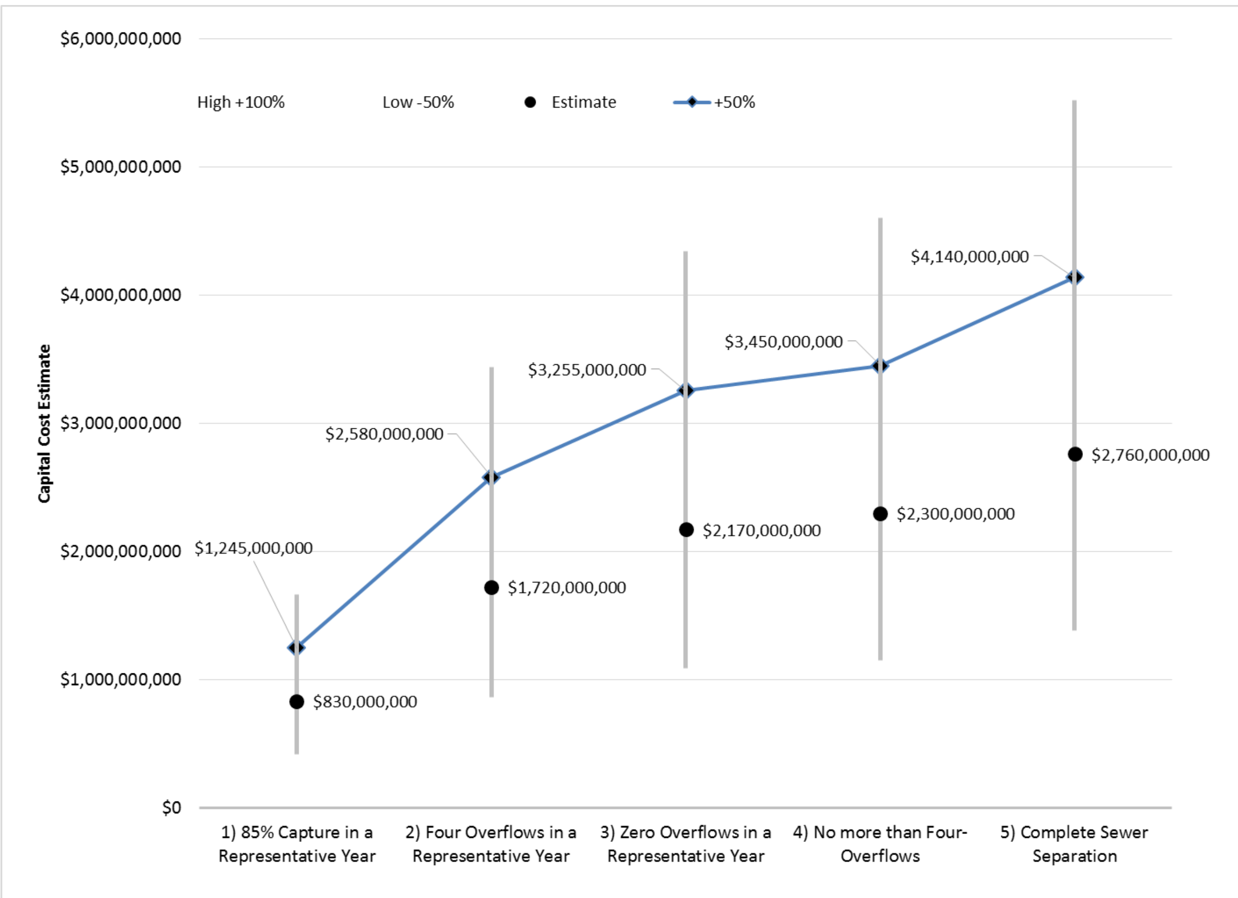


Figure 6-1. Alternative Control Limit Capital Costs

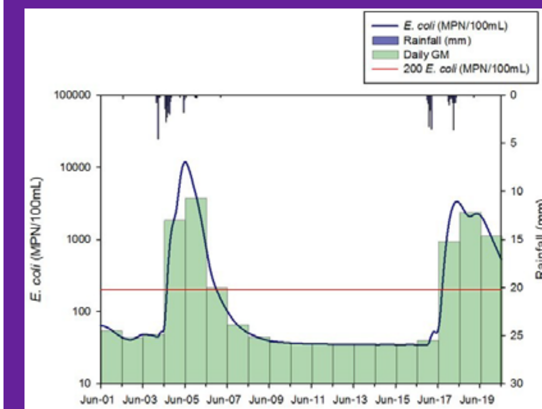
6.2 Water Quality Assessment

The water quality assessment was carried out through field collection of water quality samples from CSO discharge locations and river water sampling during dry and wet periods, followed by water quality evaluations using computer models.

The CSO discharge quality was found to be vary by location and between events, consistent with results from published information. The data were converted into event mean concentrations (EMCs) for use in the water quality assessments. The average EMCs from for nutrients were found to closely match those from the 2002 CSO Study, while the bacteria levels were found to be lower.

The EMCs were used in combination with the volume and frequency of overflows generated by the sewer system model to generate the river water quality model results. A dynamic model was used to model the bacteria in the rivers within and downstream of the City, while a loading model was used to estimate phosphorus and nitrogen loadings from multiple sources.

The water quality modeling assumed all of the CSO licencing requirements would be met for each of the alternative control limits for future conditions. This included meeting the percent capture and number of overflows limit defined for each alternative as well as meeting the treatment limits for the captured combined sewage as defined in clause 12 of EA No. 3042.



E. coli in the Red River

Computer models were used to estimate runoff from rainfall and snowmelt and river water quality based on pollutant loads for the baseline conditions and alternative control limits. The graph shows a typical example of the output for *E. coli* bacteria, with the regulatory limit of 200 cfu/100mL being met during dry weather conditions, but spiking above the limit during the rainfalls, with the elevated levels lasting a couple of days before returning to original levels.

6.3 Performance Assessments

Each of the alternative control limits provides a different level of CSO performance. The metrics that define the level of control are summarized in Table 6-1 for year-round results during a representative year.

All of the alternatives provide a significant improvement over the baseline (2013) metrics of 23 overflows and 74% capture. The three highest performing alternatives would completely eliminate overflows for the 1992 representative year.

The large infrequent rainfalls that exceed the 1992 rainfalls could produce overflows for all of the alternatives except for complete sewer separation. Overflows would be eliminated for the complete sewer separation alternative, since combined sewers would be eliminated. There would, however, be an equivalent increase in the amount land drainage discharge.

Table 6-1. Number of Overflows and Percent Capture Metrics for Alternative Control Limits
City of Winnipeg CSO Master Plan Preliminary Proposal

Control Limit	Control Limit Metrics[a]	
	Number of Overflows for a Representative Year (District Average)	Percent Capture for a Representative Year
1. 85% Capture in a Representative Year	15	85
2. Four Overflows in a Representative Year	4	98
3. Zero Overflows in a Representative Year	0	100
4. No More than Four Overflows per year	0	100
5. Complete Sewer Separation	0	100

[a] Results are shown using 1992 as the representative year.

6.3.1 Water Quality Results

Each of the alternative CSO control limits would provide a reduction of pollutant load to the rivers. All of the combined sewage captured will be treated to the defined limits, with the difference in performance resulting directly from the amount or remaining overflow. The water quality assessment provides an assessment of the performance differences between the five alternatives.

The *Manitoba Water Quality Standards, Objectives and Guidelines* (MWQSOG) provides environmental protection by defining a tiered system of standards, objectives and guidelines for specific applications. The water quality variables for the objectives and guidelines relevant to the CSO program were reviewed and used for the performance assessment.

The study found that the only pollutants of concern from the MWQSOG list of variables were bacteria and floatables. Other pollutants, including ammonia, total suspended solids and biochemical oxygen demand were reviewed and found not to be of concern, because of either the small contribution from CSOs or the minor impact on the rivers. Nutrients were also considered, and found to have only a small contribution to Lake Winnipeg, and not be an issue for the rivers.

6.3.1.1 Bacteria

The river modelling confirmed that CSOs cause large spikes in bacterial levels in the rivers during wet weather, and die-off within 2 to 3 days after the overflow events. None of the alternative control limits would meet the MWQSOG objective of 200 colony-forming units (cfu) per 100 millilitres (mL) at all times.

The degree of non-compliance varies by location for each of the alternatives. As an example, the annual non-compliance for the 85% Capture in a Representative Year alternative was estimated at 44 days at the Redwood Bridge as compared to 40 days at the Parkdale site, which is approximately 11 km downstream from the last combined sewer district. It reaches a low of 23 days per year at the Parkdale site for either the Zero Overflows in a Representative Year or No More than Four Overflows per year alternatives. The duration of non-compliance at this location for Complete Sewer Separation is higher, at 26 days per year.

The evaluation confirmed the CSO alternatives will improve the water quality, but there is no alternative that will eliminate the days of non-compliance. The compounding effects of bacteria from upstream, small streams, land drainage systems and treatment plant discharges will cause the compliance levels to be exceeded, even if all combined sewage were captured and treated.

6.3.1.2 Floatables

Floatables will be captured along with combined sewage to a minimum of 85%, and in addition each CSO control alternative includes screening for the first flush of floatables. Therefore, the CSO capture alternatives are essentially equal in terms of performance for this metric.

The complete sewer separation alternative does not include screening, and therefore will produce more floatables than the alternatives that capture CSOs, but the floatables will not include any from sanitary sewage sources.

6.3.2 Beneficial River Uses

The performance assessment considered the potential impact on beneficial river uses in addition to environmental protection. The rivers have historically provided a natural amenity with a wide range of beneficial uses, including transportation, business uses, leisure and recreational activities that could be impacted by CSOs.

6.3.2.1 Primary Recreation

Swimming or other direct contact activities are not recommended and never will be regardless of the level of CSO control. The rivers are turbid and have muddy banks that make them unsuitable for swimming, and the currents make being in the water unsafe. Primary recreation is therefore not a CSO consideration.

6.3.2.2 Secondary Recreation

Pleasure boating and fishing are popular activities, and will continue to be regardless of the level of CSO control. This use is not impaired by the current conditions, and it would not be expected to increase with higher levels of CSO control.

6.3.2.3 Irrigation

The use of river water for greenhouse irrigation, or for lawn or fairway irrigation is a potential use that was considered for protection. The benefits relate to a reduction in exposure to bacteria caused by being in contact with river water used for irrigation. The amount of use is not well documented, but the risks from exposure are expected to be low. All of the CSO capture alternatives would provide a similar degree of improvement.

6.3.2.4 Water Consumption

The potential use of river water for downstream community consumption was considered for protection. CSO discharges are not considered to impact this use, and increased levels of performance will not improve it, because of the use of modern treatment technologies to meet strict potable water quality standards will be required regardless of the CSO program.

6.3.2.5 Aesthetics

The rivers provide intrinsic value as an aesthetic amenity that could be impaired by CSOs. The rivers have been experiencing a revival in use with increased accessibility, tourism, and development along the waterfront in recent years. The City recognizes this as a use to be protected and promoted and the potential detriment from CSO floatables. Each of the alternative control limits will enhance floatables removal, as previously described, and an improvement is expected for this use.

6.3.3 Lake Winnipeg

The relatively small pollutant loadings from CSO discharges do not have much impact on Lake Winnipeg as shown in Figure 4-2, but because of the severity of the lake's condition, all sources of contamination should be considered.

Phosphorus is considered to be the limiting nutrient and therefore of the most concern for the lake. The baseline (2013) loading from CSOs for the representative year is about 15,000 kilograms (kg) per year. Implementing the 85% capture in a representative year alternative would reduce this by about half, and the higher performing alternatives would essentially eliminate it.

The master plan estimated the total phosphorus (TP) loading to Lake Winnipeg from CSOs for baseline conditions was estimated to be 0.26% of the total lake loading reported in the 2002 preliminary estimates, which would reduce to 0.14% with the 85% capture in a representative year alternative. From a practical perspective it is unlikely that this small of a change could be detected in the lake.

Treatment plants produce much higher nutrient loads than CSOs, and therefore the potential for contributions of total phosphorus (TP) and total nitrogen (TN) in terms of lake loadings from the City's STPs are estimated to decrease from 6.4% to 2.1% for TP and from 5.6% to 2.6% for TN.

Similar type reductions are not possible through the CSO program, since the loadings are so much less, and they would not be cost effective.

The second CSO consideration for Lake Winnipeg was with bacteria surviving the journey to the lake. Even with the hostile river environment, it was predicted that bacteria discharges from CSOs would not be more than from 100 to 1,000 most probable number (MPN) per 100 mL at the mouth of the lake, based on normal decay rates. The potential for longer bacterial survival times through shielding

reduction is much greater. Nutrient loadings will continue to decrease as the City continues to invest in the current STP upgrades. The total

methods was not assessed. After reaching the lake, the bacteria levels would continue to reduce through die-off and dispersion, and would not be expected to cause concern at any of the beaches.

6.3.4 Health Risk

Health risks for CSOs relate to the potential illness caused by direct contact with polluted river water. This very important issue was dealt with at length in the 2002 CSO Study and it was concluded by the advisory committee for that study that CSOs are not a health risk issue. This conclusion was considered to hold true for the current assessment.

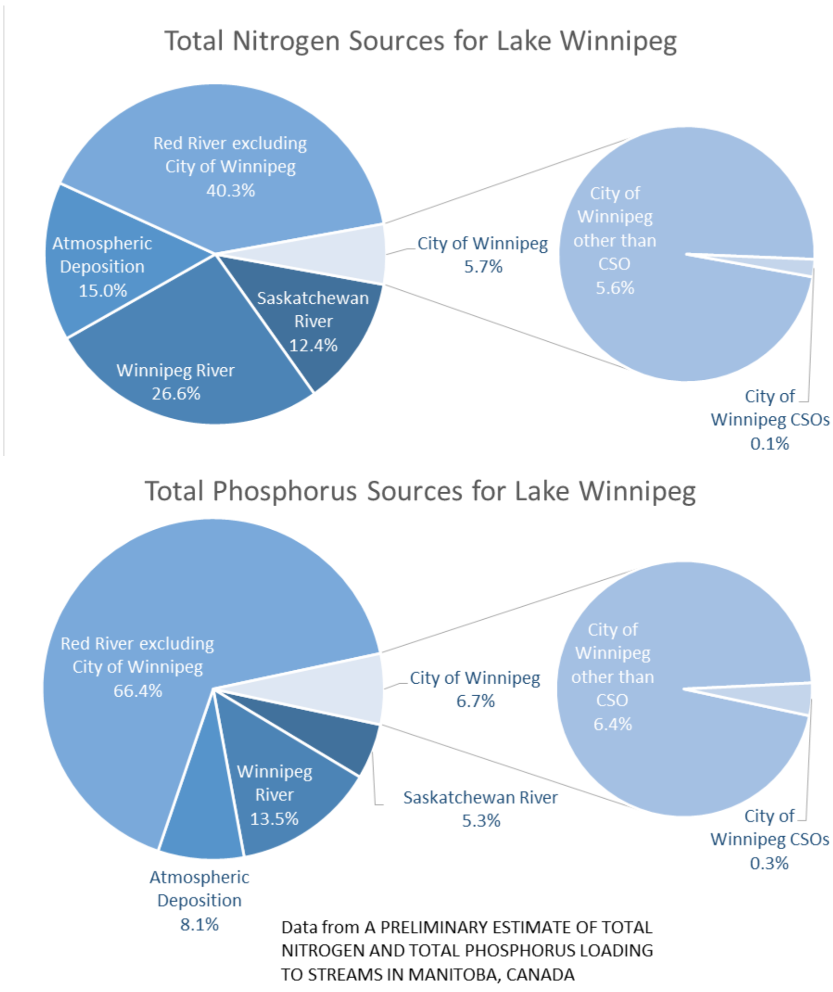


Figure 6-2. Nitrogen and Phosphorus Loading to Lake Winnipeg

Peer Review

The City held a peer review to gather an outside independent opinion of the master plan and build confidence in the direction moving forward. The peer team consisted of four individuals with direct experience with similar CSO issues from similar programs. Their experiences were similar in many ways to the CSO Master Plan, and included use of a representative year and setting of 85% as the control limit.

The peer members were officials from three major Canadian cities and one U.S. city. They participated pro-bono as individuals, not as representatives of their employers, and were encouraged to provide their input freely and without prejudice or liabilities.

The peer review workshop was carried out by first providing an overview of the entire program, addressing peer questions, and then offering the peer team the opportunity to identify the most important issues for comment. The scope of review included the study methods, its completeness and whether there were any opportunities for improvement.

The key findings from the peer review were that the master plan has followed a conventional approach and was considered by the peer team to provide a comprehensive evaluation and plan, which should positon the City well for the next steps. The peers provided a number of suggestions and insights into their programs that have been considered in the follow-up.

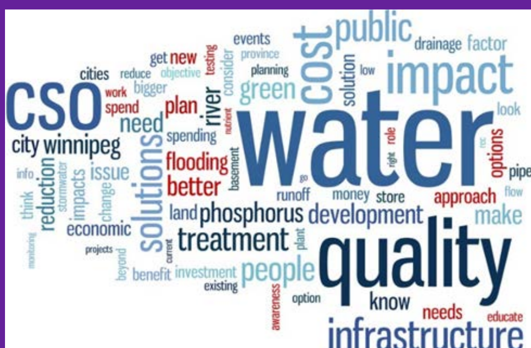
This peer review confirmed the suitability of the master plan approach and therefore has added credibility and confidence to its findings and conclusions.

"The City should try and strike a balance in the recommended plan between the needs of the regulatory authorities and the community's ability to pay."

Peer Reviewers

Public Engagement

The first phase of a public engagement program was carried out by the City based on the International Association for Public Participation (IAP2) principles, best practice and core values. It consisted of an engage website that included an animation of combined sewer overflows in Winnipeg, an online blog, public meetings and media interviews. A CSO Symposium was held on March 5, 2015 with 62 attendees and consisted of four industry experts discussing the main CSO issues for the Winnipeg situation. A stakeholder advisory committee (SAC) was setup early in the process to review the study methods and objectives and provide advice on its delivery. The SAC was requested to define Winnipeg specific value criteria that were ultimately used for evaluation of alternative control limits.



Word Cloud from 2015 CSO Symposium (word size is based on frequency of use)

The public engagement program included multiple events for the public to provide input. A Stakeholder Advisory Committee provided advice and direction during the study phase and developed the value criteria used for the evaluations. Public opinions and preferences gathered from public meetings and a City project website were used in evaluation of alternatives.

The general public was engaged through the website and the three public meetings. The public were requested to provide input at the meetings and through an online forum and survey. The results from the public engagement were integrated into the decision-making process.

Future public engagement efforts will include:

- Phase 2 – During the CSO Master Plan development once a CSO control limit has been set
- Phase 3 – Implementing the CSO Master Plan once final provincial approval for the program has been received

"…could buy 50 community schools for the same level of investment as we are talking about for CSO's" 10 underpasses and 4 major hospitals are also quoted as equivalent to the level of investment for CSOs"

SAC Member from CSO Symposium

Alternatives Evaluations

A concerted effort was made to complete a comprehensive, balanced and transparent evaluation of the alternatives. This included a formal decision-making process to evaluate and rate the five alternative control limits to provide justification for the recommendation made in the preliminary proposal.

It was considered critical that prejudgments be avoided during the technical evaluations and that all alternatives received equal consideration during the evaluation process. This was done by completing the technical evaluations separate from, and in advance of the decision-making process.

9.1 Value Criteria

The SAC was engaged to develop the set of value criteria used in the evaluation process. The value criteria are critical to a fair and balanced evaluation, since they identify what is important to the decision making process and provide the basis for reporting the results.

The SAC adopted a triple bottom line approach, where environmental, economic and social issues are included in the criteria.

- River Usability and Impacts
- Economic Sustainability and Construction Capacity
- Livability and Daily Impacts
- Lake Winnipeg and Watershed Impacts
- Innovation and Transformation
- Visionary and Broader Context
- Social Acceptability

These value criteria were then carried though the decision process, as reported in the Decision Making Report.

9.2 Decision Process

The evaluation was carried out with a team of 11 members from the City's Water and Waste Department. The team members were considered the most able to evaluate and rate the alternatives because of their familiarity with the combined sewer system operation and its issues, their participation on the master plan technical evaluations, and their impartiality to dealing with sewage issues, which can be offensive and bias the opinions of those uninitiated.

Multiple Objective Decision Analysis (MODA)

The five alternative control limits were evaluated using the MODA decision process. It provided a balanced and transparent method for equitably managing objective and subjective criteria. The evaluation used triple bottom line criteria developed by the SAC, with input on weightings and scores provided from the public engagement process. The steps used for the MODA process were as follows:

- Select decision making team
- Identify evaluation criteria
- Assign weights to criteria
- Assess the alternative's performance and assign scores
- Rank the alternatives by combining weights and scores
- Conduct a sensitivity review and analysis of the results
- Carry out a risk and reality review of the highest ranked alternative
- Make a recommendation

The performance assessments from the preliminary report provided information for scoring of the tangible metrics, while individual judgements were required from the decision team members for the more subjective criteria.

The public's opinion gathered and assessed through the public engagement program was integrated into the process. The public weightings were used for the top level value criteria developed by the SAC, and public preferences and opinion were accounted for in the alternative scoring.

It was found that there was a high level of consistence between the public, the SAC and decision team. All agreed on the two most important criteria, which were for Lake Winnipeg and River Usability.

Cost scoring for the alternatives was dealt with separately from the other weighted criteria, since costs are well defined and can be directly compared for each alternative.

The final ranking following the MODA decision process for each alternative is presented in order in Table 7-1.

Table 7-1. Ranking of Alternative Control Limits
City of Winnipeg CSO Master Plan Preliminary Proposal

Ranking Order (Highest to Lowest)	Alternative Control Limit
1	1) 85% Capture in a Representative Year
2	2) Four Overflows in a Representative Year
3	5) Complete Sewer Separation
4	3) Zero Overflows in a Representative Year
5	4) No More than Four Overflows per Year

The rankings show that complete sewer separation which took third position with the remainder of the alternatives in their original sequence.

A sensitivity review was carried out after the evaluation was complete to assess the reasons and rationale for the rankings:

- It was found the alternatives were all very closely ranked in terms of benefits when cost was not included.
- The two highest weighted non-cost criteria (Lake Winnipeg and River Usability) both favoured higher levels of CSO control, but the point spread was limited because of their not being much difference in performance between the alternatives.
- The scores for livability and the economic related criteria favoured the less intensive alternatives. The amount of construction activity was considered to be beyond the current construction industry capacity. The construction would be disruptive to local residents and businesses, and it would result in the redirection of priorities and funding from social programs.

The addition of the cost criteria clearly favoured the less intensive alternatives, which had the lower costs. The cost sensitivity showed that with the cost criterion weighted at 10% or more, the 85% Capture in a Representative Year alternative was consistently the highest ranked.

9.3 Aspirational Goal

The alternatives were assessed for their upgrade potential to deal with stricter future regulations, climate change and the burden on the current generation to pay for a costly CSO program with its marginal benefits. The City has identified the setting of an aspirational goal as a potential method for dealing with future upgrades. Following the achievement of 85% capture further increase percent capture goals can be set to eventually achieve 100% capture. This could be achieved following meeting the 85% capture goal with continued separation similar to Ottawa's 1% annual separation.

Recommended Control Limit

The technical evaluation considered a wide range of control limits, with the 85% Capture in a Representative Year alternative being the highest rated from among the five alternatives. It is therefore recommended that this control limit be specified in the alteration to EA No. 3042, and for continuation of the CSO Master Plan.

This recommendation for 85% capture in a representative year includes the use of 1992 as the representative year, thereby providing the basis for program sizing and compliance, and doesn't require the number of overflows to be included in the Licence. Compliance would be determined by measuring actual performance and comparing the volumes to the 1992 representative year. Overflow volumes would be required to meet the 85% capture limit, as defined in the Licence Clarification document, in all years where the meteorological conditions do not exceed those for the 1992 representative year.

The specific wording for the licence alteration will provide detailed information for the City to proceed. The changes to the licence will need to address the following:

1. The first two paragraphs of Clause 11 be modified to state that the control limit shall be 85% Capture for the 1992 Representative Year.
2. The method of compliance should be defined as "the elimination of overflows for conditions up to those predicted for 85% Capture of the 1992 representative year".
3. Last paragraph of Clause 11 to remain the same, which allows time for the City to complete the master plan.
4. The definition of "percent capture" is to be clarified as being on an annual basis, as reported in the regulatory working committee clarification document.
5. The licence will not make reference to the number of overflows, and therefore its definition does not require further clarification.
6. Annual reporting shall be based on actual percent capture in comparison to the representative year.

The master plan implementation period of 2030 is not achievable and requires further investigation. The final control limit and subsequent time line for implementation will be developed as part of the CSO Master Plan. Such a program will have a significant impact on future utility bill costumers. The City will continue with the master plan by identifying the general works for each combined sewer district, and developing a program budget and schedule, following the licence alteration.

Results of Recommendation

- The recommendation for the 85% Capture in a Representative Year alternative will make a major step forward in dealing with combined sewer overflows. It requires a major investment in combined sewer infrastructure. It also includes the following CSO controls:
- Control gates and in-line storage
- Screens for floatables capture
- Off-line storage
- Sewer separation of combined sewer districts where basement flooding relief is required
- Wet weather treatment as provided under the WSTP

It is the best choice from among the alternatives for the following reasons and will meet the City's vision of "doing our part:"

- It will achieve 85% capture, which was set by 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 from every combined sewer district.
- It can incorporate GI and is adaptable to enhancements but will result in an increase in estimated costs.
- Although it has the lowest cost of the five alternatives it represents a significant investment from the City in CSO management, and will be the most affordable for ratepayers, and have the least impact on competing programs 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 basement flooding relief program.
- It can be expanded in the future if climate changes or regulatory standards require more control.
- It is practicable and the most manageable alternative for planning, coordinating and constructing perspectives.

Subject to approval, the final master plan will be based on the 85% Capture in a Representative Year alternative, and will be submitted by December 31, 2017. The final phase optimization process will include functional details for the sizing and operation of each of the control options for each district. The detailed plans and schedule will be included as part of the final master plan.

The City will complete the second phase of the master plan development 21 months after acceptance of the recommendation by the Province. Any deviation from the recommendation will have significant impacts and will need reassessment. Variations from the recommendation will also have impact to the current cost estimates and analysis and require reassessment.

EXECUTIVE SUMMARY

FINAL

CSO Master Plan Executive Summary

Prepared for

Winnipeg

December 2015

Prepared By

ch2m

In Association with

DILLON CONSULTING

XCG

Contents

Section Page

Acronyms and Abbreviations

EA No. 3042	Environment Act Licence No. 3042
City	City of Winnipeg
CSO	combined sewer overflow
DO	dissolved oxygen
EMC	event mean concentration
MCWS	Manitoba Conservation and Water Stewardship
MODA	Multiple Objective Decision Analysis
NEWPCC	North End Sewage Treatment Plant
PACC	Program Alternative Cost Calculator
SAC	Stakeholders Advisory Committee
TP	total phosphorus
TN	total nitrogen
WSTP	Winnipeg Sewage Treatment Program

Executive Summary

The City of Winnipeg (City) is in the process of developing a Combined Sewer Overflow Master Plan to manage combined sewer overflows (CSO). The Master Plan is being undertaken in three phases that will respond to Provincial Environment Act Licence No. 3042 (EA No. 3042) and provide the City with a long-term plan to reduce CSO discharges to watercourses. This report presents the results of the technical evaluations and decision making. The final phase will commence after selection of a control limit by the Province, and will provide the framework that will guide the CSO implementation program over the coming decades.

This EA No. 3042 submission includes a number of documents, organized as follows:

- Preliminary Proposal – summarizes the City's proposal, with an overview of the alternatives, evaluations, and the rationale and justification for the recommendation
- Executive Summary – provides an overview of the technical content included in the Preliminary Report and Decision Report
- Decision Report – describes the process used for the alternative evaluation and the final results
- Preliminary Report – contains the study details, as well as descriptions for the monitoring program, public engagement and regulatory clarifications

1.1 Study Phase

The study phase commenced in February 2013, and has included extensive background review, data collection and technical evaluations. It has also included setup of a large urban drainage simulation model that will be used as a planning, design and operational tool as the master plan moves forward.

1.1.1 CSO Background

Combined sewers discharge a mixture of sanitary sewage and stormwater runoff to the Red and Assiniboine Rivers. The overflows, which are mostly stormwater, are of concern because they carry pollutants from the sanitary sewage directly to the environment.

CSO's are a result of a legacy design practice and not the result of a malfunctioning system. Combined sewers once carried all sanitary sewage with the stormwater directly to the rivers, without any sewage treatment. This was modified in the 1930s with the construction of the North End Sewage Treatment Plant (NEWPCC). Diversion weirs were installed to redirect up to 2.75 times the dry weather flow rate to treatment with overflows to the rivers only occurring during wet weather. This system is still in use in the older parts of the city. The design approach was changed by the 1960's with all new development being based on separated sewer systems, one for sanitary sewage and a completely separate one for stormwater.

Nearly one-third of Winnipeg, or 8,320 ha, is served by combined sewers. They overflow with nearly every rainfall, or an average of 23 times in a representative year. The combined sewer system currently captures 74 percent of the wet weather in a representative year with the remainder overflowing. The CSOs have become of increasing concern because of greater environmental awareness and regulatory standards.

Combined sewers were designed to drain stormwater from large urban areas as quickly and efficiently as possible, and there is no simple method of removing the sanitary sewage from the flows. Compliance with strict environmental regulations would be very costly. Even modest improvements would significantly increase sewer utility rates, and the question becomes whether, and to what degree, CSO control should proceed. Winnipeg is similar to around 800 other communities in the USA and Canada that are dealing with this issue.

1.1.2 Environmental Licensing of CSOs

Manitoba Conservation and Water Stewardship (MCWS) is the provincial department responsible for environmental licensing and enforcement; and issued EA No. 3042 on September 4, 2013 for the City's combined sewer system. The main submission requirements for EA No. 3042 are:

1. Preliminary Proposal by December 31, 2015
2. CSO Master Plan by December 31, 2017

Once the planning, review and decision process is complete, the final licence will be issued and the City will be obligated to comply with its terms and conditions.

The two step licensing approach provides the City with a unique opportunity to participate in the regulatory process. The first submission deals with the broader and more difficult issues, by focusing on selection of a control limit. This sets the ultimate goal for the level of performance, dealing with how many, if any, combined sewer overflows will be permitted, or what level of capture is required. This approach promotes informed decision making by identifying such things as environmental impacts, trade-offs, costs and affordability for a wide range of alternatives.

The second submission will define an implementation program based on the decision made in response to the Preliminary Proposal submission.

1.1.3 Regulatory Liaison

The CSO Master Plan has proceeded with and approach for regular collaboration. Four project liaison meetings were held with senior managers through the execution of the project and included progress updates and information transfers. A regulatory working committee was also structured with technical staff to discuss the approach and issues, and led to the preparation of a clarification document, which has been used in the evaluation.

1.1.4 Project Goals

The CSO Master Plan proceeded by reviewing the current situation and developing a range of potential plans to meet the following key drivers, which are detailed in the preliminary report:

- Public Health – The raw sewage contained in CSOs is a potential health risk issue for river users
- Aesthetics – CSOs can include hygienic and sanitary products discharge from toilets that can make their way to the rivers and be seen as floating matter
- Nutrients – Phosphorus and nitrogen are contained in sewage, and their discharges are of particular concern to the quality of Lake Winnipeg
- Aquatic Life – Fish and other aquatic life require a healthy river to live, which can be affected by such things as organic discharges that tend to deplete the oxygen supply
- Public Perception – The public's values are important to how much control and how quickly it be implemented
- Regulatory – The City is committed to following the environmental regulations process and meeting the requirements
- Cost – A CSO program is likely to be very costly and a major factor in the alternative selection and the rate of its implementation

The subsequent decision making process evaluates how well each of the alternatives meets the goals.

1.1.5 Alternative Control Limits

EA No. 3042 Clause 11 defines three control limits that must be included in the evaluation. In addition to these, the City may add other alternatives for consideration in the licensing process.

After reviewing the regulatory requirements, current situation, experience from other jurisdictions, and the potential impacts of the control limits on Winnipeg, the City refined the list of alternative control limits to be more inclusive and address specific issues, based on the following:

- The City recognized the need to balance financial stewardship with the need for improvement and has included the 85% capture alternative. This control limit is significant since it is used by USEPA as a criterion for compliance with the "presumption approach".
- Three of the control alternatives propose the use of a representative year, which is a common method used elsewhere on CSO programs. The representative year is much like using an average, in which there will be greater and lesser events about half of the time over a long term record.
- The "not to exceed" approach to design and compliance is also included and will provide comprehensive coverage of the various methods for defining alternatives.

The final list of control limits included in the study is as follows:

1. 85% Capture in a Representative Year
2. Four Overflows in a Representative Year
3. Zero Overflows in a Representative Year
4. No More than Four Overflows per Year
5. Complete Sewer Separation

The system as it existed in 2013 is defined as the baseline, and it will be used to compare and track the amount of improvement made under the CSO program and measure program progress.

1.1.6 Control Options

There are several CSO control options that can reduce or eliminate CSOs, but there is no quick fix and any measurable improvements will require a large capital investment in infrastructure. The control options range from grey infrastructure, which are those that use heavy construction, to green infrastructure, which use natural systems to manage stormwater.

The Master Plan first reviewed control options for their applicability and effectiveness, and potential to be used individually or in combination with others. The control options reviewed were as follows:

- In-line Storage – The existing combined sewers are much larger than needed to convey sanitary sewage, and could be used as temporary storage for combined sewage. The option requires the use of control gates, which would be designed and operated to avoid increased basement flooding.
- Off-line Storage – Another source of temporary storage is off-line storage. This could be provided by installing underground storage tanks adjacent to the combined sewers if property and conditions permit. The sewage from the combined sewers would be redirected to the off-line storage and dewatered by pumping it to treatment as capacity becomes available.
- Storage Tunnels – Tunnels up to about 3,000 mm in diameter could be used where the amount of off-line storage is limited. The tunnels would be located as needed and dewatered the same as for off-line storage.

- Storage/Transport Tunnels – These types of tunnels are larger in diameter and could be used for higher levels of CSO control. The storage/transport tunnels would run parallel to the interceptor and connect multiple districts. The district interconnections would be better able to handle spatially distributed rainfalls if required under the regulations, as commonly occurs with summer thunderstorms.
- Real Time Control – A large network of gate controls and pumping stations could be installed for the CSO program, and a computer system will be required for their operation. Real time controls would be added to optimize combined sewage capture by controlling gates, tank storage levels, dewatering operations and coordinating interceptor rates and treatment capacities.
- Sewer Separation – Conversion of the combined sewer system to a separated two-pipe configuration, as used in new developments, could eliminate some or all of the combined sewer area and reduce CSOs. Reducing CSOs would reduce the flow into the interceptors and the requirements for wet weather treatment.
- Green Infrastructure – There are several natural systems classified as green infrastructure that could control runoff at its source and improve water quality. These options would be used along with grey infrastructure, to meet the level of performance defined by the selected control limit. There are a few issues to be addressed before the City can commit to their use; therefore, green infrastructure has not been incorporated directly into each potential plan, but could be in the future.
- Sewage Treatment Plant Upgrading – More capacity would be required at the sewage treatment plants to treat the wet weather flows that are captured under the CSO program for all the alternatives except for complete sewer separation. Wet weather treatment could be provided by high rate clarification and high rate disinfection. The effluent from the wet weather treatment facility would be blended with the plant effluent, designed to meet the plant licence limits. The stored combined sewage would be dewatered within 24 hours in preparation for a subsequent precipitation event.
- Satellite Treatment – The combined sewage could be treated in a standalone satellite facility, located off of the existing sewer treatment plant property. In this case the effluent would be required to meet the discharge limits in Clause 12 of EA No. 3042. A licence modification to change the total phosphorus (TP) parameter from a not to exceed limit to a total loading limit would be required if this control option is selected.

1.1.7 Potential Plan Development

A major objective of the study was to define what it would take to meet each of the alternative control limits. Potential plans were developed for this purpose by selecting control options for each district that would meet the requirements on a system-wide basis.

The InfoWorks CS sewer modelling software was used for the urban drainage evaluations. InfoWorks CS is a dynamic hydraulic and hydrologic computer model that simulates the operation of the drainage system and its response to precipitation events. A network model was created for the whole city. It was used to evaluate the existing conditions, develop the potential plans and assess their performance. Its use along with river modelling provides a realistic prediction of the performance for each potential plan.

The main components included in each of the potential plans are identified in Table 1:

Table 1. Control Options selected for each Potential Plan

	Control Option Components									
Control Limit	**Control Gate**	**in-line**	**Off-line**	**Pumping Stations**	**Storage / Transport Tunnel**	**Separation**	**Floatable Control**	**NEWPCC 705 ML/d**	**NEWPCC 825 ML/d**	**Satellite Treatment**
1. 85% Capture in a Representative Year	✓	✓	✓	✓		✓	✓	✓		
2. Four-Overflows in a Representative Year	✓	✓	✓	✓		✓	✓	✓		
3. Zero Overflows in a Representative Year	✓	✓	✓	✓		✓	✓		✓	
4. No More Than Four Overflows per Year	✓	✓	✓	✓	✓	✓	✓	✓		✓
5. Complete Sewer Separation						✓		✓		

The potential plans are arranged in order of increasing level of performance. Many of the same control options are used for each plan, but in different degrees and in different combinations with other control options, described as follows:

- The first four alternatives use combinations of CSO capture and sewer separation, while complete sewer separation includes only separation. Where possible, the separation projects have been selected for combined sewer districts where basement flooding relief projects are required, thereby providing shared costs and joint benefits.
- All four CSO capture alternatives include control gates for in-line storage and screening for floatables capture.
- Off-line storage is used in each of capture alternatives, but to different degrees.
  - The 85% capture alternative has less off-line than the four and zero overflows in a representative year alternatives
  - The four and zero overflows in a representative year alternatives utilize substantial off-line storage, with the zero overflow alternative requiring the most storage because of its higher performance standard
  - The no more than four overflow alternative uses a full length tunnel paralleling the interceptor, but also incorporates a smaller amount of off-line storage where it was found to be cost effective
- The no more than four overflows alternative is the only one that uses a full length tunnel, and the only one with a conveyance requirement beyond the capacity of the existing interceptor system.
- The rate of wet weather treatment varies with each of the alternatives
  - The plans for wet weather treatment upgrading under the Winnipeg Sewage Treatment Program (WSTP) will support the 85% capture and four overflows in a representative year alternatives, with no further upgrades required under the CSO program

- The increased capture with the zero overflow in a representative year alternative would require the wet weather treatment capacity at the NEWPCC to be upgraded beyond the WSTP plans as part of the CSO program
- Further increase in performance to the no more than four overflows per year alternative would require the construction of a stand-alone satellite treatment facility along with the full length storage/transport tunnel
- Complete sewer separation would remove road drainage from the wastewater system, but would not eliminate inflow and infiltration, which would need to be treated by the wet weather treatment facilities planned to be built under the WSTP program

- The first four capture and treatment alternatives would all require extensive pumping upgrades. In-line and off-line would require distributed pumping stations to route combined sewage to treatment, and the full length tunnel would require a large lift station at the downstream end to transfer flow to the satellite treatment facility

1.1.8 Cost Estimates

Cost estimates were developed based on the control option selection and sizing for each of the potential plans. The Program Alternative Cost Calculator (PACC) tool was used to develop the estimates after being adjusted for local conditions. The PACC tool provides lifecycle costs by generating capital costs and incorporating operating costs into the estimates.

Estimates for the potential plans needed to meet each of the alternative control limits are listed in Table 2.

Table 2. Class 5 Cost Estimates for the CSO Master Plan Potential Plans

Control Limit	Cost Estimate	
	Capital Cost	Lifecycle Cost
1. 85% Capture in a Representative Year	$830,000,000	$970,000,000
2. Four Overflows in a Representative Year	$1,720,000,000	$1,850,000,000
3. Zero Overflows in a Representative Year	$2,170,000,000	$2,310,000,000
4. No More than Four Overflows per year	$2,300,000,000	$2,450,000,000
5. Complete Sewer Separation	$2,760,000,000	$2,790,000,000

The cost estimates are planning level and are considered Class 5 estimates, having an accuracy range of -50% to +100%. Costing at this level is appropriate for planning comparisons and screening assessments, but is not intended for budget authorization or procurement.

The range of estimates are illustrated in Figure 1. The higher range (-50% to +100%) represents the estimating accuracy normally expected for Class 5 estimates, with the +50% from the lower range being used as the basis for reporting at the public engagement meetings.

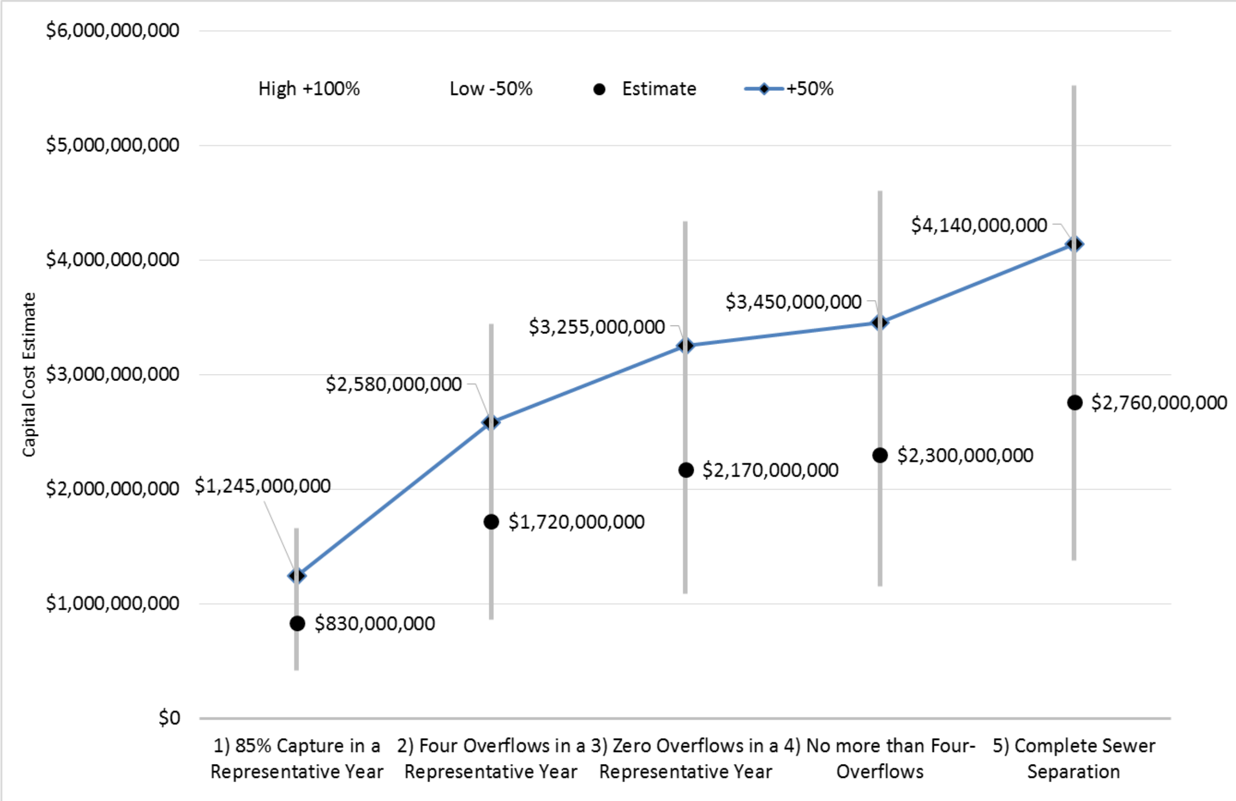


Figure 1. CSO Master Plan Class 5 Estimates and Accuracy Ranges

The public engagement program reported the capital costs with a 50% increase for each alternative, represented by the +50% line on the figure and a 30% decrease range, these ranges were also used in the City's rate model to derive potential water and waste utility rate increases for the different alternatives. This cost adjustment accounts for escalation over the program and estimating uncertainty, which will be refined as the master plan proceeds. The known potential adjustments include allowing for the use of Green Infrastructure, the amount of street repair and reinstatement that will be required with sewer works, and issues identified through the peer review.

1.1.9 Performance Assessment

Performance metrics were used for evaluating the alternatives and making informed decisions. Accomplishing this however is not simple or straightforward, since there are significant differences between the alternatives that make direct comparisons difficult, and several criterion cannot be directly measured or quantified.

The study phase only included objective criteria for the performance assessment, leaving the subjective ones and their value judgements to the decision making phase. Those used include control limit metrics, water quality parameters and beneficial river uses.

The alternative control limits provide distinct increments of performance and are arranged in ascending order to facilitate the review and evaluation. The metrics for the number of overflows and percent volume capture are shown in Table 3 for the 1992 Representative Year.

The alternatives all provide a higher level of control than the baseline condition which has 23 overflows and 74 percent capture for the 1992 representative year.

Table 3. Performance Metrics for Number of Overflows and Percent Capture for the 1992 Representative Year

Control Limit	Control Limit Metrics	
	Number of Overflows for a Representative Year (District Average)	Percent Capture for a Representative Year
1. 85% Capture in a Representative Year	15	85
2. Four Overflows in a Representative Year	4	98
3. Zero Overflows in a Representative Year	0	100
4. No More than Four Overflows per year	0	100
5. Complete Sewer Separation	0	100

All of the captured CSO will be treated. The uncaptured component will be highly diluted with surface runoff and enter the river systems as overflows. All of the floatables will be removed with the captured component, as well as most of the floatables contained in the overflows.

Each of the alternatives will function as follows:

- The 85% capture alternative will be designed to capture 85% of the wet weather volume in a representative year. The current level of impact of each district on the rivers will be reduced because of installation of control gates and screens, but the districts will still overflow an average of 15 times for the representative year.
- The four overflow alternative will be designed to limit the number of overflows for each district to an annual average of four based on the representative year. The addition of controls to each district to meet the four overflow limit results in an annual capture rate of 98% for the representative year.
- The zero overflow alternative will be designed to fully capture the largest event for the representative year. Overflows will occur in years that have rainfalls greater than the largest one in the representative year.
- The no more than four overflows per year alternative will be designed so that there will be no more than four overflow events in any historical year. This will account for spatial rainfall distributions across the entire combined sewer area and is a much higher standard than an average of four overflows per district. Achieving this standard will mean that the typical overflow will be caused by a large infrequent event, and be isolated to only a small portion of the combined sewer area.
- Complete sewer separation is the only alternative that will eliminate CSOs with certainty, since the combined sewers will be eliminated. All of the sanitary sewage and any inflow and infiltration captured by the sanitary sewers will be conveyed to sewage treatment facilities and will be fully treated before release. The surface runoff removed from the combined sewers will be redirected to the rivers through a new land drainage piping system and not be stored or treated.

1.1.10 Water Quality Assessment

The water quality parameters associated with the overflows are key performance metrics that can be used to compare alternatives and are of interest for regulatory compliance. The potential water quality issues were considered from a broad perspective for consideration in the CSO performance assessment. With respect to the CSO program it was determined that the pollutants of concern for the river environment, Lake Winnipeg and as listed under EA No. 3042 are bacteria, dissolved oxygen (DO), ammonia, total suspended solids and nutrients, total nitrogen (TN) and TP.

The City has monitored river water quality on a biweekly basis for many years, and has a large historical database which also includes sewage treatment plant effluents. The information was supplemented with both CSO discharge monitoring and in-stream river monitoring carried out in 2014 and 2015.

A comparison between the 2002 CSO Study TN, TP and bacteria event mean concentrations (EMC)s and the data collected during 2014 and 2015 revealed slightly different values which is to be expected for a variable source such as CSO. The 2015 EMCs used in the master plan assessment and the 2002 values are shown in Table 4 for comparison.

Table 4: EMC values for select Pollutants of Concern

Parameter	Unit	2002 CSO Study EMC[1]	2015 Master Plan EMC[2]
Bacteria[3]	MPN/100 mL	2.4×10^6	1.5×10^6
Total Phosphorus	mg/L	3.0	3.1
Total Nitrogen	mg/L	15.0	17.8

Notes:
1. Source CSO Management Study, Phase 1, TM 1, Table 2-8
2. Based on 2014 / 2015 Water Quality Monitoring Program data up to June 2015
3. 2002 value is fecal coliforms and 2015 value is *E. coli*

The information was used with the urban drainage model and a river water quality model to assess the impact of CSO program alternatives.

1.1.10.1 Water Quality Impacts

The water quality characteristics were identified and estimates made for the impact on the rivers for each of the alternative control limits. The results showed that there was very little difference in performance among the alternatives, and those thought to be higher performing did not always perform better. The water quality results are summarized as follows:

- Bacteria – The bacteria levels in the rivers become very high after a CSO event and remain high for a few days before returning to background levels. The number of non-compliance days is location specific and as an example the baseline condition is about 44 days for the representative year at the Parkdale site, just downstream of the city limits, and would drop to about 23 days for the best alternative.
- DO – water quality monitoring found the oxygen levels in the Red and Assiniboine to not be of concern under current conditions and would be further protected with any of the CSO alternatives.
- Ammonia – this chemical is toxic to fish and there is a requirement for its control from sewage treatment plants, but the measured discharges from CSOs are relatively minor and are not of concern.
- Total Suspended Solids – the rivers have naturally high background levels of suspended solids, and the values are largely unaffected by CSOs, which are highly diluted with surface runoff.
- Nutrients (TN and TP) – nutrient loading from CSOs are relatively low and have not been identified as being detrimental to the rivers, and only make a small contribution to Lake Winnipeg.

1.1.10.2 River Use Impacts

Another consideration is for protection of the site specific river uses. The Red and Assiniboine Rivers are not naturally pristine with public beaches and do not have sensitive fish species or a shellfish harvesting industry which would require high water quality standards. They are however valuable natural amenities that support extensive secondary recreation, and are tributary to Lake Winnipeg which supports many uses, and is in a current state of distress.

The potential impacts on river uses were assessed as follows:

- Primary Recreation – Swimming and other direct contact activities are limited and not recommended because of currents, murky water and muddy banks; this will not change with implementation of CSO controls.
- Secondary Recreation – The rivers are actively used for secondary recreation, and CSO control changes are not expected to impact the amount of use.
- Aquatic Life – The rivers support healthy sport fishery and this is not expected to change with the implementation of any of the CSO alternatives.
- Irrigation – Greenhouse and lawn irrigation is a potential use of river water, and any pollutants present could pose an illness risk to those exposed. The use of river water for irrigation is very low and the risk of contamination is also low.
- Water Consumption – The preferred source of potable water supply for downstream users is from groundwater or other surface sources, but if river water is used it would be treated with modern systems that effectively purify and disinfect the water, regardless of which alternative is implemented.
- Aesthetics – All of the CSO capture alternatives except complete sewer separation include floatables control, with no significant performance differences.

It should be noted that an important issue dealt with as part of the 2002 CSO Study was the health risk issue. After an in-depth investigation that included generation of epidemiological relationships it was determined that health risk issue was very low, and it was concluded by the 2002 CSO Advisory Committee that health risk is not a CSO program issue. This conclusion is considered to still be valid.

1.1.11 Lake Winnipeg

Nutrients from all sources are of concern because of their role on eutrophication of Lake Winnipeg, with TP being of specific concern because of it being the limiting nutrient.

The CSO study estimated that relative annual loading of TP to Lake Winnipeg from CSOs is currently 0.31% of the total lake loading. The loading is relatively low and will be even further reduced through implementation of any of the alternatives. Similar reductions will occur for TN loading.

A preliminary estimate of *E.coli* in the Red River following a CSO was completed as part of the water quality assessment. The results show that *E.coli* is not anticipated to have an influential impact on bacterial water quality at the mouth of Lake Winnipeg.

1.1.12 Watershed Assessment

Regardless of which CSO alternative control limit is selected, the benefits to the rivers and Lake Winnipeg will be marginal:

- The rivers will not be swimmable
- Recreational use of the rivers is not likely to change
- The effects on Lake Winnipeg will not be noticeable

Further improvements for the rivers or Lake Winnipeg will therefore have to be achieved through implementation of other programs. The largest source of nutrients from the City is from the sewage treatment plants, which are already being upgraded under the WSTP. Nutrient loadings will continue to decrease as the City continues to invest in the STP upgrades. The contributions of total phosphorus (TP) and total nitrogen (TN) in terms of lake loadings from the City's STPs are expected to decrease from 6.4% to 2.1% for TP and from 5.6% to 2.6% for TN.

The STP program will reduce annual TP loading by about 250,000 kg/year, and by comparison the CSOs currently contribute only about a total of 15,000 kg/year of TP. None of the CSO alternatives would completely remove all of the nutrients, since there would be a residual amount discharged from wet weather treatment, and sewer separation would result in an equivalent increase in the amount of land drainage runoff.

Anecdotal information provided through the public engagement program suggests the public favours watershed controls. Wetland development could reportedly achieve as much TP control with one project as the entire CSO program would achieve, but at a fraction of the cost.

Further improvements through a watershed based approach goes beyond the scope of the CSO program.

1.1.13 Public Engagement

The City carried out the first phase of a multi-event public engagement program aligned to the significance of the program and level of public interest based on the International Association for Public Participation (IAP2) principles, best practice and core values. The following events and activities were included throughout the development of the preliminary proposal:

- Stakeholder Advisory Committee
- Symposium
- Web sites
- Public Meetings
- Media Events

A summary of the SAC and public events is compiled within the appendices of the Preliminary Report. The public engagement and SAC reports should be referenced for more detailed information on the events and the outcomes. Some of the repeated messages from the public were as follows:

- The public considered the impact on Lake Winnipeg as the most important reason to control CSOs.
- Over two-thirds considered a medium or long term approach for implementation of a CSO program to be acceptable.
- The terminology in the CSO Licence speaking to the number of overflows permitted was confusing. They would prefer to see a plan and licence focused on percent capture and performance metrics that are volume based rather than event based. The majority of the public favored that the program duration be extended to reduce the impact on the utility bill.
- In recognition that the CSO program will not significantly affect Lake Winnipeg, there should be concurrent initiatives to implement watershed based solutions.

Future Public Engagements efforts will continue with two additional phases; Phase 2 will be undertaken during the CSO Master Plan development once a CSO control Limit has been set and Phase 3 during the implementing of the CSO Master Plan once final provincial approval has been received.

In compliance with Clause 9 of EA No.3042 the City also provides bi-annual Public Engagement progress reports to the Province.

1.2 Decision Making Phase

The decision making phase was carried out after completion of the study phase. It includes review and evaluation of each of the alternatives developed in the first phase. The second phase is reported in detail in the separate Decision Making Report.

1.2.1 Decision Making Process

A multiple objective decision analysis (MODA) was used to provide a comprehensive and balanced evaluation of the alternatives. It incorporated the tangible performance metrics from the first phase and the value judgements needed for subjective performance metric evaluations in the second phase. It required the integration of public engagement input and establishment of a decision making team for the evaluation.

The decision making team was comprised of 11 members from the Engineering Services, Environmental Standards, Wastewater Services and Information Systems and Technologies Divisions of the Water and Waste Department. The team was well qualified, having reviewed the technical details of the Master Plan and knowledgeable in combined sewer operations. The team was also considered to be in a good position to provide objective evaluations, by not being squeamish in dealing with sewage related issues.

A set of seven value criteria, in addition to cost, were used for the evaluation. The Winnipeg specific value criteria were developed by the stakeholder advisory committee (SAC), independent from the study team and decision making team. The evaluation criteria encompass a broad range of criteria fitting a triple bottom line approach, with environmental, financial and social values included. The decision subsequently clarified the definitions and made minor revisions to the criteria.

The final top level value criteria were as follows:

- River Usability and Impacts
- Economic Sustainability and Construction Capacity
- Livability and Daily Impacts
- Lake Winnipeg and Watershed Impacts
- Innovation and Transformation
- Visionary and Broader Context
- Social Acceptability

The weighting and scoring process used a combination of public engagement and decision team input. The public engagement results were used for the value criteria top level weights, with the decision team weights applied to the sub criteria. The scoring was initially made by the decision team, which were reviewed and adjustments made based on public input. A few summary points from the weighting and scoring process are listed as follows:

- Environmental and river use issues were weighted the highest, but because of only minor differences in performance among the alternatives these criteria had little influence on the rankings.
- The alternative rankings for social and economic criteria favoured the less construction-intensive alternatives, with the larger programs being less desirable because of the disruption to neighborhoods and commuters.
- The point scores for all alternatives were nearly identical prior to considering costs.

The final results for the evaluation are listed in order in Table 4.

Table 5: Scoring results from Decision Making Phase

Alternative Control Limit	Point Score
1. 85% Capture in a Representative Year	560.4
2. Four Overflows in a Representative Year	468.2
3. Zero Overflows in a Representative Year	465.0
4. No More than Four Overflows per Year	449.6
5. Complete Sewer Separation	466.9

The results show that the 85% Capture in a Representative Year alternative is the highest ranked.

A sensitivity review of the results was carried out to assess the reasons and rationale for this selection:

- The cost evaluation favoured the less intensive alternatives, with 85% Capture in a Representative Year rated the highest because of its lower cost.
- The cost sensitivity evaluation indicated that the 85% Capture in a Representative Year alternative would still be highest ranked even with the cost weighting lowered from 40 percent of the non-cost criteria to as low as 10 percent.

1.3 Peer Review

A peer review was held to gather an outside independent opinion of the master plan and build confidence in the direction moving forward. The peer team consisted of four individuals with direct experience with similar CSO issues from similar programs. Their experiences were similar in many ways to the CSO Master Plan, and included use of a representative year and selection of 85% capture as the control limit.

The key findings from the peer review were that the master plan has followed a conventional approach and was considered by the peer team to be comprehensive. The peers provided a number of suggestions and insights into their own programs that have been considered for use here and if necessary incorporated into the master plan development. The peer review confirmed the suitability of the master plan approach and has added credibility and confidence to its findings and conclusions.

1.4 Final Phase Considerations

The final phase of the master plan will take place after an alteration to the licence has been approved. Narrowing the range to a single alternative will allow for detailed development of the control options, with more focused consideration on operational and implementation issues. The program goals, operational issues, field collected data and system models will be used to optimize the plan. This will be followed by finalization of the master plan, with project level detail, an implementation schedule and budgets.

1.4.1 Program Considerations

The final master plan will provide a long term program, which will be a roadmap for CSO project implementation. The master plan must be reasonable and practicable if it is to be achieved. Several risks and implementation issues will need to be considered by the City that could impact its success, including the following:

1.4.1.1 Implementability

Implementability defines whether the potential plan will be practicable and can be implemented. The potential plans were based on tried and true control options that have been used elsewhere, and are therefore considered to be technically implementable. The greatest challenge to implementation will be securing funding and being able to assemble sufficient resources to carry out the programs in the defined time frames.

Clause 11 of EA No. 3042 makes reference to CSO implementation being completed by December 31, 2030, unless otherwise approved by the MCWS Director. All of the alternatives will be large programs comprised of multiple projects that will require extensive coordination. It will be challenging to complete any of the alternatives within the defined time frame, and not possible for the larger ones. Implementation strategies and program time frames will be dealt with in the third phase of the Master Plan.

1.4.1.2 Affordability

The CSO program will be very costly, and coming at a time when the City is faced with many concurrent demands and a major infrastructure deficit on top of that. The sewer utility will particularly be heavily burdened, with capital project financing and increased operating costs from responding to the regulatory requirement for sewage treatment plant upgrading.

Sewer utility costs are paid on the water bill with the charges applied on a user pay basis in proportion to water consumption. This means that anyone using water will pay more, with the increased rates having the potential to cause excessive hardship for the lower income earners.

1.4.1.3 Adaptability to Change

Just as the current evaluation is being carried out for changed conditions, there is a reasonable chance the conditions will change again in the future. The changes could be for a number of reasons, such as more stringent environmental regulations or in response to climate change. Adapting to the changes will depend on the size of the change and which alternative is being affected.

- All the alternatives can adapt to minor changes by adding storage and treatment or increasing the amount of separation.
- The recommended 85% Capture in a Representative Year alternative is the most expandable, since the next two higher performing alternatives, the Four Overflows and Zero Overflows in a Representative Year, incorporate the same components and the upgrades could be phased in.
- The No More than Four Overflows could be expanded by adding more storage and treatment capacity, but it is not adaptable to phased upgrading with the other alternatives.
- Complete separation is based on a single control option, and not adaptable to phasing with the other alternatives.

1.5 Conclusions

A comprehensive and transparent process was used to define and evaluate alternatives, and has concluded the 85% Capture in a Representative Year is the best choice for a control limit.

The process leading up to the conclusion included:

- Identification of alternative control limits in complete conformance with EA No. 3042 requirements
- Objective technical evaluations of potential plans and assessment of performance for each alternative control limit
- Regular liaison and progress meetings with regulators to provide updates and clarify issues

- Multiple public engagement events to provide information and solicit feedback and input
- Use of triple bottom line criteria for the evaluation, with the environmental, economic and social criteria being defined by an independent stakeholder advisory committee
- Use of a multiple objective evaluation analysis tool to equitably evaluate the objective and subjective criteria used in the evaluation
- A final sensitivity and risk assessment for the selected alternative

The merits of the 85% in a Representative Year control limit include:

- Meeting the 85% Capture in a Representative Year control limit will meet the benchmark used in the US EPA “presumption approach”.
- It will make a major step forward in CSO management, progressing from the current standard of capturing dry weather flows to active controls for wet weather.
- All though it has the lowest cost of the five alternatives considered, it still represent serious long-term investment in managing CSOs. Considering the costs associated with each alternative it also represents the most affordable and socially responsible from a utility payer perspective.
- Overflows will be reduced and floatables will be captured from every combined sewer district primary overflow.
- Cost-effective green infrastructure options will be included, with provision for future green enhancements.
- The 85% Capture in a Representative Year control limit can readily be expanded in the future. If conditions change that demand a higher level of performance, such as may be the case from objectives not being met, climate change, or more stringent regulations it can be expanded to achieve increased percent capture targets in a representative year by the addition of control options or additional combined sewer separation.

The 85% Capture in a Representative Year alternative will meet the City’s vision for “doing our part” and make manageable environmental improvements and is to be included in the City’s EA No. 3042 proposal.

1.6 Recommendation

It is recommended that the City request the province to alter EA No. 3042 to define the 85% Capture in a Representative Year as the CSO program control limit. This recommendation includes using the 1992 representative year and does not require meeting a maximum number of overflows to be met for compliance. Compliance will be based on 85% capture of the combined sewer overflow volume for the 1992 representative year. Percent capture would be based on the wet weather flow treated in comparison to the wet weather flow collected. The definition and application of percent capture is provided in more detail in the Licence Clarification document. The inclusion of percent capture and the 1992 representative year will allow the City to assess the infrastructure requirements and provide a consistent basis for measuring compliance to the control limit.

Upon approval, it is recommended that the City finalize the master plan by identifying the general works for each combined sewer district and develop a program budget and schedule for a long term implementation program.

The technical evaluations showed that the benefits of a CSO program will be marginal, and if further improvement to the rivers and Lake Winnipeg is required, it is recommended that an integrated watershed approach be pursued.

PRELIMINARY REPORT

FINAL

CSO Master Plan Preliminary Report

Prepared for

Winnipeg

December 2015

Prepared By

ch2m

In Association with

DILLON CONSULTING

XCG

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Acronyms and Abbreviations

AACE	Association for the Advancement of Cost Engineering
BFR	basement flood relief
BNR	biological nutrient removal
CBOD	carbonaceous biological oxygen demand
CCME	Canadian Council of Ministers of the Environment
CEC	Clean Environment Commission
CEPA	Canadian Environmental Protection Act, 1999
CSO	combined sewer overflow
DO	dissolved oxygen
D-R	Dose-Response
DWF	dry weather flow
EA No. 3042	Environment Act Licence No. 3042
EMC	event mean concentration
USEPA	United States Environmental Protection Agency
GI	green infrastructure
GM	geometric mean
ha	hectare
HRC	high rate clarification system
HRT	hydraulic retention time
kg	kilogram
km	kilometre
LWSB	Lake Winnipeg Stewardship Board
L	litre
LDS	land drainage sewer
MCWS	Manitoba Conservation and Water Stewardship
mg	milligram
MHI	median household income
mL	millilitre
mm	millimetre
MMWE	Management of Municipal Wastewater Effluent
MPN	most probable number
MSD	Metropolitan Sewerage District
MWQSOG	Manitoba Water Quality Standards, Objectives and Guidelines

NEMP	North End Master Plan
NEWPCC	North End Sewage Treatment Plant
NPS	national performance standards
NSWL	normal summer river water level
O&M	operations and maintenance
PACC	Program Alternative Cost Calculator
POCs	pollutants of concern
RI	Residential Indicator
RLC	Regulatory Liaison Committee
RTC	real time control
RTB	retention treatment basin
RWC	Regulatory Working Committee
SCADA	supervisory control and data acquisition
STP	Sewage Treatment Plant
SEWPCC	South End Sewage Treatment Plant
SRS	storm relief sewer
TM	technical memorandum
the City	The City of Winnipeg
TSS	total suspended solids
VSS	vortex solids separator
WEWPCC	West End Sewage Treatment Plant
WPCC	water pollution control centre
WSC	Water Survey of Canada
WSER	Wastewater Systems Effluent Regulations
WSTP	Winnipeg Sewage Treatment Program
WWF	wet weather flow

SECTION 1

Introduction

1.1 Study Background

The City of Winnipeg (the City) is required to develop a combined sewer overflow (CSO) Master Plan to comply with Provincial Environment Act Licence No. 3042 (EA No. 3042). The master plan will provide the City with a long-term direction on CSO mitigation. The issues that must be considered are complex, the program costs are high, and the benefits are difficult to define.

Manitoba Conservation and Water Stewardship (MCWS) issued EA No. 3042 to the City for Winnipeg's CSOs after the master plan had already started. Although the master plan was not planned to be developed in response to the licence, the scope of work for the master plan aligns with the licence requirements and the scheduled dates for the master plan deliverables fall within the licence deadlines.

EA No. 3042 and the master plan approach provides the City with a unique opportunity to identify and evaluate CSO control options, proactively participate in the regulatory decision process, and most importantly, promote and support informed decision making throughout the process.

The work plan for the assignment was structured into a progressive decision making approach, to be carried out in the following three phases:

1. Study phase: This phase established the information needed for selection of a control limit(s), and was accomplished by defining potential plans that meet a series of alternative control limits.
2. Visioning and decision making phase: This phase selected a control limit(s) through evaluation and rating of the merits of the potential plans developed in the first phase.
3. Long-term master plan based on the final control limit(s) selected phase: The master plan will serve as an implementation roadmap and will identify a series of projects that will meet the intent of the master plan.

The master plan expanded on the work completed for the *Combined Sewer Overflow Management Study* (2002 CSO Study) (Wardrop et al., 2002). The master plan updated information from the 2002 CSO study based on the extensive new information available from the City's Water and Waste Department. The 2002 CSO Study greatly contributed to the scientific understanding of CSOs and their impact on the Red and Assiniboine Rivers and identified mitigation options from a planning perspective. While it provided the technical basis for the Manitoba Clean Environment Commission's review during the 2003 hearings, the study was not completed to the point of establishing a functional master plan.

The master plan includes use of a much more comprehensive sewer system model than was developed for the 2002 CSO Study. The new computational model is of the entire wastewater drainage system on an InfoWorks platform. The enhanced system model provides much greater detail and accuracy in the system assessment and control option evaluations.

1.2 Purpose

This preliminary report documents the analysis of potential control options to form a CSO master plan and the process for the evaluation and recommendation of the most advantageous option to take forward considering Winnipeg-specific performance measures and value criteria.

This preliminary report is intended to first provide an objective overview of any findings and results, without judging or eliminating any potential options, so that a full range of options is available for the decision process (second report). The preliminary report first addresses primarily system performance based on tangible criterion. Other value-based and more subjective assessments are deferred to the second phase decision process reporting.

1.3 Scope

The scope of the master plan was originally defined in the City's terms of reference and was adapted to the EA No. 3042. The scope includes technical support for defining control limit alternatives and their costs and benefits, support for the decision process leading to submission of a preliminary proposal, and development of the final master plan. It does not include the development of any environmental studies or reports beyond the submission requirements defined in the EA No. 3042.

The first phase of the master plan includes identification, evaluation, and packaging of control options for each of the potential plans. A major challenge with this phase is defining and maintaining an appropriate level of detail to support objective and accurate evaluations. This requires making planning level assumptions and deferring discussions about details that are not directly relevant to the decision until later stages of the evaluation. The additional detail and fine tuning will be addressed in the third phase of the project, after final selection of a control limit.

There are many possible variations of control limits. Rather than developing potential plans for every different situation, control limits are variants in the planning process and evaluated by comparison to the originating control limit. Their performance is then assessed relative to the more detailed potential plan.

From the master plan context, control limits are in reference to a level of performance. The master plan investigated existing levels of performance and a range of performance for different potential control options to achieve zero or four overflows, for example.

Since control limits only define a level of performance, they cannot be evaluated on their own and require a method for defining and evaluating them in terms of costs and benefits. Because the conceptual level plans are developed under the first phase of the master plan for each selected control limit and the merits are assessed, any of the plans could be picked as the final master plan. This report refers to them as "potential plans".

The remainder of this preliminary report is organized as follows:

- Section 2, Background: Provides an overview of the current situation, the licensing process, and information relevant to carrying out the evaluations.
- Section 3, Alternative CSO Control Limits: Describes the potential control limits and identifies the limits selected for further consideration.
- Section 4, Technical Approach: Provides an overview of the conceptual approach and technical methodology used to assess existing conditions, evaluate control options, and develop potential plans. The technical approach and issues are common to all control options and potential plans considered.
- Section 5, Public Engagement: Provides a reference for work completed and how the preliminary report and public input relate to the master plan.
- Section 6, Regulatory Liaison: Provides a reference for the work completed and how the regulatory liaison was used during the development of the master plan.
- Section 7, CSO Control Options: Describes how control options could be applied to individual combined sewer districts in Winnipeg. Control options are techniques and solutions that can be used to mitigate CSOs.

- Section 8, Potential Plans: Describes how potential plans draw from individual control options for development of system-wide solutions, including the sewage treatment processes. Potential plans are a combination of control options developed on a planning level to meet each of the identified control limits. Potential plan variants identify differing interpretations that could be applied to the control limits. Addresses any significant “what if” scenarios, without the effort of developing new potential plans.
- Section 9, Cost Estimates: Describes the cost estimating process.
- Section 10, Water Quality Assessment: Presents an overview of water quality issues, modelling approach, and findings for selected potential plans.
- Section 11, Watershed Approach: Presents the concept of a broader watershed view for river water protection
- Section 12, Performance Assessment: Identifies the performance metrics used in the first phase and assessment of benefits for the potential plans. This was a major input into the decision making process.

SECTION 2

Background

2.1 How Are CSOs Regulated in Manitoba

The regulatory perspective for wastewater discharges in Manitoba has evolved significantly over the years. Treatment plant licensing has evolved to include lower effluent limits, CSOs are on a path to final licensing, and there has been an increased focus on protecting Lake Winnipeg.

MCWS is the regulatory body that is responsible for the licensing and enforcement of the provincial Environment Act and subsequent EA No. 3042.

The regulatory background and current perspective are described in the following section.

2.1.1 CSO Licensing History

Prior to 1988, the City had responsibility for protection of river water quality within Winnipeg and provincial licensing was not required. Even without licensing, the City has made major investments in wastewater treatment and focused the combined sewer approach on elimination of dry weather overflows. After proclamation of the Environment Act on March 31, 1988, responsibility was transferred from the City to the Province.

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, and is now referred to as the 2002 CSO Study. 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 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 litres (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 study.

The CEC conducted the hearings over a 9-day period between January and April of 2003, and submitted their report with advice and recommendations in August 2003 (CEC, 2003).

The CEC presented 20 recommendations, with two relating to CSOs as follows:

- 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."

The following other findings from the CEC related to CSO were identified in the body of the report but not included as recommendations:

- "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 the Province, and as a follow-up EA No. 3042 was issued on September 4, 2013, for continuation of the CSO program.

2.1.2 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. The main 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 there has been a great deal of attention to 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 needs to be considered when establishing POCs.

2.1.3 Protection of Lake Winnipeg

The 2002 CSO Study included an assessment of CSO discharges on the lake. Based on the review at the time, the impact of the discharges on the lake were not considered a significant issue. The results from the 2002 CSO Study are reported in Phase 1, TMs No. 4 – *Receiving Stream* and No. 7 – *Technical Framework* (Wardrop et al., 1994).

The annual nitrogen and phosphorus loadings from CSOs to the rivers were found to be minor in comparison to other sources. The annual loading from CSOs to Lake Winnipeg was found to be less than 1 percent of the nutrients going to the lake (MCWS, 2002). All of Winnipeg's wastewater treatment plants, land drainage sewers, and CSO were estimated to be 6.7 percent and 5.7 percent of the total contribution to Lake Winnipeg for total phosphorus and total nitrogen respectively.

Bacterial contamination of river water downstream of Winnipeg to the City of Selkirk, and as far as Lake Winnipeg's south basin beaches, was considered. Although there were no conclusive results at the time, there was no evidence of the bacteria surviving the exposure to elements in the river environment that occur with the long journey to the lake.

Awareness of Lake Winnipeg's worsening condition grew through the 1990s, and reached a milestone with the announcement of Manitoba's Lake Winnipeg Action Plan by the Minister of Environment on February 18, 2003. The announcement drew public attention to all sources of pollution, including those from Winnipeg, and happened to coincide with the CEC hearings.

The Lake Winnipeg Action Plan included a number of initiatives to help define and manage the sources of pollution and has been followed up by additional provincial and federal initiatives, and involvement by other environmental and special interest groups.

These actions have resulted in Lake Winnipeg now being a major focus, as demonstrated in the following multiple initiatives and action plans.

2.1.3.1 Manitoba Water Strategy

The Manitoba Water Strategy introduced in 2003 is the current policy document for the following six interrelated water policy areas:

- Water quality
- Conservation
- Use and allocation
- Water supply
- Flooding
- Drainage

The primary focus of this strategy is to develop a province-wide watershed-based approach to water planning so that future management of specific water issues is done carefully.

2.1.3.2 Lake Winnipeg Action Plan

The Lake Winnipeg Action Plan, announced in 2003, is a commitment by the Government of Manitoba to reduce nitrogen and phosphorus loads to pre-1970s levels. Six actions were identified in the plan, including establishment of a Lake Winnipeg Stewardship Board to help define further actions needed to meet the goals. The action plan is to be updated as further studies continue.

2.1.3.3 Lake Winnipeg Stewardship Board

The Lake Winnipeg Stewardship Board (LWSB) was established in July 2003 as part of the Lake Winnipeg Action Plan. The board consists of 17 members with representatives from a variety of interests and sectors including municipalities, First Nations, commercial fishing, science, and agriculture residents living in the watershed. The board provides input to the Province on meeting commitments of the Lake Winnipeg Action Plan. The board has released annual reports and submitted multiple recommendations, and has provided follow up on success of meeting the recommendations.

In the 2006 report, *Reducing Nutrient Loading to Lake Winnipeg and its Watershed: Our Collective Responsibility and Commitment to Action* (LWSB, 2006), the Manitoba government reiterated their commitment to the Lake Winnipeg Action Plan. The report contains a series of recommendations for protecting and improving the health of Lake Winnipeg. A subsequent 2009 report, *Manitoba's Progress Towards Implementing Recommendations of the Lake Winnipeg Stewardship Board* (LWSB, 2009) identifies the Province of Manitoba's progress towards implementing the recommendations in the 2006 report.

2.1.3.4 Bill 46 the Save Lake Winnipeg Act

Bill 46 was introduced to provide immediate focus on reducing the pollutants that put Lake Winnipeg's water at risk by making amendments to a number of existing acts. An amendment to the MCWS' Water Protection Act requires that the City replace or modify the NEWPCC to meet specified phosphorous and other effluent limits. The City must also ensure that its nutrient removal and recycling methods comply with specified requirements.

2.1.3.5 TomorrowNow – Manitoba's Green Plan

TomorrowNow – Manitoba's Green Plan (MCWS, 2014) is an 8-year strategic action plan to protect the environment while ensuring a prosperous and environmentally conscious economy. It includes building a green economy, addressing climate change, protecting Manitoba's land and water, preserving biodiversity, and educating and engaging Manitobans. An updated release in June 2014 incorporates an enhanced focus on the health of Lake Winnipeg.

2.1.3.6 Lake Friendly Accord

The Lake Friendly Accord established in 2009 by the South Basin Mayors and Reeves, as first proposed in TomorrowNow – Manitoba's Green Plan, seeks to engage Manitobans, other governments, and multi-jurisdiction agencies to reduce nutrient loading into Lake Winnipeg by 50 percent.

A permanent Lake Friendly Stewards Alliance was established to guide Manitoba's implementation of the accord and facilitate information sharing, enhance collaboration and co-ordination, improve reporting and accountability, and help prioritize science-based provincial action.

The goal of the Lake Friendly Stewards Alliance is to co-ordinate efforts and promote leadership to reduce phosphorus and nitrogen loading and protect water quality. The alliance is made up of stakeholder organizations having a critical role in the health of Lake Winnipeg. This includes representation from governments, conservation districts, the agricultural sector, Aboriginal communities, business groups, and environmental organizations.

About 75 other stakeholders from across Manitoba have joined the Lake Friendly Stewards Alliance.

2.1.3.7 Surface Water Management Strategy

Manitoba is implementing its first comprehensive surface water management strategy (Manitoba Government, 2014). The new sustainable approach has been designed to protect Lake Winnipeg and mitigate flood and drought damage by managing drainage and investing in flood control infrastructure.

The strategy is intended to preserve and protect wetlands and their natural ability to retain and slowly release water with natural purification.

2.1.4 Canada-wide and Federal Regulations

Under federal law, Environment Canada administers two acts concerning environmental protection of surface waters: the Canadian Environmental Protection Act, 1999 (CEPA) and the Fisheries Act. 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 Wastewater Systems Effluent Regulations, 2012 (WSER) 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) Canada-wide Strategy for the Management of Municipal Wastewater Effluent, 2009 (MMWE).

2.1.4.1 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 ensure 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 in regards to 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 (every CSO structure should at least have a baffle or screen)

The NPS are consistent with EA No. 3042 (Appendix A) Clause 7, Clause 8, and Clause 12, which read 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.

The recommendations from the CCME were considered in the development of the Federal effluent regulations.

2.1.4.2 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 CSO effluent was deposited for each month and the volume of effluent deposited via each overflow point. The first annual report was submitted by the City in February 2014.

2.1.5 Winnipeg Sewage Treatment Plant Licensing

Winnipeg's sewage treatment plants (STPs), formerly known as the water pollution control centres (WPCCs) are all licensed under the Environment Act. The most current versions of the licences are as follows:

- 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 MCWS as required under the Save Lake Winnipeg Act. The plan was approved on June 19, 2011, under the condition that the upgrade meets effluent quality criteria as listed in Table 2-1. The criteria include the proposed new effluent quality parameters for the NEWPCC as issued October 2, 2012. It is intended that the effluent limits form the basis of the next revision to the NEWPCC licence.

Table 2-1. NEWPCC Effluent Discharge Limits

Parameter	Units	Limits	Compliance
$CBOD_5$	mg/L	25	Annual 98%
TSS	mg/L	25	Annual 98%
E. coli	MPN/100 mL	200	Monthly geometric mean
Total residual chlorine	mg/L	0.02	
Total phosphorus	mg/L	1.0	30-day rolling average
Total nitrogen	mg/L	15	30-day rolling average
Ammonia nitrogen	kg/24 hours	See Table 2-2	Varies by month

Notes:
CBOD = carbonaceous biological oxygen demand mL = millilitre

kg = kilogram	MPN = most probable number
mg = milligrams	TSS = total suspended solids

The ammonia limits are specific to each STP and are based on location-specific conditions and the STP's sensitivity to aquatic life. The ammonia discharge limits are now regulated on loadings in a 24-hour period. They are at a minimum during the summer months when CSOs are normally at their highest. The limits for the NEWPCC are listed in Table 2-2.

Table 2-2. NEWPCC Ammonia Discharge Limits and Proposed New Effluent Loading Limits

Month	Kg/24 hours
January	7,580
February	8,675
March	13,057
April	29,021
May	13,331
June	7,312
July	4,507
August	2,262
September	2,663
October	3,415
November	4,035
December	5,774

The licences for the SEWPCC and WEWPCC have similar discharge limits, with ammonia discharges being specific to each location.

2.1.6 Environment Act Licence No. 3042

EA No. 3042 for CSOs was issued on September 4, 2013. The licence has adopted recommendations received from the CEC following the 2003 hearings. It is structured to accommodate development of a master plan, consistent with the master plan approach, including the following:

- It allows for the identification and evaluation of alternative control limits.
- The master plan implementation is intended to be complete by 2030, although it allows for an alternative implementation time period based on the study findings at the discretion of the MCWS Director.
- Expanding the compliance period from the recreational season to year-round.

2.2 Combined Sewer Overflow Management Study

The 2002 CSO Study was the first major study on the environmental impacts of the City's combined sewer system on the Red and Assiniboine Rivers. Prior to the 2002 study, a substantial effort had previously been made on upgrading the hydraulic capacity of combined sewers to reduce basement flooding, but the environmental focus had been on managing dry weather flows and not on the effects or methods of mitigating CSOs.

The 1992 CEC hearings (CEC, 1992) identified a lack of information and data on the operation and impacts of the combined sewers. The City's terms of reference for the 2002 CSO Study were developed to respond to this lack of information, and identified in the scope statement that "the primary objective of the project is to establish a cost effective prioritized implementation plan for remedial works based on an assessment of costs and benefits of practicable alternatives."

The 2002 CSO Study was assigned in 1994 and had a comprehensive plan for technical evaluations and stakeholder engagement. The 2002 CSO Study findings are extensively documented in a series of TMs including an illustrative plan addressing CSO management in Winnipeg.

2.3 Wastewater Collection and Treatment Systems

To evaluate potential control options, it is necessary to understand how the existing sewage collection and treatment infrastructure operates, especially during wet weather conditions.

2.3.1 Sewerage System

Wastewater is collected and conveyed to the three STPs by three types of sewer systems: combined, sanitary, and interceptor sewers. The combined and sanitary sewers collect wastewater from the source 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.

2.3.1.1 Combined Sewers

Combined sewers were installed in Winnipeg up to the 1960s. The original purpose of combined sewers was to convey 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 discharging to the rivers and convey it to the newly constructed NEWPCC. The systems were designed to intercept about 2.75 times dry weather flow (DWF), thus including a nominal amount of wet weather flow (WWF), and convey it to the treatment plant. The 2.75 interception rate was consistent with general practice at the time.

The systems operate under the same principles today. During dry weather, all flow is captured and conveyed to the treatment plants. For larger wet weather events, the combined sewer flows exceed the interception capacity and the excess flow overtops the weirs and discharges to the rivers. Such overflows occur on average about 22 times a year, although the numbers vary for individual districts.

The City's combined sewer area is split into a number of individual areas known as a combined sewer districts. A combined sewer district is an area of the city that is serviced by a network of combined sewers that convey collected sewage and runoff to the plants for treatment. The combined sewer districts have a history of basement flooding during intense summer storms. The City has carried out extensive work under basement flood relief (BFR) programs to alleviate this problem, through use of relief piping and sewer separation on an opportunistic basis.

The 2002 CSO Study identified 43 combined sewer districts including the Boyle district, the Calrossie district, and two Jefferson districts (Jefferson East and Jefferson West). The two Jefferson districts were identified as a single combined district for reporting. This resulted in 43 combined districts being assessed in the study. The districts were identified as servicing a combined sewer area of 8,700 hectares (ha) and having 72 combined sewer outfalls or overflow pipes to the rivers.

For the purposes of the master plan and for reporting requirements, the number of districts is 43, the serviced combined sewer area is reduced to 8,320 ha, and the number of discharge pipes is 79. It is important to note that this number is an estimation and includes an estimated reduction for green space areas that aren't typically serviced and an estimated reduction for any areas that have been partially separated. The total combined runoff area including the green space and partially separated combined areas is greater than 11,000 ha. There are additional outfall pipes at ten of the flood pumping stations that provide outfall capacity to relieve the system during high river levels. These ten outfall locations with dual pipes are reported as a single outflow point for this report. As well, 41 of the districts have a primary outfalls that can discharge to the receiving streams.

Changes have been made to the way the districts are identified now as compared to the 2002 CSO Study. These are a result of the BFR program, removing combined drainage area through sewer separation, and adding new overflow piping to protect basements from flooding.

The combined sewers area and districts are shown on Figure 2-1.

Figure 2-1. Combined Sewer District Map

The variations in the identification of the districts now as compared to the 2002 CSO Study is as follows:

- Boyle Combined District – Outfall was abandoned in 1996 and the collection system reconfigured to flow to Syndicate. Boyle is no longer represented as a district in the City's database.
- Calrossie Combined District – This district was separated with sanitary flow discharging directly to the Cockburn combined sewer district.
- Munroe Annex Combined District – Added as an individual combined district.

2.3.1.2 Basement Flooding 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 (SRS) and have been installed in many of the combined sewer districts to increase hydraulic capacity.

The program has proceeded more recently on a priority basis with projects having the highest benefit/cost ratio being scheduled first. The program generally provides upgrading to a minimum of a 5-year level of protection through the use of relief piping, with a longer term goal of achieving a 10-year level through supplemental measures. 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 CSO mitigation. The status of BFR for each combined sewer district is shown in Figure 2-2.

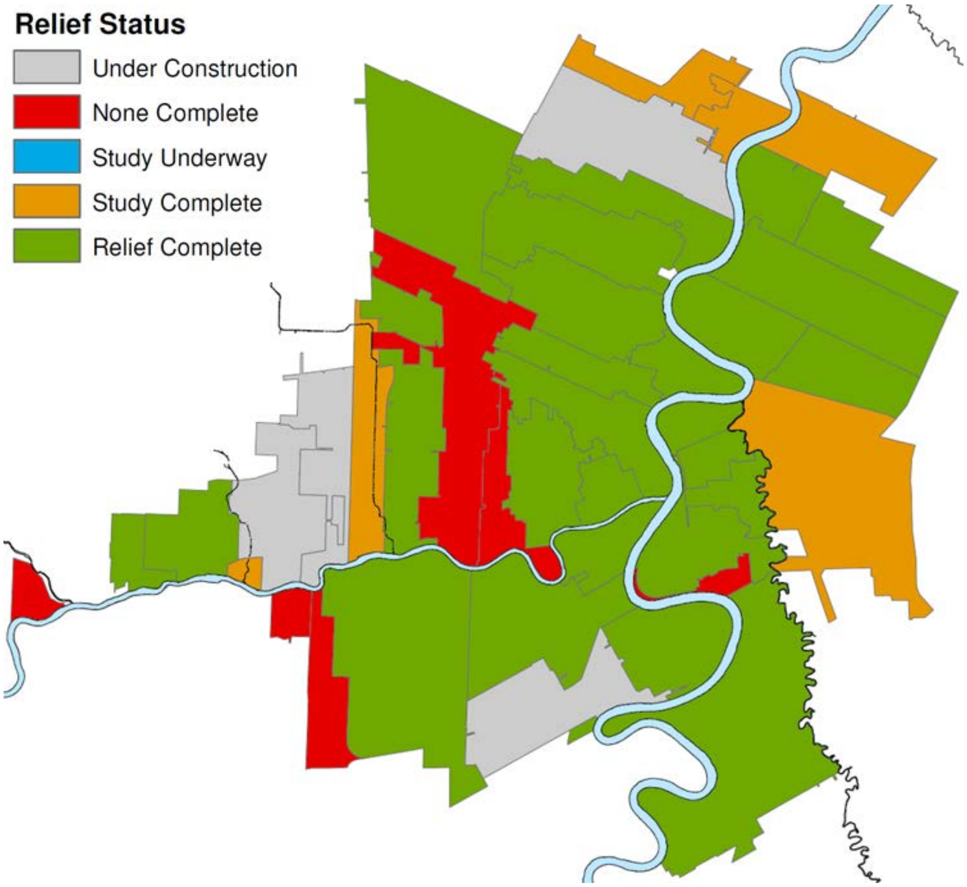

Figure 2-2. Basement Flood Relief Status in Each District

A summary of some of the more recent work and work in progress is provided in Table 2-3.

Table 2-3. Current and Future Basement Flood Relief Projects

District	Status	Dates of Construction
Cockburn West	Detailed Design	2014 – Current
Cockburn East	Not Started	
Ferry Road / Riverbend	Ongoing (Contract 1, 2, 3, 4)	2013 – Current
Jefferson East	Ongoing (Contract 1, 2, 3, 4)	2012 – Current
Mission	Concept Design	

The City has invested well over $300 million on BFR, with another $110 million budgeted for future BFR investment. The districts where work is currently underway and planned for the near term includes the Jefferson, Ferry Road, Cockburn, and Mission combined sewer districts.

Figure 2-3 provides an indication of the percentages of SRS and land drainage sewer (LDS, also known as storm sewers) pipe installed in each combined sewer district. The percentages are calculated on an SRS or LDS pipe length versus combined sewer pipe length as taken from the City's Land Based Information System. In Figure 2-3, the LDS graphic on the right demonstrates the districts where separation has been the priority and the SRS graphic on the left shows the areas where SRS relief has been the priority. As an example, the Mager district in the bottom right corner of Figure 2-3 shows low relief and high separation.

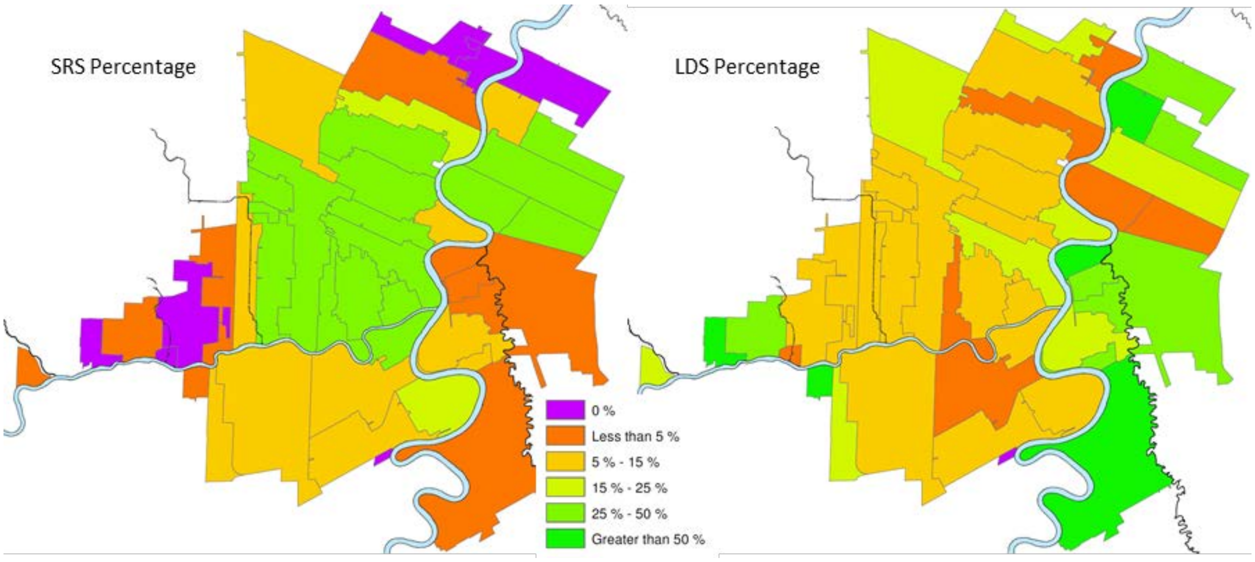

Figure 2-3. Combined Area Separation and Sewer Relief

There is high potential for integration of CSO control measures with future BFR works.

2.3.1.3 Separate Sewers

All new developments in the city have been serviced by separate sewers since the 1960s, which consist of the following:

- Sanitary sewers that collect domestic, commercial, and industrial wastewater and convey it to the STPs for treatment.
- LDS sewers that collect surface runoff from rainfall or snowmelt and convey it either directly to the rivers or to stormwater retention basins, where the water is held and then slowly released to the rivers.

2.3.1.4 Interceptor Sewers

Interceptor sewers convey wastewater and collected combined sewage from the individual sewer districts to one of the three WPCCs. There are five major interceptor sewer systems in Winnipeg, as shown in Figure 2-4. The Main, Northeast, and Northwest interceptor systems flow to the NEWPCC, while the SEWPCC and WEWPCC each have their own independent interceptor system.

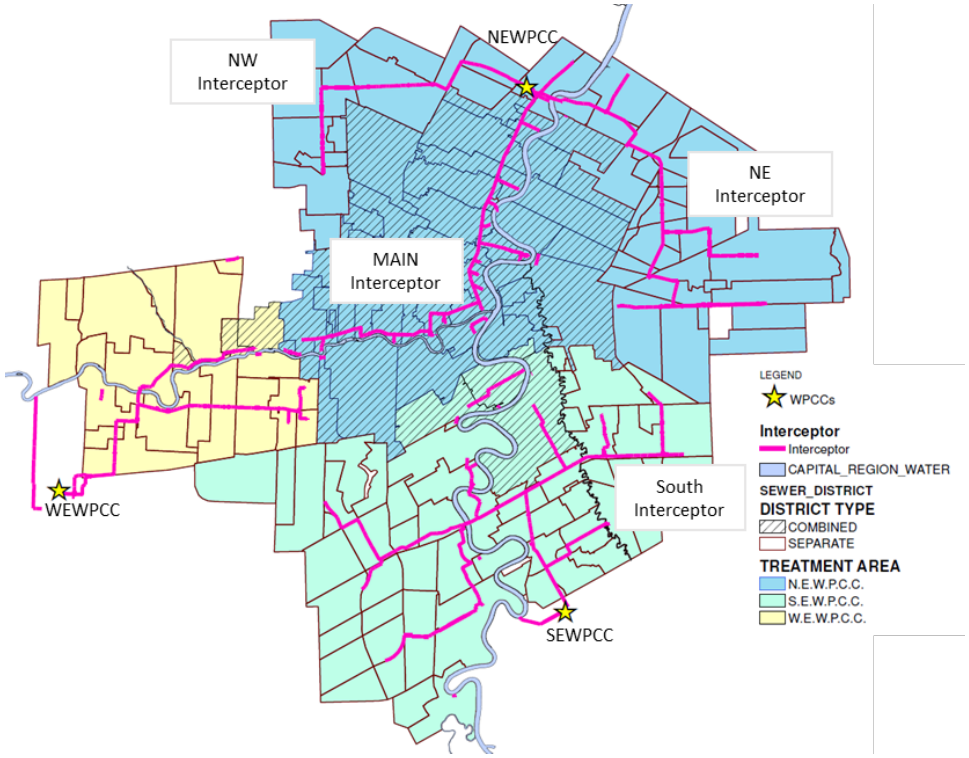

Figure 2-4. Collection System Interceptor Map

2.3.1.5 North End Interceptors

The Main interceptor, with its north-south leg located on Main Street in parallel to the Red River, serves the older part of the city and only receives flows from combined sewer districts. It collects flows from 35 of the 43 combined sewer districts representing about 7,540 ha of the current 8,320 ha of combined sewer area. The interceptor has capacity beyond what is required for 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, as shown in Figure 2-3. Flow in these interceptors are important to the CSO program because they both combine with the Main interceptor prior to reaching the plant. Flows from each of them will affect the flows and levels in the others, and all three of them contribute to and share the treatment capacity of the plant.

Two of the 79 CSO locations have the functionality to allow overflows directly from the Main interceptor to the Red River, located in the St. John's and Polson districts. These overflows can discharge by gravity when the interceptor levels are high and the river level is low.

Diversion weirs for each combined sewer district are set at an elevation that captures 2.75 times DWF. The sewage captured behind the weirs flows through an off-take pipe to either a pumping station wet well or directly to the interceptor. Most combined district discharges are pumped as shown in Figure 2-4. Sixteen districts are sufficiently high in elevation that the flow is discharged by gravity.

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

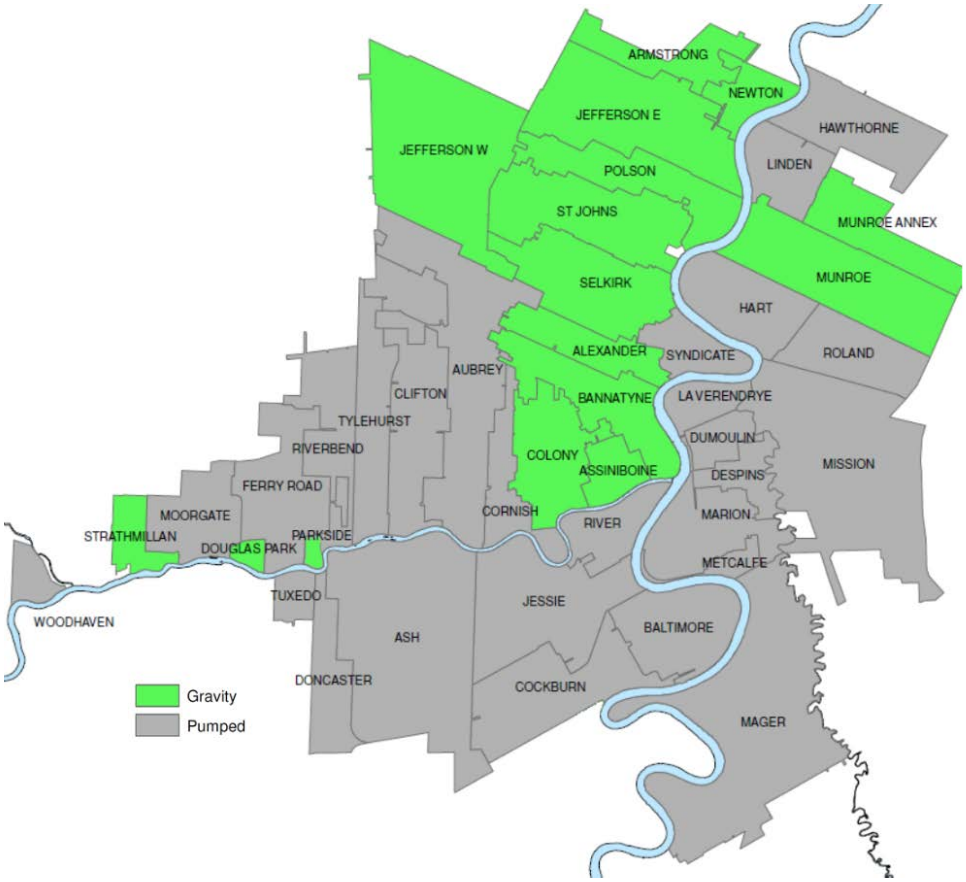

Figure 2-5. Combined District Conveyance Type – Gravity or Pumped

2.3.1.6 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 combined sewer 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 combined sewer districts.
- The west end interceptor collects separate wastewater flows from the St. James and Charleswood areas and combined sewage from Woodhaven, Moorgate, and Strathmillan combined sewer districts.

2.3.2 Sewage Treatment Plants

Winnipeg is serviced by three sewage treatment plants, NEWPCC, SEWPCC, and WEWPCC. 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 the Red and Assiniboine Rivers.

Winnipeg's three sewage treatment plants were upgraded just prior to or in parallel with the 2002 CSO Study, and the following improvements 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 sidestream in 2008. A major upgrade is in the planning phase for nutrient removal.

- Ultraviolet light disinfection was added to SEWPCC in July 1999. No further upgrades have been completed, but a capacity expansion and upgrade for nutrient removal is currently in progress.
- The WEWPCC mechanical plant constructed in the early 1990s was upgraded to nutrient removal by August 2008. The former lagoons were retained to serve as polishing ponds and provide natural disinfection.

During heavy rainfalls and high spring runoff, flows may exceed the hydraulic capacity of the biological processes at any of the three plants. The excess flow only receives primary treatment, which is blended with the biological processes effluent before being discharged to the rivers. Current plans for SEWPCC and NEWPCC upgrading include use of high rate clarification (HRC) for wet weather flows to meet regulatory limits.

2.4 River Water Quality Conditions

2.4.1 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 on the way to Lake Winnipeg. Many cities, towns, and agricultural livestock operations contribute pollutant loads to the rivers before they reach Winnipeg.

2.4.2 Pollutants of Concern

The POCs define the parameters to be considered in the master plan and provide the basis for defining the discharge controls for compliance. The identification of POCs focused on the water quality requirements to protect river uses. The 2002 CSO Study provided a reference for proceeding with the study phase of the master plan, and has been supplemented with additional water quality monitoring and adjustments for the updated MWQSOG and EA No. 3042. This combination of background information was assessed to arrive at the current POCs 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 that 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.
- 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 TSS 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. The new sewage treatment plant licences set ammonia loading limits for STP discharges, which must be considered for blended effluents.
- Toxic substances: While it was recognized that there was 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, being historically less than 10 percent of the City's total discharges. The STP environmental licences and EA No. 3042 all have limits for phosphorus.

- 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. Bacteria are not expected to survive the journey from the City to Lake Winnipeg due to the decay rate and flow path. No additional studies werer completed fro bacteria decay as part of the master plan. *E. coli* was the main bacteriological indicator assessed for the master plan development.

The master plan included a multi-year water quality monitoring program to collect and update river and CSO water quality data. The 2014-2015 data was compared to the 2002 data to reassess the POCs identified above. The water quality monitoring program is discussed throughout this report and in more detail in Appendix B. The data from the 2014-2015 program was used as the baseline for the water quality modelling and loading assessments.

2.4.3 River Uses and CSO Impacts

River uses provide the source for identifying upgrading requirements and project benefits. Detailed reviews of the 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 master plan, since there are no indications of river uses have substantially changed since that time. The previous studies therefore 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 river's 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 River supports a highly valued sports fishery.
- Recreation 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 MWQSOGs. 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: Prior surveys identified a number of greenhouses that use river water for irrigation, which could be adversely impacted by CSOs, and it is considered as a beneficial use to be protected.
- Domestic and industrial water consumption: The rivers will be protected 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.

2.4.4 Lake Winnipeg

Although CSOs are not considered an issue for Lake Winnipeg, it is prudent to include the lake in the current master plan assessments because of its distressed nature and the public and regulatory attention it has generated.

As is evident from the information presented in Section 2.1.3, the lake 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 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.

2.4.5 Water Quality Monitoring

The master plan considered the previous water quality data from the 2002 CSO Study and subsequent Red and Assiniboine River water quality monitoring programs, and carried out additional monitoring to supplement and update the data. An overview of the bi-weekly river water quality monitoring program and the CSO water quality monitoring program is provided in the following sections. A more detailed report on the CSO water quality monitoring program with the results can be referenced in Appendix B.

2.4.5.1 Bi-weekly River Water Quality Monitoring

Since 1977, the City has carried out a voluntary water quality monitoring program of the rivers at regular intervals during the recreational season, typically May to September depending on weather and river conditions. The program includes the collection of samples at 11 locations along the Red and Assiniboine rivers and at eight locations on selected small streams. Testing is carried out for 18 parameters, including nutrients, DO, and bacteria. The results are posted on the City's website. The Province of Manitoba also monitors water quality upstream and downstream of Winnipeg.

2.4.5.2 CSO Water Quality Monitoring Program

A water quality monitoring program was initiated in response to the City's compliance requirements under EA No. 3042, Clause 15, and to supplement the data needs of the master plan. As part of the compliance monitoring requirements, the City developed an Interim Monitoring Plan (City of Winnipeg, 2014a) that serves as a basis for the water quality monitoring study that was completed as part of the master plan development. 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:*
>
> *a. organic content as indicated by the five-day biochemical oxygen demand (BOD5) and expressed as milligrams per litre;*
>
> *b. total suspended solids as expressed as milligrams per litre;*
>
> *c. total phosphorus content as expressed as milligrams per litre;*
>
> *d. total nitrogen content as expressed as milligrams per litre;*
>
> *e. total ammonia content as expressed as milligrams per liter;*
>
> *f. pH; and*
>
> *g. E.coli content as indicated by the MPN index and expressed as MPN per 100 millilitres of sample.*

The interim monitoring plan provides more detail on the specifics of the monitoring program and identifies the locations where sample collection occurred. The monitoring program has provided an updated characterization of collection system discharge quality and allows for an assessment of the impact of these discharges on receiving stream water quality.

Program Methodology

The program included two distinct types of monitoring to characterize the CSO discharges and to measure the impact of the CSO discharge on the rivers. Each type of monitoring is described in the following sections.

CSO Discharge Monitoring

The objective of the CSO discharge monitoring was to characterize the POCs contained within the overflows. Data collected can be used to develop event mean concentrations (EMC) for CSO discharges. These EMCs are then applied to water quality modelling to predict receiving stream impacts.

Representative sampling was completed at a number of CSO outfall locations to establish the variable nature of CSO discharges. Early in the planning stages for the program, a number of suitable locations were selected based on a high level review of system hydraulics and upstream land use. In total, eight preliminary locations were selected for installation of the auto-samplers. Each auto-sampler was to be maintained in a location until two suitable CSO events could be captured and the results validated. Once two events were captured, the auto-sampler was moved to the next location until a total of 16 events were captured at the eight locations.

The auto-samplers were programmed to automatically start collecting samples at defined levels, which are unique to each location and change continually based on river levels. The samplers were set up with 24, 1 L bottles to allow for 24 discrete samples to be collected. They were programmed to collect a 1 L sample every 15 minutes. This allows for a total collection time frame of 6 hours. Samples could continue to collect for multiple peaks that occur during the course of a runoff event, so that varying intensity within a storm did not stop the collection process and a high probability of capturing a full sample set of 24 bottles was maintained.

The CSO discharge montioring for this portion of the program included the collection of samples at locations along the Red and Assiniboine rivers and at five locations on select small streams. Testing was carried out for 14 parameters. The results are included in Appendix B.

Data from the discharge monitoring was used to develop representative EMCs for bacteria, total phosphorus and total nitrogen and was used in the water quality assessment. Other secondary information collected including the identification of unusual concentrations of tested parameters and further understanding of the river – outfall relationship.

River and Stream Monitoring

The objective of the river and stream monitoring was to characterize the impact of CSO discharges into the rivers and streams. Two types of sampling protocol were established to complete this objective. A dry weather collection was set to characterize baseline conditions in the river without the influence of collection system discharges and a wet weather collection to characterize the river after an overflow event has occurred. The difference in quality during dry and wet weather sampling can be attributed to the discharge of runoff into the receiving water.

A regional approach was used to select the locations for river and stream sampling. Since the objective was to determine the impact of CSOs, locations were based on the City boundaries, the convergence of the two rivers and the boundaries of the combined sewer area within the City.

Dry weather sampling only begins after a 3-day stretch of minimal rainfall and no identifiable overflows. Dry weather sampling is carried out for 3 to 5 days. Wet weather sampling is carried out after a rainfall event that is significant enough to create identifiable overflows along both river systems. An identifiable overflow is determined through the evaluation of the CSO monitoring instrumentation at outfitted CSO outfalls. 30 of the 79 outfalls are outfitted with instrumentation, giving a reasonable representation of the occurrence of a widespread CSO impact.

When resources allowed, CSO discharge at the outfall was sampled during the same wet weather sampling period to establish the strength of discharge entering the receiving waters. The data collected serves as a way to observe the system operation and simulate the water quality impact of the potential CSO options.

The river and stream monitoring for this portion of the program included the collection of samples at nine locations along the Red and Assiniboine rivers and at five locations on select small streams. Testing was carried out for 15 parameters. The results are posted on the City's website.

2.5 Future Growth Projections

Use of combined sewers for new developments has been prohibited since the 1960s, so growth of the combined sewer area will not occur. Additionally, although it is acknowledged that population and related sanitary flow may increase within combined sewer districts, the City has a policy restricting discharges from any infill or re-developments to the pre-development levels, so no growth in flow rates is expected.

There is, however, a critical link between city-wide growth and CSO control options through the sewage treatment process. Combined sewage and wastewater from separate areas all flow to one of the three STPs, and essentially compete for the sewage treatment capacity. This is especially important for CSO control options where increased inflow and infiltration from separate areas will leave less capacity for treatment of combined sewage.

Future development areas considered as part of the master plan are shown in Figure 2-6.

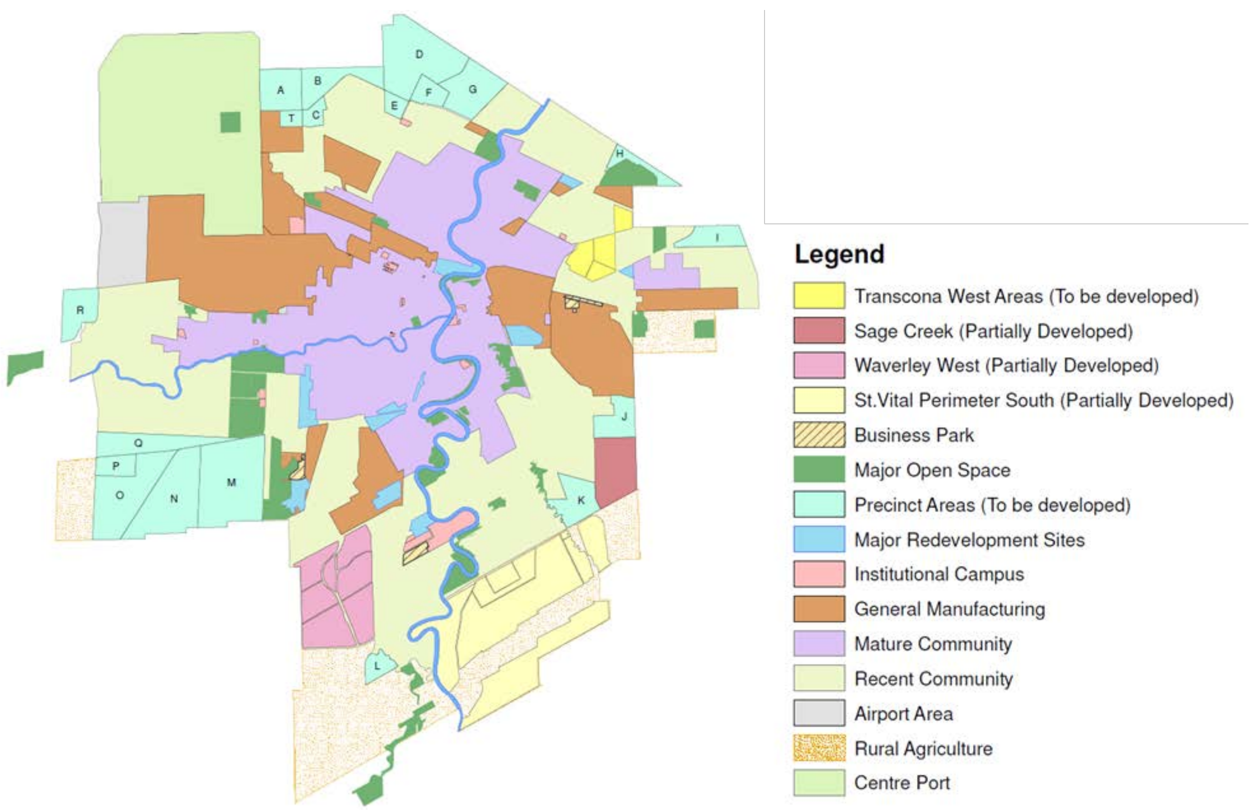

Figure 2-6. Future Development Areas

The growth projections are most important for the NEWPCC since it has the largest combined sewer area, but also applies in principle to the SEWPCC and WEWPCC.

2.5.1 NEWPCC Service Area Growth Projections

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

The estimated 2015 population for the NEWPCC 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 adding servicing for the adjacent municipalities of East St Paul, West St Paul, and Rosser.

The study included an estimate of 684,000 to the year 2067, based on a continuation of the same growth rate of 0.75 percent per year.

The study also included wastewater flow rate and quality projections, as presented in the NEWPCC treatment sections of this report.

2.5.2 SEWPCC Growth Projections

Future flow estimates for the south treatment 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 SEWPCC treatment area is the second largest area in Winnipeg. The population is expected to grow to between 229,800 and 281,000. According to the report, the 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).

2.5.3 WEWPCC Growth Projections

As shown in the future area development map, there is expected to be new residential areas in the near future that will increase DWFs. The combined districts are at the upstream limit of the treatment area and are fully developed areas. No growth within the combined districts is expected.

2.6 High River Levels

High river levels from snowmelt are a perennial occurrence with a varying degree of impact every year. They create challenging events for local and provincial flood fighting efforts and difficulty in maintaining safe sewer system operation in the city.

During spring runoff, when several months of snowfall accumulation melts and passes through the city on its way to Lake Winnipeg, water levels can increase. This was the case in 1997 when the level at James Avenue reached 229.23 metres above sea level, which means the 1997 level was over 5.5 metres above the normal summer level of 223.74 metres above sea level.

The Province and City have taken great measures to reduce the risk of spring flooding. After severe flooding and extensive damages in a 1950 flood, the floodway was built to divert river water around the city. This work included a river diking system and a series of flood pumping stations within the city.

The flood pumping stations are still in use today and are largely in the same configurations and operated in the same manner as when they were constructed.

The flood pumping stations are located on the downstream end of those combined sewer districts that are susceptible to flooding, as listed in Table 2-4. Flap gates prevent river water from entering into the combined sewers through the outfalls, and flood pumps are activated to discharge combined sewage to the river when basements are at risk of flooding.

Table 2-4. Flood Pumping Stations

Name	District	Type
Polson	Polson	Diversion and flood combined station
Newton	Newton	Diversion and flood combined station
Ash	Ash	Flood pump station
Aubrey	Aubrey	Flood pump station
Baltimore	Baltimore	Flood pump station
Bannatyne	Bannatyne	Flood pump station
Clifton	Clifton	Flood pump station
Colony	Colony	Flood pump station
Cornish	Cornish	Flood pump station
Despins	Despins	Flood pump station
Galt	Alexander	Flood pump station
Hart	Hart	Flood pump station
Jefferson	Jefferson	Flood pump station
Marion	Marion	Flood pump station
Mission flood	Mission	Flood pump station
Roland	Hart	Flood pump station
Selkirk	Selkirk	Flood pump station
St John’s	St John’s	Flood pump station
Syndicate	Syndicate	Flood pump station
Assiniboine	Assiniboine	Flood pump station
Jessie	Jessie	Flood pump station
Mager	Mager	Flood pump station
Metcalfe	Metcalfe	Flood pump station
Fort Rouge Park	River	Flood pump station
La Verendrye	La Verendrye	Flood pump station
Kildare flood pumping station	Area 18	Flood pump station
Chataway	Tuxedo	Lift and flood combined station
Dumoulin	Dumoulin	Lift and flood combined station
Cockburn	Cockburn	Lift and flood combined station
Mayfair	River	Lift and flood combined station
Hawthorne	Hawthorne	Lift and flood combined station
Linden	Linden	Lift and flood combined station

High river levels and the flood pumping system operation present a challenge for management of CSOs. Flood pumping stations generally operate during the spring, coinciding with high river levels that reduce the outfall capacities to the rivers. Flood pumps can operate with multiple on-off cycles, and may run long after precipitation events, which will need to be accounted for in the regulatory limits.

The master plan evaluates options for an annual period including the high river levels that occur in the spring. Whereas the 2002 CSO Study only evaluated CSO issues for the May 1 to September 30 recreational season, the EA No. 3042 requires year-round CSO control.

2.7 Key Drivers for the Master Plan

The foregoing section provided an overview of the CSO background issues and provides guidance on development of the key drivers for the master plan. The key drivers are specific to an individual location, so the overall costs and benefits associated with the key drivers need to be considered. The purpose of this report is to identify and document the impact of the existing system and a range of control plans on the key drivers. The most suitable path forward will be the plan with the most balanced impact on 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 for human health. Infection may be possible through direct contact and ingestion of contaminated sources. The representative contribution that CSO has in increasing this risk will be reviewed.
- Aesthetics
  - CSO discharge is a direct factor in the release of floatable material into the river systems. The appearance of floatable material along river walks and by those that commonly use the rivers for recreation may create a negative experience. Management of floatables transported through the city’s sewers can result in the reduction of floatable material in the rivers.
- Nutrients
  - Nitrogen and phosphorous 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 master plan. The health of Lake Winnipeg is a major concern and Winnipeg’s influence on this needs to be clearly outlined.
- Aquatic Life
  - CSOs can change river conditions and influence its ability to sustain life. Environmental limits are set on some of the constituents in CSO to limit this influence. The aquatic life requirements, as outlined in the Manitoba Water Quality Objectives, Standards and Guidelines, are considered in the assessment for each alternative plan.
- Public Perception
  - Many other municipalities are well along the way in implementing a control plan to deal with CSOs. CSOs have been identified as an environmental issue that needs to be addressed and the City will do their part. The public simply does not like the idea of diluted sewage entering the receiving stream. Althought this “Yuck Factor” is a real consideration, it important to educate the public on the actual impact of CSO discharges on the rivers and lakes.
- Regulatory
  - 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 the licence. The regulatory

environment is constantly changing and a program that balances the potential changes is required.

The master plan is being carried out in parallel with public engagement and regulatory consultation processes to rationalize the potential impact of this plan with all stakeholders. The range of plans will be evaluated based on the key drivers and other evaluation criteria developed through the planning process. The most suitable control plan, will be the one identified as the recommended approach. The recommendation was derived through the decision process which involved stakeholder engagement, public engagement, regulatory engagement and technical expertise. The recommended control plan is being submitted as identified in the preliminary proposal for review and agreement by the environmental regulators.

SECTION 3

Alternative CSO Control Limits

3.1 Selection of CSO Control Limits

The master plan requires that a range of CSO control limits be selected for evaluation that encompass a broad range of potential master plans without being so inclusive that the evaluation effort becomes too large and unmanageable.

The EA No. 3042 identifies specific control limits to evaluate for the collection system, and discharge limits for the captured flow. Figure 3-1 presents a schematic representation of how the licence clauses apply to the collection and treatment systems.

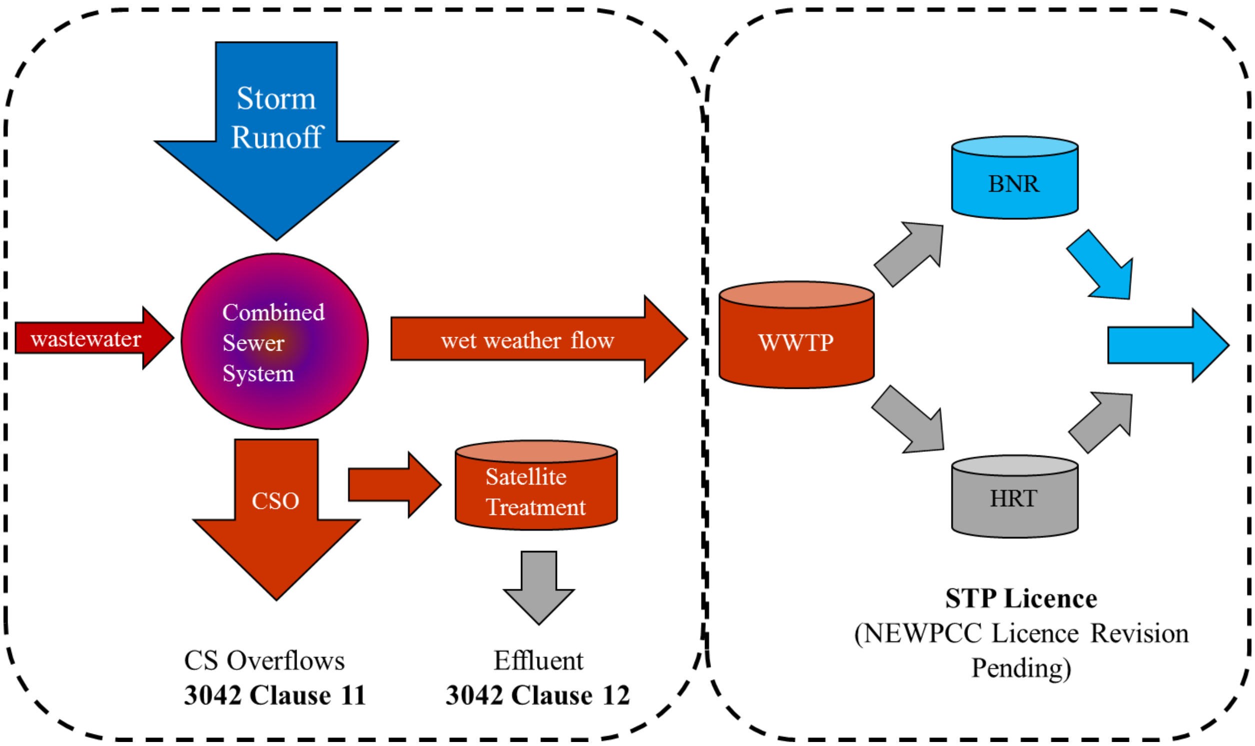

Figure 3-1. Licence Schematic

The control limits for the collection system are defined in Clause 11 and the captured combined sewage discharges are defined in Clause 12. Captured combined sewage that is conveyed to the STPs as WWF forms part of the plant flow and is regulated under the STP licences for each of the treatment plants.

3.1.1 Collection System Control Limits

Alternative collection system control limits were identified from two sources, those prescribed under Clause 11 and those of interest to the City to be considered potential alternatives.

3.1.1.1 Clause 11 Control Limits

Clause 11 stipulates that at least the following three alternatives be evaluated:

- A maximum of four overflow events per year
- Zero combined sewer overflows

- A minimum of 85 percent capture of WWF from the combined sewer system and the reduction of combined sewer overflows to a maximum of four overflow events per year. Further detail of the 85 Percent Capture limit and the approach to how it is calculated is provided in Section 4.3.2.1.

A review of the control limits prescribed in the licence indicated they were subject to interpretation, particularly when being evaluated using a representative year, which is proposed for the City master plan. Representative years are commonly used in CSO studies, with examples of their use including Edmonton, Ottawa and Toronto in Canada, and Cincinnati, OH; Evansville, IN; Omaha, NE; and Allegheny County Sanitary Authority (Pittsburgh, PA) in the US.

Most municipalities have a large historical precipitation dataset and it is not possible to run the complex and large models for all the years for which precipitation data is available. It is in the best interest of time and progress that a period representative of the long-term hydrological conditions be selected from the larger precipitation dataset. Therefore, a representative year is used to serve as a compromise between running the model over the full historical rainfall record and using just a single event, much like using a "design storm" for flood protection works.

The uncertainty in using a representative year with the clauses for the licence included the following:

- Whether the four overflow events limit was meant to be for the representative year or on a not-to-exceed basis.
- Whether the requirement for zero overflows was meant to be for the representative year, or on an absolute zero basis.

It was therefore decided to proceed based on an all-encompassing approach in which the more lenient and more stringent interpretations would be evaluated. Accordingly, the complete list of control limits is presented in Table 3-1.

Table 3-1. Alternative Control Limits

Control Limit	Description
0	Current approach to overflows
1	85% Capture in a representative year
2	Four Overflows in a representative year
3	Zero Overflows in a representative year
4	No More Than Four Overflows per year
5	Complete Sewer Separation

The following other control limits were considered, but not carried forward as alternatives for evaluation:

- Four Overflows plus 85 Percent Capture: The licence required this alternative to be considered, but it was found to already be met since meeting the four overflow limit resulted in more than 85 percent capture.
- Current approach: The City currently operates the combined sewer system with the primary objectives of avoiding dry weather overflows and maximizing basement flooding protection. Under the current program, CSOs are being reduced through sewer separation and operational improvements. While it would not be possible to meet high levels of CSO control without major infrastructure upgrading, there is a high potential for more modest operational improvements. This approach is consistent with the US EPA's nine minimum controls. The nine minimum controls are

identified as minimum technology-based controls that can be used to address CSO problems without extensive engineering studies or construction costs and can be implemented in a relatively short period of time.

3.1.1.2 85 Percent Capture in a Representative Year

The 85 Percent Capture control limit was added after an assessment was made for a knee of the curve approach. The 2002 CSO Study, as well as many other similar studies, demonstrated that there is a point where the incremental increase in performance for CSO control becomes more costly, which defines the knee of the curve. This is considered an important benchmark where the diminishing benefits from further upgrades may not warrant further investment.

The knee of the curve was found to vary depending on whether it was being determined for overflows or percent capture. After observing it was close to the 85 percent capture mark, it was decided to adopt the 85 percent capture point instead of the knee of the curve. The 85 percent capture point has the added benefit of being consistent with the US Environmental Protection Agency (EPA) approach as described in the *CSO Guidance for Long-Term Control Plan* (EPA, 1995).

3.1.1.3 Four Overflows in a Representative Year

Four Overflows in a representative year is equivalent to that used in the 2002 CSO Study and presented and reviewed by the CEC in the 2003 hearings. It is based on not exceeding a district average of four overflows over the long-term. The representative year provides the average rainfall events, and by capturing the fifth largest storm for the representative year, the limit will be met.

3.1.1.4 Zero Overflows in a Representative Year

Zero Overflows in a representative year means that the largest storm for the representative year must not cause any overflows. Since the representative year is being used and is equivalent to a long-term average, then overflows would be expected in half of the years for a long-term period of record.

3.1.1.5 No More than Four Overflows per Year

Through discussions with the MCWS working committee, it was determined that the four overflow limit was intended to apply the strict interpretation of never exceeding four overflows per year for a long-term period of record. This alternative was therefore added to the evaluation.

This is a much more stringent requirement than used for the 2002 CSO Study, because of the following:

- The worst year is limited to four overflows, which means that the average year must be less
- The "overflow event" definition from the licence is used, which means averaging of overflows is not permitted and there can be no more than four overflows to the river in the worst year

3.1.1.6 Complete Separation

It was clarified through discussions with MCWS that the zero overflow requirement was meant to be complete elimination of CSOs. The zero overflow limit is therefore to be met by complete elimination of combined sewers. By eliminating combined sewers there can be no CSOs.

3.1.2 Effluent Discharge Control Limits

The effluent treatment clauses in EA No. 3042 Clause 12 apply to the captured portion of the combined sewage, defined as follows:

> *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 (BOD5) 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

Clause 12 has been interpreted to apply to any end of pipe or centralized satellite treatment facilities not located at a STP.

The NEWPCC, SEWPCC, and WEWPCC facilities have environmental licences with specified effluent discharge requirements, and any wet weather treatment at these locations will be subject to the specific plant discharge licence.

3.2 Variations to Control Limits

There are several different interpretations and varying definitions for the control limits in addition to those previously discussed. For the master plan, the evaluations are based on a defined number of control limits, but additional variations are considered on a relative basis. This is intended to provide a method for dealing with the most important "what if" questions and provide perspective on their impacts, with a reduced effort in their evaluation.

The variations that were identified through the first phase of the master plan are listed as follows.

3.2.1.1 Representative Year

The representative year was selected from the historical database and used consistently in the evaluation.

3.2.1.2 Definition of an Overflow Event

The 2002 CSO Study did not use the overflow event definition that has been included in the EA No. 3042. This variant is intended to identify the differences and provide a perspective on the impacts.

3.2.1.3 No More Than Four Overflow Events

Not exceeding four overflows is a much higher standard than meeting four overflows for a representative year. Although it was agreed to evaluate this as a core alternative, it cannot be evaluated in the same manner as those using a representative year, and is therefore considered a variant, as described in Section 4.

3.2.1.4 Equivalent Performance

This variant would consider an approach that focuses on upgrades to the highest discharges, until the targeted control limit is met. Under this approach, upgrades would be made to the worst polluters or most cost effective upgrades. The assignment of additional CSO storage to meet the 85 Percent Capture criterion is an example of this approach.

3.2.1.5 Spatial Distribution of Rainfall

Rainfalls that occur during the summer season and cause most of the CSOs are the result of thunderstorms, which are inherently variable. Pockets of heavy rainfalls can occur in parts of the city with little, or even no, rainfall in other parts. The City maintains a rain gauge network that captures a perspective of the variation, but there has been no statistical analysis done to establish predictive relationships for the variability.

The No More Than Four Overflows alternative requires the spatial distributions to be used, and a method is applied through simple variation analysis and a limited modelling process as described in Section 4.

3.2.1.6 Other Control Limit Variants

Other variants considered but not pursued are as follows:

- Water Quality Limits – A CSO licence that allows overflows will cause the MWQSOG river limits to be exceeded during the overflow event. Therefore, these CSO discharges must be considered permitted discharges. Treating CSOs to meet the current MWQSOG river limits was not considered practical.
- Recreational Season Compliance – MCWS has clarified that year-round compliance will be required, and a program that addresses only the recreational season is unacceptable.
- Technology Based Limits – MCWS has clarified that a control limit that only specifies use of a treatment technology without discharge limits, such as primary clarification, is unacceptable.
- Loading Based Limits for Phosphorus – MCWS indicated that loading based limits may be an acceptable approach. This is not currently expected to be an issue, but may be reinitiated if satellite treatment is to be selected and phosphorus discharge concentrations become a constraint.
- Application of Clause 12 at STPs – The City has recognized that all wet weather treatment at the STP must meet plant licence limits.
- Infrastructure Renewal Integration – The City has considered potential program benefits from integrating CSO upgrades with infrastructure renewal, and will be implementing them in an opportunistic fashion during implementation, and not as part of the CSO planning process.

3.2.1.7 EA No. 3042 Licence Clarifications

As part of the master plan development, the City worked together with representatives of MCWS to reach to a common understanding of EA No. 3042. The City developed an adiditonal document which covers additional technical details for some items in EA No. 3042. This is the Licence Clarification document and is contained in Appendix C.

SECTION 4

Technical Approach

The CSO program will involve a major long-term commitment for the City with the master plan being critical to the program's definition and success. The progressive steps of identifying control limits, evaluating control options, developing potential plans, assessing their performance, and making decisions on the final master plan will have far reaching consequences. The selection from alternatives will be difficult because numerous parties are involved in the decision process with different perspectives, values, interests, and priorities.

The approach to the selection of the control limits and control options is described in the following section.

4.1 Conceptual Approach

The study's challenges include collecting and assembling information on the oldest infrastructure in the city, assessing the infrastructure and developing an understanding of its current operation, addressing a broad range of control limits, and providing meaningful performance evaluations to support an important and significant decision process.

The project delivery challenges are in developing and maintaining the right level of detail to focus on the project objectives and product quality without exceeding the budget or schedule. A conceptual evaluation was adopted because of its efficiency and expediency. Conceptual evaluations deal with broad concepts and main features, starting with a broad perspective and normally narrowing in on recommendations.

Working with an appropriate level of detail is critical to balancing the objectives. With too little detail the options may not be adequately evaluated, and with too much detail project budgets and schedules cannot be maintained. As a result, only those issues and details most significant to the decision process warrant consideration in the first phase. The first phase study was structured as follows:

- The first phase leveraged use of 2002 CSO Study findings. The extensive information collection and the scientific assessments were in large part still relevant to the current decision process.
- Meetings were held with the provincial regulators to clarify licensing issues and avoid expending effort on issues of little value.
- Two sewer models were developed using InfoWorks software, one being a city-wide all-pipes model, and the other a more skeletonized regional model better suited to the level of detail and need for quicker response times for the technical evaluations. The regional model is intended for planning level use, where less detail and quicker run times are required, while the city-wide global model is to be used for detailed assessments, and provides a tool for further development and use in the future by the City.
- The evaluation recognized the difficulty and inability to collect comprehensive sets of system monitoring information, and made use of information and experience from other programs.
- The conceptual approach does not attempt to optimize the potential plans, but to identify practicable solutions. The assessment relies on tried and true technologies with a successful track record, rather than innovative but risky approaches.
- The cost estimating process is based on an estimate classification system that recognizes a reasonable range in accuracy related to the level of project definition.

With the progressive approach, the level of detail and refinement will increase after a control limit has been selected in the decision making second phase.

4.2 Collection System Modelling

The technical approach made extensive use of computer simulation modelling of the collection systems. The study scope included setting up an InfoWorks model for the entire wastewater system, including separate wastewater sewers in addition to combined sewers.

4.2.1 Wastewater System Models

Two levels of models were prepared for the City to address their immediate and long-term modelling needs. Using two versions of models allowed for better alignment with the immediate and long-term functional and analytical requirements.

The Global Model is more detailed in terms of system information than the Regional Model. The Global Model is based on the Regional Model and was developed from available Geographic Information System (GIS) records that define all wastewater pipes and conveyance systems, such as pump stations, in Winnipeg.

The Regional Model encompasses the entire sewer system, but does not include all of the system details, only the details necessary for CSO planning and assessment. The Regional Model was developed on a fit for purpose basis for the master plan and has been used extensively to assess the CSO control options. It was used to assess the performance of the control options on an individual district basis and the potential plans on a city-wide basis for the range of control limits.

The modelling effort included the following:

- Evaluating performance under current conditions
- Estimating changes to the service area and future conditions
- Sizing control options for future conditions
- Evaluating the effectiveness of control options
- Developing and evaluating potential plans
- Developing CSO volumes and loadings for use in the water quality assessment

4.2.2 Land Drainage System Model

The project scope required high level representation of separate land drainage system flows to the rivers for water quality assessments. Skeletonized InfoWorks models were developed for this purpose instead of detailed models.

The land drainage models accounted for the following three types of discharges to the rivers within the City boundaries:

- Stormwater discharging from urban areas directly to the rivers
- Stormwater released from stormwater retention basins after being detained for a short period of time
- Runoff from small streams with drainage basins extending well beyond city limits, but with discharge points within the City

A suitable LDS InfoWorks model was created based on the runoff parameters used in the development of the Regional and Global InfoWorks models. This model was used to replicate the storm runoff flows entering Red and Assiniboine Rivers. The upstream catchments of some of the smaller rivers and creeks are expansive. Water Service Canada river gauging data for the seasonal period was used for some of the tributaries, as only La Salle had annual 1992 flow information. Missing non-recreational season data was based on the La Salle dataset. The outputs from the LDS model were used as direct inputs into the updated WASP7.5 model in the model cells closest to the outfall location into the Red or Assiniboine Rivers. The WASP7.5 model and the water quality assessment is discussed in Section 10.

4.2.3 Rainfall and Snowmelt

Rainfall and snowmelt are key input parameters for the technical assessments and directly affect control option sizing and the estimates for system performance. There were a number of challenges in establishing an approach for their use, as described in the following section.

4.2.3.1 Rainfall

Runoff from rainfall is the main cause of CSOs and it is therefore important to accurately represent in the analyses. Rainfalls must be considered on a continuous rather than single event basis because of their variability, which affects runoff rates and 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 therefore used in the evaluation.

Representative Year

The representative year approach reduces the analytical effort while providing a suitable level of accuracy for conceptual option evaluations and planning. The approach has been widely used in other studies and was the basis for the 2002 CSO Study.

With the representative year approach, the long-term records are reviewed for a single year that best represents the typical long-term conditions. The 2002 CSO Study selected 1992 as the representative year for the recreational season. The 1992 representative year had a total of 41 rainfalls above a minimum 1 millimetre (mm) threshold and is shown with rainfalls arranged in the order of depth for each event in Figure 4-1.

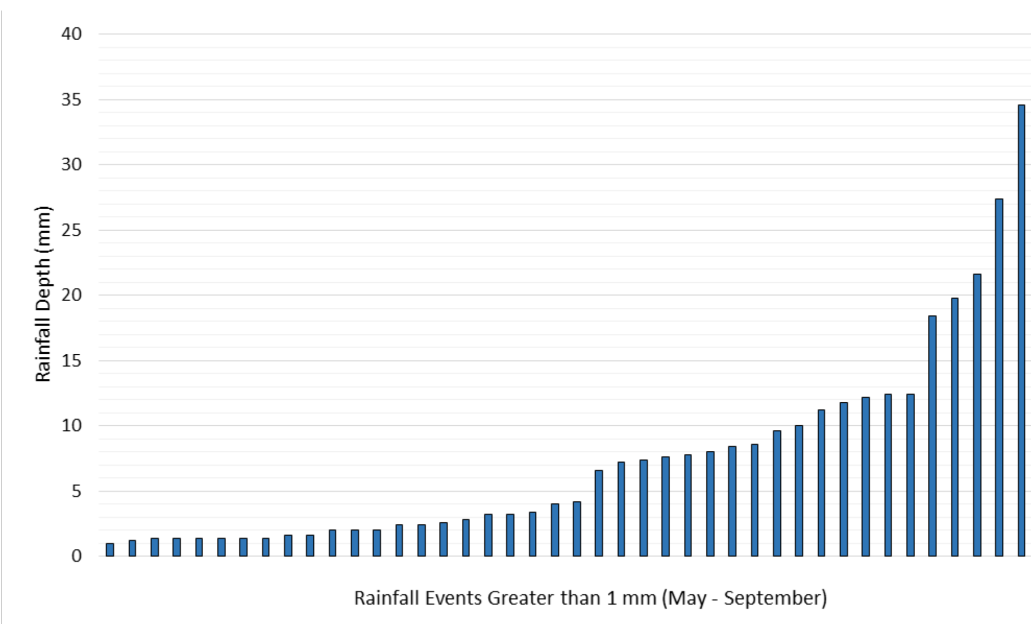

Figure 4-1. 1992 Representative Recreation Season Rainfall Depths

The 2002 CSO Study compared the volumes and intensities of rainfall ranges to long-term averages to make the selection. The representative year evaluation was updated to account for the extended period of record since the 2002 CSO Study, and 1992 was determined to still be an appropriate selection. Additionally, the period of compliance will now extend for the full calendar year, and therefore runoff from snowmelt was also considered. The evaluation was based on a statistical analysis of the annual events, as well as specific consideration for how the representative year will be applied. More detail on the representative year can be found in the Licence Clarifications document in Appendix C.

The representative year is an approach commonly used in the industry. It was used for the 2002 CSO Study as well as in similar programs such those being completed in Edmonton, Ottawa and Omaha. It provides a common basis for control system sizing and regulatory compliance that is not affected by annual variations in precipitation

The representative year is used by applying the annual 1992 precipitation events in the hydraulic model uniformly across the entire combined sewer area for the master plan.

Four Overflows in a Representative Year

Achieving a performance target of four overflows per year for the representative year means that the fifth largest storm would need to be fully captured or its runoff redirected through separation. With this objective met, there would be either more than or fewer than four overflows for each year that followed, but the long-term average would be four. This concept is illustrated in Figure 4-2. The 1992 fourth largest storm (red circle) had a total depth of 19.4 mm and there are about as many years where a fourth largest storm exceeded the one for 1992 as there are years where there were fewer.

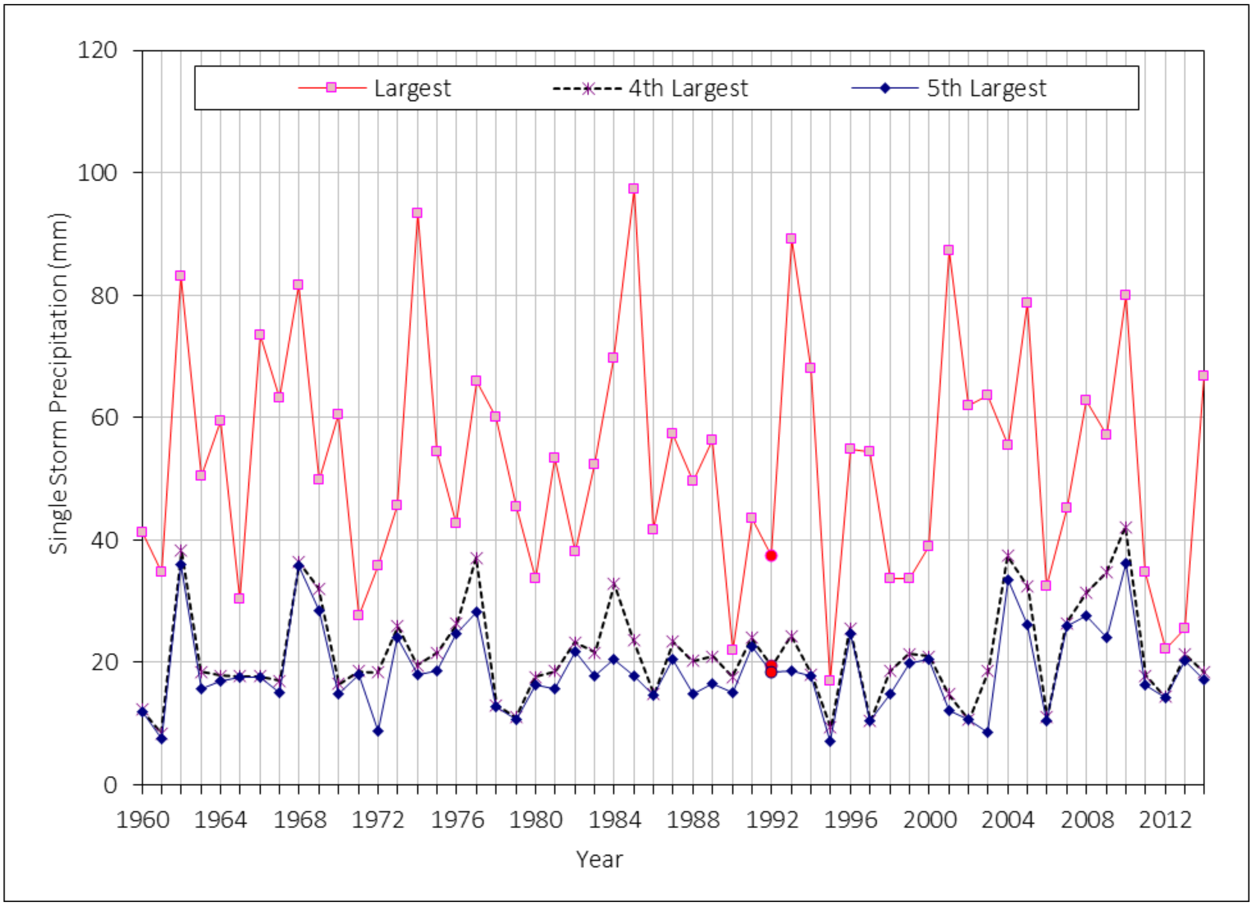

Figure 4-2. Historical Rainfall Events

Zero Overflows in a Representative Year

The storm size for Zero Overflows in a representative year varied according to specific location and district with the largest storm, shown on Figure 4-1 for 1992, being the largest for the majority of the district overflows. By ensuring the full capture of all events, there would be no CSOs for the representative year. Over the long-term there would be larger storms in other years that cause overflows, as can be seen from Figure 4-2.

Analysis of the full period of record shows that the largest storm for 1992 is also equal to the long-term fifth largest storm. This means that the largest storm also defines the not-to-exceed four overflow control limit for the long-term record. Achieving a maximum of four overflows at any one location will not meet a four overflow event limit, since the spatial distribution of the rainfalls over the large combined sewer area causes large storms to randomly occur throughout the year.

4.2.3.2 Spatial Distribution of Rainfall

The representative year uses a long-term record of rainfall data from a single rain gauge location, applied evenly across the entire combined sewer area. While this provides good probability predictions for the frequency of storms on a point basis, it misses the spatial distribution of rainfalls across the area. The City's rain gauge network, as shown in Figure 4-3, has demonstrated that a high variability of rainfall depths and intensity typically occurs across the combined sewer area for nearly every rainfall.

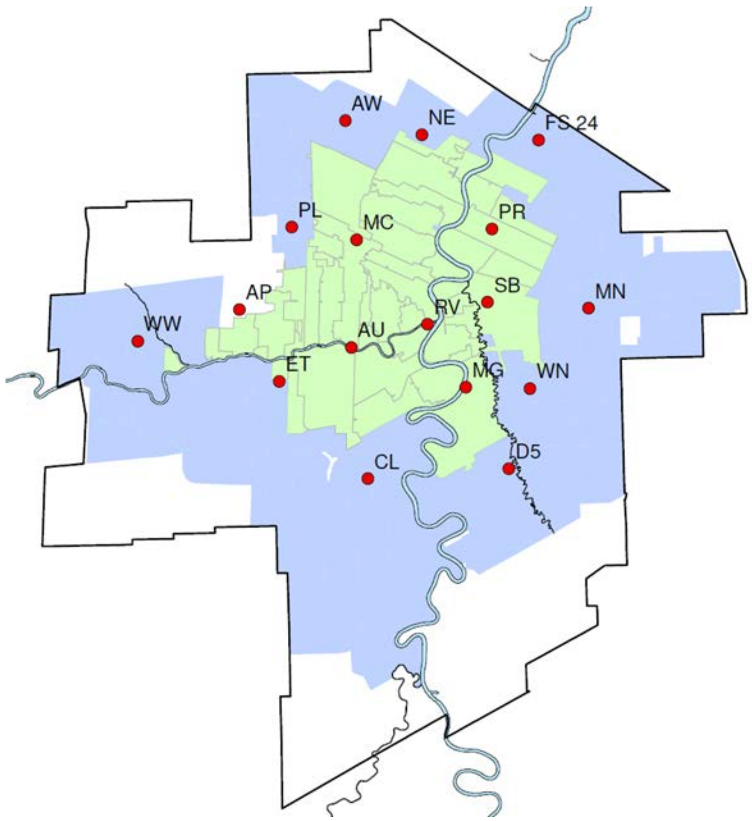

Figure 4-3. Rain Gauge Network – 1992

The rainfall distributions are illustrated by the cumulative rainfall amounts from the City's rain gauge network shown in Figure 4-4 for 1992. The 1992 representative year is shown as the dashed red line.

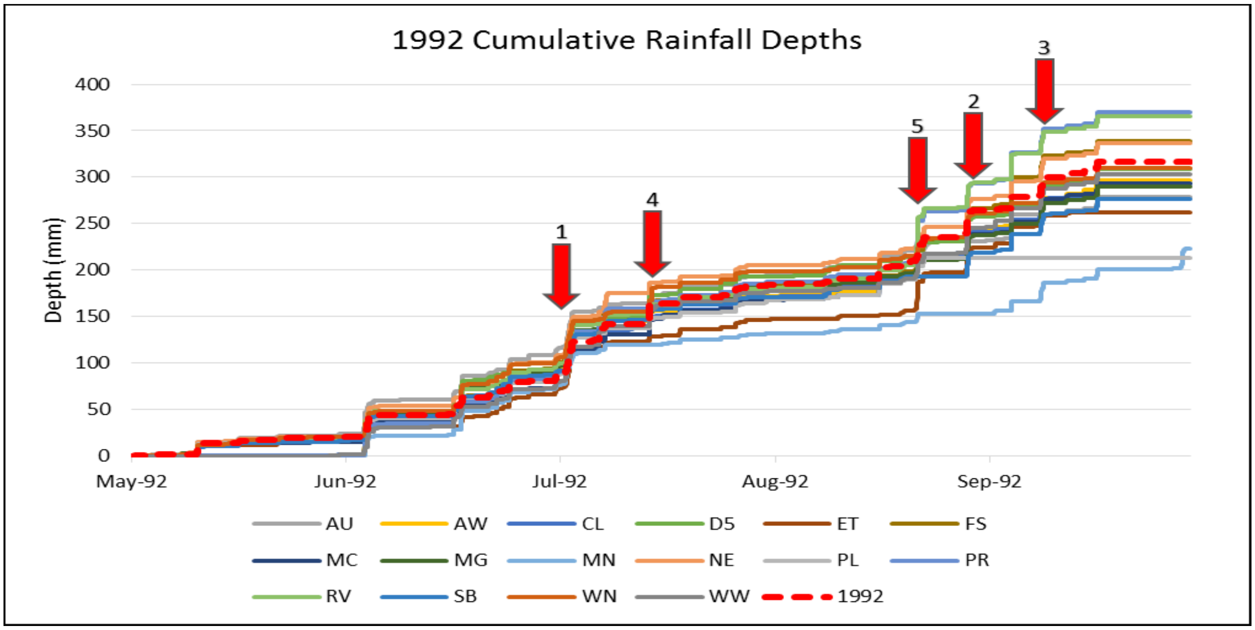

Figure 4-4. Representative Year (May-October) Cumulative Rainfall Depths

The cumulative variation shown in Figure 4-4 can be significant, particularly in reference to compliance for CSO control. The ability to evaluate control limits with these conditions is limited by the amount of data available, the absence of statistical relationships, and the processing time required for the evaluation.

No More Than Four Overflows per Year

The master plan includes evaluation of No More Than Four Overflows per year alternative, which is far more stringent than achieving an average of four overflows over all districts. Never exceeding four overflows for the worst year on record without complete separation would require spatial distributions of rainfall to be included.

The five largest events that occurred in 1992 for the 17 rain gauges in or adjacent to the CSO area were analyzed for spatial distribution. A summary of the statistical evaluation for the events is shown in Table 4-1.

Table 4-1. Spatial Rainfall Distribution Statistics for 1992

			City Rain Gauge Network Data			
		Representative Year Rainfall	Average Rainfall	Lowest Rainfall	Largest Rainfall	
Storm Number	Event	mm	mm	mm	mm	Standard Deviation
1	3-Jul-92	34.6	38.4	33.2	47.2	3.3
2	30-Aug-92	27.4	26.2	20.0	30.6	2.7
3	9-Sep-92	21.6	21.6	10.8	25.4	3.4
4	14-Jul-92	19.8	11.4	5.2	22.2	4.4
5	22-Aug-92	18.4	19.2	7.2	52.2	13.1

By assuming a normal distribution, there is a 95 percent chance that all of the rain gauges will report values within two standard deviations from the average, or a 97.5 percent chance the high limit will not be exceeded. For the representative year this means that the control options must be sized for a 45 rainfall event (38.4 mm + 2 x 3.3 mm).

Sizing of CSO control options for this limit will approximate the effects of the spatial distribution of rainfall across the combined sewer area.

4.2.3.3 Snowfall and Snowmelt

The EA No. 3042 requires year-round compliance, which means that snowmelt must be accounted for. To ensure that the modelling assessment accounted for the snowmelt aspect which occurs in Winnipeg, a detailed assessment of the snow falls and subsequent melting was completed. A liquid precipitation program written by CH2M HILL was used to convert standard precipitation data to equivalent liquid precipitation by taking into consideration the actual temperatures at the time of precipitation and whether the precipitation fell as rain or snow.

The program required inputs for hourly precipitation, daily maximum and minimum temperatures, sunrise and sunset times, snowmelt temperature, and melting rates. The output was liquid equivalent precipitation that was used to update the InfoWorks rainfall input file. This updated rainfall file allowed the CSO assessment for the full representative year of 1992.

The daily sunrise and sunset times for the representative year event of 1992 were directly extracted from the Australian Government's Geoscience Australia website for Winnipeg's latitude and longitude of 49^o 53' N and 97^o 8" W. The snowmelt program needed only monthly values for hour of sunrise and sunset (rounded to nearest hour), so that daily information was distilled to the results listed in Table 4-2 based on the hours corresponding to the rounded sunrise/sunset times from the greatest number of days each month.

Table 4-2. Monthly Sunrise and Sunset Times

Month	Sunrise Hour	Sunset Hour
January	08	17
February	08	18
March	07	19
April	06	19
May	05	20
June	04	21
July	05	21
August	05	20
September	06	19
October	07	18
November	08	17
December	08	16

The snowmelt program input data had the following assumptions to allow the liquid precipitation to be calculated:

- Units for precipitation were in inches and degrees Fahrenheit for temperature
- Hourly interval snowfall and rainfall precipitation dataset was used
- Snowmelt was assumed to occur at 32 degrees Fahrenheit at a rate of 0.09 inches per day per degree Fahrenheit, the latter of which is suggested by the snowmelt program
- Hourly temperature varies linearly between the daily minimum temperature (assumed to occur at sunrise) and the daily maximum temperature (assumed to occur three hours before sunset)
- Assessment started on October 1, 1991 to ensure snowpack was correctly accounted for at beginning of the 1992 representative year

An internal quality control review of the output precipitation data was performed. Data was adjusted where the daily snow total did not equal the daily precipitation total. This difference was presumed to be related to the actual water content of the snow. A ratio of daily precipitation to daily snow was used to reduce the snow total at each nonzero timestep.

The results of the snowmelt on an annual event basis are shown in Figure 4-5. The figure shows that two of the snowmelt events would be included in the top four events for the 1992 representative year based on cumulative depth.

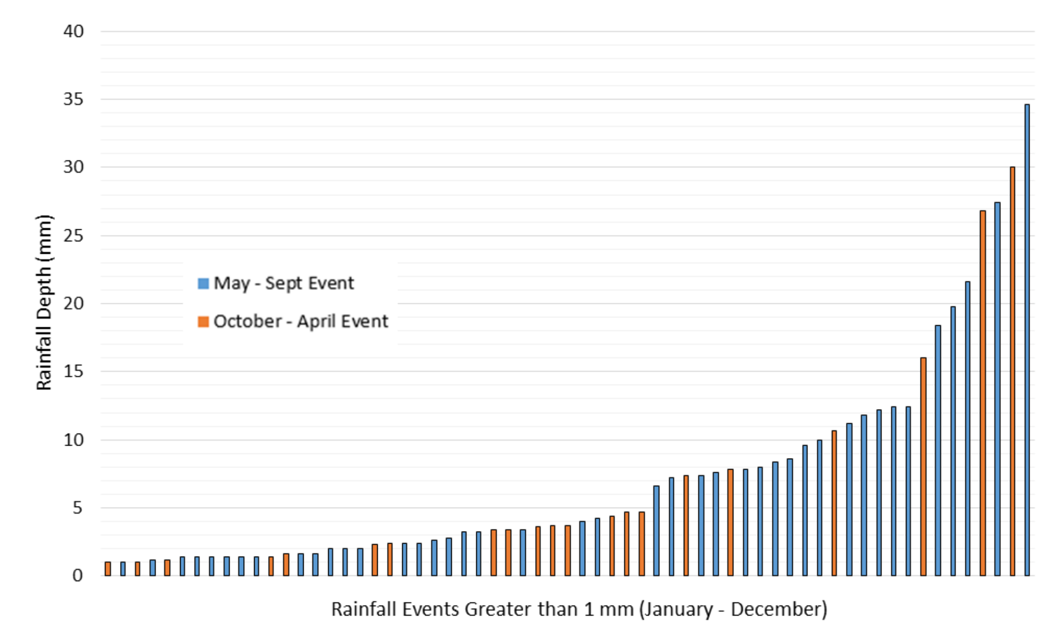

Figure 4-5. Representative Year Cumulative Rainfall Depths per Storm and Snowmelt Event

The results are not directly comparable to rainfall events for a CSO evaluation, since the rate of runoff from snowmelt is much less than that from rainfall, and the captured volume can be handled much easier because of the continual dewatering and treatment process. As shown in Table 4-2, the largest snowmelt events occur over a 2 to 3 day period. This compares to a target 24-hour dewatering period for captured combined sewage and, as a result, the snowmelt events may not necessarily cause overflows once CSO controls are in place.

Table 4-3. Snowmelt Events

	Rainfall		Duration	Depth
Date	Start	Stop	(hours)	(mm)
March 27, 1992	12:00	16:00	52	26.8
March 3, 1992	15:00	2:00	83	30

Because of the lower runoff rates, snowmelt has not been included when considering the ranking of 1992 representative year storms. Snowmelt is considered in the annual continuous series evaluations to provide comprehensive year-round results.

4.2.3.4 Climate Change

Global and regional climates are expected to change over time because of the effects of greenhouse gases on climate. Scientists have observed several environmental indicators confirming this occurrence and there is general consensus that it will continue, even with the world's best efforts to reverse the causes.

MCWS reports that Manitoba's central location in North America and northerly latitude means earlier and more severe changes to climate than in many other parts of the world. The predictions are for warmer and wetter winters and warmer and drier summers. The changes will include more extreme weather events, with more flooding and drought conditions.

Climate change is expected to have significant impacts over time, which may directly or indirectly affect the CSO program. The following list provides an indication of the potential impacts:

- Annual precipitation events are likely to vary more, with more frequent events of greater intensity.
- There will be more winter runoff because of warmer winter temperatures along with rainfall during winter months.
- Higher river levels in the spring will require more frequent use of emergency measures to protect basements.
- Lower river levels during the summer will make it more difficult to meet in steam water quality standards.

The review of climate change was limited to general observations, as follows:

- The period of record for peak annual rainfall volumes, as shown in Figure 4-2, does not indicate an increasing trend. This is a favourable trend for the CSO program, since the controls are based primarily on storage volumes.
- The historical rainfall distributions and intensities were not analyzed, and may have become more intense and more spatially distributed over time with climate change, but this would have limited impact on CSO storage volumes.
- A reduction in river flows may equire a reduction in discharges to ensure CSO continue to have a very low impact on water quality, although low and high years for river levels are to be expected and long term data would be required to determine any lasting trends.

The tools for estimating climate change include complex global circulation models and depend on a variety of assumptions, such as the trend in greenhouse gas emissions. They provide valuable insight for regional assessments, but do not provide the resolution or accuracy for specific changes, and must be supplemented and interpreted for practical applications.

The Manitoba Government Agriculture website (http://www.gov.mb.ca/agriculture/environment/climate-change/pubs/climate-change-projections-and-impacts.pdf) has summarized climate change projections from a number of sources for southern Manitoba, as follows:

- Modest increase in annual precipitation
- Substantial increase in winter precipitations
- Lower summer precipitation
- An increase in spring and fall precipitation

This assessment does not suggest there are any firm actions that should be taken at this time, but puts it in perspective as a project risk. If it turns out that rainfall volumes do in fact increase over time, or that higher discharge standards are to be met, the most likely response would be to increase the CSO capture.

4.3 Combined Sewer Overflow Control Option Assessments

4.3.1 Control Option Evaluations

The technical evaluations consider a wide range of CSO control options. In keeping with the conceptual study approach the evaluation focuses on major proven technologies. They include the same list of grey infrastructure options identified in the 2002 CSO Study, as well as consideration of green infrastructure (GI), which has seen much more use since that time.

The control options are evaluated on the basis of being applied on a single district, and then subsequently as part of a potential plan for each of the alternative control limits. In cases where the control option will not be capable of meeting the control limit by itself, its limit is still identified to facilitate use of a combination of options in the potential plan development, or for use as early action options.

The InfoWorks model provides the main control options assessment tool, with the key objective being to estimate and manage large volumes of water.

4.3.2 Dewatering Captured Sewage

Most of the CSO control options use a method of capturing and temporarily storing combined sewage with gradual dewatering to treatment. A dewatering strategy is needed for each potential plan to fit with the interceptor capacity and WWF treatment capacity. The rate and sequence of dewatering will be influenced by potential enhancements for real time controls.

The base assumption is that the full capacity of storage will be dewatered within 24 hours from the end of an overflow event. The definition of an overflow event in the EA No. 3042 states that "*An intervening time of 24 hours or greater separating a CSO from the last prior CSO at the same location is considered to separate one overflow event from another,*" which means any rainfall occurring within the 24 hours is considered the same event, but after a 24-hour dry period it is considered another event and the storage capacity must be available for use.

New or upgraded pumping capacity will be required for dewatering at each sewer district for distributed storage options. Pumping facilities must consider not only the average dewatering capacity, but the peak rates of pumping required under the strategy and the need for redundancy. In many cases the optimal solution may be to abandon existing lift stations and incorporate the DWF pumping requirements within the new pumping stations.

The storage/transport tunnel options will have a different pumping strategy and facility requirements from the distributed storage options. It would require much larger pumps, but at fewer locations.

4.3.2.1 Percent Capture Determination

The method for calculation of percent capture is defined in the EA No. 3042 and it is applied as illustrated in Figure 4-6. The general concept is for the volume represented in Item 1 (indicated by the yellow circle on the left) to be divided by the volume represented in Item 2 of the figure, with the results represented on a percentage basis.

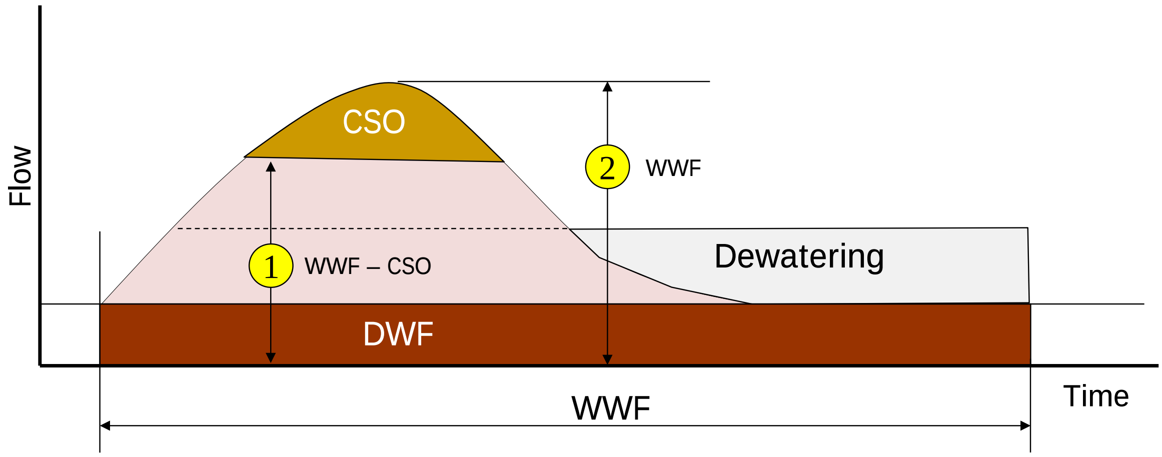

Figure 4-6. Percent Capture Representation

This clarification, as presented to MCWS, means 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. This concept is further described in the Licence Clarifications (Appendix C).

4.3.3 Basement Flooding Relief Program Integration

The BFR program has been underway for several decades and most combined sewer districts have now been provided additional relief through both the construction of relief sewers and sewer separation in various combinations, as discussed in Section 2.4.1.2. The benefits of sewer separation will be accounted for in the baseline assessments, and any potential use of increased in-line storage will be accounted for in the potential plans.

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 can be integrated into the master plan. These include Cockburn, Ferry Road, and Jefferson East.

4.3.4 Basement Flooding Assessment

Basement flooding protection is a major priority for the City, and CSO control options will avoid increasing the risk of flooding.

The general principle is that CSO options not only avoid additional risk, but also preserve the level of protection already provided. This means that water levels under storm conditions must be maintained at or below existing levels. Special considerations are therefore needed for evaluation of hydraulic impacts before options such as raising weirs can be proposed.

A high level evaluation was conducted to assess the impact of in-line storage options, which are the options where basement flooding would be most affected. The following was determined:

- A nominal increase in a fixed weir height should be manageable through options such as attention to weir placement and use of more hydraulically efficient weirs. Alternatively, effective hydraulic chamber design can offset the need for increases to weir heights.
- For higher weir height increases that could affect basement protection, the approach should be to move away from a fixed weir to a bendable or flexible weir to avoid increased head loss and the impact on upstream levels
- For even greater depths of in-line storage, a control gate should be used, with a failsafe design that folds out of the way for full flow conditions
- Floatables capture will require special considerations, and use of in-line screens or nets that accumulate debris and increasingly impede flows are to be avoided
- For any of these or other options that impact exiting upstream water levels, off-setting control options, such as use of GI or partial sewer separation, should be considered to maintain the existing level of basement flooding protection in the area

4.4 Wet Weather Flow Treatment Evaluation

All of the combined sewage that is captured and temporarily stored must be sent to treatment facilities and treated to the specified limits before release. The captured sewage must be dewatered, treated, and released within 24 hours since the system storage must be restored for the next rainfall event. The increased flow that reaches treatment as a result of these events is called WWF and will require either high rate treatment at an existing treatment plant or be sent to a new site with satellite treatment.

4.4.1 Discharge Limits

Wet weather discharge limits are defined by the environmental licences. Combined sewage that flows to an existing treatment plant will fall under the existing treatment plant licence, while combined sewage treated offsite from the STPs must comply with the discharge limits defined in Clause 12 of EA No. 3042. A comparison of the CSO limits to those for the STPs is included in Table 4-3.

Table 4-4. STP Licence Compared to the Environment Act Licence

		STP Effluent Limits		EA No. 3042, Clause 12	
Parameter	**Units**	**Limits**	**Compliance**	**Limits**	**Compliance**
$CBOD_5$	mg/L	25	Annual 98%	-	
BOD_5	mg/L	-		50	Not to exceed
TSS	mg/L	25	Annual 98%	50	Not to exceed
E. coli	MPN/100 mL	200	Monthly geometric mean	1,000	Not to exceed
Total Residual Chlorine	mg/L	0.02		-	
Total Phosphorus	mg/L	1.0	30-day rolling average	1.0	Not to exceed
Total Nitrogen	mg/L	15	30-day rolling average	-	
Ammonia Nitrogen	kg/24 hours	Varies		-	

Following are the differences in the effluent discharge limits that will affect the evaluations, shown in Table 4-3:

- STPs have higher limits for $cBOD_5$, TSS, and *E. coli*
- The phosphorus limit for satellite treatment has a not-to-exceed requirement
- There is no ammonia limit for satellite treatment

4.4.2 Treatment at Existing Facilities

The City is undertaking a major expansion and upgrading program for its STPs to increase the level of service to meet more stringent environmental regulations.

The WSTP upgrades are primarily driven by the need to add nutrient removal to both the NEWPCC and SEWPCC processes to meet the new environmental regulations, which were proclaimed into law under Bill 46, The Save Lake Winnipeg Act. The WEWPCC has already been upgraded to biological nutrient removal (BNR), and will not require further upgrading to meet the new limits.

The SEWPCC has proceeded ahead of the NEWPCC upgrading program, and is currently at the detailed design stage. In addition to BNR, the upgrades will include a new ACTIFLO HRC system to manage WWFs.

The NEWPCC is currently at the planning stage. An updated licence is pending for the NEWPCC, which will include the requirements from Bill 46. According to the June 19, 2011, letter of approval for the NEWPCC plan, the NEWPCC licence will have discharge limits similar to those for the SEWPCC with a maximum inflow rate of 705 mL/d.

Preliminary discussions on NEWPCC have indicated that an HRC facility similar to the one being designed for the SEWPCC will be included to treat flows above the 380 ML/d BNR capacity. This is assumed to be the base condition for the master plan.

4.4.2.1 NEWPCC Alternative Wet Weather Treatment

A second option for WWF treatment has been included for review in the master plan based on the findings of both the 2002 CSO Study and the North End Master Plan (NEMP) (TetrES et al., 2009).

The NEMP was completed in October 2009, well after the 2002 CSO Study, and expanded on the study's assessment. The investigations found that the maximum practicable flow rate that could be delivered through the interceptor system and treated at the plant without significant impact to the biological process sizing was 825 ML/d. Subsequent study done as part of the 2012 NEWPCC Upgrading Plan has revised this number fo 705 MLD.

The NEMP developed the design concept for the 825 ML/d option in greater detail, based on Licence 2684RR in effect at the time. For WWF treatment the NEMP assumed the following:

- ACTIFLO was selected as the basis for HRC design. Three HRC basins would be constructed with a design capacity of 425 ML/d (825-380), with one basin being fully redundant.
- Ferric chloride would be used for flocculation, with polymer and ballast sand also needed for the process.
- The ACTIFLO would produce a very thin sludge that requires thickening and disposal.
- Sludge disposal was assumed to be by lime stabilization as a separate onsite process, with ultimate disposal at a landfill.
- The WWF process required extensive chemical use for short durations. The process would add significantly to site traffic for chemical supply and sludge hauling.

4.4.2.2 SEWPCC and WEWPCC Wet Weather Treatment

The CSO program will have far less impact on the SEWPCC as compared to the NEWPCC. The master planning process will review the potential impacts to the facilities, but it is not expected that major modifications will be considered in depth for the first phase of the master plan.

Combined sewer discharges to the WEWPCC are even less significant than for the SEWPCC, and do not warrant in-depth investigations for the first phase of the master plan.

4.4.3 Satellite Treatment

The amount of combined sewage that can be sent to the STPs may be limited by the discharge limits for the blended effluents. Satellite treatment offers the opportunity to treat additional combined sewage rather than having to implement the more costly sewer separation alternative to reduce the volume.

EA No. 3042 provides the following unique set of discharge limits that would be applied to satellite treatment facilities:

- The limits are generally less restrictive than those for the STPs, except for the phosphorus limit, which would almost certainly require a method of enhanced treatment.
- The absence of an ammonia discharge limit is significant, since HRC will not remove ammonia and the new daily discharge limits for ammonia in the STP licences would be difficult to meet during the summer months when rainfall is the highest and ammonia limits are lowest.

A major drawback to satellite treatment is that it must be located offsite of the STP to be applicable. This requires the acquisition, approval, and development of a suitable site and building of process connections and transportation infrastructure.

4.5 Potential Plan Development

Potential plans are independent alternatives, with the plan selected to be carried forward to the next phase of master planning. Potential plans are developed for all the alternative control limits using one or more of the CSO control options. There are at least a half dozen proven CSO control options to be selected from, but it is not necessary or even likely that only a single control option will be used for area-wide implementation.

The potential plan development process first reviews individual control options and how they would be applied to each district. Each of the control options may have physical or practical constraints, or be too costly, which would warrant use of a combination of options. The control options are then applied on a regional bases to the entire combined sewer area, considering the balance among local controls, interceptor capacity, sewage treatment, and sewer separation.

The basic approach to potential plan development is as follows:

- In-line storage is generally considered as a low cost logical first step, but may be limited because of an increased risk in basement flooding and operational drawbacks. The potential plan evaluation includes consideration for the incremental benefits and increasing risks of progressively raising the levels of storage in the combined sewers. In most cases, in-line storage would fall far short of meeting any of the control limits on its own.
- Readily accessible offline is considered with in-line storage in the initial evaluations. In cases where insufficient offline storage is readily available, then tunnel storage will be considered as a supplement or as a replacement.

- After assessment of individual district control options, regional options that involve storage/transport tunnels will be considered. Storage/transport tunnels have the advantage of serving multiple districts and increasing the conveyance capacity to treatment.
- Treatment at WPCCs may be limited by the hydraulic carrying capacity of the interceptors and the ability to meet WPCC effluent discharge limits. Additional WWF treatment capacity can be achieved through satellite treatment.
- Potential plans will also consider the balance between sewer separation and control options. Sewer separation is generally the most expensive control option, but its cost may be offset by its use for BFR and the reduction in treatment capacity required.
- GI will be considered for its potential as a control option or as a supplemental option. Because of its versatility, it can be either incorporated into the potential plans at the time of their development or added on at any subsequent time.
- Complete Sewer Separation is to be considered as a standalone option.

4.5.1 Potential Plan Modelling Approach

The assessment of potential plans commenced with the InfoWorks modelling of incremental changes to the static weir level in the main combined sewer outfalls. These incremental increases matched the potential arrangements that could be added to the system to increase the in-line storage volumes.

These arrangements were as follows:

- Static weir increases – basic level increases associated with increasing the level of the existing static weir level
- Flexible weir – level increase to match selected flexible weir (no increase beyond existing upstream manhole level at the basement flooding point)
- Control gate – half pipe initial level, with the gate opening fully when the hydraulic level reaches the half pipe height
- Full pipe – use of a control gate to full pipe level, with the gate fully opening when the hydraulic level reaches full pipe height

Each of the weirs and gates was assessed for the full 1992 representative year event. This provided an indication of the relative storage volumes within each of the combined sewer systems. Not all locations were assessed for each of the four weir/gate arrangements as the existing weir level is at or above half pipe level, such as Bannatyne, with a weir level above full pipe level.

Where additional storage was necessary to meet the control limits, storage elements were sequentially added to the InfoWorks model based on an assessment of suitable storage by visual inspection for constructability.

The storage facilities were assessed as follows (in the order of preference):

- Latent storage – by pumping of the SRS pipes to remove all water being held in the system by the downstream river level
- Offline storage – offline storage facilities were added in strategic locations
- Storage tunnels – large pipe storage was added at locations where storage was needed to meet the control limits. Each location immediately upstream of the CSO location along the line of the existing trunk was used

A dewatering strategy was based on meeting the minimum period of 24 hours between one event finishing and next event commencing. Therefore, the maximum 24-hour dewatering period was used to define the pumping capacities at each storage facility.

The potential plan development process will inherently account for differences in control limits. For example, the extent of separation or need for satellite treatment will increase as the control limits get more stringent. This will provide for relative comparisons of the implementation plans, their budgets, and time frames to be made and considered in the performance evaluations.

4.6 Peer Review

A peer review was completed after the initial alternative control plans were identified. The review was added to the program to add confidence and credibility to the master plan by providing an external review and comparison to other similar CSO programs. A summary report of the peer review process is included in Appendix D.

The process included a review of lessons learned and advice from the other communities, not only for the technical approach, but also for perspective on stakeholder involvement, regulatory issues, and plan development. This provided insight on the best way for the City to proceed with their own CSO master plan.

Peers were invited from communities known to have been working on CSO control for several years, concentrating on communities that are similar to Winnipeg. It was considered important to include Canadian experience, but also to incorporate some experience from the US, which has much different regulatory requirements but similar technical issues. The participating Peers were from the following communities:

- City of Edmonton – Edmonton is the only city in Alberta with combined sewers and has many similarities to Winnipeg.
- City of Omaha – The geography, rivers, and combined sewer system in Omaha are much like those in Winnipeg, and in spite of having different regulatory requirements, there are many similarities between the CSO programs.
- City of Ottawa – Ottawa has proceeded with the planning and implementation of facilities on a scale similar to Winnipeg to address its CSOs.
- Metro Vancouver – The Vancouver situation is different from Winnipeg, with protection of salmon and local beaches being a priority, and Metro Vancouver has proceeded with a long-term sewer separation approach.

The peers unanimously concluded that the City’s planning to date is consistent with industry best practices. The peers suggested that the City CSO program could benefit from further interaction with other peer communities, including visits to other cities with active CSO control programs. Overall, the peers agreed that there is no “silver bullet” solution for CSOs. They agreed that no item or alternative that could substantially improve the City’s approach to CSO control had been overlooked in the work to date.

4.7 Cost Estimating

The development of costs for each of the potential plans is important in the master planning process. Cost estimates were used in two ways, firstly to identify the range of costs for control options applied to each district as part of the control option selection process, and subsequently to identify costs for potential plans as part of the decision process. Costs were difficult to determine and are subject to uncertainty and potential variation, which is typical of a planning study of this nature.

The Program Alternative Cost Calculator (PACC) tool was adjusted for Winnipeg conditions and used in the development of cost estimates. This tool was developed to provide planning-level cost estimates for CSO and other conveyance type projects, and has been used many times on similar studies.

The estimating process developed a Class 5 estimate, based on the Association for the Advancement of Cost Engineering (AACE International) cost classification system. Consistency in costing for a planning study is as important as estimate accuracy, since the options are evaluated on a relative scale, and not simply total cost. Some of the input costs are well known from previous local works, while others that are new, such as large tunnelling, are much less certain. Previous information such as the more detailed sizing and cost estimating for the wet weather treatment facilities from the treatment plant work was used as appropriate.

The sizing information for each potential plan, along with the unit costing, is the base of estimates.

Costs are developed for the construction projects, and factored for project capital costs and lifecycle costs using standard multipliers.

4.8 Water Quality Modelling

Water quality modelling of the receiving streams is included to identify as-is and project future water quality performance for the potential plans and to estimate their benefits.

The following number of modelling tools have been used to support the water quality assessment:

- The WASP7.5 model focused on in-stream water quality.
- Loading models including the regional InfoWorks model of the sanitary and combined sewer systems and the newly prepared InfoWorks LDS model were used to determine the inputs to WASP7.5.
- The loadings models were also used as input to the spreadsheet model to estimate loadings entering and exported from the Winnipeg study area.

4.9 Performance Evaluations

After the potential plans were identified they were reviewed for performance. The performance evaluations identifies the merits and benefits for each potential plan, which was then compared to their total and incremental costs. This assessment provided input into the decision making in the second phase of the master plan.

The performance criteria in this preliminary report includes the tangible metrics that define the control limits, objective criterion from the regulatory process, and those identified by the study team. These are supplemented in the decision making phase by new criterion as identified by other sources such as the stakeholder advisory committee.

The performance criteria for the potential plans that have been identified include the following:

- Number of overflows, which will be calculated using the InfoWorks model based on the regulatory or variant definitions
- Percent capture, calculated in accordance with the regulatory definition
- River water quality assessed using the water quality model
- Health and illness risk was reviewed in detail under the 2002 CSO Study. The method and relationships developed for the 2002 CSO Study will be maintained for the master plan
- Basement flooding for potential plans using the InfoWorks drainage model

The performance evaluation process recognizes that other criteria may also affect the decision and are to be included in the subsequent decision process.

Public Engagement

Proceeding with the CSO program will require a major capital investment in infrastructure, leading to river water quality benefits. As with most large public infrastructure projects in Winnipeg, various stakeholders and the community at large could be impacted in different ways. Engaging with these diverse interests provides insight on the public's values, and provides important information in the decision process. Therefore, a comprehensive public consultation and stakeholder engagement strategy was developed for the master plan, with City taking the lead on the program design and execution and the consulting team providing technical input and resource support for the program.

The consultation program consisted of several methods of stakeholder and public engagement, beginning in January 2013 and continuing through the project. The program is intended to communicate what CSOs are and why their mitigation is important, while gauging what is important to the general public in terms of the priorities and values that might shape the level of control and master plan. The strategy has been targeted at several groups, including interest groups, government agencies, and the public at-large.

5.1 Objective

This public engagement program was designed to assist with three interrelated objectives: public education, consultation, and communication.

1. **Education** - to inform residents and stakeholders about CSOs and the factors the City will use in developing specific components of the master plan.
2. **Consultation** - to gather information from residents and stakeholders that may impact and influence specific directions in the master plan.
3. **Communication** - to communicate facts about the master plan, particularly as it relates to taking action on emerging legislation and City policies.

5.2 Public Engagement Program

Several tools were selected to meet the goals of the public program. These tools included a dedicated project webpage (including blog posts, an animation, and project details), a stakeholder advisory committee, and a series of public events. The consultation and engagement efforts are one of several components of the master plan process, and is part of a multi-phase project timeline, as shown in Figure 5-1.

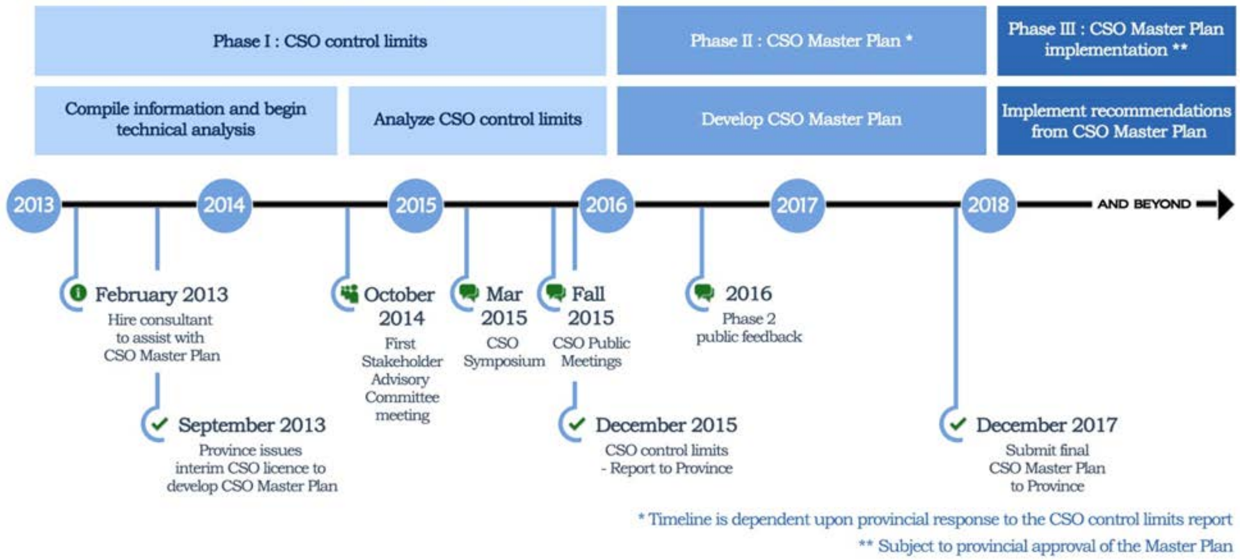

Figure 5-1. CSO Project Timeline

The public program was developed in alignment with the technical study, but in some cases the method of representation of complex issues and representation of results were modified and simplified to facilitate clearer understanding for the general public, as follows:

- Phase I of the public program encompasses the first two phases of the technical study, with a completion schedule for the end of December 2015.
- Several of the terms commonly used in technical works have been renamed for public use, such as the use of “average year” rather than “representative year.” The convention used for public programs has been adopted in the technical works where it could be readily accommodated without loss of significant interpretation.
- Reporting of results has been simplified for the public program. The public and all interested parties are to refer to the detailed technical reports when addressing specific technical issues.

Details of the public engagement program are presented in Appendix D.

5.3 Public Program Input

The public program provides key input into the master plan study direction and the decision process, as follows:

- Public opinion on the levels of performance and program expectations can help define the range of technical evaluations and issues to be considered.
- Public opinion is important in the decision process. Public values will be considered in the evaluation and rating of potential plans and control limits, which will ultimately define the final master plan.
- The Minster of Conservation and Water Stewardship will review the public engagement program and values defined by the public in setting of the final licence.

SECTION 6

Regulatory Liaison

Experience with many other CSO projects across North America has shown the collaborative approach between municipalities and the regulators to be the most successful. Development of the master plan is complex because of the many interrelated issues, and the collaborative approach provides the opportunity for disseminating information, building knowledge, and preparing for the decision process concurrently for both City and regulatory participants in a transparent manner, with the ultimate goal of consensus building and informed decision making.

The regulatory engagement process is also linked and feeds into the public engagement component, since public engagement and communication is a recommended activity and often a regulatory requirement.

6.1 Regulatory Liaison Approach

This regulatory liaison program was designed to assist with the following three interrelated objectives:

1. Information Transfer – to create a venue for MCWS, the City, and their consultants to communicate technical information.
2. Knowledge Building – to raise the collective body of knowledge about CSOs and the factors the City will use in developing specific components and recommendations for the master plan.
3. Design Process Communication – to communicate facts about the master plan, particularly as it relates to taking action on emerging legislation and City policies.

The three phased structure for the master plan was intended to provide progressive decision making and program development. The first phase, reported in this document, focused on system assessment and development of a broad range of alternative control limits. The decision process in the second phase reviews the alternatives in greater detail and identifies the merits of each for use in a decision process. The goal was to have all of the required decision information in place by the end of the first phase to support visioning and informed decision making, with no surprises. The final phase assumes that the regulatory control limits from the second phase will be used to produce a program identifying district-by-district CSO control projects.

6.2 Regulatory Engagement Format and Structure

Regulatory engagement was established using defined lines of communication and protocols, namely keeping the formal lines of communication and primary contact directly between the provincial regulators from MCWS and the City project manager.

6.2.1 Regulatory Liaison Committee

The Regulatory Liaison Committee (RLC) serves as the primary forum to facilitate high-level communication between the master plan study team and the regulator. The RLC is made up of representatives from various branches of the regulator, the City, and its consultant.

Regulatory engagement with the RLC is led by the City project manager and follows the general approach to work collaboratively as follows:

- Make contact early in the project and establish a collaborative approach
- Maintain continuous communication and transfer of knowledge

- Provide accurate and timely documentation of the project
- Uphold a cooperative, respectful relationship throughout the project
- Work through the regulatory issues and licence requirements in a purposeful manner to reach the goal of submitting the preliminary proposal

The City's project manager maintains regular communications with the project team and consultant management team with workshops as a key component of the engagement. The workshops facilitate communication, allowing each group to provide their perspective and understanding of the current situation and the expectations for the application of EA No. 3042.

Regulatory engagement focused on the following:

- Experience Elsewhere - providing a general review of CSO programs from around North America, considering their performance targets, plans, progress, and levels of success
- Performance Targets - considering metrics such as the number of overflows per year, the percentage of capture, and end of pipe discharge limits
- Compliance Monitoring and Reporting - exploring methods of measuring, quantifying, and reporting combined sewer system performance
- Control Options Assessment - discussing components of various CSO control systems to develop an appreciation for the infrastructure and operational components of CSO control systems

RLC workshops were held on November 6, 2013, November 3, 2014, and June 15, 2015. A further workshop was held on October 26, 2015 as part of visioning and decision making phase of the study.

6.2.2 Regulatory Working Committee

The Regulatory Working Committee (RWC) was formed after the regulatory workshop on November 3, 2014, to facilitate routine technical communication and collaboration. The RWC is made up of select representatives of the regulator, the City, and its consultant.

The RWC meetings have provided the forum for discussion of EA No. 3042, raising overall technical awareness, and any items that require clarification. Three RWC meetings have been held to-date, on December 18, 2014, March 3, 2015, and May 19, 2015. Topics presented through the RWC included the following:

- Use of representative year
- Definition of an overflow
- Definition of percent capture
- Definition of phosphorous discharge
- Clause 11 interpretations
- MCWS raised awareness of potential regulatory issues
- Preliminary proposal review process
- Need for "reader friendly" version for public and senior government reviews
- CSO MP Affordability Analysis

A Licence Clarifications document (Appendix C) was developed and is under review by MCWSas a result of the RWC reviews.

Combined Sewer Overflow Control Options

The overall objective of EA No. 3042 is to assess the impact of CSOs and to develop a suitable plan to manage them. The performance of the control options are assessed in comparison to the performance of the existing or baseline system in this section.

The existing system and baseline is representative of the collection system configuration at the time of the study in 2013. The baseline is the starting point that is used to compare the impact of adding control options and any other system modifications. Control options are applied to the existing system to minimize CSOs and to maximize the percentage of wastewater flow that is treated before being discharged. The control options presented in this section are assessed for their ability to reduce the number and volume of CSOs for each individual combined sewer district. The overall system is also being evaluated for percentage of capture of CSOs and the volume of pass-through flow to the WPCCs. The InfoWorks combined sewer hydraulic Regional Model was the main tool used in the evaluation of the options and the results of each evaluation are presented in the following sections.

Each of the control options is considered sequentially for each district and extended to application across the entire combined sewer area. The control options provide the foundation for development of potential plans discussed later in the report, where combinations of control options are applied on an area-wide basis to meet each of the alternative control limits.

7.1 Baseline Condition

The existing or baseline condition for the combined sewer collection system is represented by the system configuration in the InfoWorks models as prepared in 2013 and 2014. By defining the baseline conditions for the performance metrics, the level of improvement can be evaluated and applied to benefit-cost type assessments. The evaluation of baseline conditions will provide the basis for tracking progress as the CSO program moves forward.

For the purposes of the master plan, the baseline year is considered to be 2013. This is the year that the InfoWorks hydraulic models were built to represent the existing system. Any reference to the existing, current, or baseline is referencing the collection system in 2013. The Regional Model was used with the 1992 rainfall and river levels to simulate the system response for the baseline conditions and for all altenative control options unless otherwise stated.

7.1.1 Runoff Volume

Runoff is the portion of the system flow in a combined sewer that originates as rainfall or snowmelt and drains off of the land surface. Runoff volume is the volume of runoff that potentially enters the combined sewers in a defined period of time. Runoff volumes have been calculated from rainfall or snowmelt inputs through the use of the InfoWorks Regional Model. The runoff volumes can be impacted by the type of development present in the catchment area and the type of ground conditions. This can dictate how the runoff volume infiltrates, evaporates, is detained, or moves directly to the sewer system. The amount that makes its way through the sewer system and is either collected and treated or overflows to the rivers as CSO is the runoff volume.

The combined sewer area runoff volume for the 1992 representative year as calculated for each WPCC service area is listed in Table 7-1. The existing system as represented in the Regional Model with the 1992 representative year rainfall and river level data was used to produce these results.

Table 7-1. Runoff Volumes for the 1992 Representative Year

Treatment Area	Non-recreation Season	Recreation Season	Total Volume of Runoff
NEWPCC	4,410,000	7,202,000	11,612,00 m^3
WEWPCC	96,000	190,000	286,000 m^3
SEWPCC	225,000	449,000	674,000 m^3
Total Runoff Volume	4,731,000	7,841,000	12,572,000 m^3

The 2002 CSO Study addressed CSOs during the recreational season, but this requirement has been changed to year-round under EA No. 3042. The master plan therefore reports on the year-round basis, but also retains the recreational season perspective for purposes of assessing compliance with the MWQSOG. The characteristics of overflows and the way they are managed are significantly different for each perspective. Typically, runoff from snowmelt occurs over a much longer duration and at a much slower rate than summer rainfalls. High river levels in spring require special management of the overflow sites through the use of flood pumping rather than gravity discharge.

The City has maintained a program for elimination of dry weather overflows for many years. The infrastructure includes diversion structures located at every combined sewer outfall, along with lift stations where pumping is required to divert the flow to the interceptor. The diversion structures completely capture all DWFs and runoff from small rainfall or snowmelt events. An illustration of the sewage capture and overflows for the existing system is presented in Figure 7-1 for the 1992 representative year.

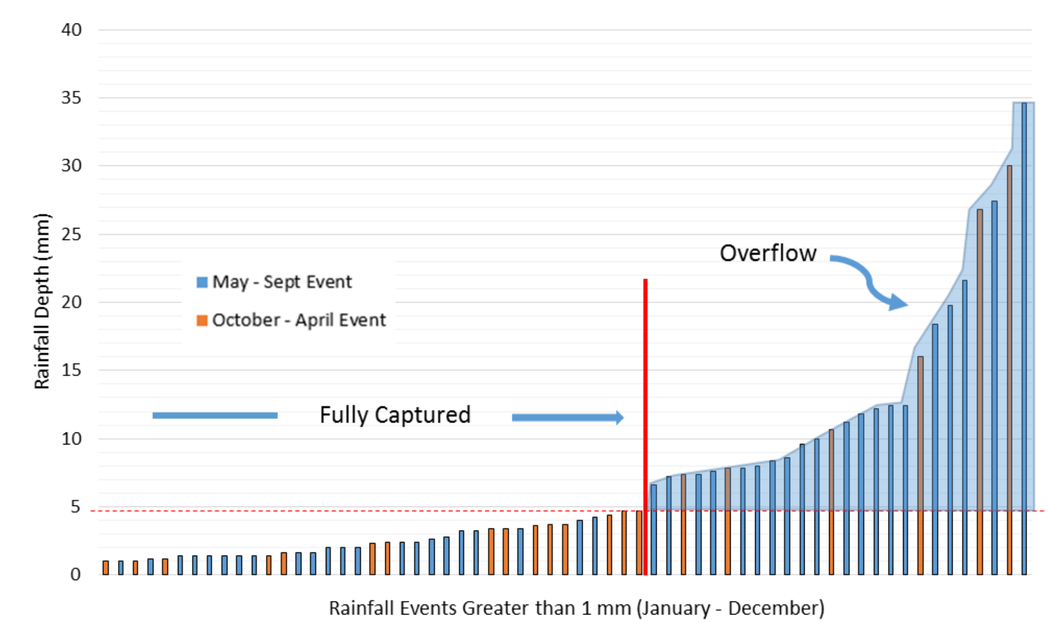

Figure 7-1. Rainfall Capture Illustration for the 1992 Representative Year

Figure 7-1 shows the representative year events, greater than 1 mm in depth, sorted from smallest to largest. Since the diversion weirs are higher than what is required for DWF alone they also fully capture runoff from small runoff events. For the example shown in Figure 7-1, a rainfall event of about 4 mm would be fully captured, and therefore overflows for about half of the runoff events are eliminated. The runoff events that are not fully captured produce CSOs as shown on the upper right side of the figure.

The number of overflows for the existing system configuration for the 1992 representative year are shown in Figure 7-2 for each of the 41 combined sewer districts with a primary outfall. The Jefferson West and Munroe Annex districts do not have an outfall that flows directly to the Red River and are not included in the reporting throughout this section. This is the baseline figure for the number of overflows, shown in terms of the recreation season, non-recreation season, and year-round values.

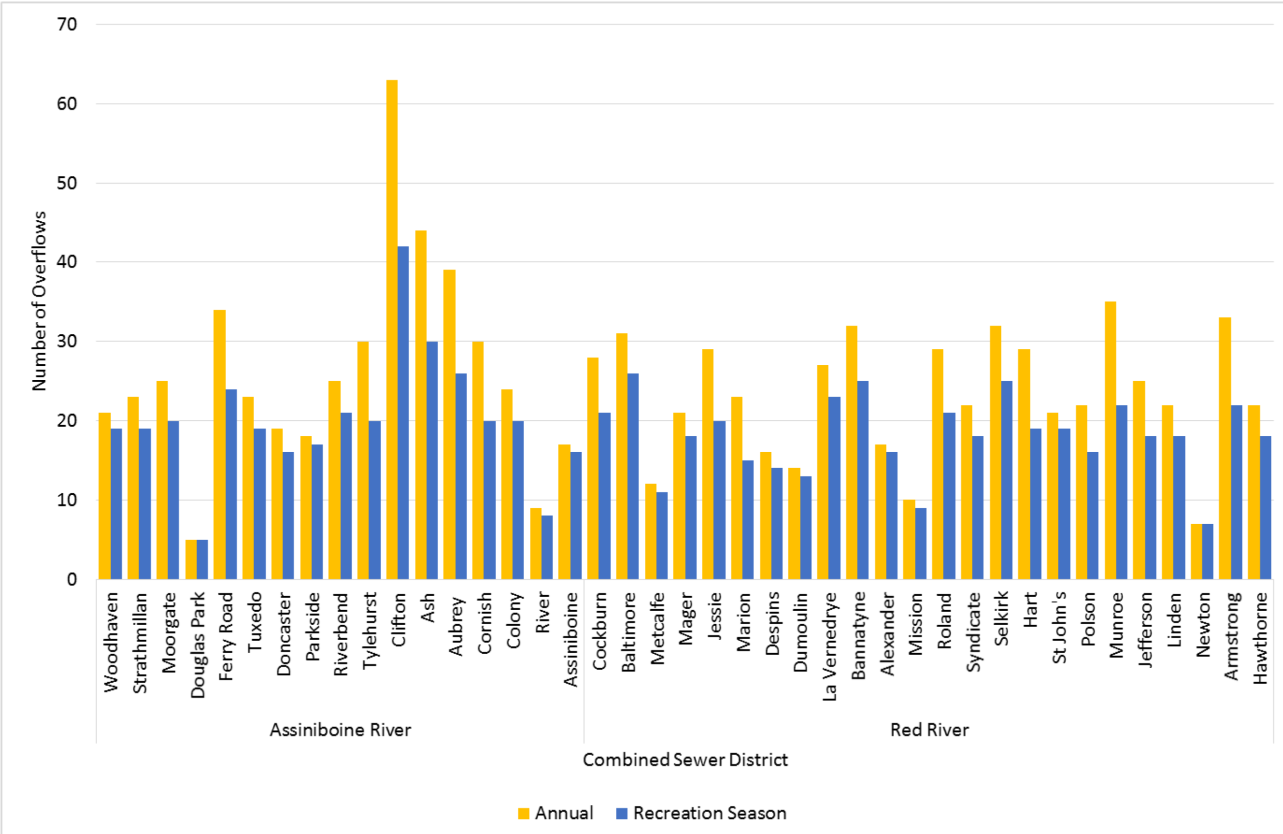

Figure 7-2. Baseline Number of District Overflows – 1992 Representative Year

The number of overflows on an area-wide basis is listed in Table 7-2 for the alternative methods for reporting overflows. The total number represents all overflows independent of location or coincidence of occurring at the same time as others.

Table 7-2. Number of Overflows for the Alternative Reporting Methods

Reporting Alternative	Recreation Season	Year-Round	Total
	(Average Number of CSOs per Period)		
2002 CSO Study	18	30 [b]	1297
Master Plan	18	23	1008
EA No. 3042 Definition	42[a]	63[a]	1008

Note:
[a] Based on the outfall with the highest number of overflows
[b] From 2005 Year-Round Assessment (Tetres, 2005)

The basis for the number of overflows reported in the table is explained further as follows:

- The 2002 CSO Study was based on averaging the number of overflows for each district for the 1992 representative year. The year-round requirement was identified after completion of the study with the results updated based on work completed in 2005 (TetrES, 2005).
- The master plan adopted the 2002 CSO Study method for calculating the number of overflows by also using the 1992 representative year. The change in the values from the 2002 CSO Study results from an increased level of detail and improved evaluation accuracy.
- The number of overflows for the EA No. 3042 is based on district-wide overflow events as described in Section 3 for the same 1992 representative year. Using this definition, the reported number of overflows is much higher for the same data set. Both of the current methods are considered for potential plan evaluations in this report.

A similar graph showing the recreational season and year-round volume of overflows for each of the 41 districts with a primary outfall for the 1992 representative year is included as Figure 7-3.

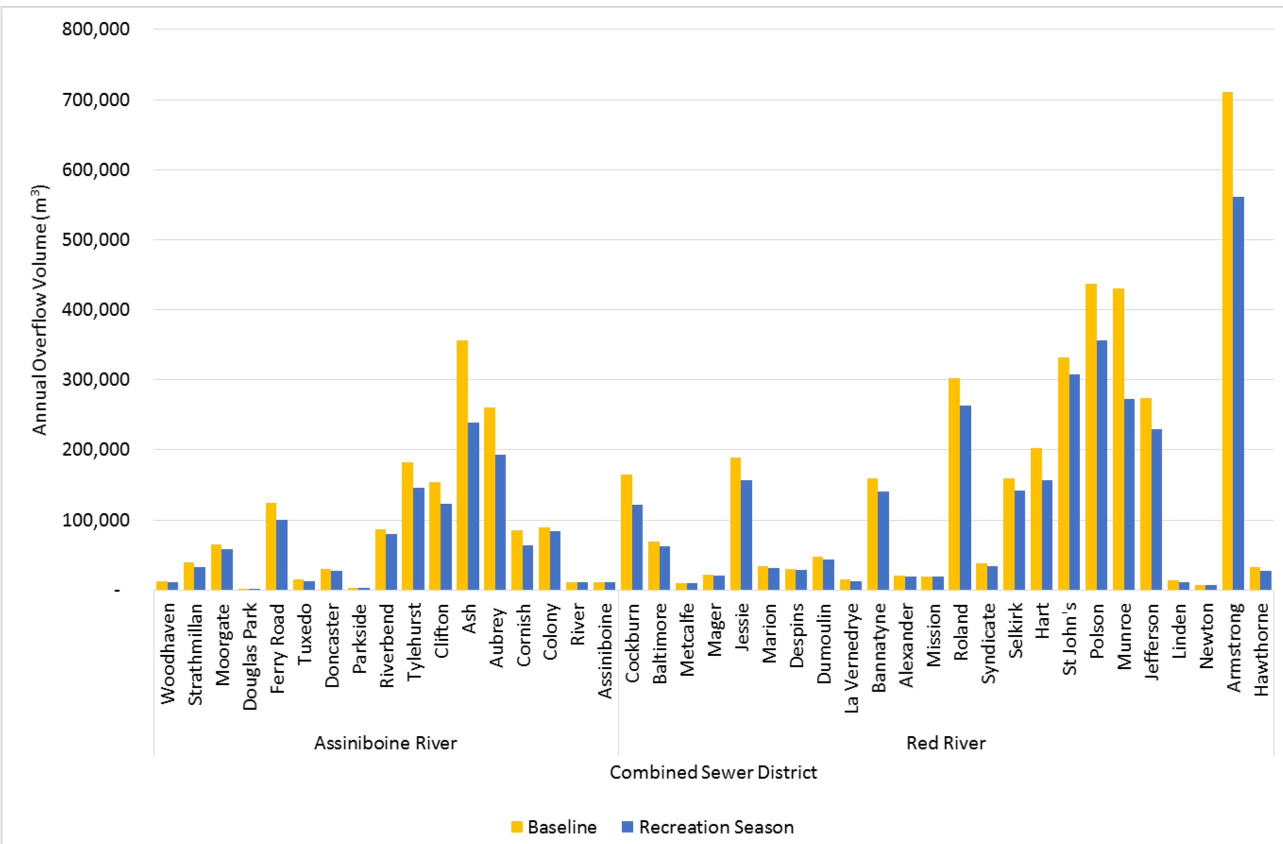

Figure 7-3. Baseline Annual CSO Volume per District – 1992 Representative Year

Figure 7-3 illustrates the following:

- The volumes of CSOs vary widely on an individual district basis, generally in proportion to the size of the districts.
- The highest CSO volume is for the Armstrong district, which is impacted by the inflow of separate land drainage from four separate sewer areas. The removal of these separate areas and corresponding runoff volumes should be considered as an early action as it uses interceptor and NEWPCC treatment capacity.

- The total CSO volumes for the 1992 representative year are 4,240,000 m^3 for the recreation season and 5,260,000 m^3 for the full year.

Percent capture is another performance metric identified in the EA No. 3042, which will be determined as described in Section 4.3.2. The baseline percent capture, calculated in accordance with the definition in Section 4.3.2.1, for the 1992 representative year on a system wide basis is approximately 74 percent.

7.1.2 Baseline Adjustment

Setting the baseline performance at 2013 will provide an accounting for improvements made from the start of the CSO Master Plan, but will not account for prior work completed. An optional approach is to include all improvements for the full period of record, or at least since the last program completed under the 2002 CSO Study.

7.1.2.1 Accounting for the Basement Flood Relief Program

The first major BFR upgrades took place on combined sewers in the 1960s on Winnipeg's inner-city systems. The second program started in 1977 and since then, the City has invested more $300 million in improving the sewer systems. The completed work has included selective sewer separation under the BFR program that provides CSO mitigation benefits.

The separation and relief completed as part of the ongoing BFR program has helped to reduce the number and volume of CSOs and may be considered as progress the City has made in dealing with CSOs. A number of combined sewer districts have had work planned and completed, the more recent work is shown in Table 7-3.

Table 7-3. Combined Sewer District Relief and Separation Project History

District	Status	Dates of Construction
Cockburn	Ongoing (Outfall Completed)	2014 –
Ferry Road / Riverbend	Ongoing (Contract 1, 2, 3, 4)	2013 –
Jefferson East	Ongoing (Contract 1, 2, 3, 4)	2012 –
Mager	Complete (Contract 1, 2, 3)	2009 – 2011
Alexander / Bannatyne	Complete (Contract 1, 2, 3, 4, 5, 8)	2005 – 2010
Strathmillan / Moorgate	Complete (Contract 1, 3, 4, 5, 6, 7)	2002 – 2005
Dumoulin / La Verendrye	Complete (Contract 1, 2, 3)	2002 – 2004
Marion / Despins	Complete (Contract 1, 2, 3, 4, 5, 6)	1998 – 2003
Boyle / Syndicate	Complete (Contract 1, 2, 3, 4)	1995 – 2002

In addition to those listed in Table 7-3, a number of other districts have had varying degrees of relief and separation work completed. These districts include Ash, Assiniboine, Aubrey, Baltimore, Clifton, Colony, Hart, Jefferson W, Jessie, Linden, Munroe, Munroe Annex, Polson, River, Roland, Selkirk, St John's and Tuxedo.

The completed work could be used to adjust the baseline from the existing 2013 system back to prior to the beginning of the relief and separation work. The adjustment would have positive implications in how the progress is reported including an increase in the percent capture and reduction in the average number of overflows. The baseline adjustment does not change the program goals and objectives, but should be used to demonstrate the progress made.

7.2 In-line Storage

In-line storage is a commonly used CSO control option, and was reported in the 2002 CSO Study as a viable option with readily available low-cost storage. Its advantages arise from the combined sewers having large volumes of readily available storage because of their large diameter and shallow slopes. The pipes are nearly empty most of the time, and their capacity is only fully used during high intensity rain events. The available storage has been even further enhanced with the addition of large storm relief sewers under the BFR program. Accessing the in-line storage would off-set the need for much more expensive CSO control options.

In-line storage would be achieved by restricting some or all of the flow from the combined sewers. It could range from a small increase in the height of the fixed weir to temporary blockage of the discharge with storage to full height of the pipe. The control devices located at the outfall end of the sewers would cause the sewage to back up in the sewer and gradually be pumped to sewage treatment.

The following concerns with in-line storage were considered as part of its review and evaluation:

- May increase the risk of basement flooding. This is particularly true for the addition of controls that impact the rate of flow from the sewers or have mechanical components that may fail during operation.
- Most of the combined sewers are old and the stresses from repeated filling and draining may accelerate their deterioration.
- The reduced rate of draining may increase sediment buildup in the sewers and result in greater production of sewer gases and odour generation.

There are engineering approaches to address most of the operational concerns, with the risk of compromising the level of basement flooding protection being of most concern. The master plan has approached the review of in-line storage on an incremental basis, beginning with the lowest cost and lowest risk options first.

7.2.1 Latent Storage

Latent storage refers to the storage in the SRS pipes that lie below the river level and cannot dewater by gravity because of backpressure from the river on the flap gate. Latent storage is the most easily accessible type of in-line storage, and must be accounted for with all in-line options because of the interconnections between the SRS and combined systems. Figure 7-4 shows how latent storage may occur at a typical outfall.

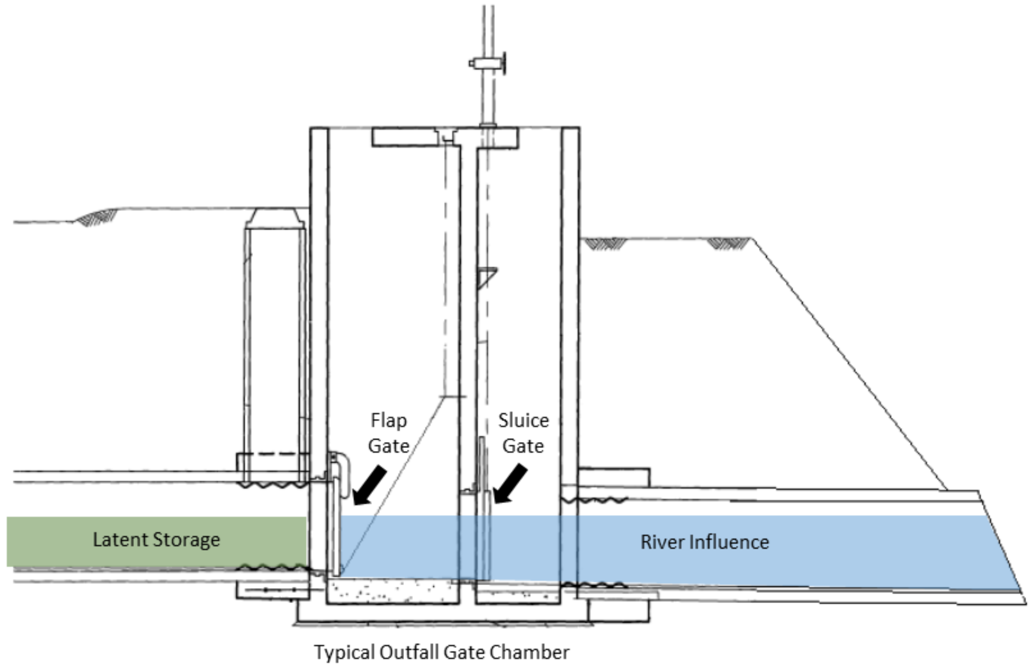

Figure 7-4. Latent Storage Schematic

Latent storage is conceptually easy to access and has low risk. Changes needed to the system to access the storage are minimal (a dewatering system and a flap gate). The system performance would be expected to be as good or better for basement flooding protection.

The dewatering system would include a lift station to fully drain the SRS and maintain it in an empty condition in preparation for the next runoff event. Conventional lift stations would be used for this purpose, with forcemains and gravity sewers used to direct the discharge to sewage treatment.

Not all combined sewer districts have SRS systems, so only those with SRS outfalls are considered for latent storage. The available volume of latent storage for each district at the normal summer river water level (NSWL) and the 5-year summer river levels are shown in Table 7-4.

Table 7-4. Latent Storage Potential in SRS System

District	Number of SRS Outfalls	Volume at NSWL m^3	Volume at 5-year Summer River Level m^3
Ash	2	1,800	12,800
Assiniboine	1	400	2,400
Aubrey	2	18,300	38,000
Baltimore	4	1,600	4,000
Bannatyne	1	1,700	7,600
Clifton	1	20	7,600
Colony	1	4,400	8,600
Cornish	1	1,500	4,300
Jessie	1	0	20
Mager	1	0	0
Marion	1	600	900
Munroe	1	0	20
Polson	1	7,600	18,400
River	1	1,300	4,700
Selkirk	1	1,700	5,300

The total available latent storage for the NSWL is 41,000 m^3. The amount of storage would increase as the river rises and would reach 115,000 m^3 at the 5-year summer river level.

The annual CSO volume comparing the latent storage option to the baseline for the 1992 representative year at the NSWL is shown in Figure 7-5. The reduction in volume attributed to the latent storage is noted by the difference between the yellow and blue bars.

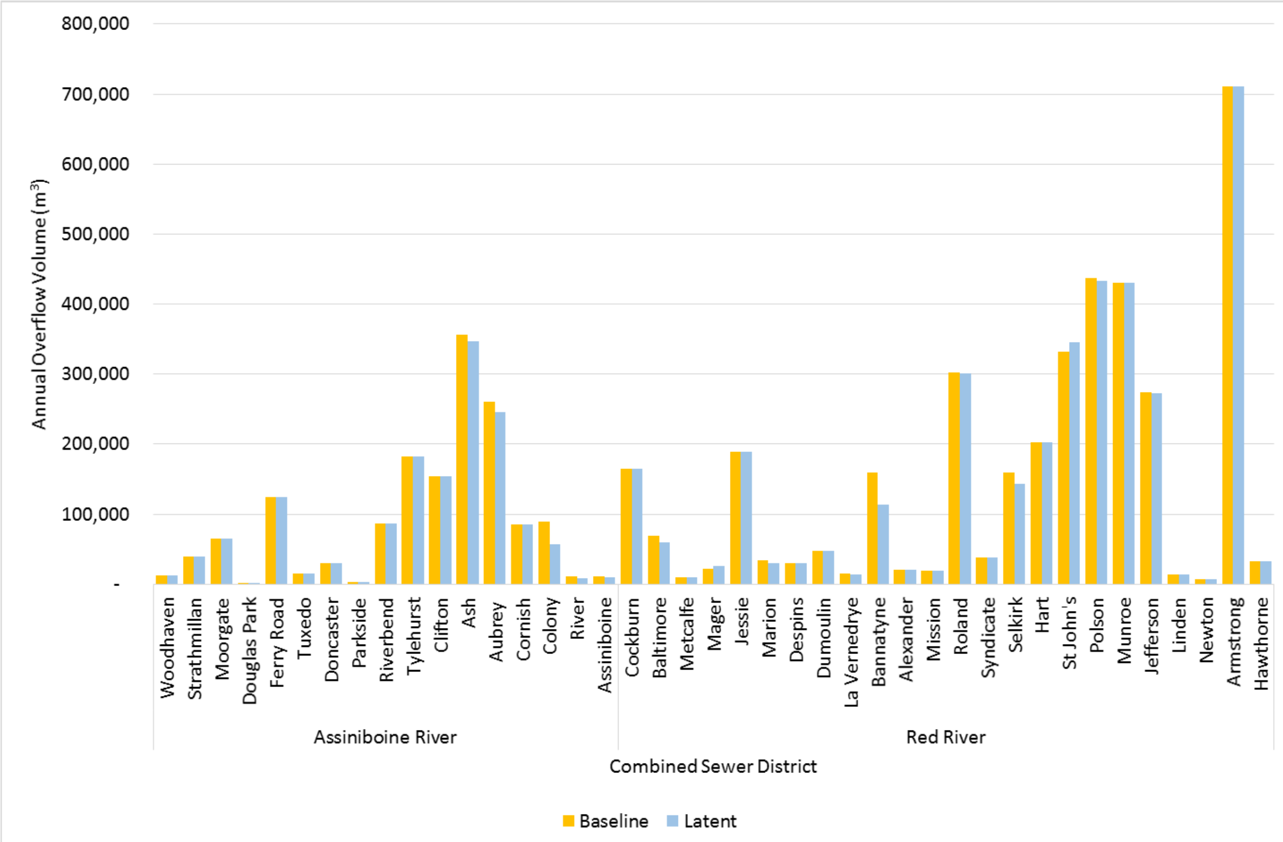

Figure 7-5. cso Volume with Latent Storage – 1992 Representative Year

The latent storage would operate for nearly every runoff event during the year. On a year-round basis it would reduce the volume of overflow by 130,000 m^3 and the frequency from 23 to 22.

The benefits of latent storage are modest on a city-wide basis. It can only be applied to 12 of the 43 districts and only provides a fraction of the storage volume needed to meet the control limits as stated in the current version of EA No. 3042. However, it uses readily available storage, and it could provide significant improvements for some individual districts. It could also be considered as an early action initiative.

7.2.1.1 SRS Flap Gate Control

By its definition, latent storage is controlled by backpressure of the river on the SRS outfall flap gate, and therefore a mechanical gate control is not required. However, when used in combination with in-line control options on the combined system, the two must be considered together, and discharge controls must be added to the SRS whenever in-line water levels increase above the river level. For this reason gate control for SRS must be considered with other in-line options, whether the latent dewatering is planned to be included or not.

The simplest method to control discharge from the SRS when storage levels exceed the river level is with flap gate control. The assumed method would be through installation of a gate such as the Grande Water Management ACU-GATE. These gates are equipped with flap latches that are hydraulically powered. The latches normally open and close when energized, which provides a fail-safe operation. If power is lost the latch would open with the flap gate being able to swing open normally.

7.2.1.2 Constructability

Latent storage takes advantage of infrastructure that is already in place. New dewatering lift stations would be required to transfer the collected combined sewage back to the collection system. This requires a connection from the SRS outfall and a forcemain from the lift station back to the combined system. Overall, this additional infrastructure takes on a relatively small footprint.

7.2.1.3 Operations and Maintenance

Additional lift stations will create added operations and maintenance (O&M) requirements. This will partially depend on the method of gate control selected for the outfalls. A hydraulically operated gate like the ACU-GATE would require inspection after each time it is operated. The control of the SRS outfalls also requires in-system level and flow monitoring to optimize the control of the pumps in the lift station and to control the outfall gate.

7.2.2 Raising Fixed Weirs

A simple approach for increasing CSO capture would be to raise the height of the existing diversion weirs. They are normally constructed of cast-in-place concrete in the form of a curb or lip across the invert of the sewer, as shown in Figure 7-7. They are set at a fixed height determined as the level that equates to 2.75 times the depth of average DWF. The depths specific to each district have been previously determined from flow monitoring and manual calculations. The weir height is typically only a fraction of the pipe diameter; therefore, raising the weirs would capture more sewage with it easily being diverted to the interceptor and routed to treatment.

Figure 7-6. Typical Combined Sewer Diversion Weir and Off-take Pipe

The InfoWorks Regional Model was used to estimate the height the weirs could be raised without compromising the level of basement flooding protection. The Global Model will be used to recheck system hydraulics once the required control limit and option is selected. It was determined that the weirs could be raised by a wide range, ranging from 0.1 m to a height of 2.1 m. The following was noted from the evaluation:

- In some cases, an increase to the weir results in changes to the sewage pumping operation because of the increase in wet well levels and the existing pump on-off set points.
- During high river levels, the discharge is controlled by the river level and flood pumping system and raising the weirs would have little or no effect.

Figure 7-7 shows the results for raising the fixed weirs in comparison to the existing conditions for the 1992 representative year. Latent storage is not included in this set of results.

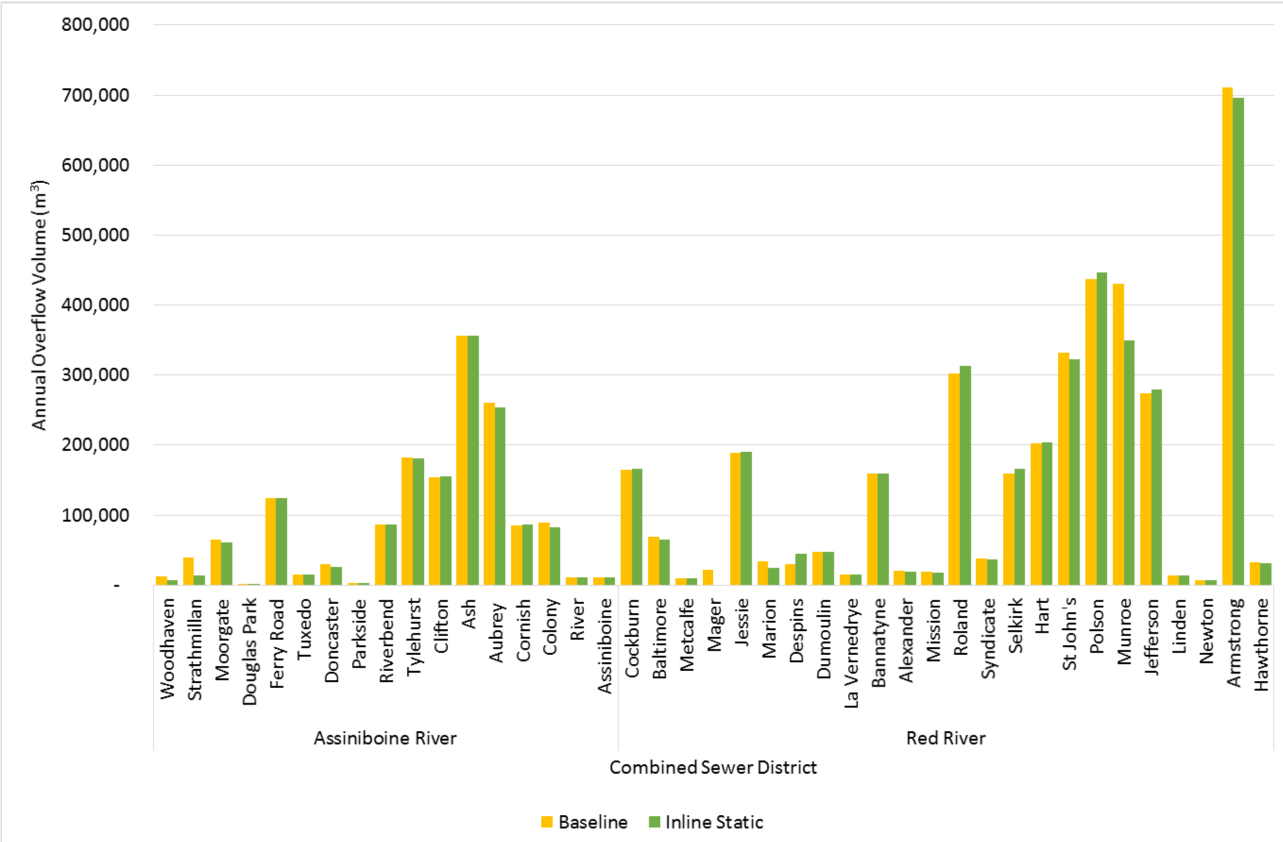

Figure 7-7. In-line cso Volume from Raising the Fixed Weir – 1992 Representative Year

The CSO volume reductions are quite modest for raising the weirs in most districts because of the limitations to weir height and the limited additional volume captured. The actual benefits, as is the case with latent storage, would be far less than needed to meet the control limits considered for the master plan. However, there are a number of locations worthy of further consideration and more detailed evaluations, particularly as early action items.

The total static in-line volume achieved by increasing the static weirs has been estimated as 18,400 m^3.

Raising the fixed weirs is the only CSO control option considered in the master plan that impacts combined sewer discharges under normal operation at high flows. An increase in weir height creates the potential for higher upstream levels, which may affect the risk of basement flooding. The hydraulic behaviour of the increased weir heights would need to be evaluated in detail prior to implementation so the level of basement flooding protection is not compromised.

When a potential impact is identified, there are several methods that can be considered for accommodating the higher weirs, if an increase in water level is to be prevented, which vary in complexity, including the following:

- Install a more hydraulically efficient weir to achieve the same upstream water levels
- Include off-setting measures to reduce flows and restore the water levels to their original values, such as sewer separation, additional SRS, or use of GI in the catchment area

As with all other in-line options, the diversion of flow from the combined system into the SRS would need to be investigated and included in this option where warranted.

7.2.3 Flexible Weirs

Flexible weirs, which in some cases are referred to as bendable weirs, are an alternative to fixed weirs and have greater storage potential. When flexed or bent, the weirs pass the same flow as fixed weirs and are not detrimental to the level of basement flooding protection. At lower water levels, the weirs return to their normal vertical position, with a crest height much greater than a fixed weir, with a greater volume of water captured. The operation of a flexible weir compared to a static weir is illustrated in Figure 7-8.

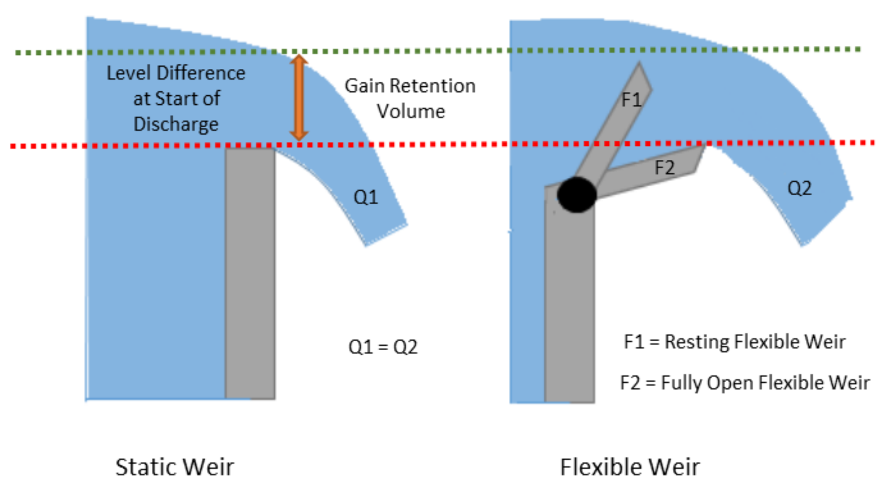

Figure 7-8. Flexible Weir vs Static Weir Schematic

Flexible weirs were evaluated with the InfoWorks model for each combined sewer district. The static weir or what would represent the flexible weir in the flexed position was set to either the existing static weir height or was increased to maintain a maximum weir height of 1.5 m if this was hydraulically permitted. The total static in-line volume achieved by applying flexible weirs is approximately 30,300 m^3.

The annual overflow results for the flexible weirs are shown in Figure 7-9 for the 1992 representative year, not including latent storage.

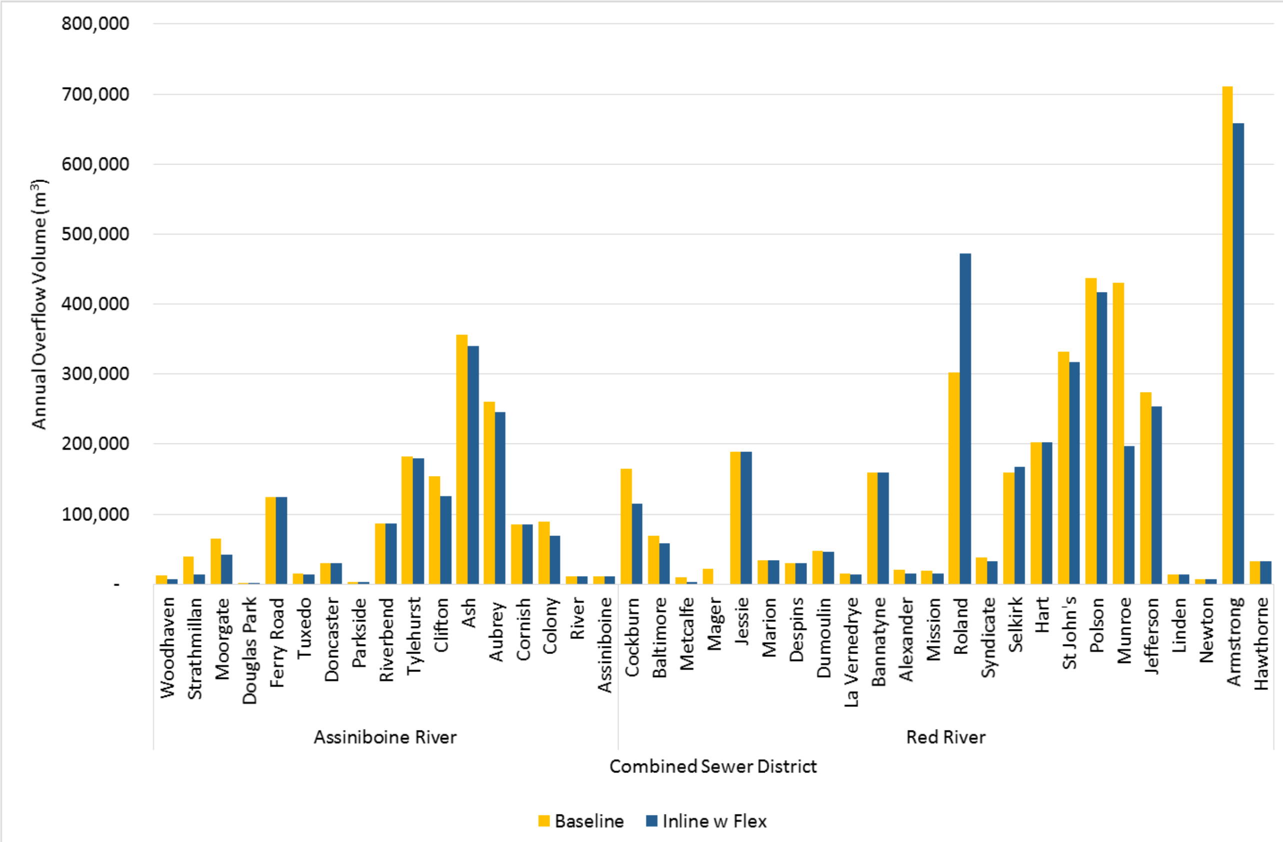

Figure 7-9. In-line cso Volume with Flexible Weirs – 1992 Representative Year

The evaluation found that flexible weirs generally outperform increasing the height of fixed weirs. The addition of flexible weirs do not achieve the control limits identified in EA No. 3042. They provide viable options for early actions and would work well in combination with latent storage.

7.2.4 Control Gates

Control gates can capture higher volumes of in-line storage, depending on their height. The gates must be fail-safe to meet these requirements and must not have a negative impact on basement flooding protection.

The Grande Water Management Systems TRU-BEND overflow bending weir was a reasonable match for these requirements. It is a product specifically designed for use in CSO applications, as shown in Figure 7-10. It pivots from the bottom and would lie flat and remain fully open during high flows. The TRU-BEND uses counterweights instead of a motorized system to maintain a fixed upstream level, without the use of any external power or controls.

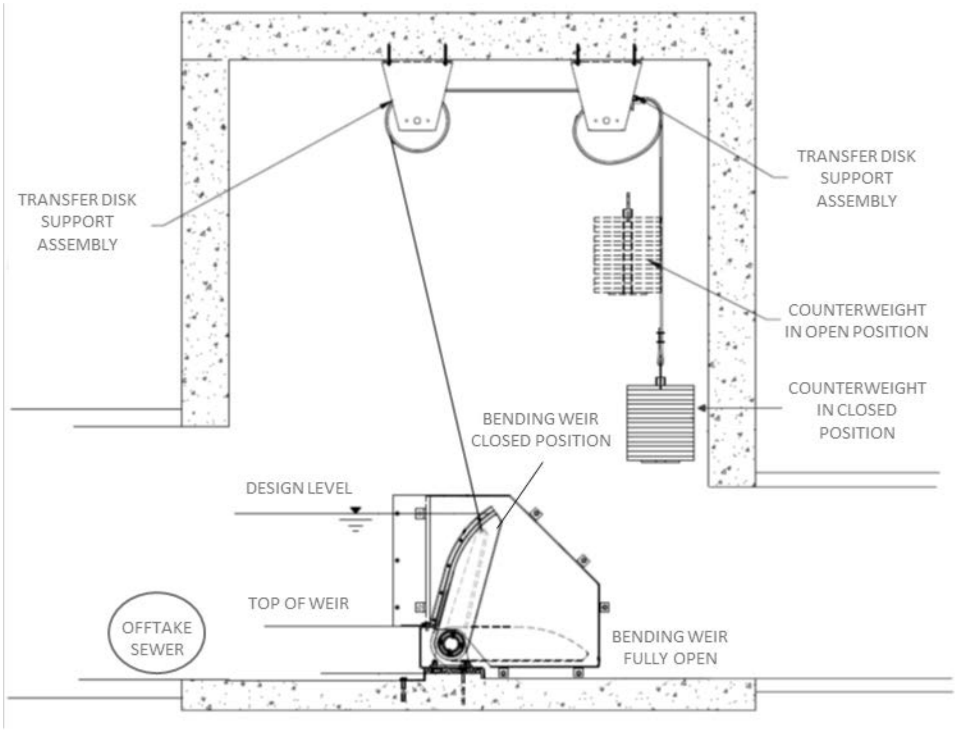

Figure 7-10. TRU-BEND Overflow Bending Weir (Grande Water Management Systems)

The TRU-BEND can be manufactured up to 1.5 m in height, which would provide a reasonable balance between storage and operational response for this control option. Greater levels of storage may increase the risk of basement flooding because the in-line storage could be full when a rainstorm hits. In keeping with this concept, the maximum depth of storage for smaller pipes would be limited to one-half of the trunk diameter.

The gates were modelled with InfoWorks for each of the combined sewer districts using a variable control weir in the same way as it was for the flexible weir evaluation. The level of the gate is related to the level in the system and when the system level increases above the top of the gate, the gate drops out of the way. After the level drops back down, the gate moves back to its original position. The annual overflow results for the gate control option are shown in Figure 7-11 without the use of latent storage dewatering.

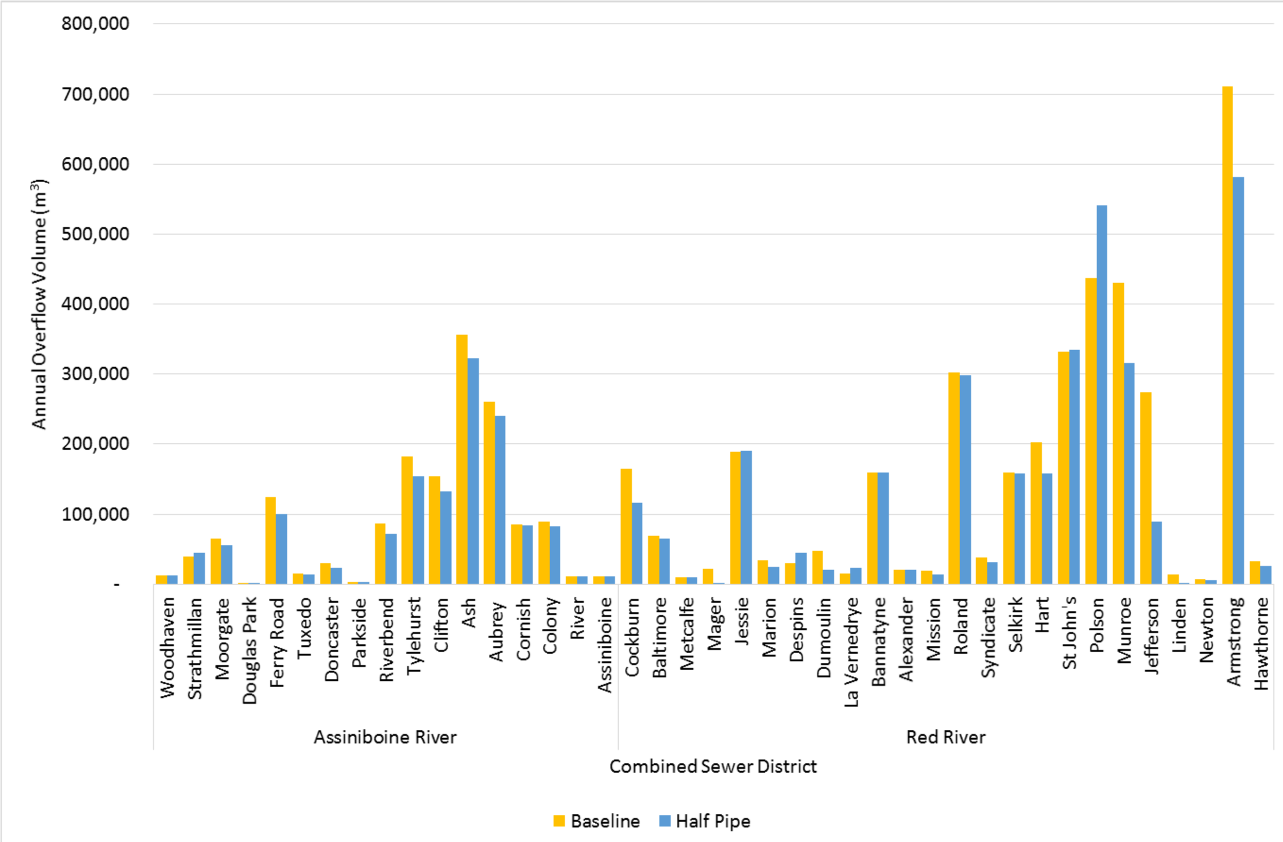

Figure 7-11. CSO Volume with Gate Control at Half Pipe – 1992 Representative Year

The control gates set to a maximum of half pipe level produce good results in a few locations, but were found to only be marginally better than the flexible weirs for most. In some cases, a static weir above the half pipe level is already in use. The total static volume used in the system at the half pipe level is approximately 50,500 m^3.

The number of overflows for the control gate option for the 1992 representative year is shown in Figure 7-12 for the 1992 representative year without latent storage.

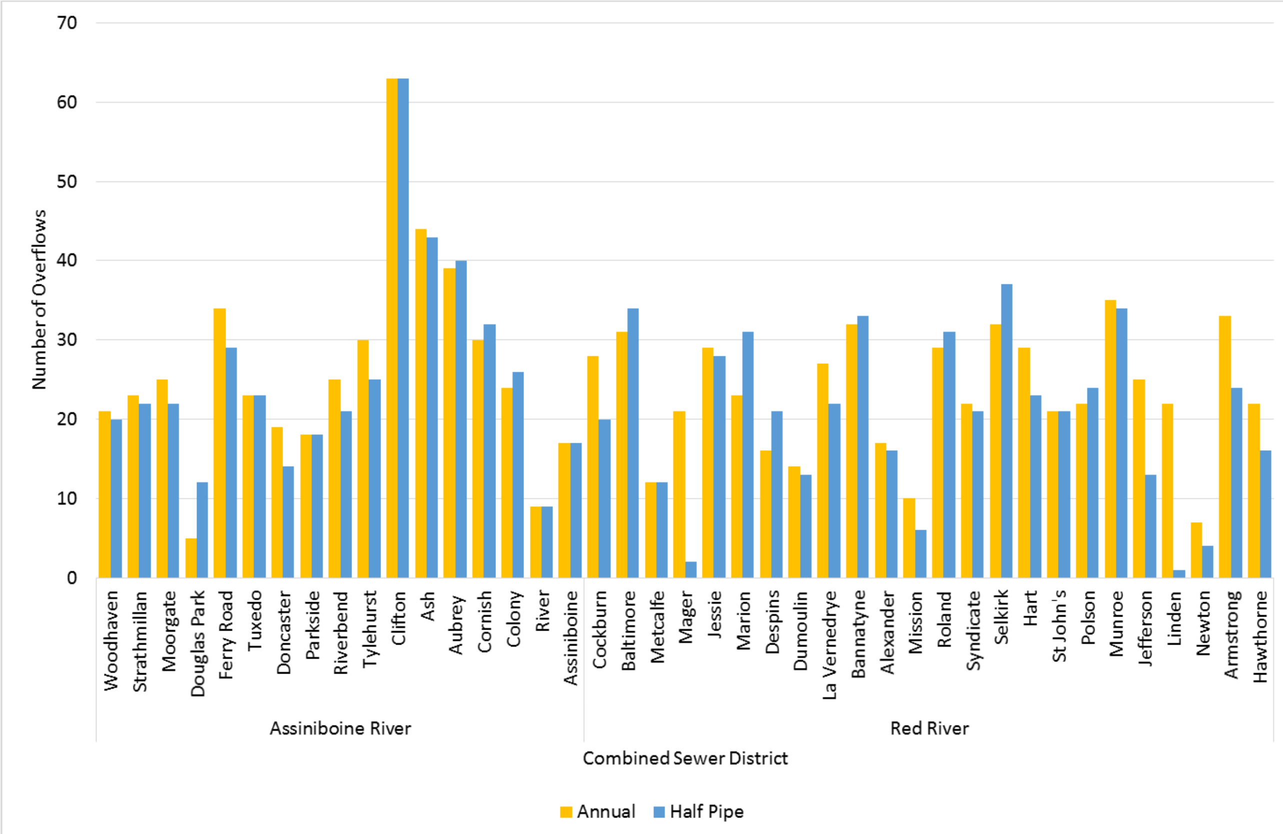

Figure 7-12. CSO Frequency with Control Gate at Half Pipe – 1992 Representative Year

These types of control gates would be useful in combination with other CSO control options, whether or not they provide in-line storage benefits by themselves. They should be considered for the following:

- Capture of in-line storage, for either long-term controls or early actions
- Use with screening facilities
- Flow diversion directly to off-line storage tanks or to flood pumping stations that discharge to off-line tanks

7.2.4.1 Constructability

In some cases, flexible weirs can be installed in place of existing weirs with minimal additional modifications. Depending on the complexity of the installation and the size of weir required, a more detailed design with a new control chamber may be required. In most cases, a gain in upstream storage retention can be achieved with a relatively minor effort.

7.2.4.2 Operations and Maintenance

This in-line control gate does include moving parts and as such will have some maintenance requirements, although they would be minor compared to other mechanical type gates.

A gate similar to the TRU-BEND gate would simplify the use of controls as compared to motorized gates because of its automatic counterweight system operation. This also has an impact on the use of more complex real time control (RTC) options.

7.2.5 Full In-line

The full potential for in-line storage has also been considered with storage levels up to the obvert (top of the sewer pipe) of each combined sewer trunk, as it was for the 2002 CSO Study. Gate control would be similar to that proposed for the 2002 CSO Study, which considered both inflatable dams (no longer being manufactured) and hydraulically activated sluice gates. The annual overflow volumes for this control option for the 1992 representative year is shown in Figure 7-13.

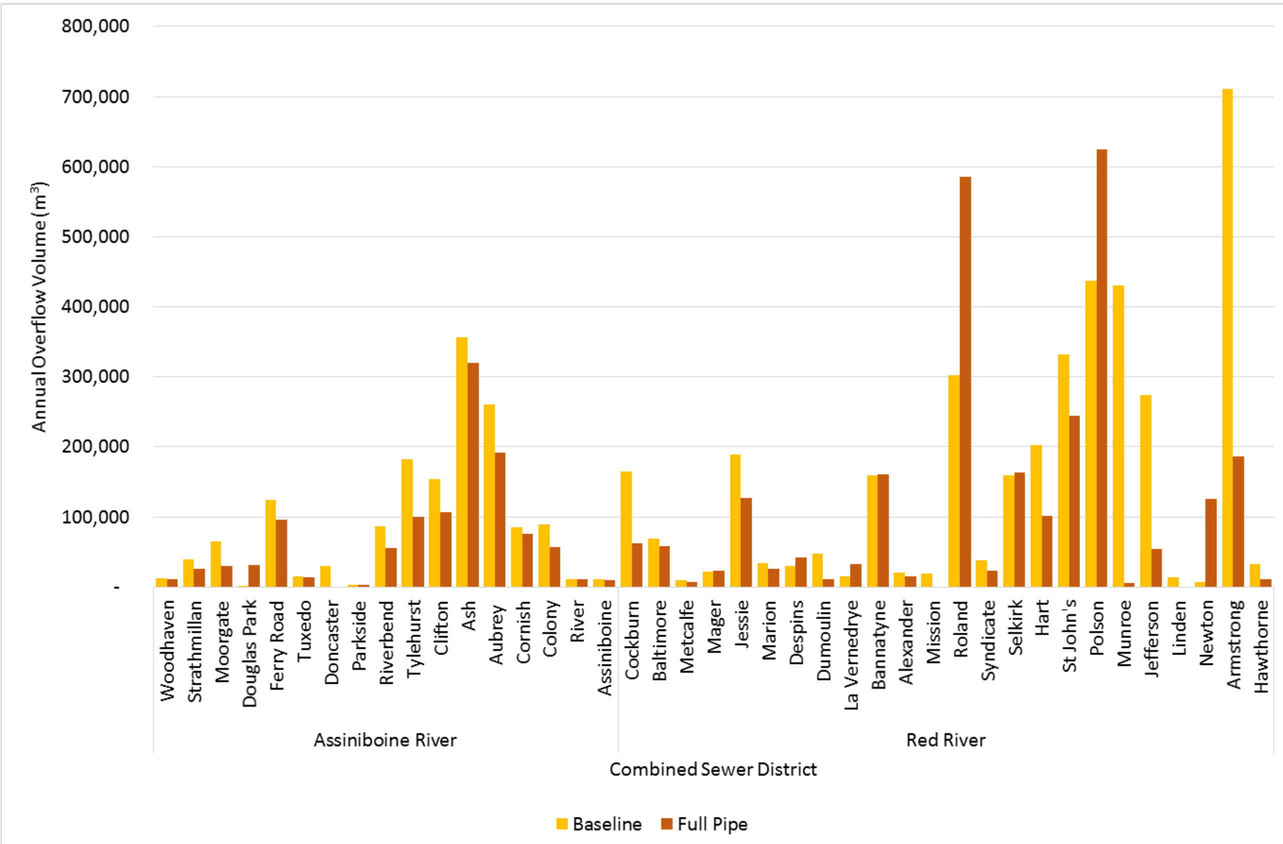

Figure 7-13. cso Volume with Full Pipe In-line – 1992 Representative Year

This control option makes maximum use of existing in-line storage, and would off-set the need for construction of much more expensive new storage. The total static volume for the full in-line retention was calculated to be approximately 255,000 m^3.

The change to the number of overflows using full in-line option is shown for each district for the 1992 representative year in Figure 7-14.

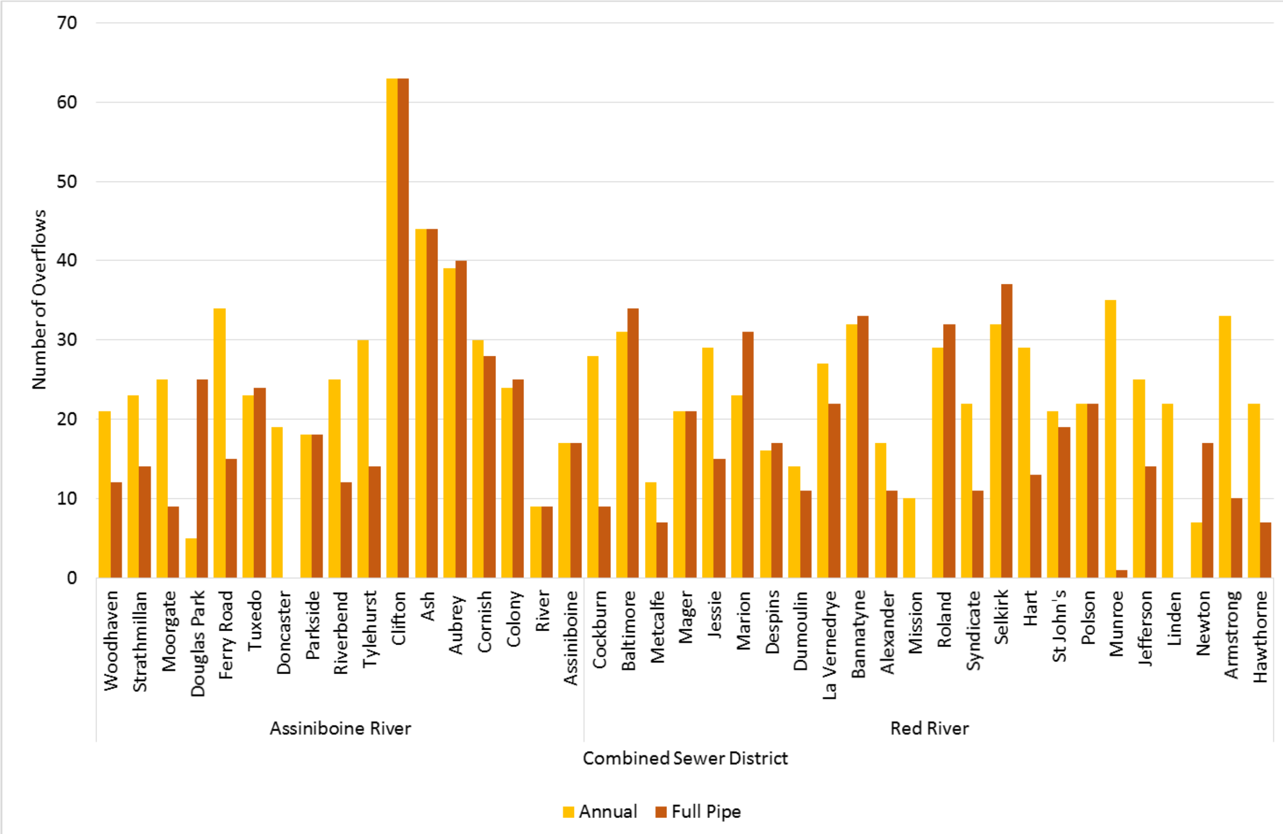

Figure 7-14. CSO Frequency with Full In-Line – 1992 Representative Year

The advantages of this control option must be balanced with its risks. The lifting of a sluice gate would take some time, as would draining of the combined sewer in advance of a pending rainfall event. It is unlikely that this option could be implemented without affecting the current level of basement flooding, unless it was combined with other off-setting works such as partial separation.

The number of overflows for the two alternative reporting methods for each in-line option is summarized in Table 7-5. It is clear that in-line alone is not sufficient to reach the control limits listed in EA No. 3042.

Table 7-5. Number of Annual Overflows for In-line Options for the Alternative Reporting Methods

	Baseline	Fixed	Flexible	Control Gate	Full In-line
District Averaging	23	23	22	21	18
EA No. 3042 Definition	63	63	63	63	63

7.3 Off-line Storage

Off-line storage refers to storage options that are not in-line, and are usually located adjacent to or near the point of discharge. Off-line may be used as a sole control option, or in combination with in-line or any other type of control. Common types of off-line storage include buried tanks or use of dedicated storage tunnels. The use of latent storage is not required when off-line storage is used by itself, but gate control may be effective in redirecting flows to storage, depending on the operating conditions in the combined system.

The off-line evaluation followed a progressive approach. Easily accessible off-line storage tanks were selected first. Districts were reviewed for suitable tank locations. Once all potential locations were found, they were assessed for application in the Regional Model for the hydraulic evaluation. The shortfall after using all of the off-line tank storage was then made up with tunnel storage. The results of this analysis are discussed in the following sections.

7.3.1 Storage Tanks

Meeting EA No. 3042 control limits will require storage volumes far exceeding those available from in-line. The first issue in using storage tanks is finding suitable locations for their construction. Accordingly, the first step in this assessment was to review the work previously carried out on site locations under the 2002 CSO Study, as reported in the *Phase 3 Technical Memorandum No.1: Control Alternatives (*Wardrop et al., 1998). After identifying the previous sites, a check was made on whether they are still available and whether they would meet the needs defined in the master plan. The next steps involved identification of additional storage locations further upstream to supplement shortfalls.

There is a preference for the off-line storage to be located on property near the outfall that can easily be accessed or acquired and likely to meet the required approvals.

A second consideration for off-line storage tanks is with the depth of installation. The 2002 CSO Study focused on the use of near surface tanks, which requires use of large pumps to lift the combined sewage from the combined sewers into storage. The pump size depends on the rate of sewage transfer and they must be large enough to match the inflow rate.

The alternative to near-surface tanks would be deeper tanks that fill by gravity. They would only need smaller pumps for dewatering after the event, but deep construction would be more costly.

7.3.1.1 Off-line Storage Locations

Off-line storage locations were identified and evaluated using multiple criteria. Large open spaces with minimal obstructions were preferred to diminish the construction impacts. Assessment criteria included the following:

- Property size
- Land ownership (that is, public or private)
- Physical attributes, such as vegetative cover, ground elevation variance, and the presence of structures
- Neighbourhood considerations

Site evaluations were made using aerial photographs, site inventories and site visits, photographs, and through the development of site maps. The site locations were assessed by superimposing 20 m by 50 m modular storage elements on the sites in proportion to the storage needed. These modules would provide 5,000 m^3 storage based on a depth of 5 m. An example of how a site location and area was reviewed at Kildonan Park is shown in Figure 7-15.

Figure 7-15. Kildonan Park Off-line Storage Site Location (Google Earth 2015)

An assessment for each location was completed by reviewing the amount of land area available and storage potential. A summary of the maximum available storage volume and number of potential locations per district is listed in Table 7-6.

Table 7-6. Off-line Storage Available per District

District	Maximum Off-line Storage Volume Available m^3	Number of Sites	District	Maximum Off-line Storage Volume Available m^3	Number of Sites
Woodhaven	0	0	Despins	2,500	1
Strathmillan	0	0	Dumoulin	2,500	1
Moorgate	0	0	La Verendrye	2,500	1
Douglas Park	0	0	Bannatyne	7,500	2
Ferry Road	8,000	1	Alexander	0	0
Tuxedo	0	0	Mission	0	0
Doncaster	2,500	1	Roland	32,500	3
Parkside	0	0	Syndicate	0	0
Riverbend	1,250*	1	Selkirk	12,500	2
Tylehurst	0	0	Hart	15,000	1
Clifton	2,500	1	St John's	15,000	2
Ash	36,250	4	Polson	21,500	2
Aubrey	3,200	1	Munroe	20,000	1
Cornish	0	0	Jefferson	25,000	2
Colony	4,000	1	Linden	0	0
River	775*	1	Newton	15,000	1
Assiniboine	350*	1	Armstrong	30,000	2
Cockburn	0	0	Hawthorne	2,500	1
Mager	0	0			
Baltimore	0	0			
Metcalfe	0	0			
Jessie	12,500	2			
Marion	5,000	1			

Note:
* Not viable from construction perspective although may be used as part of district/system wide control option

The total maximum volume of potential storage was found to be approximately 280,000 m^3; however, the useable amount was determined to be 165,000 m^3.

The maximum storage available cannot always be used, since some is located in areas proposed for separation and is not required, there are hydraulic constraints with others, and too small of an area would be economically unfeasible.

The assessment assumed the following:

- The smaller storage areas (less than 2,500 m^3) were considered too small for a conventional storage tank
- Easily accessible storage was not evenly distributed and is limited to 25 of the 43 districts

Figure 7-16 shows the annual CSO volume for the 1992 representative year using the easily accessible off-line storage along with latent storage.

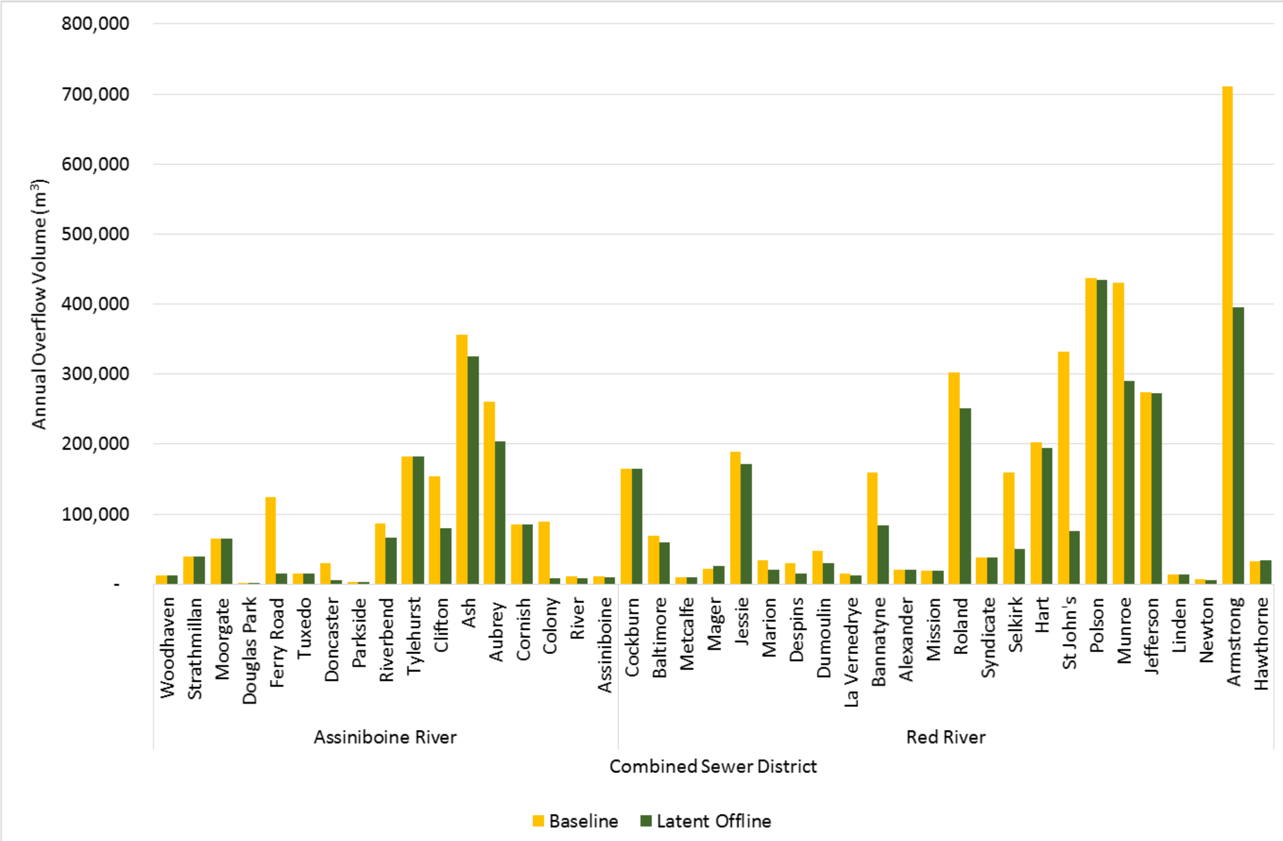

Figure 7-16. cso Volume with Accessible Off-line and Latent Storage – 1992 Representative Year

Figure 7-16 shows that the volume of easily accessible off-line storage is less than the total volume required for CSO capture and is not distributed in proportion to where storage is needed. An additional 165,000 m^3 of storage volume would be required to eliminate overflows for the four overflow control limit for a representative year. Other off-line sites could be investigated for additional storage; however, it becomes more difficult to locate suitable sites and to make use of them because of their accessibility and the difficulty associated with connecting into the collection system.

7.3.1.2 Constructability

An advantage of off-line storage is that it can be constructed without impacting the current system, so diversion of existing flows is not required while the tank is being constructed.

Parks and parking lots generally present the best opportunity for off-line storage.

The main difficulties with off-line storage tanks relates to their location. Typically, a large open space is needed near the sewer for installation of the tank. The best locations are close to the combined trunks and outfalls to maximize the opportunity to collect diverted flow. These locations are generally near the river, where soil conditions can become of concern.

7.3.1.3 Operations and Maintenance

O&M is required for the tanks for routine inspections and cleaning. The increased level of O&M is directly related to the number of times the storage is activated per year. Storage creates the potential for odour problems, which can be managed with flushing systems or aeration depending on the tank size.

7.3.1.4 Additional Considerations

The City's network of flood pumping stations present an opportunity to make use of some existing infrastructure in conjunction with off-line storage. The capacity of the flood stations is considerable, so they can easily move large volumes of collected combined sewage. For offline storage, the pumps themselves would remain the same, but the flows could be rerouted to a near-by storage element. During high levels the flood pumps would be triggered to divert flows to storage until the storage element is full. The storage element would then be dewatered as additional conveyance capacity became available.

7.3.2 Off-line Tunnel Storage

Storage tunnels offer another method of providing off-line storage. Unlike storage tanks, they take up little surface area and can be routed underground with little surface disruption. Storage tunnels can replace storage tanks or supplement them to provide storage volumes meeting the licence control limits.

Table 7-7 identifies the approximate supplemental storage volumes required to meet the four and zero overflow control limits based on the 1992 representative year.

Table 7-7. Volume of Storage Required

Control Limit	**Supplemental Tunnel Storage Required m^3**
Four Overflows for the 1992 representative year	335,000
Zero Overflows for the 1992 representative year	690,000

A summary of the total storage required by district for the four overflow and zero overflow control limits when used to supplement off-line storage tanks is listed in Table 7-8.

Table 7-8. Supplemental Tunnel Storage per District

District	Off-line Storage Volume – Four Overflows	Off-line Storage Volume – Zero Overflows	District	Off-line Storage Volume – Four Overflows	Off-line Storage Volume – Zero Overflows
Woodhaven	1,000	2,000	Jessie	16,000	25,500
Strathmillan	3,800	4,300	Marion	4,500	9,900
Moorgate	4,200	8,400	Despins	3,700	7,200
Douglas Park	0	0	Dumoulin	16,100	17,000
Ferry Road	0	1,400	La Verendrye	4,000	5,000
Tuxedo	1,500	3,000	Bannatyne	12,500	29,000
Doncaster	1,900	4,400	Alexander	5,400	10,000
Parkside	0	0	Mission	0	0
Riverbend	0	11,000	Roland	23,000	47,000
Tylehurst	0	0	Syndicate	4,200	6,100
Clifton	11,400	24,000	Selkirk	13,900	25,200
Ash	31,200	42,100	Hart	15,300	26,200
Aubrey	17,200	30,800	St John's	18,900	45,100
Cornish	5,900	10,200	Polson	44,000	90,800
Colony	4,700	19,600	Munroe	30,200	51,200
River	1,200	4,600	Jefferson	0	31,400
Assiniboine	1,800	4,300	Linden	0	1,500
Cockburn	0	1,200	Newton	1,000	2,700
Mager	0	600	Armstrong	36,700	36,700
Baltimore	6,600	12,500	Hawthorne	0	0
Metcalfe	900	1,700	**TOTAL**	342,700	653,000

Tunnels would be located near the main trunk lines and outfalls in each district to facilitate the filling and dewatering processes. Tunnel sizing was based on the location of other sewer utilities attempting to maintain the tunnels within the existing right-of-way. The elevation of the existing infrastructure was also taken into account and resulted in some modifications to diameters. To achieve the volume requirements for control, tunnels ranging between 2.1 and 5.0 m in diameter were routed through each district.

The total lengths of tunnels for the four and zero overflow control limits are about 22 kilometres (km) and 40 km respectively. Although the tunnel sizes are not large by industry standards, they are large by local standards.

The storage tunnels would provide an opportunity to achieve multiple objectives for interconnection of districts and with extra investment could enhance basement flooding protection. This would be considered at the detailed stage after selection of a control limit.

As Table 7-8 indicates, the use of off-line storage tanks along with storage tunnels would reduce the amount of tunnels required. Control option evaluations considering costs and benefits would be used to determine the proportions of each.

7.4 Storage/Transport Tunnels

Storage/transport tunnels differ from storage tunnels previously discussed in that they are designed with the intent to store and transport combined sewage from multiple districts rather than just for local single district storage.

Storage/transport tunnel options can vary in scope and size, ranging from CSO program megaprojects to shallow moderate size tunnels much like those already existing in Winnipeg. Either type can be sized to collect combined sewage from a number of sewer districts and transport it to either an existing STP or a new satellite treatment plant.

7.4.1 Deep Tunnels

There are many examples of large deep tunnels being successfully used for CSO programs. Deep tunnels are simply large sewers installed deep underground. As with the other storage options, combined sewage collected during wet weather is diverted to the deep tunnels and stored until the treatment plants have the capacity to treat it. Typical deep tunnels range in size from 3 m to 10 m in diameter, and are from 3 km to 50 km in length. The tunnels must be accompanied by drop shafts and deep lift stations to transfer the sewage to treatment.

Some of the larger North American deep tunnel projects are in Chicago, Milwaukee, Atlanta, Cleveland, and Portland. In Canada, Ottawa and Edmonton are using tunnels in their CSO programs. Other examples can be found in San Francisco, Boston, Austin, Houston, Detroit, Los Angeles, New York, and Minneapolis as well as internationally. Some representative overviews of other municipalities that have used deep tunnels are as follows:

- Chicago – The Tunnel and Reservoir Plan was one of the first and most successful applications of deep tunnel technology. It covers 175 km with typical tunnel sizes up to 10 m in diameter.
- Milwaukee – Milwaukee Metropolitan Sewerage District has been a leader in deep tunnel use for the reduction of CSOs. Phase 1 of the program was completed in 1994 and consisted of 27 km of tunnels that can hold up to 1,500 000 m^3 of wastewater. Phase 2 is 11 km long and can hold an additional 333,000 m^3 of wastewater. The tunnels are between 36.6 and 100 m below ground.
- Atlanta – The West Area CSO Storage Tunnel is 13.7 km long, with a 7.3-m finished diameter. Constructed in bedrock, it is about 51.8 m deep and can store up to 670,000 m^3.
- Cleveland – The Euclid Creek Tunnel is the first of seven storage tunnels planned for Northeast Ohio Regional Sewer District. The tunnel will be 5,485 m long and 7.3 m in diameter, able to hold about 265,000 m^3 of combined sewage. The tunnel will be bored through shale 57.8 to 67 m below ground.
- Portland – A major part of the City of Portland's 20-year CSO program has been the Willamette River CSO Tunnel Program, which includes construction of tunnels on both sides of the Willamette River. The West Side CSO Tunnel completed in 2006 is 4.3 m in diameter and 5.6 km long with a storage volume of 81,000 m^3. The new East Side CSO Tunnel is 6.7 m in diameter and is almost 9.7 km long. It used two tunnel boring machines working at depths from 30.5 to 45.7 m constructed.

- Abu Dhabi – One of the largest sewerage tunnel projects in the world, varies in diameter from 5 m to 8 m along its length. A unique feature of the project is that it is designed to allow gravity discharge from a number of existing pumping stations into the tunnel, thereby enabling decommissioning of existing pump stations and reducing O&M costs.

7.4.2 Shallow Tunnels

The most practical application for the master plan is likely to be with installation of shallower storage/transport tunnels. The City is familiar with these types of tunnels, and they do not require major drop shafts or deep pumping stations. There are many potential options for use of these types of tunnels, including the following.

7.4.2.1 Full Length Tunnel

A storage/transport tunnel following the Abu Dhabi example would provide a high level of CSO capture by extending the full length of the combined sewer area, and maximize the ability to address spatial rainfall distributions.

The distance from the furthest point on the west leg of the interceptor serving the NEWPCC to the treatment plant is about 15 km, with the west leg being about 6 km and the Main Street leg 9 km. The full length tunnel option to capture CSO using a uniform pipe would require the following:

- A 5 m diameter tunnel 15,000 m long for the four overflow control limit based on the 1992 representative year (295,000 m^3 storage volume)
- A 7.5 m diameter tunnel 15,000 m long for the zero overflow control limit based on the 1992 representative year (650,000 m^3 storage volume)

The full length tunnel option has the potential to reduce the number of existing lift stations (see Section 2.4), having them decommissioned and not replaced. This control alternative does not require additional lift stations like all of the other alternatives..

7.4.2.2 South Tunnel

A south tunnel was first identified under the *Cockburn and Calrossie Sewer Relief Works* (KGS et al., 2010) project. It would be routed from the Cockburn district, the most southerly combined sewer district, north to the River district where a pumping station would be located to lift the flows into the main interceptor for routing to the NEWPCC. The tunnel would connect to the Baltimore and Jessie districts, thereby virtually eliminating CSOs south of the Forks. This would also centralize the wet weather treatment at the NEWPCC, avoiding the need for further upgrading of the SEWPCC for CSO treatment.

The tunnel was conceptually sized at 3 or 5 m diameter depending on the use of in-line storage, approximately 5.4 km in length.

7.4.2.3 East and West Tunnels

There is an option to install parallel tunnels on each side of the Red River parallel to Main Street, similar to the approach used in Portland. The tunnels would connect to the combined districts on each side and interconnect to a single large lift station allowing for decommissioning of the existing lift stations on each side of the river. The east side would add another 9 km, but because of its additional storage volume would reduce the pipe diameter on the west side.

7.4.2.4 Main Tunnel

There are more basic tunnel options that could be used in combination with other CSO control options. A main tunnel could be installed from the NEWPCC along Main Street and terminate prior to the west leg. It would provide storage for all of the districts along the Main Street stretch, and the east side districts would either have their own storage or access the tunnel through new connections across the Red River.

Tunnels can be routed to reduce the number of CSO locations and consolidate treatment. Tunnels serve as storage that can minimize CSO frequency and volume and provide alternate collection system control methods. The hydraulic impact of the variations for tunnels is described in more detail in Section 6.

7.4.2.5 Constructability

The tunnels would typically be installed so that they are at a lower elevation than the other utilities to collect the combined sewage and to further minimize conflicts.

7.4.2.6 Operations and Maintenance

O&M access is required for each tunnel element in the system. Flushing and odour control may be required because of the low gradient and a need for increased inspections and cleaning. Similar to the tanks, the increase in O&M required is related to the number of times the element is activated. Each element will have a dewatering component that will require power and regular maintenance work. More individual tunnel elements creates a higher O&M requirement.

7.4.2.7 Additional Considerations

Basement Flood Protection – Storage/transport tunnels are intended to collect combined sewage from a series of combined sewer districts and route it towards a treatment plant. Although there may be a positive impact on the hydraulics, they do not provide a significant opportunity for increasing basement flooding protection as would be the case for storage tunnels routed within the sewer districts.

Increased System Control – Tunnels present an opportunity to divert and control flow through the system allowing for maintenance of elements that would not be normally viable such as the main interceptor or temporary shut downs of system pumping components.

Interceptor Redundancy – A secondary route to divert flows to NEWPCC is a consideration for reducing risk at the same time as increasing capacity and meeting environmental requirements.

Eliminate CSO Locations – A transport tunnel could eliminate a number of CSO outfall locations and assist to consolidate flows to a central treatment location. A transport tunnel could also be operated to handle spatially distributed rainfalls.

7.5 Real Time Control

Most of the CSO control options are intended to capture and gradually route the combined sewage to treatment. This will require flow control systems that include pumping, gates, valves, instrumentation, and an automation system to manage them. The automation system and its level of sophistication 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 include the development of a dewatering strategy for the orderly transfer of captured combined sewage to treatment and the use of RTC to manage and improve the in-system operations.

7.5.1 Dewatering Strategy

The dewatering strategy will need to be considered for each of the potential plans developed in the first phase of the master plan. The dewatering strategy must include several factors, with the key ones being the volume in storage, treatment capacity, storage recovery time, and sequence of dewatering. Each of these will affect the pumping rates and lift station requirements for every district.

7.5.1.1 Volume in Storage

The dewatering rate must be sufficient to dewater the total volume in storage within the designated time frame. The volume in storage will vary for each of the potential plans, and must be considered in relation to the pumping rates and treatment capacity.

7.5.1.2 Treatment Capacity

The peak rate of sewage treatment will be a primary constraint on the dewatering strategy. The first priority for treatment will be processing of DWFs and separate sewer area inflows, with the excess capacity used for dewatering of combined sewage. Alternative treatment capacities and the impacts on dewatering are discussed subsequently in this report.

7.5.1.3 Storage Recovery Time

The initial assumption is that the dewatering must be completed within 24 hours from the end of the runoff event. The 24-hour period complies with the EA No. 3042 definition for an inter-event period. In practice, the CSO controls need to be ready for a sequential event within 24 hours or risk noncompliance with the regulatory control limit. If a new event commences within the 24-hour period it is to be designated as the same event and would not be at risk of exceeding the regulatory control limit.

7.5.1.4 Sequence of Dewatering

The dewatering philosophy and operational flexibility will have a major bearing on the pumping rates for individual pumping stations. The pumping capacity needed to dewater at 43 locations sequentially over 24 hours is 43 times greater than dewatering them simultaneously, with the optimal strategy falling somewhere in between.

7.5.1.5 Lift Station Considerations

The lift station evaluations will consider whether a wet well/dry well or submersible type station is to be used, as well as pumping and equipment redundancy to account for mechanical failures and the use of flow and level controls.

Consideration will also be required as the design advances for integration of dewatering lift stations with DWF pumping, flood pumping station operation, grit removal from storage tanks, and screenings disposal from screen installations.

The following base assumptions have been simplified for the first phase of the study, and are captured through the cost estimating process:

- Use of wet well/dry well installations for large lift stations and submersible lift stations for standalone latent storage dewatering
- Dewatering pumping rates set at two times the 24-hour peak storage dewatering rate
- Use of the firm capacity concept for dewatering, which requires the pumping capacity to be met with the largest pump out of service

7.5.1.6 Dewatering System Operation

The dewatering system infrastructure will include physical components to maximize the use of the interceptor and provide the first level of real time control.

Each of the CSO control options will include controls to capture increased amounts of WWF. CSO storage locations will be equipped with flow control devices that can control the dewatering rate to the interceptor, either through use of variable speed pumping or a modulating control device for gravity drainage systems. A supervisory control and data acquisition (SCADA) system will monitor the amount of combined sewage in storage at each location and the operation of the interceptor.

A control strategy will define the operational philosophy and provide the logic for controlling the amount of flow that can be released at any time from each of the CSO storage locations. The basic inputs will be the following:

- Amounts of combined sewage in storage at each location
- Available treatment capacity
- The operation of the interceptor

The system will then determine the appropriate rates of discharge from each location to optimize treatment, make best use of interceptor capacity, and regenerate storage in an orderly fashion in preparation for the next event.

This system will provide the basic functionality to maximize use of the existing infrastructure, but does not include the more sophisticated components that permit transfer of flows or rainfall predictions.

7.5.2 Real Time Control Systems

RTC is a well-established technology that can enhance the operation of wet weather facilities. RTC has the potential to reduce the size of new facilities through this system optimization, thereby lowering the capital costs. As described previously, a basic RTC is planned to be incorporated in the dewatering strategy, but can also be considered as an early action item and expanded upon for the final system.

RTC was considered under the master plan for the following range of applications:

- Existing system: There are currently several combined sewer districts that discharge to the interceptor by gravity, with their discharges uncontrolled and rates unmonitored. The interceptor is only controlled through the NEWPCC raw sewage pumping operation and the levels upstream of the plant have only been tracked as part of the recent data collection campaigns. In 2009, the City also initiated the outfall monitoring program and will have information in place to be used with the InfoWorks models to develop system operation and management tools to better understand the system and focus the RTC program.

- Raising weirs: A potential early action would be to increase the amount of capture by raising the existing fixed weirs as discussed in Section 7.2.2. Depending on the option selected, this may require upgrading of the existing measurement and control infrastructure. The goal would be to maximize combined sewage capture by optimizing the use of the interceptor and existing treatment capacity. In some cases, flow controls, variable speed pumps, or even new lift stations would be required to effect the changes. Infrastructure upgrading would as much as possible be coordinated with the long-term needs for the master plan.

- Operating gates: The RTC system could provide the control logic to compliment the operation of in-line control gates as discussed in Section 7.2.4. The gates could serve as early action improvements to maximize the amount of capture and as diversion devices for filling off-line or tunnel storage at a later stage of the program. At the initial stages the RTC would provide local control for a single district, but at later stages could be expanded for control of many elements throughout the system (global control).

- Master plan optimization: The long-term merits of RTC for the master plan will depend on the CSO control options selected. Other than for the case of complete separation, there would likely be an advantage for use of RTC. Enhanced control logic would allow for inflow and discharge rates to be adjusted based on hydraulic conditions at critical locations along interceptor. Dynamic flow control would result in the interceptor or new tunnel conveyance capacity being more fully used during wet weather by shifting flows from overloaded districts to those with capacity.

A well thought out strategy will be necessary for implementation of a successful RTC system. RTC is closely tied to the human element of the operation and implementation must account for risks of failure. 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 to calculate future storm flows. The use of these highly complex RTC system have not been considered at this stage of the master plan.

7.6 Sewer Separation

Elimination of overflows through complete sewer separation is one of the control limits to be considered for the master plan. Complete separation would be a major undertaking as it would require that the existing single pipe combined system be transformed into a two-pipe separate system. Less ambitious approaches to sewer separation can also be considered either on a district-by-district basis, or even partial separation within each district.

7.6.1 Complete Sewer Separation

Complete sewer separation would be the most costly of the CSO control options, but would address the majority of the CSO issues and include the following:

- It is the only option that would guarantee the elimination of CSOs, since combined sewers would no longer exist
- It would increase the level of basement flooding protection, since the basements would no longer be connected to the same pipe as surface drainage
- It would remove flows from the network eliminating the need to treat the flows
- It would also increase capacity in the interceptors to convey more flow from other districts

There are the following two approaches to achieve complete separation while retaining the existing combined sewers:

1. For land drainage separation, the existing combined sewers would be retained for use as separate wastewater sewers with the construction of a new separate land drainage system. For districts that have SRS pipes installed, they would be integrated into the new land drainage system. This approach would include the following:
   - The new land drainage system would only capture road drainage, foundation drainage would remain in original combined system.
   - The new land drainage sewers would need to be large enough to meet the current drainage standards, approximately equal in size or somewhat larger than the existing combined system.
   - Construction would be required in every neighbourhood for every combined sewer district to achieve complete separation.
   - Foundation drainage would be significant because of poor lot drainage in the older combined sewer areas and in-line storage to capture and treat the wastewater would still be required. Overflows would be prohibited because they would be reclassified as sanitary sewer overflows.
   - The repurposed combined sewer system would be oversized for use as a wastewater system, and may be subject to sedimentation and odour generation. Where egg-shaped sewers are in use this problem may be minimal.
2. For wastewater separation the existing combined sewers would be retained as land drainage sewers, with construction of a new wastewater collection system. This approach would include the following:

- The pipe sizes for the new separate wastewater system would be smaller than for land drainage separation method since the new pipes would only capture domestic sewage and foundation drainage.
- However, the new wastewater system would be larger than those used in new developments because of the high rate of foundation drainage in combined sewer areas and in-line storage and dewatering would still be needed.
- New wastewater pipes would be routed down every street, since they would need to reconnect to every building with a wastewater service.

The drawbacks with separation are the high cost and the wide-spread disruption that is caused by its implementation. Because of its high cost, some cities such as Ottawa and Vancouver are undertaking a long-term implementation program. At 1 percent per year, the entire combined sewer area would be completely separated in 100 years.

Even after separation, it is expected that flows from foundation drains would still require management of the WWFs in the sanitary system.

Perhaps the biggest misconception with sewer separation is that the control option would replace combined sewers. This is rarely the case and is not proposed under the master plan. In fact, the intention would be to retain and repurpose the combined sewers. Retaining and reusing the combined sewers would mean the effects of aging and deterioration would still need to be addressed.

The level of basement flooding protection and land drainage service would be expected to increase with both approaches. With either approach the land drainage sewers could surcharge to street level without backing up into basements since basements would only be connected to the sanitary system.

7.6.2 Partial Separation

Partial separation within combined sewer districts has often been considered and used in BFR projects. With partial separation, only as much of the combined sewer is separated as is required for meeting BFR design objectives. This, for example, may mean only small areas within a combined sewer are separated. It does have an advantage for CSO control in that the amount of CSO is reduced.

The other consideration for the master plan is to completely separate only selected districts. They would be selected on a priority basis. Those with the highest priority would be the following:

- Districts designated for future BFR work, which allows for CSO program integration, and the cost of separation to be off-set by the elimination of the BFR costs
- Districts with partial separation in place that can readily be cost-effectively enhanced through additional separation
- Priority locations, either related to interceptor capacity, or river water quality objectives

The combined sewer districts with the highest potential for complete separation are included in Table 7-9, along with the CSO storage volume avoided by not proceeding with storage options:

Table 7-9. Priority selection of Complete Separation Projects with avoided Storage Volumes

Sewer District	Four Overflows for the 1992 Representative Year m^3	Zero Overflows for the 1992 Representative Year m^3
Ferry Road	10,000	12,000
Riverbend	3,950	5,200
Jefferson East	51,000	77,000
Cockburn	10,000	17,000
Hawthorne	5,000	7,000
Armstrong	65,000	125,000
Mission	5,800	11,000
Tylehurst	26,600	27,200

7.7 Green Infrastructure

GI refers to stormwater management practices that use natural systems for detaining, infiltrating, and evaporating water. GI includes a range of technologies that can be grouped as porous (or permeable) pavements, bioretention, and rain harvesting.

These technologies can be applicable and beneficial to the combined sewer control because they reduce the volume that might otherwise enter into the combined system. They can also reduce the pollutant loading impact of runoff and improve water quality of receiving streams. Along with reducing runoff rates and improving water quality, GI may provide cooling effects, improve air quality, and enhance the visual appeal of neighbourhoods. However, GI has little relationship to greenhouse gas emissions and the concern with climate change.

The City's *Our Winnipeg Strategy* includes a section on promoting strategies to reduce runoff using natural amenities. This includes a commitment to incorporate water sensitive urban design into the planning and development processes.

The City has some experience with GI, through localized use of porous paving, green roofs, and bioswales and has recently completed the construction of a green back lane. The City has also upgraded its design approach for stormwater retention basins to naturalized ponds.

7.7.1 Assessment of Green Infrastructure

GI would remove or reduce runoff to combined sewers, consistent with the master plan objectives. The CSO control program will require in the order of 300,000 m^3 of runoff to be managed for each major event, and although GI would not provide the complete solution, it could provide a significant contribution.

While the grey control options address the volume after being collected in the combined sewers, GI would remove it at the source. This means that GI can be implemented anywhere in the catchment area and still be effective. The technical effectiveness and cost competitiveness of GI varies with specific locations and conditions and is summarized as follows:

- Porous or Permeable Pavement – is one of the most widely used GI technologies. It has the advantage that it can be applied throughout the catchment area on streets, parking lots, sidewalks, and recreational areas for both public and private property. It is most effective since it replaces the impervious areas that generate most of the runoff.

- Bioretention – these technologies store runoff in a vegetated pervious location. It functions by removing or delaying runoff to the combined sewers. These technologies require that suitable land be available and a method of capturing and conveying runoff to the facility. They have been used effectively in ditches capturing highway runoff and at the discharge point of storm sewer systems. Their use may be limited in combined sewer areas because of the land requirements and the ability to collect runoff. For example, curb extensions in combined sewer districts would have a high potential if they are retrofitted to receive the street drainage, but planter boxes would be limited because of the limited amount of capture.
- Rain Harvesting – rain barrels and cisterns that collect roof runoff could theoretically capture large volumes of water through wide-spread use. However, their effectiveness would be limited if the runoff water is simply being diverted from pervious areas to containers and if the storage is not emptied within the 24-hour replenishment period. Most of the storage would also be on private property, with there being little control over their O&M.

The GI technologies were considered for more specific application to the master plan. It was generally found that the grey options such as in-line storage or tunnels would always be required for the optimal solution in any case, with GI not being effective or cost competitive as a replacement. Other considerations regarding GI include the following:

- GI costs vary; where conditions are ideally suited small scale implementation costs can be very low, but tend to increase as the size of the program increases. As an example, GI costs for porous pavement would be at least double that of CSO storage.
- GI relies on infiltration, evaporation, and transpiration to recover its capacity after an event, and the recovery time for local conditions cannot match that of grey infrastructure. The shortfall in meeting the 24-hour objective would reduce the GI effectiveness and have to be supplemented with grey options.
- The use of GI is site dependent, and would require access to sufficient land, which would not necessarily be optimally located.
- The success rate of implementation, and sustained O&M requirements, are unknown for local conditions.
- It is not a proven technology for Winnipeg, which is one of the main CSO control option constraints.

It was therefore concluded that GI would not be used as a control option at this stage of the master plan. This was not intended to diminish its potential for use in other applications or over the long-term.

7.7.2 Use of Green Infrastructure

In spite of the unknowns and potential concerns with GI, it is intended to be used in the future CSO program. Clause 8 of EA No. 3042 requires that GI be used in future projects as follows:

> *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.*

There are many examples from other locations of GI being used successfully for CSO projects as well as separate storm systems. It has been used in Portland, Oregon for 20 years, and its use is growing rapidly in several other US cities with large CSO programs such as Philadelphia, New York, and Cincinnati.

There are a number of specific local issues that are unlike the other large applications that should be evaluated prior to adopting GI for the master plan, as follows:

- 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 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 – use of sand and salt on streets in the winter may have a detrimental effect on GI operation, maintenance and discharge water quality, and snow plowing may be damaging to the facilities.

The local uncertainty suggests that it is premature to make definitive recommendations on GI application, and therefore a response to Clause 8 for the master plan must be based on general statements. Therefore, a GI approach must await a public policy decision rather than be based on a technical or economic evaluation. The following general principles are recommended for the initiation of a GI policy for integration into the master plan:

- Pilot studies should be undertaken to evaluate the unknowns and assess the use of GI technologies.
- Functional sizing of the master plan 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 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.

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

7.8 Floatables Control

Clause 12 of EA No. 3042 requires that floatables be addressed as follows:

> *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 emphasis on demonstrating the prevention of floatable materials provides the City with an opportunity to address the floatables issue with a practicable approach, rather than being mandated to implement a prescriptive process or achieve a defined level of performance.

7.8.1 Floatables Issue

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.

There is no formal record of discharges or register of complaints for floatables, but it is known anecdotally that common sink and toilet wastes, greases and oils, and street litter is at least occasionally observed on the rivers.

The floatables issue was investigated in more detail under the 2002 CSO Study. Floatables were captured successively for 20 rainfall events from the Alexander, Bannatyne, Mission, and Cockburn combined sewer 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 a series of 20 rainfall events. The amounts of floatables captured are shown in Figure 7-17.

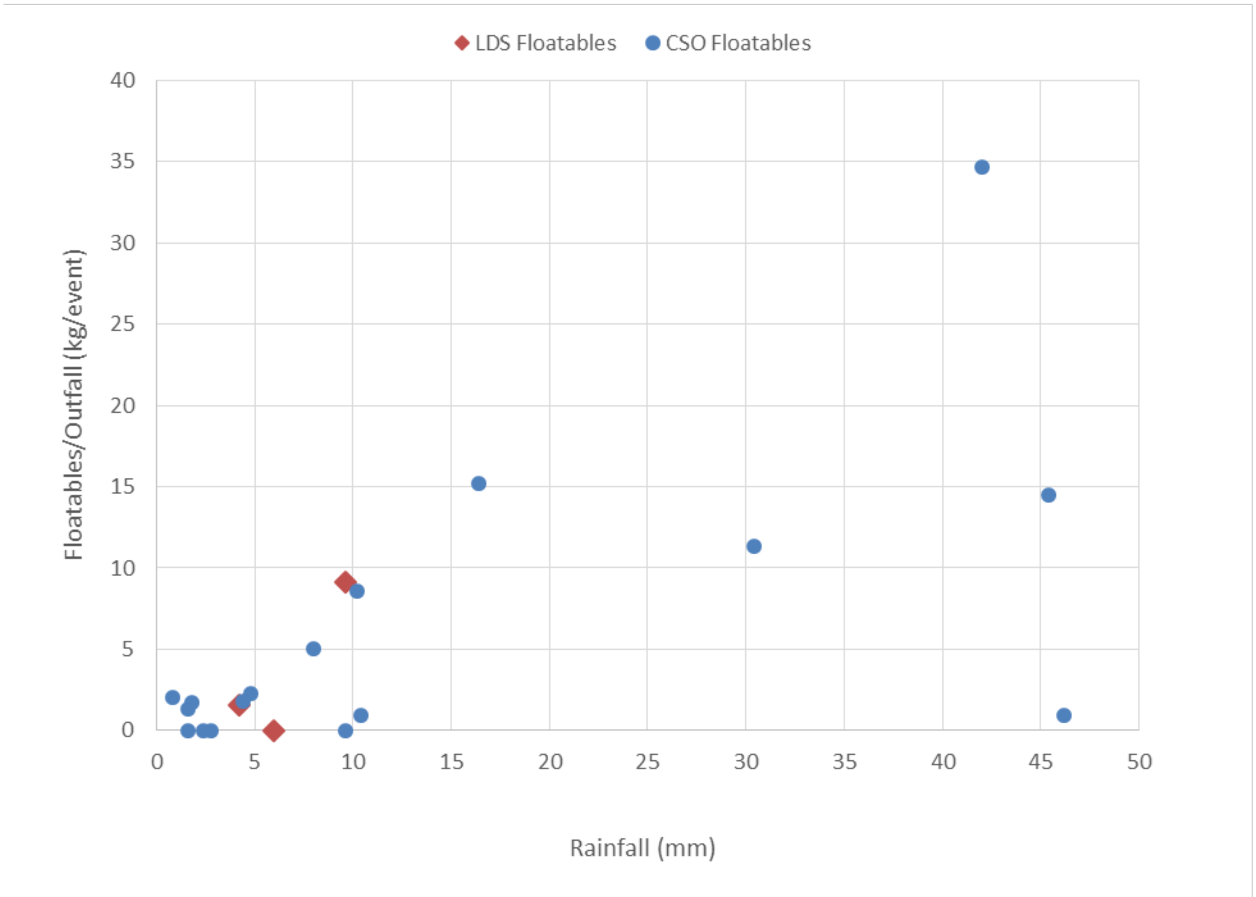

Figure 7-17. Floatables Collected from Primary Outfalls During 1996/1997 Rainfall Events (2002 CSO Study)

As shown in Figure 7-17, 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 secondary or relief outfalls that may have also been 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 combined sewer 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.

7.8.2 Control Options

Identifying a floatables capture plan is challenging for a number of reasons, which are described as follows:

- Complete capture of floatables is impracticable, since many of the discharge points cannot be readily accessed and do not have suitable hydraulic characteristics for screen installation.
- As screens become blinded by debris they restrict flow and as the screens are located at the overflow points flows can no longer be relived to protect against system surcharge and resulting basement flooding. Unobstructed emergency relief for large rainfall events needs to be retained in the sewer system to provide protection against basement flooding. Most floatables capture options require intensive O&M
- Floatables capture must be located at combined sewer discharge points that are located throughout the community, and screening facilities would be difficult to access in many of the neighbourhoods

7.8.2.1 Level of Control

Clause 12 of EA No. 3042 requires the prevention of floatable materials. Floatables will naturally be captured with all of the alternatives that use storage and since the minimum combined sewage capture rate being considered is set at 85 percent, the minimum floatables capture will also be 85 percent. As the amount of combined sewage captured is increased beyond that amount for the other control alternatives, the amount of floatables captured will also increase.

Complete screening of all outfalls would be impractical and provide little additional benefit. It would require screens to be installed in the flow path of every outfall, which would restrict flows and increase the potential for basement flooding. Avoiding this situation would require large screen sizing, which would not fit on many of the sites, or bypass structures, which would compromise the capture of floatables.

The screening rate would be based on Pareto's Principle (otherwise known as the 80-20 rule) rather than complete screening of all flows. In concept, screening only 20 percent of the overflow would result in 80 percent capture of the floatables. The 20 percent screening application would mean the following:

- All of the captured CSO events as well as the initial discharge for permitted overflows containing the most floatables would be screened.

Based on the 2002 CSO Study floatables quantification, application of the 80-20 rule would readily meet the regulatory requirement for 85 percent capture of floatables. The baseline level of capture for the representative year is currently 74 percent, which will increase to 85 percent with the 85 Percent Capture alternative, even without screening. The 80-20 screening approach would further reduce the floatables in the permitted overflows by another 80 percent and would result in gross floatables capture as high as 95 percent, depending on the characteristics of each combined sewer district.

Floatables capture and the screening options only apply to CSO control options and not sewer separation. Separated combined sewers would perform similar to land drainage sewer in separate areas and contain higher levels of natural products that are less visible on the rivers. This would result in the amount of floatables actually increasing compared to CSO control options since street litter forms the largest component of the floatables and would no longer be routed to treatment plants for disposal.

Higher levels of floatables capture are possible, but not practical and have not been proposed for the master plan.

Extending the 80-20 rule to secondary and relief outfalls would be difficult because of the difference in physical arrangements and methods of CSO control. Other technologies such as trash nets may provide a suitable option if this level of control is to be pursued.

Prior to undertaking more advanced levels of floatables control, site specific studies to identify individual district contributions and source control should be considered in more detail, as recommended in the 2002 CSO Study.

7.8.2.2 Screening

The screening option selected to be used with all CSO control options is therefore based on the 80-20 rule, with screens installed only on the primary outfall. The screening operation would require use of an in-line control gate to generate sufficient hydraulic head differential for screening operation. The control gate would capture all sewage, including floatables, up to its design capacity, and screening would only take place beyond that point. The screening operation would only take place to a predetermined rate, after which the control gate would open and the sewage allowed to overflow directly to the river, preserving the level of basement flooding protection.

There are several screens available for this application commonly used in CSO applications. The Hydro International Hydro-Jet Screen and the Grande ACU-SCREEN were both considered suitable and were identified as candidates for a pilot installation. They are both self-cleaning screens with no external power requirements.

7.9 Wet Weather Treatment

All combined sewage captured under the CSO program will require treatment. The two approaches available are routing the flows to an existing STP and providing wet weather treatment for the high flow rates or constructing a new satellite treatment offsite from the STPs.

The level of treatment will differ for the two wet weather treatment approaches. WWFs routed to a STP will be blended with STP effluent to meet the plant licence discharge limits; flows to satellite treatment must meet the discharge limits identified in Clause 12 of EA No. 3042. The discharge limits in the STP licences are generally more stringent than those for the EA No. 3042.

Each of the three existing STPs may be impacted by the CSO program. The NEWPCC receives flow from most of the combined sewer area and therefore will be impacted the most. The SEWPCC only receives flow from four combined sewer districts so will be much less impacted, and even less so for the WEWPCC.

7.9.1 NEWPCC Wet Weather Treatment

CSO control options that temporarily store combined sewage must eventually dewater the stored sewage. The dewatering strategy involves release of the sewage at controlled rates to treatment. Since the NEWPCC services most of the existing combined sewage area, it has the potential for the largest WWF treatment facility.

The two WWF control flow rates considered for the NEWPCC are 705 ML/d and 825 ML/d. The 705 ML/d rate is consistent with the current plant licencing process and the 825 ML/d rate is an enhanced rate as initially proposed in the 2002 CSO Study.

Process flow schematics are the same for both flow rates, as shown in Figure 7-18. All of the flow would enter the plant from the existing interceptor and be pumped to preliminary treatment, which includes the screening and grit removal processes. From there the flow would be split with a maximum of 380 ML/d directed to the BNR process and any excess to WWF treatment. WWF treatment would consist of HRC and then high rate disinfection. The effluent from WWF treatment would be blended with the BNR process effluent prior to discharge to the Red River. The final blended effluent would be required to meet the plant discharge limits.

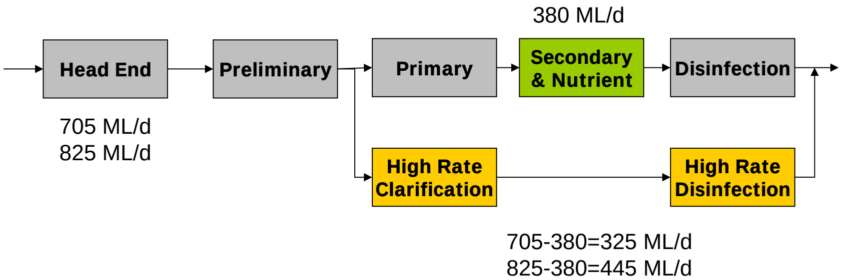

Figure 7-18. NEWPCC Process Flow Schematic

A peak inflow of 705 ML/d and a BNR capacity of 380 ML/d results in a WWF treatment capacity of 325 ML/d, while a peak inflow of 825 ML/d results in a 445 ML/d WWF treatment capacity. A flow schematic for the 705 ML/d scenario based on 2037 flow projections is illustrated in Figure 7-19.

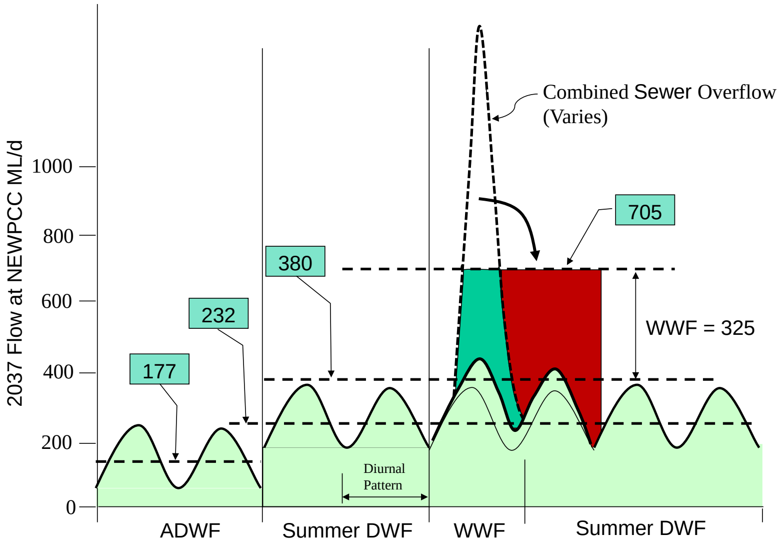

Figure 7-19. 2037 NEWPCC Flow Schematic for 705 ML/d

The wastewater and inflow and infiltration collected from the Northeast and Northwest Interceptors will take first priority, since they are not permitted to overflow and there is no detention storage available to balance their flow rates. The interceptors would continue to operate as they now do, with the controls applied to the CSO discharges in the combined sewer areas.

The dewatering strategy will limit the total inflows to the plant to the peak WWF capacity. For example, if the inflow from the Northeast and Northwest Interceptor drops off, the control system will increase the discharge from the combined sewer storage tanks to maintain the plant WWF.

Figure 7-19 illustrates that although the WWF treatment capacity is assigned at 325 ML/d, the actual capacity available for treatment of combined sewage varies, depending on diurnal patterns and flow received from other sources.

If the inflow rates from other sources drop below 380 ML/d, the excess capacity in the BNR process can be used, making the effective WWF treatment rate greater than 325 ML/d.

7.9.1.1 High Rate Treatment Facility

High rate treatment has been evaluated for the NEWPCC under the NEMP project for CSO treatment (TetrES et al., 2009), and under the current WSTP (Veolia, City of Winnipeg 2014) without the CSO program. It has also been evaluated for the SEWPCC. In all cases the designs have been based on ACTIFLO ballasted flocculation HRC with chlorination and dechlorination used for high rate disinfection. The same processes have been assumed for the master plan assessment.

For the 825 ML/d option at the NEWPCC, the design assumed three HRC units would be installed at 50 percent capacity each, which provides one fully redundant unit. The same design parameters have been used for the master plan for both the 705 ML/d and 825 ML/d options.

Table 7-10. NEWPCC High Rate Treatment Design Criteria

Parameter	Units	705 ML/d Design	825 ML/d Design
Number of Units	each	3	3
Size per Unit	ML/d	165	225
Installed Capacity	ML/d	495	675
Surface Overflow Rate	m^3/m^2/hour	120	120
Coagulation/Flocculation	Minutes	3-5	3-5
Total Retention Time	Minutes	5-7	5-7

The HRC uses microsand for the ballast and chemical addition of ferric chloride and polymer for the coagulation and settling process.

The disinfection facility is based on use of liquid sodium hypochlorite for chlorination and sodium bisulphite for dechlorination to meet the 0.02 mg/L discharge limit. The facility was sized on a three chamber design at a chlorine dosage of 10 mg/L and a contact time of 25 minutes.

The high rate treatment processes use large amounts of chemicals and chemical handling facilities must be included. It was assumed that onsite storage would be needed for 12 days of chemical usage, provided in bulk storage tanks.

7.9.1.2 Performance

The HRC and disinfection treatment processes are effective at removal of some of the WWF POCs, but are likely to need blending with the BNR effluent to fully comply. Typical removal rates for HRC along with a range of blended discharge concentrations for the hydraulic retention time (HRT) and BNR performing at peak WWF rates for the two scenarios are presented in Table 7-11. The actual treatment performance for the NEWPCC is to meet the 705 flow rate and will be developed as part of the NEWPCC upgrade project.

Table 7-11. Blended Effluent Performance from BNR and High Rate Treatment Performance

Parameter	Units	Typical HRC Removals (%)	Discharge Limit	705 ML/d Design		825 ML/d Design	
				Best	Worst	Best	Worst
$cBOD_5$	mg/L	50-80	25	28	58	30	64
TSS	mg/L	80-95	25	18	38	17	41
Total Phosphorus	mg/L	80-95	1.0	0.7	1.0	0.6	1.0
Ammonia Nitrogen	Kg/day	nil	Varies				

Table 7-11 reflects the following:

- Blended effluent from HRC at the 825 ML/d scenario is at its discharge limit, with somewhat better performance under the 705 ML/d scenario.
- $CBOD_5$ removals depend on the soluble organic fraction, which is not removed with the HRC settling process.
- TSS performance is good with HRC, and can be enhanced with changes in chemical dosages and retention times.
- Total phosphorus removals are also expected to be good because of the addition of ferric chloride. The phosphorus limit is measured on a 30-day rolling average basis and performance is expected to be within regulations.
- The HRC process is not effective at removing nitrogen or ammonia nitrogen. Ammonia discharge limits during summer months are low and the ammonia load could limit the use of HRC. The process will depend on dilution of ammonia in the WWF and the benefits of blending with the BNR effluent.

The ammonia concentrations for captured combined sewage during large storm events is unknown, and poses an uncertainty to the evaluation. With the maximum ammonia discharge for August limited to 2,262 kg/d, an average influent concentration of 5 mg/L for a full day with WWF treatment at 445 ML/d would be near the limit.

For disinfection, use of chlorine is known to effectively kill bacteria and would be expected to meet the 200 MPN/100 limits for fecal and *E. coli* bacteria. It would be dechlorinated before discharge. However, the chlorination and dechlorination processes are not without risks, since they are mechanical systems and subject to potential failures.

Although there is some uncertainty with the HRC treatment assessment, for the purposes of this report it is concluded that both WWF treatment options are viable, and can be made to function for the CSO program. More in-depth flow and treatment evaluation would be required to confirm treatment capacities and estimate effluent qualities.

7.9.1.3 Other Potential Impacts to STP Operations

The capture of large volumes of combined sewage and routing to the NEWPCC raises the following other issues and potential concerns that will need to be reviewed and addressed if the option proceeds:

- The amount of grit and screenings captured will increase and will be transported to the WPCC for removal in the existing preliminary process

- The year-round operation of CSO facilities will mean a probable reduction in wastewater temperature for periods of time during the winter and spring seasons, which may impact the biological treatment rates
- Ferric chloride residue from the HRC process will carry over in recycle and sludge processes and may have short-term effect on settling performance and phosphorus recovery
- The HRC process will generate high volumes of sludge over short durations, which will require the addition of sludge handling processes
- Chemical storage and handling facilities will be required for the HRC and high rate disinfection processes
- The WWF treatment process will increase the traffic flow for chemical supply and solids removal

7.9.2 SEWPCC Wet Weather Treatment

The SEWPCC is currently being expanded to address population growth and being upgraded to include nutrient removal. The process operation for its HRC design is somewhat different than discussed for the NEWPCC, as illustrated in Figure 7-20.

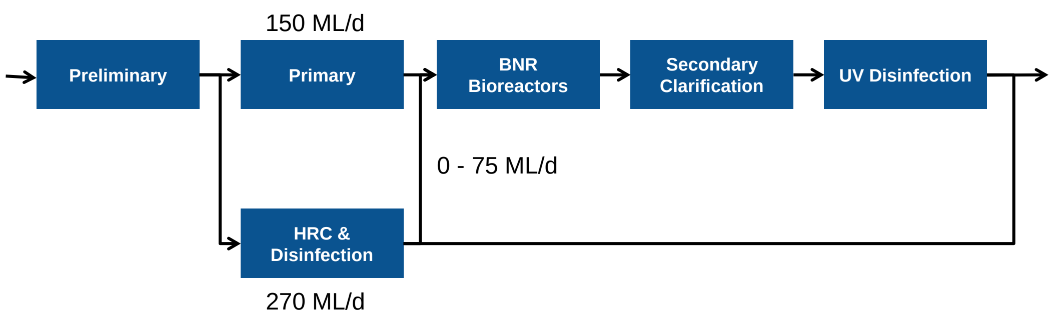

Figure 7-20. SEWPCC Process Flow Schematic

At the SEWPCC, the peak plant capacity is 420 ML/d, with the primary clarifiers having a peak rate of 150 ML/d and the BNR 225 ML/d. All flows up to 150 ML/d will receive primary and BNR treatment. When the flows exceed 150 ML/d in the spring and early summer the excess flows will only receive HRC and disinfection. Starting in August, when more stringent ammonia limits are in effect, a portion of the HRC flows will be redirected to the BNR inlet until its capacity of 225 ML/d is reached.

One of the operating differences between the NEWPCC and SEWPCC HRT is that for the NEWPCC approach, small wet weather events will be routed through the BNR without starting up the HRC. By comparison, the SEWPCC unit will experience more frequent startups, with about 100 compared to 20 times per year at the NEWPCC.

The 270 ML/d HRC design for the SEWPCC is based on two ACTIFLO trains at 135 ML/d each, with no redundancy. The chemical additions and removal rates are similar as discussed for the NEWPCC.

The HRC design (CH2M et al., 2013a) was based on review of historical flow from 2011 and 2012 and involved numeric process modelling and variations of wastewater inflow characteristics. TSS was used as the only vendor performance parameter because of $cBOD_5$ being wastewater dependent.

The SEWPCC evaluation did not consider the impacts of a CSO program. With only three large combined sewer districts discharging to the SEWPCC, it is expected that the current upgrade will be able to accommodate any changes.

The combined districts serviced by the SEWPCC are likely candidates for separation, which would benefit the SEWPCC operation. Of these, Mager has been substantially separated already and Cockburn is scheduled for large scale separation in the near future.

The south tunnel option would direct both Baltimore and Cockburn captured combined sewage to the NEWPCC, which again would benefit the SEWPCC operation.

Storage options for the combined sewer districts in the SEWPCC service area would add a uniform discharge of 20 to 30 ML/d to the SEWPCC during wet weather events. It is unlikely that the SEWPCC could absorb this additional flow under its current design, but options could be considered for sizing the storage facilities as balancing storage, such that the rate of flow to the SEWPCC does not exceed its treatment capacity.

7.9.3 WEWPCC Wet Weather Treatment

The WEWPCC has already been upgraded from a secondary plant to nutrient removal, and it is not anticipated that any further upgrading will be required under the CSO program. The WEWPCC receives little flow from combined districts, and of those Strathmillan and Moorgate have been substantially separated. Woodhaven is the other combined district in the service area and is also a likely candidate for sewer separation.

7.9.4 Satellite Treatment

There are the following two approaches for satellite treatment:

1. The treatment could take place at the end of the pipe, either for single or grouped combined sewer districts. The design would be based on the treatment rate matching, or nearly matching, the discharge rate such that only a minimal amount of combined sewage storage capacity would be required. The facilities would operate for every overflow event, up to 50 times per year in some cases.
2. A centralized treatment facility could be provided for stored combined sewage from all or a number of the combined sewer districts. This requires the use of storage facilities and transportation of the sewage to treatment.

7.9.4.1 End of Pipe Treatment

The 2002 CSO Study investigated vortex solids separators (VSS) and retention treatment basins (RTB) as applicable end of pipe treatment technologies.

The VSSs are high-rate sedimentation devices. Their prime purpose is to remove solids to the point where disinfection can be achieved. A treatability evaluation was undertaken on the Aubrey District as part of the 2002 CSO Study to determine the effectiveness of the high rate treatment options on CSOs. This treatability evaluation showed that if the Aubrey CSO is representative of Winnipeg-wide CSO characteristics, the VSS technology would be unsuitable for the Winnipeg situation. The suspended solids comprised a high percentage of the fine (poorly settling) material in the wastewater. This faction of the solids was considered too light for effective removal with the VSS process and therefore this process was not pursued further.

The RTBs act initially as a storage basin and then as a high-rate sedimentation basin. The volume of combined sewage up to the storage capacity of the RTB is captured, returned to the interceptor, and conveyed to the treatment plant for treatment. Flow in excess of the storage capacity would pass through the RTB, acting as a sedimentation basin that would allow effective disinfection, and then discharge directly to the river (after dechlorination). Chlorination would be accomplished by liquid chemicals and dechlorination would be applied. The flows in excess of the RTB sedimentation/disinfection capacity would be discharged directly to the river without disinfection.

The 2002 CSO Study found that there would be significant concerns with end of pipe treatment. The treatment would be located in or adjacent to residential areas and would be objected to by residents because of the potential for odour generation and the requirement for the transportation and use of chemicals. It is unlikely they would be approved as a permitted use in zoning or other public reviews. While these control options are technically feasible, they have not been considered further because of these practical considerations and the availability of more suitable options.

7.9.4.2 Central Satellite Treatment

The most likely reason to consider a centralized satellite treatment facility is to accommodate high rates of WWF. Flow rates of 705 ML/d and potentially 825 ML/d could be accommodated in a facility on the NEWPCC property, but the plant discharge limits are unlikely to be met for even higher rates. Since the limitation of the existing interceptor system to the NEWPCC is about 825 ML/d, higher rates of flow would be accompanied by a new storage and transport tunnel.

A centralized satellite treatment facility could treat flows from any number of districts and be located anywhere in or near the combined sewer area. The location would be selected based on the contributing combined sewer districts, and the availability of a suitable site. A location upstream from the NEWPCC would be effective in reducing the load on the Main Street interceptor, but would not serve all of the combined sewer area. A location adjacent to the NEWPCC would be ideal from a hydraulic perspective if it is to serve the majority of the combined sewer area.

Establishing a site location for the facility would be an important first step. An ideal location would be immediately to the east of the NEWPCC. The City owns large properties currently with zoning designated P3 (Parks and Recreation). There are also other potential sites adjacent to the NEWPCC with M2 zonings (General Manufacturing) that could accommodate the facility, but would be more difficult for tie-ins.

Other considerations for a large centralized facility include the following:

- A centralized facility is likely to require its own lift station. Pumping rates would be higher than required for the 825 ML/d STP option, which could be anywhere in the range of 1,000 ML/d. The pumping rate would be selected based on the trade-off between treatment and storage.
- The high rate treatment process would require its own screening and grit removal system.
- Large volumes of chemicals would have to be delivered to site on an intermittent basis. This could be done by providing onsite chemical storage or by transferring chemicals from the NEWPCC site on an as-needed basis. Chemicals include ferric chloride, polymer, and micro sand for the ACTIFLO high rate clarifier and liquid sodium hypochlorite for chlorination and sodium bisulphite for dechlorination.
- The sludge waste stream would require thickening and the thickened sludge would require processing. Ideally this would be pumped to sludge or biosolids facilities located at the NEWPCC.
- The centralized WWF treatment facility would operate from about 20 to 40 times per year depending on how captured combined sewage is managed. Because of its intermittent operation, all O&M staff would be located at the NEWPCC and only visit the site on an as-needed basis.

SECTION 8

Potential Plans

The potential plans provide the basis for evaluation of control limits and are the main product of the study phase. The evaluation and decision process that follows will result in selection of a single plan, with an associated control limit. It is to be presented in the preliminary proposal submission as required by EA No. 3042 by December 31, 2015.

The potential plans discussed in the following section have been developed using the control options described in Section 5 to meet the control limits defined in Section 3. Control limits from Clause 11 of EA No. 3042 are included, as well as additional ones that broaden the perspective. The current approach to CSO control is also described, thereby providing coverage for the full range from the current situation to complete separation of the combined sewers.

The potential plans are conceptual approaches, and are not to be considered as being refined or optimized. The goal was to develop potential plans that would be "doable" if selected, avoiding unproven technologies and overly aggressive assumptions. It is not expected that all of the complexities and issues have been addressed, but that the overall level of detail is appropriate for a planning level study, and that improvements and efficiencies will take place in subsequent phases of the program. An increased level of detail will follow based solely on the final selected control limit.

8.1 Regional Planning

The CSO program must be considered on a regional basis before individual projects can be identified for each of the sewer districts. Regional planning addresses how each of the 43 combined sewer districts and three existing STPs will function as an integrated system.

8.1.1 Planning Constraints and Practical Limitations

Regional planning must consider constraints and practical limitations in selecting control options. These constraints and limitations are summarized as follows.

8.1.1.1 Floatables Control

EA No. 3042 requires the prevention of floatables be included in the master plan. This will be accomplished through capture of floatables along with combined sewage, as well as partial screening of the overflows. The screen installations will require use of in-line control gates, which will also provide at least some degree of in-line storage for every potential plan. The only control options without screening will be the partial or complete separation options.

8.1.1.2 Green Infrastructure

The use of GI is required under the EA No. 3042 and will be included in the final master plan. It has not been included in the potential plan development since its efficacy was found to be lower than the grey options and it had a higher cost. The GI options can be added to any of the potential plans at a later date, once the desired commitment level has been established.

8.1.1.3 Treatment

The CSO controls and STPs must work together as a system and comply with both EA No. 3042 and the individual STP licences. The treatment plant capacities and wet weather components to accommodate this, as described in Section 7.9, are listed for reference in Table 8-1.

Table 8-1. STP WWF Treatment Capacity

Treatment Option	WWF Treatment Rate (ML/d)	24-Hour Volume Treated (m^3)
NEWPCC 705 ML/d	325	325,000
NEWPCC 825 ML/d	445	445,000
SEWPCC[a]	30	30,000
Satellite Treatment	Unlimited	> 445,000

Note:
[a]Maximum WWF based on current SEWPCC design

Current upgrades of the STPs include treatment of WWFs to plant effluent limits. This includes the addition of HRC at both the SEWPCC and NEWPCC. The WEWPCC only serves a small portion of the combined sewer service area, and use of HRC for wet weather treatment has not been considered.

8.1.1.4 Dewatering

The combined sewage in temporary storage along with the continuous domestic sewage must be routed to treatment. As described in Section 6.5.1, the storage is to be dewatered within a 24 hours to replenish the available storage for a subsequent event. The peak rate of dewatering depends on the volume in storage, the conveyance capacity, and the rate it can be processed at the treatment facilities.

8.1.1.5 Basement Flooding

The City has made a long-term commitment and investment toward improving the level of basement flooding protection in combined sewer areas, and it is not to be compromised by the CSO program. Control options that reduce the level of protection or add undue risk are to be avoided.

8.1.1.6 Construction

The potential plans are to be practicable, such that if chosen there would be a good likelihood the plans would be designed and approved in a reasonable time frame and the contracting industry could respond with the equipment and resources to meet the plan. Constructability issues also include meeting zoning requirements, environmental approvals, land availability, soil conditions, and riverbank construction.

8.1.1.7 Operations and Maintenance

The basic premise for O&M is that the plans are to be based on proven technologies, with the assumption that the City will expand their O&M resources to meet the potential plan needs.

8.1.1.8 Cost Effectiveness

The potential plans only consider high level costs. The emphasis is on defining “doable” plans, and not cost optimization – which would follow after confirmation of the control limit.

Affordability and scheduling are not included as constraints for potential plan selection; they are to be included in the plan evaluation and decision process.

8.1.2 Control Option Selection

Control options provide the tools to build the potential plans. Table 8-2 provides the results from the technical evaluation for each type of control option used independently for each sewer district totaled for the entire combined sewer area.

Table 8-2. Control Option Evaluation Summary

Control Option	Volume of Storage	Number of Overflows	Year-round Volume of Overflows	Percent Capture
Baseline	7,400	23	5,255,788	74%
Latent	41,000	22	5,131,937	75%
Static Weir	19,900	23	5,105,885	75%
Flexible Weir	33,000	22	4,848,564	76%
Control Gate	50,500	21	4,602,170	77%
Full Pipe	255,000	18	3,835,900	81%
Off-line Storage Tanks	165,000			
Off-line Tunnel Storage	Unlimited			
Storage/Transport Tunnel	Unlimited			
GI				

As Table 8-2 illustrates, the in-line storage options will not achieve the minimum threshold of 85 percent capture by themselves, and therefore a different control option must be selected, or a combination of control options used to meet it and the higher control limits.

8.1.3 Control Limit Goals

The goal for each of the control limits is to reduce the amount of overflow by capturing and treating it or eliminating it through separation. Determination of the actual amounts is very complex, since they depend on multiple interrelated parameters, and was carried out for the study using the InfoWorks Regional Model. A simplification of the process is used for explanation of the potential plan development in this section of the report. It assumes that a fixed volume of overflow must be managed to achieve the alternative control limits, as listed in Table 8-3. Actual results are available from the computer runs.

Table 8-3. Volume of CSO Capture Required to Achieve each Control Limit

Control Limit	Combined Sewer Runoff Volume (m^3)
85% Capture in Representative Year	N/A
Four Overflows in a Representative Year	500,000
Zero Overflows in a Representative Year	855,000
No More Than Four Overflows	1,000,000
Complete Sewer Separation	0

The combined sewer runoff volumes represent the total runoff from the combined sewer area and not the overflow volume that would be less because of capture and routing to treatment.

8.2 Potential Plans

Control options to be included in the potential plans to meet regional objectives and alternative control limits are identified in Table 8-4. Each potential plan is further explained in the following sections.

Table 8-4. Control Options – Potential Plans

Control Limit	Latent Storage	Raised / Bendable Weir	In-line Gate	Full in-line	Off-line	Tunnel Storage	Storage / Transport Tunnel	Separation	Green Infrastructure	Floatable Control	NEWPCC 705 ML/d	NEWPCC 825 ML/d	Satellite Treatment
Current Approach								✓			✓		
85% Capture in a representative year	✓		✓		✓	✓		✓	✓	✓	✓		
Four-overflows in a representative year	✓		✓		✓	✓		✓	✓	✓	✓		
Zero Overflows in a representative year	✓		✓		✓	✓		✓	✓	✓		✓	
No More Than Four Overflows per year	✓		✓		✓		✓	✓	✓	✓	✓		✓
Complete Sewer Separation		✓						✓	✓		✓		

The descriptions that follow are simplified representations of the complex evaluations that were carried out using the InfoWorks CS Hydraulic Model. They are presented for descriptive purposes and do not reflect all of the complexities of the evaluations.

8.2.1 Current Approach

The City's focus on combined sewers has been with elimination of dry weather overflows and protection against basement flooding, with a greater focus more recently on monitoring, measuring, and controlling CSOs.

Several combined sewer districts are identified for upgrading under the on-going BFR program, which will be in parallel with the master plan, as follows:Ferry Road

- Douglas Park
- Riverbend
- Parkside
- Jefferson East
- Cockburn
- Mission

Other districts identified for upgrading under the BFR program beyond 2030 include the following:

- Hawthorne
- Tylehurst

The current approach demonstrates that in spite of not having a master plan in place the CSO situation would improve.

The master plan will provide more focus on water quality and has the potential to reprioritize the BFR program; therefore, the integration of these initiatives will be evaluated in the next phase of the master plan.

8.2.2 85 Percent Capture in a Representative Year

The 85 Percent Capture control limit was adopted after reviewing the knee of the curve approach and discovering the two were nearly equal. The 85 Percent Capture is much easier to define and measure, and because of its use by US EPA in the presumptive approach, it is a significant benchmark for CSO controls.

The 85 Percent Capture limit being applied without a requirement for controlling the number of overflows means that the capture can take place anywhere in the system. This provides the opportunity to target the districts with the lowest costs for upgrading or the districts with the worst water quality.

The 85 Percent Capture limit could be achieved by an equivalent amount of sewer separation, storage options, or GI.

8.2.2.1 Treatment

WWF treatment would not be a constraint for selection of the 85 Percent Capture control options. The 705 ML/d high rate treatment facility planned for the NEWPCC would provide more than adequate treatment capacity even if only storage options were to be used and to even a greater extent with use of separation.

8.2.2.2 Separation

The current BFR program can be effectively leveraged for meeting this 85 Percent Capture control limit. Separation would be selected as the BFR alternative for the following districts:

- Ferry Road
- Douglas Park
- Riverbend
- Parkside
- Jefferson East
- Cockburn
- Mission
- Tylehurst
- Armstrong

Selection of separation for these districts is cost effective for the CSO program since major capital investments are planned for BFR already and the only real premium for CSO control would be the incremental cost to achieve separation rather than relief piping. The incremental premium for the CSO program results from the difference between the cost of separation in comparison to a basement flooding relief scheme based on relief piping.

8.2.2.3 Local and Regional Storage Control Options

This plan would include the use of latent storage, off-line storage, and gate control. It would be possible to achieve the 85 Percent Capture limit without the latent storage and gate controls, but they were included since they effectively reduce the frequency of small overflows and the control gates are needed for the screening operation.

8.2.2.4 Dewatering

Pumping capacity would be added for the latent storage and the lift stations would be upgraded to support the dewatering strategy. SRS flap gate controls would be needed to avoid premature opening of the flap gate during storage events. These upgrades would provide for maximum use of the treatment plant and interceptor capacity.

8.2.2.5 Floatables

As with all the combined sewage capture options, screening would be integrated with the control gate installation and operation.

With this plan, not all of the districts would individually reach 85 percent capture and most would overflow more than four times per year. The expected performance for this control option for the representative year is as follows:

- Percent capture = 85 percent
- Number of overflows (district average) = 15
- Number of overflow events = 63

The 85 Percent Capture potential plan includes the same control options as used with the Four Overflow and Zero Overflow potential plans for the representative year, and could be expanded in the future to a higher level of control. Other potential methods for later increasing the level of control would be through use of RTC and the addition of GI.

8.2.3 Four Overflows in a Representative Year

The four overflow control limit is similar to the one presented in the 2002 CSO Study recommendations as the illustrative implementation plan, except that the requirement is now for year-round control rather than only the recreational season. This is also the control limit reviewed by the CEC at the 2003 public hearings, and the basis for their recommendations.

The limit is based on allowing a maximum of four overflows for the 1992 representative year, uniformly distributed across the combined sewer area. This means that the fifth largest event for that year must be fully captured. As reference, this August 22, 1992, event would produce a runoff volume of 500,000 m^3 that must be managed to avoid overflows.

8.2.3.1 Treatment

The treatment options considered for the NEWPCC were 705 ML/d and 825 ML/d. The larger off-site satellite treatment option was not considered warranted for this level of control.

For a NEWPCC capacity of 705 ML/d, the WWF treatment capacity will average 325 ML/d for future conditions. This means that about 90,000 m^3 would be routed for treatment during the event, with an additional 410,000 m^3 that would need to be captured and routed to treatment or eliminated through separation. The NEWPCC can handle about 325,000 m^3 within the 24-hour time frame, which means that some sewer separation would need to be included with this level of treatment.

For a NEWPCC capacity of 825 ML/d, the WWF treatment capacity will average 445 ML/d for future conditions. Use of this higher wet weather capacity would require an increase in dewatering rates and would mean the storage could readily be dewatered within the 24-hour time frame. Separation options would not be needed at this rate of treatment.

The 705 ML/d option was selected over 825 ML/d for this control limit because of the following:

- The 705 ML/d rate is consistent with the pending regulatory licence for the NEWPCC

- It provides a higher degree of confidence in meeting the NEWPCC plant discharge limits during wet weather
- It provides adequate treatment capacity to meet the 24-hour dewatering objective when sewer separation is included
- It is within the existing interceptor capacity and provides more flexibility for uncertainty and fluctuations in wet weather from separate areas

Wet weather treatment rates for the SEWPCC and WEWPCC will be within manageable levels for the four overflow control limit. Minor upgrading of the SEWPCC may be required depending on which CSO control options are selected for the south combined sewer districts.

8.2.3.2 Separation

Selection of the 705 ML/d wet weather treatment option would require that some districts be separated to reduce the capture volumes to 325,000 m^3. The guiding factor for selecting the locations would be cost effectiveness. Separation would only be cost competitive with the other CSO control options when it can be integrated with the BFR program. Districts that are undergoing or are planned for BFR in the near term and would be considered for separation and their baseline CSO volume for the representative year are the following:

- Ferry Road
- Douglas Park
- Riverbend
- Parkside
- Jefferson East
- Cockburn
- Mission
- Tylehurst
- Hawthorne
- Armstrong

Separation of all of these districts would off-set the storage volume by 145,000 m^3, which means the remaining volume of 265,000 m^3 (410,000-145,000) could be dewatered in 20 hours.

Of these locations, the City’s highest priority districts are Cockburn and Ferry Road because of their location on the extremities of the collection area and long conveyance distances to treatment. Armstrong would be the best early action.

A consequence of separation in the combined sewer districts is that a substantial amount of foundation drainage would remain in the wastewater system. The easiest method for this would be through in-line storage, with the difference being that separated system overflows would not be permitted.

8.2.3.3 Local and Regional Storage Control Options

In-line storage provides the most cost effective method of temporarily storing combined sewage, but also brings with it a number of issues. The illustrative approach from the 2002 CSO Study was based on the use of full pipe in-line, with the assumption that the issue and risks could be appropriately managed.

The most significant issue was and remains to be with the increased risk of basement flooding. The most appropriate risk response appears to be avoidance, so the master plan has adopted a moderate approach to in-line storage, by limiting its use through the gate control option. The control gates would be sized to a maximum height of half the trunk diameter.

Latent storage would be added for all of the districts with relief piping in place. Latent storage has been estimated to provide 41,000 m^3 of storage, and when added to a volume of 50,500 m^3 for control gates, would total 91,500 m^3.

Additional storage would still be needed after accounting for the separation, control gates, and latent storage. The options for this last increment of storage include off-line tanks, off-line storage tunnels, or storage/transport tunnels. As discussed in Sections 7.5 and 7.7, the use of GI and advanced RTC are not being considered at this stage of the master plan.

The choice between off-line tanks and tunnels involves the following practical considerations:

- Near surface off-line storage tanks require high rate pumps to transfer the incoming combined sewage into the tanks, which adds considerable cost and complexity. For some locations the existing lift station pumps can be used for this purpose making the option much more cost competitive.
- Storage tunnels will be needed where space for off-line storage tanks is not available, and they can be located deep enough to avoid the use of high rate pumps. They may be able to further enhance BFR with little additional cost, which would provide an additional tangible benefit to the community.
- Storage/transport tunnels would naturally add inter-district flow capability much better than storage tunnels that are not interconnected, and be better at dealing with the rainfall spatial distributions.

Since the selection is only concerned with the four overflow control limit for a uniformly distributed rainfall and the advantages of a storage/transport tunnel would not be realized, the combination of storage tanks and storage tunnels was selected.

8.2.3.4 Dewatering

The dewatering system must return the system to readiness for the next event within 24 hours from the end of the first event. For the four overflow control limit this will require dewatering pumps be distributed throughout the system for the in-line, latent storage, off-line storage, and tunnel storage. As described in Section 5.5.1, flexibility in the pumping rates will be needed to accommodate changes in dewatering strategies, dealing with variable rain patterns, system redundancy, and future RTC plans.

8.2.3.5 Floatables

The four overflow control limit includes screening of partial flow for floatables. If this plan is implemented the majority of the runoff events will be completely captured, and intrinsically reduce floatables and improve the aesthetics. Screening of the initial overflow from the larger less frequent events will take place. High flow rates will not be screened, but the majority of floatables will have already been captured or screened by that point.

8.2.4 Zero Overflows in a Representative Year

The zero overflow control limit requires that there be no overflows for the largest event for the 1992 representative year, uniformly distributed across the combined sewer area.

As reference, this requires the management of approximately 855,000 m^3 of runoff for the event, which is nearly double the amount required for the four overflow control limit. The actual storage volume would be adjusted for the dynamic effects of dewatering during the event, and a number of other factors that are more precisely determined through the InfoWorks simulation modelling process.

8.2.4.1 Treatment

The largest storm for the 1992 representative year could not be treated within a 24-hour period if it were all captured and routed to the NEWPCC.

The 325 ML/d WWF treatment rate associated with the 705 ML/d NEWPCC design, after accounting for dewatering during the event, would need to treat a stored volume of 775,000 m^3 but would only have a capacity for 325,000 m^3 in 24 hours.

The 445 ML/d WWF treatment rate associated with the 825 ML/d NEWPCC design, after accounting for dewatering during the event, would need to treat a stored volume of 735,000 m^3 but would only have a capacity for 445,000 m^3 in 24 hours.

Satellite treatment for WWF was considered another control option, which would be located either fully off-site from the existing STPs or in combination with one that was on-site. The satellite facility could theoretically be designed to handle any design flow, although there would be practical limits for conveyance and operations.

The options considered for treatment were therefore 825 ML/d at the NEWPCC with sewer separation and satellite treatment.

The treatment constraint associated with the 825 ML/d NEWPCC design capacity could be managed by increasing the amount of sewer separation. The 445 ML/d WWF treatment capacity at the plant may treat the remainder of flow to meet the future STP licence limits, but will depend on the final designs for the NEWPCC BNR..

The existing interceptor system would require some localized upgrading to deliver the flows, with the upgrades depending on the selected locations for sewer separation.

Satellite treatment would require a standalone facility in the vicinity of the existing NEWPCC. The major advantages are that EA No. 3042 discharge limits would apply to the WWF and be easier to meet than the plant discharge limits and the NEWPCC could operate without effluent blending. The high rates of WWF would require an increase in conveyance capacity, which could be accommodated through use of a storage/transport tunnel along Main Street or with the full length tunnel control option.

The drawback to satellite treatment is with it being located off-site from the existing STP. It would require land acquisition and development approvals, and off-site O&M would be more cumbersome. Solids management and handling would be a major concern for the intermittently operating facility.

The 825 ML/d treatment level was selected for the zero overflow control limit. If this control limit is eventually chosen the storage/transport tunnel along with satellite treatment control options should be reconsidered.

The use of sewer separation with this control limit is likely to limit any impacts to the SEWPCC and WEWPCC facilities.

8.2.4.2 Separation

Districts for sewer separation need to be selected to accommodate the NEWPCC 825 ML/d treatment rate. Cost effectiveness is the primary factor for selection of areas.

The separation projects identified previously that can be integrated with future BFR projects would be the most cost effective and therefore the first priorities, which are the following:

- Ferry Road
- Douglas Park
- Riverbend
- Parkside
- Jefferson East
- Cockburn
- Hawthorne
- Armstrong

- Mission
- Tylehurst

Complete separation of these areas would offset approximately 280,000 m^3 of the required storage volume. This would bring the amount of separation for the CSO program to between 25-30 percent of the combined area.

Separation of all of these districts would off-set the storage volume by 280,000 m^3, which means the remaining volume of 455,000 m^3 (735,000-280,000) could be dewatered in approximately a 24-hour time period.

If this control option is ultimately chosen, the areas for separation will need to be refined through either complete or partial separation of combined sewer districts, as long as the total required area is separated from the combined system.

As before with the other options, there is inherent advantages to separation. It eliminates overflows and enhances the local level of basement flooding protection. The drawbacks with separation are its high cost, amount of disruption it causes to neighbourhoods, and long time frame for implementation.

As noted previously, a consequence of separation in the combined sewer districts is that a substantial amount of foundation drainage remains in the wastewater system. The easiest method for resolving this would be through in-line storage, with the difference being that as a separated system overflows would not be permitted.

8.2.4.3 Local and Regional Control Options

The issues in selection of the local and regional control options for the zero overflow control option are similar to those for four overflows discussed previously, with the exception of the storage requirements increasing to about 445,000 m^3.

In-line storage is the most cost effective method of temporarily storing combined sewage. Control gates along with latent storage will provide 91,500 m^3.

The control options for the last increment of storage include off-line tanks, off-line storage tunnels, and storage/transport tunnels. As discussed in Sections 5.5 and 5.7, the use of GI and advanced RTC are not being considered at this stage of the master plan.

The choice between off-line tanks and tunnels involves the following practical considerations:

- The total amount of accessible off-line storage is 165,000 m^3 distributed in 25 of the 43 districts; therefore, if selected, would have to be supplemented by tunnels or additional separation.
- High rate pumps must be provided with near surface storage tanks to transfer the incoming combined sewage into the tanks. In some cases the combination of gate control and existing lift station pumps can accommodate this, otherwise large pumping stations are required.
- Tunnels do not have the same site location issues.
- A major advantage of storage tunnels is that they can be designed to further enhance BFR that would provide an additional tangible benefit to the community.
- Storage/transport tunnels improve the inter-district flow and are better at addressing the rainfall spatial distributions.

Since this option is only concerned with the zero overflow control limit for a uniformly distributed rainfall and the advantages of a storage/transport tunnel would not be realized, the combination of storage tanks and storage tunnels was selected.

8.2.4.4 Dewatering

The dewatering system must return the system to readiness for the next event within 24 hours from the end of the first event. For the zero overflow control limit this will require dewatering pumps to be distributed throughout the system for the in-line, latent storage, off-line storage, and tunnel storage. As described in Section 5.5.1, flexibility in the pumping rates will be needed to accommodate changes in dewatering strategies, addressing variable rain patterns, system redundancy, and future RTC plans.

8.2.4.5 Floatables

The zero overflow control limit includes screening of partial flow for floatables. If this plan is implemented the majority of the runoff events will be completely captured and it will intrinsically reduce floatables and improve the aesthetics. Screening of the initial overflow from the larger less frequent events will take place. The highest flow rates will not be screened, but the majority of floatables will have already been captured or screened by that point.

8.2.5 No More Than Four Overflows per Year

The No More Than Four Overflows per year control limit was originally intended to be dealt with as a potential plan variant, but was later added as a core control limit after discussions with the regulatory working committee. It is an alternative interpretation of the four overflow limit, but has a higher level of performance than even the zero overflow control limit.

The higher flow rates for this alternative are a result of the following:

- No More Than Four Overflows means that maximum number of overflows in any year over the long-term is limited to four, unlike the four and zero overflow control limits for the representative year where the limit would be an average.
- This control limit is based on meeting EA No. 3042 "overflow event" definition. By this definition, an overflow from a single district would be counted as an overflow event, just as simultaneous overflows from all 43 districts would be counted as one overflow event. By comparison, the method used for the Four Overflows for the representative year control limit described previously allows for four overflows from each district to take place at any time during the year.
- Meeting the four overflow limit requires that the spatial distribution of rainfall be accounted for over the long-term record, as compared to the four and zero overflow control limits described previously that use a uniform rainfall distribution.

The potential plan for this control limit was proposed to be evaluated as a variant because of the complications in modelling it. The evaluation would require a long-term record of rainfall distributions, and the modelling effort would be excessively time consuming.

Rainfall distributions can be highly variable, particularly when measured across an area as large as the combined sewer area. It is common for pockets of intense rainfalls to occur at different locations at different times, each of which could cause overflow events.

There is limited statistical information on the spatial distribution of rainfalls for Winnipeg. Rainfall and snowfall statistics are acquired from meteorological stations such as Environment Canada's station at the Winnipeg airport, which only include a single point source. Another source of precipitation data is from the City's own rain gauge network, which has been used to support monitoring programs for BFR projects, and event reporting for internal and public information.

A method of approximating the control limit was therefore developed as presented in Section 3.2.1.3. This was done by increasing the largest rainfall for the 1992 representative year by 6.6 mm, from 34.6 to 41.2 mm. By sizing the system for the larger event, the level of confidence is increased that it will meet the sizing requirements for the higher control limit, but because of the variability of rainfalls, this does not guarantee that it will never be exceeded.

On an area-wide basis, the amount of precipitation received for the event will be the same as for the uniform distribution approach, but because of the spatial distribution a larger volume will be received at some districts than others, and therefore each of the storage facilities in the system must be sized for the largest precipitation. It has been assumed that the capture and treatment amounts will be equal to the installed volume of storage, although it is recognized that the designs could be reduced through district transfers using storage transport tunnels, or possibly advanced RTC.

This approach would add between 100,000 to 200,000 m^3 of combined sewage to the largest storm for the representative year, resulting in a total of 1,000,000 m^3 to be managed.

8.2.5.1 Treatment

The increased runoff volume, combined with a 24-hour system dewatering constraint, would exceed the WWF treatment capacity provided with the NEWPCC 825 ML/d design. Use of additional temporary storage would not be viable and satellite treatment or additional separation would be needed to manage these volumes.

A satellite facility designed for a continuous WWF rate of approximately 1,000 ML/d could meet the requirements. Separation of about 50 to 60 percent of the existing combined sewer area would effectively reduce the amount of inflow to the point that the NEWPCC 825 ML/d WWF would meet the effluent requirements.

For comparative purposes, the satellite treatment option has been selected for this alternative. The volume requiring treatment considers the following:

- The runoff volume from a spatially distributed event that is 6.6 mm larger than the largest event for the 1992 representative year.
- The ability to dewater the complete installed volume of combined sewage storage within a 24-hour period.

The discharge limits from Clause 12 of the CSO Licence would apply to the satellite treatment facility. The phosphorus limit of never exceeding 1.0 mg/L for total phosphorus would present a challenge. The removal performances for HRC with chemical addition are reported to be 80-95%, which on average would be expected to meet the requirements, but there would likely be episodic periods of it being exceeded. This issue was raised with the regulatory working committee and it was proposed that if this alternative is selected, the licence limit be changed to an annual average loading rate of 1.0 mg/L rather than a never to exceed limit.

It has been assumed that the 705 ML/d HRC would be installed as planned at the NEWPCC since interim treatment would be required to meet the plant licensing and could not wait for the CSO program.

8.2.5.2 Separation

The separation projects identified previously could be integrated with this alternative and would reduce the storage and treatment costs.

If this control option is ultimately chosen, the areas for separation will need to refined, and can be achieved through either complete or partial separation of combined sewer districts, as long as the total required area is separated from the combined system.

As before with the other options, there is inherent advantages to separation. It eliminates overflows and enhances the local level of basement flooding protection. The drawbacks with separation are its high cost, amount of disruption it causes to neighbourhoods, and long time frame for implementation.

As noted previously, a consequence of separation in the combined sewer districts is that a substantial amount of foundation drainage remains in the wastewater system. The easiest method to address this would be through in-line storage, with the difference being that as a separated system overflows would not be permitted.

8.2.5.3 Local and Regional Control Options

Satellite treatment would work most effectively with the full length storage/transport tunnel because of the following:

- A storage/transport tunnel would be required to supplement the conveyance capacity of the existing main interceptor to transfer the added flows to treatment
- The storage/transport tunnel would be most effective for dealing with spatial distributions, because of the built-in ability to transfer flow between districts

This alternative would also use control gates, similar to the other options, to capture in-line storage, reduce the size of the tunnel, and provide the needed head for proper screening operation. The control gates would also be used for RTC and managing the levels and flows in the interceptor and storage/transport tunnel.

8.2.5.4 Dewatering

The dewatering system must return the system to readiness for the next event within 24 hours from the end of the first event. Since this plan uses a storage/transport tunnel, many of the distributed pumps will not be needed, being replaced by a larger pumping station at the lower end of the tunnel, which serves as the raw influent pumps for the satellite treatment facility.

8.2.5.5 Floatables

The No More Than Four Overflow control limit includes screening of partial flow for floatables. If this plan is implemented the majority of the runoff events will be completely captured and it will intrinsically reduce floatables and improve the aesthetics. Screening of the initial overflow from the larger less frequent events will take place. The highest flow rates will not be screened, but the majority of floatables will have already been captured or screened by that point.

8.2.6 Complete Sewer Separation

Complete separation is viewed by some as the best approach for dealing with CSOs. This would be true from a CSO reduction perspective, since combined sewers would be eliminated and therefore could not produce CSOs.

This alternative is much different than those previously discussed. Whereas the 85 Percent Capture, Four Overflows and Zero Overflows for the representative year, and No More Than Four Overflows alternatives adapt existing infrastructure to the new control limits, sewer separation would add new infrastructure, while repurposing but not eliminating or replacing the exiting combined sewers. This alternative includes the following:

- The existing combined sewer area requiring separation is about 8,300 ha
- The new land drainage sewers would be sized for the current design storms, which are infrequent events, multiple times larger than the representative year events
- The separation would require large sewer networks throughout the service area, many with large diameter pipes and new outfalls to the rivers
- Street inlets to the existing combined sewers would be redirected to the new land drainage sewers, but otherwise the combined sewers would be unchanged

Complete separation is routinely considered in CSO programs. It has been adopted as the control option by other cities for their CSO programs, has been previously evaluated in Winnipeg on BFR projects as an alternative to relief piping and was considered in the 2002 CSO Study.

There are various ways to separate combined districts. The most common approach is to install a new land drainage system throughout the entire area, leaving the existing combined sewers to serve as the wastewater system. Another approach is to install new wastewater systems, leaving the existing combined sewers to function as a separate land drainage systems.

The potential plan for the master plan is based on installing land drainage sewers to collect all road drainage. The separation would be complete as far as covering the entire combined sewer area, but foundation drainage would remain as part of the wastewater system.

Installation of the land drainage sewers would be a major undertaking, with sewer construction required on nearly every street in every combined sewer district neighbourhood.

The level of effort would be different for each combined sewer district, depending on its current configuration, including the following:

- Districts that have not been upgraded through the BFR program or other sewer upgrading initiatives would require construction of new LDS on every street.
- Districts with relief sewers would require detailed engineering evaluations to determine the most appropriate method of separation. Relief sewers in most cases are as large as the original combined sewers, and present the opportunity to repurpose them as LDS under the separation program. New LDS would be required along with conversion of relief sewers to land drainage.
- Some combined sewer areas have already been partially or largely separated with this approach. For those areas the only work required would be to complete any outstanding separation.

The original combined sewers would function with little modification, as follows:

- All services connected to combined sewers would remain and convey sanitary sewage as they currently do.
- The converted combined sewers would be oversized to function as only separate wastewater sewers, but many of them are an egg-shaped, which maintains cleansing velocities and limits sedimentation and odour generation.
- The combined sewers being converted to a wastewater sewers will still collect and convey foundation drainage in the same pipe. Poor lot grading and inflow and infiltration would create a need to store captured WWF and gradually dewater it to treatment. Sewer overflows to the river would not be permitted because of their conversion to wastewater sewers and the prohibition of sanitary sewer overflows.
- The WWFs would still require treatment processes to be added at the STPs. It has been assumed the 705 ML/d HRC at the NEWPCC and 270 ML/d HRC at the SEWPCC will be installed as currently planned.

Following are several additional advantages to complete separation:

- The number of overflows would be reduced to absolute zero, and the percent capture increased to 100 percent, far exceeding that for any other CSO control options.
- The level of basement flooding protection would increase, becoming comparable to levels in new developments. This would mean the flood risk in some of the flood prone areas in combined districts would be reduced.

- The current BFR program would not be needed since it would be replaced by the sewer separation program.

Following are also significant drawbacks to be considered in the evaluation of separation:

- Complete separation is the most expensive CSO control option.
- It would take longer to implement than the other potential plans because of its high cost and the amount of construction effort involved.
- River water quality improvements would take a long time because of the slow rate of progress and sequential approach to combined sewer district separation.
- Complete separation is disruptive to neighbourhoods, and would be widespread. It would create inconvenience and would be disruptive to transportation routes, parking access, and local businesses.
- New LDS will continue to carry street litter and surface contaminates to the rivers.
- Sewer separation would add to the asset inventory to be managed with increased O&M costs.
- Land drainage sewer discharges also include a pollutant load that may be the subject of review and regulation in the future.

8.3 Potential Plan Variants

The planning process recognized that there are multiple ways to address CSOs and that it would be unreasonable to undertake technical evaluations for them all. The use of variants, as presented in Section 3, was therefore proposed to simplify the review and provide perspective on the most important issues.

As it was discovered through the progress of the study, the need for variants has been reduced. Some of the anticipated variants were eliminated through clarifications with the regulatory working committee and addressed through the following redefinition of the control limits:

- The not-to-exceed control limit has been added as the “No More Than Four Overflows” alternative control limit
- The CSO licence definition for an “overflow event” has been applied to the “No More Than Four Overflows” alternative
- Spatial distribution of rainfall has been applied to the “No More Than Four Overflows” alternative

The remaining variants, or “what if” scenarios, are presented in the remainder of this section.

8.3.1 Representative Year Alternatives

The representative year is a common approach used for CSO evaluations and was used in the 2002 CSO Study. The main reason for its use is that it greatly reduces the analytical effort. It facilitates assessment of a wider range of control options and provides a sufficient level of accuracy for conceptual planning.

The master plan used InfoWorks CS as the evaluation tool for the urban drainage and hydraulic analyses. The representative year provides the precipitation basis for year-round evaluations. InfoWorks then determines the volumes of runoff and individual flows through thousands of pipes at 15 second time steps. As the levels of detail and complexity increase so do the run times. As an example for the master plan, a simulation of the NEWPCC service area for the representative year can take over 4 days of continuous computer time. Use of the full rainfall record from 1960 to present would be excessively time consuming and not practical.

8.3.1.1 1982 Representative Year

The selection process for the representative year included review of the 2002 CSO Study approach and completion of an independent statistical review using an updated rainfall database.

The statistical review grouped precipitation for each year into increments and compared the results to the long-term averages. Two years were found to be the closest fit to the long-term average, 1982 and 1992, with the latter being picked for use in the master plan. Reaching the same conclusion as the 2002 CSO Study provides a degree of validation since a somewhat different approach was used for the evaluation with the same end result.

The snowmelt evaluation was also reviewed and it was observed that 1982 was a light year for snowmelt and the long-term conditions would be much better represented by 1992.

8.3.2 Equivalent Performance

The concept of equivalent performance is to meet or exceed a performance target using a flexible approach. The approach of interest for the master plan is to increase the capture for discharge locations with the highest loadings, allowing for commensurate reductions in other locations.

EA No. 3042 allows for this through the 85 Percent Capture criterion, but it was found to be of limited value with respect to potential plan optimization. The control limits defined in the licence require that a maximum number of overflows be met along with the 85 Percent Capture limit, and since the capture criteria is achieved by meeting the number of overflow requirements, there is no opportunity for re-balancing of capture rates.

The only control limit that provides for this is the 85 Percent Capture limit. This control limit was added to those stipulated in EA No. 3042, and is not accompanied by a limit for the number of overflows. Its use is demonstrated in the “85 Percent Capture for the representative year” control limit described previously.

8.3.3 High River Level Operation

High river levels will present unique challenges for operation of CSO controls. High river levels frequently occur in the spring because of runoff from snowmelt throughout the watershed. High river levels can also occur at other times of the year because of a combination of prolonged wet conditions and heavy rainfalls. High river levels reduce or eliminate the capacity of the gravity discharges, and can be accompanied by flood pumping station operation. Once the pumps are operational they discharge combined sewage from the collection system directly to the rivers to reduce basement flood risks.

In most cases, the controls options will provide sufficient capacity for operation during high river level conditions. The runoff during the spring will be either from snowmelt or spring rainfalls, which typically have lower intensities than summer rainfalls.

For situations where the levels in the sewers rise too high and basement flooding becomes a risk, the flood pumps are automated to reduce the in-system level by pumping sewage directly to the river. Each time the flood pumps operate a pumped discharge occurs.

CSO compliance requirements should be excluded or modified for high river level operation. The following points describe why this needs to be considered:

- Flood pumping station operation only occurs under emergency situations to prevent basement flooding damage and the associated health risks.
- High river levels can also limit the discharge capacity from the STPs, which can negate the benefits of capturing the combined sewage and routing it to treatment.

- For situations where pumped overflows occur, the river levels and flow is high and there would be less recreation taking place on the rivers under high river flows.

The need for changes in compliance for high river levels and their type will depend on the final selection of control limits and will be reviewed after the control limit is selected.

8.4 Early Actions

This section considers the on-going and potential interim works that are or could be implemented in advance of completing any of the potential plans.

8.4.1 Current Programs

The City has a well-established sewage collection and treatment program upon that is continually improved. The current programs and potential changes are defined as follows:

- The City captures and treats all DWF. For the combined sewers this consists of diversion weirs, off-take pipes, and sewage lift stations for diverting the DWFs to treatment. The peak flow rates and need for the weirs in the future will depend on the control options selected for implementation.
- DWF is pumped to the interceptors from lift stations for 25 of the combined sewer districts, with the others discharging by gravity. The operation of these lift stations, or the need for them, may change with the CSO program. The gravity overflows will at a minimum require some type of flow regulator.
- The flood pumping stations discharge combined sewage directly to the rivers when high flows occur and gravity discharge is prevented by high river levels. These stations are over 50 years old and will remain in service for most of the CSO potential plans, with possible exceptions being with the full storage/transport tunnel and complete separation. The flood pumping stations may also serve as the high rate transfer pumps for off-line storage options.
- The combined sewers themselves function primarily by gravity with little maintenance required. The lift stations require routine attendance and regular maintenance. Nearly all of lift stations are advanced in age and not built to current standards. The City continually upgrades the stations and will need to carry out major upgrades or replacements to many of them.
- A large percentage of the combined sewers are advanced in age and are in need of replacement or rehabilitation. The City carries out annual repairs and rehabilitation that would need to continue under all of the CSO potential plans.
- The BFR program is directly related to the potential CSO program, and will have a number of direct links. The tunnel options and complete separation could radically change the nature of the BFR program, and for this reason the City is anticipating that the master plan will be integrated with the BFR program.
- The current SCADA system sends alarms from outfall locations to a central control station at McPhillips Avenue. The alarms are based on sewer levels and control gate movement. They warn of overflows and generate callouts for maintenance crews to address faulty operations. There is no interaction between the lift station pumping rates and interceptor operation.
- The interceptor operations are controlled at the STPs. The wet well levels are monitored and the raw sewage pumps are operated to maintain these levels accordingly. The master plan program operation will require more advanced monitoring and controls, with direct integration between STPs and the collection system.

There are also a number of other program and initiatives related specifically to the performance of the combined sewer system that the City has implemented, as follows:

- CSO Outfall Monitoring Program – Beginning in 2010, a total of 39 discharge locations have had instrumentation installed to monitor level, flow, and flap gate inclination. These instrumented discharge locations allow the City to collect real-time data on system flows and overflows.
- Sewer Level Monitoring System – The City operates a network of level sensors at important operation point throughout the sewer system. This provides the City with operational data that can also be used to estimate the occurrence of an overflow. It allows provides City operational staff with alerts, so they can respond as needed on a real-time basis.
- Sewer Flow Monitoring Program – The City maintains a number of flow monitoring instruments that can be moved to any location in the system. The monitors are used to collect system flow and can be used to assess the operation of the system and for calibration of the City's hydraulic models.
- Biweekly River and Stream Water Quality Monitoring Program – The City collects water quality data from the Red River, Assiniboine River, and Small Streams each year from May to September as river conditions allow. A total of 19 locations are tested for 17 parameters including nutrients and bacteria. This program has been in place since 2007.
- Pilot Stormwater Retention Tank – In 2011, the City installed a stormwater retention tank that functions as off-line storage. The pilot project allows the City to gain operational experience into the operation of this type of infrastructure. Similar tanks may be used in the combined system to minimize the contribution of runoff to CSOs.
- Pilot Green Back Lane – in 2014/2015, the City completed the construction of a "green" back lane. The laneway was constructed a pilot study to gather information on the operational and maintenance requirements that this type of GI requires. Data gathered will be assessed to determine if there is any benefit in pursuing more of these type of GI installations.
- Asset Management – The City's existing asset management program includes the inspection of all the lift stations and flood pumping stations on a regular schedule. The stations are assessed for upgrades including improved data collection systems and pump capacity evaluations. Any opportunity to optimize the station to benefit overall system control is reviewed at this time. Additionally, key flow control points and interconnections within the City's system are reviewed on an ongoing basis to identify opportunities for improvement. This regular maintenance has identified opportunities to adjust weir levels, repair and adjust pipe flow, and eliminate unwanted flows entering the combined system

The WWF also affects the STP operation and is being planned to be upgraded, as follows:

- NEWPCC – Captured flow for most of the CSO potential plans will be routed to the NEWPCC for treatment, at plant design flows of either 705 ML/d or 825 ML/d. A 705 ML/d facility is currently being planned for the NEWPCC upgrading. The decision on CSO control limits will determine if this level of treatment is sufficient, or if it needs to be upgraded to 825 ML/d.
- SEWPCC – Upgrading and expansion is currently underway, and includes a HRC facility, which from preliminary evaluation appears to be adequate for all CSO potential plans.
- WEWPCC – Wet weather is treated through the primary clarification process. The contributing area for combined sewers is relatively low for the WEWPCC treatment area, and no significant changes are anticipated with any of the potential plans.

8.4.2 Maximize Use of Existing Infrastructure

Maximizing the use of existing infrastructure is one of the US EPA's nine minimum controls, and was introduced in Section 3.1.1 as being a potential first step for the master plan. It would include operational changes and implementation of minor upgrades to capture as much WWF as practicable with the existing infrastructure. Because the changes would be minor, they would not necessarily need to be a component of the final master plan.

The potential changes for maximizing existing infrastructure are as follows:

- The first step would be to raise existing weirs. Two methods are by raising fixed weirs, or by installing flexible weirs. Hydraulic evaluations would be required in each case to avoid compromising the existing level of basement flooding.
- Increasing the capture in combined sewers could cause the sewage to be rerouted to SRS outfalls for those districts with relief piping in place. This situation would have to be avoided by either keeping the levels below the interconnection levels, or by installing gate controls on the SRS flap gates.
- Lift station pumping rates would be reviewed and minor modifications made to upgrade their operation. It is not expected that new lift stations be built at this stage, but the addition of flow monitoring, minor pump modifications, and operational changes in most cases would capture more combined sewage.
- Gravity discharges are uncontrolled, unmonitored, and the flow dynamics are not fully understood. Flow control or flow monitoring is required to understand how they function to enable decisions to be made on their operation. In the long-term, flow regulation will be required to modulate the diversion rates, as will be done for lift stations. It may be that for the interim the gravity discharges function optimally.
- More information is required on interceptor operation to make appropriate adjustments to flow. Lift stations and gravity connections discharge directly to the interceptor without the collection of data on operating status. This data is needed to coordinate with the flow from separate districts and those districts that are pumped to the STP to optimize operation and avoid interceptor overflows.

Enhancement of the monitoring and control systems throughout all sewer districts are required to complete most of these tasks.

8.4.3 Early Action Projects

Early actions are an extension to maximizing use of existing infrastructure and are intended to include components of the final master plan that will yield immediate benefits.

Several upgrades for maximizing existing infrastructure are common with early actions items, including monitoring and instrumentation, lift and flood pumping station upgrading, gravity discharge control, and flap gate control.

The early actions would include a greater level of capital investment in a number of areas as summarized in the following points:

- Accessing latent storage would require the installation of small lift stations near the SRS outfalls. It would provide a direct addition to the amount of in-line storage without the need to construct storage facilities.
- Armstrong sewer district receives flows from separate LDS that is mixed with combined sewage and is either captured or overflows to the river. Disconnection of the LDS prior to reaching the combined sewers and routing it to a new LDS outfall would completely remove this contribution to the combined sewer area and provide a significant reduction in CSO.
- The current BFR program’s mandate is to reduce basement flooding. This should be aligned to integrate with the CSO program. The master plan will define areas where sewer separation is required to achieve the CSO control objectives, and will provide guidance in other areas that can then be integrated with basement flooding protection.

- Although the specific control options are still uncertain, control gates and screens have been identified for implementation on all of the potential plans that retain combined sewers. Installation of gate controls need not wait for the more intensive infrastructure that accompanies them, such as off-line tanks or tunnels. For screens, the overall combined sewer plan must be considered as screen sizes can be impacted by planned storage elements. The gates and potentially some screens could be installed throughout the combined sewer area early in the program and immediately reduce overflows.
- Global RTC should be considered for implementation to optimize overflow reduction and increase retention after upgrading the monitoring and control system, the addition of control gates, and adjustment of pumping rates.
- GI has not been identified as a core control technology for the potential plans, but can be considered as a control enhancement. GI has the advantage in that it can be implemented independently at any time in addition to the other control options and does not have to be coordinated with other CSO program component implementations.

Cost Estimates

Cost estimates are important for the master plan decision making process. Cost estimates are used to compare the relative costs of alternatives, assess value for money, and define budgeting requirements. For projects as large as the CSO program, cost estimates also can be used to evaluate affordability and ability to pay.

The master plan has identified five potential plans that are to be evaluated in terms of performance and costs. The CSO potential plans all consist of major infrastructure additions, and will be capital intensive. They will each also increase the O&M requirements, which are considered on a present worth basis as part of the lifecycle analysis.

This section describes the approach used for developing cost estimates and includes the following:

- The general cost estimating approach and assumptions used to develop cost estimates
- Markups applied to the capital costs
- Operations and maintenance costs
- Lifecycle cost estimates
- Cost estimate classification, including the level of accuracy of cost estimatesF

9.1 Future refinements affecting costsCost Estimating Approach

Cost estimating for the preliminary report of the master plan was carried out using the Program Alternative Cost Calculator tool (PACC tool). The PACC tool was originally developed for the Metropolitan Sewer District of Cincinnati, and has since been refined and applied to major CSO programs in several locations. It provides planning level cost estimates for sanitary, storm, and combined sewer programs. The tool includes costing information for commonly used control options, which can readily be updated to local conditions.

The costs presented in this report are reported in terms of April 2014 dollar values for Winnipeg. Costs from the PACC tool have been updated based on the Engineering News Record Construction Cost Index (ENRCCI) for April 2014. Since there is no ENRCCI for Winnipeg, the ENRCCI was adjusted using the RS Means Index of 100.6. This adjustment sets the ENRCCI index in April of 2014 at 10163 for Winnipeg.

The CSO program will extend over many years and there will be many factors affecting the cost of implementation. It will depend on the actual project definitions, actual labour and material costs, competitive market conditions, final project details, implementation schedule, and other variable factors. As a result, it must be recognized that final project costs will vary from the estimate presented herein, and that the PACC tool only provides a planning level tool for comparative alternative evaluations.

The PACC tool costs were updated to local conditions and used to develop the preliminary report estimates. The estimates presented are based on the project definition and assumptions as of the June 2015 draft report. Cost estimating is a continual process of refinement, as explained in the estimate classification and future cost refinement discussion sections.

9.1.1 Construction Cost Estimates

The PACC tool provides cost curves for a wide range of control options. All construction costs include the general requirments for contracting, as well as the contractor’s labour, materials, overhead and profit.

The construction costs are therefore equivalent to prices received to bid opportunities, and exclude contract contingency, engineering, and administration costs.

Cost for land acquisition is not included at this stage of the project.

The PACC tool uses a variation in approaches for applying and reporting of ancillary and operation and maintenance costs. They are included with the constructon cost in some cases and must be added in others to determine lifecycle costs, as described in the description for each control option.

9.1.1.1 Gravity Sewers and Tunnels

Construction costs for gravity sewers and tunnels depends on the installation method, pipe size, and depth. The practice in Winnipeg has been to use trenchless (tunnelling) methods of construction for all pipe sizes. The cost curve for sewer construciton is determined by their unit price and length. The unit costs used for sewer construciton is shown in Figure 9-1.

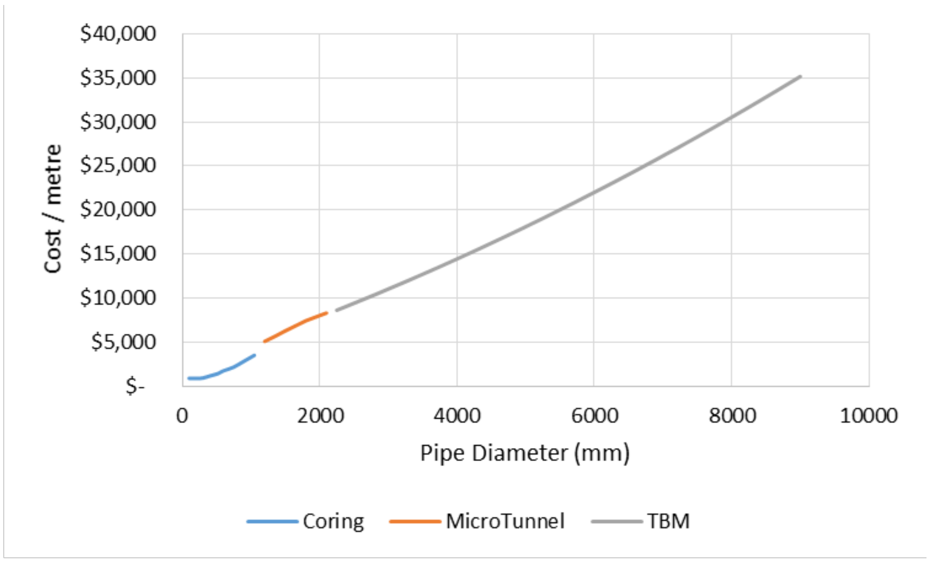

Figure 9-1. Gravity Sewer Construction Cost Curve

The unit costs for sizes that are commonly used in Winnipeg are based on recent local costs. Unit costs include utility holes, excavation, backfill, and restoration.

There has been very little construction of larger diameter pipes in Winnipeg for several years, and there is no historical data base to confirm costing. The larger diameter pipe costs were therefore based on information from the PACC tool. These values have been applied consistently to all alternatives, but will need to be updated prior for cost estimate refinement.

9.1.1.2 Control Gates and Screens

The potential plans include flexible weirs, in-line control gates, and screens for floatables. The PACC tool costs for these control options are as follows:

- Static flow control
  - A modification to an existing structure with a new fixed weir height.
  - Static Flow Control = $ 1,100,000
- Dynamic flow control and screen
  - This includes a new chamber with a control gate and partial flow screening
  - Dynamic flow control and screen = $ 4,800,000

The PACC tool does not provide a sliding scale for gate or screen sizing, and therefore the unit cost was applied uniformly for all sewer districts. Because these control options are dependent on the site conditions it is recommended that more detailed specific cost estimates be completed for all locations.

9.1.1.3 Pumping Stations

Two types of pumping stations can be used, either a submersible pump type without a dry well or a wet well/dry well type. The stations include a superstructure, pumps, valves, piping, controls, and a backup generator. The base construction costs include excavation, structure, piping, valves, pumps, and electronics, including variable frequency drives, instrumentation, and site restoration.

The PACC tool cost curve for low flow lift stations is shown in Figure 9-2.

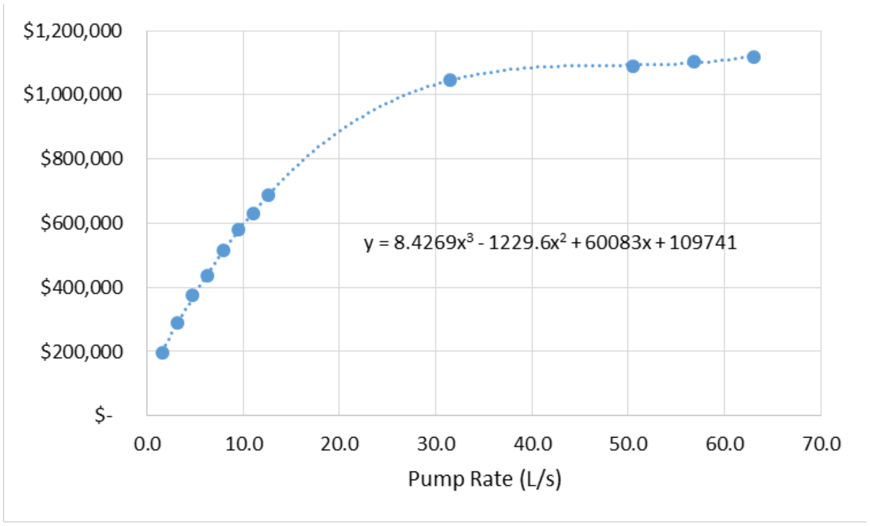

Figure 9-2. Low Flow Lift Station Construction Cost Curve

The pumping cost curve was extended to account for larger size pumps for both wet well/dry well and submersible designs as shown in Figure 9-3.

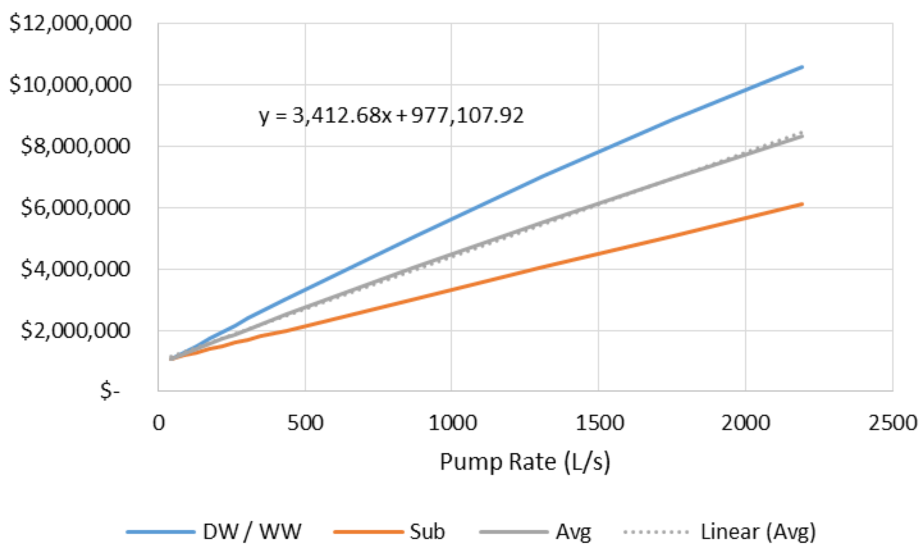

Figure 9-3. High Flow Lift Station Construction Cost Curve

The cost for larger pumping stations, as used for the satellite treatment facility, can be determined through use of the equation listed on the graph which assumes an average cost between the two types.

Lift station depth may have an impact on construction costs because deeper lift stations require more excavation and larger pumps to overcome the static head. The only deep lift station would be the one for satellite treatment, since those located in the combined sewer districts are limited in depth by the river level and local topography.

9.1.1.4 Off-line Storage

Off-line storage is provided by large near-surface concrete tanks. The PACC tool cost includes tank flushing, grit collection system, odour control and the dewatering pumps to direct the stored combined sewage to treatment.

- Storage is designed to be emptied in 24 hours.
- Transfer pumps to direct the flow from the combined sewer into storage is not included in the cost curve, and must be provided by a new transfer pumping station, or use of existing flood pumping stations.

Figure 9-4 provides the off-line storage cost curve to estimate construction cost for below ground storage.

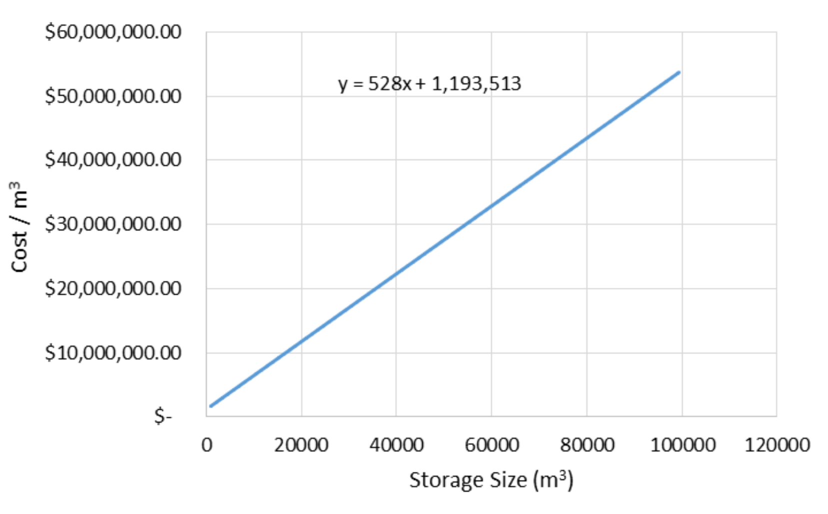

Figure 9-4. Off-line Storage Construction Cost Curve

The PACC tool off-line storage curve presented in the figure is intended for a single storage site, which means for the master plan it only applies in the 5,000 m^3 range, since the storage was assumed to apply in multiples of 5,000 m^3 and the largest off-line storage per district is about 30,000 m^3.

9.1.1.5 Wet Weather Treatment

Wet weather treatment costs at the STPs and satellite location are based on use of ACTIFLO high rate clarification and chlorination/dechlorination for disinfection. Costs are a based on the installation described in Section 4.4.2.1, which included pile foundations and building enclosures specific to Winnipeg. The sixth-tenth rule has been used for size scaling.

Costs have been assumed to be allocated between the Winnipeg Sewage Treatment Program (WSTP), which is undertaking STP process upgradings, and the CSO Master Plan as follows:

- SEWPCC and WEWPCC – WSTP includes all WWF treatment
- NEWPCC 705 ML/d – WSTP includes WWF treatment
- NEWPCC 825 ML/d – CSO MP includes incremental costs above 705 ML/d
- Satellite Treatment – CSO MP includes all WWF treatment costs

The cost allocations were unknown at the time of preparing the preliminary report estimate, and none of the treatment costs were reflected in these reported cost estimates.

9.1.1.6 Green Infrastructure

The PACC tool includes unit costs for GI alternatives, but none were included in the current list of potential plans. GI costs will be considered in future phases of the CSO Master Plan, as explained in detail in Section 7.7.

9.1.2 Construction Cost Markups

Capital costs for the potential plans were developed by adding markups for program management, engineering, finance, and administration to the construction costs. A contingency allowance was also included recognizing the planning level nature of this study.

Markups were applied as follows:

- Program Management: 2 percent
- Design and Engineering: 13 percent
- Finance and Administration: 3.25 percent. City charge for internal administration and interim financing.
- Project Contingency: 30 percent. Construction contingency was included in the construction costs estimates to account for unknown or undefined elements within each project component. Project contingency accounts for unknown or undefined elements needed to implement the alternative as a whole.
- Manitoba Retail Sales Tax: 8 percent. Under Bulletin No. 019 (MB Government 2013), sewer pipes are tangible personal property and subject to retail sales tax.
- Goods and Services Tax – (normally 5% but not included because of municipal exemptions)

The combined markup of 56.25 percent has been added equally to each potential plan.

9.1.3 Operations and Maintenance Costs

The O&M calculations are based on a 13 year present value (2015 dollars) calculation with an assumed 2% discount rate for the O&M lifecycle, and is independent of the implementation period. Cost calculations do not include salvage values. Annual O&M costs are determined by individual asset and account for all yearly expenses such as the costs of fixed and event maintenance, energy, materials, and chemicals.

9.1.4 Equipment Replacement and Residual Value

The life span of each asset type (conveyance element or facility), and part of a facility (superstructure, foundation, tankage, mechanical, electrical, etc.), is not taken into consideration. Equipment replacement costs and determining any remaining value in those assets at the end of the analysis period was not considered in the cost comparisons.

9.2 Lifecycle Cost Estimates

A lifecycle cost for each alternative was developed for comparison purposes. The lifecycle cost takes into account the capital cost and the present value of the estimated annual O&M costs. These alternative costs have been used, in conjunction with non-financial metrics, to select the alternative that best achieves the goals of the City of Winnipeg CSO Master Plan.

The resulting lifecycle cost estimates for the potential plan sized for the alternative control limits are listed in Table 9-1.

Table 9-1. Alternative Control Limit Cost Estimates

Plan	Control Limit	Collection System Capital Cost	Lifecycle + O&M
0	Current Approach	**$340,000,000**	**$350,000,000**
1	85% Capture	$830,000,000	$970,000,000
2	Four-overflows in a representative year	$1,720,000,000	$1,850,000,000
3	Zero Overflows in a representative year	$2,170,000,000	$2,310,000,000
4	No More Than Four Overflows per year	$2,300,000,000	$2,450,000,000
5	Complete Sewer Separation	$2,760,000,000	$2,790,000,000

9.2.1 Classification of Estimates

The cost estimates have been prepared for guidance in project alternative evaluations from the information available at the time of the estimate and are considered a Project Request/Long-Range Planning or Class 5 estimate as defined by the American Association of Cost Engineering (AACE, 1997). The expected accuracy for an estimate depends on the level of project definition. Since the preliminary report is based on only Class 5 planning level estimates, the estimated accuracy ranges from -50 to +100 percent. The costs for each alternative along with the range of accuracy are plotted in Figure 9-5.

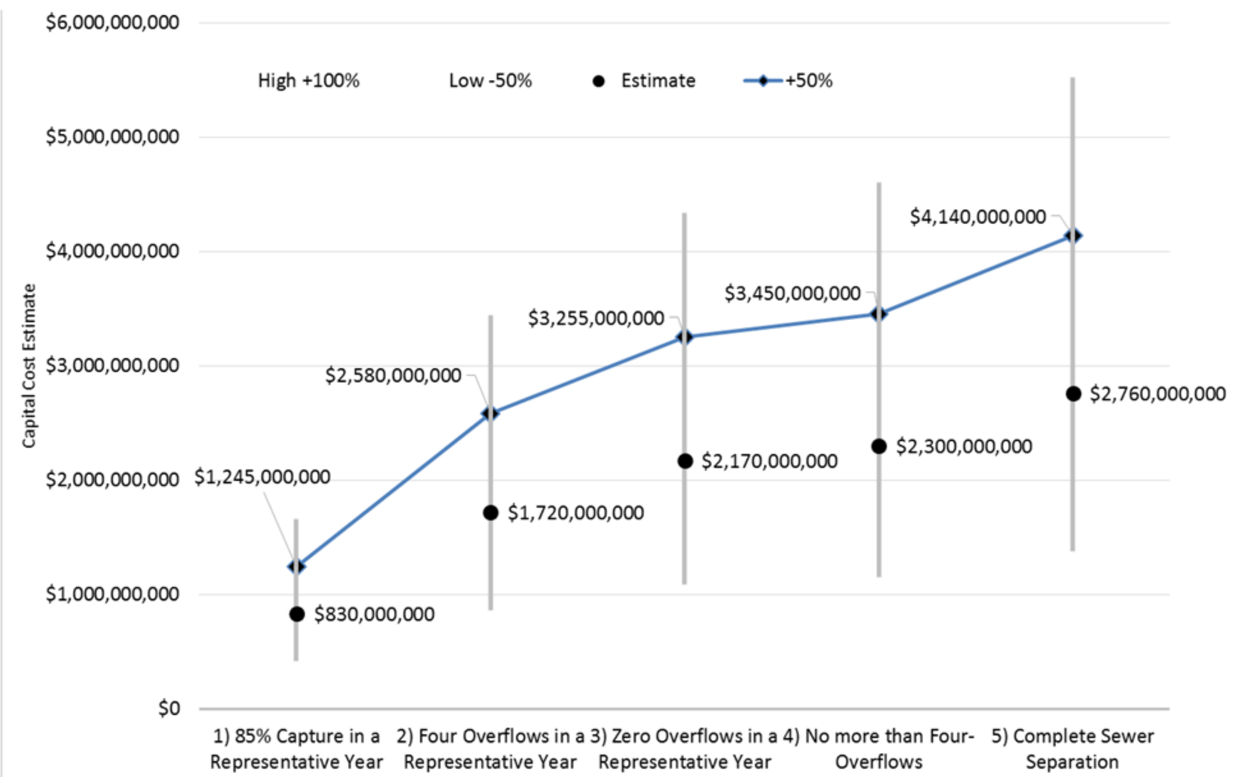

Figure 9-5: Capital Cost Estimates for Alternative Control Limits

The figure also includes a +50% estimate which was assumed as the probable final cost for preparation of storyboards for the public engagement program.

These cost estimates are to be used for the comparison of potential plans, and are not intended as project budget estimates. The final cost of the project will depend upon the actual labour and material costs, time-sensitive market conditions, implementation schedule, and other variable factors. Because of this, project feasibility and funding needs must be carefully reviewed prior to making specific financial decisions to help confirm proper project evaluation and adequate funding.

9.2.2 Future Refinements Affecting Costs

As previously noted, the level of confidence in the cost estimates is low at this early stage of project definition, and will only improve as the project proceeds and decisions are made and more details are developed. While the cost changes cannot be predicted, it is noteworthy to identify some of the potential reasons for the uncertainty:

- Drainage System Modelling: The master plan included development of a regional and global urban drainage model to evaluate current conditions, evaluate control options and develop potential plans. This model has not been calibrated, but will be used as a functional tool by the City and continually updated and refined over time. It will eventually be calibrated and provide a more accurate tool for alternative sizing and the basis for cost estimating.
- Project Definition: The amount of effort and level of detail is the most important criteria in developing cost estimates. The prelinary report provides only planning level details, and as noted by the Class 5 range of accuracy, will be subject to substantial refinement.
- Control Option selection: The potential plans were based on meeting a broad set of goals using tried and true technologies. The products and methods have all been applied elsewhere, but not on the same scale in Winnipeg. The true impacts and cost refinements will not be known until real experience has been gained with construction and operation and maintenance of the completed facilities.
- Green Infrastructure: EA No. 3042 references a requirement for use of GI, which has not been included in the cost estimates. The use of GI will require further consideration before it can be adopted and the extent of its used determined. GI will become increasingly more costly as its level of application is increased, and has the potential to significanlty increase costs.
- Unit Costs: The unit costs from the PACC tool are approximations from projects completed elsewhere, and the abiity to adjust them to local conditions is limited. More effort will be required for future stages of the master plan to develop local costs for use in more refined estimating.
- Master Plan Delivery Timeframe: Affordability of any of the alternatives will require a reasonable implementation timeframe. The current costs are assumed to be applied over a period of 13 years to align with EA No.3042. The final agreed upon delivery schedule will require cost estimate adjustment.
- Control Limit: Cost estimates are based on the five alternative control limits identified in this report. Alternative control limits or additional control requirements will require further cost adjustment.

SECTION 10

Water Quality Assessment

10.1 Water Quality Evaluation Program

The water quality evaluation program supported the development of the master plan by providing details of the water quality benefits associated with each alternative presented in Section 8. The purpose of water quality program was to support the decision process leading to the selection of a recommended alternative. The program also provided an understanding of the extent to which CSO currently influences stream water quality in the Winnipeg area and set the scene for developing watershed level solutions.

The water quality evaluation program consisted of the following two components:

- Water Quality Monitoring
- Water Quality Modelling

10.1.1 Water Quality Monitoring Program

The water quality monitoring program was carried out during 2014 and 2015 and included CSO and stream monitoring, which was used to develop EMCs for the CSO discharges and for the stream boundary flows. The monitoring was carried out for dry weather conditions, wet weather conditions and for CSO discharges. The monitoring program methodology is described in Section 2.4.5 of this report and further details and data can be found in Appendix B. Some of the key result highlights are described below.

10.1.1.1 CSO Discharge

Over a period seven months in 2015, four auto-samplers were used to collect a total of 23 data sets at various CSO discharge locations. In general, the results from 2015 agreed with those form the 2002 CSO study. Some key results form the discharge collection data sets are as follows:

- *E.coli* bacteria values were found to be highly variable, ranging from less than 10,000 MPN/100 mL to over 15.0 x 10^6 MPN/100 mL. No trend based on rainfall or location could be established.
- Total N values ranged from 0.9 mg/L to 76.3 mg/L. No trend based on rainfall or location could be established.
- Total P values ranged from 0.3 mg/L to 14.5 mg/L. No trend based on rainfall or location could be established.
- TSS values ranged from 16 mg/L to 3,270 mg/L. No trend based on rainfall or location could be established.

In general, CSO discharge is highly variable and there is no discernable trend in the values of POCs based on the locations sampled during 2015 or the intensity or duration of rainfall causing the overflow. The average values from the discharge samples were used for the 2015 EMCs as dicsused in Section 10.12.

10.1.1.2 Dry Weather Conditions – River and Stream Results

Dry weather sampling was carried out in 2014 and 2015 with a total of eight days of representative dry weather sampling. Key findings from the dry weather river and stream sample sets include the following:

- *E.coli* and Total Coliforms: The results indicated that background levels of *E.coli* in the rivers during this dry weather period were typically below the Tier II objective in the Manitoba Water Quality

Standards, Objectives and Guidelines. There were a few instances higher than the objective; however, these level spikes cannot be attributed to a specific source.

- Total Phosphorus: The results indicated that upstream of the City boundary and throughout the rivers, the total phosphorus levels are above the Tier III limit of 0.05 mg/L through both sampling periods. Small streams tested were also above the limit. As an example, during the October 2014 period, the Assiniboine River had an average level of 0.26 mg/L at the Osborne Bridge and the Red River had an average level of 0.16 mg/L at the Norwood Bridge.
- Ammonia: The results show little to no increase in the ammonia level of the Assiniboine River from the boundary to its convergence with the Red River. The Red River levels show an overall increase in level from the south boundary through the City. In general, the ammonia level in the Red River is higher than the Assiniboine River. There is a drop in the level of the Red River at the location downstream from the convergence.
- Total Nitrogen: In general, the Assiniboine River has higher levels than the Red River. As an example, the October 2014 values indicate an average level in the Assiniboine River of 1.69 mg/L at the Osborne Bridge and an average level in the Red River of 1.10 mg/L at the Norwood Bridge. There is little to no increase in levels along the Assiniboine River. There is an increase in the level of Total Nitrogen in the Red River at the location downstream from the convergence.
- Total Suspended Solids: At the upstream boundary, over the eight days of dry weather sampling, the Red River shows an average background level of approximately 180 mg/L and the Assiniboine River shows an average background level of 290 mg/L. The October 2014 results are less than the same locations in July 2015. In general, total suspended solids levels are not consistent and can vary considerably; even across the cross section of the rivers it varied by as much as 100 mg/L in the samples collected on the same day.
- There was no indication of dry weather overflows occurring.
- No significant impact from the STPs was noted.

10.1.1.3 Wet Weather Conditions – River and Stream Results

Wet weather sampling was carried out in 2015 with three separate events being monitored, each for three days in a row following each rainfall event. Key findings from the wet weather river and stream sample sets include the following:

- *E.coli* and Total Coliforms: *E.coli* typically peaked above the Tier II objective in the MWQSOG at all locations, including boundaries into the City, during the first day following a rainfall event. Values typically increased as sample locations were further downstream. Levels dropped below the objective within the three days of sampling.
- Velocities in the Red and Assiniboine Rivers move water through the City in a short period of time. Approxmiatel 1 day ater the occurance of rainfall, the concentrations of the tested constiuents were back in the range of baseline.
- The trends observed during each day following an event were not repeated over each of the three wet weather collection periods. Some trends observed in the dry weather sets are repeated during wet weather in the same pattern through the length of river (e.g. ammonia, TSS).
- Dry weather results from the Assiniboine River were on average higher than the wet weather results. This shows how the varability in conditions in the City and upstream can impact the POC values.

It is expected that results from additional sets collected would be similar showing that there is not an appreciable impact from POCs other than bacteria which show a consistently repeated trend. The spatial rainfall impact and river level and flow impacts from events occuring beyond the City boundaries may have some influence on the results observed.

10.1.2 Water Quality Modelling

The water quality modelling included two elements – the dynamic modelling of in-stream *E. coli* indicator bacteria using the US EPA's WASP7.5 software and the estimation of watershed Total P and Total N loadings using a custom spreadsheet model. The following sections present the modelling methodology as well as present the key model results for the five alternative control limits.

10.1.2.1 Dynamic River Water Quality - WASP7.5

EPA's Water Quality Assessment Simulation Program, WASP7.5 (released November 2013), was applied to the Red and Assiniboine Rivers. The purpose of the WASP7.5 modelling was to assess the impact of the dry and wet weather inputs on the predicted *E. coli* densities in the Assiniboine and Red Rivers in the Winnipeg area. Each of the five alternatives as well as Baseline (present) conditions was modelled.

The model structure was previously presented in the *Tabletop Receiving Water Assessment* (CH2M HILL, April 2014c). Key aspects of the WASP7.5 model are presented here for convenience. The WASP7.5 model was based in large measure on the original Winnipeg WASP5 model, developed in 1995. As in the original model, the Assiniboine River is modelled from Headingley to the Forks while the Red River is modelled from the south Flood Control to Lockport. A total of 34 linear WASP elements were used to define the Assiniboine River, while 64 linear WASP elements defined the Red River. Total reach length for the Red River is 62.3 km, with an average cell length of 973 m, while the total reach length for the Assiniboine River is 25.8 km, with an average cell length of 758 m. The WASP7.5 version retains the original WASP5 model cell structure, including reach length, average depth and width, and physical reach locations. In the previous WASP5 model, only two simulation options were available: TOXI and EUTRO; however, in WASP7.5, several modules are available to address a wide range of water quality issues. In this case, the Toxicant module was applied to simulate in stream *E. coli* levels. Figure 10-1 shows the WASP7.5 model framework.

No geo-referencing was possible in the original WASP5 version; however, in the updated WASP7.5 version, all model cells are geo-referenced using GIS.

A key component of the model upgrade was the addition of dynamic routing. In the previous WASP5 model, cell volumes remained constant for the entire simulation period and the instantaneous model outflow at Lockport Dam was equal to the sum of the total boundary inflow at Headingley on the Assiniboine and the Flood Control on the Red River. The most recent WASP7.5 model applies a kinematic wave solution for dynamic flow routing to better represent changing cell volumes. In addition, this upgrade enables modelling of different stage control measures at Lockport Dam. During the summer, Lockport Dam maintains a stage of approximately 5 m at the confluence of the Red and Assiniboine Rivers (the Forks), providing additional volume for assimilative capacity and lower river velocities. During the non-recreation season (October to April), the 5 m stage control is removed, and a range of flow conditions occurs, from January and February low flow, to spring flood flows. A portion of the peak spring flood flows is diverted into the Floodway, as well, elevated flood stage during non-recreation season flood flow necessitates pumping of CSO at some locations. As a consequence of these differences, during the non-recreation season, a wide range of river depths and cell volumes occur.

The revised model results were compared to results obtained previously with the original WASP5 model. The results of this analysis shown are presented in the next part of this report section. It is recommended that as future monitoring data is collected consideration be given to updating the WASP7.5 calibration.

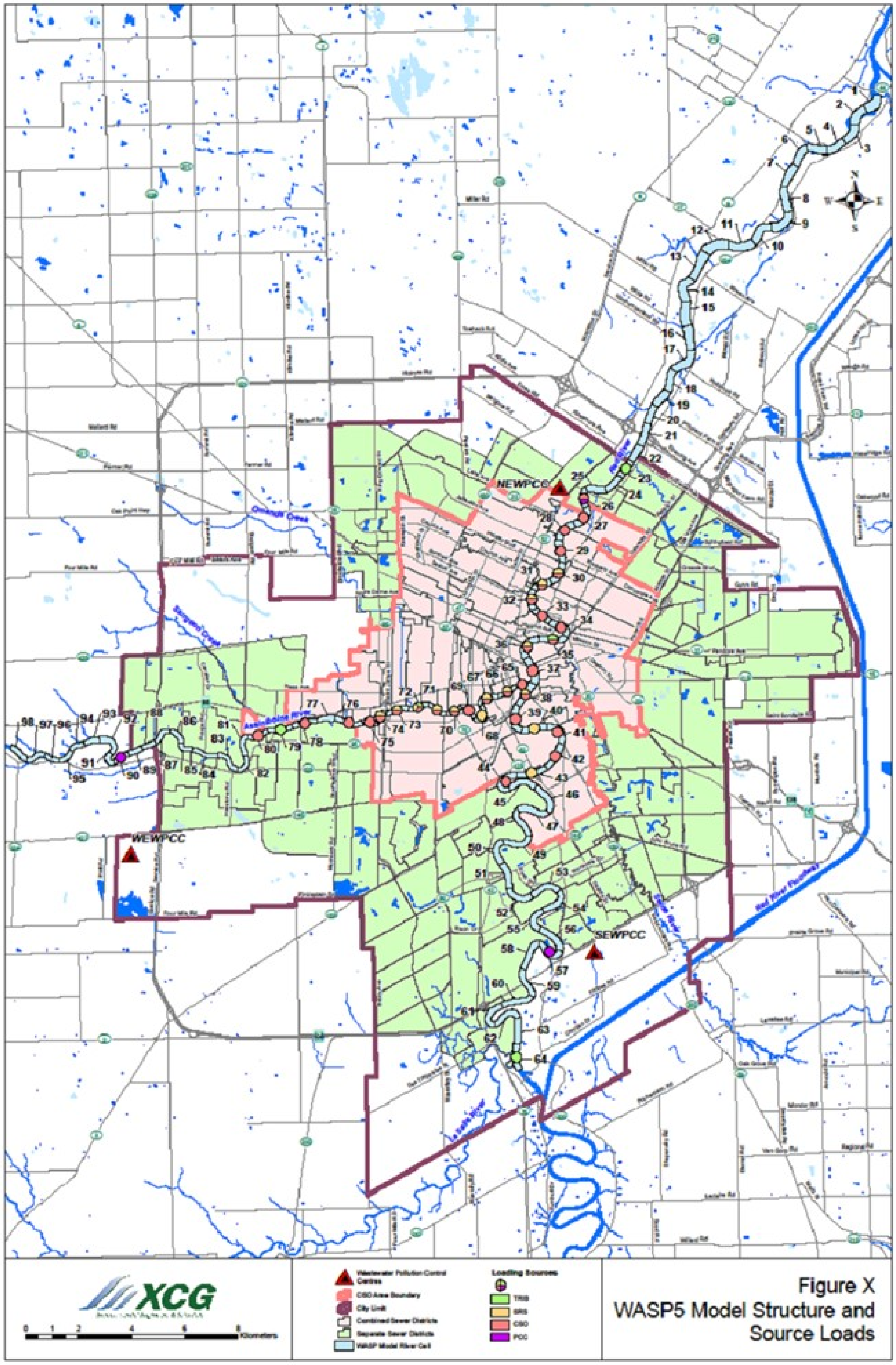

Figure 10-1. WASP 7.5 Model Framework

10.1.2.2 Comparison of WASP7.5 and WASP5 Model Results

The original WASP5 model results were compared with the results generated with the latest WASP7.5 update using the 1992 representative year rainfall and other inputs. A comparison of results for Parkdale and Main Street Bridge are provided in Figures 10-2 and 10-3, respectively. Parkdale is located on the Lower Red River (downstream of the city limits), past any significant inflows (WASP7.5 - Cell 11), while Main Street Bridge is located on the Assiniboine River, immediately upstream of the Red River confluence. In both cases, a reasonable agreement is achieved. Some differences are evident, for example, a response in late July is generated in the most recent WASP7.5 results; however, this response is absent from the 2002 WASP5 model results. As well, minor differences in peak *E. coli* levels are observed. However, overall, the agreement is acceptable and results generated by the WASP7.5 model update are consistent with previous model results. Minor differences can be attributed largely to differences in source modelling results. For example, previous CSO inflows were defined by event and at hourly intervals, whereas current CSO inflows are continuous and at 10 minute intervals. As well, updated geo-referencing of the outfall locations resulted in some minor changes in terms of which WASP7.5 cells received the inflow.

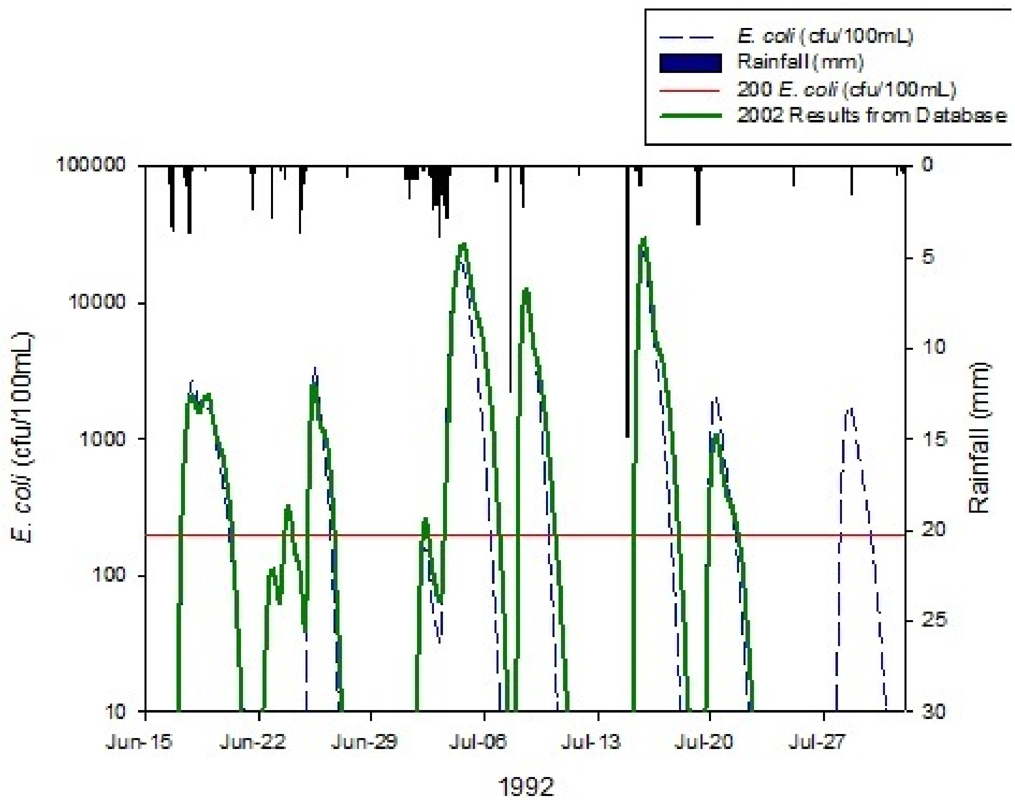

Figure 10-2. Comparison of WASP5 with WASP7.5 at Parkdale on Lower Red River

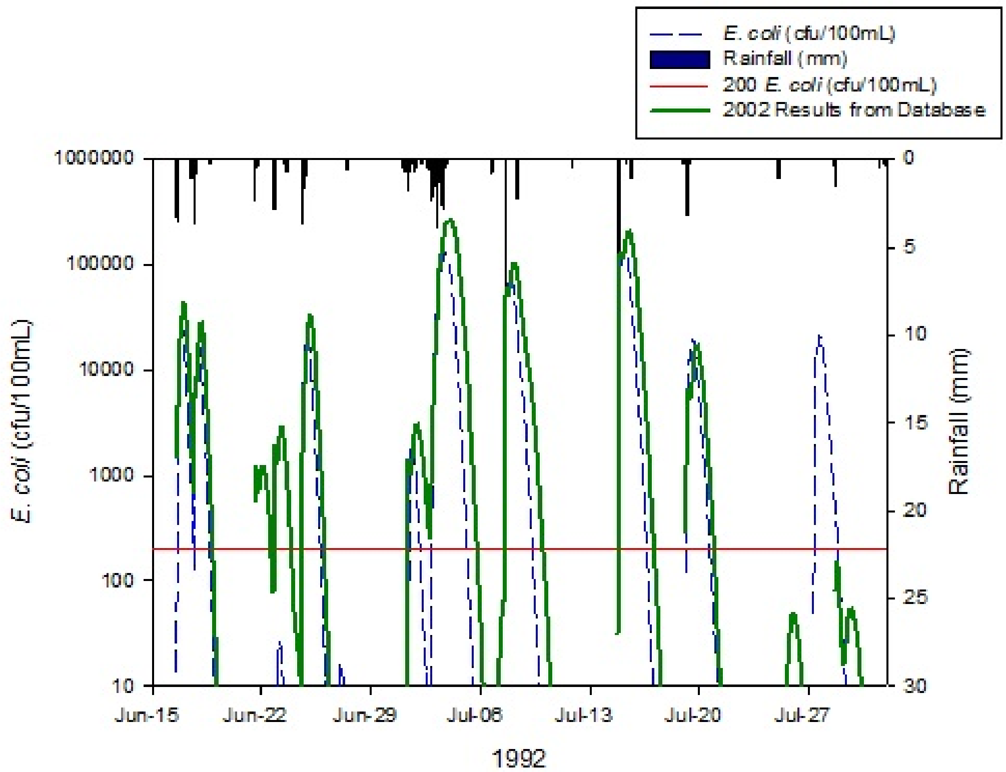

Figure 10-3. Comparison of WASP5 with WASP7.5 at Main Street Bridge on Assiniboine River

10.2 Loadings Models

The loadings models serve two primary purposes. They provide the *E. coli* time series inputs to the WASP7.5 dynamic model that are used to calculate in-stream bacterial densities. They also provide the estimates of seasonal and annual loadings of Total P and Total N originating from Winnipeg discharges within City boundaries.

The following sections present the data sources and calculation methodologies for the loadings models.

10.2.1 Upstream Boundary Flows and Loads

Daily Assiniboine River, Red River, La Salle River, Seine River, Omands Creek, Sturgeon Creek, and Grassmere Creek upstream boundary flows for 1992 were generated from Water Survey of Canada (WSC) data. Table 10-1 presents the stream stations that were employed to determine the upstream boundary flows. The station locations for the Red River at Ste. Agathe and the smaller streams were not necessarily at the point that the stream entered the study area. Hence the stream flow records were all adjusted on the basis of the ratio of the watershed at the study area boundary to the tributary area at the WSC gauge location.

Table 10-1. Water Survey of Canada Upstream Boundary Flow Stations

Years	Station Name	Station Number	Gross Drainage Area (km^2)	Station Adjustments
1913-2013	Assiniboine River At Headingley	05MJ001	16,200	None
1958-2014	Red River Near Ste. Agathe	05OC012	115,000	Adjusted to study area boundary
1986-2014	Seine River South Of Prairie Grove	05OH009	302	Adjusted to study area boundary
1915-2013	La Salle River Near Sanford	05OG001	1800	Adjusted to study area boundary
1963-2013	Grassmere Creek Drain Near Middlechurch	05OJ017	462	Adjusted to study area boundary
1978-1993	Omands Creek Near Metro Route 90	05MJ007	74.8	Adjusted to study area boundary

A review of water quality monitoring results from 2002 through 2013 was carried out for both wet and dry weather conditions. Separation of wet and dry weather was completed using both flow and observed rainfall. No clear difference was observed. Accordingly, ambient boundary *E. coli* density for both the Red and Assiniboine Rivers were defined as the geometric mean of measured *E. coli* levels at the most upstream monitoring locations. The resultant boundary ambient *E. coli* concentration was 33 MPN/100 mL. The boundary density for the Red and Assiniboine Rivers was confirmed through the 2015 City stream monitoring (See Section 2.4.5).

A small tributary stream boundary EMC for *E. coli* of 88 MPN/100 mL was developed from 2015 monitoring and applied to the smaller tributary streams for the entire simulation period.

10.2.2 Combined Sewer Overflow and Storm Relief Sewer

CSO and SRS flows were generated at 10 minute intervals for 1992 representative year (January 1 through December 31) using the calibrated and updated InfoWorks Regional Model. Outfall eastings and northings were used to assign each outfall to an appropriate WASP7.5 model cell. Figure 10-1 showed which model cells receive CSO and/or SRS inflow. Multiple inflows into a single WASP7.5 cell were summed resulting in no more than one time CSO and/or SRS series per cell. Modelled CSO flows were converted to *E. coli* loadings using an EMC of 1,500,000-MPN/100 mL, and imported directly into the WASP7.5 model. The EMC was determined from the 2015 monitoring program.

10.2.3 Sewage Treatment Plant

STP flows were also generated at 10 minute intervals using 2013 dry weather flow and using the 1992 representative year using the calibrated and updated InfoWorks Regional Model for the wet weather flow component. STP outfall locations were applied to link a STP flow time series to an appropriate WASP model cell. Figure 10-1 showed the WASP7.5 model cells receiving STP inflow. Modelled STP flows were converted to *E. coli* loadings using the allowable STP License EMC of 200 MPN/100 mL, and imported directly into the WASP7.5 model.

10.2.4 Land Drainage System

The LDS consists of two main components: direct stormwater discharge and treated stormwater (retention basins are not sized for bacteria treatment but settling provides some water quality improvements) for stormwater pond discharge.

All WASP7.5 modelled cells received at least one LDS inflow. Estimated LDS *E. coli* loading was defined by application of an EMC of 40,000 or 20,000 MPN/100 mL for untreated stormwater and stormwater from stormwater retention basins respectively. The *E. coli* LDS EMCs were taken from the 2002 CSO study. WASP7.5 cells receiving more than one LDS inflow were summed resulting in at least one LDS loading time series for each WASP cell. LDS flow time series from separated sewer areas were generated by the City of Winnipeg InfoWorks LDS model. The bacteria loadings from Master Plan alternatives (see Section 8) that generated additional stormwater through sewer separation were estimated by the Regional InfoWorks model and applying the untreated LDS EMC of 40,000 MPN/100 mL.

Table 10-2 summarizes the flow and EMC data including data sources for all the inputs.

Table 10-2. Summary of Source Load Input Data

Source	Flow	EMC
Upstream Boundary Flows Red River, Assiniboine River	• Water Survey of Canada • 1992 daily flows	• 33 MPN/100 mL • 2002-2013 City stream quality monitoring • Confirmed by 2015 City monitoring program
Small Tributary Flows	• Water Survey of Canada • 1992 daily flows	• 88 MPN/100 mL • 2015 City monitoring program.
CSO and SRS	• City InfoWorks Regional collection system model • 1992 precipitation year	• 1.5 x 10^6 MPN/100 mL • 2015 CSO monitoring results
STP	• City InfoWorks Regional collection system model • 2013 dry weather flow • 1992 precipitation year	• 200 MPN/100 mL • WPCC License bacteria effluent requirement
LDS	• City InfoWorks LDS model / City of Winnipeg InfoWorks Regional collection system model • 1992 precipitation year	• 40,000 MPN/100 mL untreated stormwater • 20,000 MPN/100 mL stormwater (retention basins) • 2002 CSO Study

10.3 Recreation Season Assessment

The recreational season assessment evaluated compliance with MWQSOG for bacteria in the Red and Assiniboine Rivers during the May 1 to September 30 recreation season. The MWQSOG for *E.coli* is designated as a Tier II objective as follows:

- Objective – 200 MPN/100 mL
- Water Use Supported – Primary water recreation
- Averaging Period – 1 day
- Applicable Period – Recreational season (May 1 to September 30)
- Exceedance Frequency – Not applicable

To assess compliance with MWQSOG, the WASP7.5 model was run using modelled (CSO, SRS, STP, and LDS) and observed (stream flows) flow time series for the 1992 recreation season. Input loads were calculated for an hourly time step using the above time series and the event mean *E. coli* concentrations presented in Table 10-2. Compliance with the MWQSOG was assessed by calculating the daily geometric mean (GM) from the model results. Any day with an *E. coli* GM < 200 MPN/100 mL GM was deemed compliant even though hourly excursions above the 200 MPN/100 mL criterion may have been observed.

Selected in-stream locations were chosen to illustrate the recreational season water quality results. They are presented in Figure 11-4 and include the following:

- Main Street Bridge on the Assiniboine River –This is located at the Assiniboine River downstream boundary. Inputs above the Main Street Bridge include boundary flows, WEWPCC effluent, CSO, SRS, LDS, and tributary streams.
- Norwood Bridge on the Upper Red River – This is located on Red River above its confluence with the Assiniboine River. Inputs above the Norwood Bridge include boundary flows, SEWPCC effluent, CSO, SRS, LDS, and tributary streams.
- Redwood Bridge on the Lower Red River – This is a location on the Red River approximately 3-4 km downstream of the confluence of the Red and Assiniboine Rivers. It represents the mixed contributions of the two rivers as well as inputs from the following: LDS, CSO, SRS and tributary inflows from the Seine River.
- Parkdale on the Lower Red River – This is a location on the Red River approximately 11 km downstream of the last direct CSO or SRS input into the Red River and about 11 km above the downstream study area boundary at Lockport. – Inputs include: all the sources upstream of the Redwood Bridge, NEWPCC effluent, LDS, CSO, SRS and tributary inflows.

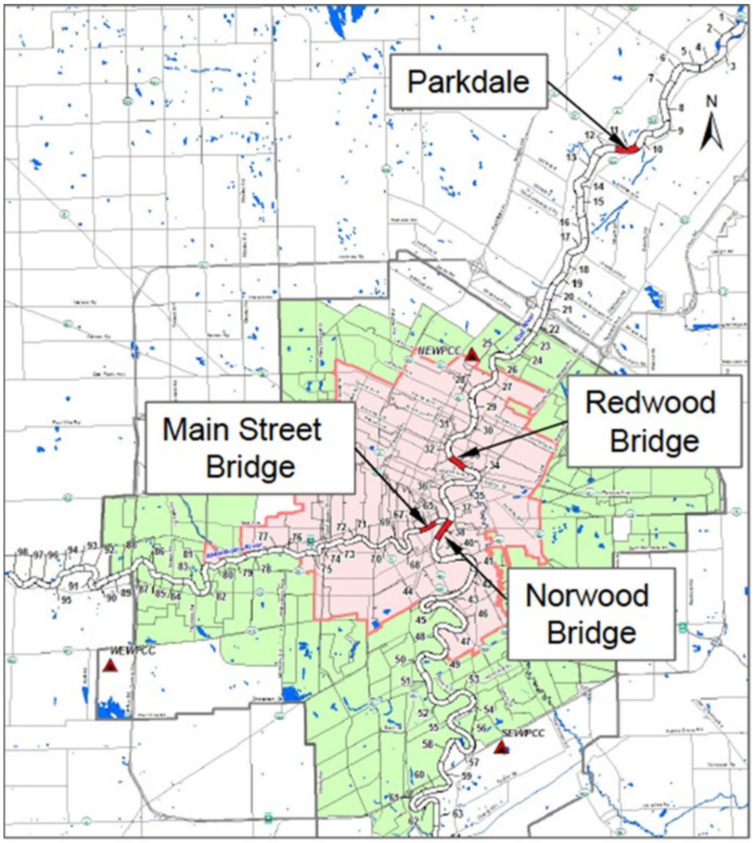

Figure 10-4. River Water Quality Results Example Locations

The details of the inputs into each WASP7.5 cell were previously presented in Figure 10-1.

10.3.1 Recreation Season Rainfall for Representative Year

The rainfall statistics by month for the May 1 to September 30, 1992, representative year are presented in Table 10-3. They are based on a 6-hour inter-event time definition.

Table 10-3. Recreation Season Rainfall for 1992 Representative Year

Period	Rainfall Statistic			
	Total Precipitation (mm)	**Number of Events**	**Peak Intensity (mm/hour)**	**Hours of Rainfall**
May	20	9	46	24
June	67	14	46	54
July	89	14	149	74
August	71	7	97	42
September	30	8	103	26
Total Recreation Season	**279**	**52**	**149**	**220**

June and July are the months with the most rainfall events and correspondingly significant rainfall volumes. Almost 60 percent of the total recreation season rainfall occurs during the June-July period. August has the second highest rainfall volume but is distributed among only seven events.

10.3.2 Recreation Season Red River and Assiniboine River Flows

The variation of major boundary inflows for the recreation season of 1992 at Headingley on the Assiniboine River and at the south Floodway on the Red River are presented in Figure 10-5. Boundary flows in both rivers generally decline through the May, June, and July period. Although in 1992 the Red River shows some seasonal peaks in the June-July period perhaps related to the volumes of rainfall previously noted. The equivalent river velocities during the recreation season are presented Figure 11-6. The Figure shows generally higher velocities in the Red River although they become the same as the Assiniboine River during the low flow period in late August. The low summer velocity is about 0.1 m/s on the Red River and about 0.15 m/s on the Assiniboine River. Springtime (May) velocities are between 0.6 and 0.7 m/s in the Red River and about 0.9 m/s in the Assiniboine River.

One factor that influences velocities and travel times is the operation of the Lockport Dam. As was noted previously, the dam maintains a 5 m stage at the confluence of the Red and Assiniboine Rivers. This effectively produces two hydrodynamic regimes within the Assiniboine River – a free flowing stream above the Kenaston Bridge and a backwater pool in the vicinity of the confluence. Lower depths and higher velocities characterize the free flowing portion of the River. The backwater portion has larger volume and longer residence times. The impact of this phenomenon on in-stream bacteria densities is further discussed in the next section.

Table 10-4 presents the estimated travel times in days that correspond with late spring (May) and summer (July) conditions in both rivers. Under the more robust spring flow regime the travel times are about a half-day for the three river reaches. During summer conditions these times are extended to 2 days +/- for each of the river reaches.

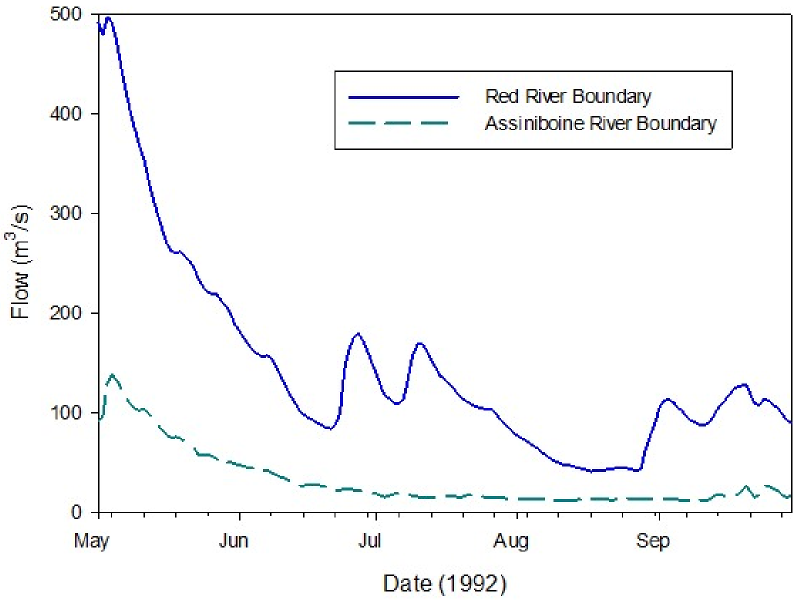

Figure 10-5. Major Upstream Boundary Flows – May to September

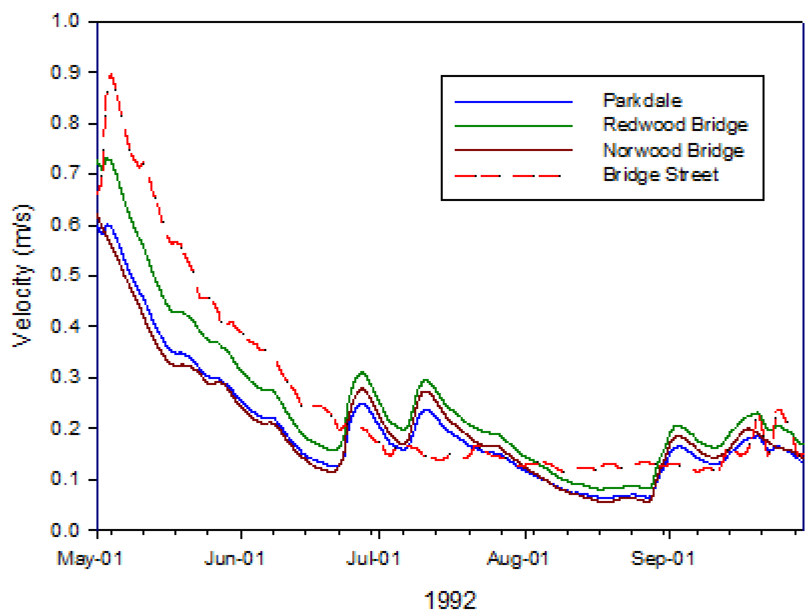

Figure 10-6. Red River and Assiniboine River Stream Velocities – May to September

Table 10-4. Estimated River Travel Times – May to September

River Reach	Average Travel Time (days)	
	Spring - Early May	Summer -Early July
Assiniboine River [a]	0.7	2.9
Upper Red River [b]	0.9	1.4
Lower Red River [c]	1.0	1.8
Lockport to Lake Winnipeg	1.4	2.5

Notes:
[a] Headingley to confluence with Red River
[b] Floodway to confluence with Assiniboine River
[c] Assiniboine River confluence to Lockport

Approximate river travel times, for the non-recreation season, are presented in Table 10-5. Relative to recreation season, non-recreation season travel times are considerable shorter during the late spring flood flows, and marginally slower during the late fall.

Table 10-5. Estimated River Travel Times – October to April

River Reach	Average Travel Time (days)	
	Fall – Late November	Spring – Late April
Assiniboine River [a]	0.8	0.3
Upper Red River [b]	1.2	0.2
Lower Red River [c]	1.0	0.2
Lockport to Lake Winnipeg	1.4	0.3

Notes:
[a] Headingley to confluence with Red River
[b] Floodway to confluence with Assiniboine River
[c] Assiniboine River confluence to Lockport

10.4 Baseline Assessment

The purpose of this section is to examine the modelled bacterial water quality under the existing or Baseline conditions at the four stream locations indicated in Section 10.4. A fifth location in the free flowing portion of the Assiniboine River was also included to assess the impact of the backwater on in-stream bacteria densities.

10.4.1 CSO Volume and Frequency

To better understand the impact of CSO discharges on river water quality, the monthly discharge statistics were assembled for the following river reaches:

- Lower Red River - Below confluence with Assiniboine River
- Upper Red River - Above confluence with Assiniboine River
- Assiniboine River - Above confluence with Red River

Table 10-6 presents the modelled monthly discharge volumes for the 1992 recreation season under baseline conditions. The largest volumes are discharged into the Lower Red River followed by the discharges into the Assiniboine River, which are less than half as large. July and August are the months with highest aggregate discharge volumes in all three river reaches.

Table 10-6. Overflow Volume Summary for Baseline Conditions

Month	Overflow Volume (m^3)		
	Lower Red River [a]	**Upper Red River [b]**	**Assiniboine River [c]**
May	112,202	22,004	53,921
June	234,989	37,662	114,453
July	983,968	187,767	450,290
August	766,760	152,281	354,240
September	451,484	85,657	208,313
Total Recreation Season	**2,549,402**	**485,369**	**1,181,217**

Notes:
[a] Below confluence with Assiniboine River
[b] Above confluence with Assiniboine River
[c] Above confluence with Red River

The monthly maximum number of overflows at any outfall is presented in Table 10-6. This statistic corresponds to the maximum number of overflows occurring at any outfall discharging to the river reach within the month indicated. The frequency of overflow activity within a river reach provides a metric that can be used to compare the performance of the five alternatives.

Table 10-6 shows that the months of June, July, and August have the highest frequency of overflows at any outfall in all three river reaches. The Lower Red River and the Assiniboine River have comparable statistics for this period while the Upper Red River has fewer number overflows at any outfall.

Table 10-7. Maximum Overflow Frequency at any Outfall for Baseline Conditions

Month	Maximum Number of Overflows at any Outfall		
	Lower Red River [s]	**Upper Red River [b]**	**Assiniboine River [c]**
May	4	1	4
June	9	7	9
July	13	9	13
August	9	6	9
September	7	5	7

Notes:
[a] Below confluence with Assiniboine River
[b] Above confluence with Assiniboine River
[c] Above confluence with Red River

The number of overflow locations active in a given month is presented in Table 10-7. This statistic corresponds to the number of overflow locations discharging to the river reach within the month indicated. The number of active overflows within a river reach provides a metric that can be used to compare the performance of the five alternatives. The three most active months in this case are July, August, and September in all three river reaches. The highest number of outfalls with overflows discharge to the Assiniboine River with nearly comparable statistics in the Lower Red River and far fewer outfalls with overflows in the Upper Red River.

Table 10-8. Number of Overflow Locations Active for Baseline Conditions

Month	Number of Active Overflows		
	Lower Red River [a]	Upper Red River [b]	Assiniboine River [c]
May	21	7	23
June	19	7	20
July	23	9	33
August	22	8	29
September	22	8	28
Total Recreation Season	**107**	**39**	**133**

Notes:
[a] Below confluence with Assiniboine River
[b] Above confluence with Assiniboine River
[c] Above confluence with Red River

10.4.2 Baseline Daily Geometric Means

The daily GMs for select locations are plotted in Figures 10-7 to 10-11 for Main Street Bridge (Assiniboine River), a fifth location on the Assiniboine River 0.9 km upstream of the Main Street Bridge (Assiniboine River) in the portion of the River with less backwater impact, Norwood Bridge (Upper Red River), Redwood Bridge (Lower Red River), and Parkdale (Lower Red River) respectively. The daily GM plots indicate modelled densities as high as 100,000 MPN/100 mL at the Main Street Bridge location showing the impact of the wet weather inputs (CSO, SRS, and LDS) into the Assiniboine River on water quality. The modelled densities at the location 0.9 km upstream of the Main Street Bridge show very similar results suggesting that the backwater pool does not have major influence on bacterial water quality.

The peak GMs at the Norwood Bridge location are lower reaching 10,000 to about 50,000 MPN/100 mL. This shows the influence of the lower volume of CSO and SRS inputs in this reach of the Upper Red River coupled with the higher river flows (greater dilution). The densities at the Redwood Bridge location are similar to those at the Main Street Bridge. This is a location downstream of the confluence and shows the influence of conditions in both rivers. The Parkdale location indicates densities somewhat lower than at the Redwood Bridge location notwithstanding the significant wet weather inputs into the Lower Red River.

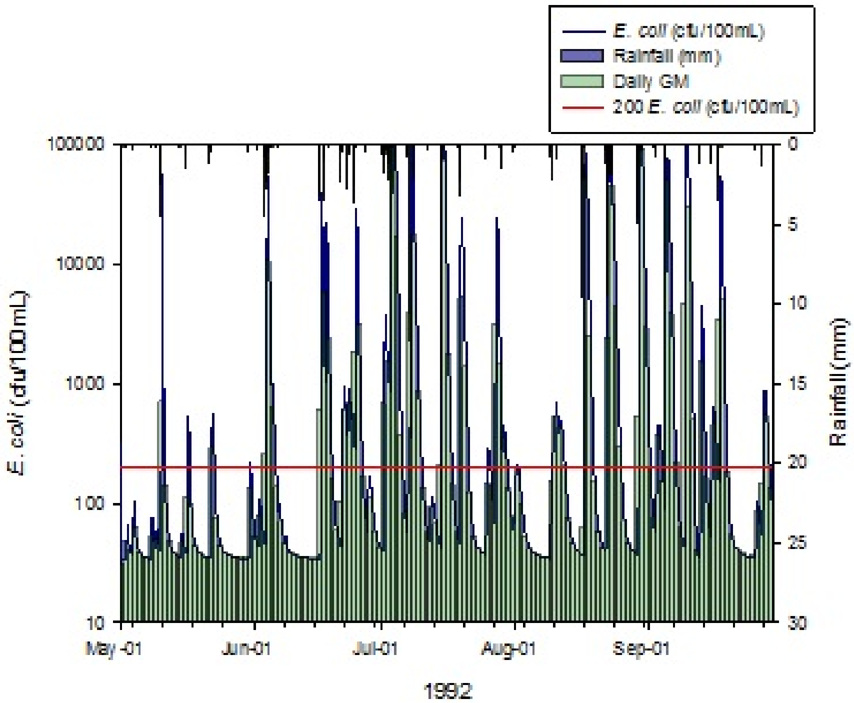

Figure 10-7. Main Street Bridge E. coli Densities for Baseline

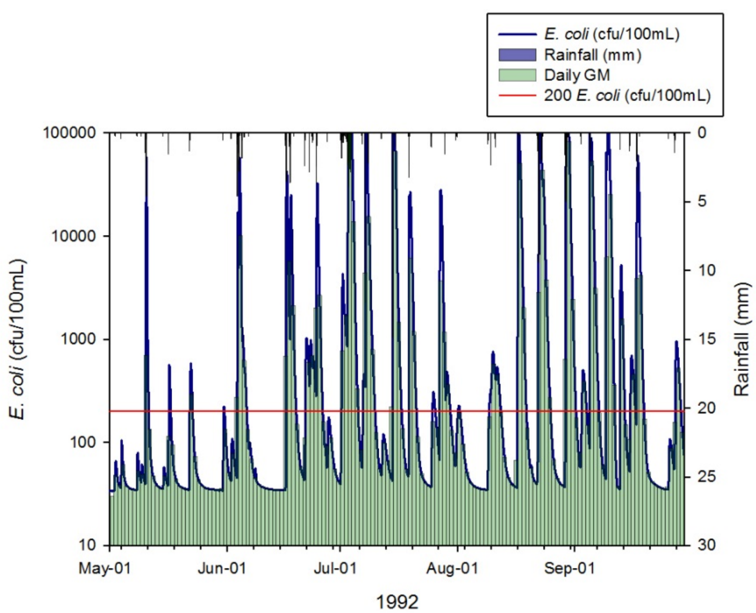

Figure 10-8. Free Flowing Assiniboine River E. coli Densities for Baseline

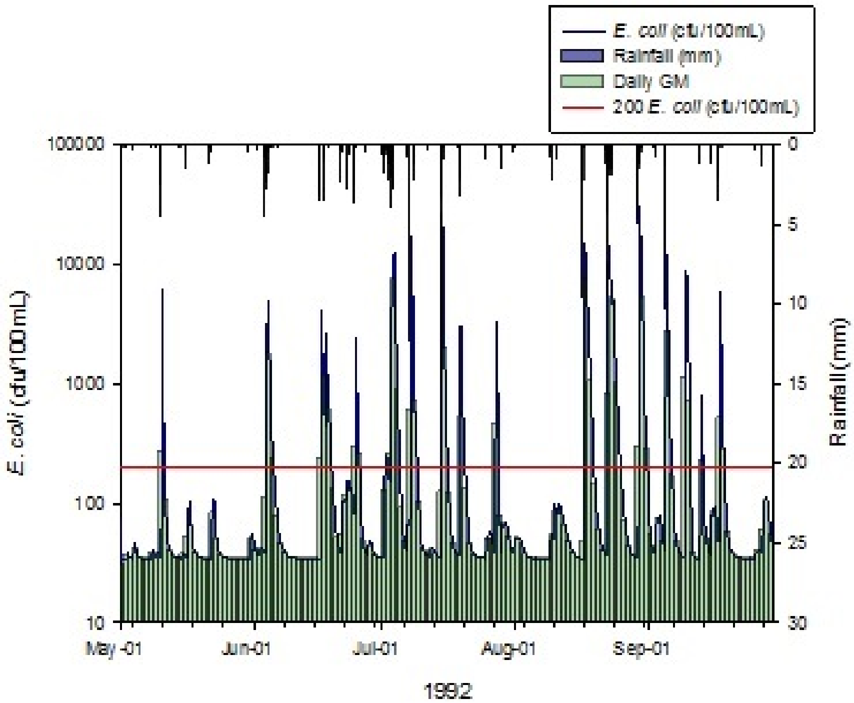

Figure 10-9. Norwood Bridge E. coli Densities for Baseline

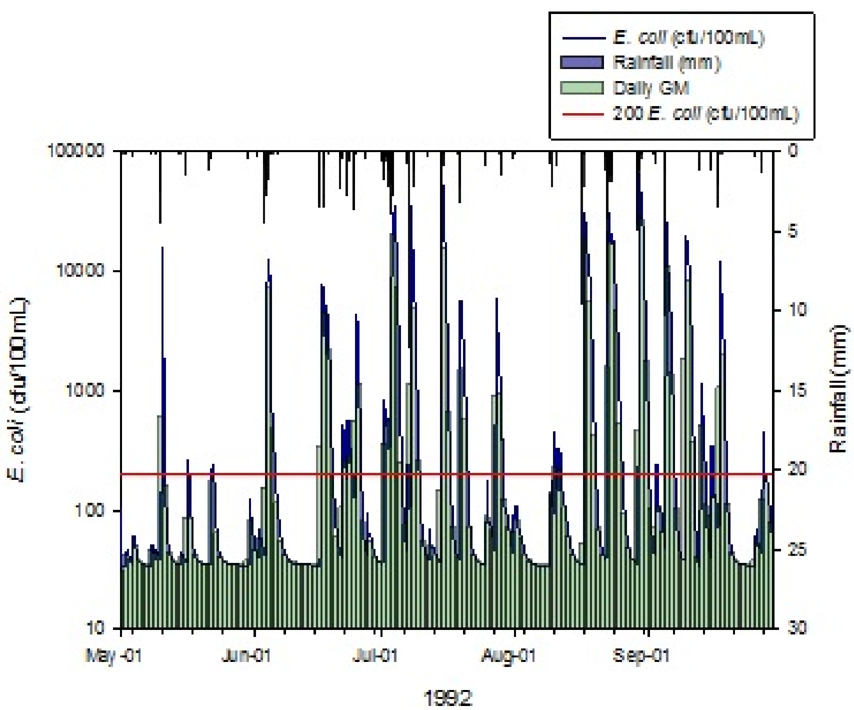

Figure 10-10. Redwood Bridge *E. coli* Densities for Baseline

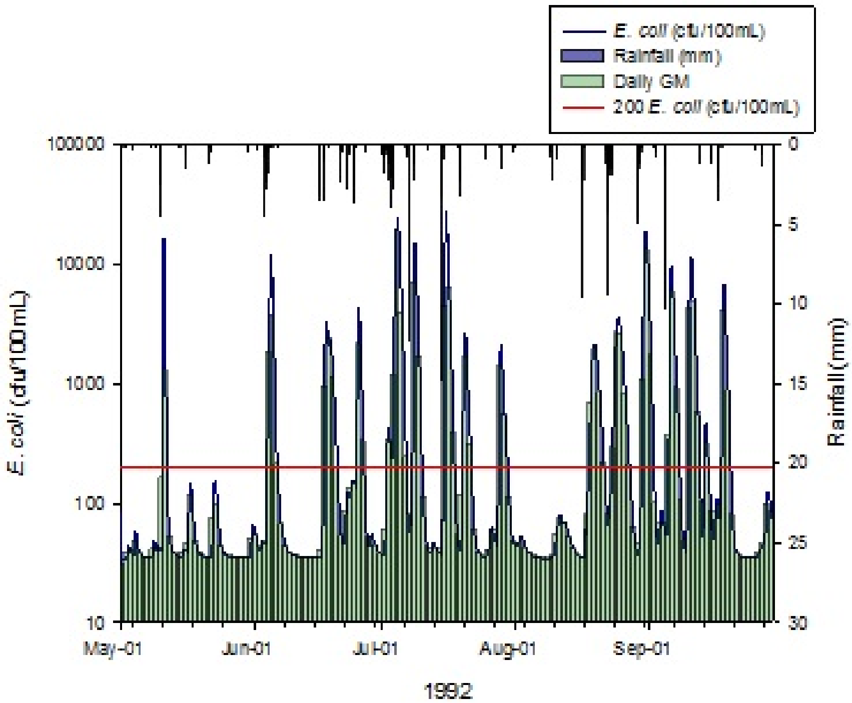

Figure 10-11. Parkdale *E. coli* Densities for Baseline

The monthly average GMs and overall recreation season GM calculated from the arithmetic mean of the daily GMs are summarized for all locations in Table 10-9. The average densities shown are indicative of monthly conditions and are not direct indicators of available recreation opportunities. Individual day GMs vary up and down from the averages shown. The averages do however provide another metric that can be used to compare the performance of the five alternatives.

Table 10-9. Baseline Monthly Average *E. coli* Density

Period	**Monthly Average *E. coli* Density (MPN/100 mL)**				
	Lower Red River [a]		**Upper Red River [b]**	**Assiniboine River [c]**	
	Parkdale	**Redwood Bridge**	**Norwood Bridge**	**Main Street Bridge**	**Less Backwater**
May	89	69	49	81	81
June	464	599	196	929	903
July	1598	1795	461	7177	7428
August	826	2534	732	6547	6194
September	863	946	233	3506	3502
Total Recreation Season	**769**	**1196**	**336**	**3668**	**3641**

Notes:
[a] Below confluence with Assiniboine River
[b] Above confluence with Assiniboine River
[c] Above confluence with Red River

Again there is little difference in mean bacteria densities between the backwater and upstream segments of the Assiniboine River.

Table 10-10 examines the number of days of non- compliance (days with a GM above 200 MPN/100/mL) in each month at each location for the recreation season. The total recreation season is 5 months or 153 days in length.

Table 10-10. Baseline Days of Non-compliance

Period	Days of Non-Compliance				
	Lower Red River [a]		Upper Red River [b]	Assiniboine River [c]	
	Parkdale	Redwood Bridge	Norwood Bridge	Main Street Bridge	Less Backwater
May	1	1	1	2	2
June	8	9	7	10	10
July	14	14	8	16	16
August	11	12	8	12	11
September	10	8	6	12	11
Total Recreation Season	**44**	**44**	**30**	**52**	50
Percentage Days Non-compliance	29%	29%	20%	34%	33%

Notes:
[a] Below confluence with Assiniboine River
[b] Above confluence with Assiniboine River
[c] Above confluence with Red River

The Main Street Bridge and the upstream locations on the Assiniboine River has the highest number of non-compliant days followed closely by the Redwood Bridge and Parkdale locations on the Lower Red River. The Norwood Bridge location on the Upper Red River has the least number of non-complaint days. This is likely the result of the lower volume and frequency of overflows and lower number of contributing outfalls in this river reach.

10.4.3 Baseline Rainfall Event Response

To illustrate the dynamics and timing of wet weather impacts, two periods from the 1992 recreational season were extracted. Specifically, June 1 to June 19 and July 1 to July 19. Both periods contained a series of rainfalls occurring over the period. Given the similarity of the results between the two locations on the Assiniboine River the analysis was carried out for only the Main Street as well as the three Red River locations.

10.4.3.1 Assiniboine River - Main Street Bridge

Figure 10-12 shows the modelled in-stream *E. coli* response to wet weather in the Assiniboine River at the Main Street Bridge during the June 1 -19, 1992, period.

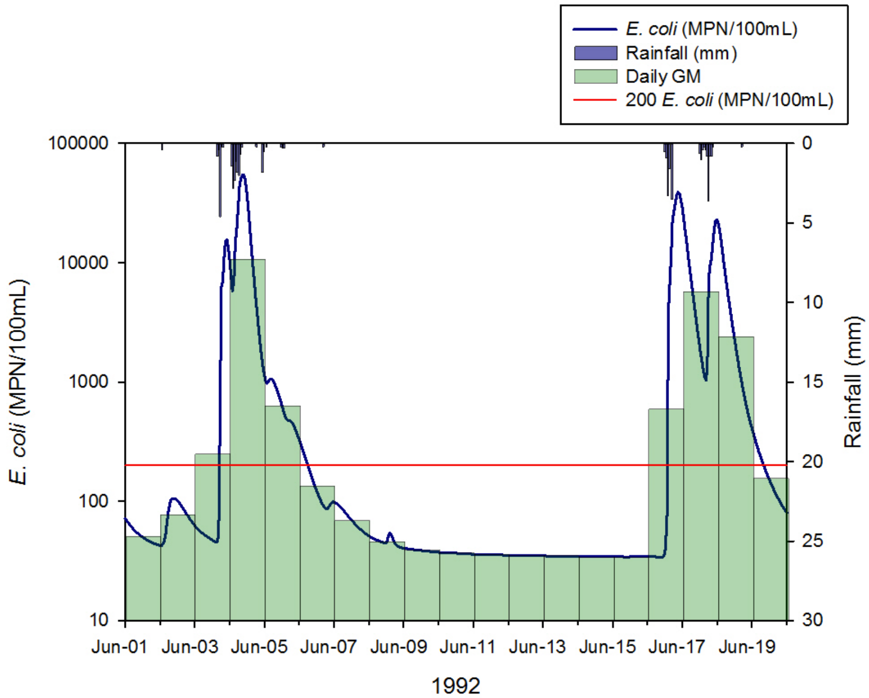

Figure 10-12. Main Street Bridge June 1 – 19

Figure 10-12 highlights the rapid increase in *E. coli* daily densities in response to rainfall on June 3 and 4 followed by a much slower return to dry weather water quality levels on about June 10. It required approximately 2 + days for densities to decline below MWQSOG and a total of 5+ days to return to baseline dry weather conditions. The second event on June 16 shows similar characteristics with a rapid rise to peak and a slow recession.

Figure 10-13 shows the modelled in-stream *E. coli* response to wet weather in the Assiniboine River at the Main Street Bridge during the July 1 -19, 1992, period.

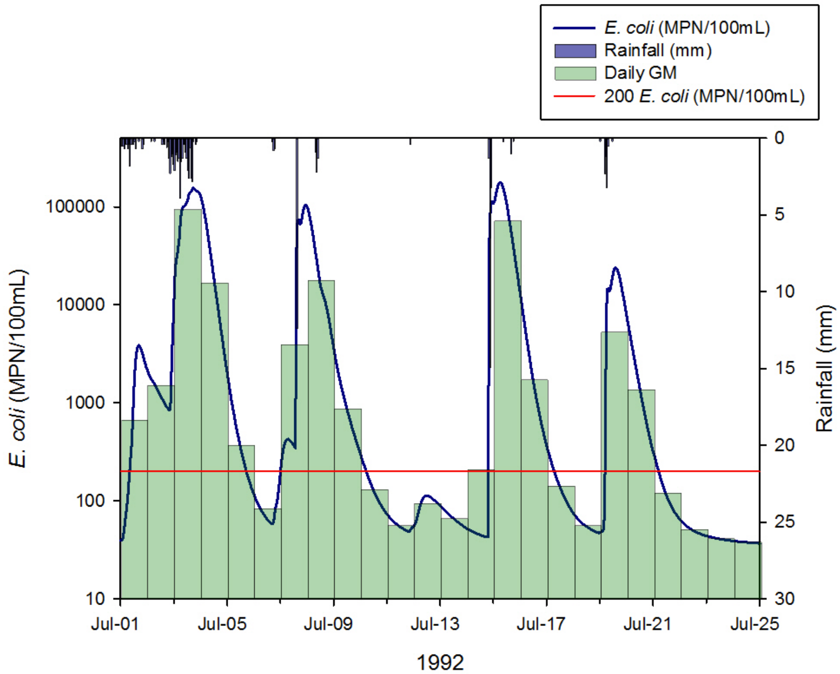

Figure 10-13. Main Street Bridge July 1 – 19

Figure 10-13 shows the impact of a number of sequential rainfall events in the period July 1 - 19. The initial rainfall occurred on July 1 - 3 with a second intense rain on July 7 – 8 and a number of events thereafter. As was indicated in Table 11-9, the multiple rainfalls during this period as well as the remainder of July resulted in 16 of 31 days in July not in compliance with the MWQSOG for *E. coli*.

It requires 2+ days (Table 11-4) for flow to travel the length of the Assiniboine River from Headingley to confluence with Red River (just below the Main Street Bridge) during July flow conditions. Thus the relatively closely spaced rainfalls observed in this period result in superimposition of in-stream densities from previous events upon subsequent events.

10.4.3.2 Upper Red River - Norwood Bridge

Figure 10-14 shows the modelled in-stream *E. coli* response to wet weather in the Upper Red River at the Norwood Bridge during the June 1 -19, 1992, period.

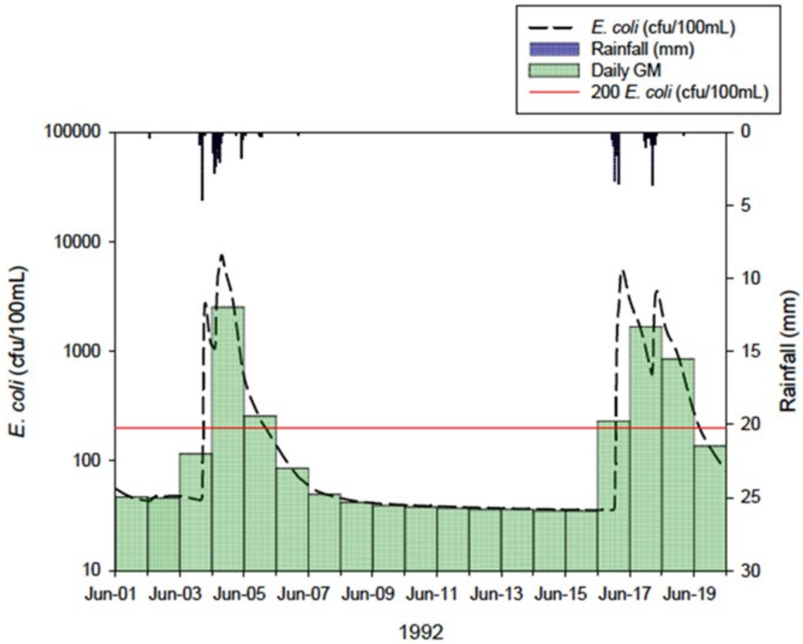

Figure 10-14. Norwood Bridge June 1 - 19

Figure 10-14 shows the same rapid increase in *E. coli* daily densities in response to rainfall on June 3 and 4 followed by a return to dry weather water quality levels by June 7-8. It required approximately 1 + days for densities to decline below MWQSOG and a total of 4+ days to return to baseline dry weather conditions. The second event on June 16 shows similar characteristics with a rapid rise to peak and a slow recession.

Figure 10-15 shows the modelled in-stream *E. coli* response to wet weather in the Upper Red River at the Norwood Bridge during the July 1 -19, 1992, period.

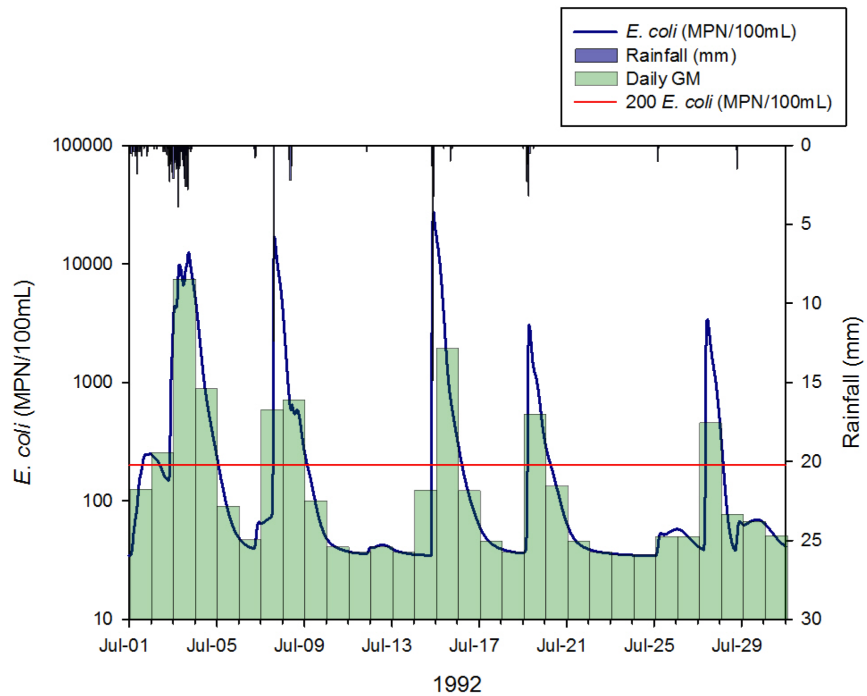

Figure 10-15. Norwood Bridge July 1 – 19

Figure 10-15 shows the impact of the sequential events in the period July 1–19.

10.4.3.3 Lower Red River – Redwood Bridge

Figure 10-16 shows the modelled in-stream *E. coli* response to wet weather in the Lower Red River at the Redwood Bridge during the June 1 -19, 1992, period.

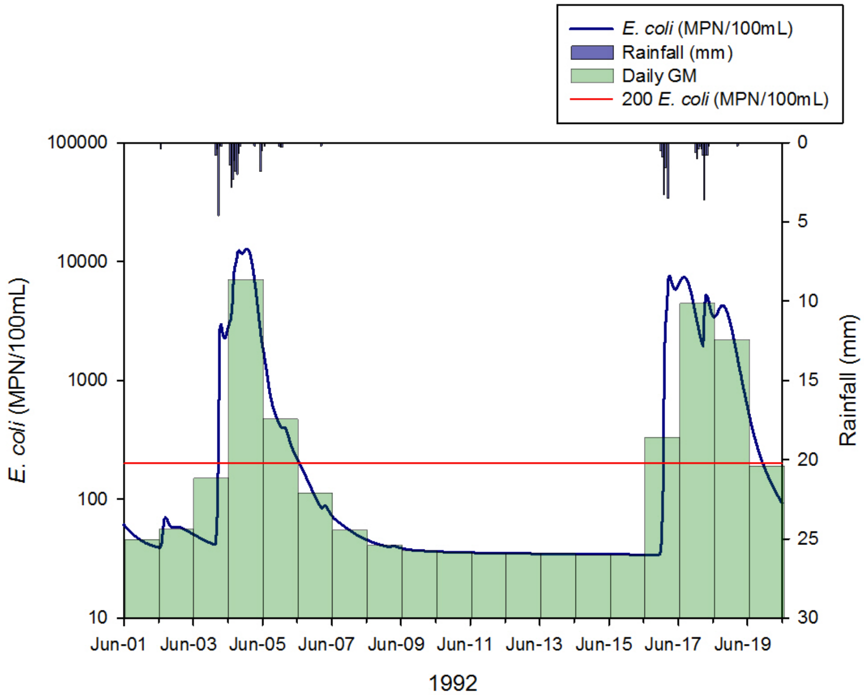

Figure 10-16. Redwood Bridge June 1–19

Figure 10-16 shows the same rapid increase in *E. coli* daily densities in response to rainfall on June 3 and 4 followed by a return to dry weather water quality levels on June 7–8. It required approximately 2 days for densities to decline below MWQSOG and a total of 4+ days to return to baseline dry weather conditions. The second event on June 16 shows similar characteristics with a rapid rise to peak and a slow recession.

Figure 10-17 shows the modelled in-stream *E. coli* response to wet weather in the Lower Red River at the Redwood Bridge during the July 1–19 1992 period. The figure shows the impact of the sequential events in the period July 1–19.

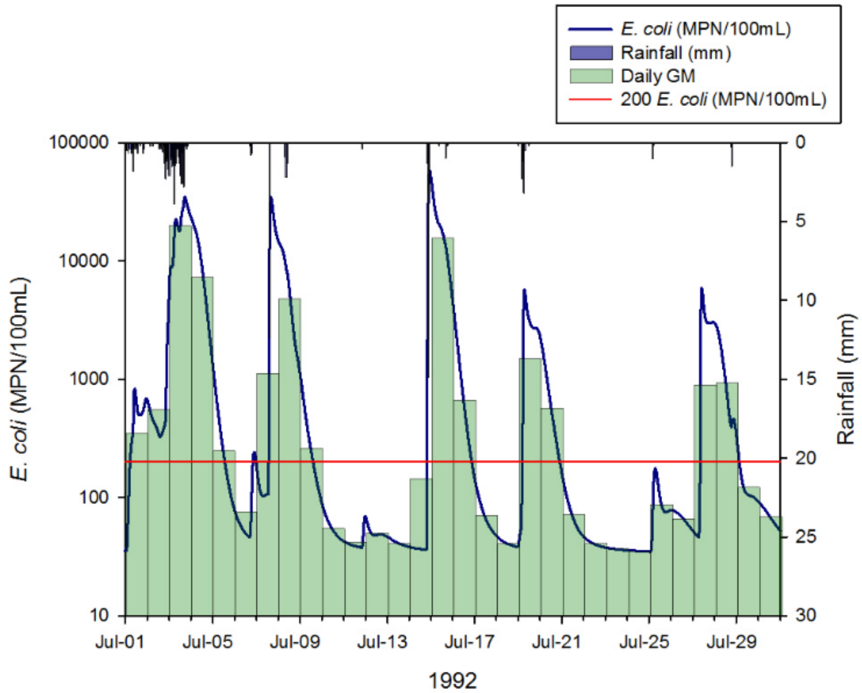

Figure 10-17. Redwood Bridge July 1–19

10.4.3.4 Lower Red River – Parkdale

Figure 10-18 shows the modelled in-stream *E. coli* response to wet weather in the Lower Red River at Parkdale during the June 1–19, 1992, period.

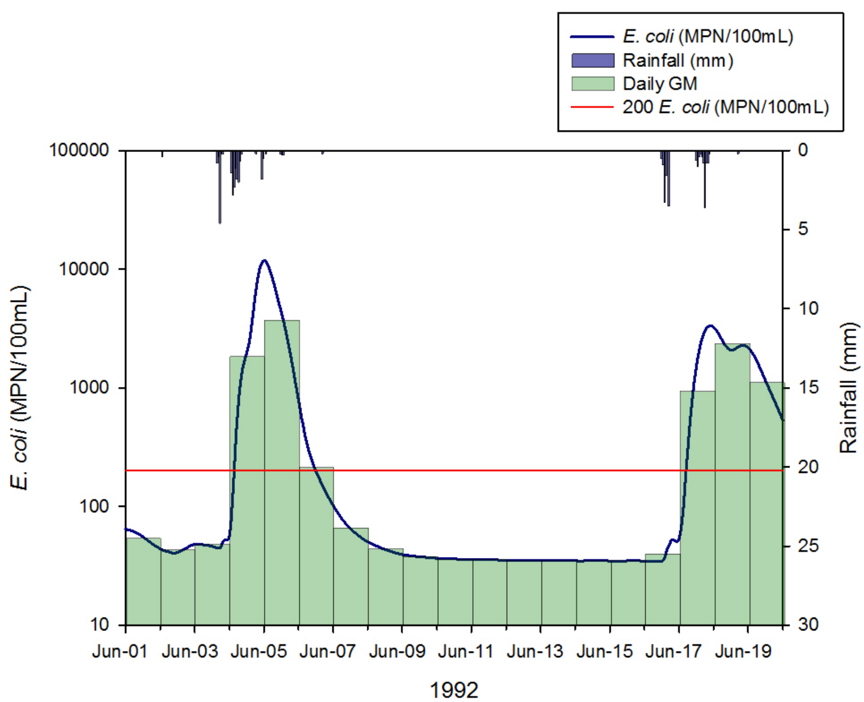

Figure 10-18. Parkdale June 1–19

Figure 10-18 shows the same rapid increase in *E. coli* daily densities in response to rainfall on June 3 and 4 followed by a return to dry weather water quality levels on June 7–8. It required approximately 2 days for densities to decline below MWQSOG and a total of 4+ days to return to baseline dry weather conditions. The second event on June 16 shows similar characteristics with a rapid rise to peak and a slow recession.

Figure 10-19 shows the modelled in-stream *E. coli* response to wet weather in the Lower Red River at the Redwood Bridge during the July 1–19, 1992, period. The figure shows the impact of the sequential events in the period July 1–19.

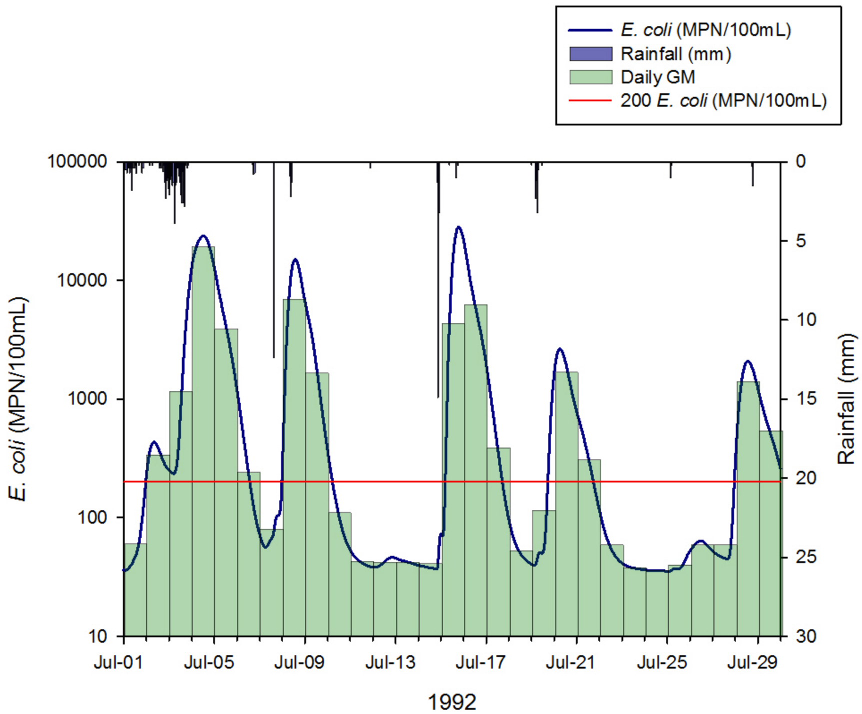

Figure 10-19. Parkdale July 1–19

10.5 Non-recreation Season Baseline Assessment

The purpose of this section is to examine the impact of CSO on river bacterial densities during the non-recreation season October to April under Baseline conditions. Part of the analysis explores the rainfall and snowmelt driving force behind the CSO and its influence on CSO volumes and frequencies.

10.5.1 Non-recreation Season Precipitation

Precipitation in the non-recreation season is in the form of both rain and snow. Figure 10-20 presents a summary of monthly precipitation depth as rainfall equivalent based on the 1992 representative year. For purposes of analysis the snowfall was converted to rainfall based on the assumption that equivalent rainfall depth would be 10 percent of the snowfall depth (that is, 1 mm rainfall equivalent = 1 cm snowfall).

Monthly snowfalls for the 1992 representative year are in the range of 4 mm to 40 mm rainfall equivalent (4 cm to 40 cm snowfall) with snow falling in each month of the non-recreation season. Only trace amounts of rain are recorded in the period from October to February with more substantial rainfall volumes in early spring months of March and April. Accordingly, any overflows occurring in the October to February period would be driven by snowmelt. In March and April the combination of rainfall and the melting of accumulated snow would drive overflows.

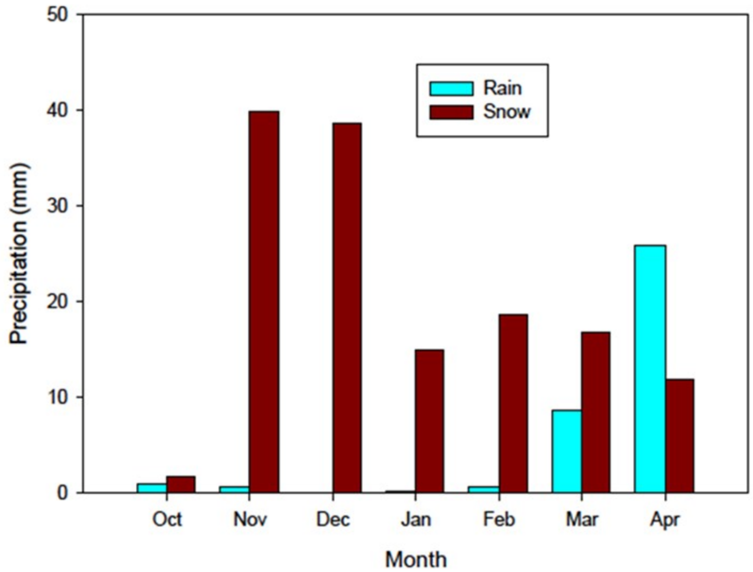

Figure 10-20. Non-Recreation Season Monthly Precipitation Rainfall Equivalent

CSO modelling with the InfoWorks Regional Model and LDS modelling with the new InfoWorks LDS model both employed a modified rainfall/snowfall input time series. The snowfall component was accumulated and melted using a degree-day method to generate runoff, which was added to the runoff from daily rainfall. As a consequence the timing of runoff events was delayed from the period when snowfall actually occurred.

Figure 10-21 presents the actual monthly total precipitation in rainfall equivalent (rainfall plus snowfall) and the modelled monthly precipitation (rainfall plus snowmelt) that was used as input to the InfoWorks Regional Model and the LDS InfoWorks models.

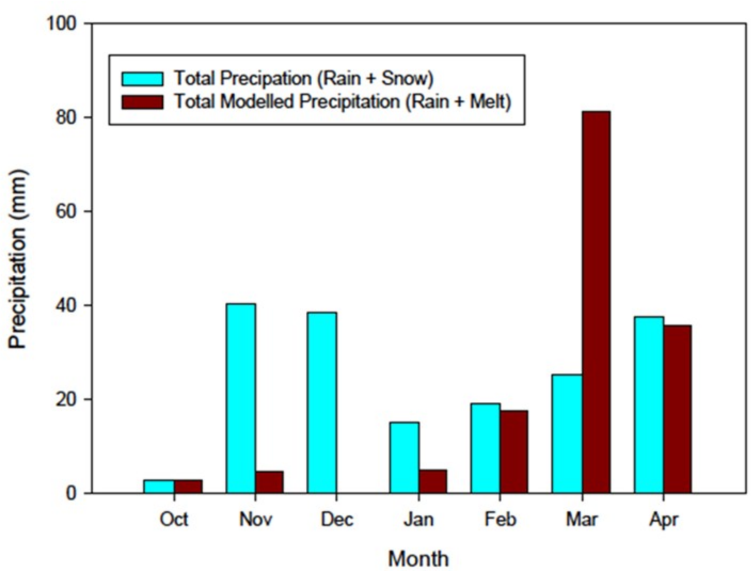

Figure 10-21. Non-recreation Season Monthly Precipitation Volumes

The bulk of the snowfall accumulates over the non-recreation season with some limited melts in January and February and the remainder melting in March and April.

10.5.2 Non-recreation Season Baseline CSO

Table 10-11 presents the modelled monthly discharge volumes for the 1992 non-recreation season.

The largest volumes are discharged into the Lower Red River followed by the discharges into the Assiniboine River, which are approximately half as large. Because of the combined effects of snowmelt and rainfall, March and April are the months with highest aggregate discharge volumes in all three river reaches. The late fall and early winter months of October, November, and December have negligible overflow volume in the representative year.

Table 10-11. Non-recreation Season Monthly Overflow Volume Summary for Baseline Conditions

Month	Overflow Volume (m^3)		
	Lower Red River [a]	Upper Red River [b]	Assiniboine River [c]
January	7,539	441	3,967
February	56,319	5,454	30,543
March	304,752	50,007	184,934
April	223,456	40,578	99,235
October	0	0	12
November	0	0	12
December	0	0	0
Total Non-recreation Season	**592,067**	**96,481**	**318,702**

Notes:
[a] Below confluence with Assiniboine River
[b] Above confluence with Assiniboine River
[c] Above confluence with Red River

The monthly maximum number of overflows at any outfall is presented in Table 10-12. This statistic corresponds to the maximum number of overflows occurring at any outfall discharging to the river reach within the month indicated. The frequency of overflow activity within a river reach provides a metric that can be used to compare the performance of the five alternatives.

Table 10-12 shows that the months of March and April have the highest frequency of overflows at any outfall in all three river reaches. The Lower Red River and the Assiniboine River have comparable statistics for this period while the Upper Red River has a fewer number overflows at any outfall. Comparable to the monthly overflow volumes, the months of October, November, and December have a maximum of zero to two overflows at any outfall.

Table 10-12. Non-recreation Season Maximum Overflow Frequency at any Outfall For Baseline Conditions

Month	Maximum Number of Overflows at any Outfall		
	Lower Red River [a]	Upper Red River [b]	Assiniboine River [c]
January	1	1	1
February	3	2	3
March	8	7	8
April	5	2	5
October	2	0	2
November	2	0	2
December	0	0	0

Notes:
[a] Below confluence with Assiniboine River
[b] Above confluence with Assiniboine River
[c] Above confluence with Red River

The number of overflows active in a given month is presented in Table 10-13. This statistic corresponds to the number of overflow locations discharging to the river reach within the month indicated. The number of active overflows within a river reach provides a metric that can be used to compare the performance of the five alternatives. The most active months in this case are again March and April in all three river reaches. A significant number of overflow locations also discharge in February on the Lower Red River (7) and the Assiniboine River (10). In October and November only a single outfall discharges into the Lower Red River and into the Assiniboine River. No outfalls discharge in December.

Table 10-13. Non-recreation Season Number of Overflow Locations Active during Month for Baseline Conditions

Month	Number of Active Overflows		
	Lower Red River [a]	Upper Red River [b]	Assiniboine River [c]
January	4	1	9
February	7	3	10
March	16	6	17
April	21	8	22
October	1	0	1
November	1	0	1
December	0	0	0
Total Non-recreation Season	**50**	**18**	**60**

Notes:
[a] Below confluence with Assiniboine River
[b] Above confluence with Assiniboine River
[c] Above confluence with Red River

10.5.3 Non-Recreation Season Baseline GMs

The daily GMs for each location in the non-recreation season are plotted in Figures 10-22 to 10-25 for Main Street Bridge (Assiniboine River), Norwood Bridge (Upper Red River), Redwood Bridge (Lower Red River), and Parkdale (Lower Red River) respectively.

The daily GM plots indicate much lower modelled densities at the Main Street Bridge with occasional days as high as 400 – 500 MPN/100 mL and only one event over 1,000 MPN/100 mL in the entire period from October to the end of February. The modelled densities in the recreation season baseline case shown in Figure 10-7 were an order of magnitude higher. The peak day GMs at the Norwood Bridge location are lower reaching about 1,000 MPN/100 mL. This again is about an order of magnitude lower than for the recreation season baseline case presented in Figure 11-8. The densities at the Redwood Bridge location are similar to those at the Main Street Bridge. This is a location downstream of the confluence and shows the influence of conditions in both rivers. The Parkdale location indicates densities somewhat lower than at the Redwood Bridge location.

The infrequent CSO activity noted in Tables 10-12 and 10-13 during the October through February period can be compared to the number of modelled bacteria "spikes" shown in the Figures 10-22 to 10-25. The number of "spikes" exceeds the CSO frequencies suggesting that LDS predominately derived from snowmelt is the source of the increased densities. The LDS *E. coli* densities were assumed to be the same as the summertime densities. If in practice the winter densities were lower there would be a corresponding reduction in bacteria "spikes" and potentially days of non-compliance.

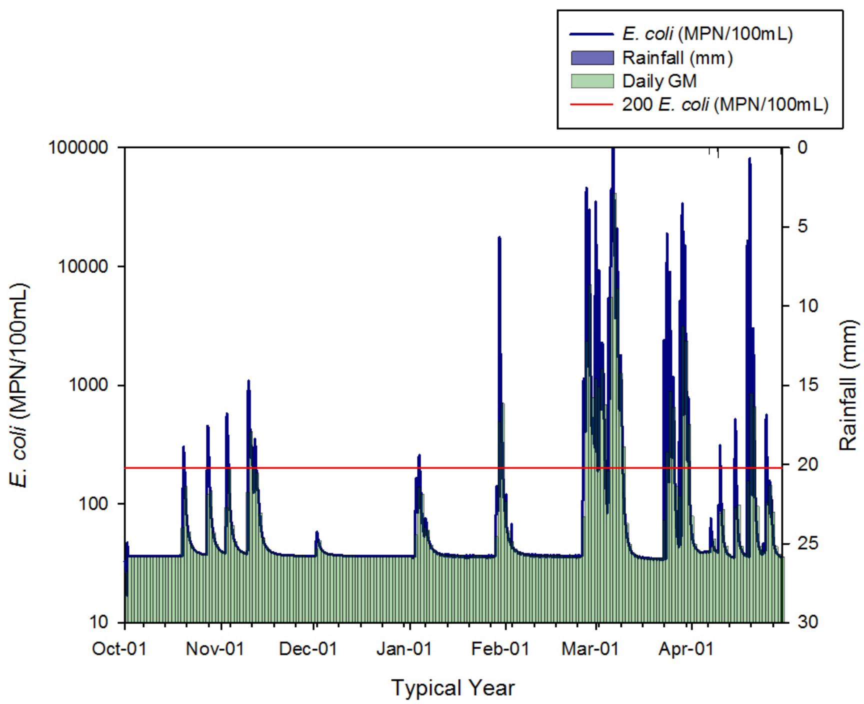

Figure 10-22. Main Street Bridge *E. coli* Densities for Non-recreation Season – Baseline

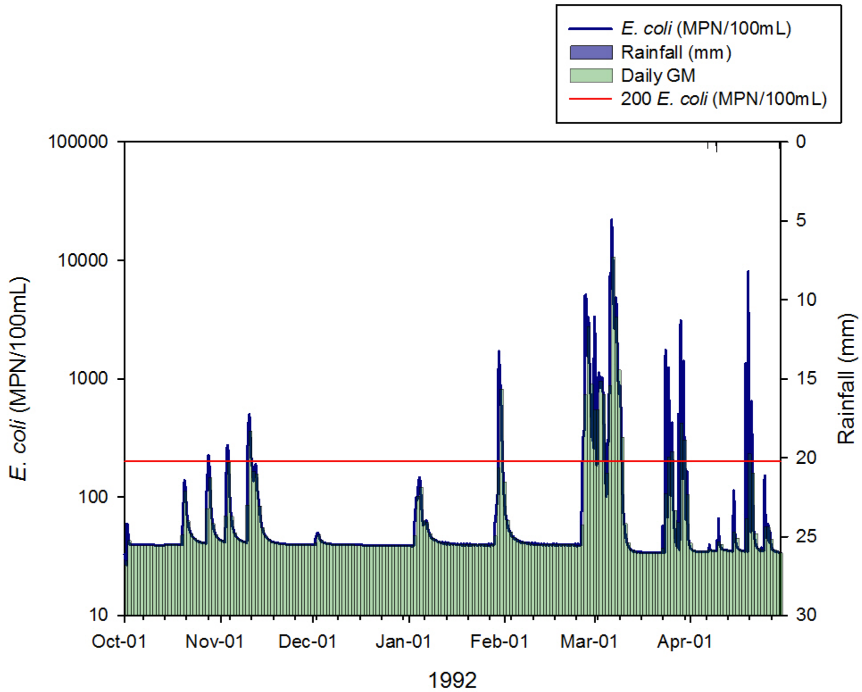

Figure 10-23. Norwood Bridge *E. coli* Densities for Non-recreation Season – Baseline

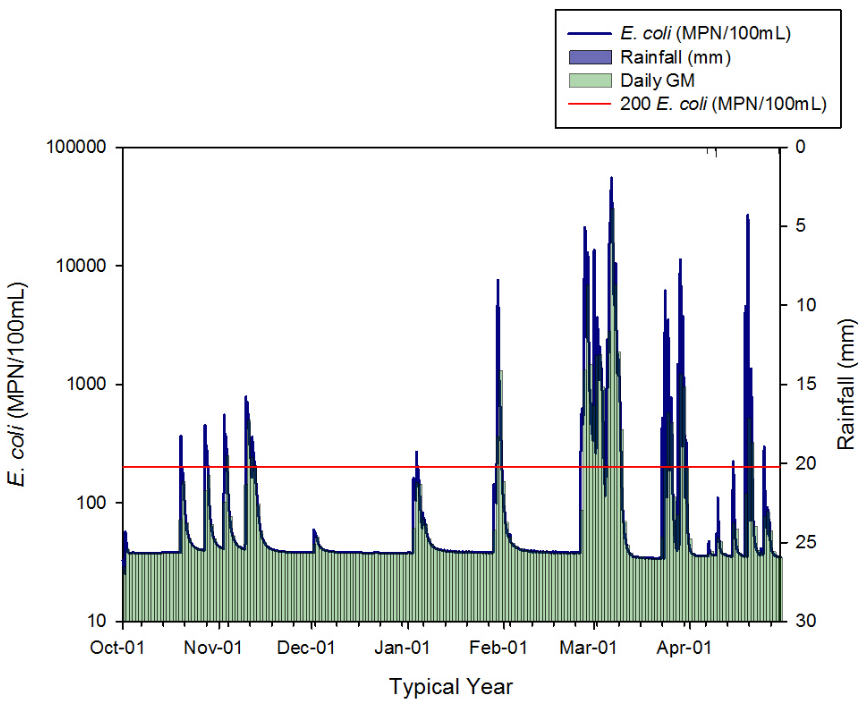

Figure 10-24. Redwood Bridge *E. coli* Densities for Non-recreation Season – Baseline

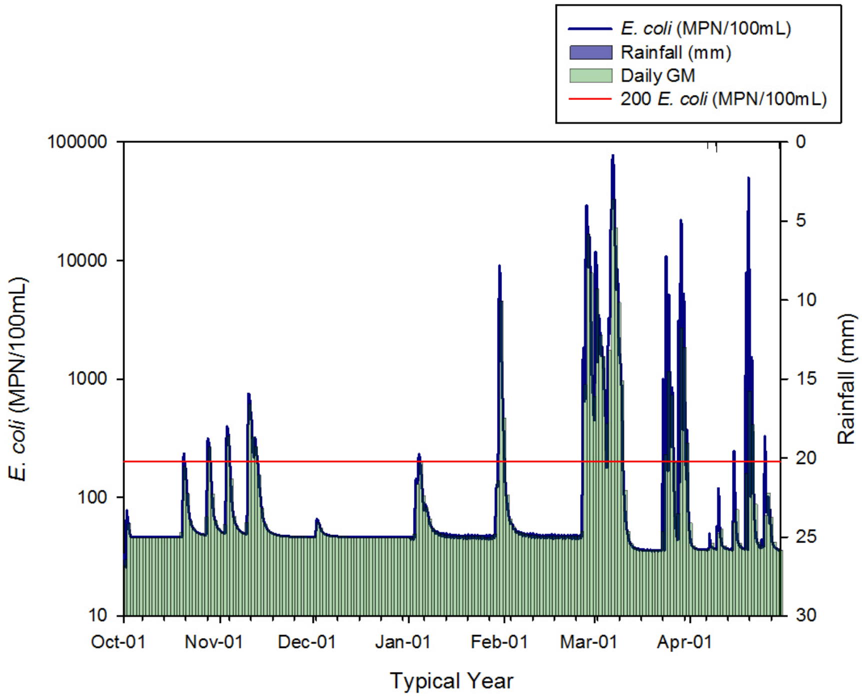

Figure 10-25. Parkdale *E. coli* Densities for Non-recreation Season – Baseline

The monthly average GMs and overall non-recreation season GM calculated from the arithmetic mean of the daily GMs are summarized for all four locations in Table 10-14.

Table 10-14. Non-recreation Season Monthly Average *E. coli* Density – Baseline

Period	Monthly Average *E. coli* Density (MPN/100 mL)			
	Lower Red River [a]		Upper Red River [b]	Assiniboine River [c]
	Parkdale	Redwood Bridge	Norwood Bridge	Main Street Bridge
October	64	53	49	48
November	103	84	71	74
December	47	39	40	37
January	215	103	78	83
February	947	393	207	424
March	2481	1658	673	2163
April	90	73	51	110
Total Recreation Season	**564**	**343**	**167**	**420**

Notes:
[a] Below confluence with Assiniboine River
[b] Above confluence with Assiniboine River
[c] Above confluence with Red River

The MWQSOG for *E. coli* does not apply during the non-recreation season so comparisons with the 200 MPN/100 mL objective would be inappropriate. In a practical sense it is unlikely that any immersive water borne recreation would occur during this period. Air temperatures are cold and the rivers are typically covered in ice from late December through late March

10.6 Current Program

The purpose of this section is to examine the water quality benefits of controlling the CSO discharges with the City's current capital program. The current City of Winnipeg program includes the planned separation of seven districts. The NEWPCC facility would remain at 705ML/d. Section 8 presents the details of current program.

10.6.1 CSO Volume and Frequency

Table 10-15 presents the modelled monthly discharge volumes for the current program. The table shows the volumes for the recreation and non-recreation seasons as well as the annual total. The largest volumes are discharged into the Lower Red River in both the recreation and non-recreation seasons. There is little, if any, discharge in the October to January period in the Lower Red River with higher volumes in the February to April period. The Upper Red River and Assiniboine River have substantial volumes in both July and August.

Table 10-15. Monthly Overflow Volume Summary for Current Program

Month	Overflow Volume (m^3)		
	Lower Red River [a]	Upper Red River [b]	Assiniboine River [c]
May	107,927	15,920	47,190
June	225,341	22,319	99,908
July	963,222	132,638	405,735
August	747,537	110,260	316,213
September	431,355	57,244	182,783
Total Recreation Season	2,475,382	338,381	1,051,829
October	0	0	0
November	0	0	0
December	0	0	0
January	7,539	0	3,775
February	56,319	737	28,503
March	304,752	17,071	170,062
April	223,456	27,238	87,781
Total Non-Recreation Season	**592,067**	**45,046**	**290,121**
Total Annual	**3,067,448**	**383,428**	**1,341,949**

Notes:
[a] Below confluence with Assiniboine River
[b] Above confluence with Assiniboine River
[b] Above confluence with Red River

Table 10-16 shows that the months of July and March have the highest frequency of overflows at any outfall in all three river reaches during the recreation season and non-recreation season respectively. All three river reaches have comparable statistics for both periods. This statistic corresponds to the maximum number of overflows occurring at any outfall discharging to the river reach within the month indicated. The frequency of overflow activity within a river reach provides a metric that can be used to compare the performance of the five alternatives.

Table 10-16. Monthly Maximum Overflow Frequency for Current Program

Season	Month	Maximum Number of Overflows at any Outfall		
		Lower Red River [a]	Upper Red River [b]	Assiniboine River [c]
Recreation Season	May	1	2	2
	June	4	6	4
	July	7	8	7
	August	5	6	4
	September	4	5	5
Non-recreation Season	October	0	0	0
	November	0	0	0
	December	0	0	0
	January	1	0	1
	February	4	3	4
	March	7	7	8
	April	2	2	3

Notes:
[a] Below confluence with Assiniboine River
[b] Above confluence with Assiniboine River
[c] Above confluence with Red River

The number of overflows active in a given month is presented in Table 10-17. This statistic corresponds to the number of overflow locations discharging to the river reach within the month indicated. The number of active overflows within a river reach provides a metric that can be used to compare the performance of the five alternatives. The two most active months in this case are July and April for the recreation and non-recreation seasons respectively in all three river reaches. On an annual basis the highest number of active overflows discharge to the Assiniboine River with nearly comparable statistics in the Lower Red River and far fewer active outfalls in the Upper Red River.

Table 10-17. Number of Overflows Active during Month for Current Program

Season	Month	Number of Active Overflows		
		Lower Red River [a]	Upper Red River [b]	Assiniboine River [c]
Recreation Season	May	19	7	20
	June	18	6	17
	July	21	9	29
	August	20	8	26
	September	20	7	25
Total Recreation Season		**98**	**37**	**117**
Non-recreation Season	October	0	0	0
	November	0	0	0
	December	0	0	0
	January	3	0	8
	February	5	2	9
	March	16	5	16
	April	19	7	19
Total Non-recreation Season		**43**	**14**	**52**
Total Annual		**141**	**51**	**169**

Notes:
[a] Below confluence with Assiniboine River
[b] Above confluence with Assiniboine River
[c] Above confluence with Red River

10.6.2 Current Program GMs

The daily GMs for select locations are plotted in Figures 10-26 to 10-29 for Main Street Bridge (Assiniboine River), Norwood Bridge (Upper Red River), Redwood Bridge (Lower Red River), and Parkdale (Lower Red River) respectively. The daily GM plots indicate modelled densities as high as 100,000 MPN/100 mL at the Main Street Bridge location showing the impact of the wet weather inputs into the Assiniboine River on water quality. The peak day GMs at the Norwood Bridge location are lower reaching 10,000 to about 50,000 MPN/100 mL. This shows the influence of the lower volume of CSO and SRS inputs in this reach of the Upper Red River coupled with the higher river flows (greater dilution). The densities at the Redwood Bridge location are similar to those at the Main Street Bridge. This is a location downstream of the confluence and shows the influence of conditions in both rivers. The Parkdale location indicates densities somewhat lower than at the Redwood Bridge location notwithstanding the significant wet weather inputs into the Lower Red River.

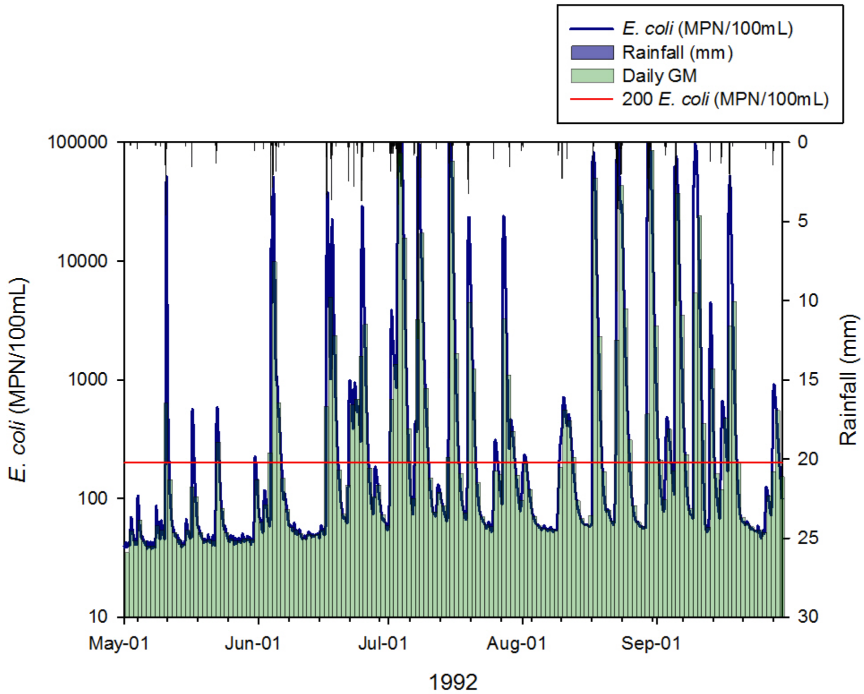

Figure 10-26. Main Street Bridge *E. coli* Densities for Current Program

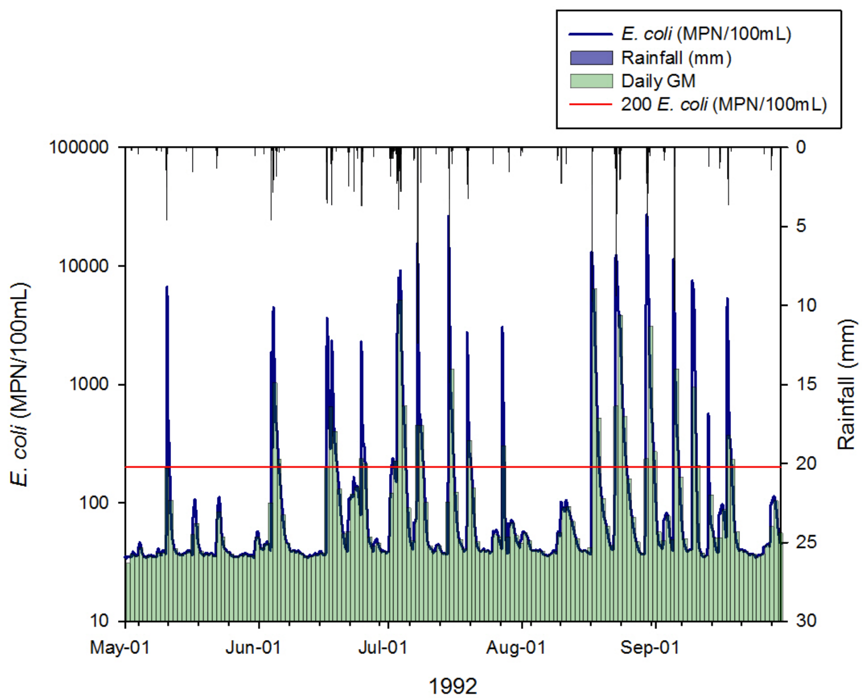

Figure 10-27. Norwood Street Bridge *E. coli* Densities for Current Program

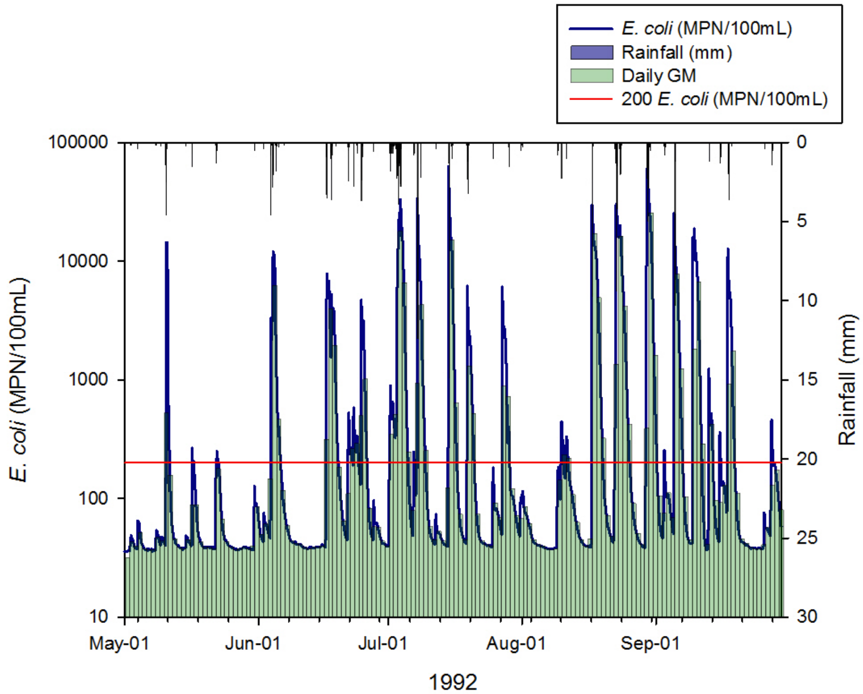

Figure 10-28. Redwood Bridge *E. coli* Densities for Current Program

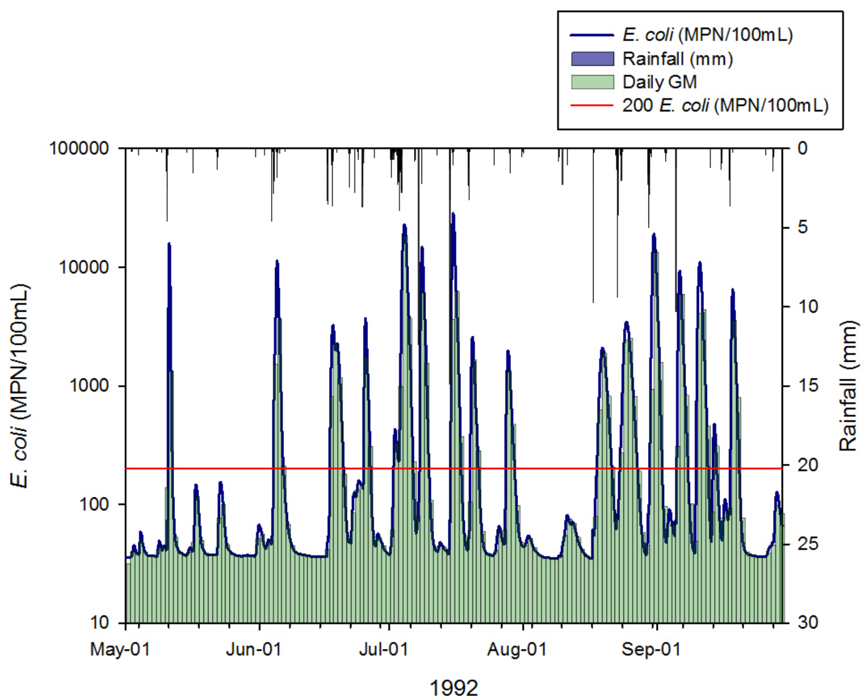

Figure 10-29. Parkdale *E. coli* Densities for Current Program

The monthly average GMs and overall recreation season GM calculated from the arithmetic mean of the daily GMs are summarized for all four locations in Table 10-18. The average densities shown are indicative of monthly conditions and are not direct indicators of available recreation opportunities. Individual day GMs vary up and down from the averages shown. The averages do however provide another metric that can be used to compare the performance of the five alternatives.

Table 10-18. Monthly Average *E. coli* Density for Current Program

Period	Monthly Average *E. coli* Density (MPN/100 mL)			
	Lower Red River [a]		Upper Red River [b]	Assiniboine River [c]
	Parkdale	Redwood Bridge	Norwood Bridge	Main Street Bridge
May	91	70	48	86
June	437	548	143	876
July	1504	1656	336	6626
August	814	2383	547	6252
September	812	779	156	2871
Total Recreation Season	**733**	**1095**	**248**	**3364**

Notes:
[a] Below confluence with Assiniboine River
[b] Above confluence with Assiniboine River
[c] Above confluence with Red River

Table 10-19 examines the number of days of non-compliance in each month at each location. The total recreation season is 5 months or 153 days in length. The Main Street Bridge location on the Assiniboine River has the highest number of non-compliant days followed closely by the Redwood Bridge and Parkdale locations on the Lower Red River. The Norwood Bridge location on the Upper Red River has the least number of non-complaint days. This is likely the result of the lower volume and frequency of overflows and lower number of contributing outfalls in this river reach.

Table 10-19. Recreation Season Days of Non-compliance for Current Program

Period	Days of Non-compliance			
	Lower Red River [a]		Upper Red River [b]	Assiniboine River [c]
	Parkdale	Redwood Bridge	Norwood Bridge	Main Street Bridge
May	1	1	0	2
June	8	9	7	10
July	14	14	8	16
August	10	12	8	13
September	10	8	5	14
Total Recreation Season	**43**	**44**	**28**	**55**
Percentage Days Non-compliance	28%	29%	18%	36%

Notes:
[a] Below confluence with Assiniboine River
[b] Above confluence with Assiniboine River
[c] Above confluence with Red River

10.7 85 Percent Capture in a Representative Year

The purpose of this section is to examine the water quality benefits of controlling the CSO discharges with 85 Percent Capture in a representative year. The 85 Percent Capture alternative includes the separation of nine districts, latent storage in SRS pipes of 10 districts, offline storage in 7 districts and tunnel storage in 3 districts. The NEWPPC facility remains at 705ML/d capacity. Section 8.2.2 of this report presents details of 85 Percent Capture.

10.7.1 CSO Volume and Frequency

Table 10-20 presents the modelled monthly discharge volumes for 85 Percent Capture. The table shows the volumes for the recreation and non-recreation seasons as well as the annual total. The largest volumes are discharged into the Lower Red River in both the recreation and non-recreation seasons. There is little, if any, discharge in the October to January period in the Lower Red River with higher volumes in the February to April period. The Upper Red River and Assiniboine River would have substantial volumes in both July and August.

Table 10-20. Monthly Overflow Volume Summary for 85 Percent Capture

Month	Overflow Volume (m^3)		
	Lower Red River [a]	Upper Red River [b]	Assiniboine River [c]
May	43,407	11,646	36,320
June	77,228	19,537	77,793
July	531,069	100,558	341,005
August	392,410	82,717	262,516
September	192,118	41,749	149,250
Total Recreation Season	1,236,232	256,207	866,884
October	0	0	0
November	0	0	0
December	0	0	0
January	2,995	0	3,369
February	18,685	1,829	24,045
March	136,595	20,712	164,143
April	92,981	27,630	77,295
Total Non-recreation Season	**251,256**	**50,170**	**268,852**
Total Annual	**1,487,488**	**306,377**	**1,135,736**

Notes:
[a] Below confluence with Assiniboine River
[b] Above confluence with Assiniboine River
[c] Above confluence with Red River

Table 10-21 shows that the months of July and March have the highest frequency of overflows at any outfall in all three river reaches during the recreation season and non-recreation season respectively. All three river reaches have comparable statistics for both periods. This statistic corresponds to the maximum number of overflows occurring at any outfall discharging to the river reach within the month indicated. The frequency of overflow activity within a river reach provides a metric that can be used to compare the performance of the five alternatives.

Table 10-21. Monthly Maximum Overflow Frequency for 85% Capture

Season	Month	Maximum Number of Overflows at any Outfall		
		Lower Red River [a]	**Upper Red River [b]**	**Assiniboine River [c]**
Recreation Season	May	1	1	1
	June	4	5	4
	July	7	7	7
	August	4	5	4
	September	4	4	4
Non-recreation Season	October	0	0	0
	November	0	0	0
	December	0	0	0
	January	1	0	2
	February	3	3	3
	March	9	7	7
	April	2	2	2

Notes:
[a] Below confluence with Assiniboine River
[b] Above confluence with Assiniboine River
[c] Above confluence with Red River

The number of overflows active in a given month is presented in Table 10-22. This statistic corresponds to the number of overflow locations discharging to the river reach within the month indicated. The number of active overflows within a river reach provides a metric that can be used to compare the performance of the five alternatives. The two most active months in this case are July and April for the recreation and non-recreation seasons respectively in all three river reaches. On an annual basis the highest number of active overflows discharge to the Assiniboine River with nearly comparable statistics in the Lower Red River and far fewer active outfalls in the Upper Red River.

Table 10-22. Number of Overflows Active during Month for 85% Capture

Season	Month	Number of Active Overflows		
		Lower Red River [a]	Upper Red River [b]	Assiniboine River [c]
Recreation Season	May	11	5	13
	June	11	4	10
	July	21	7	22
	August	17	6	17
	September	13	5	14
Total Recreation Season		**73**	**27**	**76**
Non-recreation Season	October	0	0	0
	November	0	0	0
	December	0	0	0
	January	1	0	5
	February	3	1	6
	March	10	2	9
	April	13	5	11
Total Non-recreation Season		**27**	**8**	**31**
Total Annual		**100**	**35**	**107**

Notes:
[a] Below confluence with Assiniboine River
[b] Above confluence with Assiniboine River
[c] Above confluence with Red River

10.7.2 85 Percent Capture in a Representative Year GMs

The daily GMs for select locations are plotted in Figures 10-30 to 10-33 for Main Street Bridge (Assiniboine River), Norwood Bridge (Upper Red River), Redwood Bridge (Lower Red River), and Parkdale (Lower Red River) respectively. The daily GM plots indicate modelled densities as high as 100,000 MPN/100 mL at the Main Street Bridge location showing the impact of the wet weather inputs into the Assiniboine River on water quality. The peak GMs at the Norwood Bridge location are lower reaching 10,000 to about 50,000 MPN/100 mL. This shows the influence of the lower volume of CSO and SRS inputs in this reach of the Upper Red River coupled with the higher river flows (greater dilution). The densities at the Redwood Bridge location are similar to those at the Main Street Bridge. This is a location downstream of the confluence and shows the influence of conditions in both rivers. The Parkdale location indicates densities somewhat lower than at the Redwood Bridge location notwithstanding the significant CSO inputs into the Lower Red River.

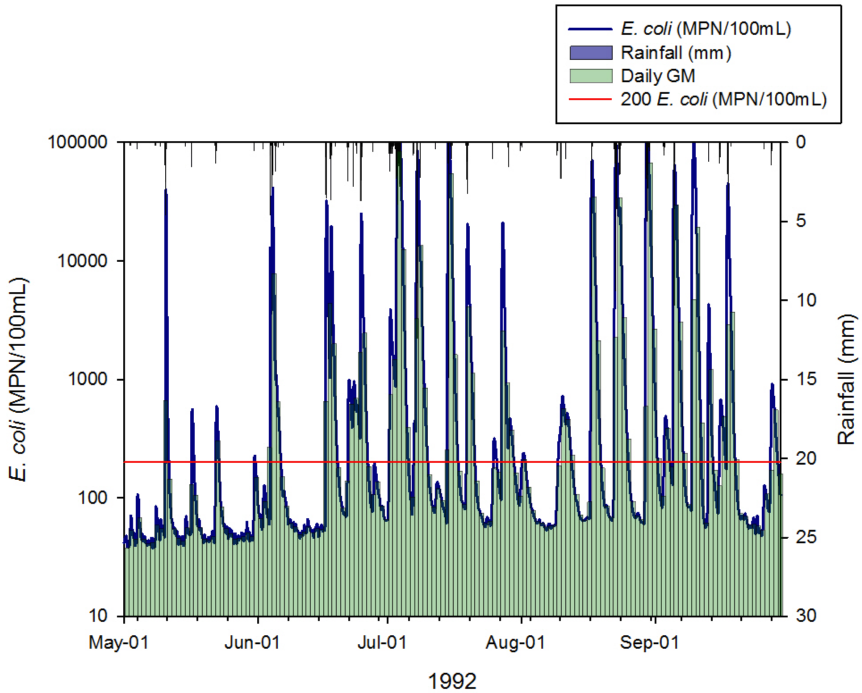

Figure 10-30. Main Street Bridge *E. coli* Densities for 85% Capture

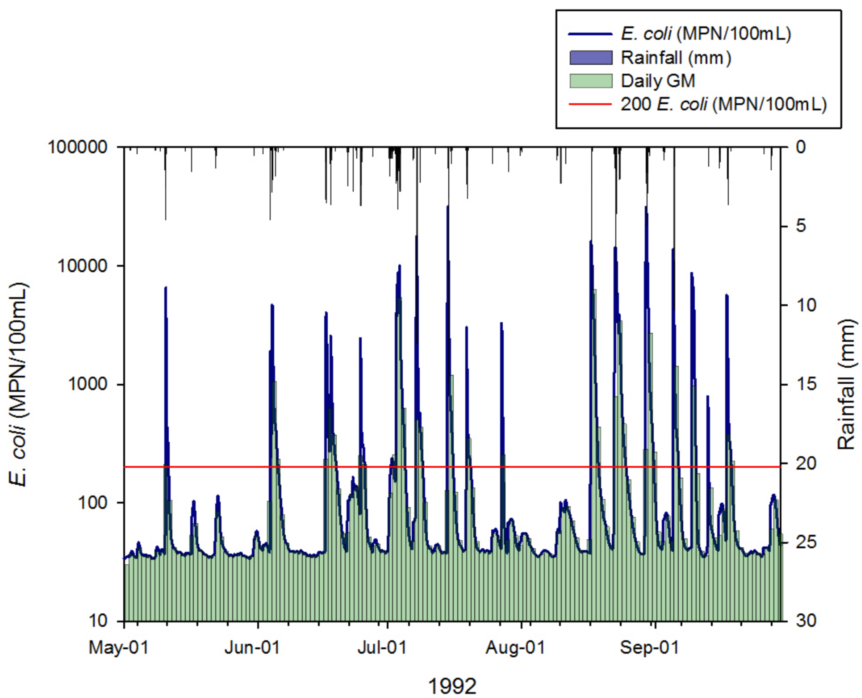

Figure 10-31. Norwood Bridge *E. coli* Densities for 85% Capture

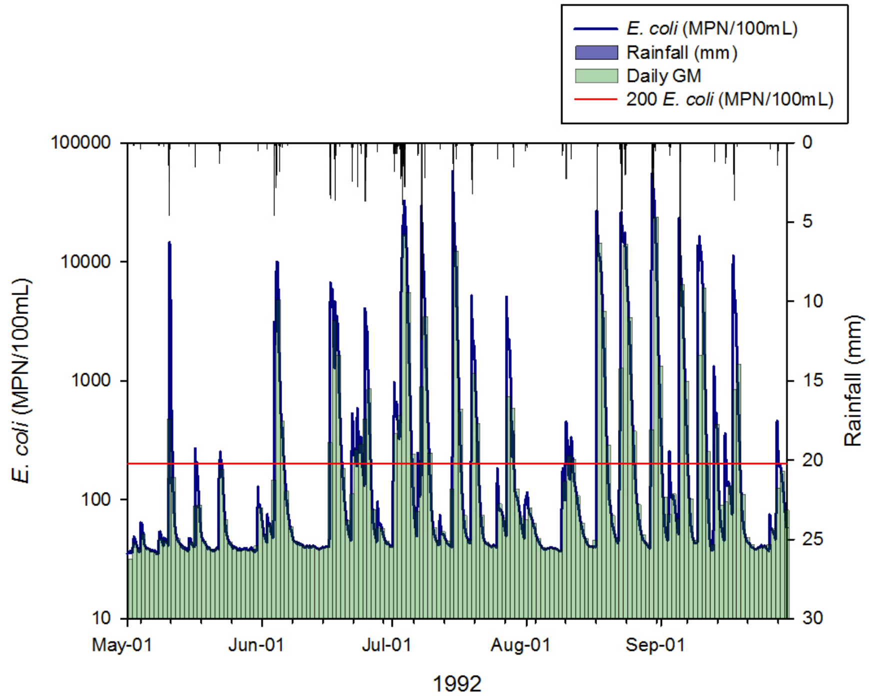

Figure 10-32. Redwood Bridge *E. coli* Densities for 85% Capture

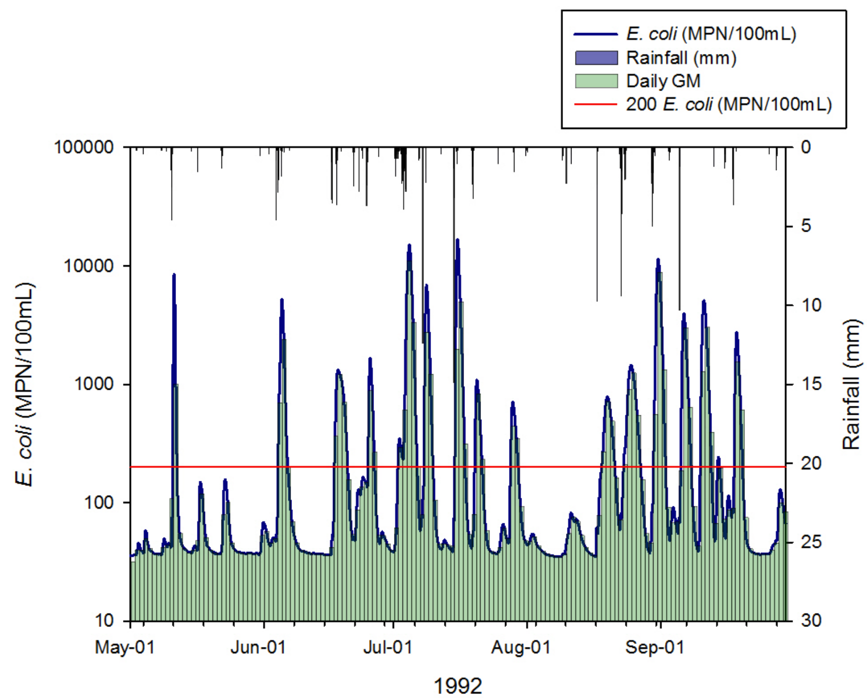

Figure 10-33. Parkdale *E. coli* Densities for 85% Capture

The monthly average GMs and overall recreation season GM calculated from the arithmetic mean of the daily GMs are summarized for all four locations in Table 10-23. The average densities shown are indicative of monthly conditions and are not direct indicators of available recreation opportunities. Individual day GMs vary up and down from the averages shown. The averages do however provide another metric that can be used to compare the performance of the five alternatives.

Table 10-23. Recreation Season Monthly Average E. coli Density for 85% Capture

Period	**Monthly Average *E. coli* Density (MPN/100 mL)**			
	Lower Red River [a]	**Upper Red River [b]**		**Assiniboine River [c]**
	Parkdale	**Redwood Bridge**	**Norwood Bridge**	**Main Street Bridge**
May	80	69	49	89
June	270	458	144	770
July	954	1455	339	5962
August	488	2087	517	4864
September	463	679	159	2365
Total Recreation Season	**452**	**956**	**243**	**2829**

Notes:
[a] Below confluence with Assiniboine River
[b] Above confluence with Assiniboine River
[c] Above confluence with Red River

Table 10-24 examines the number of days of non-compliance in each month at each location. The total recreation season is 5 months or 153 days in length. The Main Street Bridge location on the Assiniboine River has the highest number of non-compliant days followed closely by the Redwood Bridge and Parkdale locations on the Lower Red River. The Norwood Bridge location on the Upper Red River has the least number of non-complaint days. This is likely the result of the lower volume and frequency of overflows and lower number of contributing outfalls in this river reach.

Table 10-24. Recreation Season Days of Non-Compliance for Alternative 1 - 85% Capture

Period	**Days of Non-compliance**			
	Lower Red River [a]	**Upper Red River [b]**		**Assiniboine River [c]**
	Parkdale	**Redwood Bridge**	**Norwood Bridge**	**Main Street Bridge**
May	1	1	1	2
June	8	9	7	10
July	14	14	8	16
August	9	12	8	13
September	8	8	4	14
Total Recreation Season	**40**	**44**	**28**	**55**
Percentage Days Non-compliance	26%	29%	18%	36%

Notes:
[a] Below confluence with Assiniboine River
[b] Above confluence with Assiniboine River
[c] Above confluence with Red River

10.8 Four Overflows in a Representative Year

The purpose of this section is to examine the water quality benefits of controlling the CSO discharges to Four Overflows in a Representative Year. The Four Overflows alternative includes the separation of ten districts, latent storage in SRS pipes of 10 districts, offline storage in 21districts and tunnel storage in 30 districts. The NEWPPC facility remains at 705ML/d capacity. 705ML/d. Section 8.2.3 of this report presents details of Four Overflows.

10.8.1 CSO Volume and Frequency

Table 10-25 presents the modelled monthly discharge volumes the Four Overflows alternative. The table shows the volumes for the recreation and non-recreation seasons as well as the annual total. The largest volumes are discharged into the Lower Red River in both the recreation and non-recreation seasons. There is no discharge in the non-recreation season in all three rivers with the exception of modest volumes In March in both the Lower Red and Assiniboine Rivers. The Upper Red River receives discharge in only July and August.

Table 10-25. Monthly Overflow Volume Summary for Four Overflows

Month	Overflow Volume (m^3)		
	Lower Red River [a]	Upper Red River [b]	Assiniboine River [c]
May	0	0	0
June	0	0	0
July	194,409	34,054	55,918
August	120,873	12,384	32,323
September	13,105	0	389
Total Recreation Season	**328,387**	**46,439**	**88,629**
October	0	0	0
November	0	0	0
December	0	0	0
January	0	0	0
February	0	0	0
March	8,260	0	8,353
April	0	0	0
Total Non-recreation Season	**8,260**	**0**	**8,353**
Total Annual	**336,647**	**46,439**	**96,983**

Notes:
[a] Below confluence with Assiniboine River
[b] Above confluence with Assiniboine River
[c] Above confluence with Red River

The monthly maximum number of overflows at any outfall is presented in Table 10-26. This statistic corresponds to the maximum number of overflows occurring at any outfall discharging to the river reach within the month indicated. The frequency of overflow activity within a river reach provides a metric that can be used to compare the performance of the five alternatives.

Table 10-26 shows that for the Four Overflows alternative the month of July has three overflows at any outfall in all three river reaches. The remaining months have either Zero Overflows or at most 1-2 per month for all three river reaches. March is the most active non-recreation season month (3 overflows) for the Lower Red River and the Assiniboine River.

Table 10-26. Monthly Maximum Overflow Frequency for Four Overflows

Season	Month	Maximum Number of Overflows at any Outfall		
		Lower Red River [a]	Upper Red River [b]	Assiniboine River [c]
Recreation Season	May	0	0	0
	June	0	0	0
	July	3	3	3
	August	2	1	1
	September	1	0	1
Non-recreation Season	October	0	0	0
	November	0	0	0
	December	0	0	0
	January	0	0	0
	February	0	0	0
	March	3	0	3
	April	0	0	0

Notes:
[a] Below confluence with Assiniboine River
[b] Above confluence with Assiniboine River
[c] Above confluence with Red River

The number of overflow locations active in a given month is presented in Table 10-27. The months with the maximum number of overflows discharging would be July and August in all three river reaches. In contrast the non-recreation season would have few outfalls that overflow at any time during the 7-month season. This statistic corresponds to the number of overflow locations discharging to the river reach within the month indicated. The number of active overflows within a river reach provides a metric that can be used to compare the performance of the five alternatives

Table 10-27. Number of Overflows Active during Month for Four Overflows

Season	Month	Number of Active Overflows		
		Lower Red River [a]	Upper Red River [b]	Assiniboine River [c]
Recreation Season	May	0	0	0
	June	0	0	0
	July	21	8	21
	August	20	6	13
	September	4	0	1
Total Recreation Season		**45**	**14**	**45**
Non-recreation Season	October	0	0	0
	November	0	0	0
	December	0	0	0
	January	0	1	0
	February	0	0	0
	March	3	0	1
	April	0	0	0
Total Non-Recreation Season		**3**	**1**	**1**
Total Annual		**48**	**15**	**46**

Notes:
[a] Below confluence with Assiniboine River
[b] Above confluence with Assiniboine River
[c] Above confluence with Red River

10.8.2 Four Overflows in a Representative Year GMs

The daily GMs for each location are plotted in Figures 10-34 to 10-37 for Main Street Bridge (Bridge Street on the Assiniboine River), Norwood Bridge (Upper Red River), Redwood Bridge (Lower Red River), and Parkdale (Lower Red River) respectively.

The daily GM plots indicate modelled densities as high as 80,000 MPN/100 mL at the Main Street Bridge location showing the impacts of the remaining wet weather inputs (CSO and LDS) into the Assiniboine River on water quality. The peak day GMs at the Norwood Bridge are lower reaching about 10,000 MPN/100 mL. This shows the influence of the lower volume of CSO and SRS inputs in this reach of the Upper Red River coupled with the higher river flows (greater dilution). The densities at the Redwood Bridge location are similar to those at the Main Street Bridge. This is a location downstream of the confluence and shows the influence of conditions in both rivers. The Parkdale location indicates peak densities of about 10,000 MPN/100 mL.

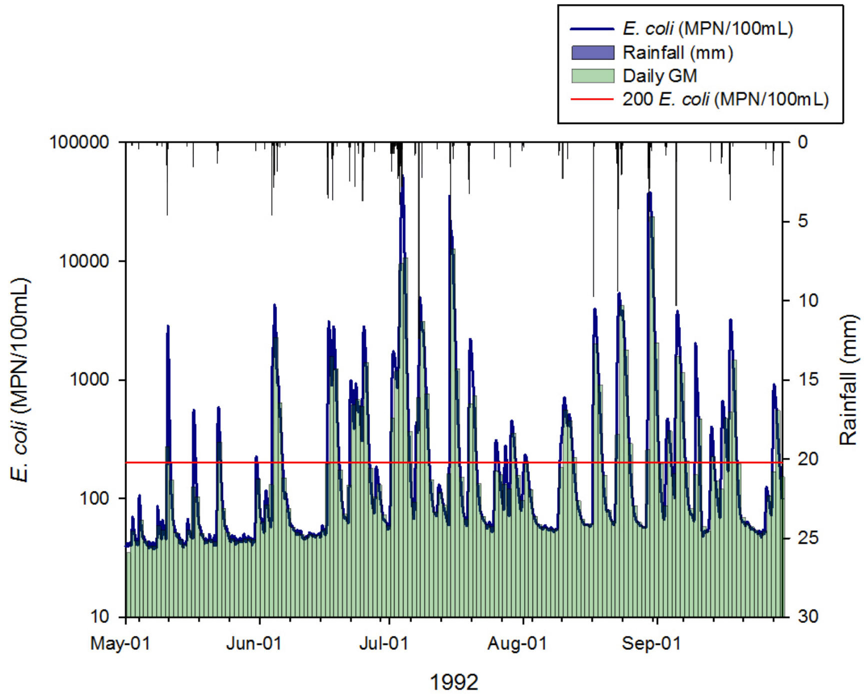

Figure 10-34. Main Street Bridge E. coli Densities for Four Overflows

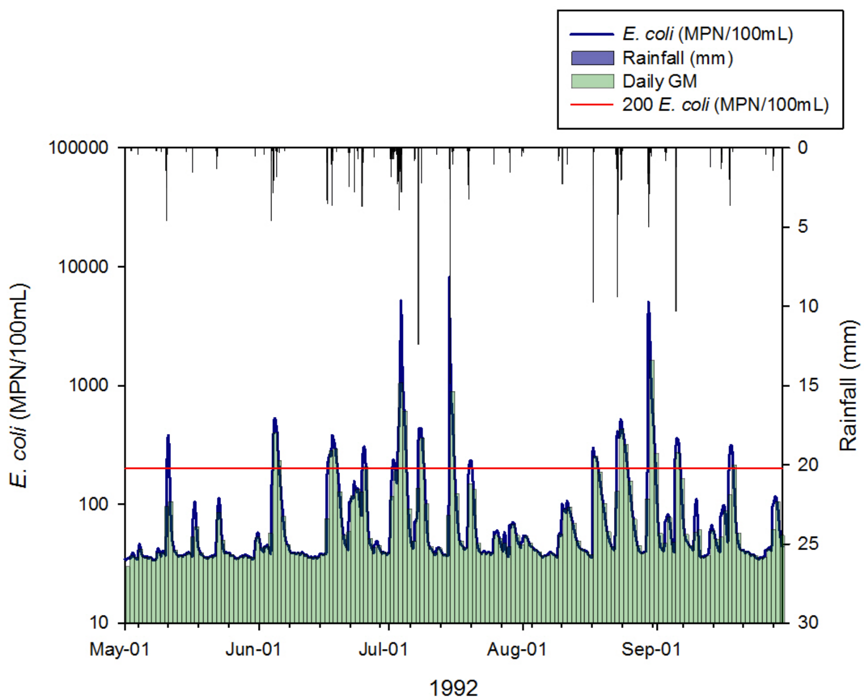

Figure 10-35. Norwood Bridge E. coli Densities for Four Overflows

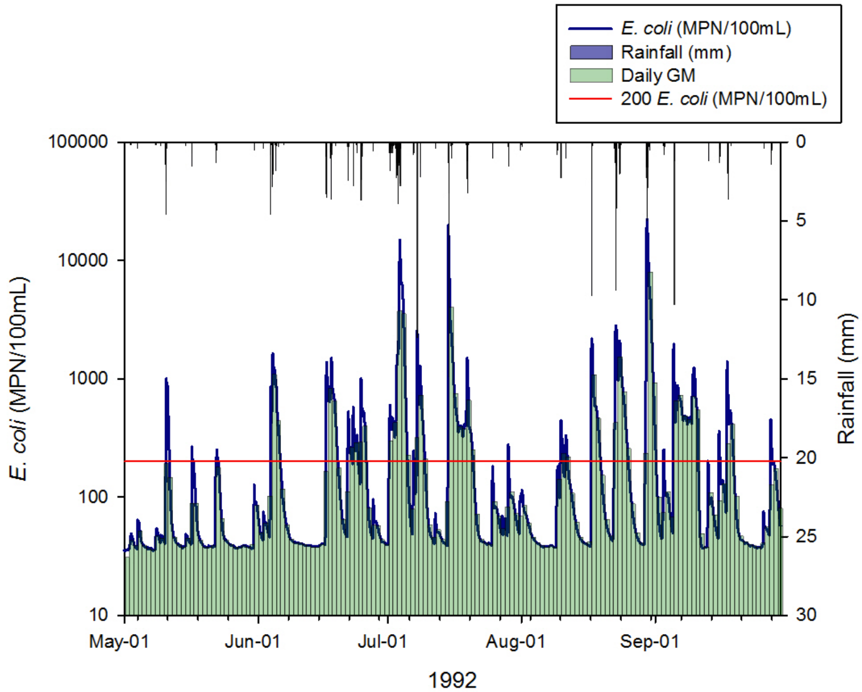

Figure 10-36. Redwood Bridge E. coli Densities for Four Overflows

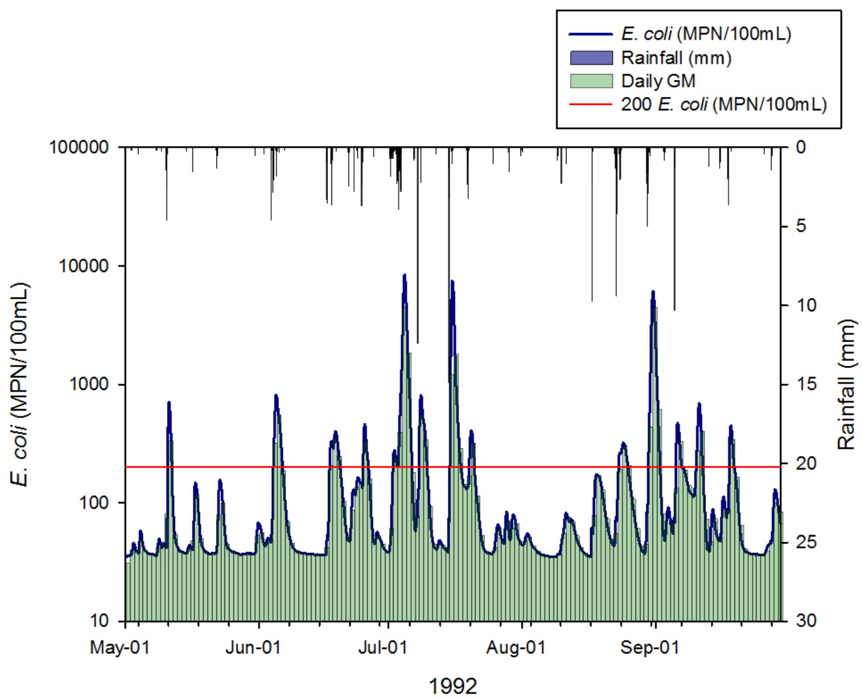

Figure 10-37. Parkdale E. coli Densities for Four Overflows

The monthly average GMs and overall recreation season GM calculated from the arithmetic mean of the daily GMs are summarized for all four locations in Table 10-28. The average densities shown are indicative of monthly conditions and are not direct indicators of available recreation opportunities. Individual day GMs vary up and down from the averages shown. The averages do however provide another metric that can be used to compare the performance of the five alternatives.

Table 10-28. Monthly Average *E. coli* Density for Four Overflows

Period	Monthly Average *E. coli* Density (MPN/100 mL)			
	Lower Red River [a]		Upper Red River [b]	Assiniboine River [c]
	Parkdale	Redwood Bridge	Norwood Bridge	Main Street Bridge
May	57	59	45	74
June	121	192	97	369
July	420	550	157	1442
August	231	497	151	1248
September	133	203	72	312
Total Recreation Season	**194**	**302**	**105**	**696**

Notes:
[a] Below confluence with Assiniboine River
[b] Above confluence with Assiniboine River
[c] Above confluence with Red River

Table 10-29 examines the number of days of non-compliance in each month at each location. The total recreation season is 5 months or 153 days in length.

Table 10-29. Recreation Season Days of Non-Compliance for Four Overflows

Period	Days of Non-compliance			
	Lower Red River [a]		Upper Red River [b]	Assiniboine River [c]
	Parkdale	Redwood Bridge	Norwood Bridge	Main Street Bridge
May	1	0	0	2
June	6	8	5	8
July	10	14	4	13
August	4	11	5	13
September	5	8	2	10
Total Recreation Season	**26**	**41**	**16**	**46**
Percentage Days Non-compliance	**17%**	**27%**	**11%**	**30%**

Notes:
[a] Below confluence with Assiniboine River
[b] Above confluence with Assiniboine River
[c] Above confluence with Red River

The Redwood Bridge location on the Lower Red River has the highest number of non-compliant days followed closely by the Parkdale location also on the Lower Red River and the Main Street Bridge location on the Assiniboine River. The Norwood Bridge location on the Upper Red River has the least number of non-complaint days.

10.9 Zero Overflows in a Representative Year

The purpose of this section is to examine the water quality benefits of the Zero Overflows in a representative year alternative. The Zero Overflows alternative includes the separation of ten districts, latent storage in SRS pipes of 10 districts, offline storage in 22 districts and tunnel storage in 36 districts. The NEWPPC facility has an increased capacity of 825 ML/d. Section 8.2.4 of this report presents details of the Zero Overflows alternative.

10.9.1 CSO Volume and Frequency

The CSO volume and frequency is zero for the representative year.

10.9.2 Zero Overflows in a Representative Year GMs

The daily GMs for each location are plotted in Figures 10-38 to 10-41 for Main Street Bridge (Bridge Street on the Assiniboine River), Norwood Bridge (Upper Red River), Redwood Bridge (Lower Red River), and Parkdale (Lower Red River) respectively.

In all cases the modelled densities are the result of LDS discharges and base stream flows since there is no CSO discharged during the representative year.

The daily GM plots indicate modelled densities as high as 10,000 MPN/100 mL at the Main Street Bridge location showing the impacts of the remaining wet weather input –LDS on the Assiniboine River water quality. The peak GMs at the Norwood Bridge are lower reaching about 1,000 MPN/100 mL. The densities at the Redwood Bridge location are similar to those at the Main Street Bridge. This is a location downstream of the confluence and shows the influence of conditions in both rivers. The Parkdale location indicates peak densities of about 1,000 MPN/100 mL.

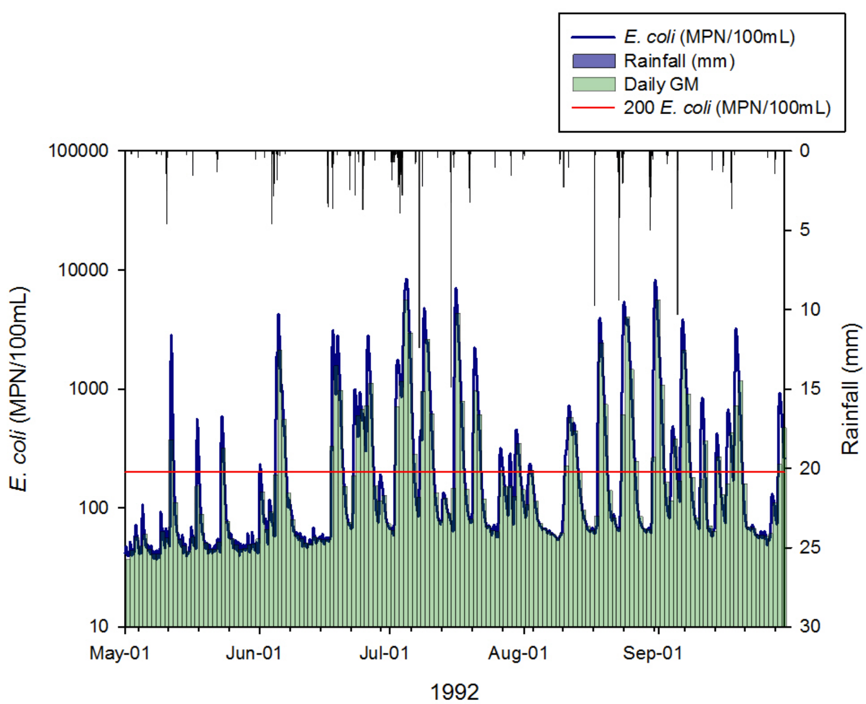

Figure 10-38. Main Street Bridge E. coli Densities for Zero Overflows

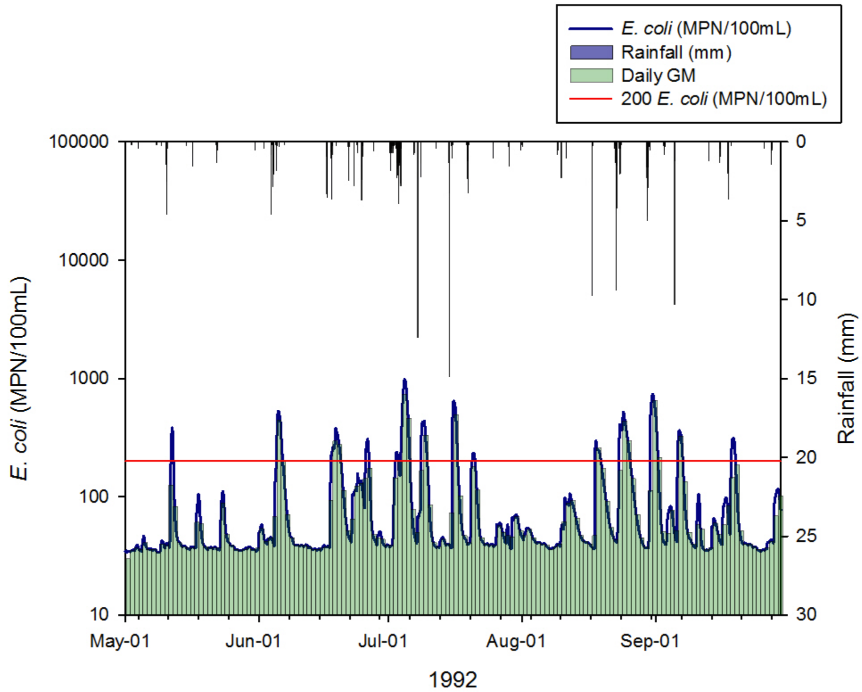

Figure 10-39. Norwood Bridge E. coli Densities for Zero Overflows

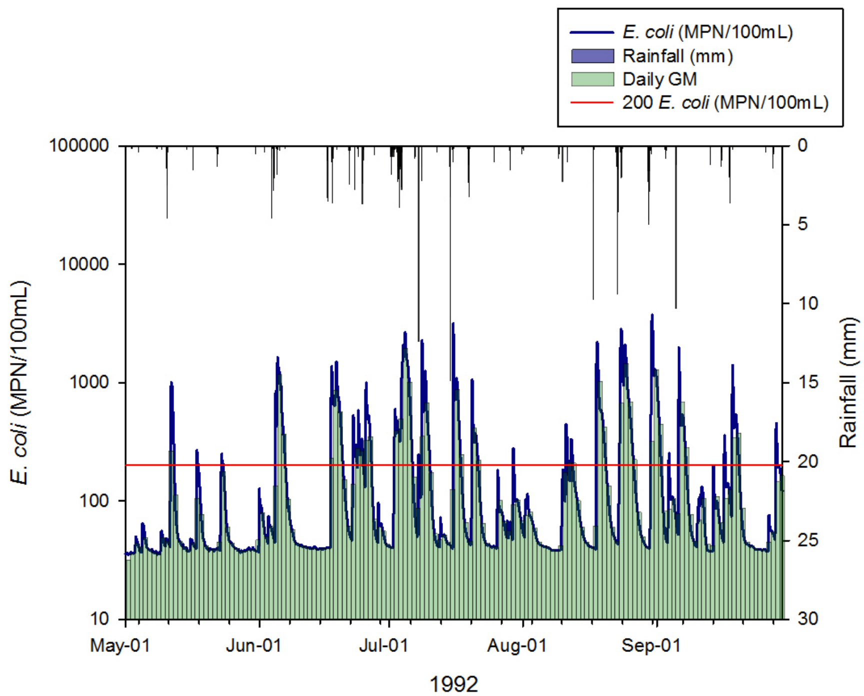

Figure 10-40. Redwood Bridge E. coli Densities for Zero Overflows

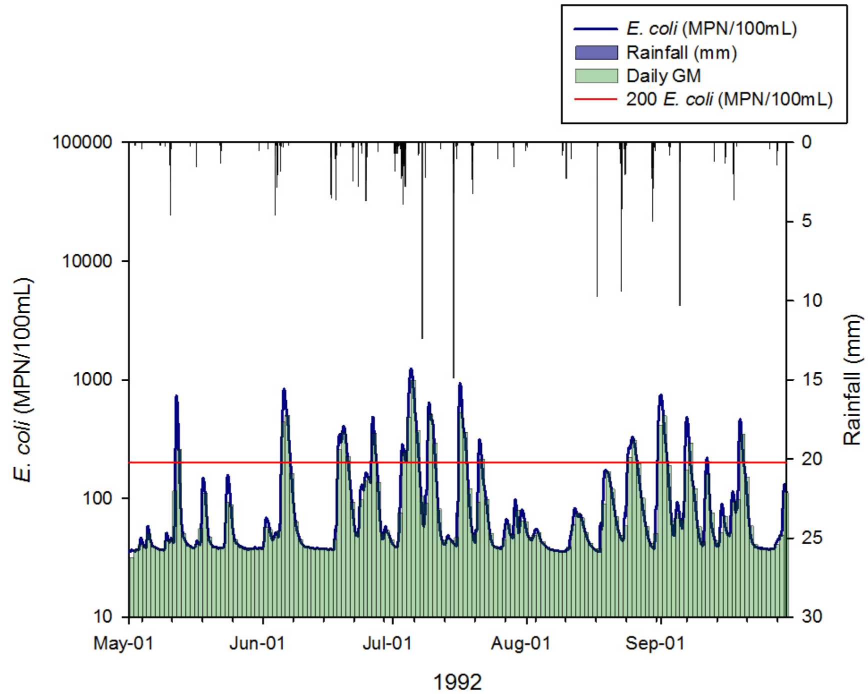

Figure 10-41. Parkdale E. coli Densities for Zero Overflows

The monthly average GMs and overall recreation season GM calculated from the arithmetic mean of the daily GMs are summarized for all four locations in Table 10-30. The average densities shown are indicative of monthly conditions and are not direct indicators of available recreation opportunities. Individual day GMs vary up and down from the averages shown. The averages do however provide another metric that can be used to compare the performance of the five alternatives.

Table 10-30. Monthly Average *E. coli* Density for Zero Overflows

Period	**Monthly Average *E. coli* Density (MPN/100 mL)**			
	Lower Red River [a]		**Upper Red River [b]**	**Assiniboine River [c]**
	Parkdale	**Redwood Bridge**	**Norwood Bridge**	**Main Street Bridge**
May	58	59	45	77
June	123	192	97	373
July	175	267	129	770
August	101	273	118	641
September	97	124	72	316
Total Recreation Season	111	184	92	437

Notes:
[a] Below confluence with Assiniboine River
[b] Above confluence with Assiniboine River
[c] Above confluence with Red River

Table 10-31 examines the number of days of non-compliance in each month at each location. The total recreation season is 5 months or 153 days in length.

Table 10-31. Days of Non-compliance for Zero Overflows

Period	Days of Non-Compliance			
	Lower Red River [a]		Upper Red River [b]	Assiniboine River [c]
	Parkdale	Redwood Bridge	Norwood Bridge	Main Street Bridge
May	1	0	0	2
June	6	8	5	9
July	9	12	4	13
August	4	10	5	12
September	3	4	2	10
Total Recreation Season	**23**	**34**	**16**	**46**
Percentage Days Non-compliance	15%	22%	10%	30%

Notes:
[a] Below confluence with Assiniboine River
[b] Above confluence with Assiniboine River
[c] Above confluence with Red River

The Main Street Bridge location on the Assiniboine River has the highest number of non-compliant days followed closely by the Redwood Bridge location on the Lower Red River. The Norwood Bridge location on the Upper Red River has the least number of non-complaint days.

10.10 No More Than Four Overflows per Year

The No More Than Four Overflows per year control limit was originally intended to be dealt with as a potential plan variant, but was later added as a core control limit after discussions with the Regulatory Working Committee. The No More Than Four Overflows alternative includes the separation of ten districts, latent storage in SRS pipes of 10 districts, tunnel storage in 10 districts and a new satellite treatment of 1,000mL/d capacity. Two potential locations for the satellite treatment facility were examined - near NEWPECC and in the Mission district. Analysis of the water quality impacts showed that there was negligible difference in compliance outcomes between the two locations and hence only the analysis of the near NEWPECC satellite facility is presented in this section. The NEWPPC facility remains at 705ML/d capacity. The details of this alternative were presented in Section 8.2.5.

10.10.1 CSO Volume and Frequency

The CSO volume and frequency is zero for the representative year.

10.10.2 No More Than Four Overflows in a Representative Year GMs

The daily GMs for each location are plotted in Figures 10-42 to 10-45 for Main Street Bridge (Bridge Street on the Assiniboine River), Norwood Bridge (Upper Red River), Redwood Bridge (Lower Red River) and Parkdale (Lower Red River) respectively.

The daily GM plots indicate modelled densities nearly 10,000 MPN/100 mL at the Main Street Bridge location showing the impacts of the LDS inputs into the Assiniboine River on water quality. The peak day GMs at the Norwood Bridge are about an order of magnitude lower reaching about 1,000 MPN/100 mL. This shows the influence of the lower volume of LDS inputs in this reach of the Upper Red River coupled with the higher river flows (greater dilution). The densities at the Redwood Bridge location are somewhat lower (~5,000 MPN/100mL) at the Main Street Bridge. This is a location downstream of the confluence and shows the influence of conditions in both rivers. The Parkdale location indicates peak densities of about 1,000 MPN/100 mL.

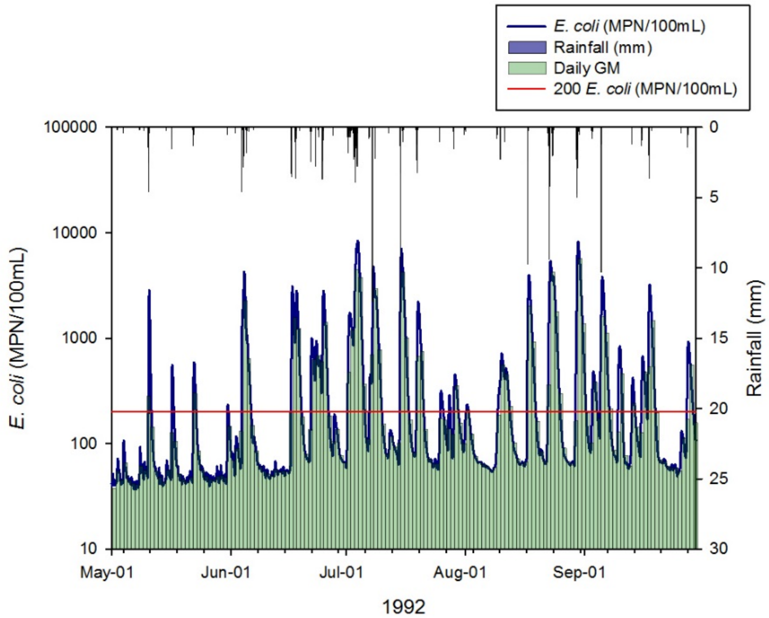

Figure 10-42. Main Street Bridge E. coli Densities for No More Than Four Overflows

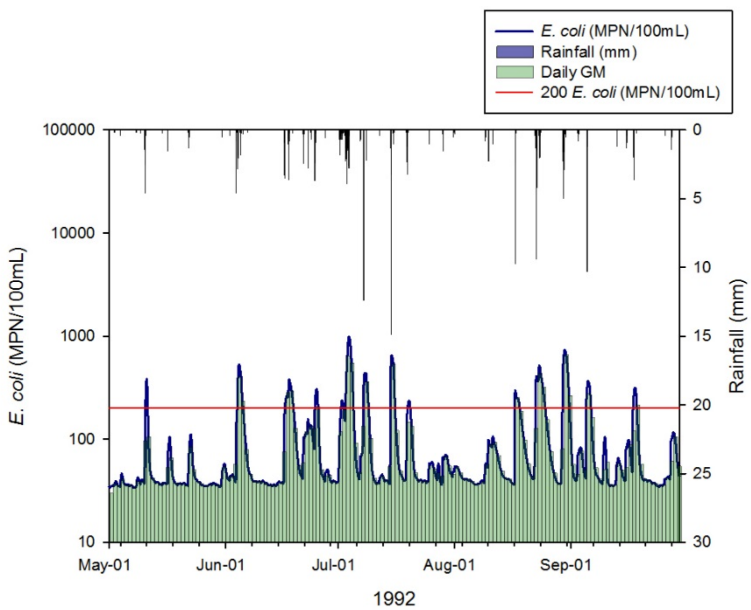

Figure 10-43. Norwood Bridge E. coli Densities for No More Than Four Overflows

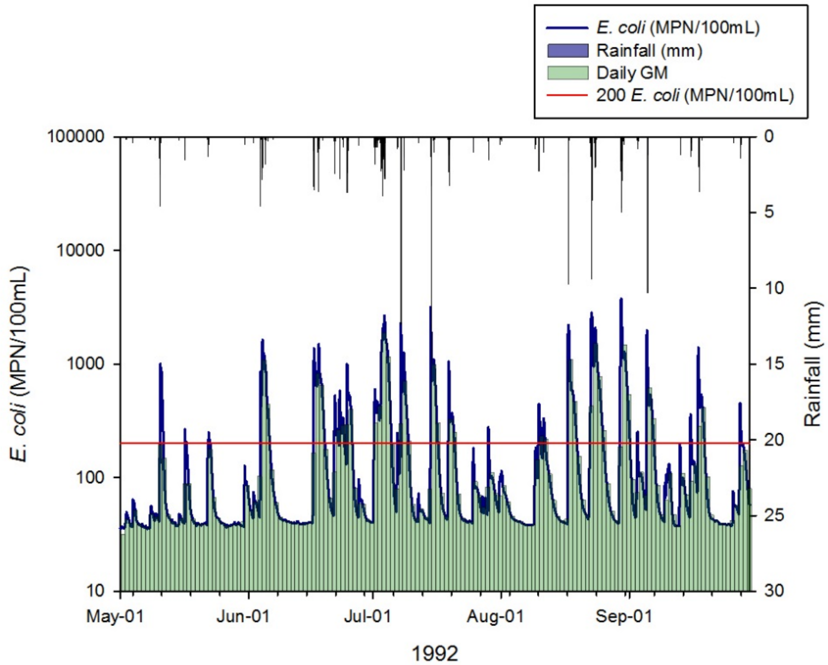

Figure 10-44. Redwood Bridge E. coli Densities for No More Than Four Overflows

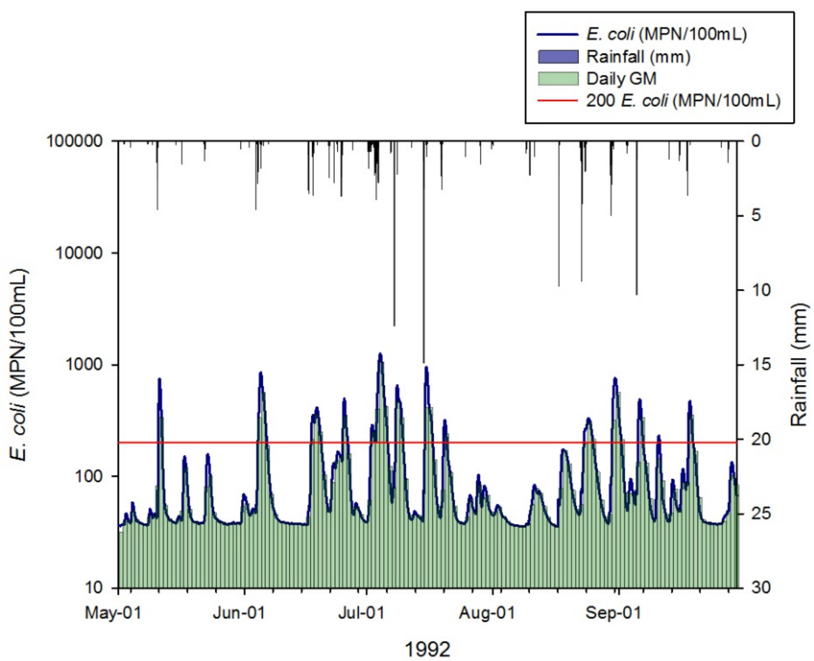

Figure 10-45. Parkdale E. coli Densities for No More Than Four Overflows

The monthly average GMs and overall recreation season GM calculated from the arithmetic mean of the daily GMs are summarized for all four locations in Table 10-32. The average densities shown are indicative of monthly conditions and are not direct indicators of available recreation opportunities. Individual day GMs vary up and down from the averages shown. The averages do however provide another metric that can be used to compare the performance of the five alternatives.

Table 10-32. Monthly Average *E. coli* Density for No More Than Four Overflows

Period	Monthly Average *E. coli* Density (MPN/100 mL)			
	Lower Red River [a]		Upper Red River [b]	Assiniboine River [c]
	Parkdale	Redwood Bridge	Norwood Bridge	Main Street Bridge
May	59	59	45	77
June	124	192	97	373
July	177	267	129	770
August	102	273	118	641
September	98	124	72	316
Total Recreation Season	**112**	**184**	**92**	**437**

Notes:
[a] Below confluence with Assiniboine River
[b] Above confluence with Assiniboine River
[c] Above confluence with Red River

Table 10-33 examines the number of days of non-compliance in each month at each location. The total recreation season is 5 months or 153 days in length.

Table 10-33. Days of Non-compliance for No More Than Four Overflows

Period	Days of Non-Compliance			
	Lower Red River [a]		Upper Red River [b]	Assiniboine River [c]
	Parkdale	Redwood Bridge	Norwood Bridge	Main Street Bridge
May	1	0	0	2
June	6	8	5	9
July	9	12	4	13
August	4	10	5	12
September	3	4	2	10
Total Recreation Season	**23**	**34**	**16**	**46**
Percentage Days Non-compliance	15%	22%	11%	30%

Notes:
[a] Below confluence with Assiniboine River
[b] Above confluence with Assiniboine River
[c] Above confluence with Red River

The Main Street Bridge location on the Assiniboine River has the highest number of non-compliant days followed closely by the Redwood Bridge location on the Lower Red River and the Parkdale location also on the Lower Red River. The Norwood Bridge location on the Upper Red River has the least number of non-complaint days.

10.11 Complete Sewer Separation

The purpose of this section is to examine the water quality benefits of controlling the CSO discharges by Compete Separation. This alternative includes the separation of all 43 combined districts and the NEWPCC facility at a capacity of 705ML/d. Section 8.2.6 of this report presents details of Complete Separation.

10.11.1 CSO Volume and Frequency

The CSO volume and frequency is zero for the representative year.

10.11.2 Complete Separation GMs

The daily GMs for each location are plotted in Figures 10-46 to 10-49 for Main Street Bridge (Assiniboine River), Norwood Bridge (Upper Red River), Redwood Bridge (Lower Red River), and Parkdale (Lower Red River) respectively.

In all cases the modelled densities are the result of LDS discharges and base stream flows since there is no CSO discharged during the representative year.

The daily GM plots indicate modelled densities as high as 10,000 MPN/100 mL at the Main Street Bridge location showing the impacts of the remaining wet weather inputs (CSO and LDS) into the Assiniboine River on water quality. The peak day GMs at the Norwood Bridge are lower reaching about 1,000 MPN/100 mL. The densities at the Redwood Bridge location are similar to those at the Main Street Bridge. This is a location downstream of the confluence and shows the influence of conditions in both rivers. The Parkdale location indicates peak densities of about 1,000 MPN/100 mL.

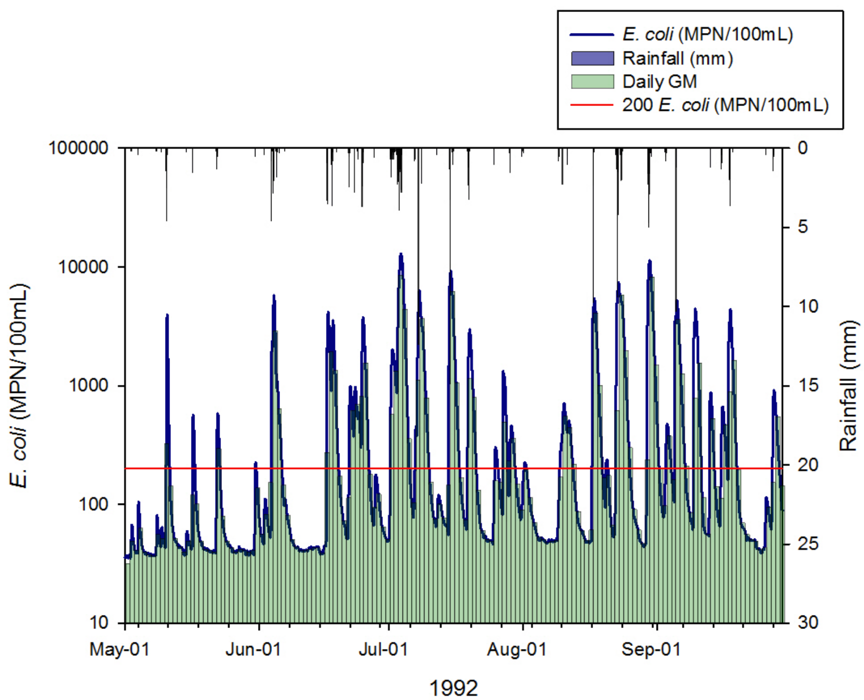

Figure 10-46. Main Street Bridge E. coli Densities for Complete Separation

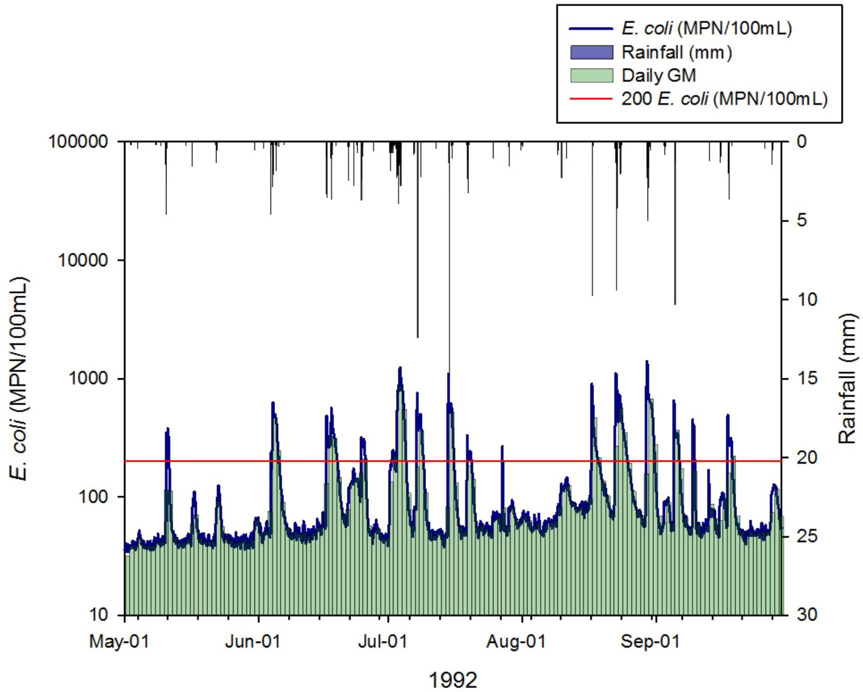

Figure 10-47. Norwood Bridge E. coli Densities for Complete Separation

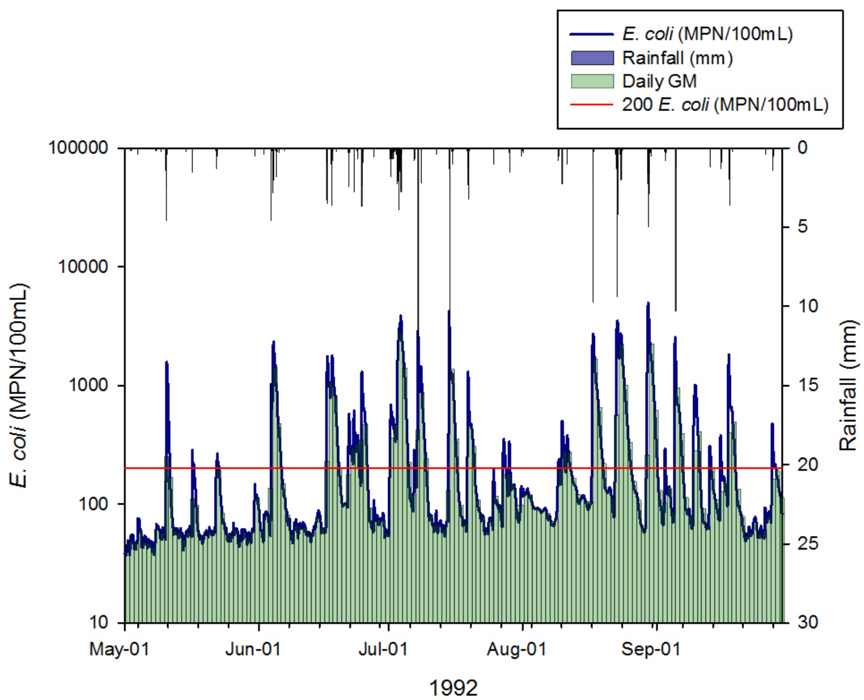

Figure 10-48. Redwood Bridge E. coli Densities for Complete Separation

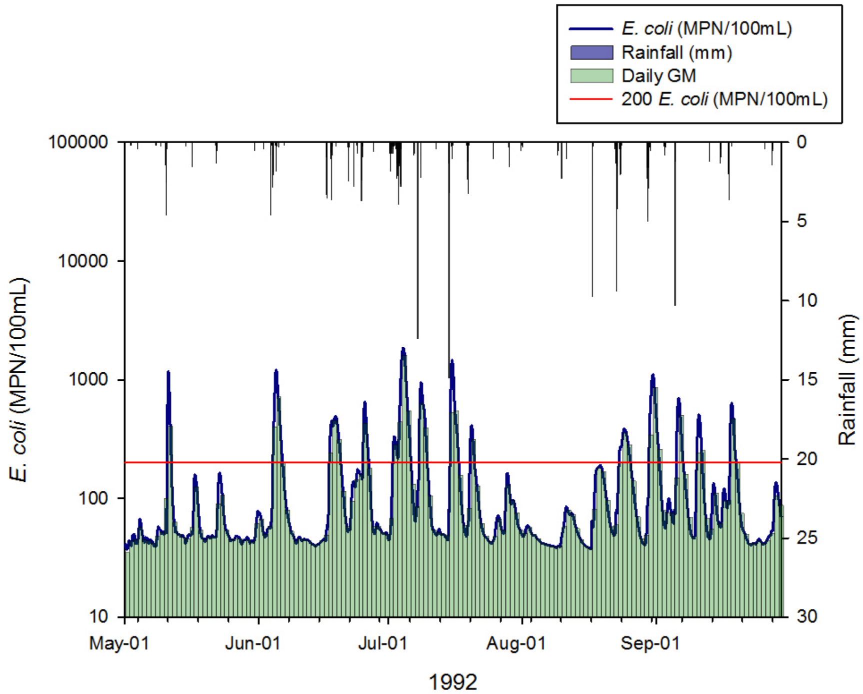

Figure 10-49. Parkdale E. coli Densities for Complete Separation

The monthly average GMs and overall recreation season GM calculated from the arithmetic mean of the daily GMs are summarized for all four locations in Table 10-34. The average densities shown are indicative of monthly conditions and are not direct indicators of available recreation opportunities. Individual day GMs vary up and down from the averages shown. The averages do however provide another metric that can be used to compare the performance of the five alternatives.

Table 10-34. Monthly Average *E. coli* Density for Complete Separation

Period	Monthly Average *E. coli* Density (MPN/100 mL)			
	Lower Red River [a]		Upper Red River [b]	Assiniboine River [c]
	Parkdale	Redwood Bridge	Norwood Bridge	Main Street Bridge
May	67	74	51	73
June	147	244	114	418
July	225	360	150	1,064
August	122	402	161	862
September	126	186	92	475
Total Recreation Season	**137**	**254**	**114**	**581**

Notes:
[a] Below confluence with Assiniboine River
[b] Above confluence with Assiniboine River
[c] Above confluence with Red River

Table 10-35 examines the number of days of non-compliance in each month at each location. The total recreation season is 5 months or 153 days in length.

Table 10-35. Days of Non-compliance for Complete Separation

Period	Days of Non-compliance			
	Lower Red River [a]		Upper Red River [b]	Assiniboine River [c]
	Parkdale	Redwood Bridge	Norwood Bridge	Main Street Bridge
May	1	1	0	2
June	7	10	5	9
July	9	12	5	15
August	4	12	7	12
September	5	7	2	12
Total Recreation Season	**26**	**42**	**19**	**50**
Percentage Days Non-compliance	17%	28%	13%	33%

Notes:
[a] Below confluence with Assiniboine River
[b] Above confluence with Assiniboine River
[c] Above confluence with Red River

The Main Street Bridge location on the Assiniboine River has the highest number of non-compliant days followed closely by the Redwood Bridge location on the Lower Red River. The Norwood Bridge location on the Upper Red River has the least number of non-complaint days.

10.12 Loadings Assessment

The loadings assessment examined the distribution of annual discharge volumes and Total P and Total N loads by source. This assessment provided an estimate of the loads exported from Winnipeg. There are in-stream transformations because of a number of factors between the City and Lake Winnipeg that will reduce the total nutrient loadings that ultimately reach Lake Winnipeg; however, the assessment of the impact of these factors is beyond the scope of the current undertaking.

10.12.1 Information Sources and Applied EMCs

EMCs were collected and updated from a number of sources. The data collected for the master plan water quality monitoring program as described in Appendix B was used to update a number of the EMC values. TP and TP values for the STPs was based on future licenceing requirements for plant effluent. TP for satellite treatment was set based on EA No. 3042. A summary of information sources for the loadings assessment is provided in Table 10-36, while applied EMCs are summarized in Table 10-37.

Table 10-36. Loading Information Sources

Variable	Location	Source
Flow	Boundary	• Water Survey of Canada flow records for the Assiniboine River and Headingley and the Red River at St. Agatha.
	LDS and Tributary	• Water Survey of Canada flow records in combination with City InfoWorks model results.
	STP, CSO, SRS	• City InfoWorks Regional collection system model
Total P and Total N	Boundary	• City 2002-2013 river monitoring program
	Tributary	• City small stream dry-weather monitoring program (May and June 2015)
	STP	• STP Effluent Limits (Licence)
	Satellite Treatment	• EA NO. 3042 Effluent Limit (Total P only); Total N assumed equal to CSO
	CSO and SRS	• City CSO monitoring result (May and June 2015)
	LDS	• Literature values for untreated stormwater (US EPA NOAA Undersea Research Program Data)
	Red River and Lake Winnipeg [a]	• A Preliminary Estimate Of Total Nitrogen and Total Phosphorus Loading To Streams In Manitoba, Canada (MCWS, 2002)

Table 10-37. Loading EMC Summary

Water Quality Parameter	Loading Source	EMC
Total P	Boundary	0.34 mg/L Assiniboine River 0.32 mg/L Red River
	Tributary	0.21 mg/L
	STP	1.0 mg/L
	Satellite Treatment	1.0 mg/L
	CSO and SRS	3.1 mg/L
	LDS	0.25 mg/L
	TOTAL ANNUAL LAKE LOADING [a]	**5,838,000 kg**
Total N	Boundary	1.7 mg/L Assiniboine River 1.1 mg/L Red River
	Tributary	1.1 mg/L
	STP	15.0 mg/L
	Satellite Treatment	17.8 mg/L
	CSO and SRS	17.8 mg/L
	LDS	2.0 mg/L
	TOTAL ANNUAL LAKE LOADING [a]	**63,207,000 kg**

Note:
[a] Total annual Lake Winnipeg loading (MCWS, 2002)

10.12.2 Volumetric Discharge

The annual volume discharge for boundary and tributary flows as well as STP, CSO, and LDS flows are presented in Table 10-38. The volumes were obtained from the input flow time series and were applied as input to both the WASP7.5 and the spreadsheet loading models.

Approximately 98 percent of the total river discharge passing through Winnipeg originates outside the City boundaries as boundary inflow from the upstream portions of the Red River, the Assiniboine River and the flow in the minor tributaries. The boundary and tributary flow total 5,274 million m^3/year. The remaining 3 percent of the volume originates within the City as a mix of wastewater treated effluent, CSO, and LDS, some of which is treated through basins. The total City volumetric contribution is 133.4 million m^3/year.

Table 10-38. Annual Volume Distribution

Source	Annual Volume – million m^3 / year
Red River Upstream Boundary	4,134
Assiniboine River Upstream Boundary	1,063
Minor Tributaries	77
Total Boundary and Tributaries	**5,274**
STP	115
Satellite Treatment	10.4
LDS	13
LDS Pond	0.4
CSO	5
Total City	**133.4**
Overall Total	**5,407.4**

10.12.3 Total Phosphorus Loadings

Annual TP loadings for baseline conditions and each modelled alternative is provided in Table 10-39. All sources, including boundary and tributary flows as well as STP, CSO, and LDS flows are presented. Table 10-40 presents relative source T P annual loads as a percentage of City loads, as well as a Lake Winnipeg loads based on the 2002 Manitoba Environment loading data. As shown, TP CSO loads progressively decrease as the level of control increases from scenario to scenario. As expected, TP CSO loads fall to zero for the zero overflow and total separation scenarios, and there is a corresponding increase in LDS TP loads.

The relative contribution of CSO to total City Total P loading drops from a baseline of over 11 percent to less than 1 percent for Four Overflows. For all the alternatives including baseline, City CSO Total P loads to Lake Winnipeg are marginal.

Table 10-39. Total P Loading Summary (Total Annual)

Source	Annual Loading (kg/year)						
	Baseline (2013)	Current Program	85% Capture	Four Overflows	Zero Overflows	No More Than Four Overflows	Complete Separation
Boundary	1,662,851	1,662,851	1,662,851	1,662,851	1,662,851	1,662,851	1,662,851
LDS	1,355	2,169	2,281	2,169	2,281	2,281	4,842
Tributaries	15,815	15,815	15,815	15,815	15,815	15,815	15,815
Pond	48	48	48	48	48	48	48
CSO/SRS	15,000	14,142	8,459	1,442	0	0	0
STP	115,224	146,166	148,080	150,400	150,168	139,863	142,695
Satellite Treatment	0	0	0	0	0	10,377	0

Table 10-40. Relative CSO Total P Loading Summary (Total Annual)

	Relative Annual Loading as a Percentage Total (Excluding Boundary Loads)						
	Baseline (2013)	Current Program	85% Capture	Four Overflows	Zero Overflows	No More Than Four Overflows	Complete Separation
CSO as % of City Total	11.40%	8.70%	5.17%	0.96%	0.00%	0.00%	0.00%
CSO as % of Red River Total[a]	0.31%	0.29%	0.17%	0.03%	0.00%	0.00%	0.00%
CSO as % of Lake Winnipeg Total[b]	0.26%	0.24%	0.14%	0.02%	0.00%	0.00%	0.00%

Note:
[a] Compared to total annual Red River loading of 4,905,000 kg/year at Selkirk Manitoba, MCWS 2002
[b] Compared to total annual Lake Winnipeg loading of 5,838,000 kg/year, MCWS 2002

10.12.4 Total Nitrogen Loadings

Annual TN loading summary for baseline conditions and each alternative, is provided in Table 10-41. All sources, including boundary and tributary flows as well as STP, CSO, and LDS flows are presented. Table 10-42 presents relative source Total N annual loads as a percentage of City loads, as well as a Lake Winnipeg loads based on the 2002 Manitoba Environment loading data. As shown, TN CSO loads progressively decrease as the level of control increases from scenario to scenario. As expected, TN CSO loads fall to zero for the Zero Overflows, No More Than Four Overflows, and Complete Sewer Separation scenarios, and there is a corresponding increase in LDS TN loads.

The relative contribution of CSO to total city TN loading drops from a baseline of approximately 4.7 percent to about 0.03 percent for the four overflow scenario. For all scenarios including baseline, City CSO TN loads to Lake Winnipeg are marginal.

Table 10-41. Total N Loading Summary (Total Annual)

Source	Annual Loading (kg/year)						
	Baseline	Current Program	85% Capture	Four Overflows	Zero Overflows	No More Than Four Overflows	Complete Separation
Boundary	5,716,051	5,716,051	5,716,051	5,716,051	5,716,051	5,716,051	5,716,051
LDS	10,843	17,355	18,247	17,355	18,247	18,247	38,736
Tributaries	82,133	82,133	82,133	82,133	82,133	82,133	82,133
Pond	380	380	380	380	380	380	380
CSO/SRS	86,128	81,205	48,571	8,282	0	0	0
STP	1,728,356	2,192,495	2,221,200	2,256,000	2,252,520	2,097,951	2,140,429
Satellite Treatment	0	0	0	0	0	184,717	0

Table 10-42. Relative CSO Total N Loading Summary (Total Annual)

	Relative Annual Loading as a Percentage Total (Excluding Boundary Loads)						
	Baseline (2013)	Current Program	85% Capture	Four Overflows	Zero Overflows	No More Than Four Overflows	Complete Separation
CSO as % of City Total	4.72%	3.54%	2.06%	0.37%	0.00%	0.00%	0.00%
CSO as % of Red River Total[a]	0.26%	0.25%	0.15%	0.03%	0.00%	0.00%	0.00%
CSO as % of Lake Winnipeg Total[b]	0.14%	0.13%	0.08%	0.01%	0.00%	0.00%	0.00%

Note:
[a] Compared to total annual Red River loading of 32,765,000 kg/year at Selkirk Manitoba, MCWS 2002
[b] Compared to total annual Lake Winnipeg loading of 63,207,000 kg/year , MCWS 2002

10.13 Comparative Assessment of Alternatives

The results of the bacteria assessment were summarized for the six alternative strategies plus the Baseline. The number of days of non-compliance with *E. coli* objectives during the May to September recreation season was used as the metric to compare strategies. Table 10.43 presents the summary.

Table 10-43. Days of Non-compliance for Complete Separation

Period	Days of Non-compliance			
	Lower Red River [a]		Upper Red River [b]	Assiniboine River [c]
	Parkdale	Redwood Bridge	Norwood Bridge	Main Street Bridge
Baseline	44	44	30	52
Current Program	43	44	28	55
85% Capture in a Representative Year	40	44	28	55
Four Overflows in a Representative Year	26	41	16	46
Zero Overflows in a Representative Year	23	34	16	46
No More Than Four Overflows	23	34	16	46
Complete Sewer Separation	26	42	19	50

Notes:
[a] Below confluence with Assiniboine River
[b] Above confluence with Assiniboine River
[c] Above confluence with Red River

The Main Street Bridge is the most downstream location on the Assiniboine River and shows the influence of all the upstream CSO and LDS discharges. During the recreation season the backwater created at the Lockport Dam influences the Assiniboine River at this location resulting in longer residence times. The results indicate that the Current Program and 85% Capture alternatives show a slight increase in the number of days of non-compliance when compared to the Baseline. In both cases there are separation projects in four districts that will discharge new LDS to the Assiniboine River Separation generates new untreated stormwater discharges from virtually every rainfall, which has relatively high bacteria density (40,000 MPN/100/mL). The results for the Four Overflows, Zero Overflows and No More Than Four Overflows alternatives are the same representing the impact of separation in five districts as well as combinations of storage and treatment. The Complete Separation alternative includes separation in all Assiniboine CSO districts and shows the impact of the new LDS.

The Redwood Bridge is located on the Upper Red River above the confluence with the Assiniboine River. It incorporates all the CSO and LDS discharges in the upper part of the Red River. There is only one district proposed for separation under the Current Program, 85% Capture, Four Overflows, Zero Overflows and No More Than Four Overflows alternatives so the amount of new LDS would be limited. The results show improvement in days of non-compliance with alternatives providing a higher degree of CSO control with the exception of Complete Separation.

The Norwood Bridge is located on the Lower Red River below the confluence with the Assiniboine River. It incorporates all the CSO and LDS discharges in the upper part of the Red River and the Assiniboine River. The results show improvement in days of non-compliance with alternatives providing a higher degree of CSO control with the exception of Complete Separation.

Parkdale is the most downstream location on the Red River and shows the influence of all the inputs discharging into the Red and Assiniboine Rivers. The results show improvement in days of non-compliance with alternatives providing a higher degree of CSO control with the exception of Complete Separation.

10.14 Comparison of 2015 and 2002 CSO Study EMCs

An assessment of POCs was completed in an early phase of the 2002 CSO Study. This previous investigation addressed DO, fecal coliforms, nutrients, ammonia, heavy metals and pesticides. Based on these analyses, fecal coliform was identified as the sole POC from the standpoint of managing CSO discharges. Since this time the focus has been on nutrient loading to Lake Winnipeg. As such the 2015 water quality assessment has focused on TP, TN and bacteria. Table 10-44 shows a comparison of these three POCs.

Table 10-44: EMC values for select Pollutants of Concern

Parameter	Unit	2002 CSO Study EMC[1]	2015 Master Plan EMC[2]
Bacteria[3]	MPN/100 mL	2.4×10^6	1.5×10^6
Total Phosphorus	mg/L	3.0	3.1
Total Nitrogen	mg/L	15.0	17.8

Notes:
1. Source CSO Management Study, Phase 1, TM 1, Table 2-8
2. Based on 2014 / 2015 Water Quality Monitoring Program data up to June 2015
3. 2002 value is fecal coliforms and 2015 value is *E. coli*

The POCs shown for 2015 are representative of the values used in the water quality model. Further sample data collected from the water quality monitoring completed after June 2015 showed similar results. The average value for both TP and TN dropped to 2.0 mg/L with a range between 0.3 mg/L to 14.5 mg/L and 11.9 mg/L with a between 0.9 mg/L and 76.3 mg/L respectively. The final average value for *E. coli* bacteria was 2.0×10^6 MPN/100 mL, the range for E.coli was between less than 10,000 MPN/100 mL to over 15.0×10^6 MPN/100 mL. This data is presented as part of Appendix B, but was not used in the water quality modelling or loading assessment presented in this report, due to time constraints. The range of data reported highlights the variability of the POCs discharged through CSOs.

The contribution of TP and TN loads from the City is trending lower with upgraded treatment at the STPs, increased environmental awareness of the general public, nutrient reduction initiatives by the City and Province and an overall increase of loading from sources beyond the City boundaries. Bacteria from CSO discharges is shown to be highly variable and can vary significantly for each overflow and for each runoff event.

10.15 *E. coli* Decay in the Red River

In order to further explore potential water quality impacts on Lake Winnipeg estimated residual bacteria from the study area reaching the entrance to the Lake was evaluated. The WASP7.5 model was used to predict peak *E. coli* densities at Lockport (the most downstream location modelled) during any hour of the recreation season. Based on the monthly average stream velocities and travel times to Lake Winnipeg the approximate decay in bacteria densities and resulting densities at the Lake mouth were then calculated. The results of the analysis showed peak summer time *E. coli* densities of about 1,000 to 10,000 MPN/100 mL at Lockport. Using a typical summer travel time of 2.5 days yields about an order of magnitude decay resulting in densities of about 100 to 1,000 MPN /100 mL at the mouth of Lake Winnipeg. These results are considered very conservative in that they do not account for any in-stream dispersion or any other influencing factors. The WASP7.5 model would need to be extended to the mouth of Lake Winnipeg to properly account for stream hydrodynamics as well as other bacteria sources and sinks.

Notwithstanding the limitations of this simple “first-cut” analysis, it shows that the City bacteria discharges are likely not a major influence on bacterial water quality at the mouth of Lake Winnipeg.

Watershed Approach

The watershed approach may be considered an extenstion to the potential plans since it adapts any of the CSO alternatives into a broader approach that prioritizes projects with the greatest benefit to the regional water bodies, independent of the jurisdictional authorities and responsibilities. While the classic CSO control approach is to focus on the CSOs and their impacts, the watershed approach considers the CSOs as one of many challenges to water quality. The watershed approach strives to focus resources (skills and finances) on controlling the pollutants and sources that most effectively impact the river uses.

Academicians have long advocated refining the current system of managing specific recognized pollutant sources with a more balanced watershed approach that ignores human-made boundaries and jurisdictions, identifies major pollutions sources, and focuses resources on controlling the sources that will have greatest impact on river and lake water quality. They endorse a watershed approach that does the following:

- Is hydrologically defined
  - Geographically focused
  - Includes all stressors (air and water)
- Involves all stakeholders
  - Includes public (federal, provincial, local) and private sector
  - Is community based
  - Includes a coordinating framework
- Strategically addresses priority water resource goals (such as, water quality, habitat)
  - Integrates multiple programs (regulatory and voluntary)
  - Based on sound science
  - Aided by strategic watershed plans
  - Uses adaptive management

11.1 Background

Water resources were managed naturally for the first several millennia of human history. Through the 19th century, Canadian water resources continued to be naturally managed, with First Nation and European immigrant water users capturing waters from streams and lakes for drinking, bathing, or industrial use. Used waters (including sewage) were returned directly to the same streams and lakes. In the 20th century Canadians started capturing and treating (or purifying) some of the used water in sewage treatment plants before returning it to the source waters, and provinces began licensing withdrawals from (uses) and discharge to (pollution) of the waterways. Discharges, the human-made sources of pollution, are now managed on a categorical basis whenever the discharge category is recognized as a significant source of pollutants. Industrial discharges are licensed in accordance with the industry type. Municipal wastewater treatment plants have been licensed, and limited by license conditions, since the mid-20th century. Licensing of municipal discharges in Manitoba first focused on the STP effluents, and are only now being considered for CSOs.

This recent management of human-made discharges, however, has not kept pace with observed degradation of the Provincial water resources. The degradation of Lake Winnipeg, the ultimate receptor of all discharges from Winnipeg and many other upstream discharges, has recently been well publicized (see Section 2.1.3), for example:

> "The water quality of Lake Winnipeg has been negatively impacted by excessive amounts of nutrients from both urban and rural sources. Lake Winnipeg is fed by a vast basin covering approximately one million square kilometres extending over four provinces and four states. More than half of the nutrients reaching Lake Winnipeg originate outside Manitoba's borders. Recent estimates indicate that 53 percent of the total phosphorus and 51 percent of the total nitrogen to Lake Winnipeg is coming from upstream jurisdictions." (From https://www.ec.gc.ca/eau-water, Lake Winnipeg Basin Stewardship Fund, accessed March 25, 2015)

Figure 11-1 shows the extent of the basin (watershed) that potentially contributes pollutants to Lake Winnipeg. The City is only a small portion of the entire area potentially affecting the lake.

Figure 11-1. Map of the Lake Winnipeg Tributary Basin
Source: www.ec.gc.ca, accessed March 25, 2015

Recent water quality analyses (MCWS 2002) have confirmed that the City's LDS, STPs, and CSOs contribute only a fraction of the pollutant loadings carried by the Assiniboine and Red River, as shown in Figure 11-2. CSOs constitue approximpaelt 11.4 percent of the City's TP load, 0.31 percent of the TP into the Red River and a lower percentage of 0.26 percent of the TP to Lake Winnipeg. The percentages for TN are similar at 4.7 percent of the City contribution, 0.26 percent of the Red River and 0.14 percent of Lake Winnipeg.poc

Nevertheless, the City's discharges do contribute to the lake loading and are subject to regulations that require significant expenditure to meet. A watershed approach would consider the potential for reducing a broad range of sources and their relative costs, leading to a overall optimized approach.

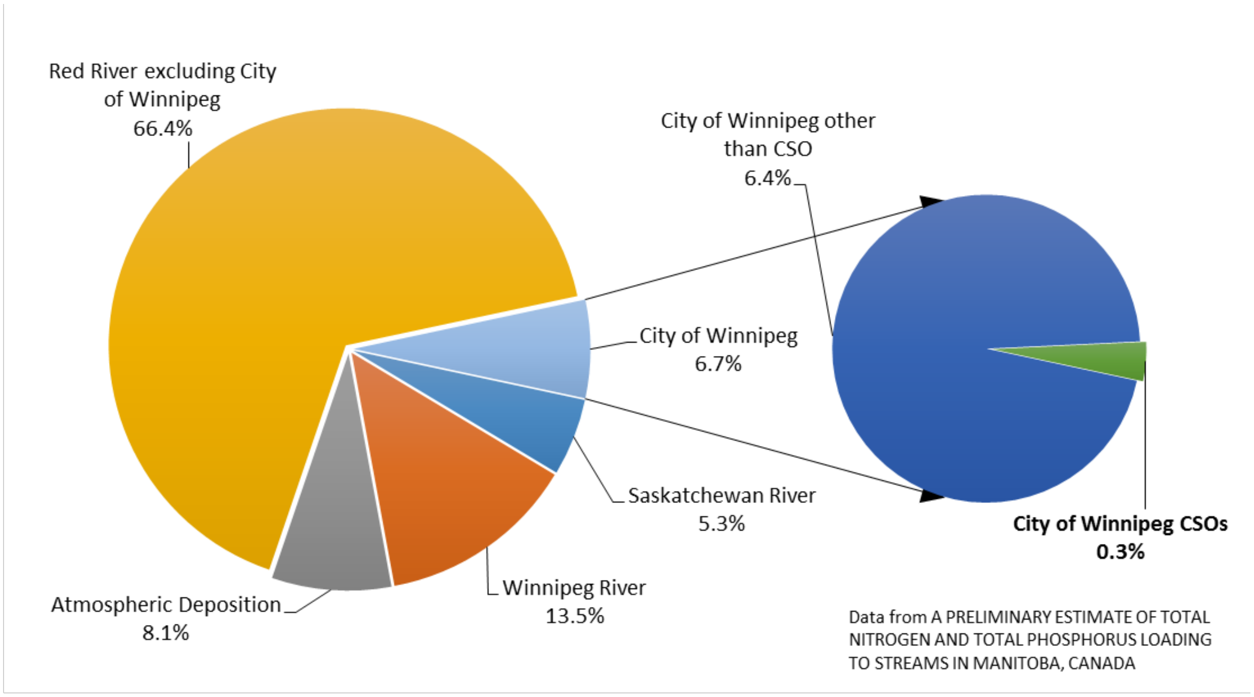

Figure 11-2. Annual Total Phosphorous Loading Distribution to Lake Winnipeg

A watershed approach to reducing pollutant discharges to the Assiniboine and Red Rivers, and potentially to all waters tributary to Lake Winnipeg, would identify the major pollutant sources throughout the watershed then concentrate resources on controlling those sources where the effort would result in the greatest reduction of pollution. The watershed approach would consider water quality improvements from a broader perspective and focus on the cumulative effects rather than individual sources. Upstream, land drainage, small streams, sanitary sewers, industrial sources, and combined sewers would all be considered and a plan identifying the best solution for all sources identified.

11.2 Findings Elsewhere

As indicated in the previous summary of CSO control experiences elsewhere (CH2M, 2014d), several communities that have completed plans for control of their CSOs have subsequently endorsed and championed watershed approaches for further improvement in the quality of the waters they impact. Each of these CSO plans have committed hundreds of millions of dollars toward improvements that upgrade the performance of their aging sewerage while reducing the frequency and volume of CSOs. Nevertheless, they choose to invest further funds and efforts in championing the watershed approach to achieve the further objective of continuous improvement in the areas water resources.

The Milwaukee Metropolitan Sewerage District, Edmonton, Portland, Omaha, Bangor, MSDGC, and NEORSD all evaluated (modelled) total loads to the receiving waters under baseline conditions, under a separation alternative, and under several other planning alternatives. All of these water quality analyses demonstrated that significant pollutant loadings from beyond the District or City boundaries will continue to cause receiving water quality standards violations even if the CSO loads are removed. To attain the goal of improved receiving water quality, the Milwaukee Metropolitan Sewerage District championed formation and funding of the non-profit Southeastern Wisconsin Watersheds Trust to build coalitions of concerned stakeholders to identify and implement projects to effectively improve watershed water quality. One unique aspect to Milwaukee's permit (licence), is that it requires implementation of a pilot project focused on creating best management practices to reduce bacteria loading from stormwater.

A watershed approach was recommended in Edmonton as part of their Combined Sewer Discharge Strategy. That watershed approach is based on the principle of managing the North Saskatchewan River quality rather than individual discharge sources. In other words, loading contributions would all be considered equal regardless if they are from upstream, small streams, or industrial, storm sewer, sewage treatment plant, or combined sewer sources. Edmonton has also developed a Total Loadings Plan and a Stormwater Quality Strategy to complement the overall total loadings approach taken on CSOs.

In Toronto, the Wet Weather Flow Master Plan was developed with the principle of managing WWF on a watershed basis and to implement management practices in a hierarchal order starting at the source, then in the system and finally at the end of pipe.

The examples elsewhere have found it not only cost effective, but also necessary and possible, to re-focus pollution control efforts through the watershed approach. They recognize the severe challenges in pursuing the watershed approach, but find it prudent to address the challenges cooperatively to more effectively improve the quality of their waters. Table 11-1 lists some of the challenges faced in pursuing the watershed approach, along with some of the means applied to overcome each challenge.

Table 11-1. High Rate Treatment Performance Metrics

Challenge	Means	Example
Not the City's responsibility	Build a coalition with the other potentially responsible agencies	Milwaukee MSD hosted workshops with representatives from watershed communities, State and Federal agencies, and citizens.
The City lacks authority	Seek cooperation with other agencies that have broader authority	Winnipeg is already seeking cooperation from the Provincial authorities.
Funding source is unclear	See volunteer funding and public private partnerships	Lake Winnipeg Basin Stewardship Fund
Necessary agencies traditionally adversarial	Emphasize the common objectives while explicitly overlooking historic quarrels	
Unclear leadership	Identify and recruit a visible leader	Milwaukee MSD championed the Southeastern Wisconsin Watersheds Trust

Note:
MSD = Metropolitan Sewerage District

11.3 Progress on Watershed Approach

The condition of Lake Winnipeg was not well understood during the completion of the 2002 CSO Study, and only became more know about the time of the 2003 CEC hearings. Athough the current master plan conclusion that CSOs only have a minor impact on the lake has not changed, it is recongnized that the lake is in such a serious state of distress that all options must be considered, and the watershed approach is best suited for this purpose.

The merits of a watershed approach and its challenges to implementation are well known. There have been several reviews and studies that reference watershed management, and the province has taken the lead with several initatives, as described in Section 2.1.3, and listed below:

- Manitoba Water Strategy (2003) – policy document focused on province-wide watershed planning
- Lake Winnipeg Action Plan (2003) – commitment to reduce nutrients discharges to Lake Winnipeg
- Nutrient Management Regulation (2008) - regulates the land application of materials containing nutrients
- Bill 46 – Save Lake Winnipeg Act (2011) – foucses on reducing nutrients, including specific requirments for Winnpeg STPs
- Surface Water Management Strategy (2014) – strategy to preserve and protect wetlands

In addition to the action already taken, there is significant potential benefit with the inclusion of the City in an overall watershed approach to Lake Winnipeg.

11.4 Winnipeg Path Forward

It is expected that the City will proceed with CSO control program to reduce the frequency and volume of CSO. The CSO program can and should be integrated with other programs under the City's jurisdiction, such as basement flooding relief, sewer rehabilitation and the WSTP upgrading program, to minimize the total cost of ownership and achieve the greatest value.

The City has limited opportunity to integrate water quality initiatives since they generally fall under different jurisdictions, being either provincial, other municipal or transboundary. Those that can be decided and controlled by the City are the STP, CSO and LDS sources. As shown through the water quality assessments, there would be little impact from replacing the combined sewers with separate sewers, and although green infrastructure and low impact developments provide some improvement, they too would not likely be perceptible on Lake Winnipeg.

The most cost effective method for achieveing improvements for Lake Winnipeg may be through a watershed basis. Two recent wetland examples reported through the media illustrate this concept:

- Big Grass Wetlands was dontated to the province by the municipalities of Lakeview and Westbourne for conservation in 2014, and was reported to reduce the amount of phosphorus entering Lake Manitoba by about 40,000 kg/year.
- Pelly's Lake water retention project near Holland Manitoba, as reported in 2015, will reduce the phosophours load to Lake Winnipeg by 3,000 kg/year by slowing the rate of runoff from the land.

The phosphorus removed from the wetlands projects may be small in comparison to the total annual load to Lake Winnipeg of 5,838,000 kg/year, but is comparable to the CSO annual loading prior to a CSO program of 15,000 kg/year. The major difference is the cost of the programs. The cost of the Pelly's Lake wetland was reported at less than $1.0 milliion, which is a fraction of the CSO program cost of $1,000 million or more.

The wetlands examples clearly demonstrate that if phosphorus reduction to Lake Winnipeg is the goal, the CSO program is not the most cost effective solution. Past practices recommended by the CEC and adopted by the province has been to regulate based on a policy of consistency in licencing. While it has been consistent and provides the perception of fairness, it discourages the discovery and implementation of cost effective watershed solutions that would likely provide better results and value for the public. A watershed approach would require taking a new perspective.

It is recommended that a watershed approach is considered in prioritizing projects, including CSO controls, where the primary objective is water quality improvement. The watershed approach would require cooperative efforts between numerous stakeholders both within and exterior to the City. The City has already taken the first step toward championing the watershed approach in that they have initiated a broad stakeholder involvement program. That program, through the City website and the CSO public events, already brought stakeholders together in recognition of the far reaching nature of water quality recommendations. Further steps toward building the watershed approach might logically involve expanding the stakeholder program beyond the City, explicitly involving more stakeholders from the Lake Friendly Stewards Alliance, Provincial authorities, and from the upper watersheds.

Performance Assessment

The previous sections presented information on the current situation, identified a number of CSO control options, developed potential plans that meet a wide range of control limits, evaluated the water quality improvements for those potential plans, and developed cost estimates. The next phase of the master plan is to review and evaluate the potential plans and develop a transparent and defensible recommendation of a control limit.

Performance evaluation metrics provide the basis for the evaluation. The evaluation should not be based entirely on program costs since most of the benefits are intangible and difficult to measure and relate to costs. The following section identifies objective performance criteria and provides preliminary assessments that can be used in the evaluation process. Other intangible and more subjective performance metrics are deferred to the decision process.

12.1 Control Limit Metrics

The alternative control limits chosen for evaluation were identified in Section 3.1. The number of overflows and percent capture used to define these limits are referred to as the control limit metrics. They provide objective metrics to compare the alternatives since they are measureable and easily understood, and have been used in CSO projects in other locations. They are required for the master plan because they are identified in the EA No. 3042 Clause 11.

A summary of the metrics for the alternative control limits to be evaluated under the master plan is provided in Table 12-1.

Table 12-1. Potential Plans Metric Evaluation Summary

Plan Alternative	Control Limit	Number of Overflows (District Averaging)	Number of Overflows (Max No Overflow Events)	Number of Overflows (Spatial)	Percent Capture (%)
	Baseline	23	63	63	74
1	85% Capture in a representative year	15	-	-	85
2	Four Overflows in a representative year	4	-	-	98
3	Zero Overflows in a representative year	0	4	-	100
4	No More Than Four Overflows per year	0	-	4	100
5	Complete Sewer Separation	0	0	0	100

Although the number of overflows and percent capture provide a good method for identifying the level of control, they provide little insight in terms of program benefits.

12.1.1 Number of Overflows

Despite the simple concept for the number of overflows, there is no standard definition on how they are to be reported. The master plan makes reference to the following two methods:

- District averaging for the representative year, as was used in the 2002 CSO Study and reported on by CEC
- Overflow events, as defined in EA No. 3042

The master plan initially adopted the district averaging method, but broadened the perspective to both methods to better respond to the licence issues.

Table 12-1 illustrates the results for both methods as applied to the alternative control limits.

12.1.1.1 District Averaging

The first column, as used in the 2002 CSO Study, is based on representative year averages. The precipitation events are applied uniformly over the combined sewer area, and the overflows from all of the districts are averaged for each event. The results are in essence are a long-term average. This method suggested the following:

- For existing conditions there are an average of 23 overflows on a year-round basis for the 1992 representative year. The previous work completed identified a district average of 22 overflows per year.
- There would be an average of four overflows for CSO controls designed for the four overflow control limit when using the representative year. In terms of performance this would mean the following:
  - Over the long-term period of record there would be more than four overflows for half of the years and less for the other half for each district.
  - Each district would average four overflows, but because the overflows could occur at different times the number of “overflow events” on the river would be more than four over a long-term period of record.
- There would be zero reported overflows per year based on the representative year for higher levels of control, since the largest event for the representative year would be fully captured.
- Overflows could still occur for large infrequent events for all but the complete separation alternative.

12.1.1.2 Overflow Events

The second column of Table 12-1 includes the number of overflows based on the EA No. 3042 definition for an “overflow event”. With this definition, overflows are counted every time there is a discharge to the river. The districts are not averaged, meaning multiple simultaneous district discharging at the same time are counted as a single overflow event, just as the discharge from a single district is counted as an overflow event.

In terms of performance this method suggested the following:

- For existing conditions there are 63 overflow events on a year-round basis for the 1992 representative year.
- For the four overflow control limit, the maximum number of overflow events from each district over a long period of record would not exceed four, based on a uniform rainfall distribution.

It was found that the four overflow control limit using this method, with uniform rainfall distribution, was equivalent to the zero overflow control limit previously described.

12.1.1.3 Spatial Distribution

The previous two overflow calculations do not account for the spatial distribution of rainfall. These random and sporadic rainfall patterns of rainfall that do occur in reality can cause localized overflows that would be counted using the overflow event definition. The third column of Table 12-1 shows the performance for a CSO control plan that accounts for the spatial rainfall distribution.

In terms of performance this method suggested the following:

- An overflow event would be recorded every time there is a precipitation event large enough to cause an overflow, which is the majority of events for existing conditions.
- The design for the “No More Than Four Overflows per year” alternative would take into account spatial distribution and therefore equal four. Over a long-term period of record the maximum number of overflow events would be four, with most years having fewer than four.
- This is the alternative requiring the highest level of control.

12.1.2 Percent Capture

Percent capture was determined in accordance with the definition included in EA No. 3042 for the representative year. As shown in Table 12-1 the percent capture increases as the number of overflows decreases.

12.2 Regulatory Compliance

Having reasonable and achievable environmental regulations in place and being able to demonstrate compliance has the following several benefits:

- There is a presumption that regulatory limits are set to protect specific uses, and the environmental benefits are achieved through compliance
- Compliance with regulations demonstrates environmental stewardship
- Compliance demonstrates good corporate citizenship

The CSO control limits have not yet been set and the ability to achieve compliance is unknown, but the MWQSOG are in place with several objectives and guidelines that relate to the CSO program. The MWQSOG defines water quality objectives for specific water uses, and if these values are met the water use is assumed to be protected.

12.2.1 Bacteria

The MWQSOG Tier II fecal coliform and *E.coli* objectives for primary recreation and irrigation in the rivers is 200 cfu/100 mL based on 1-day averaging. Combined sewage has concentrations of bacteria that will cause the objectives to be exceeded.

The objective will continue to intermittently be exceeded for each CSO control alternative. An estimate of the remaining impacts for each of the alternative control limits is presented in Table 12-2 for the representative year.

Table 12-2. Potential Plans Bacteria Metrics

Plan Alternative	Control Limit	[a] Number of Exceedances (days/year)
-	Baseline	44
1	85% Capture in a representative year	44
2	Four Overflows in a representative year	41
3	Zero Overflows in a representative year	35
4	No More Than Four Overflows per year	39
5	Complete Sewer Separation	42

Note:
[a] Determined from the worst location comparing Redwood Bridge and Parkdale locations

Table 12-2 shows the number of days the bacteria objective may be exceeded for each alternative. The general conclusions that can be made on this information are as follows:

- The CSO program will only have a marginal impact on the number of days bacteria levels will exceed the MWQSOGs, regardless of the level of control
- Compliance with bacteria objectives improves with increasing levels of CSO control (Alternatives 1-3) until it begins to backslide because of the increasing amount of separation
- Complete separation will not eliminate bacteria contamination, in fact it will only marginally improve the baseline conditions

The evaluation must consider that none of the options will achieve complete compliance with the MWQSOG objective and that CSO control may outperform sewer separation.

12.2.2 Dissolved Oxygen

MWQSOG provides minimum levels of DO for the protection of aquatic life and wildlife. Monitoring and water quality studies have shown that the DO is relatively unaffected by wet weather discharges so the minimum standards are routinely met under existing conditions. DO will not be improved with the addition of CSO controls.

12.2.3 Ammonia

Ammonia is a component of wastewater and is an important consideration for protection of aquatic life. CSO contains ammonia in nominal concentrations, but in levels that are not considered significant in terms of river loading. Wet weather treatment is also ineffective at reducing ammonia, which means there would be little if any change to discharge quality if the ammonia in the combined sewage was treated. Therefore, CSO control will not provide a benefit.

12.2.4 Total Suspended Sediment

MWQSOG provides Tier II limits of suspended sediment for the protections of aquatic life and wildlife. The objectives are based on the value of the induced change and varies with the background level. CSOs have limited effect because the combined sewage is already diluted with rainwater and flows into a water body with a naturally high background level. Since it is not an issue, CSO control will not provide a benefit.

12.3 Beneficial River Uses

The types and extent of river uses are important considerations in understanding the value and defining the benefits of CSO control programs. The following section provides an overview of river uses.

12.3.1 Primary Recreation

Primary recreation involves activities in the water like swimming and waterskiing, where immersion in the water is a part of the activity, or is at least probable.

Full immersion activity on the Red and Assiniboine Rivers is limited because the waters are unappealing. The rivers are naturally murky and turbid from carrying high sediment loads, and have steep and muddy banks. There are no beach access points, and swimming is risky because of hidden currents and floating debris that may cause safety hazards.

Waterskiing and jet-skiing have been more frequent than swimming, but the overall usage is low. The 2002 CSO Study estimated the total number of unintentional immersion events in the Red and Assiniboine Rivers from Winnipeg to Selkirk from secondary recreation at about 4,000 per year.

The 2002 CSO Study estimated the total number of immersion events on the Red and Assiniboine Rivers from Winnipeg to Selkirk inclusive to be about 7,000 per year.

12.3.2 Secondary Recreation

Secondary recreation involves activities like fishing, boating, and hiking, where immersion in the water is incidental or accidental. Secondary recreation is extensive on the rivers, with boating being the most popular. The 2002 CSO Study identified a number of considerations for secondary recreation on and along the rivers as follows:

- Between 11,000 and 70,000 power boats use the rivers, with about 60 percent being regular river users who moor their boats at private docks or marinas. Power-boating is most common between the Floodway control structure in St. Norbert and Selkirk, with the Assiniboine River used less because of shallower water.
- The rivers have historically had several commercial river boats, but this use appears will decline in response to lower water level and docking issues.
- Canoeing is estimated to involve between 200 and 1,600 users annually.
- About 200 competitive rowers use the river as a club activity.

Sport fishing is popular on the Red and Assiniboine rivers in Winnipeg and downstream at Lockport and Selkirk, with the rivers providing some of the best fishing in Manitoba.

According to the Manitoba Wildlife Federation, fish caught from the rivers are safe to eat, and with proper handling and preparation provide a safe and nutritious source of food. The Province monitors the rivers for the presence of pollutants that affect the fish with the only concern being reported as mercury levels, which is not a localized issue.

The recreational uses for the local rivers are different and on a smaller scale than for other locations than implement CSO control programs. Two specific examples of issues in other locations are as follows:

- Beaches – Winnipeg does not have bathing beaches, and direct water contact is limited.
- Shellfish – Shellfish are easily contaminated by CSOs, but shellfish harvesting does not take place in Winnipeg.

12.3.3 Irrigation

The 2002 CSO Study included a survey of greenhouse locations and found about 40 operations in the Winnipeg vicinity. The majority of the greenhouses in the area did not use the river for irrigation. This established the use of river water for irrigation as more of a dry weather issue, and the estimated risk of illness was low.

12.3.4 Illness Risks

Bacterial densities in the rivers are a risk factor for human health, which depends on the degree of contamination and amount of contact. Infection is possible from direct contact and ingestion of the water. In cases where illness does occur as a result of contact with contaminated river water, the typical symptoms would be flu-like, lasting a couple of days, typically without hospitalization.

Many attempts have been made to correlate bacterial densities in surface waters to cases of gastrointestinal disease in humans. The fundamental basis for quantification of illness from river uses is the science of epidemiology, which attempts to define the relationship among the densities at the point of human contact, the extent of exposure (usually the infective dose and the amount ingested), and the disease attributed to the exposure.

In recognition of this issue being a key factor in the CSO program decision, it was investigated at significant length as part of the 2002 CSO Study. Three Dose-Response (D-R) models were used to estimate the health risk for river users under baseline conditions and for various CSO control scenarios.

The evaluation resulted in the following conclusions:

- The number of illness caseloads for existing conditions, with STP disinfection in place, was small, ranging between 3 and 114 per year, depending on the D-R method used.
- Complete separation would only reduce the illness caseloads by 3 to 7, depending on the D-R method used.

The 2002 CSO Study illness risk assessment was summarized in *Appendix 1: Supporting Information. Illness Risk Assessment* of the final report. The findings were reviewed by the 2002 CSO Study Advisory Committee, which included the local medical officers of health, with the following conclusion:

> *CSO control will be costly and the benefits are subjective. There are many reasons to consider CSO control, including improving compliance with environmental guidelines, improvements in aesthetic and/or microbiological water quality, improving public perception and pride in the local rivers. The weight of the evidence and analysis indicates CSO control should not be considered a significant public health issue in the conventional context of avoiding disease. The extent of CSO control that is appropriate and acceptable to the community is fundamentally a public policy and a regulatory compliance issue. (Wardrop et al., 2002).*

12.3.5 Water Consumption

The CEC ruled in the *Report on Public Hearings. City of Winnipeg Wastewater Collection and Treatment Systems* (CEC, 2003) that the Red and Assiniboine Rivers should be protected as a source of raw water for domestic and industrial consumption. However, these recommendations would not require action with respect to CSO control, because of the following:

- Any use of the river water for potable drinking water would require complete treatment even if no CSOs existed (CEC, 1992).
- No guidelines are provided for industrial use.

Accordingly, there is no water consumption benefit to be applied to CSO control.

12.3.6 Aesthetics

The rivers provide a scenic amenity and are popular for passive activates such as river walks. The sight of floatable materials from CSOs observed on the rivers while participating in these activities can be repugnant, since they commonly include hygienic materials such as condoms and feminine hygiene products, and provide direct evidence of sanitary sewage. It is important to note that a large proportion of floatables are more commonly a result of LDS discharge containing materials such as Styrofoam, plastic, and metal. Floatables would still be present without CSOs.

12.3.6.1 Floatables

The MWQSOG Tier III narrative water quality guideline for floating materials requires waters to be free from debris, scum, and other floating materials in sufficient amounts to be unsightly or deleterious.

All of the potential plans will reduce the discharge of floatables. Most of the floatables will be removed as sewage is captured, and a portion of the overflows for the 85 Percent Capture, Four Overflow, Zero Overflow, and No More Than Four Overflow per year control limits will be captured by screening. Complete separation would remove all sanitary waste from river discharges, but would not include screening.

Separated storm sewers may still be a significant source of floatables, which will continue to be received from separated suburban areas and newly separated areas from CSO separation programs.

12.4 Lake Winnipeg

Lake Winnipeg is a valuable natural resource, supporting numerous public, private, and commercial activities. It is under stress and in need of actions to support its recovery. The issues and benefits for the recovery will need to extend well beyond the combined sewer districts.

The two lake issues directly related to CSO controls are nutrient and bacterial loadings.

12.4.1 Nutrient Loading

Lake Winnipeg is showing advanced signs of eutrophication caused by excess amounts of nutrients. The Red and Assiniboine contribute nutrients generated from many different sources within a drainage basin that exceeds 270,000 km^2, and encompasses several cities (such as, Winnipeg, Brandon, Grand Forks, Fargo) and large tracts of intensively cultivated agricultural lands.

Phosphorus is the limiting nutrient for Lake Winnipeg and the focus of control. MWQSOG Tier III narrative water quality guidelines for total phosphorus state that a stream should not exceed 0.05 mg/L. Boundary conditions for both the Red and Assiniboine Rivers already exceed this level.

While it can be demonstrated the phosphorus loadings from CSOs are small relative to the other sources, it is a fact that CSOs do make a contribution and need to be considered in the evaluation.

Phosphorus loadings from CSOs are relatively small compared to other sources. The phosphorus loading without CSO control is only 0.26 percent of the total lake loading under baseline conditions, and will be further reduced to half of the amount or less with implementation of a CSO program. In other words, CSO controls would not be effective in making improvement to Lake Winnipeg. Similarly, nitrogen loading under current conditions is 0.14 percent of the total lake loading and would be further reduced under any of the plan alternatives.

12.4.2 Lake Winnipeg Bacteria

Bacteria normally die-off within 2 to 3 days in the harsh river environment and would not be expected to survive the trip to Lake Winnipeg. The risk for bacteria contamination has been even further reduced by environmental regulations that now require year-round WWF disinfection.

CSOs are not considered to be a big threat to elevated bacteria levels in Lake Winnipeg.

12.5 Basement Flooding

Storm drainage is a core service provided by the City with the level of basement flooding protection being a key consideration in the evaluation of any changes to the combined sewers. The CSO control options must not reduce the existing levels of service, the potential plans must avoid any undue risks, and the evaluation process should account for potential improvements to the level of service.

The only control option identified that would reduce the level of basement flooding protection is the raising of the fixed weirs, which may be adopted as an early action. The effect would vary with the size of the change and it was recommended that the increase be offset through use of other control options in the district to result in no net impact.

The flexible weirs and control gates would not reduce the level of protection because they are designed to optimize the flow path under high flows to maintain the original capacity. The addition of an obstruction in the flow path will result in increase of risk which cannot be completely avoided; however, in these cases the increase in risk is considered minor.

The tunnel storage control option provides a major opportunity for increasing the level of basement flooding protection. The tunnels could be strategically routed through their districts and connected to an outfall while still meeting the CSO program objectives. The tunnels would be of sufficient size to add substantial hydraulic capacity.

The greatest potential for increasing the level of basement flooding protection is through sewer separation. The level of protection would increase from existing levels of what is already provided in separate sewer areas.

12.6 Constructability

All of the potential plans are considered to be constructible since they are based on commonly applied industry technologies.

Receiving the necessary approvals and public support for control options located within residential neighbourhoods could be challenging. End-of-pipe treatment is not a favourable option for this reason, and construction of off-line storage tanks and screening facilities could face similar challenges.

The difficulty with construction of off-line storage tanks will depend on the local site conditions. Acquiring property may be a challenge and existing geotechnical conditions along the riverbanks may make construction difficult. Deep tanks would have superior hydraulics benefits, but would be even more difficult to construct.

Wet weather treatment facilities located at the plants would involve complex construction, but are not unlike the projects currently underway. The satellite treatment option would have its own complications because of the need for an off-site location.

The conveyance projects with small and midsize pipes would be familiar and routine for the City and contractors. Larger diameter tunnels have not been constructed recently in Winnipeg, but are common in other locations and the construction industry would be expected to readily adapt. The soil conditions are favourable for tunneling in most areas, with some regions of the City requiring special attention to construction.

12.7 Implementability

Implementability considers the ability to deliver a program in accordance with the plan. It depends on many critical success factors and risks, such as the quality of the plan, budget availability, management commitment, program delivery model, technical and contracting capacity, local conditions, and constructability. For the potential plan evaluations the main factors that will determine the program success are the selection of a reasonable and doable plan, the time period for implementation, budget availability, and commitment for its completion.

Most of the following program implementation issues are common to all alternatives. They include balancing multiple projects with complex construction in mature neighbourhoods and extensive community disruption:

- Multiple Projects: The CSO program will span 43 combined sewer districts and three STP sites. Multiple upgrades and new construction may be included for each sewer district, requiring separate site investigations, designs, approvals, construction sites, and administration. The decision process and approvals are likely to be addressed separately for each of these since they involve separate public and local approval processes.
- Complex Construction: Underground construction deals with multiple out of sight and unknown risks. It is expected there will be large areas of favourable soil and groundwater conditions, mixed with spot locations with difficult conditions. Riverbank construction may be particularly difficult, which is where many of the CSO controls will be located.
- Mature Urban Areas: The combined sewers are all located in fully developed neighbourhoods, with extensive surface and underground works in place that will impact and, in many cases, limit construction plans and progress. Transportation routes must be kept open and neighbourhood disruption will be major impediments to progress.
- Delivery Capacity: The CSO program will require qualified resources for programming, engineering design, construction, and administration of the contracts. This will involve City staff and various combinations of the private sector for implementation. Local resources are insufficient as they exists today to deliver these types of programs, but the industries are quite flexible and would ramp up to meet the challenges. Because of the specialized nature of the work the ramp up period would take several years and only be sustained with a continual workload.
- Priorities and Commitments: The CSO program would be a high priority because of it being a regulatory requirement. Even with that, there are many examples where municipalities must deal with challenges, trade-offs, and tough decisions and cannot deliver on aggressive programs. The less aggressive the program the more likely the delivery plans will be met.

For the potential plan evaluation, the larger the program and the more approvals required, the greater the challenges with implementation, such as the following:

- The latent storage and in-line projects involve upgrades to existing facilities and would have minimal outside influences.
- Off-line tanks will be located in mature neighbourhoods, will require public input, and have the potential for difficult construction and therefore are at high risk of being delayed.
- Tunnel options have the advantage of being substantially out of sight, and not highly disruptive to neighbourhoods. The scope of tunnelling would be new to the City and not without its implementation risks.
- Floatables and satellite treatment that will require regular O&M at combined sewer outfall sites will require special reviews and approvals, which puts them at risk of delays or rejections.

- GI has been considered in developing the potential plans but has not been selected as a major component for the planning stage.
- Complete separation will be disruptive and affect every neighbourhood and will take time to achieve, even with commitments and the best of intentions. Complete separation should be considered a long-term multi-decade objective.
- Wet weather treatment facilities located at existing STP sites should be able to be completed within reasonable time frames, provided they are not impacted by other on-site activities.
- With respect to the overall program schedule, EA No. 3042 states in Clause 11 that "The Licencee shall implement the plan by December 21, 2030, unless otherwise approved by the Director."
- This would be a 13-year period from submission of the final master plan, and would be short for any of the potential plans.
- The licence was prepared without the knowledge of what is involved in the program, and allows some scheduling flexibility, subject to approval of the province.

12.8 Operation and Maintenance

The CSO program will add significantly to the City's asset inventory, the majority of which will be conveyance infrastructure. In relative terms conveyance infrastructure is not operationally or maintenance intensive, but would also include ancillary equipment such as gates, lift stations, control systems, and treatment facilities that would add to the operational and maintenance functions.

Detailed O&M estimates have not been made at this stage of the study, but the significant and unique features of the potential plans are as follows:

- The 85 Percent Capture, Four Overflow, Zero Overflow, and No More Than Four Overflow alternatives will all include upgraded lift stations, control gates, flap gate controls, and screens, and a SCADA system which will have a similar increased O&M requirement.
- Storage/transport tunnels could either partially or totally eliminate the need for lift stations, through use of direct gravity discharge from the combined sewers. A large lift station located near the treatment plant would be needed to transfer the sewage to treatment.
- The storage/transport tunnels will parallel the existing interceptor and provide redundancy and facilitate future repairs for these critical assets.
- Storage transport tunnels and complete separation could reduce or eliminate the need for flood pumping stations.
- Complete separation will have fewer mechanical systems and controls than the other options, and therefore less operational and maintenance requirements. It should also be noted that with complete separation:
  - Separation will greatly increase the City's asset value, and under Public Sector Accounting Board rules must be declared and depreciated on an annual basis.
  - Sewer separation will not include repair or replacement of any sewers. The infrastructure deficit and rehabilitation requirements that exist for older combined sewers will remain as is and still need to be addressed.
  - The operational impacts from removing storm flows from the combined sewers is unknown, with the potential need for increased flushing or odour control measures.

- The continuation of directing foundation drainage to the existing combined sewers will mean in-line storage will still be required for WWFs, although to a much smaller degree than for the other control options. It is expected the existing lift stations will continue to pump the DWFs and WWFs.

12.9 Adaptability to Change

A risk to be considered in the evaluation is the potential for future changes. Three potential causes and their impacts have been identified as follows:

- Environmental regulations are not guaranteed to be permanent or grandfathered, and could become more stringent in the future. This could require an increase to the CSO program level of performance.
- CSO control plans sized for current climatic conditions could be undersized in the future because of climate change. This would mean the control options sized for control standards today would have to be enlarged to meet the same standard in the future.
- Environmental concern for urban stormwater impacts may require treatment of LDS in the future. There is risk in creating a separate system and then needing to combine the separate system to a combined system later on to achieve treatment of LDS flow.

The dilemma for the decision process is that decisions made under current conditions may not be optimal for the future. Decisions made today could be much different than if all of the information were known. It is therefore prudent to consider how well the control options would adapt to potential changes, as follows:

- Minor increases in performance can readily be made to all potential plans, by simply adding more storage or increasing the amount of separation.
- Conveyance capacity to treatment and the STP treatment capacity become bottlenecks to expansion when their limits are reached. Additional separation would reduce the flow rate.
- If sewer separation is the ultimate goal, much of the storage volume and transportation capacity added with storage options would be redundant and not used. Sewer separation should be selected now if it is the ultimate requirement.
- If treatment of stormwater or watershed management is to be required, the selection would likely favour the storage and treatment options currently being considered.

12.10 Affordability

Affordability is of high concern and will be a major consideration in the program review and decision process. Affordability will depend on various factors, including the implementation time frame, the infrastructure solutions chosen, and the methods the City uses to fund them.

There are a number of tools available to provide guidance to a municipality on evaluating the economic impact of complying with regulator driven mandates. One such document is 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 factor is called the Residential Indicator (RI). The equation to determine the RI is:

$$\frac{Average\ Utility\ Cost\ per\ Household}{Median\ Household\ Income} \times 100\% = RI$$

An RI of 2 percent or greater is considered to be a "large economic impact" on residents. This indicator is based on a whole City basis and does not take into account economic diversity within a community.

As a secondary step to the RI, it may be applied to the income distribution through neighbourhoods to determine a more discrete spatial impact. Applying an income distribution based on an adjusted 2015 median household income (MHI) to a neighbourhood map of Winnipeg creates Figure 13-1. MHI was adjusted from 2006 MHI Census data with consumer price index adjusting rates (City of Winnipeg, 2014).

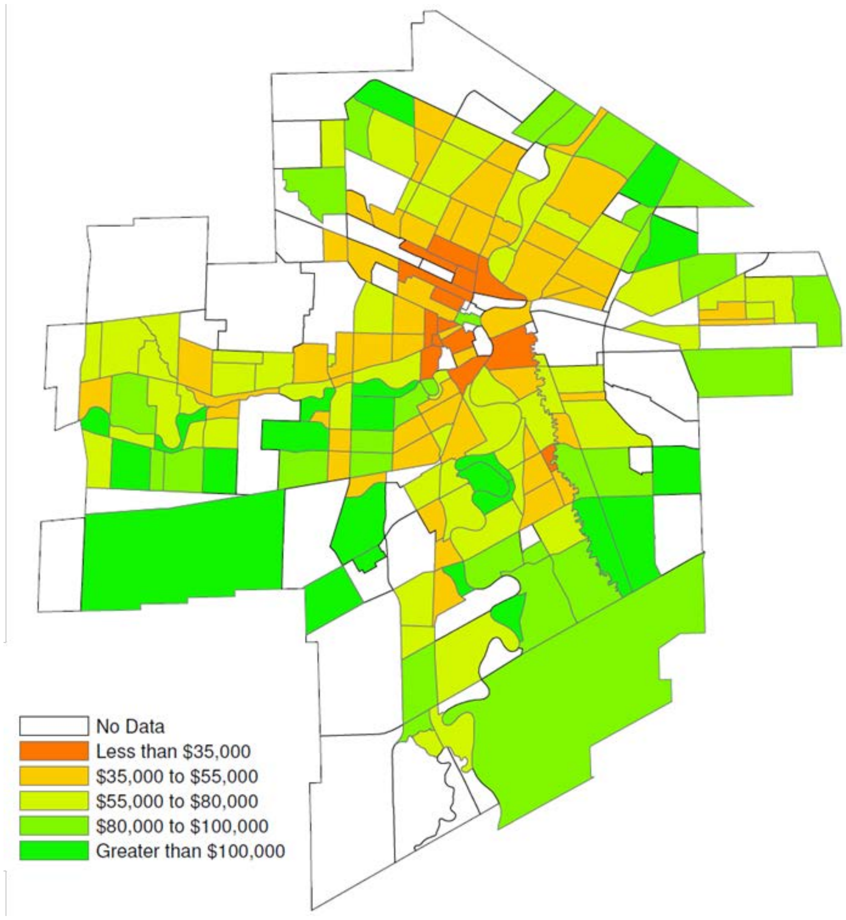

Figure 12-1. Winnipeg 2015 Adjusted Median Household Income Distribution

Figure 12-1 shows the majority of lower income neighbourhoods are within the combined sewer area. The current average utility cost (sewer and water) per household (City of Winnipeg, 2012) can be applied to the 2015 MHI to provide an indication of the current economic impact of utility rates as shown in Figure 12-2.

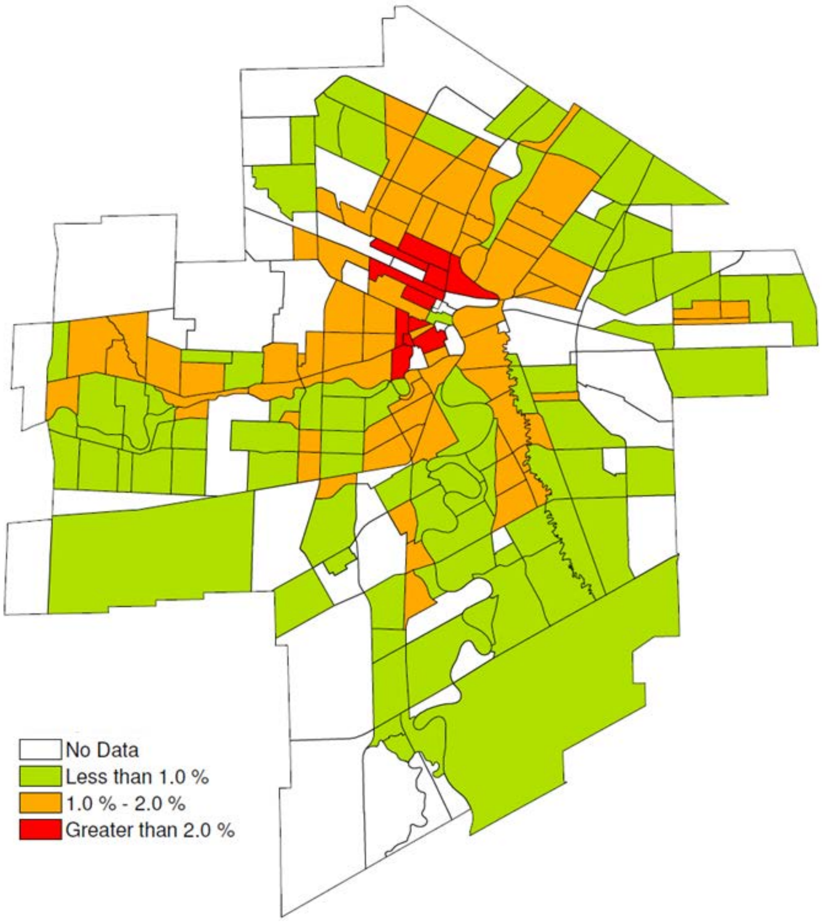

Figure 12-2. Residential Indicator Values for Current Utility Rate in Winnipeg

Figure 12-2 illustrates that the lower income neighbourhoods are already impacted by greater than 2 percent from the cost of utilities. The total cost of a master plan and the implementation time frame are significant factors in determining the most appropriate path to meeting the requirements set out in EA No. 3042. The assessment of affordability must consider the financial impact of the combined utility rate for all planned work and existing requirements for infrastructure upgrading, renewal, maintenance, and operations.

SECTION 13

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Appendix A
Environment Act Licence No. 3042

Appendix B
CSO Water Quality Monitoring Overview

Appendix C
Licence Clarifications

Appendix D
Peer Review Technical Memorandum

Appendix E
Public Engagement

Appendix F
Plan Alternative Maps

APPENDIX A
ENVIRONMENT ACT LICENSE NO 3042

Conservation and Water Stewardship

Climate Change and Environmental Protection Division
Environmental Approvals Branch
123 Main Street, Suite 160, Winnipeg, Manitoba R3C 1A5
T 204 945-8321 **F** 204 945-5229
www.gov.mb.ca/conservation/eal

CLIENT FILE NO.: 3205.00

September 4, 2013

Diane Sacher, P.Eng.,
Director, Water and Waste Department
City of Winnipeg,
112 — 1199 Pacific Avenue
Winnipeg MB R3E 3S8

Dear Ms. Sacher:

Enclosed is **Environment Act Licence No. 3042** dated September 4, 2013 issued to the **City of Winnipeg** for the operation of the Development being the existing combined sewers and overflow structures located within the City of Winnipeg with discharge of wastewater into the Assiniboine River and Red River.

In addition to the enclosed Licence requirements, please be informed that all other applicable federal, provincial and municipal regulations and by-laws must be complied with. A Notice of Alteration must be filed with the Director for approval prior to any alteration to the Development as licensed.

For further information on the administration and application of the Licence, please feel free to contact the undersigned at 204-945-7071.

Pursuant to Section 27 of *The Environment Act*, this licensing decision may be appealed by any person who is affected by the issuance of this Licence to the Minister of Conservation and Water Stewardship within 30 days of the date of the Licence.

Yours truly,

"original signed by"

Tracey Braun, M.Sc.
Director
Environment Act

c: Don Labossiere, Director, Environmental Compliance and Enforcement
Public Registries

NOTE: Confirmation of Receipt of this Licence No. 3042 ***(by the Licencee only)*** **is required by the Director of Environmental Approvals. Please acknowledge receipt by signing in the space provided below and faxing a copy (letter only) to the Department by September 18, 2013.**

On behalf of the City of Winnipeg **Date**

****A COPY OF THE LICENCE MUST BE KEPT ON SITE AT THE DEVELOPMENT AT ALL TIMES****

THE ENVIRONMENT ACT
LOI SUR L'ENVIRONNEMENT

Manitoba

LICENCE

Licence No. / Licence n° 3042

Issue Date / Date de délivrance September 4, 2013

In accordance with *The Environment Act* (C.C.S.M. c. E125) /
Conformément à *la Loi sur l'environnement* (C.P.L.M. c. E125)

Pursuant to Section 11 / Conformément au Paragraphe 11

THIS LICENCE IS ISSUED TO: / CETTE LICENCE EST DONNÉE À :

CITY OF WINNIPEG;
"the Licencee"

for the operation of the Development being the combined sewers and overflow structures located within the City of Winnipeg with discharge of wastewater into the Assiniboine River and Red River and associated tributaries, and subject to the following specifications, limits, terms and conditions:

DEFINITIONS

In this Licence,

"accredited laboratory" means an analytical facility accredited by the Standard Council of Canada (SCC), or accredited by another accrediting agency recognized by Manitoba Conservation to be equivalent to the SCC, or be able to demonstrate, upon request, that it has the quality assurance/quality control (QA/QC) procedures in place equivalent to accreditation based on the international standard ISO/IEC 17025, or otherwise approved by the Director;

"approved" means approved by the Director in writing;

"average dry weather flow" means the average daily volume of wastewater entering the combined sewer system in dry weather;

"combined sewer system" means a wastewater collection system which conveys wastewaters (domestic, commercial and industrial wastewaters) and stormwater runoff through a single-pipe system to a sewage treatment plant or treatment works;

"combined sewer overflow (CSO)" means a discharge to the environment from a combined sewer system;

"Director" means an employee so designated pursuant to *The Environment Act*;

"effluent" means treated wastewater flowing or pumped out of the combined sewer system;

"enhanced primary treatment" means wastewater treatment that utilizes a chemical coagulant/flocculant to remove suspended matter and soluble organic matter;

"Environment Officer" means an employee so appointed pursuant to *The Environment Act*;

"Escherichia coli (E. coli) " means the species of bacteria in the fecal coliform group found in large numbers in the gastrointestinal tract and feces of warm-blooded animals and man, whose presence is considered indicative of fresh fecal contamination, and is used as an indicator organism for the presence of less easily detected pathogenic bacteria;

"fecal coliform" means aerobic and facultative, Gram-negative, nonspore-forming, rod-shaped bacteria capable of growth at 44.5° C, and associated with fecal matter of warm-blooded animals;

"five-day biochemical oxygen demand (BOD_5)" means that part of the oxygen demand usually associated with biochemical oxidation of organic matter within five days at a temperature of 20° C;

"floatable material" means items such as, but not limited to, plastics and other floating debris (e.g., oil, grease, toilet paper, and sanitary items);

"grab sample" means a quantity of wastewater taken at a given place and time;

"MPN Index" means the most probable number of coliform organisms in a given volume of wastewater which, in accordance with statistical theory, would yield the observed test result with the greatest frequency;

"overflow event" means an event that occurs when there is one or more CSOs from a combined sewer system, resulting from a precipitation event. An intervening time of 24 hours or greater separating a CSO from the last prior CSO at the same location is considered to separate one overflow event from another;

"overflow point" means a point of a wastewater collection system via which wastewater may be deposited in water or a place and beyond which its owner or operator no longer exercises control over the quality of wastewater;

"percent capture" means the volume of wet weather flow treated in comparison to the volume of wet weather flow collected on a percentage basis;

"real time" means the actual time at which an event occurs;

"sewershed" means the area drained by a particular network of sewers;

"Standard Methods for the Examination of Water and Wastewater" means the most recent edition of Standard Methods for the Examination of Water and Wastewater, published jointly by the American Public Health Association, the American Waterworks Association and the Water Environment Association;

"wastewater" means the spent or used water from domestic, industrial and commercial sources that contains dissolved and suspended matter;

"wastewater collection system" means the sewer and pumping system used for the collection and conveyance of domestic, commercial and industrial wastewater;

"wet weather flow" means the combined flow resulting from:

i) wastewater;
ii) infiltration and inflows from foundation drains or other drains resulting from rainfall or snowmelt; and
iii) stormwater runoff generated by either rainfall or snowmelt that enters the combined sewer system; and

"wet weather period" means the spring thaw period and any period of precipitation capable of generating inflow to a combined sewer system that exceeds the capability of the system to convey wet weather flows to a sewage treatment plant.

GENERAL TERMS AND CONDITIONS

This Section of the Licence contains requirements intended to provide guidance to the Licencee in implementing practices to ensure that the environment is maintained in such a manner as to sustain a high quality of life, including social and economic development, recreation and leisure for present and future Manitobans.

Compliance with Licence

1. The Licencee shall direct all wastewater generated within the City of Winnipeg to sewage treatment plants operating under the authority of an Environment Act Licence or discharge wastewater to receiving waters in accordance with this Licence.

Future Sampling

2. In addition to any of the limits, terms and conditions specified in this Licence, the Licencee shall, upon the request of the Director:

a) sample, monitor, analyze and/or investigate specific areas of concern regarding any segment, component or aspect of pollutant storage, containment, treatment, handling, disposal or emission systems, for such pollutants or ambient quality, aquatic toxicity, leachate characteristics and discharge or emission rates, for such duration and at such frequencies as may be specified;
b) determine the environmental impact associated with the release of any pollutant(s) from the Development; or
c) provide the Director, within such time as may be specified, with such reports, drawings, specifications, analytical data, descriptions of sampling and analytical procedures being used, bioassay data, flow rate measurements and such other information as may from time to time be requested.

Sampling Methods

3. The Licencee shall, unless otherwise specified in this Licence:
   a) carry out all preservations and analyses on liquid samples in accordance with the methods prescribed in "Standard Methods for the Examination of Water and Wastewater" or in accordance with an equivalent analytical methodology approved by the Director;
   b) have all analytical determinations undertaken by an accredited laboratory; and
   c) report the results to the Director, in writing or in a format acceptable to the Director, within 60 days of the samples being taken, or within another timeframe acceptable to the Director.

Equipment Breakdown

4. The Licencee shall, in the case of physical or mechanical equipment breakdown or process upset where such breakdown or process upset results or may result in the release of a pollutant in an amount or concentration, or at a level or rate of release, that causes or may cause a significant adverse effect, immediately report the event by calling 204-944-4888 (toll-free 1-855-944-4888). The report shall indicate the nature of the event, the time and estimated duration of the event and the reason for the event.

5. The Licencee shall, following the reporting of an event pursuant to Clause 4,
   a) identify the repairs required to the mechanical equipment;
   b) undertake all repairs to minimize unauthorized discharges of a pollutant;
   c) complete the repairs in accordance with any written instructions of the Director; and
   d) submit a report to the Director about the causes of breakdown and measures taken, within one week of the repairs being done.

Reporting Format

6. The Licencee shall submit all information required to be provided to the Director under this Licence, in writing, in such form (including number of copies), and of such content

as may be required by the Director, and each submission shall be clearly labeled with the Licence Number and Client File Number associated with this Licence.

SPECIFICATIONS, LIMITS, TERMS AND CONDITIONS

Avoid CSOs

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 periods.

New or Upgraded Developments

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.

Public Education Plan

9. 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.

Public Notification System

10. 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.

CSO Master Plan

11. 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.

Effluent Quality Limits

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% 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:
    a) five day biochemical oxygen demand (BOD5) not to exceed 50 mg/l;
    b) total suspended solids not to exceed 50 mg/l;
    c) total phosphorus not to exceed 1 mg/l; and
    d) E. coli not to exceed 1000 per 100 ml.

Annual Progress Reporting

13. 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.

MONITORING AND REPORTING

Reporting

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

Interim Monitoring

15. 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:
    a) organic content as indicated by the five-day biochemical oxygen demand (BOD_5) and expressed as milligrams per litre;

b) total suspended solids as expressed as milligrams per litre;
c) total phosphorus content as expressed as milligrams per litre;
d) total nitrogen content as expressed as milligrams per litre;
e) total ammonia content as expressed as milligrams per liter;
f) pH; and
g) *E*.coli content as indicated by the MPN index and expressed as MPN per 100 millilitres of sample.

Record Keeping

16. 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.

REVIEW AND REVOCATION

A. If, in the opinion of the Director, the Licencee has exceeded or is exceeding or has or is failing to meet the specifications, limits, terms, or conditions set out in this Licence, the Director may, temporarily or permanently, revoke this Licence.

B. If, in the opinion of the Director, new evidence warrants a change in the specifications, limits, terms or conditions of this Licence, the Director may require the filing of a new proposal pursuant to Section 11 of *The Environment Act*.

"original signed by"

Tracey Braun, M.Sc.
Director
Environment Act

Client File No.: 3205.00

APPENDIX B
WATER QUALITY MONITORING OVERVIEW

FINAL

CSO Master Plan
Water Quality Monitoring Program

Prepared for

Winnipeg

December 2015

Prepared By

ch2m

In Association with

DILLON CONSULTING

XCG

Contents

Section Page

Tables

Figures

Acronyms and Abbreviations

BOD	biochemical oxygen demand
CSO	combined sewer overflow
EMC	event mean concentration
ha	hectares
LDS	land drainage sewer
m	metres
mg	milligram
mL	millilitre
MPN	most probable number

Water Quality Monitoring Program

1.1 Water Quality Monitoring

The Combined Sewer Overflow (CSO) Master Plan considered the previous water quality data from the *2002 CSO Study* (Wardrop et al. 2002) and subsequent Red and Assiniboine River water quality monitoring programs and carried out additional monitoring to supplement and update the data. Additional monitoring included the smaller rivers and streams that flow into the two larger Red and Assiniboine rivers.

1.1.1 Bi-weekly River Water Quality Monitoring

Since 1977, the City of Winnipeg (City) has carried out a voluntary water quality monitoring program of the rivers and small streams at regular intervals during the recreational season, typically May to September, depending on weather and river conditions. The program includes the collection of samples at 11 locations along the Red and Assiniboine rivers and at eight locations on selected small streams. Testing is carried out for 18 parameters, including nutrients, dissolved oxygen, and bacteria. The results are posted on the City's website. The Province of Manitoba also monitors water quality upstream and downstream of Winnipeg.

1.1.2 CSO Water Quality Monitoring Program

A water quality monitoring program was initiated in response to the City's compliance requirements under Environment Act Licence No. 3042, Clause 15, and to supplement the data needs of the CSO Master Plan. As part of the compliance monitoring requirements, the City developed an *Interim Monitoring Plan* (City of Winnipeg 2014) that serves as a basis for the water quality monitoring study that was completed as part of the CSO Master Plan development. 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:
>
> a. organic content as indicated by the five-day biochemical oxygen demand (BOD_5) and expressed as milligrams per litre;
>
> b. total suspended solids as expressed as milligrams per litre;
>
> c. total phosphorus content as expressed as milligrams per litre;
>
> d. total nitrogen content as expressed as milligrams per litre;
>
> e. total ammonia content as expressed as milligrams per liter;
>
> f. pH; and
>
> g. E.coli content as indicated by the MPN index and expressed as MPN per 100 millilitres of sample.

The interim monitoring plan provides more detail on the specifics of the monitoring program and identifies the locations where sample collection occurred. The monitoring program has provided an updated characterization of collection system discharge quality and allows for an assessment of the impact of these discharges on receiving stream water quality. The assessment and analysis of the water quality data as used for the CSO Master Plan is discussed in Section 11 of the Preliminary Report.

1.2 Program Methodology

The program included two distinct types of monitoring to characterize the CSO discharges and to measure the impact of the CSO discharge on the rivers.

1.2.1 CSO Discharge Monitoring

The objective of the CSO discharge monitoring was to characterize the pollutants of concern contained within the overflows.

Representative sampling was completed at a number of CSO outfall locations to establish the variable nature of CSO discharges. Early in the planning stages for the program, a number of suitable locations were selected based on a high level review of system hydraulics and upstream land use. In total, eight preliminary locations were selected for installation of the auto-samplers. Each auto-sampler was to be maintained in a location until two suitable CSO events could be captured and the results validated. Once two events were captured, the auto-sampler was moved to the next location until a total of 16 events were captured at the eight locations.

The auto-samplers were programmed to automatically start collecting samples at defined levels, which are unique to each location and change continually based on river levels. The samplers were set up with 24 1-litre bottles to allow for 24 discrete samples to be collected. They were programmed to collect a 1-litre sample every 15 minutes. This allows for a total collection time frame of six hours. Samples could continue to collect for multiple peaks that occur during the course of a runoff event, so that varying intensity within a storm did not stop the collection process and a high probability of capturing a full sample set of 24 bottles was maintained.

The results were used to develop representative EMCs for use in the water quality assessment. Other secondary information collected including the identification of unusual concentrations of tested parameters and further understanding of the river – outfall relationship.

1.2.2 River and Stream Monitoring

The overall objective of the river and stream monitoring was to characterize the impact of CSO discharges into the rivers and streams. The river and stream monitoring carried out for the CSO master plan was more comprehensive than the bi-weekly program. The CSO monitoring program included additional sample collection points to identify any differential impacts across the Red and Assiniboine Rivers and used two types of sampling protocol were established to complete this objective. A dry weather collection set to characterize baseline conditions in the river without the influence of collection system discharges and wet weather collection to characterize the river after an overflow event has occurred. The difference in quality during dry and wet weather sampling can be attributed to the discharge of runoff into the receiving water. The goal was to collect two representative sets of samples for both dry weather and wet weather conditions.

A regional approach was used to select the locations for river and stream sampling. Since the objective was to determine the impact of CSOs, locations were based on the City boundaries, the convergence of the two rivers, and the boundaries of the combined sewer area within the City. At each location on the Red and Assiniboine rivers, three samples were taken. At the locations on the other streams and rivers, one sample was taken. Three sample were taken in the larger rivers to identify differential impacts across the rivers cross section. One sample was considered representative for the small streams and rivers because they are not as wide.

Dry weather sampling only begins after a 3-day stretch of minimal rainfall and no identifiable overflows. Dry weather sampling is carried out for 3 to 5 days. Wet weather sampling is carried out after a rainfall event that is significant enough to create identifiable overflows along both river systems. An identifiable overflow is determined through the evaluation of the CSO monitoring instrumentation at outfitted CSO outfalls. At the time 30 of the 79 outfalls were outfitted with permanent instrumentation giving a reasonable representation of the occurrence of a widespread CSO impact.

When resources allowed, CSO discharge at the outfall was sampled during the same wet weather sampling period to establish the strength of discharge entering the receiving waters. Once wet weather sampling began, the sampling is continued for three consecutive days regardless of weather conditions. The data collected serves as a way to observe the system operation and simulate the water quality impact of the potential CSO options.

1.3 Overview of Results

The CSO water quality monitoring program was carried out over the period of October 2014 to 2015 and captured a significant amount of data. A late start caused by high river conditions and limited rainfall in the fall of 2014 allowed for only the collection of one dry weather data set. In 2015, the program was up and running at the start of May and successfully captured 18 CSO discharge data sets, three wet weather data sets, and one dry weather sets. All data reported on in this section is included in Appendix A.

1.3.1 River Levels

River levels can influence sample collected at discharge locations and along the rivers and streams. The river levels may in turn impact the resulting collected data. As shown in Figure 1, the level on the Red River was above the normal summer water level (NSWL) of 223.75 metres (m) from mid-May to the end of June 2015. Levels were reasonably normal outside of this range. High levels were a result of two events in the middle of May and another at the beginning of June.

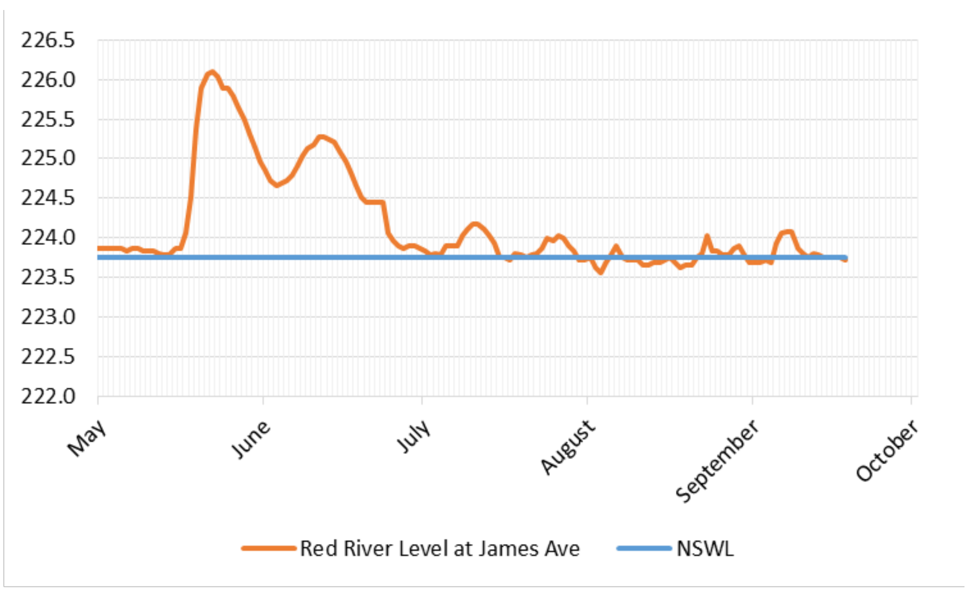

Figure 1. Red River Level at James Ave for 2015

1.3.2 Discharge Sample Collection

In 2014, two discharge locations were outfitted with auto-samplers, but no data sets were captured. In 2015, four auto-samplers were used in the program with 23 data sets captured with various numbers of samples per collection set. Table 1 provides an overview of the locations and dates of collection.

Table 1. Discharge Sample Locations and Dates of Collection

	5/1	5/7	5/15	6/7	6/22	6/28	7/16	7/23	7/28	8/23	9/4	9/5	10/13
Location													
Assiniboine	5	0	0	0	0	0	0	0	9	-	-	-	-
Jessie	24	24	-	-	-	-	-	-	-	-	-	-	-
Mission	0	0	23	24	-	-	-	-	-	-	-	-	-
Hawthorne	5	4	22	0	0	19	-	-	-	-	-	-	-
Strathmillan	-	-	0	24	13	-	-	-	-	-	-	-	-
Ash	-	-	-	-	-	-	12	12	-	-	-	-	-
Mager	-	-	-	-	-	-	-	-	-	17	0	15	-
Colony	-	-	-	-	-	-	-	-	-	0	0	17	9

Note: A zero represents an installed sampler, but no samples collected during the event

The water quality data collected from the CSO discharge locations was highly variable and dependent on both the intensity and duration of the rainfall events causing the overflow. One objective of the program was to select and sample locations based on the land use type. A second objective was to establish parameter concentrations for different types of discharge. Trends in some of the data sets at each location could be established over the course of collecting a set of data. However, this was not a consistent trend that was seen during all sets. An overview of each location is provided in the following sections.

1.3.2.1 Ash

The Ash outfall is located along the Assiniboine River in the Ash sewer district. Ash is primarily a residential area with some commercial areas along major transportation routes.

1.3.2.2 Assiniboine

The Assiniboine outfall is located on the Assiniboine River close to where the two rivers converge in the Assiniboine sewer district. This sewer district is representative of a higher density urban environment with a large proportion of commercial space and some multifamily residential.

This outfall was influenced by river levels and was impacted throughout the months of May and June. After river level normalized at the end of June, this location still presented difficulties in the collection of a complete data set. Overflows at this location are relatively short in duration with a small increase in level causing the outfall to operate.

1.3.2.3 Colony

The Colony outfall is located along the Assiniboine River in the Colony sewer district. This sewer district is representative of a high density urban environment with a large proportion of commercial space and some multifamily residential.

This outfall is subject to a quick response and short duration following a runoff event

1.3.2.4 Hawthorne

The Hawthorne outfall is located in the Hawthorne sewer district at the downstream extent of the combined sewer areas along the Red River. Hawthorne is primarily a residential area with some commercial and industrial areas along major transportation routes.

The Hawthorne location was chosen to replace Cockburn, as identified in the Interim Monitoring Plan. These two districts have very similar land usage and would be expected to produce similar quality results. Cockburn was bypassed because of the difficulty with installation at this location.

1.3.2.5 Jessie

The Jessie outfall location is located in the Jessie combined sewer district along the Red River before the river convergence. Jessie is primarily a residential area with some commercial and industrial areas along major transportation routes.

The Jessie district covers approximately 400 hectares (ha) of combined sewer area that creates a longer duration overflow. Two complete sample sets were captured shortly after an installation at this location.

1.3.2.6 Mager

The Mager outfall is located along the Red River south of the Assiniboine and Red convergence in the Mager sewer district. Mager is primarily a residential area with some commercial and industrial areas along major transportation routes.

1.3.2.7 Mission

The Mission combined sewer outfall is located in the Mission sewer district along the Seine River where it discharges to the Red River. This is a unique sewer district as the majority of land use is attributed to industrial, some heavy. There is also a mix of overland and below ground drainage.

The Mission district covers over 700 ha of combined sewer area. Similar to Jessie, this creates longer lasting overflows because of the length of time runoff takes to enter into the collection system and travel to the overflow structure.

1.3.2.8 Strathmillan

The Strathmillan outfall is located along the Assiniboine River in the Strathmillan sewer district. The land use in this area is mostly residential with some commercial areas along major transportation routes.

This location is not subject to the high level of river influence as other outfalls located further downstream along the Assiniboine. This allowed for this location to be easily outfitted with sampling equipment and resulted in the collection of two samples sets within a short timeframe.

1.3.3 Discharge Monitoring Result Summary

The results from each individual location during each event has been compiled and summarized. To show the context of the results, the average concentrations for select parameters tested are summarized in Table 2. The average value of all samples collected for each location is shown.

Table 2. Discharge Monitoring Result Overview

Location	Ammonia mg/L	BOD mg/L	Total Phosphorus mg/L	Total Nitrogen mg/L	Total Suspended Solids mg/L	E.Coli MPN/100 mL
Ash	3.66	115	2.12	10.73	386	Not Tested
Assiniboine	1.90	69	1.66	9.88	622	1,562,800
Colony	2.06	19	0.77	4.71	79	2,637,733
Hawthorne	4.73	127	2.61	15.26	504	2,758,200
Jessie	5.16	101	2.05	12.70	403	951,833
Mager	3.41	55	1.41	9.50	247	2,473,094

Table 2. Discharge Monitoring Result Overview

Location	Ammonia mg/L	BOD mg/L	Total Phosphorus mg/L	Total Nitrogen mg/L	Total Suspended Solids mg/L	E.Coli MPN/100 mL
Mission	9.54	133	3.26	18.21	499	1,819,085
Strathmillan	5.16	122	2.14	14.24	199	2,102,730

Notes:
E. coli was not tested on samples taken from the Ash location
E. coli for the first Colony sample set was not included as a precaution because values of *E.coli* were reported as higher than Fecal Coliforms which is not typical and could signify an error in reporting or testing.
BOD = biochemical oxygen demand
mg = milligram
mL = millilitre

Table 2 includes six of the 14 parameters that were tested. The parameters listed here are directly relevant to the CSO Master Plan and the analysis completed can be found in Section 10 of the Preliminary Report. These results and the other parameters for all samples sets can be found in Appendix A of this report.

Key findings from the CSO discharge sample sets include the following:

- *E.coli* bacteria values were found to be highly variable, ranging from less than 10,000 MPN/100 mL to over 15.0 x 10^6 MPN/100 mL. No trend based on rainfall or location could be established.
- Total N values ranged from 0.9 mg/L to 76.3 mg/L. No trend based on rainfall or location could be established.
- Total P values ranged from 0.3 mg/L to 14.5 mg/L. No trend based on rainfall or location could be established.
- TSS values ranged from 16 mg/L to 3,270 mg/L. No trend based on rainfall or location could be established.
- In general, CSO discharge is highly variable and there is no discernable trend in the values of POCs based on the locations sampled during 2015 or the intensity or duration of rainfall causing the overflow.

1.3.4 River and Stream Sample Collection

The river and stream sampling program was carried out over 2014 and 2015. The dates of the collection set periods are summarized in Table 3.

Table 3. River and Stream Dates of Collection

	Event 1	Event 2	Event 3
Location			
Dry Weather	October 15-19, 2014	July 2-4, 2015	-
Wet Weather	June 7-9, 2015	June 28-30, 2015	July 5-7, 2015

1.3.4.1 Dry Weather

The dry weather sample sets are meant to reflect the baseline conditions of the rivers without any impact by runoff or CSOs. In 2014, dry weather river samples were collected daily from October 15 to October 19. During 2015, a 3-day dry weather period from July 2 to July 4 was completed following a dry period from June 28 to July 1.

Key findings from the dry weather river and stream sample sets include the following:

- *E.coli* and FecalColiforms: The results indicated that background levels of *E.coli* in the rivers during this dry weather period were typically below the Tier II objective in the Manitoba Water Quality Standards, Objectives and Guidelines. There were a few instances higher than the objective; however, these level spikes cannot be attributed to a specific source.
- Total Phosphorus: The results indicated that upstream of the City boundary and throughout the rivers, the total phosphorus levels are above the Tier III limit of 0.05 mg/L through both sampling periods. Small streams tested were also above the limit. As an example, during the October 2014 period, the Assiniboine River had an average level of 0.26 mg/L at the Osborne Bridge and the Red River had an average level of 0.16 mg/L at the Norwood Bridge.
- Ammonia: The results show little to no increase in the ammonia level of the Assiniboine River from the boundary to its convergence with the Red River. The Red River levels show an overall increase in level from the south boundary through the City. In general, the ammonia level in the Red River is higher than the Assiniboine River. There is a drop in the level of the Red River at the location downstream from the convergence.
- Total Nitrogen: In general, the Assiniboine River has higher levels than the Red River. As an example, the October 2014 values indicate an average level in the Assiniboine River of 1.69 mg/L at the Osborne Bridge and an average level in the Red River of 1.10 mg/L at the Norwood Bridge. There is little to no increase in levels along the Assiniboine River. There is an increase in the level of Total Nitrogen in the Red River at the location downstream from the convergence.
- Total Suspended Solids: At the upstream boundary, over the 8 days of dry weather sampling, the Red River shows an average background level of approximately 180 mg/L and the Assiniboine River shows an average background level of 290 mg/L. The October 2014 results are less than the same locations in July 2015. In general, total suspended solids levels are not consistent and can vary considerably; even across the cross section of the rivers it varied by as much as 100 mg/L in the samples collected on the same day.
- There was no indication of dry weather overflows occurring based on the sample locations selected.
- No impact from the STPs was noted.

1.3.4.2 Wet Weather

No wet weather data sets were captured during 2014 and three were captured during 2015, as indicated in Table 3. Rainfall amounts relating to each of the collections periods is shown in Table 4. Both the Environment Canada rainfall data and the average of the City’s 31 rain gauges are shown for comparison and to provide detail on variation that is inherent with any rainfall event.

Table 4. Rainfall during Wet Weather Collection Periods

Environment Canada – Gauge 502S001					
Event 1		***Event 2***		***Event 3***	
Date	***Rainfall (mm)***	***Date***	***Rainfall (mm)***	***Date***	***Rainfall (mm)***
June 6, 2015	19.6	June 27, 2015	19.7	July 4, 2015	23.3
June 7, 2015	0.2	June 28, 2015	0.2	July 5, 2015	0.0
June 8, 2015	0.0	June 29, 2015	0.0	July 6, 2015	0.0
June 9, 2015	0.8	June 30, 2015	0.0	July 7, 2015	0.0
City of Winnipeg Rain Gauge Network					
Event 1		***Event 2***		***Event 3***	
Date	***Rainfall (mm)***	***Date***	***Rainfall (mm)***	***Date***	***Rainfall (mm)***
June 6, 2015	15.2	June 27, 2015	12.8	July 4, 2015	26.1
June 7, 2015	9.5	June 28, 2015	0.5	July 5, 2015	0.1
June 8, 2015	0.0	June 29, 2015	0.0	July 6, 2015	0.0
June 9, 2015	1.3	June 30, 2015	0.0	July 7, 2015	0.0

The objective of the wet weather monitoring was to determine if a noticeable impact from discharges following rainfall could be established. Each collection set has been reviewed and the observed trends described in Tables 5, 6, and 7.

Observed trends from the June 7-9 wet weather river and stream sample set are listed in Table 5.

Table 5. Observations from June 7 to June 9 River and Stream Sample Set

Parameter	**Location**	**Observations**
E.coli	Small Streams	• Levels decrease over the 3 days
	Assiniboine	• Levels decrease over the 3 days
	Red	• Levels decrease over the 3 days
Total Phosphorus	Small Streams	• No trend observed
	Assiniboine	• Levels decrease from day 1 to day 2
	Red	• Levels decrease from day 1 to day 2
Ammonia	Small Streams	• Bunns Creek, Seine River, and La Salle River have spikes on various days
	Assiniboine	• No trend observed
	Red	• Levels increase through the City • Increase observed at the North Perimeter Bridge

Table 5. Observations from June 7 to June 9 River and Stream Sample Set

Parameter	Location	Observations
Total Nitrogen	Small Streams	• La Salle River is high relative to others
	Assiniboine	• Levels decrease from day 1 to day 2
	Red	• Levels are consistent over the 3 day period • Levels decrease along the length of the river
Total Suspended Solids	Small Streams	• La Salle River is high relative to others
	Assiniboine	• Levels increase along the length of the river on day 1 • Levels decrease from day 1 to day 2
	Red	• Levels are consistent over the 3 day period • Levels decrease along the length of the river

Observed trends from the June 28-30 wet weather river and stream sample set are listed in Table 6.

Table 6. Observations from June 28 to June 30 River and Stream Sample Set

Parameter	Location	Observations
E.coli	Small Streams	• Levels decrease over the 3 days • Omands Creek is high relative to the others
	Assiniboine	• Level at the Osborne Bridge is higher relative to the others on all 3 days • Level at the Osborne Bridge decreases over the 3 days
	Red	• Levels increase along the length of the river on all 3 days • Level at the Lockport Bridge is high relative to the other locations
Total Phosphorus	Small Streams	• La Salle River is high relative to the others
	Assiniboine	• No trend observed
	Red	• No trend observed
Ammonia	Small Streams	• No trend observed
	Assiniboine	• No trend observed
	Red	• Levels increase through the City • Increase observed at the North Perimeter Bridge • Levels at some locations decrease over the 3 days
Total Nitrogen	Small Streams	• La Salle River and Seine River are high relative to others
	Assiniboine	• No trend observed
	Red	• No trend observed
Total Suspended Solids	Small Streams	• Seine River is high relative to the others
	Assiniboine	• No trend observed
	Red	• No trend observed

Observed trends from the July 5-7 wet weather river and stream sample set are listed in Table 7.

Table 7. Observations from July 5 to July 7 River and Stream Sample Set

Parameter	Location	Observations
E.coli	Small Streams	• Sturgeon Creek and Omands Creek were high relative to the others • Levels at most locations decrease over the 3 days
	Assiniboine	• Levels increase along the length of the river • Levels decrease over the 3 days
	Red	• Levels increase along the length of the river • Levels decrease over the 3 days
Total Phosphorus	Small Streams	• La Salle River and Bunns Creek are high relative to the others • La Salle decrease over the 3 days
	Assiniboine	• Levels decrease over the 3 days
	Red	• Levels decrease along the length of the river
Ammonia	Small Streams	• La Salle River is high relative to the others. • La Salle decrease over the 3 days
	Assiniboine	• No trend observed
	Red	• Levels increase through the City • Increase observed at the North Perimeter Bridge
Total Nitrogen	Small Streams	• La Salle River and Seine River are high relative to the others • Levels decrease over the 3 days
	Assiniboine	• Levels decrease over the 3 days • Levels increase along the length of the river
	Red	• No trend observed
Total Suspended Solids	Small Streams	• Levels at La Salle River are high relative to others
	Assiniboine	• No trend observed
	Red	• Levels decrease along the length of the river

1.3.5 Wet Weather Result Summary

Wet weather sampling was carried out in 2015 with three separate events being monitored, each for three days in a row following each rainfall event. Key findings from the wet weather river and stream sample sets include the following:

- *E.coli* and Fecal Coliforms: *E.coli* typically peaked above the Tier II objective in the MWQGSO at all locations, including boundaries into the City, during the first day following a rainfall event. Values typically increased as sample locations were further downstream. Levels dropped below the objective within the three days of sampling.
- Velocities in the Red and Assiniboine Rivers move water through the City in a short period of time. Approximately 1 day after the occurrence of rainfall, the concentrations of the tested constituents were back in the range of baseline.

- In general, the trends observed during each day following an event were not repeated over each of the three wet weather collection periods. Some trends observed in the dry weather sets are repeated during wet weather in the same pattern through the length of river (e.g. ammonia, TSS).
- Dry weather results from the Assiniboine River were on average higher than the wet weather results. This shows how the variability in conditions in the City and upstream can impact the POC values.

It is expected that results from additional sets collected would be similar showing that there is not an appreciable impact from POCs other than bacteria which show a consistently repeated trend. The spatial rainfall impact and river level and flow impacts from events occurring beyond the City boundaries may have some influence on the results observed.

References

City of Winnipeg. 2014. Interim Monitoring Plan. Environment Act Licence No. 3042. Clause 15. City of Winnipeg. Water and Water Department. August 13.

Wardrop Engineering Inc. (Wardop), TetreES Consultants Inc., CH2M HILL Canada and EMA Services Inc. 2002. *Combined Sewer Overflow Management Study* (2002 CSO Study). Final Report. Prepared for: City of Winnipeg, Water and Waste Department. November.

Appendix A
Test Results

				1	2	3	4	5	6
Parameter	Units	Measure	Type	La Salle River	Seine River	Strugeon Creek	Truro Creek	Omands Creek	Bunns Creek
				B	B	B	B	B	B
Ammonia	mg/L	Average	Dry	0.034	0.022	0.041	0.012	0.024	0.144
Ammonia	mg/L	Min	Dry	0.010	0.010	0.013	0.010	0.010	0.010
Ammonia	mg/L	Max	Dry	0.079	0.039	0.065	0.018	0.041	0.289
Ammonia	mg/L	Average	Wet	0.096	0.078	0.067	0.023	0.034	0.078
Ammonia	mg/L	Min	Wet	0.010	0.018	0.033	0.010	0.021	0.022
Ammonia	mg/L	Max	Wet	0.202	0.235	0.099	0.045	0.062	0.163
BOD	mg/L	Average	Dry	4.89	4.86	4.86	6.37	4.66	4.68
BOD	mg/L	Min	Dry	2.00	2.00	2.00	6.00	2.00	2.00
BOD	mg/L	Max	Dry	6.00	6.00	6.00	7.90	6.00	6.00
BOD	mg/L	Average	Wet	6.00	2.43	2.41	2.00	2.47	2.63
BOD	mg/L	Min	Wet	2.00	2.00	2.00	2.00	2.00	2.00
BOD	mg/L	Max	Wet	10.30	3.00	4.20	2.00	6.00	5.60
Carbonaceous BOD	mg/L	Average	Dry	6	6	6	6	6	6
Carbonaceous BOD	mg/L	Min	Dry	6.0	6.0	6.0	6.0	6.0	6.0
Carbonaceous BOD	mg/L	Max	Dry	6.0	6.0	6.0	6.0	6.0	6.0
Carbonaceous BOD	mg/L	Average	Wet	2.4	2.0	2.1	2.0	2.0	2.0
Carbonaceous BOD	mg/L	Min	Wet	2.0	2.0	2.0	2.0	2.0	2.0
Carbonaceous BOD	mg/L	Max	Wet	4.1	2.0	2.8	2.0	2.0	2.1
Conductivity	Ms/cm	Average	Dry	679	283	746	308	195	436
Conductivity	Ms/cm	Min	Dry	1	1	1	2	2	1
Conductivity	Ms/cm	Max	Dry	2080	798	2100	828	520	1177
Conductivity	Ms/cm	Average	Wet	660	548	1006	542	1234	1051
Conductivity	Ms/cm	Min	Wet	505	447	784	276	878	931
Conductivity	Ms/cm	Max	Wet	851	657	1178	748	1561	1245
Dissolved Oxygen	mg/L	Average	Dry	9.4	8.7	9.6	10.2	9.1	6.5
Dissolved Oxygen	mg/L	Min	Dry	7.8	5.8	8.6	9.2	6.8	5.9
Dissolved Oxygen	mg/L	Max	Dry	10.4	10.8	10.5	12.4	10.8	8.6
Dissolved Oxygen	mg/L	Average	Wet	8.8	6.1	6.0	6.3	6.7	6.0
Dissolved Oxygen	mg/L	Min	Wet	6.1	5.3	5.4	5.3	5.8	5.2
Dissolved Oxygen	mg/L	Max	Wet	14.3	6.8	6.9	7.1	7.4	7.3
E.Coli (End Point)	MPN/100mL	Average	Dry	164	135	175	34	300	192
E.Coli (End Point)	MPN/100mL	Min	Dry	43	15	4	7	4	23
E.Coli (End Point)	MPN/100mL	Max	Dry	430	430	649	75	866	517
E.Coli (End Point)	MPN/100mL	Average	Wet	1,224	2,307	6,336	1,519	5,578	1,615
E.Coli (End Point)	MPN/100mL	Min	Wet	23	411	186	69	201	172
E.Coli (End Point)	MPN/100mL	Max	Wet	10,000	10,000	24,200	10,000	24,200	10,000
Fecal Coliform (End Point)	MPN/100mL	Average	Dry	428	397	390	77	667	535
Fecal Coliform (End Point)	MPN/100mL	Min	Dry	93	15	4	15	4	23
Fecal Coliform (End Point)	MPN/100mL	Max	Dry	1,050	1,200	1,410	228	2,420	1,990
Fecal Coliform (End Point)	MPN/100mL	Average	Wet	1,929	3,372	16,651	1,901	7,259	2,303
Fecal Coliform (End Point)	MPN/100mL	Min	Wet	57	886	300	206	135	691
Fecal Coliform (End Point)	MPN/100mL	Max	Wet	10,000	10,000	81,600	10,000	24,200	10,000
Nitrate + Nitrite	mg/L	Average	Dry	0.09	0.06	0.20	0.05	0.11	0.07
Nitrate + Nitrite	mg/L	Min	Dry	0.04	0.02	0.04	0.02	0.05	0.02
Nitrate + Nitrite	mg/L	Max	Dry	0.25	0.07	0.39	0.07	0.35	0.10
Nitrate + Nitrite	mg/L	Average	Wet	1.18	0.36	0.14	0.06	0.07	0.12
Nitrate + Nitrite	mg/L	Min	Wet	0.07	0.14	0.07	0.01	0.01	0.07
Nitrate + Nitrite	mg/L	Max	Wet	3.67	0.87	0.31	0.13	0.14	0.31
Nitrate-N	mg/L	Average	Dry	0.08	0.06	0.18	0.06	0.09	0.08
Nitrate-N	mg/L	Min	Dry	0.05	0.05	0.07	0.05	0.05	0.06
Nitrate-N	mg/L	Max	Dry	0.25	0.07	0.39	0.07	0.25	0.12
Nitrate-N	mg/L	Average	Wet	1.12	0.34	0.13	0.05	0.05	0.10
Nitrate-N	mg/L	Min	Wet	0.02	0.14	0.03	0.02	0.02	0.04
Nitrate-N	mg/L	Max	Wet	3.56	0.79	0.30	0.12	0.14	0.28
Nitrite-N	mg/L	Average	Dry	0.04	0.04	0.14	0.04	0.06	0.04
Nitrite-N	mg/L	Min	Dry	0.01	0.01	0.01	0.01	0.01	0.01
Nitrite-N	mg/L	Max	Dry	0.05	0.05	0.25	0.05	0.25	0.05
Nitrite-N	mg/L	Average	Wet	0.05	0.03	0.01	0.02	0.03	0.02
Nitrite-N	mg/L	Min	Wet	0.01	0.01	0.01	0.01	0.01	0.01
Nitrite-N	mg/L	Max	Wet	0.11	0.07	0.02	0.07	0.07	0.03

				1	2	3	4	5	6
Parameter	Units	Measure	Type	La Salle River	Seine River	Strugeon Creek	Truro Creek	Omands Creek	Bunns Creek
				B	B	B	B	B	B
pH	-	Average	Dry	8.47	8.22	8.20	8.43	8.25	8.17
pH	-	Min	Dry	8.30	8.11	8.10	8.10	8.10	7.80
pH	-	Max	Dry	8.76	8.30	8.30	9.06	8.43	8.50
pH	-	Average	Wet	8.63	8.20	8.20	8.16	8.09	8.36
pH	-	Min	Wet	8.13	7.93	8.08	7.93	7.95	8.05
pH	-	Max	Wet	9.55	8.50	8.38	8.44	8.30	8.72
Temperature	C deg.	Average	Dry	12.7	12.8	11.9	15.2	14.0	12.9
Temperature	C deg.	Min	Dry	6.3	7.4	8.8	8.1	7.8	6.0
Temperature	C deg.	Max	Dry	21.0	20.0	17.9	25.9	23.0	23.0
Temperature	C deg.	Average	Wet	22.1	20.2	19.4	18.1	18.6	20.5
Temperature	C deg.	Min	Wet	19.1	17.3	17.5	14.8	15.8	17.8
Temperature	C deg.	Max	Wet	25.5	22.8	21.5	20.3	21.3	24.3
Total Kjeldahl Nitrogen	mg/L	Average	Dry	1.27	0.78	0.74	1.26	0.84	1.49
Total Kjeldahl Nitrogen	mg/L	Min	Dry	0.71	0.61	0.50	0.48	0.72	0.80
Total Kjeldahl Nitrogen	mg/L	Max	Dry	1.59	0.88	1.04	2.96	1.01	2.26
Total Kjeldahl Nitrogen	mg/L	Average	Wet	2.29	1.30	0.85	0.69	0.88	1.05
Total Kjeldahl Nitrogen	mg/L	Min	Wet	1.27	1.14	0.61	0.38	0.38	0.27
Total Kjeldahl Nitrogen	mg/L	Max	Wet	3.76	1.76	1.08	0.91	1.14	1.66
Total Nitrogen	mg/L	Average	Dry	1.30	0.78	0.68	1.26	0.86	1.46
Total Nitrogen	mg/L	Min	Dry	0.73	0.61	0.50	0.48	0.72	0.80
Total Nitrogen	mg/L	Max	Dry	1.59	0.88	0.87	2.96	1.10	2.16
Total Nitrogen	mg/L	Average	Wet	3.44	1.47	0.96	0.72	0.91	1.21
Total Nitrogen	mg/L	Min	Wet	1.83	0.18	0.72	0.46	0.52	0.86
Total Nitrogen	mg/L	Max	Wet	6.44	2.17	1.28	0.91	1.14	1.66
Total Phosphorus	mg/L	Average	Dry	0.41	0.15	0.12	0.34	0.13	0.19
Total Phosphorus	mg/L	Min	Dry	0.08	0.11	0.07	0.05	0.08	0.15
Total Phosphorus	mg/L	Max	Dry	0.76	0.26	0.22	0.95	0.18	0.24
Total Phosphorus	mg/L	Average	Wet	0.54	0.23	0.13	0.13	0.29	0.30
Total Phosphorus	mg/L	Min	Wet	0.30	0.18	0.08	0.09	0.08	0.18
Total Phosphorus	mg/L	Max	Wet	0.90	0.28	0.14	0.18	0.38	0.91
Total Suspended Solids	mg/L	Average	Dry	33	19	18	27	49	17
Total Suspended Solids	mg/L	Min	Dry	16	7	5	5	5	5
Total Suspended Solids	mg/L	Max	Dry	60	29	35	47	123	51
Total Suspended Solids	mg/L	Average	Wet	57	67	22	9	8	10
Total Suspended Solids	mg/L	Min	Wet	21	37	7	5	5	5
Total Suspended Solids	mg/L	Max	Wet	126	114	37	17	13	26

Red River Sample Location Results

Parameter	Units	Measure	Type	1	1	1	2	2	2	3	3	3	4	4	4	5	5	5	6	6
				South Floodway Control			Fort Garry Bridge			Norwood Bridge			Provencher Bridge			North Perimeter Bridge			Lockport Bridge	
				A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	C
Ammonia	mg/L	Average	Dry	0.010	0.010	0.010	0.118	0.132	0.143	0.102	0.110	0.101	0.023	0.044	0.073	0.224	0.180	0.140	0.203	0.173
Ammonia	mg/L	Min	Dry	0.010	0.010	0.010	0.025	0.033	0.030	0.059	0.049	0.057	0.012	0.024	0.038	0.117	0.093	0.075	0.047	0.034
Ammonia	mg/L	Max	Dry	0.012	0.010	0.010	0.182	0.227	0.233	0.145	0.177	0.145	0.044	0.078	0.109	0.298	0.251	0.184	0.302	0.250
Ammonia	mg/L	Average	Wet	0.012	0.012	0.011	0.034	0.034	0.034	0.054	0.061	0.060	0.021	0.039	0.058	0.136	0.105	0.089	0.085	0.070
Ammonia	mg/L	Min	Wet	0.010	0.010	0.010	0.021	0.010	0.022	0.032	0.036	0.042	0.010	0.023	0.031	0.090	0.079	0.076	0.054	0.040
Ammonia	mg/L	Max	Wet	0.022	0.020	0.014	0.051	0.051	0.049	0.084	0.095	0.088	0.038	0.059	0.091	0.161	0.133	0.120	0.118	0.105
BOD	mg/L	Average	Dry	4.86	4.93	4.86	4.50	4.59	4.54	4.81	4.74	4.64	4.86	4.86	4.76	5.04	5.09	4.93	5.14	4.87
BOD	mg/L	Min	Dry	2.00	2.00	2.00	2.00	2.00	2.00	2.30	2.50	2.00	2.00	2.00	2.40	2.50	2.40	2.00	2.90	2.00
BOD	mg/L	Max	Dry	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.10	6.00	6.00	6.00	6.00
BOD	mg/L	Average	Wet	2.34	2.16	2.27	2.02	2.23	2.19	2.53	2.88	2.68	2.14	2.12	2.10	2.46	2.56	2.42	3.26	2.77
BOD	mg/L	Min	Wet	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
BOD	mg/L	Max	Wet	3.00	2.60	2.80	2.20	3.10	2.70	3.70	4.30	3.70	2.70	2.40	2.40	3.20	4.30	3.30	6.60	6.20
Carbonaceous BOD	mg/L	Average	Dry	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Carbonaceous BOD	mg/L	Min	Dry	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Carbonaceous BOD	mg/L	Max	Dry	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Carbonaceous BOD	mg/L	Average	Wet	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Carbonaceous BOD	mg/L	Min	Wet	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Carbonaceous BOD	mg/L	Max	Wet	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Conductivity	Ms/cm	Average	Dry	872	874	873	877	880	879	876	874	876	1094	1036	932	995	994	993	996	996
Conductivity	Ms/cm	Min	Dry	818	820	820	856	857	858	853	850	852	1038	995	865	950	945	949	945	940
Conductivity	Ms/cm	Max	Dry	906	905	902	892	894	891	901	898	902	1115	1065	1038	1024	1024	1024	1031	1040
Conductivity	Ms/cm	Average	Wet	860	858	853	887	885	883	889	889	888	1079	980	894	959	959	959	956	957
Conductivity	Ms/cm	Min	Wet	835	829	830	850	848	846	849	847	849	1023	938	855	936	933	929	932	934
Conductivity	Ms/cm	Max	Wet	885	885	882	933	927	930	944	946	945	1119	1004	952	1000	1003	1007	1018	1014
Dissolved Oxygen	mg/L	Average	Dry	8.6	8.7	8.6	8.6	8.7	8.6	8.6	8.7	8.7	9.2	9.3	9.1	9.1	9.1	9.0	9.0	9.0
Dissolved Oxygen	mg/L	Min	Dry	5.7	5.6	5.7	6.2	6.2	6.2	6.1	6.5	6.4	7.0	7.2	6.2	6.5	6.6	6.4	6.4	6.4
Dissolved Oxygen	mg/L	Max	Dry	10.6	10.6	10.5	10.2	10.1	10.0	10.1	10.2	10.2	10.6	10.7	10.7	10.8	10.8	10.8	10.7	10.6
Dissolved Oxygen	mg/L	Average	Wet	6.4	6.4	6.5	6.7	6.7	6.6	6.5	6.5	6.3	7.1	6.7	6.5	6.6	6.6	6.5	6.2	6.1
Dissolved Oxygen	mg/L	Min	Wet	5.5	5.9	5.8	6.3	6.1	6.1	5.8	6.0	5.8	6.4	6.2	5.9	5.8	6.0	6.0	5.5	5.6
Dissolved Oxygen	mg/L	Max	Wet	7.1	7.2	7.1	7.6	7.9	7.2	7.4	7.0	6.8	7.5	7.3	7.0	7.0	7.0	7.0	7.2	6.9
E.Coli (End Point)	MPN/100mL	Average	Dry	56	19	25	38	26	17	98	89	47	57	164	63	87	69	120	290	264
E.Coli (End Point)	MPN/100mL	Min	Dry	15	1	4	13	9	4	21	15	18	15	11	19	23	23	43	23	23
E.Coli (End Point)	MPN/100mL	Max	Dry	230	40	73	93	43	43	430	230	93	93	930	210	150	124	230	930	750
E.Coli (End Point)	MPN/100mL	Average	Wet	1,230	1,240	1,219	1,219	1,250	1,236	1,242	1,229	2,335	1,343	1,270	1,248	1,385	1,416	1,401	1,849	1,773
E.Coli (End Point)	MPN/100mL	Min	Wet	16	20	15	8	16	10	26	25	30	63	29	20	131	142	161	201	100
E.Coli (End Point)	MPN/100mL	Max	Wet	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	20,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
Fecal Coliform (End Point)	MPN/100mL	Average	Dry		318			269			530			1,000			464		614	800
Fecal Coliform (End Point)	MPN/100mL	Min	Dry		4			9			15			43			23		23	437
Fecal Coliform (End Point)	MPN/100mL	Max	Dry		1,850			1,200			2,420			3,780			2,280		1,110	1,350
Fecal Coliform (End Point)	MPN/100mL	Average	Wet		1,603	200		1,909			2,191			2,845			2,580		4,785	3,081
Fecal Coliform (End Point)	MPN/100mL	Min	Wet		80			100			200			243			200		581	410
Fecal Coliform (End Point)	MPN/100mL	Max	Wet		10,000			10,000			10,000			10,000			10,000		10,000	12,000
Nitrate + Nitrite	mg/L	Average	Dry	0.32	0.32	0.32	0.32	0.33	0.33	0.32	0.32	0.32	0.32	0.31	0.38	0.36	0.36	0.36	0.40	0.36
Nitrate + Nitrite	mg/L	Min	Dry	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.25	0.17	0.09	0.21	0.20	0.20	0.24	0.05
Nitrate + Nitrite	mg/L	Max	Dry	0.69	0.70	0.73	0.72	0.72	0.73	0.73	0.73	0.73	0.37	0.47	0.73	0.56	0.56	0.60	0.66	0.65
Nitrate + Nitrite	mg/L	Average	Wet	0.75	0.72	0.76	0.73	0.73	0.73	0.73	0.74	0.74	0.42	0.56	0.72	0.68	0.61	0.61	0.61	0.61
Nitrate + Nitrite	mg/L	Min	Wet	0.49	0.15	0.49	0.50	0.49	0.48	0.51	0.53	0.53	0.26	0.45	0.51	0.48	0.47	0.47	0.46	0.50
Nitrate + Nitrite	mg/L	Max	Wet	1.32	1.33	1.34	1.32	1.33	1.33	1.35	1.36	1.35	0.69	0.89	1.35	1.09	1.04	1.04	1.00	0.96
Nitrate-N	mg/L	Average	Dry	0.31	0.31	0.32	0.32	0.33	0.33	0.32	0.32	0.32	0.32	0.30	0.38	0.37	0.36	0.37	0.40	0.40
Nitrate-N	mg/L	Min	Dry	0.06	0.06	0.06	0.06	0.06	0.06	0.05	0.05	0.05	0.25	0.17	0.09	0.21	0.20	0.20	0.24	0.24
Nitrate-N	mg/L	Max	Dry	0.69	0.70	0.73	0.72	0.72	0.73	0.74	0.74	0.74	0.37	0.47	0.74	0.57	0.57	0.62	0.69	0.67
Nitrate-N	mg/L	Average	Wet	0.75	0.72	0.76	0.73	0.73	0.73	0.73	0.73	0.73	0.42	0.56	0.72	0.66	0.60	0.60	0.61	0.60
Nitrate-N	mg/L	Min	Wet	0.49	0.15	0.49	0.50	0.49	0.48	0.51	0.52	0.52	0.26	0.45	0.51	0.46	0.46	0.46	0.49	0.49
Nitrate-N	mg/L	Max	Wet	1.32	1.33	1.33	1.32	1.33	1.33	1.34	1.35	1.33	0.69	0.89	1.34	1.09	1.03	1.03	0.98	0.94

Red River Sample Location Results

				1	1	1	2	2	2	3	3	3	4	4	4	5	5	5	6	6
Parameter	Units	Measure	Type	South Floodway Control			Fort Garry Bridge			Norwood Bridge			Provencher Bridge			North Perimeter Bridge			Lockport Bridge	
				A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	C
Nitrite-N	**mg/L**	**Average**	Dry	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Nitrite-N	**mg/L**	**Min**	Dry	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Nitrite-N	**mg/L**	**Max**	Dry	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Nitrite-N	**mg/L**	**Average**	Wet	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Nitrite-N	**mg/L**	**Min**	Wet	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Nitrite-N	**mg/L**	**Max**	Wet	0.01	0.10	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.02	0.02	0.01	0.02	0.02
pH	**-**	**Average**	Dry	8.52	8.54	8.55	8.50	8.50	8.49	8.46	8.50	8.46	8.52	8.51	8.45	8.43	8.43	8.45	8.42	8.44
pH	**-**	**Min**	Dry	8.40	8.40	8.42	8.33	8.33	8.34	8.26	8.33	8.30	8.40	8.40	8.30	8.30	8.30	8.20	8.30	8.40
pH	**-**	**Max**	Dry	8.60	8.70	8.70	8.60	8.60	8.60	8.60	8.60	8.60	8.60	8.60	8.60	8.60	8.60	8.50	8.50	8.50
pH	**-**	**Average**	Wet	8.39	8.40	8.40	8.28	8.29	8.25	8.25	8.25	8.26	8.49	8.38	8.21	8.35	8.33	8.33	8.36	8.34
pH	**-**	**Min**	Wet	8.25	8.25	8.24	8.10	8.17	8.06	8.11	8.04	8.08	8.25	8.20	8.05	8.20	8.14	8.18	8.16	8.21
pH	**-**	**Max**	Wet	8.55	8.53	8.56	8.42	8.42	8.42	8.44	8.45	8.50	8.72	8.56	8.40	8.52	8.50	8.53	8.54	8.50
Temperature	**C deg.**	**Average**	Dry	14.7	14.7	14.7	14.9	14.9	14.9	15.1	14.9	15.1	14.8	14.8	14.9	14.9	14.9	14.9	14.7	14.7
Temperature	**C deg.**	**Min**	Dry	8.0	7.9	8.1	8.4	8.5	8.4	8.8	8.7	8.6	8.9	9.0	9.0	8.7	8.7	8.7	8.6	8.7
Temperature	**C deg.**	**Max**	Dry	24.5	24.4	24.6	24.2	24.1	24.2	24.7	24.2	24.7	24.0	23.9	24.2	24.1	24.0	24.2	23.9	24.0
Temperature	**C deg.**	**Average**	Wet	21.6	21.5	21.6	21.3	21.2	21.2	21.2	21.2	21.3	21.2	21.2	21.4	21.6	45.5	21.6	21.8	21.8
Temperature	**C deg.**	**Min**	Wet	18.1	18.0	17.9	17.9	17.9	17.9	17.9	17.9	17.8	17.8	17.9	18.0	18.4	18.1	18.5	18.7	18.1
Temperature	**C deg.**	**Max**	Wet	24.0	23.9	24.1	23.7	23.6	23.8	23.5	23.5	23.6	23.4	23.3	23.6	23.9	239.0	24.0	24.0	24.1
Total Kjeldahl Nitrogen	**mg/L**	**Average**	Dry	0.97	0.97	1.00	1.07	1.03	1.06	1.02	1.06	1.05	1.26	1.19	1.14	1.28	1.22	1.26	1.24	1.17
Total Kjeldahl Nitrogen	**mg/L**	**Min**	Dry	0.89	0.91	0.93	0.86	0.89	0.91	0.85	0.90	0.91	1.00	0.96	0.93	0.99	0.92	1.02	0.92	0.91
Total Kjeldahl Nitrogen	**mg/L**	**Max**	Dry	1.07	1.07	1.08	1.20	1.19	1.25	1.12	1.17	1.12	1.47	1.41	1.31	1.50	1.41	1.40	1.47	1.39
Total Kjeldahl Nitrogen	**mg/L**	**Average**	Wet	1.15	1.08	1.10	1.16	1.17	1.17	1.22	1.25	1.20	1.18	1.20	1.16	1.23	1.17	1.17	1.19	1.22
Total Kjeldahl Nitrogen	**mg/L**	**Min**	Wet	0.80	0.86	0.88	0.93	0.83	0.85	0.91	0.87	0.87	1.01	0.96	0.89	1.01	0.94	0.95	0.95	0.91
Total Kjeldahl Nitrogen	**mg/L**	**Max**	Wet	1.69	1.51	1.38	1.50	1.51	1.40	1.51	1.90	1.50	1.52	1.53	1.42	1.44	1.42	1.44	1.53	1.69
Total Nitrogen	**mg/L**	**Average**	Dry	1.27	1.27	1.30	1.37	1.35	1.37	1.32	1.35	1.35	1.58	1.50	1.52	1.65	1.58	1.63	1.65	1.57
Total Nitrogen	**mg/L**	**Min**	Dry	0.89	0.91	0.95	1.16	1.08	1.10	1.04	1.05	1.05	1.25	1.39	1.19	1.56	1.48	1.52	1.51	1.41
Total Nitrogen	**mg/L**	**Max**	Dry	1.63	1.69	1.77	1.72	1.61	1.64	1.79	1.90	1.82	1.78	1.71	2.03	1.76	1.66	1.79	1.72	1.70
Total Nitrogen	**mg/L**	**Average**	Wet	1.90	1.84	1.85	1.89	1.90	1.89	1.95	1.99	1.94	1.60	1.76	1.88	1.90	1.78	1.78	1.81	1.83
Total Nitrogen	**mg/L**	**Min**	Wet	1.43	1.44	1.45	1.58	1.65	1.64	1.57	1.63	1.74	1.41	1.53	1.57	1.61	1.61	1.56	1.57	1.55
Total Nitrogen	**mg/L**	**Max**	Wet	2.35	2.28	2.45	2.30	2.35	2.37	2.31	2.55	2.21	1.85	2.04	2.33	2.49	2.11	2.08	2.11	2.29
Total Phosphorus	**mg/L**	**Average**	Dry	0.16	0.16	0.23	0.17	0.17	0.18	0.17	0.16	0.17	0.24	0.44	0.20	0.22	0.21	0.21	0.21	0.20
Total Phosphorus	**mg/L**	**Min**	Dry	0.13	0.14	0.15	0.16	0.15	0.15	0.15	0.14	0.14	0.16	0.16	0.15	0.17	0.16	0.17	0.16	0.17
Total Phosphorus	**mg/L**	**Max**	Dry	0.19	0.18	0.67	0.19	0.19	0.19	0.18	0.18	0.18	0.32	2.02	0.28	0.26	0.25	0.25	0.24	0.22
Total Phosphorus	**mg/L**	**Average**	Wet	0.25	0.22	0.23	0.23	0.23	0.21	0.22	0.27	0.25	0.20	0.21	0.24	0.21	0.20	0.20	0.21	0.23
Total Phosphorus	**mg/L**	**Min**	Wet	0.15	0.15	0.15	0.15	0.14	0.14	0.15	0.14	0.15	0.13	0.14	0.14	0.16	0.14	0.14	0.15	0.14
Total Phosphorus	**mg/L**	**Max**	Wet	0.47	0.41	0.35	0.31	0.33	0.32	0.41	0.48	0.37	0.29	0.36	0.35	0.27	0.29	0.26	0.28	0.42
Total Suspended Solids	**mg/L**	**Average**	Dry	222	172	153	101	108	97	108	107	118	209	189	153	111	121	121	92	64
Total Suspended Solids	**mg/L**	**Min**	Dry	80	69	62	49	44	53	37	32	36	178	123	43	85	99	106	53	53
Total Suspended Solids	**mg/L**	**Max**	Dry	516	370	300	214	208	219	269	247	264	236	242	238	136	137	162	176	79
Total Suspended Solids	**mg/L**	**Average**	Wet	329	312	286	215	250	252	232	345	318	232	260	278	172	212	200	236	204
Total Suspended Solids	**mg/L**	**Min**	Wet	195	148	154	91	118	77	131	208	190	152	162	149	72	105	115	80	71
Total Suspended Solids	**mg/L**	**Max**	Wet	510	554	538	392	376	452	388	468	517	415	322	514	350	398	356	435	362

Assiniboine River Sample Location Results

				1	1	1	2	2	2	3	3	3
Parameter	Units	Measure	Type	Headingley Bridge			Assiniboine Park Bridge			Osborne Street Bridge		
				A	B	C	A	B	C	A	B	C
Ammonia	**mg/L**	**Average**	Dry	0.020	0.017	0.016	0.017	0.017	0.018	0.015	0.015	0.014
Ammonia	**mg/L**	**Min**	Dry	0.010	0.010	0.010	0.010	0.010	0.010	0.011	0.010	0.010
Ammonia	**mg/L**	**Max**	Dry	0.035	0.021	0.022	0.027	0.034	0.038	0.021	0.022	0.021
Ammonia	**mg/L**	**Average**	Wet	0.014	0.015	0.011	0.012	0.014	0.016	0.014	0.013	0.017
Ammonia	**mg/L**	**Min**	Wet	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Ammonia	**mg/L**	**Max**	Wet	0.023	0.023	0.020	0.019	0.026	0.052	0.035	0.019	0.043
BOD	**mg/L**	**Average**	Dry	4.86	4.86	4.86	4.86	4.86	4.86	4.86	4.86	4.86
BOD	**mg/L**	**Min**	Dry	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
BOD	**mg/L**	**Max**	Dry	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
BOD	**mg/L**	**Average**	Wet	2.00	2.44	2.56	2.03	2.00	2.00	2.00	2.00	2.01
BOD	**mg/L**	**Min**	Wet	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
BOD	**mg/L**	**Max**	Wet	2.00	6.00	6.00	2.30	2.00	2.00	2.00	2.00	2.10
Carbonaceous BOD	**mg/L**	**Average**	Dry	6	6	6	6	6	6	6	6	6
Carbonaceous BOD	**mg/L**	**Min**	Dry	6	6	6	6	6	6	6	6	6
Carbonaceous BOD	**mg/L**	**Max**	Dry	6	6	6	6	6	6	6	6	6
Carbonaceous BOD	**mg/L**	**Average**	Wet	2	2	2	2	2	2	2	2	2
Carbonaceous BOD	**mg/L**	**Min**	Wet	2	2	2	2	2	2	2	2	2
Carbonaceous BOD	**mg/L**	**Max**	Wet	2	2	2	2	2	2	2	2	2
Conductivity	**Ms/cm**	**Average**	Dry	414	414	414	416	415	415	416	416	418
Conductivity	**Ms/cm**	**Min**	Dry	1	1	1	1	1	1	1	1	1
Conductivity	**Ms/cm**	**Max**	Dry	1107	1106	1107	1109	1109	1108	1110	1110	1119
Conductivity	**Ms/cm**	**Average**	Wet	1075	1086	1085	1088	1089	1088	1092	1093	1092
Conductivity	**Ms/cm**	**Min**	Wet	1000	1074	1073	1081	1080	1079	1079	1083	1082
Conductivity	**Ms/cm**	**Max**	Wet	1102	1102	1099	1104	1101	1102	1102	1105	1103
Dissolved Oxygen	**mg/L**	**Average**	Dry	8.9	8.9	9.0	9.0	8.9	8.9	8.9	8.9	8.8
Dissolved Oxygen	**mg/L**	**Min**	Dry	7.2	7.1	7.1	6.6	6.6	6.8	6.7	6.8	6.5
Dissolved Oxygen	**mg/L**	**Max**	Dry	10.3	10.2	10.2	10.3	10.1	10.2	10.2	10.2	10.2
Dissolved Oxygen	**mg/L**	**Average**	Wet	7.3	7.2	7.2	7.4	7.3	7.3	7.2	7.2	7.2
Dissolved Oxygen	**mg/L**	**Min**	Wet	6.6	6.6	6.5	7.0	6.6	6.8	6.6	6.6	6.6
Dissolved Oxygen	**mg/L**	**Max**	Wet	7.8	7.5	7.9	7.7	7.6	7.9	7.5	7.4	7.7
E.Coli (End Point)	**MPN/100mL**	**Average**	Dry	21	46	17	28	27	32	42	44	33
E.Coli (End Point)	**MPN/100mL**	**Min**	Dry	4	3	3	7	4	7	4	9	15
E.Coli (End Point)	**MPN/100mL**	**Max**	Dry	38	230	32	47	45	93	79	93	61
E.Coli (End Point)	**MPN/100mL**	**Average**	Wet	1,167	1,177	1,170	1,341	1,184	1,177	1,297	1,249	1,266
E.Coli (End Point)	**MPN/100mL**	**Min**	Wet	20	20	10	42	31	10	41	20	41
E.Coli (End Point)	**MPN/100mL**	**Max**	Wet	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000

Assiniboine River Sample Location Results

				1	1	1	2	2	2	3	3	3
Parameter	**Units**	**Measure**	**Type**	**Headingley Bridge**			**Assiniboine Park Bridge**			**Osborne Street Bridge**		
				A	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**
Fecal Coliform (End Point)	**MPN/100mL**	**Average**	Dry		449			1,317			999	
Fecal Coliform (End Point)	**MPN/100mL**	**Min**	Dry		3			4			21	
Fecal Coliform (End Point)	**MPN/100mL**	**Max**	Dry		2,210			7,920			6,290	
Fecal Coliform (End Point)	**MPN/100mL**	**Average**	Wet		2,054			2,171			2,751	
Fecal Coliform (End Point)	**MPN/100mL**	**Min**	Wet		100			100			100	
Fecal Coliform (End Point)	**MPN/100mL**	**Max**	Wet		10,000			10,000			10,000	
Nitrate + Nitrite	**mg/L**	**Average**	Dry	0.30	0.29	0.29	0.30	0.30	0.30	0.29	0.30	0.30
Nitrate + Nitrite	**mg/L**	**Min**	Dry	0.25	0.20	0.19	0.27	0.26	0.27	0.23	0.25	0.25
Nitrate + Nitrite	**mg/L**	**Max**	Dry	0.36	0.35	0.36	0.36	0.37	0.37	0.36	0.36	0.36
Nitrate + Nitrite	**mg/L**	**Average**	Wet	0.29	0.29	0.28	0.30	0.30	0.30	0.31	0.30	0.30
Nitrate + Nitrite	**mg/L**	**Min**	Wet	0.14	0.14	0.14	0.14	0.14	0.14	0.15	0.15	0.15
Nitrate + Nitrite	**mg/L**	**Max**	Wet	0.44	0.44	0.43	0.49	0.49	0.50	0.50	0.51	0.50
Nitrate-N	**mg/L**	**Average**	Dry	0.30	0.29	0.29	0.30	0.30	0.30	0.29	0.30	0.30
Nitrate-N	**mg/L**	**Min**	Dry	0.25	0.20	0.19	0.27	0.26	0.27	0.23	0.25	0.25
Nitrate-N	**mg/L**	**Max**	Dry	0.36	0.35	0.36	0.36	0.37	0.37	0.36	0.36	0.36
Nitrate-N	**mg/L**	**Average**	Wet	0.29	0.29	0.28	0.30	0.30	0.30	0.31	0.30	0.30
Nitrate-N	**mg/L**	**Min**	Wet	0.14	0.14	0.14	0.14	0.14	0.14	0.15	0.15	0.15
Nitrate-N	**mg/L**	**Max**	Wet	0.44	0.44	0.43	0.49	0.49	0.50	0.50	0.51	0.50
Nitrite-N	**mg/L**	**Average**	Dry	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Nitrite-N	**mg/L**	**Min**	Dry	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Nitrite-N	**mg/L**	**Max**	Dry	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Nitrite-N	**mg/L**	**Average**	Wet	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Nitrite-N	**mg/L**	**Min**	Wet	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Nitrite-N	**mg/L**	**Max**	Wet	0.02	0.01	0.01	0.02	0.01	0.02	0.02	0.01	0.01
pH	**-**	**Average**	Dry	8.43	8.44	8.41	8.42	8.43	8.43	8.45	8.46	8.44
pH	**-**	**Min**	Dry	8.20	8.30	8.20	8.20	8.20	8.20	8.30	8.20	8.20
pH	**-**	**Max**	Dry	8.72	8.68	8.72	8.74	8.70	8.74	8.73	8.74	8.72
pH	**-**	**Average**	Wet	8.63	8.62	8.61	8.61	8.64	8.62	8.62	8.64	8.64
pH	**-**	**Min**	Wet	8.52	8.52	8.47	8.34	8.53	8.46	8.50	8.49	8.51
pH	**-**	**Max**	Wet	8.78	8.77	8.76	8.78	8.77	8.79	8.78	8.77	8.76
Temperature	**C deg.**	**Average**	Dry	14.6	14.6	14.6	14.7	14.6	14.7	14.8	14.8	14.8
Temperature	**C deg.**	**Min**	Dry	8.2	8.1	8.4	8.6	8.4	8.6	8.9	9.0	8.9
Temperature	**C deg.**	**Max**	Dry	23.9	23.9	23.9	23.9	23.8	23.8	23.8	23.7	23.8
Temperature	**C deg.**	**Average**	Wet	21.6	21.6	21.6	21.6	21.6	21.5	21.6	21.5	21.5
Temperature	**C deg.**	**Min**	Wet	18.2	18.5	18.3	18.8	18.7	18.6	18.5	18.5	18.4
Temperature	**C deg.**	**Max**	Wet	23.8	23.9	23.8	23.8	23.8	23.6	23.7	23.6	23.6

Assiniboine River Sample Location Results

				1	1	1	2	2	2	3	3	3
Parameter	Units	Measure	Type	Headingley Bridge			Assiniboine Park Bridge			Osborne Street Bridge		
				A	B	C	A	B	C	A	B	C
Total Kjeldahl Nitrogen	mg/L	Average	Dry	1.25	1.19	1.23	1.21	1.24	1.24	1.30	1.28	1.25
Total Kjeldahl Nitrogen	mg/L	Min	Dry	0.89	0.85	0.95	0.88	0.95	0.89	1.05	1.03	0.97
Total Kjeldahl Nitrogen	mg/L	Max	Dry	1.73	1.53	1.69	1.52	1.54	1.74	1.56	1.54	1.50
Total Kjeldahl Nitrogen	mg/L	Average	Wet	1.10	1.08	1.09	1.10	1.11	1.14	1.13	1.10	1.18
Total Kjeldahl Nitrogen	mg/L	Min	Wet	0.90	0.90	0.89	0.88	0.84	0.92	0.88	0.90	0.86
Total Kjeldahl Nitrogen	mg/L	Max	Wet	1.43	1.39	1.30	1.53	1.52	1.44	1.50	1.59	2.12
Total Nitrogen	mg/L	Average	Dry	1.55	1.48	1.51	1.51	1.54	1.55	1.59	1.58	1.55
Total Nitrogen	mg/L	Min	Dry	1.13	1.06	1.16	1.15	1.22	1.16	1.28	1.32	1.23
Total Nitrogen	mg/L	Max	Dry	2.02	1.82	1.98	1.81	1.83	2.03	1.86	1.83	1.79
Total Nitrogen	mg/L	Average	Wet	1.38	1.37	1.38	1.40	1.41	1.45	1.44	1.41	1.48
Total Nitrogen	mg/L	Min	Wet	1.12	1.19	1.20	1.08	1.05	1.15	1.09	1.10	1.08
Total Nitrogen	mg/L	Max	Wet	1.68	1.56	1.61	1.67	1.66	1.68	1.65	1.74	2.34
Total Phosphorus	mg/L	Average	Dry	0.24	0.21	0.23	0.21	0.22	0.22	0.24	0.23	0.22
Total Phosphorus	mg/L	Min	Dry	0.15	0.15	0.15	0.15	0.16	0.15	0.17	0.16	0.15
Total Phosphorus	mg/L	Max	Dry	0.37	0.30	0.34	0.29	0.32	0.38	0.32	0.32	0.33
Total Phosphorus	mg/L	Average	Wet	0.17	0.17	0.18	0.18	0.18	0.18	0.18	0.18	0.18
Total Phosphorus	mg/L	Min	Wet	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
Total Phosphorus	mg/L	Max	Wet	0.27	0.28	0.29	0.29	0.29	0.28	0.28	0.28	0.30
Total Suspended Solids	mg/L	Average	Dry	246	276	252	262	265	248	228	223	259
Total Suspended Solids	mg/L	Min	Dry	198	225	215	209	216	215	211	197	217
Total Suspended Solids	mg/L	Max	Dry	321	339	332	345	334	288	261	253	306
Total Suspended Solids	mg/L	Average	Wet	186	202	191	191	209	197	189	192	190
Total Suspended Solids	mg/L	Min	Wet	108	125	130	113	121	122	123	123	123
Total Suspended Solids	mg/L	Max	Wet	252	305	271	282	402	322	277	282	280

CSO Discharge Results

Location	Measure	Ammonia	BOD	Nitrate-N	Nitrate + Nitrite	Nitrite-N	Total Phosphorus	Total Kjeldahl Nitrogen	Total Nitrogen	Total Suspended Solids	E.Coli	Fecal Coliform	Temperature	pH	Conductivity
		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	MPN/100mL	MPN/100mL	C deg.	-	Ms/cm
Ash	Average	3.66	115	0.11	0.16	0.02	2.12	10.63	10.73	386	Not Tested	6,882,083	20.65	7.58	312
Ash	Minimum	0.26	20	0.02	0.07	0.01	0.55	1.90	1.90	81	Not Tested	2,360,000	20.30	7.30	130
Ash	Maximum	12.10	540	0.49	0.53	0.04	4.37	23.60	23.60	808	Not Tested	14,100,000	21.30	7.85	883
Assiniboine	Average	1.90	69	0.56	0.64	0.08	1.66	9.25	9.88	622	1,562,800	5,753,786	17.99	7.83	321
Assiniboine	Minimum	0.23	10	0.02	0.07	0.01	0.42	2.18	2.28	79	275,000	563,000	10.70	7.35	72
Assiniboine	Maximum	4.21	294	2.64	2.81	0.53	6.14	37.70	38.20	2090	2,760,000	19,900,000	22.00	8.15	929
Colony	Average	2.06	19	0.54	0.57	0.03	0.77	4.50	4.71	79	2,637,733	11,338,778	17.66	7.96	347
Colony	Minimum	0.01	4	0.02	0.07	0.01	0.31	0.93	0.93	18	27,600	199,000	13.40	7.53	120
Colony	Maximum	6.40	46	1.63	1.67	0.05	1.71	10.70	10.70	188	5,170,000	24,200,000	20.70	9.13	830
Hawthorne	Average	4.73	127	0.17	0.22	0.03	2.61	15.09	15.26	504	2,758,200	6,038,980	15.27	7.48	395
Hawthorne	Minimum	1.24	20	0.02	0.07	0.01	0.65	4.50	5.00	99	393,000	759,000	10.40	6.80	259
Hawthorne	Maximum	17.80	440	0.71	0.76	0.10	14.50	76.30	76.30	2400	15,500,000	25,900,000	22.00	8.00	810
Jessie	Average	5.16	101	0.21	0.27	0.05	2.05	12.47	12.70	403	951,833	2,883,813	12.63	7.67	608
Jessie	Minimum	0.46	20	0.02	0.07	0.01	0.50	2.60	2.70	94	74,000	504,000	12.00	7.10	382
Jessie	Maximum	11.80	329	0.53	0.58	0.30	8.93	44.70	44.70	3270	2,360,000	15,500,000	13.00	7.93	1113
Mager	Average	3.41	55	0.86	1.15	0.28	1.41	8.37	9.50	247	2,473,094	16,186,250	18.09	7.64	380
Mager	Minimum	2.36	22	0.02	0.07	0.01	0.82	5.12	6.75	65	839,000	6,130,000	16.80	7.27	173
Mager	Maximum	7.22	182	2.73	2.93	0.70	3.10	17.30	17.30	604	6,490,000	32,400,000	19.40	8.68	615
Mission	Average	9.54	133	0.23	0.32	0.08	3.26	17.95	18.21	499	1,819,085	4,844,553	14.07	7.73	1023
Mission	Minimum	0.07	16	0.02	0.07	0.01	0.44	2.04	2.04	76	10,000	10,000	10.90	7.04	656
Mission	Maximum	34.30	470	0.91	1.05	0.62	10.00	50.30	50.30	2300	7,700,000	24,200,000	17.00	8.45	1400
Strathmillan	Average	5.16	122	1.11	1.18	0.17	2.14	13.38	14.24	199	2,102,730	7,273,784	15.33	7.20	2788
Strathmillan	Minimum	2.65	14	0.02	0.07	0.01	0.42	5.00	5.00	16	10000	10,000	14	6.82	870
Strathmillan	Maximum	14.50	875	15.70	16.30	0.57	12.20	58.50	58.50	1320	6490000	29,500,000	18	7.80	4750

ALL CSO	Average	4.45	93	0.47	0.56	0.09	2.00	11.45	11.90	367	2,043,639	7,650,253	16.46	7.64	772
ALL CSO	Minimum	0.01	4	0.02	0.07	0.01	0.31	0.93	0.93	16	10,000	10,000	10.40	6.80	72
ALL CSO	Max	34.30	875	15.70	16.30	0.70	14.50	76.30	76.30	3270	15,500,000	32,400,000	22.00	9.13	4750

*Colony September 5th Sample Set E.coli and Fecal not included

APPENDIX C
LICENSE CLARIFICATIONS

Winnipeg

Water and Waste Department

Licence Clarifications

Environment Act Licence No. 3042

October 2015

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Acronyms and Definitions

Definitions are consistent with Environment Act Licence No. 3042 (Licence) where applicable.

City of Winnipeg (City)

Clean Environment Commission (CEC)

Combined Sewer Overflow (CSO) – a discharge to the environment from a combined sewer system.

Dry weather flow (DWF) – Flow entering sewers during dry weather from homes and businesses.

Infiltration and Inflow (I&I)

Infiltration is:

- groundwater that infiltrates a sewer system through defective pipes, pipe joints, connections, or manholes; and
- generally measured during seasonally high ground water conditions, during dry weather.

Inflow is:

- water other than sanitary flow that enters a sewer system from sources which include, but are not limited to, roof leaders, cellar drains, yard drains, area drains, drains from wet areas, cross connections between storm sewers and sanitary sewers, catch basins, cooling towers, stormwater, surface runoff (including leaking manhole covers), street wash-water, or drainage; and
- generally measured during wet weather.

Manitoba Conservation and Water Stewardship (MCWS)

Regulatory Working Committee (RWC)

Runoff – Water from rainfall, snowmelt, or other sources that flows over the ground surface, onto the street, through the storm drains at the curb and into the land drainage or combined sewers and into the rivers.

Stormwater – An engineering term for wet weather flow (WWF)

Wet weather flow (WWF) – the combined flow resulting from:

i. wastewater;

ii. infiltration and inflows from foundation drains or other drains resulting from rainfall or snowmelt; and

iii. stormwater runoff generated by either rainfall or snowmelt that enters the combined sewer system.

Executive Summary

A Regulatory Working Committee (RWC) was formed between Manitoba Conservation and Water Stewardship (MCWS) and the City of Winnipeg (City) to deal with technical issues encountered while developing the Combined Sewer Overflow (CSO) Master Plan. To date, the RWC has met on three occasions and has been effective in collaborating on technical issues and Licence interpretations.

This report highlights the main issues and clarifications dealt with by the RWC. The City has recommended the following clarifications be adopted as the development of the CSO Master Plan progresses:

- Use of a Representative Year
- Definition of an Overflow
- Definition of Percent Capture

Use of a Representative Year

The City has proposed that the use of a representative year be included for the alternative control limit evaluations. Representative years are commonly used in the industry as a practical method of dealing with the large amount of hydrologic data, measuring compliance, performance reporting, and overcoming the long computer simulation times needed to process the full rainfall history. In addition, the 2002 CSO Study used a representative year approach, and its continued use will provide consistency with the information presented at the 2003 public hearings and the resulting Clean Environment Commission (CEC) recommendations.

The alternative to a representative year will be addressed with the “no more than” alternative; thereby, providing comprehensive results for both approaches for consideration in the decision process.

Definition of an Overflow

In the Licence, an overflow is calculated using the “overflow event” method. As this method only considers overflows from the worst district and will not account for improvements made to other districts, the City has proposed the use of a district averaging method to supplement this calculation and make it more comprehensive. Overflow averaging, provides a more accurate picture of the overall system performance, and would more accurately reflect CSO program progress. Moreover, overflow average will provide consistency with information presented in the 2002 CSO Study, the 2003 public hearings and the resulting CEC recommendations.

Definition of Percent Capture

The City has proposed a method to define the start and end times for the dry weather component used in the percent capture calculation as it was not defined in the Licence. The dry weather component will be calculated based on the start of the precipitation event and continue until the CSO controls return to dry weather conditions. This will be determined by the completion of the dewatering process (emptying of CSO storage facilities) and the ending of wet weather treatment.

In conclusion this clarification document provides additional detail on the rationale for these clarifications and the approaches taken for dealing with technical issues. Moreover, the clarification document is provided for information only. There are no decisions on their acceptability or use required at this time.

1 Clarification No.1 - Use of Representative Year

1.1 Current Condition:

Clause 11 of Environment Act Licence No. 3042 (Licence) requires that a plan be submitted based on evaluation of a minimum of the following alternative control limits:

- a maximum of four overflow events per year;
- zero combined sewer overflows; and
- a minimum of 85% 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.

1.2 Issue with Current:

There are a number of ways to define the combined sewer system performance, and a common understanding of the approach being used is required. One of the methods proposed by the City but not referred to in the Licence is the use of a representative year.

The 2002 CSO Study, which only dealt with the recreational season, made exclusive use of 1992 as the representative year. The result from using this approach were reviewed at the 2003 CEC hearings and reported on by the CEC in their recommendations. It is therefore important that this approach be retained for continuity.

The use of a representative year facilitates evaluation of large hydraulic data sets with large sewer systems. The InfoWorks CS hydraulic and hydrologic model being used includes approximately 17,000 pipes and takes up to five days to run a single full year simulation. Continuous modelling of all 55 years in the long term rainfall record would not be practical, but is reasonably approximated through use of a representative year.

1.3 Proposed Change:

It is proposed that the 85% capture, four overflow and zero overflow control limits be based on use of a representative year. The other two alternatives would not use the representative year. The alternative with no more than four overflows would be based on the full period of record, and the complete separation alternative would use the City's criteria for separate sewer systems.

The complete list of alternative control limits proposed by the City is as follows:

1. 85% capture in a ***representative year***;
2. four overflows in a ***representative year***;
3. zero overflows in a ***representative year***;
4. no more than four overflows per year; and
5. complete sewer separation.

Use of these alternatives conforms to the minimum requirements defined in the Licence. The four overflows plus 85% capture control limit is not explicitly listed since the minimum 85% capture value will be exceeded when the maximum four overflow criteria is met.

Addition of the representative year for the three control limits as shown will provide a direct comparison to the 2002 CSO Study results, and provide a new perspective for it not being used.

1.4 Application of the Representative Year

Using a representative year for control option sizing has the same effect as averaging annual results. A four overflow limit would be met over the long term, but more than four overflows could be expected in half of the years, and fewer than four in the rest.

The representative year evaluation was updated to account for the extended period of record since the 2002 CSO Study, and 1992 was determined to still be an appropriate selection. The evaluation was based on a statistical analysis of the annual events, as well as specific consideration for how the representative year will be applied. A summary of the approach and result is included as Appendix A.

The 1992 representative year has been used in the study to assess the performance of the baseline conditions, current program and the five alternatives in terms of overflow values and water quality impacts. The current program includes ongoing and future separation work at Jefferson, Ferry Road, Riverbend and Cockburn combined sewer districts and sewage treatment plant upgrades.

Use of the representative year would provide a threshold for measuring compliance. Much like design events used in flood control works and the City's basement flooding relief program, any recorded events smaller than the representative year should not cause overflows, while overflows would be permitted for larger events.

Annually, a comparison of the system performance relative to the representative year would be produced. It would show volume reduction resulting from the CSO program upgrades. This will also identify permitted overflows, which would be hard to quantify looking solely at annual varying rainfall.

It is also proposed that the representative year be used as the basis for measuring CSO program implementation progress. As changes are made to the system to meet the selected control limit, the representative year would be used to assess performance improvements. The system configuration would be updated in the hydraulic model and its performance evaluated using the representative year. The change in performance for the 1992 representative year would be entirely attributed to the system changes, thus avoiding normal variation in annual precipitation. The results would be reported for the representative year analysis, as well as in terms of actual year performance.

The design basis for the control limit would be established through the licensing process depending on the chosen control limit. For example, the fifth largest event in the representative year would be used to size control options for the four overflows in a representative year outcome.

1.5 Rationale for Change:

The representative year is an approach commonly used in the industry. It was used for the 2002 CSO Study as well as in similar programs such those being completed in Edmonton, Ottawa and Omaha. It would provide a common basis for control system sizing and regulatory compliance that is not affected by annual variations in precipitation.

The addition of the representative year to the evaluation while retaining the no more than four overflow alternative will permit comparative evaluation of both methods, without precluding either.

2 Clarification No.2 - Definition of an Overflow

2.1 Current Condition:

Environment Act Licence No. 3042 provides the following definition:

- "**overflow event**" means an event that occurs when there is one or more CSOs from a combined sewer system, resulting from a precipitation event. An intervening time of 24 hours or greater separating a CSO from the last prior CSO at the same location is considered to separate one overflow event from another;"

This method counts an overflow every time there is discharge from at least one outfall in the combined sewer area.

2.2 Issue with Current:

There are different methods for counting the number of overflows, and it is important that there be a common understanding of the ones being used. The 2002 CSO Study used a district averaging method as compared to the overflow event definition. The main differences between the two methods are:

- With the overflow event definition, simultaneous overflows from all 79 overflow points located in the 43 combined sewer districts would be counted as a single overflow event. Furthermore, when only one of these overflows it would also be counted as a single overflow event. The metric reported in this way would provide an accurate indication of how many times a CSO occurred somewhere in the system, but very little information on the number of locations contributing, their aerial distribution or discharge volume.
- Reporting on overflows using the overflow event definition would make it difficult to demonstrate progress during the CSO program implementation. The single worst district would define the number of overflows, and by example 42 of the 43 combined sewer districts could be upgraded with no overflows, but the last one would continue to define the number of overflows with no recognition for the progress made.
- Use of the overflow event definition would require the spatial distribution of rainfall to be accounted for in the CSO control sizing. The spatial distribution accounts for pockets of heavy rainfalls occurring at different locations at any time. This means that to achieve a maximum of four overflow events for the entire combined sewer system, the capture volume for each sewer district would have to be much higher than if the overflows were averaged for the combined sewer districts.
- Use of the overflow event definition would be more difficult to apply since historical records and evaluation techniques for spatial distribution patterns across the combined sewer system are limited and there would be a higher degree of uncertainty if used for future rainfall projections.

2.3 Proposed Change:

It is proposed that a comparative evaluation be used by retaining both methods of defining overflows. The district averaging method will be used for the representative year alternatives (85% capture, four overflows per year and zero overflows per year), and the overflow event method for the "no more than four overflow events per year" alternative.

With the district averaging method, discharge from one or more outfalls in a district will be considered an overflow, and the number of overflows for the combined sewer area will be determined by averaging overflows from all the districts (number of district overflows divided by the number of districts):

- A four overflow control limit in a representative year would mean four overflows would be permitted annually from each district.
- A zero overflow control limit in a representative year would mean there would be no overflows for the representative year, based on a uniform rainfall distribution.

An applied example using high (2009) and low (2013) rainfall years was developed for baseline conditions to demonstrate the results from the two methods. Overflows under baseline conditions for all combined sewer districts were identified for the years 2009 and 2013 and compared to the 1992 representative year, as shown in Table 1:

Table 1: Comparison of Annual CSO frequency under Baseline Conditions for the Overflow Definitions

Event Year	District Average	Overflow Events*
1992	25	63 (39)
2009	39	60 (60)
2013	21	50 (40)

** Highest number of overflows from a district (second highest)*

As shown in the table there are widely different results between the methods for baseline conditions.

Table 2 provides a projection of the number of overflows for a CSO program half-way completed. As shown in the table, the overflow events definition does not change. It would not capture the benefit of the work completed and would make it difficult to track and report on progress.

Table 2: Comparison of Annual CSO frequency for the Overflow Definitions 2

Event Year	District Average	Overflow Events*
1992	18	63 (39)
2009	20	60 (60)
2013	11	50 (40)

** Highest number of overflows from a district (second highest)*

Simulated monthly results for the three years are listed on an annual reporting basis in Appendix B.

2.4 Rationale for Change:

The district averaging approach for measuring overflows has been proposed to provide continuity with the 2002 CSO Study a basis for comparisons with the overflow event definition.

The Licence definition provides an accurate indicator of the number of times overflows occur, but would be more difficult to achieve and would not provide a good indicator of program progress.

Retaining both in the study will permit a comparative evaluation of both methods without excluding either

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3 Clarification No.3 - Definition of Percent Capture

3.1 Current Condition:

Environment Act Licence No. 3042 provides the following 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.

Percent capture must be considered along with the definition of wet weather flow (WWF), which is defined in the Licence as follows:

- **"wet weather flow"** means the combined flow resulting from:

  i) wastewater

  ii) infiltration and inflows from foundation drains or other drains resulting from rainfall or snowmelt; and

  iii) stormwater runoff generated by either rainfall or snowmelt that enters the combined sewer system

Expanding on these definitions results in percent capture being defined as:

- <u>Percent Capture</u>:

  = (WWF-CSO)/WWF x 100%

  = [(wastewater + inflow&infiltration + stormwater) – CSO] / (wastewater + inflow&infiltration + stormwater) x 100%

3.2 Issue with Current:

The use of percent capture as a CSO metric is reasonable and acceptable, and only requires clarification on how the inputs are quantified:

- Actual measurement of wet weather flows will be used when available or estimated through computer modelling when unavailable, and in either case requires a definition for how they are defined.
- Modelling results will be used for the study and analysis and are to be representative of the intended method of field measurements.

The parameter in need of clarification is the end of a wet weather event, which is difficult to define because of its classic long trailing limb caused by the delayed runoff from inflow and infiltration.

3.3 Proposed Change:

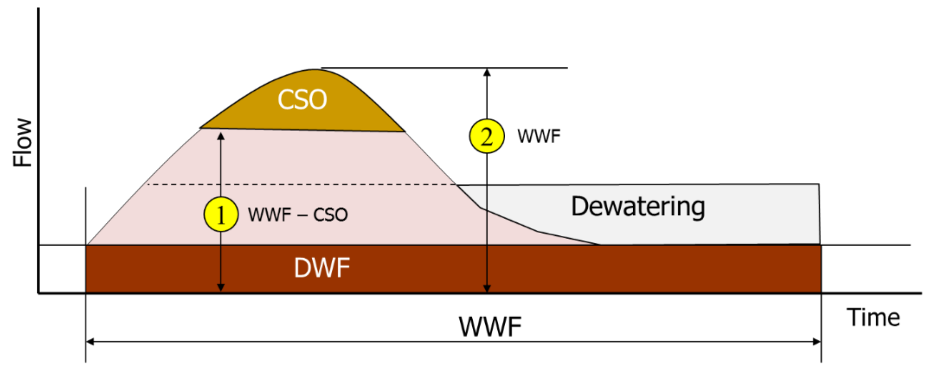
It is proposed that the percent capture definition be modified to include a method for determining the wastewater component for the percent capture:

- **"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.

The dewatering process refers to the emptying of combined sewage from CSO storage facilities.

The calculation method is illustrated in Figure 1 below.

Figure 1: Illustration of Percent Capture Calculation



- Percent capture is determined in the illustration as area 1 divided by area 2, and is reported as a percentage estimated using the hydraulic model. (No 2 in the diagram = No. 1 plus CSO volume).
- The percent capture will then be determined by the percent capture formula above (No. 1 divided by No. 2).

3.4 Rationale for Change:

The addition of starting and ending points allows for the calculation of a discrete volume for the metric.

Appendix A - Representative Year

Use of a Representative Year

It is common practice to use a representative year for alternative evaluations in CSO studies, since it provides reasonable results using a much more manageable data set compared to the long term rainfall record. It is also frequently used as a basis for defining regulatory control limits. A representative year was used in the 2002 CSO Study and for other similar studies in municipalities including Edmonton, Ottawa and Omaha, which were the locations that participated in the CSO Master Plan peer review.

Representative years are selected by evaluating all the years in the long term rainfall record and picking the one with the best fit. For the master plan, this includes review of precipitation in the recreational (May through September) and non-recreational (October through April) seasons and the river flow conditions.

There are no standard methods for selection of a representative year, but there are several examples of how it has been done elsewhere. Most of the methods used are specific to the unique characteristics of the location, taking into account both meteorological and compliance considerations.

It cannot be expected that any year will be equally representative for all conditions, so there must be consideration for its impacts on the level of control and types of controls being used. The primary consideration in selecting a year was for the recreational season to be representative, since it is the period with the highest precipitation and the most critical for sizing of CSO storage options. The objective for the non-recreational season and river flows was to avoid any extreme irregularities.

Recreation Season Precipitation

The recreational season precipitation was reviewed from several perspectives:

1. The first review was based on storm size groupings, as was done for the 2002 CSO Study.

2. The second review was a statistical assessment of the precipitation intensity.

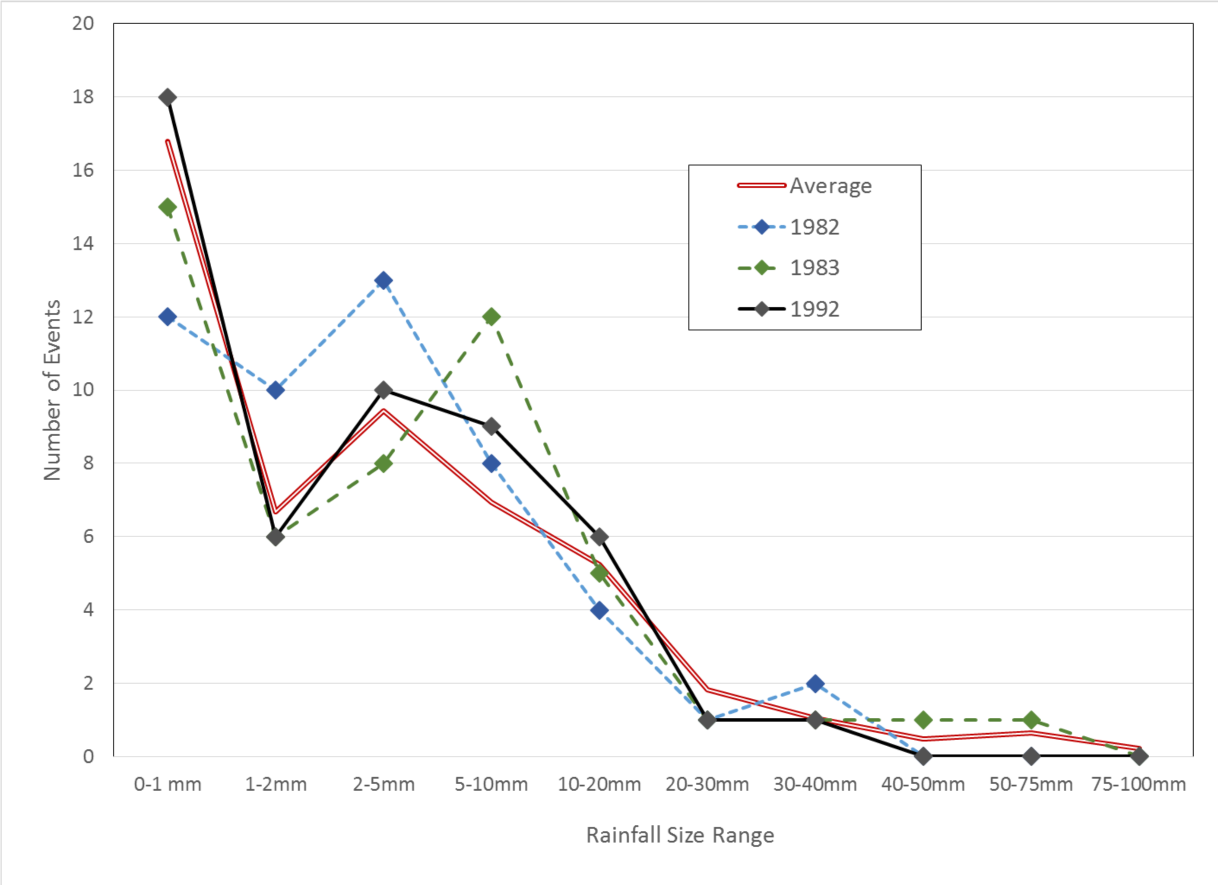
3. The third was a review of critical events that would directly affect CSO program sizing.

1) Storm Size Groupings

Precipitation events for each year of the long term record were partitioned into precipitation event totals and then compared to the long term average.

The best fit for a representative year was found to be 1992, as was the case for the 2002 CSO Study. The results of the storm grouping for 1992, along with those for 1982 and 1983 are shown in Figure1 below.

Figure 1: Storm Size Grouping Evaluation for the Representative Year Evaluation



2) Statistical Assessment

A continuous hourly precipitation record was compiled for the period from 1960 to the present for use in the statistical analysis. The record was then used to generate the following annual statistics:

- Total recreation season rainfall (mm)
- Number of events during the season
- Peak rainfall intensity recorded (mm/h)
- Standard deviation of event intensity (mm/h)
- Hourly rainfall frequency in excess of impervious runoff threshold (2.5 mm/h)
- Hourly rainfall frequency in excess of pervious runoff threshold (6.4 mm/h)
- Hourly rainfall frequency in excess of relatively large intensity thresholds (12.8, 19.2 and 25.4 mm/h)
- Average event duration (h)
- Standard deviation of antecedent period (h)

A summary of the results for the statistical analysis is presented in Table 1.

Table 1. Hourly Rainfall Analysis Summary for the Recreational Season

Site	Year	RAINFALL					HOURLY RAINFALL ABOVE (mm/hr)					ANTECEDENT	
		Total Rainfall (mm)	No. of Events	Peak Intensity (mm/hr)	std-dev (mm/hr)	Avg Duration (hours)	2.5 (0.1 in/hr)	6.4 (0.25 in/hr)	12.8 (0.5 in/hr)	19.2 (0.75 in/hr)	25.4 (1.0 in/hr)	Avg. Duration (hours)	std-dev (hours)
Station 5023222 Winnipeg Richardson International Airport Latitude: 49.92 Longitude: -97.23	1960	208.5	42	6.4	7.2	5.3	24	1	0	0	0	80.4	82.3
	1961	148.3	31	15.7	7.6	5.3	14	3	1	0	0	109	146.3
	1962	512.5	48	34.8	16.5	6.4	53	22	6	2	2	62.5	59
	1963	264.2	48	17.8	8.6	4.5	36	5	2	0	0	70.4	63.2
	1964	256.7	39	24.4	12.6	5.3	32	9	1	1	0	86	104.1
	1965	332	56	14.7	6.9	6.1	38	6	1	0	0	59	58.8
	1966	281.5	42	32.5	12.2	4.7	28	5	2	2	2	81.3	84.6
	1967	247.5	34	32	11.5	4.2	24	9	3	2	2	100.3	133.5
	1968	519.5	53	39.4	15.6	7	60	17	3	2	1	59.6	55.2
	1969	400.6	59	15.5	10.4	5.3	47	10	2	0	0	56	51.2
	1970	400.4	49	38.1	13.2	6.4	35	10	5	2	1	66	64.4
	1971	295.6	59	11.7	6.2	4	40	8	0	0	0	58	57
	1972	238.5	46	34.5	8.1	3.4	25	5	1	1	1	74.1	69.3
	1973	424.9	49	29.7	11.1	5.3	50	14	4	2	1	66.6	59.5
	1974	357.4	53	28.4	13.8	6.2	35	7	2	1	1	62.3	53.5
	1975	388.7	65	27.9	11.1	4.3	32	15	5	4	1	51.9	58.1
	1976	299.6	43	21.8	10.1	4.3	34	9	3	1	0	78.1	81.9
	1977	593.5	79	21.3	12.2	4.9	59	21	8	2	0	40.2	50.2
	1978	325.8	55	20.8	10.8	5.3	41	6	2	1	0	60.6	58.6
	1979	236.4	50	39.3	8.5	5.4	22	3	1	1	1	66.3	68.4
	1980	267.9	53	15	7.1	5.7	25	9	1	0	0	63.4	71.1
	1981	353.1	53	20.5	9.4	5.8	31	11	3	1	0	63.4	64.8
	1982	300.5	51	22.7	9.2	5.3	31	9	2	1	0	65.6	62.1
	1983	335.7	51	23.5	10.6	4.7	31	12	3	3	0	67.1	78
	1984	374.4	43	55.3	15.1	5.8	33	11	4	2	2	77	74.5
	1985	406.2	59	18.4	14.4	6.1	46	9	2	0	0	55.1	61.9
	1986	266.6	61	17.6	6.8	4.1	29	7	3	0	0	55.6	71.1
	1987	334.1	56	23.4	10.1	4.9	35	7	4	1	0	59.5	56.4
	1988	264.9	38	24.3	11.7	5.1	29	7	3	2	0	85.8	83
	1989	277.2	41	14.1	11.5	6.1	38	8	2	0	0	77.5	71.5
	1990	196.5	46	19.8	5.9	4.3	17	3	2	1	0	75.2	83.2
	1991	330.8	41	19.3	10.5	7.4	33	11	3	1	0	81.4	101.7
	1992	279.4	52	14.9	7.5	5.7	26	5	1	0	0	63.3	58.7
	1993	509.7	70	41.4	15.4	5.9	46	13	6	4	3	46.3	45.9
Station 502S001 Winnipeg Airport Latitude: 49.92 Longitude: -97.23	2007	319.6	64	13.4	5.9	3.6	35	10	1	0	0	52.1	59.4
	2008	392.9	51	19.2	12	5.4	43	10	2	1	0	63.6	57.5
	2009	323.9	57	25.3	9.8	5	29	5	2	2	0	58.3	58.3
	2013	300.6	43	25.3	9	3.7	28	10	5	2	0	81.1	72.8
10th percentile		237.9	40.4	14.5	6.9	4.1	24	4.4	1	0	0	54.2	54.7
20th percentile		264.5	42.4	15.6	7.5	4.3	26.8	5	1	0	0	58.1	57.7
30th percentile		277.4	46	18.5	8.7	4.7	29	7	2	0.1	0	59.7	58.7
40th percentile		298.8	48.8	20.4	9.7	5.1	31	7.8	2	1	0	63.1	59.5
50th percentile		321.8	51	22.3	10.4	5.3	33	9	2	1	0	64.6	63.8
60th percentile		332.4	53	24.3	11.1	5.3	35	9.2	3	1	0	66.7	69.7
70th percentile		357	54.8	27.6	11.7	5.7	37.8	10	3	2	0.9	75.1	72.6
80th percentile		397.4	58.2	32.3	12.5	6	42.2	11	4	2	1	79.5	82.1
90th percentile		450.3	61.9	38.5	14.6	6.3	47.9	14.3	5	2	2	82.7	89.7

Table 1 Notes:

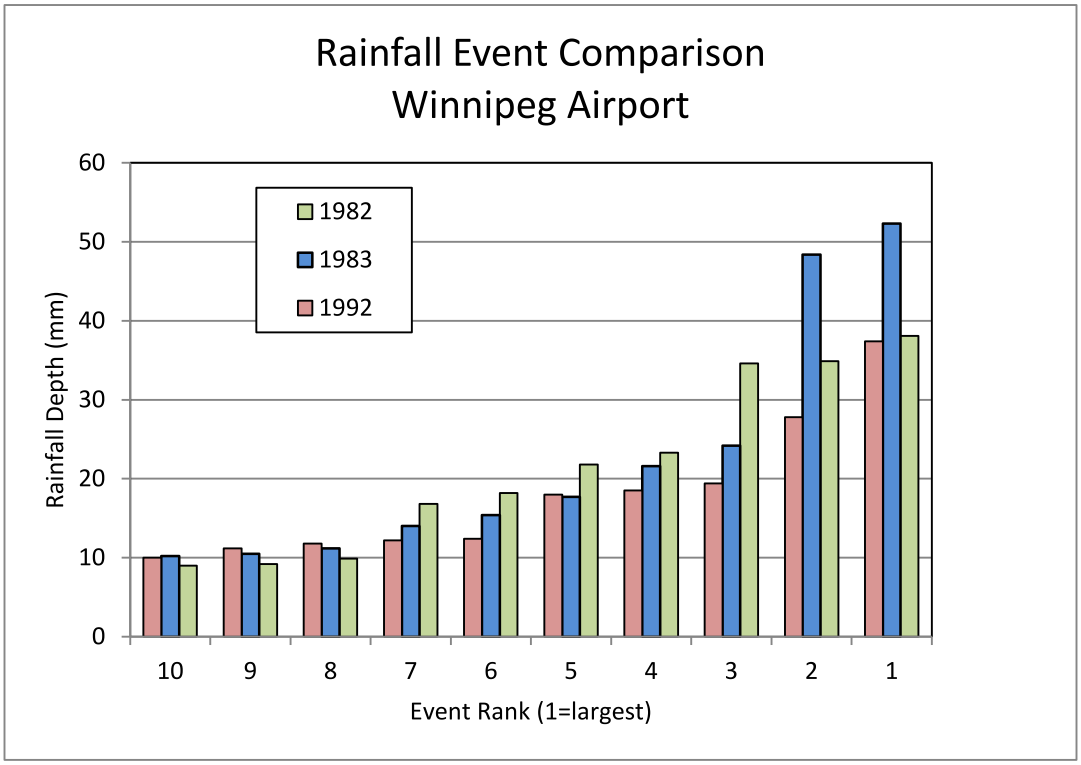
- The table includes only the data used for the statistical analysis
- Only years with 98% data coverage are included
- Some years used infill data from adjacent gauges to extend data set
- Richardson Airport gauge has hourly data from 1960 to 1994. Some years were excluded because of missing data e.g. 1994
- Richardson gauge typically operates from mid-April into November
- There is a gap in rainfall coverage from 1995 to 1999
- In 1999 new Airport gauge initiated and is providing data to date.
- New Airport gauge data limited and provides only 4 valid years. Data infill not yet applied to extend data set. More valid years may result.

The year 1982 was the best fit for these conditions, with the year 1983 also being a good fit. The rainfall intensities for 1992 are shown to be lower than average even though the totals were representative. This reflects on the type of storm.

3) Critical Events

The three years, 1982, 1983 and 1992 were reviewed for critical event sizing. As shown in Figure 2 the two largest events for 1983 were much larger than those for the other two years and would significantly overestimate the zero overflow control limit.

Figure 2: Comparison of the Large Events



Year-Round Precipitation Evaluation

A summary of the statistical results for full year and seasonally are included in Table 2. The seasonal variations were considered to be acceptable for any of the three years.

Table 2. Statistical Summary of Annual and Seasonal Rainfall

	Annual Precipitation (mm)			Winter Precipitation (mm)			Recreational Season Precipitation (mm)		
Year	Rain	Snow	Total	Rain	Snow	Total	Rain	Snow	Total
1982	420	75	484	118	75	182	302	0	302
1983	404	90	480	68	90	143	336	0	336
1992	362	142	478	37	142	152	326	0	326

40th - 60th Percentile

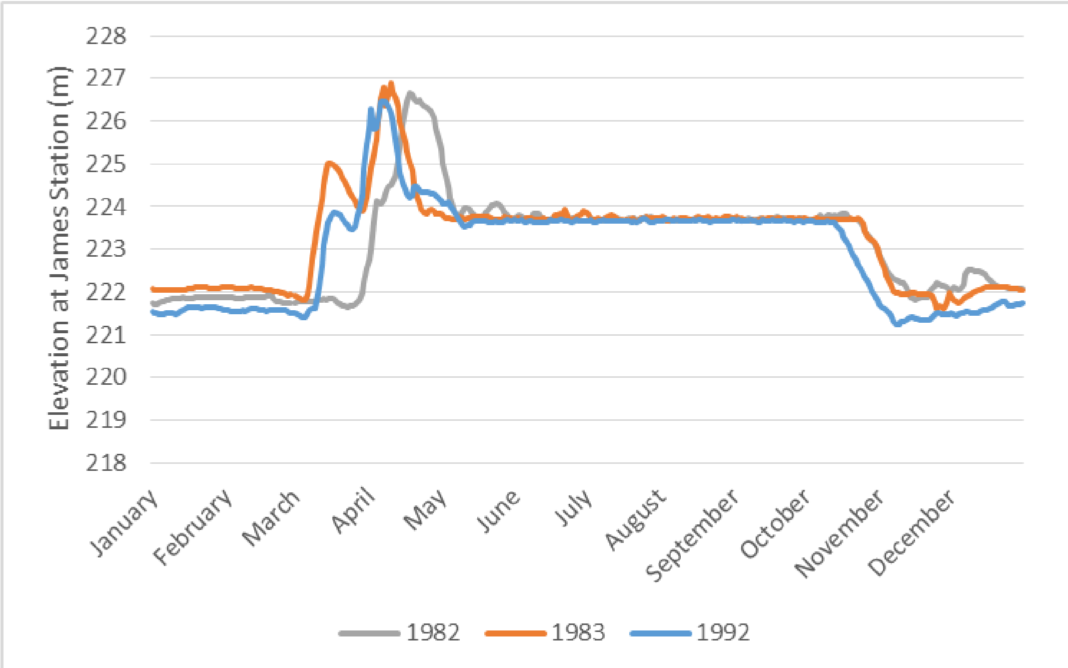
Table 2 Notes:

- Analysis based on daily rainfall volumes
- Refer to Table 1 for the full dataset summary

River Condition Evaluation

River conditions for the full period of record were identified and used to develop ranges, and confirm 1982, 1983 and 1992 were within normal ranges. The annual flows were found to be highly variable for all three years, but for most months they were within acceptable limits, and would not affect the selection of a representative year. The results are shown in terms of river levels at James Station in Figure 3.

Figure 3: River Levels at James Station



Runoff Evaluation

Continuous InfoWorks runs were made for both 1982 and 1992, with the resulting runoff volumes for baseline conditions shown in Table 3.

Table 3. Runoff Volume Summary 1982 and 1992 for Largest and 5th Largest Rainfall Events

Event	1982 CSO Volume (m^3)	1992 CSO Volume (m^3)
Largest Storm	1,161,000	690,000
5th Largest Storm	473,000	337,000

The evaluation indicates that even though the annual statistics are similar for both years, 1982 would be much more difficult to meet for the four overflow and zero overflow control limits. The difference in results relate to the specific conditions at the time of the rainfalls, including the duration and patterns for the specific rainfalls and antecedent conditions.

Final Selection

The representative year evaluation indicated that the years 1982, 1983 and 1992 all exhibited good fits for some conditions, but none of the years was best overall. A final review was made considering the most probable use of the representative year for sizing of the CSO program, based on the following considerations:

- Storm Group Sizing – most applicable to percent capture and number of overflows evaluations

- Statistical Assessment – most applicable to CSO discharge rates and end of pipe treatment options

- Critical Events – most applicable to sizing of CSO storage options

With the CSO program focusing on storage options for the four overflow or larger control limit alternatives, it can be concluded the critical events assessment is the most important factor in the representative year evaluation. In terms of critical events, the years 1982 and 1992 provide the best fit, since the largest storm for 1983 is far larger than the others and was considered non-representative.

Between the two remaining years, 1992 was selected as the representative year for the following reasons:

- The 1992 large event rainfalls are already high compared to long term standards, and even more so for 1982. It was therefore concluded that since 1982 is even larger, it would produce an overly conservative design requirement for CSO controls.
- 1992 was the best fit for storm size grouping, and therefore would be the most representative for percent capture and number of overflow assessments
- Selection of 1992 would provide continuity with the 2002 CSO Study.

Appendix B – 1992, 2009, 2013 Hydraulic Model Results

Water and Waste Department Combined Sewer Overflow (CSO) Monthly Tracking Spreadsheet for Federal Government and Provincial Reporting

OP #	Overflow Point Name	Overflow Point Location (nearest intersection)	Asset Number	1992	
				Yearly Effluent Volume Deposited (m^3)	Yearly Number of Days Effluent Deposited
1	Cockburn	Cockburn ST S @ Churchill DR	S-MA60012037	164,713	8.5
2	Osborne	Osborne ST @ Churchill DR	S-MA70006325	0	0.0
3	Kingston	Kingston ROW @ Dunkirk DR	S-MA50014591	0	0.0
4	Mager	Mager DR W @ St Mary's RD	S-MA70007510	22,652	2.2
5	Baltimore	Baltimore RD @ Churchill DR	S-MA60013599	58,903	2.5
6	Metcalfe	Metcalfe AVE @ St Mary's RD	S-MA70011115	10,335	1.8
7	Eccles East	Eccles ST @ Churchill DR	S-MA70022370	0	0.0
8	Eccles West	Eccles ST @ Churchill DR	S-MA70006655	0	0.0
9	Churchill	Churchill DR @ Hay ST	S-MA70005806	10,708	12.4
10	Jessie	Jessie AVE @ Osborne ST	S-MA70016174	188,655	5.7
11	Walmer	Walmer ST @ Lyndale DR	S-MA70008060	3,395	7.0
12	Marion	Poulin DR @ Lyndale DR	S-MA50008337	23,362	0.9
13	Despins	Despins ST @ Tache AVE	S-MA70087426	28,007	2.1
14	Dumoulin	Dumoulin ST @ Tache AVE	S-MA70047759	46,869	4.2
15	La Verendrye	La Verendrye ST @ Tache AVE	S-MA70017688	14,796	2.9
16	Lombard	Lombard AVE @ Mill ST	S-MA70012338	0	0.0
17	McDermot	McDermot AVE @ Ship ST	S-MA20013332	135,181	17.1
18	Bannatyne	Bannatyne AVE @ Ship ST	S-MA70000991	24,440	1.0
19	Galt	Galt AVE @ Duncan ST	S-MA70021229	20,730	2.3
20	Mission	Mission ST @ Archibald ST	S-MA70016004	19,695	1.0
21	Roland	Watt ST @ Archibald ST	S-MA40011011	301,103	6.7
22	Syndicate	Syndicate ST @ Rover AVE	S-MA70003283	38,589	4.1

Water and Waste Department Combined Sewer Overflow (CSO) Monthly Tracking Spreadsheet for Federal Government and Provincial Reporting					
OP #	Overflow Point Name	Overflow Point Location (nearest intersection)	Asset Number	1992	
				Yearly Effluent Volume Deposited (m^3)	Yearly Number of Days Effluent Deposited
23	Selkirk	Selkirk AVE @ Austin ST N	S-MA70007427	138,250	7.2
24	Pritchard	Pritchard AVE @ Austin ST N	S-MA00017936	0	0.0
25	Burrows	Burrows AVE @ Main ST	S-MA00017926	21,451	27.2
26	Aberdeen	Aberdeen AVE @ Main ST	S-MA00017914	0	0.0
27	Hart	Hart AVE @ Glenwood CRES	S-MA70043042	202,666	8.0
28	St John's	St John's AVE @ Fowler ST	S-MA70007551	342,728	4.8
29	Bredin	Bredin DR @ Henderson HWY	S-MA40005212	0	0.0
30	Polson	Polson AVE @ Scotia ST	S-MA00017967	80,896	4.9
31	Munroe	Munroe AVE @ Henderson HWY	S-MA70017186	430,508	14.1
32	Inkster	Inkster BLVD @ Scotia ST	S-MA00017939	354,689	5.5
33	Jefferson	Jefferson AVE @ Scotia ST	S-MA70007473	273,800	6.4
34	Linden	Linden AVE @ Kildonan DR	S-MA70016792	13,883	3.2
35	Newton	Newton AVE @ Scotia ST	S-MA00017645	6,971	3.8
36	Armstrong	Armstrong AVE @ Scotia ST	S-MA00017633	714,379	10.4
37	Kildonan Park (Rainbow Stage)	Kildonan Park @ SE Corner	S-MA70069313	0	0.0
38	Hawthorne	Hawthorne AVE @ Kildonan DR	S-MA70062167	33,266	3.5
39	Whellams	Whellams LANE @ Tamarind DR	S-MA70042861	0	0.0
40	Woodhaven	Woodhaven BLVD @ Assiniboine AVE	S-MA70019662	12,321	2.4
41	Olive	Olive ST @ Assiniboine CRES	S-MA20005373	0	0.0
42	Strathmillan	Strathmillan RD @ Portage AVE	S-MA70053789	39,590	6.8
43	Conway	Conway ST @ Portage AVE	S-MA70016333	65,328	4.3
44	Deer Lodge	Deer Lodge PL @	S-	86	0.0

Water and Waste Department Combined Sewer Overflow (CSO) Monthly Tracking Spreadsheet for Federal Government and Provincial Reporting

OP #	Overflow Point Name	Overflow Point Location (nearest intersection)	Asset Number	1992	
				Yearly Effluent Volume Deposited (m^3)	Yearly Number of Days Effluent Deposited
		Deer Lodge PL	MA70028291		
45	Douglas Park	Douglas Park RD @ Portage AVE	S-MA20008519	662	0.2
46	Ferry Road	Ferry RD @ Assiniboine AVE	S-MA70019346	124,340	21.1
47	Chataway	Chataway BLVD @ Wellington CRES	S-MA70029012	14,658	4.3
48	Doncaster	Doncaster ST @ Wellington CRES	S-MA70019277	30,180	7.9
49	Parkside	Parkside DR @ Assiniboine AVE	S-MA20008800	2,983	1.3
50	Riverbend	Riverbend CRES @ Portage AVE	S-MA20008967	87,370	4.3
51	Academy	Academy RD @ Wellington CRES	S-MA60006673	0	0.0
52	Tylehurst	Tylehurst ST @ Wolseley AVE W	S-MA20020018	182,373	9.1
53	Lindsay	Lindsay ST @ Wellington CRES	S-MA70024441	48,383	33.2
54	Clifton	Clifton ST @ Wolseley AVE	S-MA70008731	109,895	6.1
55	Ash	Ash ST @ Wellington CRES	S-MA70033504	300,268	11.4
56	Aubrey S.R.S. Outfall	Aubrey ST @ Palmerston AVE	S-MA70017585	0	0
57	Aubrey	Aubrey ST @ Palmerston AVE	S-MA70017579	245,669	9.1
58	Ruby	Ruby ST @ Palmerston AVE	S-MA70022480	5,523	21.3
59	Arlington	Arlington ST @ Palmerston AVE	S-MA70053466	0	0.0
60	Canora	Canora ST @ Palmerston AVE	S-MA70017866	711	1.8
61	Cornish C.S. Outfall	Cornish AVE @ Maryland ST	S-MA20013630	2,639	0.6
62	Grosvenor	Grosvenor AVE @ Wellington CRES	S-MA70002491	352	0.5
63	Cornish	Cornish AVE @ Langside ST	S-MA70033535	81,129	7.8
64	Spence	Spence ST @ Balmoral ST	S-MA70103641	39,251	5.2
65	Colony	Colony ST @ Granite WAY (Mostyn)	S-MA20014505	50,309	3.8

Water and Waste Department Combined Sewer Overflow (CSO) Monthly Tracking Spreadsheet for Federal Government and Provincial Reporting

OP #	Overflow Point Name	Overflow Point Location (nearest intersection)	Asset Number	1992	
				Yearly Effluent Volume Deposited (m^3)	Yearly Number of Days Effluent Deposited
66	Kennedy	Kennedy ST @ Assiniboine AVE	S-MA70068974	3,827	0.4
67	Fort Rouge Park	River AVE @ Cauchon ST	S-MA60020193	124	0.3
68	Hargrave	Hargrave ST @ Assiniboine AVE	S-MA20014087	870	1.1
69	Donald	Donald ST @ Assiniboine AVE	S-MA20014095	1,101	1.2
70	Mayfair	Mayfair AVE @ Queen Elizabeth WAY	S-MA70004387	11,039	0.6
71	Assiniboine	Assiniboine AVE @ Main ST	S-MA70008123	5,036	2.3
72	Strathcona	Strathcona ST @ Portage AVE	S-MA20011477	38,746	55.6
73	Plinguet	Plinguet ST @ Archibald ST	S-MA70041411	0	0.0
74	Cherrier	Cherrier ST @ Dufresne AVE	S-MA50002504	0	0.0
75	Doucet	Doucet ST @ Dufresne AVE	S-MA50002528	0	0.0
76	Prosper	Prosper ST @ Evans ST	S-MA50002566	0	0.0
77	Dubuc	Dubuc ST @ Seine ST	S-MA70022443	0	0.0
78	Gareau	Gareau ST @ Evans ST	S-MA70033704	0	0.0
79	Comanche	Comanche RD @ Iroquois BAY	S-MA50010965	0	0.0
80	Aubrey Flood (Pumped)	Aubrey ST @ Palmerston AVE	S-MA70017556	0	0.0
81	Clifton Flood (Pumped)	Clifton ST @ Wolseley AVE	S-MA70042741	4,757	0.1
82	Cornish Flood (Pumped)	Cornish AVE @ Sherbrook Bridge	S-MA70017433	607	0.0
83	Despins Flood (Pumped)	Despins ST @ Tache AVE	S-MA70087428	2,538	0.1
84	Dumoulin Flood (Pumped)	Dumoulin ST @ Tache AVE	S-MA70016522	25	0.0
85	Marion Flood (Pumped)	Poulin DR @ Lyndale DR	S-MA70105998	7,110	0.1
86	La Verendrye Flood (Pumped)	La Verendrye ST @ Tache AVE	S-MA70109090	202	0.0

Water and Waste Department Combined Sewer Overflow (CSO) Monthly Tracking Spreadsheet for Federal Government and Provincial Reporting

OP #	Overflow Point Name	Overflow Point Location (nearest intersection)	Asset Number	1992 Yearly Effluent Volume Deposited (m³)	1992 Yearly Number of Days Effluent Deposited
87	Cockburn Flood (Pumped)	Cockburn ST S @ Churchill DR	S-MA60012037	0	0.0
88	Linden Flood (Pumped)	Linden AVE @ Kildonan DR	S-MA70016792	0	0.0
89	Ash Flood (Pumped)	Ash ST @ Wellington CRES	S-MA70016005	6,562	0.1

NOTE: Based on Hydraulic Modelling Results covering the representative year 1992

LEGEND:

Overflow Points Associated with **N.E.W.P.C.C.**	Overflow Points Associated with **S.E.W.P.C.C**	Overflow Points Associated with **W.E.W.P.C.C.**		
Indicates Overflow Point **Is Monitored**	Indicates Overflow Point **Is Monitored**	Indicates Overflow Point **Is Monitored**	Please note that the above results are based on the current 2013 Regional Model and no outfall monitors were installed during this period of 1992.	
Indicates Overflow Point **Not Monitored**	Indicates Overflow Point **Not Monitored**	Indicates Overflow Point **Not Monitored**		

Water and Waste Department Combined Sewer Overflow (CSO) Monthly Tracking Spreadsheet for Federal Government and Provincial Reporting

OP #	Overflow Point Name	Overflow Point Location (nearest intersection)	Asset Number	2009	
				Yearly Effluent Volume Deposited (m^3)	Yearly Number of Days Effluent Deposited
1	Cockburn	Cockburn ST S @ Churchill DR	S-MA60012037	20,230	14.0
2	Osborne	Osborne ST @ Churchill DR	S-MA70006325	2,930	2.0
3	Kingston	Kingston ROW @ Dunkirk DR	S-MA50014591	0	0.0
4	Mager	Mager DR W @ St Mary's RD	S-MA70007510	4,390	3.0
5	Baltimore	Baltimore RD @ Churchill DR	S-MA60013599	5,090	3.5
6	Metcalfe	Metcalfe AVE @ St Mary's RD	S-MA70011115	4,190	2.9
7	Eccles East	Eccles ST @ Churchill DR	S-MA70022370	100	0.1
8	Eccles West	Eccles ST @ Churchill DR	S-MA70006655	410	0.3
9	Churchill	Churchill DR @ Hay ST	S-MA70005806	31,470	21.9
10	Jessie	Jessie AVE @ Osborne ST	S-MA70016174	387,127	10.6
11	Walmer	Walmer ST @ Lyndale DR	S-MA70008060	15,989	22.6
12	Marion	Poulin DR @ Lyndale DR	S-MA50008337	81,714	3.5
13	Despins	Despins ST @ Tache AVE	S-MA70087426	92,171	5.1
14	Dumoulin	Dumoulin ST @ Tache AVE	S-MA70047759	110,558	11.8
15	La Verendrye	La Verendrye ST @ Tache AVE	S-MA70017688	31,394	4.6
16	Lombard	Lombard AVE @ Mill ST	S-MA70012338	10	0.0
17	McDermot	McDermot AVE @ Ship ST	S-MA20013332	311,712	25.1
18	Bannatyne	Bannatyne AVE @ Ship ST	S-MA70000991	90,680	2.5
19	Galt	Galt AVE @ Duncan ST	S-MA70021229	63,997	4.4
20	Mission	Mission ST @ Archibald ST	S-MA70016004	118,237	3.8
21	Roland	Watt ST @ Archibald ST	S-MA40011011	598,880	9.9
22	Syndicate	Syndicate ST @ Rover AVE	S-MA70003283	74,019	5.8

Water and Waste Department Combined Sewer Overflow (CSO) Monthly Tracking Spreadsheet for Federal Government and Provincial Reporting					
				2009	
OP #	Overflow Point Name	Overflow Point Location (nearest intersection)	Asset Number	Yearly Effluent Volume Deposited (m^3)	Yearly Number of Days Effluent Deposited
23	Selkirk	Selkirk AVE @ Austin ST N	S-MA70007427	244,130	10.3
24	Pritchard	Pritchard AVE @ Austin ST N	S-MA00017936	0	0.0
25	Burrows	Burrows AVE @ Main ST	S-MA00017926	83,044	41.5
26	Aberdeen	Aberdeen AVE @ Main ST	S-MA00017914	0	0.0
27	Hart	Hart AVE @ Glenwood CRES	S-MA70043042	342,306	10.8
28	St John's	St John's AVE @ Fowler ST	S-MA70007551	670,955	9.0
29	Bredin	Bredin DR @ Henderson HWY	S-MA40005212	167	0.1
30	Polson	Polson AVE @ Scotia ST	S-MA00017967	224,366	9.2
31	Munroe	Munroe AVE @ Henderson HWY	S-MA70017186	568,608	20.0
32	Inkster	Inkster BLVD @ Scotia ST	S-MA00017939	678,829	7.8
33	Jefferson	Jefferson AVE @ Scotia ST	S-MA70007473	517,828	8.5
34	Linden	Linden AVE @ Kildonan DR	S-MA70016792	84,363	10.9
35	Newton	Newton AVE @ Scotia ST	S-MA00017645	56,205	6.3
36	Armstrong	Armstrong AVE @ Scotia ST	S-MA00017633	1,171,809	13.9
37	Kildonan Park (Rainbow Stage)	Kildonan Park @ SE Corner	S-MA70069313	0	0.0
38	Hawthorne	Hawthorne AVE @ Kildonan DR	S-MA70062167	156,591	9.5
39	Whellams	Whellams LANE @ Tamarind DR	S-MA70042861	4,490	0.3
40	Woodhaven	Woodhaven BLVD @ Assiniboine AVE	S-MA70019662	7,330	5.1
41	Olive	Olive ST @ Assiniboine CRES	S-MA20005373	70	0.0
42	Strathmillan	Strathmillan RD @ Portage AVE	S-MA70053789	27,710	19.2
43	Conway	Conway ST @ Portage AVE	S-MA70016333	13,540	9.4
44	Deer Lodge	Deer Lodge PL @	S-	1,390	0.2

Water and Waste Department Combined Sewer Overflow (CSO) Monthly Tracking Spreadsheet for Federal Government and Provincial Reporting

OP #	Overflow Point Name	Overflow Point Location (nearest intersection)	Asset Number	2009	
				Yearly Effluent Volume Deposited (m³)	Yearly Number of Days Effluent Deposited
		Deer Lodge PL	MA70028291		
45	Douglas Park	Douglas Park RD @ Portage AVE	S-MA20008519	2,019	0.4
46	Ferry Road	Ferry RD @ Assiniboine AVE	S-MA70019346	260,030	35.5
47	Chataway	Chataway BLVD @ Wellington CRES	S-MA70029012	37,102	8.8
48	Doncaster	Doncaster ST @ Wellington CRES	S-MA70019277	63,104	11.1
49	Parkside	Parkside DR @ Assiniboine AVE	S-MA20008800	6,869	1.8
50	Riverbend	Riverbend CRES @ Portage AVE	S-MA20008967	181,405	6.0
51	Academy	Academy RD @ Wellington CRES	S-MA60006673	32	0.1
52	Tylehurst	Tylehurst ST @ Wolseley AVE W	S-MA20020018	280,036	12.0
53	Lindsay	Lindsay ST @ Wellington CRES	S-MA70024441	146,666	40.1
54	Clifton	Clifton ST @ Wolseley AVE	S-MA70008731	290,942	13.4
55	Ash	Ash ST @ Wellington CRES	S-MA70033504	603,618	24.2
56	Aubrey S.R.S. Outfall	Aubrey ST @ Palmerston AVE	S-MA70017585	20,271	29.5
57	Aubrey	Aubrey ST @ Palmerston AVE	S-MA70017579	465,462	14.3
58	Ruby	Ruby ST @ Palmerston AVE	S-MA70022480	18,621	27.1
59	Arlington	Arlington ST @ Palmerston AVE	S-MA70053466	150	0.1
60	Canora	Canora ST @ Palmerston AVE	S-MA70017866	6,940	5.2
61	Cornish C.S. Outfall	Cornish AVE @ Maryland ST	S-MA20013630	10,463	2.0
62	Grosvenor	Grosvenor AVE @ Wellington CRES	S-MA70002491	15,011	1.5
63	Cornish	Cornish AVE @ Langside ST	S-MA70033535	197,109	14.7
64	Spence	Spence ST @ Balmoral ST	S-MA70103641	143,657	24.3
65	Colony	Colony ST @ Granite WAY (Mostyn)	S-MA20014505	123,219	7.1

Water and Waste Department Combined Sewer Overflow (CSO) Monthly Tracking Spreadsheet for Federal Government and Provincial Reporting

OP #	Overflow Point Name	Overflow Point Location (nearest intersection)	Asset Number	2009	
				Yearly Effluent Volume Deposited (m³)	Yearly Number of Days Effluent Deposited
66	Kennedy	Kennedy ST @ Assiniboine AVE	S-MA70068974	11,803	0.9
67	Fort Rouge Park	River AVE @ Cauchon ST	S-MA60020193	8,128	3.8
68	Hargrave	Hargrave ST @ Assiniboine AVE	S-MA20014087	3,628	2.1
69	Donald	Donald ST @ Assiniboine AVE	S-MA20014095	12,311	3.6
70	Mayfair	Mayfair AVE @ Queen Elizabeth WAY	S-MA70004387	36,241	1.7
71	Assiniboine	Assiniboine AVE @ Main ST	S-MA70008123	36,557	7.8
72	Strathcona	Strathcona ST @ Portage AVE	S-MA20011477	108,389	45.8
73	Plinguet	Plinguet ST @ Archibald ST	S-MA70041411	0	0.0
74	Cherrier	Cherrier ST @ Dufresne AVE	S-MA50002504	0	0.0
75	Doucet	Doucet ST @ Dufresne AVE	S-MA50002528	0	0.0
76	Prosper	Prosper ST @ Evans ST	S-MA50002566	0	0.0
77	Dubuc	Dubuc ST @ Seine ST	S-MA70022443	0	0.0
78	Gareau	Gareau ST @ Evans ST	S-MA70033704	0	0.0
79	Comanche	Comanche RD @ Iroquois BAY	S-MA50010965	0	0.0
80	Aubrey Flood (Pumped)	Aubrey ST @ Palmerston AVE	S-MA70017556	28,116	0.2
81	Clifton Flood (Pumped)	Clifton ST @ Wolseley AVE	S-MA70042741	30,198	0.3
82	Cornish Flood (Pumped)	Cornish AVE @ Sherbrook Bridge	S-MA70017433	9,763	0.2
83	Despins Flood (Pumped)	Despins ST @ Tache AVE	S-MA70087428	26,101	0.4
84	Dumoulin Flood (Pumped)	Dumoulin ST @ Tache AVE	S-MA70016522	0	0.0
85	Marion Flood (Pumped)	Poulin DR @ Lyndale DR	S-MA70105998	34,937	0.3
86	La Verendrye Flood (Pumped)	La Verendrye ST @ Tache AVE	S-MA70109090	2,858	0.2

Water and Waste Department Combined Sewer Overflow (CSO) Monthly Tracking Spreadsheet for Federal Government and Provincial Reporting					
				2009	
OP #	Overflow Point Name	Overflow Point Location (nearest intersection)	Asset Number	Yearly Effluent Volume Deposited (m^3)	Yearly Number of Days Effluent Deposited
87	Cockburn Flood (Pumped)	Cockburn ST S @ Churchill DR	S-MA60012037	0	0.0
88	Linden Flood (Pumped)	Linden AVE @ Kildonan DR	S-MA70016792	0	0.0
89	Ash Flood (Pumped)	Ash ST @ Wellington CRES	S-MA70016005	27,259	0.3

NOTE: Based on Hydraulic Modelling Results covering the representative year 2009

LEGEND:			
Overflow Points Associated with **N.E.W.P.C.C.**	Overflow Points Associated with **S.E.W.P.C.C**	Overflow Points Associated with **W.E.W.P.C.C.**	
Indicates Overflow Point **Is Monitored**	Indicates Overflow Point **Is Monitored**	Indicates Overflow Point **Is Monitored**	Please note that the above results are based on the current 2013 Regional Model and no outfall monitors were installed during this period of 2009
Indicates Overflow Point **Not Monitored**	Indicates Overflow Point **Not Monitored**	Indicates Overflow Point **Not Monitored**	

Water and Waste Department Combined Sewer Overflow (CSO) Monthly Tracking Spreadsheet for Federal Government and Provincial Reporting					
				2013	
OP #	Overflow Point Name	Overflow Point Location (nearest intersection)	Asset Number	Yearly Effluent Volume Deposited (m^3)	Yearly Number of Days Effluent Deposited
1	Cockburn	Cockburn ST S @ Churchill DR	S-MA60012037	160,301	4.7
2	Osborne	Osborne ST @ Churchill DR	S-MA70006325	1,488	0.8
3	Kingston	Kingston ROW @ Dunkirk DR	S-MA50014591	0	0.0
4	Mager	Mager DR W @ St Mary's RD	S-MA70007510	34,896	1.7
5	Baltimore	Baltimore RD @ Churchill DR	S-MA60013599	88,810	1.9
6	Metcalfe	Metcalfe AVE @ St Mary's RD	S-MA70011115	18,246	1.8
7	Eccles East	Eccles ST @ Churchill DR	S-MA70022370	58	0.0
8	Eccles West	Eccles ST @ Churchill DR	S-MA70006655	1,675	0.1
9	Churchill	Churchill DR @ Hay ST	S-MA70005806	10,395	6.9
10	Jessie	Jessie AVE @ Osborne ST	S-MA70016174	203,475	2.9
11	Walmer	Walmer ST @ Lyndale DR	S-MA70008060	3,949	3.3
12	Marion	Poulin DR @ Lyndale DR	S-MA50008337	25,406	0.6
13	Despins	Despins ST @ Tache AVE	S-MA70087426	48,196	1.9
14	Dumoulin	Dumoulin ST @ Tache AVE	S-MA70047759	55,105	3.4
15	La Verendrye	La Verendrye ST @ Tache AVE	S-MA70017688	17,885	2.2
16	Lombard	Lombard AVE @ Mill ST	S-MA70012338	0	0.0
17	McDermot	McDermot AVE @ Ship ST	S-MA20013332	174,786	9.8
18	Bannatyne	Bannatyne AVE @ Ship ST	S-MA70000991	55,414	1.1
19	Galt	Galt AVE @ Duncan ST	S-MA70021229	34,842	2.0
20	Mission	Mission ST @ Archibald ST	S-MA70016004	49,038	1.1
21	Roland	Watt ST @ Archibald ST	S-MA40011011	400,549	3.8
22	Syndicate	Syndicate ST @ Rover AVE	S-MA70003283	50,839	2.6

Water and Waste Department Combined Sewer Overflow (CSO) Monthly Tracking Spreadsheet for Federal Government and Provincial Reporting

OP #	Overflow Point Name	Overflow Point Location (nearest intersection)	Asset Number	2013	
				Yearly Effluent Volume Deposited (m³)	Yearly Number of Days Effluent Deposited
23	Selkirk	Selkirk AVE @ Austin ST N	S-MA70007427	163,064	5.0
24	Pritchard	Pritchard AVE @ Austin ST N	S-MA00017936	0	0.0
25	Burrows	Burrows AVE @ Main ST	S-MA00017926	54,489	16.4
26	Aberdeen	Aberdeen AVE @ Main ST	S-MA00017914	0	0.0
27	Hart	Hart AVE @ Glenwood CRES	S-MA70043042	208,499	4.4
28	St John's	St John's AVE @ Fowler ST	S-MA70007551	452,478	3.4
29	Bredin	Bredin DR @ Henderson HWY	S-MA40005212	59	0.0
30	Polson	Polson AVE @ Scotia ST	S-MA00017967	111,277	3.1
31	Munroe	Munroe AVE @ Henderson HWY	S-MA70017186	317,551	9.9
32	Inkster	Inkster BLVD @ Scotia ST	S-MA00017939	399,008	3.2
33	Jefferson	Jefferson AVE @ Scotia ST	S-MA70007473	312,996	3.7
34	Linden	Linden AVE @ Kildonan DR	S-MA70016792	18,264	2.0
35	Newton	Newton AVE @ Scotia ST	S-MA00017645	44,400	4.9
36	Armstrong	Armstrong AVE @ Scotia ST	S-MA00017633	720,714	6.6
37	Kildonan Park (Rainbow Stage)	Kildonan Park @ SE Corner	S-MA70069313	0	0.0
38	Hawthorne	Hawthorne AVE @ Kildonan DR	S-MA70062167	44,386	2.1
39	Whellams	Whellams LANE @ Tamarind DR	S-MA70042861	0	0.0
40	Woodhaven	Woodhaven BLVD @ Assiniboine AVE	S-MA70019662	18,665	1.9
41	Olive	Olive ST @ Assiniboine CRES	S-MA20005373	0	0.0
42	Strathmillan	Strathmillan RD @ Portage AVE	S-MA70053789	41,135	4.2
43	Conway	Conway ST @ Portage AVE	S-MA70016333	83,162	2.7
44	Deer Lodge	Deer Lodge PL @	S-	756	0.2

Water and Waste Department Combined Sewer Overflow (CSO) Monthly Tracking Spreadsheet for Federal Government and Provincial Reporting					
				2013	
OP #	Overflow Point Name	Overflow Point Location (nearest intersection)	Asset Number	Yearly Effluent Volume Deposited (m^3)	Yearly Number of Days Effluent Deposited
		Deer Lodge PL	MA70028291		
45	Douglas Park	Douglas Park RD @ Portage AVE	S-MA20008519	1,991	0.4
46	Ferry Road	Ferry RD @ Assiniboine AVE	S-MA70019346	134,724	15.4
47	Chataway	Chataway BLVD @ Wellington CRES	S-MA70029012	19,034	2.6
48	Doncaster	Doncaster ST @ Wellington CRES	S-MA70019277	43,093	6.5
49	Parkside	Parkside DR @ Assiniboine AVE	S-MA20008800	5,889	1.1
50	Riverbend	Riverbend CRES @ Portage AVE	S-MA20008967	124,458	2.9
51	Academy	Academy RD @ Wellington CRES	S-MA60006673	7	0.0
52	Tylehurst	Tylehurst ST @ Wolseley AVE W	S-MA20020018	193,646	5.6
53	Lindsay	Lindsay ST @ Wellington CRES	S-MA70024441	83,007	23.3
54	Clifton	Clifton ST @ Wolseley AVE	S-MA70008731	109,874	3.5
55	Ash	Ash ST @ Wellington CRES	S-MA70033504	219,575	6.5
56	Aubrey S.R.S. Outfall	Aubrey ST @ Palmerston AVE	S-MA70017585	5,944	19.9
57	Aubrey	Aubrey ST @ Palmerston AVE	S-MA70017579	182,169	5.0
58	Ruby	Ruby ST @ Palmerston AVE	S-MA70022480	5,208	21.3
59	Arlington	Arlington ST @ Palmerston AVE	S-MA70053466	32	0.0
60	Canora	Canora ST @ Palmerston AVE	S-MA70017866	2,147	2.4
61	Cornish C.S. Outfall	Cornish AVE @ Maryland ST	S-MA20013630	6,262	0.8
62	Grosvenor	Grosvenor AVE @ Wellington CRES	S-MA70002491	6,729	1.9
63	Cornish	Cornish AVE @ Langside ST	S-MA70033535	68,297	4.2
64	Spence	Spence ST @ Balmoral ST	S-MA70103641	70,471	3.8
65	Colony	Colony ST @ Granite WAY (Mostyn)	S-MA20014505	61,253	2.5

Water and Waste Department Combined Sewer Overflow (CSO) Monthly Tracking Spreadsheet for Federal Government and Provincial Reporting					
				2013	
OP #	Overflow Point Name	Overflow Point Location (nearest intersection)	Asset Number	Yearly Effluent Volume Deposited (m^3)	Yearly Number of Days Effluent Deposited
66	Kennedy	Kennedy ST @ Assiniboine AVE	S-MA70068974	10,233	0.6
67	Fort Rouge Park	River AVE @ Cauchon ST	S-MA60020193	2,726	2.0
68	Hargrave	Hargrave ST @ Assiniboine AVE	S-MA20014087	3,032	1.0
69	Donald	Donald ST @ Assiniboine AVE	S-MA20014095	5,905	2.6
70	Mayfair	Mayfair AVE @ Queen Elizabeth WAY	S-MA70004387	26,313	0.8
71	Assiniboine	Assiniboine AVE @ Main ST	S-MA70008123	21,470	3.6
72	Strathcona	Strathcona ST @ Portage AVE	S-MA20011477	58,637	32.0
73	Plinguet	Plinguet ST @ Archibald ST	S-MA70041411	0	0.0
74	Cherrier	Cherrier ST @ Dufresne AVE	S-MA50002504	0	0.0
75	Doucet	Doucet ST @ Dufresne AVE	S-MA50002528	0	0.0
76	Prosper	Prosper ST @ Evans ST	S-MA50002566	0	0.0
77	Dubuc	Dubuc ST @ Seine ST	S-MA70022443	0	0.0
78	Gareau	Gareau ST @ Evans ST	S-MA70033704	0	0.0
79	Comanche	Comanche RD @ Iroquois BAY	S-MA50010965	0	0.0
80	Aubrey Flood (Pumped)	Aubrey ST @ Palmerston AVE	S-MA70017556	23,540	0.2
81	Clifton Flood (Pumped)	Clifton ST @ Wolseley AVE	S-MA70042741	25,986	0.3
82	Cornish Flood (Pumped)	Cornish AVE @ Sherbrook Bridge	S-MA70017433	6,012	0.1
83	Despins Flood (Pumped)	Despins ST @ Tache AVE	S-MA70087428	19,150	0.4
84	Dumoulin Flood (Pumped)	Dumoulin ST @ Tache AVE	S-MA70016522	0	0.0
85	Marion Flood (Pumped)	Poulin DR @ Lyndale DR	S-MA70105998	24,184	0.3
86	La Verendrye Flood (Pumped)	La Verendrye ST @ Tache AVE	S-MA70109090	1,555	0.1

Water and Waste Department Combined Sewer Overflow (CSO) Monthly Tracking Spreadsheet for Federal Government and Provincial Reporting

OP #	Overflow Point Name	Overflow Point Location (nearest intersection)	Asset Number	2013 Yearly Effluent Volume Deposited (m^3)	2013 Yearly Number of Days Effluent Deposited
87	Cockburn Flood (Pumped)	Cockburn ST S @ Churchill DR	S-MA60012037	0	0.0
88	Linden Flood (Pumped)	Linden AVE @ Kildonan DR	S-MA70016792	0	0.0
89	Ash Flood (Pumped)	Ash ST @ Wellington CRES	S-MA70016005	20,600	0.3

NOTE: Based on Hydraulic Modelling Results covering the representative year 2013

LEGEND:

Overflow Points Associated with **N.E.W.P.C.C.**	Overflow Points Associated with **S.E.W.P.C.C**	Overflow Points Associated with **W.E.W.P.C.C.**	
Indicates Overflow Point **Is Monitored**	Indicates Overflow Point **Is Monitored**	Indicates Overflow Point **Is Monitored**	Please note that the above results are based on the current 2013 Regional Model and no validation against outfall monitor data has taken place
Indicates Overflow Point **Not Monitored**	Indicates Overflow Point **Not Monitored**	Indicates Overflow Point **Not Monitored**	

APPENDIX D
PEER REVIEW TECHNICAL MEMORANDUM

FINAL

CSO Master Plan
Peer Review

Prepared for

Winnipeg

November 2015

Prepared By

ch2m

In Association with

DILLON CONSULTING

XCG

TECHNICAL MEMORANDUM

Peer Review

PREPARED FOR:	City of Winnipeg
PREPARED BY:	CH2M
DATE:	November 27, 2015
REVISION NO.:	1
PROJECT NUMBER:	470010

1.0 Background

The City of Winnipeg (City) is in the process of developing a Combined Sewer Overflow (CSO) Master Plan. Winnipeg is working towards better management of CSOs, much like many other cities in North America. In developing the requirements for the master plan, the City recognized the value of learning from other cities. The City selected consultants with experience on other CSO projects and included a review of experience in the proposal scope of work. Drawing on the success of this approach, the City has also proceeded with a peer review, which has included the direct engagement of participants from other similar projects for their review and comment on the work done on Winnipeg's program.

This peer review technical memorandum describes the purpose, scope, and process for the peer review, the peers involved, and the conclusions the peer review team reached regarding the City's CSO Master Plan.

2.0 Purpose

The peer review was intended to add confidence and credibility to the master plan by providing an external review and comparison to other similar programs. The CSO Master Plan is a large and complex project that must review the current situation, identify methods and combinations of methods for improvement, evaluate their performance under a number of different scenarios, and make a recommendation for an approach forward. It must then present the information in a complete and concise manner for others to make an informed decision. The outcome is critical because the master plan is the first major submission within a regulatory commitment to a very large and costly long-term capital program.

A review of lessons learned and advice from others, not only for the technical approach but also for stakeholder involvement, regulatory issues, and plan development, could provide insight on the best way for the City to proceed.

3.0 Scope

The scope of work required the peers to review the project plan, technical approach, and progress made and provide their opinions on the comprehensiveness and completeness of the study. The approach was also intended to solicit comments on what has been tried elsewhere, what has and has not worked, and to identify opportunities for improvement.

The peer review was structured to review the entire master planning approach, and was not focused on a single issue or concern.

4.0 Process

The peer review was structured to identify the issues of most concern and opportunities with the most potential for improvement. This was accomplished by selecting peers with relevant experience from projects of the same nature and size, and by structuring the workshop to draw out the most relevant issues.

Peers were invited from communities known to have been working on CSO control for several years, concentrating on communities that are similar to Winnipeg. It was considered important to include Canadian experience, but also to incorporate some experience from the US, which has much different regulatory requirements but similar technical issues. Accordingly, the peers were sought from the following communities:

- City of Edmonton – Edmonton is the only city in Alberta with combined sewers and has many similarities to Winnipeg.
- City of Omaha – The geography, rivers, and combined sewer system in Omaha are much like those in Winnipeg, and in spite of having different regulatory requirements, there are many similarities between the CSO programs.
- City of Ottawa – Ottawa has proceeded with the planning and implementation of facilities on a scale similar to Winnipeg to address its CSOs.
- Metro Vancouver – The Vancouver situation is different from Winnipeg, with protection of salmon and local beaches being a priority, and Metro Vancouver has proceeded with a long-term sewer separation approach.

The peers were invited to participate as individuals, rather than representatives of their communities. The services were provided pro-bono and the peers were encouraged to offer input and opinions freely, without prejudice or risk of liability.

The workshop included a comprehensive project overview to allow the peers to identify the most important issues for reporting back to the City. CH2M developed a list of topics for the workshop, which was used as a checklist to confirm the peers were familiar with all the main elements of the CSO Master Plan.

CH2M reviewed all of the topics on the checklist with the peers on the first day of the two day workshop. The information was presented objectively, providing the peer team with a complete briefing and orientation. The City did not attend this first session and CH2M responded to requests for clarifications but did not defend the decisions or study findings. The peer group then decided as a team which of the topics to focus on for the presentation to the City on the second day.

The main topics on the checklist were as follows:

1. Problem Definition
2. Master Planning Approach
3. Control Option Evaluations
4. Water Quality Evaluations
5. Performance Assessment
6. Decision Process
7. Regulatory Liaison
8. Public Engagement
9. Risks
10. Specific Questions

4.1 Approach

A peer review prospectus was developed in advance of the workshop to define the process and expectations. The peer review was carried out in the following major steps.

Background Review
A collection of reports and project information was assembled and distributed to the peer team. The information included the technical report and previously prepared presentations. Links were also provided to program information, notably the following:

- Environment Act Licence No. 3042
  http://www.winnipeg.ca/waterandwaste/pdfs/sewage/csoLicense.pdf
- Winnipeg CSO Project website
  http://wwdengage.winnipeg.ca/cso-mp/

Briefing and Orientation
The first day was spent with the consultant team, acquainting the peers with the City CSO system and program, the planning and analyses completed to date, answering questions, and providing time for the peers to identify their main concerns and topics for reporting regarding the Winnipeg CSO program.

Presentation
The second day was scheduled to meet with City project management staff to discuss the peer reviewer's observations and opinions. It also provided time for further clarifications and dialogue on the rationale for the program approach and further development of opportunities suggested by the peers.

Documentation
The peer workshop was recorded as meeting notes. The notes were provided to the peers, which they have all reviewed and confirmed as an accurate account of the discussions. This report has been prepared as an overview of the process and findings, to support the master plan documentation.

4.2 The Peers

Each of the peers responded favourably to the request, and contributed to an extremely knowledgeable and well-informed team. The peers all had familiarity with these types of reviews and they quickly grasped the content and issues.

The team members participating as peers were as indicated in Table 1.

Table 1. Peers Participating

Name	Role and Organization	Contact
Chris Ward	Branch Manager Drainage Services City of Edmonton	(780) 496-5658 Chris.Ward@edmonton.ca 9803-102A Avenue 6th Floor, Century Place Edmonton, Alberta T5J 3A3
Louis Julien	Senior Water Resources Engineer Infrastructure Services Department City of Ottawa	(613) 580-2424 x21504 Louis.Julien@ottawa.ca 100 Constellation Drive Ottawa, Ontario K2G 6J8

Paul Wilting	Division Manager, Collection System, Project Delivery Liquid Waste Services Metro Vancouver	(604) 432-6447 Paul.Wilting@metrovancouver.org
Jim Theiler	Engineer IV CSO Program Coordinator City of Omaha Public Works	(402) 444-4923 James.Theiler@CityofOmaha.org

In addition to providing a broad cross section of programs, the peers also provided input from different perspectives, including senior administrative, planning, program implementation, and project delivery roles.

A summary of the peer members and the pertinent features of their CSO programs is as follows:

Chris Ward, Branch Manager Drainage Services, City of Edmonton

- *Organizational Role:* Chris leads the planning, construction, operation, and maintenance of sanitary and stormwater drainage. Chris was actively involved from the start of their CSO control strategy in the monitoring, modelling, planning, and implementation of the CSO plan.
- *Program Details:* Edmonton developed its first CSO control strategy in the 1990s and has been working on continual improvement since. There are 19 CSO locations in Edmonton, three of which make up 90 percent of the volume, but are not the most frequent. The solution was to target these three major overflows based on volume. This solution included the implementation of real time control (RTC) on the existing sewers and tunnels, and the construction of a new conveyance tunnel that would also provide some storage. The sewer system now includes a number of deep conveyance and storage tunnels. Tunnelling is relatively inexpensive in Edmonton because the City of Edmonton self performs the tunnel construction and owns its tunnelling machines. Since 1999, Edmonton has also spent over $180,000,000 on its CSO program, $85,000,000 of which was on high rate wet weather flow wastewater treatment at the City of Edmonton's Gold Bar wastewater treatment plant. Wastewater treatment in Edmonton is carried out by EPCOR, a separate municipally owned corporation. Now that they have achieved their initial target, another study is underway to determine a reasonable target level of CSO control. Edmonton rainfall can be spatially variable, with localized high intensity storms, up to 100 millimetres (mm) in 1 hour; 50 mm/hour is fairly common. The City of Edmonton makes extensive use of rainfall radar to assist in operating RTC where they can reduce flooding and or discharges by taking advantage of storage in other areas of the City less affected by the intense localized storm. Edmonton has applied 1981 as the representative year to measure system performance. The objective of the original program was 85 percent capture with a future goal of meeting the environmental equivalent of sewer separation.
- *Lessons Learned:* Lessons learned include the importance of checking for illicit connections using a camera survey before implementing RTC. The City of Edmonton inadvertently flooded a major building that had made an illicit connection. The biggest lesson for the wastewater treatment aspect of CSO control is that more effort should have been spent on solids handling and treatment because the volume of solids captured in the high rate wet weather flow treatment has far exceeded their expectations.

Louis Julien, Senior Water Resources Engineer, Infrastructure Services Department, City of Ottawa

- *Organizational Role:* Louis has been responsible for CSO master planning and the implementation of RTC in the City of Ottawa since 2000.

- *Program Details:* The City of Ottawa was asked by their regulator to develop a long-term control plan, but a major spill has put pressure on them to significantly reduce or even eliminate CSOs more quickly. The original CSO plan recommended a very large $200,000,000 tunnel, which some felt was unnecessary. Ottawa reviewed their existing CSO strategy and concluded that RTCs could assist in achieving their objective of zero overflows in a representative year more cost effectively. RTCs could reduce CSOs by two-thirds, a prediction realized through implementation. In the 1960s, they built interceptors and treatment and started with opportunistic separation, which is still a part of their program. Ottawa has greatly reduced its combined sewage service area from 28 km^2 to about 7 km^2 and plans ultimately to decrease the area to about 6 km^2. Ottawa has applied the year 1980 as the representative year to measure system performance.

- *Lessons Learned:* After completing the environmental assessment, the project team recognized that Ottawa can get tangible benefits (such as, basement flooding relief, interceptor twinning) from the tunnel program by building two shorter inter-connected tunnels rather than a single, longer tunnel. Both tunnels will operate by gravity, with one of the two operating as an inverted siphon with flood-relief to the Ottawa River during major events.

Paul Wilting, Division Manager, Collection System, Project Delivery, Liquid Waste Services, Metro Vancouver

- *Organizational Role:* Paul supervises a team of 30 engineers who provide construction and maintenance services for the trunk sewer collection system of Metro Vancouver.

- *Program Details:* Metro Vancouver serves a population of approximately 2.5 million in the lower mainland of British Columbia. Upstream sewers are the responsibility of each member municipality of Metro Vancouver. Metro Vancouver is a cooperative of 21 municipalities. Key worries are bathing beaches and the Fraser River Salmon fishery. The objective of Metro Vancouver is the eventual elimination of combined sewers.

- *Lessons Learned*: Paul echoed Jim's comment, "the plan you have is often not what gets built." Their original plan, which started in 1989, was directed at storage and treatment. They then moved to a separation approach, and as a result they now have a variety of interim solutions. Thirty years in, Vancouver has 1,400 to 1,600 CSOs per year totaling about 40 million m^3, although the flows are beginning to reduce. Impacts of CSOs are very different on the ocean, which is impacted by very strong currents.

Jim Theiler, CSO Program Coordinator, City of Omaha Public Works

- *Organizational Role:* Jim is the CSO Program Coordinator for the City of Omaha and has been involved with the program since 2000.

- *Program Details:* Omaha Public Works is a regional provider for sewerage and sewage treatment for about 400,000 people within the City of Omaha and another 800,000 people in the surrounding communities. The combined sewer area is about 100 km^2, about 10 percent of the total service area. Like Winnipeg, Omaha lies on a large river much influenced by upstream quality and flow. Omaha started CSO management planning in 2006, and has now spent $400,000,000 since 2009 in implementing CSO related controls. The CSO program has ramped up to about $100,000,000 a year and is expected to stay at that level through 2027. The year 1969 was selected and used for evaluating CSO controls.

- *Lessons Learned:* Omaha learned that technology changes with time and that it is necessary to be flexible and be prepared to change the plan. Omaha has continued to implement the original plan while at the same time working with the State regulator to make revisions to the plan. Jim, as well as the other peers, strongly recommended working collaboratively with the regulator. By doing this they have kept the State well informed and been able to tailor their CSO management program to their budget and thus make it affordable.

5.0 Peer Conclusions

The peers noted that although there are details unique to Winnipeg, the project is much like their own experiences in dealing with regulatory issues and in developing long term CSO control plans. The peers found the regulatory requirements typical in most respects, with the exception of the licence requirement for a not-to-exceed limit of 1.0 mg/L for phosphorus.

The peers unanimously concluded that the City's planning to date is consistent with industry best practices. The peers also suggested that the City CSO program could benefit from further interaction with, including visits to other cities with active CSO control programs. Overall, the peers agreed that there is no "silver bullet" solution for CSOs. They also agreed that no item or alternative that could substantially improve the City's approach to CSO control had been overlooked in the work to date.

The peers decided to focus their review and the discussion with the City of Winnipeg participants on their ten most important considerations. Recommendations and observations from the peer discussions include the following:

1) "Do nothing" is not an option.
   a) The City should try and strike a balance in the recommended plan between the needs of the regulatory authorities and the community's ability to pay. The peers strongly recommended proceeding with early actions, thereby getting the regulator on side early.
   b) The City should not wait, but rather should do low-cost improvements and early actions quickly and consider the US Environmental Protection Agency nine minimum controls (such as, weir adjustment and RTC).
2) The CSO control plan needs two stages, short-term targets and aspirational goals, recognizing the following:
   a) Everything changes as time progresses
   b) Climate and weather is changing
   c) Radar rainfall tracking is very useful in keeping up with the convective storms typical on the plains
3) RTCs are not inherently bad. They can be used to increase storage cheaply. Start with a simple system and expand as operations staff gets comfortable with it. Pick the best site, and make sure to get the operators to help design it.
   a) Optimize the flow going to the plant through the off take pipes. Note that the model has the information, but recognize the staff can optimize the flow management without a model.
4) The City should clearly tie options to rate impacts and add variation in implementation time to stabilize the rate impacts.
5) The peers recommend continued emphasis on public engagement.
   a) Present the goals in a way that the public and elected officials can understand. The concept design reviewed to date is the technical report, it will be augmented with an executive summary and a concise decision summary report.
   b) Justify study and data acquisition costs by emphasizing that the big dollar projects need to be supported by sound analysis. The City needs to be confident in the model results.
   c) Emphasize the volume reduction metric rather than frequency of overflows.

   d) Reach out to the First Nations.

6) The CSO program needs an internal champion. The peers advise the City to hire or develop a CSO manager and team that includes operations staff to carry the program through implementation.

7) The City should continue to refine the cost tool. Overall, they felt tunnelling and storage costs looked low. The peers recommended including a higher contingency in the estimates.

8) The concept report recommendations are generally consistent with industry experience, with the following additions:

   a) Green infrastructure needs to have greater emphasis. It is not the only solution but can be well-received by the public.

   b) Options need realistic, operations-oriented optimization.

9) The City is advised to bring an experienced contractor in early during planning to provide practical advice on implementation.

   a) Investigate alternative delivery methods.

10) The peers advise that new issues will likely emerge that may need changes to the plan, such as the following:

   a) Added solids handling as flows increase

   b) Air and odour management

   c) Grit management and disposal

APPENDIX E
PUBLIC ENGAGEMENT

Winnipeg
Water and Waste Department

CSO MASTER PLAN
PHASE 1
PUBLIC PARTICIPATION REPORT

October 2015

For more information on this report, please contact:

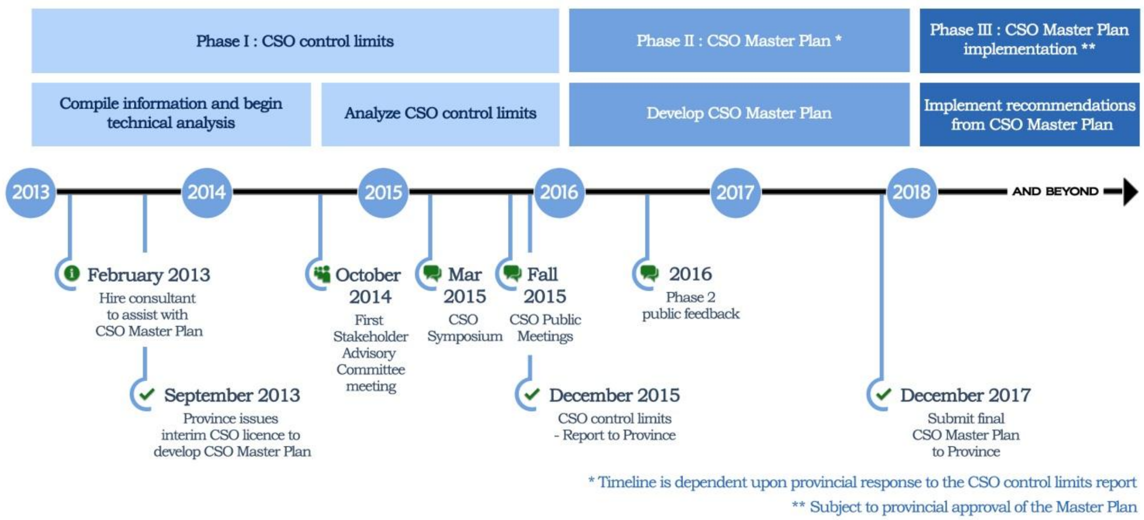
Tiffany Skomro
Public Engagement & Research
1199 Pacific Ave

TABLE OF CONTENTS

BACKGROUND

In February 2015 the City of Winnipeg initiated a public engagement process to receive feedback on a plan to reduce combined sewer overflows and manage their effects in an environmentally sound, sustainable and cost-effective manner.

To help educate the public on what CSOs are an animation was created: http://www.winnipeg.ca/waterandwaste/sewage/cso/index.html



Information on the public engagement for the CSO Master Plan is available on the website, which includes CSO topics that help to educate stakeholders on project matters: http://wwdengage.winnipeg.ca/cso-mp/

Phase 1: CSO control limits

The work of Phase 1 of public engagement is included in this report, which identified values to help shape decision criteria used to evaluate five CSO control limits.

Criteria:

- **River usability** – a control limit's impact on the water quality, bacteria levels, public health, odour, aesthetics, recreation, etc. in Winnipeg rivers
- **Value for cost & affordability** – a control limit's cost and the impact on future utility bills
- **Lake Winnipeg** – a control limit's impact on the health of Lake Winnipeg and the watershed
- **Visionary & broader context** – a control limit's impact on other City projects and priorities now and in the future
- **Economic sustainability & construction capacity** – a control limit's impact on the economy and our ability to complete it efficiently

- **Livability** – a control limit's impact on the lives of citizens during and post construction
- **Innovation & transformation** – a control limit's impact on the quality of life in Winnipeg

CSO Control Limits:

1. 85% capture in an average rainfall year
2. Four overflows in an average rainfall year
3. Zero overflows in an average rainfall year
4. No more than four overflows per year
5. Complete sewer separation

Future phases of Public Engagement

Public engagement efforts will continue in two additional phases:

Phase 2 – a CSO Master Plan will be developed once a CSO control limit has been set

Phase 3 – implementing the CSO Master Plan once provincial approval has been received

PUBLIC FEEBDACK

Public feedback was collected from February 18, 2015 – October 5, 2015:

- Comments on the website – 20 comments
- Direct email (incl. via web form) – 1 email
- Comments in writing – 2 letters
- A **CSO Symposium** held on Thursday, March 5, 2015 – 62 attendees and 4 panelists
- Two **public meetings**:

Public Meeting Date	Attendees
Monday, September 14, 2015	24
Tuesday, September 15, 2015	29

- The CSO animation was played as part of the Water & Waste booth at Home Expressions, March 27-29, 2015.
- Rivers West promoted the work of the CSO Master Plan in its May 2015 News Bulletin.

In-person events were live-streamed and recorded so that presentations could be watched at a viewer's convenience.

A Stakeholder Advisory Committee was also brought together to share perspectives and help in developing a CSO Master Plan. The Committee met four times:

- October 2, 2014
- November 19, 2014
- January 28, 2015
- April 9, 2015

Committee membership, presentations and notes can be found online:
http://wwdengage.winnipeg.ca/cso-mp/sac/

Reports

Reports for the feedback received can be found in the following report:

- Summary of Comments and Responses
- Symposium Feedback Report
- Phase 1 Feedback Report
- Stakeholder Advisory Committee: What was heard

For further detail, please refer to the specific reports available online at wwdengage.winnipeg.ca/cso-mp/

Also available online are the materials used during the public engagement process, including presentations and storyboards, as well as live-streaming captures of the in-person events.

METHODOLOGY

The public engagement process is based on IAP2 principles, best practices, and core values.

Responses from the symposium, public meetings and website are based on self-selecting respondents who are more likely to respond because they would like to express an opinion on the topic at hand. While these opinions are valuable, they cannot be viewed as representative of all Winnipeggers.

PROMOTION

Several methods were used to inform stakeholders throughout the engagement process:

- 124 invites were mailed out to key stakeholders (see Appendix A)
- Water & Waste email News was mailed out:

Date	Total emails Sent	Total emails Opened	No. of Click-throughs
February 18, 2015	3,876	2,053 (53%)	281
March 2, 2015	3,949	1,832 (46%)	133
September 2, 2015	4,589	2,330 (50.8%)	73
Sep 11, 2015	4,594	1,895 (41.2%)	38

- Information was also included in the first edition of the City of Winnipeg's Public Engagement News:

Date	Total emails Sent	Total emails Opened	No. of Click-throughs
October1, 2015	3,811	1,904 (50%)	116

- Print advertisements were placed in the Winnipeg Free Press:
    - February 27, 2015
    - September 3, 2015
- Media interviews were held:
    - CJOB June 3, 2015 Richard Cloutier Morning show
    - CJOB Taped Interview June 24, 2015
    - CBC Radio Taped Interview June 24, 2015
    - CBC French TV September 15, 2015
    - CBC English TV September 15, 2015
- Events were also promoted through press releases and the City of Winnipeg's social media accounts, featuring the hashtag #WpgCSO.

CSO SYMPSOSIUM – GROUP BREAKOUT SESSIONS

The results of the group breakout sessions are provided in Appendix C. A summary of the sessions is depicted as a word cloud, where frequently repeated words appear larger.

APPENDIX A

KEY STAKEHOLDERS INVITED

LIST OF KEY STAKEHOLDERS INVITED

1. Chalmers Neighbourhood Renewal, Coalition of Manitoba Neighbourhood Renewal Corporations (SAC)
2. International Institute for Sustainable Development (SAC)
3. Lake Friendly, Partnership of the Manitoba Capital Region (SAC)
4. Manitoba Eco-Network (SAC)
5. Manitoba Heavy Construction Association (SAC)
6. Old St. Vital BIZ (SAC)
7. Rivers West (SAC)
8. Winnipeg Chamber of Commerce (SAC)
9. Manitoba Conservation and Water Stewardship (SAC)
10. Partnership of the Manitoba Capital Region
11. Winnipeg Regional Health Authority, Community Health Advisory Councils
12. Consumers Association of Canada (Manitoba)
13. Winnipeg Rowing Club
14. Association of Manitoba Municipalities
15. Canadian Federation of Taxpayers (Manitoba)
16. Manitoba Chamber of Commerce
17. Centre for Indigenous Environmental Resources (CIER)
18. Federation of Canadian Municipalities (FCM)
19. Manitoba Water & Wastewater Association (MWWA)
20. Green Action Centre
21. Provincial Council of Women of Manitoba (PCWM)
22. Western Canada Section American Water Works Association (WCS AWWA)
23. Save Our Seine
24. Manitoba Wildlands
25. Grindstone Cottage Owners Association
26. Nature Manitoba
27. Paddle Manitoba
28. International Joint Commission - Red River Board
29. Delta Marsh Field Station
30. Lake Winnipeg Research Consortium
31. Fish Futures
32. Winnipeg Water Watch
33. CPAWS
34. Manitoba Wildlife Federation
35. Manitoba Fly Fishers Association
36. North Red CFDC or Red River North Tourism
37. Ducks Unlimited
38. Western Canada Wilderness Committee, Manitoba
39. Nature Conservancy of Canada
40. Manitoba Lodges and Outfitters Association

41. Manitoba Paddling Assn
42. The Forks
43. Manitoba Naturalist Society
44. St. Norbert Arts Centre
45. Canadian Water Resources Association
46. Red River Catfish Preservation Society
47. Manitoba Pork
48. Lake Winnipeg Foundation
49. Red River Basin Commission
50. Transition Winnipeg
51. Council of Canadians
52. Green Manitoba
53. Overton Environmental Enterprises
54. Environmental Health Association of Manitoba (EHA-MB)
55. H20: Ideas and Action for Canada's Water
56. Lake Friendly
57. RM of West St. Paul
58. RM of East St. Paul
59. RM of St. Andrews
60. RM of St. Clements
61. RM of Rosser
62. City of Selkirk
63. City of Gimli
64. Brokenhead Ojibway Nation
65. Southern Chiefs' Organization
66. KGS
67. Stantec
68. Dillon Consulting Ltd
69. Scatliff+Miller+Murray
70. APEGM
71. ACEC-MB
72. Manitoba Environmental Industries Association
73. Southeast Community Futures Development Corp
74. Southeast Resource Development Council
75. Manitoba Health
76. Freshwater Institute
77. HTFC Planning & Design
78. LM Architectural Group
79. MIT
80. Manitoba Municipal Government
81. CDEM
82. Manitoba Clean Environment Commission
83. University of Manitoba

84. University of Winnipeg
85. Red River College
86. International Facility Managers Association of Manitoba
87. Building Owners Association of Manitoba
88. Winnipeg Trails Association
89. Recreational Trails Consultant, Province of Manitoba
90. Urban Development Institute
91. Institute of Urban Studies
92. Sport Manitoba
93. Forks North Portage Partnership
94. Daniel McIntyre/St Matthews Community Association
95. North End Community Renewal Corporation
96. Spence Neighbourhood Association
97. West Broadway Development Corporation
98. Bike Winnipeg
99. Enterprises Riel
100. North Point Douglas Women's Centre
101. Centre Venture

APPENDIX B

CSO SYMPOSIUM
LIST OF ATTENDEES

LIST OF CSO SYMPOSIUM ATTENDEES

1. Winnipeg Chamber of Commerce
2. International Institute for Sustainable Development
3. Lake Friendly, Partnership of the Manitoba Capital Region
4. CH2MHill
5. Old St.Vital BIZ
6. Manitoba Eco-Network (x2)
7. Inland Pipe
8. Eng-Tech
9. Manitoba Conservation and Water Stewardship (x4)
10. Manitoba Liquor & Lotteries
11. Step-Up Waste Management Solutions
12. Save Our Seine
13. Waste 'n Watertech
14. University of Manitoba (x2)
15. City of Winnipeg Councillor (x2)
16. MMM Group (x2)
17. Aboriginal Affairs and Northern Development Canada
18. KGS Group (x2)
19. Safeway
20. St.Pierre Public Works
21. St.Pierre Village
22. Lake Winnipeg Foundation
23. Red River Basin Commission (x2)
24. AECOM (x3)
25. CEC
26. BDM Projects
27. Paddle Manitoba
28. Power & Mine Supply
29. CNRC
30. AYO
31. InfraCor
32. Rivers West
33. Qualico (x2)
34. GEM Equities
35. MIT/Green Buildings
36. Old Saint Boniface Residents Association
37. Citizen (x17)

APPENDIX C

CSO SYMPOSIUM
GROUP BREAKOUTS FEEDBACK

1) **What stood out to you from the Panel presentation and discussion?**

- Absence of comprehensive watershed management plan for the City of Winnipeg (bigger picture thinking is missing!)
- How do we recognize water quality as a priority within the larger economic landscape
- Economic investment as transformational
- Lack of regulations (federal/provincial level)
- Transformation from open sewers to recreational rivers
- Ratio of nutrient reduction into Lake Winnipeg vs. financial impact
- What's the objective if water quality achievement is not feasible? Basement flooding?

- Surprised by total length of combined sewer (1000 kms -> cost a lot to change)
- Need to fix infrastructure as it ages
- Lack of green initiatives in MB
    - Are we shying away from it?
    - Cost
- Need to consider lifecycle analysis
- Surprised by how small an impact it is <1%
- Need to think of long-term – structural deficit
- Where? End of pipe or source?
    - Reduce runoff
    - Work within system we have
- Low impact development
    - Put water back in the ground where it falls (permeable paving)
- Flooding is human-made problem
- Store water
- Cost benefit analysis, engage politicians, legislation, water budget, etc.
- No clear/obvious right answer
- Different answers depending on location
- Solution needs to be non point source

- CSO impacts on recreational/water quality are extensive when it happens
- CSO not the large contributor to phosphorus
- CSOs does not = phosphorus (or other nutrient) issues
- Very important issue – green infrastructure possibilities need to be considered
- Impact on aboriginal population
    - e.g. are dollars better spent on CSOs or other significant community based initiatives i.e. Roseau, Brokenhead
- The 1% factor to be addressed by significant dollars –> why?
- Why talk phosphorus? And not E.Coli?

- In “22 events” what is composition of liquids and solids
    - how much waste water goes into
- Factor in the lifestyle changes that are necessary even though people will have to “adjust ways”
- Good video, do more

- What’s the objective water quality or regulation
- Water quality (P), spending money on CSO is poor investment
- Needs to be a discussion City <-> Province what/which problem are we trying to solve. That discussion hasn’t happened.
- There appears to be no communication plan
- Opportunity cost of “solving” CSO issue
- Look at CSOs in broader context
- People concerned about water quality
- Water quality over CSO amounts
- Look at multiple benefits for any option -> bang for $
- Learn from best practices/lessons learned in other jurisdictions
- Look at economic development opportunities
- Where does the money come from/cost
- Less than 1% - who has the biggest impact?
    - How do we do this as part of a normal infrastructure projects as opposed to one off mega-projects
- Take a long term approach = more affordable
- Need multi-party approach -> water shed approach -> many sources
- Educate Winnipeg and surroundings on what impacts we have on rivers & lakes

- Stop looking @ 90s – stop talking about the 1%, but rather set targets to concrete goals
- Do you want to spend $ elsewhere + not fix CSO?
- Magnitude of $ that is needed ->where is the best place to spend
- Is the objective to improve what quality or
- What is the GOAL?
- Focus on the task – make a choice + lets go
- 10% reduction is pretty good
- Stop dumping – embarrassment
- Talked about phosphorus along, only 1 aspect. What about the other chemicals, factors?

- Issue of economic benefit is a factor worth considering
- Spending all the $ won’t improve water quality
- Vs load (phosphorus is huge)
- Are we reducing CSOs or water quality

- Def. of CSOs is useless – can be 1 hr, 1 day, 1 week -> quantity overflow
- 22 overflows x 79? They don't all discharge @ the same time.
- $ invested into surface water mgmt. maybe worthwhile
- Greenspace/bioretention important for new dev.
- Hank: converting section in retention areas could store stormwater/economic spin-offs

- What is the actual estimated cost?
- Where does that money come from?
- Idea of protecting environment and waterways
- Watershed approach will just reducing CSOs fix the problem
- "1%"
- How to effectively spend $$
    - Don't think it's the right direction for spending $$
- Water quality trading
    - What role can MB play beyond Winnipeg
- What's the question
    - If water quality or CSOs
    - Still doing it same way
- Other cities used innovate approaches to existing/adapting infrastructure
- More consciousness of environment
- More extreme flooding
- Regulatory issue
- River users + raw sewage in CSO events -> "perception issue"
- Public perception is different than reality of the impact
- Incentive for individuals, and other "front of pipe" and what impact can be achieved instead?

2) **What is important for the City to consider as it creates a plan to manage the effects of combined sewer overflows?**
   a) **What issues, opportunities or considerations do you see that should be addressed?**

- Consider other measures beyond phosphorus
- Financial impact on taxpayers
- Existing by-laws and building codes should be re-examined. e.g. holding tank for stormwater runoff for 'asphalt deserts'
- Considerations for drains that don't go anywhere
- Re-designing roads to slow the stormwater

- Cost, who pays?
- What is the goal
  - Basement flooding
  - Phosphorus reduction
- Public engagement
- Who sets goals?
  - Are we representative?
  - What are the interests/concerns of the public?
- More info about combining solutions e.g. H.Venema – Nutrient removal
- Diverting waste
- What is bigger impact: N End treatment plant or CSO?
- What is the GOAL?
- Low hanging fruit
- Use landscape architecture
- Population density

- Efficient/effective
- Series of smaller solutions/interventions leading to bigger approach
- Personal + business incentives as part of solution
- Share more of the data and create awareness of issues + solutions
- What are the city by-laws related to green roofs and other potential design strategies
- What is cost factor of treatment centres? What is the 1% factor (phosphorus) worth in terms of cost?

- Stage construction e.g. roads needs replace, do sewers, PLAN
- Water quality vs. CSO reduction -> what's the focus
- Cottage country – beach, loss revenue
- Role of city planning – new development, infrastructure, infill
- We should do something

- It’s the right thing to do
- Do we replace infrastructure only when it fails
- Incorporating green infrastructure
- Water trading – part of the solution
- Alternative solutions to handle/store overland flooding, overland is P-rich
- Consider “front of pipe” solutions -> demand side
- We have to address existing CS systems
- How do we measure the impacts/benefits
- Look at similar size cities & climates for ideas
- Know what the capacities are & where
- How do we get the most impact with the limited $
- Start small & make targeted impacts

- Make a meaningful/measurable difference!
- Obstacles that hinder/prevent innovators from creating solutions. Departmental red tape to get projects off the ground (run around)
- Need to think differently
- Dissemination of info

- Issue -> $/revenue
    - 80/20 rule, huge investment for nominal result
    - Stringent licence
- Considerations
    - Province should step up
    - Are you really approve water quality
    - Risk implications
    - Protecting existing infrastructure
    - Solutions are based on region/area
- Opportunities
    - Innovation
    - Economic spin-offs
    - Job creation
    - Innovative solutions?
    - Sewer renewal
    - Educating public on reality of CSO impact on our rivers

- Green infrastructure is huge
- Take water where it lands and deal with it
- What are lifecycle costs on investment?
- New land management planning
    - New criteria
    - Uses of land

- Where are conditions the worst (e.g. events even when it's not really wet weather)
- Wet weather flows – how can you manage the storm water (better)?
    - How much store water runoff at each site
- System
- Pay a tax for land drainage
    - Economic incentives
    - "Stormwater fees"
    - In other cities making people aware of individual role to play
- CSOs if eliminate stormwater flow, more sewage capacity for density
- Capacity of current treatment plants
- Where does Winnipeg fit into bigger watershed in terms of impact?
- Land ownership – where is this in the equation

b) How would you assess or evaluate river quality?

- More data collection, more tech
- See floatables
- Concentrations of pollutant parameters: TP, BOD
- Riparian zones, shoreline health, re-established buffer zones – have supporting by-laws

- Ongoing monitoring
    - What are you testing?
    - How often?
    - Before and after flood/snow
- Recreational usage
- Species diversity (long term)
- Habitat
- E.Coli
- Solution: cap overflows, divert, store
- Consider: debris, fecal matter, Ph, aesthetics
- Micro-portable waste water treatment plants (MBR)
- Treat it before it hits the river
    - Consider cost and use and age of infrastructure (79 sites!)

- Sampling, monitoring
- Chemicals, nutrients, aesthetics, appearance, aromas, fish suitability
- Need to know more about the science aspects in terms of river quality
- What are the details around how the St.John's, Scotia St places work and all land drainage spots "the 76"
- The survey percentages of river activity use
- Inform + educate = create better knowledge
- Some importance to factor in what other jurisdictions are doing: learn from others

- Swimmable, fishable, in water sports
    - Is it achievable, clay + silts
    - Winnipeg 'muddy waters'
- What the "measureable" pollutants?
    - Pharma, ecoli, etc.
- Reduce odour from rec activities
- Return river to rec quality
- Small scale & measurable impact

- Perception or reality

- Floatables
- Testing water/parameters at the CSO sites
- Test up and down stream
- Sensitivity of testing
- Land drainage quality – testing?
- Bigger picture vs. fixing the 1%
- Development, managing runoff
- Landscaping within certain districts – duty to make it better

- Excellent water quality, but wouldn't swim in it
- Water treatment plant upgrades will show improvement in water quality
- Number of nutrients in water
- Shouldn't evaluate it based on colour

- Look at indicator organisms
- If you can keep it out of treatment plant
    - Source control
    - Decentralized treatment
- Surface drainage will take more than a pipe "flow slipping"
- Low impact development – how does this work in downtown Winnipeg where its already developed?
- Complications from winter – sand, gravel, etc.
- Spring runoff
    - Top level of parkades -> park (manage drainage)
    - Green buildings/roofs
    - In sewers too
    - Green alleys in Chicago

3) As planning continues what information might be important for public and stakeholders to know or hear about?

- Clearly identify the objective
- What other precedents from other cities
- Prove that they've explored and exhausted all options, that what they are doing is the answer
- Maximize on existing WTP
- Let's know about what you can do as an individual, what everyone can do about it. e.g. front of pipe
- Think outside the box, change thinking from 50s
- BIG picture plan from infrastructure to multi-point solutions
- We want to know about low flow toilets, water reduction, greywater system
- Pilot projects of best practices – educate people about results
- Reference your proposed solutions e.g. this solution "A" works in Minneapolis

- Numbers
  - Ph, flow, E.Coli, pharmaceuticals, impact with no action
- Many options -> present a variety, and how they would work with planning dept.
- Cost, who pays?
- Benefits of CS? Supporting surface water management through treatment facility
- Benefits to removing/retrofitting CS
- How does this impact new development?
- How does this change planning?
- More info to public will make it easier later to implement
- Precedents from similar cities
  - Size, demographics, geography, geology

- Cash cost
  - How much do we spend?
  - What is the cost benefit
  - Overall bang for buck
- Justifying sewer pipes vs. hospitals
- Spending on treatment plants? Prevents algae blooms, reduce basement flooding
- Championing the goals -> focus on what do we get for what we are spending
- Education + awareness, the hidden unknowns
- Help people know the "provincial legislation and criteria/requirements" "The Letter" What other alternatives are there? Upstream control vs. the city.
- Get a better handle on the issue
- Create better communication: another stage of videos to build off the first one -> general public will learn it better

- Better collaboration between city/province so the public can feel that an effective and coordinated approach is happening on the subject

- Facts
- Costs
- Disclosure vs. selling the solution
- Educate the public
- Options vs. values
- Is this where we want to spend our money
- Money to go water quality vs. CSO reduction
- Are we going to cleaner water, cleaner L.Wpg. or CSO reduction
- Water trading solutions
- Green technologies – could we benefit water quality more cost effectively
- Could Seine River be used as a pilot
- Water quality
    - Nutrients P,N
    - Aesthetics
    - Coliform
- Is there room for multiple solutions, beyond CSO and beyond city boundaries
- Public should know what the results of their activities on water quality, and what they can do to help
- The 1% # - is it going to help water quality
- Why should they are about the "1%"
- Where does this fit with climate change, impacts of more rainfall events
- How do we define water quality as a community?
- What are we willing to pay to get this water quality
- Role of consultant in CSO MP process, versus implementation

- Construction impacts
- Letting people know this is happening! Important!
- Systems built for human health, framing it in a way that people understand it
- People aren't aware of green infrastructure potential solutions, how effective they are or are not
- Some development hasn't changed its ways
- Current rules + practices of [development] haven't been enforced
- Public needs to be more aware of how developers must operate
- What are the cost of the infrastructure options? Cost of other control option "current" info – is there a new # figure is 13 years old – 2002
- What are city's controls factors, city can't do it alone! Needs province.
- Volume of run off in a big #
- When will the Master plan be complete?
- Include the options in the plan for awareness, options +/- forces people to think

about it

- Fargo option – not practical for Manitoba due to agriculture sacrifice – what are the cost implications of this option
- Could we store what where we convey it?
- Not likely because you'd compromise

- Everybody needs to understand that improving CSOs will have minimal impact to the environment + water quality
- Make a plan to reduce overflows
- People to be educated on actual pollutant level of river
- Bottom line: Province will review the final report + we will have to deal with their decision.
- Government does not tend to invest in improvements that cannot be seen

- CSOs and bacteria and "BOD" – where do these fit in?
- "Floatables" – condoms, poop, syringes
- Fact vs. fiction
- How are they collecting the data? (monitoring)
    - Make it available to public
- Video was clear on what CSOs are -> but now: what is the effect on water
    - Does it affect our drinking water? (Not just in Winnipeg, but downstream)
- Clear on cost and effectiveness
- What is the real benefit to basement flooding (now + later) – what change for investment?
- Budget process – with structural deficit, need transparent process
- Public education on human health impacts
    - Safety precautions
    - Awareness when events are happening (so rec users can make informed decisions)
    - Same goes for treatment plant discharges
- Incentive e.g. in Seine River area

APPENDIX D

PUBLIC MEETINGS
LIST OF ATTENDEES

LIST OF CSO PUBLIC MEETINGS ATTENDEES

1. University of Manitoba (x2)
2. Wawanesa Insurance
3. Belgian Club
4. Celco Automation
5. Manitoba Health
6. Spence Neighbourhood Association
7. BDM
8. Manitoba Conservation and Water Stewardship (x3)
9. RM of St. Andrews (x4)
10. MIT
11. Green Action Centre
12. First Person Strategies
13. Weston Residents Hsg Co-op
14. Stantec Consulting
15. CH2M
16. Aboriginal Affairs Canada
17. The Uniter
18. Chalmers Neighbourhod Renewal
19. Save Lake Winnipeg
20. AECOM
21. 71 Roslyn Condo Board
22. RM of East St.Paul
23. Terracon Development (x2)
24. CBC Manitoba
25. City of Winnipeg Councillor (x2)
26. Citizen (x22)

APPENDIX E

PUBLIC MEETINGS
QUESTIONS & RESPONSES

PUBLIC MEETINGS QUESTIONS & RESPONSES

1. Are basement backups caused by combined sewer systems?
   - Yes, basement backups can be caused by high levels in both the combined and separate sewer systems if the home/business is not protected by a backwater valve and sump pump system. The City of Winnipeg and the Province of Manitoba have a joint program to assist residential homeowners subsidize the cost of installing a backwater valve and sump pump system. Further information can be found here.

2. Is the reduction of basement backups factored into the cost/benefit analysis for the CSO plans?
   - Yes, it is factored into each of the CSO options.

3. The presentation refers to Wastewater Systems Effluent regulations and states that ammonia is not a factor due to dilution—has the City sampled for ammonia?
   - Yes we have sampled for ammonia as part of the CSO water quality monitoring program that we have undertaken over the last two summers.

4. Are water samples taken at the outfall before it reaches the river?
   - Yes, water samples were taken upstream, in the outfall, prior to the overflow discharging to the river at 8 locations. We also take samples in the river.

5. What causes CSO overflows during the winter?
   - Many factors can cause dry weather overflows during the winter, such as rapid snow melt, water main breaks or a high water table leading to infiltration.

6. Do any of the CSO options include in-line storage?
   - All the proposed options will have some component of in-line storage depending on the level of storage required.

7. What will the zero overflow option consist of? Would it be dedicated transport tunnels?
   - The zero overflow option will consist of tunnels and controlled pumping.
   - Dedicated tunnels can span multiple combined sewer districts to store the storm water and pump to the treatment plant once the storm event peaks have passed.

8. Do the CSO options consider green technologies like storm water management? What would this look like?

- As part of all the options, green technologies will be incorporated in some form.
- Green technologies could include but not limited to rain gardens, green streets, bioswales, etc.

9. Do the CSO options proposed have the capacity to deal with the impacts of climate change and extreme weather?
   - All options will be impacted by climate change. The additional storage volume required will depend on the recommended option, which will be designed at a later stage.

10. Can phosphorus be managed through the CSO Master Plan (CSO MP)?
    - The CSO MP may not be the best way to address the phosphorus issue. Phosphorus in the captured flow will be treated at the sewage treatment plants once the nutrient upgrades are complete.

11. How does the City plan to manage growth in the core areas, given that most combined sewers are found there?
    - The CSO Licence does not allow for increased CSOs due to further development.

12. How many overflows occur in the Cockburn CS district? Is the City in compliance by not adding additional CSOs?
    - The Cockburn district had 18 CSO events in 2014.
    - There is currently separation work being undertaken in Cockburn.
    - Any new development is restricted to pre-development runoff flows.

13. Is the plan to install a two-pipe system (complete separation)? Is it difficult to construct?
        - Until we have a control limit set, we do not know how much of the system will be a complete separation (two-pipe system).
    - Complete separation the most costly option but it can be done with time and coordination.

14. What would the impact be on sewer/water utility bills if Option 5 (complete separation) were spread out over 60 years?
        - The impact would be less, but inflation would need to be factored in. The total costs would be more for this scenario. Further information regarding implementation time can be found here.

15. What time period was used to calculate the "average rainfall?" Does this include climate change?
    - About 30 years of data was used to calculate the "average rainfall."

- Climate change will need to be factored into the design and will be done at a later stage.

16. When work begins on limiting CSOs, will the entire 1000 KM of sewers be affected?
    - No, only parts of the 1000KM of pipe will be affected as there has already been previous work done in combined sewer areas.

17. What control limit would the Ness/Route 90 sewer work fall under? How many years will that take?
        - That work is under the current program – see the information displayed on the "Current Approach to CSOs" storyboard.
    - This program is ongoing and is projected to be completed in about 10 years.
    -

18. Why do the storyboards have an Option 0 (current approach), considering MB Conservation and Water Stewardship provided the City a Licence to explore different CSO management options?
    - The Province issued the Environment Act Licence No. 3042, which pertains to the management of CSOs.
    - There are five proposed CSO Control Limit Options and option zero ("Current Approach to CSO") storyboard is shown as a baseline to disclose the work the City is currently undertaking.

19. Do you know how much volume is discharged into the rivers when you average 22 overflows a year?
    - About 1% of the total annual sewage generated is lost to overflows.

20. When overflows discharge to the rivers, has nitrogen or phosphorus been removed? What is the impact on our waterways?
    - No, nitrogen and phosphorus are not captured when CSOs occur.
    - Nitrogen and phosphorus amount in CSOs is a small component of the total nutrient loadings to Lake Winnipeg. We want to do our part in reducing those numbers but it is also our responsibility to inform the public that eliminating CSOs will have very little impact on the health of Lake Winnipeg.

Water and Waste Department

CSO MASTER PLAN
PHASE 1 PUBLIC PARTICIPATION
FEEDBACK REPORT

October 2015

For more information on this report, please contact:

Tiffany Skomro
Public Engagement & Research
1199 Pacific Ave

TABLE OF CONTENTS

BACKGROUND AND METHODOLOGY

In February 2015 the City of Winnipeg initiated a public engagement process to receive feedback on a plan to reduce combined sewer overflows and manage their effects in an environmentally sound, sustainable and cost-effective manner.

Public feedback on the second part of the public engagement process was collected from September 2 – October 5, 2015. Feedback was captured at the public meetings using live polling technology and dotmocracy, and online through a survey.

Public Meeting Date	Attendees
Monday, September 14, 2015	24
Tuesday, September 15, 2015	29

Responses for polling technology questions ranged from 50 to 54.
There were 13-23 responses received online, with more responses received for the criteria.
A parallel survey was provided to the Stakeholder Advisory Committee, where results can be found in its separate report (*Stakeholder Advisory Committee: What was heard*).

Since the respondents of the feedback methods are self-selecting, the results are not scientific and only a summary of the responses received. This means that no estimates of sampling error can be calculated and therefore no margin of error is attributed to the results in the report. It is not recommended to extrapolate the results to a general population.

LIVE POLLING RESULTS

Questions were asked at the Public Meetings using live polling technology.

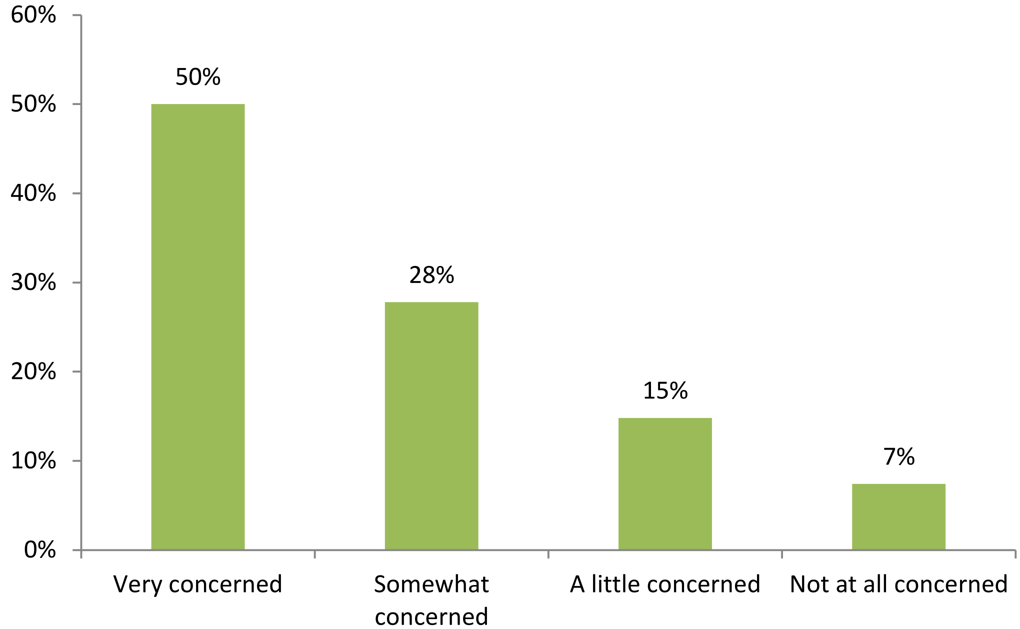
Profile of Respondents

AREA OF CITY	TOTAL % (n=51)
Southwest	22%
Southeast	20%
Northwest	18%
Northeast	4%
Downtown	20%
Outside of Winnipeg	18%

AREA OF INTEREST	TOTAL % (n=53)
Government agency	25%
Member of the general public	23%
Environmental interest	19%
Engineering consultant	13%
Other	21%

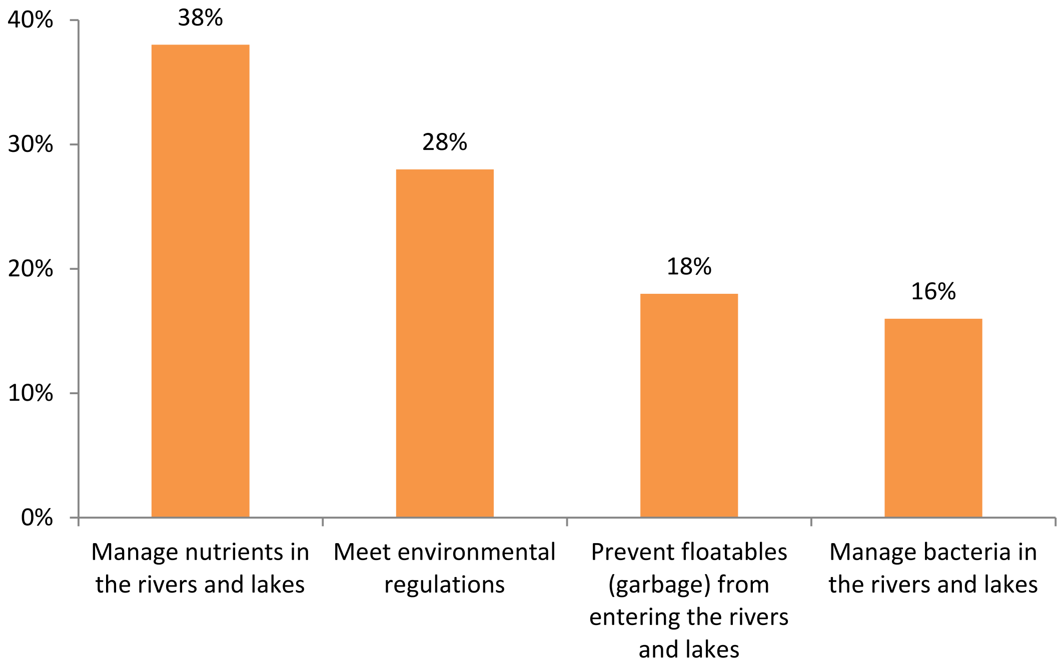
Concern for CSOs

"How concerned are you about CSOs?" (n=54)

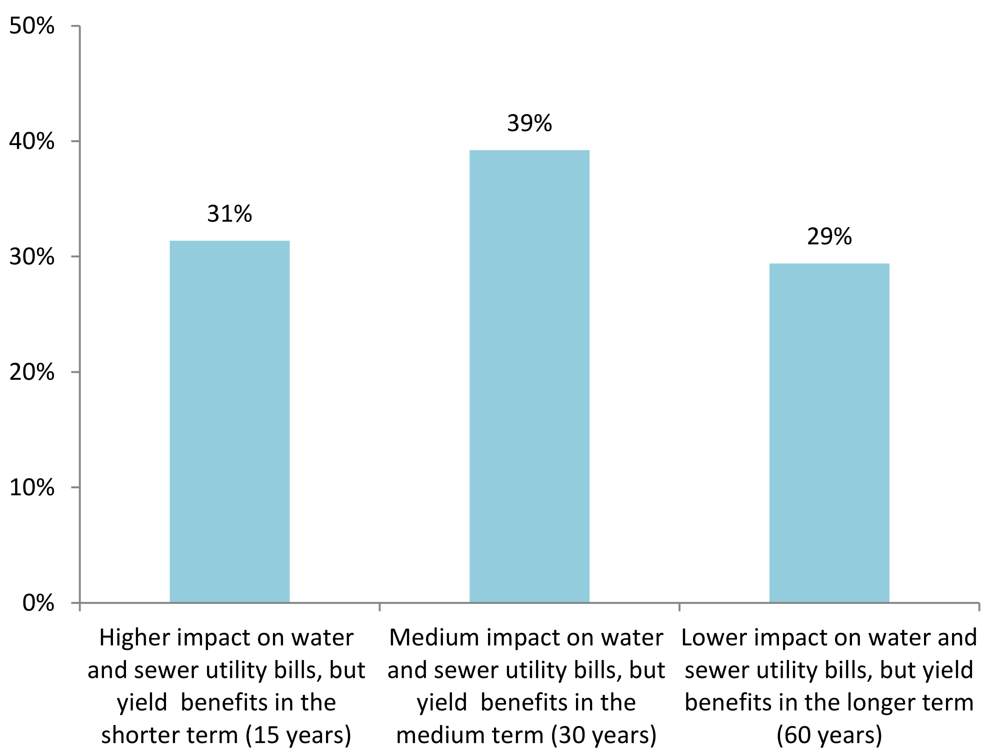


Controlling CSOs

"The most important reason to control CSOs is to:" (n=50)



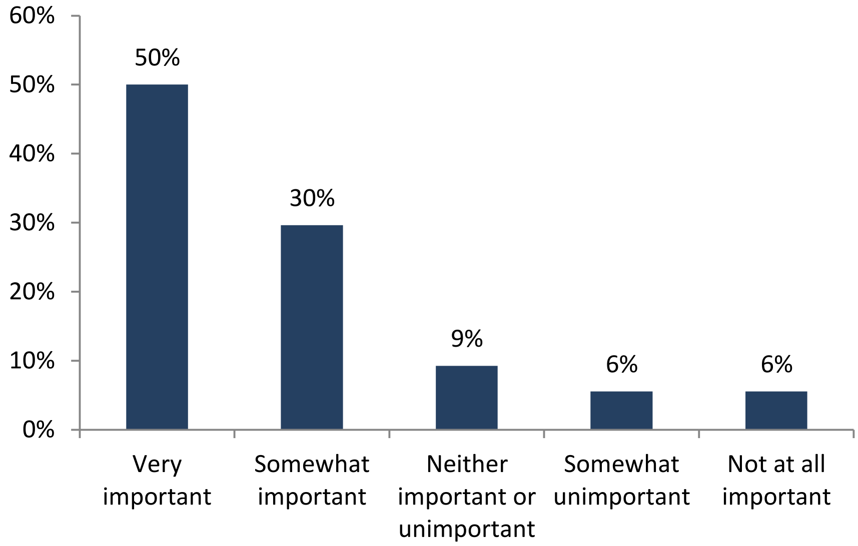
"Provincial legislation requires us to limit CSOs. The limit options have significantly different costs and environmental impacts. We could complete this work in the following ways—which would you prefer:" (n=51)



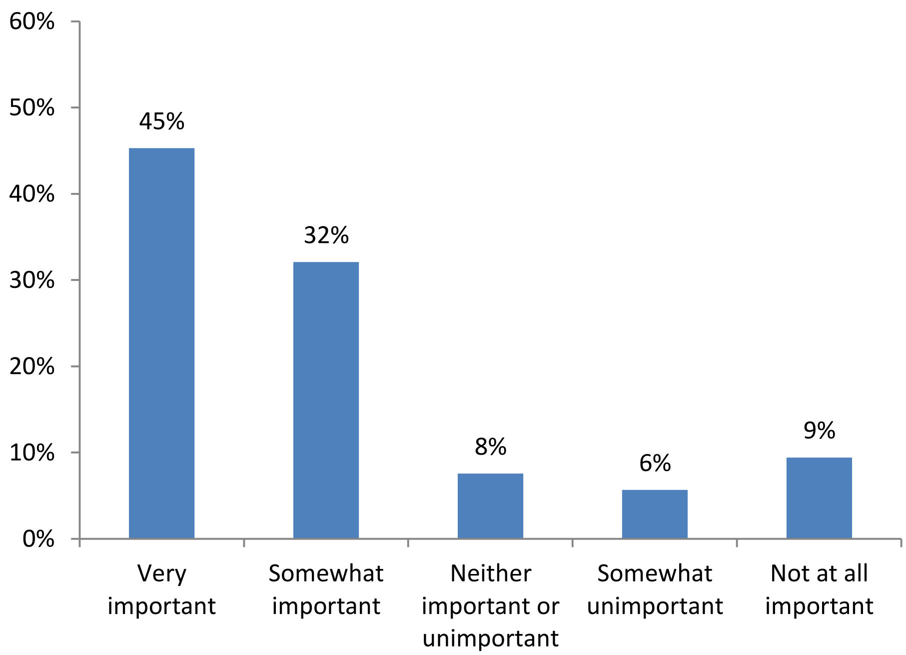
Priority of CSOs

A question was asked near the start of the presentation, and asked again at the end of the presentation to assess how opinions changed.

INITIAL: *"Compared to other infrastructure priorities in Winnipeg, like Bus Rapid Transit, Waverly Underpass or Sewage Treatment Plant Upgrades, how important is limiting CSOs?" (n=54)*



REPEAT: *"Compared to other infrastructure priorities in Winnipeg, like Bus Rapid Transit, Waverly Underpass or Sewage Treatment Plant Upgrades, how important is limiting CSOs?" (n=53)*



FEEDBACK ON CRITERIA AND OPTIONS

Feedback on the Criteria

Respondents were provided seven criteria that were being used to evaluate the different control limit options. They were asked to pick their top three most important criteria.

Respondents at the public meetings were given three dot stickers to place on the criteria they supported. The responses received were counted as votes. The overall number of respondents per criterion is not known. Online respondents were also only allowed three choices as the criteria they most supported.

The top three criteria are Lake Winnipeg, River Usability and Livability.

Criterion	TOTAL VOTES	Public Meeting Votes	Online Votes (n=23)
Lake Winnipeg	**33**	16	17
River Usability	**25**	13	12
Livability	**23**	15	8
Innovation & Transformation	**21**	11	10
Economic Sustainability & Construction Capacity	**17**	9	8
Value for Cost & Affordability	**17**	8	9
Visionary & Broader Context	**17**	12	5

Feedback on the Options – Public Meetings

Respondents were presented five CSO control limit options and were given dots for the options they supported. The responses received were counted as votes. The overall number of respondents per option is not known.

CSO Control Limit Options	Votes
Complete Sewer Separation	12
No more than Four Overflows per Year	5
Zero Overflows in an Average Rainfall Year	4
85% Capture in an Average Rainfall Year	3
Four Overflows in an Average Rainfall Year	3

The most supported option is “complete sewer separation”, while the least supported are “85% capture in an average rainfall year” and “four overflows in an average rainfall year”.

The Current Approach to Overflows was also communicated in a storyboard to provide information on the current infrastructure improvement program, where no votes were intended to be received. There were 4 votes registered for this program.

Feedback on the Options – Online

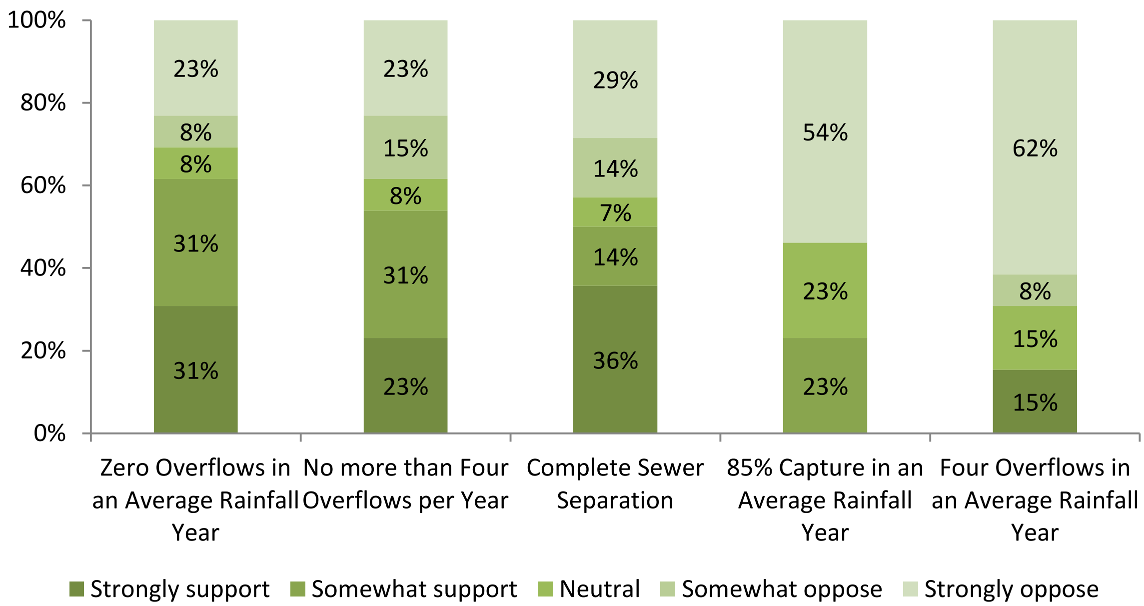
Respondents were presented five CSO control limit options, using a sliding scale to rate each of the option. By assigning a value to the responses a mean could be calculated, where a higher mean correlates to a greater support for the option.

5 = Strongly support
4 = Somewhat support
3 = Neutral
2 = Somewhat oppose
1 = Strongly oppose

CSO Control Limit Options	Mean
Zero Overflows in an Average Rainfall Year	3.4
No more than Four Overflows per Year	3.2
Complete Sewer Separation	3.1
85% Capture in an Average Rainfall Year	2.2
Four Overflows in an Average Rainfall Year	2.0

The most supported option is "zero overflows in an average rainfall year", while the least supported is "four overflows in an average rainfall year".

"Please review all five options and rate each using the scroll bar below:" (n=13-14)



Other Comments Received

Some comments were received at the Public Meetings:

- “Can you guarantee that streets will be repaired as work is done. NOT like at Ness + Route 90 where the streets are still in terrible condition.”
- “Can you guaranty that our basments won’t constantly be flooded with sewage etc.”
- “Have the Province pay for this, if they want it. The pollution from CSO doesn’t greatly impact Lake wpg or the river so why do it.”
- “What ever option is sent to province. Please include <u>green</u> infrastructure options in <u>all</u>”
- “Where do leed initiatives figure into these plans where rainwater is stored on-site and used for toilet flushing, landscape watering.”
- “Missing from the presentation is the results of the city’s efforts in the past to manage rainwater flows to the combined sewers and to water courses/streams in the combined sewers areas”
- “Missing from this discussion was any details the impact of options on sewage treatment operations.”

APPENDIX A

LIST OF LIVE POLLING QUESTIONS

LIST OF LIVE POLLING QUESTIONS

1) **Who will win the Grey Cup this year?** [QUESTION TO TEST KEYPADS ARE WORKING]
   A. Winnipeg Blue Bombers
   B. Saskatchewan Roughriders
   C. Ottawa Redblacks
   D. Who cares, when does hockey start?

2) **What brings you to this meeting?**
   A. Member of the general public
   B. River user
   C. Environmental interest
   D. Engineering consultant
   E. Government agency
   F. Other

3) **What area of Winnipeg are you from?**
   A. North West (N of Assiniboine River, W of Red River)
   B. North East (N of Dugald Rd, E of Red River)
   C. South East (S of Dugald Rd, E of Red River)
   D. South West (S of Assiniboine River, W of Red River)
   E. Downtown
   F. Outside of Winnipeg

4) **How concerned are you about CSOs?**
   A. Very concerned
   B. Somewhat concerned
   C. A little concerned
   D. Not at all concerned

5) **Compared to other infrastructure priorities in Winnipeg, like Bus Rapid Transit, Waverly Underpass or Sewage Treatment Plant Upgrades, how important is limiting CSOs?**
   A. Very important
   B. Somewhat important
   C. Neither important or unimportant
   D. Somewhat unimportant
   E. Not at all important

6) **The most important reason to control CSOs is to:**
   A. Meet environmental regulations
   B. Manage nutrients in the rivers and lakes
   C. Manage bacteria in the rivers and lakes
   D. Prevent floatables (garbage) from entering the rivers and lakes

7) Provincial legislation requires us to limit CSOs. The limit options have significantly different costs and environmental impacts. We could complete this work in the following ways—which would you prefer:

A. Higher impact on water and sewer utility bills, but yield benefits in the shorter term (15 years)
B. Medium impact on water and sewer utility bills, but yield benefits in the medium term (30 years)
C. Lower impact on water and sewer utility bills, but yield benefits in the longer term (60 years)

8) Compared to other infrastructure priorities in Winnipeg, like Bus Rapid Transit, Waverly Underpass or Sewage Treatment Plant Upgrades, how important is limiting CSOs? [POST]

A. Very important
B. Somewhat important
C. Neither important or unimportant
D. Somewhat unimportant
E. Not at all important

Winnipeg
Water and Waste Department

CSO MASTER PLAN
PHASE 1 PUBLIC PARTICIPATION
SUMMARY OF COMMENTS AND RESPONSES

October 2015

For more information on this report, please contact:

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Among the various free-form methods to comment, below is a summary of the feedback received along with responses (where applicable).

DATE RECEIVED	SOURCE	COMMENT	RESPONSE
Feb 25/15	Website	*In response to "How does development impact CSOs?"* It's a good thing run-off control regulations are in place that force developers to act responsibly because the 'bottom line' mentality would guarantee no such provisions would be made. A long, narrow bungalow condo development was recently completed in SW River heights along the former CN Rail Oak Point Subdivision right-of-way all the way from Corydon north to Academy Road. I was pleased to see absolutely gigantic fibreglass tanks buried deep beneath the homes' basements about every second or third set of bungalows. I suspect the temporary storage capacity of these tanks will ensure less run-off than even a primarily grassy strip of land was able to provide. I live behind a still-undeveloped segment of that right-of-way and during heavy rains and snow-melts, considerable water flowed visibly off the grass onto the lane and into the catch basins.	No response required.

March 2/15	Website	Sorry, but this problem that is extremely important is over my head and i really wouldn't have anything to contribute except in the way of taxes, as I'm sure that this will take millions of $'s to implement. It's too bad that during the information presented on line, that a $ figure was not given, nor was how the provincial government will be involved. It also would have been nice to know if I could find out if my area has combined sewer hookup or not.	Thank you for your comment Pam. To learn more about much it will cost to reduce CSOs you can visit today's topic. To find out where the combined sewer area is you can view this map. If you still want to know for your specific property you can contact 311.
March 2/15	Website	The big error in waste water design is using too small of inside diameter PVC pipes. Eight inches or 200 mm is too small. The minimum has to be raised to sixteen inches or 400 mm. Chancellor in Fort Garry is a very good example why 8" pipe is too small. A large additional load was added to the existing infrastructure during the 1980's with disasterous effects. All because there was no upgrade to handle the increased load. The downtown area is mostly all 16" pipe because its a combined system and the oldest part of the city. The engineers believe when one 16" pipe is replaced by two pipes, the pipe size can be cut in half. Silly old rabbits. Sewage is not at like potable water. Only 90% of sewage moves down the pipe. There's 10% that does not move. In fact, 10% keeps on pilling upon the previous 10% that settles until the pipe is blocked. People get raw sewage backing up into their basements and then call 311 for some service. The moral is use 16" or 400mm just as engineers of 1900 did. Sickness and disease has to be minimized, not pipes.	Thank you for your comment Phil. Since the 1970s the current minimum diameter for a City sewer main is 250 mm, or 10". Common sewer diameters are 10", 12", 15", 18" (250mm, 300mm, 375mm, 450mm), while 16" pipe is more of a water main size. The City's standards also require pipes to be at a slope sufficient to have the velocity required to scour and remove the sediment from the pipe. In fact, sometimes using too large a pipe can result in an increase in sediment buildup due to the flow slowing down. Pipe sizes are always chosen based on the expected flows and installed at a grade to minimize sedimentation. Additional information on City design standard can be found on our website. Also, the City has an extensive sewer main clearing and inspection program that removes any buildup and helps to identify trouble spots.

March 5/15	Website	I don't know enough about the subject to comment, and that is why it was my intention to attend this evening. I am not feeling well, so will postpone to another meeting. I will follow the discussion through the website. Thanks for giving the public an opportunity to participate and be heard.	No response required.
March 5/15	Letter	Would someone be able to send me a summary of this evenings talk: • Salient points • Summary of issues • Required input with dates for submission	I understand you were looking for some information about the CSO Symposium event that look place on March 5, 2015. The proceedings were recorded and can be found here: http://wwdengage.winnipeg.ca/cso-mp/online/. Many of the key issues are being discussed right now on our site: http://wwdengage.winnipeg.ca/cso-mp/ and a time line of the CSO Mater Plan process can be found here: https://wpgwaterandwaste.files.wordpress.com/2014/09/cso-timelinev22.jpg. If you have any other questions or comments please let me know and I'll be happy to help.

March 6/15	Website	One of the questions at the symposium was, "Do CSO affect the rivers colour?". Supposedly the correct answer is no. I have witnessed a City CSO discharging to the Assiniboine River and it was black and smelled sewage-like not brown and odourless like the river. That black discharge hugged the shoreline and eventually was eddied into the main river. This discharge was occurring during normal weather conditions and not during some winter melt or wet weather event. The outfall's location is along the river walk between the Forks and the Legislature, I think, just east of the Mid-town Bridge. Outfalls of this nature need to be on the City's priority list for correction.	Thanks for your comment Robert. Winnipeg's rivers are naturally murky brown in appearance due to the large amounts of suspended soils in the water, which isn't affected by CSOs. If you see discharge to the river, such as the one you describe, please note the date, time and location and report it to 311.

Sept 2/15	Website	The information is enlightening and as the previous commentor stated, somewhat over my head in terms of suggestions. My biggest concerns are: 1) presently, what state (pollution wise) are both the Assiniboine and the Red rivers in? How is pollution (OR pollutants) measured and what so far has been recommended as an acceptable level? HOW BAD is it? most citizens will definitely want to know this at the meeting or before please. 2) what businesses along the riverways impact on leakage of chemicals & other toxins or spills, into the rivers? are they held responsible for accidental releases into the CSO system? If so, what happens: fines?, Large ones? Are they public record?….vital for 'peggers to know about this please. 3) ban of chemical use on all lawns should be immediately introduced IMHO. Our lakes and rivers are far too important and we seem to be taking notice way too late. 4) what can the general public do to help cut down with waste entering our waterways? In plain language, what should be used in washing, cleaning, watering etc… 5) overall costs $$$$-wise please, a breakdwon of time line for this huge project, who will be responsible for very tough/stringent oversight? what consulting companies have been on board thus far, with what requirements will be needed, input from cities elsewhere and what they have initiated? Pros & cons presented please. Honestly. The "Budget" is my huge concern. Wpg is not known for controlling costs on some VERY significant projects to date. In fact, it's been a nightmare. Must take this seriously. Citizens attending will want facts, figures and clear concise answers.	Hi Jan, We've put together some information for you based on your comment: 1. The pollutants of concern for CSOs are Total Nitrogen, Total Phosphorous and bacteria. We have water quality data for our rivers posted on the web. There are also provincial water quality standards available for review, too. Finally, we are also publishing CSO monitoring results here. 2. The sewer bylaw governs what can and can't be discharged into our sewer systems and the fine schedule. It can be found here. Individual property violations are not published. 3. A synthetic lawn pesticide ban has been introduced by the Manitoba Government. For more information on this ban, please visit Conservation and Water Stewardship website. 4. Citizens of Winnipeg can definitely help protect our waterways. A great resource is Lake Friendly. 5. Cost can vary from $0.6 to $4.1 Billion depending on the level of CSO control selected by the Province. CH2M Consulting has been hired as the prime consultant. The City has been engaging other municipalities to seek input on what they have done. These will be included in the Preliminary Proposal to the Province. Additional pros and cons will be presented at the public open house on September 14-15 and will be posted on our website shortly. If you can't make it in person, you can also voice your opinion online.

Sept 2/15	Website	Sorry-One other comment as I noticed the timeline states: "DEC 2017… Submit final CSO Master Plan to Province" with CSO Masterplan IMPLEMENTATION Phase III after 2018 and beyond….. How does the City of Wpg pay for all of this?	Thank you for your comment, Jan. The project will be funded through increases in water and sewer utility bills. The City will also try to secure funding from other levels of government.
Sept 9/15	Website	*In response to "What are the potential ways that we can implement CSO control strategies?"* water resevoirs. there were so many in the city and they slowly being taken away for new neighbourhoods. water retainments for drought seasons..when there is too much rain on one side of the country there is always drought and forest fires else where. heck even water reserves for fire stations ease up on the water supply from shoal lake..so many ways. air it all to the public before the meetings so thee usca constant flow of feedback and ideas. water reserves that can be used for the organic compost strategy program..air like a political campaign people..	No response required.
Sept 13/15	Website	I am sorry, but your survey questions and possible answers are quite unintelligible. I hope the public meeting is more edifying.	No response required.

Sept 14/15	Website	I attended the public meeting organized by the City this morning . It was well organized and informative. I chose the forth option because it allowed for the biggest storage capacity in-line, with water to be moved to treatment plants when it was feasible to do so. This larger capacity can also mean in very dry years water can be stored for city watering use. With climate change droughts can be as likely as extreme precipitation events. Rather than the complete separation of drainage and sewer, this water can be treated and used if needed, or returned treated to the river. Also, one would hope that the city engineers, in planning renewal for the old infrastructure in a third of our city, will note the excellent opportunity to apply transformative transitions using proven green strategies for slowing, spreading and seepage of overland waters.	No response required.
Sept 14/15	Letter	Thank you for the opportunity to learn off plans + to have some feedback – good democratic practice.	No response required.
Sept 15/15	Website	The meeting September 14 was very informative. It was well presented and easy to understand. The health of the rivers and Lake Winnipeg is very important, but health of people comes first, and having three major sewage events in less than six weeks is not healthy for the residents of my building. We need immediate help!	No response required.
Sept 15/15	Email	I would support less to no discharge, and encourage City of Winnipeg to include upgrades in taxes etc. This is just not a good option in 2015 – this day in age to dump sewer waste in our rivers and lakes in just bad news for future generations and my children.	This email is to confirm receipt of your feedback. Thank you for your feedback.

Sept 28/15	Website	Thinking outside of the box for a minute - there are some excellent composting toilets out there. One that I have personally seen is the Nature's Head composting toilet, which has excellent reviews and apparently less odour than conventional toilets. People are putting them in their apartments, in their basements. How about promoting a solution like that? *Response:* Interesting, thank-you. I will read through the by-law carefully, however my first thought is that if it is composted it does not contain water, so is it "wastewater"? There are many diapers changers and dog walkers that are dealing with waste but not "wastewater".	For out of the box thinking, green infrastructure will be included as part of our strategy to help delay and divert the amount of runoff entering the combined sewer system during wet weather events. Regarding composting toilets, under sewer by-law no. 92/2010, section 28(1) requires wastewater to be discharged to an adjacent sewer main. One rationale for this clause is to ensure that all wastewater is treated and disposed of properly at the wastewater treatment plants to safeguard against public health issues. If pathogens in the composting toilet are not fully composted, there may be concerns with its disposal and the possible spread of disease to the public. *No further response required.*

Oct 1/15	Website	So if its going to be paid for by increases in water and sewer bills, basically it will become impossible to afford living here. Great! What next? *Response:* And i think protecting rivers and lakes is a great idea. The thing is though, when the city is forced to do something that will cost billions and probably be billions more over budget, just to prevent 5% of nitrogen and 6% phosphorus and a little poop from entering the rivers? There will still be huge amounts of algae in lake Winnipeg and all the main contributors to that, dont have to do a thing. That is what frustrates me. And also the fact that manitoba will force winnipeg to go full out on this project, so cost will be minimum 4.1 billion, and like everything else be 20% or more over budget, while the other governments only put up 250 million each, and our water bills go from 200 to 600.	The City will seek funding opportunities from the other levels of government. We are doing our part to protect the long term health of our rivers and lakes. *No further response required.*
Oct 5/15	Website	*In response to the above response posting, another comment was provided:* I agree! There must be a clear value statement, like 'reducing nitrogen by 50% at the lake entry'. And what would happen to some very specific individuals if the goals aren't met including budget overruns. I for example know well what would happen if I don't pay property tax. Similarly, I'd like to see something significant happening to people who mismanage my paid taxes.	No response required.

Oct 1/15	Website	*In response to "[What would happen if we fully separated sewers?]"* Of course the work would not all be done at once, but it is important to begin the work, and organize it to get the minimum disruption, for example not too much in the same area at the same time. It should be a concentrated effort so that the work would be completed in as short a time as possible.	Thank you for your comment. Sewer separation will have the greatest impact on livability of the control options being considered. Typical sewer renewals cause only localized traffic disruptions unless it is on a major traffic route. However, sewer separation could involve sewer construction on potentially every street throughout a neighbourhood. An implementation program will be developed once a control option is selected by the Province.
Oct 1/15	Website	*In response to "[How are CSO controls measured?]"* Both measures are important, but the frequency of sewer overflows tells us more about the adequacy of the system. The volume depends more on an act of nature.	Thank you for your comment. The combined sewer system is designed to capture 2.75 times the dry weather flow and convey this to the wastewater treatment plants. In this respect, the system is working as it was intended.
Oct 1/15	Website	*In response to "[What are the potential ways that we can implement CSO control strategies?]"* It is important that we increase permeable surfaces and decrease the impermeable. The city defeats this objective when it requires parking lots to be paved with impermeable materials instead of something like quarter round. All of the strategies are important. Citizens can do their part, but the heavy work has to be done by the city. It has been years since the Clean Environment Commission ordered the city to start replacing the combined sewer system. Get on with it!	Any development in the City is required to meet pre-development run-off flows. An example would be a gravel site is later developed, the run-off from the new development would have to be designed to discharge the same as if it was the gravel site. Since the Clean Environment Commission hearings, we have been doing our part to mitigate CSOs through sewer separation and operational improvements.

Oct 2/15	Website	Given the size of this project, this is a great opportunity for the city to become more transparent. I can see the timeline, which is good. It would be nice to add what will be the outcome of each phase and $$ budgeted/spent. With as much details as possible - given that every taxpayer would foot the bill. As for the options, it would be nice to see the cause and effect. Like by spending so much per household, we would achieve ..% reduction in this and that. Te project should be very open to the public bidding, so that wide range of alternatives could be considered. For example, if rain water is the problem - should we try to capture that (clean) water instead of mixing it with sewage and then spending $$ on more sewage treatment facilities?	Thank you for your comment. As currently shown in the timeline, December 2015 is when we will provide the Province with our preliminary proposal and recommendation on the control limits. The Province will select a control limit and we will have until December 2017 to provide an implementation plan on how we will achieve this goal. At this point we will come back and engage with the public in developing the implementation plan. The Plan may include but not limited to the following: green technologies; deep tunnels; in-line/off-line storage; and separation. For this project CH2M was awarded the consultant contract for $4.1 million for the CSO Master Plan. This consists of all work until December 2017. The project will be funded through increases in water and sewer utility bills. The City will also try to secure funding from other levels of government. The storyboards provided during the public engagement process outline the options and their associated costs.
Oct 2/15	Website	Re: admin says: March 3, 2015 at 10:35 am To find out where the combined sewer area is you can view this map. ACCESS IS DENIED …. must be member, etc. (blog) This came to me as I have signed up for City of Winnipeg subscribed e-mail from COW website …E-mail title …'Public Engagement News -COW'. My response should be the ability to response in e-mail form and not be forced to accept COW's choice.	Thank you Ruby for letting us know about this error, and we have corrected it so that you can see the image. If you would like to submit your comments on the project you can always email us.

Oct 5/15	Website	Thank you for this opportunity to participate. 1. Whatever the final design, it will be costly. Consider establishing a land drainage utility to fund the costs. This is in keeping with the concept of polluter-pays and is equitable and fair to all. As well, land owners will take measures to reduce run-off in order to avoid paying. It doesn't have to be a complicated system either – KISS. 2. Obey the law. The current Environment Act CSO License (section 8) states that the CoW shall not increase the frequency or volume of CSOs due to new and upgraded land development activities and shall use green technology and innovative practises in the design and operation of all new and upgraded storm and wastewater infrastructure. This is clearly not happening – case in point, new Walmart on Taylor (and many many others). 3. Incorporate green practises into the building requirements/code in order to reduce peak flows. Green roofs are a good example of this and provide other benefits as well. There are many examples of how this works (Dockside Green in Victoria) and a good guide is "Artful Rainwater Design; Creative Ways to Manage Stormwater" by Echols and Pennypacker. 4. Reinstitute regular inspections of commercial and residential locations that may be diverting rain water into the sewer system (i.e. the south area of the City in particular). Good luck!	Thank you for your comment. Instituting a land drainage surcharge or changes in the building requirements to incorporate green technology would be a policy issue that would need to be decided at a higher level. Any development in the City is required to meet pre-development run-off flows. An example would be when a gravel site is later developed, the run-off from the new development would have to be designed to discharge the same as if it was the gravel site. In this example the developer may meet the requirement by installing a number of options to hold the water: roof storage, parking lot storage, underground tanks, retention ponds, etc. Green technologies will be incorporated where possible. Some green technologies require building owners to install, operate and maintain, such as the green roofs mentioned. We have been conducting regular Lot Grading By-law inspections since 1995, to ensure that sump pump water is being properly discharged onto private property. An additional sump pump inspection program was undertaken in 2007. It was determined that 20,807 homes out of 22,773 had a sump pump hose connected at the discharge outlet at the foundation – 91%. The most common violation is placing the hose so that the water drains onto the street or lane. We conduct regular inspections and issue by-law infraction notices as required.

Water and Waste Department

CSO MASTER PLAN SYMPOSIUM FEEDBACK REPORT

March 2015

For more information on this report, please contact:

Tiffany Skomro
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BACKGROUND AND METHODOLOGY

In February 2015 the City of Winnipeg initiated a public engagement process to receive feedback on a plan to reduce combined sewer overflows and manage their effects in an environmentally sound, sustainable and cost-effective manner.

Public feedback was captured using live polling technology at the CSO Symposiums held on March 5, 2015.

The event featured 4 panelists and included 62 attendees. There were 59 active polling technology respondents, where responses per question ranged from 46 to 58.

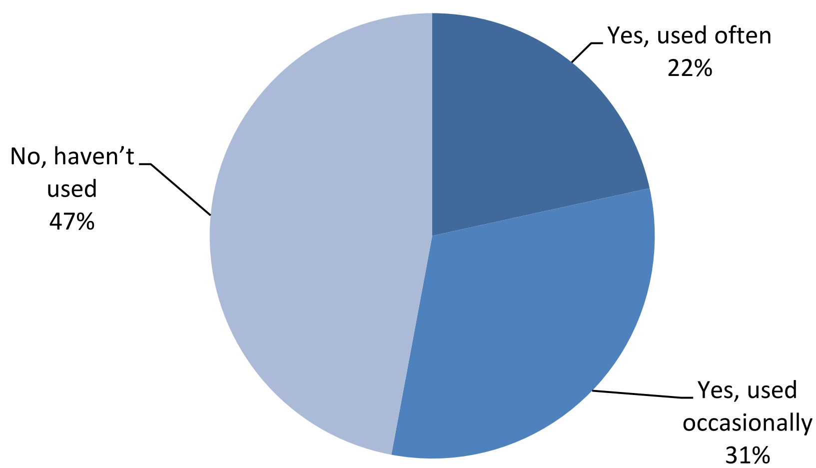
Since the respondents of the polling technology are self-selecting, the results are not scientific and only a summary of the responses received. This means that no estimates of sampling error can be calculated and therefore no margin of error is attributed to the results in the report. It is not recommended to extrapolate the results to a general population.

PROFILE OF RESPONDENTS

AREA OF INTEREST	TOTAL % (n=51)
Environmental interest	27%
Engineering consultant	20%
Government agency	18%
Business interest	16%
Member of the general public	12%
River user	4%
Other	4%

Recreational Water Use

"During the open-water recreational season, have you used the rivers in Winnipeg for recreational purposes in the last 2 years? " (n=51)



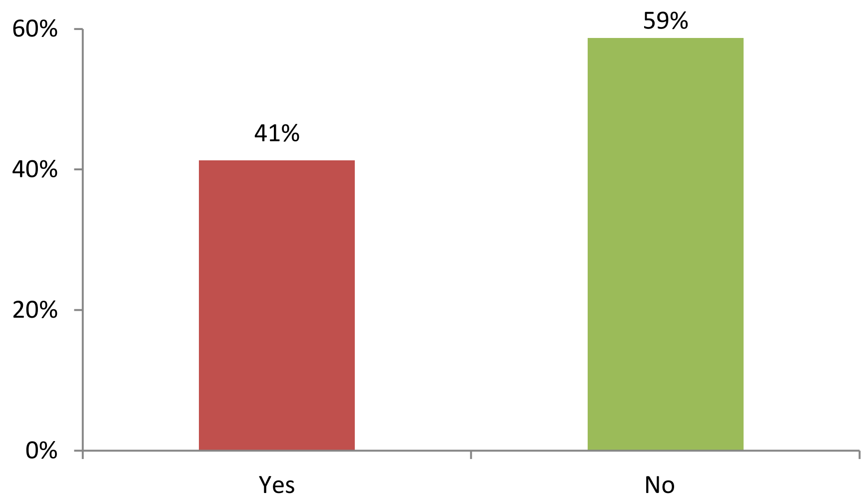
RESEARCH RESULTS

Questions were asked at the Symposium using live polling technology.

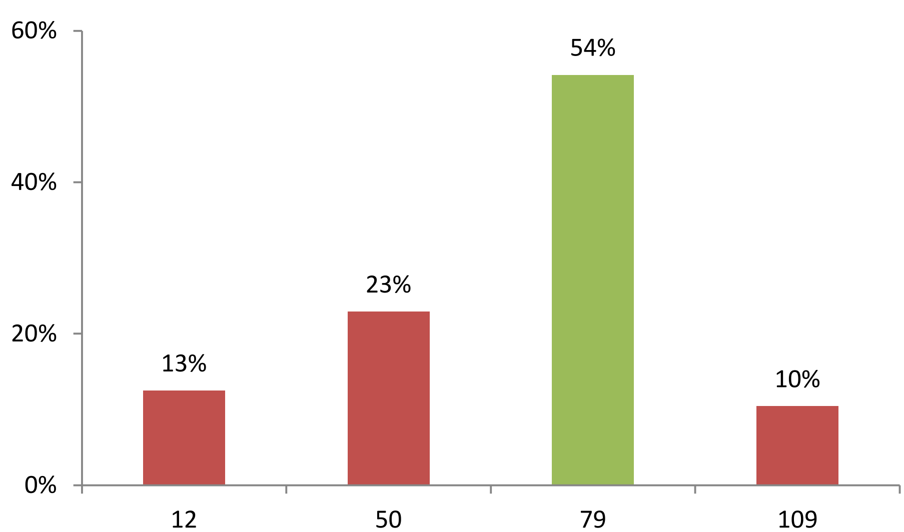
Gauging Understanding of CSOs

Some questions were used to gauge respondent's understanding and perceptions around CSOs. The correct answer is in green, while the incorrect answer(s) are in red.

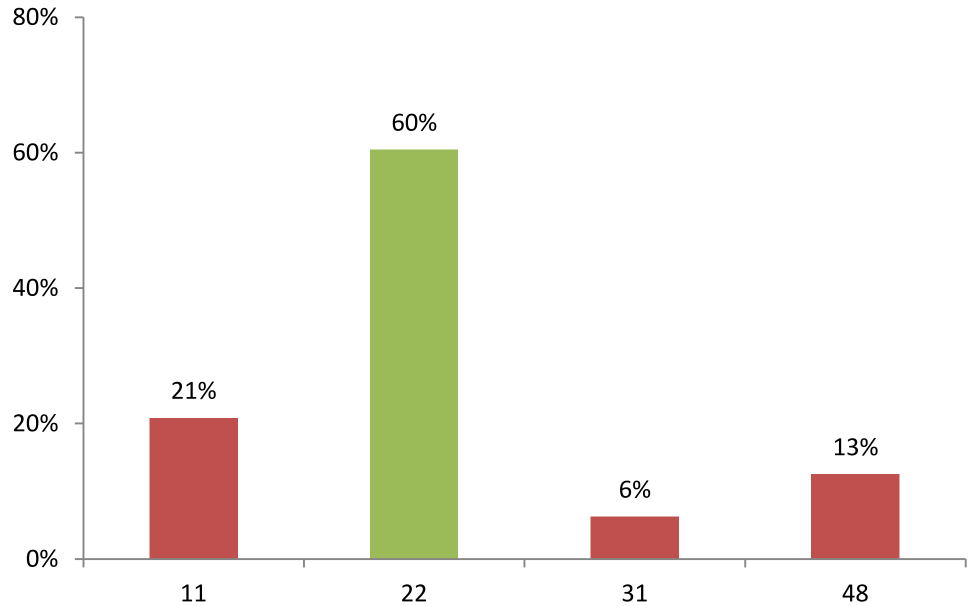
"Do CSOs affect the rivers' colour?" (n=46)



"How many CSO outfalls are in the city?" (n=48)



“Over a year, on average how often do combined sewers overflow in Winnipeg?” (n=48)

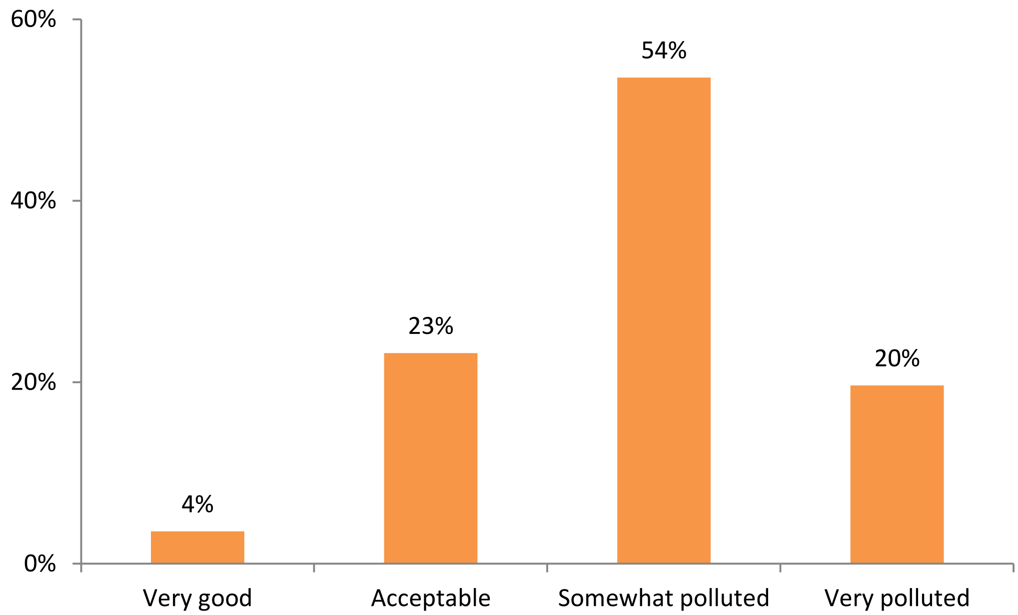


Evaluating Waterways

A series of questions were asked to assess audience perceptions around our waterways.

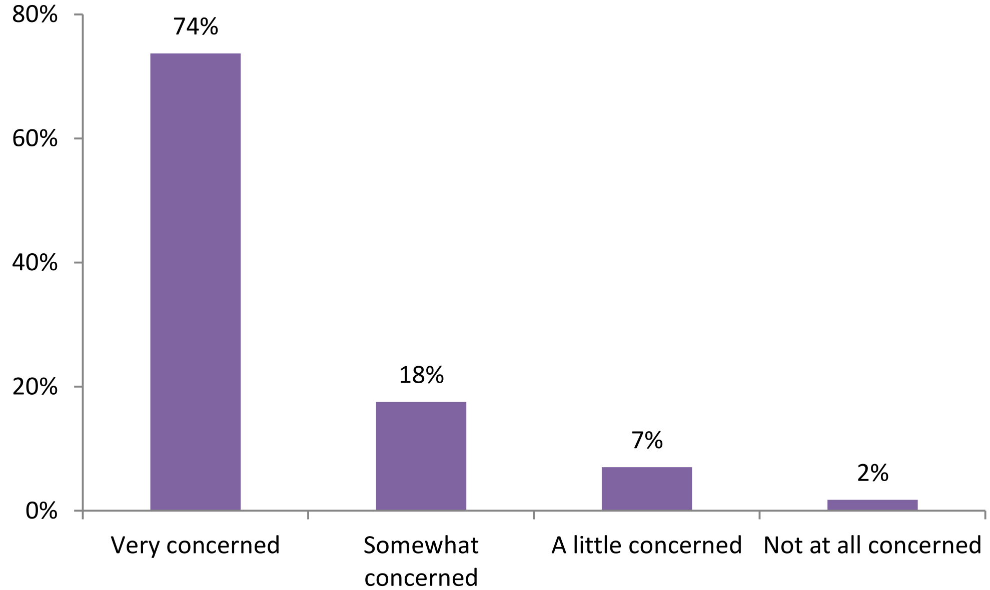
Most respondents (74%) felt the quality of Winnipeg's rivers and streams were either somewhat polluted or very polluted.

"How would you rate the quality of Winnipeg's rivers and streams?" (n=56)



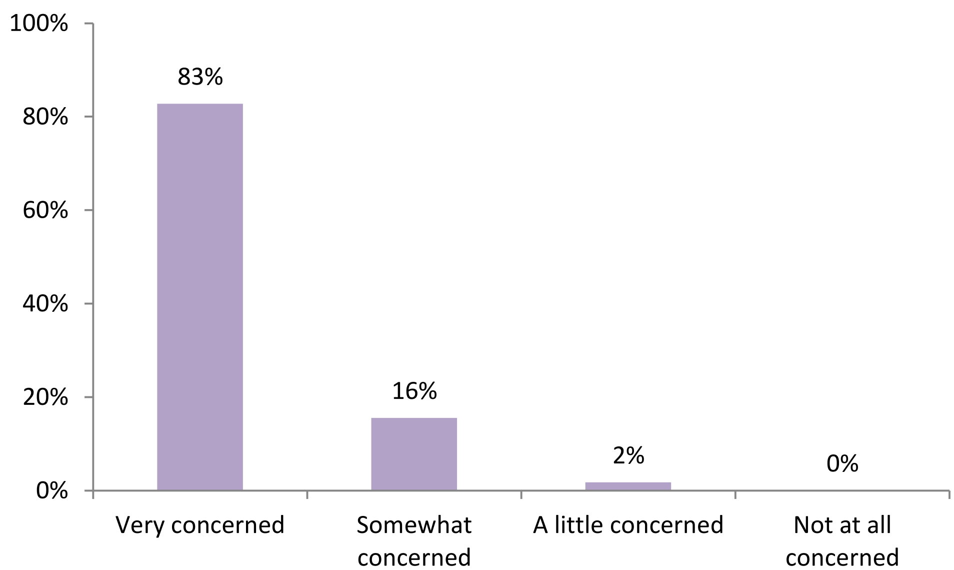
A majority of respondents (74%) felt very concerned about the state of Winnipeg's rivers and streams.

"How concerned are you about the state of our rivers and streams?" (n=57)



An even stronger majority of respondents (83%) felt very concerned about the state of Lake Winnipeg.

"How concerned are you about the state of Lake Winnipeg?" (n=58)

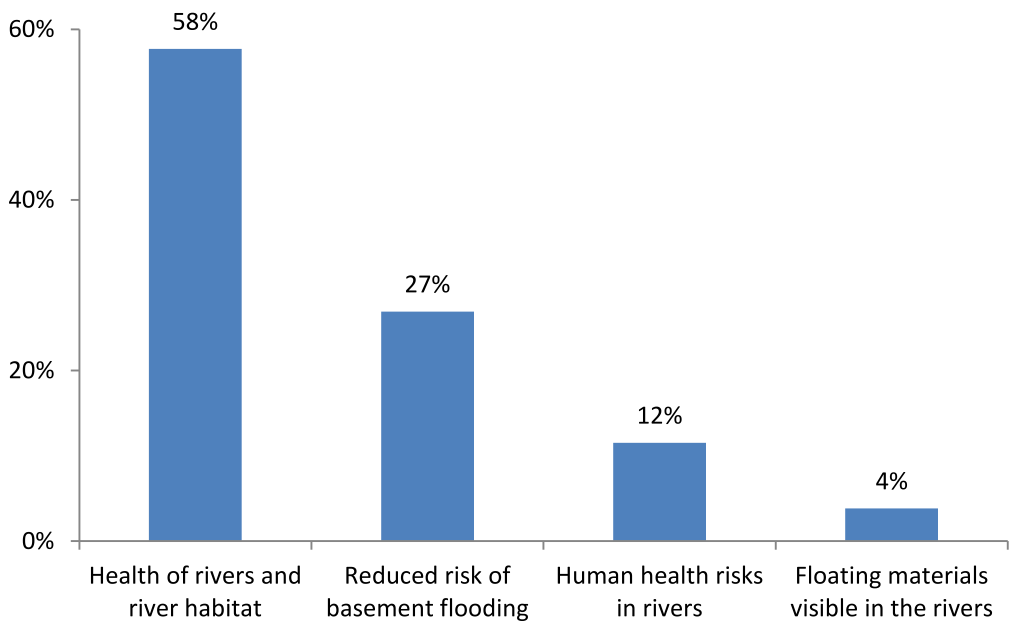


Initial CSO Perceptions

After playing an introduction video on CSOs, and before starting the first presentation, a couple of questions were asked to assess initial audience perceptions.

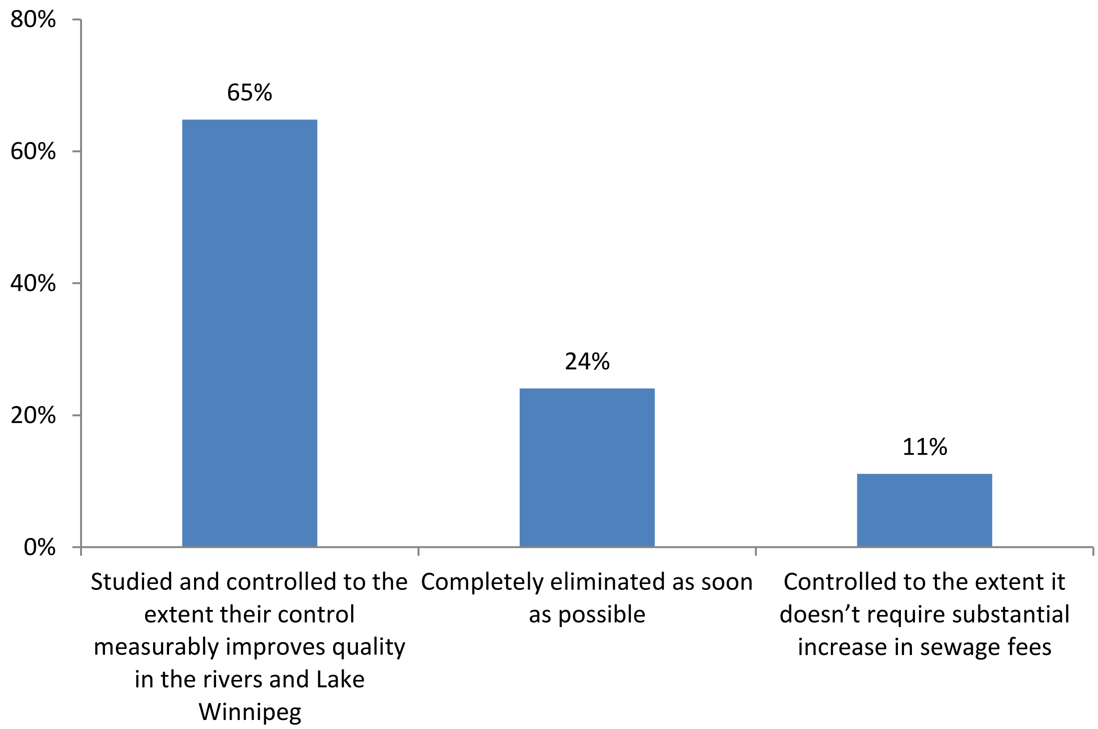
Most respondents (58%) felt "health of rivers and river habitat" was the main impact of CSOs.

"What do you think is the most significant result or impact of CSOs?" (n=52)



Most respondents (65%) felt that CSOs should be "studied and controlled to the extent their control measurably improves quality in the rivers and Lake Winnipeg".

"CSOs should be:" (n=54)

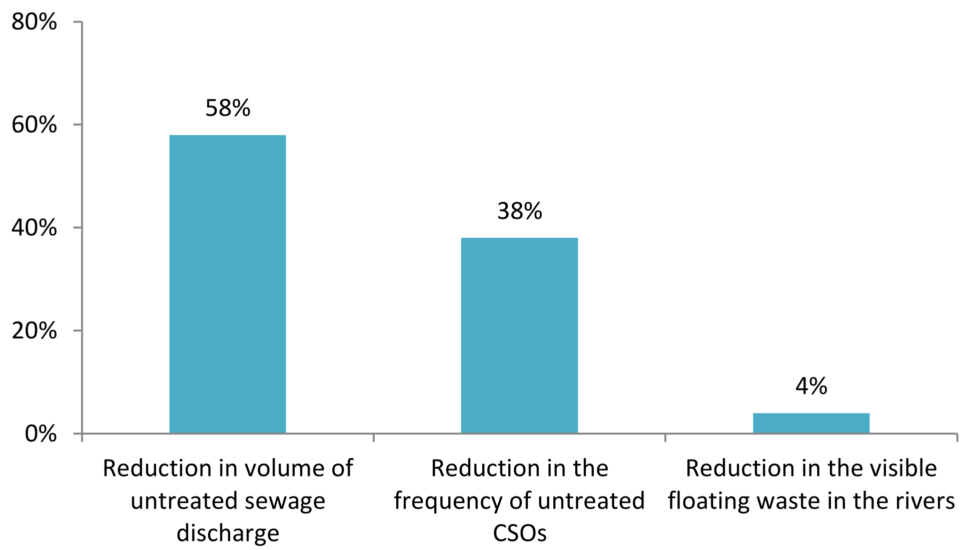


Benefit Metrics for CSO Control Limits

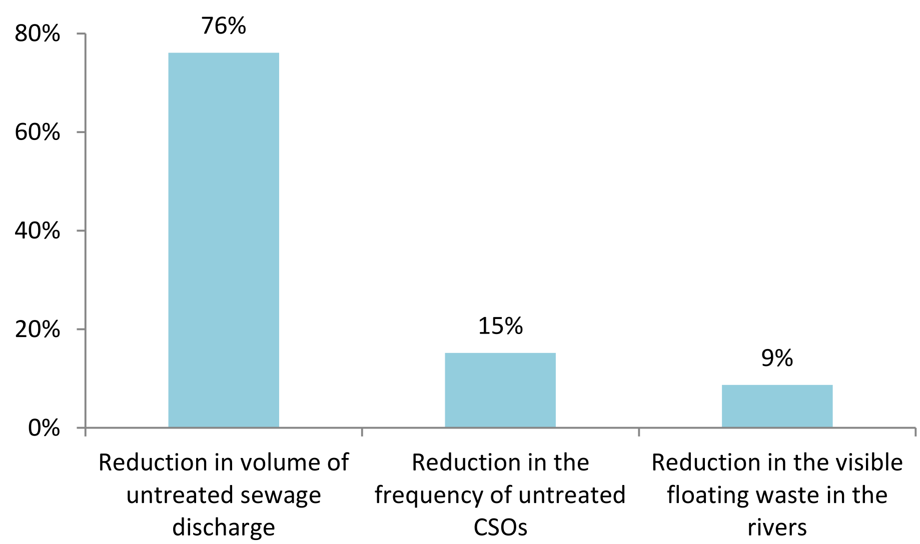
A question was asked at the end of the introductory presentation, and asked again at the end of the panel presentations to assess how opinions changed.

Initially, most respondents (58%) felt that CSOs control benefit should be measured by "reduction in volume of untreated sewage discharge". This increased to 78% when the question was repeated.

INITIAL: *"CSOs control benefit should be measured by:" (n=50)*



REPEAT: *"CSOs control benefit should be measured by:" (n=46)*



APPENDIX A

LIST OF QUESTIONS

LIST OF LIVE POLLING QUESTIONS

1. Who will win the Stanley Cup?
    a. Winnipeg Jets
    b. Edmonton Oilers
    c. Winnipeg Blue Bombers
    d. Toronto Maple Leafs
    e. Brandon Wheat Kings

2. Do CSOs affect the rivers' colour?
    a. Yes
    b. No (c)

3. How many CSO outfalls are in the city?
    a. 12
    b. 50
    c. 79 (c)
    d. 109

4. What brings you to this event?
    a. Member of the general public
    b. River user
    c. Environmental interest
    d. Engineering consultant
    e. Government agency
    f. Other

5. Over a year, on average how often do combined sewers overflow in Winnipeg?
    a. 11
    b. 22 (c)
    c. 31
    d. 48

6. During the open-water recreational season, have you used the rivers in Winnipeg for recreational purposes in the last 2 years?
    a. Yes, used often
    b. Yes, used occasionally
    c. No, haven't used

7. What do you think is the most significant result or impact of CSOs?
    a. Reduced risk of basement flooding
    b. Human health risks in rivers
    c. Floating materials visible in the rivers
    d. Health of rivers and river habitat

8. CSOs should be:
    a. Completely eliminated as soon as possible
    b. Controlled to the extent it doesn't require substantial increase in sewage fees
    c. Studied and controlled to the extent their control measurably improves quality in the rivers and Lake Winnipeg

9. CSOs control benefit should be measured by:
    a. Reduction in the frequency of untreated CSOs
    b. Reduction in volume of untreated sewage discharge
    c. Reduction in the visible floating waste in the rivers

10. How would you rate the quality of Winnipeg's rivers and streams?
    a. Very good
    b. Acceptable
    c. Somewhat polluted
    d. Very polluted

11. How concerned are you about the state of our rivers and streams?
    a. Very concerned
    b. Somewhat concerned
    c. A little concerned
    d. Not at all concerned

12. How concerned are you about the state of Lake Winnipeg?
    a. Very concerned
    b. Somewhat concerned
    c. A little concerned
    d. Not at all concerned

13. CSOs control benefit should be measured by:
    a. Reduction in the frequency of untreated CSOs
    b. Reduction in volume of untreated sewage discharge
    c. Reduction in the visible floating waste in the rivers

City of Winnipeg
CSO MASTER PLAN PHASE 1
Stakeholder Advisory Committee: What was heard

Prepared by:

FIRST PERSON STRATEGIES

November 2015

Table of Contents

Appendices

1.0 Introduction

As part of the requirements for the Environment Act Licence No. 3042 issued by the Province of Manitoba, the City of Winnipeg is developing a Combined Sewer Overflows (CSO) Master Plan to manage the effects of combined sewer overflows in an environmentally sound, sustainable and cost-effective manner. Under the terms of the Licence the City of Winnipeg will submit:

- a preliminary proposal evaluating CSO control limits by December 31, 2015 ("Phase 1"), and
- a final CSO Master Plan by December 17, 2017, for controlling CSOs to the defined limits ("Phase 2").

In September 2014, the City of Winnipeg established a CSO Master Plan Stakeholder Advisory Committee (SAC). As an important component of a broader public engagement process, the SAC was asked to provide input on stakeholder needs and concerns to help ensure a plan to limit CSOs and protect river quality reflects the values of Winnipeg families, business and river users, and is sustainable.

CSOs and CSO management involve a broad spectrum of stakeholders. An important goal for the SAC was to bring together a variety of perspectives early in the planning process to ensure that input from diverse interests would be incorporated into decision making on CSO management to the maximum extent possible. In Phase 1 of the Master Plan, the work of the SAC involved:

- Learning about CSO management and regulation, including the current situation in Winnipeg and control limits under consideration.
- Identifying important questions, issues and concerns.
- Contributing to the development of criteria to evaluate control options.
- Providing feedback on the relative importance of each criterion.
- Providing feedback on the specific control limit options under consideration.

> **Level of Impact**
>
> *"The City will look to the SAC for ideas, suggestions, trade-offs and to help formulate solutions, and will incorporate SAC advice and recommendations into CSO Master Plan decisions to the maximum extent possible."*
> *– CSO SAC Terms of Reference*
>
> The City of Winnipeg is working with the SAC at the "collaborate" level on the International Association of Public Participation (IAP2) Spectrum for Participation.

The SAC will reconvene for Phase 2 of the Master Plan, once Phase 1 results have been reviewed and the Province of Manitoba sets control limits.

2.0 Stakeholder Advisory Committee members

The committee includes up to 15 members of the community, bringing diverse perspectives to the table including citizen, environmental, river users, business and industry representatives with an interest or stake in CSO impacts and control strategies. Current SAC representatives include:

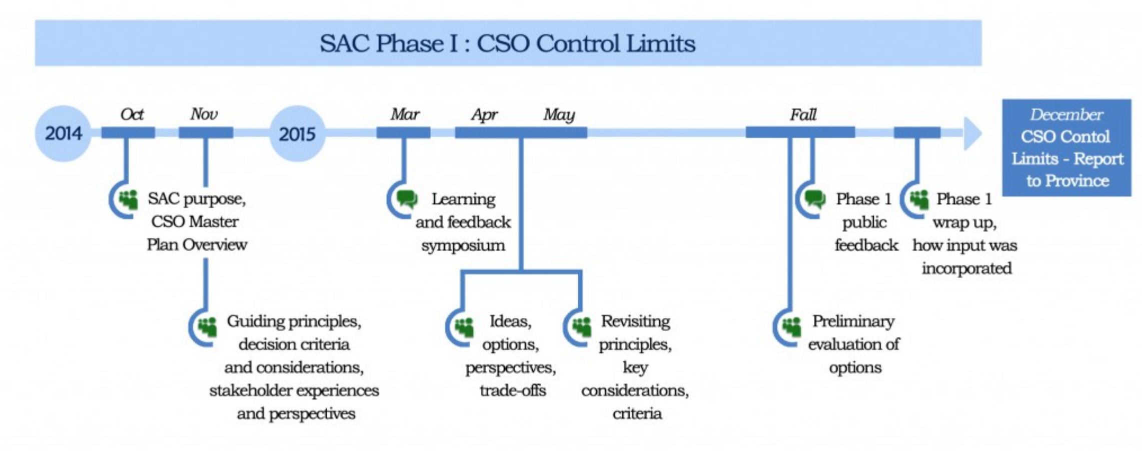
Organization	Representative
Chalmers Neighbourhood Renewal Corporation; Coalition of Manitoba Neighbourhood Renewal Corporations (Winnipeg)	Dale Karasiuk
International Institute of Sustainable Development	Henry David Venema
Lake Friendly; Partnership of the Manitoba Capital Region	Colleen Sklar
Manitoba Eco-Network	Megan Krohn
Manitoba Heavy Construction Association	Chris Lorenc
Old St. Vital BIZ	Colleen Mayer
Rivers West	Julie Turenne-Maynard
Winnipeg Chamber of Commerce	Carmine Militano

Over the course of Phase 1, the Consumer Association of Canada (Manitoba) and the Winnipeg Rowing Club also contributed to SAC deliberations. Additional efforts were made as the SAC got underway to reach out to river users and the rowing club to engage them more formally in the SAC and to document their input and concerns via phone and email.

The Province of Manitoba is represented on the Committee. Representatives from the following provincial departments and branches participate on the SAC:

Provincial Department & Branch	Representative
Manitoba Conservation and Water Stewardship (Environmental Compliance and Enforcement)	Yvonne Hawryliuk
Manitoba Conservation and Water Stewardship (Environmental Approvals)	Siobhan Burland Ross
Manitoba Conservation and Water Stewardship (Water Quality)	Joy Kennedy

3.0 Process



Phase 1 of the Stakeholder Advisory Committee process took place between October 2014 and September 2015. The following table details the various ways the SAC provided input:

1. In-person meetings
Four facilitated meetings were attended by SAC members, provincial representatives and City project team members. - **Meeting 1:** Overview of CSO Master Plan process and current situation in Winnipeg. - **Meeting 2:** Committee perspectives on CSO planning, overview of decision process for control limits. - **Meeting 3:** Licence overview, input on CSO animation video and public symposium. - **Meeting 4:** Public symposium debrief, defining community values for Master Plan, and input on evaluation criteria.
2. Conference call
- A conference call was held in October 2014 for committee members unable to attend the October meeting.
3. CSO symposium
- Three SAC members participated in a panel discussion as part of a public symposium on CSOs in March 2015. - Several other SAC members attended and participated in small group breakout discussions.

4. Submissions and emailed references (Appendix A)
- A formal submission was received by SAC member Chris Lorenc (Manitoba Heavy Construction Association). - Emailed reference materials were received by SAC member Colleen Sklar (Lake Friendly, Partnership of the Manitoba Capital Region).
5. Online survey
- One survey was conducted to collect input on evaluation criteria and control limit options. - One survey was conducted to collect feedback on meetings and SAC process.

In addition, SAC members were invited to participate in two public meetings held in September 2015.

Information about the SAC's purpose, terms of reference, a list of members, meeting notes, presentations and key links were posted on the project website at http://wwdengage.winnipeg.ca/cso-mp/sac/.

4.0 What was heard

The following is a summary of the key themes and outcomes resulting from the SAC input received during Phase 1 of the Master Plan. Feedback received has been grouped into three areas: input on public engagement process; issues, opportunities and concerns; and input on criteria and control limit options.

> *No votes will be held to determine the SAC's position on issues or recommendations to the City of Winnipeg. Where consensus exists, it will be noted. Where it does not exist, minority opinions will be considered to have merit and will be noted. In the context of the SAC, consensus will be defined as "I will support the decision of the group." The opinions of all committee members will be valued and taken into consideration.*
>
> *– CSO SAC Terms of Reference*

4.1 Input on public engagement process

The SAC provided input on presenting information on CSOs and the Winnipeg context to the public, and on promoting the public engagement process:

- **CSO video, content for symposium:** The SAC was clear that providing context for the CSO Master Plan and defining the problem it is trying to solve would be an essential to increasing public understanding. SAC members suggested a video or graphics, available online and that could be easily shared, would be helpful in this regard. Several SAC members suggested it would be helpful to provide context specific to where CSOs fit into the broader picture of what is being discharged into the rivers by the City, industry, and others – and what else is being done, by who, to address river water quality.

- **Promoting opportunities for input:** Members of the SAC suggested that the spring 2015 CSO symposium event be promoted via social media and email. It was suggested a save the date be circulated, followed by a brief and easy to distribute overview of the event – including links to the video animation and webpage.

- **Stakeholder outreach:** Committee members also provided suggestions for additional stakeholder groups and individuals to contact about public meetings, and were in turn provided with information about public meetings and opportunities for participation to share back to their networks and contacts. SAC members suggested the symposium be promoted to students and that sustainability offices of post-secondary institutions be targeted for attendance, as they are often aware of relevant research and initiatives occurring on campus.

- **SAC participation at public events:** Three SAC members contributed water stewardship, business, and community perspectives as speakers in a moderated discussion at the spring 2015 symposium event. Several other SAC members also attended the symposium, and helped capture participant input as table facilitators in small group breakout sessions. A couple of SAC members attend the fall 2015 public meetings as well.

4.2 Key themes: Issues, opportunities and concerns

4.2.1 Licence and Master Plan intent – improving water quality, or addressing aesthetics and perception?

Members of the SAC felt greater clarity was necessary concerning the purpose of the Master Plan as mandated by the licence. Was it to protect Lake Winnipeg from nutrient loading to protect rivers ecosystems, or to ensure that rivers are aesthetically pleasing? Meet a public policy objective? Some felt that this was not a two-way dialogue – that the terms of the licence were mandated by the Province with minimal consultation, and without consideration of the potential financial impacts on the City. The broader view of where CSO fits in environmental management needs to be understood.

4.2.2 Discernible impact on Lake Winnipeg?

There was some discussion amongst the SAC as to whether CSOs have any discernible impact on Lake Winnipeg. It was noted by some SAC members that given the nutrient load from all City of Winnipeg discharges (wastewater plants and CSOs) versus loading from the watershed as a whole was in the range of approximately 7% of total Manitoba based sources or 3% of total watershed sources. It is agricultural run-off from fertilizer (potassium and nitrogen) that is having a major impact on the lake. It was noted that this is exacerbated by the fact that drainage works have sped up the flow to rivers, while wetlands, which naturally retain and filter water have continued to be filled. Some asked whether this is being taken into account in the licence discussion and options under consideration.

4.2.3 Competing priorities for investment

Some SAC members noted that this is not the only licence being issued to the City by the Province, and questioned whether they are all of equal importance and whether anyone is looking at how licence requirements will be prioritized. Other SAC members suggested that with limited public funds available and competing priorities for investment, the costs of mitigating CSOs outweigh its benefits (incremental benefits, diminishing returns) – balance is needed. It was noted that trade-offs would have to be considered, and that a discussion regarding the potential tax burden would have to take place with the larger community. Some SAC members indicated CSO mitigation simply shouldn't be a priority for investment if the cost-benefit "isn't there" – if water protection is a priority for the City and Province, investments that offer the best long-term cost-benefit should be pursued.

4.2.4 Demonstrate leadership with innovative solutions

Several SAC members felt strongly that the City should demonstrate leadership and seek innovative solutions to mitigating CSOs. Some innovations discussed included:

- **Increased focus on "front of pipe, not end of pipe" solutions:** Discussion included piloting and applying green infrastructure, temporary storm water retention options, clear and enforced land use policies, incentives to industry, business, individuals for better storm water management as essential parts of a plan to mitigate CSOs.
- **Maximize City investment with watershed approaches:** Discussion included City funding upstream improvements (e.g. paying farmers to reduce their agricultural runoff) for a better return on investment in water quality than CSO mitigation – equivalent or greater amount of nutrient reduction makes this "trade" more cost effective.
- **CSOs are a complex problem that requires a "three-headed" solution:** Discussion included bringing government, business, and non-government organizations (NGOs) together to explore innovative, more complete and effective solutions.

4.2.5 Models and solutions must take climate change into account

Many SAC members noted it was imperative to integrate climate change considerations into any plans for CSO management, as severe weather will be more extreme – wet and dry. The SAC was clear - proposed infrastructure and CSO controls must take this into account.

4.3 Input on values, criteria and options for Master Plan

4.3.1 Values, criteria identified

SAC members were asked to provide input on community values for the CSO Master Plan and criteria that should be used to evaluate control options in Phase 1. The SAC raised the following points in terms of community values and criteria in response:

- **Lake Winnipeg** – impact on nutrients, lake health and use
- **Value for money** – maximize benefits and include basement flooding in assessment; focus on low-hanging fruit and best value for money
- **CSOs in broader context** – recognize other contributors and factors related to water quality; coordinate with related initiatives
- **Vision** – keep future generations in mind, social acceptability
- **Innovation & transformation** – consider the cost of doing business in Winnipeg, retaining good talent, innovation; consider how incentives and disincentives fit in; coordinate with other projects, initiatives
- **Economic benefit** – develop a program management approach which maximizes the opportunities for capacity building and economic benefits
- **Livability** – factor in potential for construction fatigue, i.e. residents getting fed up with the extent and duration of construction related disruption
- **River use** – coordinate with existing plans and projects, address misperceptions of what can actually be achieved in terms of river quality with enhanced control of CSOs
- **Social acceptability** – consider need for citizens to see the City "doing its' part"; role of education, creating awareness

The feedback received was used to help define community values in order to help finalize the evaluation criteria used for Phase 1, which was shared at September 2015 public meetings.

4.3.2 Relative importance of criteria and feedback on control options

In fall 2015 the project team finalized the criteria to evaluate the CSO control limit options, and SAC members were asked to respond to an online survey, which paralleled a survey provided to the public. The survey included a question about the relative importance of each criterion, as well as a question where they could review information about the five options under consideration and rate each one.

***Question*: Which 3 criteria do you feel are the most important in evaluating the CSO control limit options? (n=6)**

Criterion	SAC Votes
Value for Cost & Affordability	4
Lake Winnipeg	4
River Usability	3
Visionary & Broader Context	3
Innovation & Transformation	2
Economic Sustainability & Construction Capacity	1
Livability	1

Of the six responses received from SAC members, “Value for Cost & Affordability” and “Lake Winnipeg” were considered the most important criteria when evaluating CSO control limit options (four votes each), followed by “River Usability” and “Visionary & Broader Context” (three votes each).

***Question*: Please review all five options and rate each using the scroll bar provided. (n=6)**

Respondents were provided five options that were being considered for CSO control limits. By assigning a value to the responses a mean could be calculated, where a higher mean correlates to a greater support for the option.

5 = Strongly support
4 = Somewhat support
3 = Neutral
2 = Somewhat oppose
1 = Strongly oppose

Option	Mean
Four overflows in an average rainfall year	3.7
Zero overflows in an average rainfall year	3.5
No more than four overflows per year	3.2
85% capture in an average rainfall year	2.8
Complete sewer separation	2.8

The most supported option is “four overflows in an average rainfall year”, while the least supported options are “85% capture in an average rainfall year” and “complete sewer separation”.

Appendix A: Submissions

From: **Colleen Sklar** <csklar@shaw.ca>
Date: Wed, Sep 23, 2015 at 7:53 AM
Subject: Water square Rotterdam

CSO management from urban infrastructure - 2600 cubic meters of water held by urban storm water infrastructure. Three office buildings and public space disconnected from CSOs.

Appendix B: Terms of Reference

City of Winnipeg Combined Sewer Overflows Master Plan
Stakeholder Advisory Committee (SAC)
Terms of Reference

1. Introduction

The terms of reference are intended to provide pragmatic guidelines for the Stake Advisory Committee (SAC). These terms of reference are not exhaustive; the SAC may encounter circumstances not covered in this document. In these instances, the SAC members are encouraged to consult with the City of Winnipeg project team and the facilitator as to how best to address such circumstances.

2. Background

The City of Winnipeg is developing a Combined Sewer Overflows (CSO) Master Plan. During dry weather, all flow in the combined sewers is carried to the sewage treatment plants but during heavy rainfall or snowmelt, theses sewer are designed to overflow when the additional volume exceeds the capacity of the system. As part of the requirements for the *Environment Act* Licence No. 3042 issued by the Province, the City of Winnipeg will submit:

- a preliminary proposal evaluating CSO control limits by December 31, 2015, and
- a final CSO Master Plan by December 17, 2017, for controlling CSOs to the defined limits.

3. Committee Purpose

The purpose of the SAC is to help the City of Winnipeg (project team) develop a plan to manage the effects of combined sewer overflows (CSOs) on our rivers in an environmentally sound, sustainable and cost-effective manner. Stakeholder input is essential to ensure that this important initiative to protect the health of our water ways moves forward in a way that reflects the values of Winnipeg families, business and river users and is sustainable. An important component of a broader public engagement process, the SAC will help ensure the resulting CSO Master Plan is reflective of stakeholder needs and input.

4. Level of Impact

The International Association of Public Participation (IAP2) provides a Spectrum for Participation that provides a reference to help establish a common understanding of the level of impact the SAC has in decision making related to the CSO Master Plan. The project team has made a commitment to work with the committee at the "collaborate" level on the spectrum.

> **Stakeholder engagement goal:** To partner with the SAC in the development of the Master Plan, including the development of performance targets and the development of control specifics and implementation plans.
>
> **Promise to Stakeholders:** The City will look to you for ideas, suggestions and trade-offs and to help formulate solutions and will incorporate your advice and recommendations into CSO Master Plan decisions to the maximum extent possible.

5. Composition and Structure of the Committee

The SAC will include up to 15 members of the community, bringing a variety of perspectives to the table, including ecological, industry, and citizen representatives with an interest or stake in CSO impacts and control strategies. The committee will also include members from the City of Winnipeg project team and an independent consultant as chair/facilitator.

SAC membership is fixed. Committee members will be directly involved in committee meeting discussions. Organizations will designate a primary representative. Although an alternate may attend meetings in instances where a primary committee member cannot attend, it is desirable that the most consistent involvement possible is maintained.

Primary and alternate committee members will receive meeting notes, materials and agendas. Presentation materials shared at SAC meetings may also be posted for public review on the City's project web page.

6. Committee Meetings and Term

The following approaches will be used to support an effective and meaningful engagement process with the SAC:

- Agenda – Circulate to SAC members one week in advance.
- Meetings – Use a workshop format to create a meaningful problem-solving environment and maintain consistency with agenda to the extent possible.
- Materials – Support participant learning by identifying ways to make it easy for the SAC members to track and access reference materials.
- Feedback – Seek participant feedback using a variety of approaches including verbal session evaluation, feedback forms at session, or online survey.
- Notes – Circulate to the SAC for feedback prior to sharing with public.

The SAC will be engaged during two phases of the CSO Master Plan process:

- Phase 1: Regulatory Performance Targets (Wrap-up October 2015)
- Phase 2: CSO Master Plan (Wrap-up October 2016)

7. Decision Making Input

No votes will be held to determine the SAC's position on issues or recommendations to the City of Winnipeg. Where consensus exists, it will be noted. Where it does not exist, minority opinions will be considered to have merit and will be noted. In the context of the SAC, consensus will be defined as "I will support the decision of the group." The opinions of all committee members will be valued and taken into consideration.

More specifically, SAC members' decision making involves:
- Contributing input for consideration by the project team in their decision making.
- No decisions will be made by the SAC unless asked by the project team. Where a decision is requested, it will be made by consensus.
- If requested, only SAC members will be involved in consensus decisions, and alternates only when primary member is not present.
- Decisions may be requested and made on SAC meeting and logistical requirements.

SAC activities and input will be summarized and included in a public participation report.

8. Roles and Responsibilities

Committee members

The role of SAC members is to invest time and energy in learning about the CSO management practices and regulation, review and provide input on potential CSO control limits and control methods, and provide input on and engage in the public participation process. Members are encouraged to represent the views of their organization/constituents/networks and facilitate a two-way flow of information in support of broader public education and engagement. This is a voluntary position.

Responsibilities of committee members are:
- Prepare for, attend, and participate in scheduled meetings between October 2014 and November 2016, normally scheduled from 4:00 pm to 6:00 pm, depending on need
- Participate in various public event(s) scheduled throughout the process
- Learn about CSOs and work constructively and collaboratively with committee members
- Identify an alternate representative in the event of a conflict with a scheduled meeting
- Allow name and organization to be posted on project website

Project team members

Project team members will work with the SAC in order to contribute background, context and subject matter expertise and explain the CSO Master Plan process, considerations and decision making criteria, and arrange for supports in order to help members achieve the SAC purpose.

Responsibilities of project team members are:
- Prepare and provide materials for review and discussion
- Arrange for meeting scheduling and logistics
- Be responsive to concerns raised by the committee, but not ask the committee to formally approve or disapprove any actions, or vote on issues or recommendations
- Incorporate the committee's advice and recommendations into decision-making to the maximum extent possible

Facilitator

The facilitator will support the work of the SAC through a focused process design and meeting facilitation.

Responsibilities of the facilitator are:

- Confirm SAC member participation, and act as a resource to SAC on process and expectations
- Facilitate (chair) committee meetings
- Enforce norms, ground rules developed by the SAC and project team and facilitate respectful and productive meetings and group dialogue
- Arrange preparation of meeting notes

Provisions for guests, observers

From time to time, the project team may request the participation of additional guest specialists, experts or consultants to contribute additional knowledge or technical insight to the committee's deliberation and discussion.

9. Committee Spokesperson

SAC members are encouraged to provide comments to the project team. In the event that a media enquiry is made, committee members are strongly encouraged to refer the media to the project team/manager.

10. Conflict of Interest

All SAC members, primary and alternates are required to disclose any conflict of interest in writing to the project team.

Appendix C: Meeting 1 Notes & Presentation (October 2, 2014)

Winnipeg

City of Winnipeg's Combined Sewer Overflow Master Plan

Winnipeg

Outline

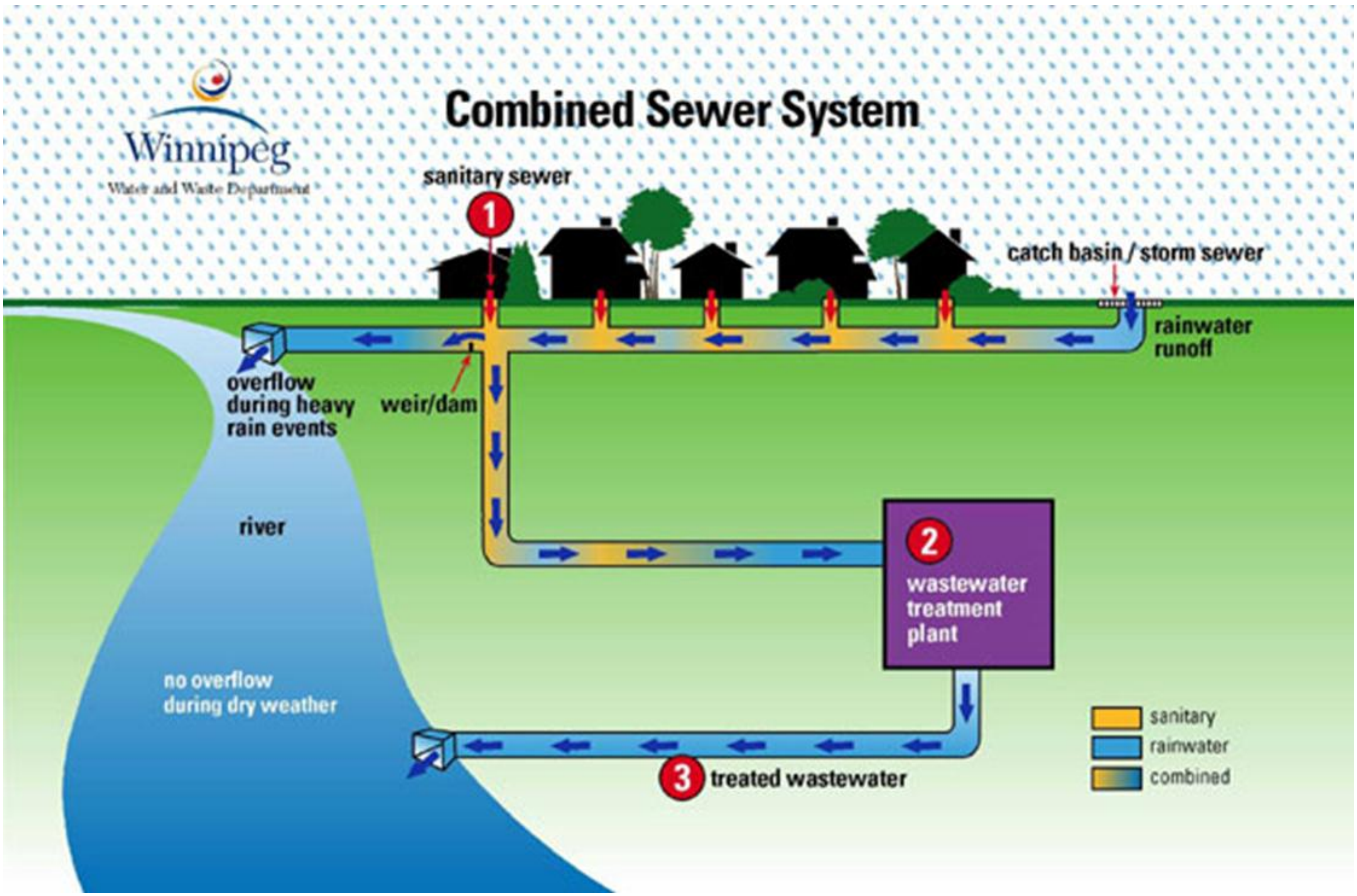
- Winnipeg's Sewer History
- All about Combined Sewers
- Progress on Addressing Combined Sewer Overflows
- Combined Sewer Overflow Licensing
- The Combined Sewer Overflow Master Plan
- Next Steps

Winnipeg’s Sewer History

- 1880’s-1930’s
  - sewers were constructed and flowed to the rivers
- 1930’s-1960’s
  - construction of sewage treatment plants
  - construction of interceptor sewers (divert dry weather flows to treatment plants)
  - most new sewers were combined sewers
- 1960’s - today
  - installing separate sewers only

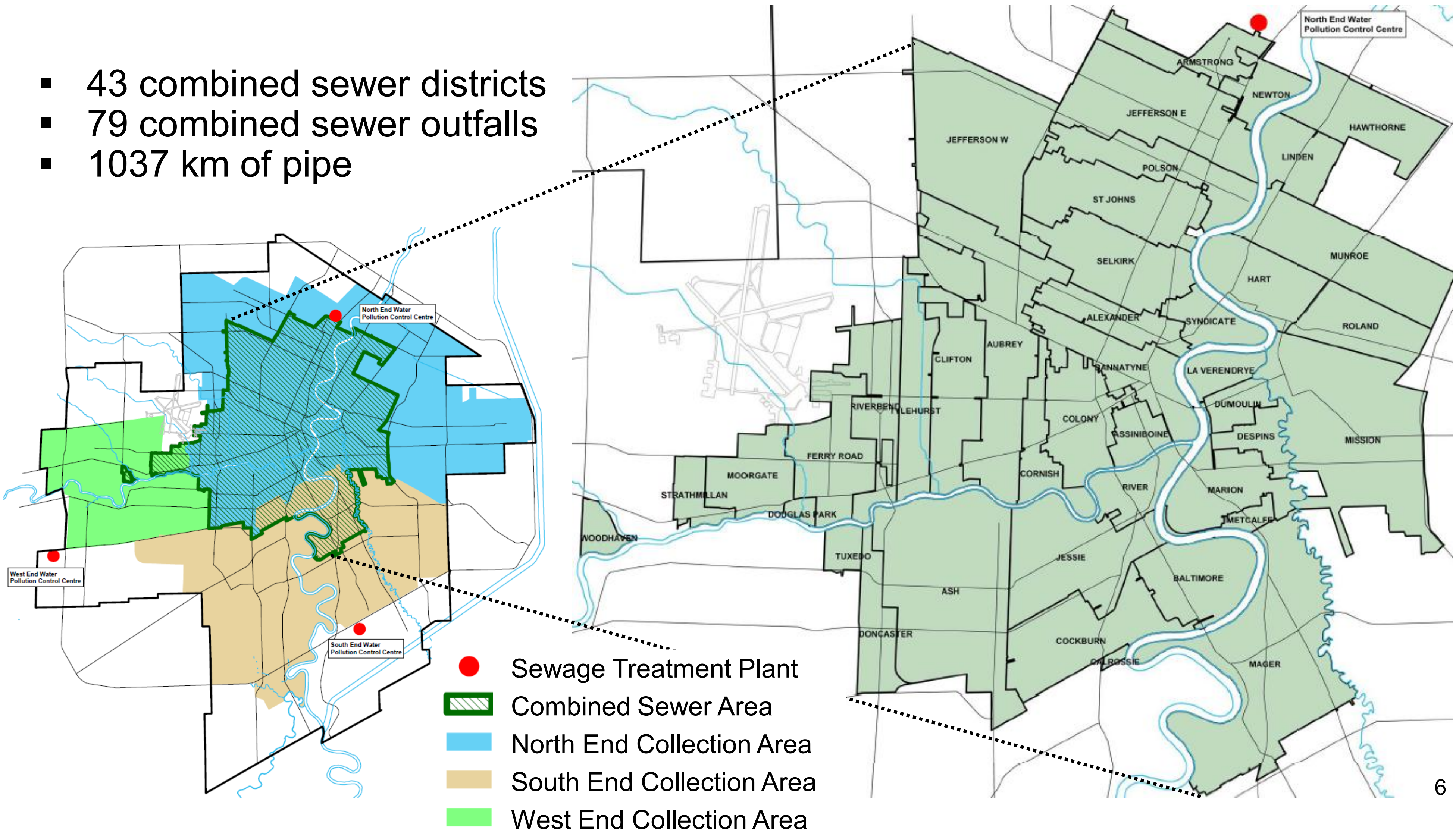
What are combined sewers?

- A single pipe system, built between 1880’s and 1960’s, that collects both:
  - wastewater from homes and businesses, and
  - rainfall runoff and snow melt


Winnipeg
Water and Waste Department
Combined Sewer System
sanitary sewer
1
catch basin / storm sewer
rainwater
runoff
overflow
during heavy
rain events
weir/dam
river
2
wastewater
treatment
plant
no overflow
during dry weather
3
treated wastewater
sanitary
rainwater
combined

Combined Sewer System area

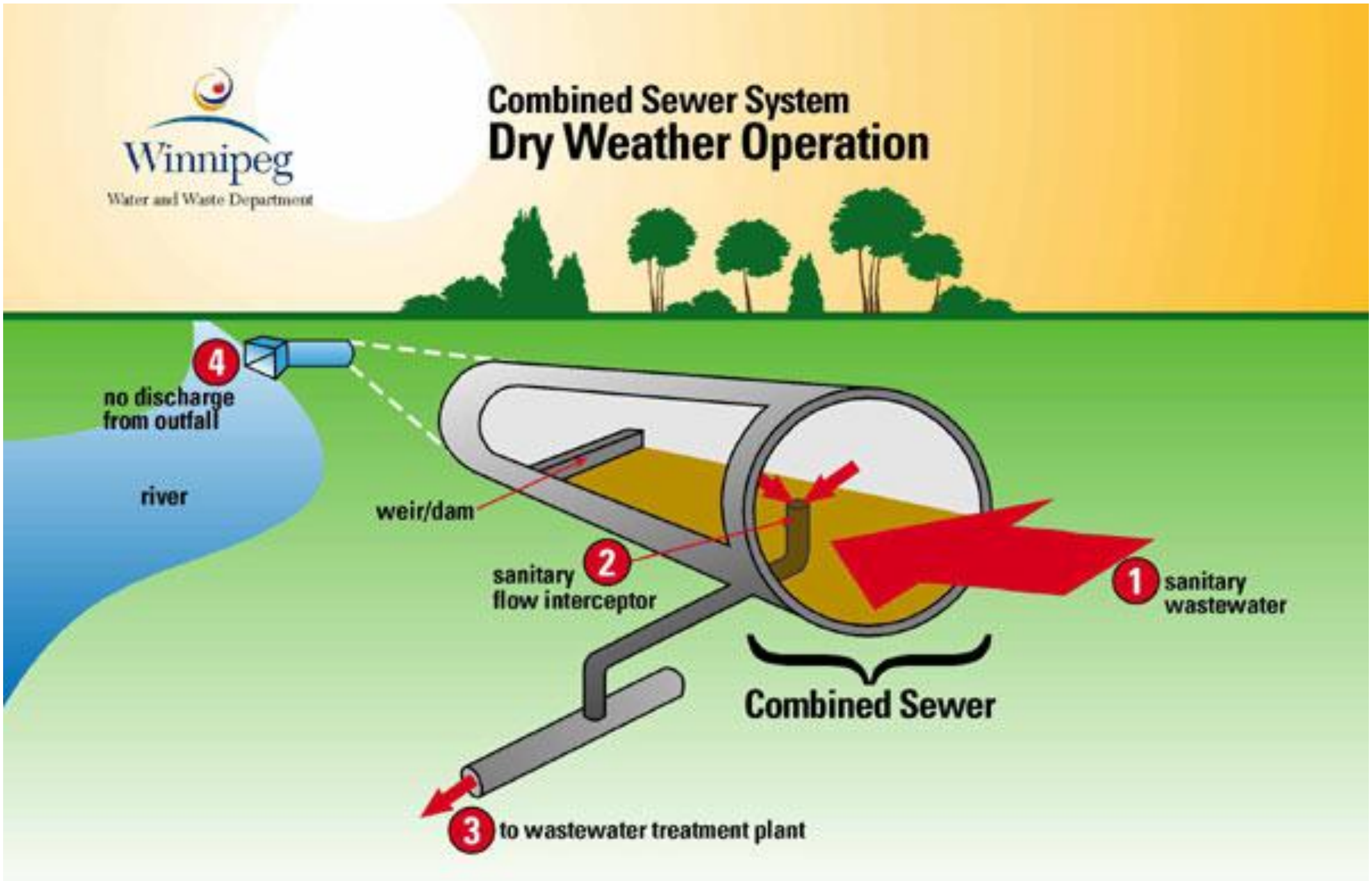
- 43 combined sewer districts
- 79 combined sewer outfalls
- 1037 km of pipe

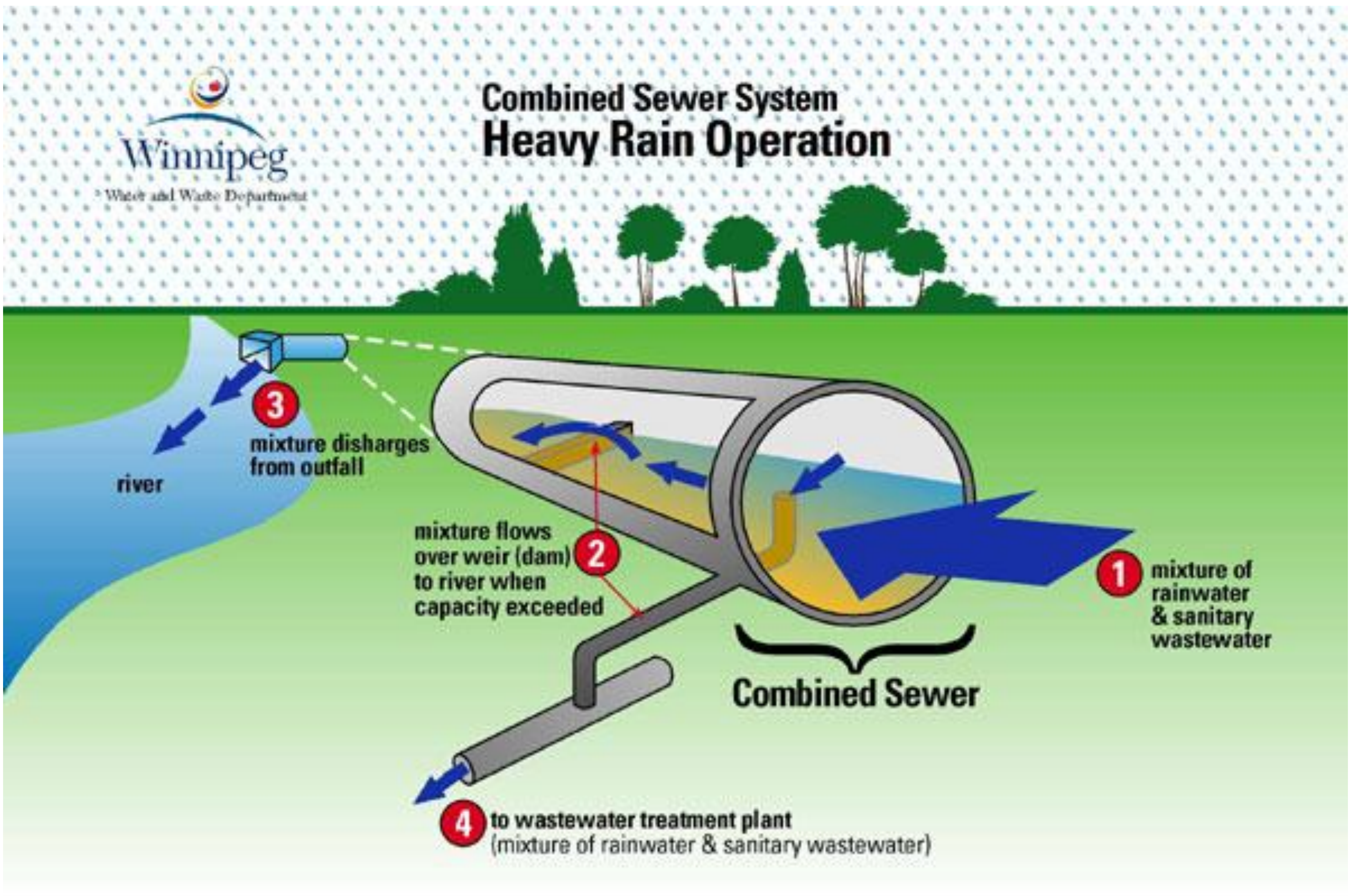


Winnipeg

What is a combined sewer overflow?

- During dry weather, all flow in the combined sewers is carried to the sewage treatment plants
- During heavy rainfall or snowmelt, designed to overflow when the additional volume exceeds the capacity of the combined sewer system
  - the excess drains directly to the river without reaching the sewage treatment plant
  - called combined sewer overflows (CSOs)
- On average, occur about 22 times/year
- Typically 1% of the total annual sewage collected is lost through CSOs


Winnipeg
Water and Waste Department
Combined Sewer System
Dry Weather Operation
4
no discharge
from outfall
river
weir/dam
2
sanitary
flow interceptor
1
sanitary
wastewater
Combined Sewer
3
to wastewater treatment plant


Winnipeg
Water and Waste Department
Combined Sewer System
Heavy Rain Operation
3
mixture disharges
from outfall
river
mixture flows
over weir (dam)
to river when
capacity exceeded
2
1
mixture of
rainwater
& sanitary
wastewater
Combined Sewer
4
to wastewater treatment plant
(mixture of rainwater & sanitary wastewater)

Winnipeg

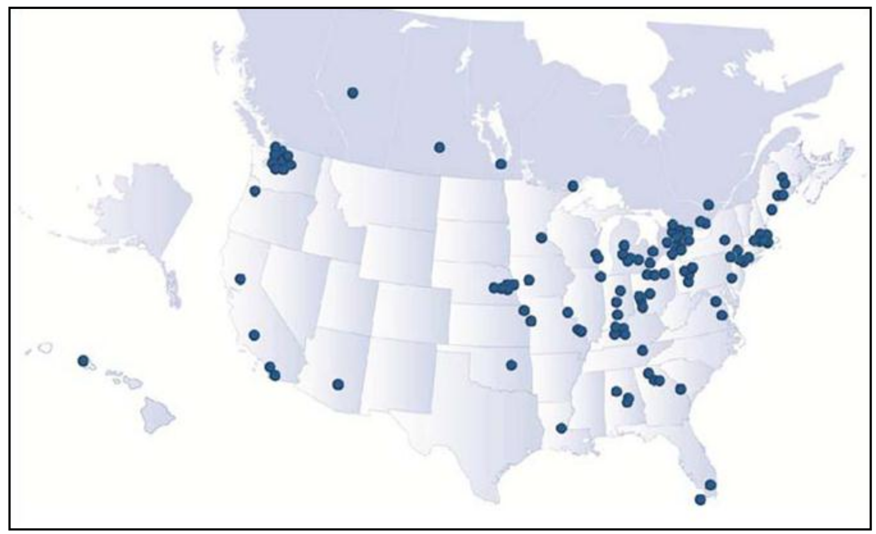
Why do combined sewer overflows occur?

- Help protect against basement flooding
- Help protect sewage treatment plant and collection system

Winnipeg

Are CSOs unique to Winnipeg?

- Many older cities had combined sewer systems
- Most still have CSOs when it rains
- Most are working to reduce CSO impacts



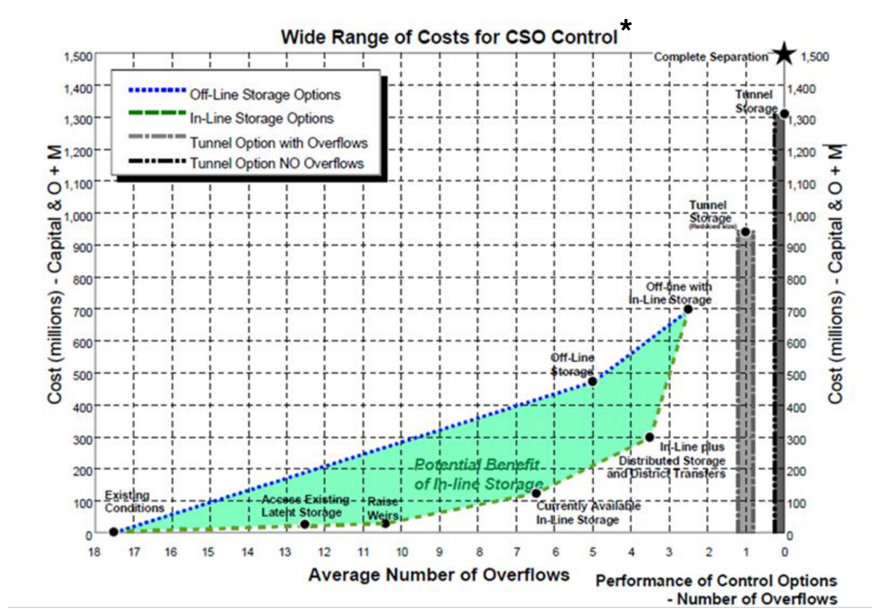
Winnipeg

Why should we reduce CSOs?

- Every time there is an overflow, there is a temporary discharge to the river of:
  - bacteria
  - floating debris
  - organic material
  - common urban pollutants from land drainage (e.g., oils, lawn/garden fertilizers)

Have we investigated CSOs?

- 2002 was the first major Winnipeg CSO study
  - started in 1993
  - multi-year planning study of CSO impacts
  - submitted during Clean Environment Commission public hearings in 2003



*From 2002 Report

- Cost implications:
  - costs rise exponentially to reduce the number of CSOs

Winnipeg

What have we accomplished to date?

- Identified and reduced dry weather overflows through system upgrades
    - upgrading pumps, raising weirs, replacing pipes
- Identified and removed large inflows into the sewer system (e.g., ditches connecting to the sewer system)
- Developed and installed a computer monitoring system to provide early detection of high sewer levels and allow crews to respond and mitigate

Winnipeg

What CSO projects are complete?

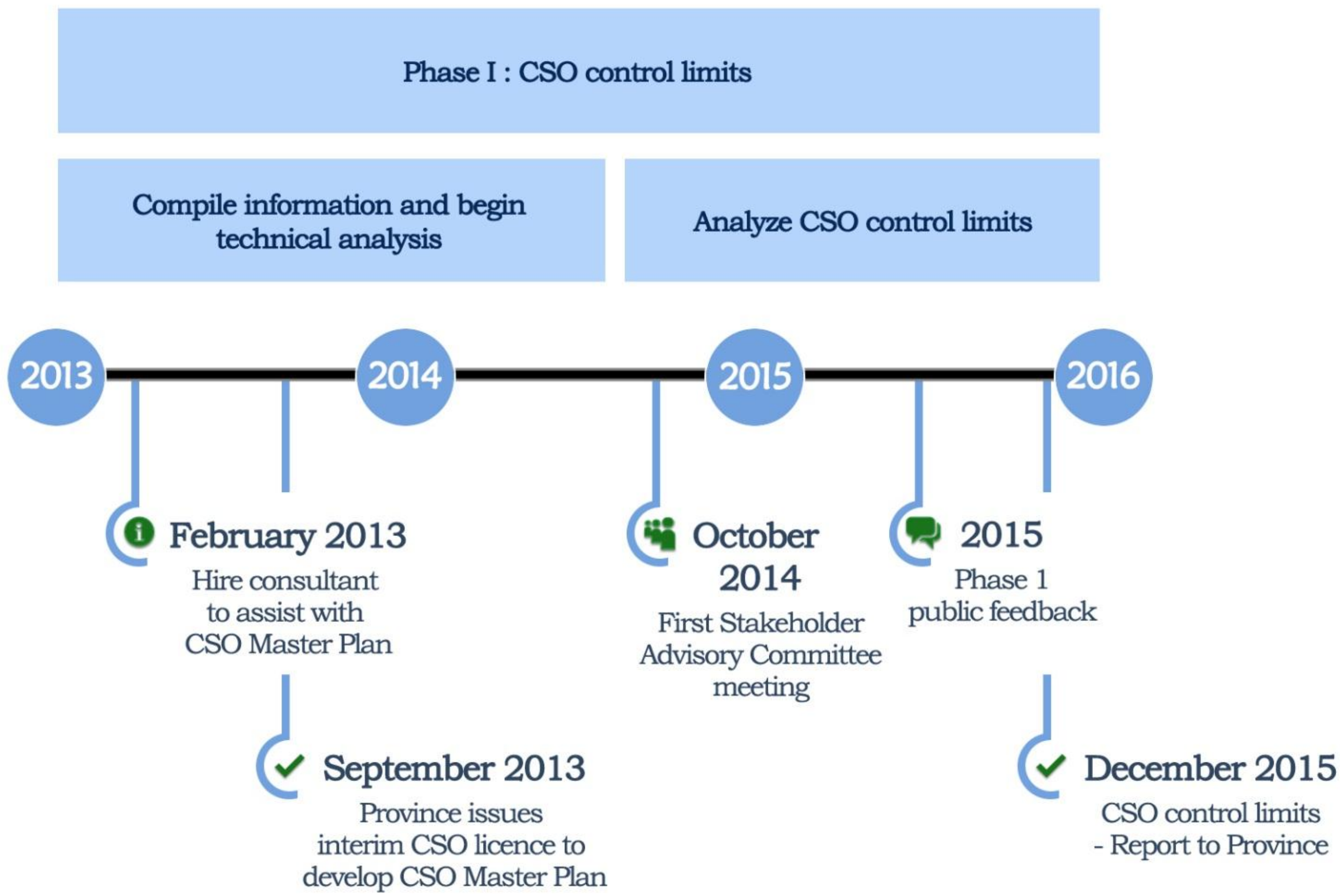
- Invested over $75 million on investigating and reducing CSOs:
  - CSO outfall monitoring program
  - pilot stormwater retention tank
  - revised low-impact development standards to limit runoff
  - interceptor and collection system sewer flow monitoring
  - sewage pumping station improvements and capacity upgrades

Winnipeg

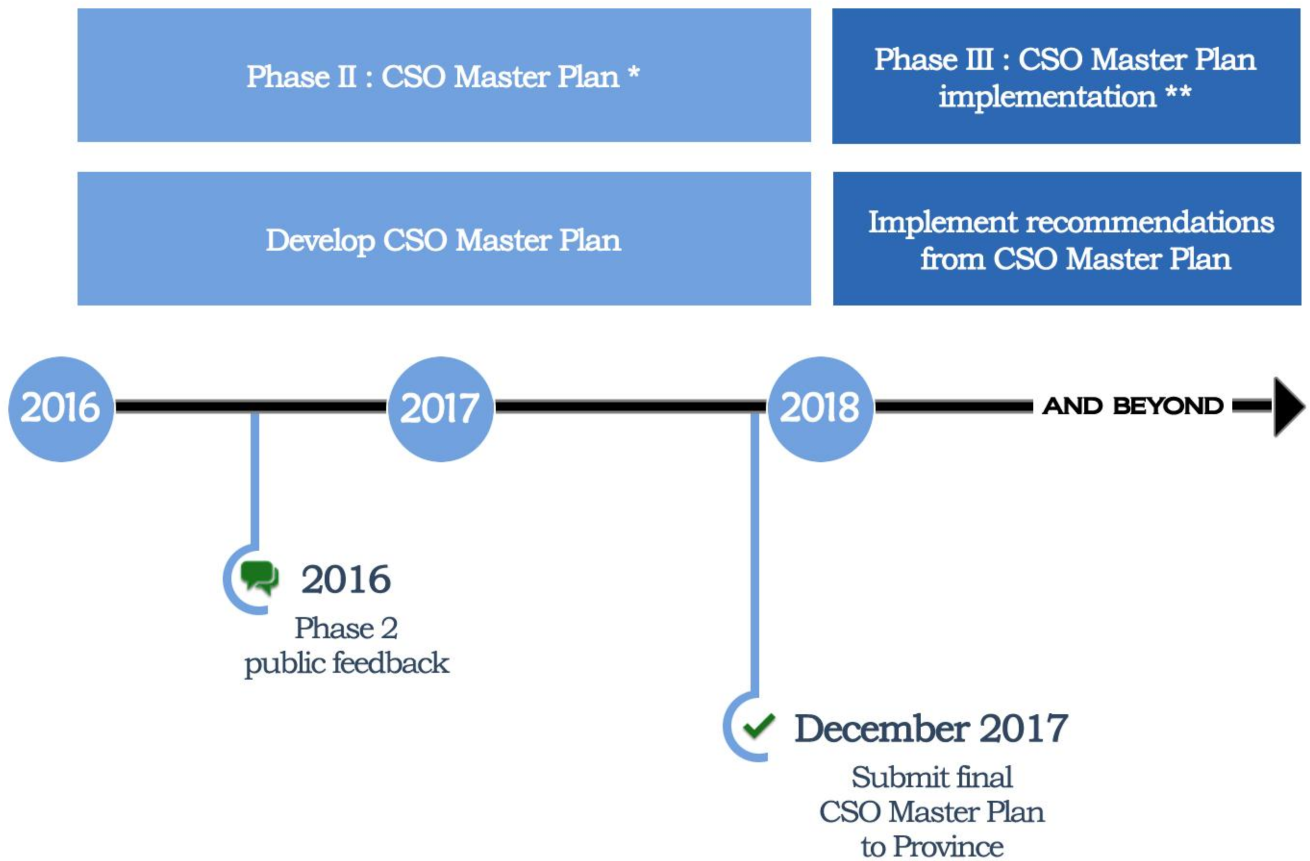
What CSO projects are complete? (cont'd)

- Combined sewer renewals and replacements
- Combined sewer and basement flood relief studies
- Combined sewer separation projects
  - 1389 hectares separated out of 9705 hectares of combined sewer district

CSO Master Plan Timeline



CSO Master Plan Timeline



* Timeline is dependent upon provincial response to the CSO control limits report

** Subject to provincial approval of the Master Plan

What are the CSO regulatory requirements?

- The Province:
  - has regulatory responsibility since enactment of the Environment Act in 1988
  - Manitoba Conservation and Water Stewardship issued Environment Act Licence No. 3042 (EA No. 3042)
- Federal Requirements (2012)
  - policy for CSOs requires identification of discharge points and annual reporting of overflows

What are we required to do under Environment Act Licence No. 3042?

- Issued by the Province of Manitoba on September 4, 2013
- City will undertake work to:
  - develop a better understanding of CSO impacts and evaluate options
  - develop a long-term implementation program
- City will report back to the Province with a:
  - Preliminary Proposal by December 31, 2015
  - Final Master Plan by December 31, 2017

Winnipeg

What are we required to do under Environment Act Licence No. 3042? (cont'd)

- Public education plan
  - submitted December 31, 2013
- CSO event reporting procedure
  - submitted December 31, 2013
- Water quality monitoring plan
  - submitted January 31, 2014
- Public notification system of CSO events
  - to be submitted by December 31, 2015

What needs to be included in the preliminary proposal?

- CSO limits to be evaluated:
  - EA No. 3042 requires:
    - maximum of 4 overflows events per year
    - zero combined sewer overflows
    - at least 85% capture <u>and</u> a maximum of 4 overflow events/year
  - explore other relevant control limits

What CSO control limits are used elsewhere?

- Maximum use of existing infrastructure
- Nine minimum controls (US CSO Policy)
- Environmental equivalent of separation (Edmonton)
- No more than 4 to 6 overflows/year (US CSO Policy)
- Capture and treat 85% of wet weather flows (US CSO Policy)
- River water quality standards:
  - not established for CSOs impacts

Winnipeg

How will we evaluate CSO control limits?

- Criteria to evaluate CSO Control Limits:
  - feedback from the SAC
  - feedback from the public engagement process
  - affordability
  - constructability
  - maintainability
  - environmental stewardship

What are CSO control options?

Control Option	Concerns
Sewer separation	Disruption, residual untreated stormwater
System flow balancing and real time controls	Modest control improvement, risk of increased basement flooding
Increase wet weather treatment at plants	Would threaten existing sewage plant licence compliance
Conveyance-storage tunnels	Constructability and maintenance
Green infrastructure	Modest control improvement, drainage retrofit takes decades,

Winnipeg

What are the next steps?

- Work on CSO Master Plan is in progress
- Technical evaluations are underway
- Additional Stakeholder Advisory Committee meetings
- Regular liaison meetings with Provincial staff

Combined Sewer Overflow Master Plan
Stakeholder Advisory Committee
Meeting #1 Notes

Thursday, October 2, 2014, 4-6pm
Fort Rouge Recreation Centre, 625 Osborne Street

In Attendance:

Ani Terton	Manitoba Eco-Network
Jim Robinson	Lake Friendly / PMCR
Carmine Militano	Winnipeg Chamber of Commerce
Chris Lorenc	Manitoba Heavy Construction Association
Joy Kennedy	Manitoba Conservation and Water Stewardship (Water Quality)
Dale Karasiuk	Chalmers Neighbourhood Renewal
Colleen Mayer	Old St. Vital BIZ
Dorothea Blandford	Winnipeg Rowing Club
Tiffany Skomro	City of Winnipeg
Patrick Coote	City of Winnipeg
Andrew McMillan	City of Winnipeg
Ho Lau	City of Winnipeg
David Marsh	Dillon Consulting (guest)
Dennis Heinrichs	Dillon Consulting (guest)
Michelle Kuly Holland	First Person Strategies (facilitator)
Krista Stobart	First Person Strategies (recorder)

Regrets:

Colleen Sklar	Lake Friendly / PMCR
Megan Krohn	Manitoba Eco-Network
Julie Turenne-Maynard	Rivers West
Henry Borger	Manitoba Heavy Construction Association
Hank Venema	IISD
Gloria Desorcy	Consumers Association of Canada (Manitoba)
Tracey Braun	Manitoba Conservation and Water Stewardship (Licensing)
Christine Hutlet	Rivers West / Red River Basin Commission

Agenda:
1. Session opening, welcome & introductions
2. Committee purpose & overview
3. City project team presentation on CSOs and CSO Master Plan
4. Q & A
5. Session wrap up

1. Session opening, welcome & introductions

Committee members thanked for participating and introductions made.

Meeting #1 Purpose:
To ensure participants understand why they are here, what the committee is being asked to do, and to share information about the City of Winnipeg's sewer system, combined sewer overflows (CSOs), and the CSO Licence and master plan process underway.

Deliverables / Outcomes:
1. Understanding, clarity on terms of reference.
2. Greater understanding of the City's sewer system, combined sewer overflows (CSOs).
3. Identification of questions, items for clarification.

Meeting Guidelines:
- Strive to meet the stated purpose and expected outcomes of meeting
- Respect the agenda
- Listen actively to others
- No one-on-one side conversations while other are speaking, no interrupting
- Manage your own input – focused responses, comments and questions, not long speeches
- Where consensus exists, or has been reached, support group decisions
- Phones on silent, urgent calls responded to outside meeting room

Committee adopted meeting guidelines.

Committee members asked to identify their expectations:
- Be able to ask questions throughout process

2. Committee purpose & overview

Terms of Reference reviewed and adopted.

Discussion / Questions:
- Why is this a 2-year project?
    - There are 2 phases – 1) control limits and control options and 2) developing a Master Plan.
- Will the proposed CSO Master Plan go to Council?
    - The Proposed CSO Master Plan will be reviewed by the City to an appropriate level at different stages which may include Committee signoff.
- How does this process relate to the previous study (2002)?
    - This is a continuation of that work and is a more formalized process to develop a plan.

Committee members asked for feedback on methods of sharing materials:
- A collaborative site
- Meeting minutes should also be shared with alternates
- Hard copies also useful

Meeting notes and materials will also be shared publicly on City of Winnipeg project website.

Phase 1 - CSO Control Limits SAC Timeline:

3. City project team presentation on CSOs and CSO Master Plan

Reference: PowerPoint presentation – will be circulated and posted on project website.

4. Q & A

Discussion / Questions:

- Can you define "clean" in terms of the water leaving the treatment plants? How do the pollution levels of discharge from a CSO compare to the discharge leaving a treatment plant?
  - The Province has licensed discharge levels from treatment plants. Results are posted on City of Winnipeg website.
- Is there science that supports elimination of all combined sewers? Are outflows of CSOs monitored?
  - The science is typically a risk based approach assessing environmental quality by identifying, evaluating, and managing existing and potential future risks to the environment and human health. Yes, 39 of the City's combined outflows are monitored for occurrence of overflows; currently 2 are being monitored temporarily for water quality. There's also an overflow risk from separate systems but this risk is much lower.
- How have you historically determined where to do infrastructure upgrades?
  - Control centre continually monitors and flags problem areas; we also undertake condition assessments of pipes and use basement flooding statistics.
- What are other cities doing with their combined sewer systems? Are any jurisdictions going to zero combined sewers?
  - There is an Experience Elsewhere Report available and the project team will put together a presentation to provide information on what other cities are doing.
- Can you provide examples of low impact development standards/practices?
- Presentation has talked about cost effectiveness, but nothing in presentation states that the main driver is (or should be) environmental improvement of waterways, and not just about meeting the CSO Licence. The presentation

should clarify outcomes… e.g. what are the benefits, what environmental standards will improvements be designed to? When talking to stakeholders the context of cost/benefit should be shared.

- Is the objective to reduce the number of overflow events?
- Will the Province handle some of the public consultation? Would like more details on what the public consultation process will involve.
  - We're working with the Province. The City is planning to go to public in June.
- The SAC needs to understand the social licence and the sustainability/environmental merits of this project. At the end of the day the public needs to be persuaded. This Committee should speak that language because we will be the ambassadors of the social benefit/rationale that underpins the project investments.
  - A key role of the SAC is to help the project team frame the context for the public.
- For a potential multimillion dollar project, consider dynamic modeling to ensure the right solutions/conclusions.
- How was it determined that there needs to be a maximum of four overflows events per year? If 85% capture is desired, why does it matter how many overflows/year?
  - Four tends to be the number that the EPA regulates to in the United States and was adopted here. Not sure exactly how EPA came up with four. Four overflows, 85% capture and the elimination or removal of no less than the mass of the CSO pollutants identified as causing water quality impairment are outlined in the US EPA CSO Control Policy as adequate levels of control to meet water quality based requirements. It's in the licence requirements that the Province has set and was also examined as part of the 2002 study.
  - The City is looking beyond the CSO limits set in the licence and examining other control limits.
- Is there a definition of the environmental standard objective to which we're developing the CSO Master Plan? What are the desired measurable outcomes? What exactly are we trying to do and how do we get there? Need information on how we define that standard.
  - The input from this group will help define the objectives and standards. The desired outcome will be an improvement in water quality. We are assessing the impact CSO are having on water quality and potentially proposing upgrades to our sewer infrastructure to address them.
- The context of the project should link to "Our Winnipeg".

5. Session wrap up

Next meeting – how do we talk about these concepts with stakeholders and the public

Meeting Logistics – please provide feedback on meeting time/location/day of week. Also looking for input on planning the larger symposium (Jan/Feb 2015)

Next meeting: Wednesday, November 19
Anhang Room, 2nd Floor, Millennium Library; 251 Donald St.

6. Follow-up Conference Call

A conference call was held for the committee members not in attendance at the October 2 meeting.

Call Attendees:

Colleen Sklar	Lake Friendly / PMCR
Megan Krohn	Manitoba Eco-Network
Julie Turenne-Maynard	Rivers West
Gloria Desorcy	Consumers Association of Canada (Manitoba)
Tracey Braun	Manitoba Conservation (Licensing)
Siobhan Burland Ross	Manitoba Conservation (Licensing)
Patrick Coote	City of Winnipeg
Andrew McMillan	City of Winnipeg
Tiffany Skomro	City of Winnipeg

Agenda:
- Welcome
- Recap committee roles and responsibilities
- Recap City presentation from Oct. 2 meeting with Q & A

Welcome, technical check and introductions

Recap committee roles and responsibilities:
- Reviewed committee purpose
- 2 year commitment, 2 phases of input
  - Short term (Phase 1) focus: 2014 & Spring 2015 - control limits
  - Longer term (Phase 2) focus: Master Plan for implementation of changes to achieve targets
- Influence: Collaborate level on International Association of Public Participation (IAP2) Spectrum
- Communication:
  - Primarily via facilitator by email
  - Shared resources via shared site and hard copy materials
  - Meeting notes and materials will be posted online
  - Primary and alternates will receive meeting materials

Recap City presentation from Oct. 2 meeting with Q & A:

Presentation given via webinar (pdf version provided to those who called in)

Discussion / Questions:
- Has the province and the city been setting aside funding to construct improvements to CSOs, or are they waiting for the Master Plan to be finished before funding?
  - (Province) Don't know the answer from the Province's point of view.
  - (City) There have been yearly allocations in the budget, but much depends on outcome of the Master Plan.

- It was noted the SAC group will be involved in setting targets, but targets are set in the licence. Can you clarify?
    - SAC will have a role in evaluating targets.
- As part of the options considered with the Master Plan will there be an opportunity to use infrastructure design to hold back storm water (e.g. pilot project at UofW)?
    - Green infrastructure is being considered.

7. Summary of Action Items and Administrative Follow-ups

As of November 10, 2014

Complete:

- COMMITTEE MEMBERS: Provide feedback on meeting time/location/day of week and input on planning the larger symposium (Jan/Feb 2015)
    - *November meeting date set for:*
        - *Wednesday, November 19, 3:45 – 6:00p.m., Anhang Room, 2nd Floor, Millenium Library, 251 Donald St.*

- FACILITATOR: Circulate meeting notes to Committee members and alternates for feedback and comment prior to Meeting #2.

- FACILITATOR: Post meeting notes, PowerPoint presentation and reference materials on shared site for Committee members.

- Where possible, CITY PROJECT TEAM: Provide additional information in response to questions and comments raised at the meeting.
    - *Responses and additional information provided below:*

    - Can you provide examples of low impact development standards/practices?
        - Low Impact Development (LID) is a storm water management strategy that seeks to mitigate the impacts of increased runoff and storm water pollution. Management practices promote the use of natural systems for infiltration, evapotranspiration, and reuse of rainwater. Green roofs, swales, retention basins are some examples of sustainable storm water management solutions to control runoff from new developments ensuring they have low impact with regards to runoff.

    - Presentation has talked about cost effectiveness, but nothing in presentation states that the main driver is (or should be) environmental improvement of waterways, and not just about meeting the CSO Licence. The presentation should clarify outcomes… e.g. what are the benefits, what environmental standards will improvements be designed to? When talking to stakeholders the context of cost/benefit should be shared.
        - We are going to assess and report on the potential improvement in water quality for a range of control limits.

    - Is the objective to reduce the number of overflow events?
        - Other City's CSO programs typically involve reducing the number of overflows and it's likely we will need to do the same. Once a need to address water quality is confirmed the main considerations are

typically what to limit them too, how to do it, sustainability, cost and time needed to achieve it.

- For a potential multi-million dollar project, consider dynamic modeling to ensure the right solutions/conclusions.
    - o Hydraulic models of the sewer system and a water quality river model are being developed as part of the project.

- The context of the project in public communications should link to "OurWinnipeg"
    - o This project aligns with the direction set out for the water and waste department in Our Winnipeg, its policies and initiatives. The CSO Master Plan project was one of the example projects outlined in Our Winnipeg.

In progress:

- COMMITTEE MEMBERS: Book the following tentative dates and times for upcoming meetings at the Buchwald Room, 2nd Floor, 251 Donald St.
    - o Thursday, March 12, 2015, 3:45-6:00pm
    - o Thursday, April 9, 2015, 3:45-6:00pm
    - o Thursday, May 28, 2015, 3:45-6:00pm

- CITY PROJECT TEAM: Produce hard copies of meeting notes, PowerPoint presentation and reference materials for Committee members at next meeting.

- CITY PROJECT TEAM: Share meeting notes and PowerPoint presentation publicly on City of Winnipeg project website following Committee feedback.

- CITY PROJECT TEAM: Prepare a presentation on Experience Elsewhere.

Appendix D: Meeting 2 Notes & Presentation (November 19, 2014)

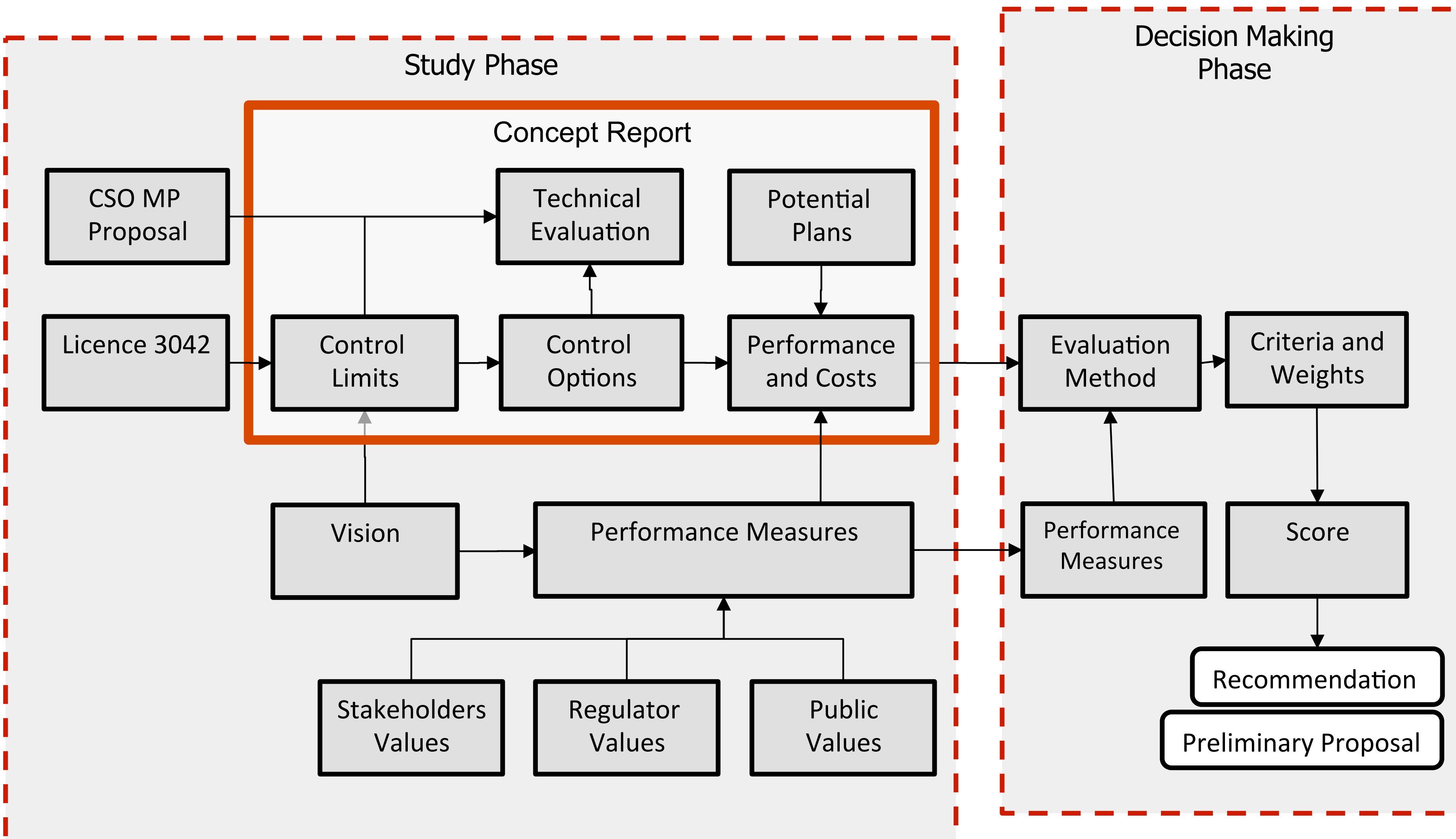
City of Winnipeg's Combined Sewer Overflow Master Plan

SAC Mtg. #2

What CSO Control Limit do we want to achieve and how are we going to do it?

- We want to develop an acceptable limit for the number of CSOs
- We are going to look at a range of modifications to the existing combined sewer system
- We will evaluate the options using criteria specific to Winnipeg
- We will include the input of regulators, stakeholders and the public

Decision Making Roadmap



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Decision Making Process

- Analysis of Control Options
- Experience Elsewhere – lessons learned
- Performance Measures
- Input from regulator, stakeholders and public
- Weight criteria and scoring exercise based on weighted criteria
- Recommendation submitted to Province by Dec 2015

Winnipeg

Control Limits

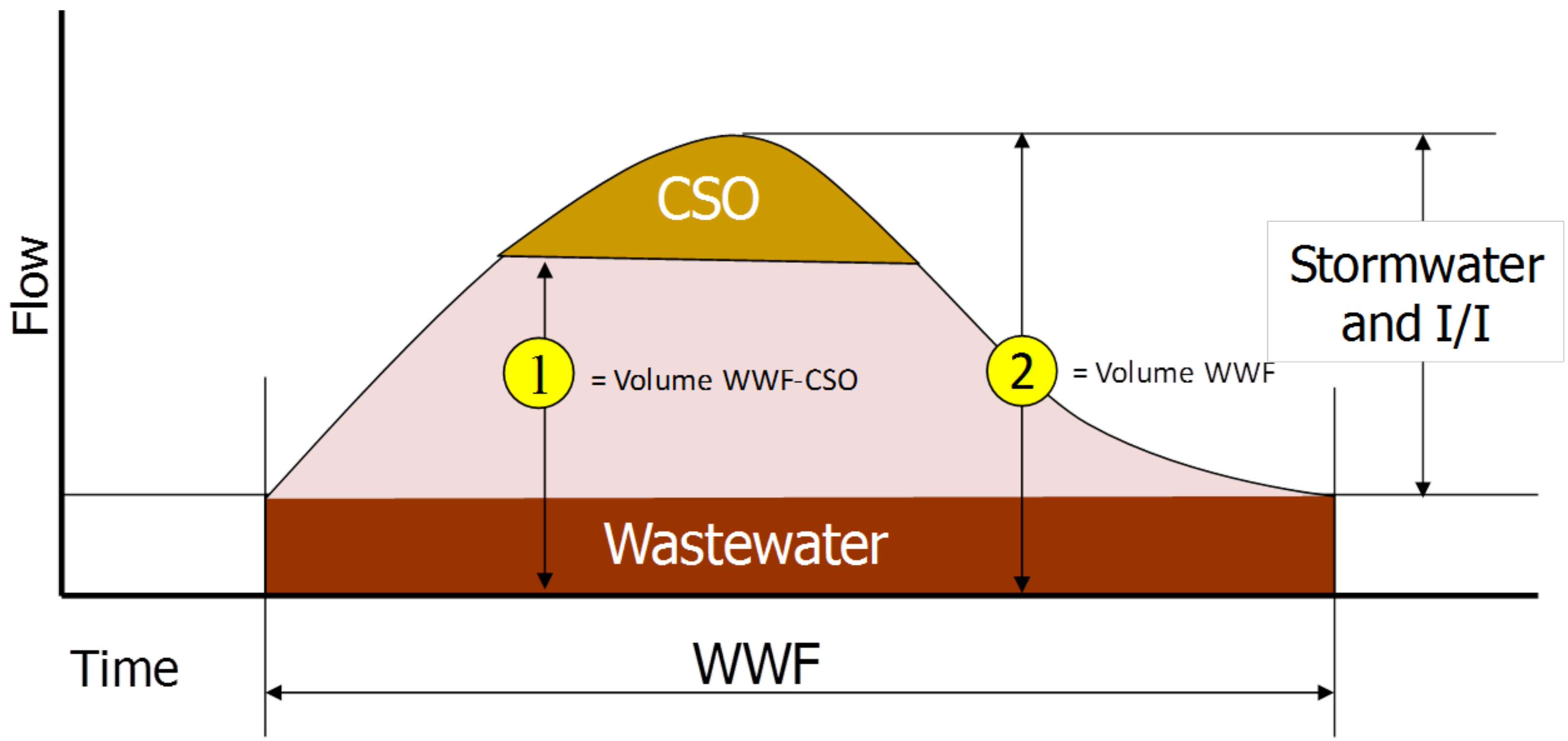
- As part of the CSO licence we are looking at what modifications need to be made to our combined sewer system to limit CSOs to:
  - zero overflows,
  - four overflows,
  - a minimum of 85% volume capture of web weather flow with a maximum of four overflows, and
  - a range of other limits.

Winnipeg

Control Limits Cont'd

- Other approaches being considered:
  - Watershed Approach
  - Environmental Equivalent of Separation
  - Water Quality Performance
  - Maximum use of existing infrastructure
  - ‘‘Knee-of-the-Curve’’ or best use of resources

Control Limits Cont'd

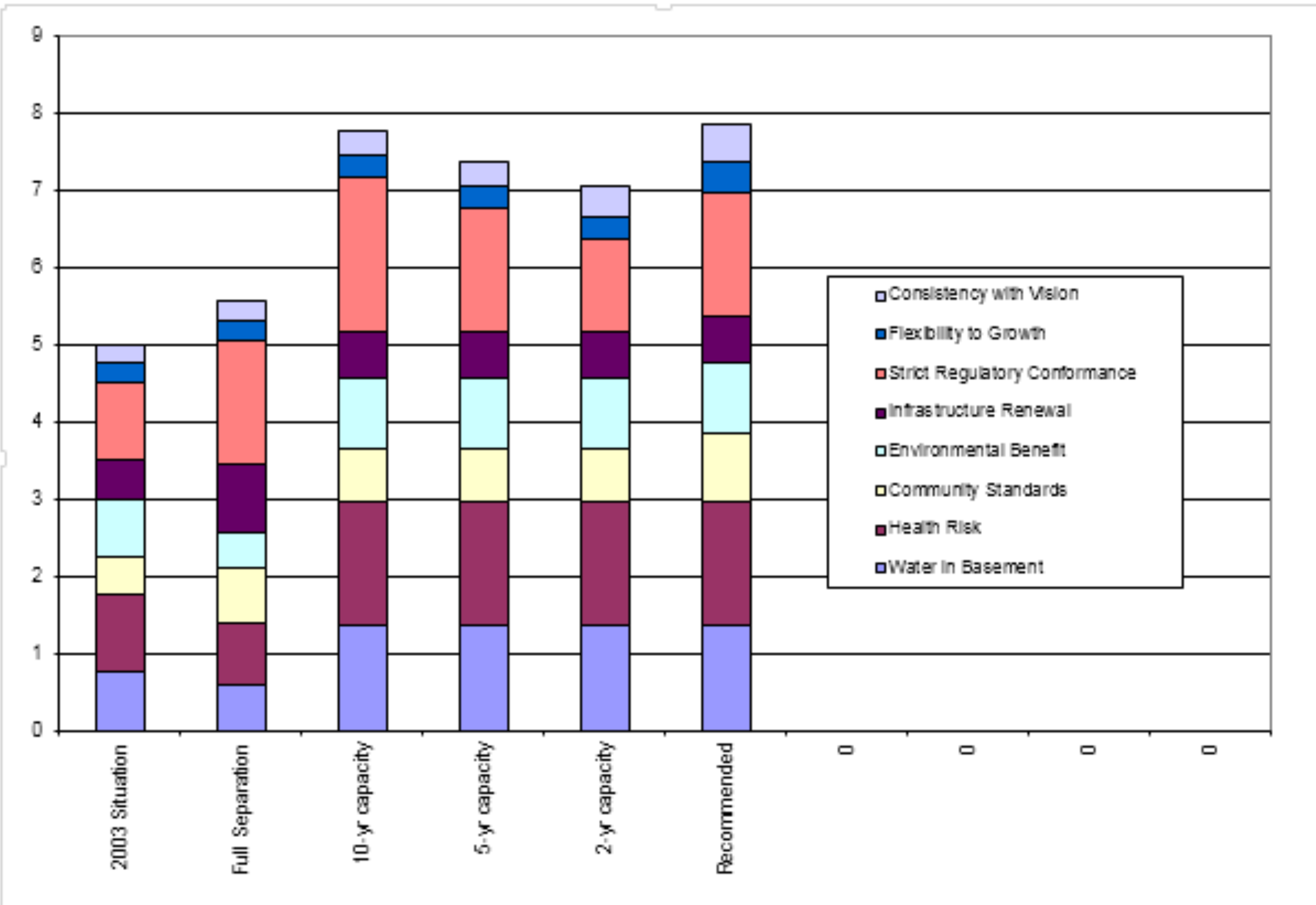


Winnipeg

Develop a Common Vision for the CSO Master Plan

- Environmentally responsible
- Affordable
- Sustainable
- Regulatory compliance
- Politically acceptable
- Preventing Basement Flooding
- Community Values

Scoring Matrix – Example



Winnipeg

Developing Performance Measures for Winnipeg CSO Control

- System performance measures:
  - Number of overflow events
  - Volume of overflows
  - Duration of overflow
  - Flow diverted to treatment
- Environmental performance measures:
  - Water Quality
  - Nutrients
  - Aesthetics

Developing Performance Measures for Winnipeg CSO Control Cont'd

- Affordability
  - Utility Rates
  - Whole Life cost
- Regulatory Compliance
- Community Values
  - Construction industry
  - Traffic disruption
  - Sustainability
  - Feasibility

Questions?

Combined Sewer Overflow Master Plan
Stakeholder Advisory Committee (SAC)
Meeting #2 Notes

Wednesday, November 19, 2014, 4:15 PM – 6:30 PM
Anhang Room, Millennium Library, 251 Donald Street

In Attendance:

Henry David (Hank) Venema	International Institute of Sustainable Development
Ani Terton	Manitoba Eco-Network
Chris Lorenc	Manitoba Heavy Construction Association
Dale Karasiuk	Chalmers Neighbourhood Renewal Corporation
Julie Turenne-Maynard	Rivers West
Joy Kennedy	Manitoba Conservation and Water Stewardship (Water Quality)
Yvonne Hawryliuk	Manitoba Conservation and Water Stewardship (Environmental Compliance and Enforcement)
Andrew McMillan	City of Winnipeg – Water and Waste
Patrick Coote	City of Winnipeg – Water and Waste
Tiffany Skomro	City of Winnipeg – Water and Waste
Duane Griffin	City of Winnipeg – Water and Waste
Michelle Kuly Holland	Facilitator
Dennis Heinrichs	Consultant – Dillon
Brendan Salakoh	Consultant – Dillon

Regrets:

Ho Lau	City of Winnipeg – Water and Waste
David Marsh	Consultant – Dillon
Tracey Braun	Manitoba Conservation and Water Stewardship (Environmental Approvals)
Carmine Militano	Winnipeg Chamber of Commerce
Colleen Mayer	Old St. Vital Biz
Colleen Sklar	Lake Friendly Manitoba; Partnership of the Manitoba Capital Region
Gloria Desorcy	Consumer Association of Canada
Dorothea Blandford	Winnipeg Rowing Club

Agenda:

1. Session opening & administrative items
2. Licence background and context from regulator
3. Committee perspectives on CSO planning:
    a. What perspectives are around the table, and why are they important
    b. Important considerations for planning (issues, opportunities, constraints)
    c. What would help increase public understanding and interest about CSO Master Plan

4. Decision making on control limits: process and criteria
5. Session wrap up and next steps

1. Session opening & administrative items

Introductions were given. Administrative items were noted. The previous meeting's notes were adopted.

It was noted that the Millennium Library would serve as the primary venue for future meetings and events.

Binders were circulated and, along with the Basecamp website, will serve as a repository for SAC information (e.g. agendas, notes, presentations, background information, and terms of reference).

Meeting #2 Purpose:

- To learn more about the context, perspectives, and experiences of SAC members;
- To begin gathering input on important considerations and criteria for the CSO Master Plan, including issues, opportunities and constraints;
- To gather preliminary input into defining a guiding vision for the CSO Master Plan; and,
- To set the criteria for defining control limits.

SAC members were asked what their personal objectives were for the meeting. Responses included:

- Understanding different perspectives;
- Understanding the process;
- To absorb and learn;
- To ensure that the proposed solutions are cost effective (value for money), efficient, sustainable, innovative (e.g. green infrastructure), and in the public interest;
- To make connections with different groups; and,
- To ensure that decisions are not made in silos, and that solutions are made in concert with related initiatives (e.g. other river or lake programs).

2. Licence background and context from regulator

Tracey Braun (Manitoba Conservation and Water Stewardship – Environmental Approvals) sent her regrets, and was not able to present on this agenda item. Tracey offered to respond to any question or concerns regarding the licence and asked that be forwarded to the Province. Questions included:

- How do some of the new, larger developments in the City of Winnipeg comply with clause #8 of the licence?
- How were the Province's targets and metrics developed? How did they arrive at their measures?

Additional discussion regarding the licence:

- Clause #12 outlines the effluent quality standards, which are non-negotiable.
- Clause #11 prescribes the development of the CSO Master Plan; it's up to the City to determine how they will meet the Province's targets. #11 also outlines the minimum requirements.

3. Committee perspectives on CSO planning

Discussion on the hydraulic model:

The City noted that the consulting team is developing a hydraulic model. The water quality model, takes into account every CSO outfall in the City. It was noted that while bio-retention systems are not typically modeled in detail for these types of studies, flow can be taken out of the model (e.g. through area reduction) to simulate the effects that such green infrastructure might have on flows. It was also noted that 2D run-off was not simulated in the model. This type of run-off overland flow modelling is not necessary for this study and is more likely to be used in very detailed flood modeling (rather than in CSO and river quality modeling) and is very costly.

- How does the modeling fit in with river and waterfront development plans (Go To the Waterfront, Vision 2030)?
- How is climate change being considered in the model?

Discussion on CSO and licence context:

It was noted that both the modeling and licence discussions might be too technical for some of the SAC members, particularly without the licence's context being presented.

- It was added that the licence needs to be presented and understood, including its background and intent, before the SAC can provide meaningful feedback.

It was noted that CSOs' impacts (and why they are problematic) need to be understood before any solutions can be debated. It was not clear to some SAC members whether CSOs were an aesthetic problem, a public health problem, a water quality problem, a problem for Lake Winnipeg, or some combination of those problems.

It was suggested that a video (or other form of graphic content) could be prepared to explain the CSO context. The City added that an animation explaining CSOs is currently being developed.

There was discussion about what the animation should include. It was reiterated that context, understanding, and the definition of the problem is needed first.

- A concise background brief (whether in video, presentation, or document format) would be helpful, as would an explanation as to what the group is trying to achieve.

There was some discussion as to whether CSOs have any discernible impact on Lake Winnipeg. It was noted that the nutrient load from all Winnipeg discharges (wastewater plants and CSOs) versus loading from the watershed as a whole was in the range of approximately 7% of Manitoba based sources or 3% of watershed sources. Rather, it is agricultural run-off from fertilizer (potassium and nitrogen) that is having a major impact on the lake, some argued. This is exacerbated by the fact that drainage works have sped up the flow to rivers, while wetlands (which naturally retain and filter water) have continued to be filled.

- Some asked whether this is being taken into account in the licence discussion, and whether the City is being unfairly targeted.
    - It was noted that all municipalities must comply with effluent quality standards (clause #12 in the licence), not just the City of Winnipeg.

It was reiterated that the intent or objective of the licence is unclear. It was asked whether the purpose of the Master Plan is to:

- Protect Lake Winnipeg from nutrient loading?
- Protect the rivers' ecosystems?
- Ensure that the rivers are aesthetically pleasing?
- Meet a public policy objective?

It was noted that until there is a clear answer, it will be difficult to develop any meaningful stakeholder advisory process and input towards deciding on solutions to mitigate CSOs and comply with the licence.

Some felt that this was not a two-way dialogue – rather, they felt as though the terms of the licence were mandated by the Province with minimal consultation, and without consideration of the potential financial impacts on the City. The broader view of where CSO fits in environmental management needs to be understood by the SAC. These meetings need to address this need.

Discussion regarding public education / symposium:

It was noted that prior to going to the wider public, it is necessary that the SAC and project team have a better understanding of the context, impacts, and intent of the licence. There must also be answers to outstanding questions, or the project might not be well received by the community (particularly if the costs are going to be significant). People must be shown that there is value for money in mitigating CSOs. The Province must also understand that at a certain point, the costs of mitigation begin to outweigh its benefits (incremental benefits/ diminishing returns) – therefore, there needs to be some balance. It was noted that trade-offs would have be discussed, and that a discussion regarding the potential tax burden would have to take place with the larger community.

The symposium date has been tentatively set for January 28, 2015. There was some discussion as to whether the group was ready for the symposium, and whether an additional SAC meeting needed to be held prior. Some were hesitation to have their names associated with the SAC, in that a symposium with few answers and little background context might reflect poorly on the group.

Discussion on innovative solutions:

Some noted that the City must demonstrate leadership, seeking innovative solutions to mitigating CSOs. Some innovations discussed included:

- Green infrastructure
- A system of trading credits. For example, the City pays a farmer upstream to reduce the runoff their farm drains into the river; the amount investing has greater return than that of a City solution, but sees the equivalent or greater amount of nutrient reduction, making the "trade" more cost effective. An example in Ottawa was alluded to.

4. Decision making on control limits: process and criteria

The City made a brief Power Point presentation to give an overview of the decision process for selecting an acceptable control limit for CSOs and where stakeholders fit into the process.

Reference: The Control Limits SAC Presentation November 19, 2014 will be circulated and posted on the project website.

5. Session wrap up

Future meeting dates/times/locations are as follows:
- Thursday, March 12, 2015, 3:45-6:00pm
- Thursday, April 9, 2015, 3:45-6:00pm
- Thursday, May 28, 2015, 3:45-6:00pm

All meetings to be held at the Millennium Library (Buchwald or Anhang Room, 2nd Floor) at 251 Donald Street.

The symposium is tentatively set for Wednesday, January 28, 2015 (tentatively 5 - 8 PM) in the Carol Shields Room Auditorium (Millennium Library, 251 Donald Street).

Attendees were thanked for their participation, and the meeting was adjourned.

6. Summary of Action Items and Administrative Follow-ups

Complete:

- Where possible, CITY PROJECT TEAM: provided additional information in response to questions and comments raised at the meeting.
    - *Responses and additional information provided below.*
    - How is runoff represented in the hydraulic model?
        - o Runoff is represented in the collections model based on the amount of permeable and impermeable area draining to the combined, land drainage and wastewater sewer networks being studied.
    - How does the modeling fit in with river and waterfront development plans (Go to the Waterfront, Vision 2030)?
        - o For the first phase of the project we would look to identify a “Value” to include in our vision for the project such as master plan coordination. Following the first phase when we have selected a control limit we will be looking at the ways we can achieve and deliver it in the second phase. This is where we would look at coordination with other projects, which can provide significant cost savings, reduce disruption and achieve better results through development efficiencies.
    - How is climate change being considered in the model?
        - o We are looking at our historic rainfall record and using statistical analysis. We are also looking at risk analysis. Looking at climate change is all about risk. E.g.: There is a risk of larger more intense

rainfall events - in terms of the existing combined system this would result in future larger CSO events but there may be less small events. E.g.: There is a risk of an extended dry period - in terms of the existing combined system this would result in less future CSO events.

- Some noted that the nutrient load from all Winnipeg discharges (wastewater plants and CSOs) versus loading from the watershed as a whole was in the range of approximately 7% of Manitoba based sources or 3% of watershed sources.
  - This comment is referring to a November 2002 nutrient loading report undertaken by the Province (A Preliminary Estimate of TN and TP Loading to Streams in Manitoba). This report and another relevant earlier nutrient trend report can be found here. http://www.gov.mb.ca/conservation/waterstewardship/water_quality/index.html
  - The 2002 report is based on long term (1994 -2001) river monitoring data and estimates total nutrient contributions from the City of Winnipeg to Lake Winnipeg These estimates are TN (total nitrogen) is 5.7% and of TP (total phosphorus) 6.7%. As these percentages cover the three sewerage treatment plants, land drainage and CSO discharges, the report estimates CSO only make up 79 tons a year or 0.1% of TN and 16 tons a year or 0.3% of TP.
  - Lake Winnipeg is estimated to receive 63,207 tons a year of TN and 5,838 tons a year of TP.

In progress:

- J. TURENNE-MAYNARD/H. VENEMA: Opportunity to follow up by email or phone to provide additional information on hydraulic modelling.

- FACILITATOR/CITY PROJECT TEAM: Provide feedback, questions, and clarifications on licence to Province for response.

- PROVINCE: Prepare a background brief of the licence context (video, presentation, or document format) and explanation as to what the group is trying to achieve as it relates to the licence.

- CITY PROJECT TEAM/FACILITATOR: Confirm and provide further details for symposium, 2015 meetings to SAC.

- FACILITATOR: Circulate meeting #2 notes to Committee members and alternates for feedback and comment prior to posting on project webpage.

- FACILITATOR: Post meeting #2 notes and PowerPoint presentation and reference materials on shared site for Committee members.

- CITY PROJECT TEAM: Produce hard copies of final meeting #2 notes and presentation for Committee members at next meeting.

- CITY PROJECT TEAM: Share meeting notes and presentation publicly on City of Winnipeg project website following Committee feedback.

Appendix E: Meeting 3 Notes & Presentation (January 28, 2015)

Regulatory Considerations: Combined Sewer Overflows (CSOs)

Siobhan Burland Ross, M.Eng., P.Eng.
Manager, Municipal and Industrial
Environmental Approvals Branch
Manitoba Conservation and Water Stewardship

January 28, 2015

Manitoba

Manitoba

Combined Sewer Overflows (CSOs)

- Both storm water and wastewater, including domestic and industrial wastewater
- Storm water is dilute
- High and variable flows

Manitoba

Clean Environment Commission (CEC)

- CEC Report on Public Hearings (2003):
  - City’s original plan: 2053
  - CEC’s recommendation: 2023 – 2028 with significant action taken by 2006
- Current Licence: 2030

Clean Environment Commission (CEC)

- CEC recommended:
  - managing CSOs on an annual basis and not just during the recreational season
  - targeting CSO districts on a priority basis
  - implementing public notification for release of raw sewage

Manitoba

Canada-Wide Strategy

- **CSOs/SSOs included in Strategy – Manitoba signed in 2009:**
- CSO/SSO do not increase in frequency due to development
- Within 7 years (2016) meet the national overflow standards for CSO/SSO
- Within 7 years (2016) have long term plans in place to reduce CSOs and capture substances

Canada-Wide Strategy

National Standards in Strategy:

- No increase in CSO frequency due to development or redevelopment
- No CSO discharge during dry weather
- Removal of floatable materials

Wastewater Systems Effluent Regulation

Federal WSER requires that facilities identify the location of all CSOs and report on the quantity of wastewater discharged via CSO

MWQSOG

Manitoba Water Quality Standards, Objectives and Guidelines

- Regulation in 2011
- Phosphorus limit of 1 mg/L applies to existing facilities >820 kg TP (~2000 persons)
- Cumulative load includes multiple treatment facilities and combined sewer overflows

Manitoba

Environment Act Licence

- Conservation and Water Stewardship issued Environment Act Licence No. 3042 to address CSOs that contains a requirement for the City to develop a plan for approval by 2017 to be implemented by 2030.

Manitoba

Environment Act Licence

- No increase in CSOs due to development
- Use of green technology
- Public notification/education plans
- Require a plan to meet requirements by 2030
- Minimum requirements for treatment
- Reporting requirements

Manitoba

Environment Act Licence

- Intent of the requirements is to provide the equivalent of primary treatment to the majority of the wastewater collected in the CSO system (85%)
- Requires that the City propose in the plan submitted per Clause 11 how the requirements of Clause 12 will be met.

Environment Act Licence

- Clause 12 Requirements:
  - Removal of floatable materials
  - Effluent quality (at least 85%):
    - BOD5 < 50 mg/L
    - TSS < 50 mg/L
    - Total phosphorus < 1 mg/L
    - E.coli < 1000/100 mL

Licence Timelines

- **December 31, 2013**
  - Public Education Plan (9)
  - CSO event notification plan (14)
- **January 31, 2014**
  - Interim monitoring plan (15)
- **May 1, 2014**
  - Interim monitoring begins (15)
- **December 31, 2015**
  - Public Notification System (10)
  - Preliminary Proposal for the CSO system (11)
- **December 31, 2017**
  - CSO Master Plan (11)
- **March 31 of each year**
  - Annual progress report (13)
- **December 31, 2030**
  - Implementation of approved CSO Master Plan (11)

Combined Sewer Overflow Master Plan
Stakeholder Advisory Committee (SAC)
Meeting #3 Notes

Wednesday, January 28, 2014, 4:00 PM – 6:30 PM
Carol Shields Auditorium, Millennium Library, 251 Donald Street

In Attendance:

Ani Terton	Manitoba Eco-Network
Dale Karasiuk	Chalmers Neighbourhood Renewal Corporation
Carmine Militano	Winnipeg Chamber of Commerce
Colleen Mayer	Old St Vital Biz
Colleen Sklar	Lake Friendly Manitoba; Partnership of the Manitoba Capital Region
Joy Kennedy	Manitoba Conservation and Water Stewardship (Water Quality)
Siobhan Burland Ross	Manitoba Conservation and Water Stewardship (Environmental Approvals)
Yvonne Hawryliuk	Manitoba Conservation and Water Stewardship (Environmental Compliance and Enforcement)
Andrew McMillan	City of Winnipeg – Water and Waste
Patrick Coote	City of Winnipeg – Water and Waste
Tiffany Skomro	City of Winnipeg – Water and Waste
Michelle Kuly Holland	Facilitator
Dennis Heinrichs	Consultant – Dillon
David Marsh	Consultant – Dillon

Regrets:

Chris Lorenc	Manitoba Heavy Construction Association
Henry David (Hank) Venema	International Institute of Sustainable Development
Gloria Desorcy	Consumer Association of Canada
Julie Turenne-Maynard	Rivers West
Dorothea Blandford	Winnipeg Rowing Club

Agenda:

1. Session opening & administrative items
2. Licence background and context from regulator
3. City of Winnipeg update and presentation of animation video
4. CSO Symposium details review and feedback
5. Session wrap up and next steps

1. Session opening & administrative items

Introductions were given. Administrative items were noted. The previous meeting's notes were adopted via email.

Meeting #3 Purpose:

- To clarify the intent and details of CSO licence;
- To have an update on the CSO Master Plan;
- To review and discuss an outline of the Symposium event.

SAC members were asked what their personal objectives were for the meeting. Answers included:

- Looking forward to hearing from the Province in regards to the licence and getting additional detail
- Understanding the format of the Symposium, and obtaining additional detail

The Facilitator proposed to amend agenda to flip Agenda Items #2 & #3 in terms of order, which was accepted by the SAC members.

2. City of Winnipeg update and presentation of animation video

The City provided an introduction on the animation video, providing background for why it was created. The intent of the animation is provide the general public with a high level overview of CSOs, history of combined sewer systems, what a CSO event is, and how a CSO event occurs. The animation explains in additional detail the physical components of the CSO system and its operation in dry weather in light rain or snow melt and in heavy rain or snow melt.

The animation was presented to the SAC members, who had the following comments and observations:

- Is the animation available to the public and can it be shared? The City indicated that it will be available in the immediate future, as there are some minor technical issues being resolved. The intent is for the animation to be shared, and the City encourages this, with proper attribution.
- Animation indicates that 32% of the City by area is located in CS districts. Has this gone down, and wasn't this originally higher? The City explained that some districts have been 'decombined' (separated), and that the overall percentage has lowered as City infrastructure improvements.
- Nutrient loading is indirectly indicated in the animation, including its impacts downstream on Lake Winnipeg. Will there be any explanation about nutrient loading, and what other cities, towns, and industry are doing?

- Animation is good at indicating that CSOs are one of multiple sources that impact river water.

The City indicated that the animation would be shown at the Symposium event, and the SAC members would be informed via email when the animation is publically available.

3. Licence background and context from regulator

Siobhan Burland Ross (MB Conservation & Water Stewardship) delivered a presentation regarding CSOs, regulations, and background behind the City's Environmental Licence. A copy of the presentation was distributed to the SAC members in advance of the meeting, and is on the website.

During the presentation the Province indicated that two other jurisdictions in Manitoba have combined sewer systems, but not at the scale of the Winnipeg system. It was also indicated that the Licence is in essence a 'licence to plan', and that a new licence will be issued after the CSO Master Plan has been submitted and reviewed. Conditions and terms of the existing licence will be revisited and altered then. The Province also indicated the need for flexibility in the final plan to adapt and grow as knowledge of the combined sewer system expands and experience of the success of solutions is incorporated back into the plan.

Discussion on MB Conservation presentation and CSO Licence:

The following observations and points were made during follow up discussion with the SAC members:

- When the Province was negotiating on national standards, how was new development in CS districts addressed? There have been developments in CS districts in Winnipeg, and how were these addressed? The Province indicated that the municipal wastewater strategy was signed in 2009, and new developments are not permitted to increase CSO events. The City also indicated that their regulations require new development to be restricted to pre equals post flows, and cannot increase the overall rate of flows.

- Is the timeline shown still valid? It was indicated that the timeline is still valid.

- What is the role of the federal government in these regulations? The federal regulation requires the identification of CSO locations and monitoring of CSO events with regular reporting.

- A question was raised regarding the previous CEC report on CSOs, which identified priorities, including specifically targeting Combined Sewer (CS) districts. Is this being addressed in the current CSO Master Plan? The City indicated yes, and that all 42 CS districts are being looked at and examined as part of the Master Plan. Monitoring and reporting has occurred since the previous CEC report, and the current CSO Master Plan will identify which CS districts should be prioritized, and with what mitigation and / or control measures.

- There are a lot of Licenses being issued to the City by the Province but are they all of equal importance? Is there anyone looking at the bigger picture of how all these are going to be prioritized?

4. CSO Symposium details review and feedback

An overview of the outline for the CSO Symposium Event was provided. The CSO Symposium is tentatively scheduled for March 5th, 2015 in the Carol Shields Auditorium.

The Symposium format proposes that the event would begin with presentations and a panel discussion, followed by a breakout session with attendees.

The City is exploring the potential for partnership with a member of the media to moderate the panel discussion and assist in promoting the Symposium prior to the event. There will also be an on-line presence for the event, placing materials online, aimed for those who are interested but cannot attend or those looking for additional information. The City is looking at potentially integrating real time voting technology for the event.

The breakout session will have discussion questions to get a greater understanding around CSO issues and how they should be approached.

The SAC members had the following comments and observations:

- Can inputs from industry be included in the overview, e.g. what is actually being discharged into the rivers? There is an education component here and there is a need to explain why this issue is important to average citizens.

- Can someone on the discussion panel address what local businesses and industries are doing to help address this issue? There is a need to emphasize that all parties are part of the solution, and government cannot do it alone. The City indicated that there are regulations for business and industrial to meet discharge standards and monitoring to assess quality. Regarding what industry was doing the City would request that this be addressed in one of the panel member presentations.

- CSOs are a complex problem, and that these types of problems require a three-headed solution working together: government, businesses, and Non-

Government organisations (NGOs). This approach is occurring in many other complex areas, and there is a need to have a conversation about this.

- Are the impacts of climate change are being considered as part of the CSO Master Plan? The City indicated that climate change was being considered. Rain events and severe weather will be more extreme, and localized, in the future. Proposed infrastructure and CSO controls must take this into account.

- There is a clear need to clearly identify the 'why am I here' and 'why is this important' in the Symposium event. This is important for the messaging of the event, and in materials in advance of the meeting.

- What does the City want and / or need from SAC members for the Symposium event? The facilitator indicated that SAC members are encouraged to attend and participate; report back to others what you heard in the discussions at the event; and that the City would request that SAC members help reach out to people and groups who should attend the event. Follow up questions were asked regarding what materials or information would assist SAC members in getting the word out, and what lead times might be required. The following ideas were provided by the SAC members:

    - Social media, email, twitter – electronic formats that are easy to distribute;
    - One-pager overview – what is this event about, timelines, why we need you to come, why is it important to you, a couple links to resources, include link to CSO animation & webpage;
    - There is still a need for hard copy materials to complement electronic formats;
    - A "Save the Date" email notice, then follow up notice with materials.

- A question was raised in regards to whether students are being engaged in the process or this event, as they are future tax payers, and whether post-secondary education institutions are being included. There was discussion about including representatives from Sustainability Offices of the post-secondary institutions, as they are often aware of the research and initiatives that are occurring on campus.

- A question was whether other environmental groups in the City would be invited, such as Save Our Seine. The City indicated that they would reach out to these groups and invite them to the Symposium.

5. Session wrap up

Future meeting dates/times/locations are as follows:

- Thursday, April 9, 2015, 3:45-6:00pm

- Thursday, May 28, 2015, 3:45-6:00pm

All meetings to be held at the Millennium Library (Carol Shields Auditorium, Buchwald or Anhang Room, 2nd Floor) at 251 Donald Street.

Attendees were thanked for their participation, and the meeting was adjourned.

6. Summary of Action Items and Administrative Follow-ups

In progress:

- All SAC MEMBERS – Provide information on any groups that should be invited to the CSO Symposium.
- CITY – Inform SAC members when CSO animation is publically available on the City's website.

Appendix F: Meeting 4 Notes & Presentation (April 9, 2015)

City of Winnipeg's

Combined Sewer Overflow

Master Plan

SAC Mtg. #4

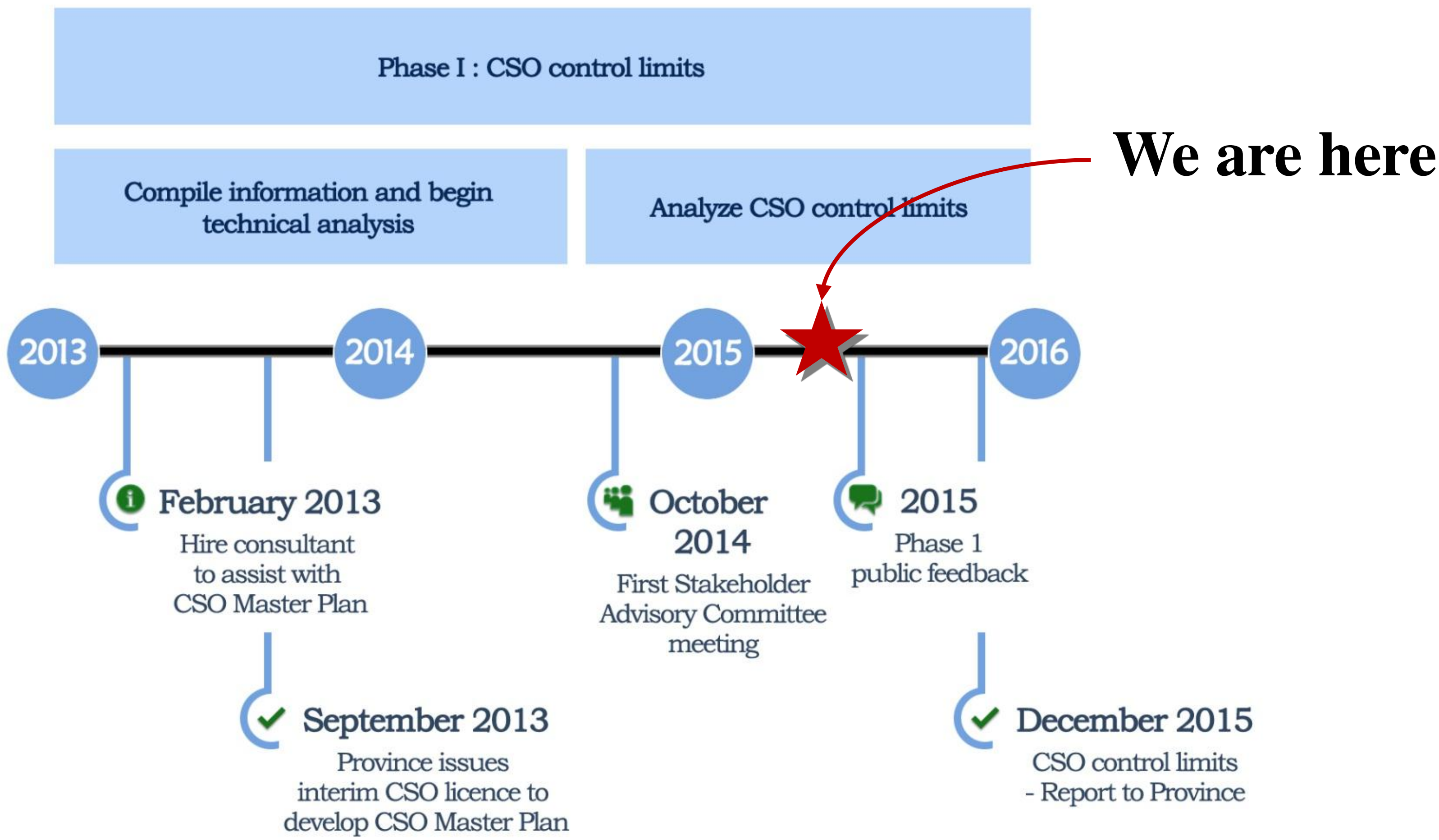
Progress Update

CSO
city winnipeg
cities
reduce
objective
get new
testing
work
bigger
spend
plan
need
river
consider
events
province
planning
nutrient
green
cost
public
drainage factor
solution
low
impact
look
info
think
reduction
stormwater
impacts
issue
change
solutions
spending
flooding
better
basement
water
role
right
rec
options
pipe
go
runoff
money
store
approach
flow
land phosphorus development
make
economic
monitoring
projects
treatment
plant
current
beyond
benefit
investment
existing
people
quality
awareness
option
know
needs
educate
infrastructure

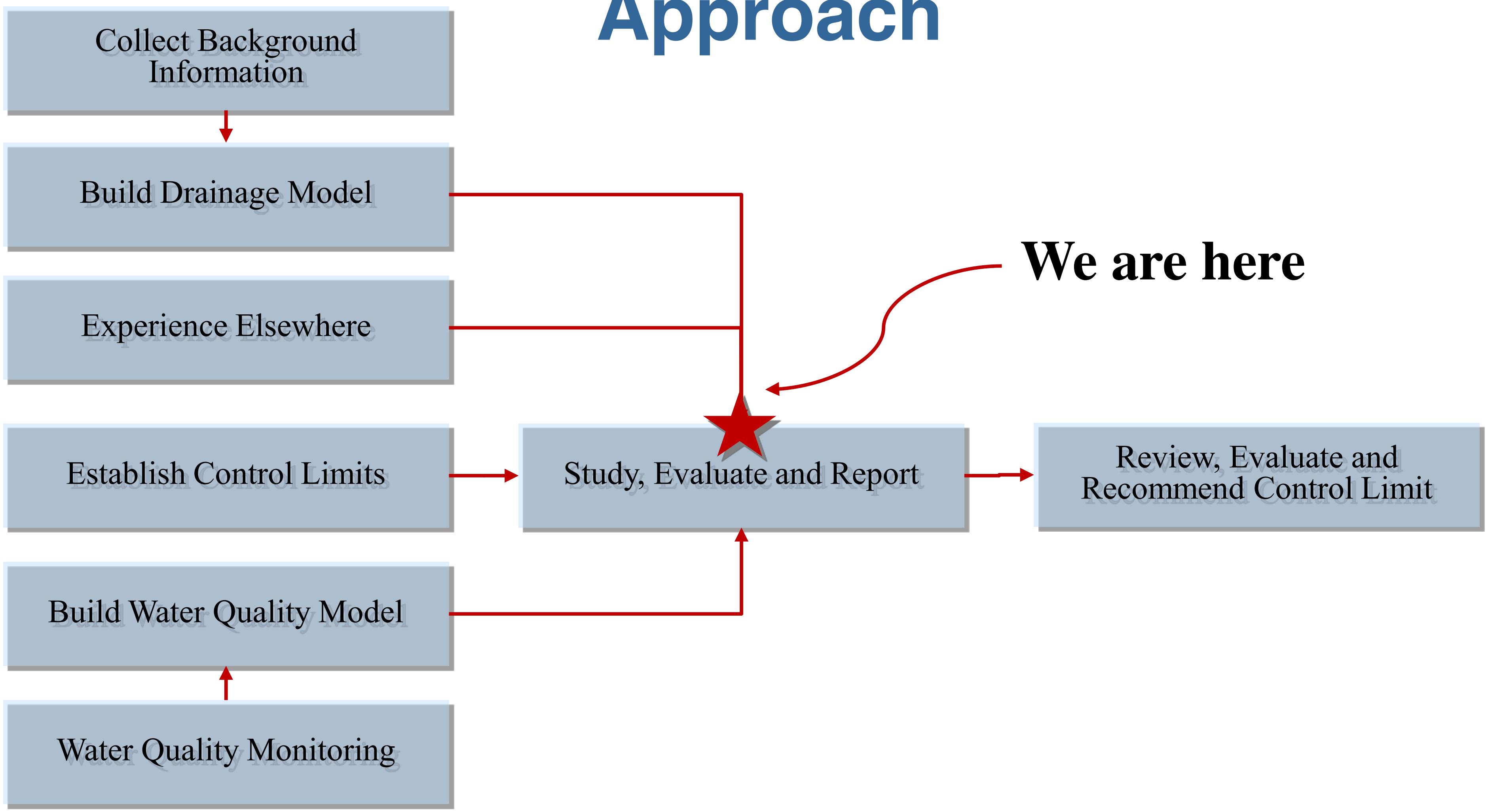
Purpose

- Update on Master Plan progress
- Review the decision making process, values and evaluation criteria

CSO Master Plan Timeline



Approach


Collect Background Information
Build Drainage Model
Experience Elsewhere
Establish Control Limits
Build Water Quality Model
Water Quality Monitoring
Study, Evaluate and Report
Review, Evaluate and Recommend Control Limit
We are here

Winnipeg

Background and Modelling Progress

- Build Drainage Model
  - city-wide wastewater model (InfoWorks)
  - used to design and evaluate control options
  - develop potential plans from control options
- Water Quality Model
  - continuing to monitor water quality
  - evaluating river water quality using WASP7
- Control Limits
  - on-going discussions with the province on clarifications

Winnipeg

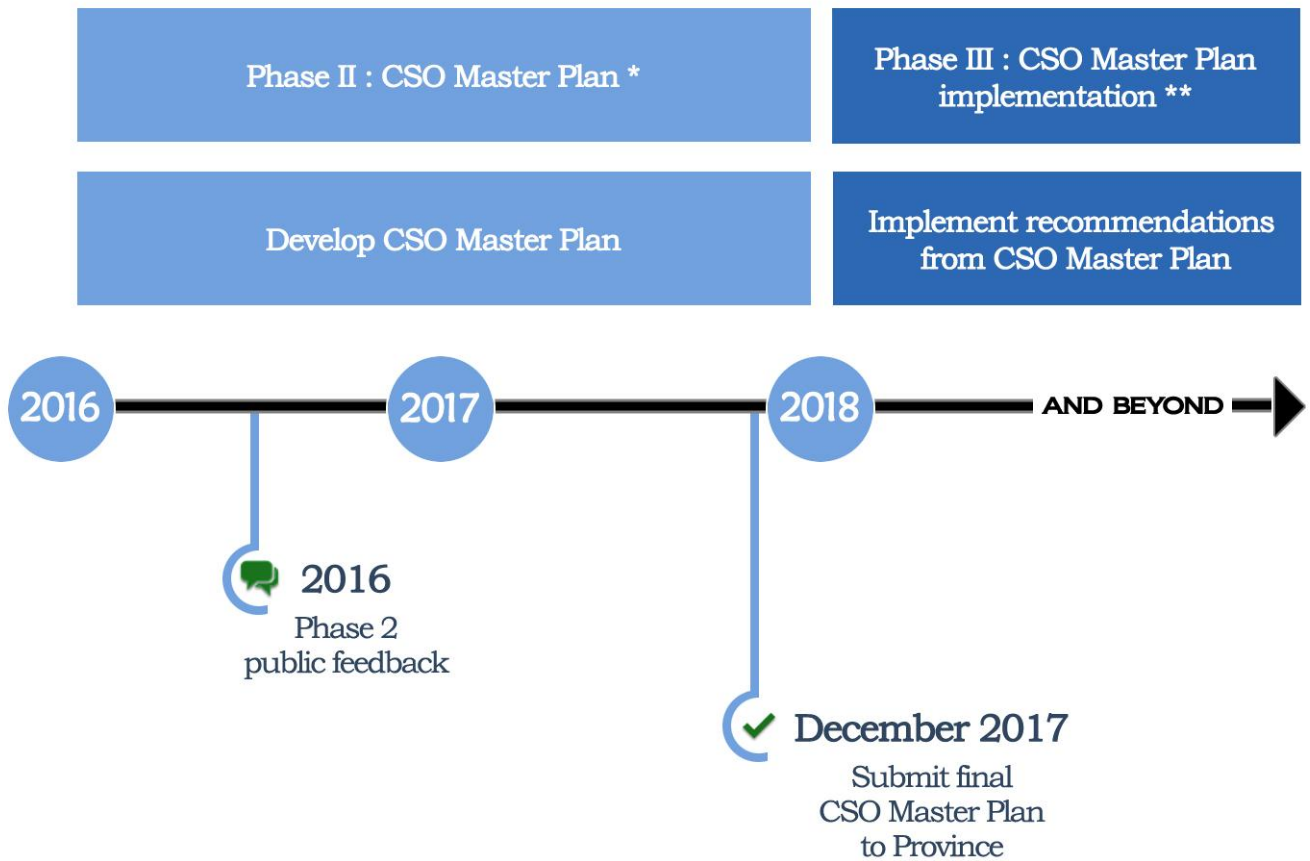
Evaluating and Reporting Progress

- Preliminary Proposal Report – In progress
  - technical document including background, potential plan development, cost estimates, performance evaluations
- Preliminary Proposal Decision Report – Pending
  - reader-friendly – potential plans, benefits and costs
  - to include public input – *"what is important"*
  - provide the basis for comparing, evaluating and recommending potential plans (one for each control limit)

Evaluating and Reporting Progress (cont'd)

- Preliminary Proposal Submission
  - report with analysis and recommendation
  - required under CSO Licence 3042, clause 11 – by end of Dec. 2015

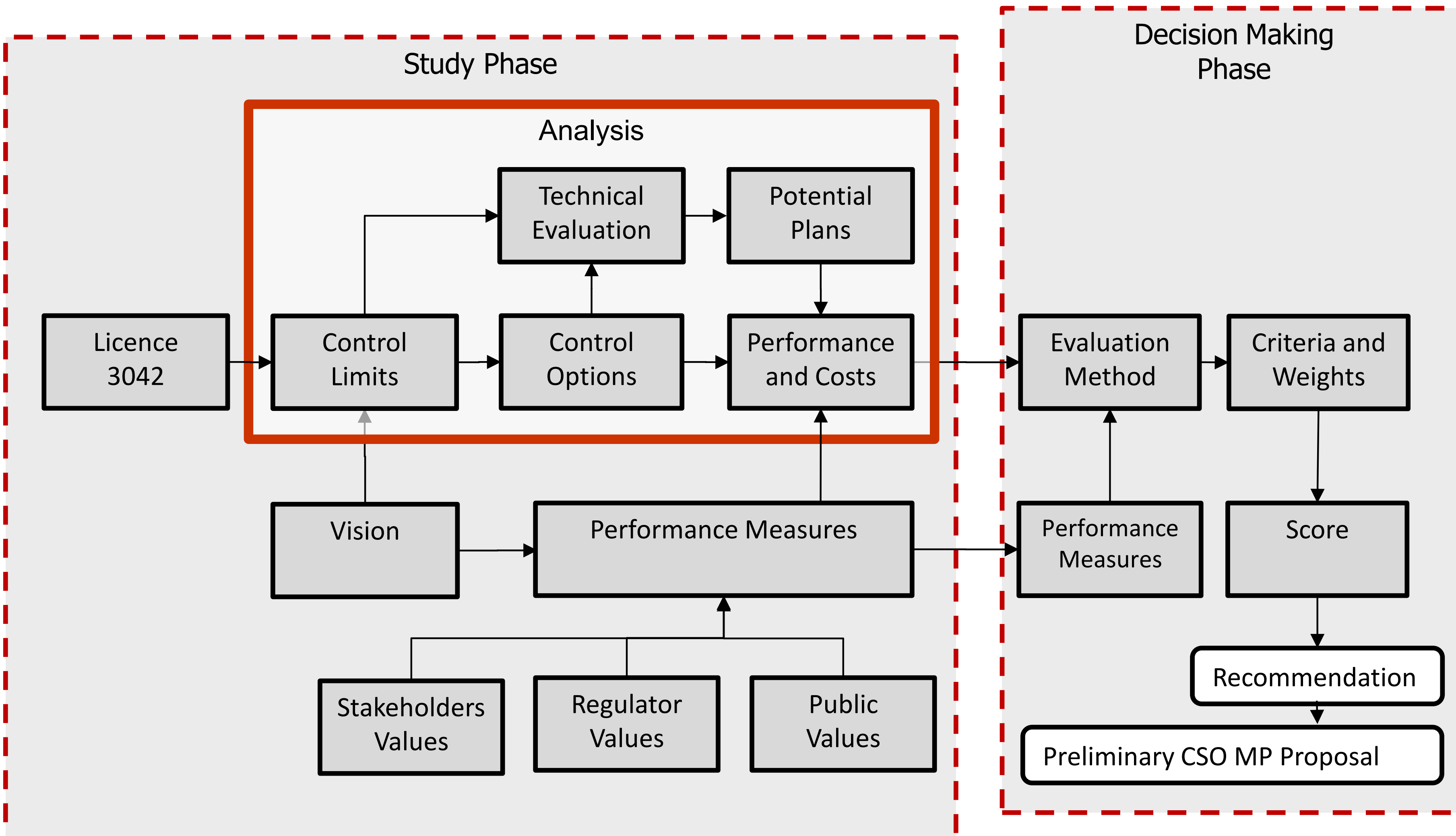
CSO Master Plan Timeline



* Timeline is dependent upon provincial response to the CSO control limits report

** Subject to provincial approval of the Master Plan

Decision Making Roadmap



Decision Making Process

- Analysis of control options
- Experience elsewhere – lessons learned
- Establish performance measures
- Input from regulator, stakeholders and public
- Scoring exercise based on weighted criteria
- Recommendation submitted to Province by Dec. 2015

Winnipeg

Control Limits

- Part of the CSO licence
- Evaluate modifications to combined sewer system to reduce CSOs to:
  - zero overflows per year
  - four overflows per year
  - a minimum of 85% volume capture of wet weather flow with a maximum of four overflows

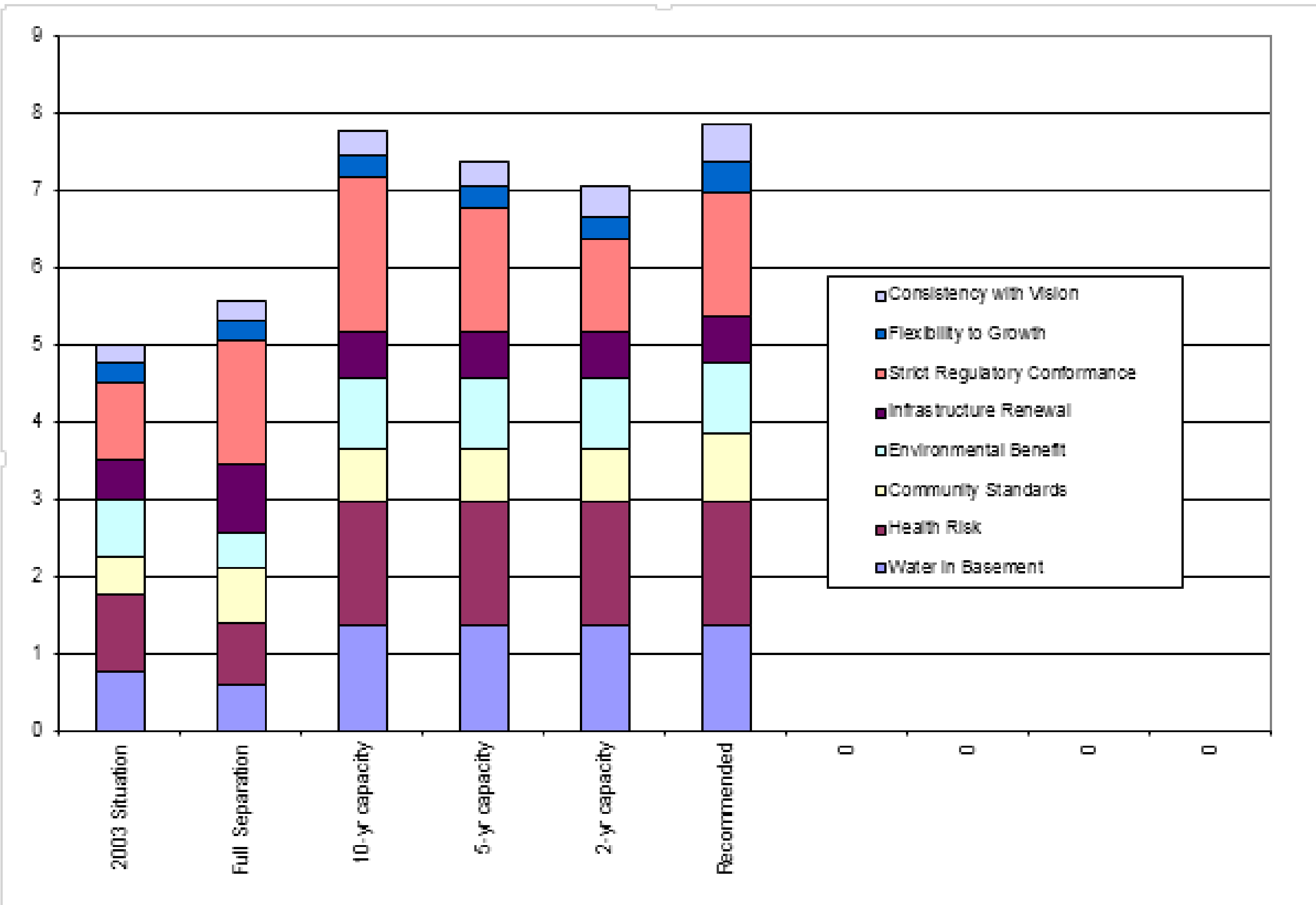
Control Limits Cont'd

- Assessing other approaches:
  - watershed approach
  - environmental equivalent of separation
  - water quality performance
  - maximum use of existing infrastructure
  - "Knee-of-the-Curve" or best use of resources

Develop a Common Vision for the CSO Master Plan

- Environmentally responsible
- Affordable
- Sustainable
- Regulatory compliant
- Politically acceptable
- Preventing basement flooding
- Community values

Scoring Matrix – Example



Developing Performance Measures for Winnipeg CSO Control

- System performance measures:
  - number of overflow events
  - volume of overflows
- Environmental performance measures:
  - public health (Pathogens)
  - nutrients
  - aesthetics (floatables)

Developing Performance Measures for Winnipeg CSO Control Cont'd

- Affordability
  - water and sewer utility rates
  - whole life cost
- Regulatory compliance
- Community values
  - construction industry
  - traffic disruption
  - sustainability
  - competing priorities for funding in Winnipeg
  - river use

Questions?

Combined Sewer Overflow Master Plan
Stakeholder Advisory Committee (SAC)
Meeting #4 Notes

Thursday, April 9th, 2014, 4:00 PM – 5:40 PM
Buchwald Conference Room, Millennium Library, 251 Donald Street

In Attendance:

Karla Zubrycki	International Institute of Sustainable Development
Megan Krohn	Manitoba Eco-Network
Dale Karasiuk	Chalmers Neighbourhood Renewal Corporation
Carmine Militano	Winnipeg Chamber of Commerce
Siobhan Burland Ross	Manitoba Conservation and Water Stewardship (Environmental Approvals)
Christine Hutlet	Lake Friendly Stewards Alliance
Andrew McMillan	City of Winnipeg – Water and Waste
Patrick Coote	City of Winnipeg – Water and Waste
Tiffany Skomro	City of Winnipeg – Water and Waste
Michelle Kuly Holland	Facilitator
David Marsh	Consultant – Dillon

Regrets:

Joy Kennedy	Manitoba Conservation and Water Stewardship (Water Quality)
Henry David (Hank) Venema	International Institute of Sustainable Development
Chris Lorenc	Manitoba Heavy Construction Association
Colleen Mayer	Old St. Vital BIZ
Yvonne Hawryliuk	Manitoba Conservation and Water Stewardship (Environmental Operations Compliance and Enforcement)
Colleen Sklar	Lake Friendly Manitoba; Partnership of the Manitoba Capital Region
Dennis Heinrichs	Consultant – Dillon

Agenda:

1. Session opening & administrative items
2. CSO Symposium update and review
3. City of Winnipeg CSO Master Plan update
4. Input on vision & community values for CSO Master Plan
5. Session wrap up and next steps

1. Session opening & administrative items

Introductions were given. Administrative items were noted. The previous meeting's notes were adopted.

Meeting #4 Purpose:

- To review and recap the CSO Symposium Event
- To provide an update on the overall Winnipeg CSO Master Plan project
- To provide input on Vision & Community Values for CSO Master Plan

2. CSO Symposium Debrief and Discussion

Tiffany Skomro provided an update and overview of the CSO Symposium event. A Word Cloud graphic was presented to summarize key words heard during the facilitated table conversations.

SAC members had the following comments and observations about the CSO Symposium event:

- Liked having facilitators at each table to facilitate discussions;
- Presentations & speakers were very good: interactive, use of technology, dialogue at the tables show the diversity of views and opinions;
- Good energy in the room, people were engaged in the event; size and number of people were good; how do we move from 'spend' to 'investment'?
- Having speakers first may have introduced some 'bias' into the conversations e.g. Winnipeg's CSOs 1% contribution to Lake Winnipeg phosphorus. How do we avoid or address bias from having dialogue after speakers? Understood that speakers needed to provide some context for discussion.

June Public Events

Tiffany Skomro provided an overview and update for the public engagement events. Sessions will be held in the afternoon and evening, and dates will be sent out to the SAC members when confirmed. The content/format of the June public events are being refined, but will include:

- Information for the public on different options;
- Focus will be on the control options, and input from the public on the values and criteria that should be used to evaluate the various control options;
- Will involve a combination of engagement approaches, including polling technology, open house boards, and presentation.

3. Update on CSO Master Plan Process

Patrick Coote presented an update on the overall CSO Master Plan project, including:

- Current project status;
- Overall timelines;
- Approach;
- Background and modeling progress;
- Regulatory liaison meetings with the Province;
- Evaluating and Reporting Progress;
- Decision Making Roadmap;
- Control Limits;
- Developing a Common Vision for the CSO Master Plan; and
- Developing Performance Measures for CSO.

The SAC members received this update as information.

4. Input on Vision & Community Values for CSO Master Plan

Michelle Kuly Holland provided introduction on vision and community values in regards to the CSO Master Plan, and provided a handout summarizing community values identified in input gathered to-date from SAC meetings and the public symposium. Michelle introduced a discussion exercise for the SAC members to review and dialogue on these values, in order to provide additional detail and thoughts for inclusion in the June public event materials.

The SAC members then broke into two sub-groups to work through themes, and reconvened to back brief the wider group and discuss.

The following points were raised by SAC members during their discussion:

- Lake Winnipeg – impact on nutrients, lake health and use
- Value for Money – maximize benefits, basement flooding (integration), low hanging fruit (best value for money)
- CSOs in broader context – recognize other contributors and factors related to water quality, coordinate with related initiatives
- Vision - need to keep in mind future generations, social acceptability (image)
- Innovation & Transformation – keeping in mind the cost of doing business in Winnipeg, cost of retaining good talent, costs & innovation, incentives (where do they fit in), disincentives, coordination with other projects
- Construction Industry – capacity of industry, potential to create artificial economy and reduce buying power
- Livability – Construction fatigue (residents getting fed up with the extent and duration of construction related disruption)

- River Use – Coordinate with other plans & projects, perception of what will actually be achieved in river quality
- Social acceptability – New category suggested. Image, doing our part, education awareness

The feedback was taken by the City to use in finalizing the criteria to go to the public in June.

5. Session wrap up

Next steps:

- Once vision & values are defined, what are the relative importance of these in terms of to each other, and to each control option;
- Update on submission to Province;
- SAC members invited to attend and participate in the June public events.

Next SAC meeting:

- There was a discussion amongst those in attendance about the need to have a SAC meeting in May, versus capturing feedback on-line. SAC members generally concurred, but wanted the decision to be made by the wider group.
- There will be no SAC meeting in the fall. An update will be provided via email in regards to the submission to Province.

Attendees were thanked for their participation, and the meeting was adjourned.

6. Summary of Action Items and Administrative Follow-ups

In progress:

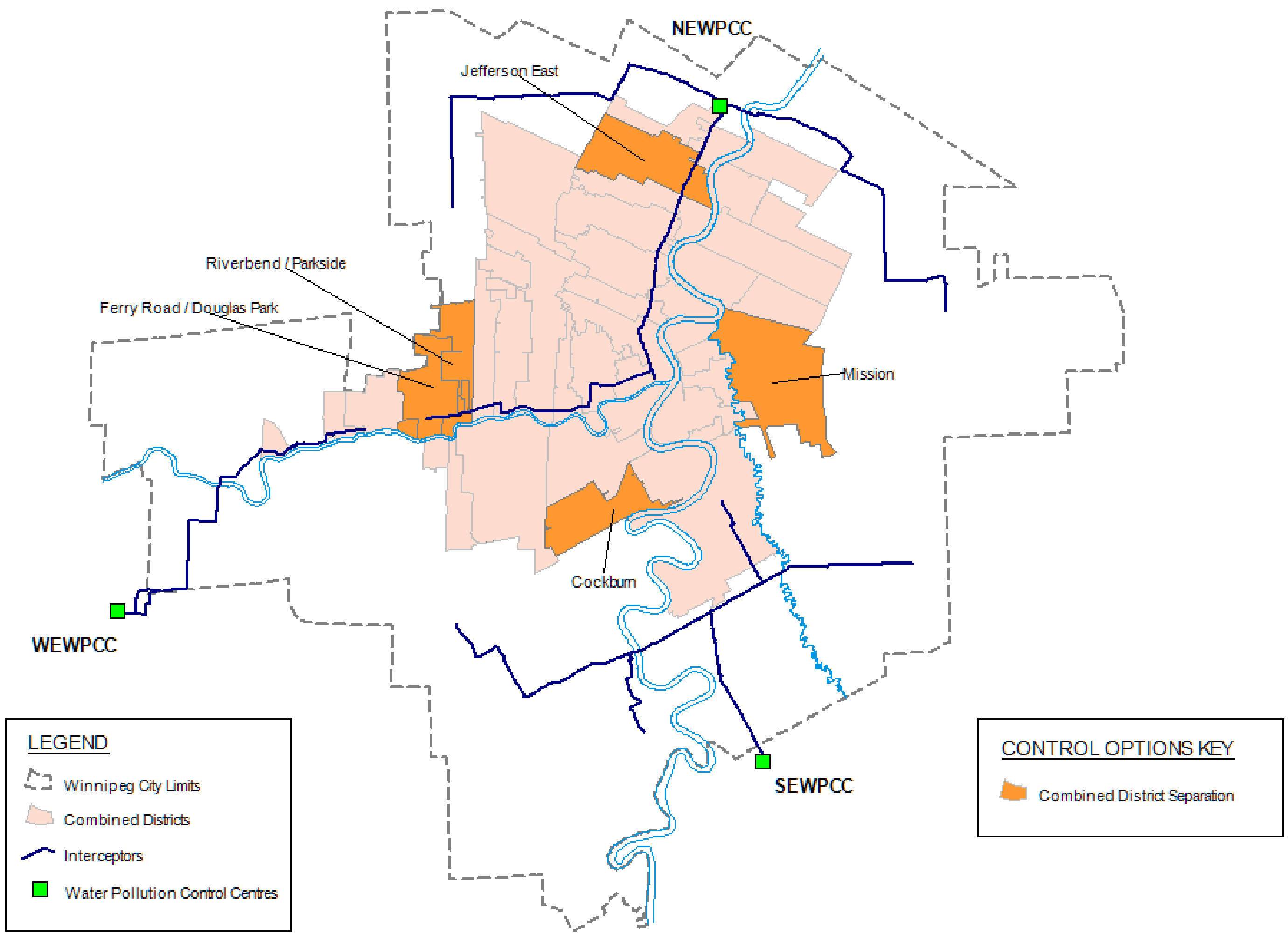
- CITY PROJECT TEAM/FACILITATOR: Confirm and provide further details for the June Public Events to SAC. SAC members are encouraged to attend and participate.
- FACILITATOR: Confirm cancellation of May SAC meeting to SAC members.
- CITY PROJECT TEAM: Share meeting notes and PowerPoint presentation publicly on City of Winnipeg project website following Committee feedback.
- CITY PROJECT TEAM: To provide email update on status of provincial submittal in the fall.

APPENDIX F
PLAN ALTERNATIVE OVERVIEW MAPS

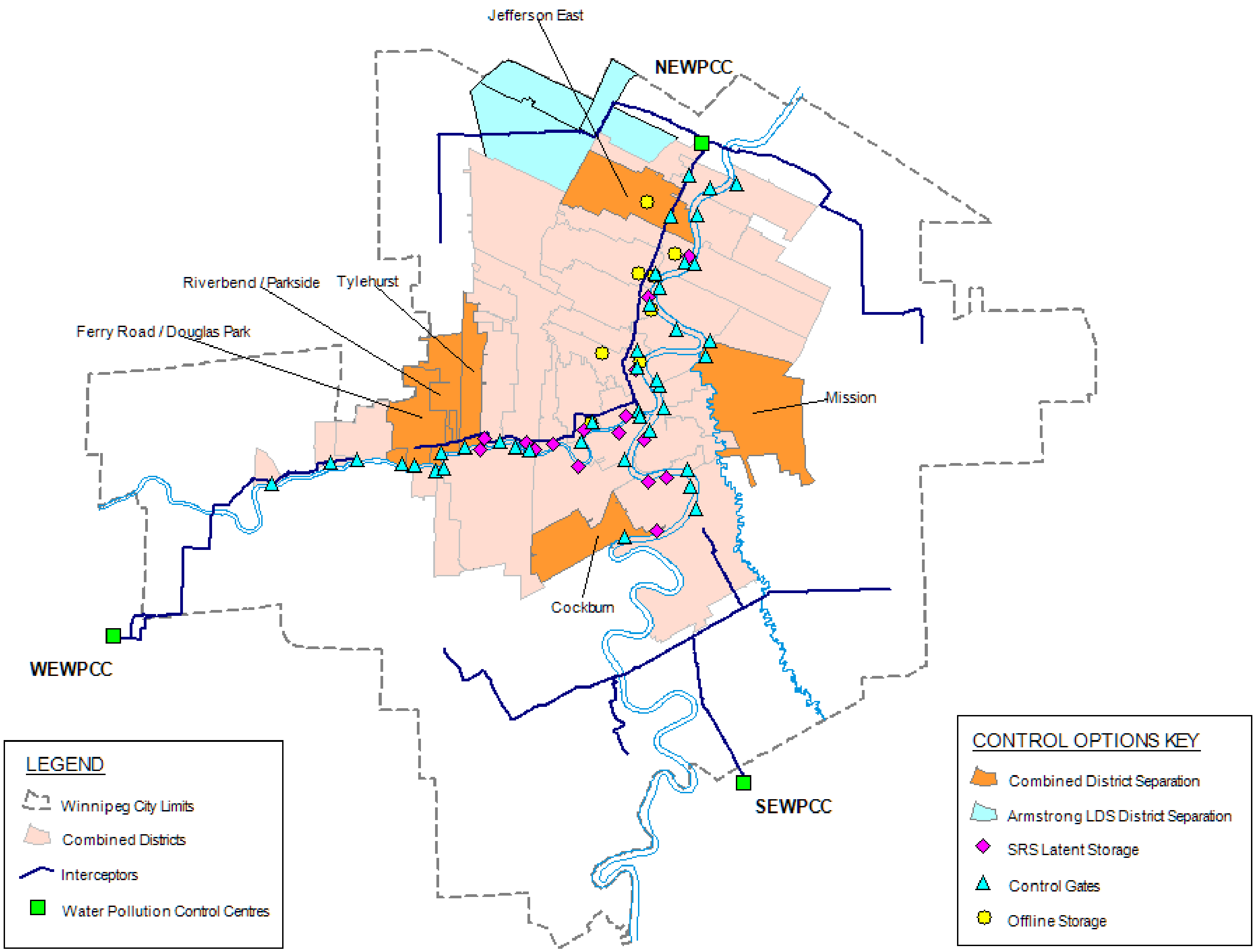
Plan Summary Table

Control Limit	Latent Storage	Raised / Bendable Weir	In-line Gate	Full in-line	Off-line	Tunnel Storage	Storage / Transport Tunnel	Separation	Green Infrastructure	Floatable Control	NEWPCC 705 ML/d	NEWPCC 825 ML/d	Satellite Treatment
Current Approach								✓			✓		
85% Capture in a representative year	✓		✓		✓	✓		✓	✓	✓	✓		
Four-overflows in a representative year	✓		✓		✓	✓		✓	✓	✓	✓		
Zero Overflows in a representative year	✓		✓		✓	✓		✓	✓	✓		✓	
No More Than Four Overflows per year	✓		✓		✓		✓	✓	✓	✓	✓		✓
Complete Sewer Separation		✓						✓	✓		✓		

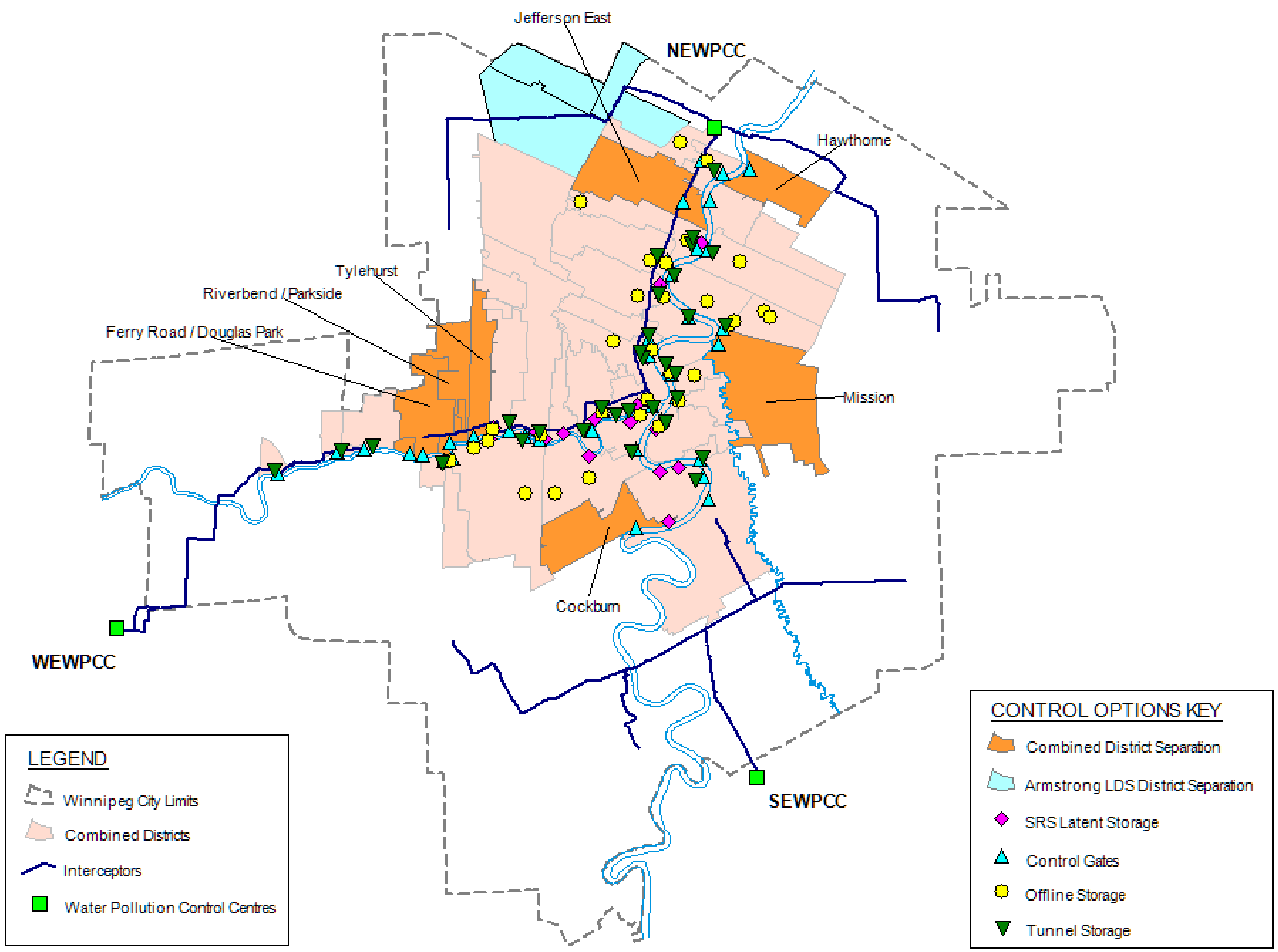
Current Program (Basement Flood Relief)



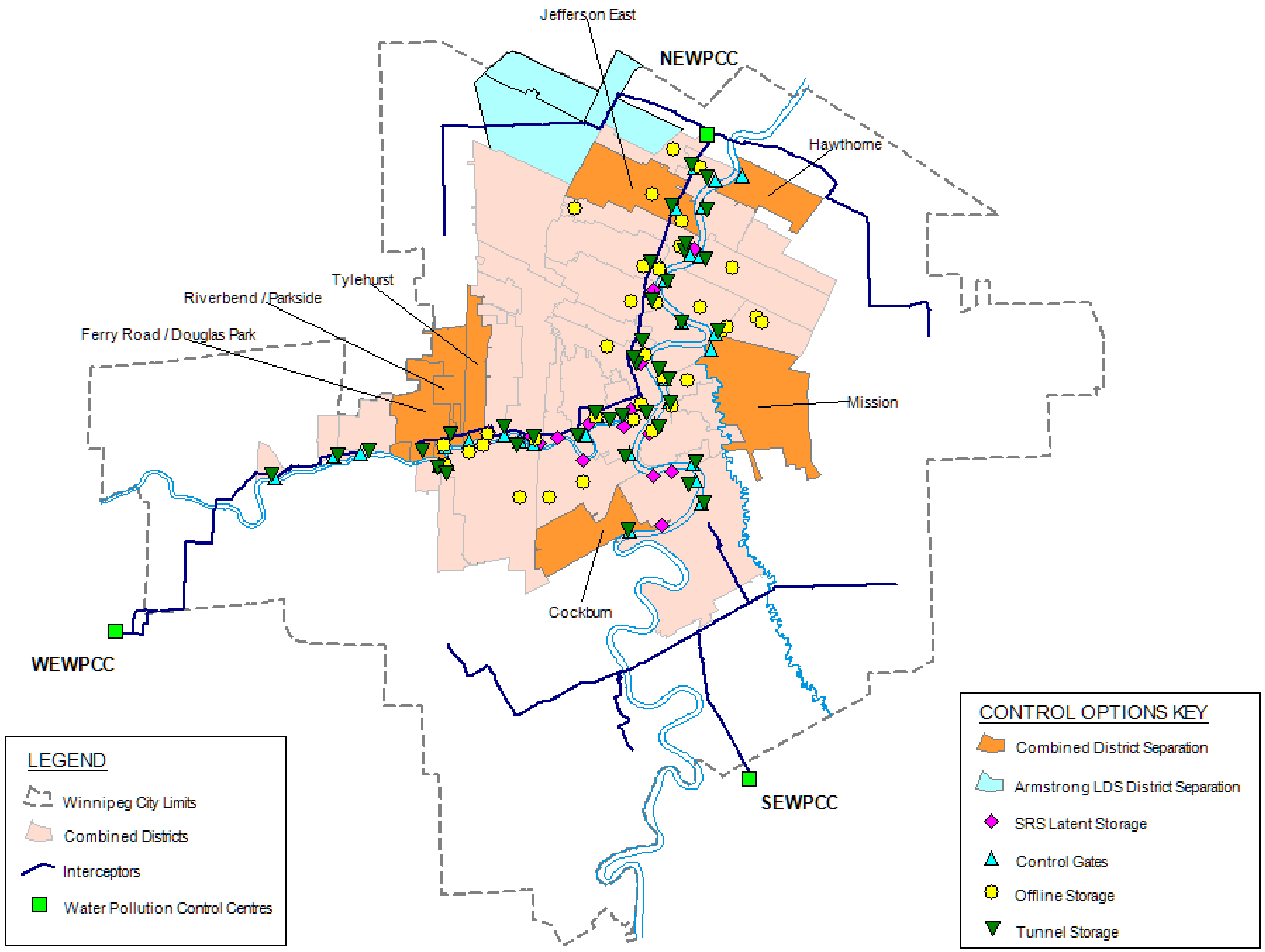
Alternative 1
85% Capture in a Representative Year



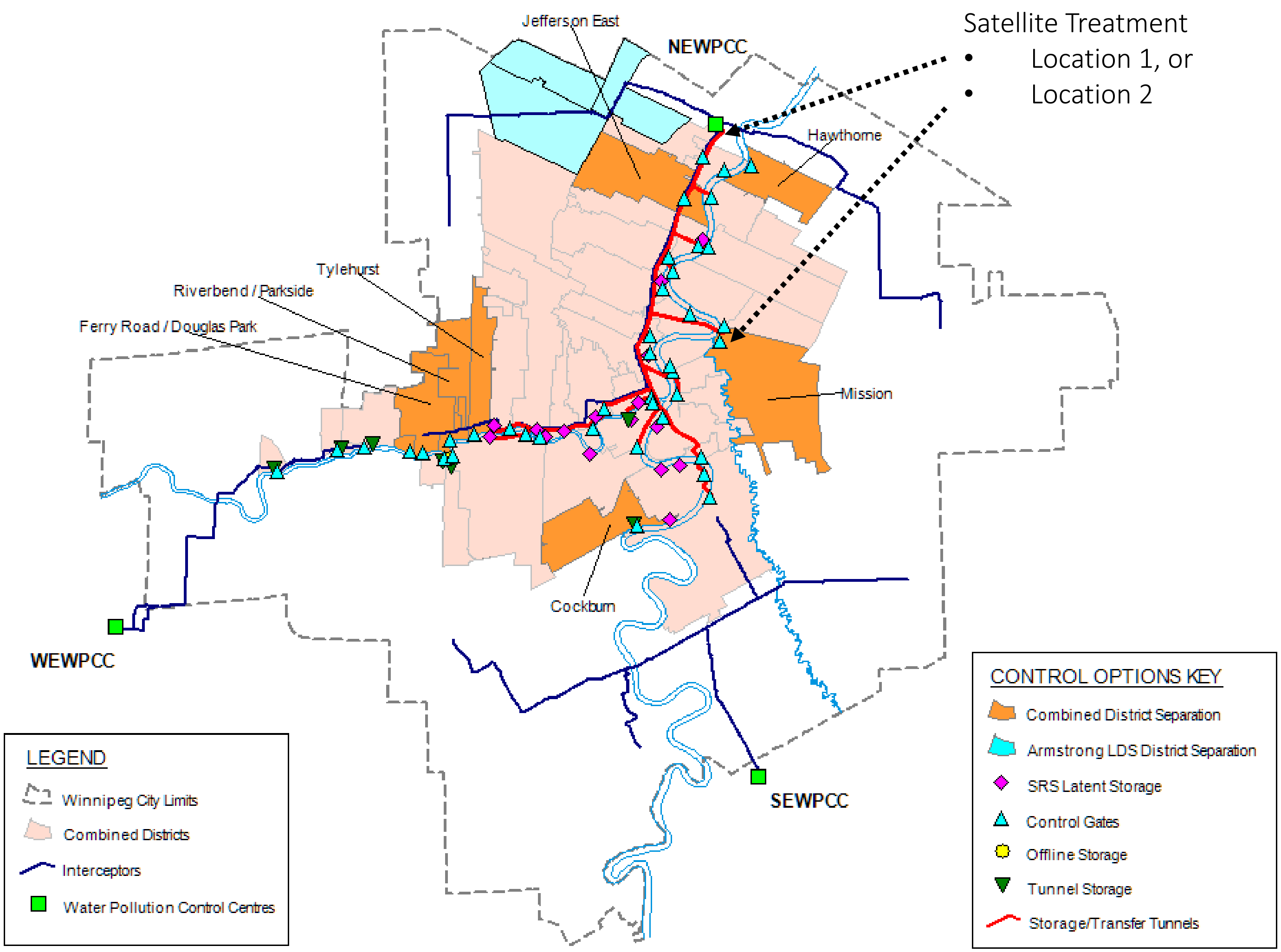
Alternative 2
Four Overflows in a Representative Year



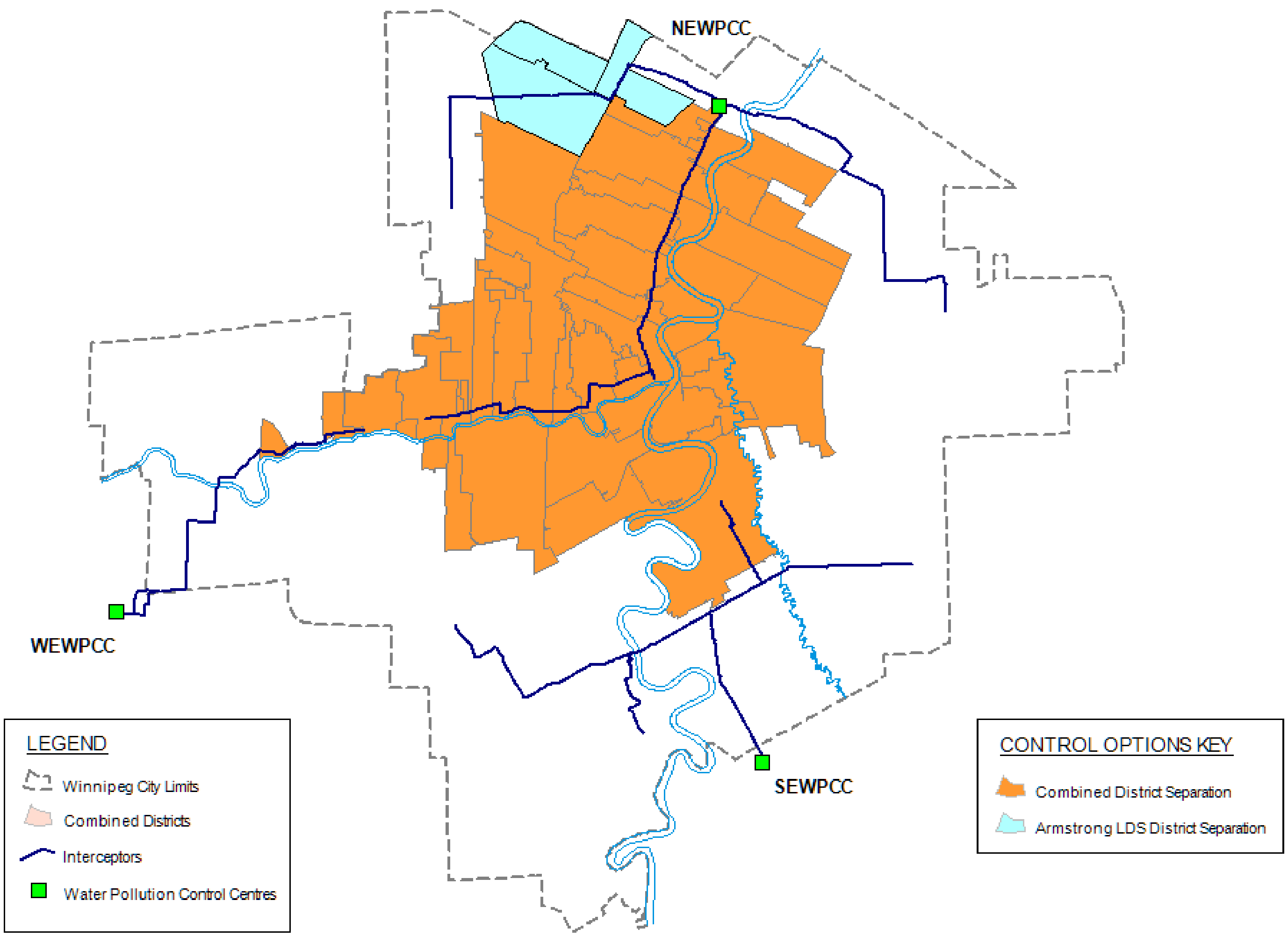
Alternative 3
Zero Overflows in a Representative Year



Alternative 4
No more than Four Overflows per Year



Alternative 5
Complete Sewer Separation



DECISION MAKING REPORT

FINAL

CSO Master Plan
Decision Making Report

Prepared for

Winnipeg

December 2015

Prepared By

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In Association with

DILLON CONSULTING

XCG

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Acronyms and Abbreviations

City	City of Winnipeg
CSO	combined sewer overflow
EA No. 3042	Environment Act Licence No. 3042
EPA	Environmental Protection Agency
MODA	Multiple Objective Decision Analysis
SAC	Stakeholders Advisory Committee

Summary

Environment Act Licence No. 3042 (EA No. 3042) requires that a preliminary proposal be submitted by December 31, 2015 to establish a control limit for the combined sewer overflow (CSO) program. Selection of the control limit is critical for the CSO program since it defines the level of performance, and will be the major factor affecting its cost. This decision making report presents the method used and the results of the evaluation.

The evaluation used a multiple objective decision analysis (MODA) process. The evaluation was based on a triple bottom line approach, with a balance of environmental, economic and social criteria. The MODA process uses a weighting process applied to the value criteria, followed by alternative scoring. It accommodates subjective criteria and value judgements, which form a major part of the CSO program decisions. The cost criteria, which are not subjective, were applied separately.

The public's values and preferences were obtained from the public engagement program and integrated into the process. City of Winnipeg (City) specific value criteria were defined by the Stakeholder Advisory Committee (SAC) and used as the basis for comparing alternatives. Multiple public events provided the source for input of public opinions. Public values were incorporated into the value criteria weightings, and public preferences into the alternative scoring process, and are used in the results presented in this report.

There was a high level of consistency between the public and decision team rankings for value criteria, with environmental concerns and protection of river uses being the highest. The choice for the best alternative varied widely between the public meeting results, online survey, SAC selection and decision team, with the more informed groups tending to favour the less costly options.

The 85% Capture in a Representative Year control option was ranked the highest control limit. All of the alternatives were ranked close together for the non-cost criteria, with the spread increasing after the alternative costs were included. The lower cost alternatives received the most points, and strongly favoured the 85% Capture in a Representative Year alternative.

The 85% Capture in a Representative Year alternative was therefore selected as the recommended control limit to be presented to the province in the preliminary proposal. It will require a major investment from the City, and will result in a long term commitment to a CSO control program.

SECTION 1

Introduction

The CSO Master Plan was structured into three phases. The first phase was a study designed to review the current situation, identify potential plans, and assess their performance in meeting alternative control limits. The study included review and incorporation of previous works carried out under the *Combined Sewer Overflow Management Study* (2002 CSO Study) (Wardrop et al., 2002) and experience from other cities with similar programs. The study results are included in the *CSO Master Plan Preliminary Report* (CH2M et al., 2015)

The second phase of the CSO Master Plan was a visioning and decision making phase. EA No. 3042 provides the opportunity for the City to evaluate alternative control limits and make a recommendation to the province. The Preliminary Report as well as the City's evaluation of alternatives and recommendation will be included in the Preliminary Proposal, which is to be submitted before December 31, 2015. The final decision by the province will rely heavily on the information prepared and submitted in the Preliminary Proposal.

The final phase of the CSO Master Plan will be completed after the control limit decision has been made, and is to be submitted by December 31, 2017.

The purpose of this Decision Making Report is to document the City's review, evaluation and decision making process undertaken for the Preliminary Proposal.

The control limit decision is critical to the CSO program and deals with multiple complex issues. The study phase was based on objective evaluations, identifying and quantifying measurable metrics for the alternatives, avoiding value judgements. Decision making in the second phase extends beyond the tangible metrics defined in the first phase, and is intended to provide a comprehensive and balanced evaluation. It utilizes a process to also incorporate value judgements for the intangible and subjective criteria, as considered appropriate by the project specific decision team.

This Decision Making Report describes the basis for decision making process and the final the recommendation from the City for the CSO Master Plan. The third and final phase of the master plan will develop an implementation plan based on selection of the final control limit.

Regulatory Requirements

EA No. 3042 was issued to the City for control of its CSOs on September 4, 2013. It sets out a number of requirements that will lead to a reduction of CSOs. The technical requirements are being addressed by the City through the CSO Master Plan. The main deliverables related to EA No. 3042 are the following:

1. Submission of a Preliminary Proposal by December 31, 2015
2. Submission of a CSO Master Plan by December 31, 2017

The licensing approach provides the City with a unique opportunity to provide relevant information to the Province for consideration in the refinement of CSO licensing in Manitoba as follows:

- The two step submission requirement focuses the initial decision on selection of the control limit. This is the visionary level of the combined sewer performance, and addresses how much CSO is acceptable by considering social, economic and environmental impacts.
- Reasonable time frames to respond, thereby allowing the City to undertake the appropriate issue investigations and technical evaluations needed for the decision process.
- The process provides the opportunity for stakeholder engagement. The CSO issues are complex and not of the type that evokes spontaneous public engagement.
- The process promotes collaborative participation and informed decision making on the part of the City, regulators and stakeholders. It allows the City to identify alternative control limits, evaluate their practicality and merits, and have meaningful input into the final decision.

CSO Program Alternatives

3.1 Alternative Control Limits

The alternatives that must be evaluated and reported on are defined in Clause 11 of EA No. 3042. In addition to the three control limits identified, the City may identify and evaluate other alternatives for consideration in the final selection of a control limit for the CSO program.

The final list of alternative control limits, as defined in the study phase, is as follows:

1. 85% capture in a representative year
2. Four overflows in a representative year
3. Zero overflows in a representative year
4. No more than four overflows per year
5. Complete sewer separation

Other alternatives considered for evaluation include the do-nothing alternative and the current approach; both approaches were rejected for not fitting the City's vision or the intent of the regulatory process.

The full range of final alternatives control limits is shown graphically in Figure 3-1.

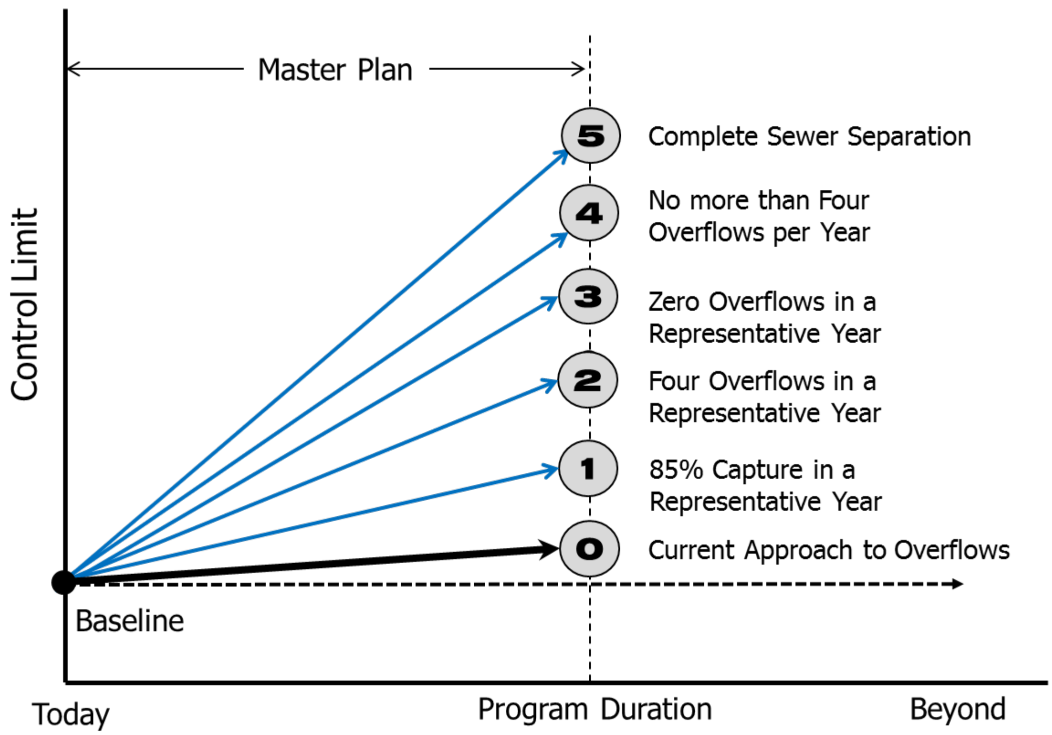

Figure 3-1. Alternative Control Limits

As described in the Preliminary Report, the alternative control limits meet the requirements of Clause 11 with and without use of a representative year and are described further in Table 3-1

Table 3-1. Alternative Control Limits

EA No. 3042 Control Limits to be Evaluated	Alternative Control Limits	
	Representative Year	Not to Exceed
Additional control limits defined by City	1) 85% Capture in a representative year	N/A
A maximum of four overflow events per year	2) Four overflows in a representative year	4) No more than four overflows per year
A minimum of 85% capture and a maximum of four overflow events per year	Achieved with the four overflow alternative	Achieved with the no more than four overflows per year alternative
Zero combined sewer overflows	3) Zero overflows in a representative year	5) Complete sewer separation

N/A = not applicable

The 85% Capture in a Representative Year alternative, without reference to a maximum number of overflows, was added by the City. It is used by the U.S. Environmental Protection Agency (EPA) for the presumptive approach to CSO control (U.S. EPA, 1995), is an industry benchmark, and was found to conform closely to the "knee-of-the-curve" analysis for Winnipeg.

The decision process is simple in concept, requiring only selection of one alternative from a choice of five, but difficult in practice because of the need to understand the issues and make informed judgements. The outcome is very important since it will establish the basis for design of all the infrastructure needed to meet the control limit and establish the water quality and other benefits that result.

3.2 Potential Plans

Although control limits define levels of performance, more information is required on how the limits would be implemented, on their operation and maintenance, and what they would cost. The CSO Master Plan developed potential plans for this purpose. Potential plans provide a practicable approach for implementation of each of the alternative control limits. They were developed to be implementable; that is, if selected they would provide a reasonable approach. They are not optimized plans and they avoid new technologies that do have not a proven track record.

The potential plans for each control limit were described and discussed in the Preliminary Report. Planning level costs were also prepared and presented for each potential plan. Performance assessments were also reported for tangible metrics, including their impact on river water quality.

Decision Process

4.1 Decision Making Approach

A structured decision making approach was used for the evaluations and development of a recommendation. The process was defined and administered by CH2M, with the evaluations and recommendations made by a City decision team, incorporating results from the public engagement process.

The decision requires that the alternatives be evaluated for a number objectives, with the alternatives being rated in terms of cost and non-cost criteria. CH2M selected a MODA approach for the decision making, which is a familiar tool that has been used for these types of evaluations many times. The tool was adjusted to meet the specific CSO Master Plan needs.

The MODA approach and decision tool was applied as follows:

1. Select decision making team
2. Identify evaluation criteria
3. Assign weights to criteria
4. Assess the alternative's performance and assign scores
5. Rank the alternatives by combining weights and scores
6. Conduct a sensitivity review and analysis of the results
7. Carry out a risk and reality review of the highest ranked alternative
8. Make a recommendation

4.2 Decision Making Team

The decision making team was made up of 11 members from the City's Water and Waste Department. The team members were from the Engineering Services, Environmental Standards Wastewater Services and Information Systems and Technologies of the Water and Waste Department. All team members were all familiar with combined sewer systems and their operations.

All members had at least some level of participation in the CSO Master Plan, and all had reviewed the Preliminary Report. This was considered to be a knowledgeable team, with a sound working knowledge of the issues, potential plans and expected performance of each alternative.

It was recognized that team members from the department would not be totally independent or free of bias, but that this would be offset by them being knowledgeable and in the best position to make an informed decision.

The decision team would also be in the best position to make an objective evaluation. The topic of sewage in any form is offensive to many in the general population, which can overwhelm emotions and result in prejudgment of alternatives (sometimes referred to as the "yuck factor"). Those who have worked in the industry are more aware of the issues and would be more inclined to view them objectively. In other respects, department workers are also citizens with the same concerns for the environment and wellbeing of the City as anyone else.

4.3 Evaluation Criteria

Selection of an appropriate set of evaluation criteria is critical for an effective evaluation. The City engaged the SAC to establish a set of Winnipeg specific "Value Criteria" for this purpose early in the process, as described in the *Stakeholder Advisory Committee: What was Heard* (First Person Strategies,

2015) Public Engagement report. The first step was to provide educational information to the SAC on the reason for the project and the expected outcomes. After a period of engagement they then identified a wide range of criteria they felt should form part of the decision process, listed as follows:

1. River usability and impacts
   – User safety, aesthetics, public health
2. Economic sustainability and construction capacity
   – Construction costs, local economy
3. Value for money and affordability
   – Utility rate benchmarks , cost benefit, whole life cost
4. Livability and daily impacts
   – Traffic disruption, maximizing local improvement opportunities
5. Lake Winnipeg and watershed impacts
   – Nutrient loading, river ecosystem health
6. Innovation and transformation
   – Green infrastructure, local economic and social opportunities
7. Visionary and broader context
   – Legacy of infrastructure, basement flooding, other Winnipeg plans
8. Social acceptability
   – Political acceptability, need to do something, public support

The criteria encompass what would be expected in a triple bottom line evaluation, which includes economic, environmental and social issues. The value criteria developed by the SAC covers important criteria that needs to be considered when evaluating a CSO Master Plan for the City.

The criteria were reviewed by the decision team at a group workshop. The decision team developed definitions for interpretation of the criteria to provide common understanding and consistency. Only minor adjustments were made to the criteria for its final use as follows:

- The value for money and affordability criteria were separated out into a standalone cost criterion
- Broad criteria were subdivided into subcategories to clarify components and simplify scoring
- Minor revisions were made to better categorize the alternatives

4.4 Public Engagement

The first phase of a public engagement program was carried out by the City based on the International Association for Public Participation principles, best practice and core values. Public engagement was considered an essential part of the process, and public input was solicited for incorporation into the evaluation process. The public engagement program is described in the Preliminary Report and detailed in the appendices. It included multiple initiatives to provide information on the CSO program and consult with the public, including the following:

- Public meetings
- Online survey
- SAC
- Symposium

- Website blog

The public responses were reviewed for public priorities and opinions related to the CSO program and are described in the following sections.

4.4.1 Public Meetings and Online Survey

Public meetings were held on September 14 and 15, 2015. The events were publically advertised and open to all. The meetings provided information on the value criteria and alternatives, and invited public participation and comments.

A process for identifying the most important value criteria was used by providing the participants with three dots to be applied to the storyboards with the criteria they considered the most important. The participants were also requested to select one of the five alternatives that they most supported for implementation.

An online survey was used to broaden the reach and extend the time for the scoring process. A copy of the presentation material was provided online as well as an identical set of questions. The results are combined in Table 4-1.

4.4.1.1 Non-Cost Value Criteria

The public preferences for the value criteria from the events are listed in Table 4-1.

Table 4-1. Public Input on Value Criteria from highest to lowest

Value Criteria	Votes
Lake Winnipeg	33
River Usability	25
Livability	23
Innovation and Transformation	21
Value for Cost and Affordability	17
Visionary and Broader Context	17
Economic Sustainability and Construction Capacity	17

These value criteria rankings were subsequently carried forward to the evaluation criteria weightings.

4.4.1.2 Alternative Selection

The selection for the most supported alternative was done by applying a dot to the storyboard at the public meetings, and by using a sliding scale for the online survey. The results are listed in Table 4-2.

Table 4-2. Public Input on Support for Alternative Control Limits

Alternative Control Limit	Public Meeting (Total)	Online Survey (Average)
85% Capture in a Representative Year	3	2.2
Four Overflows in a Representative Year	3	2.0
Zero Overflows in a Representative Year	4	3.4
No More than Four Overflows per Year	5	3.2
Complete Sewer Separation	12	3.1

The two methods report the results differently, but clearly show a trend towards selection of the more intensive alternatives.

4.4.1.3 Cost Criteria

The Value for Cost & Affordability criterion was included in the public event choices, and was ranked in a tie for lowest by the public. The MODA process deals with cost separately from non-cost criteria, and discussed later in Section 5.3 of this report.

There were some very specific concerns stated by the public about the CSO program costs, summarized in Section 4.4.3 and detailed in the public engagement appendix. The general public expressed concerns about their own ability to pay, while the SAC made references to the limited amount of public funds being available and of completing priorities.

4.4.2 SAC Review

The SAC was requested to complete the same survey as used for the public meetings and online surveys.

In response to the value criteria, the SAC's order of ranking was as follows:

1. Value for Cost and Affordability
2. Lake Winnipeg
3. River Usability
4. Visionary and Broader Context
5. Innovation and Transformation
6. Economic Sustainability and Construction Capacity
7. Livability

In response to the most supported alternative, the SAC selected the alternatives in the following order:

1. Four Overflows in a Representative Year
2. Zero Overflows in a Representative Year
3. No More than Four Overflows per Year
4. 85% Capture in a Representative Year
5. Complete Sewer Separation

The SAC provided advice on issues and processes, and developed the list of value criteria. The SAC scoring and rating values have been used for comparison of results, but because of the lower number of participants has not been used to the same extent as those from the general public events.

4.4.3 Public Comments and Opinions

A number of questions were asked at the public meetings and at the Symposium held on March 5, 2015 using live polling technology. Public comments were also received from a project blog site being run in parallel with the project.

A compilation of the most relevant responses and comments is included in Table 4-3. While these responses and opinions are valuable, they should not be viewed as being representative of the entire general public.

Table 4-3: Compilation of Most Relevant Comments from the Public Engagement Program

Issue	Public Response or Comment
Level of Concern	The level of concern reported by participants at the symposium was as follows: • 74% consider rivers somewhat or very polluted • 74% were very concerned about rivers • 83% were very concerned about Lake Winnipeg The response to a level of concern question at the public meetings was as follows: • 50% were very concerned about rivers at the start of the meeting This response decreased to 45% after hearing the presentation
Lake Winnipeg	Concern over Lake Winnipeg water quality was repeated several times
Reason for CSO Control	The reason for a CSO program as reported at the public meetings was the following: • 38% to control nutrients • 18% to control floatables 16% to control bacteria
Cost and Affordability	Cost was identified as a concern several times, with further comments being the following: • How will we pay for this? • Public is concerned about the potential for cost overruns Public suggested the province should pay
Implementation Period	A question was asked at the public meeting about the preferred time frame for CSO program implementation, with the answers being the following: • 31% in support of 15 years • 39% in support of 30 years • 29% in support of 60 years Other comments on the time for implementation were: • Important to get started Get on with it
What other Concerns	The public offered the following additional concerns: • Streets won't be repaired • Basements may flood Health of people should come first
Other Control Options	The public offered the following other suggestions: • Include use of green infrastructure • A watershed approach should be used Identify what citizens can do to help
CSO Performance Metrics	The preference for volume based metrics (instead of the number of overflows) increased from 58% to 76% from the start of the symposium to its end

SECTION 5

Evaluation

The formal evaluation was carried out in a series of steps. The first steps were carried out by the decision team in advance of the September public meetings. Once the results from the public were available adjustments were made for the public input. This section describes the process and reports on the final results prepared by the decision team with the public input included.

5.1 Weights

The MODA approach requires that weights be applied to the criteria. This was initially carried out through a group weighting workshop by the decision team, and then adjusted for public input.

The top level criteria were assigned weights first, followed successively by weights for sub-criteria. The weighting system required the most important criterion to be assigned a weighting of 10. The others in that criteria level were then assigned weights between 1 and 10 relative to the highest. It was essential that the criteria be considered on a relative basis. Any number of criteria could be weighted as a 10, as long as at least one was assigned a value of 10.

This weighting process was continued for each level, and then the factored weightings were calculated for each of the criteria to be scored. The factored weights were not provided to the decision team until after the scoring was completed.

The top level weights for the criteria were then substituted with the values obtained from the public engagement process, with the final set of weights for the non-cost criteria listed in Table 5-1.

There was a high level of consistency in the applied weighs, with the three highest being Lake Winnipeg, River Usability and Impacts and Livability and Daily Impacts. The selection of these criteria by group is summarized as follows:

- Lake Winnipeg was rated the highest by the public, the SAC and the decision team
- River Usability was rated the second highest by the SAC and the decision team, and third highest by the public
- Livability was also weighted high, being rated second by the public and third by the decision team

The differences in the Innovation and Transformation, Visionary and Broader Context, and Sustainability and Construction Capacity are likely to require a larger knowledge base to appreciate their importance and value over the life of the master plan.

Table 5-1. Final Value Criteria and Assigned Weights

	Value Criteria	Decision Team	Public Weight 1	Criteria Weight 2	Factored Weight 2	Criteria Weight 3	Factored Weight 3	Final Weight
1	**River Usability and Impacts**	9	8					
	Protection of River Uses and Public Health			10	2.29			
	Primary Recreation					9	0.57	0.57
	Secondary Recreation					10	0.63	0.63
	Fishing					10	0.63	0.63
	Irrigation					2	0.13	0.13
	Domestic Water Consumption					5	0.32	0.32
	Aesthetics			10	2.29			2.29
	Yuck Factor			10	2.29			2.29
	Safety			5	1.14			1.14
2	**Economic Sustainability and Construction Capacity**	7	5					
	Local Economy			9	1.61			1.61
	Construction Capacity			10	1.79			1.79
	Economic Sustainability			9	1.61			1.61
3	**Livability and Daily Impacts**	8	7					
	Traffic Disruptions			10	4.12			4.12
	Maximizing Local Improvement Opportunities			7	2.88			2.88
4	**Lake Winnipeg and Watershed Impacts**	10	10					
	Lake Winnipeg			10	5.00			
	Nutrient loading					10	2.78	2.78

Table 5-1. Final Value Criteria and Assigned Weights

	Value Criteria	Decision Team	Public Weight 1	Criteria Weight 2	Factored Weight 2	Criteria Weight 3	Factored Weight 3	Final Weight
	Bacteria					8	2.22	2.22
	River Ecosystem			10	5.00			
	Bacteria					9	1.45	1.45
	Dissolved oxygen/total suspended solids					6	0.97	0.97
	Ammonia					6	0.97	0.97
	Floatables					10	1.61	1.61
5	**Innovation and Transformation**	5	6					
	Green Solutions			6	1.57			1.57
	Employment Opportunities			10	2.61			2.61
	Social Opportunities			7	1.83			1.83
6	**Visionary and Broader Context**	7	5					
	Legacy of Infrastructure			9	1.41			1.41
	Basement Flooding			10	1.56			1.56
	Other Winnipeg Plans			5	0.78			0.78
	Growth Catalyst			8	1.25			1.25
7	**Social Acceptability**	7	7					
	Local Political Acceptability			8	2.43			2.43
	Public Support			10	3.04			3.04
	Contemporary Standards (need to do)			5	1.52			1.52

5.2 Scores

The fourth step of the MODA process was to score the alternatives. The scoring required that a score of 10 be assigned to the highest rated alternative control limit for each criterion, with the others considered on a relative basis, similar to the process for the weighting process.

This approach requires that the team be familiar with all alternatives prior to scoring, since the criterion is evaluated simultaneously for all alternatives. It produces a relative rating, and not an absolute score.

5.2.1 Performance Assessments

The performance assessments from the Preliminary Report were used for tangible performance metrics. Phosphorous loading is an example of a tangible performance metric, since it can be defined in terms of kilograms per year discharged for each alternative control limit.

5.2.2 Value Judgements

The evaluation also includes a number of intangible criteria that are subjective. They are difficult to evaluate, since they cannot be quantified and are valued differently by those doing the scoring. The MODA method accommodates this through clear criterion, the use of relative comparisons and use of multiple scorers to balance opinions. Social Opportunities is an example of an intangible criterion.

5.2.3 Public Opinion

The results from public engagement were used for scoring in a similar manner as for the weighting, with the initial scoring being done by the decision team and then updated after receipt of final public input. The comments and opinions were reviewed for common themes and consistent messages of interest to the evaluation processes. The following main issues and opinions were well accounted for through the decision team evaluation, with the one exception being the supported alternative, which varied widely:

- Complete Sewer Separation was selected by those attending the public meetings
- Zero Overflows in a Representative Year was selected from the online survey
- The SAC selected Four Overflows in a Representative Year
- The decision team selected 85% Capture in a Representative Year

The scoring for Public Support under the Social Acceptability criterion was therefore adjusted in the evaluation to account for the public's preference. This was accounted for by assigning a value of 10 to the Complete Sewer Separation alternative in accordance with the process, and scoring the other alternatives in proportion to the Table 4-2 values.

5.3 Cost Evaluation

The cost criteria are tangible and a different method was used for the evaluation. They include capital costs for construction and longer term operation and maintenance cost, which can be converted to present value for direct comparison, and therefore are not subject to interpretation.

The cost weighting is a major factor in the evaluation. Therefore, an iterative method was used to select the weighting assigned to cost, as follows:

1. An initial weighting for cost in comparison to non-cost scores was agreed upon.
2. The cost per point was then determined for the non-cost scores by dividing the lowest cost by the maximum possible non-cost points.

3. The equivalent costs were determined for a series of non-cost criteria by multiplying the cost per point by the number of points, using the point difference between the highest alternative (complete separation) and the lowest (85% Capture in a Representative Year).
4. The equivalent costs were then compared to the anticipated values for the improvement.
5. This comparison identified what the decision team should be willing to pay for the improvement.
6. By reviewing a range of non-cost criteria, the decision team assessed their comfort level in the cost weighting, and made adjustments as necessary.

The initial cost calculation was based on it being a percentage of non-cost criteria. This was adjusted to a percentage of total cost for the final assessment. An initial cost valued at 40% of the non-cost criteria is equal to a cost weight of 29% of the total.

The decision team reviewed a wide range of cost criteria using this method and was satisfied with a cost weighting of 29%. This cost weighting is less than the value the City uses for rating of competitive proposals, which is set at a minimum of 40%.

Cost points were totaled using the same method the City uses for evaluation of competitive proposals. The method involved assigning the maximum points to the least cost alternative, with the remainder assigned points based on multiplying the maximum points for cost by a ratio of the lowest cost divided by the alternative's cost.

5.4 Ranking Results

The ranking process was completed by combining the weights with the scores.

The final combined weights from the public engagement and decision team inputs used for the final evaluation are shown for the top level criteria in Figure 5-1.

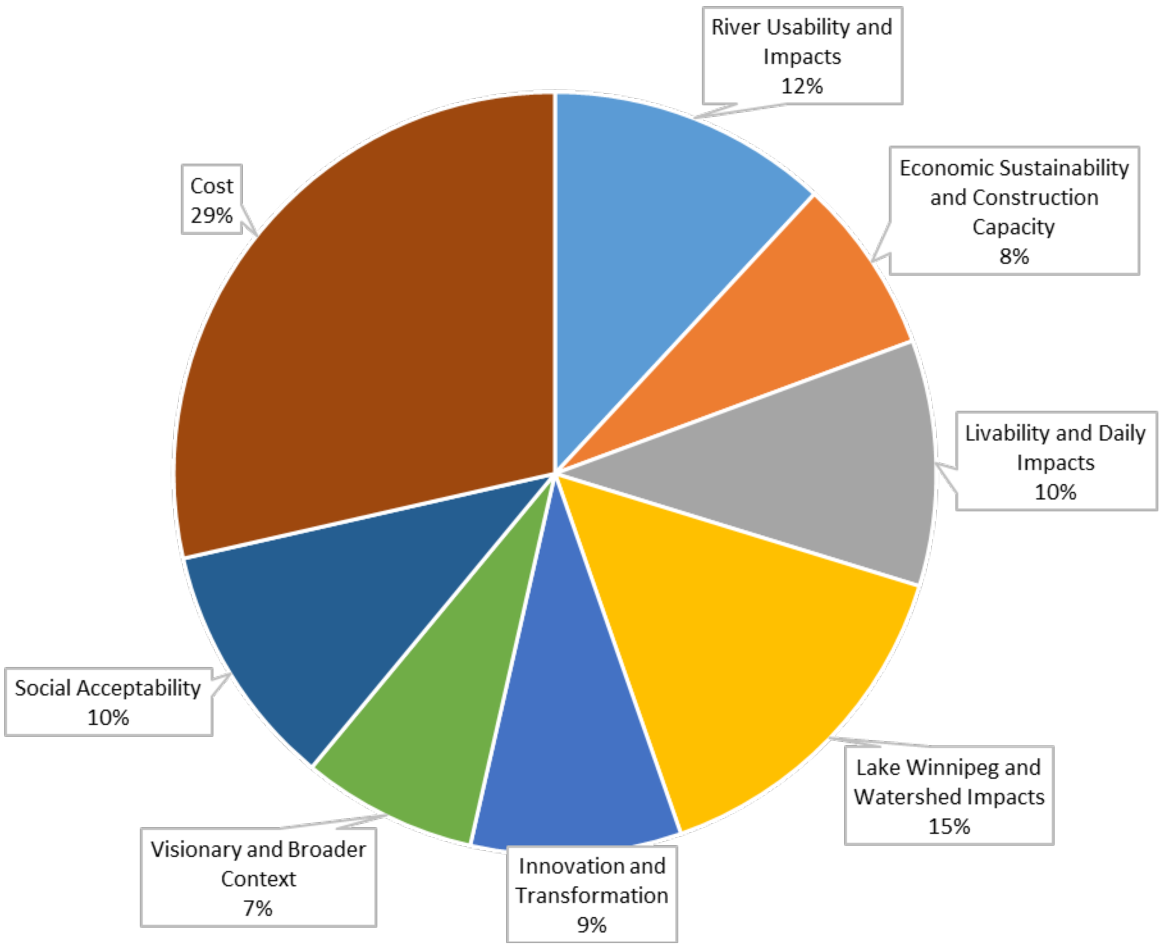

Figure 5-1. Percentage Weights for Value Criteria (Cost and Non-Cost Criteria)

The scores recorded for each decision team member were applied to the weights and totaled, resulting in the alternative weighted score rankings as shown in Figure 5-2.

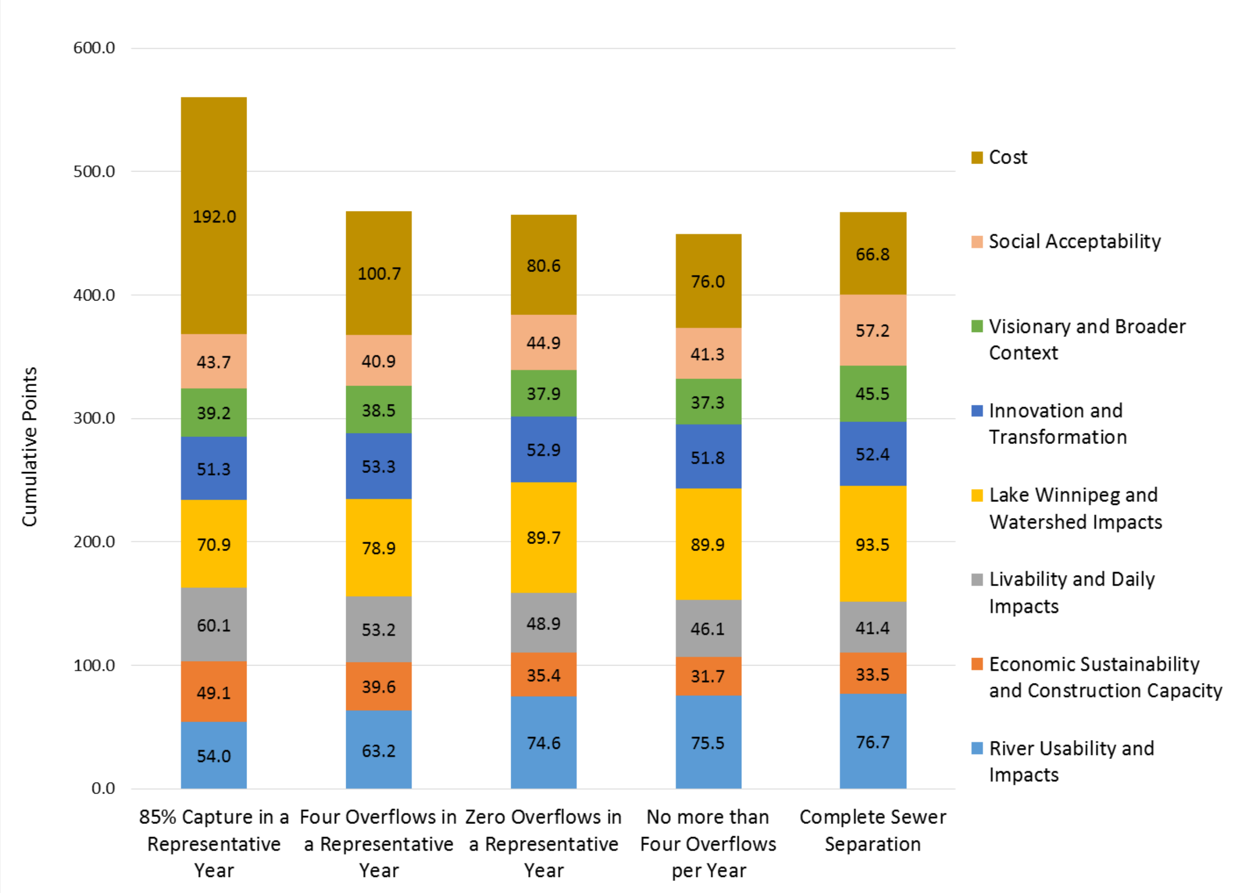

Figure 5-2. Alternative Final Ranking

5.5 Analysis of Results

The evaluation results were reviewed with the decision team after completion of the ranking process. The review looked at process sensitivity to cost, scoring inconsistencies and general irregularities.

5.5.1 Cost Sensitivity

Cost was assigned the highest weighting of all the value criteria, and could affect the rankings. The cost weights were varied from 0 to 50 percent to test its sensitivity. The results were as follows:

- The alternatives are all nearly equal when cost in weighted at 10 percent
- As the cost weight increases above 10 percent, the 85% Capture in a Representative Year becomes the highest ranked alternative
- At a total weighting cost of 29 percent, the 85% Capture in a Representative Year alternative has about a 20 percent lead over the next highest alternative
- At a cost weighting of 50 percent, the 85% Capture in a Representative Year has about a 37 percent lead over the next highest alternative

The cost sensitivity suggests that without considering costs the alternatives have a similar ranking, but if costs are included in the evaluation, the 85% Capture in a Representative Year alternative will always have the highest ranking.

5.5.2 Scoring Variability

The scoring results were reviewed for individual scoring spread and variability. Following are some of the key observations:

- The ***Economic Sustainability and Construction Capacity*** *criteria was scored with the greatest consistency.* All of the team members scored the 85% Capture in a Representative Year alternative the highest.
- The ***Livability and Daily Impacts*** criteria had consistent scoring, with the 85% Capture in a Representative Year being scored highest or second highest by all of the team members.
- Most scores for ***River Usability*** and ***Lake Winnipeg and Watershed Impacts*** were highest for complete sewer separation, but the zero and no more than four alternatives also scored high.
- ***Social Acceptability*** had varied results but this is a somewhat subjective criteria, and likely to reflect divergent opinions on what is acceptable.
- ***Innovation and Transformation*** had the highest scatter. This is a somewhat obscure concept, and may reflect uncertainty in the definition, or how innovation and transformation are viewed.
- The ***Visionary and Broader Context*** criteria was split between both extremes. This may suggest the scorer had different interpretations of the definitions, or different opinions on the alternatives. Participants scoring it the highest for complete sewer separation also gave complete sewer separation the highest scores for other criteria.

The scatter was found to be relatively low and did not significantly affect the results. The small amount of scatter may be the result of normal variation with the complex issues or may indicate some favouritism or uncertainty in definitions. It was not considered significant enough to make any adjustments. Any biases in selection process would be balanced out by having the scoring done by a team.

5.5.3 Ranking Rationale

The group results were reviewed to assess and interpret the rationale and reasoning for the rankings.

The ranking values at a cost weight of 10 and 29 percent are shown in Table 5-2.

Table 5-2. Decision Team Alternative Rankings

Alternative Control Limit	**Scores**	
	Cost Weight = 10%	Cost Weight = 29%
85% Capture in a Representative Year	416.4	560.4
Four Overflows in a Representative Year	392.7	468.2
Zero Overflows in a Representative Year	404.5	465.0
No More than Four Overflows per Year	392.5	449.6
Complete Sewer Separation	416.8	466.9

The complete results for all top level criteria are shown graphically in Figure 5-3.

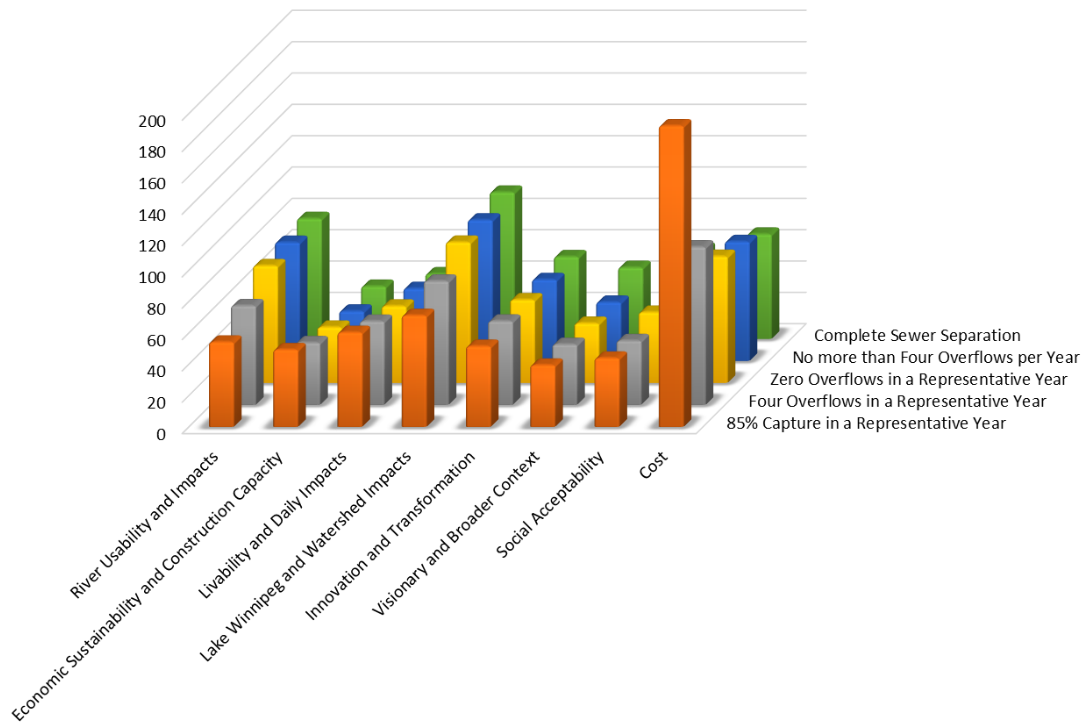

Figure 5-3. Value Criteria Weighted Scores

A review of the results and the decision team considerations of the alternatives is as follows:

- ***River Usability*** had the second highest weighting but Complete Sewer Separation only scored 22.7 points more than the 85% Capture in a Representative Year alternative:
  - The bacteria levels were not considered a significant issue because of limited amount of primary recreation in the rivers, the amount of improvements with CSO control would only be marginal, and the 2002 CSO Study conclusions by the Advisory Committee indicating that CSOs should not be considered a health risk issue all contributed to the small differences.
  - Rivers are already being actively used in accordance with their appropriate uses, and are not considered impaired. River uses are not expected to change substantially with implementation of a CSO program.
  - Aesthetics of the rivers would increase with floatables control.
  - The Yuck Factor was recognized, but was not considered to be a major factor by the decision team.
- ***Economic Sustainability and Construction Capacity*** was rated 15.6 points higher for the 85% Capture in a Representative Year alternative than for complete sewer separation. The decision team viewed the investment in CSO upgrades as being detrimental to the local economy, and beyond the construction industry capacity.
- ***Livability and Daily Impacts*** was rated highest for the 85% Capture in a Representative Year alternative, with scoring being 18.7 points higher than points for Complete Sewer Separation. The

decision team viewed the larger projects to have a detrimental impact on livability and daily impacts, which for complete sewer separation would turn the combined sewer area into a large construction zone, disrupting vehicular traffic, local businesses and living conditions.

- **Lake Winnipeg and Watershed** had the highest weighting, with Complete Sewer Separation scoring only 22.6 points higher than 85% Capture in a Representative Year. This results from the small change in water quality between alternatives. Improvements to Lake Winnipeg loading could be made much more *effectively* and economically through alternative watershed improvements.
  - The nutrient loadings from CSOs are comparatively small, with the reduction in phosphorus loading from CSOs control being only a fraction of a percent.
  - CSOs were also found to have minimal impact on the river systems, which already support healthy aquatic life.
- *The* ***Social Acceptability*** criteria was rated the highest for Complete sewer separation, with it scoring 13.5 points more than the 85% Capture in a Representative Year alternative. This criteria includes the public's choice of alternatives, and the reaction of public and politicians to the programs.
- The ***Visionary and Broader Context*** criteria had a lower impact on the scores with highest score being assigned to complete sewer separation. It scored in the range of 6.3 points higher than for 85% Capture in a Representative Year.
- ***Innovation and Transformation*** scores were the most consistent among alternatives, with the range from high to low being only 2.0.

Overall, it can be concluded that the alternatives were considered very similar in performance, and that cost is the main differentiator. Including cost impacts in the assessment clearly favours the 85 percent capture alternative. The City also recognizes cost as significant criteria because of current City infrastructure demands and the affordability consideration of Winnipeg utility rate payers who pay for the project.

SECTION 6

Conclusions

Based on the results from the decision making process, the following can be concluded:

- The decision process provided a logical and transparent method for incorporating the triple bottom line technique into alternative evaluations.
- The Winnipeg specific value criteria developed by the SAC provide a comprehensive triple bottom line basis for alternative evaluation.
- The public engagement program produced multiple responses and comments have been used as input into the decision and evaluation of results.
- Two environmentally related criteria, Water Quality and River Usability, were considered as the most important for the evaluation, since they were weighted in the top three by both the decision team and the public.
- Livability was also considered an important evaluation criterion, as it was also weighted as one of the top three by both the decision team and public.
- Even though CSOs are considered offensive and deteriorate water quality, the fact that they do not cause high levels of impartment, the nutrient loadings from CSOs are relatively low, and the discharges do not create a health risk problem had a major impact on the results.
- A CSO program based on the 85% Capture in a Representative Year alternative would provide a regulatory limit equal to that used by the US EPA for their presumptive approach and would meet the City's vision of "doing our part".
- There was very little difference in ranking between all five alternative control limits when program costs were not included, which results from there not being a significant difference in performance with increased levels of CSO control. Therefore the levels of improvement from increasing the program beyond the 85% Capture in a Representative Year alternative would be modest and in many cases not be measurable but the costs are significant.
- There are large increments in cost with increasing levels of CSO control, which dominates the ranking of alternatives when both cost and non-cost alternatives are included.
- The cost sensitivity analysis indicated that the alternatives essentially ranked even without costs, but the 85% Capture in a Representative Year in the representative year alternative was still ranked highest with costs weighted at 10 percent of the non-cost cumulative weighting, and even higher as the cost weighting increased.
- It can therefore be concluded that the high cost and limited value from increasing the level of control beyond the 85% Capture in a Representative Year alternative would not be warranted, and that 85% capture in a representative year be recommended as the appropriate control limit.

SECTION 7

Recommendation

After review of the alternatives, completion of the comprehensive evaluation and consideration of public input, it is recommended that the "85% Capture in a Representative Year" control limit be selected as the alternative for the CSO Master Plan. This recommendation includes using the 1992 representative year and does not require meeting a maximum number of overflows to be met for compliance. Compliance will be based on 85% capture of the combined sewer overflow volume for the 1992 representative year. Percent capture would be based on the wet weather flow treated in comparison to the wet weather flow collected. The definition and application of percent capture is provided in more detail in the Licence Clarification document.

The 85% Capture in a Representative Year alternative was the highest rated and will meet the City's vision for "doing our part" and making manageable environmental improvements. Among its benefits are the following:

- It is based on a triple bottom line evaluation, with the value criteria weightings derived from a public engagement process
- It will meet the 85 percent capture benchmark, which is used in the US EPA "presumption approach," under which the alternative's achievement would be presumed to provide an adequate level of control to attain water quality.
- It represents a significant investment by the City in CSO management (current estimate is $0.6 to $1.2 billion) although also has the lowest cost of the five alternatives considered making it the most affordable overall.
- It takes a major step forward in CSO management, progressing from fixed weir and opportunistic sewer separation to active controls and optimization of existing interceptor and treatment infrastructure.
- It reduces overflows and incorporates floatables capture from every combined sewer district.
- It will be adaptable to allow for cost-effective green infrastructure, and provides for future green enhancements.
- It is expandable, and there would be relatively minimal throw away costs for upgrading to the "four overflows in a representative year" or "zero overflows in a representative year" alternatives, to meet either more stringent regulations or adapt to climate change.
- It is the most practicable and manageable alternative from planning, coordinating, and constructing perspectives of the five alternatives considered.

SECTION 8

References

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