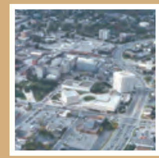
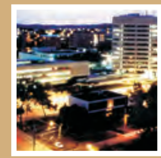
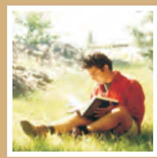
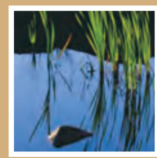
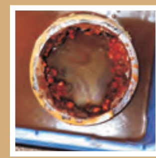





People Engaged ✦ Places Defined ✦ Progress Driven

Official Plan officiel

Une collectivité qui s'engage ✦ Un plan précis ✦ La route du progrès

Stormwater Background Study

January 2006

Developing a single, up-to-date Official Plan that fosters sustainable growth, economic development and a high quality of life to attract people and investment.

Élaborer un seul Plan officiel à jour qui favorise la croissance durable, le développement économique et une qualité de vie élevée afin d'attirer des gens et des investissements.

Greater | Grand Sudbury™
www.city.greatersudbury.on.ca

City of Greater Sudbury
Official Plan

Stormwater Background Study

Prepared for:
The City of Greater Sudbury
P.O. Box 5000, Station A
200 Brady Street, Tom Davies Square
Sudbury, Ontario
P3A 5P3

Prepared by:
Earth Tech Canada Inc.
1040 Lorne Street South, Unit 1
Sudbury, Ontario
P3C 4R9

EO 71981 January 2006

EXECUTIVE SUMMARY

Context

The City of Greater Sudbury (Greater Sudbury) is conducting a comprehensive review of its existing official plans that were developed for the former municipalities. The intent of this exercise is to produce a new Official Plan for Greater Sudbury under the Planning Act for the newly amalgamated City. As a key component of this review, the City is undertaking a series of Background Studies to set the context for the new Official Plan and identify both the challenges and opportunities that will be translated into Official Plan Policies and Programs. One such background study addresses stormwater management and is the subject of this report.

Objectives

The purpose of the document is to present background information, policy options and technical information to be considered during the process of creating a new Official Plan. It should be noted that this is not a policy document and not all of the options discussed herein may find a place in the new Official Plan. Similarly, new ideas not discussed in this report may emerge during the consultations and deliberations associated with the new Official Plan process.

Study Area

Greater Sudbury was formed on January 1, 2001 and represents the amalgamation of the communities that comprised the former Regional Municipality of Sudbury as well as several unincorporated townships. It is now the largest city by population in Northern Ontario and one of largest cities by land area in Ontario.

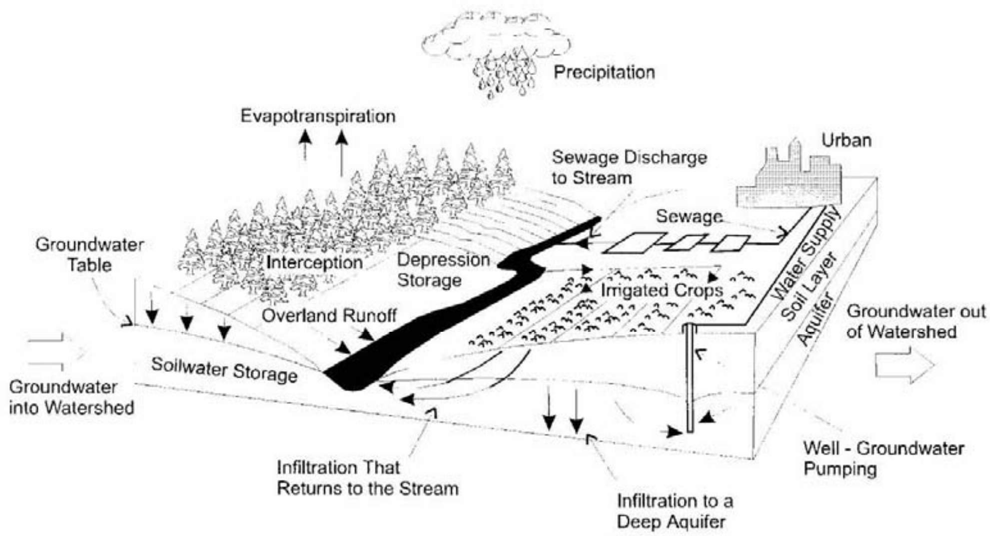
The study area is defined by the municipal boundaries of Greater Sudbury. Within these municipal boundaries are 330 lakes that are at least ten hectares in size, along with several hundred smaller lakes and ponds. These lakes provide drinking water and facilitate outdoor recreation in the form of swimming, canoeing, boating and sport fishing.

Hydrologic Cycle[1]

The hydrologic cycle describes the continuous circulation of water between the oceans, atmosphere, and land. Water is supplied to the atmosphere by evapotranspiration, which includes evaporation from all water, snow, vegetation, and other surfaces, plus transpiration from plants. It is returned to the land through precipitation. Within the hydrologic cycle, water may be stored by vegetation, snowpacks, land surfaces, water bodies, saturated subsurface zones, and unsaturated subsurface zones/soils. Water may be transported between these storages via overland runoff, streamflow, infiltration, groundwater recharge, and groundwater flow, among other processes (Figure 1.1).

[1]Ministry of Environment, Stormwater Management Planning and Design Manual, March 2003, p. 1-4

Figure 1.1: Hydrological Cycle



Source : After, M. L. Davis, D. A. Cornwell, **Introduction to Environmental Engineering,** 1991.

Definitions:
Overland runoff – water that travels over the ground surface to a channel
Streamflow – movement of water via channels
Groundwater flow – movement of water through the subsurface
Infiltration – penetration of water through the ground surface
Groundwater recharge – water that reaches saturated zone

Humans interact with the hydrologic cycle by extracting water for agricultural, domestic and industrial uses, and returning it as wastewater discharges. Urban development may also interfere with the natural transfers of water between storage components of the hydrologic cycle.

Stormwater Management

Stormwater management refers to the procedures or methods used to design drainage works that control the quantity of stormwater runoff, preserve or enhance the quality of stormwater runoff, reduce erosion and prevent flooding.

Stormwater management is required to mitigate the effects of urbanization on the hydrologic cycle, which include increased runoff, and decreased infiltration of rainfall and snowmelt.

Public Consultation and Meetings

Two Public Information Sessions were held to present information to, and obtain input from, the public, stakeholders and government agencies. The Public Information Sessions were coordinated with ongoing public consultation associated with the preparation of the new Official Plan. The sessions followed a "drop-in" format with display boards presenting project information.

The first Public Information Session was held at the following three locations:

Centennial Arena-Hall
4333 Centennial Road, Hanmer
Monday, March 29, 2004 - 7 p.m. to 9 p.m.

Centre Lionel E. Lalonde Centre (former Trillium Centre)
239 Montée Principale, Azilda
Tuesday, March 30, 2004 - 7 p.m. to 9 p.m.

Tom Davies Square - Foyer
200 Brady Street, Sudbury
Wednesday, March 31, 2004 - 7 p.m. to 9 p.m.

At this first Public Information Session, the following was presented:

- The study purpose, scope and an overview of the watersheds within the City.

- The key issues, identified challenges and opportunities related to both quantity and quality of stormwater runoff in the City.

- The stormwater management strategies developed to address the challenges and opportunities.

- The proposed criteria to be used for prioritizing the watersheds and watershed studies.

- A description of the next steps in the study.

The session provided an opportunity for the public to discuss the study, identify and/or confirm major stormwater management issues facing Greater Sudbury, and share ideas about the prioritizing of Greater Sudbury's watersheds. Comments and input received at the session were carefully reviewed and incorporated into the subsequent phase of the study.

The second Public Information Session was held at the following three locations:

Centennial Arena-Hall
4333 Centennial Road, Hanmer
Tuesday, June 1, 2004 - 1 p.m. to 3 p.m.

Centre Lionel E. Lalonde Centre (former Trillium Centre)
239 Montée Principale, Azilda
Tuesday, June 1, 2004 - 7 p.m. to 9 p.m.

Tom Davies Square
200 Brady Street, Sudbury
Wednesday, June 2, 2004 - 7 p.m. to 9 p.m.

At the second Public Information Session, additional findings were presented. These included:

- The key issues, identified challenges and opportunities related to both quantity and quality of stormwater runoff in the City.

- The stormwater management strategies developed to address the challenges and opportunities.

- Identification of priority watersheds that warrant more detailed studies.

- A description of the components of the Urban Drainage Policy for the City.

The session afforded an opportunity for the public to review and discuss the study recommendations. All comments and input received were considered during the preparation of the final documentation for the study.

Project Information presented at the two Public Information Sessions was presented to the Greater Sudbury Lake Improvement Advisory Panel (GSLIAP) and the Ramsey Lake Advisory Panel on June 2, 2004.

These two advisory panels were appointed by the City Council to provide advice to the City on matters related to the health of all lakes in the City of Greater Sudbury, and the health of Ramsey Lake, respectively. GSLIAP is composed of six expert members representing various agencies and institutions, as well as six citizen members. The Ramsey Lake Advisory Panel is composed of six citizen members.

A questionnaire was distributed to the Lake Stewardship Committee members by the “Waterfront and Rural Study Team”, and the responses applicable to stormwater management were considered during identification of problem areas within the various watersheds and subwatersheds.

Stormwater Management Policy Options

Urban Drainage Policy options specific to the City of Greater Sudbury are presented as well as direction for the inclusion in the Official Plan. By addressing Urban Drainage in the New Official Plan, an opportunity to advance local stormwater management initiatives is provided.

General Objectives

The new Official Plan Urban Drainage Policy statements should be prefaced by general statements regarding the need to:

a. Ensure that the constraints and opportunities associated with urban drainage are properly recognized and are integrated into community planning and design;

b. Reduce, to acceptable levels, the potential risk of health hazards, loss of life and property damage from flooding;

c. Reduce, to acceptable levels, the incidence of inconvenience caused by surface ponding and flooding;

d. Ensure that the quality of stormwater discharged to receiving water bodies meets provincially accepted criteria;

e. Ensure that any development is designed and constructed in such a manner as to minimize; the impact of change to the groundwater regime, increased pollution, increased erosion or increased sediment transport; and

f. Maintain the natural stream channel geometry, insofar as it is feasible while achieving the above objectives.

Applicable Design Guidelines

The City, through its Urban Drainage Policy, will adopt technical and procedural guidance for stormwater management planning and design. The City reserves the right to modify these guidelines at any time, as local experiences demonstrate preferred approaches. It is the responsibility of the proponent to ensure that the most up-to-date version is being utilized.

In addition to the requirement for stormwater management designs to comply with the City's policy, the proponent is required to satisfy any other regulatory agency concerns not explicitly identified in this policy (i.e. MOE, MNR, NDCA, DFO).

It is stressed that the technical and procedural guidance provided in the latest version of the Ministry of the Environment's Stormwater Management Planning and Design Manual should be adhered to.

Urban Drainage Policy

The following sections include policy options regarding stormwater management practices and design criteria that should be considered during the completion of watershed plans, subwatershed plans and site specific stormwater management reports.

- Policy Options for Watersheds

  The following policy options recognize that there is already significant urbanization within several of the watersheds within the limits of the City.

  - Protect Drinking Water Supplies

    The City shall, in conjunction with the NDCA, develop and implement source protection plans for surface and groundwater drinking water supplies. Early priorities will be Lake Ramsey, the Wanapitei System, the Vermilion System and the major drinking water aquifers.[2]

[2] The Earthcare Sudbury Local Action Plan, "City of Greater Sudbury, Becoming a Sustainable Community", 2003, p. 33

- **Reduce Nutrient Levels in Area Lakes**

  The City shall improve phosphorus removal at its waste water treatment plants, develop and implement a program for inspection and maintenance of septic systems, and create an awareness campaign to help citizens reduce nutrient runoff from their properties. The City will also study the feasibility of introducing a by-law requiring septic maintenance agreements between installer and property owners.[3]

- **Reduce the Impacts of Stormwater**

  The City shall reduce the use of road salt and install stormwater management facilities where storm sewers enter lakes that supply potable water. Through source protection plans, the City will identify other actions to reduce the impacts of pollutants on water quality.[4]

- **Address Lake Acidification and Other Industrial Impacts**

  The City shall implement a watershed-liming program on lakes with a low pH as the next step in land reclamation. The City shall also continue to press for the cleanup of creosote from Junction Creek.[5]

- **Increase the Understanding of Local Water Resources**

  The City shall improve the basic scientific understanding of the area's watersheds, including water quality and fisheries.[6]

- **Policy Options for Subwatersheds**

  The policy options for subwatersheds are to be read in concert with those prepared for watersheds. In order to ensure the protection of urban watersheds and provide the opportunity to improve the quality of receiving water bodies, the importance of stormwater management retrofit is emphasized.

  - **Subwatershed Studies for Priority Areas**

    The City shall undertake the subwatershed studies, as recommended in this report. Study priorities shall be re-established every 5 years.

    The City shall ensure the implementation of the recommended works resulting from the subwatershed studies. Implementation priorities shall be re-established every 5 years.

---

[3] Ibid.
[4] Ibid., p.34
[5] Ibid.
[6] Ibid.

- **Implementation of Subwatershed Plan Recommendations**

  The implementation of the subwatershed plan recommendations shall take place in an efficient, cost effective manner.

- **Stormwater Quantity and Quality Control**

  All subwatershed plans shall incorporate the primary objective of no net increase in peak flow rates, unless a more stringent criterion is identified in a watershed plan or outlet design. Subwatershed plans must also assess means of stormwater quality control to ensure the protection of and provide opportunities to improve the quality of receiving water bodies.

- **Defining Quality Control Criteria for Subwatershed Studies**

  In order to achieve the goal of "sustainable urban watershed", the City must identify the appropriate level of stormwater quality control at the subwatershed study development stage. Stormwater management retrofit opportunities must also be recognized.

- **Stormwater Management Retrofit Opportunities**

  The City shall utilize the opportunity created during public infrastructure development, renewal and maintenance to implement plans to enhance the quality of the stormwater runoff entering urban lakes and rivers.

- **Shoreline Development**

  The City's stormwater management design criteria for new shoreline development shall meet or exceed provincial standards to ensure that water quality in urban lake environments will not deteriorate due to stormwater runoff.

- **Site Specific Policy Options**

  The current version of the City's Engineering Design Manual should be utilized to determine appropriate stormwater management measures for each site, supplemented by the policy options included in this section and technical and procedural guidance provided in the latest version of the Ministry of Environment's Stormwater Management Planning and Design Manual.

  - **Sites in Areas with Subwatershed Plans**

    Applications for draft plan approval of subdivisions within areas where a Subwatershed Plan has been completed shall demonstrate, through a Stormwater Management Report, how the proposed development will provide stormwater management in accordance with the Subwatershed Plan.

- Sites in Areas without Subwatershed Plans

  Applications for draft plan approval for sites located in areas where a Subwatershed Plan is not yet finalized shall include a Stormwater Management Report containing site-specific details, as required by the City.

- On-Site Storage

  For areas where a subwatershed plan has not advanced in sufficient detail to define downstream stormwater management facilities or where a development will result in unacceptable peak flow increases downstream, on-site stormwater management (storage) facilities for peak flow control will be required.

- Overland Flow Routes

  For all new developments, an overland flow route must be clearly defined to provide continuous overland drainage of major system flows to the nearest major watercourse. The overland flow route (major system) shall be entirely contained within the road right-of-way or easements Conveyance of the Regional or 100-year design storm peak flow (which ever is larger) is required.

- Erosion and Bank Stability

  Existing watercourses shall be left in their natural state whenever possible. The banks must be able to convey either the Regional or 100-year design storm peak flow (which ever is larger).

- Maintenance of Stormwater Management Facilities

  Developers are required to monitor and operate all on-site quality control ponds and shall ensure that the facility meets regulatory agency requirements prior to the City assuming ownership of the facility.

- Ownership of Stormwater Management Facilities

  Stormwater management facilities for subdivisions will be on lands transferred to the City at no cost to the City. Construction costs shall be borne by the Developer, while long term responsibility for the stormwater management facility shall be assumed by the City.

- Rear Yard Catchbasins

  In general, the use of rear yard catchbasins is to be minimized. In areas where rear yard catchbasins cannot be avoided and drainage must follow a rear lot line, rear yard catchbasins shall be provided at a minimum spacing of one every three lots.

- Foundation Drains and Roof Leaders

  Foundation drains shall normally discharge by sump pump onto the ground at a location acceptable to the City. Roof leaders shall discharge at ground level (onto splash pads where required) and flows will be directed away from buildings, to prevent seepage into the foundation drains.

- Best Management Practices

  The City shall adopt the Best Management Practices included in Section 5 of this report, to provide guidance for stormwater management associated with different types of development, including new development, re-development, retrofit and waterfront.

FUTURE SUBWATERSHED STUDIES

The order in which future stormwater studies should be undertaken was determined through the application of the same criteria that was used to prioritize the watersheds and subwatersheds.

Water quality, conveyance and development potential were all taken into account.

Subwatershed Name	Priority	Estimated Cost	Estimated Time Required to Complete
Nepahwin/Robinson	1	$200,000	10 months
Ramsey Lake	2	$200,000	10 months
Whitson River	3	$200,000	10 months
Azilda	4	$150,000	8 months
Richard Lake	5	$ 50,000	6 months
Junction Creek	6	$200,000	10 months
Mud Lake	7	$150,000	8 months
Simon / McCharles Lake	8	$ 50,000	6 months
Chelmsford	9	$150,000	8 months
Whitson Lake	10	$ 50,000	6 months
Garson	11	$100,000	6 months
Meatbird Creek - Lively	12	$ 50,000	6 months
Coniston	13	$200,000	10 months
Wahnapitae	14	$100,000	6 months
Dowling	15	$100,000	6 months
Copper Cliff	16	$ 50,000	6 months
Kelly Lake	17	$100,000	6 months

TABLE OF CONTENTS

1.0 INTRODUCTION 1
1.1 Context 1
1.2 Objectives 1
1.3 Study Area 1
1.4 Hydrologic Cycle 2
1.5 Water Balance 3
1.6 Changes to the Hydrologic Cycle 3
1.7 Changes in Stream Response to Storm Events 4
1.8 Changes in Stream Morphology 4
1.9 Changes to Water Quality 5
1.10 Changes in Aquatic Habitat and Ecology 6
1.11 Stormwater Management 6
1.12 Public Consultation and Meetings 6

2.0 OVERVIEW 9
2.1 Study Area 9
2.2 Overall Drainage in the Study Area 9

3.0 WATERSHED CHARACTERIZATION 12
3.1 Water Use 12
3.2 Land Use 12
3.3 Flood Events 12
3.4 Municipal Drains 13
3.5 Spanish / Vermilion Rivers Water Management Plan 13
3.6 Public Consultation and Meetings 13
3.7 Summary of Evaluations 14
3.7.1 Watersheds 14
3.7.2 Subwatersheds 24

4.0 STORMWATER MANAGEMENT POLICY OPTIONS 42
4.1 Incorporating Stormwater Management Policies in the New Official Plan 42
4.1.1 General Objectives 42
4.1.2 Applicable Design Guidelines 43
4.2 Urban Drainage Policy 43
4.2.1 Policy Options for Watersheds 43
4.2.1.1 Protect Drinking Water Supplies 43
4.2.1.2 Reduce Nutrient levels in area Lakes 44
4.2.1.3 Reduce the Impacts of Stormwater 44
4.2.1.4 Address Lake Acidification and Other Industrial Impacts 44
4.2.1.5 Increase the Understanding of Local Water Resources 44
4.2.2 Policy Options for Subwatersheds 45
4.2.2.1 Subwatershed Studies for Priority Areas 45

4.2.2.2 Implementation of Subwatershed Plan Recommendations ... 45
4.2.2.3 Stormwater Quantity and Quality Control ... 46
4.2.2.4 Defining Quality Control Criteria for Subwatershed Studies ... 46
4.2.2.5 Stormwater Management Retrofit Opportunities ... 47
4.2.2.6 Shoreline Development ... 47
4.2.3 Site Specific Policy Options ... 47
4.2.3.1 Sites in Areas with Subwatershed Plans ... 47
4.2.3.2 Sites in Areas without Subwatershed Plans ... 47
4.2.3.3 On-Site Storage ... 48
4.2.3.4 Overland Flow Routes ... 48
4.2.3.5 Erosion and Bank Stability ... 49
4.2.3.6 Maintenance of Stormwater Management Facilities ... 49
4.2.3.7 Ownership of Stormwater Management Facilities ... 50
4.2.3.8 Rear Yard Catchbasins ... 50
4.2.3.9 Foundation Drains and Roof Leaders ... 50
4.2.4 Best Management Practices ... 51

5.0 STORMWATER BEST MANAGEMENT PRACTICES ... 52

5.1 Quantity Control ... 52
5.2 Quality Control ... 52
5.2.1 On-Site Quality Control ... 53
5.3 Integration of Quality and Quantity in Facility Design ... 53
5.4 Blue/Green Concepts in Facility Design ... 53
5.5 Winter Road Maintenance ... 53
5.6 Development ... 55
5.6.1 New Development ... 55
5.6.2 Redevelopment ... 55
5.6.3 Retrofit ... 56
5.6.4 Shoreline Development ... 56
5.7 State-of-the-Art Techniques for Stormwater Quality Control: End-of-Pipe Solutions ... 57
5.7.1 Wet Ponds ... 57
5.7.2 Constructed Wetlands ... 59
5.7.3 Infiltration Facilities ... 60
5.7.4 Batch-Dry Detention Facilities ... 60

6.0 INTENSITY-DURATION-FREQUENCY CURVES, DESIGN CRITERIA AND COMPUTER MODELING TECHNIQUES ... 61

6.1 Intensity-Duration-Frequency (IDF) Curves ... 61
6.2 Regional Storm ... 62
6.3 Snowmelt ... 63
6.4 Design Storm Applications ... 64
6.4.1 Storm Drainage Systems ... 64
6.4.2 Bridge and Culvert Design ... 72
6.4.3 Stormwater Management Detention Facility Design ... 72
6.4.4 Flood Conveyance Design Storm ... 73
6.4.5 Snowmelt plus Rainfall ... 74
6.4.6 Climate Change Impacts ... 75
6.4.7 Computer Modeling Techniques for Stormwater Management ... 76

7.0 THE DRAINAGE ACT, R.S.O. 1990 79
7.1 Use of the Drainage Act Process for Stormwater Management Purposes 80
7.1.1 Scenario 1 81
7.1.2 Scenario 2 81
7.1.3 Scenario 3 82
7.2 Use of the Drainage Act for Existing Drains 82
7.3 Maintenance of Systems Constructed Pursuant to the Drainage Act 83
7.4 Listing of Possible Policies That Could Be Reviewed by the City of Greater Sudbury with Respect to Stormwater Management in Rural or Semi-rural Watersheds 83
7.4.1 Scenario 1 - Where No Existing Municipal Drain Exists and Improvements Are Being Considered 83
7.4.2 Scenario 2 - in an Area Where Development Is Proposed and the Outlet Is an Existing Municipal Drain 84
7.4.3 Scenario 3 - Where it Is Determined That There Is Not a Municipal Drain Existing but Where the Upstream Work Should Be Constructed and Be Served by a New Municipal Drain as the Outlet 84
8.0 FUTURE SUBWATERSHED STUDIES 85
8.1 Prioritization of Future Subwatershed Studies 85
8.2 Estimated Costs and Time Required to Complete Future Subwatershed Studies 85
8.3 Cost Sharing 86
8.4 Dedicated Funding 86

Table of Contents Continued

FIGURES

Figure 2-1 Major Drainage Basins in the Sudbury Area (NTS)

Figure 5-1 Wet Pond (MOE, 2003)
Figure 5-2 Constructed Wetland (MOE, 2003)
Figure 5-3 Infiltration Basin (MOE, 2003)

Figure 6-1 Updated IDF Curves
Figure 6-2 100-Year Design Storms, City of Greater Sudbury
Figure 6-3 Regional (Timmins) Design Storm, City of Greater Sudbury
Figure 6-4 Snowmelt plus Rainfall Design Storm, City of Greater Sudbury

TABLES

Table 3-1 Public Input

Table 5-1 Stormwater Management for Developments
Table 5-2 Retrofit Opportunities for Stormwater Management in Urbanized Areas

Table 6-1 Storm Sewer Design Criteria
Table 6-2 Rainfall Intensity
Table 6-3: Runoff Coefficients
Table 6-4: Manning Roughness Coefficient
Table 6-5 Bridge and Culvert Design Criteria
Table 6-6 Recommended Modeling Techniques

Table 8-1 Future Subwatershed Studies

DRAWINGS

Drawing 1 City of Greater Sudbury Watershed Summary

Drawing 2-1 East Wanapitei River Watershed
Drawing 2-2 Lower Junction Creek Watershed
Drawing 2-3 Onaping River Watershed
Drawing 2-4 Panache Watershed
Drawing 2-5 Ramsey Watershed
Drawing 2-6 Upper Junction Creek Watershed
Drawing 2-7 Whitewater Watershed
Drawing 2-8 Whitson River Watershed

Table of Contents Continued

APPENDICES

Appendix A Evaluation Table for Prioritizing Watersheds

Appendix B Inventory of Dams and Structures

Appendix C Public Consultation and Meetings Information

Appendix D Rainfall Analysis

Appendix E Drainage Act Information

STORMWATER BACKGROUND STUDY

1.0 INTRODUCTION

1.1 Context

The City of Greater Sudbury (Greater Sudbury) is conducting a comprehensive review of its existing official plans that were developed for the former municipalities. The intent of this exercise is to produce a new Official Plan for Greater Sudbury under the Planning Act for the newly amalgamated City. As a key component of this review, the City is undertaking a series of Background Studies to set the context for the new Official Plan and identify both the challenges and opportunities that will be translated into Official Plan Policies and Programs. One such background study addresses stormwater management and is the subject of this report.

1.2 Objectives

The purpose of the document is to present background information, policy options and technical information to be considered during the process of creating a new Official Plan. It should be noted that this is not a policy document and not all of the options discussed herein may find a place in the new Official Plan. Similarly, new ideas not discussed in this report may emerge during the consultations and deliberations associated with the new Official Plan process.

1.3 Study Area

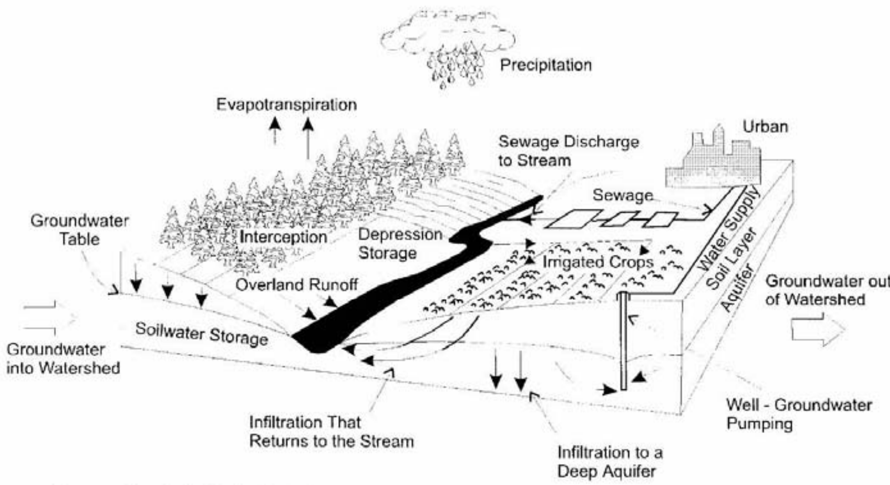
Greater Sudbury was formed on January 1, 2001 and represents the amalgamation of the communities that comprised the former Regional Municipality of Sudbury as well as several unincorporated townships. It is now the largest city by population in Northern Ontario and one of largest cities by land area in Ontario.

The study area is defined by the municipal boundaries of Greater Sudbury. Within these municipal boundaries are 330 lakes that are at least ten hectares in size, along with several hundred smaller lakes and ponds. These lakes provide drinking water and facilitate outdoor recreation in the form of swimming, canoeing, boating and sport fishing.

1.4 Hydrologic Cycle[1]

The hydrologic cycle describes the continuous circulation of water between the oceans, atmosphere, and land. Water is supplied to the atmosphere by evapotranspiration, which includes evaporation from all water, snow, vegetation, and other surfaces, plus transpiration from plants. It is returned to the land through precipitation. Within the hydrologic cycle, water may be stored by vegetation, snowpacks, land surfaces, water bodies, saturated subsurface zones, and unsaturated subsurface zones/soils. Water may be transported between these storages via overland runoff, stream flow, infiltration, groundwater recharge, and groundwater flow, among other processes (Figure 1.1).

Figure 1.1: Hydrological Cycle



Source : After, M. L. Davis, D. A. Cornwell. **Introduction to Environmental Engineering**, 1991.

Definitions:
Overland runoff – water that travels over the ground surface to a channel
Streamflow – movement of water via channels
Groundwater flow – movement of water through the subsurface
Infiltration – penetration of water through the ground surface
Groundwater recharge – water that reaches saturated zone

Humans interact with the hydrologic cycle by extracting water for agricultural, domestic and industrial uses, and returning it as wastewater discharges. Urban development may also interfere with the natural transfers of water between storage components of the hydrologic cycle.

[1] Ministry of Environment, Stormwater Management Planning & Design Manual, March 2003, p. 1-4

1.5 Water Balance

For any system with defined boundaries (e.g., a watershed), a water balance may be used to describe hydrologic cycle. More specifically, the water balance provides for an accounting of water transfers across the system's boundaries over some time period. Any difference between inflows to the system and outflows from the system during this time period must be balanced by a change of storage within the system. [2]

1.6 Changes to the Hydrologic Cycle[3]

A major consequence of the increase in impervious area which accompanies urbanization is an increase in direct runoff and a corresponding decrease in infiltration. Urbanization also results in decreased evapotranspiration. The net effect of conventional development practices on an urban stream is a dramatic change in the hydrologic regime of the stream.

Effects include:

- an increase in the magnitude and frequency of runoff events of all sizes;
- delivery of more of the stream's annual flow as surface storm runoff rather than base flow or interflow; and
- increases in velocity of flow during storms

The decrease in infiltration that occurs with urbanization reduces soil moisture replenishment and groundwater recharge. In Ontario, a significant proportion of domestic and agricultural water supplies are from a groundwater source. Groundwater is also the source of stream baseflow which is important for sustaining aquatic life.

The preservation of the natural hydrologic cycle, to the greatest extent possible, will not only maintain groundwater recharge so as to reduce baseflow impacts, but it will reduce the potential for flooding and erosion, and hence, the size and cost of stormwater infrastructure. Therefore, it is one of the primary goals of stormwater management.

[2] Ibid.
[3] Ibid.

1.7 Changes in Stream Response to Storm Events[4]

Urban floods differ from those in natural basins in the shape of the flood hydrographs, peak magnitudes relative to the contributing area, and times of occurrence during the year. The imperviousness of urban areas along with the greater hydraulic efficiency of urban conveyance elements cause increased peak stream flows but also more rapid stream response. Summer floods resulting from high intensity thunderstorms are more common in urban areas. Infiltration and evapotranspiration are much more reduced at this time of the year under developed conditions.

The goal of stormwater management is to minimize the risks of loss of life and property damage due to urban floods.

1.8 Changes in Stream Morphology[5]

Stream channels in urban areas respond and adjust to the altered hydrologic regime that accompanies urbanization. The severity and extent of stream adjustment is a function of the degree of watershed imperviousness as well as the stream type. Examples of stream adjustments include:

- increased stream cross-sectional area to accommodate higher flows;
- significant downcutting of the stream channel;
- increased sediment loads in the stream because of increased instream erosion as well as watershed inputs;
- modification of the streambed (typically the grain size of channel sediments shifts from coarse-grained particles to a mixture of fine- and coarse-grained particles); and
- changes in characteristics such as location and meander pattern in response to stream crossings by roads and pipelines.

There may also be direct modifications of streams, such as straightening and/or lining, by humans to "improve" drainage and reduce flooding risks.

A critical issue is the level of development at which stream morphology begins to change significantly. Research models developed in the Pacific Northwest (U.S.) suggest that a threshold for urban stream stability exists at approximately 10% imperviousness of a watershed. Watershed development beyond this threshold consistently results in unstable and eroding channels. The severity and extent of stream adjustment is a function of the magnitude of the change in the sediment-flow regime and the resistance of the channel materials to erosion.

[4] Ibid., p. 1-6
[5] Ibid., p. 1-7

The goal of stormwater management is to protect the aquatic ecosystem, as well as the stream's aesthetic and recreational values, by maintaining a stable fluvial system.

1.9 Changes to Water Quality[6]

Deterioration of urban stream water quality is associated with two phases of urbanization. During the initial phase of development, an urban stream can receive a significant pulse of sediment eroded from upland construction sites, even if erosion and sediment controls are used. In the second phase of urbanization, the washing off of accumulated deposits from impervious areas during storms becomes the dominant source of contaminants.

Urban stormwater runoff may contain elevated levels of suspended solids, nutrients, bacteria, heavy metals, oil and grease, as well as sodium and chloride from road salt. Urban runoff may also cause increased water temperatures.

The change in the sediment load of a stream is one of the key factors affecting channel erosion but elevated levels of suspended solids, including both organic and inorganic matter, may have a number of other effects on receiving water. Increased turbidity interferes with photosynthetic activity by reducing light penetration. Solids in suspension may clog gills and interfere with fish feeding, and the deposition of sediment may cover spawning areas and smother benthic communities. Organic matter exerts an oxygen demand and may severely depress the levels of dissolved oxygen in the receiving water. In addition, several other stormwater contaminants are commonly associated with solids.

The priority of stormwater management with respect to water quality has been control of suspended solids. However, many of the Stormwater Management Practices can successfully remove other stormwater contaminants as well. Measures that prevent or minimize releases of contaminants that may be carried to streams by stormwater are, of course, preferable to treatment options.

Groundwater quality may also be affected in urban areas, and care must be taken that the stormwater management controls chosen do not contribute to groundwater degradation.

[6] Ibid., p.1-8

1.10 Changes in Aquatic Habitat and Ecology[7]

The ecology of urban streams and other aquatic habitat is shaped and molded by extreme shifts in hydrology, geomorphology and water quality that accompany the development process. Stresses on the aquatic communities of urban streams and other water resources are often manifested as:

- a shift from external (leaf matter) to internal (algal organic matter) stream production;
- a decline in aquatic habitat quality;
- a reduction in diversity in the fish, plant, animal and aquatic insect communities in the stream;
- a loss of sensitive coldwater species;
- a destruction of freshwater wetlands, riparian buffers and springs; and
- a decline in wetland plant and animal community diversity.

1.11 Stormwater Management

Stormwater management refers to the procedures or methods used to design drainage works that control the quantity of stormwater runoff, preserve or enhance the quality of stormwater runoff, reduce erosion and prevent flooding.

Stormwater management is required to mitigate the effects of urbanization on the hydrologic cycle, which include increased runoff, and decreased infiltration of rainfall and snowmelt.

1.12 Public Consultation and Meetings

Two Public Information Sessions were held to present information to, and obtain input from, the public, stakeholders and government agencies. The Public Information Sessions were coordinated with ongoing public consultation associated with the preparation of the new Official Plan. The sessions followed a "drop-in" format with display boards presenting project information.

The first Public Information Session was held at the following three locations:

Centennial Arena-Hall
4333 Centennial Road, Hanmer
Monday, March 29, 2004 - 7 p.m. to 9 p.m.

[7] Ibid., p. 1-10

Centre Lionel E. Lalonde Centre (former Trillium Centre)
239 Montée Principale, Azilda
Tuesday, March 30, 2004 - 7 p.m. to 9 p.m.

Tom Davies Square - Foyer
200 Brady Street, Sudbury
Wednesday, March 31, 2004 - 7 p.m. to 9 p.m.

At this first Public Information Session, the following was presented:

- The study purpose, scope and an overview of the watersheds within the City.
- The key issues, identified challenges and opportunities related to both quantity and quality of stormwater runoff in the City.
- The stormwater management strategies developed to address the challenges and opportunities.
- The proposed criteria to be used for prioritizing the watersheds and watershed studies
- A description of the next steps in the study.

Details are included in Appendix “C”.

The Session provided an opportunity for the public to discuss the study, identify and/or confirm major stormwater management issues facing Greater Sudbury, and share ideas about the prioritizing of Greater Sudbury’s watersheds. Comments and input received at the session were carefully reviewed and incorporated into the subsequent phase of the study.

The second Public Information Session was held at the following three locations:

Centennial Arena-Hall
4333 Centennial Road, Hanmer
Tuesday, June 1, 2004 - 1 p.m. to 3 p.m.

Centre Lionel E. Lalonde Centre (former Trillium Centre)
239 Montée Principale, Azilda
Tuesday, June 1, 2004 - 7 p.m. to 9 p.m.

Tom Davies Square
200 Brady Street, Sudbury
Wednesday, June 2, 2004 - 7 p.m. to 9 p.m.

At the second Public Information Session, additional findings were presented. These included:

- The key issues, identified challenges and opportunities related to both quantity and quality of stormwater runoff in the City.
- The stormwater management strategies developed to address the challenges and opportunities.
- Identification of priority watersheds that warrant more detailed studies.
- A description of the components of the Urban Drainage Policy for the City.
- A list of priority watersheds that warrant more detailed studies.

Details are included in Appendix "C”.

The sessions afforded an opportunity for the public to review and discuss the study recommendations. All comments and input received were considered during the preparation of the final documentation for the study.

Comments received during the second Public Information Sessions are provided in Appendix “C”.

Project Information presented at the two Public Information Sessions was presented to the Greater Sudbury Lake Improvement Advisory Panel (GSLIAP) and the Ramsey Lake Advisory Panel on June 2, 2004.

These two advisory panels were appointed by the City Council to provide advice to the City on matters related to the health of all lakes in the City of Greater Sudbury, and the health of Ramsey Lake, respectively. GSLIAP is composed of six expert members representing various agencies and institutions, as well as six citizen members. The Ramsey Lake Advisory Panel is composed of six citizen members.

A questionnaire was distributed to the Lake Stewardship Committee members by the “Waterfront and Rural Study” team, and the responses applicable to stormwater management were considered during identification of problem areas within the various watersheds and subwatersheds.

2.0 OVERVIEW

2.1 Study Area

The Study Area is limited to the City of Greater Sudbury with consideration being given to the 25 watersheds, wholly or partly contained within the City limits[8]. The City encompasses 3,640 km^2 and contains 330 lakes (each with a surface area greater than 10 hectares). There are also several hundred smaller lakes and ponds. The water surface area within the City is approximately 12% of the City's surface area[9].

2.2 Overall Drainage in the Study Area

As the City of Greater Sudbury is found south of northern Ontario's height of land, all of the waterbodies in the area eventually flow into the Great Lakes.[10] Four major drainage basins are located within the study area: the Spanish River, the Wanapitei River, the Whitefish River and the French River.

Five major river systems are contained within the four major drainage basins.

The Spanish River Basin contains the Spanish River and Vermilion River. The Vermilion River flows out of the City of Greater Sudbury at the southwest, entering the Spanish River just outside of the study area, which continues flowing southwest into the North Channel.

The Wanapitei River Basin contains the Wanapitei River and drains south into the French River.

The Whitefish River Basin contains the Whitefish River and drains south into the North Channel.

The French River Basin contains the French River, which flows west along the southern boundary of the basin, entering Georgian Bay.

The major drainage basins are shown in Figure 2.1.

---

[8] "The Past, Present and Future of Sudbury's Lakes," by D. Pearson, J. Gunn and W. Keller, *in* The Physical Environment of the City of Greater Sudbury, Ontario Geological Survey, Special Volume 6, 2002.

[9] "The Physical Environment of the Sudbury Area and its Influence on Urban Development," by O.W. Saarinen and W.A. Tanos, *in* The Physical Environment of the City of Greater Sudbury, Ontario Geological Survey, Special Volume 6, 2002.

[10] Ibid.

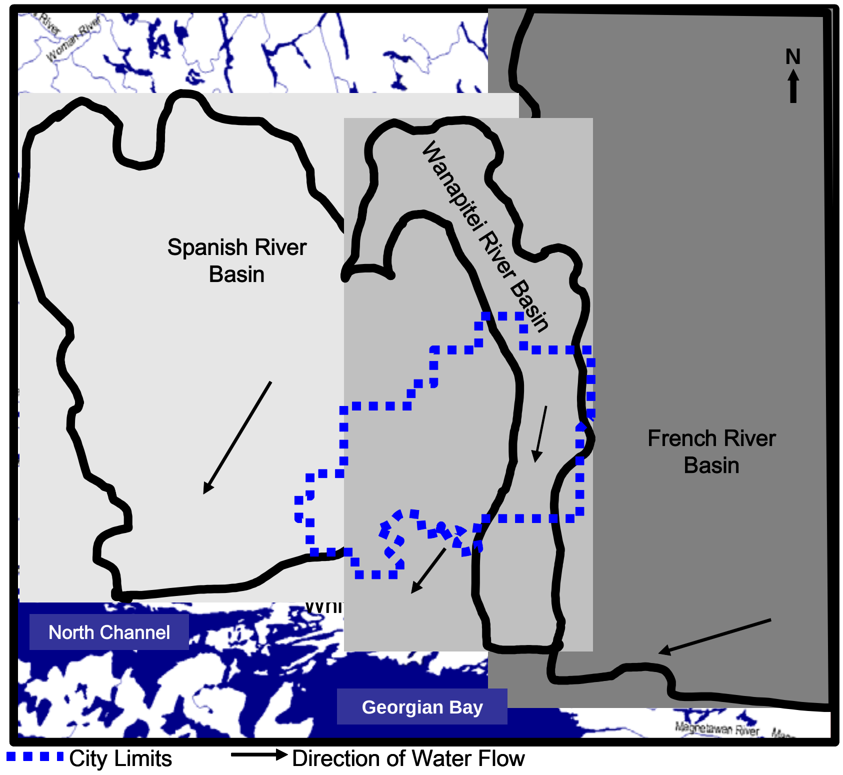


Figure 2-1: Major Drainage Basins in the Sudbury Area (NTS)

Each of the four basins can be divided into a number of smaller sub-basins, referred to as "watersheds" in this report. A watershed is an area of land that drains to a single outlet, is associated with specific lakes and rivers and is divided from other watersheds by a natural high ridge of land (divide). There are 25 of these watersheds wholly or partly contained within the City of Greater Sudbury. The boundaries of these watersheds are shown on Drawing 1.

The watersheds within the Spanish River basin are:

a. Upper Vermilion Watershed;

b. Roberts River Watershed

c. Rapid River Watershed;

d. Nelson River Watershed;

e. Sandcherry Creek Watershed;

f. Mid Vermilion Watershed;

g. Whitson River Watershed;

h. Whitewater Watershed;

i. Upper Junction Creek Watershed;

j. Lower Junction Creek Watershed;

k. Ramsey Watershed;

l. Fairbank Watershed;

m. Lower Vermilion Watershed;

n. Onaping Watershed:

o. Cameron Watershed; and

p. Lower Spanish River Watershed.

The Wanapitei River Basin is comprised of:

a. Wanapitei Watershed;

b. Emery Creek Watershed; and

c. East Wanapitei River Watershed.

The Whitefish River Basin contains:

a. Panache Watershed

The watersheds within the French River Basin include:

a. Kukagami Watershed;

b. Sturgeon River Watershed;

c. Spring Creek Watershed;

d. Red Deer Watershed; and

e. Nepewassi Watershed.

3.0 WATERSHED CHARACTERIZATION

During the characterization of the watersheds within Greater Sudbury and identification of areas that require further study, consideration was given to water use, land use, flood events, dams, municipal drains and input received from various stakeholders.

3.1 Water Use

Potable water supply, wastewater assimilation, recreation, ecological and historical use of lakes and rivers in the Greater Sudbury area were reviewed[11]. This enabled prioritisation of watersheds relative to water use.

3.2 Land Use

Many of the lakes and rivers within the boundaries of the City of Greater Sudbury are downstream receivers of stormwater runoff. Therefore, they are directly affected by land use within the respective watersheds.

Existing land use information was obtained from the City in the form of ArcView GIS files in NAD83 coordinates. The original source of this information was the Ministry of Natural Resources (MNR) Natural Resources and Values Information System (NRVIS), which is a geographic information system (GIS) used to manage digital land-use information.

Future land use (potential growth areas) was identified through review of information provided by the City[12].

Both existing and future land use information was delineated within the boundaries of corresponding watersheds in order to determine the relative percentages of defined land use within each watershed. This enabled prioritisation of watersheds in the context of land use.

3.3 Flood Events

Historical flood data was analysed. This was completed through review of the NDCA report entitled *Watershed Inventory, 1980*, which details flood events from the early 1900s until 1980 and newspaper articles regarding flooding subsequent to 1980. The locations and dates of flood events were then overlaid onto the watershed mapping.

A preliminary analysis was undertaken in order to determine if the flooding could be attributed to inadequate conveyance, increased runoff from urbanization or other land-use changes, or the natural flow pattern of large watercourses. This enabled prioritisation of watersheds relative to flooding (quantity) concerns.

[11] City of Greater Sudbury, various reports.
[12] City of Greater Sudbury, Proposed Development Areas, 2003.

3.4 Municipal Drains

Municipal Drains are drains that come under the authority of the Drainage Act, which is discussed further in Section 7. There are several municipal drains in Greater Sudbury. Design reports specific to each municipal drain were obtained from the City and findings reviewed. The locations of all Municipal Drains are shown on Drawing 1.

3.5 Spanish / Vermilion Rivers Water Management Plan

Due to new legislative requirements around power generation in Ontario, a Water Management Plan will be developed for the Spanish and Vermilion River systems. Organizations with water control structures on the Spanish and Vermillion Rivers including Inco Ltd., Domtar Inc., the City of Greater Sudbury, Falconbridge Limited, Nickel District Conservation Authority and the MNR, will cooperatively prepare a Water Management Plan for these waterways. The newly created plan will attempt to address the socio-economic and environmental concerns or issues that are related to the water management operations and how they influence water flows and levels.

3.6 Public Consultation and Meetings

As a part of the study process, two Public Information Sessions were held to present information to, and obtain input from the public and review agencies. The first Public Information Session occurred in March 2004 during which results from the initial stages of the study were presented. A second Public Information Session was held in June 2004. The sessions provided an opportunity for the public to review and discuss the study findings and recommendations. Input that was received during and subsequent to the Public Information Sessions has been summarized in the following table and was considered during the preparation of the final documentation for this study.

Date	Comment	Resulting Action
March 31, 2004	▪ Stream bank erosion/sediment in drainage ditch (dug in 2002) just upstream of Junction Creek near the Adanac Ski Hill (Appendix C).	▪ Issue included on the Junction Creek Subwatershed Fact Sheet.
May 17, 2004	▪ There was concern voiced by the residents of the Nepahwin Lake area about the quantity and quality of stormwater currently being discharged into the lake via storm sewer outlets. ▪ Residents are also concerned about the ongoing and potential development in the watershed and its impacts on the lake.	▪ Influenced prioritization of future subwatershed studies. ▪ Issues included on the Nepahwin/ Robinson Subwatershed Fact Sheet.
May 31, 2004	▪ McCharles Lake residents are concerned about existing flooding in the area and the possibility that flooding may increase as upstream development occurs. ▪ Residents also concerned about the potential water quality impacts of the nearby Walden Landfill Site.	▪ Influenced prioritization of future subwatershed studies. ▪ Issues included on the Simon/ McCharles Lake Subwatershed Fact Sheet.

Date	Comment	Resulting Action
May 2004	▪ Landowner planning future development located partially within the Junction Creek floodplain in New Sudbury.	▪ Influenced prioritization of future subwatershed studies. ▪ Included reference to the development proposal on the Upper Junction Creek Watershed and the Junction Creek Subwatershed Fact Sheets.

Table 3-1: Public Input

Project Information presented at the two Public Information Sessions was presented to the Greater Sudbury Lake Improvement Advisory Panel (GSLIAP) and the Ramsey Lake Advisory Panel on June 2, 2004.

These two advisory panels were appointed by the City Council to provide advice to the City on matters related to the health of all lakes in the City of Greater Sudbury, and the health of Ramsey Lake, respectively. GSLIAP is composed of six expert members representing various agencies and institutions, as well as six citizen members. The Ramsey Lake Advisory Panel is composed of six citizen members.

A questionnaire was distributed to the Lake Stewardship Committee members by the "Waterfront and Rural Study Team", and the responses applicable to stormwater management were considered during identification of problem areas within the various watersheds and subwatersheds.

There were no formal comments received from Regulatory Agencies regarding the study, however the NDCA did participate in the completion of the Study.

It is anticipated that there will be more involvement/input from stakeholders during the completion of the individual subwatershed studies.

3.7 Summary of Evaluations

3.7.1 Watersheds

Each of the 25 watersheds located within the City of Greater Sudbury was evaluated utilizing the following criteria.

a. Have existing water quantity problems that could be attributed to urban stormwater runoff;

b. Have significant development potential;

c. Have existing water quality problems that could be attributed to urban stormwater runoff; and

d. Require more detailed analysis to determine solutions to the problems listed above.

The first criterion, “Have existing water quantity problems that could be attributed to urban stormwater runoff”, compares the number of historical flooding events (on a low/medium/high frequency scale) with land use.

The second criterion, “Have significant development potential”, gave each watershed a rating of either low (<3) or high (>3) development potential depending upon the number of existing registered development plans.

To satisfy the third criterion, “Have existing water quality problems that could be attributed to urban stormwater runoff”, results of the spring phosphorus sampling were used as an indicator. If the Provincial Water Quality Objective (PWQO) of 20 μg/L of phosphorus was exceeded within the last five years in any lake within a watershed, the land use information within that watershed was reviewed to determine if the problems could be attributed to urban or agricultural land uses. Not every lake in the City has been sampled, consequently some watersheds were not represented.

Evaluating the 25 watersheds using the criteria described above, led to the identification of eight prioritised watersheds:

a. East Wanapitei River;

b. Lower Junction Creek;

c. Onaping River;

d. Panache;

e. Whitson River;

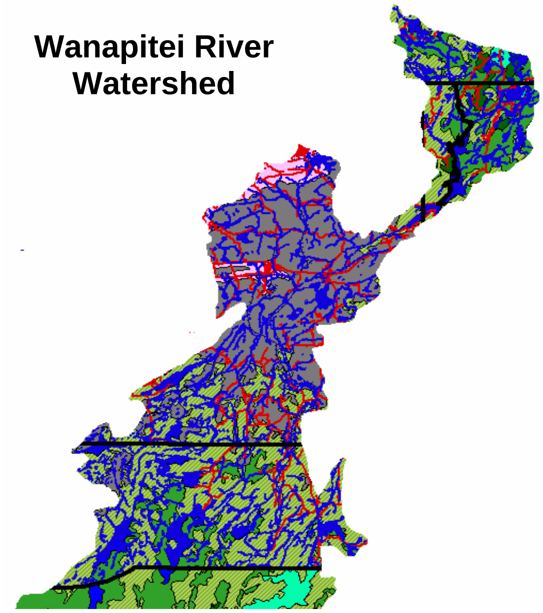
f. Whitewater;

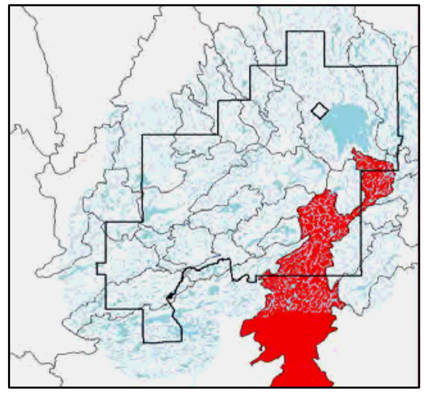
g. Upper Junction Creek; and

h. Ramsey.

Fact Sheets were then prepared for the 8 prioritised watersheds.

Priority Watershed Fact Sheet	WANAPITEI RIVER





Features

Area:	903 km^2
Existing Land Use:	Rural (forest); Urban (Communities of Wahnapitae and Coniston); Mine Tailings and Bedrock
Development Potential:	Moderate
Dams:	Stinson Dam, Coniston Dam
Municipal Drains:	None
Lake/River Uses:	Homes, recreation, Wanapitei Water Treatment Plant, Falconbridge Smelter Water Supply, Coniston Wastewater Treatment Plant, Wahnapitae Sewage Lagoons, hydroelectric generation
Urban Water Body:	Wanapitei River

Primary Stormwater Issues

- Potential negative impact upon water quality due to uncontrolled stormwater discharges from existing urban areas and wastewater treatment facility effluent
- Growth potential will require stormwater quality and quantity control
- Some historic flood events in the Wahnapitae area
- Major municipal drinking water source (upstream of urban areas in watershed)

Related Studies

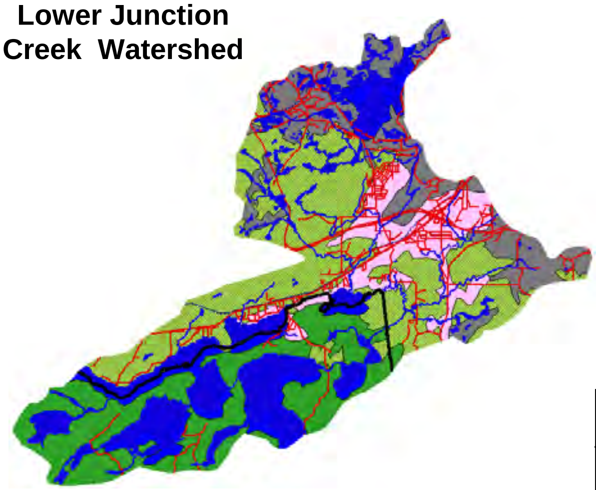
- Floodline Mapping – Wanup (1983) and Summary Report (1983)
- Floodline Mapping – Moose Creek (Wahnapitae) (1986)
- Flood and Fill Line Study – Capreol, Dowling and Wahnapitae Areas (1979)

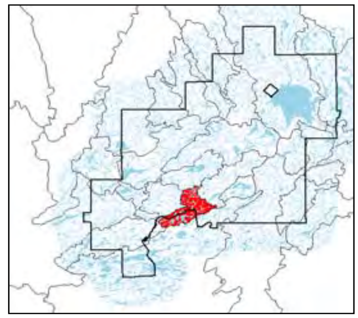
Alternative Stormwater Management Strategies

- Provide source control by reducing rate and volume of runoff on-site
- Construct stormwater management facilities to provide storage for quantity and/or quality management
- Undertake conveyance system modifications
- Implement stormwater quality management policies and outreach programs

Priority Watershed Fact Sheet	LOWER JUNCTION CREEK

Lower Junction Creek Watershed





Features

Area:	106 km^2
Existing Land Use:	Rural (forest); Urban (Communities of Lively and Naughton); Mine Tailings and Bedrock
Development Potential:	High
Dams:	Kelly Lake Weir
Municipal Drains:	None
Lake/River Uses:	homes, cottages, recreation, Walden and Lively Wastewater Treatment Plant effluent outfalls
Urban Water Bodies:	Simon Lake, Meatbird Lake, Mud Lake, McCharles Lake, Junction Creek

Primary Stormwater Issues

- Impact upon water quality due to uncontrolled stormwater discharges from existing urban areas
- Poor water quality in Junction Creek likely due to uncontrolled stormwater discharges from existing urban areas, past industrial pollution and wastewater treatment plant effluent
- Historical poor water quality (high nutrient levels) in Simon Lake likely due to past industrial pollution (historical loading from Kelly Lake), use of lawn fertilizers in urban areas and wastewater treatment plant effluent
- Water quality in Simon Lake appears to have improved over the past 25 years.
- Historical poor water quality (high nutrient levels) in McCharles Lake likely due to past industrial pollution (historical loading from Kelly Lake), use of lawn fertilizers in urban areas and wastewater treatment plant effluent from upstream
- Growth potential at many different locations will require stormwater quality and quantity control
- Winter salting of roads
- Significant number of historic flooding events in downstream portion of subwatershed near confluence with Vermilion River and at various locations along the main channel

Alternative Stormwater Management Strategies

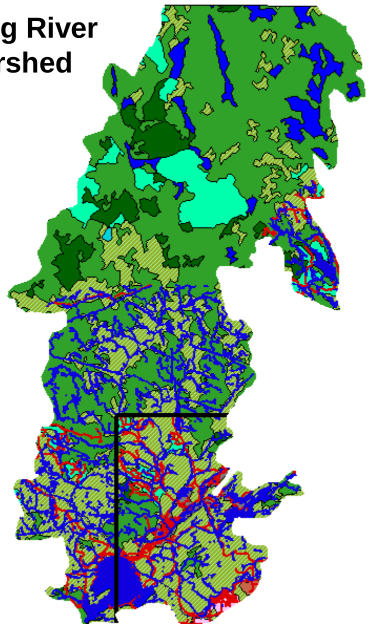
- Provide source control by reducing rate and volume of runoff on-site
- Construct stormwater management facilities to provide storage for quantity and/or quality management
- Undertake conveyance system modifications
- Implement stormwater quality management policies and outreach programs

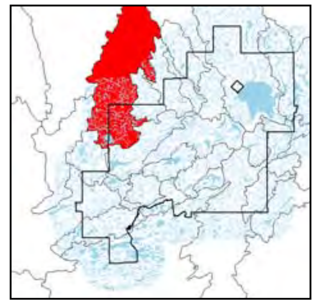
Related Studies

- Floodplain Mapping of Junction Creek (1980)
- Junction Creek Watershed Management Study (1982)

Priority Watershed Fact Sheet	ONAPING RIVER

Onaping River Watershed





Features

Area:	780 km^2
Existing Land Use:	Rural (forest); Urban (Communities of Dowling, Onaping and Levack)
Development Potential:	Low
Dams:	Windy Lake Dam, Moose Creek 1 Dam, Moose Creek 2 Dam, Moose Creek 3 Dam, Strathcona Treatment System Dam
Municipal Drains:	None
Lake/River Uses:	Dowling and Levack Wastewater Treatment Plant effluent outfalls
Urban Water Body:	Onaping River

Primary Stormwater Issues

- Potential negative impact upon water quality due to uncontrolled stormwater discharges from existing urban areas
- Significant number of historic flooding events in downstream portion of watershed near confluence with Vermilion River

Alternative Stormwater Management Strategies

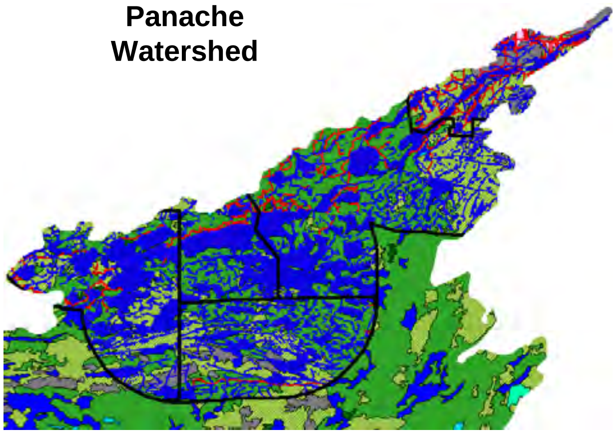
- Provide source control by reducing rate and volume of runoff on-site
- Construct stormwater management facilities to provide storage for quantity and/or quality management
- Undertake conveyance system modifications
- Implement stormwater quality management policies and outreach programs

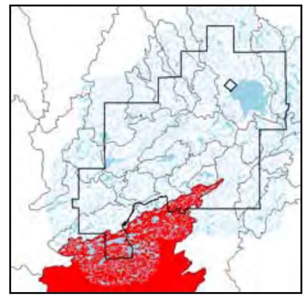
Related Studies

- Flood Damage Reduction Programme for Onaping River at Dowling (1982)
- Flood and Fill Line Study – Capreol, Dowling and Wahnapitae Areas (1979)

Priority Watershed Fact Sheet	PANACHE

Panache Watershed





Features

Area:	1380 km^2
Existing Land Use:	Mine Tailings and Bedrock; Urban (Sudbury); Rural (forest)
Development Potential:	Low
Dams:	Grant Lake Dam, McFarlane Lake Dam
Municipal Drains:	None
Lake/River Uses:	homes, cottages, recreation, private drinking water supply, McFarlane Wastewater Treatment Plan effluent outfall
Urban Water Bodies:	Daisy Lake, Richard Lake, McFarlane Lake

Related Studies

- Southend Drainage Study
- Whitefish River Floodplain Mapping (1983)

Primary Stormwater Issues

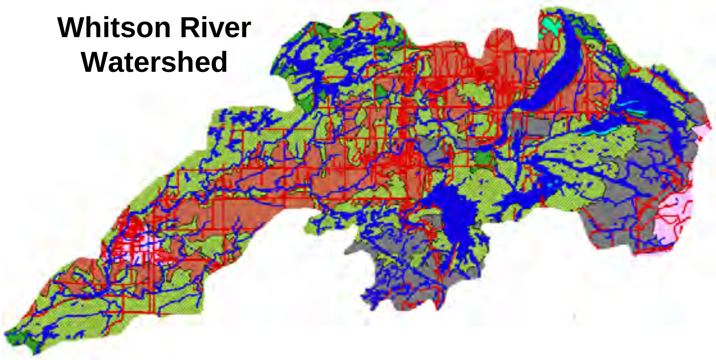
- Impact upon water quantity and quality resulting from uncontrolled stormwater discharges from existing urban areas
- Poor water quality (high nutrient levels) in McFarlane Lake likely due to the use of lawn fertilizers in urban areas, wastewater treatment plant effluent and use of septic systems
- Freeze on creation of new unserviced lots on McFarlane Lake due to poor water quality
- Growth potential will require stormwater quantity and quality control
- Winter salting of roads
- High potential for flooding in urbanized portion of the watershed, due to development and existing stormwater infrastructure

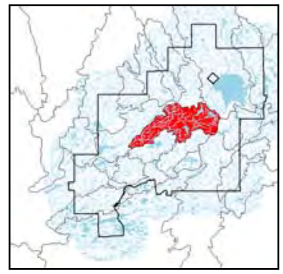
Alternative Stormwater Management Strategies

- Provide source control by reducing rate and volume of runoff on-site
- Construct stormwater management facilities to provide storage for quantity and/or quality management
- Undertake conveyance system modifications
- Implement stormwater quality management policies and outreach programs

Priority Watershed Fact Sheet	WHITSON RIVER

Whitson River Watershed





Features

Area:	333 km^2
Existing Land Use:	Agricultural; Rural (forest); Urban (Blezard Valley, Hanmer, Val Caron, Val Therese, McCrea Heights); Mine Tailings and Bedrock
Development Potential:	High
Dams:	Goudreau Dam, Whitson Lake Dam
Municipal Drains:	Dominion Drive, Vern Drive, Pierobon, Castonguay, Pilon, Soenens, Butkevich, Paquette-Simard, Rayside Concession 5, Sylvestre, Perrault, Trottier, Rayside Concession 6, Pawlowicz, Rainville, Van Drunen, Whitson Tributary Branch (Drain 4), Quesnel, Denis, Lariviere
Lake/River Uses:	homes, cottages, recreation, Azilda and Chelmsford Wastewater Treatment Plants
Urban Water Body:	Whitson River, Whitson Lake, Garson Lake, McCrae Lake
Other:	Municipal wells located in watershed

Primary Stormwater Issues

- Impact upon water quality resulting from uncontrolled stormwater discharges from existing urban areas, runoff from agricultural areas and wastewater treatment plant effluent
- Significant number of historic flooding events along the main channel
- Growth potential will require stormwater quantity and quality control

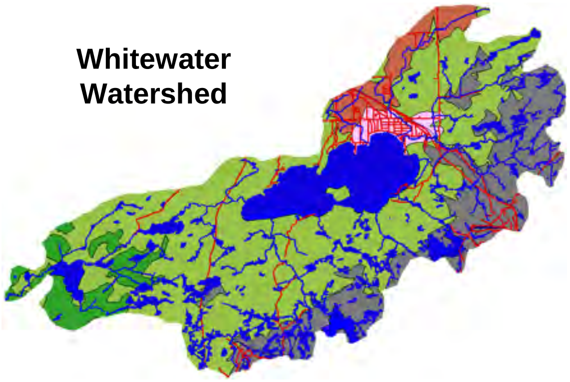
Related Studies

- Whitson River Hydrologic Analysis (1988)
- Flood Protection – Whitson River and Chelmsford (1992)
- Floodplain Mapping – Whitson River (1978)

Alternative Stormwater Management Strategies

- Provide source control by reducing rate and volume of runoff on-site
- Construct stormwater management facilities to provide storage for quantity and/or quality management
- Undertake conveyance system modifications
- Implement stormwater quality management policies and outreach programs

Priority Watershed Fact Sheet	WHITEWATER



Features

Area:	134 km^2
Existing Land Use:	Agricultural; Rural (forest); Mine Tailings and Bedrock; Urban (Community of Azilda)
Development Potential:	Freeze on creation of new unserviced lots on Whitewater Lake due to poor water quality Moderate in other areas of Azilda
Dams:	Whitewater
Municipal Drains:	Paquette-Simard, Simard, Trillium Centre,
Lake/River Uses:	homes, cottages, recreation
Urban Water Body:	Whitewater Lake, Moore Lake

Related Studies

- Flood Damage Reduction Study – Landry Creek (1984)
- Floodplain Mapping of Azilda-Whitewater Lake Area (1978)
- Drainage Design Reports: Paquette/ Simard Drain, Simard Drain and Simard Drain F and G, Trillium Drain

Primary Stormwater Issues

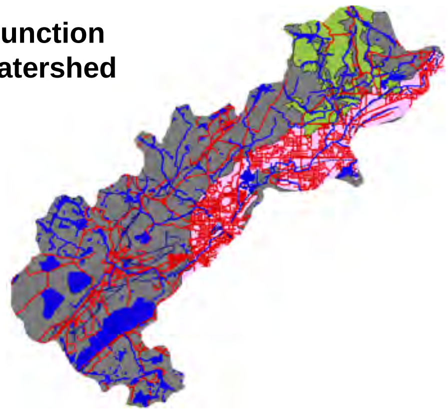
- Impact upon water quality resulting from uncontrolled stormwater discharges from existing urban areas and runoff from agricultural areas
- Poor water quality (high nutrient levels) in Whitewater Lake likely due to the use of lawn fertilizers in urban areas, agricultural runoff and use of septic systems
- Freeze on creation of new unserviced lots on Whitewater Lake due to poor water quality
- Growth potential in Azilda will require stormwater quantity and quality control
- Winter salting of roads
- Some historic flooding events along the Whitewater Lake tributaries through Azilda due to uncontrolled stormwater runoff

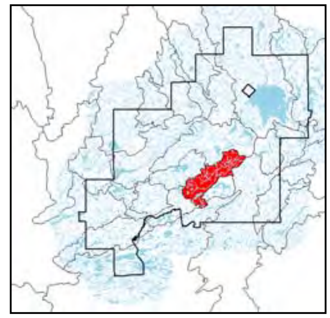
Alternative Stormwater Management Strategies

- Provide source control by reducing rate and volume of runoff on-site
- Construct stormwater management facilities to provide storage for quantity and/or quality management
- Undertake conveyance system modifications
- Implement stormwater quality management policies and outreach programs

Priority Watershed Fact Sheet	UPPER JUNCTION CREEK

Upper Junction Creek Watershed





Features

Area:	156 km^2
Existing Land Use:	Mine Tailings and Bedrock; Urban (Communities of New Sudbury, Garson, and Copper Cliff); Rural (forest)
Development Potential:	High
Dams:	Maley Dam, Frood Dam, Nickeldale Dam, Clarabelle Dam, Lady Macdonald Lake Dam, Copper Cliff Creek Dam
Municipal Drains:	None
Lake/River Uses:	Houses, recreational, Sudbury and Copper Cliff Wastewater Treatment Plants, Garson Sewage Lagoons
Urban Water Body:	Junction Creek, Kelly Lake

Alternative Stormwater Management Strategies

- Provide source control by reducing rate and volume of runoff on-site
- Construct stormwater management facilities to provide storage for quantity and/or quality management
- Undertake conveyance system modifications
- Implement stormwater quality management policies and outreach programs

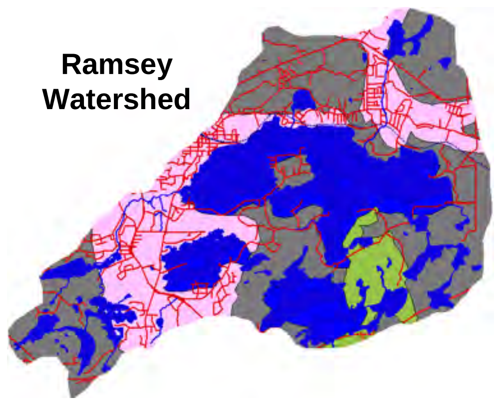
Primary Stormwater Issues

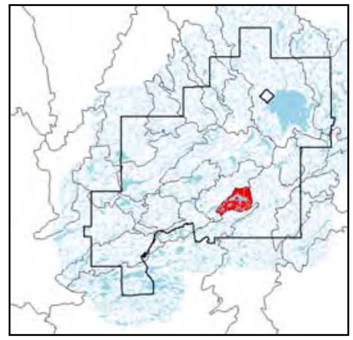
- Impact upon water quality due to uncontrolled stormwater discharges from existing urban areas
- Poor water quality in Junction Creek and Kelly Lake likely due to uncontrolled stormwater discharges from existing urban areas, past industrial pollution and wastewater treatment plant effluent
- Growth potential will require stormwater quality and quantity control
- Winter salting of roads
- Numerous historic flooding events, both along the main channel and in tributaries, due to uncontrolled stormwater runoff from urban areas
- Existing erosion problems along Junction Creek
- Upper Junction Creek has become a cold water fishery habitat. An appropriate level of protection from stormwater effects is required.

Related Studies

- Maley Dam Study
- Nickeldale Reservoir Preliminary Engineering Report (1967) and Addendum (1977)
- Floodplain Mapping of Junction Creek (1980)
- Junction Creek Watershed Management Study (1982)
- The Ponderosa – A Concept for Development (1988)
- Junction Creek Waterway Park Community Improvement Plan (1991)
- Nolin Creek Flood Control Project (1997)

Priority Watershed Fact Sheet	RAMSEY





Features

Area:	61 km^2
Existing Land Use:	Urban (Sudbury); Mine Tailings and Bedrock
Development Potential:	High
Dams:	Ramsey Lake Dam, Lake Nepahwin Dam, Lake Laurentian Dam, Robinson Lake Dam
Municipal Drains:	None
Lake/River Uses:	homes, cottages, recreation, David Street Water Treatment Plant
Urban Water Bodies:	Ramsey Lake, Minnow Lake, Lake Laurentian, Lake Nepahwin, Bennett Lake, Robinson Lake, Lily Creek, Still Lake, St. Charles Lake, Hannah Lake, Middle Lake, Bethel Lake, Perch Lake

Related Studies

- South End Drainage Study

Primary Stormwater Issues

- Potential negative impact upon water quality due to uncontrolled stormwater discharges from existing urban areas
- Poor water quality (high nutrient levels) in several lakes likely due to the past industrial pollution and use of lawn fertilizers in urban areas
- Growth potential will require stormwater quality and quantity control
- Winter salting of roads
- Some historic flood events within local storm drainage systems due to uncontrolled urban stormwater runoff
- Extremely sensitive area, multiple lake uses at City's centre; current public pressure to enhance Lake Nepahwin
- Major municipal drinking water source

Alternative Stormwater Management Strategies

- Provide source control by reducing rate and volume of runoff on-site
- Construct stormwater management facilities to provide storage for quantity and/or quality management
- Undertake conveyance system modifications
- Implement stormwater quality management policies and outreach programs

3.7.2 Subwatersheds

Twenty-Nine subwatersheds were identified within the 8 prioritized watersheds and then evaluated utilizing the same evaluation criteria that was used during evaluation of the watersheds. This effort led to the identification of 17 prioritized subwatersheds that encompass areas where, amongst other things, growth is most likely to occur in the City and will necessitate the completion of subwatershed studies and creation of subwatershed plans.

a. Wahnapitae;

b. Coniston;

c. Meatbird Creek/Lively;

d. Mud Lake;

e. Simon/McCharles Lake;

f. Dowling;

g. Richard Lake;

h. Blezard Valley/Val Caron/Hanmer;

i. Chelmsford;

j. Whitson Lake;

k. Azilda;

l. Copper Cliff;

m. Garson;

n. Junction Creek;

o. Kelly Lake.

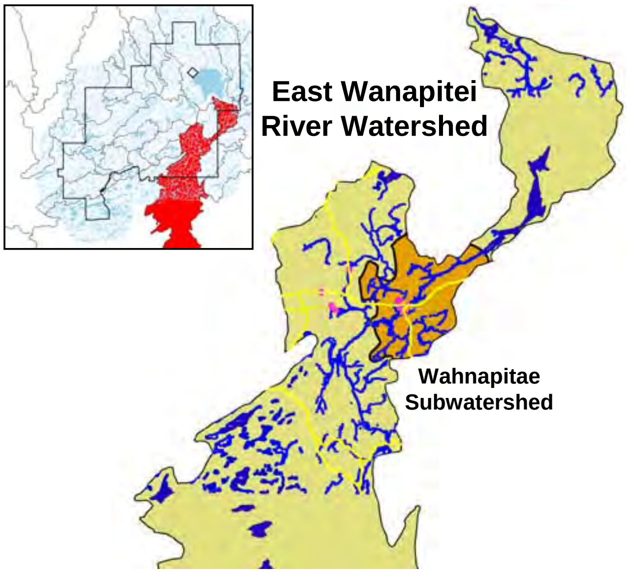
p. Nepahwin/Robinson;

q. Ramsey Lake;

Fact Sheets were then prepared for the 17 prioritised subwatersheds.

Non-priority watersheds and subwatersheds do not require further study at this time; however, the Urban Drainage Policy options address stormwater management goals and objectives for all areas.

Urban Subwatershed Fact Sheet	WAHNAPITAE
Priority Watershed	**EAST WANAPITEI RIVER**



Features

Area:	47 km^2
Location:	Wanapitei River from Stinson Dam to Coniston Dam through Wahnapitae
Existing Land Use:	Urban (Community of Wahnapitae); Mine Tailings and Bedrock
Development Potential:	Moderate
Dams:	Stinson Dam, Coniston Dam
Municipal Drains:	None
Lake/River Uses:	Homes, recreation, Wanapitei Water Treatment Plant, Wahnapitae Sewage Lagoons, hydroelectric generation
Urban Water Body:	Wanapitei River

Related Studies

- Floodline Mapping – Wanup (1983) and Summary Report (1983)
- Floodline Mapping – Moose Creek (Wahnapitae) (1986)
- Flood and Fill Line Study – Capreol, Dowling and Wahnapitae Areas (1979)

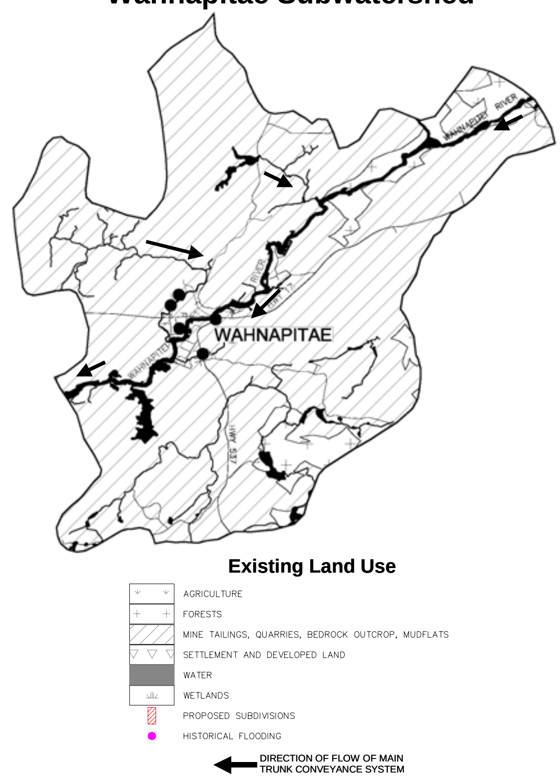
Primary Stormwater Issues

- Potential negative impact upon water quality due to uncontrolled stormwater discharges from existing urban areas
- Growth potential will require stormwater quality and quantity control
- Some historic flood events in the Wahnapitae area
- Major municipal drinking water source (upstream of urban areas in watershed)

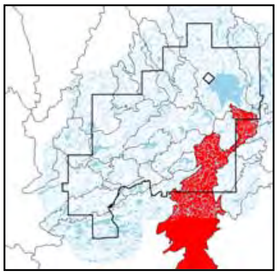
Alternative Stormwater Management Strategies

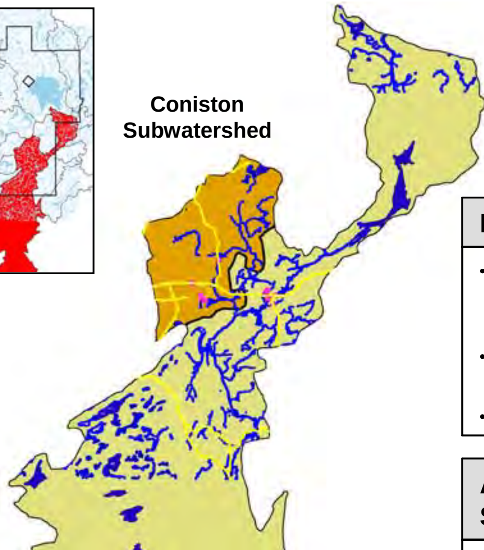
- Provide source control by reducing rate and volume of runoff on-site
- Construct stormwater management facilities to provide storage for quantity and/or quality management
- Undertake conveyance system modifications
- Implement stormwater quality management policies and outreach programs

Wahnapitae Subwatershed



Urban Subwatershed Fact Sheet	CONISTON
Priority Watershed	**EAST WANAPITEI RIVER**





East Wanapitei River Watershed

Primary Stormwater Issues

- Potential negative impact upon water quality due to uncontrolled stormwater discharges from existing urban areas and wastewater treatment plant effluent
- Growth potential will require stormwater quality and quantity control
- Significant flood event history

Alternative Stormwater Management Strategies

- Provide source control by reducing rate and volume of runoff on-site
- Construct stormwater management facilities to provide storage for quantity and/or quality management
- Undertake conveyance system modifications
- Implement stormwater quality management policies and outreach programs

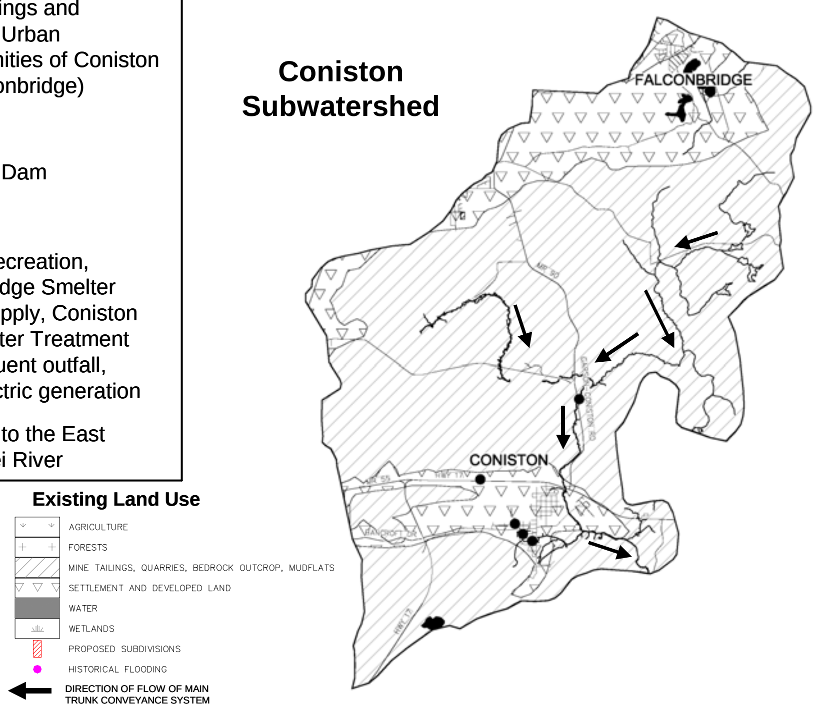
Features

Area:	82 km^2
Location:	Portion of watershed upstream of Coniston that drains through Coniston to the Coniston Dam
Existing Land Use:	Mine Tailings and Bedrock; Urban (Communities of Coniston and Falconbridge)
Development Potential:	Moderate
Dams:	Coniston Dam
Municipal Drains:	None
Lake/River Uses:	homes, recreation, Falconbridge Smelter Water Supply, Coniston Wastewater Treatment Plant effluent outfall, hydroelectric generation
Urban Water Body:	Tributary to the East Wanapitei River

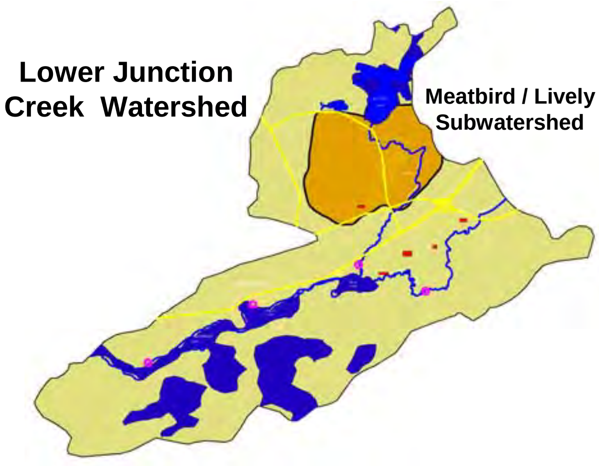
Related Studies

- Coniston Flood Control Remedial Works (1982)

Coniston Subwatershed



Urban Subwatershed Fact Sheet	MEATBIRD/LIVELY
Priority Watershed	**LOWER JUNCTION CREEK**



Primary Stormwater Issues

- Potential negative impact upon water quality due to uncontrolled stormwater discharges from existing urban areas and wastewater treatment plant effluent
- Growth potential will require stormwater quality and quantity control
- Winter salting of roads

Features

Area:	13 km^2
Location:	Meatbird Creek from outlet of Meatbird Lake to confluence with Junction Creek
Existing Land Use:	Rural; Mine Tailings and Bedrock; Urban (Community of Lively)
Development Potential:	Moderate
Dams:	None
Municipal Drains:	None
Lake/River Uses:	homes, Lively Wastewater Treatment Plant effluent outfall
Urban Water Bodies:	Meatbird Creek, Junction Creek

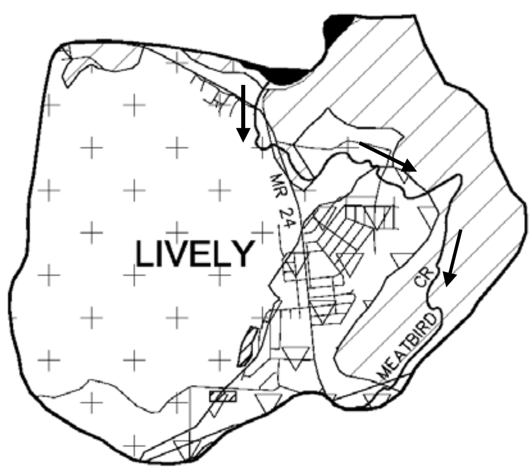
Alternative Stormwater Management Strategies

- Provide source control by reducing rate and volume of runoff on-site
- Construct stormwater management facilities to provide storage for quantity and/or quality management
- Undertake conveyance system modifications
- Implement stormwater quality management policies and outreach programs

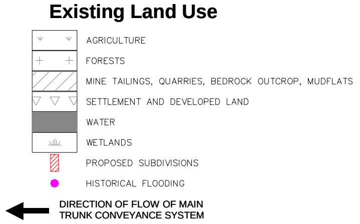
Related Studies

- Floodplain Mapping of Junction Creek (1980)
- Junction Creek Watershed Management Study (1982)

Meatbird / Lively Subwatershed

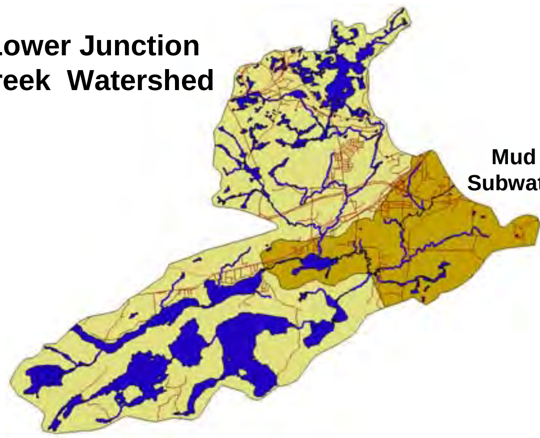


Existing Land Use



Urban Subwatershed Fact Sheet	MUD LAKE
Priority Watershed	**LOWER JUNCTION CREEK**

Lower Junction Creek Watershed



Features

Area:	23 km^2
Location:	Junction Creek, from the outlet of Kelly Lake to the outlet of Mud Lake
Existing Land Use:	Rural (forest); Urban (Community of Lively); Mine Tailings and Bedrock
Development Potential:	High
Dams:	Kelly Lake Weir
Municipal Drains:	None
Lake/River Uses:	homes
Urban Water Bodies:	Junction Creek, Mud Lake

Related Studies

- Floodplain Mapping of Junction Creek (1980)
- Junction Creek Watershed Management Study (1982)

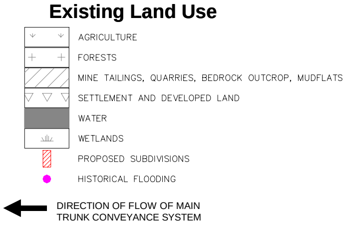
Primary Stormwater Issues

- Impact upon water quality due to uncontrolled stormwater discharges from existing urban areas
- Poor water quality in Junction Creek likely due to uncontrolled stormwater discharges from existing urban areas, past industrial pollution (historical loading from Kelly Lake) and use of lawn fertilizers in urban areas
- Growth potential at many different locations will require stormwater quality and quantity control
- Winter salting of roads

Alternative Stormwater Management Strategies

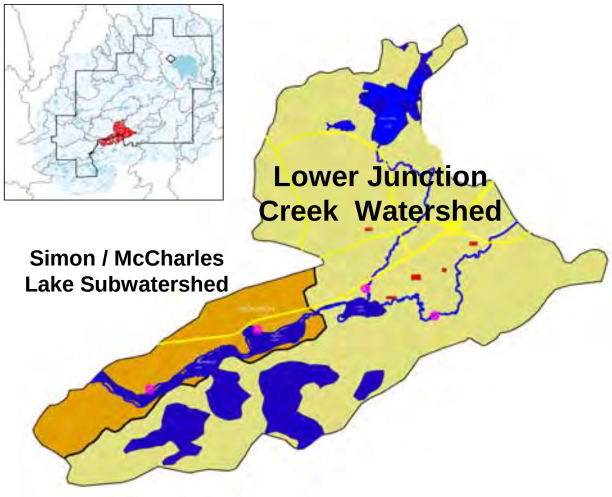
- Provide source control by reducing rate and volume of runoff on-site
- Construct stormwater management facilities to provide storage for quantity and/or quality management
- Undertake conveyance system modifications
- Implement stormwater quality management policies and outreach programs

Existing Land Use



Mud Lake Subwatershed

Urban Subwatershed Fact Sheet	SIMON / MCCHARLES LAKE
Priority Watershed	**LOWER JUNCTION CREEK**



Features

Area:	18 km^2
Location:	Simon Lake to McCharles Lake
Existing Land Use:	Rural (forest); Urban (Community of Naughton and waterfront homes)
Development Potential:	Low
Dams:	None
Municipal Drains:	None
Lake/River Uses:	homes, cottages, recreation, Walden Wastewater Treatment Plant effluent outfall
Urban Water Bodies:	Simon Lake, McCharles Lake, Junction Creek

Alternative Stormwater Management Strategies

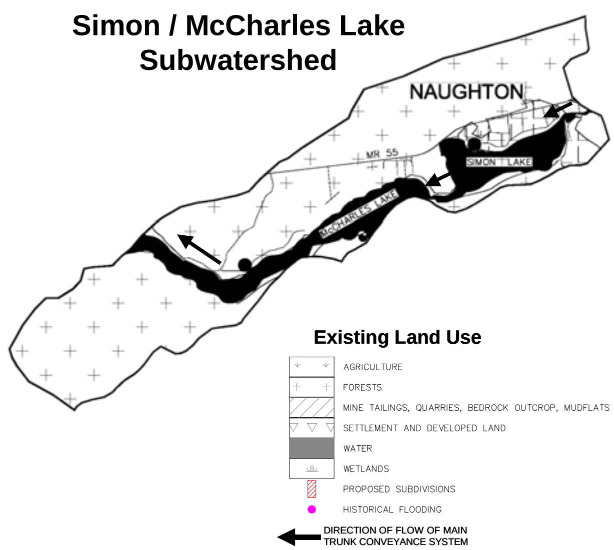
- Provide source control by reducing rate and volume of runoff on-site
- Construct stormwater management facilities to provide storage for quantity and/or quality management
- Undertake conveyance system modifications
- Implement stormwater quality management policies and outreach programs

Primary Stormwater Issues

- Impact upon water quality due to uncontrolled stormwater discharges from existing urban areas
- Poor water quality in Junction Creek likely due to uncontrolled stormwater discharges from existing urban areas, past industrial pollution and wastewater treatment plant effluent
- Historical poor water quality (high nutrient levels) in Simon Lake likely due to past industrial pollution (historical loading from Kelly Lake), use of lawn fertilizers in urban areas and wastewater treatment plant effluent
- Water quality in Simon Lake appears to have improved over the past 25 years.
- Historical poor water quality (high nutrient levels) in McCharles Lake likely due to past industrial pollution (historical loading from Kelly Lake), use of lawn fertilizers in urban areas and wastewater treatment plant effluent from upstream
- Growth potential at many different locations will require stormwater quality and quantity control
- Winter salting of roads
- Significant number of historic flooding events in downstream portion of subwatershed near confluence with Vermilion River and at various locations along the main channel

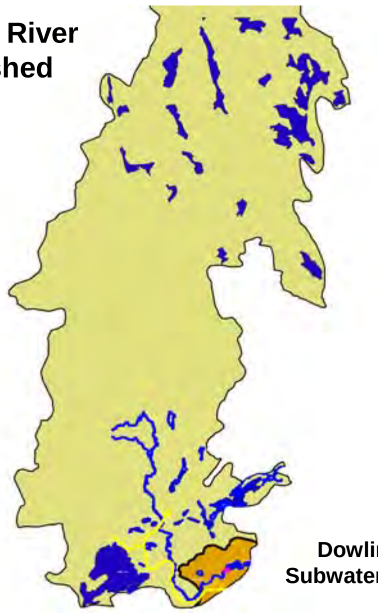
Related Studies

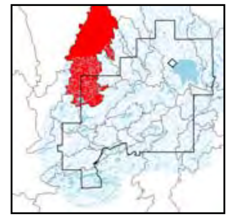
- Floodplain Mapping of Junction Creek (1980)
- Junction Creek Watershed Management Study (1982)



Urban Subwatershed Fact Sheet	DOWLING
Priority Watershed	**ONAPING RIVER**

Onaping River Watershed





Features

Area:	18 km^2
Location:	Onaping River, west of Main Street in Dowling, to confluence with Vermilion River
Existing Land Use:	Agricultural; Rural (forest); Urban (Community of Dowling)
Development Potential:	Low
Dams:	None
Municipal Drains:	None
Lake/River Uses:	Dowling Wastewater Treatment Plant effluent outfall
Urban Water Body:	Onaping River

Related Studies

- Flood Damage Reduction Programme for Onaping River at Dowling (1982)
- Flood and Fill Line Study – Capreol, Dowling and Wahnapitae Areas (1979)

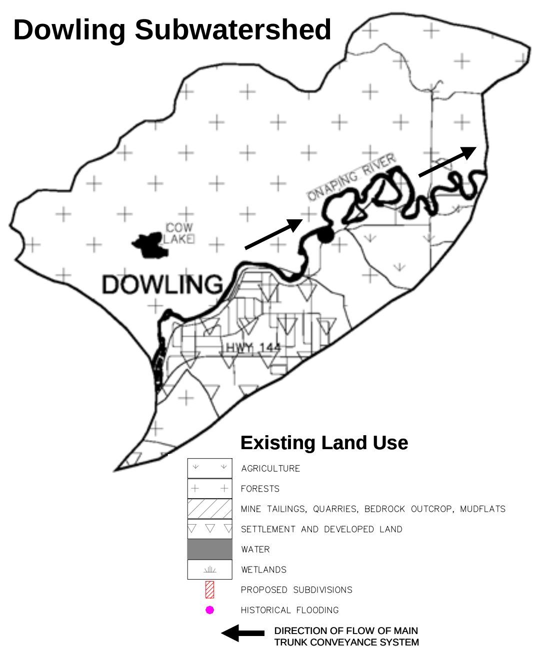
Primary Stormwater Issues

- Potential negative impact upon water quality due to uncontrolled stormwater discharges from existing urban areas
- Significant number of historic flooding events in downstream portion of watershed near confluence with Vermilion River

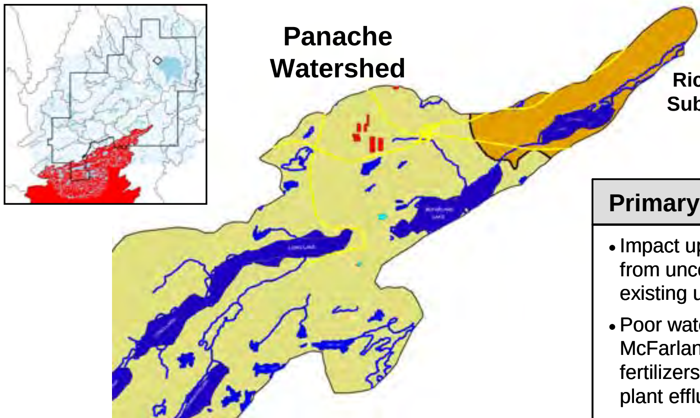
Alternative Stormwater Management Strategies

- Provide source control by reducing rate and volume of runoff on-site
- Construct stormwater management facilities to provide storage for quantity and/or quality management
- Undertake conveyance system modifications
- Implement stormwater quality management policies and outreach programs

Dowling Subwatershed



Urban Subwatershed Fact Sheet	RICHARD LAKE
Priority Watershed	**PANACHE**



Features

Area:	9.5 km^2
Location:	Daisy Lake to McFarlane Lake
Existing Land Use:	Mine Tailings and Bedrock; Urban (Sudbury); Rural (forest)
Development Potential:	Low
Dams:	None
Municipal Drains:	None
Lake/River Uses:	homes, cottages, recreation, private drinking water supply, McFarlane Wastewater Treatment Plant effluent outfall
Urban Water Bodies:	Daisy Lake, Richard Lake, McFarlane Lake

Related Studies

- Southend Drainage Study
- Whitefish River Floodplain Mapping (1983)

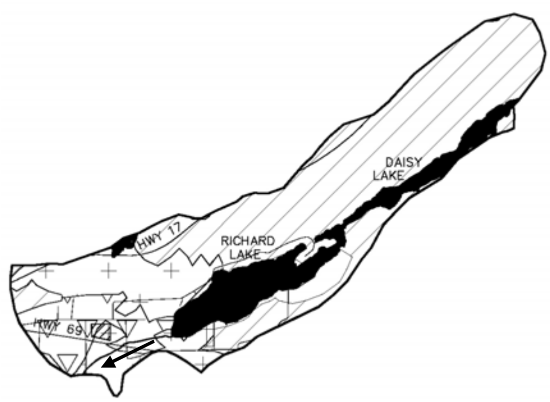
Primary Stormwater Issues

- Impact upon water quantity and quality resulting from uncontrolled stormwater discharges from existing urban areas
- Poor water quality (high nutrient levels) in McFarlane Lake likely due to the use of lawn fertilizers in urban areas, wastewater treatment plant effluent and use of septic systems
- Freeze on creation of new unserviced lots on McFarlane Lake due to poor water quality
- Growth potential will require stormwater quantity and quality control
- Winter salting of roads

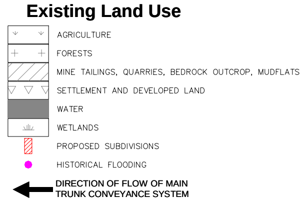
Alternative Stormwater Management Strategies

- Provide source control by reducing rate and volume of runoff on-site
- Construct stormwater management facilities to provide storage for quantity and/or quality management
- Undertake conveyance system modifications
- Implement stormwater quality management policies and outreach programs

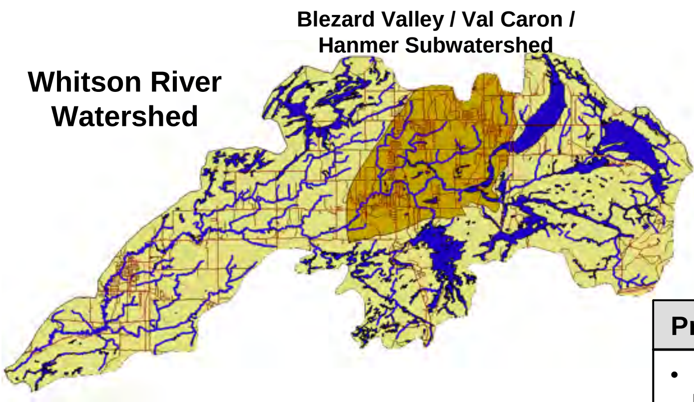
Richard Lake Subwatershed

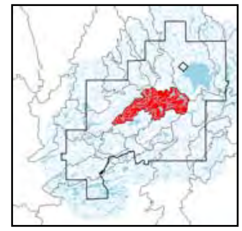


Existing Land Use



Urban Subwatershed Fact Sheet	BLEZARD VALLEY / VAL CARON / HANMER
Priority Watershed	**WHITSON RIVER**





Primary Stormwater Issues

- Impact upon water quality resulting from uncontrolled stormwater discharges from existing urban areas, runoff from agricultural areas and wastewater treatment plant effluent
- Significant number of historic flooding events along the main channel
- Growth potential will require stormwater quantity and quality control

Features

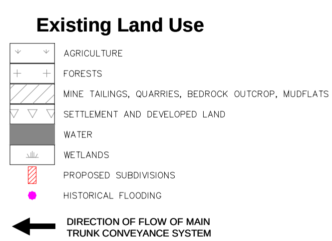
Area:	54 km^2
Location:	Whitson River from Moose Lake to just downstream of Municipal Road 15, west of Blezard Valley
Existing Land Use:	Agricultural; Rural (forest); Urban (Blezard Valley, Hanmer, Val Caron, Val Therese)
Development Potential:	High
Dams:	None
Municipal Drains:	Hanmer Drain
Lake/River Uses:	homes, cottages, recreation
Urban Water Body:	Whitson River
Other:	Municipal wells located in subwatershed

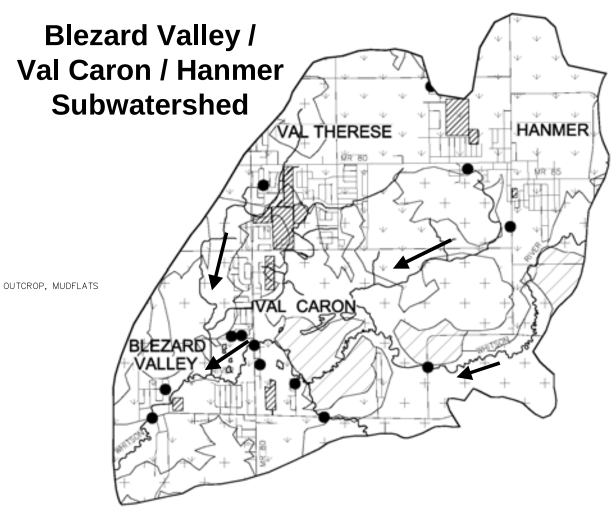
Alternative Stormwater Management Strategies

- Provide source control by reducing rate and volume of runoff on-site
- Construct stormwater management facilities to provide storage for quantity and/or quality management
- Undertake conveyance system modifications
- Implement stormwater quality management policies and outreach programs

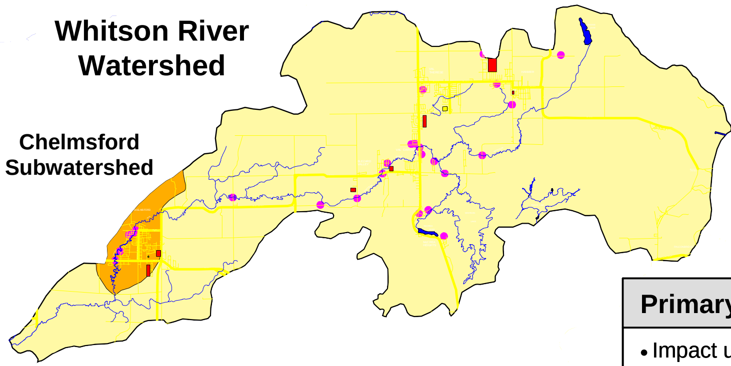
Related Studies

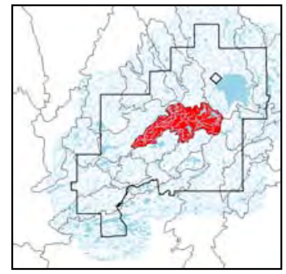
- Whitson River Hydrologic Analysis (1988)
- Flood Protection – Whitson River and Chelmsford (1992)
- Floodplain Mapping – Whitson River (1978)
- Drainage Design Report: Hanmer Drain





Urban Subwatershed Fact Sheet	CHELMSFORD
Priority Watershed	WHITSON RIVER





Features

Area:	12 km^2
Location:	Tributary of Whitson River from Municipal Road 15 to confluence with main branch of Whitson River
Existing Land Use:	Agricultural; Rural (forest); Urban (Chelmsford)
Development Potential:	High
Dams:	Goudreau Dam
Municipal Drains:	Bradley Drains D, H, K, L Castonguay Drains A, B Rayside Concession 5 Drains A, B Sylvestre Drain A
Lake/River Uses:	homes, cottages, recreation, Chelmsford Wastewater Treatment Plant effluent outfalls
Urban Water Body:	Whitson River

Alternative Stormwater Management Strategies

- Provide source control by reducing rate and volume of runoff on-site
- Construct stormwater management facilities to provide storage for quantity and/or quality management
- Undertake conveyance system modifications
- Implement stormwater quality management policies and outreach programs

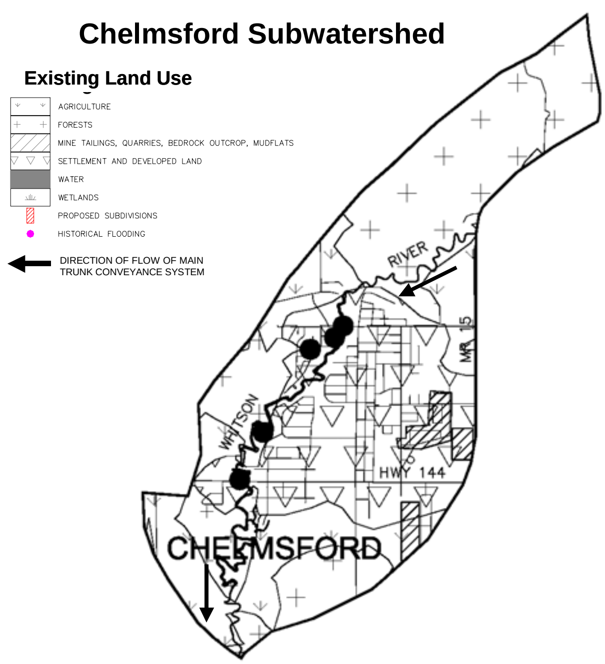
Primary Stormwater Issues

- Impact upon water quality resulting from uncontrolled stormwater discharges from existing urban areas, runoff from agricultural areas and wastewater treatment plant effluent
- Significant number of historic flooding events along the main channel
- Growth potential will require stormwater quantity and quality control

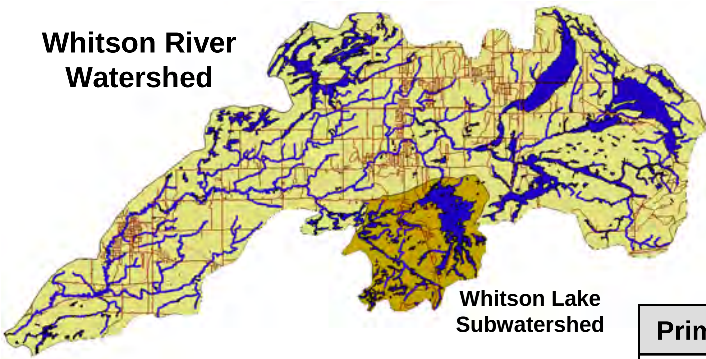
Related Studies

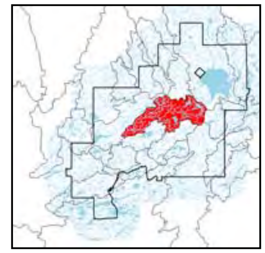
- Whitson River Hydrologic Analysis (1988)
- Flood Protection – Whitson River and Chelmsford (1992)
- Floodplain Mapping – Whitson River (1978)
- Drain Design Reports: Bradley Drain, Bradley Drain Extension, Castonguay Drain, Sylvestre Drain

Chelmsford Subwatershed



Urban Subwatershed Fact Sheet	WHITSON LAKE
Priority Watershed	WHITSON RIVER





Features

Area:	38 km^2
Location:	Area Upstream of and Including Whitson Lake
Existing Land Use:	Agricultural; Rural (forest); Urban (waterfront homes); Mine Tailings and Bedrock
Development Potential:	Low
Dams:	Whitson Lake Dam
Municipal Drains:	None
Lake/River Uses:	homes, recreation
Urban Water Body:	Whitson Lake, McCrea Lake

Related Studies

- Whitson River Hydrologic Analysis (1988)
- Flood Protection – Whitson River and Chelmsford (1992)
- Floodplain Mapping – Whitson River (1978)

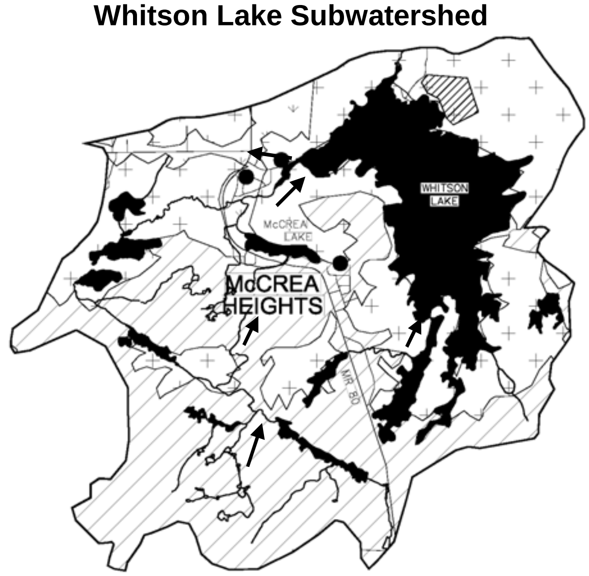
Primary Stormwater Issues

- Impact upon water quality resulting from uncontrolled stormwater discharges from existing urban areas and runoff from agricultural areas
- Growth potential will require stormwater quantity and quality control.

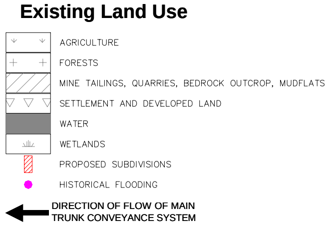
Alternative Stormwater Management Strategies

- Provide source control by reducing rate and volume of runoff on-site
- Construct stormwater management facilities to provide storage for quantity and/or quality management
- Undertake conveyance system modifications
- Implement stormwater quality management policies and outreach programs

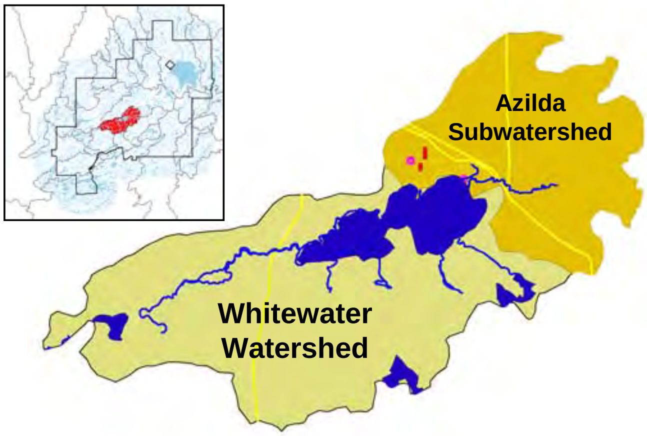
Whitson Lake Subwatershed



Existing Land Use



Urban Subwatershed Fact Sheet	AZILDA
Priority Watershed	**WHITEWATER**



Primary Stormwater Issues

- Impact upon water quality resulting from uncontrolled stormwater discharges from existing urban areas and runoff from agricultural areas
- Poor water quality (high nutrient levels) in Whitewater Lake likely due to the use of lawn fertilizers in urban areas, agricultural runoff and use of septic systems
- Freeze on creation of new unserviced lots on Whitewater Lake due to poor water quality
- Growth potential in Azilda will require stormwater quantity and quality control
- Winter salting of roads
- Some historic flooding events along the Whitewater Lake tributaries through Azilda due to uncontrolled stormwater

Features

Area:	44 km^2
Location:	Northeast portion of Whitewater Watershed
Existing Land Use:	Agricultural; Rural (forest); Mine Tailings and Bedrock; Urban (Community of Azilda); front on lake
Development Potential:	Freeze on creation of new unserviced lots on Whitewater Lake due to poor water quality Moderate in other areas of Azilda
Dams:	None
Municipal Drains:	Paquette-Simard Drain C Simard Drains A, C, D, E, F, Trillium Centre Drains A, B, C
Lake/River Uses:	homes, cottages, recreation
Urban Water Body:	Whitewater Lake, Moore Lake

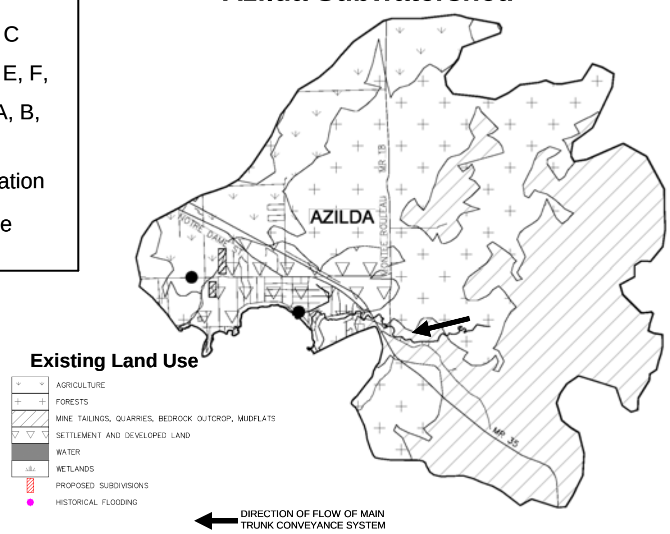
Alternative Stormwater Management Strategies

- Provide source control by reducing rate and volume of runoff on-site
- Construct stormwater management facilities to provide storage for quantity and/or quality management
- Undertake conveyance system modifications
- Implement stormwater quality management policies and outreach programs

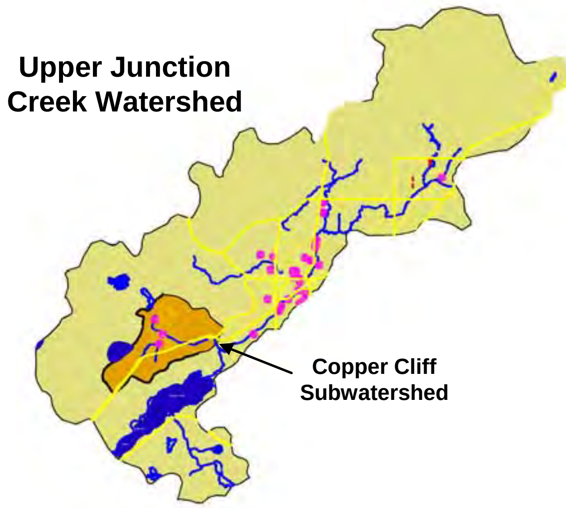
Related Studies

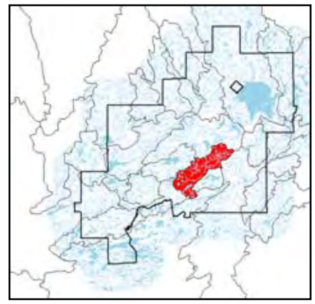
- Flood Damage Reduction Study – Landry Creek (1984)
- Floodplain Mapping of Azilda-Whitewater Lake Area (1978)
- Drainage Design Reports: Paquette/ Simard Drain, Simard Drain and Simard Drain F and G, Trillium Drain

Azilda Subwatershed



Urban Subwatershed Fact Sheet	COPPER CLIFF
Priority Watershed	**UPPER JUNCTION CREEK**



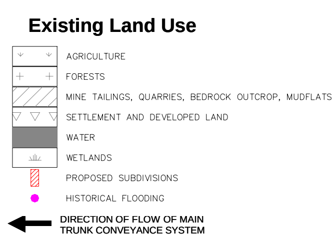


Features

Area:	9.4 km^2
Location:	Copper Cliff Creek from Lady MacDonald Lake Dam to Junction Creek
Existing Land Use:	Mine Tailings and Bedrock; Urban (Community of Copper Cliff)
Development Potential:	Low
Dams:	Lady MacDonald Lake Dam, Copper Cliff Creek Dam
Municipal Drains:	None
Lake/River Uses:	Copper Cliff Wastewater Treatment Plant
Urban Water Body:	Copper Cliff Creek

Related Studies

- Floodplain Mapping of Junction Creek (1980)
- Junction Creek Watershed Management Study (1982)

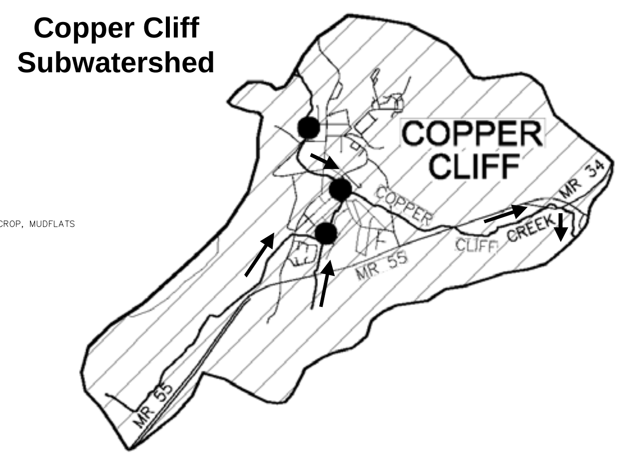


Primary Stormwater Issues

- Impact upon water quality due to uncontrolled stormwater discharges from existing urban areas
- Poor water quality in Copper Cliff Creek likely due to uncontrolled stormwater discharges from existing urban areas and past industrial pollution
- Growth potential will require stormwater quality and quantity control
- Winter salting of roads
- Numerous historic flooding events, both along the main channel and in tributaries, due to uncontrolled stormwater runoff from urban areas

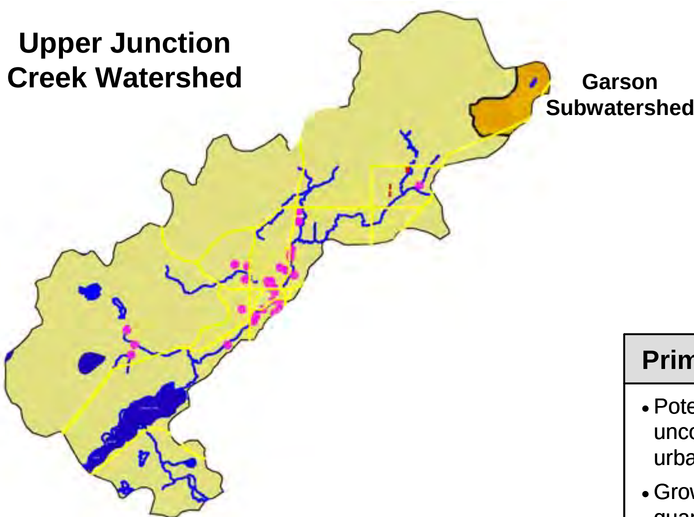
Alternative Stormwater Management Strategies

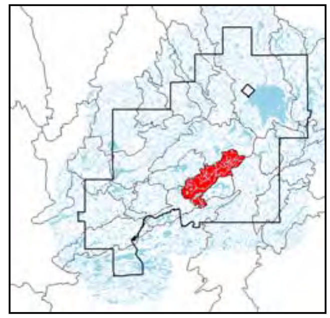
- Provide source control by reducing rate and volume of runoff on-site
- Construct stormwater management facilities to provide storage for quantity and/or quality management
- Undertake conveyance system modifications
- Implement stormwater quality management policies and outreach programs



Urban Subwatershed Fact Sheet	GARSON
Priority Watershed	UPPER JUNCTION CREEK

Upper Junction Creek Watershed





Primary Stormwater Issues

- Potential impact upon water quality resulting from uncontrolled stormwater discharges from existing urban areas and sewage lagoon outfall
- Growth potential will require stormwater quality and quantity control
- Winter salting of roads

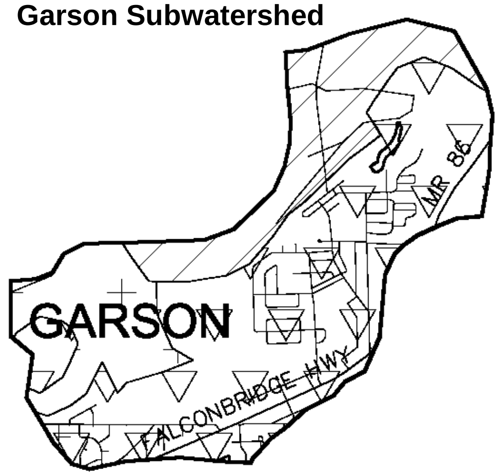
Features

Area:	5 km^2
Location:	Northeast portion of watershed to Junction Creek at O'Neil Drive
Existing Land Use:	Urban (Community of Garson); Mine Tailings and Bedrock
Development Potential:	Low
Dams:	None
Municipal Drains:	None
Lake/River Uses:	Garson Sewage Lagoon effluent outfall
Urban Water Body:	Junction Creek

Alternative Stormwater Management Strategies

- Provide source control by reducing rate and volume of runoff on-site
- Construct stormwater management facilities to provide storage for quantity and/or quality management
- Undertake conveyance system modifications
- Implement stormwater quality management policies and outreach programs

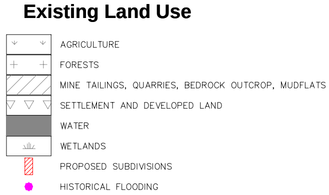
Garson Subwatershed



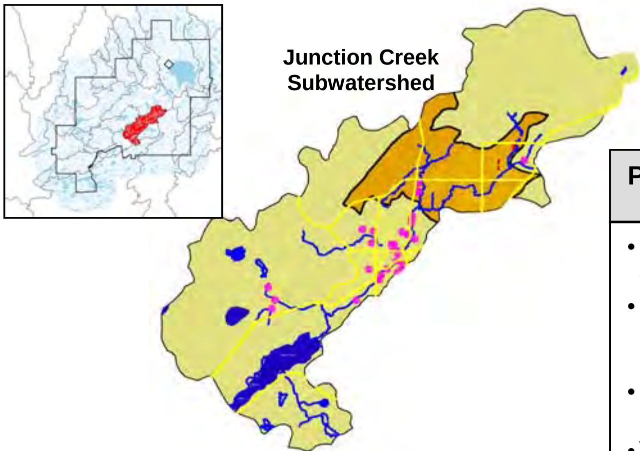
Related Studies

- Floodplain Mapping of Junction Creek (1980)
- Junction Creek Watershed Management Study (1982)

Existing Land Use



Urban Subwatershed Fact Sheet	JUNCTION CREEK
Priority Watershed	**UPPER JUNCTION CREEK**



Upper Junction Creek Watershed

Primary Stormwater Issues

- Impact upon water quality due to uncontrolled stormwater discharges from existing urban areas
- Poor water quality in Junction Creek likely due to uncontrolled stormwater discharges from existing urban areas and past industrial pollution
- Growth potential will require stormwater quality and quantity control
- Winter salting of roads
- Numerous historic flooding events, both along the main channel and in tributaries, due to uncontrolled stormwater runoff from urban areas
- Existing erosion problems along Junction Creek
- Upper Junction Creek has become a cold water fishery habitat. An appropriate level of protection from stormwater effects is required

Alternative Stormwater Management Strategies

- Provide source control by reducing rate and volume of runoff on-site
- Construct stormwater management facilities to provide storage for quantity and/or quality management
- Undertake conveyance system modifications
- Implement stormwater quality management policies and outreach programs

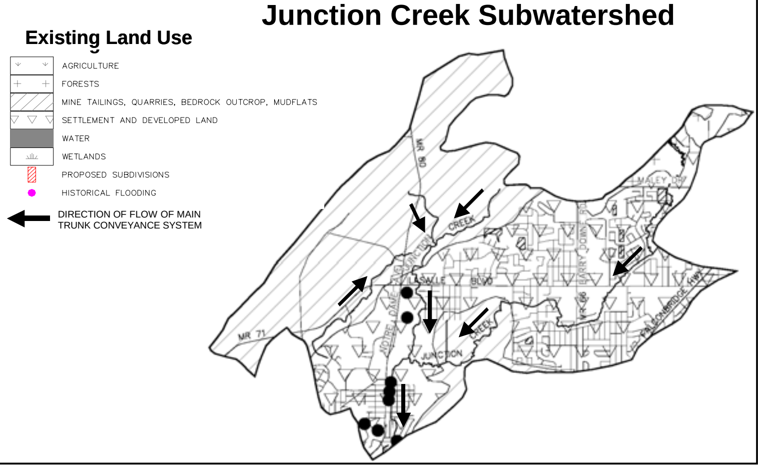
Features

Area:	28 km^2
Location:	Junction Creek and Nolin Creek from Maley Dam to Elm Street
Existing Land Use:	Mine Tailings and Bedrock; Urban (New Sudbury); urban walking trails
Development Potential:	Moderate
Dams:	Maley Dam, Frood Dam, Nickeldale Dam
Municipal Drains:	None
Lake/River Uses:	houses, recreational
Urban Water Body:	Junction Creek

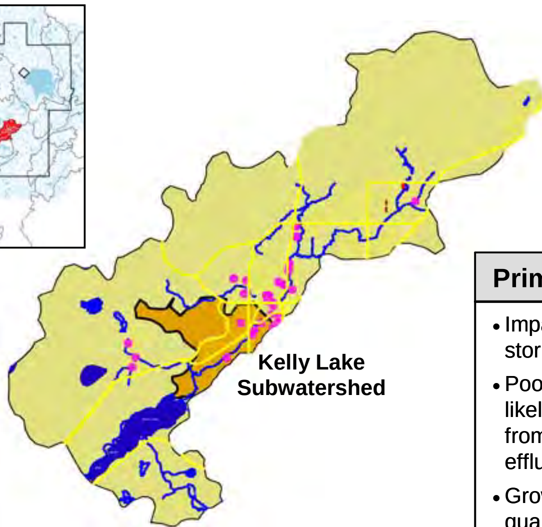
Related Studies

- Maley Dam Study
- Nickeldale Reservoir Preliminary Engineering Report (1967) and Addendum (1977)
- Floodplain Mapping of Junction Creek (1980)
- Junction Creek Watershed Management Study (1982)
- The Ponderosa – A Concept for Development (1988)
- Junction Creek Waterway Park Community Improvement Plan (1991)
- Nolin Creek Flood Control Project (1997)

Junction Creek Subwatershed



Urban Subwatershed Fact Sheet	KELLY LAKE
Priority Watershed	**UPPER JUNCTION CREEK**



Features

Area:	10.4 km^2
Location:	Junction Creek from Brady Street to Kelley Lake
Existing Land Use:	Mine Tailings and Bedrock; Urban (Sudbury)
Development Potential:	Low
Dams:	None
Municipal Drains:	None
Lake/River Uses:	Sudbury Wastewater Treatment Plant
Urban Water Body:	Junction Creek, Kelly Lake

Related Studies

- Floodplain Mapping of Junction Creek (1980)
- Junction Creek Watershed Management Study (1982)
- Junction Creek Waterway Park Community Improvement Plan (1991)

Primary Stormwater Issues

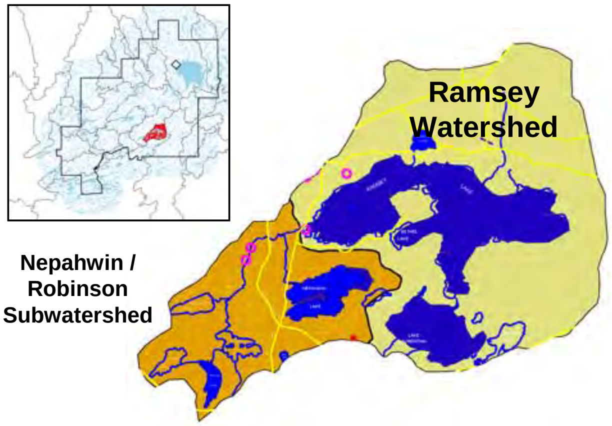
- Impact upon water quality due to uncontrolled stormwater discharges from existing urban areas
- Poor water quality in Junction Creek and Kelly Lake likely due to uncontrolled stormwater discharges from existing urban areas, wastewater treatment effluent and past industrial pollution
- Growth potential will require stormwater quality and quantity control
- Winter salting of roads
- Numerous historic flooding events, both along the main channel and in tributaries, due to uncontrolled stormwater runoff from urban areas

Alternative Stormwater Management Strategies

- Provide source control by reducing rate and volume of runoff on-site
- Construct stormwater management facilities to provide storage for quantity and/or quality management
- Undertake conveyance system modifications
- Implement stormwater quality management policies and outreach programs

Kelly Lake Subwatershed

Urban Subwatershed Fact Sheet	NEPAHWIN / ROBINSON
Priority Watershed	**RAMSEY**



Features

Area:	17 km^2
Location:	Portion of Ramsey Lake watershed downstream from Ramsey Lake
Existing Land Use:	Urban (Sudbury); Mine Tailings and Bedrock
Development Potential:	Moderate
Dams:	Ramsey Lake Dam, Lake Nepahwin Dam, Robinson Lake Dam
Municipal Drains:	None
Lake/River Uses:	homes, cottages, recreation, private drinking water sources
Urban Water Bodies:	Lake Nepahwin, Bennett Lake, Robinson Lake, Lily Creek, Still Lake, St. Charles Lake, Hannah Lake, Middle Lake

Related Studies

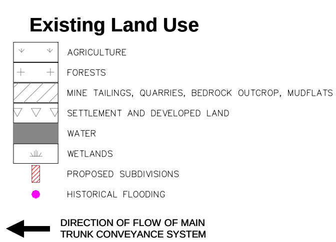
- South End Drainage Study

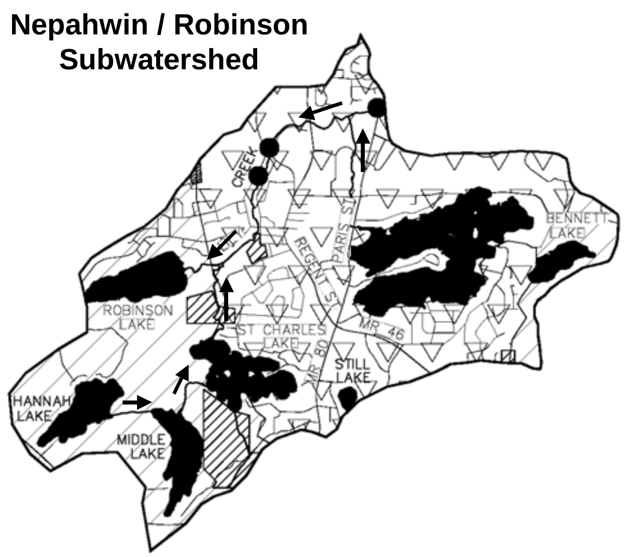
Primary Stormwater Issues

- Potential negative impact upon water quality due to uncontrolled stormwater discharges from existing urban areas
- Poor water quality (high nutrient levels) in some lakes likely due to the past industrial pollution and use of lawn fertilizers in urban areas
- Growth potential will require stormwater quality and quantity control
- Winter salting of roads
- Some historic flood events within local storm drainage systems due to uncontrolled urban stormwater runoff
- Extremely sensitive area, multiple lake uses at City's centre; current public pressure to enhance Lake Nepahwin

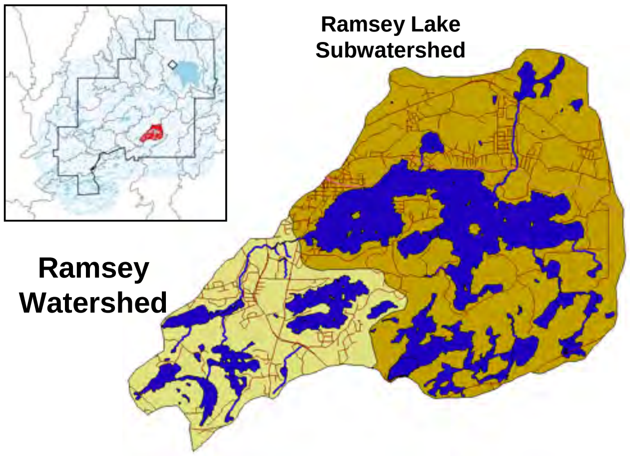
Alternative Stormwater Management Strategies

- Provide source control by reducing rate and volume of runoff on-site
- Construct stormwater management facilities to provide storage for quantity and/or quality management
- Undertake conveyance system modifications
- Implement stormwater quality management policies and outreach programs





Urban Subwatershed Fact Sheet	RAMSEY LAKE
Priority Watershed	**RAMSEY**



Features

Area:	44 km^2
Location:	Portion of Ramsey Lake watershed
Existing Land Use:	Urban (Sudbury); Bedrock
Development Potential:	Moderate
Dams:	Ramsey Lake Dam, Lake Laurentian Dam
Municipal Drains:	None
Lake/River Uses:	homes, recreation, drinking water source
Urban Water Bodies:	Ramsey Lake, Minnow Lake, Lake Laurentian, Bethel Lake, Perch Lake

Related Studies

- South End Drainage Study
- Minnow Lake Community Improvement Plan (1991)
- Ramsey Lake Community Improvement Plan Public Participation Document (1992)
- Ramsey Lake Community Improvement Plan (1994)

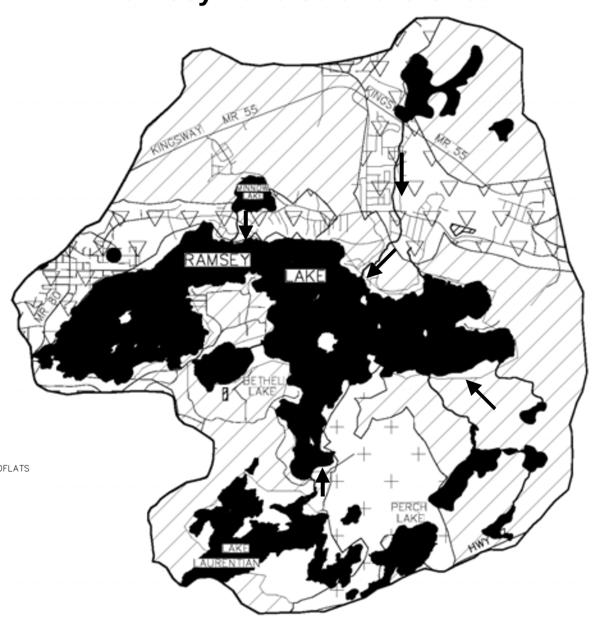
Primary Stormwater Issues

- Potential negative impact upon water quality due to uncontrolled stormwater discharges from existing urban areas
- Poor water quality (high nutrient levels) in some lakes likely due to the past industrial pollution and use of lawn fertilizers in urban areas
- Growth potential will require stormwater quality and quantity control
- Winter salting of roads
- Some historic flood events within local storm drainage systems due to uncontrolled urban stormwater runoff
- Extremely sensitive area, multiple lake uses at City's centre; current public pressure to enhance Minnow Lake

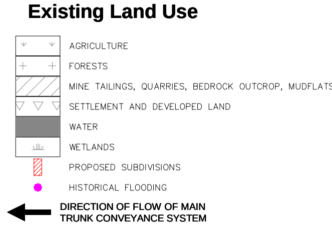
Alternative Stormwater Management Strategies

- Provide source control by reducing rate and volume of runoff on-site
- Construct stormwater management facilities to provide storage for quantity and/or quality management
- Undertake conveyance system modifications
- Implement stormwater quality management policies and outreach programs

Ramsey Lake Subwatershed



Existing Land Use



4.0 STORMWATER MANAGEMENT POLICY OPTIONS

In this section, Urban Drainage Policy options specific to the City of Greater Sudbury are presented as well as direction for the inclusion in the Official Plan. By addressing Urban Drainage in the New Official Plan, an opportunity to advance local stormwater management initiatives is provided.

4.1 Incorporating Stormwater Management Policies in the New Official Plan

Stormwater management will form an important component of Greater Sudbury's new Official Plan. An approach to incorporating stormwater management objectives into the new Official Plan has been identified based on experience in the Sudbury area and involvement with municipal stormwater management initiatives in Ontario and elsewhere.

No attempt has been made to ensure that the language in the following sections is compatible with the text for the Official Plan. The Urban Drainage Policy options are presented for the City to review and format for incorporation into the new Official Plan.

4.1.1 General Objectives

The new Official Plan Urban Drainage Policy statements should be prefaced by general statements regarding the need to:

a. Ensure that the constraints and opportunities associated with urban drainage are properly recognized and are integrated into community planning and design;

b. Reduce, to acceptable levels, the potential risk of health hazards, loss of life and property damage from flooding;

c. Reduce, to acceptable levels, the incidence of inconvenience caused by surface ponding and flooding;

d. Ensure that the quality of stormwater discharged to receiving water bodies meets provincially accepted criteria;

e. Ensure that any development is designed and constructed in such a manner as to minimize; the impact of change to the groundwater regime, increased pollution, increased erosion or increased sediment transport; and

f. Maintain the natural stream channel geometry, insofar as it is feasible while achieving the above objectives.

4.1.2 Applicable Design Guidelines

The City, through its Urban Drainage Policy, will adopt technical and procedural guidance for stormwater management planning and design. The City reserves the right to modify these guidelines at any time, as local experiences demonstrate preferred approaches. It is the responsibility of the proponent to ensure that the most up-to-date version is being utilized.

In addition to the requirement for stormwater management designs to comply with the City's policy, the proponent is required to satisfy any other regulatory agency concerns not explicitly identified in this policy (i.e. MOE, MNR, NDCA, DFO).

It is stressed that the technical and procedural guidance provided in the latest version of the Ministry of the Environment's Stormwater Management Planning and Design Manual should be adhered to.

4.2 Urban Drainage Policy

The Urban Drainage Policy options for Sudbury have been developed following review of policies from other municipalities and recognize the general objectives stated in Section 4.1.1.

The following sections detail policy options regarding stormwater management practices and design criteria that should be considered during the completion of watershed plans, subwatershed plans and site specific stormwater management reports.

4.2.1 Policy Options for Watersheds

The following policy options recognize that there is already significant urbanization within several of the watersheds within the limits of the City.

4.2.1.1 Protect Drinking Water Supplies

The City shall, in conjunction with the NDCA, develop and implement source protection plans for surface and groundwater drinking water supplies. Early priorities will be Lake Ramsey, the Wanapitei System, the Vermilion System and the major drinking water aquifers.

Safe drinking water is essential to human health. To protect sources of drinking water, the provincial government has developed legislation that requires sources protection plans to be prepared for all of Ontario's watersheds. The goal of source protection is to safeguard human health by ensuring that current and future sources of drinking water in Ontario's lakes, rivers and groundwater are protected from potential contamination and depletion. Since water knows no jurisdiction, and upstream activities affect downstream communities, source protection plans must be prepared jointly on a watershed basis by the stakeholders in that watershed. Source protection plans will identify risks of contamination or depletion to sources of drinking water to establish measures to reduce those risks.

4.2.1.2 Reduce Nutrient levels in area Lakes

The City shall improve phosphorus removal at its wastewater treatment plants, develop and implement a program for inspection and maintenance of septic systems, and create an awareness campaign to help citizens reduce nutrient runoff from their properties. The City will also study the feasibility of introducing a by-law requiring septic maintenance agreements between installer and property owners.

Many area lakes and groundwater systems are at risk from excess nutrients – particularly nitrogen and phosphorus that come from wastewater treatment plants, septic systems and fertilizers.[13]

4.2.1.3 Reduce the Impacts of Stormwater

The City shall reduce the use of road salt and install stormwater management facilities where storm sewers enter lakes that supply potable water. Through source protection plans, the City will identify other actions to reduce the impacts of pollutants on water quality.

Urban stormwater runoff contains a host of pollutants picked up as it crosses streets, parking lots and yards – pesticides, herbicides, motor oil, road salt, animal feces and other contaminants – all of which end up in lakes and rivers.[14]

4.2.1.4 Address Lake Acidification and Other Industrial Impacts

The City shall implement a watershed-liming program on lakes with a low pH as the next step in land reclamation. The City shall also continue to press for the cleanup of creosote from Junction Creek.

Many of the area's lakes have been adversely affected by historical industrial activities, especially mining and smelting. This has led to erosion, acidification, metal contamination, the deposition of wood waste on lake bottoms (in Minnow Lake), and contamination from a former creosote plant (in Junction Creek and Kelly Lake). Smelter emissions have been drastically cut and other practices that led to these impacts have long since ceased, and recovery is underway.[15]

4.2.1.5 Increase the Understanding of Local Water Resources

The City shall improve the basic scientific understanding of the area's watersheds, including water quality and fisheries.

To be effective, watershed planning must take an integrated approach that considers the interrelationships among water, land, and air. Many human activities on land can affect water quality, for example, as can air pollution.[16]

---

[13] The Earthcare Sudbury Local Action Plan, "City of Greater Sudbury, Becoming a Sustainable Community", 2003, p. 31
[14] Ibid.
[15] Ibid.
[16] Ibid., p. 32

4.2.2 Policy Options for Subwatersheds

The policy options for subwatersheds are to be read in concert with those prepared for watersheds. In order to ensure the protection of urban watersheds and provide the opportunity to improve the quality of receiving water bodies, the importance of stormwater management retrofit is emphasized.

4.2.2.1 Subwatershed Studies for Priority Areas

The City shall undertake the subwatershed studies, as recommended in this report. Study priorities shall be re-established every 5 years.

The City shall ensure the implementation of the recommended works resulting from the subwatershed studies. Implementation priorities shall be re-established every 5 years.

Currently, there are several areas in the City that are being developed in the absence of watershed and subwatershed plans. In these areas, stormwater management reports are being prepared on a site-by-site basis to respect general design principles instead of the recommendations of a subwatershed plan. This is resulting in the application of design criteria that may not be optimum.

In order to promote stormwater management at the subwatershed level, the City has begun a process of preparing subwatershed plans, through the completion of or identification of the requirement of future subwatershed studies for priority urban areas in the City. These prioritized subwatersheds are listed in Section 3.7.2.

Subwatershed Plans will address the general stormwater management objectives stated in Section 4.1.1. While providing recommendations to address these general objectives, a subwatershed plan will typically identify:

a. Opportunities to integrate stormwater management facilities into public park or open spaces, providing the overall function of these spaces is preserved or enhanced;

b. Phasing of construction, identification of growth vs. non-growth components, and cost sharing implications; and

c. Ownership and maintenance of facilities.

4.2.2.2 Implementation of Subwatershed Plan Recommendations

The implementation of the subwatershed plan recommendations shall take place in an efficient, cost effective manner.

The City must take the opportunity to implement the subwatershed plan at the appropriate time, integrating the work with development within the subwatershed. When an application for draft plan approval is submitted, the recommendations of the subwatershed plan should be referenced and appropriate coordination of efforts between the City and the developer should be undertaken.

4.2.2.3 Stormwater Quantity and Quality Control

All subwatershed plans shall incorporate the primary objective of no net increase in peak flow rates, unless a more stringent criterion is identified in a watershed plan or outlet design. Subwatershed plans must also assess means of stormwater quality control to ensure the protection of and provide opportunities to improve the quality of receiving water bodies.

Increased peak flow rates due to new development must be controlled before being discharged to approved outlets. In general, post-development peak flow rates must not exceed pre-development peak flow rates, or if a subwatershed plan exists, the peak flow rates identified in the plan. A stormwater management report must detail how the peak flow rates will be controlled to satisfy downstream constraints and the requirements of the subwatershed plan if one exists.

In the absence of specific recommendations regarding subwatershed peak flow control, the minimum level of peak flow control shall be control of the post-development 2-year peak flow rate to pre-development levels prior to discharge into the minor system (storm sewers), and control of the post-development 100-year peak flow rate to pre-development levels prior to discharge into the major system (surface drainage system).

Water quality storage requirements based on receiving water bodies are provided in the current version of the Ministry of the Environment's Stormwater Management Planning and Design Manual. *Normal Protection Level* (as defined in Table 3.2 of the manual) shall be considered the minimum acceptable level in Greater Sudbury.

4.2.2.4 Defining Quality Control Criteria for Subwatershed Studies

In order to achieve the goal of "sustainable urban watershed", the City must identify the appropriate level of stormwater quality control at the subwatershed study development stage. Stormwater management retrofit opportunities must also be recognized.

For each individual subwatershed study, consideration should be given to the acceptable level of stormwater quality control for that specific subwatershed and corresponding urban waterbodies. The City must identify appropriate "predevelopment conditions" to which the stormwater management criteria will be applied. Setting "predevelopment" conditions prior to existing conditions, may allow for improvement of the receiving waterbodies.

The City recognizes that there is already significant urbanization within several of the watersheds within the limits of the City. In order to ensure the sustainability of the urban watersheds and provide opportunities for the potential enhancement of the urban lakes, the importance of stormwater management retrofit opportunities must be recognized in the objectives of the subwatershed studies.

4.2.2.5 Stormwater Management Retrofit Opportunities

The City shall utilize the opportunity created during public infrastructure development, renewal and maintenance to implement plans to enhance the quality of the stormwater runoff entering urban lakes and rivers.

Whenever possible, the City will retrofit existing infrastructure to promote a higher level of stormwater runoff quality control.

4.2.2.6 Shoreline Development

The City's stormwater management design criteria for new shoreline development shall meet or exceed provincial standards to ensure that water quality in urban lake environments will not deteriorate due to stormwater runoff.

In several lakes, inappropriate shoreline development (such as the construction of breakwalls and docks with solid foundations and the clearing of native vegetation) has led to aquatic habitat loss, soil erosion, and pesticide and fertilizer runoff.

4.2.3 Site Specific Policy Options

The current version of the City's Engineering Design Manual should be utilized to determine appropriate stormwater management measures for each site, supplemented by the policy options included in this section and technical and procedural guidance provided in the latest version of the Ministry of Environment's Stormwater Management Planning and Design Manual.

4.2.3.1 Sites in Areas with Subwatershed Plans

Applications for draft plan approval of subdivisions within areas where a Subwatershed Plan has been completed shall demonstrate, through a Stormwater Management Report, how the proposed development will provide stormwater management in accordance with the Subwatershed Plan.

Applicants will be required to submit a Stormwater Management Report that demonstrates how the provisions of the Subwatershed Plan have been addressed.

4.2.3.2 Sites in Areas without Subwatershed Plans

Applications for draft plan approval for sites located in areas where a Subwatershed Plan is not yet finalized shall include a Stormwater Management Report containing site-specific details, as required by the City.

The following information shall be included in the Stormwater Management Report:

a. The overall drainage plan for the site, indicating upstream drainage areas conveyed across the site and the ultimate outlet (major overland flow route) from the site to the municipal drainage system;

b. A plan of proposed on-site stormwater quantity control measures that will satisfy downstream constraints. Post-development peak flow rates from the site will be limited to pre-development peak flow rates, unless detailed analysis shows that such storage is not required;

c. A plan for erosion control;

d. A description of the measures proposed to control quality on-site; and

e. A general grading plan, illustrating conformance with the City's overall stormwater management objectives.

4.2.3.3 On-Site Storage

For areas where a subwatershed plan has not advanced in sufficient detail to define downstream stormwater management facilities or where a development will result in unacceptable peak flow increases downstream, on-site stormwater management (storage) facilities for peak flow control will be required.

If on-site management of peak flow is required, a stormwater management report must be submitted to the City. For small sites (less than two hectares), the modified rational method may be used instead of hydrologic modelling.

Ponding limits, if applicable, must be shown on the drawings, with a maximum ponding depth in parking areas of 0.3 m. The spill location from ponding and on-site overland flow route must also be clearly shown.

The minimum orifice size for any control structure is 75 mm to prevent clogging. All on-site storage of stormwater will require City approval and may require approval from other regulatory agencies.

For small sites where it is impractical to implement on-site stormwater management measures (due to size or local site conditions), the City may collect cash-in-lieu of on-site stormwater management facilities. This will assist with the recovery of the costs of any downstream facilities that may be required to mitigate uncontrolled runoff from developments of this type. Application of this policy is at the sole discretion of the City, on a case-by-case basis or as outlined in the Subwatershed Plan.

4.2.3.4 Overland Flow Routes

For all new developments, an overland flow route must be clearly defined to provide continuous overland drainage of major system flows to the nearest major watercourse. The overland flow route (major system) shall be entirely contained within the road right-of-way or easements. Conveyance of the Regional or 100-year design storm peak flow (which ever is larger) is required.

Smaller, more frequent storms, usually generating flows less than or equal to the 10 year design storm peak flow rate, are typically conveyed by ditches and storm sewers (the "minor" system). Larger, less frequent storms, up to, and including the 100 year design storm or Regional storm, exceed inlet and sewer capacity and are typically conveyed via surface drainage systems (overland flow routes) including roadways and major ditches (the 'major' system). This is considered the "dual drainage concept" of stormwater management.

For low points in the major drainage system, drainage should be directed to a safe outlet. Safe outlets at low points are typically walkways or open sections in the curb draining to parks, open spaces, channels, or valleys. The water level along the major system overland flow route shall not affect buildings, and the depth of water on roads shall not exceed 0.15 m.

For major system flow calculations, a dual-drainage model (such as DD-SWMM or OTTSWMM) shall be employed. Alternatively, the major system flows can be considered to be the entire storm flow less the total minor system (storm sewer) capacity.

4.2.3.5 Erosion and Bank Stability

Existing watercourses shall be left in their natural state whenever possible. The banks must be able to convey either the Regional or 100-year design storm peak flow (which ever is larger).

In areas to be developed where erosion or bank instability is already an issue, the City may require appropriate stabilization measures to be put in place. Alteration to watercourses will be in accordance with current City, NDCA, and MNR standards. Work that may disturb the aquatic environment shall be carried out in accordance with the DFO and MNR guidelines and approvals.

Where increased downstream erosion is a possible result of proposed development, the City may require the developer to demonstrate that adequate control of flows are present on-site to mitigate the potential downstream effects. In the absence of detailed studies, the City will require complete control of a 5-year storm, released over a period of 48 hours.

Where open watercourses exist on site, the opportunities to preserve the natural watercourse rather than enclose it shall be addressed. Maintenance requirements for existing natural channels on site, and possible enhancement opportunities (stabilization, naturalization) shall be discussed with the City, and where applicable shall form part of the overall stormwater management plan for the site.

4.2.3.6 Maintenance of Stormwater Management Facilities

Developers are required to monitor and operate all on-site quality control ponds and shall ensure that the facility meets regulatory agency requirements prior to the City assuming ownership of the facility.

Maintenance shall include monitoring sediment accumulation in the pond forebay, sediment removal and grounds keeping (i.e. lawn care, trash removal, etc.). Monitoring requirements will be established through consultation with the City. Monitoring requirements may include, but not be limited to, flow recording and sampling / laboratory analysis for specific water quality objectives.

The Developer will typically be responsible for maintenance of the facility for 2 years following initial acceptance by the City.

4.2.3.7 Ownership of Stormwater Management Facilities

Stormwater management facilities for subdivisions will be on lands transferred to the City at no cost to the City. Construction costs shall be borne by the Developer, while long term responsibility for the stormwater management facility shall be assumed by the City.

On-site stormwater management facilities, subject to site plan approval, will be on lands transferred to the City at no cost to the City. All costs associated with the construction and initial maintenance of on-site facilities shall be borne by the Developer.

4.2.3.8 Rear Yard Catchbasins

In general, the use of rear yard catchbasins is to be minimized. In areas where rear yard catchbasins cannot be avoided and drainage must follow a rear lot line, rear yard catchbasins shall be provided at a minimum spacing of one every three lots.

Each required rear yard catchbasin shall be entirely on one lot, a minimum of 1 m from the property line. Positive drainage between lots must be secured either through an easement or restriction on Title.

The practices in other municipalities in Ontario range from an outright ban on rear yard catchbasins, to provision of a catchbasin on each lot, to policies similar to Sudbury's. The first two policies have the advantage of removing the potential for downstream residents to impact the drainage of the upstream lots through modifications to their lot drainage (i.e. through the construction of amenities). However in many areas of Sudbury, site grading is more difficult due to the presence of rock, therefore some flexibility in the requirements of site grading plans may be required.

4.2.3.9 Foundation Drains and Roof Leaders

Foundation drains shall normally discharge by sump pump onto the ground at a location acceptable to the City. Roof leaders shall discharge at ground level (onto splash pads where required) and flows will be directed away from buildings, to prevent seepage into the foundation drains.

Some municipalities in Ontario allow foundation drains to be connected by gravity to the storm sewer system, provided that the elevation of the basement floor is above the top of the storm sewer, and where it can be demonstrated that an acceptable level of protection from basement flooding is provided under major storm conditions. Other municipalities allow discharge of sump pumps to the storm drainage system. While these practices are acceptable elsewhere (e.g. most municipalities in southern Ontario), the City currently does not provide private storm drain connections to individual lots.

Advantages of providing private drain connections for foundation drains include the avoidance of nuisance ponding caused by sump pump discharge on the surface, and the potential to remove or bypass sump pumps by direct gravity discharge to the storm drain. Provision of a private drain connection may also reduce the frequency of illegal connections to the sanitary sewer (for example, to avoid surface discharge some residents discharge their sump pumps to basement laundry tubs, which drain to the sanitary sewer). The disadvantage of providing private drain connections is largely the additional cost and increased potential of surcharging the storm sewer. The current practice of discharging sump pumps to the surface will remain in place subject to future policy review, or special circumstances.

Roof leaders will discharge to the ground surface, and flows will be directed away from buildings (onto splash pads where required), to prevent seepage into the foundation drains. Where possible in residential areas, roof leaders should discharge to grassed areas to encourage overland flow/infiltration on-site, providing both water quality and quantity benefits.

4.2.4 Best Management Practices

The City shall adopt the Best Management Practices included in Section 5 of this report, to provide guidance for stormwater management associated with different types of development, including new development, re-development, retrofit and waterfront.

It is highly recommended that the proponent review the technical and procedural guidance provided in the latest version of the Ministry of the Environment's Stormwater Management Planning and Design Manual.

As the City does not wish to remove all flexibility from proponents in providing innovative solutions to stormwater management, the Best Management Practices presented in this document should be considered a minimum range of practices to be considered. Aggressive commitments and efforts will be required by the City and it's citizens to promote stormwater management measures that will ensure the sustainability of the urban subwatersheds and provide opportunities for enhancement of the urban lakes.

5.0 STORMWATER BEST MANAGEMENT PRACTICES

General strategies for stormwater management are provided in this chapter. In addition, specific approaches associated with various types of development, including new development, re-development, retrofit and waterfront are discussed. Details regarding current state-of-the-art techniques for stormwater quality control are provided towards the end of this chapter.

It is intended that the information in this section supplement relevant information in the City's current Engineering Design Manual.

It is highly recommended that the proponent review the technical and procedural guidance provided in the latest version of the Ministry of Environment's Stormwater Management Planning and Design Manual.

5.1 Quantity Control

Increased peak flow rates due to new development must be controlled before being discharged to approved outlets. In general, post-development peak flow rates must not exceed pre-development peak flow rates, or if a subwatershed plan exists, the peak flow rates identified in the subwatershed plan.

A stormwater management report must detail how the peak flow rates will be controlled to satisfy downstream constraints and the requirements of the subwatershed plan if one exists.

In the absence of specific recommendations regarding peak flow control, the minimum level of peak flow control shall be control of the post-development 2-year design storm peak flow rate to pre-development levels prior to discharge into the minor system (storm sewers), and control of the post-development Regional or 100-year design storm peak flow rate (which ever is larger) to pre-development levels prior to discharge into the major system (surface drainage system).

5.2 Quality Control

In addition to peak flow control, stormwater quality control must be provided. Stormwater quality control options shall be subject to a selection process. The rationale for the selection of the recommended alternative for a specific site must be provided.

In each case, on-site quality control shall be considered first as part of an integrated design.

As a minimum, the proponent shall consider the use of wet ponds, constructed wetlands, infiltration techniques, and batch dry detention facilities for end-of-pipe stormwater quality control.

For smaller sites (less than 10 hectares) where wet ponds are not feasible, stormwater quality control may have to be addressed exclusively with on-site measures.

5.2.1 On-Site Quality Control

It is preferred that stormwater quality be addressed as close to the source of runoff as possible. On-site controls are much more flexible and may include infiltration, oil grit separators (for commercial or industrial sites with high imperviousness), buffer strips, enhanced swales, or bio-retention areas. A preliminary assessment of feasible alternatives to address stormwater quality on-site shall be performed and then reviewed with the City prior to finalizing designs.

Infiltration of stormwater will be encouraged for every site where local conditions make infiltration feasible and desirable.

5.3 Integration of Quality and Quantity in Facility Design

In many situations, the requirements for both quantity and quality control lead to the use of a multi-purpose stormwater management pond. If a stormwater management pond is required to provide peak flow attenuation (quantity control), the facility can usually be easily adapted to provide stormwater quality control benefits.

During the development of stormwater management plans, the proponent is encouraged to consider the multi-purpose aspect of stormwater management facilities, incorporating both quantity and quality control elements into the facility.

5.4 Blue/Green Concepts in Facility Design

"Blue/Green" technologies refer to a more naturalized means of maintaining a natural water budget on a given site. The general approach includes lessening the volume of runoff close to its source; maintaining groundwater recharge; improving the quality of runoff by filtering it through vegetation; detaining peak flows; integrating a combination of management practices with existing features; and protecting and restoring streams for natural stormwater conveyance.

Blue/green alternatives can be less expensive than conventional methods, and the City encourages innovative approaches. Examples of blue/green approaches that should be considered during the evaluation of stormwater management practices include: bio-retention basins; roof gardens; porous-asphalt parking areas; constructed wetlands; and channel rehabilitation/restoration and enhancement.

5.5 Winter Road Maintenance

Although roadway salting and sanding is necessary to maintain safe winter road conditions, it is recognized that the applied salt and sand can harm the environment. Stormwater runoff can carry salt, sand and other roadway contaminants into local waterways. Potential problems could result from sediment accumulation and toxic concentrations of metals entering downstream receivers.

Best management practices for road salting and sanding operations shall consider the following:[17]

a. Reducing the accumulation of snow and ice on the roads, therefore reducing the need for salt;

b. Better prediction of when and where salt/sand needs to be applied;

c. Improved accuracy of salt/sand placement, reducing the amount lost to ditches and shoulders;

d. Improved storage and handling of salt in storage areas;

e. Removal of plowed roadway snow to an approved snow dump facility prior to melting;

f. Locating snow dump facilities so as to avoid sensitive environments and to take advantage of areas of high spring volume freshet;[18]

g. Clear delineation of snow dump facilities in a manner that is visible in the winter; and

h. Proper management of discharge melt water to protect surface and groundwater resources. This is sometimes addressed by one or more of the following measures: inclusion of a silt fence on the down gradient side of the snow disposal area; incorporation of a vegetated buffer strip for melt water; and/or incorporation of collection/retention/sedimentation for melt water.

Best management practices for the management of snowmelt at commercial sites in order to reduce the amount of sand and grit transported offsite include:

a. Plow to down gradient portion of pavement;

b. Provide silt fencing or sediment control where feasible;

c. Provide a vegetated buffer strip between the stockpile and drainage outlet where feasible; and

d. Sweep the area as soon as possible after snowmelt.

[17] Transportation Association of Canada, December 1999.

[18] Environmental Science and Engineering, January 2001.

5.6 Development

5.6.1 New Development

General approaches for different types of new development are outlined below. It is stressed that the approaches listed in the table below should not be considered all inclusive, but only represent minimum considerations for each type of development.

	Residential		Commercial/Industrial
	< 10 hectares	> 10 hectares	
On-Site Measures	▪ Roof leader to rain barrels ▪ Roof leader to soak away pit ▪ Rear lot drainage ▪ Accepted minimum grades ▪ Rain gardens ▪ Oil/grit separators for paved areas	▪ Roof leader to rain barrels ▪ Roof leader to soak away pit ▪ Rear lot drainage ▪ Accepted minimum grades ▪ Rain gardens ▪ Oil/grit separators for paved areas	▪ Oil/grit separators ▪ On-site detention (roof storage, parking lot storage) ▪ Buffer strips ▪ Enhanced swales ▪ Infiltration trenches ▪ Rain gardens
Subwatershed Stormwater Management	▪ n/a	▪ Wet pond ▪ Dry pond ▪ Constructed wetland	▪ Wet pond ▪ Dry pond ▪ Constructed wetland

Table 5-1: Stormwater Management for New Developments

5.6.2 Redevelopment

Stormwater management requirements shall be based on the amount of impervious area created by redevelopment and the potential impact on water quality.

Stormwater management measures are required if redevelopment increases the imperviousness of the site by more than 10%, or if redevelopment involves a new land use, such as commercial/industrial use, for which stormwater runoff quality could potentially be a concern.

Where conditions prevent onsite stormwater management measures, practical alternatives may be considered, such as off site best management practices for equivalent sized areas, cash-in-lieu, watershed restoration, or off site retrofitting. The City may request a cost sharing agreement to incorporate the requirements within a larger facility to be implemented as redevelopment presents a retrofit opportunity.

5.6.3 Retrofit

The following table identifies the most likely retrofit opportunities in urbanized areas currently experiencing stormwater quantity and quality problems. It is anticipated that the City would normally be the proponent for retrofit projects.

Location	Type of Retrofit	Benefits
Existing stormwater detention facilities	▪ Usually retrofitted as a wet pond or stormwater wetland capable of multiple storm frequency management. ▪ Addition of extended detention by retrofitting forebay in existing facility.	▪ Quality control ▪ Peak flow control ▪ Erosive flow reduction ▪ Sediment removal
Immediately upstream of existing road culverts	▪ Often a wet pond, wetland, or extended detention facility capable of multiple storm frequency management.	▪ Quality control ▪ Peak flow control ▪ Erosive flow reduction
Immediately below or adjacent to existing storm drain outfalls	▪ Usually water quality measures, such as sand filters, vegetative filters or other minor storm treatment facilities.	▪ Quality control ▪ Sediment removal
Directly within urban drainage and flood control channels	▪ Usually small scale weirs or other flow attenuation devices to facilitate settling of solids within open channels.	▪ Quality control ▪ Sediment removal
Road right-of-way	▪ Usually ponds or wetlands capable of multiple storm frequency management.	▪ Quality control ▪ Sediment removal
Within large open spaces, such as golf courses and parks	▪ Usually ponds or wetlands capable of multiple storm frequency management.	▪ Quality control ▪ Peak flow control ▪ Erosive flow reduction
Within or adjacent to large parking lots	▪ Usually water quality measures such as sand filters or other organic media filters (e.g. bioretention), infiltration trenches, buffer strips, etc.	▪ Quality control ▪ Spill containment ▪ Sediment removal

Table 5-2: Retrofit Opportunities for Stormwater Management in Urbanized Areas

5.6.4 Shoreline Development

In several lakes, inappropriate shoreline development (such as the construction of breakwalls and docks with solid foundations and the clearing of native vegetation) has led to aquatic habitat loss, soil erosion, and pesticide and fertilizer runoff.

Best management practices for new and existing shoreline developments shall be addressed by:

a. The inclusion of a 15 m buffer zone adjacent to the shoreline;

b. Restoration of a 15 m buffer zone adjacent to the shoreline, to be implemented through public education initiatives;

c. A public information initiative regarding the restricted use of pesticides, herbicides and fertilizers on waterfront properties; and

d. Initiatives to restore failing septic systems or replacement with holding tanks.

5.7 State-of-the-Art Techniques for Stormwater Quality Control: End-of-Pipe Solutions

This section provides specific details regarding current state-of-the-art techniques for stormwater quality control practices that are most applicable to the Sudbury area. For all alternatives, the facilities must be:

a. Within the developed lands (unless it is a regional facility constructed on public lands with direct involvement of the City);

b. Outside Natural Hazard Areas;

c. Outside wetland boundaries; and

d. Outside the Regional Storm floodplain (unless a two-zone or special policy area is applied).

5.7.1 Wet Ponds

It is anticipated that water quality will be controlled through the use of wet ponds for subdivisions and/or larger developments. The number of ponds shall be minimized through identification of opportunities to build larger centralized facilities during completion of subwatershed studies.

Wet ponds shall be designed in accordance with requirements detailed in the Ministry of Environment's Stormwater Management Planning and Design Manual.

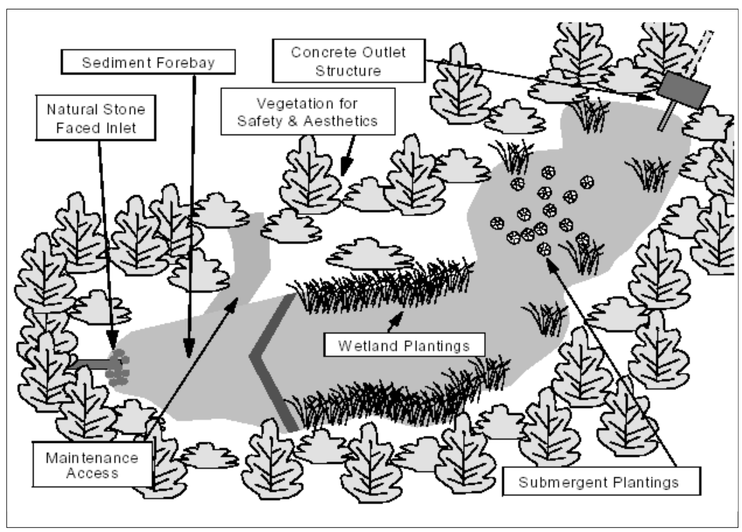


Figure 5-1: Wet Pond (MOE, 2003)

Special attention shall be given to the following:

a. A forebay shall be provided to remove most of the sediment prior to the main pond cell. The forebay shall be a minimum depth of 1 m **after** the accumulation of approximately 10 years of sediment (and typically 1.5 m to 2 m when newly constructed or cleaned out). Since the bulk of the sediment load is expected in the spring, the forebay should be inspected annually after the spring runoff. The forebay shall be 20%-30% of the pond area, with a minimum length/width ratio of 2:1. Dispersion and settling distance calculations shall be performed, as per examples contained in the Ministry of Environment's Stormwater Management Planning and Design Manual, to ensure that the forebay operates correctly.

b. Access roads must be provided to the pond inlet, outlet and forebay. The access road to the forebay must support heavy equipment suitable for sediment removal and should be paved with asphalt. Turnaround areas shall be provided.

c. If sediment is not to be removed from the site in a 'wet' slurry state, then a drying area shall be provided.

d. A winter spill outlet shall be constructed above the ice level to ensure that drainage can spill from the pond if winter thaws cause significant flows prior to the ice melting and the normal outlet being clear of ice. An ice build up of 0.3 m above the permanent pool shall be accommodated.

e. A safety bench, no more than 0.5 m deep, 3 m wide and surrounding the entire pond shall be incorporated into the design to provide shallow water at locations where people may fall into the facility.

f. For safety reasons, side slopes shall not exceed 5:1.

g. To prevent ice from clogging the inlet pipe, the inlet pipe shall be located above the ice level of the permanent pool.

The City of Greater Sudbury encourages the incorporation of safety features and naturalized landscaping into the design of ponds, in order to make them an amenity to the public and to blend in with the local environment. Fencing of ponds is discouraged.

From a constructability standpoint, the presence of rock will be a factor in determining whether a pond is economically feasible and whether lining the pond to retain runoff will be required. When a pond is located in gravel, sands or fractured bedrock, a liner may be required. A geotechnical investigation will be required to determine whether a facility will need to be lined.

Acceptable liner options include:

a. 150 mm to 300 mm of clay (minimum 50% passing #200 sieve, maximum permeability of 1×10^{-5} cm/s);

b. A 30 mm synthetic liner; and

c. Bentonite.

The City may accept, following review, alternatives if the design is prepared by a professional engineer and supported by a geotechnical report.

5.7.2 Constructed Wetlands

Constructed wetlands have the same requirements as wet ponds, with the permanent pond portion of the main pond replaced with constructed wetland features. Similar constraints for ice build up should be considered as with wet pond design, in terms of locating the inlet above the permanent pool ice level and providing an emergency spill approximately 0.3 m above the high water elevation to account for ice build up.

The wetland design must include a planting plan, incorporating native trees, shrubs, and aquatic plants. The short growing season must be taken into account.

The plan must address water quality, aesthetics, temperature, and public safety. The wetland should blend into the natural environment. The design should consider the use of a peat filter as part of the treatment train through the wetland. The potential for high chlorides in the spring runoff should be addressed by either using a grassed infiltration or small pond area to pretreat runoff, in combination with salt-tolerant plants.

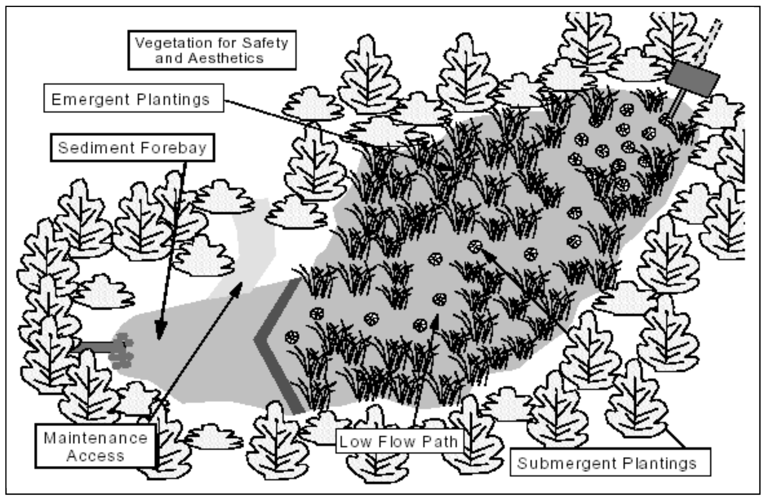


Figure 5-2: Constructed Wetland (MOE, 2003)

The wetlands shall be designed for a maximum depth of 2 m during the Regional or 100-year design storm (which ever is larger). The extended detention depth should not exceed 1 m. The permanent pool depth shall be between 0.15 and 0.3 m, with the exception of micropool areas (not more than 5% of the total wetland), which shall be an additional 0.3 m deep.

5.7.3 Infiltration Facilities

Suitability of infiltration facilities is heavily dependent upon groundwater conditions and, in the Sudbury area, the presence of rock and local sub-surface drainage. Particular attention must be given to the fate of the shallow groundwater infiltrated, direction of flow, hydraulic retention time, and location where shallow groundwater will be expressed again as surface drainage.

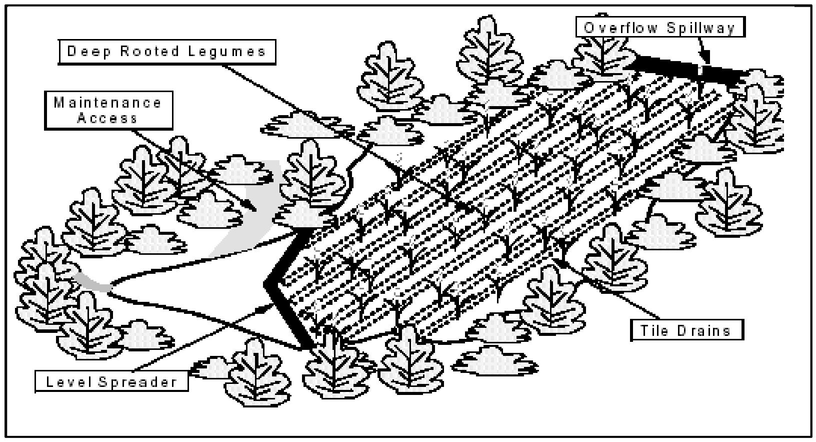


Figure 5-3: Infiltration Basin (MOE, 2003)

A geotechnical study must be conducted at the preliminary design stage to demonstrate that infiltration rates are suitable, and that the fate of the infiltrated stormwater serves as a suitable management strategy for the runoff (i.e. surface waters are not impacted and pollutants are not re-introduced to surface waters or wells).

End-of-pipe infiltration facilities must be accompanied by pre-treatment of runoff to remove most of the coarse sediment in order to prolong the life of the facility and reduce the risk of the facility clogging with sediment. The pre-treatment may be a forebay, oil / grit separator, or buffer/filter strip depending on the application.

From a constructability standpoint, the amount of rock present may dictate whether an infiltration trench is economically feasible.

5.7.4 Batch-Dry Detention Facilities

Batch dry detention facilities would only be appropriate in areas that are relatively small, heavily urbanized, and where stormwater from the site is not expected to be heavily contaminated. Typically a forebay or oil/grit separator would be installed upstream of the dry detention cell to remove coarse sediment. A valve in the detention cell would normally be closed. When the detention cell fills following rainfall, the runoff is tested to ensure that water quality is suitable for discharge. The actual parameters tested, and whether suitable field tests are available, must be discussed with the City and MOE at the conceptual design stage to ensure that the design is feasible. If testing indicates that the runoff is suitable for discharge to the natural outlet without further treatment, a valve will be opened and the runoff allowed to drain from the facility to the watercourse. If testing indicates that the runoff is not acceptable, it can either be diverted to another treatment location (i.e. wetland or lagoon), or directed to a sanitary sewer.

6.0 INTENSITY-DURATION-FREQUENCY CURVES, DESIGN CRITERIA AND COMPUTER MODELING TECHNIQUES

6.1 Intensity-Duration-Frequency (IDF) Curves

Updated IDF curves were developed using rainfall data collected by Environment Canada at Science North and at the Sudbury Airport. The data from both sites was not significantly different and was combined to extend the record to 43 years. An overview of the methodology employed to develop the updated IDF curves is provided in Appendix D.

A comparison of the updated IDF curves and those currently used by the City (which were based on data collected at the Sudbury Airport from 1971 to 1990) reveals that the updated IDF curves are approximately 10% higher than those currently used by the City for a range of return intervals and durations.

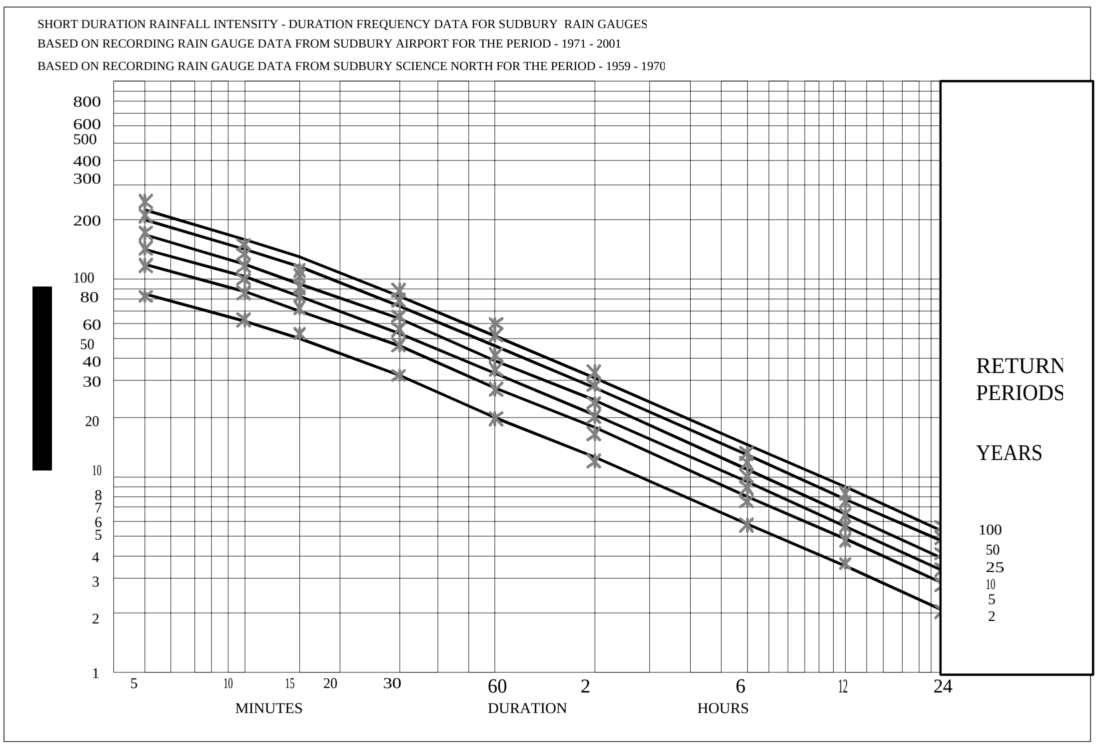


Figure 6-1: Updated IDF Curves

Each of these best-fit curves can be described by the following equations:

a. 2-year return period

$$\text{Rainfall Intensity (mm/hr)} = \frac{429.375}{[T\text{ (min)} + 4.25]^{0.7325}}$$

b. 5-year return period

$$\text{Rainfall Intensity (mm/hr)} = \frac{600.938}{[T\text{ (min)} + 4.00]^{0.7325}}$$

c. 10-year return period

$$\text{Rainfall Intensity (mm/hr)} = \frac{726.563}{[T\text{ (min)} + 3.938]^{0.74}}$$

d. 25-year return period

$$\text{Rainfall Intensity (mm/hr)} = \frac{847.03}{[T\text{ (min)} + 3.938]^{0.74}}$$

e. 50-year return period

$$\text{Rainfall Intensity (mm/hr)} = \frac{986.25}{[T\text{ (min)} + 3.75]^{0.7375}}$$

f. 100-year return period

$$\text{Rainfall Intensity (mm/hr)} = \frac{1092.988}{[T\text{ (min)} + 3.656]^{0.735}}$$

6.2 Regional Storm

The Timmins storm is an actual rainfall event measured near the City of Timmins in 1961, and is generally considered the extreme rainfall event characteristic to Northern Ontario.

With a rainfall volume of 193 mm over 12 hours, the event is approximately twice as large as a 100-year storm event for long-duration storms. For rainfall lasting 2 hours, the average rainfall intensity of the Timmins storm is approximately equal to a 100-year rainfall event. For durations of one hour or less, the Timmins storm is for the most part less than a 10-year storm.

6.3 Snowmelt

In addition to the design rainfall events, consideration of rainfall plus snowmelt during the spring thaw period must be considered. When drainage areas that have significant upstream storage or routing such that the lag time between the peak rainfall and peak flow is in the order of several days, then the effect of snowmelt can be significant. The spring thaw period generally produces high volumes of runoff over a period of several days to several weeks. Rainfall occurring during the spring thaw has the potential to generate higher runoff rates than at other times in the year due to the added effect of snowmelt.

Runoff generated by a rainfall plus snowmelt event is dependant on more than rainfall intensity and distribution. The depth of snow, the water content of the snow, the air temperature, and the condition of the underlying soil (frozen or saturated) will all have a significant effect on runoff.

Rainfall on fresh snow (low water content) will produce very little runoff, as the snow will simply absorb the rain, which will be slowly released as the snowpack melts. Rainfall on ripe snow (approximately 50% water content) will generate more runoff than the same rainfall event on dry ground, especially if the underlying ground is still frozen (impermeable) or is saturated due to snowmelt from before the start of the rain event.

The recommended design rainfall plus snowmelt event was developed by Environment Canada's Atmospheric Environment Service (AES) for M.M. Dillon Ltd. using Sudbury snow and rainfall data during the completion of the Whitefish River flood plain assessment in 1983. AES provided IDF values with durations from 1 to 10 days for rainfall plus snowmelt using data over a 27 year period (1954 to 1980 inclusive). Five data sets were generated, each using a different snowmelt model based on the degree-day method.

Two separate analyses were conducted by AES to verify the predicted values and determine the snowmelt model that most accurately represented the observed data:

a. Comparison with observed data and estimated rainfall plus snowmelt values from Sudbury meteorological records and observed runoff from nearby watersheds.

b. The water equivalent depth of the snowpack before melt was used to predict the amount available for melt for selected return periods. This was then compared to values generated by the five models for a period of 10 days.

Further details of these analyses can be found in Appendix A of the Whitefish River Flood Plain Mapping Technical Report. The study identified the following model for use in snowmelt calculations for the Greater Sudbury Area:

$$\mathbf{SM = 0.08\ (T_a - 32)}$$

where SM = snowmelt (in/day)
T_a = Mean Daily Air Temperature (°F)

By comparing the IDF values for rainfall and rainfall plus snowmelt, it is evident that for any given return period, the critical event is dependant on the storm duration. For example, the critical 100-year event will be rainfall only up to storm durations of three (3) days. For storm durations greater than three (3) days, rainfall plus snowmelt becomes the critical design event.

The reason for this is that the spring thaw occurs over a relatively long time period and the snowpack will absorb a portion of the rainfall during short duration storms. Rainfall events during the spring thaw will generally produce large volumes of runoff over long periods of time as the snowpack gradually melts.

The selection of the appropriate design storm will be dictated by whether runoff volume or peak flow is most critical. Storm sewer design is dependant on peak flows, so the rainfall IDF values should be used. Large stormwater management facilities with detention times greater than 72 hours should consider using both the rainfall and rainfall plus snowmelt IDF values to determine peak flow and storage volume requirements.

6.4 Design Storm Applications

6.4.1 Storm Drainage Systems

For the design of the minor system, the return interval of the design storm shall be selected based on the classification of the road to be serviced. The following guidelines shall be followed during selection of the design storm.

Road Classification	Design Storm Return Period
Urban Arterial	10 year
Rural Arterial/Collector Road	5 year
Local Road	2 year

Table 6-1: Storm Sewer Design Criteria

Storm sewer design shall be undertaken using the Rational Method and the appropriate design storm included in the updated IDF curves provided in this document.

Time of Concentration (min)	Rainfall Intensity		
	2 year (mm/hr)	5 year (mm/hr)	10 year (mm/hr)
15	49.2	68.5	82.4
16	47.4	66	79.3
17	45.8	63.6	76.5
18	44.3	61.5	73.9
19	42.9	59.5	71.5
20	41.5	57.7	69.3
21	40.3	56	67.2
22	39.2	54.4	65.3
23	38.1	52.9	63.5
24	37.2	51.5	61.8
25	36.2	50.2	60.2
26	35.3	48.9	58.7
27	34.5	47.7	57.3
28	33.7	46.6	56
29	33	45.6	54.7
30	32.3	44.6	53.5
31	31.6	43.7	52.4
32	31	42.8	51.3
33	30.3	41.9	50.3
34	29.8	41.1	49.3
35	29.2	40.3	48.4
36	28.7	39.6	47.5
37	28.2	38.8	46.6
38	27.7	38.2	45.8
39	27.2	37.5	45
40	26.7	36.9	44.2
41	26.3	36.3	43.5
42	25.9	35.7	42.8
43	25.5	35.1	42.1
44	25.1	34.6	41.5
45	24.7	34.1	40.8
46	24.4	33.6	40.2
47	24	33.1	39.6
48	23.7	32.6	39.1
49	23.4	32.1	38.5
50	23	31.7	38
51	22.7	31.3	37.5
52	22.4	30.9	37
53	22.1	30.5	36.5
54	21.9	30.1	36
55	21.6	29.7	35.6
56	21.3	29.3	35.1
57	21.1	29	34.7
58	20.8	28.6	34.3
59	20.6	28.3	33.9
60	20.4	28	33.5

Table 6-2: Rainfall Intensity

Runoff coefficients shall be based on the proposed land use.

Allowance must be made for inflows from adjacent areas. A minimum runoff coefficient of 0.5 shall be used for all upstream areas where future residential development is possible, and 0.8 for areas where future industrial development is possible. The area of potential future development must be reviewed and accepted by City staff.

Where appropriate, the amount of exposed rock in existing and ultimate conditions should be explicitly highlighted and runoff coefficients adjusted accordingly for pre-development and post-development conditions.

Calculations shall be provided for the time of concentration from the most remote part of the storm sewer catchment area, but shall be no less than 15 minutes for the initial upstream inlet. For pre-development conditions or for undeveloped upstream areas, the time of concentration should be calculated using the Bransby Williams, SCS Upland Method, or Airport Formula.

The City must approve the location of the connection of the proposed storm drainage system to the existing City drainage system.

- **Urban for 5 to 10-year storms**

Land Use		Runoff Coefficient	
		Min.	**Max.**
Pavement	- asphalt or concrete	0.80	0.95
	- brick	0.70	0.85
Gravel roads and shoulders		0.40	0.60
Roofs		0.70	0.95
Business	- downtown	0.70	0.95
	- neighborhood	0.50	0.70
	- light	0.50	0.80
	- heavy	0.60	0.90
Residential	- single family urban	0.30	0.50
	- multiple, detached	0.40	0.60
	- multiple, attached	0.60	0.75
	- suburban	0.25	0.40
Industrial	- light	0.50	0.80
	- heavy	0.60	0.90
Apartments			
Parks, cemeteries		0.50	0.70
Playgrounds (unpaved)		0.10	0.25
Railroad yards		0.20	0.35
Unimproved areas		0.20	0.35
		0.10	0.30
Lawns	- Sandy soil		
	- flat, to 2%	0.05	0.10
	- average, 2 to 7%	0.10	0.15
	- steep, over 7%	0.15	0.20
	- Clayey soil		
	- flat, to 2%	0.13	0.17
	- average, 2 to 7%	0.18	0.22
	- steep, over 7%	0.25	0.35

Table 6-3: Runoff Coefficients
(MTO – Drainage Management Manual, 1997)

For flat or permeable surfaces, use the lower values. For steeper or more impervious surfaces, use the higher values. For return period of more than 10 years, increase above values as 25-year – add 10%, 50-year – add 20%, 100-year – add 25%.

The coefficients listed above are for unfrozen ground.

Manning's formula shall be used in determining the capacity of all storm sewers. The capacity shall be based on the pipe flowing full.

The maximum allowable flow velocity for the design flow shall be 4 m/s, and the minimum shall be 0.75 m/s.

The minimum pipe size shall be 300 mm.

Table 6-4: Manning Roughness Coefficient
(MTO – Drainage Management Manual, 1997)

	Manning Roughness Coefficients
I. Sewers	0.011 – 0.013
A. Concrete pipe storm sewers	0.012 – 0.014
B. Verified clay pipe	0.009 – 0.011
C. Steel pipe (smooth)	
D. Monolithic concrete:	0.015 – 0.017
1. Wood forms, rough	0.012 – 0.014
2. Wood forms, smooth	0.012 – 0.013
3. Steel forms	
E. Cemented rubble masonry walls:	
1. Concrete floor and top	0.017 – 0.022
2. Natural floor	0.019 – 0.025
F. Laminated treated wood	0.015 – 0.017
G. Smooth walled polyethylene pipe	0.011 – 0.013
Corrugated interior polyethylene pipe (tentative)	0.024
H. Corrugated steel pipe or pipe arch	
68 x 13 mm corrugation (riveted, annular)	
Unpaved	0.024
25% paved	0.021
100% paved	0.012
68 x 13 mm helical	
Unpaved: 600 to 1525 mm Φ range:	0.016 – 0.024
25% paved: 600 to 1525 mm Φ range:	0.015 – 0.021
100% paved: all sizes	0.012
68 x 25 mm riveted (annular)	
Unpaved	0.027
25% paved	0.023
100 % paved	0.012
76 x 25 mm helical	
Unpaved: 900 to 1980 mm dia.:	0.021 – 0.027
25% paved: 900 to 1980 mm dia.:	0.019 – 0.023
100% paved: all sizes	0.012
152 x 51 mm corrugation (annular)	
Unpaved 1550 – 4500 mm dia., or 1900 to 5050 mm span	0.030 – 0.033
25% paved	0.026

Table 6-4 (Continued)

	Manning Roughness Coefficients
II. Road Gutters	
A. Concrete gutter, trowelled finish	0.012
B. Asphalt pavement:	
1. Smooth texture	0.013
2. Rough texture	0.016
C. Concrete gutter with asphalt pavement:	
1. Smooth	0.013
2. Rough	0.015
D. Concrete pavement:	
1. Float finish	0.014
2. Broom finish	0.016
E. Brick	0.016
For gutters with small slope where sediment may accumulate, increase values by 0.002.	
III. Lined Open Channels	
A. Concrete, with surfaces as indicated:	
1. Formed, no finish	0.013 – 0.017
2. Trowel finish	0.012 – 0.014
3. Float finish	0.013 – 0.015
4. Float finish, some gravel on bottom	0.015 – 0.017
5. Gunite, good section	0.016 – 0.019
6. Gunite, wavy section	0.018 – 0.022
B. Concrete bottom float-finished, sides as indicated:	
1. Dressed stone in mortar	0.015 – 0.017
2. Random stone in mortar	0.017 – 0.020
3. Cement rubble masonry	0.020 – 0.030
4. Dry rubble (riprap)	0.020 – 0.030
C. Gravel bottom, sides as indicated	
1. Formed concrete	0.017 – 0.020
2. Random stone mortar	0.020 – 0.023
3. Dry rubble (riprap)	0.023 – 0.033
D. Asphalt	
1. Smooth	0.013
2. Rough	0.016
E. Wood, planed, clean	0.011 – 0.013
F. 1. Good section	0.017 – 0.020
2. Irregular section	0.022 – 0.027
G. Riprap	0.035 – 0.040
H. Rock cut	0.025 – 0.045
IV. Unlined Open Channels	
A. Earth, uniform section:	
1. Clean, recently completed	0.016 – 0.018
2. Clean, after weathering	0.018 – 0.020
3. With short grass, few weeds	0.022 – 0.027
4. In gravelly, soil, uniform section, clean	0.022 – 0.025

Table 6-4 (Continued)

	Manning Roughness Coefficients
B. Earth, fairly uniform section:	
1. No vegetation	0.022 – 0.025
2. Grass, some weeds	0.030 – 0.035
3. Dense weeds in deep channels	0.030 – 0.035
4. Sides clean, gravel bottom	0.025 – 0.030
5. Sides clean, cobble bottom	0.030 – 0.040
C. Dragline excavated or dredged:	
1. No vegetation	0.028 – 0.033
2. Light brush on banks	0.035 – 0.050
D. Rock:	
1. Based on design section	0.035
2. Based on actual mean section:	
a. Smooth and uniform	0.035 – 0.040
b. Jagged and irregular	0.040 – 0.045
E. Channels not maintained, vegetation uncut:	
1. Dense weeds, high as flow depth	0.08 – 0.12
2. Clean bottom, brush on sides	0.05 – 0.08
3. Clean bottom, brush on sides, high stage	0.07 – 0.11
4. Dense brush, high stage	0.10 – 0.14

V. Grassed Channels and Swales[2]

Depth of flow:	Up to 0.2 m		0.2 – 0.5 m	
Velocity	0.6 m/s	1.8 m/s	0.6 m/s	1.8 m/s
A. Kentucky bluegrass:				
1. Mowed to 0.05 m	0.07 – 0.045		0.050 – 0.035	
2. Length 0.1 to 0.15 m	0.090 – 0.060		0.060 – 0.040	
B. Good stand, any grass				
1. Length 0.30 m	0.180 – 0.090		0.120 – 0.070	
2. Length 0.60 m	0.300 – 0.190		0.200 – 0.100	
C. Fair stand, any grass:				
1. Length 0.30 m	0.140 – 0.080		0.100 – 0.060	
2. Length 0.60 m	0.250 – 0.130		0.170 – 0.090	

VI. Natural Watercourses

A. Minor stream (surface width at flood stage < 30 m).	
1. Fairly regular section:	
a. Some grass and weeds, little or no brush	0.030 – 0.035
b. Dense growth of weeds, depth of flow materially greater than weed height	0.035 – 0.050
c. Some weeds, light brush on banks	0.035 – 0.050
d. Some weeds, heavy brush on banks	0.050 – 0.070
e. Some weeds, dense willows on banks	0.060 – 0.080
f. For trees within channel with branches submerged at high stage, add 0.01 to 0.02 to above values	
2. Irregular section with pools, slight channel meander; channels (a) to (e) above, add 0.01 to 0.02	

Table 6-4 (Continued)

	Manning Roughness Coefficients
3. Mountain streams, no vegetation in channel, banks usually steep,	
trees and brush along banks submerged at high stage:	0.040 – 0.050
a. Bottom of gravel, cobbles and few boulders	0.050 – 0.070
b. Bottom of cobbles with large boulders	
B. Flood plains (adjacent to natural streams):	
1. Pasture, no brush:	0.030 – 0.035
a. Short grass	0.035 – 0.050
b. High grass	
2. Cultivated areas:	0.030 – 0.040
a. No crop	0.035 – 0.045
b. Mature row crops	0.040 – 0.050
c. Mature field crops	0.050 – 0.070
3. Heavy weeds, scattered	
4. Light brush and trees:	0.050 – 0.060
a. Winter	0.060 – 0.080
b. Summer	
5. Medium to dense vegetation:	0.070 – 0.110
a. Winter	0.010 – 0.160
b. Summer	0.150 – 0.200
6. Dense willows, summer, not bent over by current	
7. Cleared land with tree stumps, 250 – 370 hectare:	0.040 – 0.050
a. No sprouts	0.060 – 0.080
b. With heavy growth of sprouts	
8. Heavy stand of timber, a few down trees, little undergrowth:	0.100 – 0.120
a. Flood depth below branches	0.120 – 0.160
b. Flood depth reaches branches (n increases with depth)	
C. Major stream (surface width at flood stage > 30 m): Roughness coefficient is usually less than for minor streams of similar description on account of less effective resistance offered by irregular banks or vegetation on banks. Roughness values may be somewhat reduced. Follow general recommendations if possible.	
The roughness value for larger streams of mostly regular section, with no boulders or brush, may be in the range.	0.028 – 0.033
Sources: American Iron and Steel Institute (1980); Herr, L.A. et al, (1965) Sears, J.K. (1969) Bradley, J.N. (1978)	

6.4.2 Bridge and Culvert Design

The following guidelines shall be followed for selecting the appropriate design storm for bridges and culverts. Peak flows resulting from both the 6 hour Chicago distribution and the 24-hour AES distribution should be calculated with the more critical flow of the two used for design.

Road Classification	Design Storm Return Period	
	Span < 6m	Span > 6m
Urban Arterial	50 year	100 year
Rural Arterial/Collector Road	25 year	50 year
Local Road	10 year	25 year

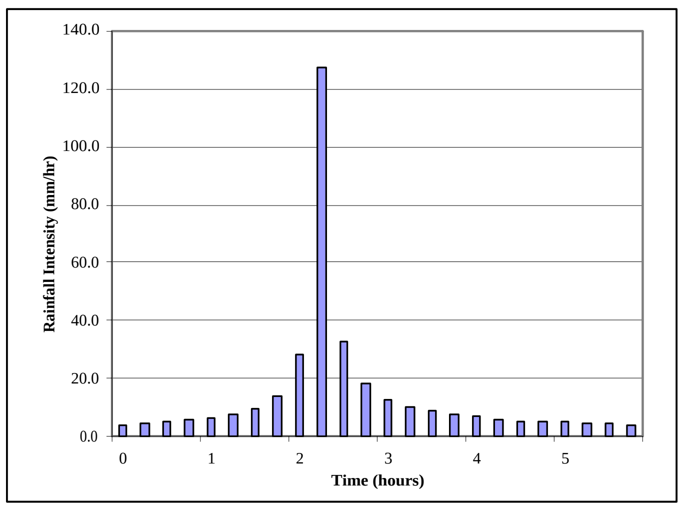
Table 6-5: Bridge and Culvert Design Criteria

6.4.3 Stormwater Management Detention Facility Design

Stormwater management detention facilities are required to control flows up to the 100-year design storm. For the 100-year storm, the peak stormwater flows resulting from two storm distributions should be calculated and compared: the 6-hour Chicago storm distribution (typically critical for fast-draining urban watersheds) and the 24-hour AES storm distribution (critical for slower-draining larger rural watersheds). Of the two design storms, the storm that produces the highest peak flow should be used as the design storm for flood conveyance. The two storms are shown in the following figure.

100-Year Chicago Storm Hyetograph
6 hour duration, 15 minute time step

Time (hours)	Rainfall Intensity (mm/hr)	Time (hours)	Rainfall Intensity (mm/hr)
0.25	4.1	3.25	12.9
0.50	4.5	3.50	10.3
0.75	5.0	3.75	8.7
1.00	5.7	4.00	7.5
1.25	6.5	4.25	6.7
1.50	7.8	4.50	6.1
1.75	9.9	4.75	5.5
2.00	14.0	5.00	5.1
2.25	28.3	5.25	4.8
2.50	127.1	5.50	4.5
2.75	32.6	5.75	4.2
3.00	18.0	6.00	4.0



100-Year 24-hour AES Storm Hyetograph
1 hour time step

Time (hours)	Rainfall Intensity (mm/hr)	Time (hours)	Rainfall Intensity (mm/hr)
1.00	0.6	13.00	8.7
2.00	0.6	14.00	8.7
3.00	0.6	15.00	3.8
4.00	0.6	16.00	3.8
5.00	2.5	17.00	2.5
6.00	2.5	18.00	2.5
7.00	5.6	19.00	0.6
8.00	5.6	20.00	0.6
9.00	11.2	21.00	0.6
10.00	11.2	22.00	0.6
11.00	25.0	23.00	0.6
12.00	25.0	24.00	0.6

a. Provide source control by reducing rate and volume of runoff on-site
b. Construct stormwater management Coniston Flood Control Remedial Works (1982)
c. and/or quality management
d. Undertake conveyance system modifications
e. Implement stormwater quality management policies and outreach programs

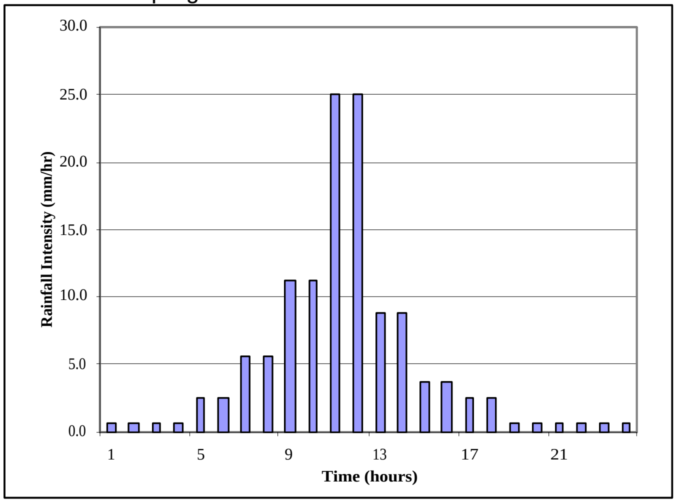


Figure 6-2: 100-Year Design Storms, City of Greater Sudbury

6.4.4 Flood Conveyance Design Storm

For flood assessment and design of major overland flow conveyance systems, the design peak flow utilized should be the largest of those generated by the 100-year design storm or the Regional storm (the Timmins storm). For the 100-year storm, the stormwater flows resulting from two storm distributions should be calculated and compared: the 6-hour Chicago storm distribution (typically critical for fast-draining urban watersheds) and the 24-hour AES storm distribution (critical for slower-draining larger rural watersheds). Of the three design storms, the storm that produces the largest flow should be used as the design storm for flood conveyance. The three storms include the two storms from the previous figure (100-year 6-hour Chicago storm distribution and 100-year 24-hour AES storm distribution); in addition to the Timmins storm shown in the figure below.

Timmins Storm

1 hour time step

Time (hours)	Rainfall Intensity (mm/hr)	Time (hours)	Rainfall Intensity (mm/hr)
1.00	15.0	7.00	43.0
2.00	20.0	8.00	20.0
3.00	10.0	9.00	23.0
4.00	3.0	10.00	13.0
5.00	5.0	11.00	13.0
6.00	20.0	12.00	8.0

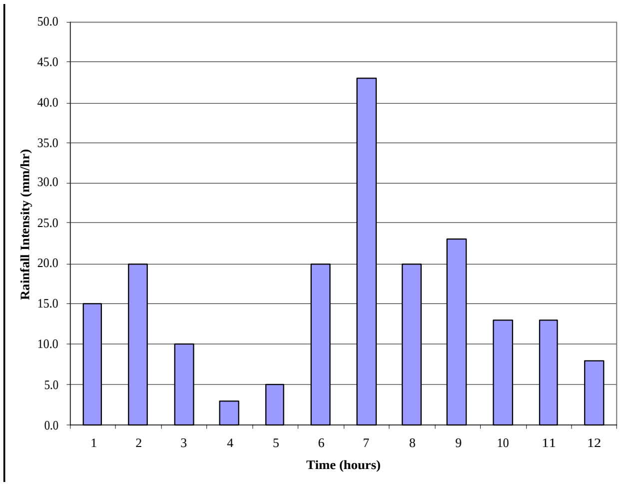


Figure 6-3: Regional (Timmins) Design Storm, City of Greater Sudbury

6.4.5 Snowmelt plus Rainfall

For stormwater management facility and conveyance designs, the potential for rainfall plus snowmelt exceeding design rainfall without snowmelt should always be verified.

Using the snowmelt model described in the previous section, a 10-day rainfall plus snowmelt distribution was developed with the IDF data provided by AES using the following methodology:

a. Computation of the accumulated depth of rainfall plus snowmelt at the end of day 1 through day 10;

b. Computation of incremental values for each day; and

c. Division of each of the one-day totals in half and rearranging those values such that the largest one-day values would be located centrally in the “design storm” distribution. The next highest values would be located on either side of the largest value until the smallest one-day values would be located at the beginning and end of the design event.

The resulting design storm distributions for rainfall plus snowmelt events are provided below.

10 day Rainfall + Snowmelt Design Events (mm/hr Equivalent Rain)

Duration (days)	Return Period (years)					
	2	5	10	25	50	100
1	1.6 mm/hr	2.1 mm/hr	2.4 mm/hr	2.8 mm/hr	3.1 mm/hr	3.4 mm/hr
2	1.3	1.7	1.9	2.2	2.4	2.7
3	1.2	1.4	1.6	1.9	2.1	2.3
4	1.0	1.3	1.4	1.7	1.8	2.0
5	0.9	1.1	1.3	1.4	1.6	1.7
6	0.8	1.0	1.1	1.3	1.4	1.6
7	0.8	0.9	1.0	1.2	1.3	1.5
8	0.7	0.9	1.0	1.1	1.3	1.4
9	0.7	0.8	1.0	1.1	1.2	1.3
10	0.6	0.8	0.9	1.0	1.2	1.3

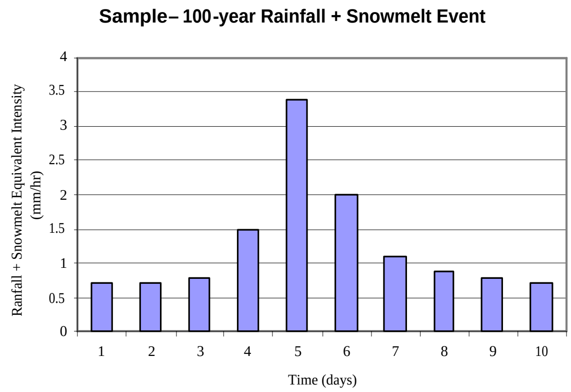


Figure 6-4: Snowmelt plus Rainfall Design Storm, City of Greater Sudbury

6.4.6 Climate Change Impacts

As part of the development of design storms for the City of Greater Sudbury, a literature review was conducted to assess the potential increase in rainfall due to climate change. Although there is no consensus in the literature regarding whether climate change has already resulted in higher rainfall or whether climate change will, in fact, even result in higher rainfall at all, there is some support among researchers for a 15% increase in rainfall depth in Canada (Hengeveld, 2000, Ciarmatiori et al, 2000, Watt et al, 2003).

Faced with a potential increase in 15% in rainfall depth, the following recommendations are made.

a. Storm Sewer Design

The only implication on storm sewer design is that it may result in a smaller level of service than originally intended.

For example, since a 5-year storm is roughly 15-20% larger than a 2-year storm, climate change may effectively decrease the level of service of some pipes from 5 years to 2 years.

Similarly, climate change may effectively decrease the level of service of a pipe designed for a 2 year storm to something slightly less than 2 years. However, since the pipes typically have some reserve capacity based on the requirement to use standard pipe sizes, and since there is ultimately no problem with a slightly lower level of service, the recommendation is to make no allowance in storm sewer design for the potential effects of global warming.

b. Stormwater Management Facility - Water Quality Design

The sizing of permanent pool volumes and extended detention volumes for water quality design of stormwater management facilities, are based on Table 3.1 of the MOE Stormwater Management Practices Planning and Design Manual. Since a design storm is not used when applying this Table, the change in design rainfall due to global warming may not change how the ponds are designed. More rainfall may cause runoff to bypass the facilities slightly more often, but the long-term operation may not be significantly impaired. Since the only impact is a small potential increase in uncontrolled runoff due to increased bypass, it is not recommended to change the water quality design until such time as the MOE revises Table 3.1.

c. Conveyance Design and Flood Control

Quantifying potential impacts on flood control due to utilization of larger design storms is made complex because of the use of different storms for pre-development, existing, short term, and long term situations. Redrawing flood elevations and revising hydrologic calculations for existing conditions is an extremely complex task. As a result, the preferred approach is not to change the design storm, but to make *over-control of flow* an objective where appropriate to address potential for climate change. It is recommended that all stormwater management facilities target a release rate of 85% of pre-development rates for the 100-year storm to offset potential impacts of global warming on flooding potential.

6.4.7 Computer Modeling Techniques for Stormwater Management

When required, hydrologic studies shall employ appropriate modeling techniques with defensible parameters. The proponent is to assume full responsibility for the proper application of hydrologic models. The City will accept modeling performed with OTTHYMO, SWMHYMO, Visual OTTHYMO, MIDUSS, or DD-SWMM. The proponent must obtain approval from the City prior to using any other models.

For small sites (less than 2 hectares), the modified rational method may be utilized for analysis instead of hydrologic computer modeling.

Site Size	Storm Sewer Design Modeling Technique	Major System Modeling Technique	Stormwater Management Facility Sizing		
			Peak Flow Control	Water Quality Control	Erosion Control
Small (< 2 hectares)	▪ Rational Method	▪ Rational Method	▪ Modified Rational Method ▪ Post-development peak flow rates must not exceed pre-development peak flow rates (2 to 100 year design storm), or if a subwatershed plan exists, the peak flow rates identified in the subwatershed plan.	▪ Pond not recommended	▪ Generally not required
Medium (upstream catchment < 10 hectares)	▪ Rational Method	▪ Rational Method or Hydrological Model (e.g. DD-SWMM or SWMHYMO with DUALHYD)	▪ Hydrologic Model ▪ Post-development peak flow rates must not exceed pre-development peak flow rates (2 to 100 year design storm), or if a subwatershed plan exists, the peak flow rates identified in the subwatershed plan.	▪ Pond not recommended	▪ Generally not required
Large (upstream catchment > 10 hectares)	▪ Rational Method	▪ Rational Method or Hydrological Model (e.g. DD-SWMM or SWMHYMO with DUALHYD)	▪ Hydrologic Model ▪ Post-development peak flow rates must not exceed pre-development peak flow rates (2 to 100 year design storm), or if a subwatershed plan exists, the peak flow rates identified in the subwatershed plan.	▪ MOE Guidelines or specific criteria from subwatershed plan	▪ 48 hour extended detention of 2-year design storm, or if a subwatershed plan exists, specific criteria in the subwatershed plan

Table 6-6: Recommended Modeling Techniques

As a minimum, when hydrologic models are applied, the following information must also be provided:

a. A drainage area map, clearly showing the site, any external drainage areas, and the receiving watercourse (or storm sewer);

b. Plans showing areas of development, street locations and land uses, as well as modeling parameters used for each pre-development and post-development sub-catchment (e.g. CN, overland drainage length, % impervious, etc.); and

c. If storage is proposed for post-development conditions, conceptual plans detailing storage facility locations and volumes, control structures, and outlet locations are required.

7.0 THE DRAINAGE ACT, R.S.O. 1990

The Drainage Act is a provincial statute that provides for the design and construction of drainage projects where a petition that satisfies the necessary criteria is submitted to the affected Municipality. The petition may be from a group of landowners, either rural or urban or a combination of such, provided they either constitute 51% of the owners in the area requiring drainage, or provided that the acreage that they own is at least 61% of the land area in the area requiring drainage.

As well, a petition may be initiated by the signature of the individual in the Municipality who has jurisdiction over the roads.

When a petition is submitted for a drainage works, the petition must initially be reviewed by the Ministry of Natural Resources or the Conservation Authority if one exists, to determine if there are any concerns with respect to a new drainage project in their area of jurisdiction. If there is not, and a thirty day review period has expired, the Municipality is obligated to appoint a consulting engineer to review the petition, meet with the owners, determine if the petition is sufficient and to prepare a report on the petition if all is in order. The report that the Engineer submits is to address the requirements of the petitioners. The Engineer is obligated to carry any works that he deems necessary to an outlet and this may involve going significantly further downstream of the area requiring drainage and could involve going into other municipal jurisdictions.

The Engineer in his report has to determine the cost of the project and who or what landowners and authorities within the watershed should be assessed a portion of the cost.

One section of the Drainage Act requires that any increased costs of crossing road allowances, railways or utilities are to be assessed to the road authorities, railways or utilities. This makes the Drainage Act a very convenient piece of legislation when projects are considered that cross road allowances, railways or utility easements.

The Municipality if it so chooses may request a preliminary report pursuant to Section 10 of the Drainage Act in advance of proceeding with a full and final engineering report.

The Drainage Act requires that all projects be scrutinized either by the local Conservation Authority or by the MNR. Today Fisheries and Oceans Canada (DFO) has a working agreement with most Conservation Authorities and it is customary to submit most projects to DFO for review and approval. The main environmental review agency on projects is thus Fisheries and Oceans. If it is determined that there are other environmental concerns that need be addressed, Fisheries and Oceans has the jurisdiction to invoke the CEAA process.

If any other body or provincial agency determines that environmental studies are necessary in connection with a drainage project, they may initiate such but they are responsible for the costs of undertaking any studies involved with such.

There exists a document entitled Design and Construction Guidelines for Works Pursuant to the Drainage Act, which provides criteria for most drainage projects. The Provincial Ministry of Agriculture and Food, administers the Drainage Act and provides grants to agricultural properties assessed on a drainage project. This Ministry has determined that grants are only obtainable on assessments that relate to a project that is designed to convey runoff from a two (2) year storm event, as set out in the Guidelines, notwithstanding that road and rail crossings may be designed to accommodate a more significant event.

With respect to the grant, two-thirds (2/3) of the assessments to agricultural properties in District Municipalities are paid by the Province. Restructuring within the City of Greater Sudbury has not affected the grant. Generally, it is held that all municipalities north of Parry Sound are District Municipalities; therefore the grant is 2/3. In southern Ontario, in Regional Municipalities and Counties, the grant is 1/3. The grant is only paid to properties that are considered to be agricultural. To date, there is no definition of what constitutes an agricultural property, and it is generally left to the engineer to identify the agricultural properties. There have been suggestions however that the Drainage Act may be some day altered to the affect that properties will have to demonstrate a certain annual agricultural income to be eligible for the applicable grant.

With respect to closed drainage projects, the conventional design of tiled or piped agricultural drains is for a 12 to 25 mm drainage coefficient, which is a fraction of a 2-year storm event.

Provided there are no agricultural grants involved, a project may be designed to a higher design storm level.

The Drainage Act also allows special benefit assessments to be made to parties who have requested components of work on the project in excess of the work necessary to satisfy the basic intent. Examples of such would be the construction of fencing along a project or a watering facility for livestock. Special benefits for other purposes could be levied but the agricultural grant may not apply.

7.1 Use of the Drainage Act Process for Stormwater Management Purposes

There is a minimum of three scenarios that could be involved where the Drainage Act may be used for stormwater management considerations. The first would be in a fully agricultural watershed where stormwater management is necessary to control costs or to obtain outlet. The second scenario would be in a combined urban/rural watershed where a drainage project is constructed in a more urban setting and the discharge must be reduced to the capacity of an agricultural drain downstream.

The third possibility would be within a fully urban watershed where it is necessary to reduce a drainage system's discharge from an upstream urban watershed to outlet in a downstream urban system that has been constructed to a lesser design standard.

7.1.1 Scenario 1

In the situation where a fully agricultural watershed exists, projects have been submitted where a stormwater management facility has been constructed upstream of other agricultural properties to provide for the reduction and controlled discharge of upstream waters so that an existing smaller watercourse or drain downstream may suffice as an outlet with no or minor improvements. Where it is shown that the works result in a savings of cost as opposed to constructing a large downstream improvement, grant monies may be paid on agricultural assessments in the full project.

Another example of where stormwater management under the Drainage Act could be used in a rural watershed is where upstream owners are desirous of more substantial drainage outlets and yet downstream owners may want lesser work done and where the ground gradient does allow stormwater management to be undertaken. In this situation, a facility could be constructed that would allow a new small diameter closed drain or a smaller open channel to serve as the outlet downstream of a new and more significant upstream project.

7.1.2 Scenario 2

This is the scenario where an upstream urban watershed is to be served by a new drainage system and must outlet into a smaller downstream agricultural outlet. A good example of such work would be a project where an urban area is served by new storm drains designed to a 2 to 10 year storm event with overflow provisions and such discharge into a stormwater management facility. The facility would then be designed so that the outlet is to the level of service existing downstream which could be a closed agricultural drain designed to a 12 to 25 mm coefficient or an open channel designed to a 2 year runoff event. It would normally be expected that the 100 year or the major runoff event would also be controlled to the pre-existing 100 year event so that downstream impacts are not increased.

In this scenario, the upstream urban watershed would be assessed the majority, or all, of the costs of the stormwater management facility and as well the costs of the upstream drainage. If the upstream drainage itself were constructed through any process other than the Drainage Act, of course the costs would be absorbed in the normal fashion. The stormwater management facility could still be constructed under the Drainage Act and it would be left to the Engineer to determine if there should be any assessment to downstream lands because of the facility and if the grants should apply.

The Drainage Act creates a convenient medium to allow for the construction and the approval of the stormwater management facility and also provides a forum for the downstream owners to participate in the design process.

7.1.3 Scenario 3

In this scenario, the Drainage Act could used to construct a drainage scheme serving an urban area with a controlled outlet into either an existing urban outlet or into a new urban outlet. In this scenario, there would be no limitations on design standards since there would be no provincial grant monies involved and no agricultural assessments. The Drainage Act does however provide the medium for the undertaking of the project, for the obtaining of approvals of the project and for the distribution of costs on the project.

The disadvantage of the Drainage Act is that there is a time factor involved to complete the necessary meetings and there are also avenues of appeal available should any assessed party chose to object to either the scheme or his share of the costs of the scheme.

7.2 Use of the Drainage Act for Existing Drains

There is a further section of the Drainage Act, known as Section 78 that allows a Municipality to appoint an engineer, without a petition, where it is deemed either at the Municipality's initiation or upon the request of a group of owners that an improvement is necessary to an existing drain. The Engineer is appointed to act on such a project in a similar fashion that he is appointed under a petition drain and follows all the same steps. The one criterion is that the Engineer not provide for an entirely new drain. The project has to be considered as an improvement to an existing drain and some aspect of the existing drain must remain.

A situation where, in an urbanizing watershed, Section 78 could be considered is where a drain does serve urban lands in part and rural lands in part and there is a desire to improve the drainage in the upper watershed. The Municipality could appoint an Engineer to make a review of the existing drain and to address drainage improvements to be undertaken in the upper watershed and the works necessary to ensure that the downstream drainage system serves the upstream improved drainage works without substantial improvements. In this situation, the Engineer could indeed recommend the construction of a stormwater management facility.

The Engineer would have the ability if he felt it was appropriate to assess the cost of this stormwater management facility in full or in part to the road authority if he determined the primary purpose of the project was to provide for improved drainage of roads. (This would also apply for a new petitioned drain.)

As indicated in the previous discussion, if the Engineer deemed that this would also avoid perhaps a needed improvement in the lower watershed, he could as well assess a portion of the costs to the downstream agricultural lands and such would be eligible for the grant.

7.3 Maintenance of Systems Constructed Pursuant to the Drainage Act

The Engineer that prepares a report on either a petition drain or a Section 78 drain is also required to provide for the maintenance of such. Normally the Engineer prepares a separate schedule for the maintenance of the project and describes what maintenance may be undertaken. It is then the Municipality's responsibility through the Drainage Superintendent's program to initiate, when needed, any required works of maintenance and the costs are to be assessed proportional to the maintenance schedule that the Engineer contains in his report.

In the City of Greater Sudbury, the Municipality has required the Drainage Superintendent to prepare a program of scheduled maintenance on all existing drains. The program has been in place for two years and a number of existing projects have now been improved in the years 2002 and 2003. The intention is that the program continues such that all drains are improved on a regular basis.

7.4 Listing of Possible Policies That Could Be Reviewed by the City of Greater Sudbury with Respect to Stormwater Management in Rural or Semi-rural Watersheds

7.4.1 Scenario 1 - Where No Existing Municipal Drain Exists and Improvements Are Being Considered

a. Drainage improvements are to be designed so that the minor and major downstream flows are maintained within the limits of the existing downstream watercourse. Where necessary, stormwater management is to be constructed such that both the minor and major runoffs are consistent with pre-development conditions.

b. Outlet deficiencies in downstream watercourses are to be reviewed and considered in any new drainage projects.

c. Where the Municipality is concerned with respect to the outlet in a rural setting, a report of a Drainage Engineer shall be obtained and the necessity of constructing an improvement pursuant to the Drainage Act shall be considered.

7.4.2 Scenario 2 - in an Area Where Development Is Proposed and the Outlet Is an Existing Municipal Drain

a. The report of a Drainage Engineer is to be obtained and recommendations are to be made available as to the upper limit of runoff from the upper watershed.

b. The report shall also evaluate the necessity of constructing improvements in the downstream drainage project as part of the upstream improvements.

c. The report shall also determine the necessity of undertaking stormwater management for the upstream watershed and the advisability of having the stormwater management incorporated as part of the downstream drain.

7.4.3 Scenario 3 - Where it Is Determined That There Is Not a Municipal Drain Existing but Where the Upstream Work Should Be Constructed and Be Served by a New Municipal Drain as the Outlet

a. The Municipality shall appoint an Engineer to make a report pursuant to the Drainage Act. A decision will be made whether the appointment is to be pursuant to a petition of the Engineer responsible for the roads or by upstream landowners satisfying the requirements of Sections 4(1)(a) or 4(1)(b) of the Drainage Act.

b. Where such report is implemented, the downstream work shall be constructed to a level consistent with the Design and Construction Guidelines for works under the Drainage Act. Where any works are constructed to a greater standard, the Municipality or the petitioning landowners shall be responsible for the increased costs.

c. Any urban component comprising either road drainage or stormwater management to control downstream flows shall also be paid by the Municipality or by the urban owners in the area requiring drainage as per the recommendations of the Drainage Engineer.

8.0 FUTURE SUBWATERSHED STUDIES

8.1 Prioritization of Future Subwatershed Studies

The order in which future stormwater studies should be undertaken was determined through the application of the same criteria that was used to prioritize the watersheds and subwatersheds.

Water quality, conveyance and development potential were all taken into account.

8.2 Estimated Costs and Time Required to Complete Future Subwatershed Studies

The estimated cost and time required to complete future subwatershed studies were determined by comparing the total urban area within the subwatershed with the total urban area within the Algonquin Road subwatershed and then pro-rating the cost and time required to complete the Algonquin Road subwatershed study.

Subwatershed Name	Priority	Estimated Cost	Estimated Time Required to Complete
Nepahwin/Robinson	1	$200,000	10 months
Ramsey Lake	2	$200,000	10 months
Whitson River	3	$200,000	10 months
Azilda	4	$150,000	8 months
Richard Lake	5	$ 50,000	6 months
Junction Creek	6	$200,000	10 months
Mud Lake	7	$150,000	8 months
Simon / McCharles Lake	8	$ 50,000	6 months
Chelmsford	9	$150,000	8 months
Whitson Lake	10	$ 50,000	6 months
Garson	11	$100,000	6 months
Meatbird Creek - Lively	12	$ 50,000	6 months
Coniston	13	$200,000	10 months
Wahnapitae	14	$100,000	6 months
Dowling	15	$100,000	6 months
Copper Cliff	16	$ 50,000	6 months
Kelly Lake	17	$100,000	6 months

Table 8-1: Future Subwatershed Studies

8.3 Cost Sharing

As a guiding principle, stormwater management is implemented to benefit a development; therefore, related costs (i.e. engineering, capital, operation and maintenance, and land) should be incurred by the development.

Currently, developers are required to undertake stormwater management studies and then implement the findings. Initial funding must be provided by the developer, and then recovered through the sale of homes or properties. In some cases, ownership, along with ongoing operation and maintenance are eventually transferred to the City.

When the opportunity exists for a stormwater management facility to serve additional upstream development (either existing or future), cost sharing amongst benefiting parties should be considered. This could be established according to the relative contribution of flow to the facility.

8.4 Dedicated Funding

Given the cost of stormwater management infrastructure, it is recommended that the City consider the use of dedicated funding mechanisms. Such mechanisms include, but are not limited to:

- Utility or full-cost recovery models (base utility or surcharge on the water bill);
- Property tax models (dedicated tax increment or surcharge on the property tax bill);
- Other models (local improvements, development charges, and public private partnerships).