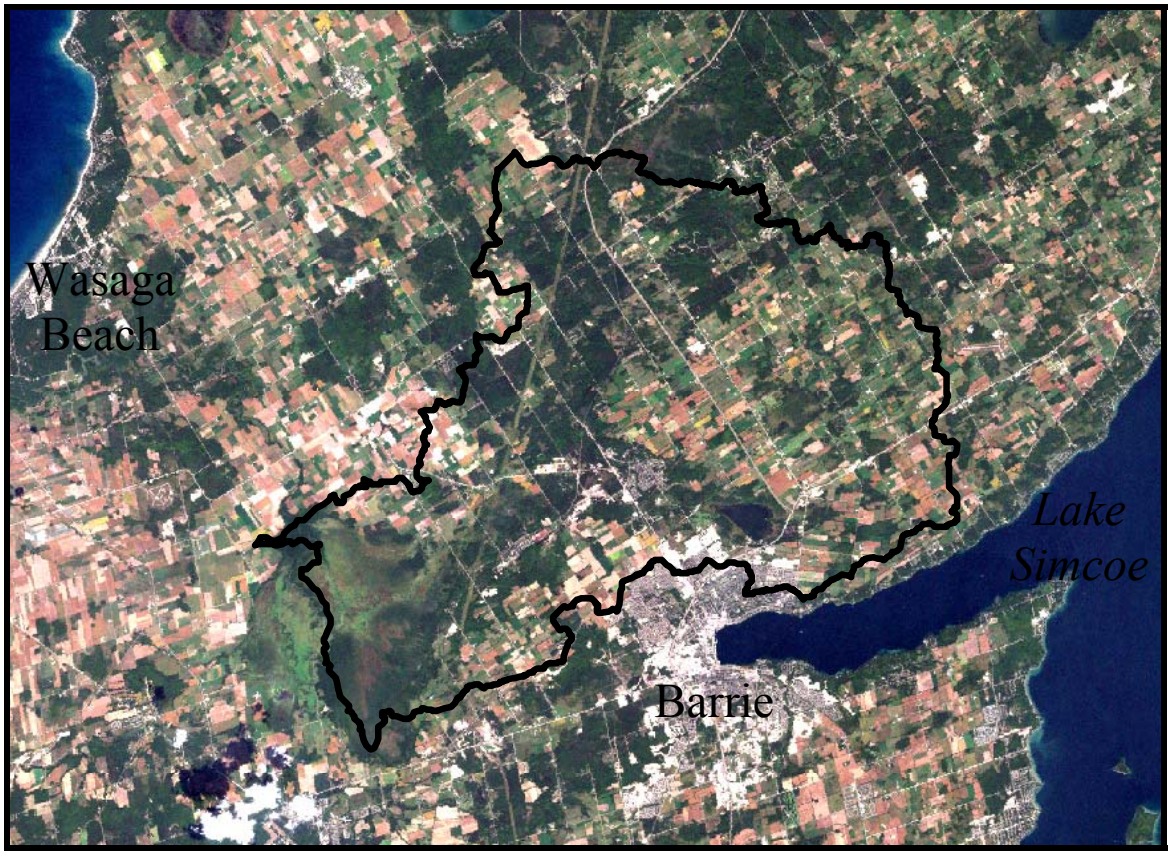
WILLOW CREEK SUBWATERSHED PLAN



December 2001

Nottawasaga Valley
Conservation Authority

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The updated appendices are posted on NVCA's website at www.nvca.on.ca along with the Subwatershed Plan.

Updates: Please note that updates to both the appendices and the subwatershed plan itself will be posted on our website.

Willow Creek

Subwatershed Plan

December 2001
(2001-2020)

Prepared by the Nottawasaga Valley Conservation Authority
for the
City of Barrie
Oro-Medonte Township
Springwater Township

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1.0 INTRODUCTION

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This section of the plan outlines the specific water related issues associated with Willow Creek, the goal and objectives that were developed to address these issues, the study approach and background information on the subwatershed.

1.1 Subwatershed Planning, an Ecosystems Approach

Ontario residents are very aware of the significance of our water resources and the importance of providing them with adequate protection. Public concerns have been well documented across the province relating to the cumulative impacts of land uses and development on the quality and quantity of both our surface and ground waters.

Some of these impacts include significant reductions in base flow (particularly during recent summer droughts), and contamination of both surface and ground water. It must be emphasized that these impacts are usually not limited to the municipality in which they occur, but also affect adjacent and downstream municipalities. For example, disturbing a stream's headwater wetlands and discharge areas has the potential for significant impacts on downstream municipalities through reduced the streams base flow, water quality impairment, increased flooding, and erosion.

One of the most effective ways of dealing with these cross-boundary issues is to study the entire area that may be affected by the land use or development impacts. In most cases the water management issues can be addressed within a subwatershed. This approach assures the assessment of all impacts on the entire ecological unit (the subwatershed) and it's functions, rather than simply focusing on the isolated impacts on a specific feature within a municipal boundary.

Support for a coordinated watershed planning and ecosystems approach comes from the *Provincial Policy Statement* which indicates that *"a coordinated approach should be achieved when dealing with issues which cross municipal boundaries including, … ecosystems and watershed related issues; and shoreline and riverine hazards"* [1]

In response, a growing number of municipalities and regulatory agencies have implemented watershed and subwatershed management plans as a means of addressing these cross-boundary issues. In order to provide the broad watershed context, the Nottawasaga Valley Conservation Authority (NVCA) developed the *Nottawasaga Valley Watershed Management Plan* dealing with water management issues across the entire Nottawasaga River Valley.

The goal of the Watershed Plan is the "*conservation of natural resources within our watershed in a co-operative, integrated manner in which human needs are met in*

1 "Provincial Policy Statement". Government of Ontario, Queen's Printer 1997, Section 1.1.1.e, Page 2

balance with the need to sustain the natural environment".[2]

One of the recommendations from the Watershed Plan was the preparation of subwatershed studies for the "high priority subwatersheds". Criteria such as the significance of the ecological features, impacts from flooding, and stresses due to land use practices, determined the priority.

Black Ash Creek, which passes through the Town of Collingwood was the first subwatershed study undertaken and addressed significant flooding issues and natural heritage identification.

The municipalities within the Willow Creek Subwatershed (City of Barrie, Oro-Medonte and Springwater Townships) recognized that working together through a subwatershed study would address many of the land use and water management issues associated with the Willow Creek. They formed a partnership with NVCA (the coordinating agency) and the Ontario Government to carry out this study. This study will act as valuable technical input to municipal planning documents such as official plans, secondary plans and subdivision applications.

The plan provides water management recommendations to municipalities, NVCA, and other stakeholders to assist in their decision–making responsibilities. It provides a tool to assist in striking the balance between the demands for growth and the need to ensure, over the long term, a safe, clean, and self-sustaining ecosystem

The plan will provide water management direction in the following areas:

- The integration and co-ordination of water resource management (e.g. surface and ground water quality)
- The identification and protection, of the natural heritage system, groundwater recharge/discharge areas, as well as the identification of restoration opportunities
- The protection of human life and property from water-related hazards, such as flooding, erosion and sedimentation

Water quality of investigations within Willow and Matheson Creek as well Little Lake are significant components of the plan.

The development of a water balance provides a context for understanding ground and surface water quality and quantity issues. It guides the development of the water management standards and criteria necessary to sustain the aquatic ecosystem. If required in the future, it also provides the scientific basis for the development of a water budget and allocation framework to ensure sustainability of water usage by all sectors of the community.

In the past, stormwater management (SWM) facilities have been constructed to limit adverse environmental impacts of urban runoff through the land development process on a

2 Nottawasaga Valley Watershed Management Plan 1996-2015, page 19

"case-by-case" basis. This isolated approach is not the most effective or efficient way of managing stormwater. The plan promotes the effective integration of storm water management practices on a subwatershed basis (including facilities within new development areas and those already in operation).

The identification, protection, and restoration of Willow Creek's Natural Heritage System are also very important issues addressed in this plan. The natural heritage system integrates the existing "green lands" systems of the municipalities and the County and adds a more detailed inventory of the significant natural features and areas using criteria developed by the Province of Ontario.

1.2 Subwatershed Issues

The issues associated with Willow Creek are those of a rural subwatershed with the additional pressures of a rapidly growing population in the City of Barrie and Simcoe County.

A list of subwatershed management issues was derived from previous studies, staff experiences, and consultation with the municipalities.

- There is a need to better understand and protect surface and groundwater
- There is a need to better understand the subwatersheds hydrologic cycle as a basis for managing water and help ensure the sustainability of water usage
- Natural heritage features and functions must be identified, protected, and where possible restored
- Best management practices for land use and stormwater needs to be apply across the subwatershed
- Flood and erosion damage must prevent

The subwatershed plan focuses on resolving these issues in a clear, concise and easily understood manner.

1.3 *Goal and Objectives*

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Subwatershed Plan Goal:

The goal is: "*To conserve Willow Creek's natural resources in a cooperative, integrated manner in which human needs are met in balance with the need to sustain and where possible restore the health of the natural environment."*

Subwatershed Plan Objectives:

These objectives are required to implement our goal and address the Willow Creek issues listed above:

Aquatic:

- The identification and assessment of aquatic resources in the subwatershed such that protection of water quality and quantity can be afforded through an informed planning process and restoration efforts can be targeted at impaired areas.
- The co-ordination of water resource management within the subwatershed including the development of water and nutrient budgets, stormwater management, erosion and flood control
- The enhancement of water conservation practices

Terrestrial:

- The identification and protection of the natural heritage system
- The identification of opportunities for rehabilitation and restoration of natural heritage features (including stream corridors, wetlands and forest habitats

1.4 Study Approach

The approach that was taken to develop this plan was to focus on identifying and resolving the specific water related issues associated with the Willow Creek Subwatershed. The goal and objectives were established to address these issues. The plan and implementation strategy was then developed to achieve these objectives and address the issues.

The phased approach used to create the plan is described below.

Phase I Background Review and Mapping: This phase developed the Terms of Reference, identified the subwatershed issues, goal and objectives. It gathered information on the significant natural heritage features that characterize the area. This included developing the technical water resources background information, initial data collection and model development.

Phase II Evaluation: The study refined the phase 1 models providing the basis for a water balance, water quality and quantity assessments. It identified management measures to mitigate the potential impacts. NVCA staff field checked and confirmed the Natural Heritage System mapping.

Phase III Plan Preparation: This phase developed the subwatershed plan including the implementation strategy, and suggested monitoring requirements.

Compatibility with the Environmental Assessment (EA) Process:
The process through which this plan was developed, is compatible with the "environmental assessment process" set out in the document, *Municipal Class Environmental Assessment* (Municipal Engineers Association, June 2000). This Class Environmental Assessment

process represents an approved planning procedure for municipal projects. It ensures that social, economic and environmental factors are considered in the planning and design of new infrastructure (including stormwater management facilities).

Planning horizon:
The studies planning horizon or context is twenty years (2001-2020), however due to the rapidly changing planning and development landscape, it is recommended that the plan be reviewed after five years to determine its effectiveness.

1.5 Public Consultation

The planning process for the subwatershed plan provided a variety of opportunities for public and municipal input, including:

- A review of issues and concerns raised in earlier processes including the Nottawasaga Valley Watershed Management Plan, municipal planning documents and special event forums such as those on the Oro Moraine etc.
- Establishment of a Steering Committee, which was made up of representatives from the City of Barrie, Oro-Medonte and Springwater Townships, MOE, OMAFRA, Simcoe County and NVCA. MNR was also involved through circulation of minutes and documents. The committee acted as a very important conduit for public and staff comments and input. Interest groups and concerned citizens provided input and comments through steering committee members, staff and at related information sessions such as those for the Oro Moraine
- Consultation with the municipal councils
- A public open house was held November 22, 2001 at the Simcoe County Administration Building attracting between 25-30 people. Valuable comments and input was obtained from this meeting and incorporated into this final plan.

1.6 Background Information

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1.6.1 Drainage

Willow Creek subwatershed is approximately 339 sq. km located in the northeast corner of the Nottawasaga River Watershed **(Map 1)**. The total length of Willow Creek is 45 km. Along this length, the stream channel drops in elevation some 152 m from the headwaters to its confluence with the Nottawasaga River. Matheson Creek is the largest tributary in terms of catchment area and baseflow contribution.

This subwatershed is important to the Nottawasaga River's aquatic ecosystem because of its size, the amount of discharge, and the coldwater habitats (primarily Matheson Creek). Much of the headwaters of Willow and Matheson Creeks are located on the Oro Moraine, a very important recharge area and headwater of several other streams. A portion of the southern shoreline of Little Lake is within the City of Barrie. The lake is very important to both the City of Barrie and Springwater Township for recreation and aesthetics.

Willow Creek drains in a southwesterly direction into Little Lake, through the village of Midhurst and eventually into Minesing Swamp (a 6000 ha, internationally significant wetland), where it joins the Nottawasaga River. The study area also includes the Swaley, Downey and Giffen drains shown on Map 1. Although they are not directly connected to the Willow Creek, they were included for historical reasons. These drains may have been connected to Willow Creek at one time, and the waters flow from Willow Creek into these drains to the Nottawasaga River during significant storm events.

1.6.2 Physiography

The identification of landforms within the Willow Creek Subwatershed **(Map 2)** helps us understand how the various soil types were formed and how drainage characteristics vary over the area. Knowing the location of course, un-compacted soils identifies potential groundwater recharge or discharge areas.

The Willow Creek subwatershed is divided into two landform types: the Simcoe Uplands, which covers approximately two-thirds of the area and the Simcoe Lowlands covering the rest. Both were formed during the late stages of continental glaciation and the postglacial lacustrine activities of Lake Algonquin.

The uplands are made up of Drumlinized Till Plains and the Oro Moraine (sometimes known as the Bass Lake Kame Moraine), both have glacial and glaciofluvial origins. These uplands and ridges stand from 60 m to 120 m above the valley floor. They were islands within glacial Lake Algonquin after the last ice age retreat. The old Algonquin shoreline cliffs and beaches are found along the sides of these uplands. The sands and gravel were likely laid down in the Oro Moraine, with most of the fine sand and silt being carried away by a continuous flow of water. The Oro Moraine is a very important physiographic and natural feature. It is a major groundwater recharge area and the headwaters for Matheson Creek and to a lesser extent, the Willow Creek Branch.

The Lowlands are made up of sand and clay plains with the sand along the creeks and the clay in the flats north and west of Minesing. Depressions on the lowlands are filled with organic soils such as those found in Minesing Swamp.

1.6.3 Soils

The soils that were derived from the weathering process of the various materials deposited after glaciation are quite varied **(Map 3)**. They include well-drained sands and sandy loams of the Simcoe Uplands (Sargent, Bondhead, Tioga, Vasey, Dundonald, and Bookton series). Making up almost three quarters of the study area, these course soils permit infiltration and recharge local aquifers, which in turn provide important baseflow to the many streams in the area.

The imperfectly and poorly drained loams, sandy loams, silty and marly clay, clay loams and muck soils of the Simcoe Lowlands (Guerin, Lyons, Granby, Simcoe-Berrien, Schomberg, Smithfield, and Minesing series) make up the other twenty-five percent.

Some of these soils such as Schomberg and Smithfield Silty Clays are very productive agricultural soils.

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1.6.4 Land Use Summary

Land use within the Willow Creek Subwatershed is primarily agricultural and rural in nature (approximately 90%). Agricultural operations are generally mixed farming, dairy, beef and cash crops. Hay, grain, corn, soybeans and some potatoes are typical crops with pasture and grazing being less common.

The largest built-up areas of the subwatershed are within the City of Barrie, the settlement area of Midhurst as well as along the Highway 11 corridor. Most new development will be through secondary plans, within the City of Barrie, Snow Valley, Midhurst, Centre Vespra, and Craighurst. The municipalities may establish some additional development through rural residential developments or adult lifestyle communities.

Aggregate extraction is also a significant existing land use within the study area because of the quality of aggregate resources found in the Simcoe Uplands. Aggregate extraction applications to expand and /or develop new operations are being processed for two locations adjacent to Highway 400.

1.6.5 Cultural Heritage

Simcoe County has a rich, well documented First Nations and European settlement history. Willow Creek Depot (now called Fort Willow), located at the west end of the subwatershed **(Map 1)**, makes a significant contribution to that history. It was located on elevated ground overlooking Minesing Swamp. The site (also simply called "Nottawasaga" in early military records) is closely linked to the Nine Mile Portage from Kempenfelt Bay to Willow Creek, as it was the northwest terminus of the portage. The First Nations initially developed this portage as a travel and trade route. This route was an important link between Lake Ontario and the Upper Great Lakes. French explorers, missionaries and later fur traders used it.

During the war of 1812 the portage was of vital significance in moving large quantities of military supplies north to Sault Ste. Marie and Fort William (Thunder Bay). However, these supplies often accumulated at the Willow Creek landing because only small loads could be transported on the shallow waters of the Creek, especially during the summer season. As a result a depot was constructed to store the supplies about a mile south of the landing on the nearest high land and was called Willow Creek Depot. The Depot and Nine Mile Portage played an important role in Canadian history in the early 1800's as a transportation route, but their use declined in the mid-1800s with the construction of roads and the railway.
Currently, the Fort Willow Improvement Group (a volunteer organization) is dedicated to its restoration and preservation. Their historical displays and self-guided tours are important local attractions

2.0 ECOSYSTEM MANAGEMENT

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This section describes the subwatershed's ecosystems. It identifies the significant natural heritage features, examines aquatic ecosystem (water quality and fisheries resources) and makes recommendations to help ensure their protection.

The natural heritage system is made up of interconnected terrestrial (land based) and aquatic (water based) ecosystems. Although terrestrial and aquatic components are linked, discussion of the two ecosystems separately is useful because of the requirements for land use planning in the province as reflected in of the "Provincial Policy Statement" (PPS).

It has long been recognized that our natural heritage areas are a very important, shared, public and private trust. Landowners are stewards of their land and along with municipalities, manage the land use of these natural heritage areas independently and through plans, agreements and partnerships.

Our natural heritage areas are valued for their long-term contribution to the environmental quality of the provincial, regional and local ecosystems. They are also very important to the economic and social fabric, and in many instances help to define the character of an area. For example, the Oro Moraine and Minesing Swamp play a major role in defining the natural landscape of the Willow Creek subwatershed, as well as contributing to its social, cultural and economic fabric.

2.1 Natural Heritage Ecosystem

Natural Heritage Ecosystem is an integrated network of interconnected natural features and their functions including aquatic and terrestrial habitats such as woodlands, watercourses, wetlands etc. Also considered part of the system are the natural corridors and valley lands that link these features together, enabling exchange of biota, energy and other components of the ecosystem.

The natural heritage system was identified using the province's criteria, guidelines and policies as outlined in the *Provincial Policy Statement (PPS)* and the *Natural Heritage Reference Manual*. This approach provides the municipalities with the most useful information that can be directly inserted into their land use planning process and is supported by the PPS.

While the individual components that make up the natural heritage system have been documented, the entire interconnected system has been identified and mapped as a single entity (except for wetlands which have the most restrictive policies requirements). In many cases it is difficult to partition the natural heritage system into its individual components (such as wildlife habitats, woodlands and valley lands). From a planning perspective, there is no compelling reason to do so, as they are all interconnected and

require the same level of protection under section 2.3.1 b of the *Provincial Policy Statement* (PPS).[3]

This "systems" approach to natural heritage identification has been promoted for some time. For example, Riley and Mohr (1994), state in *The Natural Heritage of Southern Ontario's settled Landscapes*; "*Integrated networks of conservation lands and water are the appropriate and practical method to define the natural landscape we wish to conserve*".[4]

The Ministry of Natural Resource's (MNR) *Natural Heritage Reference Manual* states that "*The use of a natural heritage system approach facilitates the co-ordination of ecosystem-based and watershed based issues across planning authority boundaries as recognized in section 1.1.1(e) of the PPS, by recognizing important linkages (e.g. features such as valleylands and ecological functions such as hydrological connectivity) that extend beyond planning area boundaries*" [5]

This is also the approach used by Simcoe County, Oro-Medonte and Springwater Townships in identifying their natural heritage systems for their Official Plans.

This approach for the Willow Creek Subwatershed Plan permits the identification, coordination and integration of the natural heritage system, across the three participating municipalities and in greater detail than does the County's Greenland study.

2.1.1 Natural Heritage System Identification

The Willow Creek Subwatershed Plan illustrates the natural heritage system on **Map 4.**

While the PPS sets the minimum protection standards through its policies, there is nothing in the policy statement that is intended to prevent municipalities from going beyond those minimum standards. The municipalities within the Willow Creek Subwatershed have in some instances already gone beyond the PPS in identifying their Natural heritage system. Springwater Township for example, protects all wetlands from development not just "provincially significant" wetlands.

The Ministry of Natural Resources defines what is "significant" for wetlands and Areas of Natural and Scientific Interest using established evaluation procedures. For the rest of the natural heritage system, "significant" is defined by the PPS as "*ecologically important in terms of features, functions, representation or amount, and contributing to the quality and diversity of and identifiable geographic area or natural heritage system".*[6]

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3 "Provincial Policy Statement". Government of Ontario, Queen's Printer 1997, Page 8

4 "The Natural Heritage of Southern Ontario's Settled Landscapes", Riley and Mohr, OMNR 1994, page 32

5 "Natural Heritage Reference Manual," OMNR. June 1999, section 3.1, page 35

6 "Provincial Policy Statement". Government of Ontario, Queen's Printer 1997, Page 18

We started the process of mapping significant features of the Willow Creek Subwatershed by integrating all existing natural heritage information such as the "Greenlands" studies from Simcoe County, Oro-Medonte and Springwater Townships and the City of Barrie's planning documents (**Map 4)**.

Supplemental information such as the forest information from OBM mapping, and digital colour infrared air photos (1998) interpretation was used along with field investigations in the spring and summer of 2001, to identify our "proposed additions to the natural heritage system"**.**

In order to clearly identify the most sensitive areas, we identified the "no development or site alteration" areas. They are the wetlands and flood plain lands that are subject to the most restrictive designations within municipal official plans. We added the "class 4-7" wetlands in Oro-Medonte Township. The other municipalities already placed these wetlands in their most restrictive designation.

The criteria for identifying our "proposed additions to the natural heritage system" are those suggested by the province in MNR's Natural *Heritage Reference Manual* and are outlined in **Appendix A**.

The Willow Creek Natural Heritage System includes the following "significant" natural features and areas:

- Areas of Natural and Scientific Interest (ANSIs) – These are areas of land and water containing natural landscapes or features that have been identified as having life science or earth science values related to protection, scientific study or education. The provincially significant life sciences ANSI of Minesing Swamp as well as part of the regionally significant Copeland Forest Resource Management Area and a small portion of Martin Farm South are included within the natural heritage system.

- Fish Habitats – These areas are the spawning grounds, nursery, rearing, food supply and migration areas on which fish depend directly or indirectly in order to carry out their life processes. The Willow Creek and Little Lake have been identified as primarily a warmwater fishery, with some cool water habitat west of Midhurst supporting brown trout. Matheson Creek provides cold and cool water habitats. To protect this fishery, a **minimum of 30 metres** on either side of the stream and its tributaries has been identified as part of the natural heritage system. This area of self-sustaining natural vegetation is particularly important in landscapes where the stream is not already part of a wetland, forest, or larger forested valley lands.

- Groundwater Recharge/Discharge Areas – Known sensitive ground water recharge and discharge areas were included in the natural heritage system since they maintain surface and groundwater quality and quantity. Many of these areas

are associated with headwater wetlands and stream corridors. As additional groundwater studies are undertaken, any new information concerning sensitive groundwater areas will be incorporated into this plan.

- Significant Portions of the Habitat of Endangered and Threatened Species – Endangered species "*means any native species, as listed in the regulations under the, that is at risk of extinction throughout all or a significant portion of its Ontario range if the limiting factors are not reversed*".[7] It is our understanding that American Ginseng (listed as an endangered species by the National Committee on the Status of Endangered Wildlife in Canada) occurs in the Midhurst /Snow Valley area.

  "*Threatened species means any native species that is at risk of becoming endangered throughout all or a significant portion of its Ontario range if the limiting factors are not reversed*"[8] The Eastern Massasauga Rattlesnake, sited in Minesing Swamp, is the only threatened species we are aware of in the subwatershed.

  "Vulnerable" species are indigenous species of fauna and flora that are particularly at risk because of low or declining numbers and need to be closely monitored. Three vulnerable species (Cerulean Warbler and Spotted Turtle found in the Minesing swamp and a Red-Shouldered Hawk spotted in he vicinity of Little Lake) have been documented within the subwatershed.

  Six rare plant species have been identified (all but one in Minesing Swamp) including, Ram's-head Lady's-slippers; Beaked Spike-rush; Eastern Prairie White-fringed Orchid; Hackberry Emperor; Marsh Valerian; Houghton's Umbrella-sedge; and one bird species, the Tufted Titmouse seen within the subwatershed in Oro-Medonte Township.

  Protection of the species found within Minesing Swamp, has been ensured by securement of a large portion of the swamp as public lands, municipal planning policy, and a keen public awareness of the significance of this internationally recognized wetland. The plan encourages the protection of all species at risk, as they are an important component of the Natural heritage system.

- Wetlands – All wetlands are very important since they help to maintain and improve our water quality through trapping of sediments, retaining nutrients, contaminants and removing bacteria. Wetlands also moderate water temperature, maintain base flows, attenuate floods, store carbon, provide important groundwater recharge/discharge functions, control erosion and provide recreational and economic benefits.

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7 "Provincial Policy Statement". Government of Ontario, Queen's Printer 1997, Page 14
8 Provincial Policy Statement". Government of Ontario, Queen's Printer 1997, Page 18

As a result of their importance to our ecosystem, all known wetlands are included in the natural heritage system.
In order to protect them it is necessary to have all wetlands identified. Therefore we are proposing that the Ministry of Natural Resources map all unevaluated wetlands. The next step would be to evaluate these wetlands. However, this may not be necessary for many municipalities as they are protecting all wetlands not just provincially significant wetlands

- Wildlife Habitats – These are areas where plants, animals, and other organisms live, and find adequate amounts of food, water, shelter, and space needed to sustain their populations.

- Woodlands – These are treed areas, woodlots or forested areas that provide environmental and economic benefits such as erosion prevention, water retention, wildlife habitats, recreation and the sustainable harvest of woodland products. Riley points out in Southern Ontario's Settled Landscapes that "*Across Southern Ontario, woodland losses have exceeded those of almost and other major ecosystem"*. [9]

  Significant woodlands were identified that generally are larger than 40ha. (30ha. in Springwater Township from their Official Plan) and/or also provide additional important ecological functions such as protecting headwater areas and groundwater recharge areas. They contain diverse community types, ages, and composition providing important functions such as wildlife habitats. They are often connected to each other (e.g.; between Minesing Swamp and Copeland Forest and the Oro Moraine) via the linkage of Matheson Creek and the Willow Creek. They may also be contiguous to other significant natural heritage features such as wetlands.

- Valley lands – These are the natural areas that occur in the valley or other landform depressions that have water flowing through or standing for some period of the year. Valley lands associated with Matheson and Willow Creeks represent the skeleton or framework for the Willow Creek Natural Heritage System. They provide critical linkages and contain important fish and wildlife habitats. They act as both corridors and core areas for many different species.
  In some cases, the areas identified represent the actual defined valley, in other cases with no defined valley or wider riparian vegetation, a strip 30 m on either side of the stream has been identified.

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2.1.2 Restoration and Rehabilitation

Map 5 identifies priority natural areas where restoration such as tree planting and wetland rehabilitation would enhance and improve the natural heritage system. This

9 "The Natural Heritage of Southern Ontario's Settled Landscapes", Riley and Mohr, MNR, 1994 page 27.

includes linkage areas as well as priority riparian sites along the watercourses that need planting to establish the minimum of 30 m natural vegetation along both sides of the stream.

The un-vegetated headwater areas would represent the highest priority for restoration. In addition, since previous studies (Rush 1996) have identified significant erosion sites in Midhurst between St Vincent Street and Highway 27, this area should also be considered a priority for restoration and re-vegetation)[10]

Upland areas where plantings would eventually fill in open spaces making for larger interior forest blocks have been noted. This would improve the wild life habitats, for those species requiring larger interior forest patches.

In order to improve our surface and ground water quality, reduce flooding, and provide wildlife habitats, the study proposes not only to protect all existing wetlands, but also to encourage the restoration of wetlands that have been drained or impaired. Known potential wetland restoration areas have been identified on **Map 5**. However, it must be emphasized that because of the value of wetlands, the restoration of any wetland area would constitute a top priority regardless of whether or not it has not been identified on **Map 5**.

Naturally any rehabilitation or restoration work could only proceed with the landowner's permission and often through partnerships with interested groups such as youth groups (scouts and guides), and conservation organizations such as naturalist clubs Ducks Unlimited etc.

2.1.3 Natural Heritage System Recommendations

The Willow Creek Subwatershed Plan recommendations are outlined in the body of this report (numbered consecutively). They address the issues as they are reviewed and discussed in the body of this plan.
Please see **Table 4.1** in Section 4.0 for a summary of all recommendations and implementation requirements.

Recommendation #1
Municipalities should incorporate policies in their official plan indicating that "no development or site alteration" shall be permitted within all evaluated wetlands. All wetlands (as defined by the province) should be evaluated.

NVCA will implement a similar policy protecting all wetlands through its planning/permitting processes. The value and contribution of all wetlands to our natural heritage system has been well documented. This has been recognized by Springwater Township in their official plan as it protects all evaluated wetlands from development. The

10 Willow Creek Erosion Sites, Nadine Rush, NVCA, 1996.

Plan is recommending that the City of Barrie and Oro-Medonte Township similarly protect all evaluated wetlands in their official plan.

Recommendation #2:
The proposed additions to Willow Creek Natural Heritage System, as identified in Map 4 should be incorporated into municipal planning documents. Policies to protect the system and its functions from incompatible land use and development should also be included.

The subwatershed study has provided a more detailed examination of the significant natural heritage features. As a result there are numerous "proposed additions to the natural heritage system" that have been identified based on the criteria outlined by the province. It is very important that the municipalities, including the County, incorporate these additions to the natural heritage system into their planning documents with appropriate protection polices.

It must be emphasized that the "proposed additions to the Natural Heritage System" will not affect landowners existing uses, or resource management opportunities for their property.

If a landowner is within our proposed additions to the natural heritage system, they can continue to manage and enjoy these lands as they do now.
Landowners would only be affected if they applied to their municipality for a change in land use, such as for a subdivision development. If the proposed additions to the natural heritage system were incorporated into the municipality's official plan, then the appropriate official plan policies would apply. This may include the requirement for an environmental impact study identifying the natural features and functions, the possible impacts from the proposal on these functions and how the impacts will be mitigated.

Eliminating the potential impacts from development on our natural heritage system is a common objective of landowners, developers, municipalities, approval authorities and review agencies.

The additions to the natural heritage system identified in this plan represents a reconnaissance level study that is for the most part, a "red flag" or an "early environmental warning system". It locates the significant natural areas where additional environmental impact studies (EISs) should be undertaken to assist the municipalities in the planning and decision making process. The EIS provides councils with the appropriate environmental information upon which to make informed decisions.

Recommendation #3:
Landowners, environmental organizations and interested agencies should consider the restoration and rehabilitation areas identified in Map 5 when identifying projects. Rehabilitation of headwater streams and wetlands should be a priority along with re-vegetation of the Willow Creek riparian areas in Midhurst between St Vincent Street and Highway 27 to reduce the effects of erosion.

The landowners and partner organizations may choose their rehabilitation projects from a variety of the identified riparian, wetland or upland sites. Selecting projects from these priority areas will provide the greatest benefits to the aquatic or terrestrial ecosystems.

It must be emphasized that no restoration program can proceed without the permission and full cooperation of the landowners.

2.2 Aquatic Ecosystems

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The aquatic ecosystem is interconnected to, and an integral part of, the natural heritage system. Stream riparian areas have been identified on **Map 4** as a significant part of the natural heritage system. **Map 5** indicates those riparian areas that need rehabilitation, as they do not have adequate vegetation cover.
The Plan reviews the current status of the aquatic ecosystem, identifies the objectives, provides targets (where possible) and makes recommendations to help ensure they are achieved.

2.2.1 Water Quality and Stream Health

Commencing in October 2000, NVCA's Watershed Health Monitoring Department initiated a stream health or biological assessment of Willow Creek for the subwatershed study (see **Appendix B** for more details).

Stream health is a measure of how closely a stream's habitat, water quality and living community match its historical potential. We are able to evaluate a site's potential by comparing it to other streams (reference sites) that share similar physiographic and historic attributes such as soil types, substrate, gradient, temperature, and groundwaters flows, but are still in a "pristine" (unimpaired) condition.

Biological monitoring was borne out of the concept that the community of living things at a site tells a lot about habitat and water quality. In a biological sense, unimpaired streams are those in which living communities are largely shaped by natural features. Impaired streams communities are a manifestation of human influences. Benthic (bottom dwelling) invertebrates are particularly useful indicators and have been used in many studies.

- To establish baseline water quality conditions prior to development or other land use change. Various community indicators and analytical approaches can then be used to detect changes over time to habitat and water quality

- As surrogate indicators and to provide early warning of potential impacts to the fish community
- As diagnostic indicators to determine the magnitude, range of effect and cause of impairments to the aquatic system

Our approach to biological monitoring uses the BioMAP (Biological Monitoring and Assessment Program) protocol. BioMAP enables a stream health prognosis to be made based on an assessment of the aquatic invertebrate community present at a site.

To augment the biological surveys, water chemistry, temperature, hydrometric and bacteriological sampling was undertaken throughout the ice-free period of 2001.

MOE also carried out a water quality study of Little Lake during the summer of 2001.

A complete treatment of water chemistry information is provided in Appendix B (and linked spreadsheet files in the website version).

The priorities of the stream health monitoring aspect of the study were to:

- Classify the biological conditions of stream reaches as either “impaired”, “unimpaired”, or “below potential” (see Appendix B for definitions) to facilitate prioritization of stream reaches for rehabilitation and protection efforts
- Characterize water chemistry and pollutant load trends throughout the basin to guide restoration works, assist in the development of a nutrient budget, determine the frequency of pollutant exceedences of the “Provincial Water Quality Objectives” (Ontario Ministry of Environment, February, 1999) and compare Phosphorus loads against the assimilative capacity of the system
- Classify the thermal regime of Willow and Matheson Creeks at the reach level and generate an understanding of base flows at nodes in the system that are important from a modeling and management perspective

The recommendations to protect the aquatic ecosystem and stream health that come from the results of the stream health monitoring in **Appendix B** are outlined in section 2.2.3.

2.2.2 Fisheries Resources

The Willow Creek Subwatershed supports both warmwater and coldwater fish communities as described below.

<u>Warmwater Fish Habitats</u>

Little Lake and the adjacent reaches of Willow Creek (including Willow Creek between St. Vincent St. and Little Lake; plus between Little Lake and Simcoe Road 93, contain the following species:

- largemouth bass

- walleye (these fish spawn in the vicinity of Simcoe Road 93)
- northern pike
- black crappie

Willow Creek between the Nottawasaga River and Simcoe Road 28 holds:
- northern pike

Willow Creek Upstream from Simcoe Road 93 including tributaries contains:
- warmwater baitfish community
- northern pike

Please note that there has been some indication of the presence of coldwater habitat reaches upstream from Hwy. 11. There may still be the potential to provide coldwater habitat conditions in some locations.

Swaley Creek Drain (Muskrat Creek) between the Nottawasaga River and the Vespra Valley Rd. contains:
- northern pike (provides spawning and nursery habitat)

The Swaley Drain north of Highway 26 supports:
- warmwater baitfish

<u>Warmwater Ecosystem Objectives and Targets</u>
The ecosystem objective for the warmwater habitats is a diverse, stable and productive warmwater lake and stream ecosystem, linked to the cool/cold water habitats within the system.

The management standards and targets for the warmwater habitats should not compromise ecosystem targets identified for any of the more sensitive cool/cold water habitats of Willow Creek.

The following are the ecosystem targets for the above warmwater habitats of the Willow Creek system.

1. Summer stream temperatures should be lowered wherever possible (e.g. through planting of riparian vegetation).
2. Base flow should be maximized (i.e. limit evaporation and maximize adjacent infiltration).
3. Water quality should be enhanced and suspended solids reduced through nutrient management, sediment/erosion controls and rehabilitation of riparian vegetation.
4. Dissolved oxygen concentrations should be at saturation.
5. Water taking must ensure maintenance of the aquatic ecosystem and biotic communities on a sustainable basis.

In general, natural channel forms and functions should be maintained. Impaired and

degraded streams should be enhanced through the implementation of Best Management Practices (BMPs) for riparian vegetation and stream rehabilitation.

Coldwater Fish Habitats

Willow Creek between Simcoe Road 28 and St. Vincent Street holds resident brown trout and mottled sculpin.

Matheson Creek and the following tributaries contain native brook trout, resident brown trout and mottled sculpin:

1. Aunt Maggie's Creek
2. Tributary crossing Gill Road in Lot 3,Con.3 former Vespra Twp.
3. Tributary entering Matheson Creek in Lot 2, Con. 3, former Vespra Twp.
4. Tributary entering Matheson Creek in Lot 41, Con. 2, former Flos Twp.
5. Tributary entering Matheson Creek in Lot 43, Con. 2, former Flos Twp.
6. Tributary entering Matheson Creek in Lot 44, Con. 2, former Flos Twp.
7. Various other tributaries

Black Creek extending upstream from Carson Road and the following tributaries contain native brook trout:

1. Mink Creek
2. Keast Creek
3. Tributary flowing in east ditch of main entrance road into Snow Valley Resort
4. Tributary crossing Snow Valley Road at Lot 13, Con7 former Vespra Twp. (resident brook trout observed in on-line pond on south side of Snow Valley Road)
5. Tributary crossing in Lot 11 Con. 7 former Vespra Twp. flowing out of Springwater Prov. Park.
6. Various other tributaries

Cool water Fish Habitats

Swaley Creek Municipal Drain extending upstream from the 9th Line former Vespra Twp. (includes the eastern branch of the Swaley Drain known as the Binnie Drain) contains:

- mottled sculpin

Cold/Cool water Ecosystem Objectives and targets

The Ecosystem objective for the cool/cold water habitats of the Willow and Matheson Creek is a diverse, stable and productive cold/cool water stream ecosystem linked to warmwater habitat in the system including Little Lake.

The following targets or standards, contribute to the cold/cool water stream ecosystem.

1. Four p.m. stream temperatures should be less than 22 °C on a standardized sample day where the maximum air temperature is 30 °C 11
2. Base flow should be maximized through protection of existing recharge zones on the Oro Moraine and Snow Valley area (and elsewhere) and maximizing infiltration during the development process
3. Water quality should be enhanced, and suspended solids reduced through nutrient management, sediment/erosion controls and rehabilitation of riparian vegetation.
4. Dissolved oxygen concentrations should be at saturation.
5. Water taking must ensure maintenance of the aquatic ecosystem and biotic communities on a sustainable basis.

In general, natural channel forms and functions should be maintained. Impaired and degraded streams should be enhanced through the implementation of Best Management Practices (BMPs) for riparian vegetation and stream rehabilitation.

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2.2.3 Aquatic Ecosystem Recommendations

The following recommendations are needed to meet the aquatic ecosystem objective of protecting water quality, the fisheries resources as outlined above, and address the issues that resulted from the Stream Health monitoring report (**Appendix B.)**

Recommendation # 4

No development or site alteration should occur within a minimum of 30m on either side of a natural stream or watercourse, maintaining the natural vegetation. In the case of municipal drains, a minimum 30 m wide vegetated buffer should be established on the side of the drain not accessed for clean out.

Recommendation # 5

Phosphorus data from 2001 suggest that MOE would classify Willow Creek as a "Policy 2" receiver since phosphorus concentrations commonly exceed the provincial water quality objective (PWQO). MOE policy indicates that a remedial strategy for parameters exceeding the PWQO should be developed and that future discharges should not result in further PWQO exceedences (both magnitude and frequency). Matheson Creek appears to be a "Policy 1" receiver for phosphorus and future discharges should ensure that any phosphorus increases are not sufficient to result in PWQO exceedences for that (or any other) parameter.

Remedial strategies should adopt a philosophy of project design that addresses the widest possible range of stream health impairments at a site or over a reach. For example, agricultural projects that reduce manure-contaminated run-off to streams

11 Stoneman and Jones, 1996 DFO/MNR Habitat Management Series.

should be augmented where possible with riparian works to improve shading and in-stream work to improve fish habitat and reduce erosion (where necessary). Projects on private lands may be best achieved through an incentive program such as the one offered through NVCA's "Healthy Waters" grant program (for which Willow/Matheson Creek landowners are eligible under current guidelines)

Recommendation # 6
Establish a long term monitoring program based on biological surveys at 5 sites in the subwatershed to track stream health impacts from land use change.

3.0 WATER MANAGEMENT

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This section provides the technical and engineering water management information for the subwatershed plan. It includes the models for existing and future hydrologic conditions, stormwater management criteria and water balance calculations. Please note that much of the technical data is located in **Appendix D and E.**

3.1 ***Existing Hydrologic Conditions***

Various background information materials were reviewed to establish the existing conditions within the Willow Creek Subwatershed. A site visit was completed on 28 February 2001 and again on 12 June 2001.

3.1.1 Surface Water Drainage

Willow Creek consists of several tributaries and drains a total area of approximately 340 km^2. The most significant tributary of Willow Creek is Matheson Creek, which drains the northwest corner of the Willow Creek Subwatershed. The upper reach of Willow Creek passes through Little Lake prior to its confluence with the Matheson Creek tributary. Near the downstream end of the Subwatershed, Willow Creek empties into the Minesing Swamp prior to joining the Nottawasaga River. The general drainage pattern of the Willow Creek Subwatershed is from northeast to southwest. The Nottawasaga River flows in a northerly direction to Wasaga Beach where it empties into Georgian Bay.

3.1.1.1 Municipal and Tile Drainage Systems

Artificial land drainage comprising of municipal drains and tile drainage systems have been identified using Artificial Drainage System maps prepared by the Ontario Ministry of Agriculture and Food (OMAF). These drains have been included as part of the overall watercourse network and can be seen in **Map 1**.

3.1.1.2 Subwatershed Discretization

The Willow Creek Subwatershed was discretized (divided) into individual catchments and coded in the ISWMS model. Catchments were delineated using available background information as well as Ontario Base Maps (OBMs) and Digital Elevation Mapping (DEM). Approximately 20 catchments were delineated following the general level of discretization established in the 1988 MacLaren Plansearch report (see **Map 6**).

3.1.1.3 Baseflows

Baseflow is recognized as an important contributor to the biological habitat quality and to the structure of aquatic ecosystems identified in Willow Creek. Groundwater discharge is crucial to the maintenance of baseflow and to buffering thermal changes that could otherwise impact aquatic habitat. In addition, high baseflow conditions dilute pollutant concentrations and provide additional wetted area within the stream environment that biota can colonize. Subsequent to colonization, as animals conduct their regular life cycle processes, these additional areas contribute to assimilative capacity for both phosphorus

and nitrogenous compounds.Stream baseflow measurements were completed by the NVCA as part of the water quality analysis and are presented in **Appendix B**.

3.1.1.4 Streamflows

As part of a separate NVCA flow monitoring study, an ultrasonic flow monitoring device was installed on the bridge across Willow Creek at Simcoe Road 28. Continuous flow depths were logged for the monitoring period between May and October 2001. Due to the nature of the rainfall events encountered throughout the monitoring period, it was not possible to establish a rating curve over the full range of depths recorded and the range and frequency of events was limited. In addition to gathering general background flow information, it was intended that flows from this separate study could be used to provide data to calibrate and verify the hydrologic computer model. Unfortunately, this was not possible. Should the monitoring program be continued next year, it may be desirable to fully establish the rating curve and to obtain an adequate number of suitable rainfall/flow events to for calibration and verification.

Using HYDAT streamflow data available from the Water Survey of Canada, the monthly minimum, maximum and mean flows were calculated based on historical flow data from the flow monitoring station located near Midhurst. As shown in **Figures 3.1a and 3.1b**, the mean monthly streamflows for the period on record (1973 to 1998) range between 0.24 m^3/s and 3.53 m^3/s. Based on this analysis, the highest monthly mean flow occurs in April, while the lowest monthly mean flow occurs in August. The maximum and minimum monthly mean flows between 1973 and 1998 were 7.63 m3/s (April 1982) and 0.051 m3/s (August 1989).

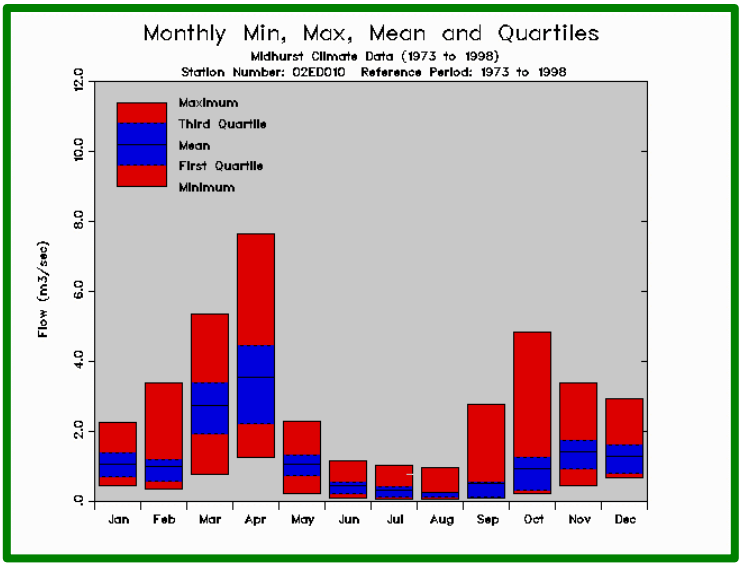
3.1.2 Hydrologic Modelling

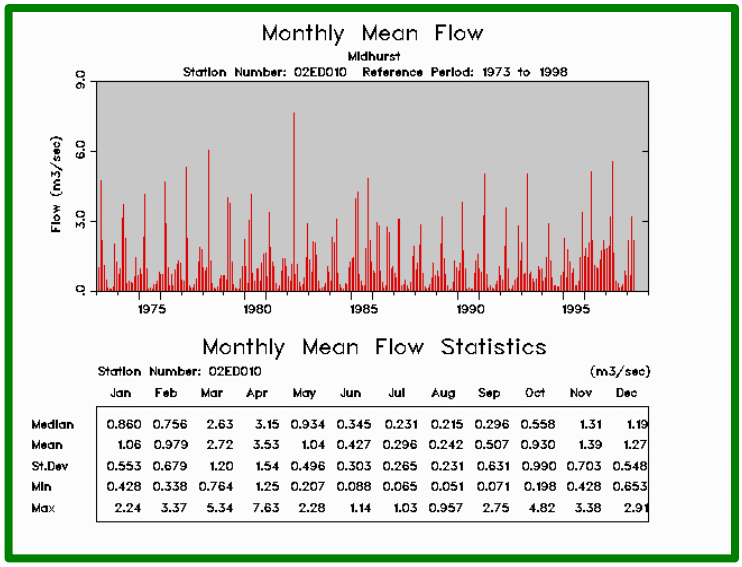
Streamflows reflect the time variation in discharges and are characterized by their frequency, duration and magnitude. Streamflows include peak flows generated from surface runoff caused by rainfall and snowmelt events, as well as groundwater discharges that appear as baseflow.

The combination of streamflow characteristics (i.e. frequency, magnitude and duration) controls many of the natural and ecological functions that occur in the creeks and streams present in the Willow Creek Subwatershed. Low streamflows (i.e. baseflows) sustain aquatic and terrestrial ecosystems in periods of no rain or runoff. Moderate streamflows with a return period of ½ to 1½ years contribute to the natural evolution of channel shape and form through erosion. Seasonal flooding such as that resulting from spring freshets provides nutrients and sediments to wetlands and floodplains and provides spawning opportunities for a number of fish species. High streamflows resulting from snowmelt events and extreme rainfall events such as the Timmins Storm can lead to natural hazards and a risk to human life and property.

Development within the Willow Creek Subwatershed will result in changes to peak flows, runoff frequency and duration, and response times to a given rainfall event. Development

will also result in changes to the existing water balance component quantities such as infiltration and runoff. In order to assess the extent of these changes, it is necessary to first establish the existing conditions of the subwatershed.





Monthly Mean Flow Statistics

Station Number: 02ED010 (m3/sec)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Median	0.860	0.756	2.63	3.15	0.934	0.345	0.231	0.215	0.296	0.558	1.31	1.19
Mean	1.06	0.979	2.72	3.53	1.04	0.427	0.296	0.242	0.507	0.930	1.39	1.27
St.Dev	0.553	0.679	1.20	1.54	0.496	0.303	0.265	0.231	0.631	0.990	0.703	0.548
Min	0.428	0.338	0.764	1.25	0.207	0.088	0.065	0.051	0.071	0.198	0.428	0.653
Max	2.24	3.37	5.34	7.63	2.28	1.14	1.03	0.957	2.75	4.82	3.38	2.91

Figure 3.1a (left) and 3.1b (right): (a) monthly minimum, maximum and mean streamflows for Midhurst station from Water Survey of Canada (HYDAT) for period from 1973 to 1998, and (b) monthly mean flow statistics for Midhurst station.

3.1.2.1 Peak Flow Modelling

For the study area, the **I**ntegrated **S**tormwater and **W**atershed **M**anagement **S**ystem (**ISWMS**®) by Greenland, was utilized to develop the hydrologic model reflective of existing conditions. The initial phase (i.e. flood forecasting) of the new software system was developed for the Nottawasaga Valley Conservation Authority, and combines the usefulness of both unit hydrograph runoff generation methods and US EPA's SWMM based models. This study will apply the unit hydrograph runoff generation methods, typically used in similar subwatershed planning studies across Ontario, to model the hydrology of the Willow Creek Subwatershed. Additional information regarding the hydrologic modelling methodology and technical details is provided in **Appendix D**.

Model Calibration

To improve the accuracy of our hydrologic model we initially intended to calibrate the model using precipitation and streamflow data collected during the study period. Unfortunately suitable data was not collected and the model was therefore not calibrated.

Hydrologic Model Results – Existing Conditions

The results of the single event hydrological modeling for a range of return period events and flow nodes are summarized in **Table 3.1**. In addition, **Figure 3.2** illustrates typical design storm event hydrographs at node 1019 located at the bottom of the Willow Creek Subwatershed just prior to the confluence with the Nottawasaga River. Flow node locations for the ISWMS model are identified in **Map 6**.

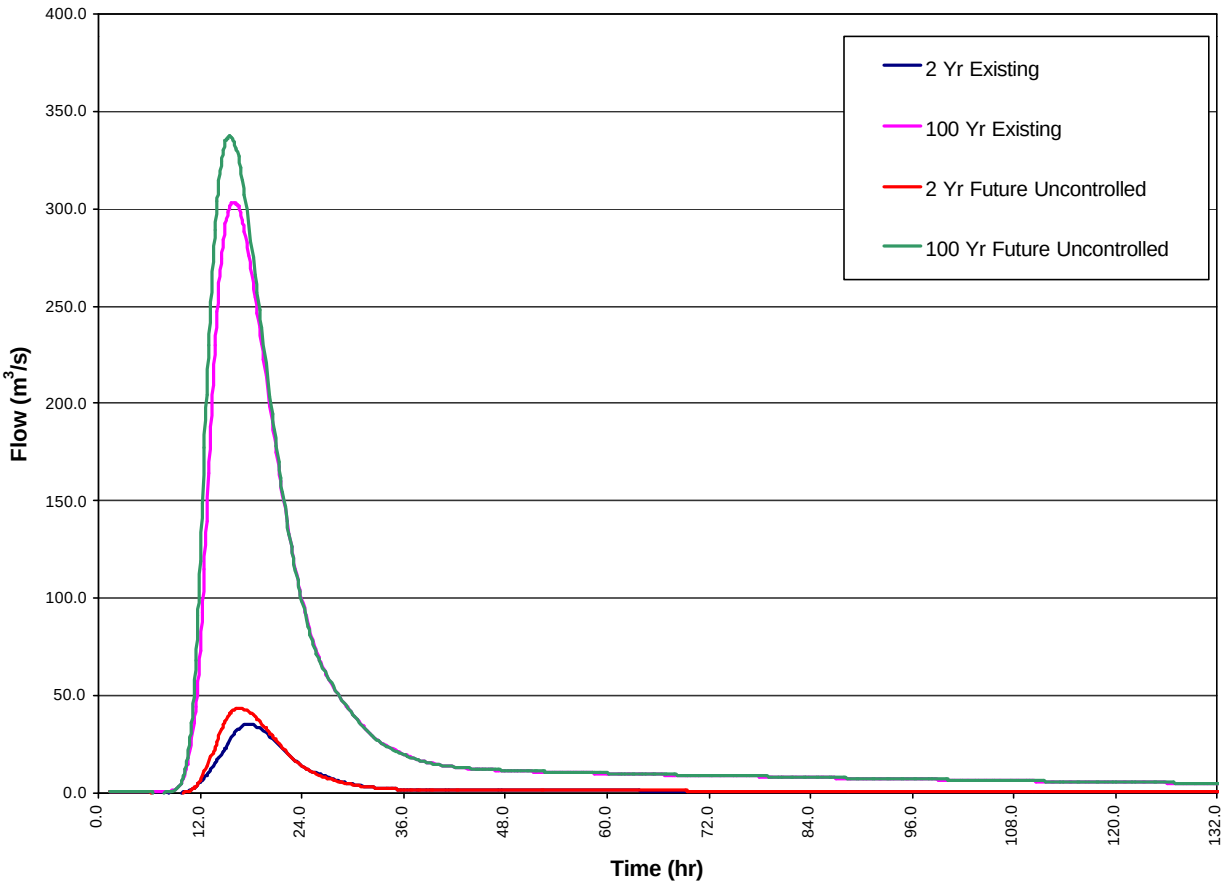
3.1.2.2 Water Balance Modelling

Water balance modelling was completed for both existing and future conditions within the Willow Creek Subwatershed. A Water balance is a form of hydrologic accounting whereby the distribution of water over a specified period is quantified for the various components of the hydrologic cycle. It is anticipated that the results of the water balance will be helpful in developing future water allocation strategies, however, this is not within the scope of this study. A sketch illustrating the different processes associated with the hydrologic cycle is provided in **Figure 3.3**. The primary components of the overall water balance presented in this plan include rain, snowmelt, evapotranspiration, runoff, baseflow, and deep groundwater storage. Additional information regarding the water balance methodology and technical details is provided in **Appendix E**.

Table 3.1
Summary of Peak Flows for Existing and Future Uncontrolled Conditions

Flow Node	Drainage Area km^2	Condition	2 Year (m^3/s)	5 Year (m^3/s)	10 Year (m^3/s)	25 Year (m^3/s)	50 Year (m^3/s)	100 Year (m^3/s)	Regional (m^3/s)	Timmins Storm Reduction Factor
1000	17.9	Existing	4.6	10.7	15.6	22.4	27.9	33.7	63.9	100
		Future	4.6	10.7	15.6	22.4	27.9	33.7	63.9	
1001	21.6	Existing	5.2	12.5	18.2	26.8	32.8	39.8	76.7	100
		Future	5.4	13.0	18.8	27.2	33.8	40.9	77.3	
1002	25.7	Existing	5.0	12.7	18.8	27.7	34.8	42.4	83.0	100
		Future	5.1	12.7	18.8	27.7	34.8	42.4	83.0	
1003	25.5	Existing	6.0	14.7	21.5	31.8	39.0	47.1	90.7	100
		Future	6.5	15.6	22.6	32.6	40.6	49.0	92.1	
1004	51.2	Existing	10.9	27.2	40.0	59.2	73.4	89.2	158.0	94
		Future	11.4	28.1	41.2	60.1	75.2	91.1	159.4	
1005	64.9	Existing	14.1	35.1	51.5	75.9	94.1	114.3	201.8	94
		Future	14.7	36.0	52.7	76.7	96.0	116.3	203.2	
1006	75.1	Existing	16.0	39.7	58.4	86.1	106.9	129.9	230.8	94
		Future	16.8	41.2	60.4	87.9	109.9	133.3	234.2	
1007	95.5	Existing	21.8	53.1	77.5	113.3	140.4	170.1	281.2	90
		Future	22.7	54.6	79.5	115.1	143.4	173.5	284.2	
1008	98.9	Existing	22.3	54.4	79.5	116.3	144.2	174.8	289.5	90
		Future	23.3	56.2	81.8	118.5	147.6	178.7	293.2	
1009	109.7	Existing	1.2	2.8	4.9	7.8	10.2	12.7	103.5	87
		Future	1.4	3.2	5.1	8.2	10.6	13.1	108.3	
1010	63.5	Existing	7.0	19.4	29.4	44.1	56.1	69.1	136.9	94
		Future	7.8	20.9	31.5	47.0	59.6	73.2	143.3	
1011	15.5	Existing	2.3	6.1	9.2	13.7	17.3	21.2	43.8	100
		Future	2.3	6.1	9.2	13.7	17.3	21.3	43.8	
1012	79.1	Existing	9.2	25.2	38.2	57.3	72.8	89.5	163.6	90
		Future	10.0	26.8	40.3	60.1	76.2	93.6	169.8	
1013	94.6	Existing	11.9	32.2	48.2	72.6	92.0	113.0	203.9	90
		Future	13.7	35.7	53.2	78.8	99.5	121.7	218.8	
1014	229.2	Existing	15.2	40.1	60.2	89.7	113.6	139.4	221.9	82
		Future	19.6	48.5	71.5	104.8	131.5	160.1	248.3	
1015	246.6	Existing	18.7	48.7	72.7	107.9	136.3	166.9	262.4	82
		Future	23.5	58.0	85.2	124.5	156.0	189.6	291.4	
1016	30.0	Existing	5.2	13.0	19.2	28.2	35.4	43.1	88.3	100
		Future	6.0	14.5	21.2	30.8	38.4	46.6	93.4	
1017	276.5	Existing	23.7	61.4	91.6	135.7	171.1	209.4	303.3	79
		Future	29.3	72.2	106.0	154.8	193.8	235.5	339.3	
1018	11.9	Existing	2.9	7.2	10.7	15.7	19.7	24.0	43.8	100
		Future	3.0	7.5	11.0	16.2	20.3	24.7	44.7	
1019	337.8	Existing	35.3	90.9	134.7	198.2	249.1	303.6	439.9	79
		Future	43.4	105.5	153.8	222.9	278.5	337.5	481.0	

Figure 3.2
Existing and Future Uncontrolled Flows
Node 1019



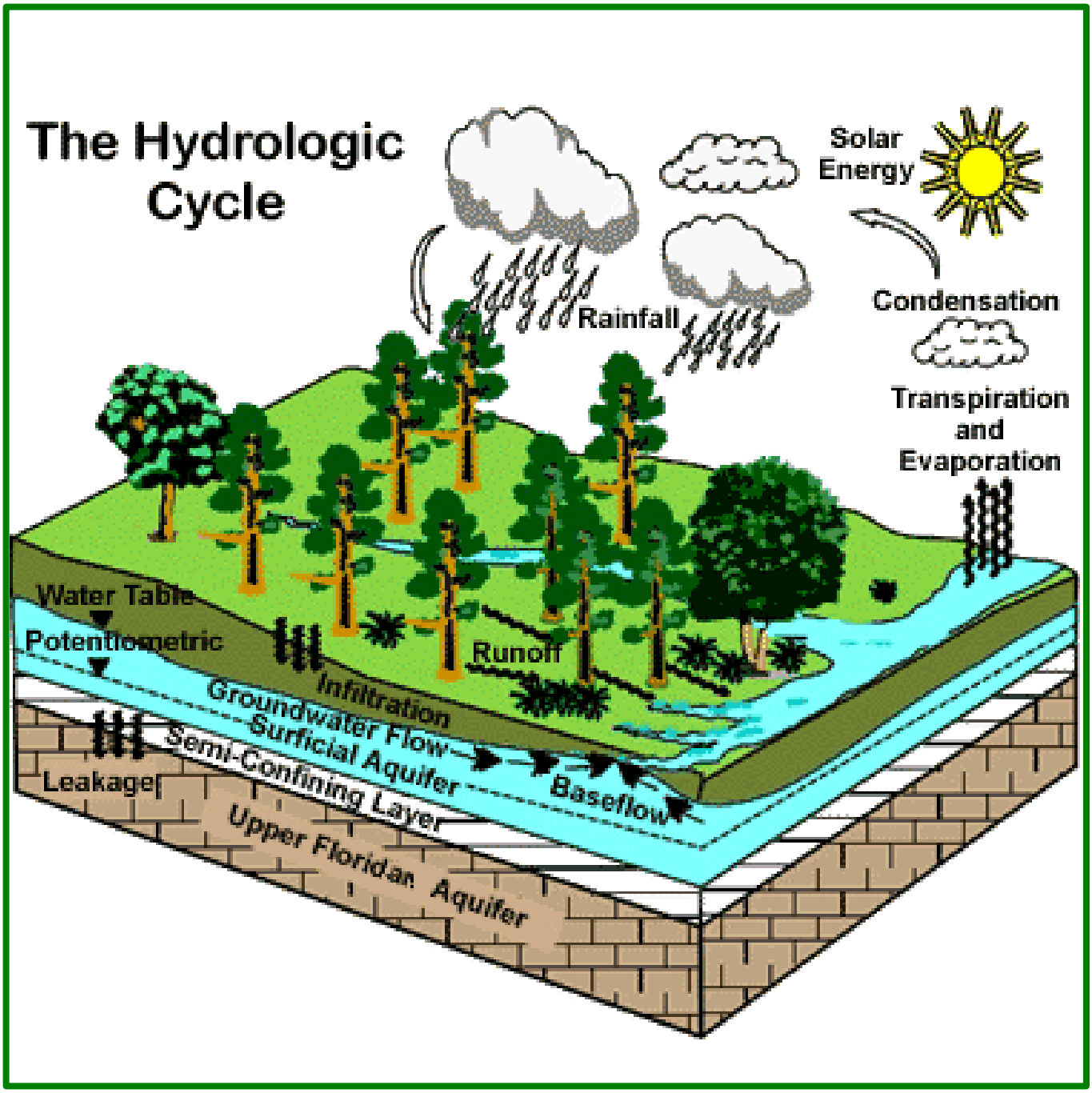


Figure 3.3: Processes associated with the hydrologic cycle.

Water Balance Results - Existing conditions

The results of the annual water balance analysis for existing conditions including pervious and impervious areas for the entire Willow Creek Subwatershed are presented in **Table 3.2** and **Figure 3.4.** Based on a total average annual precipitation of 926 mm, approximately 576.6 mm is lost to evapotranspiration. In addition, approximately 181.5 mm and 167.9 mm comprises of runoff and infiltration respectively. Approximately 114.7 mm of the infiltration component accounts for baseflow while approximately 53.2 mm of the infiltration component accounts for deep groundwater storage. Using the revised catchment areas based on the DEM, along with GIS techniques for obtaining area-weighted parameter values, the water balance was further discretized for all individual catchments within the Subwatershed. Annual water balance calculation sheets for all identified catchments within the Subwatershed are presented in **Appendix E**. Based on this analysis for existing conditions, **Map 8** depicts the relative infiltration quantities for the Willow Creek Subwatershed.

3.2 Modelling Future Hydrologic Conditions

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Future hydrologic conditions were estimated using the Official Plan land use documents obtained from the City of Barrie and the Townships of Oro-Medonte and Springwater (see **Appendix C**). Based on the revised land use, parameter values for the hydrologic model were revised from existing conditions and future peak flows were predicted. The future water balance model was also calculated based on revised land use to determine the potential impacts of future development on groundwater recharge, runoff and baseflow within the Willow Creek Subwatershed.

Peak Flows

As shown in **Table 3.1** and **Figure 3.2**, future development (based on the Official Plan) will increase peak flows in some areas of the Subwatershed. The net result, for example, of the proposed development on the peak flow for the 2-yr and 100-yr design storm at the bottom of the Subwatershed (i.e. Node 1019) is an increase of 23% and 9%, respectively.

Water Balance

The results of the annual water balance analysis for future conditions including pervious and impervious areas within the entire Subwatershed are presented in **Table 3.2** and **Figure 3.4.** Based on a total average annual precipitation of 926 mm, approximately 561.4 mm is lost to evapotranspiration. In addition, approximately 202.7 mm and 161.9 mm comprises of runoff and infiltration respectively. Approximately 110.6 mm of the infiltration component accounts for baseflow while approximately 51.3 mm of the infiltration component accounts for deep groundwater storage. Relative to existing conditions, the future proposed development will result in a reduction in actual evapotranspiration (-2.6%), an increase in runoff volume (+11.7%), a decrease in deep

Table 3.2
Existing and Future Water Balance Quantities for Willow Creek Subwatershed

Water Balance Component	**Condition**	**Depth (mm)**	**Volume (m^3)**	**Percent (%)**
Inputs				
Rainfall	Existing	717.0	242,274,000	77.4
	Future	717.0	242,274,000	77.4
Snowmelt	Existing	209.0	70,620,900	22.6
	Future	209.0	70,620,900	22.6
TOTAL	Existing	926.0	312,895,000	100.0
	Future	926.0	312,895,000	100.0
Outputs				
Actual ET	Existing	576.6	194,817,000	62.3
	Future	561.4	189,685,000	60.7
Runoff	Existing	181.5	61,329,900	19.6
	Future	202.7	68,529,400	21.9
DGWS	Existing	53.2	17,977,700	5.7
	Future	51.3	17,322,300	5.5
Baseflow	Existing	114.7	38,770,100	12.4
	Future	110.6	37,357,900	11.9
TOTAL	Existing	926.0	312,895,000	100.0
	Future	926.0	312,895,000	100.0

Figure 3.4: Existing and Future Water Balance Results

Annual Water Balance
Willow Creek Subwatershed
Total Watershed

EXISTING CONDITIONS

Calculated Water Balance Components
Urban Lawns/Shallow Rooted Crops (spinach, beans, beets, carrots)
Moderately Rooted Crops (corn and cereal grains)
Pasture and Shrubs
Mature Forests

Calibrated Infiltration Factor	Topography	Soils	Cover	Total
Annual	0.091	0.312	0.134	0.536

HYDAT Data (mm)	Streamflow	Baseflow	Runoff
Annual	297.7	126.8	170.9

Component Area (ha)	Weighted WHC (mm)	BF Factor
30163.6	192	0.683

Rain (mm)	Snowmelt (mm)	Potential ET (mm)	Actual ET (mm)	Surplus (mm)	Infiltration (mm)	Streamflow (mm)	Baseflow (mm)	Runoff (mm)	DGWS (mm)
717.0	209.0	593.0	579.5	346.5	185.9	287.6	127.0	160.6	58.9
Component Volume (m^3)									
216,272,846	63,041,876	178,870,011	174,783,831	104,530,890	56,080,093	86,753,501	38,302,704	48,450,797	17,777,390

Calculated Water Balance Components
Swamp/Fen/Marsh

Component Area (ha)	AET as Percent of PET	INF as Percent of Surplus	BF as Percent of Surplus	DGWS as % of Surplus
3018.5	100.0	0.0	0.0	0.0

Rain (mm)	Snowmelt (mm)	Potential ET (mm)	Actual ET (mm)	Surplus (mm)	Infiltration (mm)	Streamflow (mm)	Baseflow (mm)	Runoff (mm)	DGWS (mm)
717.0	209.0	593.0	593.0	333.0	0.0	333.0	0.0	333.0	0.0
Component Volume (m^3)									
21,642,977	6,308,762	17,899,980	17,899,980	10,051,759	0	10,051,759	0	10,051,759	0

Calculated Water Balance Components
Open Water

Component Area (ha)	AET as Percent of PET	INF as Percent of Surplus	BF as Percent of Surplus	DGWS as % of Surplus
237.6	100.0	0.0	0.0	0.0

Rain (mm)	Snowmelt (mm)	Potential ET (mm)	Actual ET (mm)	Surplus (mm)	Infiltration (mm)	Streamflow (mm)	Baseflow (mm)	Runoff (mm)	DGWS (mm)
717.0	209.0	593.0	593.0	333.0	0.0	333.0	0.0	333.0	0.0
Component Volume (m^3)									
1,703,384	496,523	1,408,796	1,408,796	791,111	0	791,111	0	791,111	0

Calculated Water Balance Components
Impervious Urban Area

Component Area (ha)	AET as Percent of RAIN+MELT	INF as Percent of Surplus	BF as Percent of Surplus	DGWS as % of Surplus
164.2	10.0	0.0	0.0	0.0

Rain (mm)	Snowmelt (mm)	Potential ET (mm)	Actual ET (mm)	Surplus (mm)	Infiltration (mm)	Streamflow (mm)	Baseflow (mm)	Runoff (mm)	DGWS (mm)
717.0	209.0	593.0	92.6	833.4	0.0	833.4	0.0	833.4	0.0
Component Volume (m^3)									
1,177,416	343,208	973,790	152,062	1,368,561	0	1,368,561	0	1,368,561	0

Calculated Water Balance Components
Sand/Gravel/Rock Pits

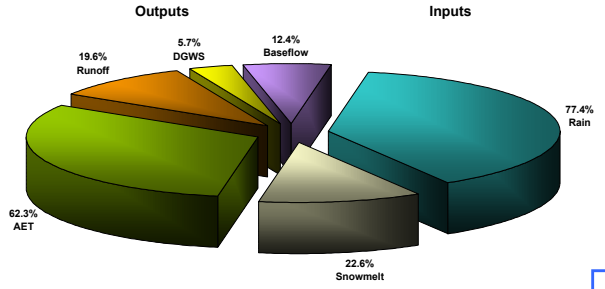
Component Area (ha)	AET as Percent of RAIN+MELT	BF as Percent of INF	RO Coefficient
206.0	30.0	70.0	0.5

Rain (mm)	Snowmelt (mm)	Potential ET (mm)	Actual ET (mm)	Surplus (mm)	Infiltration (mm)	Streamflow (mm)	Baseflow (mm)	Runoff (mm)	DGWS (mm)
717.0	209.0	593.0	277.8	648.2	324.1	551.0	226.9	324.1	97.2
Component Volume (m^3)									
1,477,065	430,553	1,221,617	572,286	1,335,333	667,666	1,135,033	467,367	667,666	200,300

TOTAL VOLUME (m^3)									
242,273,688	70,620,922	200,374,194	194,816,955	118,077,655	56,747,760	100,099,965	38,770,070	61,329,895	17,977,689
TOTAL DEPTH (mm)									
717.0	209.0	593.0	576.6	349.4	167.9	296.2	114.7	181.5	53.2

INPUTS % Rain	INPUTS % Melt	OUTPUTS % AET	% BF	% RO	% DGWS
77.4	22.6	62.3	12.4	19.6	5.7

Willow Creek Existing Conditions Water Balance (Annual)
Midhurst Climate Data (1967 to 1992)



TOTAL AREA = 33,790 ha

FUTURE CONDITIONS

Calculated Water Balance Components
Urban Lawns/Shallow Rooted Crops (spinach, beans, beets, carrots)
Moderately Rooted Crops (corn and cereal grains)
Pasture and Shrubs
Mature Forests

Calibrated Infiltration Factor	Topography	Soils	Cover	Total
Annual	0.091	0.311	0.134	0.536

HYDAT Data (mm)	Streamflow	Baseflow	Runoff
Annual	297.7	126.8	170.9

Component Area (ha)	Weighted WHC (mm)	BF Factor
29096.2	193	0.683

Rain (mm)	Snowmelt (mm)	Potential ET (mm)	Actual ET (mm)	Surplus (mm)	Infiltration (mm)	Streamflow (mm)	Baseflow (mm)	Runoff (mm)	DGWS (mm)
717.0	209.0	593.0	579.7	346.3	185.6	287.5	126.8	160.7	58.8
Component Volume (m^3)									
208,619,992	60,811,127	172,540,663	168,663,470	100,767,649	54,012,487	83,645,690	36,890,529	46,755,162	17,121,958

Calculated Water Balance Components
Swamp/Fen/Marsh

Component Area (ha)	AET as Percent of PET	INF as Percent of Surplus	BF as Percent of Surplus	DGWS as % of Surplus
3018.5	100.0	0.0	0.0	0.0

Rain (mm)	Snowmelt (mm)	Potential ET (mm)	Actual ET (mm)	Surplus (mm)	Infiltration (mm)	Streamflow (mm)	Baseflow (mm)	Runoff (mm)	DGWS (mm)
717.0	209.0	593.0	593.0	333.0	0.0	333.0	0.0	333.0	0.0
Component Volume (m^3)									
21,642,977	6,308,762	17,899,980	17,899,980	10,051,759	0	10,051,759	0	10,051,759	0

Calculated Water Balance Components
Open Water

Component Area (ha)	AET as Percent of PET	INF as Percent of Surplus	BF as Percent of Surplus	DGWS as % of Surplus
237.6	100.0	0.0	0.0	0.0

Rain (mm)	Snowmelt (mm)	Potential ET (mm)	Actual ET (mm)	Surplus (mm)	Infiltration (mm)	Streamflow (mm)	Baseflow (mm)	Runoff (mm)	DGWS (mm)
717.0	209.0	593.0	593.0	333.0	0.0	333.0	0.0	333.0	0.0
Component Volume (m^3)									
1,703,384	496,523	1,408,796	1,408,796	791,111	0	791,111	0	791,111	0

Calculated Water Balance Components
Impervious Urban Area

Component Area (ha)	AET as Percent of RAIN+MELT	INF as Percent of Surplus	BF as Percent of Surplus	DGWS as % of Surplus
1231.5	10.0	0.0	0.0	0.0

Rain (mm)	Snowmelt (mm)	Potential ET (mm)	Actual ET (mm)	Surplus (mm)	Infiltration (mm)	Streamflow (mm)	Baseflow (mm)	Runoff (mm)	DGWS (mm)
717.0	209.0	593.0	92.6	833.4	0.0	833.4	0.0	833.4	0.0
Component Volume (m^3)									
8,830,142	2,573,919	7,303,032	1,140,406	10,263,654	0	10,263,654	0	10,263,654	0

Calculated Water Balance Components
Sand/Gravel/Rock Pits

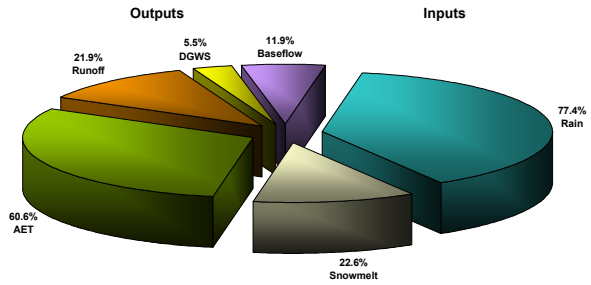
Component Area (ha)	AET as Percent of RAIN+MELT	BF as Percent of INF	RO Coefficient
206.0	30.0	70.0	0.5

Rain (mm)	Snowmelt (mm)	Potential ET (mm)	Actual ET (mm)	Surplus (mm)	Infiltration (mm)	Streamflow (mm)	Baseflow (mm)	Runoff (mm)	DGWS (mm)
717.0	209.0	593.0	277.8	648.2	324.1	551.0	226.9	324.1	97.2
Component Volume (m^3)									
1,477,065	430,553	1,221,617	572,286	1,335,333	667,666	1,135,033	467,367	667,666	200,300

TOTAL VOLUME (m^3)									
242,273,560	70,620,884	200,374,088	189,684,938	123,209,507	54,680,154	105,887,248	37,357,895	68,529,353	17,322,258
TOTAL DEPTH (mm)									
717.0	209.0	593.0	561.4	364.6	161.8	313.4	110.6	202.8	51.3

INPUTS % Rain	INPUTS % Melt	OUTPUTS % AET	% BF	% RO	% DGWS
77.4	22.6	60.6	11.9	21.9	5.5

Willow Creek Future Conditions Water Balance (Annual)
Midhurst Climate Data (1967 to 1992)



TOTAL AREA = 33,790 ha

GREENLAND

groundwater storage (-3.6%), and a decrease in baseflow (-3.6%). Additional water balance calculation sheets for all identified catchments within the Willow Creek Subwatershed are provided in **Appendix E**.

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3.3 ***Stormwater Control Targets for Future Development***

It is premature at this time to size and to establish recommended locations of required stormwater management facilities. Pond sizes and locations will be established at the Secondary Plan (SP) and/or Functional Servicing Plan (FSP) stage. It is important at this time, to establish the recommended levels of stormwater control targets and measures (section 3.4) within the Willow Creek Subwatershed in order to help achieve the aquatic ecosystem objectives and targets outlined in section 2.2.2 of this plan:

- SWM ponds constructed within the Willow Creek Subwatershed must provide Level 1(maximum) protection
- The minimum erosion requirement shall consist of the 25 mm post-development peak flow released over a 24-hour period. Should it be identified at the SP or FSP stage that erosion control over and above the 25 mm 24-hr minimum criteria is necessary, and then an erosion analysis shall be completed to determine the required level of protection
- The minimum level of protection for quantity control shall be post-to-pre flow control for the 2-yr through 100-yr design storms, unless, it can be demonstrated that an alternate level of control can be provided while still maintaining post-to-pre flow conditions at identified flow nodes downstream of the proposed development
- Wherever possible, efforts should be made to minimize temperature impacts on receiving waters by incorporating measures such as littoral plantings and bottom draw outlet structures into the overall design of SWM facilities
- Design of SWM control measures must conform to the guidelines as identified in the *Stormwater Management Planning and Design Manual* (MOE Draft Final report, November 1999) and the *Technical Standards for Stormwater Management Within the NVCA Watershed* (NVCA, May 2000)

3.4 Stormwater Management Control Measures

There are three main categories of stormwater controls; these include source controls, conveyance controls and end-of-pipe controls. It is desirable to combine various stormwater controls within the overall strategy, wherever possible. Opportunities for combining stormwater controls with various industry needs should also be encouraged and specific controls are recommended for control of runoff from construction sites.

Source Controls

Lot level (source controls) are measures utilized to reduce the quantity of runoff from developed properties within a subwatershed. Typical source controls include the following:

- Reduced lot grading

- Roof leaders directed to ponding areas
- Roof leaders directed to soakaway pits
- Sump pumping of foundation drains.

Conveyance Controls

Conveyance controls are designed to reduce the quantity of runoff transported from properties within a subwatershed to the receiving waters. Examples of conveyance controls include:

- Pervious pipe systems
- Catch basin modifications
- Grassed swales
- Pervious catch basins

End-of Pipe Controls

End-of-pipe controls are measures used to service multiple lots, residential subdivisions and industrial/commercial areas. They can be designed to provide both quantity and quality/erosion control to meet a variety of stormwater management requirements. Examples of end-of-pipe facilities include the following:

- Dry ponds
- Wet ponds
- Constructed wetlands
- Hybrid wetland/wet ponds
- Infiltration trenches
- Infiltration basins
- Buffer strips
- Filter strips
- Oil/grit separator.

Opportunities for Re-use and Recycling of Stormwater for Irrigation and Industrial Purposes and for Maintaining and Enhancing Existing Baseflow Conditions

Opportunities for incorporating local agricultural and recreational/industrial needs for water with stormwater management plans should be encouraged within the Subwatershed. As an example, irrigation needs for crops and/or golf course greens and fairways could be considered when designing and locating stormwater management ponds. With proper design skills, excess runoff that would normally be released to the stream could be stored and used at a later time during dry periods for irrigation purposes. This approach is currently being considered in Alliston, where options are being explored to combine polished wastewater treatment plant effluent with stormwater runoff for irrigation of surrounding farmland. Measures such as this, along with a review of irrigation and water use practices within the subwatershed, could help reduce the impact on baseflow conditions and subsequent impacts on aquatic habitat and health, particularly during the summer months.

An example of incorporating industry needs with site stormwater management is the collection of roof runoff for use as cooling water for equipment such as refrigeration units. Not only does this help to reduce the volume of runoff from the site but it also reduces the amount of water that would otherwise be pumped from underground aquifers.

In order to quantify the impacts of existing and future surface and groundwater use on baseflow conditions, the water balance model completed for the Willow Creek Subwatershed could be refined further to include information (if available) such as water taking permits, well records, farm irrigation records and practices, commercial/industrial water use records and practices, and additional flow monitoring as required. With appropriate modifications, the water balance model could potentially be used to evaluate proposed surface and groundwater management strategies and to determine the preferred option(s).

Erosion and Sediment Controls During Construction

In order to reduce sediment loading of streams during construction of the proposed lands within the Subwatershed, it is important that sediment and erosion control measures be identified and incorporated into site plans prior to initiation of earthworks on site. Following implementation, sediment controls must be properly checked, cleaned and maintained in place during all phases of construction. Erosion and sediment control measures which should be considered for implementation into individual site plans include, but are not limited to:

- Site management practices
- Construction scheduling
- Temporary sediment basins
- Temporary sediment traps
- Silt fences
- Seeding and mulching
- Drainage diversions
- Brush barriers
- Check dams
- Storm drainage inlet protection
- Vibration pads
- Conveyance channels

The guidelines for the design of erosion and sediment control measures provided in the following documents should be followed:

- *Guidelines on Erosion and Sediment Control for Urban Construction Sites* (MNR, *et al*, 1987)
- *Technical Guidelines, Erosion and Sediment Control* (MNR, 1989)
- *Erosion and Sediment Control*. MTC. Drainage Manual, Volume 2, Chapter F (MTO, 1985)
- *Erosion and Sediment Control Training Manual, (MOE,1997)*

All stormwater management facilities should adhere to the recommended design guidelines as set out in the *Stormwater Management Planning and Design Manual - Draft Final Report* (MOE, 1999). In addition, the following should be completed for each SWMP

- A geotechnical investigation to assess the suitability of the proposed site to accommodate a stormwater management pond, particularly in regard to groundwater levels and slope stability concerns
- A landscape plan, including recommended plantings about the facility
- A construction phasing plan

Development proponents should prepare a detailed Storm Water Management Report that discusses how storm water generated from the proposed Plan of Subdivision will be managed in accordance to the intent of the recommended master drainage plan. Likewise, any alterations to urban storm water management strategies resulting from servicing difficulties/constraints identified during the detailed design stage should be discussed and rationalized in the Storm Water Management Report.

All new development proposals must prepare site-specific storm water management reports that shall include:

- The proposed drainage scheme for the development
- The proposed Storm Water Management Practices that will be incorporated into the system
- The proposed methods for minimizing erosion and sedimentation during construction

3.5 ***Water Management Recommendations*** Return to Table of Contents

As part of the Water Management Component of the Willow Creek Subwatershed Plan, the following recommendations are presented to enable proper management of stormwater and water balance in the future:

7. The recommended stormwater control targets and measures as outlined in sections 3.3 and 3.4 should be followed.

8. The existing flow characteristics should be maintained at the flow nodes identified in Table 3.1 and shown on Map 6 Sub-catchments.

9. The hydrologic model should be calibrated and verified.

10. Once the hydrologic model is calibrated, and as development proceeds, floodplain mapping should be revised/completed for the Willow Creek Subwatershed.

11. Stormwater management pond locations and sizing should be established at the Secondary Plan or Functional Servicing Plan stage.

12. **A hydrologic computer model such as Visual OTTHYMO should be used by development proponents for calculating flows to size flood control facilities at the Functional Servicing Plan stage. Site-specific parameter values should be established during the Secondary Plan stage.**
13. **Functional Servicing Plans should be completed as part of Secondary Plans and should be integrated with on-going water management projects by the NVCA (e.g. flood forecasting model and the Simcoe County groundwater management study).**
14. **The existing water balance should be maintained or enhanced throughout the Willow Creek Subwatershed (maximizing infiltration to counteract the increase in hard surfaces) as future development occurs.**
15. **As additional funding becomes available, the water balance model should be refined to include surface and groundwater usage such as for agricultural, domestic, commercial and industrial purposes. A more accurate estimate of water takings will help ensure long-term sustainable water usage.**

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4.0 SUMMARY OF RECOMMENDATIONS, IMPLEMENTATION STRATEGY AND MONITORING

Recommendations, implementation and monitoring requirements are outlined in **Table 4.1**. It is a summary of management recommendations for the Willow Creek Sub-watershed based on hydrologic modeling, stream health assessments and the public consultation process.

A great deal of the plan recommendations will be implemented through the municipal planning process. Policies and development criteria and standards may be recommended for inclusion in planning documents and utilized during the plan review processes of approval authorities and review agencies.

Computer models, data and other information will be maintained and updated by the appropriate review agencies, approval authorities and municipalities. NVCA will play a major role as keeper and updater of the data and computer models, ensuring that cumulative impacts from development and cross- boundary water management issues are addressed. This information will be placed on the Internet through NVCA's web site at www.nvca.on.ca.

Monitoring:
Despite our best efforts to establish a subwatershed management plan for the study area to maintain and enhance the features and functions of the natural environment, the plan is based on a finite set of information and assumptions about future land use and development. Consequently, it is very important that a set of "indicators" be established that can be monitored over time to determine the environmental health of the subwatershed.

The following **Table 4.1** outlines the specifics of the monitoring recommendations as part of the implementation strategy.

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Table 4.1: Summary of Recommendations and Implementation Strategy.

Subwatershed Component	Recommendations	Lead/ Support Agencies	Implementation Mechanism	Time Frame
Natural Heritage System	#1 Municipalities should incorporate policies in their official plan indicating that "no development or site alteration" shall be permitted within all evaluated wetlands. All wetlands (as defined by the province) should be evaluated.	Municipalities /NVCA and MNR for wetland evaluations	Official Plans/Zoning By-laws and Approval Authorities reviews	Next Official Plan /Zoning Update
	#2 The proposed additions to Willow Creek Natural Heritage System, as identified in Map **4** should be incorporated into municipal planning documents. Policies to protect the system and its functions from incompatible land use and development should also be included.	Municipalities /NVCA	Official Plans /Zoning by-laws and Approval Authorities	Next Official Plan /Zoning Update

	and rehabilitation areas identified in **Map 5** when identifying projects. Rehabilitation of headwater streams and wetlands should be a priority along with re-vegetation of the Willow Creek riparian areas in Midhurst between St Vincent Street and Highway 27 to reduce the effects of erosion.	groups and organizations (DU, Scouts etc)		
Aquatic Ecosystem	# 4 No development or site alteration should occur within a minimum of 30m on either side of a natural stream or watercourse, maintaining the natural vegetation. In the case of municipal drains, a minimum 30 m wide vegetated buffer should be established on the side of the drain not accessed for clean out.	Municipalities& NVCA	Official Plans & Zoning By-laws; Approval Authorities reviews	Next Official Plan & Zoning updates
	#5 Phosphorus data from 2001 suggest that MOE would classify Willow Creek as a "Policy 2" receiver since phosphorus concentrations commonly exceed the provincial water quality objective (PWQO). MOE policy indicates that a remedial strategy for parameters exceeding the PWQO should be developed and that future discharges should not result in further PWQO exceedences (both magnitude and frequency). Matheson Creek appears to be a "Policy 1" receiver for phosphorus and future discharges should ensure that any phosphorus increases are not sufficient to result in PWQO exceedences for that (or any other) parameter.	Municipalities/ MOE; NVCA Approval Authorities;	Official Plan Updates; Secondary Plans; On-going Reviews; Health Water/ Futures Programs	As dev. proceeds through secondary plan; On-going restoration.
Subwatershed Component	**Recommendations**	**Lead/ Support Agencies**	**Implementation Mechanism**	**Time Frame**
	#6 Establish a long term monitoring program based on biological surveys at 5 sites in the subwatershed to track stream health impacts from land use change.	Municipalities Developers and NVCA	Through Development proposals and/or municipal commitments	monitoring will continue in 2002; long-term needed
Water Management	#7 The recommended stormwater control targets and measures as outlined in sections 3.3 and 3.4 should be followed.	Municipalities/ MOE; CA, Approval Authorities	Secondary and Functional Service Plans &Stormwater Management Plans	On-going, as developm-ent proceeds
	#8 The existing flow characteristics should be maintained at the flow nodes identified in Table 3.1 and shown on Map 6 Sub-catchments.	Municipalities./ MOE; NVCA,Appr. Authorities	Functional Service Plans &Stormwater Management Plans	On-going, as dev. proceeds
	#9 The hydrologic model should be calibrated and verified.	NVCA	Through existing or future programs (groundwater study)	2002-2003
	#10 Once the hydrologic model is calibrated, and as development proceeds, floodplain mapping should be revised/completed for the Willow Creek Subwatershed.	NVCA/ Municipalities	Through Secondary Plans & development proposals	On-going
	#11 Stormwater management pond locations and sizing should be established at the Secondary Plan or Functional Servicing Plan stage.	Municipalities/ MOE; NVCA,appro.	Secondary Plans & Functional Service Plans	As develop-ment.

		Authorities		proceeds
	#12 A hydrologic computer model such as Visual OTTHYMO should be used by development proponents for calculating flows to size flood control facilities at the Functional Servicing Plan stage. Site-specific parameter values should be established during the Secondary Plan stage.	Municipalities/ NVCA, Approval Authorities	Secondary Plans, Functional Service Plans &Stormwater Management Plans	As develop-ment. proceeds
Water Management	#13 Functional Servicing Plans should be completed as part of Secondary Plans and should be integrated with on-going water management projects by the NVCA (e.g. flood forecasting models and groundwater management study).	Municipalities/ MOE; NVCA, Approval Authorities	Secondary Plans, Functional Service Plans	As develop ment. proceeds
	#14 The existing water balance should be maintained or enhanced throughout the Willow Creek Subwatershed (maximizing infiltration to counteract the increase in hard surfaces) as future development occurs.	Municipalities/ MOE; NVCA, Approval Authorities	Secondary Plans, Functional Service Plans &Stormwater Management Plans	As develop ment. proceeds
	#15 As additional funding becomes available; the water balance model should be refined to include surface and groundwater usage such as for agricultural, domestic, commercial and industrial purposes. A more accurate estimate of water takings will help ensure long-term sustainable water usage.	Municipalities MOE,/NVCA	MOE/NVCA Ground water Initiative	Next 18 mo. As project proceeds.