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City of Peterborough

Flood Reduction Master Plan

Prepared by:

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Executive Summary

In July 2004, the City of Peterborough (the City) was hit by a severe rainfall event that caused significant flood damage. Flood damage was reportedly in excess of $100 million in direct physical damages to private and public property. In addition, the City suffered indirect damages such as disruption in residential living conditions, loss of business, and loss of wages or income.

Shortly after the flood, the City retained UMA Engineering Ltd. (UMA) to investigate the causes and determine remedial measures to improve the operation of the drainage system and reduce the risk of damage from future flooding. UMA undertook a City-wide Flood Reduction Master Plan Study (the Study) under the Environmental Assessment Act to plan infrastructure improvements as part of the City's overall systems, before dealing with project-specific issues. The study included two sets of five ward-based public information meetings – the first set gathered information on flooding damage from the public while the second set presented alternative solutions and gathered information on public priorities for solutions. As part of the consultation process, a Technical Committee provided a wide range of input, and a Citizen's Advisory Committee provided valuable direction on the perspectives and interests of the public.

What caused the damage? In July 2004, the City was hit by extreme rainfall that was well beyond typical urban drainage design thresholds. However, information obtained from the first set of public meetings indicated that the City is also routinely negatively impacted by much lesser rainfall events, including those within current design thresholds. UMA's analysis identified the following causes for the flood damage:

- **Unprecedented heavy rainfall** of an intensity of more than twice the current design standard used by most municipalities, centred on the largely impervious downtown core, resulting in high runoff.
- **Insufficient storm sewer capacity** caused primarily by ineffective water collection and undersized pipes. Approximately 80% of the City's storm trunk sewers analysed do not meet current 5-year design standards.
- **Poorly defined overland flow routes** caused primarily by filling in of natural waterways over time without accommodating the water elsewhere. Over 225 properties in the City are vulnerable to overland flow damage from a 100-year storm event.
- **Unwanted water getting into the sanitary sewer system** leading to system overflow. It is believed to be primarily a result of foundation drain and illegal roof leader connections and inflow through aging pipes and manholes. In "dry" weather, the wastewater treatment plant receives up to twice as much water as the public utility commission (PUC) water treatment plant delivers to residents. In "wet" weather, this number climbs to six or more times the PUC water delivered.

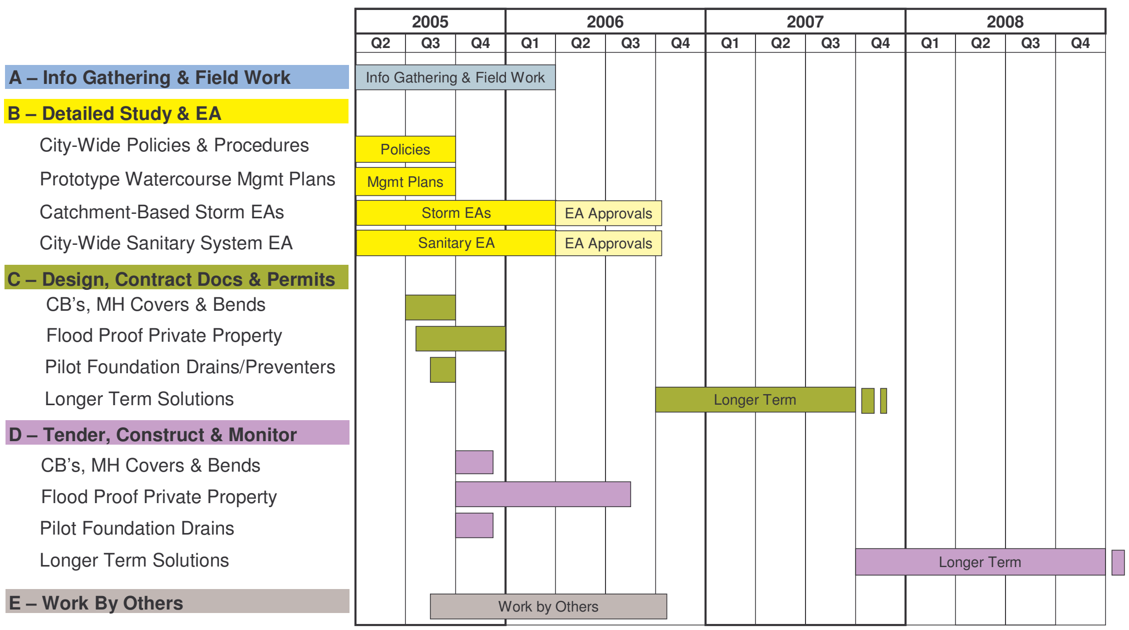
Key Study Findings To improve the operation of the City's drainage and sanitary systems, UMA identified a "toolbox" of potential solutions. The appropriate set of "tools" or solutions to help reduce the risk of future flooding damage is expected to vary across the City. This Study provides the overall action plan, called the Master Plan, to determine which solutions to apply, to which systems, and in which parts of the City. We summarize the prioritization of works as follows:

- The public has set preventing basement flooding from sanitary sewage as a priority.
- Four catchments are in need of urgent drainage system attention: Jackson, Curtis, Beyersville/Harper, and Riverview.

Recommended Action Plan The Master Plan maps out the broad steps to reduce flooding damage in the City and outlines the short term activities required to begin the journey. The analysis undertaken as part of the Master Plan indicates that the City is currently at risk of damage in the event of future storms. The Action Plan derived from the Master Plan Study provides the broad steps to reduce flooding damages – it converts our Study analysis results into inter-related action steps. However, timing is driven by the duration of each of the steps, the inter-relationship of the steps, and availability of funding and other resources. **Figure ES-1** shows a summary of the ***earliest possible timing*** for implementation of the Master Plan, based on unlimited availability of funds and other resources. It is **very important** to begin the Master Plan immediately, and progress through the steps quickly and systematically to maintain the momentum over a number of years. Important next steps for the City are:

- Prepare a detailed implementation plan, including amounts / sources of funding and other resources.
- Prepare detailed terms of references for the most urgent action steps.

Figure ES-1 – Recommended Action Plan



Additional Recommendations

In addition to the Recommended Action Plan, we recommend the City consider the following two items which will enhance the success of Master Pan implementation:

Consultation: The Technical Committee and Citizens Advisory Panel were instrumental in the successful completion of the Master Plan. As the flood reduction program moves forward, the Technical Committee should be re-formed with representation from a number of topic-specific agencies, and a Citizen's Advisory Panel should monitor and report on progress and performance, in addition to providing input on public consultation.

Reporting: Key aspects of successful implementation of the Master Plan are monitoring and subsequent reporting. It is recommended that the following measures be reported on annually to monitor the progress of the action plan and demonstrate cost effectiveness:

- The percentage of unwanted wet and dry weather flow within the sanitary sewer system;
- The number of houses vulnerable to flooding which are located within overland flow routes / conservation authority flood lines;
- The percentage of storm sewers meeting current criteria; and
- Summary of cost-benefit analysis for individual detailed studies.

1.0 Introduction

1.1 Introduction and Master Plan Process

In July 2004, the City of Peterborough (City) was hit by a severe rainfall event that caused extensive flood damages. Significant flood damages also occurred in a June, 2002 storm event. Both events resulted in serious property damage, economic business loss, damage and interruption of municipal services that occurred through the backup of sanitary sewage into basements and uncontrolled overland flows. In August 2004, the City of Peterborough's Flood Review Committee retained UMA Engineering Ltd. (UMA) to carry out a comprehensive Stormwater System Evaluation and Flood Reduction Analysis. Hereafter referred to as the Flood Reduction Master Plan Study (the Study), the purpose of this Study is to recommend solutions to reduce local flooding problems. It does this through recommendations of various alternative solutions to improve the operation of the sanitary and storm water systems. The Study Area, as identified in **Figure 1**, includes all lands within the City's existing municipal boundaries.

All municipal projects in Ontario require approval under the *Environmental Assessment Act* (EAA). However, carrying out individual environmental assessments (EAs) and/or seeking exemptions to comply with the requirements of the EAA is onerous, time consuming, and expensive. Since municipalities undertake hundreds of projects, the Municipal Engineers Association (MEA) *Municipal Class Environmental Assessment (Municipal Class EA)* (2000) enables the planning and implementation of municipal infrastructure projects using an approved procedure designed to protect the environment. The *Municipal Class EA* process provides a decision-making framework that enables the requirements of the EAA to be met in a timely and cost-effective manner.

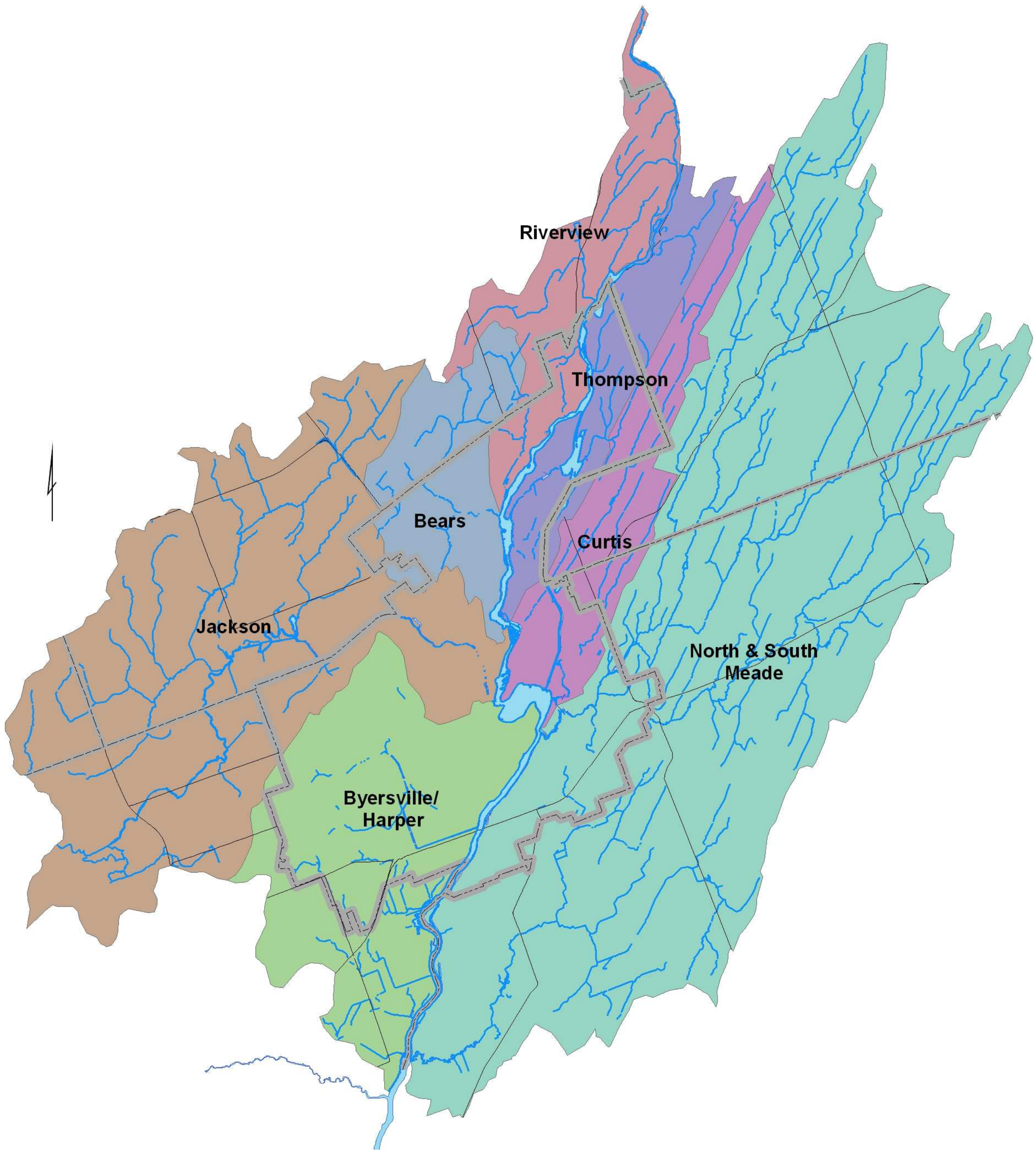
Given the broad nature of the identified problems and recognizing the need for a coordinated approach to the City's complex urban drainage and sanitary sewer systems, this Study will be conducted as a Master Plan under the Ministry of the Environment's definition. Accordingly, the Study will support and provide the framework to facilitate subsequent Municipal Class EA approvals for specific future projects identified with the City of Peterborough.

1.2 Municipal Class EA Master Plan Process

Environmental Assessment or EA is a decision-making process used to promote good environmental planning by assessing the potential effects of certain activities on the environment. The purpose of the EAA is the "betterment of the people of the whole or any part of Ontario by providing for the protection, conservation and wise management in Ontario of the environment", where the broad environment includes the natural, social, cultural, constructed and economic environments. To achieve this, the EAA ensures that environmental problems or opportunities are considered and their effects are planned for before development or building takes place.

Approved by the Minister of the Environment on October 4, 2000, the *Municipal Class EA* provides a streamlined, self-administered framework for EA planning of municipal projects under the provisions of the EAA. The *Municipal Class EA* enables the planning and execution of municipal projects using an approved procedure, which ensures that potential effects on the natural, social, cultural, technical and economic/financial environment are taken into consideration on a consistent basis. Most importantly, when the *Municipal Class EA* process is followed, the City is not required to obtain project-specific approval under the EAA.

Figure 1 – Catchment Study Areas



The *Municipal Class EA* recognizes that, in many cases, it is better to plan infrastructure improvements as part of an overall system, before dealing with project-specific issues. This allows the proponent to better define the need and justification for individual or specific projects within a broader planning context before proceeding with individual works on a project-by-project basis.

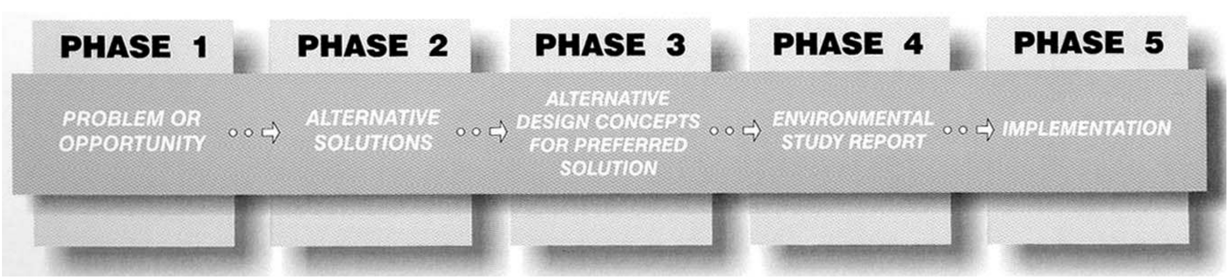
The Master Plan process differs from project specific studies in several aspects. It facilitates long range planning that enables a municipality to identify opportunities and proactively develop strategies for addressing any associated issues. This approach generally yields a framework for planning and implementation of subsequent projects (or a course of action), in combination with a phased implementation plan or program that covers an extended period of time. Though these projects may be implemented as separate works, collectively they form part of the overall management system embodied in the Master Plan.

Prior to the implementation of specific projects recommended within the context of the Master Plan, it is first necessary to determine their level of complexity and potential effects on the environment.

1.3 Study Approach

In keeping with the Master Plan process, this Study has incorporated the key principles of successful environmental assessment planning. Consequently, assessment level undertaken for this Study has addressed the first two phases of the *Municipal Class EA* process by providing the Problem Statement, regarding the nature and/or extent of the problem including an explanation of the source for the concern, and the need for a solution **(Phase 1)**. This Study also provides a description and assessment of Alternative Solutions, coupled with the decision-making process used to select the Priority Study Areas **(Phase 2)(Figure 2)**.

Figure 2 – The Municipal Class EA Planning and Design Process



In addition to the Project Team, external regulatory agencies, interested stakeholders and the public have participated throughout the process. As equal partners in the Study, each of the participants has provided input and has therefore played an integral role in the planning and decision-making processes.

1.4 Problem Statement

Basement flooding is caused by excessive unwanted flow entering the sanitary sewer system, and uncontrolled overland flows. The basement flooding is associated with both extreme and less severe storm events and is caused an unacceptable frequency and magnitude of damages. To reduce the risk of damage caused by flooding, improvements to the operation of the storm drainage system (both storm sewer and overland flow systems) and the sanitary sewer system, are required.

1.5 Five Year Review Requirements

A time lapse may occur between the filing of the Master Plan and the implementation of each project. In such cases, the proposed project and the environmental mitigation measure approvals may no longer be valid.

If the period of time from filing of the Notice of Completion of the Master Plan in the public record to the proposed commencement of project construction exceeds five years, the proponents shall review the planning and design process and the current environmental setting to ensure that the project is still valid given the current planning context. The review shall be recorded in an addendum to the Master Plan which shall be placed on the public record.

Notice of Filing of Addendum shall be placed on the public record with the Master Plan Addendum and shall be given to the public the review agencies. A period of 30 calendar days shall be provided for review and response. If no request is received, the proponent is free to proceed with implementation.

1.6 Purpose and Organization of this Report

This Report has been prepared to document and provide a traceable and easily understood record of the planning and decision-making processes. The Report is organized as follows:

- ***Executive Summary:*** Provides an overview of why the Study, and summarizes recommendations
- ***Section 1 – Introduction:*** Includes an explanation of the reason why the Study is being conducted under the Municipal Class EA Master Planning process. Provides an overview of the Report contents, details on the Project Team, and the time frame over which the planning process was undertaken.
- ***Section 2 – Public and Agency Consultation:*** Documents the public and regulatory agency consultation activities carried out throughout the Study (e.g., notices, letters, display boards, and public meeting summaries).
- ***Section 3 – Drainage System Analysis:*** Provides a description of the urban drainage network, and identifies causes contributing to flooding within the City.
- ***Section 4 – Alternative Solutions:*** Documents various alternative solutions for the storm, overland flow and sanitary sewer systems. This section describes Phase 2 of the Municipal Class EA process.
- ***Section 5 – Decision-Making to Set Priorities:*** Provides a description of the rationale for setting priorities in the recommended works.
- ***Section 6 – Recommended Action Plan:*** Provides details on the purpose, scope, schedule and cost of further works required to reduce flood damage.
- ***Section 7 – References –*** Lists the background reports and studies examined as part of this Study.
- ***Appendix A:*** Includes specific public and regulatory agency consultation materials (e.g., press releases/notices) and information received (e.g., input and opinions) as well as other detailed material referenced in the Master Plan Report.

1.7 Project Team Organization

UMA led this study and our inter-disciplinary Project Team consists of specialists in Drainage and Hydrology and Hydraulics, Environmental and Land Use Planning, and Public/Regulatory Agency Consultation. Key staff involved in the Study were:

UMA Engineering Ltd.
- Ms. Donna Querengesser, Project Manager
- Mr. Brian Worsley, Project Engineer
- Ms. Renée Pettigrew, Project Coordinator and Environmental Planner
- Ms. Clara Tucker, Senior Water Resource Engineer
- Ms. Janelle Weppler, Water Resource Engineer (EIT)
- Mr. Jeff Atherton, GIS Specialist
- Mr. Leo Gohier, Stakeholder Liaison
- Mr. Marcel LeBlanc, Strategic Project Advice
- Mr. Andrew Ritchie, Strategic EA Advice
- Mr. Andy Dalziel, Sewer Rehabilitation Advice

Cumming + Company
- Ms. Susan Cumming, Public Facilitator/Mediator

Verbatim Strategic Communications
- Ms. Jane Davidson, Media Relations and Public Information Advisor

1.8 Study Schedule

Initiated in August 2004, the Study was completed over an approximately eight-month period (August 2004 to May 2005).

The Flood Reduction Master Plan is subject to approval by the City and does not require formal approval under the EAA. The Master Plan will be made available for a **minimum 30-day public review period**. As requests for an order to comply with Part II of the EAA do not apply to Master Plans**, the Master Plan is considered approved following the 30-day review period.** At this time the City may proceed with its implementation after approval by City Council's Flood Review Committee.

It is important to note that, more detailed environmental inventories, evaluations and assessments will be required prior to design and construction of any proposed works. The scope and level of analysis is dependent upon the potential complexity and the degree of environmental impact associated with the planned works (Schedule A, B or C).

The requirements of Phases 1 and 2 of the *Municipal Class EA* process will have been satisfied for many of the recommended projects (those considered as a Schedule A). However, for some Schedule B projects, Phases 1 and 2 will need to be revisited. In addition, for Schedule B projects, it will be necessary to fulfill the consultation and documentation requirements. For identified Schedule C projects, the City will need to complete Phases 3 and 4 of the *Municipal Class EA* process.

2.0 Public / Agency Consultation

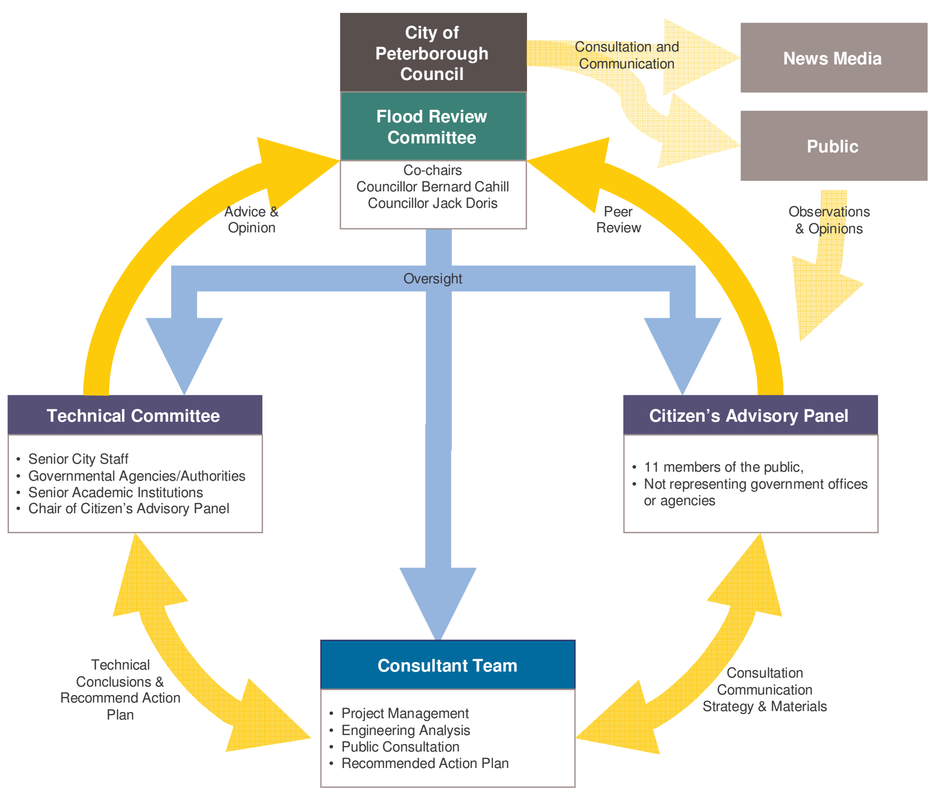
2.1 Consultation Approach

An integral component of the Study was building strong relationships with individuals and groups who are affected by the outcome. It was important proactively, collaboratively and candidly with all external agencies and interested stakeholders to meet the City's goal of reducing the risk of future flooding. Our approach was designed to fulfill the following objectives:

- Allow the general public, City Council, stakeholders and external agencies (both federal and provincial) to have an opportunity to participate in the study process as well as contribute to decisions at an appropriate time.
- Provide factual information to all affected/interested stakeholders as soon as reasonably possible, and
- Make contact with external agencies to obtain legislative or regulatory approvals, or to collect pertinent technical information.

Figure 3 identifies the interaction of study stakeholders.

Figure 3: Interactions of Study Stakeholders



2.2 Flood Review Committee

The Flood Review Committee (FRC) comprises all members of City Council and was co-chaired by Councillor Bernie Cahill and Councillor Jack Doris. FRC responsibilities included overseeing the completion of the Study and making recommendations to Council at milestone decision points as well as planning for funding expenditures for the completion of the Study beyond the scope of the approved work program.

2.3 Agency Consultation

2.3.1 Technical Committee

The Technical Committee (TC) consisted of representatives of key academic and governmental agencies involved in water resource management and public policy, and senior City staff. A list of members is provided below.

Table 1- Technical Committee Members.

Gerry Rye	Director, Utility Services Department	City of Peterborough
Malcolm Hunt	Director of Planning and Development	City of Peterborough
David Bonsall	Manager, Engineering & Construction	City of Peterborough
Peter Southall	Manager, Public Works Division	City of Peterborough
Chris Bradley	Director of Public Works	County of Peterborough
Paul Ford	Senior Hydroclimatologist	Environment Canada
Joe Gallivan		Ministry of Municipal Affairs and Housing
Robert Fox	Flood Warning System Program Leader	Ministry of Natural Resources
Allan Oberholzer	Supervisor	Ministry of the Environment
David Burritt	Watershed Engineer	Otonabee Conservation
Bruce Kitchen		Parks Canada
Lawrie Keillor-Faulkner	Professor	Sir Sandford Fleming College
Jim Buttle	Professor	Trent University

The TC was the primary resource group for the Consultant Team and provided the interface between the day-to-day technical functions required to fulfill the Study work program and the broader policy-based direction provided by the FRC. The TC provided input through a series of five (5) meetings at milestones (modeling, analysis, action plan) throughout the study. A copy of meeting agendas and minutes is provided in Appendix A.

2.3.2 Letters and Notices

The following letters and notices were sent the external agencies:

- Notice of Study Commencement – November 10, 2004
- Notice of Public Information Meeting # 2 – February 14, 2005
- Notice of Study Completion – March 31, 2005

2.4 Public Consultation

2.4.1 Citizen's Advisory Panel

The Citizen's Advisory Panel (CAP) was made up of 11 members of the public, not representing government offices or agencies on the Technical Committee. The recruitment process involved advertising in the *Peterborough This Week* and the *Peterborough Examiner* with a two week submission window. CAP members consisted of:

- Dave Barry
- Colin Campbell
- Ann Farquharson
- Brad Kalus
- Ron Lawes
- Don Mackay
- Deidre Moher
- Jean-Pierre Pawliw
- Doug Ryan
- Dhawal Shah
- Andrew Stevenson

The members of CAP selected Ann Farquharson as chairperson.

CAP provided input and advice on the study process and public consultation early in the process, and used its local knowledge and professional expertise to conduct a review of UMA's work on behalf of the community. A total of four meetings were held throughout the study process. A copy of meeting agendas and minutes is provided in Appendix A.

2.4.2 First Series of Public Information Meetings (PIM #1)

Five Public Information Meetings (PIMs) were held (one in each municipal ward) throughout the City of Peterborough between 5:00 p.m. and 9:00 p.m. for the general public. A newspaper notice of the meetings was published in the *Peterborough This Week* on September 16 and 23 and in the *Peterborough Examiner* on September 17 and 24. The following is a listing of the detailed locations and dates:

- Tuesday, September 28, 2004 at Kenner Collegiate Vocational Institute, Ward 1 – Otonabee
- Wednesday, September 29, 2004 at Calvary Church, Ward 2 – Monaghan
- Tuesday, October 5, 2004 at Northminster United Church, Ward 5 – Northcrest
- Wednesday, October 6, 2004 and Auburn Bible Chapel, Ward 4 – Ashburnham
- Thursday, October 7, 2004 at Murray Street Baptist Church, Ward 3 – Town

The first part of the meeting was a drop-in/roundtable working session from 5:00 p.m. to 7:30 p.m. that outlined the Study process, provided key information about the urban drainage network, and offered an opportunity to complete a Basement Flooding Survey for the July 2004 storm, and the previous June 2002 and July 1980 floods. The formal part of each evening was from 7:30 p.m. to 8:30 p.m. with a question and answer session led by UMA. The public commented on observed conditions, identified concerns, and asked questions.

The meeting was facilitated by Sue Cumming of Cumming + Company, an independent consultant engaged to facilitate the question and answer part of the public meetings. Representatives from UMA were present throughout the meeting to provide information, answer questions and receive comments from all participants. The public was encouraged to provide anecdotal evidence on what they had experienced. Many brought photographs and provided detailed information about the July 15th 2004 storm. All information was entered into the project Geographical Information System (GIS) database.

Specific display materials presented at the PIM included:

- City Storm System Plan
- City Sanitary System Plan
- Wet Weather Flow Schematic
  - How Flooding Occurs
  - Storm Sewer System
  - Overland Flow System
  - Sanitary Sewer System
- Ward 1 Overview Map
- Ward 2 Overview Map
- Ward 3 Overview Map
- Ward 4 Overview Map
- Ward 5 Overview Map

Display material was available after the public meeting through the project website. A copy of the display material and the Public Meeting Summary Report documenting the first round of public meetings is included in Appendix A.

In addition, Basement Flooding Surveys were made available to solicit feedback to understand how the City's storm, sanitary and overland flow systems performed under rainstorm events. Surveys were available to the public from October through to the end of January. A total of 403 were mailed in and another 26 were submitted though the project website.

2.4.3 Notice of Study Commencement

A Notice of Study Commencement for the Flood Reduction Master Plan was placed in the *Peterborough This Week* on November 19 and 26, 2004 and in the *Peterborough Examiner* on November 20 and 27. The Notice announced the commencement of the Master Planning Study and provided details regarding the process and solicited input from interested and affected parties. A copy of the Notice is provided in Appendix A.

2.4.4 Second Round of Public Information Meeting (PIM #2)

A second round of public information meetings was also held throughout the City by municipal ward. The following is a list of detailed locations and dates:

- Wednesday, February 23, 2005 at Grace United Church, Ward 1 – Otonabee
- Thursday, February 24, 2005 at the Evinrude Centre, Ward 2 – Monaghan
- Tuesday March 1, 2005 at the Northminster United Church, Ward 3 – Northcrest
- Wednesday, March 2, 2005 at the Auburn Bible Chapel, Ward 4 – Ashburnham
- Thursday March 3, 2005 at the St. James United Church, Ward 5 – Town

The meeting format was similar to the first round of public meetings with a drop-in format from 5:00 p.m. through to 7:00 p.m. The formal part of the evening began with a UMA presentation followed by a question and answer session facilitated by Sue Cumming of Cumming + Company. A copy of the presentation material and public meeting summary report is provided in Appendix A.

A Notice of the public meetings was published in the *Peterborough This Week* on February 11, 18 and 25 and in the *Peterborough Examiner* on February 12, 19 and 26. Direct notification letters were mailed out in advance of the PIM inviting applicable regulatory agencies, affected municipalities, and those who expressed an interest in the Project to attend the public meeting. The letters also provided a contact name if people required further information or had any questions. A copy of the notification letters and notice is provided in Appendix A of this Report.

The purpose of the second series of public meeting was to:

- Introduce participants to the Class EA process followed for Master Plan Projects,
- Present the causes of flooding,
- UMA analysis of the storm, sanitary and overland flow routes and
- Present the alternative solutions.

Representatives from UMA and the City were on hand to answer questions. The public were encouraged to fill out a Comment Form, to assist UMA in confirming the causes, prioritize works and identify additional alternative solutions. A total of 120 forms were received up until the cut off date of March 18, 2005.

2.4.5 Notice of Study Completion

A Notice of Study Completion for the Flood Reduction Master Plan was placed in the *Peterborough This Week* on April 1 and 8 and in the *Peterborough Examiner* on April 2 and 9. The Notice announced the completion of the Master Planning Study and provided details regarding the process to be followed and solicited input from interested and affected parties.

3.0 Drainage System Analysis

3.1 Urban Drainage Systems

Urban drainage systems are typically composed of a combination of swales, ditches, culverts, roadside curbs, catch basins, and storm sewers. Storm sewers are designed to convey most of the runoff from frequent rainfall events that would, on average, only be exceeded every 1, 2, or 5 years. Several factors impact on the capacity of storm sewer design such as:

i. The percentage of the drainage area assumed to be hard surfaced)formally 30%, now 45%),
ii. The frequency at which the design rainfall will be exceeded (formerly 1, now 5 years),
iii. The time before flows are captured into the system (formerly 20 minutes now 5 minutes),and
iv. The slope of the drainage area.

In addition to the storm sewer system, modern urban drainage design practice also considers a second drainage system consisting of the natural low points in the landscape to provide a continuous flow path to a suitable lake or river. This secondary system is often referred to as the overland flow or major system as it conveys the runoff from major rainfalls exceeding the design capacity of the minor system. The storm sewer system (pipes), are often referred to as the minor system as it conveys more frequent rainfall events.

Overland flow routes were not typically considered in design of urban drainage systems in Canada until the 1980's. Overland flow routes are designed to safely convey water that overflow from the storm sewer system, typically up to the 100-year event.

Sanitary sewers may also convey some rainfall. In most older cities, the sanitary sewers were designed as combined sewers where both sanitary sewage and storm runoff are conveyed in the same pipe. Peterborough is fairly unique among older cities, in that its sanitary sewers were not designed as combined sewers, but were only intended to convey sanitary sewage. However, until 1991, foundation drains where allowed to be connected to the sanitary sewer, consequently, a significant portion of the flow in the City's sanitary system is either groundwater or rainfall related.

The combination of the storm sewers or minor system, overland flow systems or major systems, and sanitary sewer system comprise the urban drainage network. Complications arise when the sanitary sewer system is interconnected with the storm / overland flow systems. Over time, roof leaders or downspouts as well as foundation drains or basement weeping tiles, have been connected to the sanitary system.

3.2 Causes of Flooding

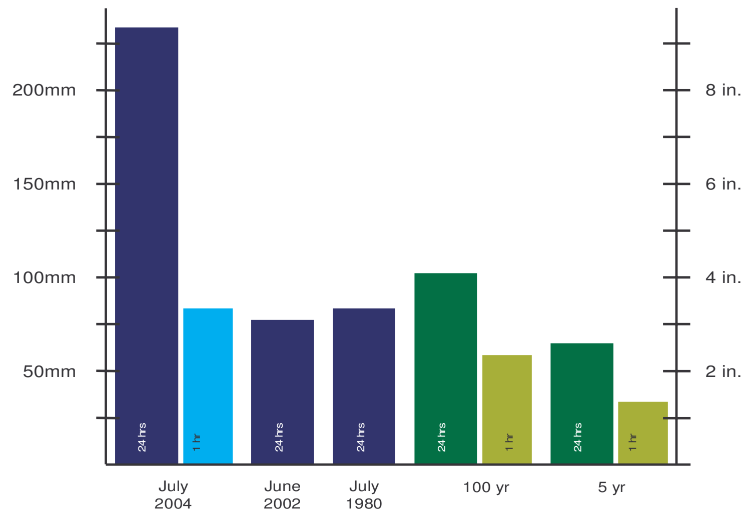
Based on the City-wide analysis undertaken as part of the Study, four main causes of flooding damages were identified and discussed below.

3.2.1 Extreme Rainfall Event

The intensity of the July 2004 storm event that impacted the City was more than twice the current design standard used by most municipalities. In fact, the City was inundated with almost the entire volume of a 24-hour, 100-year design storm in only 1 hour.

The July 2004 storm event was centred on the largely impervious downtown core, which contributed to the severe overland flows. **Figure 4** identified the July 2004, June 2002 and July 1980 storm events in blue, as well as the 100-year and 5 year design standards in green.

Figure 4 – Storm Events and Design Standards

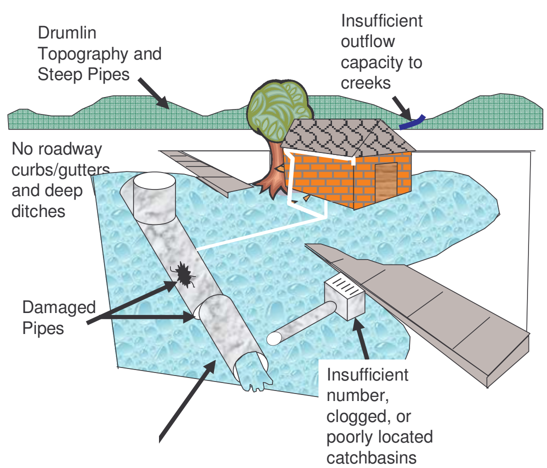


3.2.2 Insufficient Storm Sewer Capacity

Insufficient storm sewer capacity results in increased duration and rate of overland flows. Key contributing causes of insufficient storm sewer capacity are identified in **Figure 5** and include:

- Not all roadways enable efficient inflow of water to the storm sewer system due to lack of curbs and gutters or deep ditches, and an insufficient number of, or poorly located catchbasins; and
- Not all pipes are sized to the current 5-year design standard, causing “bottlenecks” in the conveyance of the system.

Figure 5 – Insufficient Storm Sewer Capacity

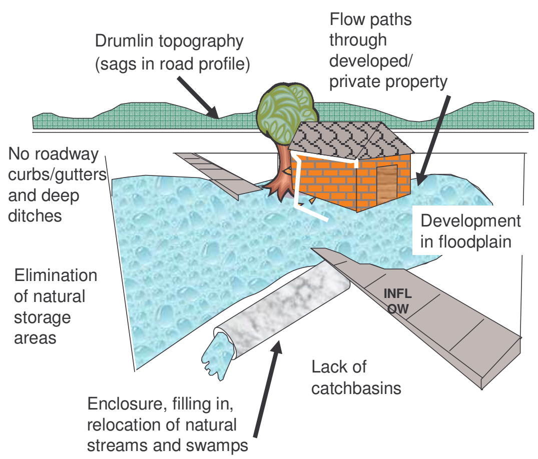


3.2.3 Poorly Defined Overland Flow Routes

Poorly defined overland flow routes resulted in erosion and property damage and are identified in **Figure 6**. Key contributing causes include:

- Enclosure, filling in, or relocation of natural watercourses and swamps without defining or building alternate conveyance and storage functions,
- Development on the floodplain or on low points in the landscape, which were once natural watercourses or swamps, and
- Not all roadways enable efficient conveyance of water due to lack of curbs and gutters, deep ditches, or grading of adjacent lands.

Figure 6 – Poorly Defined Overland Flow Routes

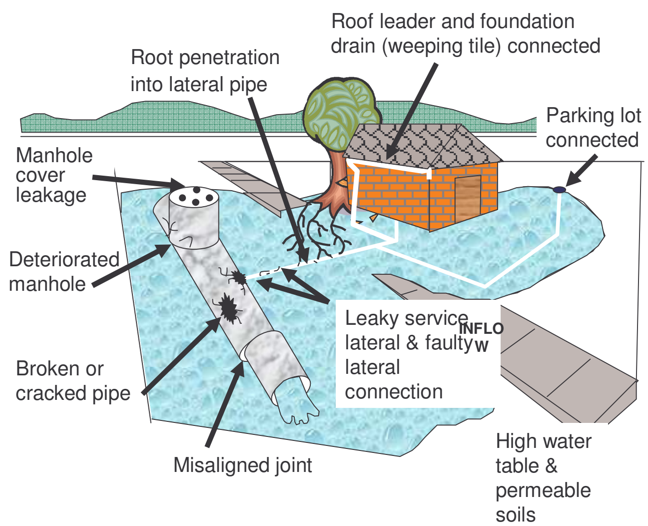


3.2.4 Unwanted Water Getting into Sanitary System

Unwanted water getting into the sanitary system results in basement flooding and wastewater treatment plant bypass. Key contributing causes are identified and **Figure 7** and include:

- Interconnections between the storm and sanitary systems, through inflow through sanitary sewer manhole covers,
- Foundation drains were legally connected to the sanitary system in the City until 1991. This source could contribute up to 100 times the typical domestic usage,
- Roof leaders or downspouts illegally connected to the sanitary system in the City, and
- Groundwater inflow into the sanitary system through damaged or misaligned sanitary sewer pipes.

Figure 7 – Unwanted Water into Sanitary System



3.3 System Analysis

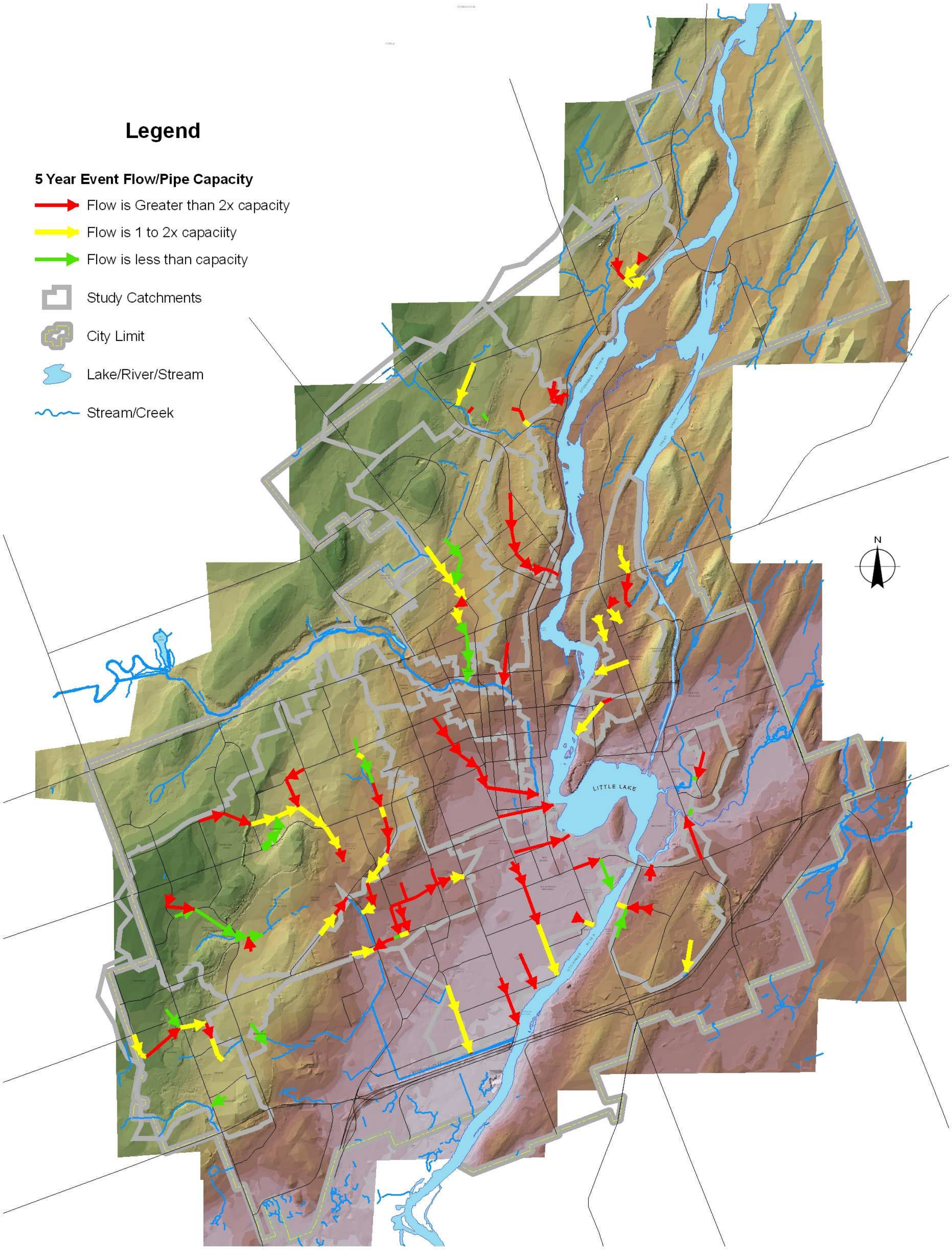
3.3.1 Storm Sewer System

The modeling approach used provides a screening tool to identify both major overland flow requirements, and relative levels of storm sewer service throughout the City. All storm sewer networks draining more than approximately 20 ha were modelled to provide a schematic of the City's trunk storm sewer system (**Figure 8**).

The schematic model represented a number of hydraulically similar pipes with one "schematic" pipe. Catchment boundaries were delineated based on property lines, elevations & contours, and sewer shed limits. Available aerial photographs were used to determine a number of factors including surface topography, pipe slopes, and catchment impermeability, slope and width. Pipe diameters and slopes were obtained from as-built drawings for every modeled pipe. The effectiveness of the trunk schematic model was verified by a "fine" model by modeling all pipes in one area. It was found through this comparison, that our trunk schematic or coarse model is more conservative and therefore appropriate for the screening level analysis required for this Study. This modelling approach is consistent with the City-wide master planning level of this Study and the coarseness of the input information available from the City.

Based on the trunk schematic modeling, we concluded that the majority of the City's trunk storm sewers (82%) do not have enough capacity to convey flow from a 5-year storm event – the City's design standard and the most widely used standard in the province. The result is that parts of the storm sewer system act as bottlenecks, resulting in more overland flows over public roadways and private property.

Figure 8 Storm Trunk System Schematic



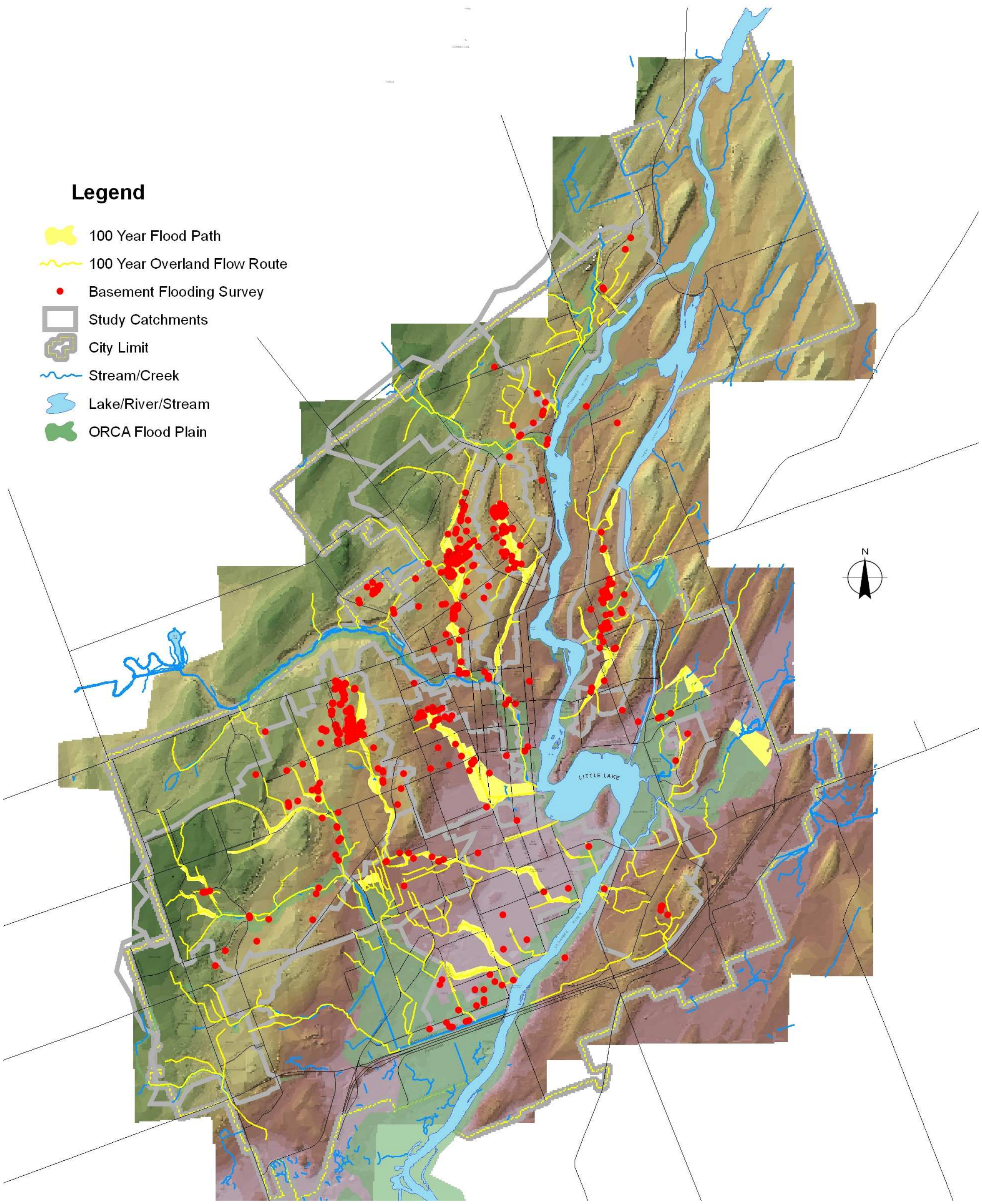
3.3.2 Overland Flow System

During heavy rainfall, water that does not flow into or through the storm sewer system (i.e., the storm pipes) spills overland and flows along the low points in the landscape – whether that be across public property such as down the road or across private property. Until approximately 20 to 30 years ago, consideration of where storm sewer system “overflow” (major system flows) went or its impacts, were not common Engineering practice.

Analysis of overland flows was undertaken by applying a 100-year storm event to the trunk storm system model discussed above. The path and width of flows exceeding the capacity of the storm sewer system was based on coarse contours of the City’s landscape. The overland flow analysis was verified by comparison with the Basement Flooding Survey results and ORCA flood lines.

Based the modeling, overland flow paths for the 100-year storm event were found to be as shown in **Figure 9**. Over 225 properties in the City are vulnerable form a 100-Year storm event.

Figure 9 100-Year Overland Flow Schematic



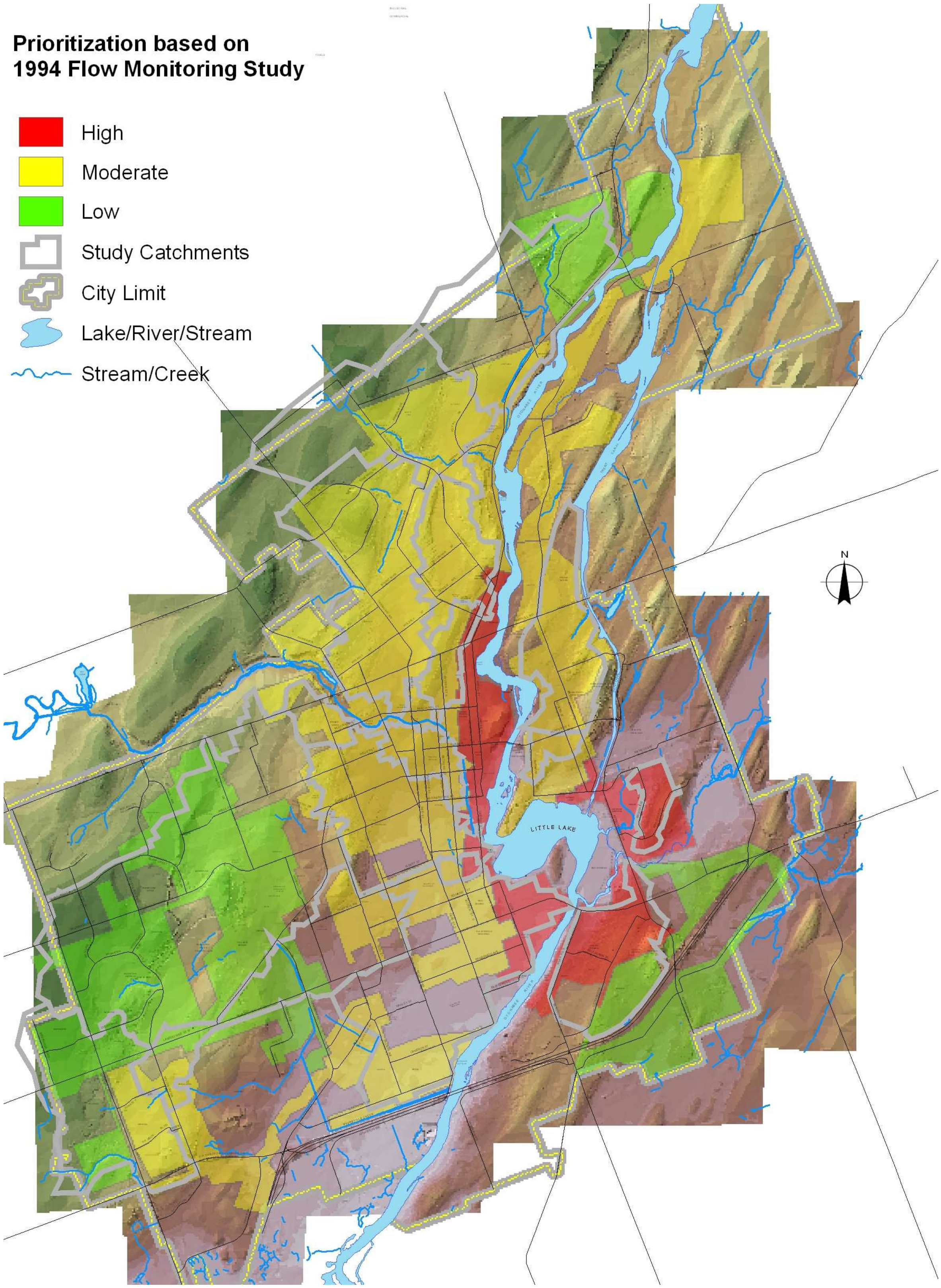
3.3.3 Sanitary Sewer System

In "dry" weather, the wastewater treatment plant receives approximately twice as much water as the public utility commission (PUC) water treatment plant may reasonable be assumed used within City residents homes. In "wet" weather, this number climbs to six or more times the PUC water delivered.

The screening approach used for the sanitary sewer system focused on the unwanted water flows getting into the system. Since Peterborough's sanitary sewer system is not/ was not designed as a combined sewer system, analysis of system wet weather flows will require data on the location/source, and rainfall relationship of the unwanted flow or infiltration/inflow plaguing the city's sanitary sewer system.

We used the Flow data provided in a 1994 Gore and Storrie Report to categorize the City's 17 different sewer sheds based on unwanted (extraneous) flow information relative to City criteria and MOE guidelines for inflow and infiltration (**Figure 10**). The City's downtown core and East City were found to have very high levels of unwanted water getting into the sanitary sewer systems. These areas generally have older sewers and are located closer to the river where groundwater levels are higher. The areas where the inflow and infiltration is within standards are generally the high elevations in newer parts of the City, away from the downtown core.

Figure 10 Sanitary Sewer System



3.3.4 Impact of Development, New Growth and Infill

As an adjustment to the study, the City asked UMA to review and provide recommendations on several development applications. We provided comments on the potential impact of the proposed developments on existing drainage infrastructure and provided recommendations so that the proposed development will not have an adverse impact on the frequency or magnitude of downstream flooding.

New development will add to the load on the storm sewer, overland flow, and sanitary sewer systems. Historically, the City has required the stormwater management system for new developments to comply with current development control requirements, but did not have the tools to consider the impact of additional upstream flows on downstream flood susceptible areas. We recommended that the City over-control post-development flows, as required, to decrease the frequency and magnitude of downstream flooding. In addition, unless an overland flow route can be demonstrated to have sufficient capacity to safely convey flows to the river without impacting upon private property, overland flows should be contained on site.

4.0 Alternative Solutions

Based on our analysis, we identified the following "toolbox" of potential solutions. The City will select the appropriate set of "tools" to help reduce the risk of damage from future flooding, depending on the specifics of the problem at various locations across the City. In the case of follow-on studies, the City will prioritize the work.

4.1 Storm System

4.1.1 Detailed Storm and Watercourse Flood Reduction EA's

How contributes to problem: The analysis undertaken for the Master Plan determined and quantified drainage system deficiencies on a city-wide basis. The identification of specific local alternative solutions will require more detailed information/analysis and the presentation of specific alternative solutions to the public.

How this resolves the problem: Detailed site-specific drainage studies provide:

- A means of identifying alternative local solutions,
- Assessment of the impact of alternative solutions on downstream areas,
- Public and agency input on specific alternative solutions,
- Selection of the most cost effective solution and
- Identification of specific interrelationships between identified alternative solutions.

Pros and Cons:

Detailed site-specific studies will:

- Provide the best long term drainage solution,
- Ensure that upstream drainage improvements do not result in additional downstream flooding,
- Incorporate public and agency input and provide EA approved preliminary engineering drawings of the preferred alternative.

However, the preparation of detailed site-specific studies will require:

- A large amount of detailed information (substantial amounts of which are currently not available)
- A period of months to a year or more to complete and
- May require the replacement of relatively new downstream infrastructure.

4.1.2 Watercourse Management, Access and Maintenance Plans

How this contributes to problem: Manmade or altered watercourses are generally not self maintaining as sediment transport has only recently been added to the design process. Periodic removal of accumulated sediments / debris from manmade / altered creeks within City boundaries will therefore be required until such time as the creeks can be redesigned in accordance with natural channel design principles.

Currently sediments and debris are carried into the creeks by runoff and deposited in locations where flow velocities slow down (for sediments) or at constrictions such as bridges and culverts (for debris). The deposition of material within stream channels will reduce capacity and increase the frequency of the watercourse overtopping it's banks and causing flooding

How this resolves the problem: Ensuring that there are clearly defined actions to access the watercourse in order to facilitate removal of accumulated sediments / debris and restoration of failed bank stabilisation works, will maintain creek capacity and reduce the frequency of bank overtopping / flooding.
.

Pros and Cons: Removal of accumulated sediments and debris and restoration will restore creek capacity and reduce the frequency of bank overtopping / flooding. However restoration of bank stabilization works may be short lived as the Detailed Storm and Watercourse Flood Reduction EA's are likely to require some alterations to the existing creek channel configuration.

4.1.3 City-Wide Policy Review

Storm Drainage Design Standards

How this contributes to problem: Municipal storm drainage design standards assume a consistent level of service. In locations where existing downstream sewers were designed to a lower standard than new works, the frequency of downstream overland flows / flooding will be worsened by the enhanced upstream capacity.

How this resolves the problem: The dilemma facing Peterborough is not unique and is/has been faced by and by other municipalities. Updating standards to consider factor in area specific control rates will ensure that downstream overland flow and storm sewer drainage limitations are appropriately considered.

Pros and Cons: Updated development and design criteria will help to ensure that development does not cause adverse flooding/drainage impacts to existing residents. However, the occurrence of storms in excess of the selected design standard may still result in increased downstream flows/flooding.

Environmental Constraint Analysis and Mapping

How this contributes to problem: Though the concept of setting aside "green" areas on the landscape for passive human use or for environmental protection purposes has been around for many years, it wasn't until the 1970s that municipalities began to incorporate the environment into planning. Consequently, development was often allowed to occur within areas susceptible to flooding or to natural hazards, such as valleylands and floodplains.

How this resolves the problem: Valleylands, watercourses and their associated floodplains, as well as hazard lands constitute an integral part of the natural water-related ecosystem. Consequently, these natural features and functions represent a constraint to development in the form of their physical hazard, but also an opportunity to preserve or restore these predominately natural areas.

To accommodate further growth within the City, an environmental constraint analysis is required to formulate a constraint map that clearly identifies areas within the City's boundaries where future development should or should not occur. This will enable the City to best manage growth while simultaneously minimizing future flood damages through non-structural solutions. This is accomplished by identifying the areas at risk and then discouraging inappropriate development in these areas.

Pros and Cons: Once the constraint areas are mapped, they can be so designated within the City's Official Plan thereby protecting these areas from future development, while preserving their unique, unusual or high quality environmental characteristics.

4.1.4 Sewer Maintenance Program

How it contributes to problem: Like most Cities Peterborough sets priorities for the sewer maintenance and inspection activities based upon the personal experience of the maintenance staff as to potential problem spots. Consequently not all sewers will be inspected.

How this resolves the problem: Optimizing the planning, prioritization, and scheduling of sewer maintenance and inspection activities through the effective use of sewer system attribute, condition, and work record information will maximise the chances of preventing problems from occurring.

Pros and Cons: A proactive work program will maximise the chances of preventing problems before they occur, however a period of time may be required to fine tune the program.

4.1.5 Emergency Preparedness and Response

How this contributes to problem: The central coordination of departments and agencies involved in the flood response is vital for the safety of the community in the event of flooding in the future. The City's Emergency Management Plan will be reviewed in terms of scope and mandate and will address such factors as the coordination of dam owners upstream of the City.

How this resolves the problem: The intent of updating the City's Emergency Management Program is to ensure that lessons learned are recorded and acted upon. City officials and staff and the public will be better prepared to respond to future flood emergencies, should they arise.

Pros and Cons: The City will be better prepared to respond to future situations.

4.1.6 Public Awareness Program

How it contributes to problem: When residents don't understand how their actions contribute to the problem it is difficult to bring about change or a shift in attitudes. A coordinated communication program delivered across a variety of media such as themed newsletters, a website and through volunteer or school groups will convey the messages on what can be done. Simple measures such as ensuring raked leaves and grass clipping are kept clear of catchbasins will improve the operation of the sewer system.

How this resolves the problem: Informed residents can implement flood reduction measures to protect their homes and property from future risk of damage.

Pros and Cons: The advantage of this program is that it shows the city is taking action to educate residents on what they can do for themselves. The disadvantage is the success of the program is dependent on the level of residents participation.

4.1.7 Additional Catch Basins

How contributes to problem: The analysis undertaken for the Master Plan and site visits determined that the capacity of the existing storm sewers cannot be fully used because there are not enough catch basins to capture runoff.

How this resolves the problem: The installation of additional catch basins upstream of and along pipes determined to have adequate capacity, will allow the capacity of the existing storm sewer system to be more fully used. This in turn will reduce the amount and frequency of overland flow.

Pros and Cons: Installing additional catch basins will more effectively capture runoff and reduce overland flows. However, care must be taken to ensure that sufficient capacity exists downstream, or the additional flows being captured will worsen downstream flooding.

4.1.8 Flood-Proofing Private Property

How contributes to problem: Properties located within overland flow routes or Conservation Authority flood lines will be susceptible to flood damages.

How this resolves the problem: Flood proofing of properties can provide a cost effective means to reduce potential flood damages

Pros and Cons: Flood proofing of properties reduces flood damages, however storms which exceed the limits of the flood proofing will still cause flood damages.

4.1.9 Reline Pipes

How contributes to problem: Deteriorated / cracked pipes may have less capacity through increased roughness or additional ground water flow.

How this resolves the problem: Relining pipes provides a means to restore pipes without having to dig up the roadway

Pros and Cons: Relining can improve structural strength and reduce groundwater flow within storm sewers, however removing groundwater from storm sewers may increase groundwater inflow into the sanitary sewer system.

4.1.10 Improve Outfalls

How contributes to problem: Elevated water levels above the top of pipes in receiving streams will reduce the capacity of the storm sewers system.

How resolves the problem: Twinning, reconstructing or re-routing storm outfalls to eliminate the negative effects of elevated outlet water levels will increase overall storm sewer capacity.

Pros and Cons: Improving outlet capacity can be a cost effective means to improve overall storm sewer capacity. However, outlet improvements will only be effective where the outlet capacity is the weakest link.

4.1.11 Provide New Storage Ponds

How this contributes to problem: Capacity limitations within the existing storm sewer system contribute to increased frequency and severity of overland flows/flooding.

How this resolves the problem: Enlarging or creating new stormwater management ponds provides a means of reducing flow rates and the frequency and severity of flooding.

Pros and Cons: New or enlarged stormwater management ponds will reduce downstream flows/flooding. However, storms in excess of the pond design, will still cause flooding.

4.1.12 Re-Engineer Roadway

How this contributes to problem: The lack of consistent ditches/ditch inlets and/or curb and gutters reduces the effectiveness of the roadways both as a means of conveying runoff into the storm sewer system and as a way of containing runoff within the roadway.

How this resolves the problem: Rebuilt roadways with either consistent ditches/culverts or curb and gutter drainage will increase capture to the storm sewer system and conveyance along the roadway.

Pros and Cons: Rebuilt roadways will potentially improve storm sewer and overland flow conveyance. However, reconstructing roadways for hydraulic considerations alone may not be cost effective when other requirements such as traffic, utility and roadway life cycle costs are considered.

4.1.13 Twin Pipes and/or Increase Pipe Sizes

How this contributes to problem: The analysis undertaken for the Master Plan indicated that a significant number of the City's storm sewer pipes have less than half the required 5 year capacity.

How this resolves the problem: Twinning pipes, or increasing pipe sizes provides a means to increase pipe capacity to the City's design standard.

Pros and Cons: Twinning pipes will increase capacity and reduce flooding problems along the new sewer. However, if pipe twinning is not based on a detailed study, downstream flooding may be made increased.

4.2 Sanitary Sewer System

4.2.1 Smoke Testing

How this contributes to problem: Illegal/improper connections of roof drains and catch basins to the sanitary sewers results in excessive flows at the treatment plant, sewer surcharging and basement flooding.

How this resolves the problem: Smoke testing of sanitary sewers provides a relatively quick means to identify catch basins and roof drains which are illegally/improperly connected to the sanitary sewer. Once illegal connections are identified, measures can be initiated to remove them.

Pros and Cons: Smoke testing is a quick and effective means to identify the majority of illegal/improper connections, however smoke testing will not identify connections with a trap on them; 'trapped connections' will require dye testing to be identified.

4.2.2 Detailed Sanitary Sewer Study

How this contributes to problem: Flow monitoring work previously undertaken by the City and comparison of population figures, PUC water plant output and City wastewater treatment plant flows indicate that an excessive volume of unwanted flow is entering the City's sanitary sewer system.

How this resolves the problem: A detailed sanitary sewer study examining rainfall, in-sewer flows, groundwater elevations, soil types, water consumption data, and sewer pipe capacity is required to precisely determine the nature, location & source of inflows to the sanitary sewer system, and monitor the success of remedial measures.

Pros and Cons: Identification and elimination of unwanted flow into the sanitary sewers will greatly reduce incidents of basement flooding and increase available capacity at the treatment plant, however reduction of unwanted sanitary system flows is notoriously difficult and will take a multi-year program to achieve.

4.2.3 Disconnect Downspouts and Parking Lot Drains

How contributes to problem: During rainfall events, flows within the sanitary sewer system have been noted to be 6 or more times water consumption. Excess flow within the sanitary sewer system causes basement flooding, and places an unnecessary load on the treatment plant.

How this resolves the problem: Individual downspouts and parking lot drains can account for up to 100 times the flow that would be produced by a typical household. The removal of downspouts and parking lot drains from the sanitary sewer system will remove a significant source of unwanted flow from he sanitary sewer system.

Pros and Cons: Removal of connected downspouts and parking lot drains will reduce the frequency of basement flooding and lessen the load on the treatment plant, however identification and rerouting of connected downspouts and parking lot drains, will require a sustained effort.

4.2.4 Disconnect Foundation Drains and Install Sump Pumps

How this contributes to problem: Foundation drains connected to sanitary sewer systems deliver unwanted rainfall and groundwater to sanitary sewers. In high water table areas, the amount of water from this source could be significantly more than the normal household water use. Disconnection would prevent this unwanted water from reaching the sanitary sewer system.

How this resolves the problem: Disconnection involves installing a sump pump in each home with a disconnected foundation drain. The sump pump would then direct stormwater and groundwater overland either into overland flow swales or into the storm sewer system, thereby reducing the volume of water entering the sanitary sewer system.

Pros and Cons: Flows to the sanitary sewer system are reduced, as are costs associated with the unnecessary treatment of rainwater, and the frequency of basement flooding. A disadvantage is that it requires construction in basements and on private property and lawns, which can be difficult. Also, homeowners are responsible for maintaining the sump pumps, and the sump pump discharges require an outlet to prevent nuisance water around homes and on sidewalks and streets. Power failures during large storms and provision of alternative-powered backup sump pumps are often a concern to residents.

4.2.5 Seal Manhole Covers

How contributes to problem: During rainstorm events manholes located at low points within roadways can account for 10 or more times the flow that a typical household would.

How this resolves the problem: Sealing manhole covers to prevent rainwater from getting into the sanitary sewer system will reduce the frequency of basement flooding and the load on he treatment plant.

Pros and Cons: Sealing manholes located at low points within roadways provides a quick and simple means to reduce unwanted flow within the sanitary sewer system, however care must be taken to ensure that adequate ventilation of the sewer system is maintained, and that sealed manholes are resealed upon completion of routine maintenance activities.

4.2.6 Install Backflow Preventers

How contributes to problem: Excessive unwanted flow within the sanitary sewer system can result in basement flooding.

How this resolves the problem: Where the sources of the excessive unwanted flow within the sanitary sewer system can not be identified and removed, the installation of backflow preventers can keep sanitary sewage out of basements.

Pros and Cons: Backflow preventers can provide an effective means of keeping sewage out of basements, however they must be installed and maintained properly to function as required, and will be much more effective when used in combination with a sump pump and foundation drains disconnected from the sanitary sewer.

5.0 Decision-Making for Priorities

5.1 Decision-Making Rationale

Making decisions on how best to reduce the risks of flooding in the City presents significant challenges for the following reasons:

- The interconnectivity of the storm sewer, overland flow and sanitary sewer systems;
- The potential for impact of upstream flows on downstream capacity and visa versa; and
- The reality of limited financial and other resources.

How does the City determine which alternative solutions to apply, to which systems, in which parts of the City, and in what order? This section of the report describes the rationale for making these decisions so that the reader may trace the steps and replicate the conclusions. Note that the first question: *Which alternative solutions?* is addressed as part of the next phase of the Flood Reduction Program.

Recall the opportunity statement:

Basement flooding is caused by excessive unwanted flow entering the sanitary sewer system, and uncontrolled overland flows. The basement flooding is associated with both extreme and less severe storm events and is caused an unacceptable frequency and magnitude of damages. To reduce the risk of damage caused by flooding, improvements to the operation of the storm drainage system (both storm sewer and overland flow systems) and the sanitary sewer system, are required.

We have identified the following broad public objectives:

A. **Meet Public Priorities for Flood Damage Protection:** Where is the public's greatest concern for protection from flood damage? Against damages resulting from (i) insufficient storm sewer capacity, (ii) poorly defined overland flow routes, or (iii) unwanted water getting into the sanitary system.

B. **Provide Consistent Level of Service City-Wide:** The premise is that all parts of the City should receive a consistent level of protection against damage from future flooding. This can be measured by evaluating the existing capacity against the City's standard: 5-year design standard for storm sewer system, 100-year design standard for overland flow, and MOE inflow/infiltration guidelines for sanitary sewer system.

C. **Provide Best Value for Money:** Provision of the best return on investment (ROI) for the City as measured by the highest benefit/cost ratio.

5.2 Which Systems

To help determine the City's priorities for reducing future flooding, we asked the public to rank the following five statements as part of a Comment Form provided at the second set of Public Information Sessions:

- Ponding on private property
- Ponding on public roadways
- Basement flooding from sanitary sewage
- Basement flooding from storm water
- Erosion and property damage from overland flows

The public has set preventing basement flooding with sanitary sewage as a priority.

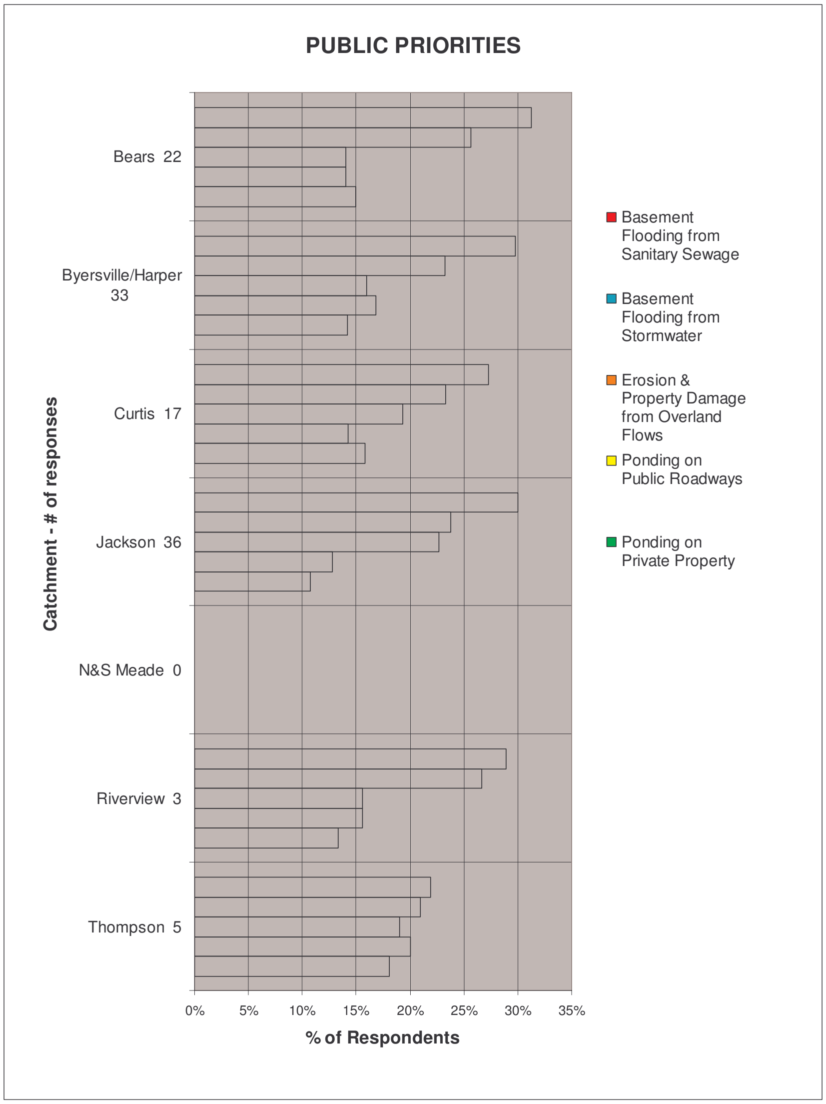
The chart to the right (**Figure 11**) displays the information collected from the Comment Forms and shows, consistently across the City, that the public's priorities are:

- Basement flooding from sanitary sewage (29% of respondents – City-wide)
- Basement flooding from stormwater (24%)

Followed by:

- Erosion and property damage from overland flows (18%)
- Ponding on public roadways (15%)
- Ponding on private properties (14%)

Figure 11 Public Priorities for Flood Damage Protection



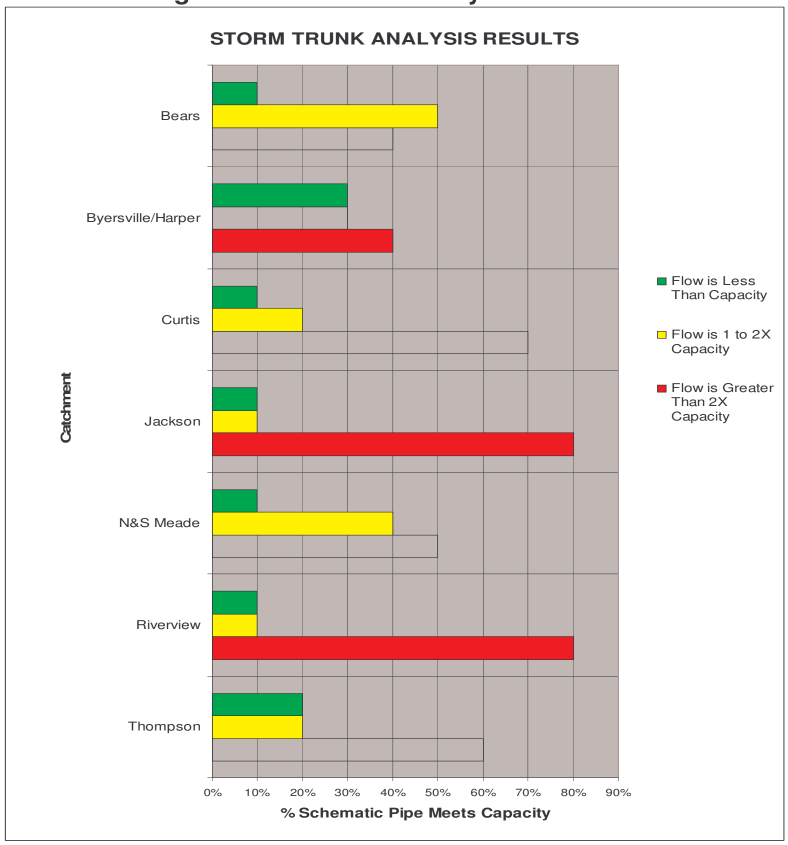
5.3 Which Parts of the City

We investigated the ability of the City's existing storm sewer system to protect against a 5-year storm event (the current storm sewer design standard for most municipalities including the City).

Three City catchments are in need of urgent attention to storm sewer capacity: Jackson, Riverview, and Curtis.

The chart to the right (Figure **12**) displays a summary of our schematic trunk sewer analysis, within each of the catchments (recall the Schematic Storm Sewer System diagram – Figure 8, from Section 3). For each catchment, the bars show the percentage of analyzed trunk storm sewer that fall into one of three categories:

Figure 12 Trunk Storm System Schematic Results



- GREEN when pipes analyzed met the 5-year design capacity (good),
- RED when pipes analyzed had flow greater than two times capacity (bad), and
- YELLOW when pipes had flow somewhere between one and two times capacity.

The chart shows that the priority for improvements to the storm sewer system, based on bringing the existing pipes to current design standards consistently across the City, should be as follows:

- Jackson and Riverview (80%)
- Curtis (70%)
- Thompson (60%)
- N & S Meade (50%), followed by
- Bears and Byersville/Harper.

To determine the priority areas for the overland flow system, we looked at the susceptibility of properties to damage from a 100 year storm event (the current overland flow design standard for most municipalities including the City).

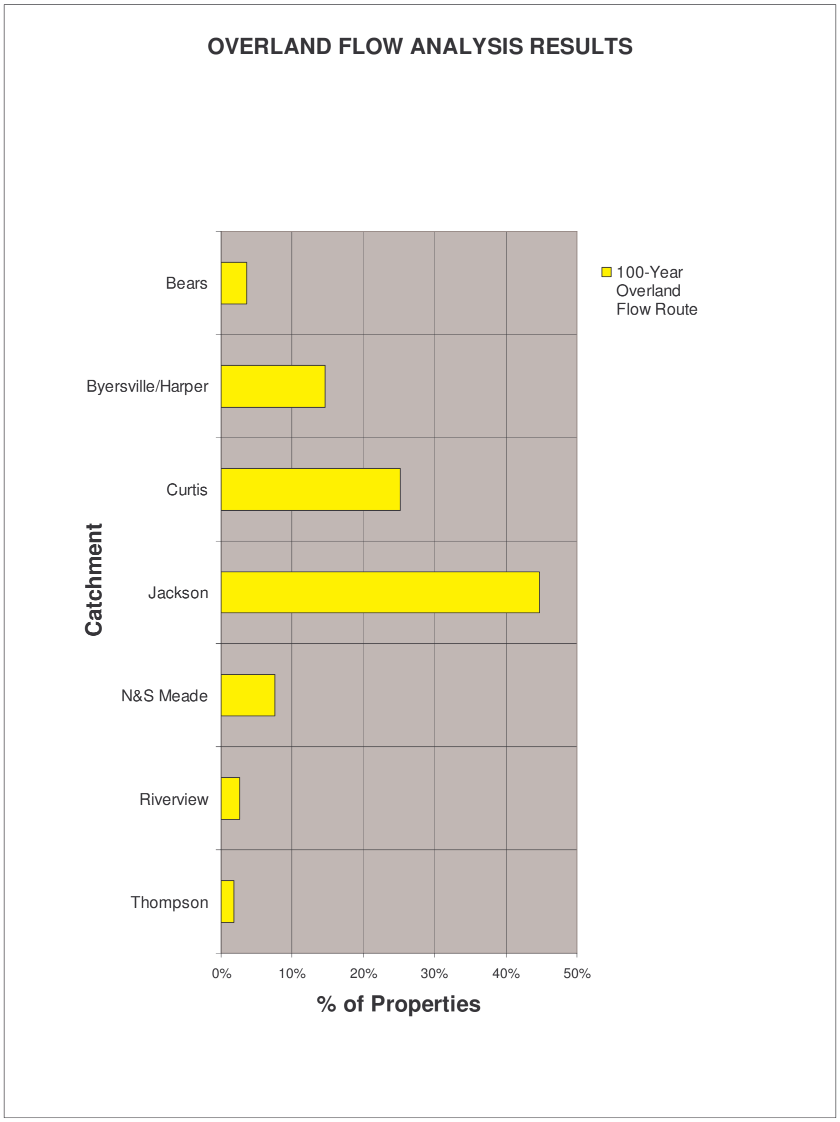
Three City catchments are in need of urgent attention to controlling overland flow: Jackson, Curtis, and Beyersville/Harper.

The chart to the right (Figure x) displays a summary of our schematic overland flow route analysis, within each of the catchments. We determined the number of properties within the Schematic Overland Flow Routes shown on Figure 9, from Section 3. The YELLOW bars represent the properties within the 100-year overland flow route area, catchment expressed as a percentage of total City-wide.

The chart shows that the priority for improvements to the overland flow system, based on number of properties vulnerable to flood damage, should be as follows:

- Jackson (100 properties)
- Curtis (55 properties)
- Byersville/Harper (30 properties)
- N & S Meade (13 properties), followed by
- Bears, Riverview, and Thompson (each less than 10)

Figure 13 100-year Overland Flow Schematic Results



5.4 Which Order

We summarize the prioritization of works as follows:

- The public has set preventing basement flooding with sanitary sewage as a priority.
- Four catchments are in need of urgent drainage system attention:
    - Jackson,
    - Curtis,
    - Beyersville/Harper, and
    - Riverview.

We have combined the storm sewer and overland flow systems because of the interconnectivity of these systems. Although Riverview is a storm sewer system priority, we placed it fourth in priority when combining the storm sewer and overland flow systems because it is less vulnerable to overland flow damage than the other three catchments.

6.0 Recommended Action Plan

6.1 Overview

To improve the operation of the City's drainage and sanitary systems, we identified a "toolbox" of potential solutions. The appropriate set of "tools" or solutions to help reduce the risk of future flooding damage varies across the City. This Study provides the overall action plan, called the Master Plan, to determine which solutions to apply, to which systems, and in which parts of the City.

6.1.1 Detailed Task Outline

The Master Plan maps out the broad steps to reduce flooding damages in the City and details the short term activities required to begin the journey. **Figure 14** shows a summary of the broad steps of the Master Plan. Each of these broad steps is important to achieving the overall objective of reducing the risk of flood damage, as follows:

- **Program Management:** To lead and manage the Master Plan, including planning for funding, coordinating parts of the plan, and facilitating city-wide and inter-related system decision-making – which solutions to apply, to which systems, in which parts of the City.
- **Information Gathering and Field Work:** To collect the required information and field data to enable the required detailed local-level studies.
- **Detailed Study and Environmental Assessment:** To develop and screen alternative flood reduction solutions to select the preferred solution and confirm feasibility.
  - Review and change, as required, ***city-wide policies and procedures*** for development and design, emergency preparedness and response, public awareness, and watercourse and sewer system maintenance.
  - Conduct ***detailed catchment-based storm system and watercourse studies*** to determine the preferred flood reduction solution, with appropriate environmental assessments, and considering both the urban drainage system and watercourses.
  - Conduct a ***detailed city-wide sanitary system study*** to determine the causes of unwanted water getting into the sanitary system and select remedial measures.
- **Design and Contract Documents**: To work out the details of the selected solution so that it will function as required and can be constructed.
- **Tendering and Construction:** To build the works.

6.1.2 Schedule

As the City is currently at risk of damage in the event of future storms, it is important to begin the Master Plan immediately and progress through the steps quickly and systematically. However, timing is driven by the duration of each of the steps, the requirement that certain steps must take place before others, and available funding. **Figure 15** shows a summary of the ***earliest possible timing*** for the Master Plan, based on the duration and relationships of the steps, and assuming unlimited availability of funds and other resources. It is common tendency, in an attempt to speed up the Master Plan, to skip steps but this may add to the cost of later steps or increase the risk of flood damages in other areas of the City.

This Master Plan provides the broad steps to reduce flooding damages – it converts our Study analysis into inter-related action steps. It is **very important** to begin the Master Plan immediately and maintain the momentum over a number of years. Beginning immediately enables earliest possible provision of quick wins and longer term solutions.

Figure 14 Flood Reduction Action Plan

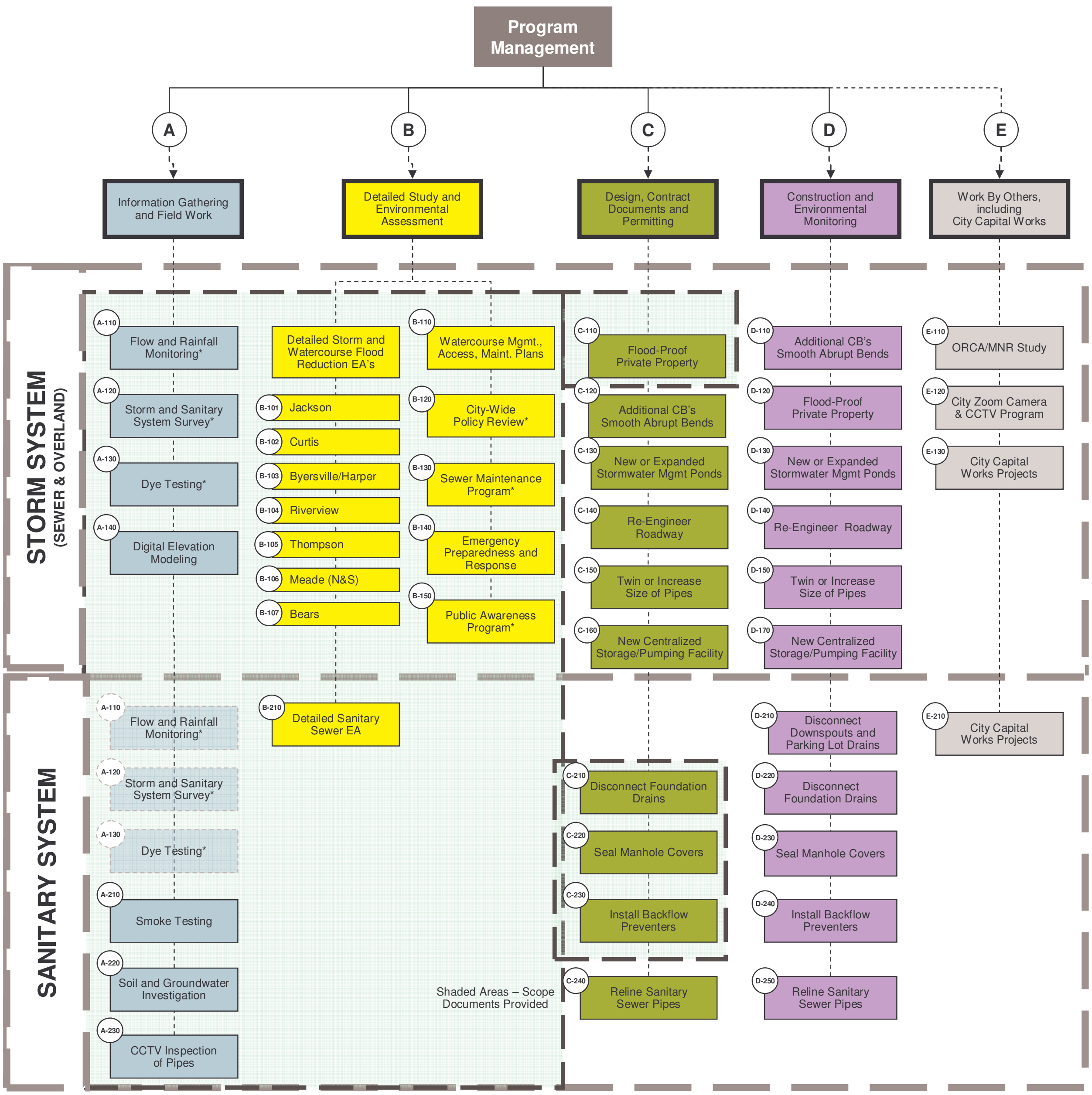
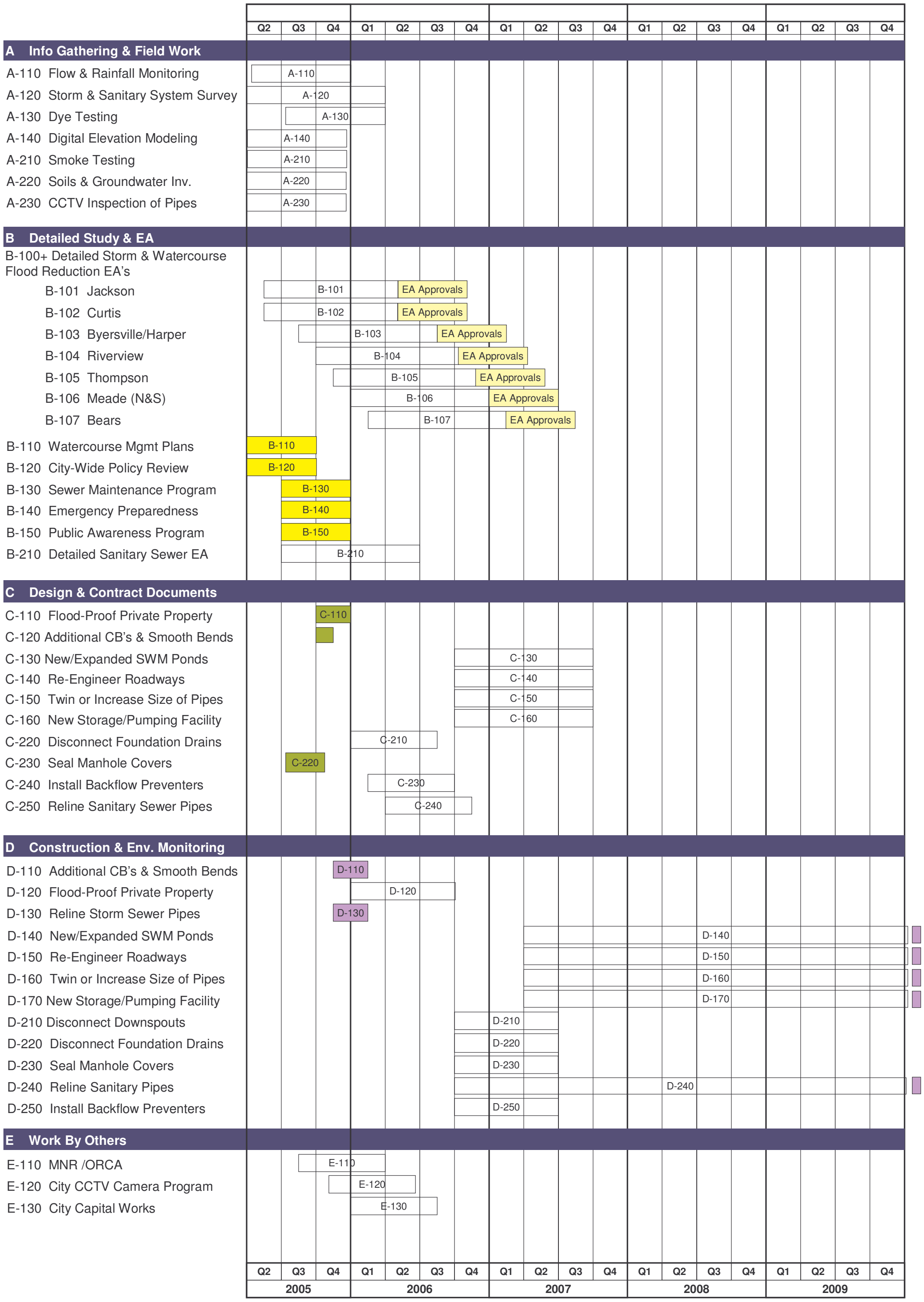


Figure 15 Flood Reduction Schedule



6.1.3 Program Management

Purpose:	To lead and manage implementation of the Master Plan, including controlling the scope-cost-time parameters, integrating the different components, and balancing various stakeholders' needs.
Inputs:	• Flood Reduction Master Plan Report
Activities:	The following basic elements will be addressed in the project management procedures and systems: • **Integration** - Provide a single point of contact to interface with stakeholders. - Integrate program components and focus decision-making on the best overall solutions to meet objectives. - Refine the action plan provided in the Flood Reduction Master Plan including scope, budget and schedule expressed as a program of design and construction packages; plans for management of communications, risk, the environment, and quality; and roles, responsibilities and authorities of stakeholders. - Continuously identify issues and resolve conflicts. - Efficiently collect and filter relevant information for decision-making. • **Scope, Cost and Time Management** - Develop detailed and realistic baseline control documents for scope, cost and time, including sources of funding and resources. - Continuously monitor and forecast against baseline scope, cost and time. - Take corrective action, as required. - Establish a change management process. - Report on project progress and performance. • **Communications Management** - Identify program objectives and scope, lines of communication, and stakeholder roles, responsibilities and authority. - Conduct stakeholder consultation to meet the requirements of the Municipal and Canadian Environmental Assessment Acts. - Set program documentation procedures for filing, printing, and distribution. • **Quality Management** - Develop and communicate a quality management plan that outlines tasks, responsibilities, and documentation requirements. - Plan and arrange peer reviews and value engineering studies. • **Risk Management** - Identify and quantify all risk factors, decide on appropriate risk responses, and develop a risk management plan. - Periodically monitor the risk management plan and adjust, as required. - Report status.
Schedule:	Starts immediately continues through life of program.
Cost:	$100,000 per annum

6.1.4 Information Management

Purpose:	To create and manage high-quality, effective, and strategic information infrastructures for the next phases of the project.
Inputs:	• CCTV Camera Data • Flow Monitoring Data • Theoretical Flows Data • Sanitary & Storm Infrastructure Data • Inspection Data • Project Documents • Geographic Information System • GPS Data • XPSWWM Data • HEC-RAS Data
Activities:	Engineering Management Information & Systems (EMIS) would cover a broad spectrum of resources relating directly to the use of computers, computing methods, software, and information management in engineering by providing a forum for understanding the application of emerging technologies that impact critical engineering issues of representation, management and integration of information throughout the entire life of the project To support the large amounts of information compiled, EMIS will include the following activities: • Engineering Information Management Gap Analysis • System Architecture • Data modeling • Date warehousing • GIS
Schedule:	Begin immediately
Cost:	$50,000 for the Engineering Information Management Gap Analysis which will set out the additional scope requirements.

6.2 Environmental Assessment

6.2.1 Municipal Class Environmental Assessment Process

Approved by the Minister of the Environment on October 4, 2000, the *Municipal Class EA* provides a streamlined, self-administered framework for EA planning of municipal projects in accordance with the provisions of the EA Act. The *Municipal Class EA* enables the planning and execution of municipal projects in accordance with an approved procedure that is designed to consider potential effects on the natural, social, cultural, technical and economic/financial environment are taken into consideration on a consistent basis. Provided the *Municipal Class EA* process is followed, the City is not required to obtain project-specific approval under the EA Act.

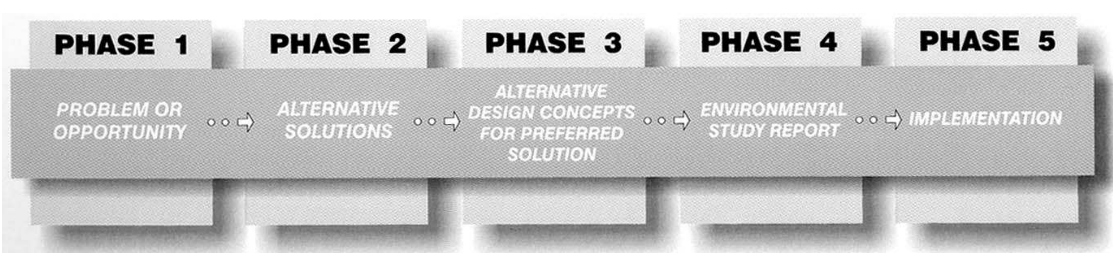
The *Municipal Class EA* meets the intention of the EA Act by providing for; the identification of problems or opportunities, giving due regard to the need to protect the environment and minimize environmental effects; and involving of the public and regulatory agencies in the planning and decision-making processes. Given that municipal projects vary in their level of environmental impact, projects are classified in terms of "schedules". The three schedules for municipal undertakings are as follows:

Schedule A projects are limited in scale, have minimal adverse environmental impacts and require no public notification or documentation. Schedule A projects generally include normal or emergency operational and maintenance activities. As such, these projects are pre-approved and may proceed to implementation without following the full Class EA planning process.

Schedule B projects have the potential for some adverse environmental impacts. Schedule B projects generally include improvements and minor expansions to existing facilities. The proponent is required to undertake a screening process, involving mandatory contact with the directly affected public and regulatory agencies, so that they are aware of the project and that their concerns are addressed. The proponent is required to prepare a Project File Report and make it available for public review for a minimum 30-day period following the completion of Phases 1 and 2, prior to proceeding with Phase 5 – Implementation (**Figure 16**).

If there are no outstanding concerns or objections following the 30-day review period, the project can proceed to design and construction. However if outstanding concerns remain that cannot be resolved, affected and interested stakeholders may request the Minister of the Environment to require the proponent to comply with Part II of the EAA (referred to as a Part II Order). Alternatively, a municipality may elect to conduct the project planning as a Schedule C undertaking (see below). The Minister determines whether or not this is necessary, and the Minister's decision is final.

Figure 16: Municipal Class EA Planning and Design Process



Schedule C projects have the potential for significant environmental impacts and must proceed under the full planning and documentation procedures of the *Municipal Class EA* document, that is Phases 1 through 4. These projects generally include construction of new facilities and major expansions to existing facilities. Schedule C projects require that an Environmental Study Report (ESR) be prepared and filed in the public record for review by the public and regulatory agencies for a minimum 30-day period following the completion of Phases 1 and 4, prior to proceeding with Phase 5 (Implementation).

Provided there are no outstanding concerns or objections following the 30-day review period, the project can proceed to design and construction (Phase 5). However if outstanding concerns remain that cannot be resolved, affected and interested stakeholders may request the Minister of the Environment to require the proponent to comply with Part II of the EA Act (referred to as a Part II Order). As above, the Minister determines whether or not this is necessary, and the Minister's decision is final.

6.2.2 Canadian Environmental Assessment Process

The Canadian Environmental Assessment Act (CEAA) is a legislated environmental assessment process designed to integrate environmental considerations in projects where there is a federal decision or responsibility, whether as proponent, land administrator, source of funding or regulator. At this point, the full range of applicable CEAA triggers is not known. The City of Peterborough intends to apply for Canada-Ontario Municipal Rural Infrastructure Funds (COMRIF) funding.

An EA under the CEAA is a systematic approach to organizing and documenting the environmental effects of a proposed project and determining the need to mitigate these effects, to modify the project or to recommend further assessment. A screening level EA under CEAA is a self-directed study, meaning the Responsible Authority (RA) determines the scope of the EA, the scope of a screening level study accommodates both simple, routine projects as well as larger, more complex projects. It provides the RA with the greatest degree of management and flexibility over the scope and pace of the EA process (as compared to the comprehensive level EA). Screenings will vary in length and depth of analysis depending on the circumstances of the proposed project, the existing environment and the likely environmental effects. Some screenings may require only a brief review of the available information, while others may need new background studies and be much more thorough and rigorous. A screening must address the following factors:

- The 'environmental effects' of the project including cumulative effects, and the effects of possible accidents or malfunctions;
- The significance of the environmental effects;
- The technically and economically feasible measures that would reduce or eliminate any significant adverse environmental effects of the project;
- Any other matter relevant to the screening that the responsible authority may feel is necessary for an accurate assessment of the environmental effects; and
- Comments from the public received in accordance with the Act and the regulations.

Once the report is complete, the RA must determine whether or action is required to that will enable the project to proceed (i.e., to provide the funding, land interest, permit or other authorization). The RA makes this determination based on the significance of effects. Once the RA has made a decision, it must give public notice concerning its course of action. The RA will formally allow the project to proceed if it has been shown that it is not likely to cause significant adverse environmental effects, taking into account any appropriate mitigation measures, if necessary. The RA also describes a follow-up or monitoring program.

It is a requirement under the Act that Responsible Authorities (RA) establish a public registry for the purpose of facilitating public access to records relating to environmental assessments and to operate a registry in a manner that provides convenient public access. In addition, the federal RA's are requested to register screenings on the Federal Environmental Assessment Index (FEAI), which is managed by the Canadian Environmental Assessment Agency. The FEAI is an electronic listing of the EAs conducted by all RAs under CEAA. It contains contacts and document listing related to specific EAs.

6.3 A: Information Gathering and Field Work

6.3.1 A-110 Flow Monitoring and Rainfall Monitoring

Purpose:	The purpose of flow monitoring is to collect accurate, current information on the flow characteristics of the study area, and the associated rainfall intensity, total volume, rate, and duration. Information collected will be used for various applications including computer model calibration; development of area specific modeling parameters relative to design values; and inflow and infiltration identification and quantification
Inputs:	• Any Water Survey of Canada, City or Conservation Authority locations already established
Activities:	• **Rainfall Monitoring (Storm and Sanitary):** Up to 12 rain gauges at appropriate sites in the City in addition to the 9 currently in place that are owned, maintained, and operated by the City. • **Storm Sewer Flow Monitoring:** Set up including dye dilution calibration and install up to 30 temporary flow monitors (depth-velocity meters), located per plan provided by the City, by study area. The equipment is to remain in place for the following 6 months. • **Sanitary Sewer Flow Monitoring:** Set up including dye dilution calibration and install up to 25 (9 fixed with 16 rotating) flow monitors (depth-velocity meters). The equipment is to remain in place for the following 12 + months, located per plan provided by the City, prioritized by downtown with rings moving out • **Watercourse Flow Monitoring:** 10 gauges to be installed as per plan provided by the City, exact location to be field verified. The equipment is to remain in place for the following 6 months. • All results and performance information generated during the period in electronic formats. • Installation, commissioning, service, and maintenance for the equipment used, including download, clean and verify depth/velocity readings weekly basis • Site hydraulic analysis to optimize placement of monitoring devices • Quality assurance programs/procedures and dye dilution calibration to ensure data integrity and accuracy.
Deliverables:	• Flow and rainfall results and performance data at 5 minute intervals, in excel format.
Schedule:	• Should start immediately. Duration will be six months for storm and watercourse flow monitoring, and twelve plus for rainfall and sanitary flow monitoring (to confirm I/I reduction contributable to reduction measures and seasonal/annual I/I variations/fluctuations).
Cost	• **Rainfall monitoring:** 12 gauges at $2500 = $30,000 • **Storm Sewer Flow Monitoring:** assume 30 monitors for 6 months @ $10k/year = $150,000 • **Sanitary Flow monitoring:** assume 25 monitors for 12 months @ $10,00 per year =$250,000, followed by utilization of City Monitors • **Watercourse Flow Monitoring:** assume 10 monitors for 6 months @ 10 K/year = $50,000 • **TOTAL** = $430,000

6.3.2 A-120 Storm and Sanitary System Survey

Purpose:	To prepare a detailed digital version of the storm and sanitary sewer, overland flow, and creek systems.
Inputs:	• Paper database on engineering "as built" drawings (.tif files) • Digital "as built" drawing • City of Peterborough Digital Elevation Model • Existing Public Works and Land Information department's computer standards and format.
Activities:	• Global Position RTK System (GPS) or Total Station Survey to capture horizontal positions and elevation to 0.02 meters or better for manholes, culverts, and catch basins. • Storm system: pipe size, depth, location, pipe type, connectivity, manhole locations, depths, catchbasins, culvert sizes, lengths, and slopes. • Sanitary System: pipe size, depth, location, pipe material, connectivity, manhole locations, depths, first floor elevation. • Creek systems, cross sections at structure upstream and downstream faces, Road centre line profile, opening width, shape, elevation.
Deliverables:	• Pipe, overland flow and watercourse network data in digital format, suitable for importing into water resource modeling software (SWMM and EXTRAN) and compatible with the City's GIS system.
Schedule:	• Should start immediately, • Delivered by study area to the priorities provided • Duration: 6 months with 2 crews
Cost:	• $500,000

6.3.3 A-130 Dye Testing

Purpose:	To confirm connectivity and cross-connections where trap present, and obvious downspouts that go into ground that did not show up on smoke testing
Inputs:	• Storm and Sanitary System Survey • Smoke Testing
Activities:	• For the study areas identified by the City, conduct dye testing to confirm connectivity • Inflow sources including downspouts, area drains, patio drains, window well drains, stairwell drains and driveway drains that may not always be detected with smoke testing due to trapped building service laterals or clogged drains. Suspect sources should be recorded during smoke testing and/or during house-to-house surveys for subsequent dyed water testing.
Deliverables:	• Report that outlines connectivity
Schedule:	• Can start when Storm and Sanitary System Survey information is available.
Cost:	• $100,000

6.3.4 A-140 Digital Elevation Modeling

Purpose:	To develop a Digital Elevation Model (DEM) and contours to support further detailed studies and environmental assessments.
Inputs:	• Project area provided by the City – approximately 129 square kilometres • Delivery area based on Flood Reduction Master Plan catchments
Activities:	• A digital elevation model for the City of Peterborough to be used for future registration of a maximum resolution of 25cm pixel Orthophotography. • Calculated 1-metre contours with a vertical accuracy of one half the contour interval or +- 0.5 of a metre and spot elevations. • The DEM created from the terrain data, and the planimetric mapping will be used to support floodplain-mapping programs and related applications such as hydrology modeling. • Digital Elevation Model (DEM) that will meet the needs to generate any future orthorectified images to create 3D mapping
Deliverables:	• Contour delivery will be a computer generated seamless citywide set of GIS layers of 1-metre contours (contours to meet or exceed map accuracy standards of +- 0.5 metre) • Spot elevations • An accurate digital contour mapping to provide preliminary delineation using spatial analysis of the overland flow path network (low points). • Ground elevations for modeling inputs for the storm and sanitary models
Schedule:	• Start immediately
Cost:	• $100,000

6.3.5 A-210 Smoke Testing

Purpose:	To identify roof downspouts and catch basins cross connected to the sanitary sewer and cross connections between the sanitary and storm sewers.
Inputs:	Pilot area at pre-determined location previously identified in the 1994 Gore and Storrie Report.
Activities:	• Methods include door-to-door notification within 24 hrs of test, as well as newspaper notices. • Notify Fire and Police departments in detail of which streets on which days • Block upstream and downstream manholes to isolate a section of the line, as appropriate • Start blower and then place over manhole • Introduce smoke through centrally located manhole. • Smoke under pressure will fill the main sewer line plus all connected areas • Smoke will flow through all openings to the surface revealing connected downspouts • Record on engineering plans location of smoke • Best results are on dry days
Deliverables:	• Itemization of all verified and suspected cross connections • Suspected location requiring verification with dye testing
Schedule:	• Start immediately
Cost:	• $300,000

6.3.6 A-220 Soils and Groundwater Investigation

Purpose:	To identify areas of high watertable and soil permeability and to understand soil runoff characteristics
Inputs:	• Location, depth, number of boreholes, and duration of monitoring • Delivery area based on Flood Reduction Master Plan catchments
Activities:	• Develop rationale for proposed sampling program based on previous experience and regional geologic mapping and in meetings with the City (2 meetings) • Present borehole program to the City for approval • Coordinate the clearance of underground utilities and services • Arrange for site access to sampling locations for standard truck-mounted power auger to an average depth of 5 m • Collect soil samples using standard split spoon sampling at 0.76m depth intervals and techniques based on protocols documented in the MOE sampling guideline. • Field log soil samples characteristics observed in the samples in accordance with the Unified Soil Classification System. • Analyze soil grain size with sieve and hydrometer methods (allow for 200 sieve and hydrometer tests). • Install monitoring wells (piezometers) to a typical depth of 5 m assuming the majority are ¾ " solvent welded PVC standpipes and some 2" Environmental-Grade flush threaded well casing/screens are needed. • Survey ground surface elevations and top of well/piezo casing elevation at each borehole location to City of Peterborough benchmark. • Record water table elevations over time (40 long term monitoring wells) (allow for 24 sets of readings) • Seal and close out boreholes, returning site to existing conditions • Cap and lock groundwater monitoring wells and piezometers • Decommission boreholes, piezometers and wells in accordance with O. Reg. 903 • Conduct analysis at an accredited lab and report
Deliverables:	• Soils and Groundwater Investigation Report by study area including logs of boreholes, grain size distribution curves, bi-weekly water table levels, and Certificates of Analysis • 1:10,000 scale Contour plan of groundwater free surface • 1:10,000 scale Plans of surficial soil type zones • Water resource monitoring
Schedule:	• could start immediately, linked to storm study
Cost:	• 200 boreholes at $500 per, plus data acquisition = $200,000

6.3.7 A-230 CCTV Inspection of Pipes

Purpose:	Inspect and evaluate storm and sanitary sewers identified as priorities by the zoom camera inspection program, identify rehabilitation and maintenance requirements based on data collected, and create a searchable repository for inspection and recommendation records.
Inputs:	• Results from the recent city-wide zoom camera inspection program completed after the July 15th flood
Activities:	• Pipeline Assessment - Develop work program covering the phased inspection of storm and sanitary sewers flagged as priorities by the zoom camera inspection program - Produce delivery schedule based on 8 predefined work areas - Video inspect sewers in accordance with NAAPI inspection standards - Code inspections using WRc Defect Rating approach - Index and review CCTV inspection videos and WRc Defect Coding files - Evaluate structural and service deficiencies to establish performance ratings - Identify rehabilitation and maintenance requirements required to address deficiencies - Prioritize follow-up requirements based on condition and strategic importance • Information Management - Develop MS Access data repository to hold inspection reports, and rehabilitation and maintenance work records - Create interface forms facilitating query and search of stored data - Link database records to ArcGIS to facilitate spatial display of query results - Transfer inspection videos to DVD-R - Train two technicians in the maintenance and use of the application
Deliverables:	• Digital format CCTV inspection videos stored on DVD-R • Inspection data files containing WRc Defect Coding • Prioritized listing of recommended maintenance and rehabilitation activities • Searchable database containing inspection reports and recommended work activities
Schedule:	• Start immediately
Cost:	• $500,000

6.4 B: Detailed Study and Environmental Assessment

6.4.1 B-100+ Detailed Storm and Watercourse Flood Reduction EAs

Purpose:	To identify the severity and frequency of flooding, and associated damages within each catchment area, and identify and assess alternative and cost effective solutions that can be technically implemented, for alleviating existing problems and potential problems from future development. Assess and rank solutions in terms of flood reduction, erosion and water quality effectiveness.
Inputs:	• Field work information, including flow monitoring, rainfall monitoring, digital terrain modeling, storm sewer system survey, dye testing, and soil and groundwater investigation • Flood Reduction Master Plan Report, UMA (April 2005) • Background information from ORCA and area townships and population and land use information • July 2004 Peterborough Flood Study – by the MNR in partnership with ORCA
Activities:	Each of the studies will comprise the following steps: **Coordination and Environmental Assessment** • **Coordination:** Identify and consult with all stakeholders including the affected agencies identified in the Municipal Class Environmental Assessment (EA)(June 2000). Coordinate information gathering and field work through City. • **Environmental Assessment:** Conduct study in accordance with the Municipal Class EA process. Upon completion of the Existing Conditions Assessment, identify any Municipal Class EA Schedule A works that provide significant value at low cost and should be implemented immediately, and prepare Terms of Reference for implementation. • **Public Consultation:** Activities include advertisement of Notice of Study Commencement (Phase 1); public meeting upon completion of existing conditions assessment (Phase 1); public meeting upon completion of the Alternative Solution Evaluation (Phase 2); and Notice of study completion and publication of Environmental Study Report (Phase 2). **Detailed Flood Reduction Studies** • **Gather Information and Review**: Conduct a literature review of previous reports, obtain available data, conduct field investigations, and request additional information needed to perform the study. • **Develop Models:** Develop hydrologic models using the PCSWM or XP SWMM hydrologic model (or approved equivalent). Calibrate model for acceptable replication of actual historic events to gain confidence that the models are reproducing the real-world situation. • **Assess Existing Conditions:** - Develop a comprehensive inventory of the City's existing **storm drainage infrastructure**, including associated natural and socio-economic inventories. Assess current drainage systems and outlets to identify drainage constraints and/or capacity restrictions including impacts of storm sewer capacity surcharges on overland flow rates and volumes, overland flow discharges on watercourse capacity, flood damages and in-stream erosion. Assess the ability of existing infrastructure to meet current and future demands. - Develop hydrological model for pipe network using PCSWM or XPSUM.

	Develop hydrological/hydraulic models for surface assessment using SWIMO, UOZ, GAWSER, HEC-Z, HEC-ROD or any other approved model. - Develop a comprehensive inventory of the existing **watercourse infrastructure** for the catchment, including associated natural and socio-economic inventory. Assess the study area to identify drainage constraints and/or capacity restrictions. Analyze how often specific flood levels might occur at all required points in the study catchment for existing and future land use conditions. - Prepare a Statement of Problems and Opportunities based on the assessment of existing conditions and hold PIC #1. • **Identify and Evaluate Alternative Solutions** - Generate alternative storm drainage system (sewer and overland) including required in-stream works for the provision of storm sewer, roadway profiles and storm water management measure opportunities to implement hydrologic and hydraulic models and to describe the existing storm drainage system and to assess scenarios of alternative solutions, considering existing and future land use, and the impact of watercourse alternatives to achieve flood reduction or habitat improvement benefits. - Generate alternative watercourse solutions for provision of flood reduction opportunities, considering the impact of storm drainage alternatives. Modify the hydrologic and/or hydraulic models to describe the effects of each alternative (individually and in combination) on flood levels and habitat potential. - Identify and summarize all reasonable and feasible alternative solutions and establish the Class EA Schedule (i.e., A, B or C) under which each alternative falls. - Develop an evaluation process that includes physical, economic, environmental and social/cultural/health implications. Assess and evaluate the alternative solutions to select the Preferred Solution, and hold PIC #2. • **Develop Preliminary Design Concepts:** Generate preliminary design information to confirm the feasibility of the Preferred Solution including preliminary sizing for all proposed components. • **Develop Implementation Plans and Prepare Flood Reduction EA Study Report:** Develop recommendations for addressing short, medium and long term needs and opportunities, considering the City's financial capability. Prepare a draft Report including a logical implementation plan / staging plan, Class EA Schedule, other EA requirements, and estimated capital costs. Issue the Notice of Study Completion and finalize the Report, incorporating input from review agencies and the public, for acceptance by the City.
Deliverables:	• A calibrated model of the catchment. • An Environmental Study Report (ESR) that includes an Executive Summary, the results of the study, preliminary designs and drawings, supporting calculations, all relevant correspondence, and any future approvals required to implement the solution(s). File the ESR in the public record for the Class EA.
Schedule:	Should begin immediately, stagger catchments to reflect availability of input information.
Cost:	Base model Creeks, $400,000; Alternatives $100,000; Conceptual D $50,000 Urban $900,000 base model; Alternatives $300,000, Conceptual D $50,000 Ecology & Socio Economic: $100,000; EA $300,000 Total: $2,100,000 (all 7 catchments)

6.4.2 B-110 Watercourse Management, Access and Maintenance Plans

Purpose:	To provide a mechanism for the City to obtain applicable regulatory permits / approvals to carry out required maintenance, restoration and enhancement activities.
Inputs:	Existing City Watercourse Management Plans (Riverview, Thompson, Curtis)
Activities:	• Select one of the three existing Management Plans listed above, use as a prototype, and implement recommended activities: - Provide regulatory agencies with details of upcoming in-water works schedule, locations and extent of proposed work - Arrange for site visit between City, ORCA, MNR and DFO to ensure all are familiar with the work site. - Identify regulatory agency information needs to issue permit /approval - Identify regulatory agency timing for review of applications and issueing permit/approval - Develop Best Management Practices to allow the City to provide more comprehensive applications - Clearly convey prescribed mitigation measures to be included within Tender Package - Develop Construction Monitoring /Inspection Program to be followed during and following construction to protect the natural environment - Prescribe natural or bio-engineering solutions where warranted • Based on implementation experience of the prototype, modify existing Management Plans, prioritize, complete and implement remaining Watercourse Management Plans, starting with Bears Creek.
Deliverables:	• Short term mechanism to allow creek maintenance activities to proceed, pending completion of Detailed Storm and Watercourse Flood Reduction EA studies • Facilitation of debris removal from creeks
Schedule:	• Start immediately
Cost:	• $25,000 for facilitation of prototype implementation

6.4.3 B-120 City-Wide Policy Review

Purpose:	To recommend new development standards and practices based on a detailed review of existing standards and practices used in other jurisdictions. To review and recommend changes to the City of Peterborough's existing land use controls, including the review of relevant bylaws, policies, and development standards to prevent the flooding of private property
Inputs:	Existing City development standards and how they evolved over time Development standard practices used in other jurisdictions
Activities:	**Storm Drainage Design Standards** • Review guidelines and design standards from other jurisdictions (survey format). • Review and update the City's municipal design policies and standards related to storm drainage and design for the protection against basement flooding (different design standards for deep versus shallow sewers). • Update rainfall—duration-intensity frequency analysis (IDF curves). **Sanitary Design Standards** • Review downstream capacity based on current City/MOE standards, Foundation Drain Collector guidelines, pipe capacity and observed inflow and infiltration component **Development Reviews** • Provide allowable storm sewer unit flow release rates based on trunk storm sewer model set up for the Master Plan for identified development areas **Environmental Constraint Analysis and Mapping** • Identify lands which should be protected from future development and/or where special conditions should be imposed prior to development to mitigate any identified adverse impacts. - Use existing GIS and Flood Reduction Master Plan information - Consider existing agency policy restrictions - Develop ranking methodology for weighting of natural resources and land uses as they relate to the ecological integrity of the catchments. - Map the environmental constrains using GIS
Deliverables:	Updates standards for application to future studies / developments
Schedule:	• start immediately
Cost:	• $50,000

6.4.4 B-130 Sewer Maintenance Program

Purpose:	Optimize the planning, prioritization, and scheduling of sewer maintenance and inspection activities through the effective use of sewer system attribute, condition, and work record information.
Inputs:	• Sewer Cleaning, Zoom Camera and CCTV Inspection data • Historical sewer maintenance records • GIS and Storm and Sanitary System Survey
Activities:	• Review sewer cleaning, zoom camera and CCTV inspection data: - identify locations where sewer cleaning/flushing is required based upon field observations - input recommended sewer maintenance requirements into sewer data repository developed under A-230 • Review historical maintenance practices - within the City (identify categories, resources and objectives) - within other communities in Canada and Internationally • Develop Maintenance Guidelines - Refine maintenance selection and scheduling criteria based on review of resource availability, system attributes, environmental factors and likely system failure modes - Calibrate maintenance/inspection scheduling parameters within the database • Document maintenance programming work process
Deliverables:	• Sewer Maintenance Work Process Reference covering the selection and scheduling of maintenance and inspection activities
Schedule:	• In conjunction with A-230 CCTV Inspection of Pipes
Cost:	• $50,000

6.4.5 B-140 Emergency Preparedness and Response

Purpose:	To review the management of the July 2004 flood and improve the City's current Emergency Management Plan, including coordination with other stakeholders.
Inputs:	• Flood Reduction Master Plan – review of public concerns • Report by Emergency Management staff • Reports by member agencies of the Emergency Control Group: Mayor's office, City Administrator, Public Information Officer, Police Chief, Fire Chief, Director of Utility Services, Director of Community Services, Medial Officer of Health, General Manager of Peterborough Utility Commission, Duty Officer, and Telecommunication Officer • Reports by other affected agencies
Activities:	• Formalize Interagency Coordination - Identify potential agencies required in case of emergency including City Staff and external government agencies (Emergency Management Ontario, ORCA, MNR and MOE) - Determine coordination of the various roles and cooperation required between agencies, including coordination among various dam owners for timing of opening dams and the downstream impacts - Formalize agreements with external agencies that include activation processes, description of service to be provided, contact names, financial considerations (if any), and instructions on committing City funds (if permitted) • Review and Revise City's Emergency Management Plan - Gather and review information, including lessons learned from 2002 and 2004 floods, requirements of Emergency Management Act (O. Reg. 380/04), and best practices from other communities including tools such as a Flood Forecasting and Warning System (interactive Geographic Information System database) - Review coordination of various volunteers - Review evacuation plan (aged, disabled, impaired) - With input from various City and external agencies, identify alternatives for improvement, analyze their potential effectiveness, and determine revisions to the Emergency Management Plan • Review Revised Emergency Management Plan - Review City's Emergency Operation Centre - Review adequacy and function of centre facilities - Review communication plan and media coordination (public inquiries and information tracking database) - Review funding issues and partnership opportunities
Deliverables:	• Updated City of Peterborough Emergency Plan
Schedule:	• Formalize Interagency Coordination: Start immediately. 4 to 6 weeks • Review and Revise City's Emergency Management Plan: Start immediately. Estimated duration is 3 to 4 months. • Review City's Emergency Operation Centre: Longer term - 6 to 8 weeks
Cost:	• $75,000 to $100,000 depending on availability of City staff, outside agency cooperation, and status of the Hazard Identification and Risk Assessment legislative requirements due by 30 Dec 2005.

6.4.6 B-150 Public Awareness Program

Purpose:	To heighten City-wide public awareness on actions and activities to reduce the risk of future flood damage through changed behaviours and practices. To communicate the progress and performance of implementation of the Master Plan.
Inputs:	• Work undertaken by other parts of the Master Plan Program • Current City communications and public awareness efforts
Activities:	• Conduct public awareness best practice research • Identify and present strategies, roles for key partners, and early approaches to generate increased awareness • Enhance partnerships with community, business and environmental stakeholders • Develop clear problem statements and simple "how-to" programs for issues such as lot grading, rood leader extensions, urban storm water drainage systems, local surface drainage • Implement Public Awareness Programs City-wide • Monitor and evaluate programs and progress. • Coordination of public awareness program with overall Flood Reduction Program of Work. • Develop Communications Plan including: a website, newsletters, open houses, media, earth days, school, community service clubs and volunteers groups • Investigate the enactment of a bylaws including its effectiveness in other communities where it has been imposed. • Communicate the effectiveness of the Master Plan on an annual basis
Deliverables:	• Report of Situational Analysis and Best Practice Research
Schedule:	• Duration of Master Plan
Cost:	• Up to $100,000; depending on scope

6.4.7 B-210 Detailed Sanitary Sewer EA

Purpose:	To reduce basement flooding with sanitary sewage by reducing the unwanted flows into the sanitary system.
Inputs:	• Results from ongoing Program of Works: Smoke Testing, Turbidity Testing, Sanitary System Survey, Soils and Groundwater Investigation, Closed Circuit Television (CCTV) Inspection of Sanitary Pipes, and Dye Testing • Results from Work By Others: Rainfall Data from ORCA and the City • Existing information: reports, as-built data, planning and demographics
Activities:	**Coordination and Environmental Assessment** • **Coordination**: Identify and consult with all stakeholders including the affected agencies identified in the Municipal Class Environmental Assessment (EA). Coordinate information gathering and field work through the City. Coordinate outputs with others working on disconnection of basement drains. • **Environmental Assessment:** Conduct study in accordance with the Environmental Assessment Act and Phases 1 and 2 of the Municipal Class EA process. Upon completion of the Existing Conditions Assessment, identify any Municipal Class EA Schedule A works that provide significant value at low cost and that should be implemented immediately. Prepare Terms of Reference for implementation. • **Public Consultation:** Carry out a public consultation process. There will be one (1) public information centre (PIC) held upon completion of the Alternative Solution Evaluation; and opportunity for public input during the 30-day Notice of Completion review. **Detailed Sanitary Sewer Study** • **Gather Information and Review:** Conduct a literature review of previous reports, obtain available data including zoom camera and CCTV results, conduct field review, and request additional information needed to perform the study. • **Develop Models:** Develop a model of existing trunk system to reflect current developments, and calibrate the model using rainfall and flow monitoring data, incorporating modifications to the dry weather and wet weather flow parameters, as required. • **Analyze Flow Data:** Evaluate the information obtained from rainfall and flow monitoring and other supplemental data to categorize the wastewater flow into its various components; sanitary flow, infiltration, and inflow, and make recommendations for further study to identify infiltration and inflow sources. • **Sewer System Evaluation Survey:** Determine / document the specific location, estimated flow rate, method of rehabilitation and cost of rehabilitation versus cost of transportation and treatment for each defined source of infiltration/inflow. • **Identify and Evaluate Alternative Solutions:** Generate alternative solutions for the reduction of inflow and infiltration, and perform a cost-effectiveness analysis to determine the ratio of costs to correct I/I conditions to the costs for transportation and treatment of these flow. Identify and summarize all reasonable and feasible alternative solutions and establish the Class EA Schedule (i.e. A, B or C) under which each alternative falls. Develop an evaluation process that includes physical, economic, environmental and social/cultural/health implications, assess and evaluate the alternative solutions to select the Preferred Solution, and hold a PIC.

	• **Develop Preliminary Design Concepts:** Generate preliminary design information to confirm the feasibility of the Preferred Solution including sizes for all proposed components. • **Develop Implementation Plans and Prepare Study Report:** Develop recommendations for addressing short, medium and long term needs and opportunities, with consideration for the financial capability of the City. Prepare a draft Report including a logical implementation plan / staging plan, Class EA Schedule, other EA requirements, and estimated capital costs. Issue Notice of Study Completion. Finalize the Report, incorporating input from review agencies and the public, for acceptance by the City.
Deliverables:	• Calibrated model of the existing trunk sanitary sewer system • A comprehensive report that includes an Executive Summary, the results of the study, preliminary designs and drawings, supporting calculations, all relevant correspondence, and any future approvals required to implement the solution(s). The final report shall be the Environmental Study Report filed in the public record for the Class EA.
Schedule:	Start immediately
Cost:	$200,000 for the first year

6.4.8 C110 Flood-Proof Private Property

Purpose:	To reduce the impact of basement flooding damage from sewer backup and overland flow, and other damage.
Inputs:	Locations of most flood prone houses
Activities:	• Review Flood reduction measures: • Identify appropriate measures for site specific constraints • Provide recommendations / drawings
Deliverables:	Reduction in frequency of private property flooding
Schedule:	Start immediately
Cost:	Site specific

6.4.9 C-210 Disconnect Foundation Drains

Purpose:	To develop a phased disconnection program that provides a deliberate and well-planned approach to reduce damages from basement backups and sanitary sewer overflows that will prevent excessive expenditure of funds and enable timely implementation.
Inputs:	• Field investigations, basement floor elevations for homes in the areas that had experienced basement backups • Wet-weather response rates and dry-weather flow rates of the sanitary collection systems • Elevation and rainfall data were used in a model simulation calibrated to field-measured peak sewage levels to identify which homes had the potential for basement backups.
Activities:	• Consider a pilot project of approximately ten properties. • Select properties as potential candidates for foundation drain disconnection as follows: - Does the property have weeping tile connected to the sanitary or storm sewer system? - Does the property have roof leaders connected to the sanitary or storm sewer system? - Is the property or residence included in an area which historically has had basement flooding or is known to be contributing excess flow causing basement flooding downstream? - Is there adequate lot grading to direct flows away from the foundation? - Does the receiving pipe system have adequate capacity or is it historically a problem area? • Investigate the separation of the footing drain connections in basements • Install check valves for backflow prevention, including disconnection of footing drain connections to the sanitary house leads, thereby preventing damage to the basement floor that could result from a build-up of water pressure underneath • Disconnect and reroute footing drain flows to new sumps at the disconnection point for pumping footing drain flows to a location in each yard that would keep the discharged water away from the house and not create a nuisance or safety hazard • Install sump pumps to discharge water from the homes, both a standard sump pump and a water-powered backup pump that can operate in the event of a power outage • Investigate a curb drainage system to prevent wetness problems on homeowner property and to prevent icing on sidewalks and roadways
Deliverables:	• Inflow and infiltration reduction
Schedule:	• Begin in concert with flow monitoring and groundwater monitoring programs
Cost:	• Estimate 100 disconnections @ $15,000 each = $1,500,000

6.4.10 C-220 Seal Manhole Covers

Purpose:	To develop a phased disconnection program that provides a deliberate and well-planned approach to reduce extraneous flows.
Inputs:	• Survey downspouts and disconnect (by priority area) • Residential and parking lots • Fines
Activities:	Field Inspection program to identify candidate manholes
Deliverables:	Physical installation of manhole inflow reduction measures
Schedule:	Begin Immediately
Cost:	500 manholes @ $200 each = $100,000

6.4.11 C-230 Install Backflow Preventers

Purpose:	To reduce the impact of basement flooding damage from sewer backup and overland flow, and other damages.
Inputs:	• Survey downspouts and disconnect (by priority area) • Residential and parking lots • Fines
Activities:	• In combination with Foundation Drain disconnection • Elevation different smallest between sewer and basement (first floor data) • In overland flow areas • Basement flooding survey results • City incentives • City trained and approved plumbing contractors • Related to high water table
Deliverables:	Physical installation of backflow preventers
Schedule:	Begin in concert with flow monitoring and groundwater monitoring programs
Cost:	500 homes at $1000 each = $1,000,000

6.5 Additional Recommendations

In addition to the Recommended Action Plan, we recommend the City consider the following two items which will enhance the success of Master Pan implementation:

Consultation: The Technical Committee and Citizens Advisory Panel were instrumental in the successful completion of the Master Plan. As the flood reduction program moves forward, the Technical Committee should be re-formed with representation from a number of topic-specific agencies, and a Citizen's Advisory Panel should monitor and report on progress and performance, in addition to providing input on public consultation.

Reporting: Key aspects of successful implementation of the Master Plan are monitoring and subsequent reporting. It is recommended that the following measures be reported on annually to monitor the progress of the action plan and demonstrate cost effectiveness:

- The percentage of unwanted wet and dry weather flow within the sanitary sewer system;
- The number of houses vulnerable to flooding which are located within overland flow routes / conservation authority flood lines;
- The percentage of storm sewers meeting current criteria; and
- Summary of cost-benefit analysis for individual detailed studies.
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