Long Point Region Watershed Characterization Report

DRAFT

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Ontario

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1.0 INTRODUCTION

Following the public inquiry into the Walkerton water crisis, Justice Dennis O'Connor released a report in 2002 containing 121 recommendations for the protection of drinking water in Ontario. Since the release of the recommendations, the Government of Ontario has introduced legislation to safeguard drinking water from the source to the tap, including the Clean Water Act in 2006, which provides a framework for the development and implementation of local, multi-stakeholder source protection plans.

The Clean Water Act focuses on the protection of municipal drinking water supplies. It sets out a risk-based process on a watershed scale to identify vulnerable areas and associated drinking water threats, and requires the development of policies and programs to reduce or eliminate the significant risks to sources of municipal drinking water sources. The Province, through the Ministries of the Environment (MOE) and Natural Resources (MNR), is working in partnership with municipalities, Conservation Authorities, Conservation Ontario, water users, land owners and other stakeholder groups to develop the local science based source protection plans.

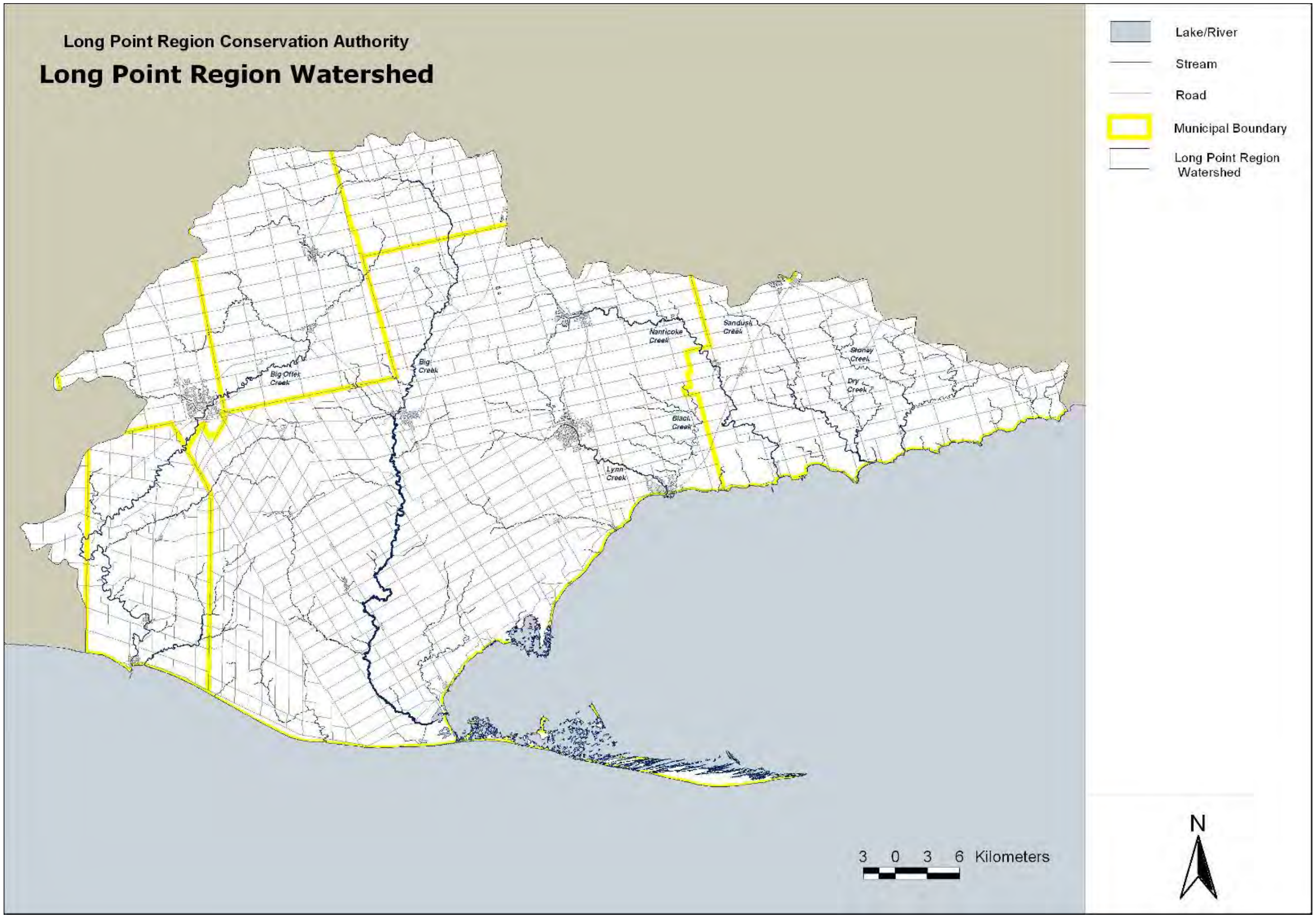
The first step in the development of the plan is to describe the physical and human characteristics of the watershed. The Watershed Characterization Report provides information ranging from geology, hydrology and hydrogeology, groundwater and surface water quality, population distribution, land uses, municipal and private water use, a description of the water supplies, potential drinking water threats and issues, and a brief description of existing policies and programs to protect drinking water sources. The Watershed Characterization Report forms the foundation of the Technical Assessment Report, which will identify all known drinking water source issues and significant threats in the watershed, and the Source Protection Plan.

The first chapter of the report provides an overview of the watershed and the Lake Erie Source Protection Region, and introduces the main stakeholders and partners in the local source protection planning process. Chapter Two is a summary of the physical characteristics of the watershed, while Chapter Three provides an overview of the human characteristics, including population and land use. Summaries of water management strategies and water use in the watershed are provided in Chapters Four and Five. Chapter Six describes both private and municipal drinking water sources in the watershed, and provides some preliminary discussion of the types of potential threats to the sources of municipal drinking water. Chapter Seven follows with a discussion of potential drinking water issues in the watershed and lists the main data and knowledge gaps in determining and documenting drinking water issues. Chapter Eight concludes the report with a description of the existing policies and programs that already provide protection of sources of drinking water.

1.1 Long Point Region Source Protection Area

The Long Point Region (LPR) watersheds cover an area of approximately 2,900 square kilometres in Southern Ontario. **Map 1.1** shows the several watercourses and watersheds that make up Long Point Region, each with their own unique traits and values. The combined length of all the streams and their tributaries equals over 3,700 kilometres. The LPR watershed is almost 100 kilometres at its widest point and 60 kilometres running north to south. The LPR also has 225 kilometres of Lake Erie shoreline, including the internationally renowned Long Point sand spit.

Map 1.1 Long Point Region Watersheds



The ground surface elevation ranges from 357 metres above sea level in the northwest (west of Norwich), to 169 metres above sea level in the southeastern limits of the study area along the Lake Erie shoreline. Moderate relief is apparent in the central part of the study area (north of Tillsonburg, Otterville, Courtland, and Waterford) these areas correspond to the Tillsonburg, Courtland, St. Thomas and Paris moraines.

Early settlers were attracted to the area due to the presence of flat plains, which were more easily cleared. Other attractions were the transportation afforded by Lake Erie, the abundance of fish, wildlife and fur as well as the more moderate climate. The subsequent alteration of the plains and the surrounding heavily forested lands has had a significant impact on the surface and groundwater quality and quantity.

1.2 Lake Erie Source Protection Region

In response to the Walkerton water crisis, and the ensuing recommendations made by Justice O'Connor from the Walkerton Inquiry, the Province of Ontario has undertaken a process to protect the quality and quantity of sources of drinking water. Key partners included in the process are municipalities and conservation authorities. Conservation authorities will coordinate the development of technical and scientific knowledge, and facilitate the planning process. Municipalities will participate in the planning process and play a lead role in implementing the plans.

In an effort to share knowledge and resources, a partnership was formed in 2004 between the Grand River, Long Point Region, Catfish Creek and Kettle Creek Conservation Authorities (CA) to form the Lake Erie Source Protection Region. The Grand River Conservation Authority (GRCA) acts as the lead authority for the region. **Map 1.2** shows the territory covered by the Lake Erie Region, including municipal boundaries and main rivers and tributaries. The four CAs agreed to jointly undertake research, public education, and watershed planning and management for the advancement of drinking water source protection for the respective watersheds. The watersheds have a long history of partnership and cooperation, and also have a natural association by containing most inland rivers and streams flowing from Ontario directly into Lake Erie.

Combined, the region represents a diverse area, ranging from intense agricultural production to large, and rapidly expanding urban areas. The region spans an area from the City of St. Thomas in the west, to Halton Hills on the east, and as far north as Dundalk. The area includes, in whole or in part, 49 upper and lower tier municipalities, as well as two First Nations communities.

1.3 Watershed Partners and Interested Parties

Several partnerships and relationships have been formed within the Long Point Region to discuss and manage watershed-related issues in the watersheds. Partners include ten upper and lower tier municipalities; federal and provincial governments; non-governmental organizations; private landowners; Long Point Region Conservation Authority (LPRCA); the Long Point Foundation for Conservation; Conservation Ontario; partner and neighbouring conservation authorities, and academic institutions.

Map 1.2: Lake Erie Source Protection Region

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A strong forum for partnerships for dealing with watershed-scale issues has existed in the Long Point Region watershed for decades. The watershed municipalities have managed natural resources on a watershed-scale basis through the Long Point Region Conservation Authority and its predecessors since 1948. The LPRCA and municipalities have also coordinated the efforts of government agencies and other partners to carry out a wide range of watershed conservation programs and activities.

Following an extensive consultation with our various partners, the LPRCA approved a *Watershed Strategies Document* (2002) which states the LPRCA Mandate:

> *The Long Point Region Conservation Authority will work with our local communities, and our many other partners, to achieve the Conservation, restoration, development and responsible management of our water, land and natural habitats through programs that balance human, environmental and economic needs.*

A vast amount of research and work in watershed management has been undertaken by partners in the watershed, in conjunction with the LPRCA. Recent studies have focused on the management and understanding of water quantity requirements and detailed assessment of groundwater resources. In addition, the first *State of the Watershed* study (Gagnon, Giles, 2004), focused on the Lynn River-Black Creek watershed, was recently published.

2.0 PHYSICAL DESCRIPTION OF THE WATERSHED

Understanding the physical characteristics of the watershed is key to protecting and managing water. Interactions between surface water, groundwater and potential sources of contamination require an understanding of the physical characteristics of the bedrock and surficial geology, physiographic regions and significant natural features within the watershed. The following sections are intended to provide these characteristics, as well as some discussion surrounding their significance to drinking water sources.

2.1 Bedrock Geology

Glacial sediments in the Long Point Region are underlain by Upper Silurian to Middle Devonian bedrock consisting mainly of limestones, dolostones and shales. This Paleozoic succession is subdivided into 10 formations. In order from oldest to youngest, these are the Salina, Bertie and Bass Island, Oriskany, Bois Blanc, Onondaga, Amherstburg, Lucas, Dundee and Marcellus Formations. The Amherstburg and Lucas Formations comprise the Detroit River Group. These rocks were deposited in the Michigan basin at the same time that the more easterly rocks of the Onondaga Formation were deposited in the Appalachian basin. Similarly, the Bass Island Formation rocks were deposited in the Michigan basin contemporaneously with the deposition of the Bertie Formation rocks in the Appalachian basin.

The bedrock formations subcrop in the Long Point Region as east-southeast trending bands, as shown in **Map 2.1**. Structurally, the strata dip gently to the south. Brief descriptions of the formations are provided below.

2.1.1 Salina Formation

The oldest Paleozoic bedrock subcropping beneath Long Point Region is the Salina Formation, deposited during the Upper Silurian roughly 420 million years ago. This formation consists of Upper Silurian interbedded shale, mudstone, dolostone, and evaporates including gypsum and salt (Johnson et al. 1992) and subcrops in the far northern boundary of Long Point Region. Gypsum from the Salina Formation is mined near Hagersville to produce wall-board and other related construction products (Johnson et al. 1992). The Salina Formation outcrops in the town of Hagersville, and outside the village of Springvale west of Hagersville.

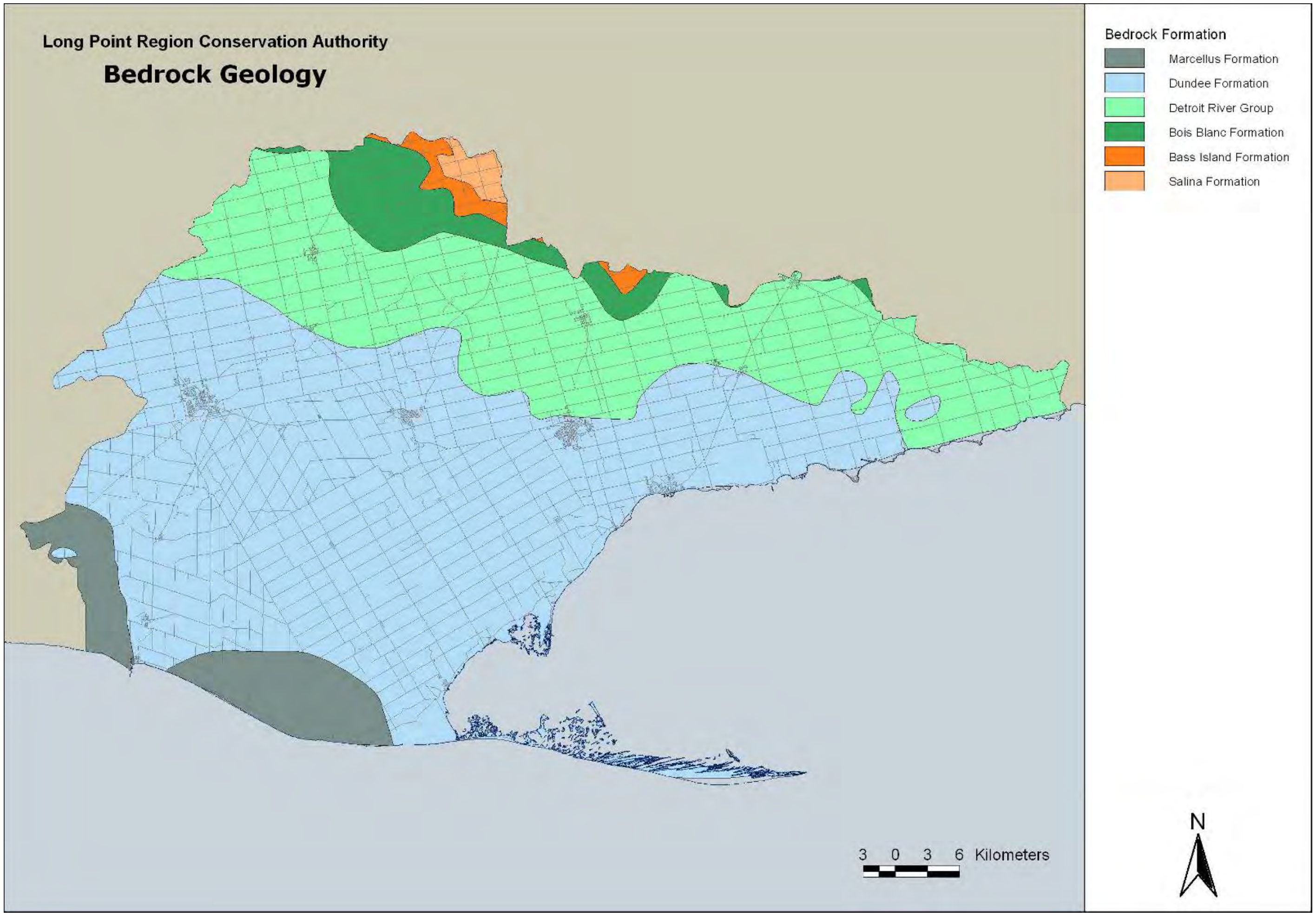
2.1.2 Bertie and Bass Islands Formations

Subcropping south of the Salina Formation are the younger (Late Silurian) Bertie and Bass Islands formations. The contact between the Salina Formation and the overlying Bertie and Bass Islands formations is conformable.

The Bertie Formation was deposited in the Appalachian Basin, while the laterally equivalent Bass Islands Formation was deposited contemporaneously in the Michigan Basin. According to Johnson et al. (1992), “The lateral transition from the Bertie Formation to the Bass Islands Formation is gradational, occurring north and west of Wilsonville”.

The Bertie and Bass Island formations subcrop as a narrow (1-3 km wide) band of Upper Silurian oolitic and microsucrosic brown dolostone with minor thin beds of shaley dolostone along the northern edges of watershed (Barnett 1982; Johnson et al. 1992).

Map 2.1: Bedrock Geology of Long Point Region



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2.1.3 Oriskany Formation

The Oriskany Formation is a very small and localized (approximately 6 km^2) subcrop of Lower Devonian coarse-grained, calcareous, quartz sandstone with a thin basal conglomerate approximately 10 km east of Hagersville. It is estimated to have a maximum thickness of less than 6 m (Johnson et al. 1992).

The Oriskany Formation was deposited in an erosional depression during an extended period of erosion in the early Devonian. It pinches out laterally between the Bertie and Bois Blanc formations. The contact between the Oriskany Formation and the underlying Bertie Formation is sharp and disconformable, showing pronounced small-scale karst features (Johnson et al. 1992).

2.1.4 Bois Blanc Formation

Stratigraphically overlying the Oriskany Formation and the Bertie and Bass Islands formations is the Early Devonian Bois Blanc Formation. The contact between the Bois Blanc Formation and the other formations is disconformable and marked by significant relief, suggesting a pronounced period of erosion before rocks of the Bois Blanc Formation were deposited (Johnson et al. 1992).

The Bois Blanc Formation consists of cherty brownish grey, fossiliferous limestone and is estimated to be roughly 3 to 15 m thick in Long Point Region. This unit is well exposed east of the watershed where it forms the caprock of the Niagara Peninsula's Onondaga Escarpment (Johnson et al. 1992).

The disconformity between the Bois Blanc Formation and the underlying Bertie, Bass Islands and Oriskany formations may be significant from a hydrogeologic perspective. The lower surface of the Bois Blanc Formation is interpreted to be highly fractured and locally paleokarstic (Johnson et al. 1992), and therefore able to transmit greater volumes of water than the more competent overlying and underlying rock. Singer, Cheng and Scafe (2003) state that the Bois Blanc Formation has excellent groundwater-yielding capacity.

2.1.5 Onondaga, Amherstberg and Lucas Formations (Detroit River Group)

Stratigraphically overlying the Bois Blanc Formation are the formations that comprise the lower to middle Devonian Detroit River Group. These rocks subcrop in an easterly trending band that extends from Norwich and Otterville, beneath Waterford and eastward to Lake Erie. Within Long Point Region, the Detroit River Group consists of the Onondaga, Lucas and Amherstburg formations.

East of Hagersville, the Bois Blanc Formation is overlain by the Onondaga Formation. The contact between the Bois Blanc and Onondaga formations is poorly understood, but is believed to be disconformable (Johnson et al. 1992). The Middle Devonian rocks of the Onondaga Formation consist of cherty fossiliferous limestone (Johnson et al. 1992; Telford and Tarrant 1975).

West of Hagersville, the crinoidal limestones and dolostones of the Amherstburg Formation overlie the Bois Blanc Formation. The contact between the Bois Blanc and Amherstburg formations is poorly defined and largely interpretative. The lateral contact between the contemporaneous Amherstberg Formation (deposited in the Michigan basin) and the Onondaga Formation (deposited in the Appalachian basin) is gradational (Johnson et al. 1992).

The Lucas Formation conformably overlies the Amherstberg Formation and consists of microcrystalline limestone (Johnson et al. 1992). The Lucas Formation is thickest in the western part of the study area. It gradually thins and pinches out near Port Dover.

2.1.6 Dundee Formation

The Dundee Formation subcrops throughout most of the south and central parts of the watershed, and overlies the Lucas Formation west of Port Dover, and the Amherstberg Formation east of Port Dover. The contact between the Dundee and Lucas formations is unconformable. It is described as sharp, undulatory and erosional. The contact between the Dundee and Amherstberg formations is poorly understood but is believed to be unconformable (Johnson et al. 1992).

The rocks of the Dundee Formation are usually a grey to brown fossiliferous limestone. However, in the Dunnville area, the Dundee Formation is described as brown, medium-bedded, fine-grained, weakly cherty, and poorly fossiliferous (Barnett 1978). In the Tillsonburg area, it consists of an upper medium brown microcrystalline limestone above a crinoidal limestone with quartz sand grains and chert (Barnett 1982).

The Dundee Formation outcrops along Black Creek, Nanticoke Creek, a small area just north of the town of Nanticoke and the Lake Erie shoreline between Port Dover and Nanticoke.

Within Long Point Region, several karst features are associated with the Dundee Formation (Barnett 1978). Karst is a distinctive type of topography or terrain, formed primarily by the dissolution and collapse of carbonate and evaporite rocks by mildly acidic groundwater. Sinkholes are circular to semi-circular surface depressions that are symptomatic of karst terrain. Barnett (1982) mapped several sinkholes within the watershed, ranging up to 15 m in diameter and 8 m deep.

The wide openings caused by the dissolution and collapse of karstic rocks indicates that they are generally highly permeable. From a hydrogeological standpoint, bedrock aquifers in these karstic rocks are also highly susceptible to groundwater contamination because surface water and contaminants tend to flow directly into the aquifers via sinkhole drains.

2.1.7 Marcellus Formation

The Marcellus Formation subcrops in the southwest part of the study area, next to the shoreline of Lake Erie. It conformably overlies the Dundee Formation.

The Marcellus Formation is between 3 and 15 m thick and consists of black, organic-rich shale with a few minor, thin, impure carbonate interbeds (Barnett 1982, 1993; Johnson et al. 1992). The Marcellus Formation marks a sharp change in the bedrock from older carbonate-dominated bedrock to shale-dominated strata (Johnson et al. 1992).

2.2 Quaternary Geology

The bedrock is overlain by a thick veneer of sediments deposited during the Quaternary Period (1.8 Ma to present). The surficial geology of the watershed consists primarily of sediments deposited during late Wisconsinan glaciation. The topography and landforms of the watershed are largely defined by these glacial deposits, and define the three distinct physiographic regions within the Long Point Region: the Norfolk Sand Plain, the Haldimand Clay Plain, and a portion of the watershed that lies within the Horseshoe Moraine physiographic region (Chapman and Putnam 1984) see **Map 2.2**)).

The Norfolk Sand Plain is a low-relief, silty sand and gravel plain that extends through most of the western portion of Long Point Region. It ranges in thickness from less than a metre to over 25 m in isolated areas (Barnett 1982). The east part of Long Point Region is characterized by low-relief lacustrine clay of the Haldimand Clay Plain (Chapman and Putnam 1984).

The Horseshoe Moraine physiographic region is situated in the north-western portion of Long Point Region. It comprises several easterly-trending and two northerly-trending elongated end moraines that provide low to moderate relief above the Norfolk Sand Plain. In some areas, it is discernible as slightly hummocky topography. The easterly-trending moraines include (from north to south) the St. Thomas, Norwich, Tillsonburg, Courtland, and Mabee moraines. The two northerly-trending end moraines are the Paris and Galt moraines.

All the end moraines within the study area are kilometres in length. In general, the surface relief of the moraines decreases southward toward Lake Erie. The moraines located nearest to Lake Erie (including the north-trending Paris and Galt moraines) are smaller because they have been more subjected to erosion and burial by the encroachment of glacial Lake Erie (Barnett 1982; Chapman and Putnam 1984). The St. Thomas Moraine (the oldest of the moraines in the area) shows the greatest relief (Chapman and Putnam 1984). It is located in the northwest corner of the watershed, and extends beneath the towns of Mount Vernon and Mount Elgin (Barnett, 1982).

Postglacial and erosional processes during the Holocene (beginning 10 000 years ago) continued to reshape parts of the landscape within Long Point Region. The 40-km long Long Point spit began to form in Lake Erie roughly 7,600 years ago when coarse-grained sediments were carried by long shore currents from the west (Davidson-Arnott and Van Heyningen 2003).

The sediments in Long Point Region were mainly deposited during the late Wisconsinan glacial period (beginning 30,000 years before present). The continental scale glacier termed the Laurentide ice sheet repeatedly advanced and retreated through Ontario. The ice front advanced forward during cold periods (glacial stades) and retreated when the climate temporarily warmed (glacial interstades) leaving behind a complex subsurface sedimentological record. During the late Wisconsinan, the Laurentide ice sheet thinned and formed a series of sublobes. Each of these sublobes deposited a series of distinct subglacial tills and associated landforms. Deposits within Long Point Region are predominately associated with the advance and retreat of ice lobes originating from the Lake Erie and Lake Ontario basins. These deposits are listed in **Table 2.1**.

2.2.1 The Nissouri Stade

The oldest glacial deposit exposed in Long Point Region is the Catfish Creek Till, deposited during the Nissouri Stade (25 to 18 ka) (Barnett 1982; 1992). It was during this time period that the Laurentide ice sheet advanced as one thick cohesive ice sheet, depositing an extensive subglacial till sheet throughout southwestern Ontario.

The Catfish Creek Till is composed of stacked layers of subglacial lodgement till, as well as stratified glaciofluvial and glaciolacustrine sediments and supraglacial till layers and lenses (Dreimanis, 1982; Barnett, 1992). It is described in Long Point Region as a gritty highly calcareous sandy silt till (Barnett 1982). It is often described as hardpan in water well drillers' records because of its stoniness and hardness (Barnett 1978; 1982; 1992).

Map 2.2: Quaternary Geology of Long Point Region

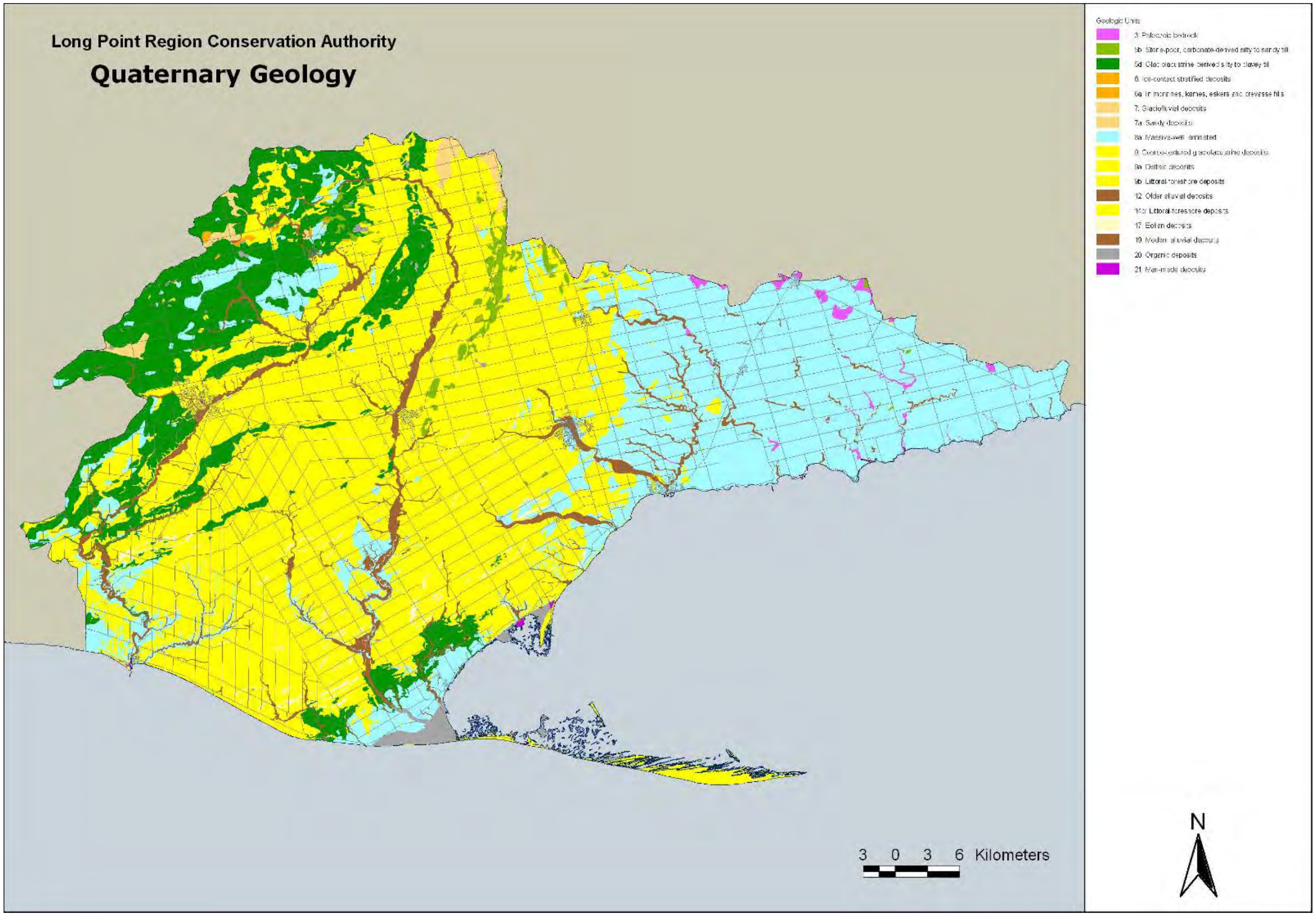

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Table 2.1: Quaternary Deposits Located in Long Point Region Watershed

Age (y.b.p.)*	Glacial Stage	Substage	Glacial Stade/ Interstade	Associated Deposits
5,000-11,500	Wisconsinan	Late Wisconsinan	Holocene/ Recent	Modern alluvium, organic deposits, Long Point spit, Eolian sand dunes
11,500-12,000			Twocreekean Interstade	Shoreline Formation Glaciolacustrine Deposition
12,000-13,200			Port Huron Stade	Wentworth Till, Norfolk Sand Plain, Haldimand Clay Plain
13,200-14,000			Mackinaw Interstade	Paris/ Galt Moraines
14,000-15,500			Port Bruce Stade	Port Stanley Till, Glaciolacustrine Deposits
15,500-18,000			Erie Interstade	Glaciolacustrine Deposits
18,000-25,000			Nissouri Stade	Catfish Creek Till
25,000-53,000		Middle Wisconsinan		Undifferentiated tills and deposits
53,000-80,000		**Early Wisconsinan**		

* y.b.p. represents number of years before present

The Catfish Creek Till is exposed in only a few locations in Long Point Region, including near Tillsonburg and associated with drumlins near Hagersville. However, it is believed to form a laterally extensive subsurface till plain throughout the Region. The maximum observed thickness in outcrop is 2.5 metres, although stratigraphic units of similar composition have been described in borehole logs in thicknesses of up to 23 metres (Barnett 1982).

2.2.2 Port Bruce Stade

The next major depositional event is associated with the Port Bruce Stade (approximately 14,000 to 15,500 years ago), when the advancing Laurentide Ice Sheet caused the formation of a large glacial lake (Lake Leverett) in the Erie basin. This led to the deposition of glaciolacustrine silts and clays in some portions of the watershed (Barnett 1982). Port Stanley Till was deposited when ice moved radially outward from the centre of the Lake Erie basin across the watershed (Barnett 1982; 1992).

The Port Stanley Till is a silt to clayey silt till with few clasts. Within Long Point Region, it consists of up to 5 layers of subglacial till separated by glaciolacustrine sediments resulting from lake level fluctuations within the Lake Erie basin (Barnett, 1982; 1992).

The Port Stanley Till underlies younger glaciolacustrine sediments across most of the Region; however, it outcrops in the north-western portions of the watershed north of Tillsonburg. It also comprises the vast majority of sediments in the easterly-trending end moraines within the study area (including the St. Thomas, Norwich, Tillsonburg, Courtland and Mabee moraines) (Barnett, 1993). These moraines formed as the ice lobe receded from the northwest to the southeast across the Region.

Ponding of glacial meltwater during ice recession led to the deposition of the fine-grained glaciolacustrine sediments on top of the Port Stanley Till in the northwest portions of the watershed (Barnett 1982).

2.2.3 Mackinaw Interstade

The Wentworth Till and the Paris and Galt moraines were deposited during the Mackinaw Interstade (14,000 to 13,500 years ago) when the Erie-Ontario lobe of the Laurentian ice sheet retreated southward. The Wentworth Till is the youngest till located in Long Point Region, and is restricted to areas east of the Paris Moraine. It is commonly overlain by glaciolacustrine sediments (Barnett 1982), however it outcrops in some areas northeast of Delhi along the Paris Moraine, in areas approximately 3 kilometres north of Port Rowan, and in drumlins north of Hagersville (Barnett 1978).

Within the Region, the Wentworth Till is a very poorly sorted massive clayey silt to silty clay containing minor coarse sand, pebbles and boulders (Barnett 1978). It becomes gradually coarser-grained toward the northwest.

The Paris and Galt moraines are not well exposed in the Region as younger glaciolacustrine sediments have largely buried these two features. Both moraines are composed of Wentworth Till (Barnett 1978).

2.2.4 Port Huron Stade

The Norfolk sand plain and the Haldimand clay plain were formed during the latter stages of the Port Huron Stade (13,500 to 13,000 years ago). During this time, Long Point Region was inundated with large, deep glacial lakes with progressively lower lake levels (Barnett 1992). The Haldimand clay plain and the Norfolk sand plain comprise most of the surficial sediments of the eastern and central parts of the Long Point Region, respectively.

The Haldimand Clay Plain consists of fine-grained silts and clays deposited at the bottom of a deep glacial lake basin. The Norfolk sand plain consists of fine- to medium-grained, massive to laminated sand, deposited in the shallower parts of glacial lakes (Barnett 1978). In Long Point Region, the sands are generally five to ten metres thick (Barnett 1978).

A small drumlin field is located north of Hagersville. The long axes of the drumlins are aligned to the east-northeast. Most of the drumlins are composed of Wentworth Till (Barnett 1978).

2.2.5 Recent Deposits

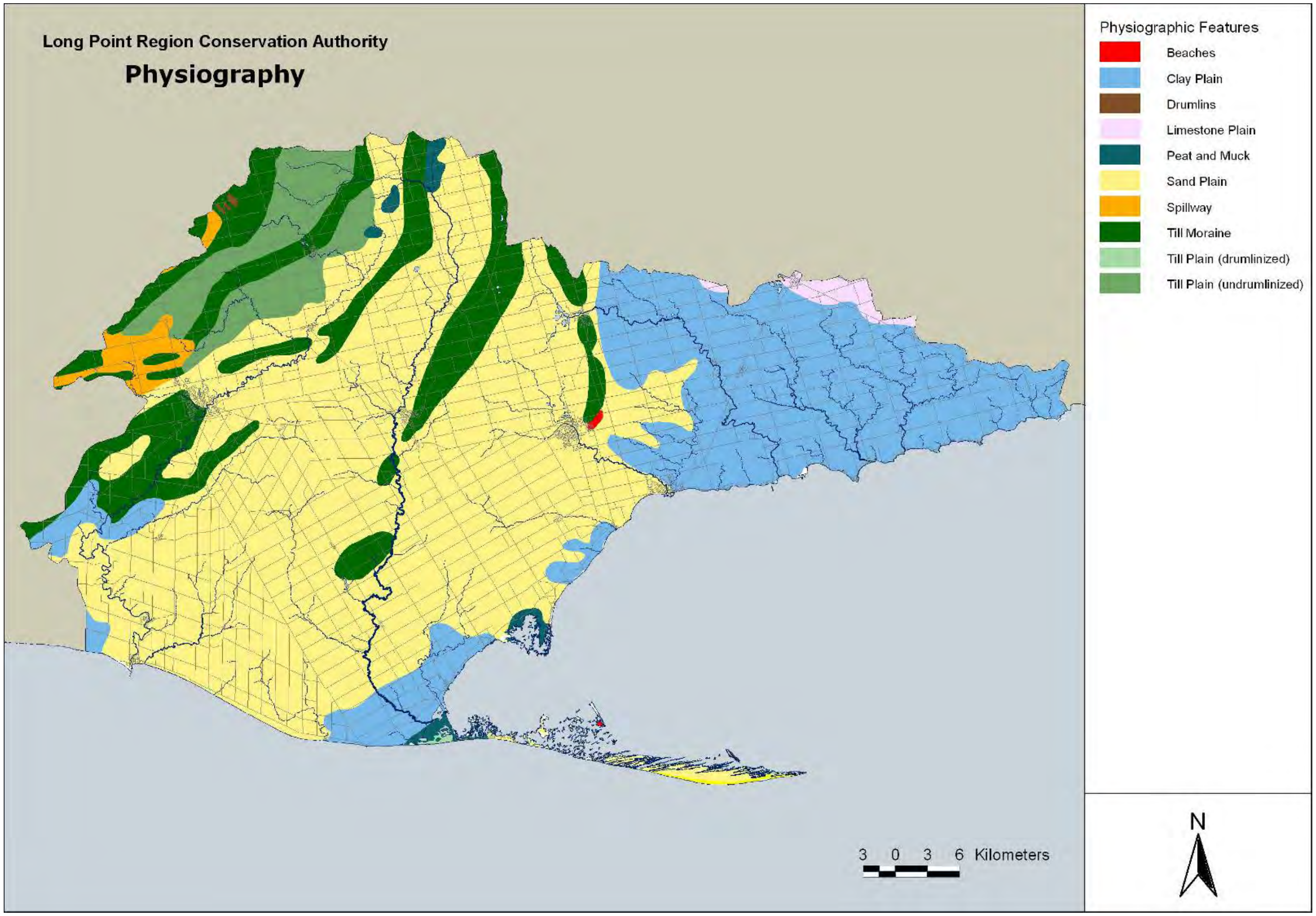
Modern alluvial sediments deposits associated with Big Creek, Big Otter Creek and the Grand River represent the most recent localized deposits of the study area (Barnett, 1992).

2.3 Physiographic Regions

There are three distinct physiographic regions within the study area; the Norfolk Sand Plain, the Haldimand Clay Plain, and a portion of the study area lies within the Horseshoe Moraine physiographic region (Chapman and Putnam, 1984), as indicated in **Map 2.3**.

The Norfolk Sand Plain is characterized as a low-relief, silty sand and gravel sand plain that extends through most of the western portion of the study area. The sand plain ranges in thickness from less than a metre to over 25 metres in isolated areas (Barnett, 1982).

Map 2.3: Physiography of Long Point Region



Produced using information provided by the Ministry of Natural Resources, Copyright © Queen's Printer, 2007. CHAPMAN, L.J. AND PUTNAM D.F. 1984: PHYSIOGRAPHY OF SOUTHERN ONTARIO; ONTARIO GEOLOGICAL SURVEY, MAP P.2715 (COLOURED). SCALE 1:600 000.

The area east of the communities of Waterford and Simcoe is characterized by low-relief lacustrine clay plain (Chapman and Putnam, 1984), the Haldimand Clay Plain.

The Horseshoe Moraine region situated in the north-western portion of the study area includes several end moraines that provide low to moderate relief above the sand plain and some areas exhibit slightly hummocky topography. Several of these moraines were deposited at the front of the Lake Erie Ice Sublobe during the last glaciation (Chapman and Putnam, 1984). These moraines, which run east-west roughly paralleling the current Lake Erie shoreline, include (from north to south) the St. Thomas, Norwich, Tillsonburg, Courtland, and Mabee moraines. The Paris and Galt moraines also lie within the study area; however, these two moraines are oriented north-south as they were deposited by the Lake Ontario Ice Sublobe and not the Lake Erie Sublobe.

There exists a direct relationship between the surficial geology and the groundwater and surface water hydrology across the study area. In general, areas with clay and fine-grained soils lying at surface (e.g., the Haldimand Clay Plain in the eastern part of the Long Point Region) tend to have more streams and tributaries than those areas with coarser-grained surface sediments. This is because of the low infiltration capacity of clay-rich soils. Precipitation falling on the clay plain commonly travels as overland flow to surface water features rather than infiltrating to the groundwater system. In contrast, areas with coarser sand and gravel at surface (e.g., the Norfolk Sand Plain and moraines) have fewer tributaries as a larger portion of precipitation percolates downward to recharge the groundwater system (Waterloo Hydrogeologic Inc., October 2004).

2.4 Natural Features

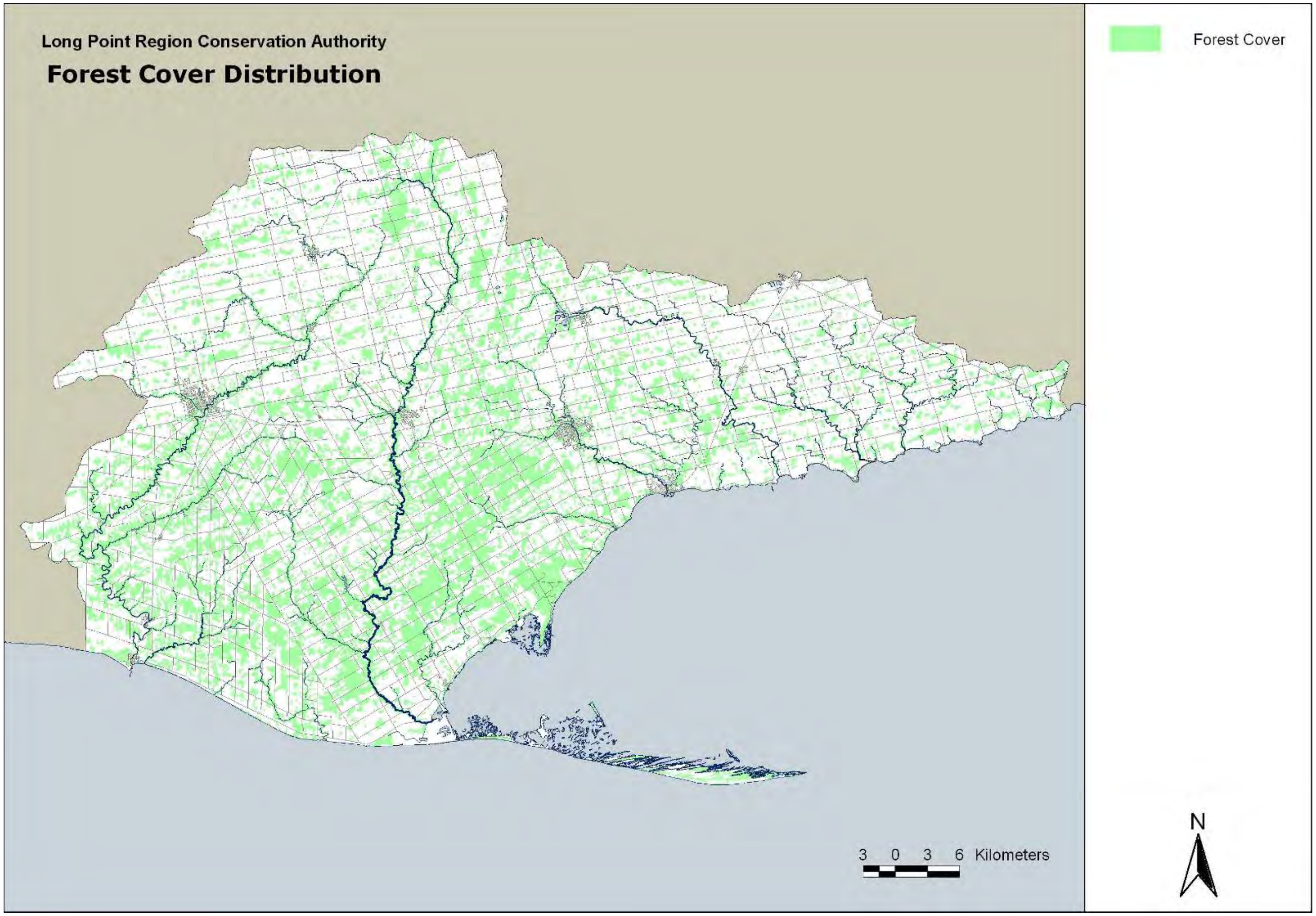
2.4.1 Forests and Vegetation Cover

The majority of land within the Long Point Region (LPR) watersheds is developed as farmland; however, woodlands do occupy about 20 percent or approximately 577 square kilometres of the total area (see **Map 2.4)**. The Long Point Region Conservation Authority is one of the most significant forest land owners in the watershed, along with the Province of Ontario and Norfolk County. Through a private land reforestation program, the Long Point Region Conservation Authority adds close to 45 hectares of future forests to the land cover annually.

The LPR watersheds fall within the Deciduous Forest Region of Canada. Forests within this forest region are typically dominated by Maple, Beech, Ash and Oak species. However, there are significant forest pockets which are representative of the broader Carolinian Life Zone and include species such as Tulip Tree, Black Gum, Sassafras, Black Oak, and Cucumber Tree. These tree species are rare in Canada and occur naturally only in southern parts of Ontario north of Lake Erie. The LPR woodlands also support a variety of shrubs and herbaceous species typical of the Carolinian Zone, the Deciduous Forest Region and the more northerly Great Lakes - St. Lawrence Forest Region.

Fauna species, particularly birds, reflect to a large degree the patterns of vegetation. Many southern or Carolinian bird species (e.g. Chuck-will's-widow, Red-bellied Woodpecker, Acadian Flycatcher, Hooded Warbler, Yellow-breasted Chat) are found in the deciduous forests of the watershed. Species typical of the more northerly Great Lakes - St. Lawrence Forest Region include Broad-winged Hawk, Yellow Bellied Sapsucker, Golden Crowned Kinglet, Red-breasted Nuthatch, Solitary Vireo, and Dark-eyed Junco (Norfolk Field Naturalists, 1987). More detailed descriptions of the flora and fauna within the watershed can be found in Bowles (1997), Brant Field Naturalists (1996) and Norfolk Field Naturalists (1987).

Map 2.4: Forest Cover in Long Point Region



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The Long Point Region Conservation Authority has a rich history of forest management dating back to 1948 when the Big Creek Valley Conservation Authority was formed as one of the earliest of the conservation authorities in Ontario. The Conservation Authorities Act had been passed in 1946 to allow formation of authorities in watersheds where serious resource management problems existed and where there was local, community interest and commitment. One of the first initiatives of the new authority was to recognize the need to protect water-holding areas in head-waters areas of the Big Creek Valley. Both the original *Big Creek Valley Conservation Report* (1953) and the second, *Big Creek Region Conservation Report* (1963), recommended acquisition of some 5,261 hectares or 13,000 acres of forest lands. By 1963, the Big Creek Region C.A. had acquired 952 hectares of forest land (Dept. Lands and Forests, 1963). The Authority's "Forestry Advisory Board" was known to "continually recommend" that "the acquisition of woodlands for the purpose of wind breaks to protect soil, water-holding areas to prevent flooding and drought, recreation and nature trails, wildlife refuge and the demonstration of practical forest management be vigorously pursued."

The Otter Creek Conservation Authority was formed in 1954, and it too had forest land acquisition as one of its early priorities. *The Otter Valley Conservation Report* (1957) recommended the purchase of 1,987 hectares of forest land. By 1962, the Authority's forest land holdings totalled 422 hectares (Dept. Lands and Forests, 1962).

In 1970, the Big Creek Region and Otter Creek conservation authorities amalgamated to form the Long Point Region Conservation Authority. The LPRCA has continued the tradition of land acquisition to protect significant wetland and source-areas and to acquire forest areas with management potential since 1971. Forested land holdings now account for over 3,800 hectares of the total 4,770 hectares of LPRCA lands. The Authority continues to recognize the acquisition and wise management of forest lands for integrated uses as an important part of its mandate, especially for source water protection.

It is now widely accepted that an integrated ecosystem-based approach to forest management is required to maintain the ecological integrity and productive capacity of the forest while providing multiple benefits to society (Heilman, 1990; Kimmins, 1992). This paradigm, termed ecosystem management, is founded on the concept of sustainability. The overall goal for the future management of LPRCA forest lands reflects this approach to management.

The following excerpt from the *Long Point Region Conservation Authority Forest Management Plan* 2000-2019 provides the basis for future forest management in the LPRCA watershed.

(Note: Objective 2 outlines the role of forest management in maintaining water quality and quantity values.)

LPRCA Forest Management Plan: OBJECTIVES AND STRATEGIES

Goal: *To ensure the ecological sustainability of the LPRCA forests and its associated natural heritage features and values through the utilization of an integrated ecosystem-based approach to management.*

The following objectives and strategies will assist the LPRCA in meeting this goal:

Objective 1: ***To maintain healthy forest ecosystems. To conserve the structure, function and natural diversity of the forest environment.***

Strategies:

Manage forests to:

- Provide a diversity of naturally occurring forest types on a variety of site conditions.
- Provide a diversity of flora and fauna characteristic of the region.
- Conserve populations of provincially vulnerable, threatened, or endangered species of flora and fauna and to protect and enhance significant natural features.
- Provide a diversity of wildlife habitat types.
- Provide a diversity of age classes and ensure forest stand development through all seral stages with special consideration for modifying conventional silvicultural systems for managing forests which have the potential to exhibit characteristics associated with late seral ("old growth") forests.
- Conserve water quantity and quality.

Objective 2: To conserve downstream water quantity and quality.

Strategies:

- All management within the Authority's forest properties shall promote conservation of water quantity and quality consistent with the LPRCA Watershed Strategies.
- Maintain forest cover through proper forest management techniques and by planting trees where appropriate and where lands are available.
- In consultation with partners, develop standards and guidelines for forestry practice which will protect soil, water quality and quantity, and riparian habitats during and after forest management operations.
- Maintain access roads and trails in good condition. Install culverts where necessary to maintain water flow where access roads cross streams and seeps.

Objective 3: To conserve Natural Heritage Woodlands.

Strategies:

- The Authority should develop a Natural Heritage strategy for protecting rare and unique forest communities.
- The Authority should protect 20% of its forest lands as Natural Heritage Woodlands.
- All management within Backus Woods shall be subject to the Management Plans for Backus Woods (December 1986) and the Conservation Easement Agreement for Backus Woods (LPRCA, OHF, MNR December 1989).
- The Authority has also proposed Watson Conservation Area as a Natural Heritage Woodland.
- In addition to Backus Woods and Watson Conservation Area, the Authority should protect one or more forest properties (or attempt to acquire) and/or areas within properties as Natural Heritage Woodlands to achieve a target of 20% of forest land so designated.

***Objective 4*: To facilitate public input and expert guidance into the management of LPRCA forests.**

Strategies:

- The Authority should establish a five part program for public consultation including:
- Opportunities to obtain scientific and technical input to assist with the development of forest policies and management strategies.
- Partnerships with local interest groups for demonstration projects and for implementing management activities.
- Opportunities to co-manage forest lands with other public forest owners where possible and appropriate, especially where the other public forest is adjacent to LPRCA forest lands.
- Opportunities for public input to forest management plans, 5-year schedules of management activities, and annual work programs.
- Where applicable, submit “Notice of Intent” to harvest and a copy of the silvicultural prescription to the appropriate municipal or regional authorities.

Objective 5: To demonstrate leadership and excellence in forest management.

Strategies:

- The Authority should adopt applicable principles, criteria and indicators for sustainable forest management as established by the Canadian Council of Forest Ministers (CCFM, 1995).
- In consultation with its partners, the Authority should review standards and guidelines for forestry practice and develop performance standards and practices which are appropriate for the various forest communities within the watershed and reflect the Authority’s objectives for forest management on its properties.
- Manage all forest areas as examples of sustainable forest management.
- Designate and promote one or more properties or areas within properties as highly visible demonstration areas of the application of various silvicultural systems and sustainable management practices.

Objective 6: To manage forest resources for multiple benefits.

Strategies:

- Promote responsible recreational, educational, scientific uses of forest properties.
- Promote Natural Heritage Woodlands and demonstration forest areas as tourism destinations.
- Encourage the use of forest properties for outdoor education.
- Manage forests to provide a variety of habitats for wildlife.
- Identify properties or parts of properties which can be managed for timber production, in conjunction with the Authority’s forest management goals/objectives.

- Encourage the use of forest properties for scientific research, especially Backus Woods and Authority lands within the south Walsingham Sand Ridges Carolinian Canada site.

Objective 7: To protect the integrity and health of the forest.

Strategies:

- In consultation with the local, provincial, and federal authorities as appropriate, implement management practices to promote forest health, including a strategy for monitoring of insects and disease.

- Develop a program for the control of invasive and exotic species in LPRCA forests.

- Work with watershed residents to remove rubbish from forest properties and to control illegal dumping of rubbish and theft of trees on Authority properties.

- Implement a program to install gates at all access points and to mark property boundaries.

Objective 8: To acquire additional forest lands.

Strategies:

- Additional forest areas should be targeted for acquisition as opportunities arise with priority given to those lands which conform to the LPRCA land acquisition guidelines (LPRCA, 1995) and complement the overall goal and forest management objectives.

- The Authority should continue to place not less than 50% of annual net revenues in reserve to provide funds for future land acquisition.

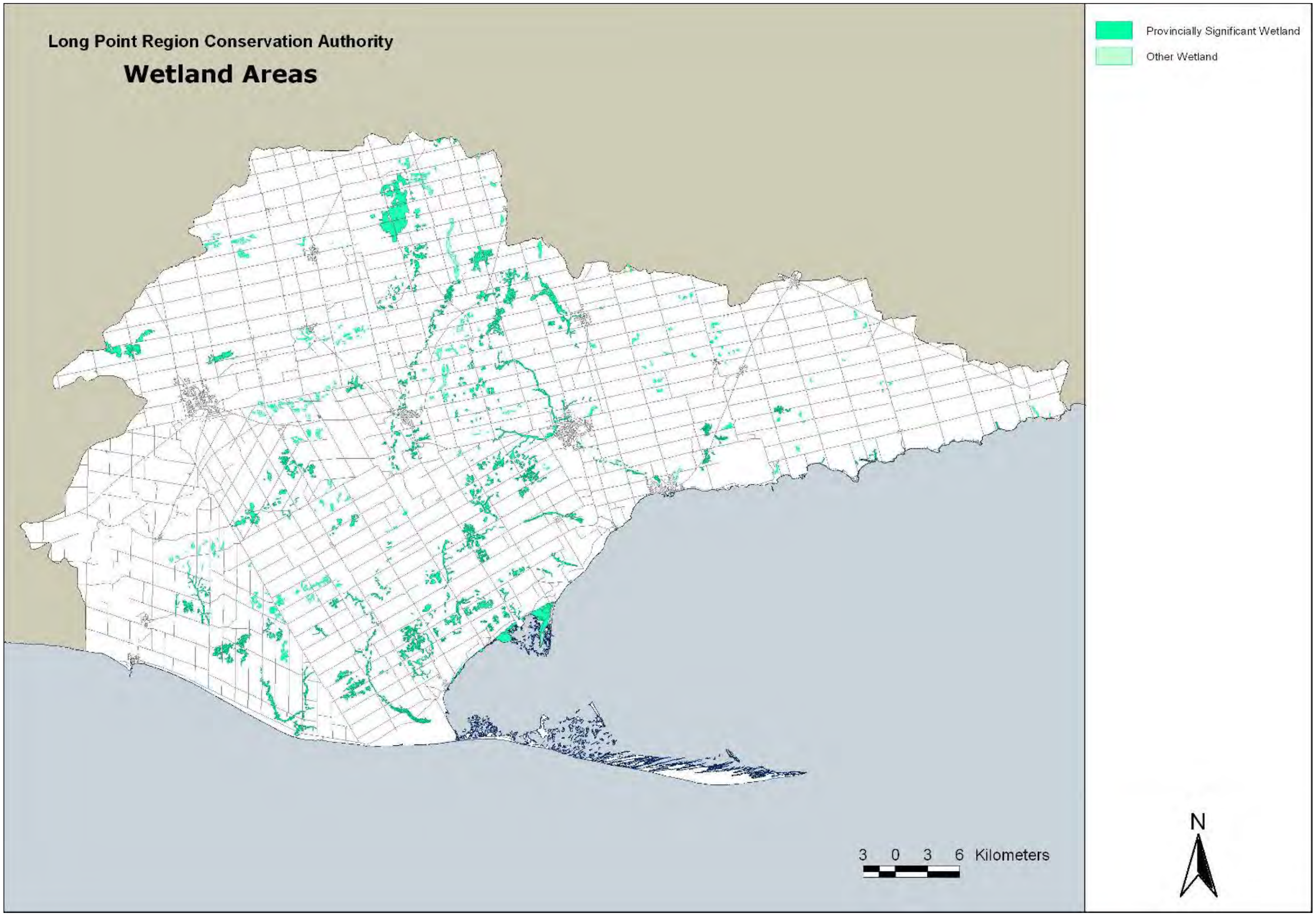
(Long Point Region Conservation Authority Forest Management Plan 2000 – 2019)

2.4.2 Wetlands

Wetlands are a significant feature of the watershed. Although a large percentage of the original wetlands have been lost through clearing, filling and drainage, there are still almost 160 square kilometres of evaluated wetlands in the Long Point Region watersheds (**Map 2.5**). The Long Point wetland complex, which includes the wetlands at the mouth of Big Creek, covers 75 square kilometres on its own. This wetland is internationally recognized under the Ramsar Convention and as the Long Point Biosphere Reserve.

The inland wetlands are no less valuable, especially for their role as protector of our surface and groundwater resources. These wetlands absorb heavy rainfall and runoff events and release these waters slowly over time, either as surface flow or as recharge to the groundwater aquifers. The vegetation of the wetland also helps by filtering out contaminants.

Map 2.5: Wetlands in Long Point Region Watershed



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Efforts are ongoing to reverse the trend of wetland loss. The LPRCA, provincial and municipal governments, and private landowner partners are undertaking projects to redesign drainage systems through wetlands and constructing new artificial wetlands. Other actions are taking place through the municipal development plan review process, which implements provincial policies for the protection of the wetlands and Conservation Authority regulations which can be used to prevent the loss of their hydrologic functions. Many of the forest properties that the LPRCA has acquired over the years have a wetland component.

2.4.3 Wetland and Forest Riparian Areas

All wetlands and forest cover help protect and enhance water quantity and quality values of the watershed. Depending on the issues impacting the water resources, the forest and wetland cover that acts as an immediate buffer to the surface streamflow can be even more valuable.

Within the LPR watersheds, the amount of riparian forest and wetland along the watercourses are estimated at 40 percent, (based on a 15 metre buffer on each side of the stream). In addition, many of these watercourses have been provided with a grassed buffer by landowners using best management practices.

The following describes an example of the typical work being undertaken in this area to improve the riparian areas:

2.4.3.1 South Creek Sub Watershed Riparian Buffer Restoration

Situated within Norfolk County, the South Creek subwatershed occupies an area of 27.5 square kilometres (2,746 hectares). South Creek is a tributary of North Creek which flows into Big Creek at Delhi below the Lehman’s Reservoir. South Creek flows from west to east through a 29.6 kilometre network of municipal drains and streams that outlet into North Creek at the Lehman’s Reservoir, a secondary source of drinking water supply for the town of Delhi, Ontario.

Agricultural land use practices and rural homesteads in the South Creek subwatershed have a high demand for water. Irrigation of agricultural crops is a common practice to improve crop yields with 66 permits to take water registered with the Ontario Ministry of Environment. There are 120 rural drinking water wells associated with homesteads.

Ecosystem components (natural areas) like riparian areas, wetland and forest cover are critical components of surface and ground water flow pathways. They are “hydrological features” as they function to provide water quality and quantity benefits to all users. They are considered “green” infrastructure and provide an integral ecological contribution to ecosystem and community health, source water protection and long-term farm sustainability. Properties of watersheds such as extent (percent riparian buffer cover) of naturally vegetated areas can be used as measures of watershed health.

The South Creek subwatershed, situated in the Norfolk Sand Plain, represents a typical watershed within agricultural landscape of Southwestern Ontario. The area supports a diverse array of agricultural business practices (75.1 percent agriculture land use) that require drainage to meet farm business objectives. South Creek, like many other streams in the agricultural landbase, has been straightened and modified to promote artificial sub-surface drainage from agricultural fields. This modification has removed some of the riparian corridor and natural attributes essential to the physical integrity, aquatic habitat and water quality/quantity associated with healthy ecosystems (as summarized in **Table 2.2**).

The South Creek subwatershed has a very low amount of riparian buffer; thereby putting water resources are at risk and vulnerable. Federal guidelines state that 75 percent of first to third order streams should be naturally vegetated in order to achieve a healthy ecosystem and associated community benefits (Environment Canada).

In recent years, three BMP projects of this nature have been successfully completed by Norfolk County with farmers in the South Creek subwatershed on municipal drains. What has become apparent from this is that there is a desire by farmers to implement BMPs that will effectively protect and enhance water resources, provide benefits to their farm operation, reduce drainage ditch maintenance costs and be at no financial cost to them as a participating landowner.

Table 2.2: South Creek Subwatershed Natural Areas Summary

Natural Area	Total Amount	Sub Watershed %	Restoration Target (%)	Analysis (Comments)
Forest Cover	467.5ha	17	30	Average % forest cover for Norfolk County is 25% but fragmentation is a concern.
Wetland	216.2ha	7.9	10	Wetland protection and restoration BMP's initiated with farmers through the Wetland Drain Restoration Project.
Riparian Buffer	11936m	30.4	75	Very low amount of buffer; high restoration priority.

2.5 Climate

The Long Point Region, which has low latitude and elevation compared to other parts of Southern Ontario, has a moderate temperate climate. A moderate temperate climate denotes a moderate, even precipitation throughout the year and a temperatures ranging from warm to hot and humid in summers to below freezing in winter. Winters are mild compared to the rest of Ontario due to its southerly location. The proximity to Lake Erie also creates a moderating effect. With Lake Erie to the south, winds coming across the lake are warmer in winter and cooler in summer than the land, thereby moderating air temperatures over the watershed.

Climate in Southern Ontario is quite varied throughout the year and although there are forecasted normals and averages, the daily and seasonal weather patterns can be quite different and unpredictable. This region is affected by jet streams, lake effects from the Great Lakes, high and low pressure cells and clashing weather coming from the cold Arctic and the warm moist Gulf of Mexico. It is, thus, easier to discuss the normal climate patterns of the year than to predict the daily weather patterns in such a complicated climatic zone.

General weather patterns in this region consist of four seasons, including winters that see some precipitation in the form of snow, and summers that are hot and humid. **Figure 2.1** shows the daily average and extreme temperatures for the region, for each month of the year. Winter is generally considered to have temperatures lower than zero degrees Celsius, beginning in December and lasting until late February or early March. Spring usually lasts two months, followed by four months (June to September) of summer and two months of autumn (Sanderson, 1998). The average annual temperature is about seven and a half to eight degrees Celsius. Extreme temperatures in this region have been known to reach as low as -37 degrees Celsius in January and as high as 40 degrees Celsius in July (see **Table 2.3**).

Figure 2.1: Long-term Average Monthly Temperature and Precipitation in Long Point Region

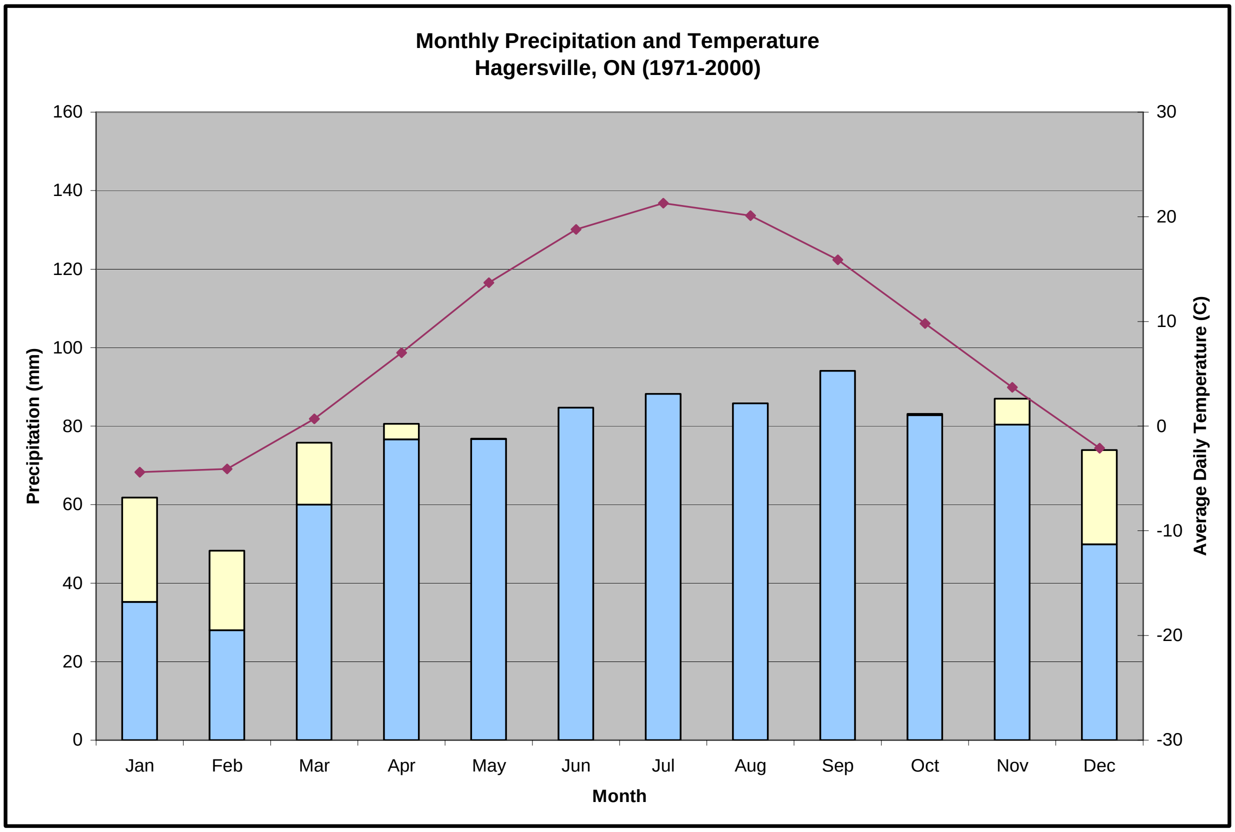

Table 2.3: Normal and Extreme Daily Temperatures, 1971-2000

Location	Temperature	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Culloden Easey	Daily Average (°C)	-6.3	-5.2	-0.1	6.5	13.5	18.4	20.8	19.8	15.4	9.1	3.1	-3	7.7
	Standard Deviation	2.9	2.9	2.1	1.6	2.2	1.3	1.1	1.2	1	1.4	1.6	2.8	
	Daily Maximum (°C)	-2.9	-1.6	3.9	11.2	19	23.9	26.4	25.2	20.5	13.5	6.4	0.1	
	Daily Minimum (°C)	-9.8	-8.9	-4.1	1.8	8	12.9	15.2	14.3	10.3	4.6	-0.2	-6.1	
	Extreme Maximum (°C)	15	18	23	29	32	36	37	36	33	25	20.6	18	
	Extreme Minimum (°C)	-30	-28	-23	-13	-4	1	6	1	-2.2	-7.8	-15		
Delhi CDA	Daily Average (°C)	-5.7	-5.3	0	6.6	13.2	18.4	20.9	20	15.6	9.4	3.5	-2.5	7.8
	Standard Deviation	2.8	2.6	2.1	1.6	1.9	1.3	0.9	1.2	1	1.7	1.6	2.5	1.3
	Daily Maximum (°C)	-2.1	-1.3	4.4	11.9	19.3	24.4	27	25.7	20.9	14.2	7.2	1	12.7
	Daily Minimum (°C)	-9.4	-9.4	-4.3	1.2	7.1	12.3	14.8	14.2	10.2	4.5	-0.2	-5.9	2.9
	Extreme Maximum (°C)	18.3	16	25	29.5	33	36.7	**40.6**	36.7	36.1	31.7	25	19.5	
	Extreme Minimum (°C)	-33.9	-30	-25	-15	-6.1	-1.7	3.3	-0.6	-3.9	-9.4	-18.9	-28	
Dunville Pumping Station	Daily Average (°C)	-4.8	-4.6	0	5.7	11.9	17	20.4	20.1	16.2	10	4.6	-1.2	7.9
	Standard Deviation	2.7	2.5	1.9	1.5	1.4	1.2	0.9	1	0.8	1.6	1.4	2.5	
	Daily Maximum (°C)	-1.3	-0.8	4	10.1	16.5	21.2	24.6	24.3	20.4	14.1	8.2	2.2	
	Daily Minimum (°C)	-8.3	-8.3	-4	1.3	7.2	12.7	16.2	15.9	12	5.8	1.1	-4.6	
	Extreme Maximum (°C)	10.6	15	23	28.5	29.5	32	33	31.7	29.4	24.4	19.5	16.1	
	Extreme Minimum (°C)	-28.5	-27	-22.8	-14	-3.3	1.7	5.6	2.5	-1.7	-8.3	-13	-27	
Foldens	Daily Average (°C)	-6.3	-5.4	-0.3	6.5	13.3	18.3	20.7	19.9	15.7	9.4	3	-3.1	7.6
	Standard Deviation	2.7	2.7	2.2	1.6	2.1	1.4	1.1	1.2	1.1	1.7	1.6	2.7	0.8
	Daily Maximum (°C)	-2.9	-1.8	3.6	11.2	18.7	23.6	25.9	25	20.6	13.7	6.3	0	12
	Daily Minimum (°C)	-9.7	-9	-4.3	1.7	7.9	12.9	15.4	14.8	10.8	4.9	-0.3	-6.2	3.3
	Extreme Maximum (°C)	15	19	24	29.5	32.5	35.5	36.5	37	33.3	28.3	20.6	18	
	Extreme Minimum (°C)	-31	-26.5	-22.8	-13	-4	0	4	2	-1.1	-8.3	-15.5	-24	
Hagersville	Daily Average (°C)	-4.4	-4.1	0.7	7	13.7	18.8	21.3	20.1	15.9	9.8	3.7	-2.1	8.4
	Standard Deviation	2.4	2.4	1.9	1.5	2	1	1.5	1.2	1	1.2	1.5	2.8	1.5
	Daily Maximum (°C)	-0.7	-0.2	5.1	12.1	19.4	24.5	26.9	25.5	21.1	14.4	7.2	1.2	13.1
	Daily Minimum (°C)	-8	-8	-3.8	1.8	7.9	13	15.7	14.6	10.6	5	0.1	-5.3	3.6
	Extreme Maximum (°C)	15	18	25.5	30.5	32.5	35.5	38.5	36.5	32	28.5	20	18	
	Extreme Minimum (°C)	-26.5	-26	-20	-11	-2.5	2	4.5	4	-2	-6	-14	-23	
Port Stanley	Daily Average (°C)	-5.5	-5.2	0	6.1	12.4	17.2	20	19.4	15.6	9.4	4.1	-2	7.6
	Standard Deviation	2.7	2.7	1.9	1.4	1.6	1.2	0.8	1.1	0.9	1.7	1.4	2.7	1
	Daily Maximum (°C)	-1.7	-0.9	4.1	10.6	17.6	22.2	25.2	24.6	20.8	14.2	7.7	1.5	12.2
	Daily Minimum (°C)	-9.4	-9.5	-4	1.6	7.2	12.2	14.7	14.1	10.4	4.5	0.4	-5.4	3.1
	Extreme Maximum (°C)	14.4	13	21	27.2	31.7	34.4	34.4	33.9	31.7	25.6	20	15.5	
	Extreme Minimum (°C)	-32.8	-32	-27.2	-16.7	-5	-0.6	3.3	0	-2.2	-8.3	-18.9	-31.7	
Woodstock	Daily Average (°C)	-6.3	-5.4	-0.3	6.4	13.2	18.2	20.4	19.6	15.4	9.1	3.1	-3	7.5
	Standard Deviation	2.8	2.8	2.3	1.7	2.1	1.3	1	1.2	1.1	1.7	1.6	2.7	0.8
	Daily Maximum (°C)	-2.3	-1.1	4.2	11.6	19.2	24.1	26.4	25.3	20.9	14.1	6.8	0.5	12.5
	Daily Minimum (°C)	-10.2	-9.6	-4.8	1.1	7.1	12.2	14.5	13.7	9.8	4.1	-0.7	-6.5	2.6
	Extreme Maximum (°C)	18.3	20	25	30.5	35	37	38.9	36.1	37.2	29.4	22.8	18	
	Extreme Minimum (°C)	**-36.7**	-32.2	-31.1	-16.7	-6.7	-0.5	2.8	0.6	-3.9	-10.6	-21.1	-29.4	

Annual average precipitation over the watershed is generally between 950 to 1,075 millimetres, as seen in **Map 2.6**. There is no rainy season in this region; precipitation is fairly evenly distributed throughout the year. A majority of precipitation in the winter still falls as rainfall instead of snowfall. Even in the coldest month of January, more than half the precipitation falls as rain, and the rest is snowfall. Snowfall across the LPRCA is between 100 centimetres to 150 centimetres between the months of November to April (see Table 2.4).

Map 2.6: Annual Average Precipitation in Long Point Region, 1971-2000

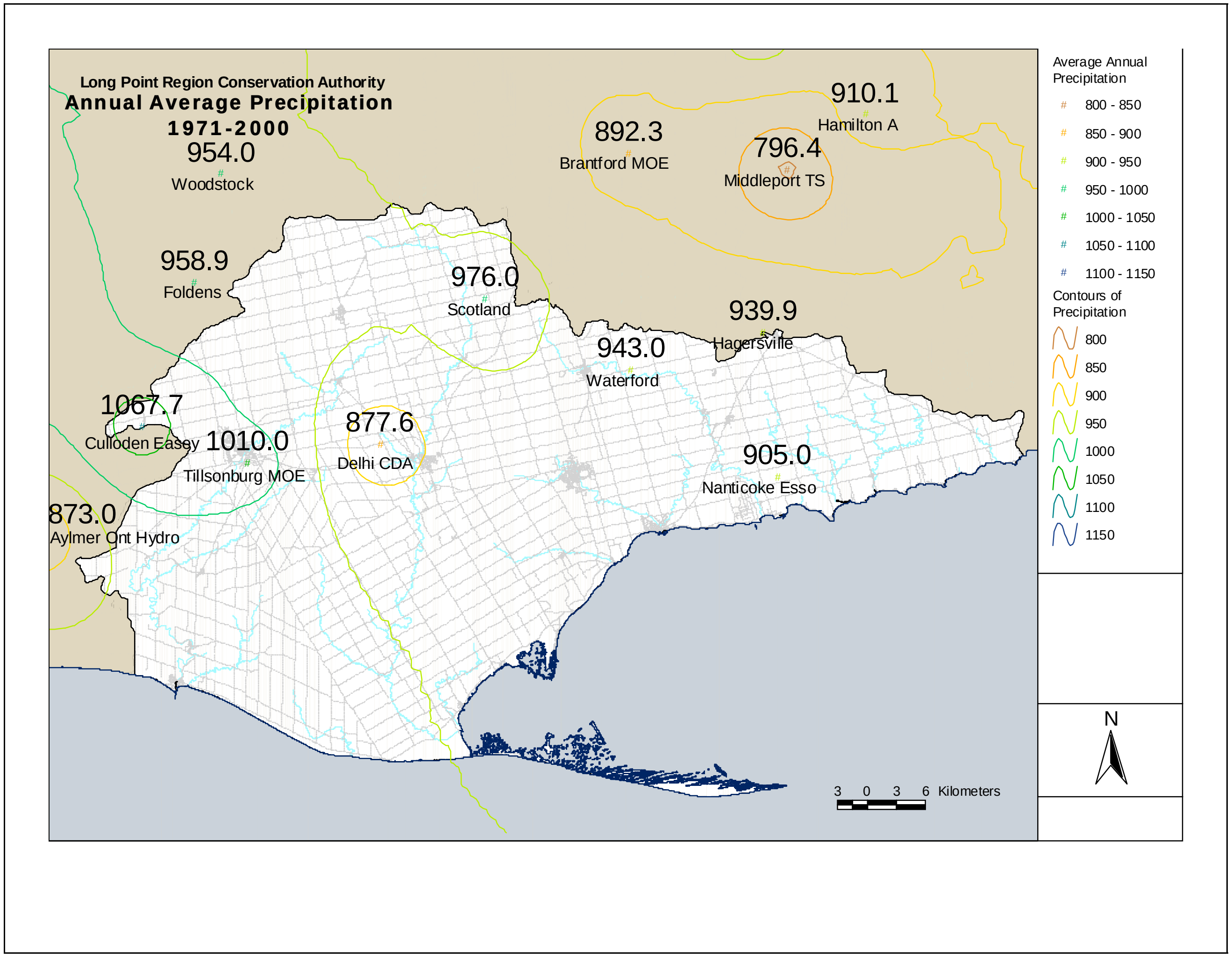

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Table 2.4: Normal Precipitation Average from 1971-2000 in Long Point Region

Location	Precipitation	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Aylmer Ont Hydro	Rainfall (mm)	49	38.2	53.9	78.2	80.1	86.4	81.4	86.9	89.2	82.9	87.6	59.2	872.9
	Snowfall (cm)	37	27.7	19	3.7	0	0	0	0	0	0.3	7.4	21.2	116.3
	Precipitation (mm)	86.1	65.9	72.9	81.9	80.1	86.4	81.4	86.9	89.2	83.2	95.1	80	988.8
	Extreme Daily Rainfall (mm)	80	45.6	29.2	47.8	45.2	53.4	79.6	65.2	75.4	67	60.6	40	
	Extreme Daily Snowfall (cm)	20.2	29	16.4	11.4	0	0	0	0	0	2.5	12	19.4	
	Extreme Daily Precipitation (mm)	80	45.6	36.2	47.8	45.2	53.4	79.6	65.2	75.4	67	60.6	42	
Culloden Easey	Rainfall (mm)	36.8	31.2	59	84.9	84.2	94.7	95.3	90.7	101.5	86	92.8	56	913.1
	Snowfall (cm)	43.7	28.8	22.9	5.3	0.2	0	0	0	0	0.9	13.5	39.1	154.4
	Precipitation (mm)	80.5	60	81.9	90.2	84.4	94.7	95.3	90.7	101.5	87	106.4	95.1	1067.7
	Extreme Daily Rainfall (mm)	54.4	52.6	62	51.8	60.4	116	68.4	88.4	58.8	68.4	63.6	38.8	
	Extreme Daily Snowfall (cm)	30	19	20	12	5	0	0	0	0	6	17	25	
	Extreme Daily Precipitation (mm)	54.4	52.6	62	51.8	60.4	116	68.4	88.4	58.8	68.4	63.6	38.8	
Foldens	Rainfall (mm)	32.7	28.3	57.2	73.9	77.1	86.6	98.8	93.3	91.7	76.1	76.6	47.2	839.4
	Snowfall (cm)	32.9	23.1	17.1	5.6	0.4	0	0	0	0	1	11	28.5	119.5
	Precipitation (mm)	65.6	51.3	74.3	79.4	77.5	86.6	98.8	93.3	91.7	77.1	87.6	75.7	958.9
	Extreme Daily Rainfall (mm)	40.6	47.2	50.8	47.2	53	78.4	110	102.4	73	74.6	64	63	
	Extreme Daily Snowfall (cm)	22.9	16.8	23.4	15	4	0	0	0	0	8.4	17.8	24.1	
	Extreme Daily Precipitation (mm)	40.6	47.2	50.8	47.2	53	78.4	110	102.4	73	74.6	64	63	
	Extreme Snow Depth (cm)	17	17	6	2	0	0	0	0	0	3	6	17	
Hagersville	Rainfall (mm)	35.2	28	60	76.6	76.7	84.7	88.2	85.8	94.1	82.8	80.4	49.9	842.4
	Snowfall (cm)	26.6	20.3	15.8	4	0.1	0	0	0	0	0.3	6.6	24	97.5
	Precipitation (mm)	61.8	48.2	75.7	80.6	76.9	84.7	88.2	85.8	94.1	83.2	86.9	73.9	939.9
	Extreme Daily Rainfall (mm)	37.6	43.2	46.7	38.9	47.5	80	78.4	82.6	64.6	87.4	77	40.4	
	Extreme Daily Snowfall (cm)	25.4	17.8	27.9	10.2	3	0	0	0	0	6	45.7	23	
	Extreme Daily Precipitation (mm)	37.6	43.7	46.7	38.9	47.5	80	78.4	82.6	64.6	87.4	78	40.4	
Nanticoke Esso	Rainfall (mm)	31.2	36.7	66.2	81.1	73.9	83.6	95.4	90.2	110.5	85.5	83.8	66.8	904.9
	Snowfall (cm)	33.1	30.9	13.3	2.6	0	0	0	0	0	0.3	4.3	33.4	117.9
	Precipitation (mm)	64.3	67.5	79.5	83.7	73.9	83.6	95.4	90.2	110.5	85.7	88.1	100.2	1022.6
	Extreme Daily Rainfall (mm)	35.7	41	37.6	46.8	45	51.2	90.2	83	63	54.1	74.6	58.2	
	Extreme Daily Snowfall (cm)	33	53.5	12	10.2	0	0	0	0	0	5	23.4	35.1	
	Extreme Daily Precipitation (mm)	35.7	53.5	37.6	46.8	45	51.2	90.2	83	63	54.1	74.6	58.2	
	Extreme Snow Depth (cm)	19	39	25	2	0	0	0	0	0	0	5	15	
Tillsonburg	Rainfall (mm)	40.3	35.7	66.5	77.6	81.8	87	87	82.8	94	82.9	85.5	61.1	882.1
	Snowfall (cm)	35.5	26.7	17.9	4.6	0.1	0	0	0	0	0.4	10.5	31.9	127.6
	Precipitation (mm)	75.9	62.4	84.4	82.2	81.8	87	87	82.8	94	83.3	96	93	1009.7
	Extreme Daily Rainfall (mm)	51.4	48	45.7	51	51.8	89.7	76	67.3	61.2	87.4	63.8	56.1	
	Extreme Daily Snowfall (cm)	22.9	22.4	15	25	2	0	0	0	0	12.7	15.2	21.4	
	Extreme Daily Precipitation (mm)	51.4	48	45.7	51	51.8	89.7	76	67.3	61.2	87.4	63.8	56.1	
	Extreme Snow Depth (cm)	50	41	25	4	0	0	0	0	0	0	11	31	
Waterford	Rainfall (mm)	30.7	28	54.5	70.4	73	87.2	89.2	81.1	98	76.3	73.7	51.2	813.4
	Snowfall (cm)	37.4	27.4	17.8	4.5	0.2	0	0	0	0	0.7	8.2	32.7	129
	Precipitation (mm)	68.3	55.4	72.3	74.9	73.3	87.2	89.2	81.1	98	77.1	81.9	83.9	942.5
	Average Snow Depth (cm)	5	5	2	0	0	0	0	0	0	0	0	3	
	Median Snow Depth (cm)	4	4	1	0	0	0	0	0	0	0	0	1	
	Snow Depth at Month-end (cm)	4	4	1	0	0	0	0	0	0	0	1	3	
	Extreme Daily Rainfall (mm)	47	48.4	43.4	38.8	53.4	89.9	115	45.4	76.6	65	60.6	38.4	
	Extreme Daily Snowfall (cm)	30	30	15	11	5	0	0	0	0	7	15	21	
	Extreme Daily Precipitation (mm)	47	48.4	43.4	38.8	53.4	89.9	115	45.4	76.6	65	60.6	38.4	
	Extreme Snow Depth (cm)	55	35	30	15	0	0	0	0	0	3	15	27	

The seasonal thaw of spring often brings long, low intensity rainfall and when coupled with the melting snow can make the spring season appear to be constantly wet and overcast. The summer often brings short, high intensity rainfalls with high evapotranspiration rates, which makes precipitation appear to be infrequent and less than the other seasons. As seen in **Figure 2.1**, precipitation amounts are in actuality slightly lower in the winter months and higher in the summer and fall months, despite the perception of wetter winters and drier summers in this region.

Map 2.6 shows the average annual precipitation in the Long Point Region watersheds. The water requirements for human and environmental purposes over the course of the year, however, are quite variable. The demands on the climate to replenish the streams and groundwater aquifers are often not met during the summer months, while the winter and spring seasons often see a surplus of water for human and environmental needs.

In any given month the amount of rain and snow varies greatly and a dry month will cause noticeably lower stream flows, while a month of rainy weather will saturate the soil and raise river levels. A winter with little snow accumulation will lead to moderate spring flows; whereas cold winters with heavy snow can lead to heavy spring runoff and floods. Floods or heavy rainfalls in any month can be a concern for drinking water sources, if sewers are unable to handle the excess runoff and treatment plants are forced to bypass before treatment is completed. Also, heavy rainfall may churn up sediments or mobilize nutrients and reintroduce them into the source supply through wells to groundwater or overland to surface water bodies.

Humidity plays a large role in the air temperature in the summer. Winds can help to cool down and circulate the air, but winds from the south can bring more warm and moist air from the Gulf of Mexico. In the winter, winds predominately come from the northwest, which can bring down more cold dry air from the Arctic, creating a wind chill factor.

In addition, the LPRCA is developing programs and models for the use of radar data, in combination with an increased number of precipitation gauge sites to determine climatic patterns and precipitation variation (see **Map 2.7** for locations of precipitation monitoring stations in the Long Point Region watersheds).

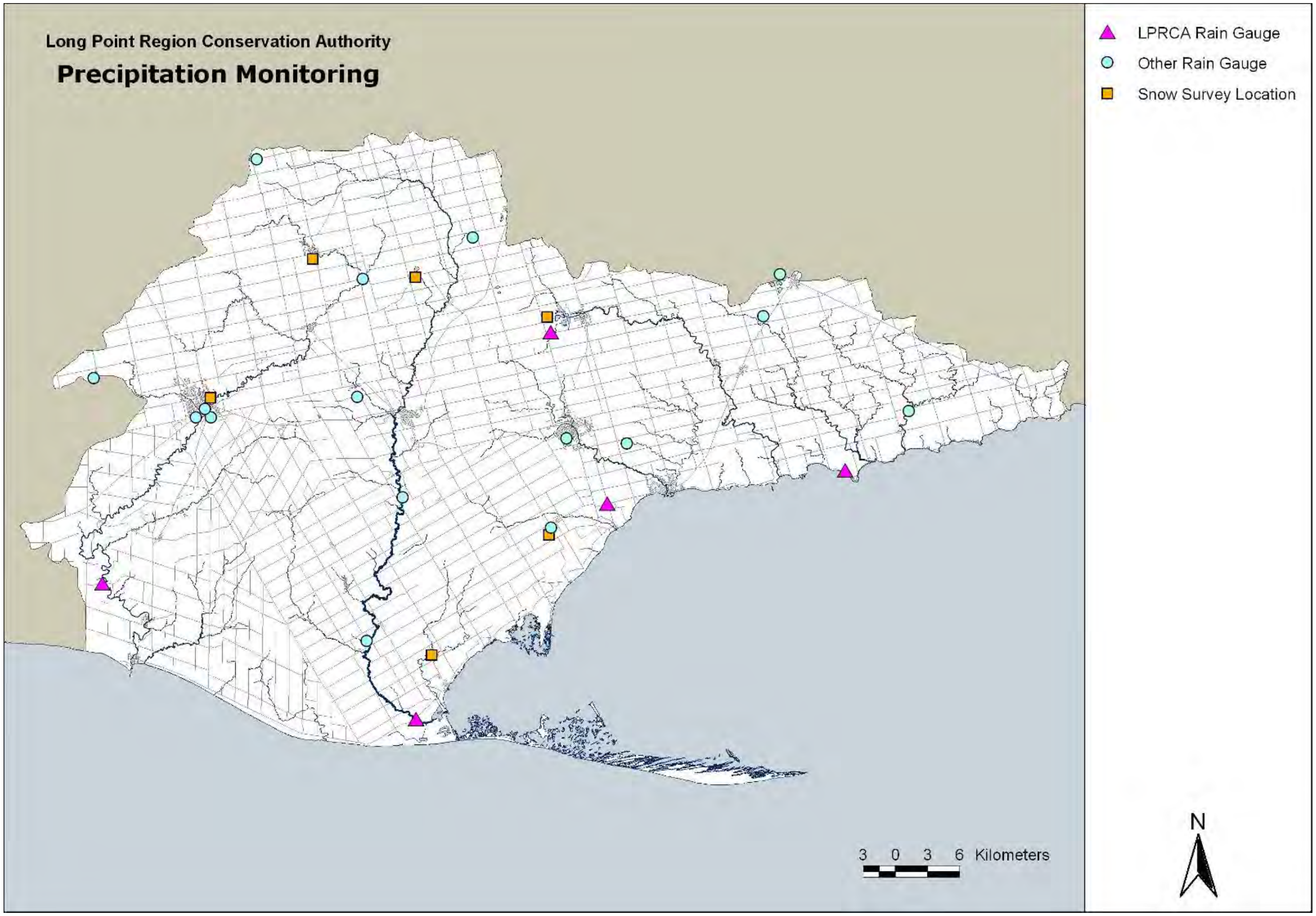
2.6 Hydrology and Hydrogeology

2.6.1 Water Quantity Monitoring

The flow monitoring network in the Long Point Region has been expanded in recent years with the re-opening of a number of historic gauges. There are ten active Water Survey of Canada (WSC) gauges in the Long Point Region as shown on **Map 2.8**. The gauge network is denser in the western part of the region and is focused on the larger watercourses. There are three gauges in the Big Otter Creek watershed covering most of the watershed area. Historic stream flow data is available starting in 1948 with the longest continuous data set from 1960 to present. There are four stream gauges in the Big Creek watershed with two gauges in continuous operation since 1955 and two recently re-opened gauges.

The other three stream gauges are on Young Creek, Nanticoke Creek and the Lynn River. The gauge on Young Creek has been operated for various periods since 1963. The Lynn River gauge has a continuous data set beginning in 1957. The Nanticoke Creek gauge is the only gauge in the eastern part of the region and has been in operation since 1969. There is also historic flow data available for North Creek, Little Otter Creek, South Otter Creek, Dedrick Creek, Patterson Creek, Fishers Creek and Hemlock Creek in the western part, and Sandusk Creek in the eastern part of the region.

Map 2.7: Precipitation Monitoring Stations in Long Point Region



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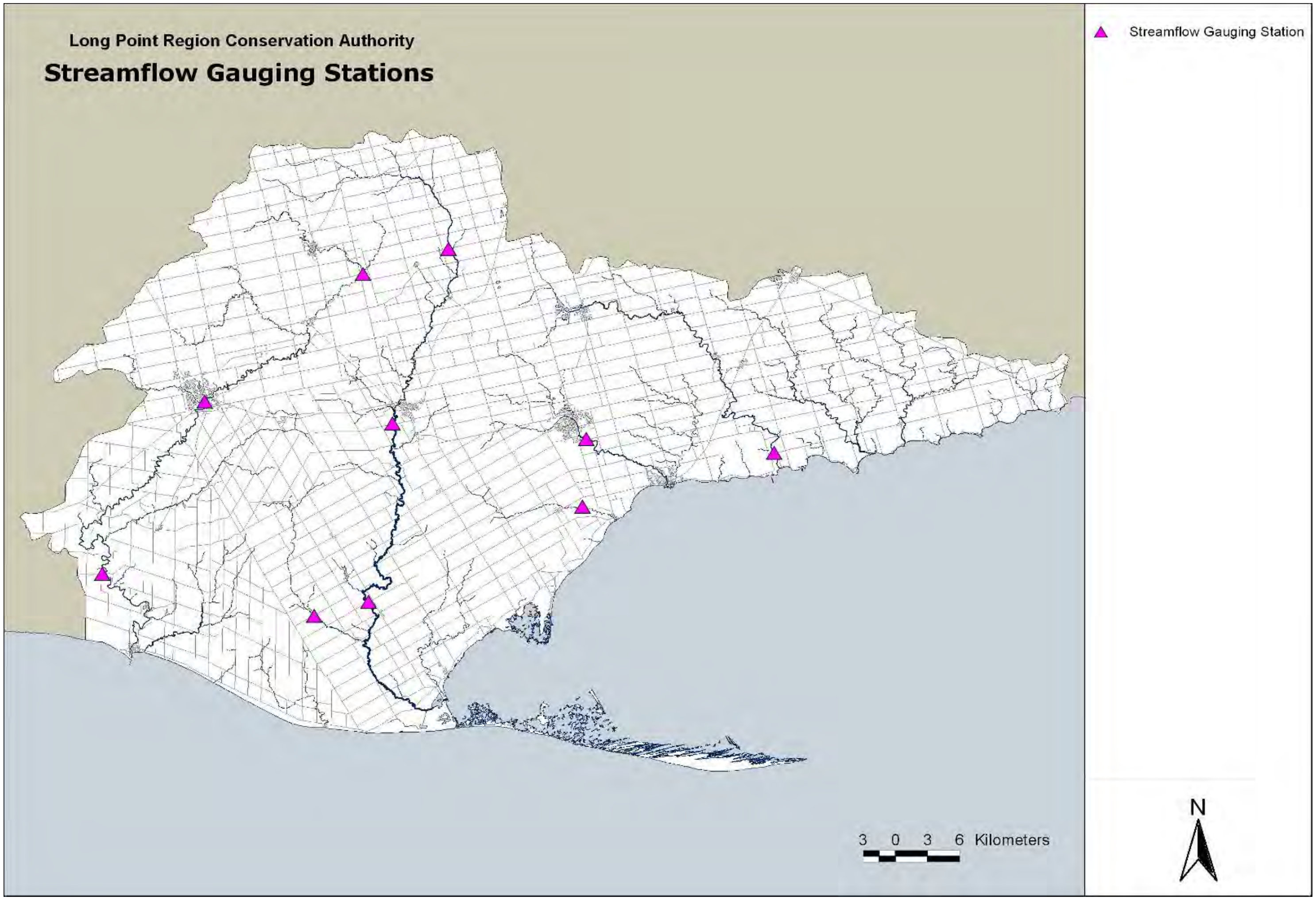
Map 2.8: Streamflow Gauging Stations in Long Point Region



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2.6.2 Surface Water Hydrology

The Long Point Region covers an area of approximately 2,900 square kilometres along the Lake Erie shoreline. The region is comprised of several watersheds and watercourses. The combined length of all the streams and their tributaries within the Long Point Region equal over 3,700 kilometres. The Long Point Region can be broken down into 12 major watershed groups, summarized in **Table 2.5** and described below. Most of the western watersheds are within the Norfolk Sand Plain, an area characterized by low runoff, high soil infiltration and sustained baseflows. The eastern watersheds are within the Haldimand Clay Plain, an area characterized by high runoff and low soil infiltration. The eastern watersheds have a higher density of tributaries than the western watersheds. The river systems are shallower and tend to dry up during the summer months.

Table 2.5: Summary of Watershed Characteristics, Water Usage and Study Locations

Major Watershed Groups	General Characteristics (e.g. physiography, fisheries)	Drainage Area (km^2)	PTTW	Stream Gauges #	Field Study Sites	STPs	Large Storage Areas
Big Otter Creek (Includes Little Otter)	Upper parts Till plain, rest sandy soils Cold water fishery with small coldwater tributaries	712	406	5 (2)		2	2
South Otter Creek	Cold water – sand plain	111	141	2 (2)			
Clear Creek	Cold water – sand plain	105.65	139				
Big Creek	70% sands and Gravels, high baseflow 15% area is forested Numerous cold-water streams	750	1069	7 (3)	42	1	3
Dedrick Creek – Young Creek	Several significant cold water fishery streams	263	224	3 (2)		1	2
Lynn River-Black Creek	Western part on sand plain, Eastern on clay plain, Cool water fishery	285	237	2 (1)	21	1	2
Nanticoke Creek	Upper portion is coldwater fishery Lower portion is warm water	180	186	1		2	2
Sandusk Creek	Situated on Clay plain	158	3	2 (1)		1	
Stoney Creek	Situated on Clay plain	118	3				
Evans Creek	Situated on Clay plain	63	3				
Hickory Creek	Situated on Clay plain	21.5	1				
Fories - Stelco Creek	Situated on Clay plain	4.30					

Notes: number in brackets represent gauges that are no longer in operation. STP denotes sewage treatment plant effluent.

The Long Point Region has among the highest number of permitted surface and ground water users of any area in Southern Ontario (see **Map 2.9**). Demand for irrigation water during the summer months can affect stream flow throughout the region, but is focused in the western watersheds on the Norfolk Sand Plain. Several hundred small dams have been constructed on virtually every tributary of Big Creek and Big Otter Creek and other small watercourses in the watershed, to store water as a source for irrigation. They were constructed mainly in the last half of the 20th century. There are also several old mill dams that were constructed in the 1800's and replaced or maintained in various states since. In addition the LPRCA operates a number of small dams for multipurpose uses, including flood control, low flow augmentation, drinking water supply, irrigation, recreation and wildlife habitat. Selected dams and reservoirs in the Long Point Region are shown on **Map 2.10**.

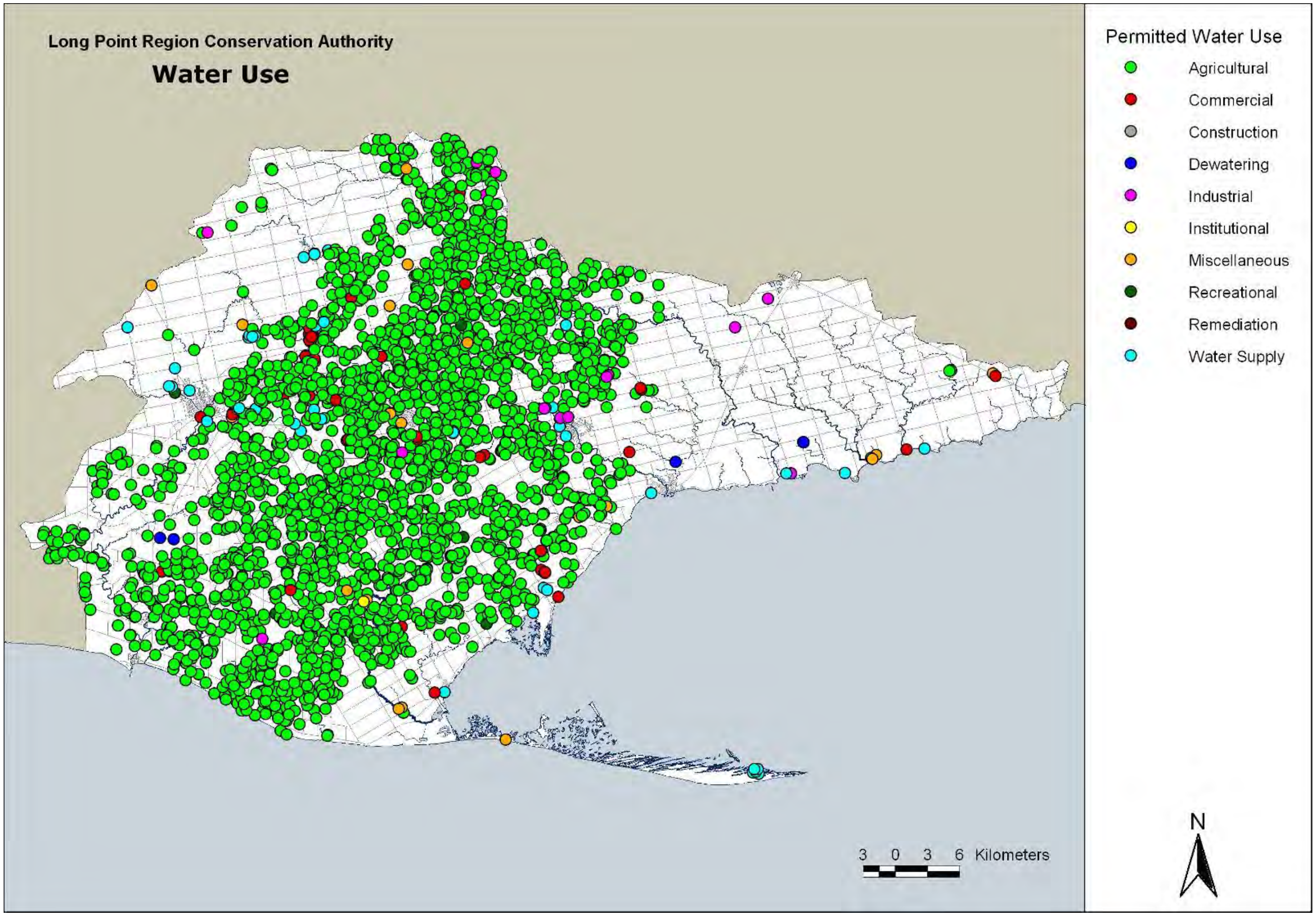
Big Otter Creek

Big Otter Creek is the second largest watershed in the region, draining an area of approximately 712 square kilometres. The upper part of the watershed, in the northwestern corner of the region, is in till plain. The creek flows southward in the Norfolk Sand Plain through the communities of Norwich, Otterville, and Tillsonburg before draining to Lake Erie at Port Burwell. The Big Otter watershed is characterized by moderate runoff, soil infiltration, and base flows. The largest tributary, Little Otter Creek, joins Big Otter Creek past Straffordville. Little Otter is classified as a cold water stream and drains approximately 117 square kilometres.

There are three active gauges in the Big Otter Creek watershed. The first one is located in the upper part of the watershed above Otterville. It was installed in 1964. The second one is located approximately half-way down the watershed at the Town of Tillsonburg. This gauge is the oldest active gauge in the watershed and has been in operation since 1960, except for a brief period from 1998-2002 where flow levels were not taken however water levels were continuously recorded during this time. The final gauge is located near the community of Calton. It has been in operation since 1975 and captures approximately 95 percent of the drainage area including Little Otter Creek. Prior to 1975 the gauge was located downstream near the community of Vienna where it had been in operation since 1948. The flow distribution at the Calton gauge is given in Figure 2 shows both a runoff component with high 90^{th} percentile flows in the spring and a strong groundwater fed baseflow component with steady median and 10^{th} percentile low flows throughout the summer months.

There are two reservoirs on Big Otter Creek which include the Norwich Dam in the community of Norwich and the Otterville Dam in the community of Otterville. The Norwich Dam is operated by LPRCA and is managed through the use of a control valve. Recreation, water supply, flood control and flow augmentation opportunities are provided by the Norwich Dam. The Otterville Dam is not operated by LPRCA but is passively operated by the municipality There are also numerous small, private control structures within the watershed that are used to store water for irrigation. Agricultural and other water users within the watershed can significantly reduce stream flow within Big Otter Creek.

Map 2.9: Permitted Water Takings in Long Point Region by Water Use



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Map 2.10: Selected Dams and Reservoirs in Long Point Region

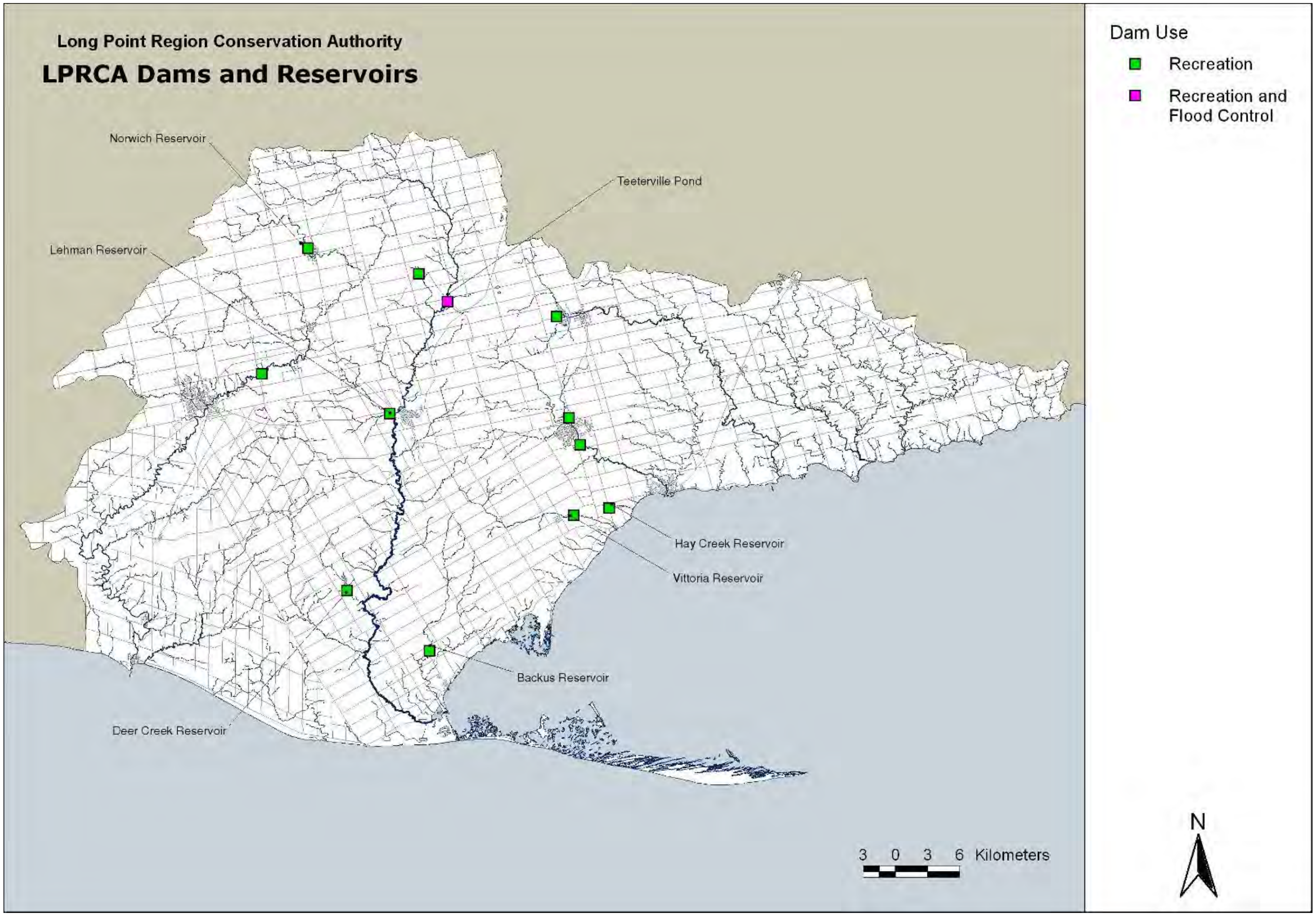

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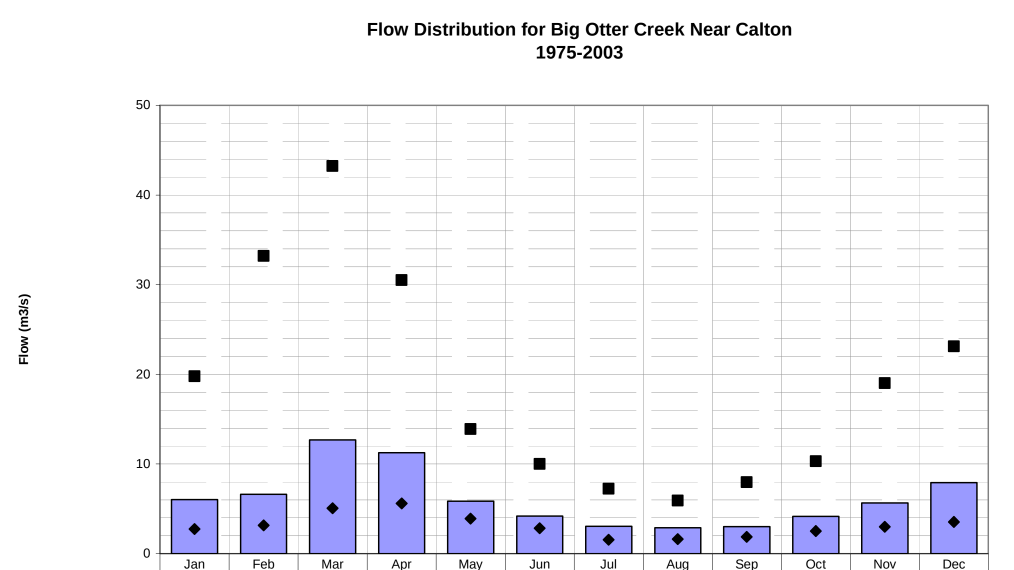
Figure 2.2: Flow Distribution for Big Otter Creek near Calton Gauge

Showing Median, 10th and 90th Percentile Flows



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Median	6.0	6.6	12.7	11.3	5.9	4.2	3.1	2.9	3.0	4.1	5.7	7.9
10th Percentile Flow	2.8	3.2	5.1	5.6	3.9	2.8	1.5	1.6	1.9	2.5	3.0	3.5
90th Percentile Flow	19.8	33.2	43.2	30.5	13.9	10.0	7.3	5.9	8.0	10.3	19.0	23.1

South Otter and Clear Creeks

South Otter Creek drains an area of approximately 111 square kilometres adjacent to the lower portion of Big Otter Creek along the Lake Erie shoreline. Clear Creek is similar in size and drains an area of approximately 106 square kilometres to the east of South Otter Creek. Both creeks are within the Norfolk Sand Plain and are characterized by low runoff, high infiltration, and groundwater fed base flows. There are no active gauges in this watershed grouping, but there was an historic gauge located on South Otter Creek near its outlet to Lake Erie at Port Burwell. The gauge operated from 1964 to 1978.

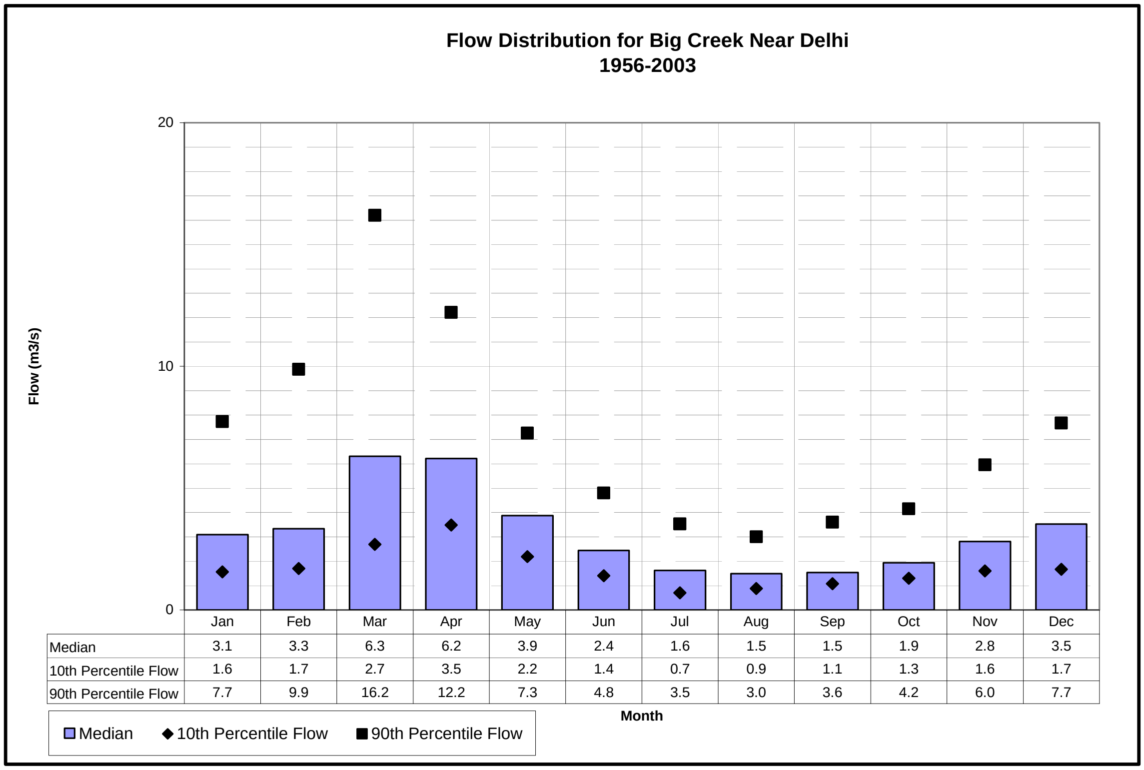
Big Creek

Big Creek is the largest watershed in the Long Point Region with a total drainage area of 750 square kilometres. Big Creek headwaters are at the most northerly part of the region. The creek flows predominately southward through the community of Delhi, where it joins with North Creek through Lehman's Reservoir. From Delhi, stream flow continues southward picking up Venison Creek downstream of Walsingham and finally draining into Lake Erie near Port Rowan.

The Big Creek watershed is on the Norfolk Sand Plain. The watershed is characterized by very low runoff and high baseflow. Water use within the watershed is significant with over 1,000 permits to take water or approximately one and a half permits per square kilometre. Irrigation is the primary water use within the watershed and can significantly reduce summer flows in the creek.

Figure 2.3: Flow Distribution for Big Creek near Delhi Gauge

Showing Median, 10th and 90th Percentile Flows



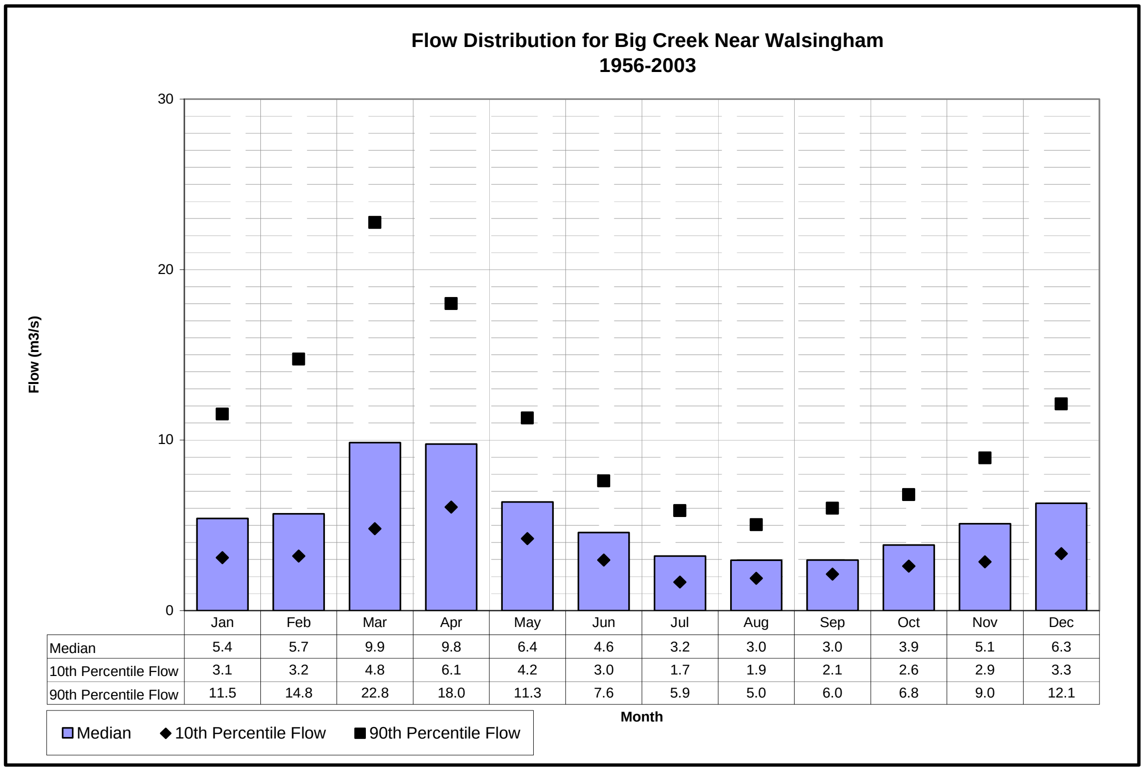
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Median	3.1	3.3	6.3	6.2	3.9	2.4	1.6	1.5	1.5	1.9	2.8	3.5
10th Percentile Flow	1.6	1.7	2.7	3.5	2.2	1.4	0.7	0.9	1.1	1.3	1.6	1.7
90th Percentile Flow	7.7	9.9	16.2	12.2	7.3	4.8	3.5	3.0	3.6	4.2	6.0	7.7

There are three reservoirs in the Big Creek watershed. The Teeterville Reservoir is located in the upper portion of the watershed on Big Creek. It is used for recreation, flood control, and low flow augmentation. Lehman's Reservoir is located in the community of Delhi on North Creek. It is used for recreation (shore fishing) and to supplement the community of Delhi's drinking water supply. The final reservoir is located on Deer Creek, a tributary of Big Creek. Most of the Big Creek tributaries have small private dams and reservoirs used for irrigation.

The narrow monthly flow distribution in **Figure 2.3** and **Figure 2.4** shows the moderating effects of high soil infiltration and reservoir operations upstream of the gauge. There is a very high base flow component throughout the year with fairly steady median and 10th percentile flows.

Figure 2.4: Flow Distribution for Big Creek near Walsingham Gauge

Showing Median, 10th and 90th Percentile Flows



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Median	5.4	5.7	9.9	9.8	6.4	4.6	3.2	3.0	3.0	3.9	5.1	6.3
10th Percentile Flow	3.1	3.2	4.8	6.1	4.2	3.0	1.7	1.9	2.1	2.6	2.9	3.3
90th Percentile Flow	11.5	14.8	22.8	18.0	11.3	7.6	5.9	5.0	6.0	6.8	9.0	12.1

Dedrick-Young Creeks

The Dedrick -Young Creek watershed group drains a combined area of 263 square kilometres. The main watercourses in this watershed group are Dedrick, Young, and Hay creeks, but this area also includes some small Lake Erie tributaries. The watershed is mainly within the sand plain. With groundwater fed baseflows the area contains several significant cold water streams. There are two reservoirs, both used for recreation, the Hay Creek Dam on Hay Creek and Vittoria Pond on Young Creek.

There is one reactivated stream gauge on Young Creek downstream of the Vittoria Pond Reservoir which has been in operation for various periods since 1963. There was also a stream gauge on Dedrick Creek near its outlet to Lake Erie at Port Rowan. This gauge was in operation from 1963 to 1984.

Lynn River-Black Creek

The Lynn River flows from north of the community of Simcoe southeasterly to Lake Erie at Port Dover. It is joined by Black Creek in Port Dover just prior to draining into Lake Erie. The combined drainage area of this watershed group is approximately 285 square kilometres.

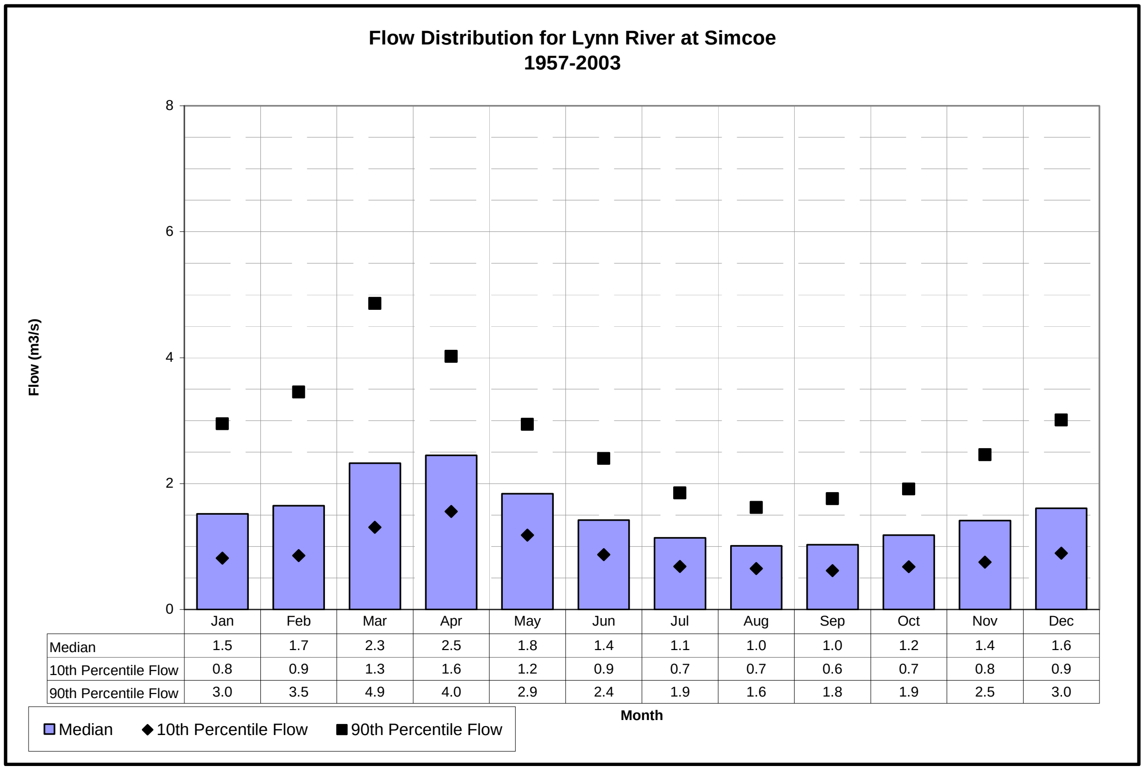
The watershed drains two different portions of the region. The Lynn River is largely in the Norfolk Sand Plain. The area is characterized by low runoff, high soil infiltration, and sustained baseflows. The Lynn River is considered a cool water fishery. Black Creek is in the Haldimand Clay Plain with high runoff and low baseflows. There is a higher density of tributaries in the

Black Creek watershed than the Lynn River. Black Creek is predominately a warm water fishery.

There is one active stream gauge on the Lynn River at Simcoe. It has been in continuous operation since 1957. The flow regime for the Lynn River gauge is given in **Figure 2.5**. There are also two controlled reservoirs on the Lynn River, Crystal Lake (Quance Dam) in Simcoe and Silver Lake (Misner Dam) in Port Dover. There are no stream gauges on Black Creek.

Figure 2.5: Flow Distribution for Lynn River at Simcoe Gauge

Showing Median, 10th and 90th Percentile Flows



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Median	1.5	1.7	2.3	2.5	1.8	1.4	1.1	1.0	1.0	1.2	1.4	1.6
10th Percentile Flow	0.8	0.9	1.3	1.6	1.2	0.9	0.7	0.7	0.6	0.7	0.8	0.9
90th Percentile Flow	3.0	3.5	4.9	4.0	2.9	2.4	1.9	1.6	1.8	1.9	2.5	3.0

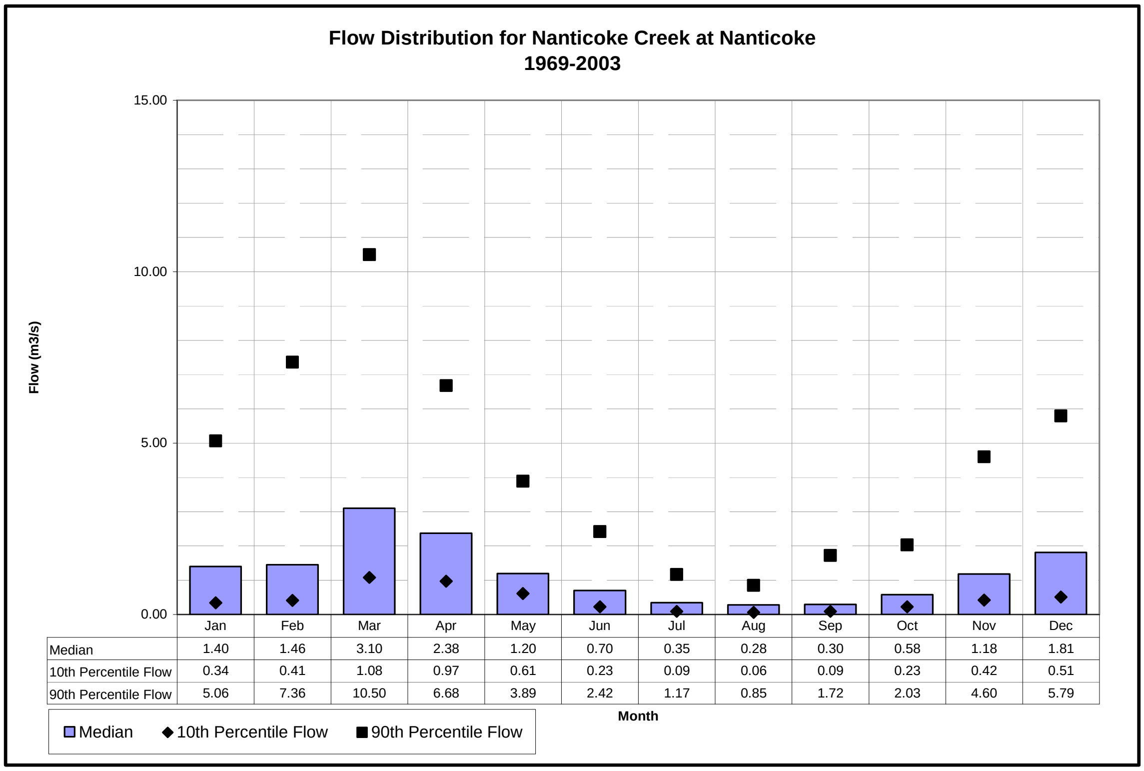
The narrow monthly flow distribution and high base flows show the moderating influence of the Norfolk Sand Plain and the small drainage area upstream of the gauge.

Nanticoke Creek

Nanticoke Creek begins as a cool water fishery in the Norfolk Sand Plain with groundwater fed baseflows. From there it enters into a series of lakes, ponds, and wetlands called the Waterford Ponds, in the community of Waterford. It changes to a warm water fishery after it passes into the Haldimand Clay Plain past the community of Waterford. The watershed narrows significantly on the Clay Plain as the watercourse heads south to Lake Erie at Nanticoke. There is one stream gauge on Nanticoke Creek near the community of Nanticoke which captures most of the watershed. The gauge has been in operation since 1969 and its flow distribution is given in Figure 2.6: Flow Distribution for Nanticoke Creek at Nanticoke Gauge **Figure 2.6**.

Figure 2.6: Flow Distribution for Nanticoke Creek at Nanticoke Gauge

Showing Median, 10th and 90th Percentile Flows



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Median	1.40	1.46	3.10	2.38	1.20	0.70	0.35	0.28	0.30	0.58	1.18	1.81
10th Percentile Flow	0.34	0.41	1.08	0.97	0.61	0.23	0.09	0.06	0.09	0.23	0.42	0.51
90th Percentile Flow	5.06	7.36	10.50	6.68	3.89	2.42	1.17	0.85	1.72	2.03	4.60	5.79

Base flow, shown by 10th percentile flow, is low throughout the year. Median flows are also low during the summer months. The wide monthly distribution shows a large runoff component to the flow regime as is expected from the influence of the Haldimand Clay Plain.

Sandusk Creek

Sandusk Creek is a small watershed of 158 square kilometres in the eastern part of the region. It is situated entirely on Haldimand Clay Plain, with high runoff, low soil infiltration, and low baseflows. This watershed has a high density of tributaries and drains directly into Lake Erie. There are no active stream gauges on Sandusk Creek, but two stream gauges were located near Hagersville and Selkirk in the 1990's.

Stoney, Evans, Hickory and Fories-Stelco Creeks

This last watershed group covers a combined area of approximately 207 square kilometres. It includes Stoney, Evans, Hickory, and Fories-Stelco Creeks, as well as some small Lake Erie tributaries. Each of these creeks drains an area of Haldimand Clay Plain, with high runoff and low soil infiltration. There is little to no base flow during the summer months. There are no stream gauges in this watershed group.

2.6.3 Hydrogeology

Within Long Point Region, groundwater has largely been characterized through the use of the MOE's Water Well Information System (WWIS). Groundwater resources, as summarized below, are found within both overburden and bedrock aquifers. Two overburden aquifers are located in the western portion of Long Point Region and one bedrock aquifer is utilized in the eastern portion of Long Point Region. In the western portion of Long Point Region, an upper, unconfined overburden aquifer consists of sand and gravel within approximately ten metres of ground surface while the lower overburden aquifer is confined by a less permeable layer of silt and clay till. In the eastern extents of the Region, in the vicinity of the Haldimand Clay Plain, the Dundee Formation, a regional bedrock aquifer, is utilized since the clay-rich overburden sediments do not yield significant quantities of groundwater.

2.6.3.1 Overburden Aquifers

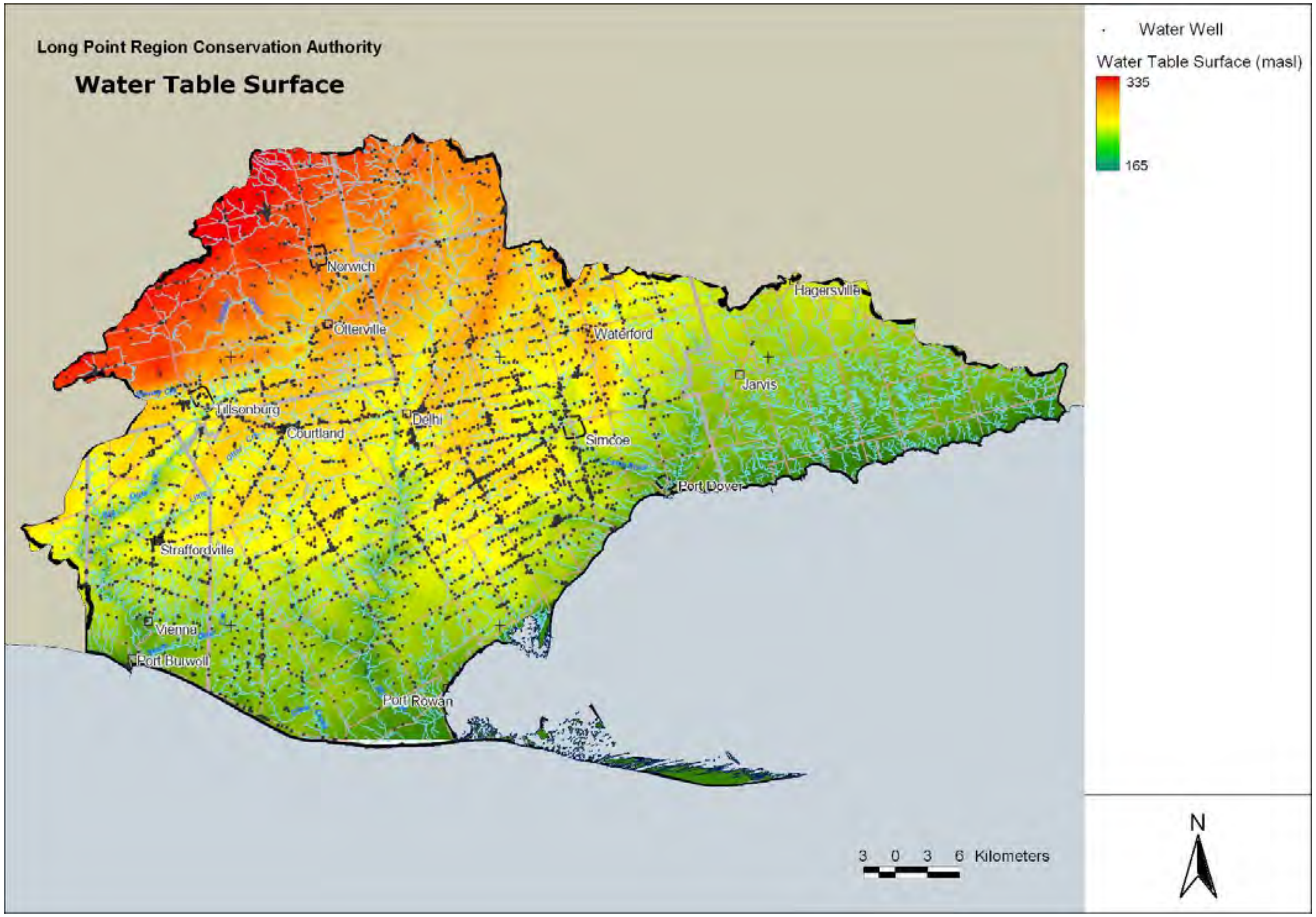
Overburden within the Long Point Region is highly variable both in thickness and composition. Significant overburden aquifers generally are located in the western half of Long Point Region, within the glaciolacustrine sands of the Norfolk Sand Plain where sand and gravel deposits can be greater than ten metres thick (Waterloo Hydrogeologic Inc., 2003). Two significant overburden aquifers are located in the vicinity of the Norfolk Sand Plains; one located within relatively shallow sediments and one within deeper sediments. These two aquifers are typically separated by a layer of low permeability material, however these low permeability sediments may be absent in some areas. The upper, shallow aquifer is unconfined and comprised of the sand and gravel deposits related to the Norfolk Sand Plains. The lower aquifer, interpreted to grade from medium- to fine-grained sand, pinches out to the east of the communities of Simcoe and Waterford where the Haldimand Clay Plain becomes the dominant surficial feature (Waterloo Hydrogeologic Inc., 2003). Within the Haldimand Clay Plain, there is no evidence of an underlying sand layer (Waterloo Hydrogeologic Inc., 2003).

A regional water table elevation map is shown in **Map 2.11**. This map is based on the static water levels in wells completed in overburden at depths less than 15 metres and assumes unconfined conditions (Waterloo Hydrogeologic Inc., 2003). The map was also augmented with the elevation of surface water streams and rivers to constrain water table elevations. Regionally, the elevation of the shallow groundwater table is a subdued reflection of the ground surface topography. Water table elevations range from 337 masl in the north-western portion of Long Point Region, to 166 masl adjacent to Lake Erie. The groundwater gradient is also consistent throughout the area, with the exception of steeper gradients in the deep river valleys of Big Otter and Big Creek river courses. Regionally, the direction of groundwater flow is southerly to south-easterly towards Lake Erie. Groundwater flow divides generally follow surface watershed boundaries.

2.6.3.2 Bedrock Aquifers

The occurrence and movement of groundwater in bedrock formations are governed by the rock type, structure and, in some cases, by the thickness and type of the overlying overburden. In sedimentary rocks such as those in Long Point Region, groundwater movement commonly occurs in weathered rock and fractures, and less commonly in crevices, vugs, and other pore spaces characteristic of carbonaceous rocks. The movement of groundwater through these features may improve permeability with time due to rock dissolution; such features are referred to as solution-enhanced features.

Map 2.11: Water Table Surface in Long Point Region



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Domestic bedrock wells within Long Point Region are typically completed within the upper 10 to 30 metres of the Dundee Formation (Waterloo Hydrogeologic Inc., 2003). Within Long Point Region, wells are often completed in the Dundee Formation where the Haldimand Clay Plain forms the dominant overburden cover. In this area, there are insufficient groundwater resources within the overburden as a result of its clay-rich nature.

The regional bedrock potentiometric surface, created from static water levels of bedrock wells, is shown on **Map 2.12**. This map shows higher elevations (314 masl) are located in the northwestern portion of the Region, sloping towards lows (144 masl) adjacent to the Lake Erie shoreline. Groundwater flow direction in the bedrock is from north to south towards the lake (Waterloo Hydrogeologic Inc., 2003).

2.6.3.3 Key Hydrologic Processes

The Long Point Region can be broken down into two hydrologic areas. The eastern watersheds are predominantly runoff driven with little or no interaction between the ground and surface water systems, while the western watersheds are strongly influenced by groundwater-surface water interactions.

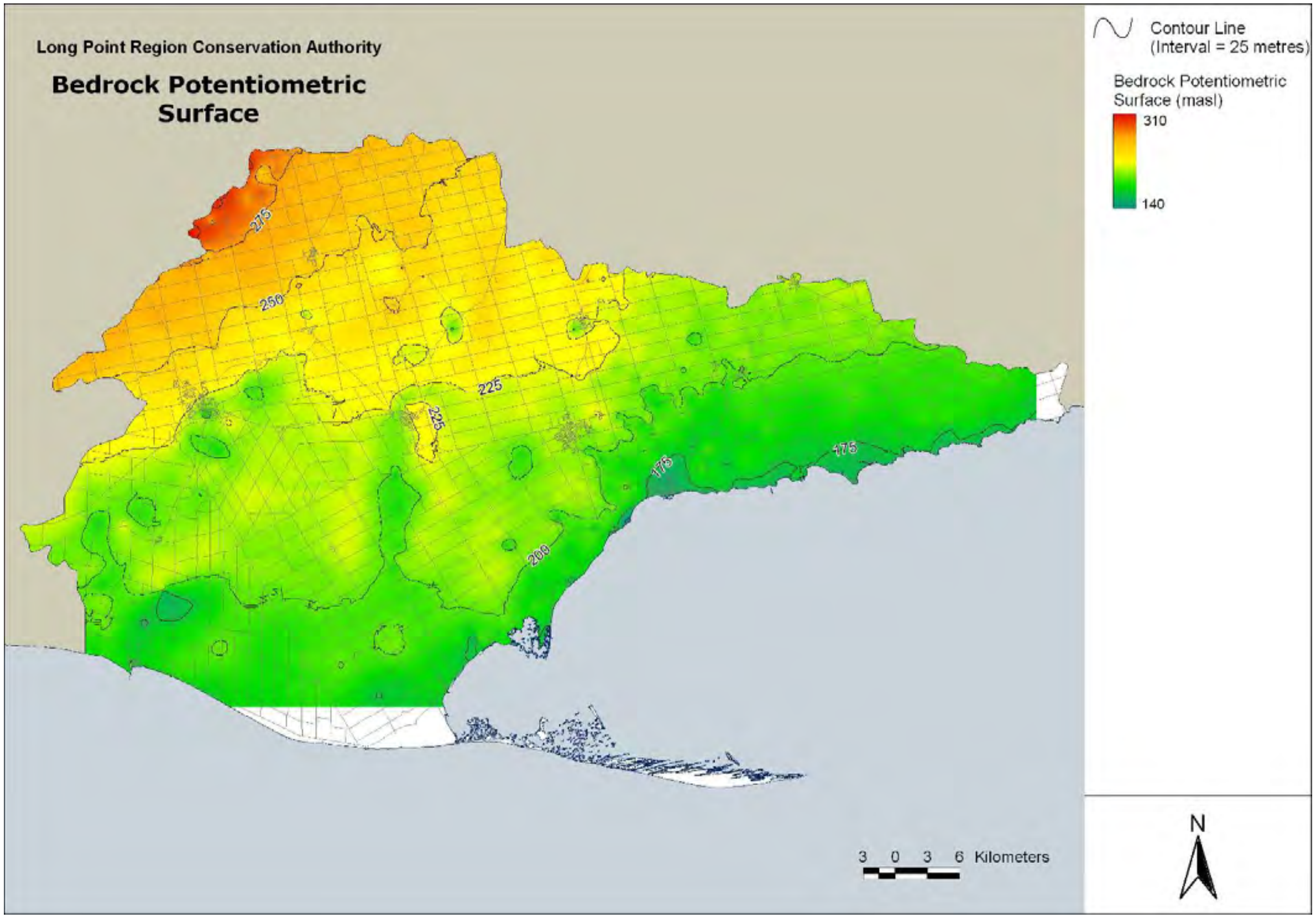
In the eastern part of the region the low permeability of the Haldimand Clay Plain inhibits a large degree of interaction between the groundwater and surface water systems. Subsequently the surface water hydrology of this area is almost entirely driven by runoff, as shown by the dense drainage network and low baseflows.

In the western watersheds groundwater discharge forms a key component of the surface water flow regime. The western watersheds drain a large area of Norfolk Sand Plain that contains large deposits of highly permeable course-grained sands and gravels. This highly permeable surficial geology allows water to flow through it fairly easily with points of recharge and discharge throughout the area. Watercourses in this area have higher and more stable baseflows as a result of discharges from the groundwater system. There is evidence that the shallow groundwater system is connected to the deeper regional system along some of the river systems (Waterloo Hydrogeologic Inc et. al. May 2003), which can result in sustained baseflows in surface watercourses during prolonged dry periods when recharge and runoff is limited.

2.6.3.4 Significant Recharge Areas

The main driver of recharge in the Long Point Region is the nature of the Quaternary geology. There are three distinct regions of recharge in the Long Point area, as illustrated in **Map 2.13**. The northwest corner of the watershed is characterized by an area of moderate recharge. The surficial materials in this area are generally a fine-grained till material with low permeability interspersed with pockets of coarse-gained deposits with higher permeability. The central western portion of the watershed, characterized by the Norfolk Sand Plain, is an important area of very high recharge and is generally comprised by coarse-grained sands with a high permeability. High amounts of recharge in the Norfolk Sand Plain contribute to the shallow overburden groundwater system located within this area. The eastern part of the watershed is characterized by the Haldimand Clay Plain, generally comprised of a fine-grained clay-rich material with low permeability. The clay-rich nature of this area limits recharge to the deeper groundwater system in this part of the watershed.

Map 2.12: Bedrock Potentiometric Surface in Long Point Region



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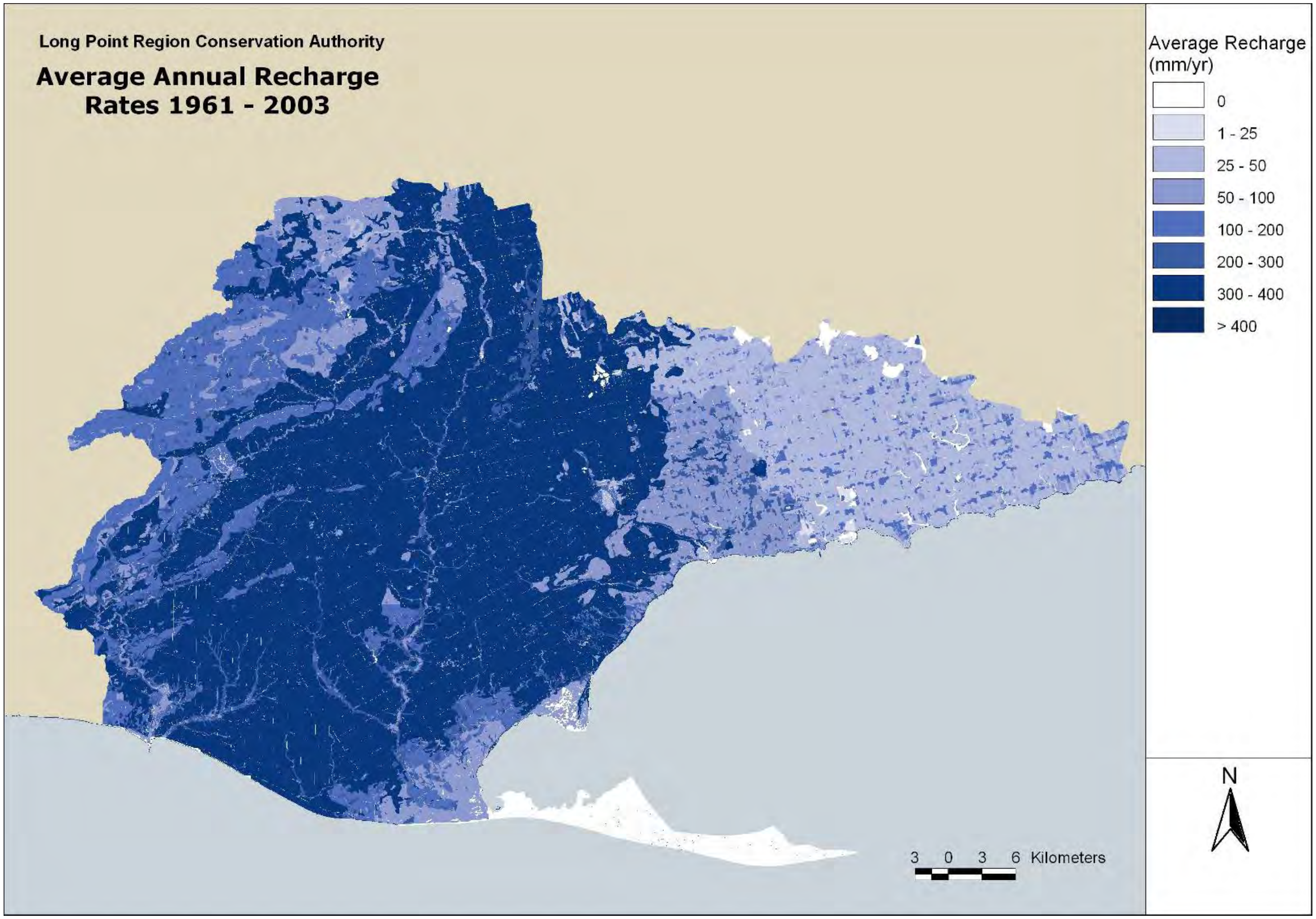
Map 2.13: Average Annual Groundwater Recharge in Long Point Watershed



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2.6.4 Surface and Groundwater Interactions

Interaction between groundwater and surface water occurs predominantly in the western portion of the watershed region, where a shallow groundwater system is located within the sandy, coarse-grained deposits of the Norfolk Sand Plain. Water courses in this part of the region are typically classified as cool water with sustained base flows indicating discharge from the groundwater system. High seasonal water use from both surface and ground sources can affect the groundwater-surface water interaction dynamics. During years with little precipitation and hence decreased recharge, increased water use for agricultural irrigation stresses both the surface water and groundwater systems. These changes can affect the hydraulic gradients driving surface-groundwater interactions such as groundwater discharge to surface water systems, and horizontal and vertical groundwater flow directions.

In the eastern portion of the watershed region, the Haldimand Clay Plain has an overall low permeability, therefore inhibiting a large degree of interaction between the groundwater and surface water systems. As a result, watercourses are runoff driven with little base flow provided by groundwater discharge. Additional information on groundwater and surface water interactions will be determined during Water Budget work in this watershed.

2.7 Water Quality Summary

2.7.1 Water Quality Monitoring

2.7.1.1 Surface Water Quality Monitoring

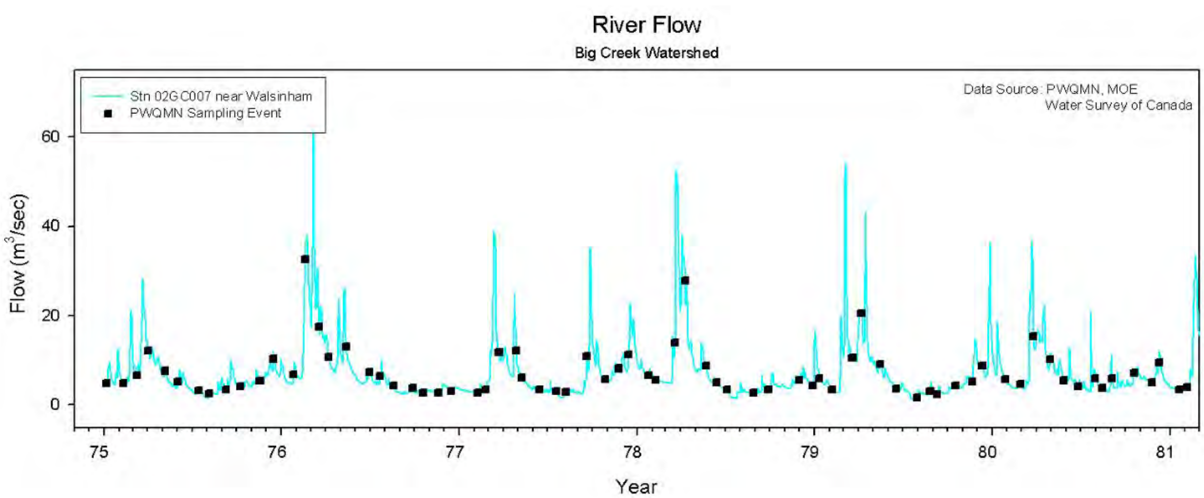
Surface water quality monitoring has historically focused on characterizing the chemical and physical attributes of the creeks and rivers within a watershed. The Provincial Water Quality Monitoring Network (PWQMN) is an important long-term monitoring program for Ontario which facilitates the characterization of the chemical and physical aspects of water quality. However, financial cutbacks by the province over the last decade, along with limited capacity of Conservation Authorities, have resulted in a decrease in the number of sites monitored and the frequency at which they are sampled.

As part of the partnership in the PWQMN program the Ontario Ministry of the Environment (MOE) is responsible for the laboratory analysis while the Conservation Authorities are responsible for collecting the samples. In the Long Point Region, the number of monitoring sites fell from a high of 25 in 1975 to a low of zero from 1996 to 1999. In 1996 when the MOE cut funding to the PWQMN program, Long Point Region Conservation Authority (LPRCA) did not have the internal capacity to continue monitoring on its own leaving a four year data gap for watershed wide sampling from 1996 to 1999. However, in 2000 LPRCA re-evaluated their programs and began monitoring again at a few selected PWQMN sites. In 2002 when the MOE started re-building the PWQMN, LPRCA resumed sampling at a total of ten sites.

The number of annual samples taken per site has also declined over the years. Currently the MOE allows for eight samples per year to be taken at each of the PWQMN sites; however, historically a total of 12 samples per year were taken at each site. Water quality is highly variable and is sensitive to season, time of day, temperature, flow-stage, spills, soil types, basin topography and many other factors. Due to this, water quality samples must be collected over the range of stream-flows that are representative of the stream at the sample-collection site (Environmental Commissioner of Ontario, 2002; Painter et al., 2000). Consequently, many samples are required to adequately characterize water quality over a range of environmental conditions. Painter et al. (2000) recommends that at least ten samples be taken per year to adequately characterize ambient surface water quality in streams, while Meybeck et al. (1996) suggest 12 samples per year for a multipurpose monitoring program, such as the PWQMN. The current eight samples per year per site limits the network's ability to characterize water quality over a full range of environmental conditions such as low and high flows or the effects of seasonality (e.g. under ice conditions). Therefore, any interpretation of the PWQMN data must be in context of the flow and seasonal conditions represented by the data.

Generally, water quality samples collected within the Long Point Region were collected during low to moderate flows (**Figure 2.7**). This was likely a result of limited manpower and logistical challenges associated with sampling high flow events. However, starting in 2005 there has been an attempt to characterize high flow events.

Figure 2.7: Water Quality Sampling Events as they Relate to Stream Flow at Walsingham in Big Creek Watershed



Under the current PWQMN program, the Long Point Region Conservation Authority (LPRCA) monitors ten sites, which have all been historically sampled. In addition to these sites, eight monitoring sites were added as part of the Long Point Region Conservation Authority's capacity building in 2005 and are analysed by a private laboratory. Each of the 18 sites within the current monitoring network is sampled eight to ten times per year to be consistent with the PWQMN program. **Map 2.14** illustrates the location of the PWQMN and new 2005 sites currently being monitored by the LPRCA.

Current water quality samples are analyzed for routine chemistry, nutrients and metals (**Table 2.6**). For more information on laboratory methods and detection limits refer to Ontario Ministry of the Environment (1994a). Water samples were collected using standard sampling procedures as set out by the Ministry of the Environment (MOE) (Aaron Todd pers. comm.). Sites with easy access were sampled directly from the stream with the sample bottle upstream of where the samplers were standing. Sites with bank access were sampled from the shore with a stainless steel bucket attached to an extension rod. Finally, sites with only bridge access were sampled by lowering a stainless steel pail from the bridge into the stream. Sample bottles were rinsed three times on site with the sample water prior to filling. Samples were preserved if necessary, stored on ice and couriered to the MOE laboratory.

Table 2.6: List of Water Quality Variables Analysed in PWQMN Stream/River Samples

Water Quality Variable Category	Water Quality Variables
Nutrients	Dissolved Nutrients: ammonia, nitrate, nitrite; phosphate Total Nutrients: Total phosphorus, Total Kjeldahl nitrogen
Solids	Total Suspended solids; Total dissolved solids
Major Ions/Anions	Calcium; Magnesium, Sodium, Potassium; Hardness; Chloride
Routine Chemistry	pH; Alkalinity; Conductivity
Metals	Aluminum; Barium, Beryllium; Cadmium; Chromium, Copper; Iron; Manganese; Molybdenum; Nickel; Lead; Strontium; Titanium; Vanadium; Zinc
Routine Physical	Turbidity; Temperature

Dissolved oxygen, conductivity, pH and temperature are monitored in the field at the time of sample collection using an YSI™ data sonde. Temperature has also been monitored throughout the watershed since 2002, using a series of temperature loggers to determine if temperatures are on the rise within critical areas, such as cold water fish habitat.

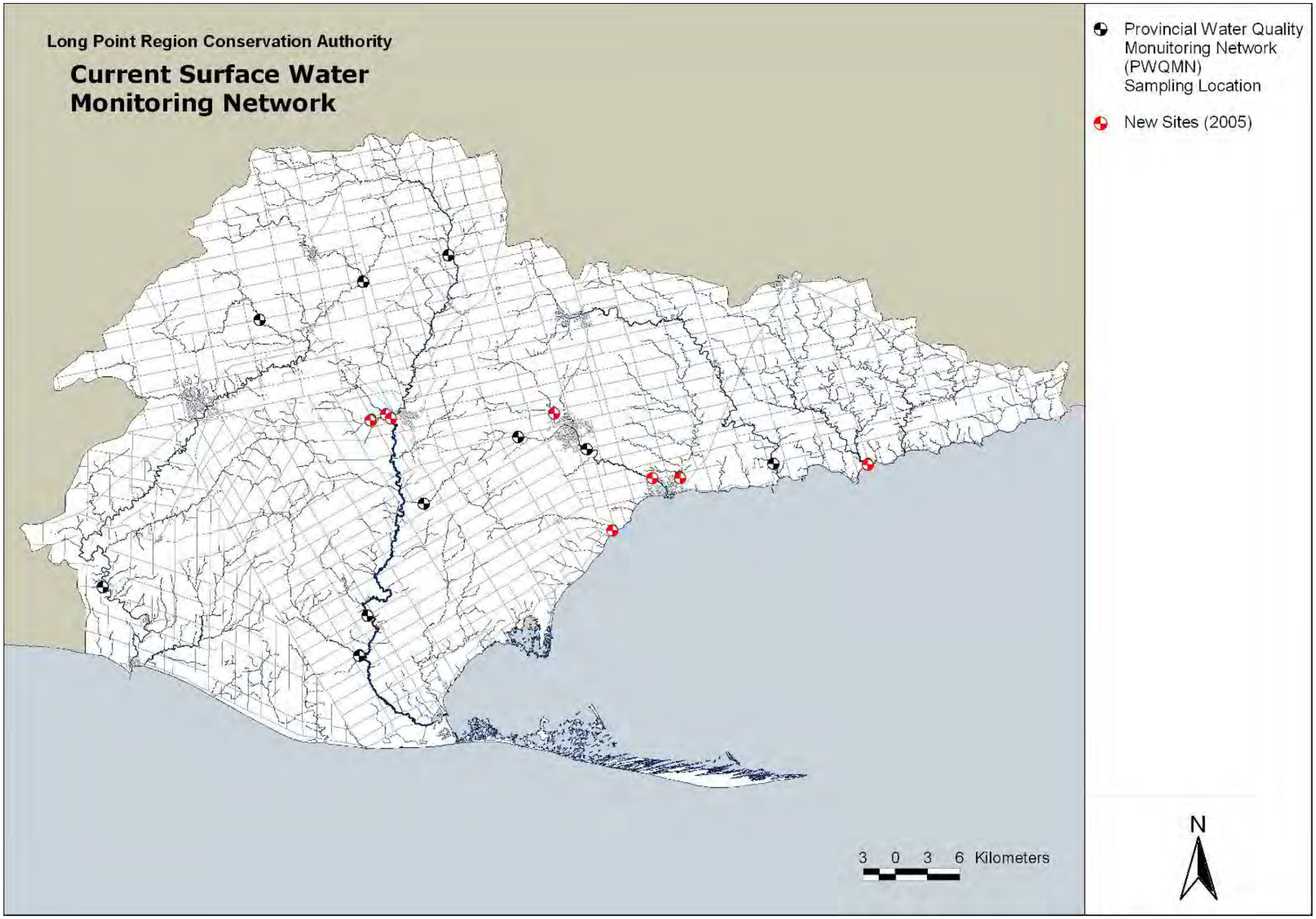
Pesticides have only sporadically been monitored for at a few PWQMN sites across the Long Point Region. These samples were also collected using the procedure previously described.

Historically, no routine monitoring of the major reservoirs within the Long Point Region has been carried out. However, historical watershed studies have commented on the general characteristics of some reservoirs.

Generally samples for bacteria or pathogens were not routinely collected as part of the long-term PWQMN monitoring program. Significant variability in sampling and analysis methodologies provides for some hesitation when including these parameters as part of a long-term monitoring program. However, *E. Coli* samples have been taken at each of the PWQMN sites since 2002 and processed by the local public health units.

Routine monitoring for benthic macroinvertebrates has been carried out as part of the Ontario Benthos Biomonitoring Network (OBBN) program since 2002. Benthic surveys are taken at the same ten sites at which the PWQMN samples are taken from. In 2004, as part of the state of the watershed project, intensive benthic surveys were preformed throughout the Lynn River and Black Creek watersheds (Gagnon and Giles, 2004).

Map 2.14: Surface Water Quality Monitoring Sites in Long Point Region Watershed



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2.7.1.2. Groundwater Quality Monitoring

Groundwater is primarily monitored in Long Point Region through the Provincial Groundwater Monitoring Network (PGMN), a network of wells distributed throughout the province that provide insight on long-term ambient trends and conditions. The monitors are typically sited so that they are reflective of broad hydrogeologic conditions, away from areas where pumping or contamination may impact those data collected. The MOE owns the monitoring infrastructure and manages the data gathered through the program, but in many cases the program is locally administered by Conservation Authorities.

There are currently 11 PGMN wells at 9 locations within Long Point Region Conservation Authority's jurisdiction. The wells are located throughout the central portion of the Region, as shown on **Map 2.15**. Ten of the eleven wells are completed in overburden and one well is completed in bedrock. Water levels in the wells are monitored through a combination of manual and electronic means. Where electronic dataloggers are in place, water levels are recorded hourly and uploaded to the MOE on a prescribed basis. Manual measurements are made in all wells on a quarterly basis. Water samples for quality monitoring have not yet been obtained to date.

2.7.2 Surface Water Quality Conditions and Trends

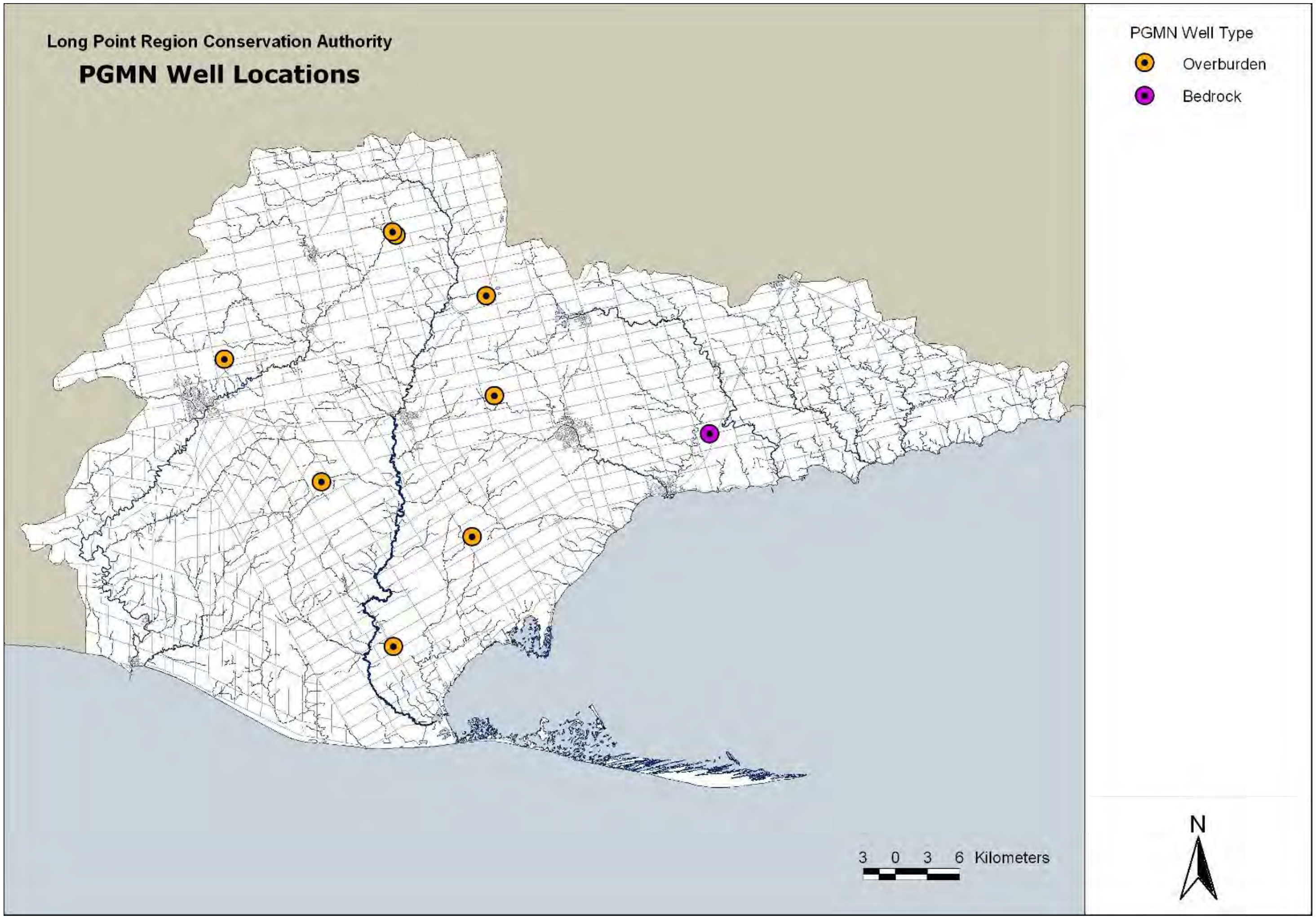
The following summary is based on findings from the *Water Quality Technical Assessment Report* for the Long Point Region watershed, which examined the most recent contiguous four year set of data (2002-2005) in an attempt to identify the water quality conditions and trends found within the Region (Evans, 2006).

Water quality sampling within the Long Point Region watershed occurred on a routine basis whereby flow was not always considered. This is evident when dates of sampling events are graphed against stream flow (see **Section 2.7.1, Figure 2.7**). Generally, sampling was performed across a range of flows; however, peak events were missed for some years. This potential bias towards sampling at low to moderate flows indicates that the results from the monitoring data presented here has mainly characterized base- flow and likely has not captured the changes in water quality which occur during high flow events.

The inherent geology and current landuse practices appear to be driving some of the chronic surface water quality issues within the Long Point Region. For example, watersheds draining the clay and till plains tend to have the highest non-filterable residue and nutrient concentrations (e.g. Big Otter Creek, and Nanticoke Creek). Land use practices such as intensive agricultural production or urban development (such as the Lynn River watershed) are also contributing to the overall high nutrient levels found within the Long Point Region.

Streamflow across the Long Point Region varies widely. Big Otter Creek has the highest flows relative to the other watersheds within the region that were gauged. Both Big Creek and Nanticoke Creek have similar stream flows, which were lower than those found in Big Otter Creek but higher than other streams across the Long Point Region, such as the Lynn River and Young Creek. The streams whose headwaters originate in the Norfolk Sand Plain (e.g. Big Otter Creek, Big Creek, and Nanticoke Creek) are primarily groundwater fed resulting in a continuous base-flow, whereas those tributaries whose headwaters reside in the Horseshoe Moraine (clayey till) or the Haldimand Clay Plain (e.g. Black Creek or Sandusk Creek) usually have intermittent flow during the summer months.

Map 2.15: Provincial Groundwater Monitoring Network Well Locations in Long Point Region



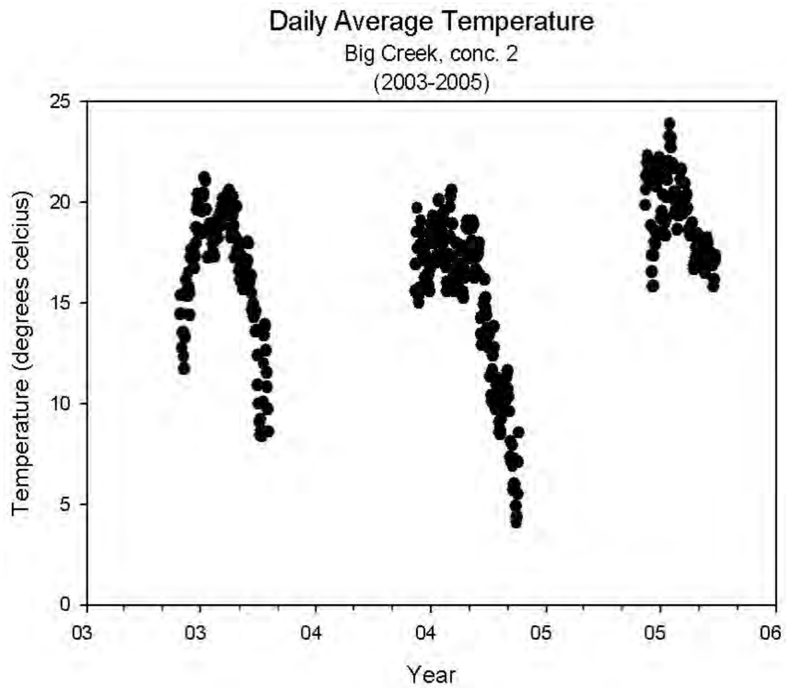
Although the natural base-flow for those streams within the Norfolk Sand Plain is continuous through the low flow summer months, the numerous permits to take water, online impoundments and tile or municipal drains, could eventually have a negative effect on base-flow levels, which in turn could negatively impact water quality. In order to sustain the current base-flow while still allowing for the numerous water takings, there needs to be adequate recharge of the aquifers within the region. Therefore, it is important that nearby wetlands and moraines are protected.

Dissolved oxygen is an important indicator of the river's ability to sustain aquatic life. Within the Long Point Region dissolved oxygen levels have rarely been observed to dip below six milligrams per litre (Evans, 2006), which is above the four milligram per litre lower threshold for cold water biota and is considered to be adequate for aquatic life. However, samples were generally only taken during the day which would not have accounted for the diurnal fluctuation or the range of values an organism truly experiences. Thus, determining if dissolved oxygen within the Long Point Region was limiting to aquatic organisms could not accurately be assessed with the 2002-2005 sampling regime and diurnal monitoring should be employed as part of future monitoring programs.

Super-saturation of dissolved gases can also be potentially hazardous to aquatic life. Within most of the five watersheds analysed gas saturation levels for dissolved oxygen (DO) have been reported as high as 140 percent. Super-saturation of gases within the water can lead to gas exchange problems in aquatic life such as blood gas trauma in fish (Fidler and Miller, 1994). However, there has yet to be a criteria set for the upper limit of DO for the protection of aquatic life.

The warming trend in summer water temperature values across several watersheds (e.g. Big Creek and Patterson Creek) is of obvious concern (**Figure 2.8**). High temperatures can limit the diversity of aquatic species present as well as impact dissolved oxygen saturations. 24 degrees Celsius is generally the temperature threshold between cool and warm water fish species (Stoneman and Jones, 1996). Prolonged periods of time during which temperatures are above 24 degrees Celsius creates stress for cold or cool water species thus limiting the ability for them to inhabit these areas of the creek. Increased water temperatures can also impact oxygen saturation of freshwaters thereby impacting metabolic rates, growth and reproduction of freshwater fish (Gordon, 1996). Many of the tributaries within the Long Point Region (e.g. Big Creek, Big Otter Creek) have been described as thermally stressed. However, there are watersheds within the Long Point Region that have temperatures and habitats suitable to continue supporting the present cold water fisheries (e.g. the Dedrick-Young Creek watershed and Kent Creek).

Figure 2.8: Temperature Logger Data Illustrating Daily Average Temperature Values in Big Creek, 2003-2005 (Near Concession 2)



Several studies (McTavish, 1986; Wilcox, 2005) indicate that there is a strong relationship between land-use practices and surface water quality. Within the watersheds of the Long Point Region most of the land area is designated as agricultural of which a high percentage is row cropped and tile drained. Land-use of this type can result in waterways becoming enriched through runoff of fertilizers and erosion of soils. This relationship is apparent throughout the Long Point Region especially with respect to the elevated nutrient and non-filterable residue concentrations found.

Big Otter Creek

Nitrate and phosphorus concentrations within the Big Otter Creek watershed were consistently above the Canadian Guideline (2.93 milligrams per litre) and Provincial Water Quality Objective (PWQO; 0.03 milligrams per litre) and as a result are the most serious nutrient issues within the Big Otter Creek watershed (**Figure 2.9** and **Figure 2.10**). In fact, median nitrate levels within Spittler Creek were among the highest across the entire Long Point Region. Spittler Creek was the most impaired area within the watershed with respect to all water quality parameters tested except for phosphorus and non-filterable residue levels, which were highest downstream on lower Big Otter Creek.

Figure 2.9: Nitrate Concentrations Between 2002 and 2005 at Three PWQMN Monitoring Sites in Big Otter Creek Watershed

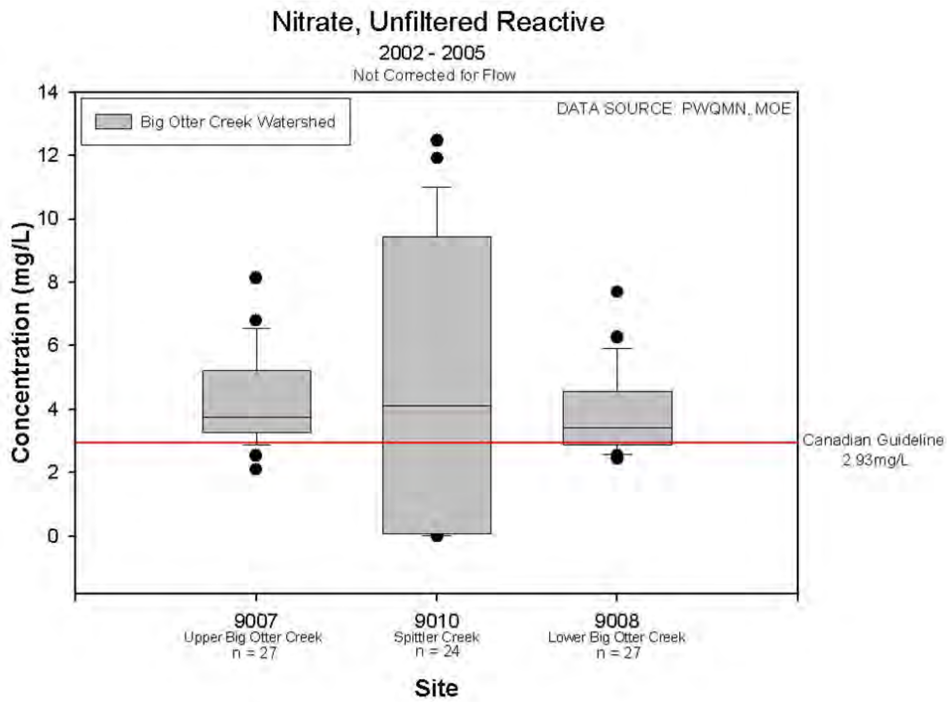
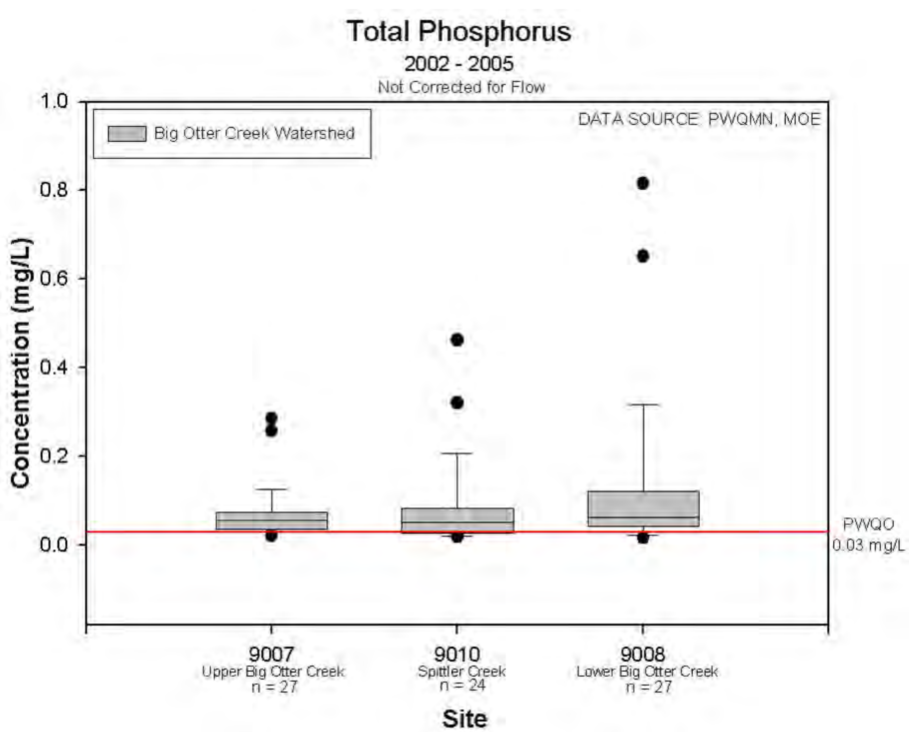


Figure 2.10: Phosphorus Concentrations Between 2002 and 2005 at Three PWQMN Monitoring Sites in Big Otter Creek Watershed

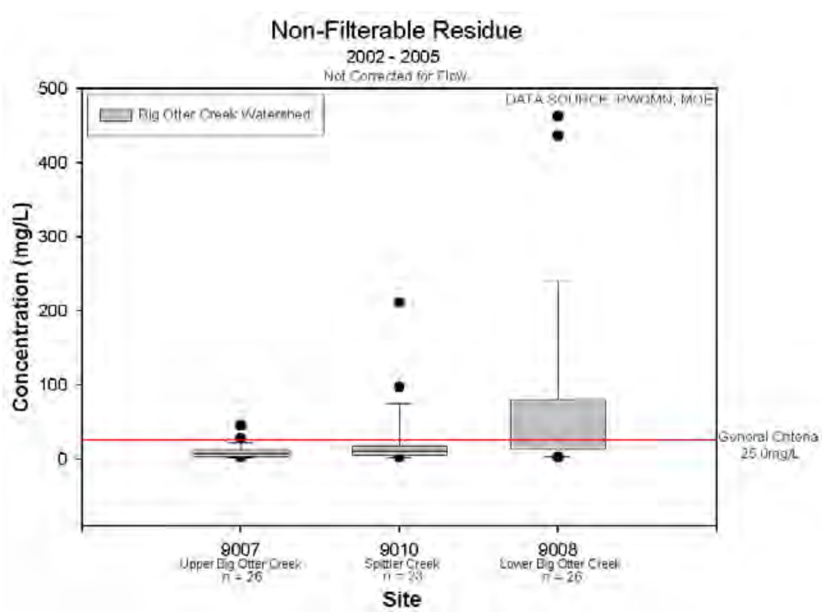


Land-use including intensive agricultural production, urban development, wastewater treatment plant effluents, the underlying geology and the topography within the Big Otter Creek watershed are all likely contributing to the degradation in water quality. The higher nitrate and organic nitrogen concentrations found within Spittler Creek are likely as a result of the intensive agriculture, namely fertilizer run-off and livestock stream access. Fausto and Finucan (1992) found that phosphorus concentrations within the Big Otter Creek watershed were mainly anthropogenically driven by fertilizers, household effluent, industry and improper milk-house wash water disposal.

Big Otter Creek has been identified as Canada's largest source of sediment contamination to Lake Erie (Cridland, 1997). Although median values were just over the 25 milligram per litre benchmark, the 95th percentile value (367.25 milligrams per litre) indicates that there are times when significant inputs do occur (**Figure 2.11**). Big Otter Creek reacts to event flows extremely quickly and tends to be flashy (Stone, 1993) resulting in increased erosion and sedimentation. This phenomenon is also compounded by the soil type, lack of riparian vegetation and the deeply incised banks within the lower portion of the watershed. Other potential non-filterable residue contributions could be due to the upstream wastewater treatment plants at Norwich and Tillonsburg.

Bacterial concentrations have also been identified as an issue within the Big Otter Creek watershed. Regular beach postings within the watershed prompted the start of the CURB program in 1992. As a result of this study, tributaries within the upper watershed were found to have higher bacterial counts relative to the main branch and as such improvement measures were focused within those areas (e.g. Spittler Creek). Since the implementation of the program bacterial counts have decreased, however, beach postings are still occurring at Port Burwell. It has been hypothesized that some of the bacteria found at the Port Burwell beaches may be originating from the high bacterial concentrations emptying into Lake Erie from Silver Creek in the Catfish Creek watershed (McCarron and McCoy, 1992).

Figure 2.11: Non-filterable Residue Concentrations between 2002 and 2005 at Three PWQMN Monitoring Sites in Big Otter Creek Watershed



Big Creek Watershed

Compared to other watersheds within the Long Point Region Big Creek is not a major contributor of nutrients or non-filterable residue (NFR) to Lake Erie. Flow within Big Creek is partially regulated through several wetlands, reducing flow intensity and acting as a sediment sink thereby reducing the sediment concentrations reaching Lake Erie (Stone, 1993). Due to the wetlands and high degree of riparian cover the Big Creek watershed does not react as quickly to event flows compared to Big Otter Creek.

Generally water quality was better within Trout Creek compared to other sites sampled within the Big Creek watershed. The upper Big Creek region was the most impaired with respect to nitrogen and chloride concentrations (**Figure 2.12**, **Figure 2.13** and **Figure 2.14**) but Venison Creek and lower Big Creek were the most impaired with respect to phosphorus and non-filterable residue concentrations (**Figure 2.15**, **Figure 2.16**).

Figure 2.12: Nitrate Concentrations Between 2002 and 2005 at Three PWQMN Monitoring Sites in Big Creek Watershed

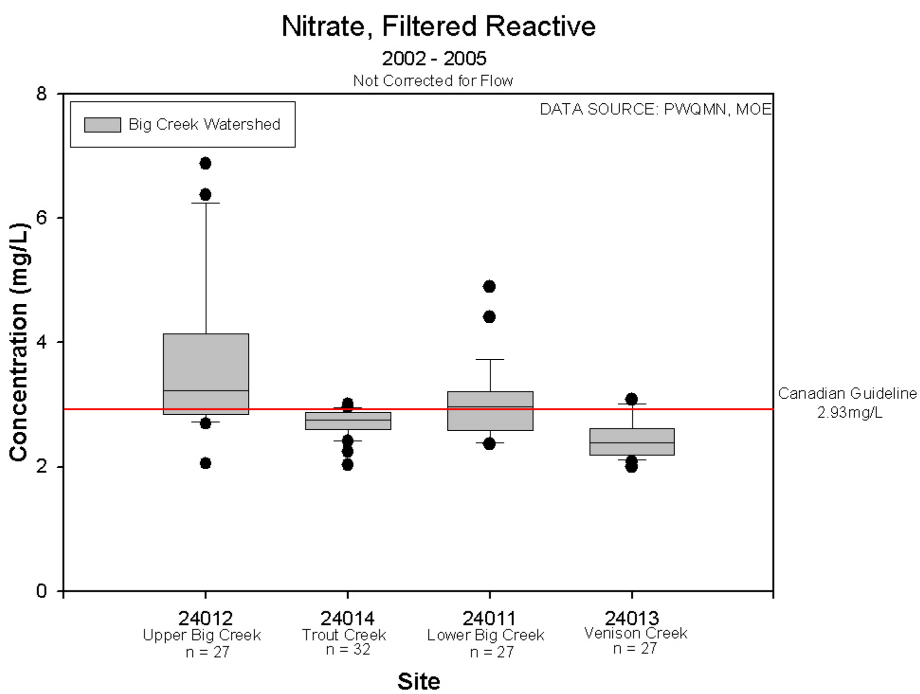


Figure 2.13: Total Kjeldhal Nitrogen Concentrations Between 2002 and 2005 at Three PWQMN Monitoring Sites in Big Creek Watershed

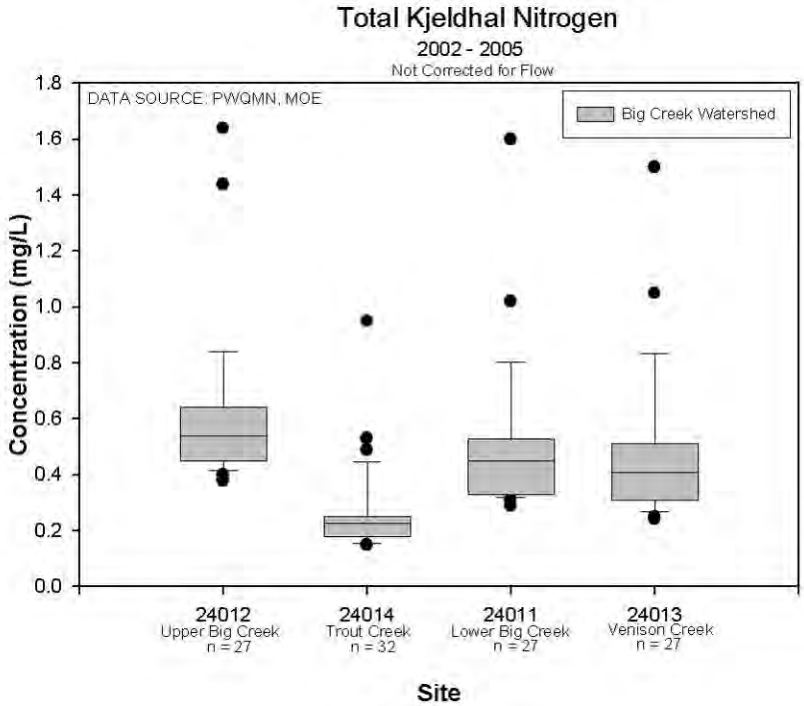


Figure 2.14: Chloride Concentrations Between 2002 and 2005 at Three PWQMN Monitoring Sites in Big Creek Watershed

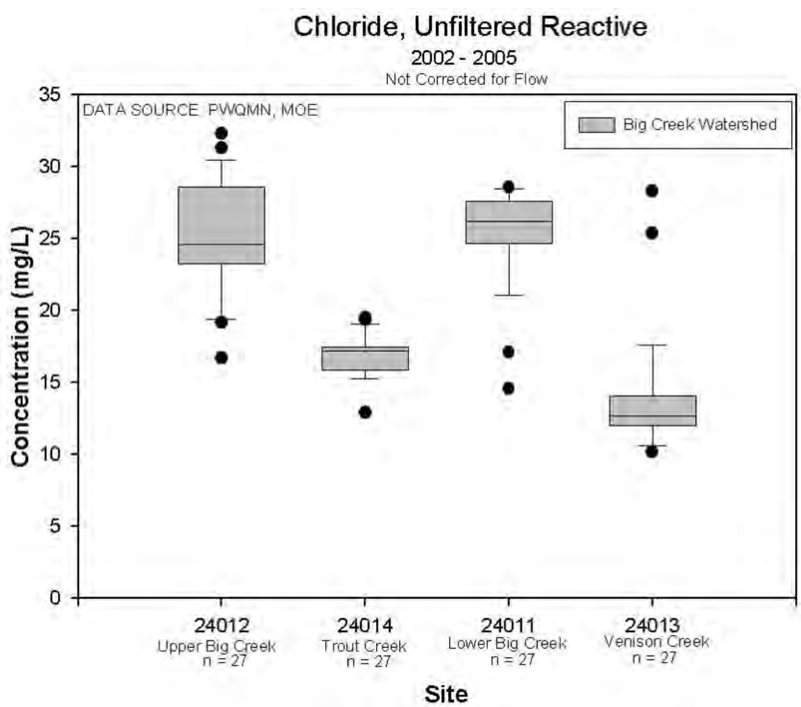


Figure 2.15: Phosphorus Concentrations Between 2002 and 2005 at Three PWQMN Monitoring Sites in Big Creek Watershed

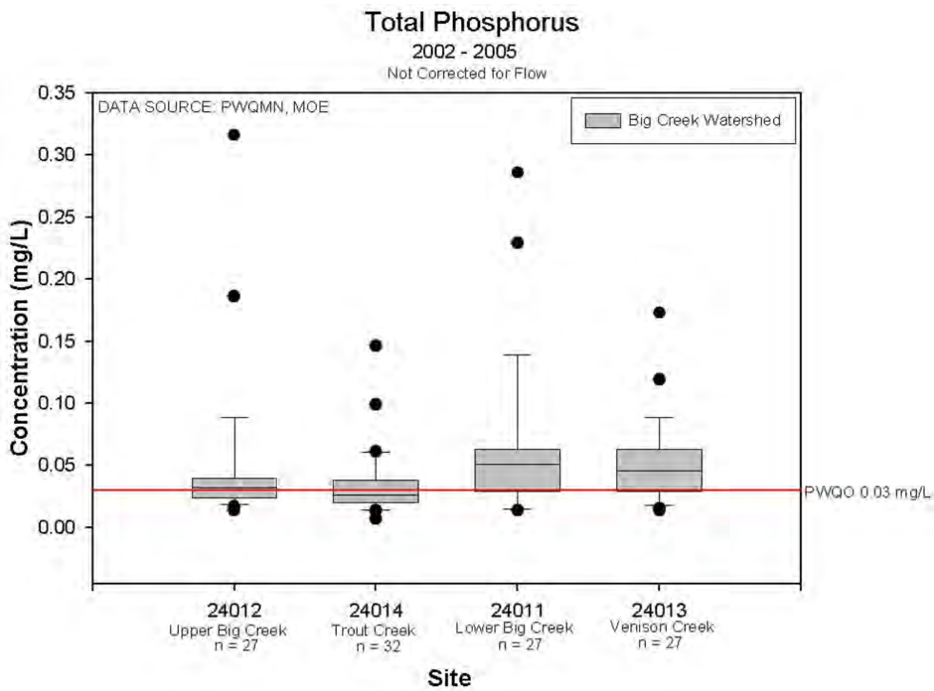
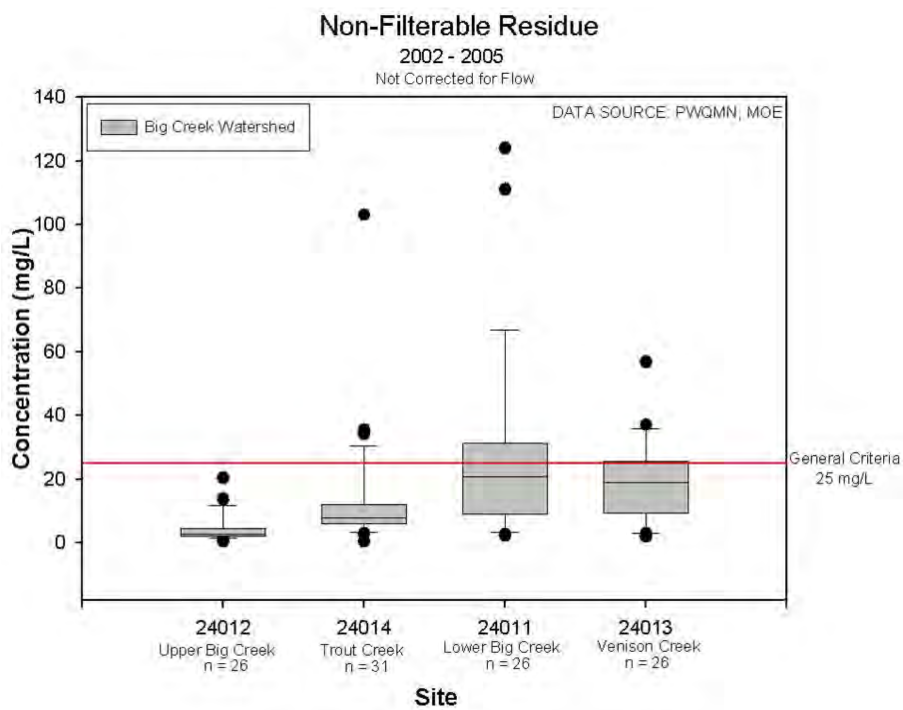


Figure 2.16: Non-filterable Residue Concentrations Between 2002 and 2005 at Three PWQMN Sites in Big Creek Watershed



The intensive agriculture and fertilizer application within the upper Big Creek watershed is likely responsible for the high nitrate concentrations as well (**Figure 2.12**). The relatively low nitrate concentrations found within the downstream tributaries (Trout Creek and Venison Creek) is likely having a positive impact on the water quality within lower Big Creek.

Phosphorus was routinely above the provincial objective (0.03 milligrams per litre) within the lower portion of the watershed (lower Big Creek and Venison Creek) (**Figure 2.8**). Likely these inputs are a reflection of the upstream cumulative inputs from the Delhi wastewater treatment plant, and the intensive fertilizer application to crops within the watershed. Also these higher phosphorus levels are likely associated with the higher non-filterable residue concentrations occurring in the lower portion of the watershed.

Lynn River Watershed

The impact of urban development on the Lynn River is reflected by extremely high concentrations of nitrite, ammonia and phosphorus found directly downstream of the town of Simcoe and its Water Pollution Control Plant (**Figure 2.17**, **Figure 2.18** and **Figure 2.19**).

Within the Lynn River watershed other tributaries, such as Kent Creek (a groundwater fed creek with minimal urban or agricultural impacts) have significantly better water quality than that found in the lower portion of the Lynn River. Rarely do samples taken on the Lynn River, downstream of the Water Pollution Control Plant (WPCP), meet the Canadian guideline for nitrite or the PWQO for total phosphorus. High nitrite and unionized ammonia levels found within aquatic systems tend to be associated with organic pollution through the disposal of sewage or organic waste (Hem, 1985; Hydromantis Inc. et al., 2005). Within the Lynn River the high nitrite and unionized ammonia levels are likely a result of the Simcoe WPCP. Both unionized ammonia and nitrite are highly toxic to aquatic life which likely is having a negative effect on the fish populations present.

Currently Norfolk County is carrying out an assimilative capacity study to better understand the Lynn River's ability to effectively assimilate the WPCP effluent from the Simcoe Plant (pers. comm. Bob Fields).

Figure 2.17: Nitrite Concentrations Between 2002 and 2005 at Three PWQMN Monitoring Sites in Lynn River

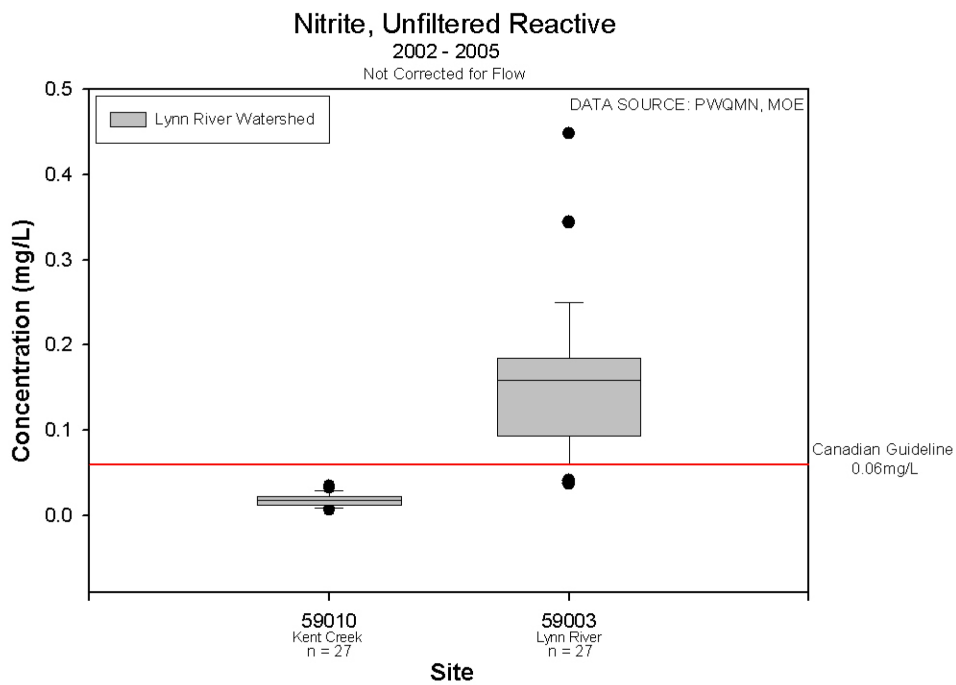


Figure 2.18: Unionized Ammonia Concentrations Between 2002 and 2005 at Three PWQMN Monitoring Sites in Lynn River Watershed

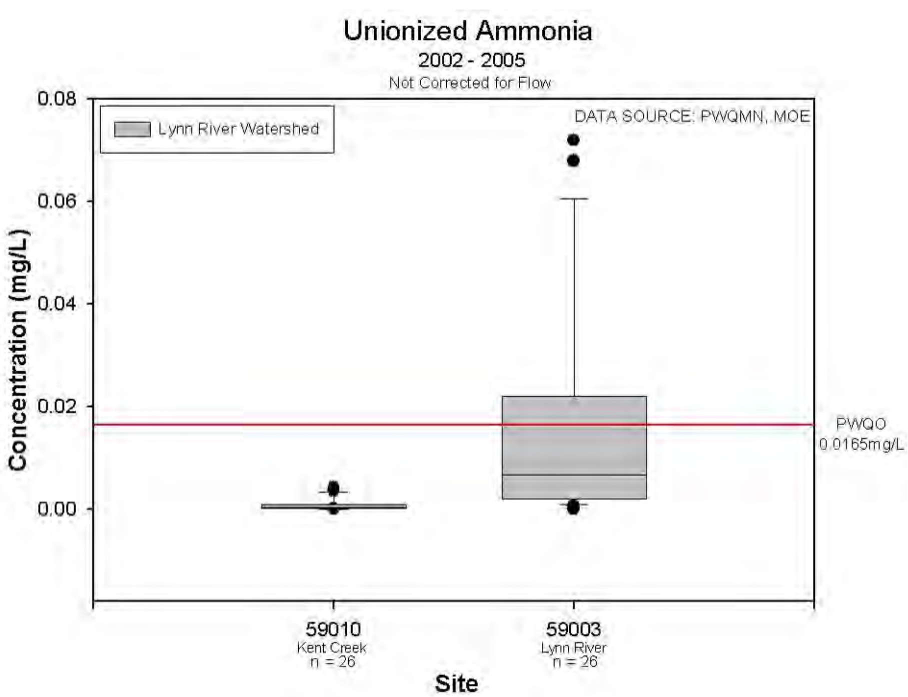
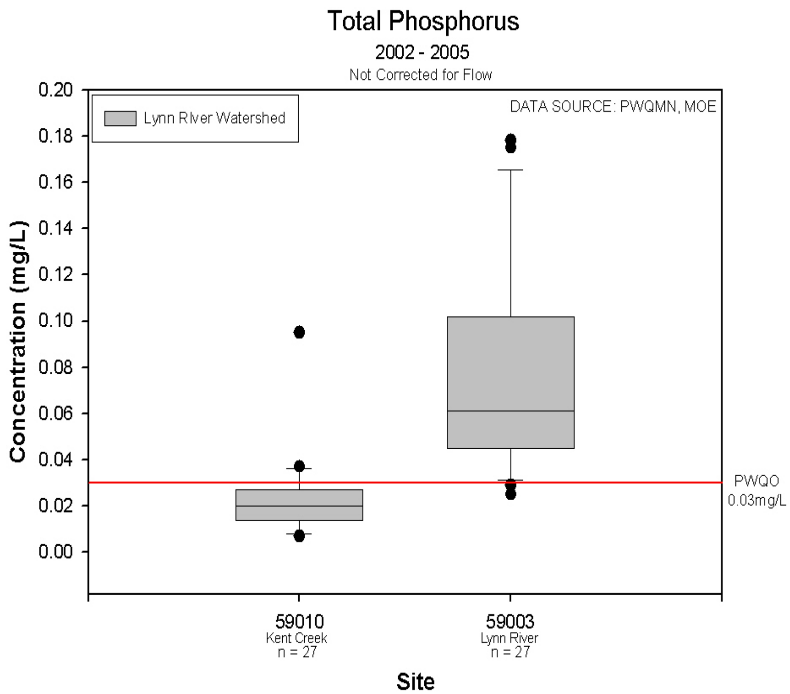


Figure 2.19: Phosphorus Concentrations Between 2002 and 2005 at Three PWQMN Monitoring Sites in Lynn River Watershed



Nanticoke Creek Watershed

Generally, within the Nanticoke Creek watershed nutrient concentrations significantly increase as the creek flows out of the Norfolk Sandplain and into the Haldimand Clayplain. The Waterford Water Pollution Control Plant (WPCP) located on the clay plain likely adds to this. This increase within the upper portion of the watershed is likely as a result of the cumulative urban impact from the town of Waterford, the WPCP effluent and the transition in soil types within the contributing drainage area from sandy to clay based soils. The headwaters within the Norfolk Sand Plain tend to have better water quality compared to the rest of the creek which resides within the Haldimand Clay Plain (Van De Lande, 1987).

Total phosphorus and non-filterable residue (NFR) inputs are the most significant water quality issues within the Nanticoke Creek watershed and appeared to progressively increase from upstream to downstream (**Figure 2.20** and **Figure 2.21**). Phosphorus has been shown to historically increase during the summer low flow season which could be as a direct result of the increased NFR accumulation that also occurs during this time (Long Point Region Conservation Authority, 1979a). Although Nanticoke Creek was not historically considered a major contributor of nutrient concentrations to Lake Erie (Long Point Region Conservation Authority, 1979a), recent data indicates that the highest median NFR and phosphorus concentrations are found near the mouth of Nanticoke Creek relative to other tributaries within the Long Point Region. However, the Nanticoke Creek does not appear to be as event driven as Big Otter Creek whose maximum concentrations were much higher. Again the high concentrations found within the lower reaches of the Nanticoke Creek are likely a combination of upstream impacts from urban and WPCP effluent and the increased erosion due to higher base flows, topography and livestock access to streams.

Dissolved oxygen levels have been found to decrease downstream of Waterford rendering the creek beyond this point unsuitable as cold water fish habitat (Van De Lande, 1987). G. Douglas Vallee Ltd. (2004) speculated that the low dissolved oxygen levels found in the summer were likely as a result of the effluent from the Waterford WPCP making up a substantial percentage of the summer base-flow. Norfolk County has since developed a contingency plan detailing the necessary monitoring and appropriate actions required to mitigate these impacts. Currently an assimilative capacity study is underway to help determine if an upgrade to the Waterford WPCP is required for Nanticoke creek to effectively assimilate its effluent (pers. comm. Bob Fields). Upgrades such as tertiary treatment, or the addition of sand filters and disinfectants could potentially help reduce the level of contaminants within the effluent thus improving the downstream water quality.

Figure 2.20: Phosphorus Concentrations Between 1982 and 1986 at Six PWQMN Monitoring Sites and Between 2002 and 2005 at One PWQMN Monitoring Site in Nanticoke Creek Watershed

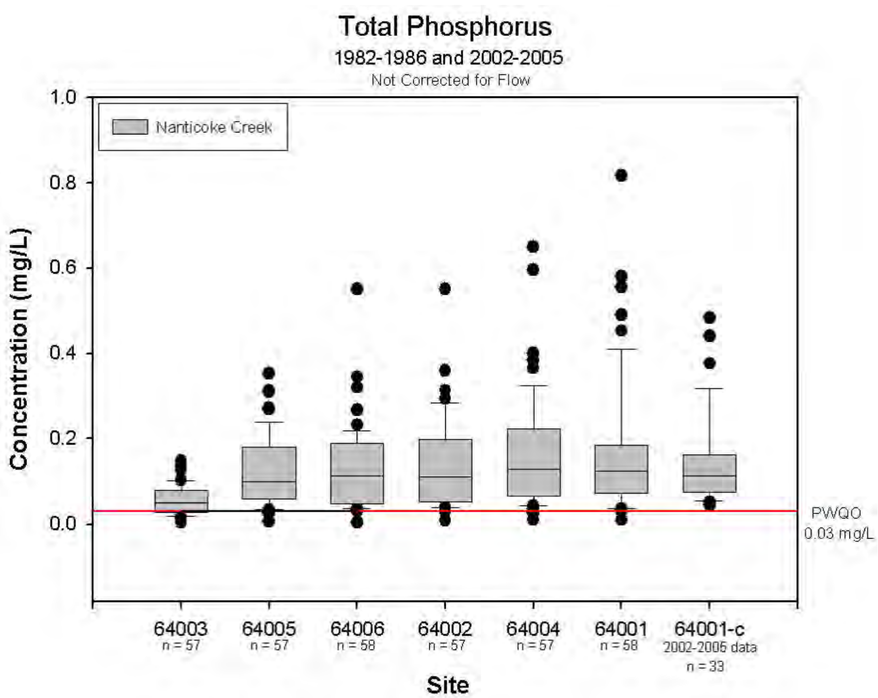
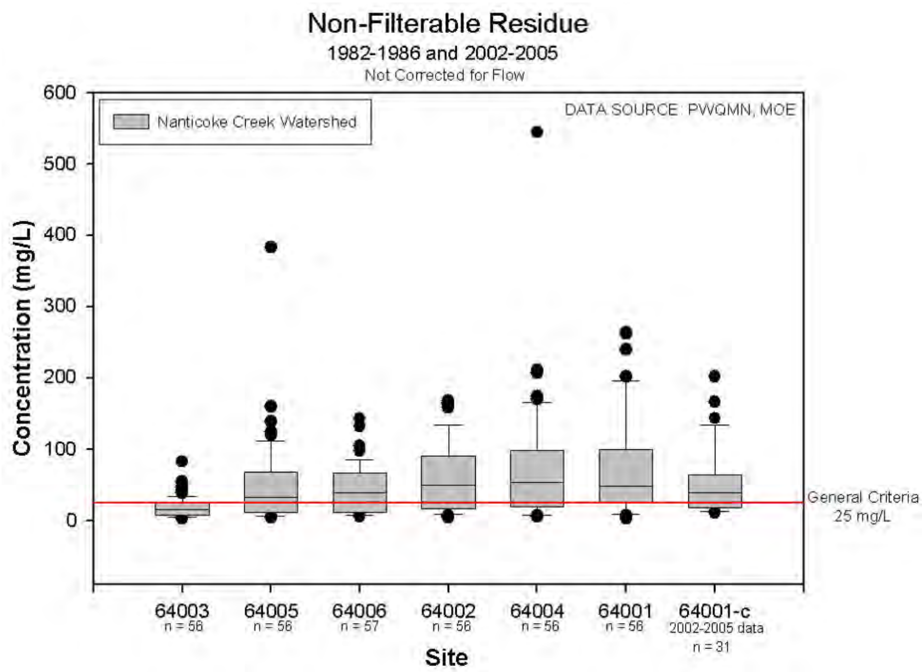


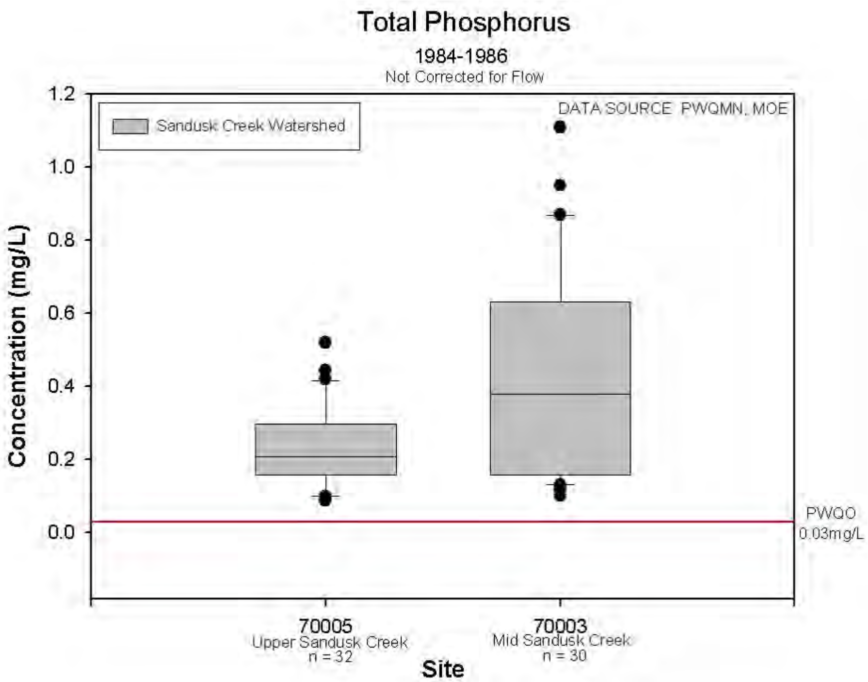
Figure 2.21: Non-filterable Residue Concentrations Between 1982 and 1986 at Six PWQMN Monitoring Sites and Between 2002 and 2005 at One PWQMN Monitoring Site in Nanticoke Creek Watershed



Sandusk Creek Watershed

Phosphorus and non-filterable residue levels are the primary water quality issues within the Sandusk Creek watershed, and tend to progressively increase from upstream to downstream (**Figure 2.22** and **Figure 2.23**). The entire Sandusk Creek watershed resides within the Haldimand Clay Plain which has a natural tendency for higher sedimentation and sediment associated nutrient concentrations, such as phosphorus. There are no natural retention areas within the Sandusk Creek watershed to help augment summer low flows (Morse et al., 1982). Therefore the Sandusk Creek watershed tends to be a 'flashy' system during rain events due to soil type (clay), lack of forest cover and the lack of infiltration capacity of the soils (Long Point Region Conservation Authority, 1979b). However, given the relatively low flows found within this watershed, it is only considered to be a moderate contributor of nitrate and phosphorus to Lake Erie (Long Point Region Conservation Authority, 1979b).

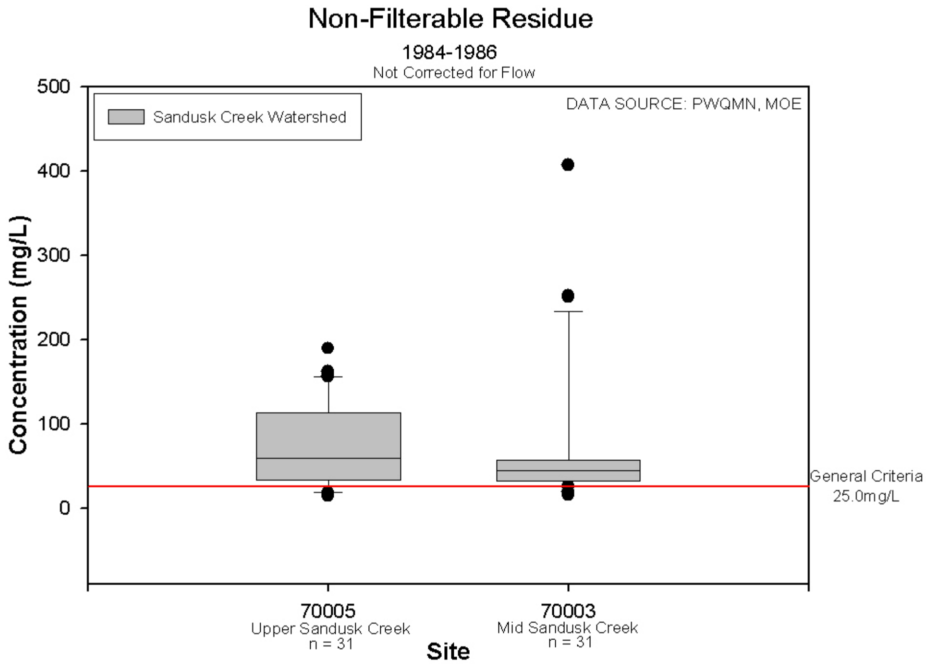
Figure 2.22: Phosphorus Concentrations Between 1984 and 1986 at Two PWQMN Monitoring Sites in Sandusk Creek Watershed



Dedrick Creek and Young Creek Watersheds

Water quality within the Dedrick Creek and Young Creek watersheds tend to be fairly good and those streams within the Norfolk Sand Plain, such as Young Creek, have been identified as a biologically significant salmonid cold water stream habitat (Long Point Region Conservation Authority, 1979c; Bernier and Reynolds, 1976). Young Creek tends to be of better water quality compared to Dedrick Creek, which is likely due to the numerous springs along Young Creek that continually recharge, cool and dilute the water (Van de Lande, 1987).

Figure 2.23: Non-filterable Residue Concentrations Between 1984 and 1986 at Two PWQMN Monitoring Sites in Sandusk Creek Watershed



The Port Rowan drinking water intake and Water Pollution Control Plant (WPCP) both take and discharge within the same general area in Lake Erie. This is of potential concern for the raw water quality taken up by the drinking water intake. Norfolk County routinely monitors the raw water quality used to supply the Port Rowan drinking water treatment. Bacterial samples are taken weekly; nitrate, nitrite and THM are sampled for quarterly and a full chemical analysis is done yearly. Norfolk County has also recognized the potential issues related to having a discharge and intake within the same general vicinity and thus have implemented safeguards to reduce the impact on the water quality (pers. comm. Bob Fields). Future raw water analyses at the location of the Port Rowan drinking water treatment plant intake should be performed to ensure the WPCP effluent is not having a negative impact..

Very little water quality information exists for the other watersheds within the Long Point Region. However, it is generally thought that their nutrient or NFR contributions to Lake Erie are minimal and given that there are no surface drinking water sources or recreational areas within these watersheds, they have not been considered a priority for monitoring.

Spills and wastewater treatment plant bypasses are a significant threat to downstream water users in the Long Point Region. Although spills are not considered to be a chronic water quality problem they can still have a tremendous impact on aquatic health and are of potential risk to drinking water if the spill is substantial enough to cause contamination of the Lake Erie intake waters. There is also the risk of transportation related spills that could impact the municipal water supplies in Tillsonburg, Delhi and Simcoe which are in close proximity to Highway 3, a major route between Detroit and Windsor and Buffalo and Niagara. Given the inherent risk to the region's drinking water supply and the limited response time in a spill emergency, it is imperative that spill response protocols are in place.

Preliminary trend assessment yields variable results with respect to whether nutrient levels are decreasing or increasing over time. Generally, at any site across the entire Long Point Region where a discernable trend was evident, nitrate concentrations appeared to be slightly increasing where as phosphorus and TSS appear to be decreasing or staying the same. Nitrite and ammonia concentrations have been dramatically increasing over time just below the Simcoe Water Pollution Control Plant in the Lynn River. However, the most apparent change in water quality overtime has been the increase in chloride levels found at most sites. This is likely as a direct result of an increase in road-salt application. Although, levels across the Long Point Region are still low relative to the Environment Canada benchmark. Re-assessing these trends in the future as more current data becomes available would be helpful in identifying if new trends are emerging. Measures such as improved wastewater treatment, road salt management strategies and targeted implementation of agricultural beneficial management practices are needed to curb these increasing trends.

2.7.2.1 Water Quality Data Gaps

The current sampling frequency does not allow for the characterization of flow events which limits the ability to properly calculate loads or statistically analyse for trends. More specifically, increased monitoring at the mouth of the major tributaries to Lake Erie within the Long Point Region should commence so relative contributions of sediment and nutrient loading can be properly assessed.

The assimilative capacity of the waterways within the Long Point Region continuing to receive wastewater effluent is not well known and further monitoring is required understand the extent the wastewater treatment plants impact the waterways to which they discharge.

There are certain water quality parameters for which there is a lack of data such as pesticides, metals, persistent chemicals and emerging contaminants (e.g. pharmaceuticals), which limits our ability to characterize their spatial and temporal traits across the watershed. This is also true for dissolved oxygen which should be continuously monitored to adequately understand the diurnal fluctuation occurring.

There is a lack of current water quality data for the reservoirs within the Long Point Region. Future monitoring within and upstream of the reservoirs, especially the Lehman Reservoir which is used as a drinking water source, will be necessary to fully identify any water quality concerns within the reservoirs and the potential sources.

Designing an integrated monitoring and reporting plan would capitalize on data resulting from other stream and biological monitoring as well as subwatershed planning programs within the Long Point Region Conservation Authority and increase our understanding of the water quality issues and the associated ecological processes being impacted.

The current Provincial Water Quality Objectives and the Canadian Water Quality Guidelines may not be appropriate for all watersheds across Ontario. However, identifying useful watershed or basin specific targets within the Long Point Region has not been thoroughly investigated. Further exploration into identifying local benchmarks or targets will likely require further academic investigation and monitoring.

Comprehensive assessment is required to understand the contributions of point and non-point sources so that strategies can be developed to reduce these relative inputs.

Intensive water quality and flow monitoring is required to reassess the relative loads for the major tributaries draining to Lake Erie to understand the influence of these creeks on the near shore with respect to public health (e.g. drinking water intakes and beaches).

2.7.3 Regional Groundwater Quality Conditions and Trends

The characterization of groundwater chemistry is an important consideration in hydrogeological studies. As well as being available in sufficient quantities, the geochemical properties of groundwater must be compatible with the intended use (e.g., potable, agricultural, industrial).

The geochemical composition of groundwater is a result of many processes, including interaction with atmospheric gases, reaction with minerals, bacteriological processes, anthropogenic effects, and other subsurface reactions and processes. Although there is a public perception that all instances of undesired compounds in groundwater are a result of anthropogenic contamination, groundwater may be rendered unusable due to entirely natural geochemical processes. For instance, some industrial processes are very sensitive to scaling issues, which may eliminate groundwater high in hardness from use. Groundwater may have attained naturally high concentrations of arsenic or total dissolved solids which would eliminate it from use as a source of potable water. Consequently, there is a need to better understand the ambient quality of groundwater and its controlling processes. This in turn allows for a stronger understanding of the impacts other contaminants may have on groundwater and provides insight into pollution trends and their effects on the aquifer system.

Groundwater geochemistry generally evolves as it moves along its flowpath. Typically, groundwater originates as precipitation and is generally low in total dissolved solids, slightly acidic, and somewhat oxidizing (Freeze and Cherry, 1979). Upon infiltration, the recent precipitation tends to increase in acidity and begins to react with the geologic material it encounters. As groundwater continues along its flowpath, it may evolve from being dominated by the anion bicarbonate and having relatively low total dissolved solids to sulphate domination and finally domination by the anion chloride and having relatively high total dissolved solids (Freeze and Cherry, 1979). This sequence is commonly referred to as the Chebotarev sequence and can account for the spatial variations in geochemistry that are often observed. The process of geochemical mapping and the recognition of geochemical trends can assist in distinguishing provenance and source identification (i.e. natural versus anthropogenic).

Within Long Point Region, there have been no long-term groundwater quality monitoring programs, but there have been several studies which have characterized groundwater quality through small-scale sampling programs. The following is a description of findings from previous studies within Long Point Region:

A. Hickinbotham (1977) summarized the results of analyses for major ions, nitrate, fluoride and physical chemical characteristics in the bedrock, shallow overburden and deep overburden aquifers. Approximately 15 samples were taken from each aquifer for this study. Results showed that groundwater from the bedrock and deep overburden aquifers often contained high sulphur concentrations. Overall results from this study showed the quality of the water to be generally hard in nature.

B. Blackport & Associates (1997) completed a survey evaluating groundwater quality for the Regional Municipality of Haldimand-Norfolk. The report reviewed and evaluated the water quality and septic system survey data from 10 hamlets, the majority of which are located on the Norfolk Sand Plain, within Haldimand-Norfolk Counties. The report discussed the potential for contamination within the shallow groundwater system within the sand plain where the more permeable sandy aquifer commonly overlays less permeable silt and clay. Flow in the shallow system is predominantly horizontal and the direction is locally controlled by streams and topography. Blackport & Associates (1997) concluded that the hamlets situated on the more permeable, shallow hydrogeologic systems were more susceptible to degraded groundwater quality (i.e. bacteria, NO32-, Cl-) from septic system effluent and the application of fertilizer and road salt.

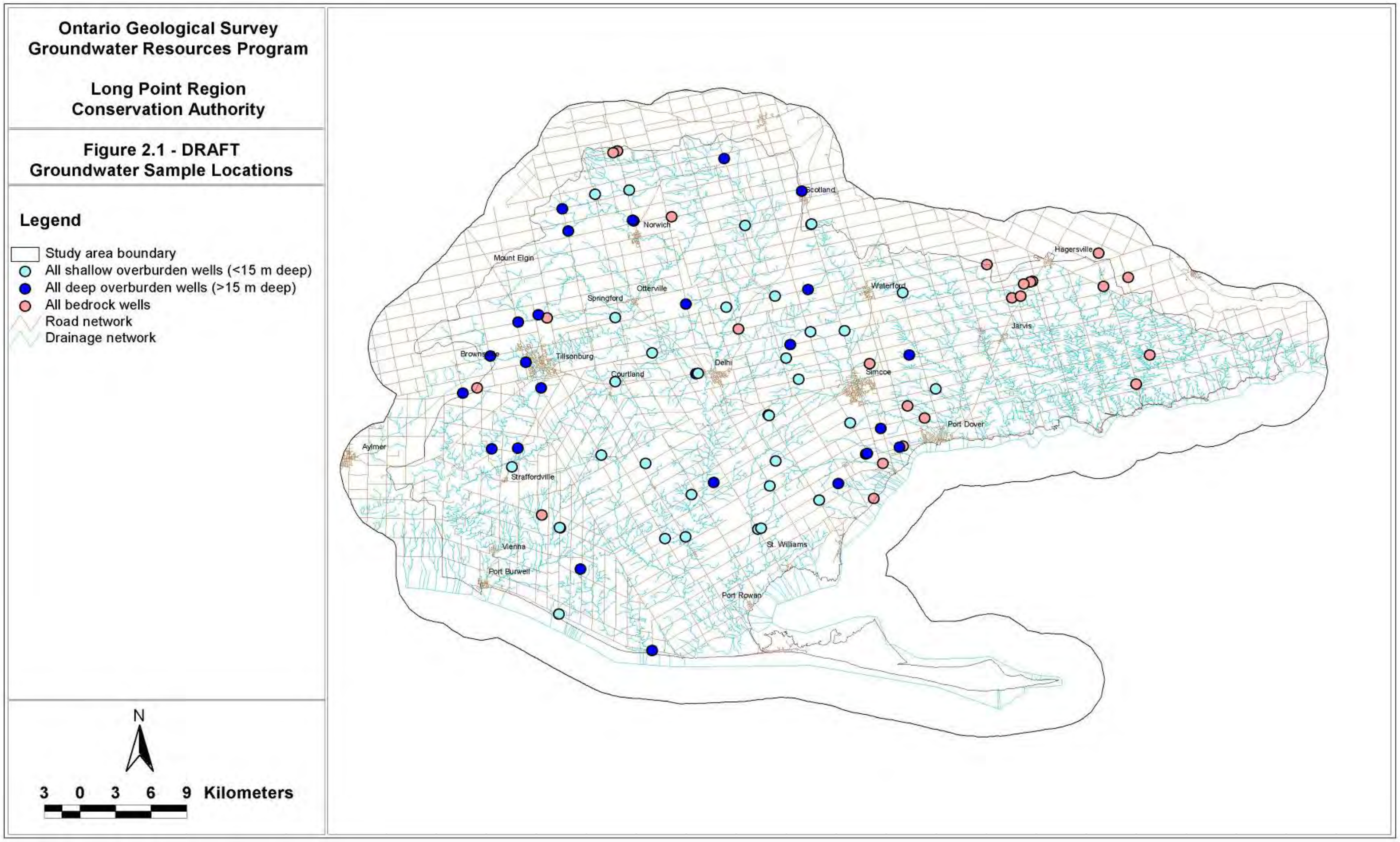
C. As a part of the County of Oxford Phase II Groundwater Protection Study (Golder, 2001), a groundwater quality survey for untreated drinking water was carried out at selected domestic residences within the County. The study focused on sampling wells that were completed in both the shallow overburden aquifer and bedrock aquifer for organic, inorganic and microbiological parameters. The results of the survey concluded that the quality of the raw water within the County was generally good. However, high concentrations of chloride and nitrate in the shallow aquifer reflected a higher susceptibility of that aquifer to surficial sources of contamination such as fertilizer and road salt. The bedrock aquifer was found to contain elevated concentrations of total dissolved solids (TDS) and SO42- and higher levels of specific conductivity. However, these were considered to be natural characteristics of the aquifer.

More recently, in collaboration with the Ontario Geological Survey, Environment Canada and the Grand River Conservation Authority, a small-scale groundwater quality study was completed across Long Point Region (Strynatka and Patterson, 2006). As a component of this study, a total of 91 groundwater samples were collected from private residences from the three aquifers across the Region and analyzed for a suite of major/minor ions, metals and general physical properties. The geochemical data was used to understand the chemical processes occurring in the study area and its relation to groundwater quality. The following discussion provides a summary of the Strynatka and Patterson (2006) study:

Groundwater samples analyzed for this study were collected from three hydrostratigraphic facies: shallow overburden (wells <15 m deep), intermediate to deep overburden (wells >15 m deep), and bedrock. The 15 m depth used to delineate the shallow and deep overburden aquifers was based on the groundwater mapping presented in the Norfolk Groundwater Study (Waterloo Hydrogeologic Inc., 2003). The shallow overburden aquifer was assumed to be an unconfined system, whereas the deep overburden and bedrock aquifers were assumed to be semi-confined to confined aquifers. In total, 35 samples were collected from the shallow overburden aquifer, 29 samples from the deep overburden aquifer, and 26 samples from the bedrock aquifer. Within the shallow overburden, 7 of the samples were collected from dug wells and 12 samples were collected from sandpoints. Sample locations are shown in Map 2.16.

The analytical results obtained from the groundwater samples were used to characterize trends and identify hydrogeochemical processes in each of the aquifers within Long Point Region. Basic summary statistics for selected physical properties, major ions, total dissolved solids (TDS), total Kjeldahl nitrogen (TKN) and F^- for each aquifer are presented in **Table 2.7**.

Map 2.16: Groundwater Sample Locations in Long Point Region



Produced using information provided by the Ministry of Natural Resources, Copyright © Queen's Printer, 2007. Banks, W., Strynatka, S., Patterson, T. and Piggott, A.R., in press. Long Point region groundwater resources study; Ontario Geological Survey, Groundwater Resources Study.

The relative percentages of the major ions for each sample are shown in **Figure 2.24** as a Piper diagram. **Figure 2.25**, **Figure 2.26**, and **Figure 2.27** present Piper diagrams corresponding to each of the 3 aquifers. **Figure 2.25** shows the distribution of major ions from groundwater sampled from shallow overburden. The following interpretations were made from this figure:

A. Overall, groundwater samples from the shallow overburden are predominantly of the Ca2+, HCO3- type. This water type is a reflection of the nature of the carbonate-rich glacial overburden sediments within Long Point Region. The Ca2+, HCO3- water type is also generally indicative of younger waters. The shallow overburden aquifer, predominantly located across the Norfolk Sand Plain, is generally unconfined, readily allowing for surficial recharge into these shallow groundwaters. Consequentially, these waters are not in the groundwater system for a long enough time to develop the qualities characteristic of more mature groundwaters. Many of these waters also exhibit elevated NO3- concentrations (3.5 to 15 mg/L), indicating direct influence by surface waters, and the higher relative Na / K concentrations exhibited on the cation plot may be linked to surficial influences.

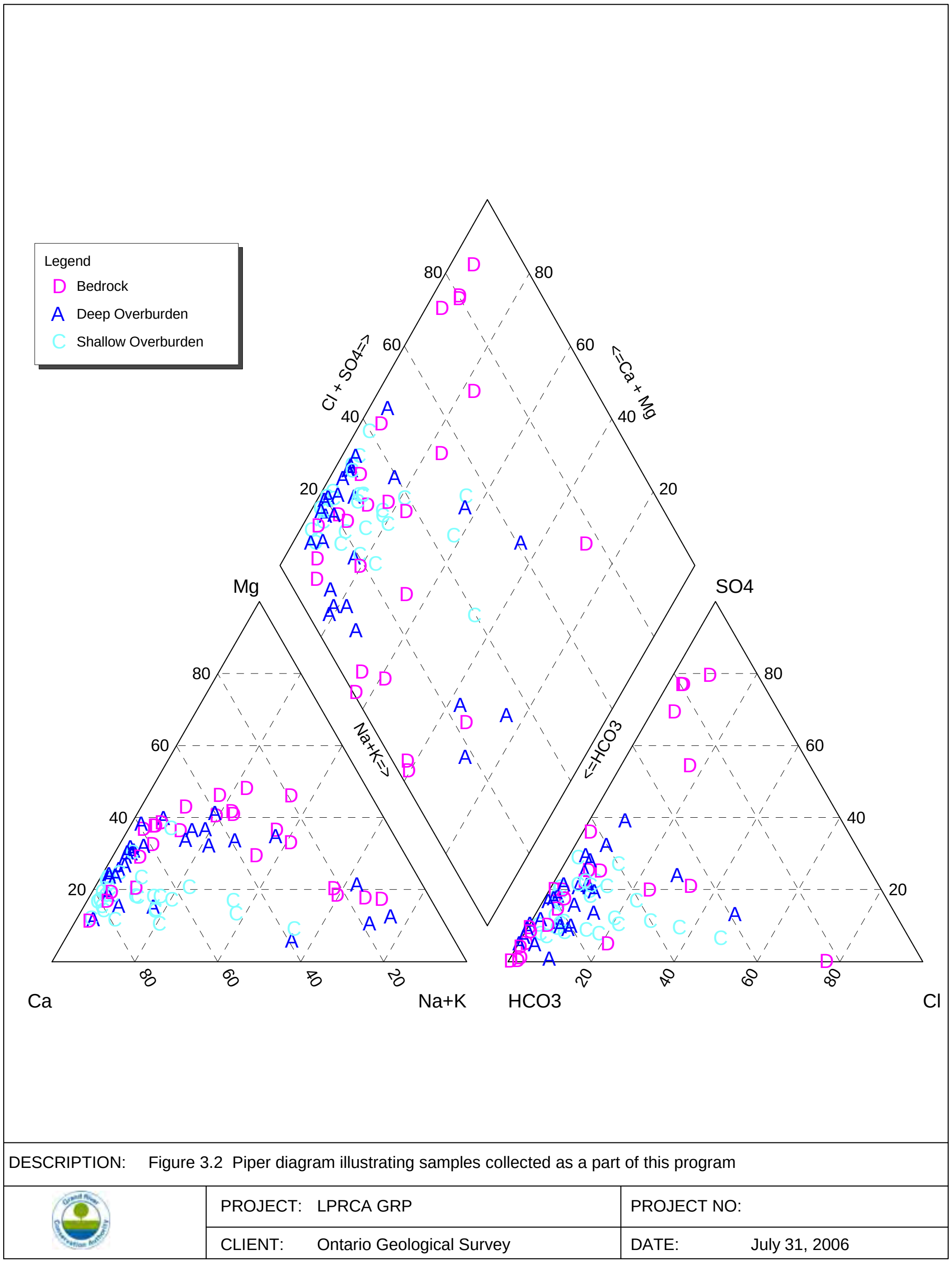
B. The second group of samples on **Figure 2.25** are no longer the immature Ca2+, HCO3- water type, as they plot towards the Na+ + K+ axes on the cation plot and the Cl- axis on the anion plot. These samples are associated with elevated dissolved organic carbon (DOC) concentrations, and are therefore likely reflecting the influences of road salt, septic effluent, livestock manure or a combination or these. Depending on the depth to the water table from the ground surface, there is generally little overlying protection afforded to this aquifer and it is vulnerable to surficial inputs. Additionally, the condition of the well can also act as a pathway allowing for the downward migration of salts and chemicals. Several well conditions can create a pathway for surficial materials to enter the subsurface such as cracked, poorly fitted or missing well caps, cracked well casings or a poor seal around the well itself.

Table 2.7: Summary of Selected Geochemical Analyses

		Field Temp.	pH	Specific Conductivity	Field Dissolved Oxygen	Alkalinity	TDS	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	Cl^{-}	SO_4^{2-}	HCO_3^{-}	NO_3^{2-}	TKN	F^{-}
		(deg. C)		µS/cm		(mg CaCO3/L)											
	Mean	10.47	8.08	582	8.22	209	313	78.7	13.3	19.4	2.4	30.0	42.9	253	4.9	0.13	0.17
Shallow Overburden	Median	10.84	8.08	533	9.16	198	295	77.3	11.7	8.50	0.9	19.5	41	239	3.5	0.09	0.05
n=31	S.D.	2.21	0.15	235	2.27	61.5	126	26.5	6.6	25.6	3.8	46.9	23.5	74	4.9	0.15	0.35
	Max.	14.46	8.26	1480	11.61	367	749	143.0	30.5	110	19.9	241	104	445	15	0.77	1.80
	Min.	4.10	7.53	295	3.60	125	161	10.0	3.6	1.70	0.3	1.9	12.7	150	0.10	0.02	0.05
	Mean	11.66	8.15	551	6.77	204	299	63.1	17.9	21.3	2.3	23.7	48.3	247	4.1	0.14	0.51
Deep Overburden	Median	11.63	8.20	515	6.46	202	284	63.3	18.5	6.9	0.9	13.1	45.7	244	0.6	0.10	0.15
n=27	S.D.	1.84	0.12	245	2.23	49	140	28.8	7.7	37.6	3.3	50.8	36.5	60	5.2	0.13	0.63
	Max.	16.42	8.33	1587	11.25	307	872	116.0	39.0	184	13.3	270	158	372	16.4	0.53	2.10
	Min.	8.41	7.85	287	2.79	109	143	11.0	4.2	2.6	0.6	0.5	1.5	131	0.1	0.02	0.05
	Mean	11.03	8.10	940	6.26	249	632	109	41.8	40.9	3.3	45.8	241	301	2.2	0.40	1.4
Bedrock	Median	10.95	8.14	593	6.05	220	309	64.4	23.9	31.9	2.1	13.9	43.3	266	0.1	0.24	1.2
n=25	S.D.	1.22	0.20	722	2.13	118	608	126	39.6	44.6	3.1	77.9	396	144	6.8	0.33	0.9
	Max.	15.30	8.39	2700	9.99	650	2335	530	141	186	12.6	330	1440	790	31.6	1.29	3.5
	Min.	9.34	7.56	207	3.06	118	123	10.6	6.0	5.4	0.6	0.7	0.25	142	0.1	0.04	0.2

All data is in mg/L unless otherwise indicated

Figure 2.24: Piper Diagram Showing Relative Percentages of Major Ions for Each Sample



The two samples which plot near the Cl- apex on the anion plot were collected from sand points and are associated with elevated Na+, TKN and DOC, indicating influences from a combination of road salt, septic effluent or livestock manure. These waters, plus the samples which show a higher Cl- percentage, have likely been influenced by surficial activities such as road salt, fertilizer and septic effluent. The three samples which plot near the Na+ + K+ vertex are associated with solely elevated Na+ (not K+), TKN and DOC, indicating septic effluent has likely affected these samples.

Figure 2.25: Piper Plot Representing Shallow Overburden Samples

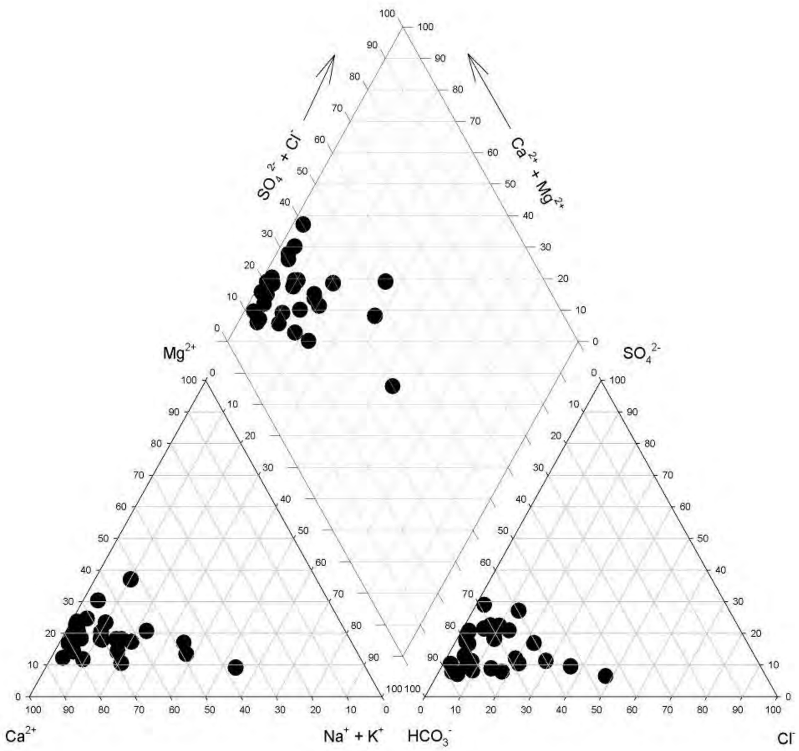


Figure 3.3a Piper plot representing shallow overburden samples

By classifying the water samples according to TDS, it was found that dilute waters (TDS < 300 mg/L) were predominantly found throughout the Norfolk sand plain. Dilute waters are indicative of either younger, recharge waters that have not traveled extensively throughout the groundwater system or groundwater that has traveled through a well-leached geological system. Waters with the highest TDS concentrations (> 1,000 mg/L) were found within the bedrock aquifer underlying the Haldimand clay plain. The geochemistry of the groundwater suggests that the water has either undergone sluggish flow or is older in age, thus developing a high solute concentration. Additionally, thermodynamic equilibrium between calcite and dolomite suggests recharge waters affect the shallow overburden aquifer and to a lesser degree the deep overburden aquifer; data for the bedrock aquifer suggest this aquifer is not affected by recharge waters. Ion exchange with clay minerals is likely occurring within the deep overburden and bedrock aquifers as Na+ : Cl- molar ratios are generally greater than 1. This suggests a Na+ source other than road salt (i.e. halite or formational salts) within these two aquifers.

Figure 2.26: Piper Plot Representing Deep Overburden Samples

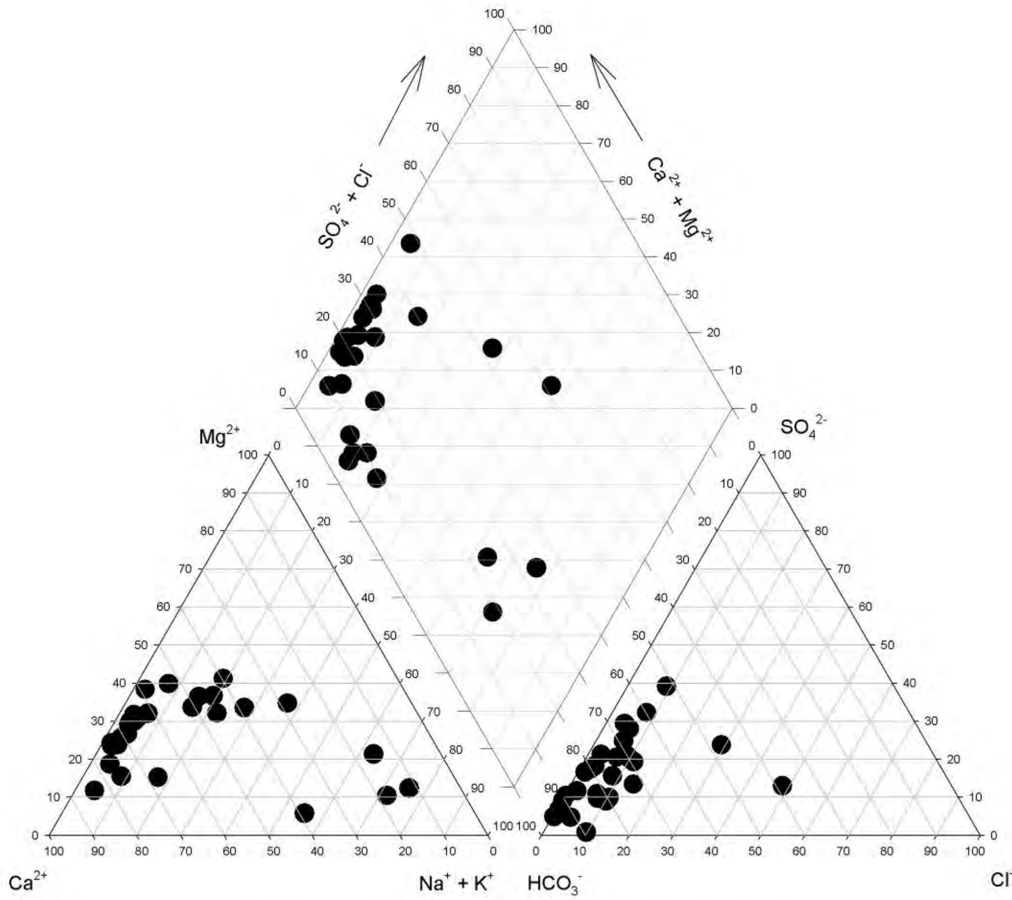


Figure 3.3b Piper plot representing deep overburden samples

Figure 2.26 presents the Piper diagram for groundwater samples from the deep overburden aquifer. This water is predominantly of the Ca^{2+} + Mg^{2+}, HCO_3^- type. When compared to samples from the shallow overburden, these deeper samples appear to reflect a larger Mg^{2+} and Na^+ + K^+ influence in their composition.

Higher F- concentrations were found in all bedrock groundwater relative to the overburden aquifers. This likely results from the dissolution of fluoride-bearing minerals within the bedrock, however bedrock mineralogy is currently unknown. Several deep overburden groundwater samples exhibited higher F- and Sr- concentrations. These may be locations where an upward vertical hydraulic gradient exists between the bedrock and deep overburden aquifers.

In 2006, the Ontario Ministry of the Environment released a document entitled 'Ontario Drinking Water Quality Standards' (Ontario Ministry of the Environment, 2006). The purpose of this document was to provide information about safe drinking water for the protection of public health and presents minimum level standards, objectives and guidelines for Ontario drinking water quality.

Figure 2.27: Piper Plot Representing Bedrock Samples

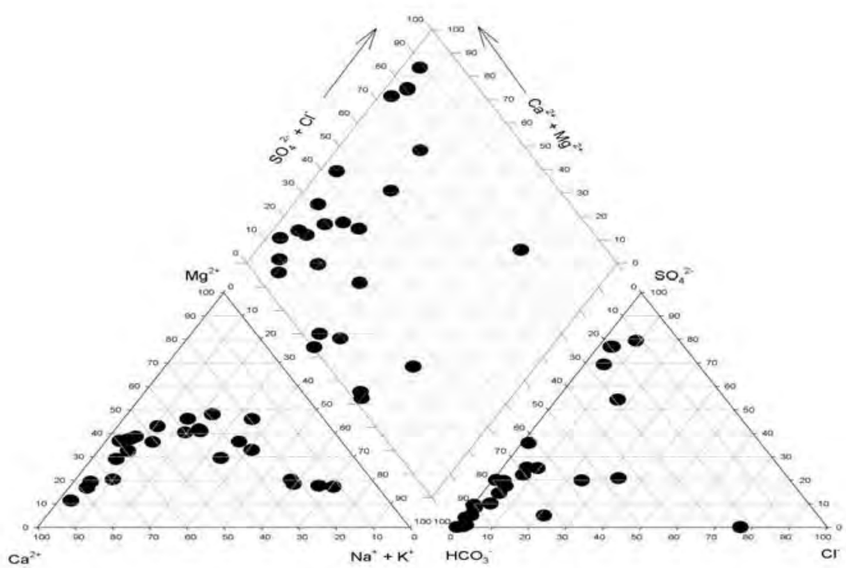


Figure 3.3c Piper plot representing bedrock samples

The Piper diagram representing the groundwater samples from the bedrock aquifer is illustrated in **Figure 2.27**. From this diagram, two distinct groups can be observed. The first group, comprising most of the samples, shows a general migration from Ca2+-rich water to Mg2+, Na+ + K+ -waters, which is reflective of more mature samples. This same water group, as it migrates away from the Ca2+ apex, also migrates away from HCO3- apex, becoming SO42- and Cl- enriched. The second, smaller group of samples is strongly SO42- enriched bedrock groundwaters. These are likely older waters in the bedrock system enriched in SO42- through the dissolution of sulphate-bearing minerals within the bedrock. Of the bedrock groundwaters, only one sample illustrates an elevated Cl- concentration, plotting near the Cl- apex on **Figure 2.27**. This sample is associated with elevated Na+ and TKN concentrations, indicating that this sample has likely been impacted by septic effluent or manure.

The data collected from the Strynatka and Patterson (2006) study was compared to the Ontario Ministry of the Environment Ontario Drinking Water Quality Standards (Ontario Ministry of the Environment, 2006) Maximum Acceptable Concentrations (MAC), Interim Maximum Acceptable Concentrations (IMAC) and Aesthetic Objectives (AO). The MAC is established for parameters, when present above a certain concentration, that have known or suspected adverse health effects whereas the IMAC was established for parameters where there were insufficient toxological data to establish a MAC (Ontario Ministry of the Environment, 2006). An AO is established where the parameter may impair taste, odour or colour of the water or which may interfere with good water quality control practices (Ontario Ministry of the Environment, 2006).

Table 2.8 summarizes the number of samples which exceed their respective MAC, IMAC and AO as given in the Ontario Drinking Water Quality Standards (Ontario Ministry of the Environment, 2006).

Table 2.8: Number of Samples from Each Aquifer that Exceed MOE Ontario Drinking Water Quality Standards

		MAC	IMAC	AO	Shallow Overburden	Deep Overburden	Bedrock
					n=31	n=27	n=25
As			0.025		0	0	0
B			5		0	0	0
Ba		1			0	0	0
Cd		0.005			0	0	0
Cr		0.05			0	0	0
Cu				1	0	0	0
Fe				0.3	2	0	0
Mn				0.05	9	2	1
Na				200	0	0	0
Pb		0.01			0	0	0
Sb			0.006		0	0	0
Se		0.01			0	0	0
Zn				5	0	0	0
F		1.5			0	3	8
Cl				250	0	1	1
NO2		1			0	0	0
NO3		10			6	4	2
SO4				500	0	0	6
DOC				5	2	0	1
TDS				500	4	2	9
Colour	TCU			5	3	0	4
Turbidity	NTU			5	0	1	0

All units are in mg/L except where given

From **Table 2.8,** two samples exceeded the AO for Fe. Iron is essential to humans for enzyme function and hemoglobin, therefore high levels are not a health risk. Levels of Fe in drinking water greater than 0.3 mg/L may cause a brownish colour on laundry, plumbing fixtures and in the water itself and may also produce a bitter taste in water.

Similar to Fe, Mn can stain laundry and fixtures black, and at excessive concentrations can cause an undesirable taste in beverages. It can also cause a coating on pipes which may slough off as a black precipitate. A total of 12 samples exceeded the AO for Mn in this study, with the majority found within the shallow overburden aquifer.

Eleven samples exceeded the MAC for F-, of which most were found within the bedrock aquifer. The optimum level of F- is 0.5-0.8 mg/L to help prevent tooth decay and recommended levels are between 0.5 mg/L and 1.5 mg/L (Fitzgerald et al. 1997). However, F- concentrations between 1.5 – 2.0 mg/L can result in the yellowish-brown mottling of enamel (Fitzgerald et al.1997). Higher concentrations can cause dental fluorosis and osteosclerosis.

Two samples were found to exceed the AO for Cl-. In general, aqueous Cl- is a common non-toxic element present in small amounts in drinking water. Major sources are natural salt deposits in the aquifer, road salt and septic tank systems, fertilizers etc.

Nitrite and NO32- are present in groundwater as a result of plant and animal decay, the use of agricultural fertilizers, domestic sewage or treated wastewater contamination, or geological formations containing soluble nitrogen compounds. They are primarily of concern because generally they are indicators of surficial contamination. There is a risk that babies and small children may suffer blood-related problems (methaemoglobinaemia, also known as blue baby syndrome) with excess nitrate intake. Older children and adults drinking the same water are unaffected. Most water-related cases of methaemoglobinaemia are associated with the use of water containing more than 10 mg/L nitrate as nitrogen. In Canada, no cases of the condition have been reported where the NO32- concentration was consistently less than the MAC (Fitzgerald et al. 1997). Where both NO2- and NO32- are present, the total of NO2- plus NO32- should not exceed 10 mg/L. A total of 12 samples exceeded the MAC for NO32- for this study; 6 samples within the shallow overburden aquifer, 4 samples within the deep overburden aquifer and 2 samples within the bedrock aquifer.

Six samples, all within the bedrock aquifer were found to have SO42- concentrations which exceed the AO. Levels greater than 500 mg/L, SO42- can cause a laxative effect, however, regular users adapt to high levels of SO42- in drinking water and problems are usually only experienced by visitors and new consumers. Sulphate can also be converted into sulphide by some anaerobic bacteria creating odour problems and potentially greatly accelerating corrosion.

High DOC (greater than 5.0 mg/L) is an indicator of possible water quality deterioration during storage and distribution, or septic contamination. It is also an indicator of potential chlorination by-product problems. Two samples within the shallow overburden and 1 sample from the bedrock aquifer were found to exceed the AO for DOC.

In total, 49% of the shallow overburden samples, 38% of the deep overburden samples and 65% of the bedrock samples exceeded the MAC, IMAC or AO concentrations for at least one parameter. In the shallow overburden, exceedences are primarily the result of anthropogenic influences such as the application of nitrogen-containing fertilizers and road salts. The bedrock aquifer, which is generally well protected by a layer of glaciolacustrine clay, likely develops its geochemical character from geologic processes.

Generally, the groundwater quality found within Long Point Region was found to vary significantly between the 3 different aquifers. These variations were the results of the geologic setting (overburden versus bedrock) and also from surficially-derived chemicals entering the groundwater system. The variation between aquifers suggested different provenance (anthropogenic versus natural) for these parameters.

Comparisons with Ontario Drinking Water Standards (MOE, 2006) show the bedrock aquifer to supply the 'poorest' relative quality and most mineralized groundwater. The nature of this water however, generally appeared to be related to the ambient geochemistry of the groundwater system rather than anthropogenic activity. Where anthropogenic impacts were apparent within the bedrock aquifer, it was likely a result of poorly constructed or improperly maintained wells and less so through recharge entering the groundwater system. The water quality issues within the shallow overburden aquifer also showed poorer quality in accordance to the Ontario Drinking Water Standards, but the degraded quality is likely the result of fertilizer, road salt, manure, septic systems etc. that have entered the aquifer system. Notably higher NO32- and associated elevated K+ concentrations in the overburden aquifers suggests the downward migration of fertilizers into the aquifer systems. The deep overburden aquifer displayed the best relative groundwater quality because it was afforded a certain degree of protection from surficial activities by the overlying confining sediments and has not been affected by the same geologic processes as the bedrock-derived groundwater.

2.8 Aquatic Ecology

2.8.1 Fisheries

The Long Point Region watersheds include a variety of fish species and habitat as the area encompasses coldwater streams, warm water streams, inland lakes and ponds, and Lake Erie. The cold water streams support resident and migratory salmonid populations that include Brook, Brown Trout, Rainbow and Pacific Salmon. Unfortunately poor land use practises have degraded the salmonid habitat which has decreased the population size. Warm water systems support Bass, Pike, Perch, Sunfish, Bull Head, Channel Catfish and other panfish species (Ontario Ministry of Natural Resources Simcoe Fisheries Management). Many of the inland lakes and ponds are small reservoirs and rehabilitated gravel extraction pits over one hectare in surface area, where fish populations include Large Mouth Bass, Yellow Perch, Sunfish and Crappie. Lake Erie which is the smallest of the Great Lakes provides valuable spawning and nursery habitat through shoreline marshes which includes the Long Point Bay. Species found within the Long Point Bay include Largemouth and Smallmouth Bass, Yellow Perch, Northern Pike, Sunfish, Rock Bass, Carp and Bull Head (Ontario Ministry of Natural Resources Simcoe Fisheries Management). Lake Erie can be divided into three main basins which includes central, eastern and western, where the Long Point Region watersheds mainly encompass the eastern basin. Species found within the eastern basin include: Rainbow Smelt, Yellow Perch, Rainbow and Brown Trout, Pacific Salmon, Lake Whitefish, Lake Herring and Lake Trout.

2.8.1.1.1 Fisheries Management Plan

Two fisheries management plans are followed within the watersheds this includes the Simcoe District Fisheries Management Plan 1987-2000 and the Aylmer District Fisheries Plan. The Aylmer District Fisheries Plan differs as it mainly focuses on the Big Otter watershed which is a warm water migratory creek. The concentration of the fisheries management plan for the Big Otter watershed is to decrease sediment loading due to siltation, decrease nutrient levels in the river and maintain or decrease where possible the temperature of the river.

The outcome of the Simcoe Districts Fisheries Management Plan 1987-2000, outlined 19 specific problems in regards to fish management within the watershed. The specific issues can be grouped into four categories which include habitat destruction, demand/supply imbalances, resource use conflict and inadequate knowledge. These issues can have severe implications on the fish population and habitat, which is why a fisheries management plan is needed to alleviate impacts, protect habitat, increase and protect the fisheries population.

The fisheries management objective of southern Ontario is to provide recreation and economic benefits while at the same time keeping a healthy fish community (Ontario Ministry of Natural Resources Simcoe Fisheries Management). The Simcoe Fisheries Plan uses the general objective from Ontario as the main goal of fisheries management and refines the management strategy under four categories. The categories include sport fishing, bait fishing, commercial fishing and provincial rare and endangered species which were then further divided into objectives and sub objectives and then constructed into strategies and targets.

The general sport fish objective is to "meet the demand for sport fishing within the limits of a wisely managed and rehabilitated resource" (Ontario Ministry of Natural Resources Simcoe Fisheries Management). The general objective outlines five main sub objectives:

1) Meet projected demand for trout fishing by increasing resident Trout in inland waters by 20 percent, migratory trout in lake Erie and tributaries by 15 percent;

2) Increase angling activity for warm water fish species in ponds and streams by 14 percent;

3) Meet projected demand for small mouth bass in Long Point Bay by increasing the average Bass population levels over the long-term by 15 percent;

4) Increase sport fishing activity for non-salmonid fish species in Long Point Bay and Lake Erie by 14 percent; and

5) Increase opportunities for fish viewing in the area.

   (Ontario Ministry of Natural Resources Simcoe Fisheries Management)

The commercial fish general objective is to maintain a viable commercial fishing industry which will be accomplished through seven strategies and targets:

1) Collect information on fish population in Lake Erie with a focus on Long Point Bay and Eastern Bay;

2) Regulate harvest so that commercial fish stocks are not over exploited;

3) Accurately estimate annual commercial fish harvest;

4) Encourage the commercial fishing industry to expand markets for underutilized species;

5) Reduce incidental catches of restricted fish species;

6) Protect fish habitat along Long Point Bay and the Lake Erie shoreline; and

7) Resolve angler/commercial fisherman conflicts.

The Bait Fish objective is to maintain the current baitfish production through strategies that include:

1) Preventing over harvest of baitfish stocks in Lake Erie;
2) Direct additional bait fishing effort to in land waters;
3) Encourage private culture of baitfish; and
4) Accurately estimate the annual commercial baitfish harvest.

The Provincially rare and endangered fish species objective is to "prevent the extinction of any native fish species" (Fisheries management) where strategies to accomplish the objective include:

1) Identify and monitor populations of rare or endangered fish species;
2) Protect rare fish population and their habitat; and
3) Keep public informed of the status of rare and endangered fish species.

2.8.2 Aquatic Macroinvertebrates

Aquatic macroinvertebrate sampling within the watershed has varied in the last four years as the Les Stanfield protocol was used in 2002 and 2003, along with the Ontario Benthos Biomonitoring Network (OBBN). There are currently ten provincial water quality monitoring network sites within the watershed being sampled; however, the samples only cover eight creeks which may not be completely representative of all watercourses in Long Point Region watershed.

Sampling within the watershed was conducted at 19 sites in 2002 and 2003, within the Lynn River/Black Creek watershed, which followed the protocol from Les Stanfield's *Stream Assessment Protocol for Ontario* (1997). The sites are illustrated in **Table 2.9** and **Map 2.17**. The data collected was given a value based on the Hilsenhoff Index related to how tolerable the invertebrate is to differing water quality. The resulting data from the 2002/2003 benthic sampling can be found within the *Lynn River State of the Watershed Project* (Gagnon and Giles, 2004). A summary of the scores for the sites are provided in **Table 2.10** and in **Map 2.18** (2002) and **Map 2.19** (2003).

Table 2.9: Summary of Sampling Locations for Aquatic Macroinvertebrates in Lynn River, Long Point Region Watershed

Waterbody	Station	Location
Black Creek	BT1	Upstream side of Reg. Rd.5, north of Reg. Rd.3
	BT2	Lynn Valley Rd. between Regional Rd.5 and East ¼ Line Rd. Nanticoke. Downstream side.
	B2	Upstream side of Conc.6 Woodhouse before East ¼ Line Rd. Nanticoke
	B3	Upstream side of Hwy.3 between Regional Rd.5 and O'Mahoney Rd.
	B4	Upstream side of Conc.13 Townsend (before Reg.Rd.5)
Catfish Creek	C1	Downstream side of Conc.6 Woodhouse before East ¼ Line Rd. Nanticoke
	C2	Upstream side of Conc.14 Townsend after O'Mahoney Rd.

Table 2.9: Summary of Sampling Locations for Aquatic Macroinvertebrates in Lynn River, Long Point Region Watershed

Waterbody	Station	Location
Davis Creek	D1	Upstream side of Davis St. W, Simcoe
	D2	Downstream of Regional Rd.24 and Cloett Rd.
Eerinburgh Creek	E1	Reg. Rd.3 and downstream of Blueline Rd.
	E2	Upstream of Blueline Rd. Before the pump house dam.
Kent Creek	K1	Upstream of Hillcrest Rd. just past West St. W.
	K2	Hwy.3 and upstream side of Charlotteville East ¼ Line Rd
Lynn River	L2	Upstream side of Regional Rd.3
	L3	Upstream side of Lynn Valley Rd. near Ryerse Rd.
Patterson Creek	P1	Upstream side of Hunt St., Simcoe
	P2	Upstream side of Windham Rd.11
	P3	Downstream of Windham East ¼ Line Rd.
Spring Creek	S1	Downstream of Hwy.24 and Lynn Valley Rd.

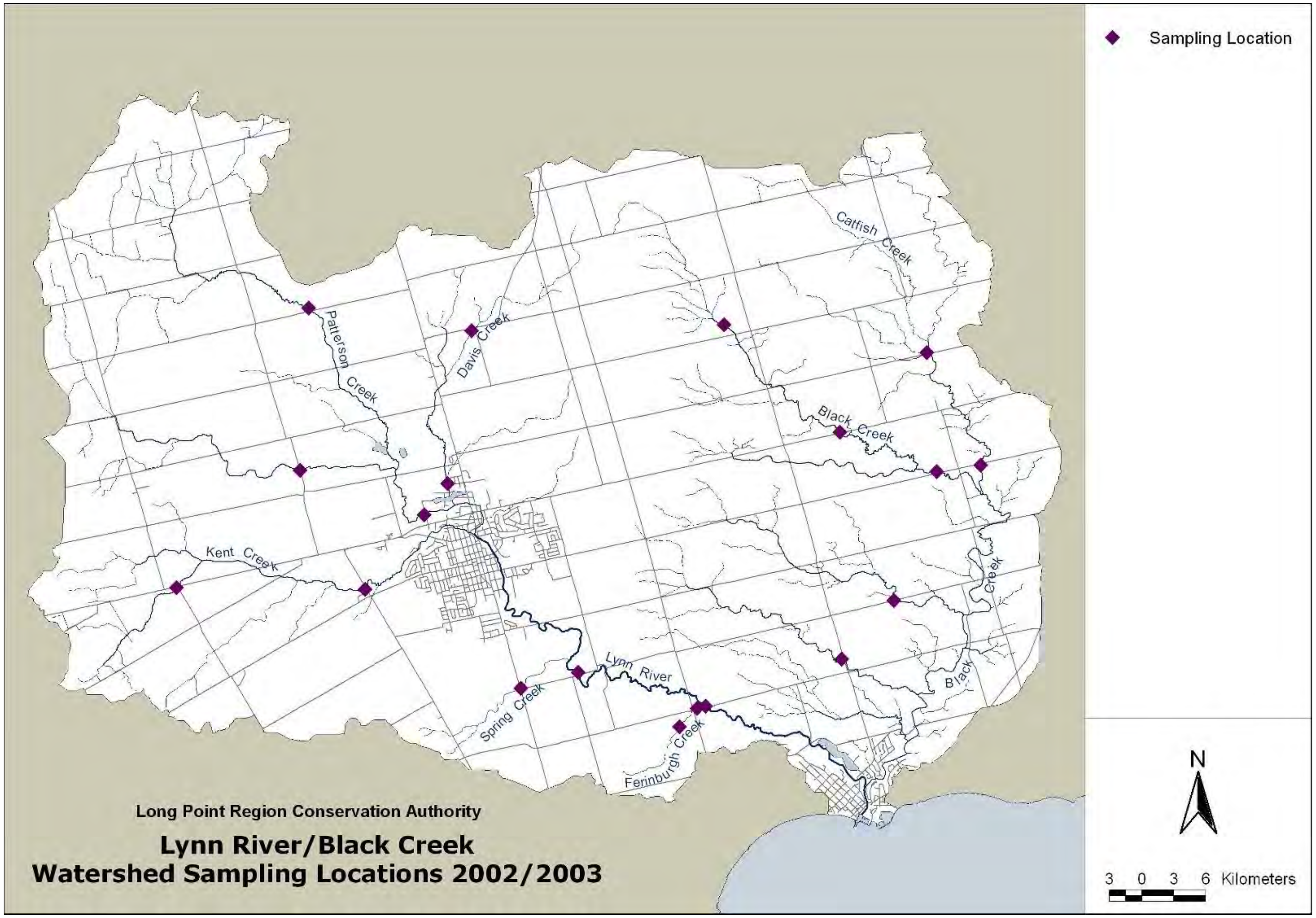
Taken from the Lynn River Report (Gagnon and Giles, 2004)

Table 2.10: Summary of the Aquatic Macroinvertebrate Results for 2002-2003

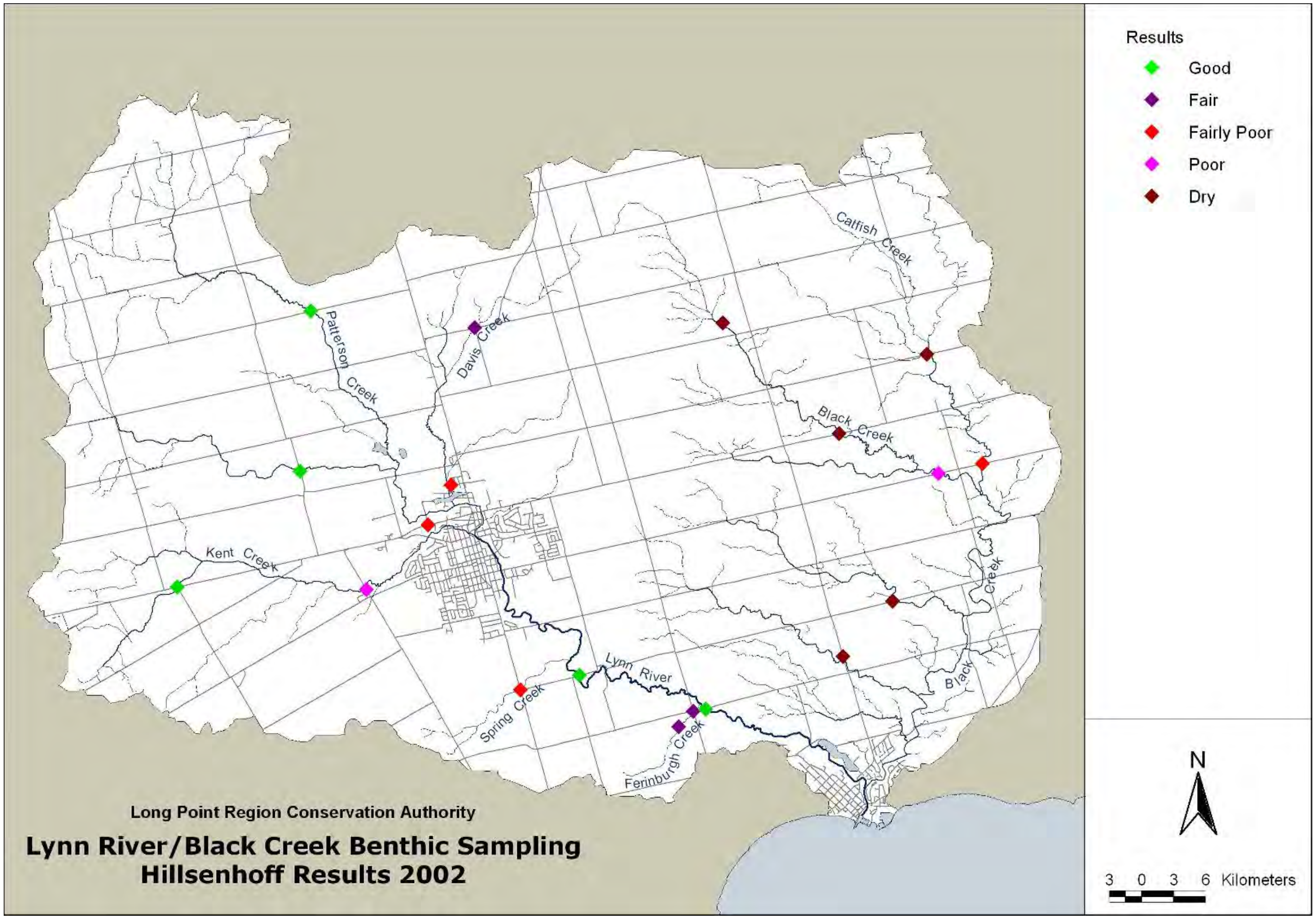
Station	2002			2003		
	# of Taxa	Score	Rating	# of Taxa	Score	Rating
B2	8	7.01	Poor	13	6.39	Fairly Poor
B3	Dry	Dry	Dry	12	6.26	Fairly Poor
B4	Dry	Dry	Dry	9	6.45	Fairly Poor
BT1	Dry	Dry	Dry	11	6.23	Fairly Poor
BT2	Dry	Dry	Dry	14	6.81	Poor
C1	6	6.18	Fairly Poor	15	6.37	Fairly Poor
C2	Dry	Dry	Dry	14	4.82	Good
D1	11	6.43	Fairly Poor	16	6.7	Poor
D2	10	5.1	Fair	10	6.85	Poor
E1	11	5.74	Fair	14	4.45	Good
E2	11	5.73	Fair	10	6.72	Poor
K1	12	6.54	Poor	13	6.26	Fairly
K2	13	4.7	Good	11	6.37	Fairly
L2	7	4.49	Good	9	4.61	Good
L3	10	4.86	Good	12	5.98	Fairly
P1	10	6.06	Fairly Poor	13	6.08	Fairly Poor
P2	11	4.47	Good	13	5.26	Fair
P3	12	4.54	Good	15	6.04	Fairly Poor
S1	6	6.07	Fairly Poor	7	7.15	Poor

Taken from the Lynn River Report (Gagnon and Giles, 2004)

Map 2.17: Benthic Sampling Locations in Lynn River and Black Creek, 2002-2003



Map 2.18: Benthic Sampling Results for Lynn River and Black Creek, 2002



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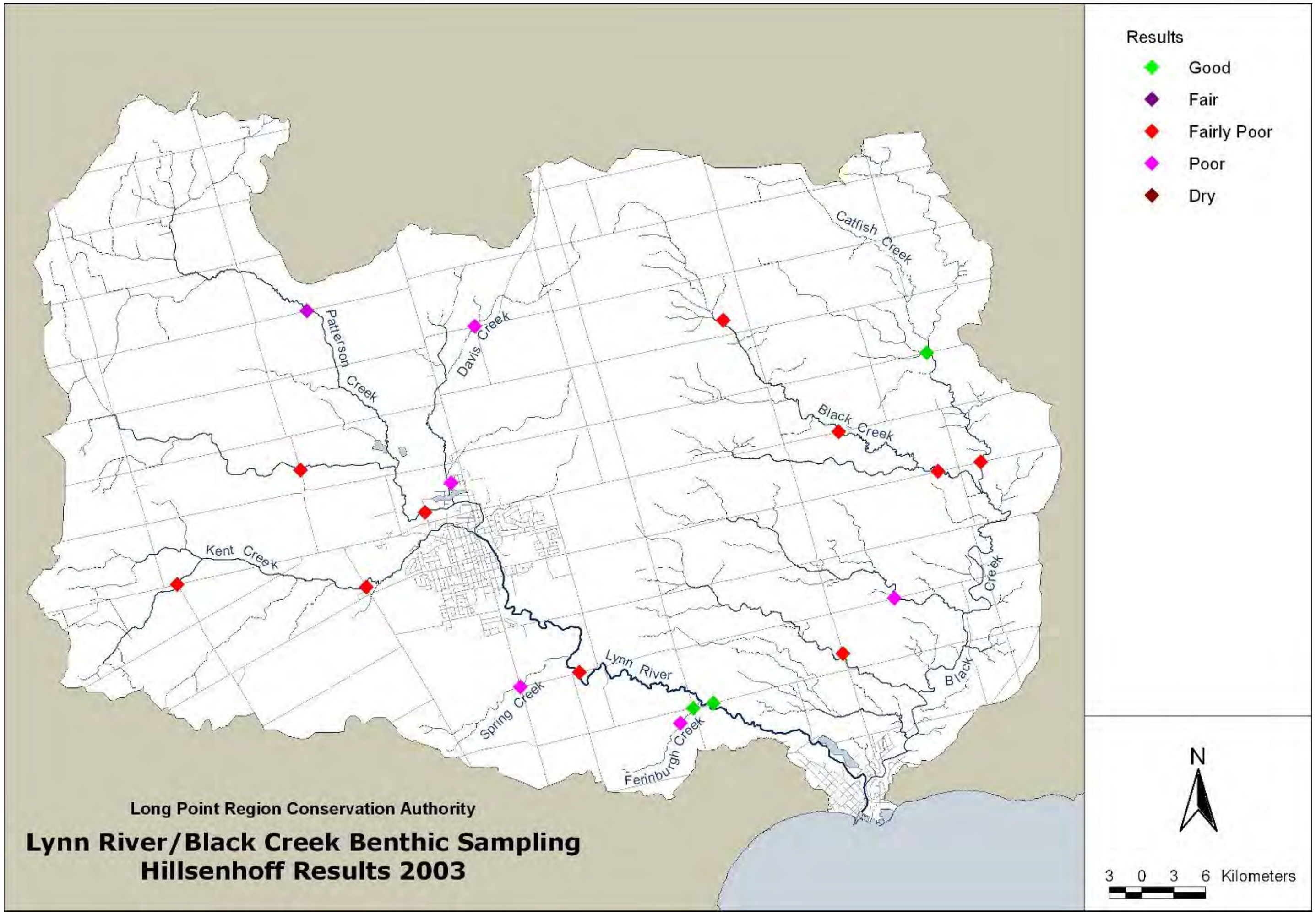
Map 2.19: Benthic Sampling Results for Lynn River and Black Creek, 2003



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The sites sampled within the watershed produced ratings that were generally fairly poor for 2003 however water quality sampling presents overall good water quality results in the watershed (Long Point Region Conservation Authority, 2005). One of the reasoning's behind a few of the low ratings from the Hilsenhoff index may be due to the Norfolk Sand Plain where sand covers rocks and debris in many rivers and creeks that aquatic macroinvertebrates prefer for habitat.

The Ontario Benthos Biomonitoring Network (OBBN) protocol was initiated in 2002 for provincial water quality. Sampling has continued each year following the OBBN protocol at each of the Provincial Water Quality Monitoring Network Sites and the data has been put into the OBBN database. **Map 2.14** illustrates the sampling sites for Provincial Water Quality Monitoring Network. One of the gaps of the data is that the results have not currently been computed, organized or put into an index which makes it hard to generalize present water quality of the watershed based on aquatic macroinvertebrates. Furthermore there has been little data collection from the major reservoirs within the watershed and in 2002 there was a data gap in the benthic invertebrate sampling as a result of dry sampling locations.

2.8.3 Species and Habitats at Risk

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and the Species at Risk Act (SARA) (Environment Canada, 2006) identify many species at risk that are found within the Long Point Region watersheds. In addition, the distribution and population trends of the species at risk within the watersheds are summarized in the Essex-Erie Recovery Strategy draft report (Essex-Erie Recovery Team, draft 2006). The species at risk are listed below along with the main threats to the species population.

Pugnose Shiner (*Notropis anogenus)*

The Pugnose Shiner is considered endangered by COSEWIC and by the SARA. The Essex-Erie Recovery Strategy has listed the species as having a declining population trend in the Long Point Bay area. The Pugnose Shiner is a wetland dependant species where threats include water pollution, siltation, removal of littoral vegetation and reduction in habitat.

Eastern Sand Darter (*Ammocrypta pellucida)*

The Eastern Sand Darter is classified as threatened by COSEWIC and the SARA. Decline of the population is due to siltation, sand bar removals, dam building and water pollution.

Lake Chubsucker (*Erimyzon sucetta)*

The Lake Chubsucker is considered threatened by COSEWIC and SARA. The Essex-Erie Recovery Strategy recognizes the species as having a stable population trend in the Long Point Bay area. The species is dependant on healthy wetland. Declining populations are likely due to siltation, wetland drainage, increased water turbidity and pollution.

Spotted Gar (*Lepisosteus oculatus)*

The Spotted Gar is not common in Canada (the northern limit of the species range is in the most southern part of southern Ontario). The species is considered threatened by COSEWIC and SARA. The Essex-Erie Recovery Strategy lists the Spotted Gar as having a stable population in the Long Point Bay. Water pollution and the destruction of shallow weedy bays need for breeding are main threats to the species.

Channel Darter (*Percina copelandi)*

The Channel Darter is classified as threatened under COSEWIC and SARA. The Essex-Erie Recovery Strategy lists the species as having a declining population in Lake Erie. Threats to the population include sedimentation, deteriorating water quality associated with agriculture and development, and limited access to areas with moderately to rapidly flowing waters important to the breeding of the species.

Lake Sturgeon (*Acipenser fulbescens)*

The Lake Sturgeon is classified as special concern under COSEWIC. The Essex-Erie Recovery Strategy lists the species as declining in Long Point Bay and Lake Erie. Historically the Sturgeon has experienced a dramatic decline, but there is evidence that there is a reproducing population in Long Point Region (Essex-Erie Recovery Team, draft 2006). Threats include agriculture development, construction of dams, habitat contamination caused by chemicals, toxins, fertilizers and the introduction of non-native species.

Grass Pickerel (*Esox americanus vermiculatus)*

The Grass Pickerel is listed under COSEWIC and SARA as a special concern. The Essex-Erie Recovery Strategy lists the species as stable along Long Point Bay. Threats include loss of habitat, or decline in quality which includes silting of streams, loss of flow from farmland drains and an increase in water turbidity.

Northern Brook Lamprey (*Ichyomyzon fossor)*

The Northern Brook Lamprey prefers warm water and declining populations are due to application of non-selective chemicals in streams to control the introduced parasitic Sea Lamprey. In addition siltation is also a possible threat. COSEWIC and SARA list the fish as special concern.

Bigmouth Buffalo (*Ictiobus cyprinellus)*

The Bigmouth Buffalo is listed as a special concern under COSEWIC and SARA. Low populations in Ontario are due to temperature as the fish likes warm muddy enriched poorly oxygenated waters.

Silver Chub (*Macrhybopsis storeriana)*

The Silver Chub is classified as a species of special concern by COSEWIC and SARA. The Silver Chub was common in Lake Erie up until the 1950s. The decline seemed to correspond with downward population trends in prey, including Mayfly Nymphs, caused by the eutrophication of lakes.

Warmouth (Lepomis gulosus)

The Warmouth is listed as a species of special concern by COSEWIC and SARA. The species has a limited distribution which includes the Lake Erie shore between Point Pelee and Long Point (COSEWIC). The Essex-Erie Recovery Strategy lists the species as having a stable population trend for the Long Point Bay.

Essex-Erie Recovery Strategy (draft 2006)

The Essex-Erie Recovery Team produced a draft report that identifies species at risk within the Essex-Erie Region and associated recovery strategies. Strategies identify priority areas within the study area that have a high distribution of priority species. The priority areas in the Long Point Region watersheds are shown in **Map 2.20**, and include the Big Creek watershed, Long Point Bay, Dedrich Creek and Big Otter Creek. The study lists the distribution of the fishes at risk and ranks the priority of recovery by looking at historical data and extant species (1990 to 2005) which is described below and taken directly from the Essex-Erie Recovery Strategy draft.

Long Point Bay (including the Inner Bay and Big Creek)

Long Point Bay supports historical and existing populations of four high priority species (Pugnose Shiner, Eastern Sand Darter, Lake Chubsucker and Spotted Gar). Three medium priority species are also represented (Grass Pickerel, Warmouth and Pugnose Minnow). Historical records of two medium priority species (Lake Sturgeon and Silver Chub) and one low priority species (Bigmouth Buffalo) are also known (Essex-Erie Recovery Team, draft 2006).

The largest tributary of Long Point Bay is Big Creek which supports populations of Warmouth, Grass Pickerel and Greenside Darter as well as historical records of two high priority species – Eastern Sand Darter and Lake Chubsucker. There are also historical records of the Northern Brook Lamprey. Additional surveys will help confirm the presence or absence of these three species in Big Creek (Essex-Erie Recovery Team, draft 2006).

Secondary core areas were identified based on the presence of at least one historical population of a high priority species. Secondary core areas recognize that several high priority species at risk depend on the aquatic health of habitats beyond the primary core areas identified above, and that the recovery needs of these species should be assigned high priority. Specifically, the Black Redhorse and presumed extirpated population of the Eastern Sand Darter from inland watercourses require higher prioritization of habitat recovery (Essex-Erie Recovery Team, draft 2006).

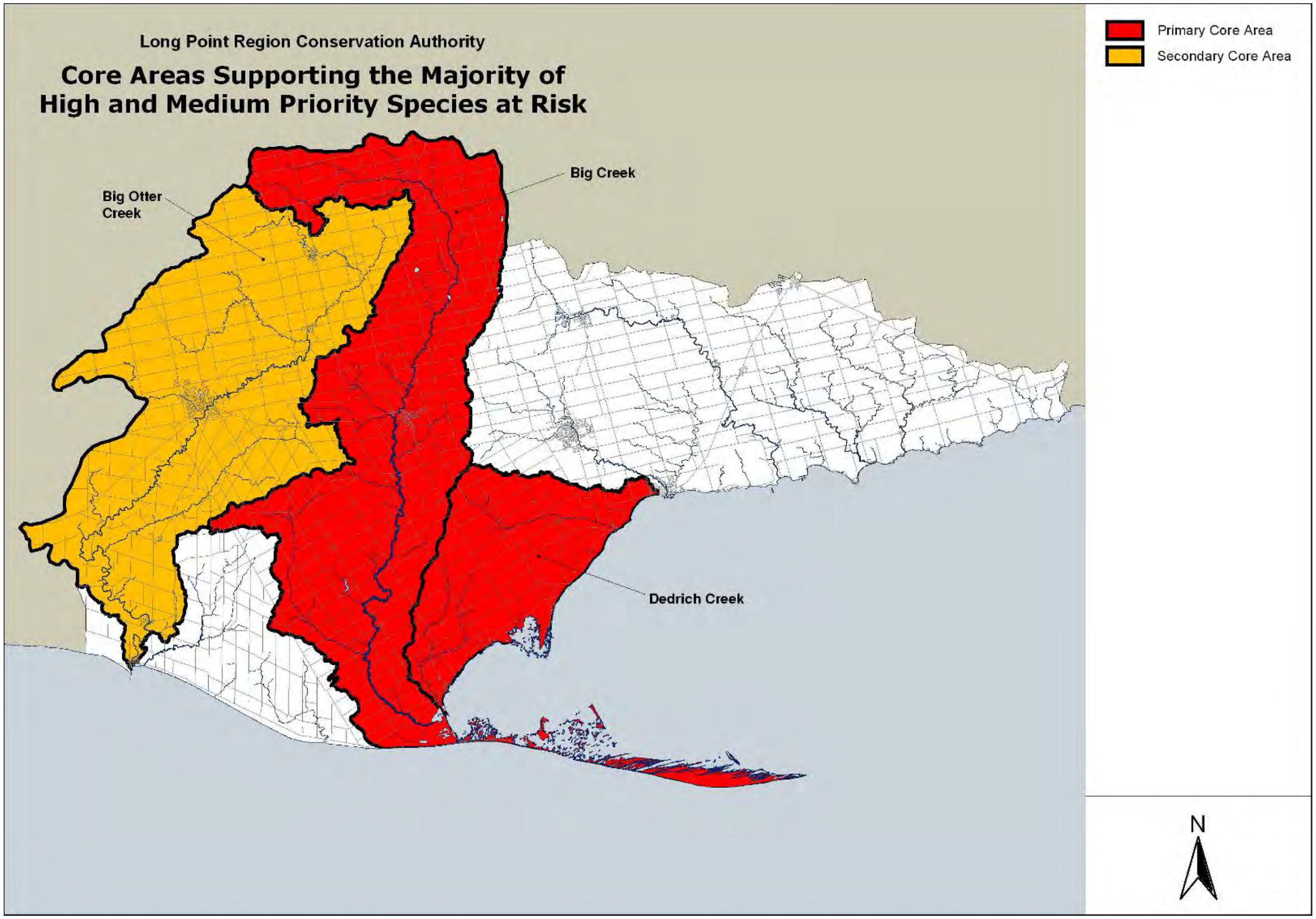
Catfish Creek and Big Otter Creek

Catfish Creek supported historical populations of Eastern Sand Darter and Black Redhorse. Big Otter Creek supported historical populations of one high priority species (Eastern Sand Darter) and a low priority species (Northern Brook Lamprey) (Essex-Erie Recovery Team, draft 2006).

2.8.4 Invasive Species

Invasive aquatic species within the watershed include Carp, Round Goby, Sea Lamprey and Zebra Mussels. The species have been found in many of the water systems within the watershed; however, studies concerning the distribution, population increases and the amount of damage the species are causing have not been conducted, making it difficult to evaluate the extent of the population.

Map 2.20: Core Areas Supporting High and Medium Species at Risk in Long Point Region Watershed



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3.0 HUMAN CHARACTER

In order to understand the conditions and trends of the physical characteristics of the watershed that determine the availability of clean, potable water, a discussion is needed of the human characteristics and the human impact on the watershed. This section describes the history of human settlement in the Long Point Region watersheds, the current land uses, patterns of human settlement, and provides future population growth projections.

3.1 Settlement History

Historians report that, while hunting was the main food source, the early native inhabitants were producing agricultural products such as "squashes, tobacco, corn, beans and other vegetables" at least by the 1600's (Big Creek Region Conservation Report, 1963). French and British traders subsequently were attracted to the area by the fur trade.

Formal British and European settlement began in the late 1700's in what was called the "Long Point Settlement". Saw and grist mills were constructed by 1797. The most important crop at this time was wheat which could be converted into flour or whisky and the surplus exported. Farmers were attracted initially to the relatively open plains of old Norfolk, which were "easily brought into a state of cultivation" (Big Creek Region Conservation Report, 1963). The heavily forested areas surrounding the plains presented much more of a challenge. At first, trees were cleared and burned. Later, trees provided lumber for buildings and fences. Several large pines were marked for exclusive use as spar trees for the King's Navy. The number of water powered sawmills peaked at around 1851. The use of steam power for sawmills then became the preferred method, which allowed for the mill to be set up closer to the trees that needed to be cleared. The amount of forest cover declined from over 70 percent in the 1850's to less than 15 percent in the 1960's. Reforestation and other forms of regeneration have regained some of that loss to the point where this area now has a cover of 20 percent. Based on recent timber harvests, the quality of the timber has also increased significantly in the last half century due to improved forest management practices.

By the mid 1800's some of the crop land started to become less productive due to erosion and loss of nutrients. The loss of useful crop land due to wind and water erosion prompted the establishment of the first Provincial Forest Station at St. Williams in 1908. The value of windbreaks and reforestation was gradually realized.

The towns and villages developed around the water powered mills, inns and taverns similar to other development of Upper Canada. The communities of Simcoe, Waterford, Tillsonburg, Fredericksburg (now Delhi), Port Rowan, Port Dover, Vittoria, Nanticoke, Port Ryerse, Normandale and St. Williams were already established by the 1840's (Big Creek Region Conservation Report, 1963).

As these communities developed, so did the problems of water pollution associated primarily with sewage and food processing wastes being dumped into the watercourses. A survey in 1955 found that the Lynn River below Simcoe had the most severely polluted waters. A "modern" sewage treatment plant has since been constructed (late 1950's) to service the Town and the quality has significantly improved since. Surface water quality in the lower Lynn River is presently graded at B+ according to the watershed report card based on information taken from the Lower Lynn River Watershed Report Card 2003 (Long Point Region Conservation Authority, 2004). Overall, the subwatershed has excellent substrate conditions, in-stream cover and good water quality. However, a poor rating near the top end of the watercourse was found. The Simcoe sewage treatment plant is now near capacity and the water quality downstream is becoming an issue.

3.2 Municipalities and Municipal Structure

Long Point Region contains, in whole or in part, ten upper and lower tier municipalities including Norfolk, Haldimand, Brant, Elgin and Oxford Counties, the Townships of Malahide, Bayham, South-West Oxford and Norwich, and the Town of Tillsonburg, as shown on **Map 3.1**. Since the mid-1970s, the municipal structure in Long Point Region has changed through several amalgamations. As a result, responsibility for water, wastewater, stormwater and solid waste management has become more complex, often involving both upper and lower tier municipalities.

3.3 Population Trends in the Long Point Region Watershed

The total population of Long Point Region in 2001 was approximately 99,000, the majority of which is located in rural areas. However, a few larger urban centres have developed. The main population centres in Long Point Region include the towns of Simcoe, Tillsonburg, Port Dover and Delhi (see **Map 3.2**).

3.3.1 Population Distribution and Density

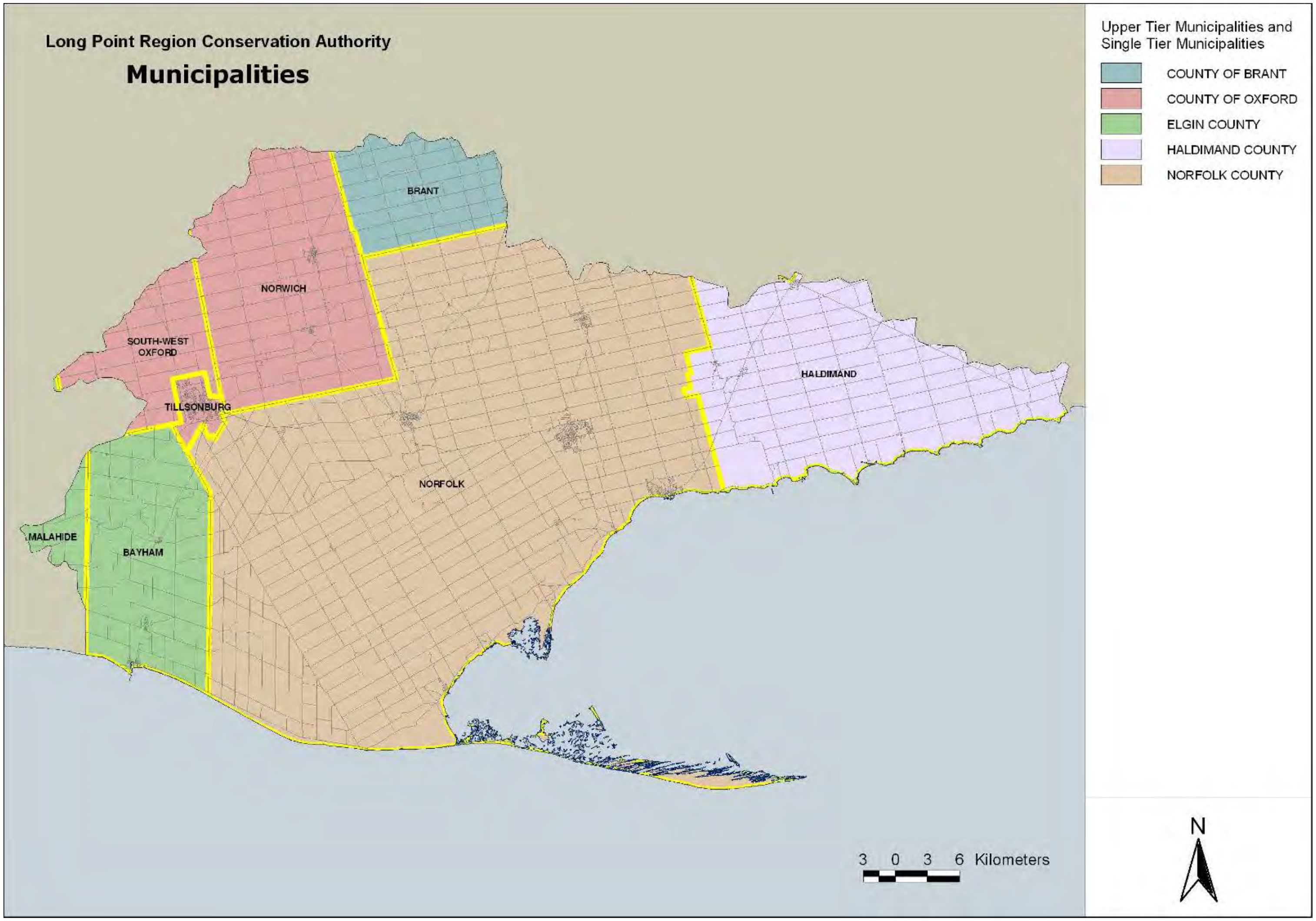
The largest town in the watershed is Simcoe in Norfolk County, with a 2001 population of approximately 14,180 (Marshall Macklin Monaghan Limited, 2004). The town is expected to accommodate over 24 percent of the Norfolk's growth over the next several decades.

The Town of Tillsonburg, in Oxford County, has a current population of approximately 14,000 people, and is expected to accommodate over 21 percent of the Oxford's growth until 2031 (Hemson Consulting Limited, 2006).

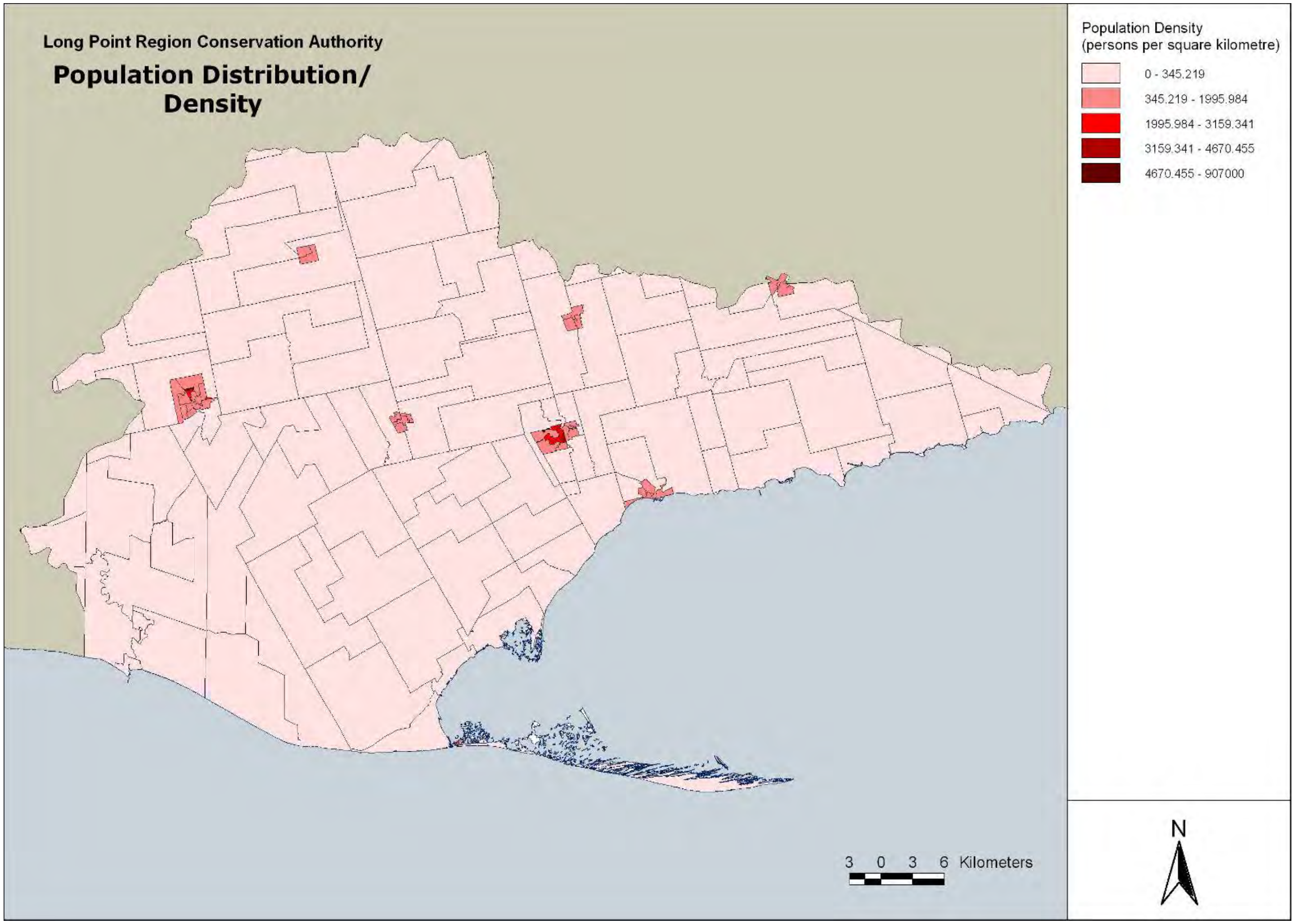
The smaller centres of Port Dover (5,530 people in 2001) and Delhi (4,000 people in 2001) in Norfolk County are expecting to accommodate 6 percent and 10 percent, respectively, of the County's overall growth over the next 50 years (Marshall Macklin Monaghan Limited, 2004).

Map 3.2 illustrates the population density (persons per square kilometre) and distribution in Long Point Region.

Map 3.1 Municipalities in Long Point Region



Map 3.2: Population Distribution and Density in Long Point Region



Source: Statistics Canada, Population and Dwelling Counts, 93F0051XIE, 2001.

3.3.2 Population Forecasts

The Long Point Region watersheds are located to the west of the new Provincial Greenbelt around the Greater Golden Horseshoe. Due to limited population growth allowed within the Greenbelt area, communities surrounding it are expected to experience higher growth rates as populations "leapfrog". However, the province has not identified the municipalities within Long Point Region as being urban growth centres (with the exception of Brant County where growth is expected to occur outside the Long Point Region watersheds), and as such will not experience the same level of growth as larger centres to the north (Hemson Consulting Limited, 2005).

Table 3.1, below, provides a detailed summary of the population distribution in Long Point Region, as well as population forecasts to the year 2031. The table indicates that the majority of the growth in Long Point Region will be in Norfolk County (Marshall Macklin Monaghan Limited, 2004) and the Town of Tillsonburg in Oxford County (Hemson Consulting Limited, 2006). Most of the growth within Norfolk County is and will occur in the serviced towns of Port Dover, Simcoe and Port Rowan, rather than in rural areas (Marshall Macklin Monaghan Limited, 2004).

The portion of Haldimand County falling in Long Point Region has a mainly rural population with limited expected growth. The only serviced areas in Haldimand County that fall within Long Point Region are Jarvis/Townsend and Hagersville, which are expected to get approximately 6.4 percent and 14 percent of the County's growth to 2031 (Hemson Consulting Limited, 2005).

Table 3.1: Population Forecasts for Municipalities in the Long Point Region

Municipality	Population 2001	Population Forecast 2031	Average Annual Growth 2001-2031 (ppl/yr)	% 2001 Population in Long Point Region Watershed
Malahide Township	830*	1162*	11	10%
Municipality of Bayham	6,042	9,978	131.2	97.5%
Southwest Oxford	1,900*	2,671*	25.7	30%
Tillsonburg	14,000	21,600	253.3	100%
Township of Norwich	7,755	8,468	23.8	75%
Norfolk County	59,211*	74,907*	523.2	95%
Haldimand County	13,254*	16,588*	111.1	29%
Brant County	1,074*	1,139*	2.2	3%
Total	**99,217**	**127,606**	**1081.5/yr**	

* Estimate of total population of area in the Long Point Region watershed.

3.3.3 Serviced and Non-Serviced Area Trends

Areas of the watershed that are already serviced are expected to receive the most growth in population over the next several decades, as restrictions on land uses limit the number of new serviced settlements (see **Map 3.3** for locations of serviced areas in Long Point Region). Growth is expected to occur as infill within established and serviced rural communities, resulting in intensified rural residential populations.

Rural non-serviced populations are expected to remain stable as a result of increased land use restrictions on non-residential rural land imposed by the provincial government. However, a slight increase in rural residential population outside of designated hamlets in Norfolk County may occur as a result of previously created severances that may be constructed on in the future.

3.4 General Land Use

Land use planning plays a crucial role in management and protection of water. A strong understanding of the land use distribution across the watershed is required in order to understand where sources of existing and potential contamination can originate. An understanding of land use distribution will also allow appropriate planning to take place to protect existing and future drinking water sources.

Land uses in the Long Point Region watershed are characterized by a few small urban commercial, industrial and residential centres, surrounded by less-populated rural land used for intensive agricultural production. **Map 3.4** shows the distribution of land cover across the watershed. The map illustrates the dominance of agricultural land uses in rural areas of the watershed, however it does not specifically identify the significant proportion of resort residential development along the lakeshore.

According to the 2001 census, about 78 percent of the total land area of the watershed is actively farmed. In some parts of the watershed, the proportion of farmland is even higher, especially in the Norfolk Sand Plain where soils are well drained and the land is relatively flat.

3.4.1 Designated Growth Areas

Most of the lands designated for growth are within or immediately adjacent to the existing urban areas as well as the Lake Erie Industrial Park and the Townsend Community. Many planning studies and documents are available from the municipalities which provide great detail on the present supply of residential and employment lands and the demand for such lands over the long-term. These reports generally indicate that the demand can be accommodated by the identified supply.

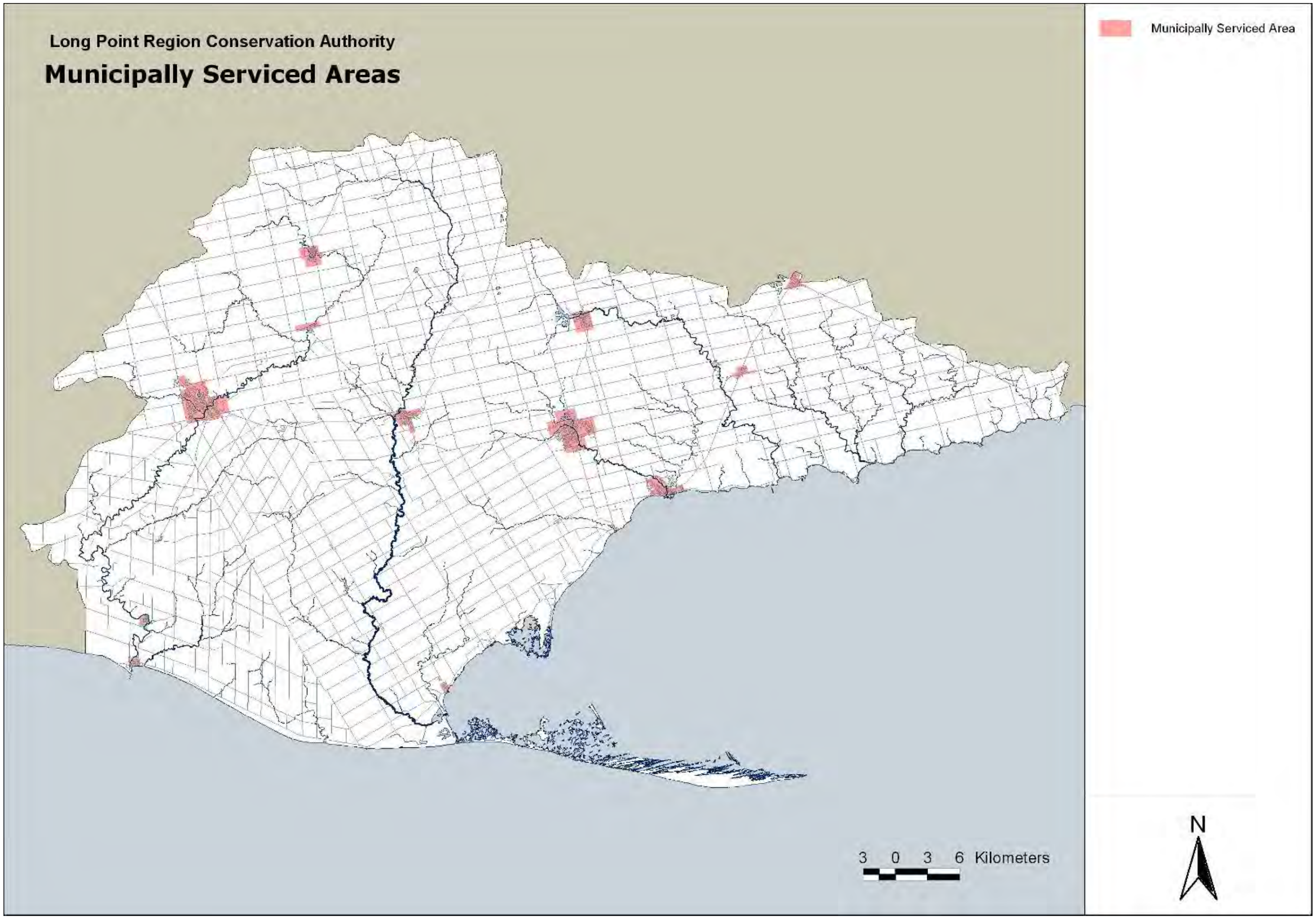
3.4.2 Industrial and Commercial Sector Distribution

As noted in Section 3.4.1, the major growth areas are already established. The commercial growth is focused on redevelopment of the downtown cores as well as larger commercial growth along the Highway 3 and 19 corridors through Simcoe, Delhi and Tillsonburg.

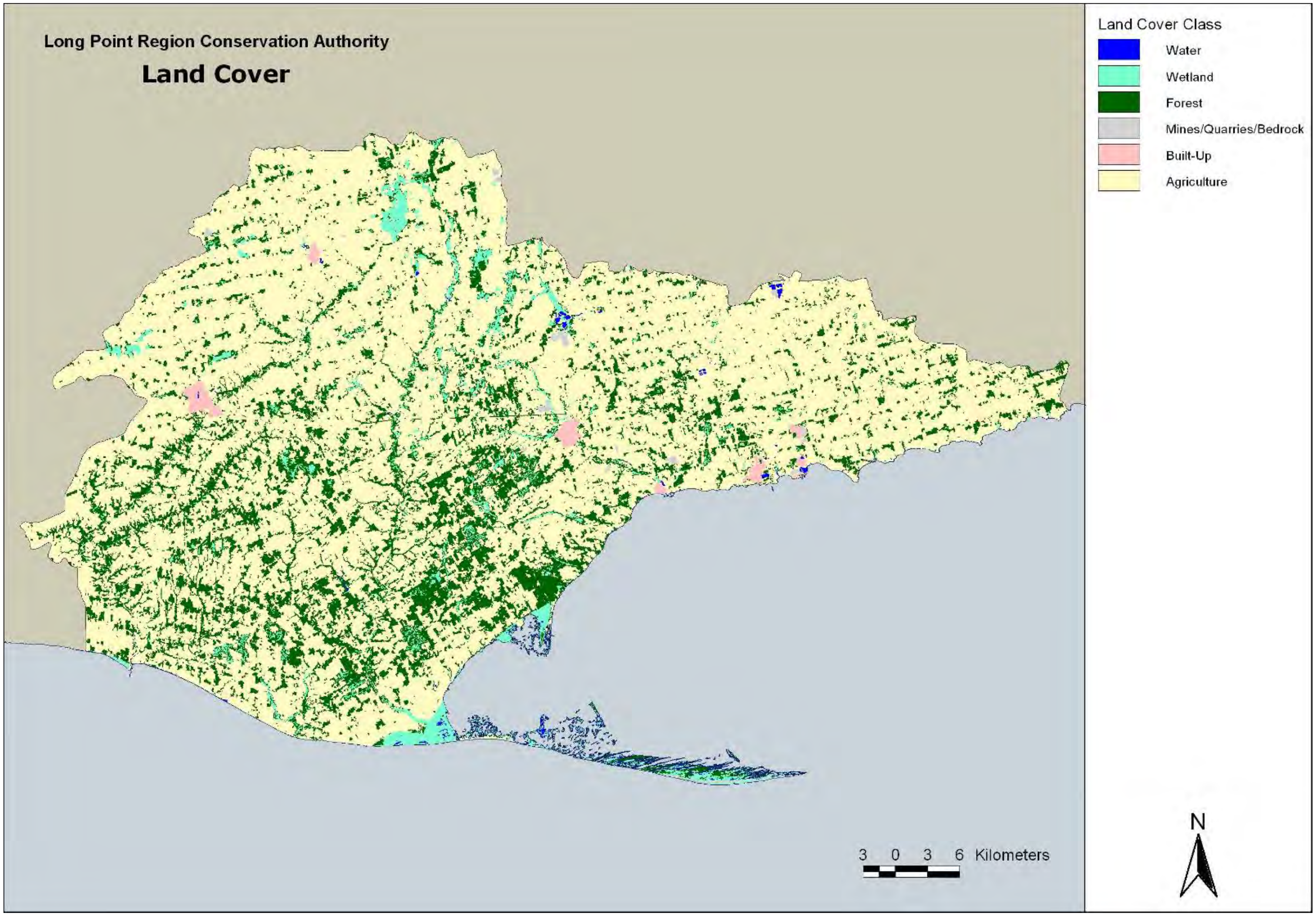
3.4.3 Brownfields

There are relatively few areas that would be classified as “brownfield sites” though detailed studies have not been undertaken. The Municipal Official Plans do however, address the issue of redeveloping lands that have been previously used, and require environmental site assessments that would address any issues of contaminants that exist on site.

Map 3.3: Municipally Serviced Areas in Long Point Region



Map 3.4: Land Cover in Long Point Region



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3.4.4 Mining, Aggregate Extraction, Utilization of Petroleum Resources

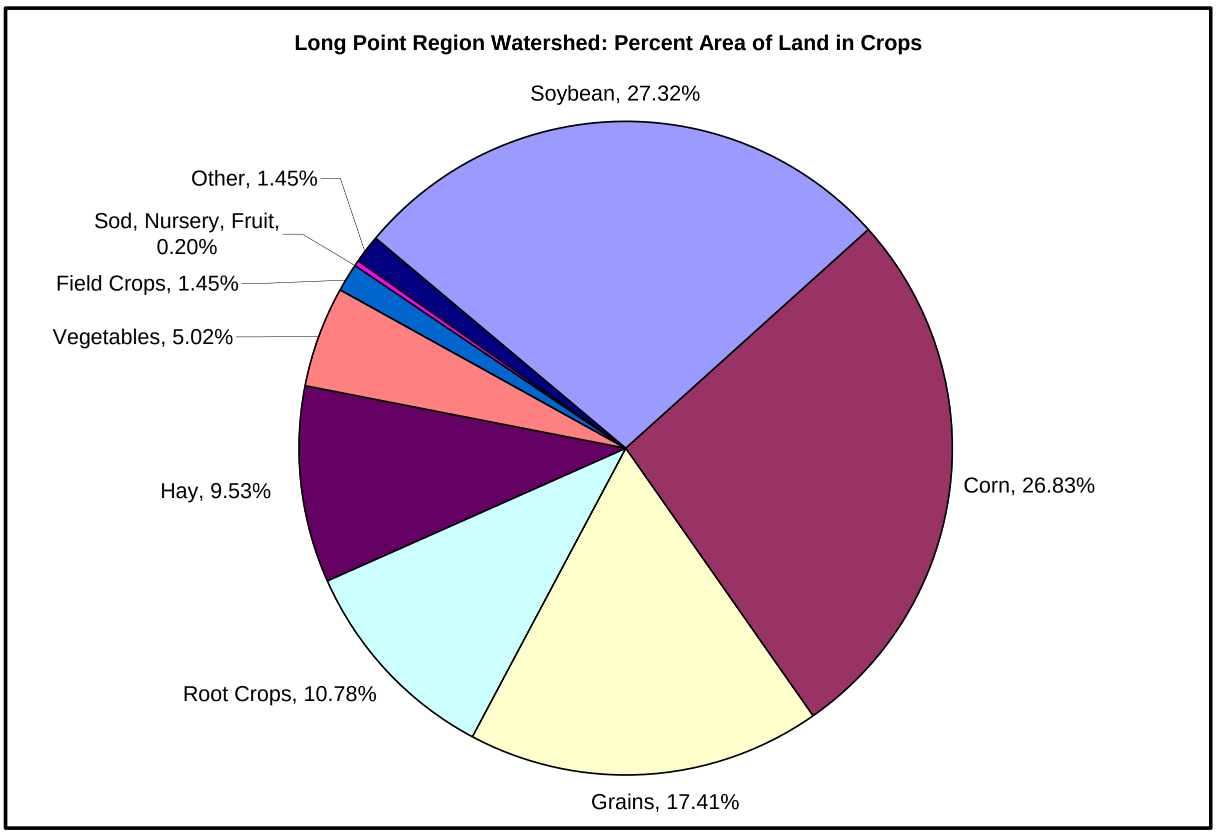
Petroleum resources and mineral aggregates play an important economic role in this area. Existing and potential petroleum and mineral aggregate resource activities are protected, and the extractive industry permitted to operate as free from land use conflict as possible, by policies of the municipalities while ensuring minimal environmental impact and social disruption. The policies also recognize that exhausted pits and quarries and mineral and petroleum resource lands need to be rehabilitated for appropriate uses that are compatible with the surrounding area and environment.

Bedrock Resource Areas, and Sand and Gravel Resource Areas, as identified by the Ministry of Natural Resources, are mapped in the Official Plans for protection and appropriate development. There is no mining activity in the LPRCA.

3.4.5 Agricultural Resources

Agriculture is a large part of the Long Point Region watershed, with 78 percent of the land area designated and used for agricultural purposes. Both livestock and agricultural crops are prominent practices, with 61 percent overall in cropped agricultural land. There are a total of 43,100 head of cattle, 149,100 heads of swine and 2,979,200 heads of poultry across the watershed. As illustrated in **Figure 3.1**, the majority of crops grown in the watershed are soybean (27.3 percent), corn (26.8 percent), and grains (17.4 percent).

Figure 3.1: Distribution of Cropped Agricultural Lands in Long Point Region Watershed



The nature of agricultural activities has been adapted to make best use of the unique characteristics of soil and climate. The watershed has been divided into 12 sub-basins, to get a sense of the differences across the watershed for agricultural practices. The bulk of the sub-basins have coarse textured sandy soils of the Norfolk Sand Plain, which are productive agricultural soils for root crops and vegetables. The Norfolk Sand Plain occupies substantial portions of the Big Otter Creek, Big Creek, Dedrich-Young Creek and Lynn River and Black Creek watersheds. The eastern side of the watershed is clay plain which supports hardier kinds of agricultural crops. Throughout much of this region the water table is relatively shallow and the susceptibility to contamination tends to be high.

Cropping Characteristics in the Long Point Region

Agricultural crops in the Long Point Region watershed are regionally varied due to the different soil types in the watershed. For instance, the Norfolk Sand Plain has substantial portions of root crops, vegetables and some fruits and nursery crops. Vegetables and root crops on the sand plain make up a large percentage of land relative to the rest of south western Ontario, due to the location on ideal sandy soils. These high value crops require very careful management; soil nutrient levels must be maintained within a narrow range to achieve optimal quality as well as yield. The clay plain however, has very little or no agricultural land supporting root crops, vegetables or field crops, but have much higher percentages in soybeans and hay than the sand plain sub-basins. Vegetables and root crops such as tobacco and potatoes generally have smaller field sizes but higher water requirements than other row crops. The concentration in the sand plain also poses risks to reduced water availability for crops due to fast infiltration rates. Supplemental water from irrigation is required at times of moisture stress. These intensive practices minimize the likelihood that nutrients and other inputs will be transported through the highly permeable soils to the groundwater. Nevertheless, excessive irrigation or times of high rainfall (particularly if they follow irrigation) can cause leaching.

Livestock

Livestock farming in the Long Point Region watershed is not as prominent as agricultural crops. The eastern basins have a higher concentration of livestock per hectare of farmland, which could pose problems of nutrient loading. Most manure is handled in solid form throughout the area (most likely associated with poultry and beef production); there is some liquid manure handling (likely associated with hog production and some dairy production). The soils in these areas tend to be finer textured and less susceptible to leaching. In addition, the intensive field crop program throughout the area provides a large enough demand for nutrients to utilize the nitrogen and phosphorus available in livestock manure. Notwithstanding, good management is required to minimize the risk of groundwater contamination. This is particularly true for areas around wells (either currently active or abandoned). Farms in the clay plain have more than double the number of cattle per hectare of farmed land as the rest of the watershed, as well as higher concentrations of swine and poultry, at about a third more. The northern sub-basins of the central watershed have the highest concentrations of all types of livestock in the watershed, as seen in **Table 3.2**.

Watersheds with a high proportion of livestock farming could likely be high in nutrient loading due to the concentration of livestock. Manure spreading could be a function of the impact of the livestock which could pose risks of high nutrients in the basin. The most southerly sub-basins in the centre of the watershed seem to have the lowest incidence of manure spreading, while the headwaters of these same creeks report the highest applications by area. Runoff into the creeks and groundwater system could be an issue in these watersheds. Livestock can also introduce bacteria and silt from the banks directly into the waterways if proper fencing is not in place.

Table 3.2: Livestock Farming in Long Point Region Watershed

	Total Numbers			Average Number Per Farm			Per Hectare Farmed Land		
Sub-basin	**Cattle**	**Pigs**	**Poultry**	**Cattle**	**Pigs**	**Poultry**	**Cattle**	**Pigs**	**Poultry**
2GC-01-01	3,230	5,160	120,960	53	570	4,851	0.34	0.54	12.7
2GC-04-01	5,750	14,070	170,050	68	699	3,401	0.19	0.45	5.5
2GC-04-02	14,770	61,410	829,820	105	929	12,941	0.45	1.86	25.1
2GC-05-01	600	1,950	53,960	31	779	3,078	0.04	0.13	3.6
2GC-07-01	360	610	80,370	25	147	3,716	0.03	0.05	6.1
2GC-08-01	800	3,690	145,760	30	700	7,923	0.03	0.13	5.0
2GC-08-02	270	0	0	45		0	0.07	0.00	0.0
2GC-08-03	6,030	26,380	265,780	86	1146	10,356	0.25	1.09	11.0
2GC-09-01	3,230	5,080	572,480	58	650	15,225	0.14	0.21	24.2
2GC-10-01	1,870	0	68,840	73		5,782	0.35	0.00	12.7
2GC-11-01	2,500	8,860	371,230	57	784	14,105	0.14	0.50	21.1
2GC-12-01	3,710	21,930	299,970	63	1209	9,187	0.24	1.42	19.4
Clay Plain	**8,810**	**27,090**	**489,770**	**63**	**593**	**6,607**	**0.31**	**0.65**	**14.95**
Sand Plain	**34,310**	**122,050**	**2,489,450**	**56**	**648**	**7,860**	**0.15**	**0.49**	**11.27**
LPRCA	**43,120**	**149,140**	**2,979,220**	**58**	**630**	**7,550**	**0.19**	**0.53**	**12.19**

Agricultural Management Practices

Management practices include such activities as conservation tillage and grassed waterways, and are preventative actions against erosion into the waterways or chemical runoff. Across the watershed, to reduce the amount of sediment loading in the waterways, 13.2 percent of farms reported using grassed waterways, 5.9 percent use contour cultivation and 11.2 percent use strip cropping. Approximately 42.7 percent of farms that reported use winter cover crops and 25 percent use windbreaks or shelter belts to help prevent the removal of topsoil by wind. Crop rotation is the most widely used conservation practice at 46.3 percent of farms reporting, which increases the longevity, productivity and environmental quality of farmland by replacing nutrients into the soil.

Use of Irrigation

The use of irrigation in the Long Point Region watershed is quite extensive in the sand plain, as it is generally applied to specialty crops such as tobacco, vegetables, sod, fruit and root crops such as potatoes and ginseng. It is rare that other crops are irrigated unless it is for sweet corn or in dry years. The use of irrigation is concentrated in the Norfolk Sand Plain area in Norfolk County where there is a higher percentage of specialty crops grown in well drained soils. Approximately 35 percent of the farms reported using irrigation, accounting for 15.3 percent of the cropped land area. However, in one basin more than half of the farms irrigate, accounting for as much as 27 percent of the cropped land area (see **Table 3.3**). Conversely, on the clay plain on the east side of the watershed, irrigation was very minimal, with only two percent of farms reporting using irrigation, accounting for only half a percent of the cropped land area.

Irrigation for agriculture in the Long Point Region watershed is concentrated in the summer months of July and August with some exceptions earlier or later in the growing season. The concentration of these large water takings during warmer and often dryer periods, and in a limited area, creates a risk of developing problems of water shortages in both groundwater and surface water sources.

Table 3.3: Irrigation in Long Point Region Watershed

Use of Irrigation	Number of Farms	Area (ha)	Percent of Cropped Land	
Sub-basin			**# Farms**	**Area**
2GC-01-01	0.67	n/a	0.62%	n/a
2GC-04-01	100.58	1,650.25	26.92%	6.99%
2GC-04-02	67.55	1,291.86	17.36%	4.68%
2GC-05-01	95.53	2,039.14	46.23%	19.88%
2GC-07-01	71.86	1,893.70	35.71%	20.54%
2GC-08-01	179.99	4,409.81	47.87%	20.93%
2GC-08-02	35.50	734.53	53.70%	26.93%
2GC-08-03	126.98	3,281.37	38.77%	16.88%
2GC-09-01	65.11	2,060.09	23.26%	10.83%
2GC-10-01	1.58	n/a	2.88%	n/a
2GC-11-01	50.04	1,503.41	25.90%	10.37%
2GC-12-01	2.69	214.44	2.08%	1.61%
In Clay plain	**4.93**	**214.44**	**1.86%**	**0.54%**
In Sand Plain	**793.14**	**18,864.16**	**35.08%**	**15.34%**
Watershed	**798.07**	**19078.61**	**29.49%**	**11.06%**

3.4.6 Protected Areas

The largest protected areas in Long Point Region include the Long Point Sandspit and Upper Marshes as well as the newly designated St. Williams Conservation Reserve.

3.5 Infrastructure

A watershed's public infrastructure system represents a crucial link to population growth and ecological health. Efficient and well-planned transportation systems, including roads, railways, public transit and airports, are required to move people and goods throughout the watershed. In many cases, the accessibility and location of roads or public transit focuses population growth to an area, which in turn requires water, wastewater and stormwater management services.

The quality and adaptability of infrastructure systems ultimately determines long-term sustainability of not only municipal drinking water services, but also drinking water sources.

The following sections briefly describe infrastructure systems currently in place in the Long Point Region watershed, including transportation, landfills, wastewater and stormwater systems. Locations of selected infrastructure systems are shown on **Map 3.5**.

3.5.1 Transportation

Transportation plays an important role in determining the quality of life within a community through the level of service and accessibility to employment, social, recreational and shopping opportunities provided by the transportation network. Road, rail, and water transportation all play roles in goods movement throughout the Long Point Region watersheds. The roads also facilitate the safe and efficient movement of both people and goods through the area at minimal economic, environmental and social cost. Additionally, the network is intended to promote the development pattern and therefore influences the placement of other water related infrastructure such as water, wastewater and stormwater management services and be supportive of economic activity.

The major north-south highways through Long Point Region are Highways 24, 19, 59 and 6. The major east-west Highway is number 3. It is important to note that Highway 3 is a major route between the Niagara-Buffalo and Windsor-Detroit industrial centres, acting to transport chemicals and other goods and materials used for manufacturing. Several of the municipal water supply sources are within close proximity to Highway 3.

A significant amount of commercial shipping takes place along and near the Lake Erie shoreline. Two commercial docks are located at the Nanticoke Industrial Complex. The raw material and products associated with Stelco, Ontario Power Generation, and Imperial Oil are the principal users of these docks. Large Lake Erie freighters regularly take shelter in the Long Point Bay during storm events. Two municipal and many communal and private drinking water intakes are along the shoreline.

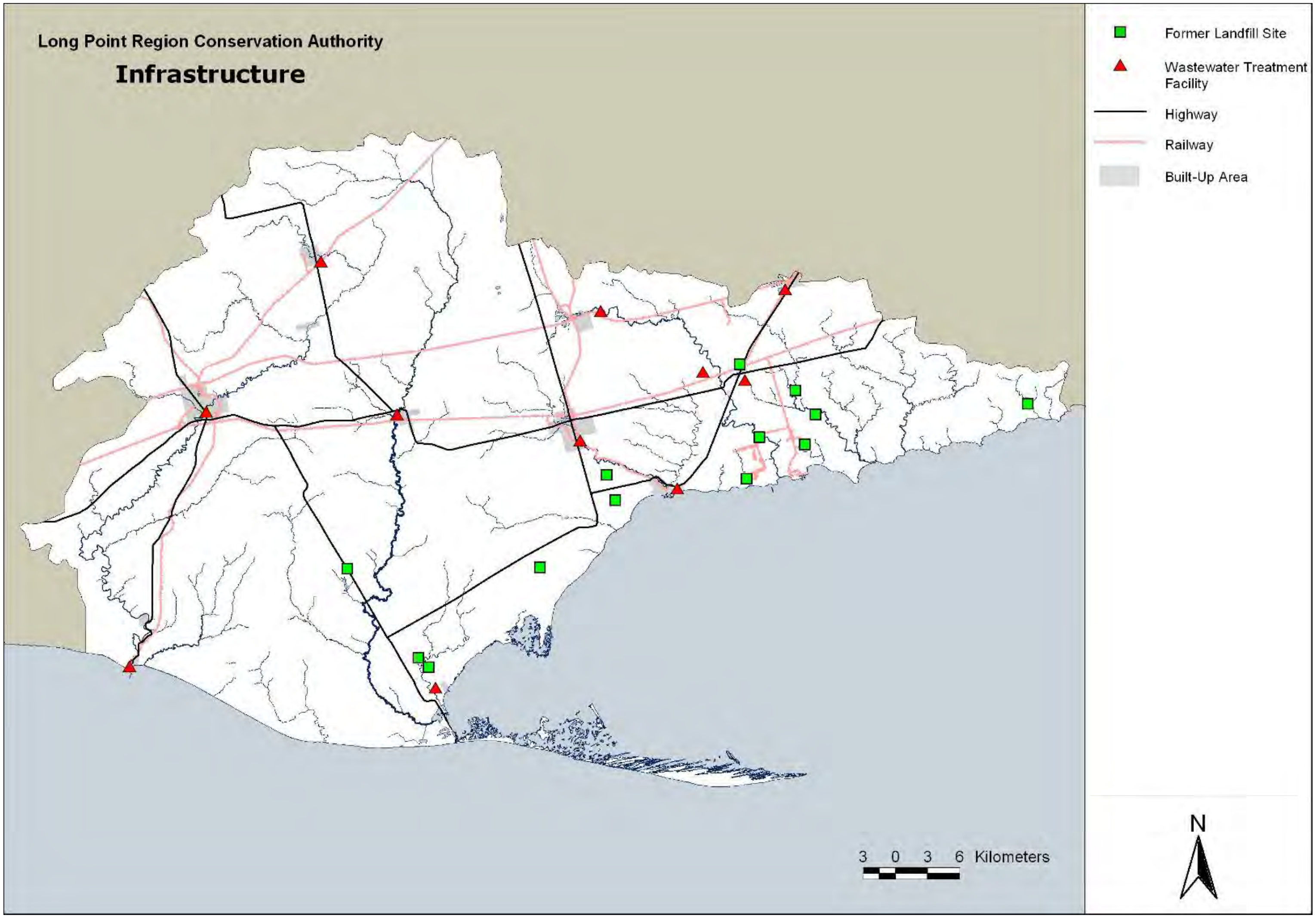
3.5.2 Wastewater Treatment

There are 12 municipal wastewater treatment plants in the Long Point Region watersheds. **Map 3.5** provides the location of these sites along with the areas that they service. Many of these municipal sites are undergoing studies to determine their capacity and needs for upgrades. The remaining areas of development are serviced by private sewage treatment (normally tile beds) or pump outs which are trucked to the municipal sites.

3.5.3. Stormwater Management

Most of the development that has taken place since the 1980’s has incorporated stormwater management systems intended to minimize the impacts of stormwater runoff on the quality and quantity of the receiving water bodies. The methods used have evolved along with the guidelines provided by the Ontario Ministry of the Environment (MOE). The municipalities and Conservation Authority review development proposals to ensure that the intent of the MOE guidelines is addressed. In some cases new development has been required to provide “over designed” systems to address localized issues created by earlier development that did not consider downstream impacts. There are still a few locations that have combined sanitary/storm sewers. These sites are being replaced with properly separated systems as redevelopment and replacement takes place.

Map 3.5: Selected Infrastructure in Long Point Watershed



3.5.4 Landfills

There are no public landfills currently operating within the Long Point Region watershed. Two transfer stations operate in Simcoe and South Walsingham. **Map 3.5** shows the location of closed landfill sites in the Long Point Region as well as one active refinery landfarm which is used by Esso Refinery located in Nanticoke. The refinery landfarm is permitted under an MOE Certificate and handles oily sludges and digested biosolids from the wastewater treatment plant located on the property. In addition a landfill site may be in operation on the Stelco property, Lake Erie Steel, in Nanticoke. Many of the closed sites are being monitored to ensure that they do not impact the groundwater.

There are numerous data gaps associated with the knowledge of present locations of possible contamination spots within the watershed and related past and present monitoring information. An example includes monitoring of past landfill sites within the watershed.

3.5.5 Implications of Geology and Land Use for Source Protection

Land use practices in the watershed can have an increased risk to ground and surface water depending on the geology of the area. The geology can determine the infiltration, runoff and recharge rate of precipitation which corresponds to how fast and easily contaminants may be able to move and infiltrate the ground and surface water. The Norfolk Sand Plain is very permeable, and this can be a concern as runoff from agricultural practices such as fertilizers and pesticides can easily move into the soil which can lead to groundwater supplies. In addition, since the sand plain is very permeable, agricultural crops in the area often require higher levels of water for irrigation since the infiltration rate may be too fast for the crop roots to uptake.

The Haldimand Clay Plain provides moderate to good protection to the groundwater as infiltration of clay is low although precipitation moves very quickly over clay which would increase runoff. Agricultural land uses in this area may benefit from having water storage on the surface; however, fertilizers, pesticides and manure have an increased chance of moving into water systems through runoff. In addition, paved land in and surrounding the area increases the runoff rate and quickly moves precipitation over the clay and possibly into ground and surface water systems.

4.0 WATERSHED MANAGEMENT PLAN

The Mandate of the Long Point Region Conservation Authority is to "…work with our local communities, and our many other partners, to achieve the conservation, restoration, development and responsible management of our water, land and natural habitats through programs that balance human, environmental and economic needs"(Long Point Region Conservation Authority Watershed Strategies, October 2002). The conservation authority has four main objectives:

1. To ensure that the Long Point Region watershed lands and waters are properly safeguarded, managed and restored.

2. To protect, manage and restore watershed woodlands, wetlands and natural habitats.

3. To develop and maintain programs that will protect life and property from natural hazards such as flooding and erosion.

4. To provide opportunities for the public to enjoy, learn from and respect the watersheds natural and cultural environments.

The objectives are then divided into smaller groups of strategies, which explain how to achieve the objectives. Additional long-term and annual business plans are created to illustrate when the aims will be carried out and the associated finances.

The four main objectives of LPRCA correlate to source water protection goals as water is being managed, protected and restored in a conservation approach that can increase and uphold good water quality. In addition, programs that are geared towards reducing erosion and flooding lessen the chance of contamination running into the groundwater supply. Providing education to residents may increase the need and want of landowners to protect source water in their area. Strategies within the LPRCA plan reveal specific intents which correspond to source protection initiatives. These include:

- Undertaking projects and providing assistance to landowners to enhance the quantity and quality of water supply;

- Undertake background reviews of information regarding water quality and quantity in watershed;

- Undertake studies to enhance and fill data in regards to water quality and quantity; and,

- Develop and implement programs that provide assistance to landowners in regards to management of wetlands, riparian and buffer zones, and habitat improvement.

(Long Point Region Conservation Authority Watershed Strategies, October 2002)

There are many strategies within the LPRCA objectives that correspond to source water protection goals; however, the above four illustrate the major source water protection aims.

5.0 WATER USES AND VALUES

Long Point Region's rivers and tributaries provide multiple functions for the communities in the watershed. Recreational, commercial/industrial and aesthetic uses of the river system draw both watershed residents and visitors to the area.

5.1 Water Uses

The following list are the top 15 water uses within the basin, as reported in the study entitled *Water Use in the Long Point Region Watershed* (Wong and Bellamy, 2005):

1. Agricultural – Irrigation
2. Municipal Water Supply
3. Aquaculture
4. Rural Domestic
5. Agriculture
6. Remediation
7. Dewatering – Construction
8. Aggregate Washing
9. Golf Course Irrigation
10. Commercial – Other
11. Dewatering – Pits and Quarries
12. Industrial – Other
13. Recreational – Aesthetics
14. Water Supply – Campgrounds
15. Miscellaneous

A description of these water uses is included in this section, followed by the estimation of the volume of water takings, in Section 5.2. Other uses of water are also described that are of importance to the Long Point Region watershed, which do not remove water from their source, including such uses as instream flows and recreation uses.

Agriculture is a very large aspect of the Long Point Region watershed, with approximately 78 percent of the land in agriculture. Agricultural water use is divided into crop irrigation uses and other agricultural water uses including washing and livestock watering as seen on the list as the top and fifth uses in the watershed, respectively. Livestock operations require water year round to provided drinking and washing water for the animals, while crop irrigation is only required during the summer months of July and August. Only certain crops such as tobacco, root and vegetable crops require irrigation and on average, these crops need four irrigation applications in a normal climatic year. During a dry season however, crops could require as many as ten irrigation events over the summer, which could stretch from as early as May to first frost in the fall. With the intensity of such crops as tobacco, ginseng and vegetables growing in the Long Point Region watershed, especially in the Norfolk Sand Plain, water requirements for agriculture are very substantial.

Commercial water use includes both golf courses and aquaculture operations. Golf courses apply for permits to irrigate greens and fairways on a seasonal basis, generally between April and September. Golf course irrigation accounts for 0.7 percent of the total water uses, or about two and a half percent of the non-municipal and non-agricultural irrigation water uses. Aquaculture operations with a surface water permit generally divert water from a stream, into holding tanks or ponds and return it back to the watercourse downstream of the fish farm, with minimal losses. From groundwater sources, aquaculture will remove groundwater for the holding tanks and discharge it into a nearby surface water system.

Industrial permits to take water are mostly for aggregate washing and dewatering, however there are smaller operations such as food processing and manufacturing that also have a permit in the Long Point Region watershed. These industrial uses account for 2.4 percent of all uses in the watershed, with dewatering at 1.3 percent, aggregate washing at 0.9 percent and other minor industrial uses at 0.2 percent of the total water uses. Other industrial water requirements are often incorporated in the municipal supply if they are connected to the system, and these uses are not accounted for in this estimate. For example, the Lake Erie Industrial Park is on the Nanticoke municipal system and is not required to get a separate permit for their water use.

Environmental water needs include maintaining river levels, called instream flows, to sustain the full natural ranges of life for all aquatic organisms. Ecological water uses require water to stay in the environment for fish and wildlife. The term ecological flow requirements encompass both these needs, and are important for the maintenance of environmental quality in a watershed. Different aquatic organisms, including fish and invertebrates, have varying requirements for water levels in rivers during the year. A variety of other requirements such as water temperature, groundwater contributions and stream structure or geomorphology, are needed to ensure the quality of the environment will function properly to support organisms. In the Long Point Region watersheds, certain aspects of ecological flow requirements need to be incorporated with the impacts of water takings in a particular stream to understand the ideal flows versus realistic flows that can be maintained in that watercourse.

There are several parks including Long Point and Turkey Point Provincial Parks where many recreational water-related activities are available to visitors. The parks provide access points to the Lake Erie shoreline and to various points along the different water courses in the watershed region. Swimming opportunities are provided at the many beaches that are along the Lake Erie shoreline at the parks, as well as at several inland ponds and reservoirs such as the reservoir at Deer Creek Conservation Area.

Fishing is available in the Long Point Region watershed, generally on catch and release streams, ponds and reservoirs. Sport fishing and fishing excursions are available as well as a Long Point Bay Anglers Association.

Boating opportunities include canoeing, kayaking, sailing and motorized boating in the watershed and shoreline areas. Many of the larger streams in the watershed are used for canoeing and kayaking, for example, organized canoe routes are maintained on the lower portions of Big Creek and Otter Creek. Other boating excursions are available such as a cruise on the Lynn River, while the Port Dover Harbor Marina provides excellent opportunities to service many boating needs. There are many marinas and harbours along the Lake Erie shoreline that provide access to boating opportunities on the smallest of the Great Lakes.

The Long Point Sand Spit extends out into Lake Erie about 33 kilometres and has many beautiful features. The sand dunes, woodlands, marshes and ponds provide excellent stopping grounds for migratory waterfowl and the monarch butterfly. During migration season, the bird watching towers in the Long Point Marsh and Lee Brown Waterfowl Management Area are a great place to view these animals. Scuba diving is also available at Long Point, which is designated a United Nations World Biosphere Reserve.

5.2 Water Use Inventory

This section is a summary of the water use requirements within the Long Point Region watershed for 2005, which are described in detail in a report entitled *Water Use in the Long Point Region Watershed* (Wong and Bellamy, 2005). The report is an initial inventory of the present-day water uses, broken down into four subgroups: Municipal Supply, Agricultural, Unserviced Population and Other Permitted Takings (larger than 50,000 litres per day). The estimates were determined using the best available data: municipalities were contacted directly to establish municipal water use; Census of Population and Census of Agriculture were utilized to determine rural domestic as well as agricultural water use; and the Permit to Take Water (PTTW) database was used to quantify any water uses that did not fall into the previous three categories. The water use estimates were refined after a phone survey of the permit holders was completed, with a 52 percent response rate.

The analysis of all water use data identified the water uses and percentages within the basin, as seen in **Figure 5.1** and in **Table 5.1** with the volumes per month.

Figure 5.1: Major Water Uses on an Annual Basis in Long Point Region Watershed

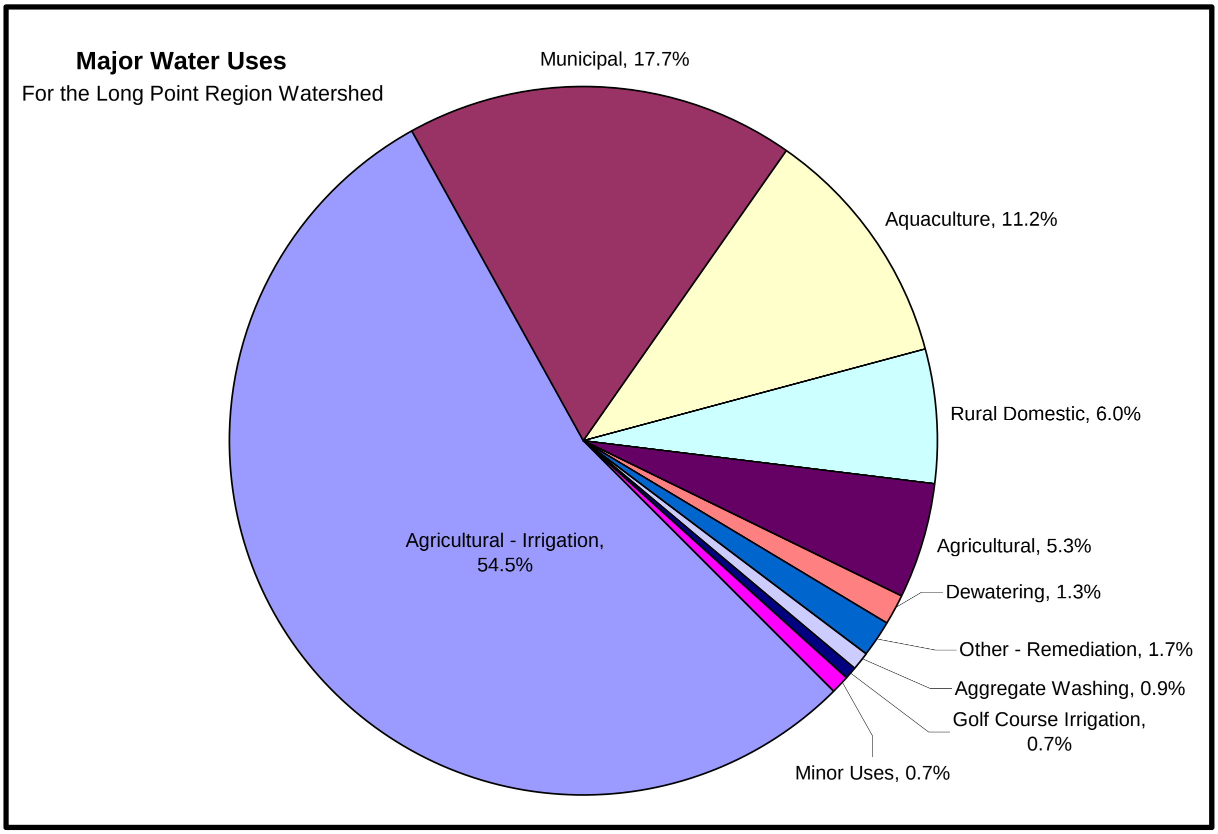


Table 5.1: Total Water Use Comparison (in cubic metres)

	Water Use	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**TOTAL**
1	Agricultural - Irrigation	-	-	-	-	-	7,995,750	15,991,500	7,995,750	-	-	-	-	31,983,000
2	Municipal	843,040	810,460	854,000	803,610	888,210	923,680	959,060	935,850	917,910	832,830	801,730	807,980	10,378,390
3	Aquaculture	557,340	503,410	557,340	539,370	557,340	539,370	557,340	557,340	539,370	557,340	539,370	557,340	6,562,280
4	Rural Domestic	297,700	268,900	297,700	288,100	297,700	288,100	297,700	297,700	288,100	297,700	288,100	297,700	3,505,300
5	Agricultural	174,660	157,760	174,660	169,030	174,660	169,030	524,930	524,930	519,300	174,660	169,030	174,660	3,107,350
6	Other - Remediation	83,700	75,600	83,700	81,000	83,700	81,000	83,700	83,700	81,000	83,700	81,000	83,700	985,500
7	Dewatering - Construction	44,700	40,370	44,700	43,260	44,700	43,260	44,700	44,700	43,260	44,700	43,260	44,700	526,300
8	Aggregate Washing	-	-	-	-	74,680	72,270	74,680	74,680	72,270	74,680	72,270	-	515,520
9	Golf Course Irrigation	-	-	-	-	67,420	65,250	67,420	67,420	65,250	67,420	-	-	400,180
10	Other - Commercial	22,550	20,370	22,550	21,820	22,550	21,820	22,550	22,550	21,820	22,550	21,820	22,550	265,480
11	Dewatering - Pits and Quarries	20,890	18,870	20,890	20,210	20,890	20,210	20,890	20,890	20,210	20,890	20,210	20,890	245,940
12	Other - Industrial	11,250	10,160	11,250	10,880	11,250	10,880	11,250	11,250	10,880	11,250	10,880	11,250	132,410
13	Aesthetics	-	-	-	-	2,250	2,180	2,250	2,250	2,180	2,250	-	-	13,350
14	Campgrounds	-	-	-	-	1,690	1,640	1,690	1,690	1,640	-	-	-	8,350
15	Other - Miscellaneous	680	610	680	660	680	660	680	680	660	680	660	680	7,990
16	Manufacturing	230	210	230	230	230	230	230	230	230	230	230	230	2,760
17	Schools	40	40	40	40	40	40	40	40	40	40	40	40	500
18	Food Processing	17	16	17	17	17	17	17	17	17	17	17	17	203
	TOTAL	2,056,797	1,906,775	2,067,757	1,978,227	2,248,007	10,235,387	18,660,627	10,641,667	2,584,137	2,190,937	2,048,617	2,021,737	58,640,803

5.2.1 Agricultural Water Use

Agricultural water use was divided into two categories: crop irrigation water use and livestock/farming operation water use. This division was based on the information available for the two categories, as well as the differing water requirements for each use throughout the year. Water use for livestock and other farming operations are generally year-round takings, as opposed to crop irrigation, which only occurs during the summer growing season. Other farming operations such as greenhouse and nursery operations are considered in this water use category.

Crop irrigation is a very considerable portion of water takings in the LPRCA watershed. Irrigation is the requirement of supplemental water onto cropped fields when natural precipitation is insufficient. The estimation of irrigation water requirements was completed using the irrigated area estimation from Census of Agriculture information and a demand model, estimating an average number of irrigation events likely to occur in the watershed per growing season. This demand model (GAWSER) bases the irrigation water requirements on soil moisture content, and averaged four irrigation events per year in the LPRCA watershed. The irrigation demand model only considers irrigation events meant for maintaining soil moisture at adequate levels for plant growth, but irrigating for climate control, such as spring irrigation to protect against frost, was not considered in this exercise. To determine a possible breakdown of the source of irrigation water, the Permit to Take Water database was consulted. It was determined that from the 2,720 agricultural irrigation sources, 1,761 were supplied by groundwater and 959 were supplied from surface water, producing a 65 percent, 35 percent split, respectively. Irrigated crops in this watershed may include tobacco, ginseng, potatoes, sod and vegetables, and the water requirements for all irrigation activity accounts for approximately 32.0 million cubic metres per year.

While annual totals are useful for comparison purposes, seasonal and annual temporal changes in water use must be considered for an accurate representation of water taking. Although agricultural irrigation is the largest water user on an annual basis, their water takings are concentrated into only the months of June to August. During these summer months, the water requirement for agricultural irrigation is often much more than the combined total of all other water takings on a monthly basis. During an extreme dry year, which requires more irrigation than an average year, this demand for water is much more pronounced.

Livestock (mainly cattle, poultry and swine) water demands were estimated using a water use coefficient for daily water requirements and the number of livestock in the watershed. The volume of water requirements for livestock and other year-round agricultural is relatively small, accounting for 3.1 million cubic metres per year.

5.2.2 Municipal Water Supply

Municipal water use is the supply of water provided through a central distribution system operated by a municipality. Municipal water use includes urban domestic use, whether indoor or outdoor, and also includes uses for industrial, commercial, institutional or other uses that rely on municipalities for their water supply.

The Long Point Region is predominantly in the Norfolk Sand Plain, making groundwater easily accessible for municipal supply, as well as for other uses. Several municipalities rely solely on groundwater sources, including Simcoe, Tillsonburg, Courtland, Waterford, Norwich, Otterville, Springford, Straffordville, Dereham Centre and Mount Elgin. Communities adjacent to Lake Erie utilize this source for municipal water, including Port Rowan and Port Dover in Norfolk County and Hagersville, Jarvis and Townsend in Haldimand. The western side of the Long Point

Region watershed is in Elgin County (Municipality of Bayham, Township of Malahide) and some of these communities are serviced by the Elgin Area Water Supply System, which also pumps from Lake Erie. Delhi has the only in-land surface water supply from North Creek, but also takes water from groundwater wells. Municipal water use is estimated at 10.4 million cubic metres per year in this watershed for about 60,000 residents.

5.2.3 Unserviced Domestic Water Use

Unserviced domestic water use is all water uses for domestic (indoor and outdoor residential water use) use that are not on a municipal distribution system. Generally, these are rural communities and lakeshore residential/cottage properties. Water could be taken from private wells or cisterns. The estimation of unserviced domestic water use was based on population estimates and per capita water use rates for rural residents.

Rural domestic per capita water use has traditionally been much lower than urban domestic use. While the actual rate varies depending on a large number of factors, 160 litres per day was assumed to be the rural domestic per capita water use rate (Vandierendonck and Mitchell, 1997). It should be noted that a large percentage of this water is likely returned to the shallow groundwater system via septic systems. This water use is assumed to be relatively constant throughout the year. The rural population in the Long Point Region is estimated to be 58,600 and draw 3.5 million cubic metres of water per year.

5.2.4 Other Permitted Water Takings

For water uses in the watershed that did not fall into the three previously mentioned categories (municipal, agricultural and rural unserviced), the Ministry of the Environment (MOE) Permit to Take Water database was used. The MOE requires any person taking greater than 50,000 litres of water on any day of the year (animal watering, domestic usage and firefighting excluded) to apply for a PTTW. The PTTW database information was queried to determine the maximum amount of water required for each category, including many industrial and larger commercial operations.

Excluding the permits that have been expired for over ten years, cancelled, temporary, agricultural or municipal water supply permits, 50 Permits to Take Water remain in the Long Point Region watershed. **Map 2.9** shows the distribution of permitted water takings in Long Point Region by water use. These 50 permits have a total of 75 sources associated with them. Of the 75 sources, 61 rely on groundwater, and 14 draw from surfacewater bodies, relating to 81 percent and 19 percent, respectively. The top five water use sectors requiring permits are aquaculture, remediation, dewatering, aggregate washing and golf course irrigation in this watershed (see **Table 5.1** above for a breakdown of uses).

A phone survey of the 50 water takers in the Long Point Region was completed in the summer of 2005 (June to August), to get better estimates or actual volumes of water use by each user. The survey generated responses from 26 of the 50 permits (52 percent response rate) to refine the estimates of their water uses. Where no data could be obtained from the user, adjustments were made based on seasonality of the water takings. For instance, golf course irrigation is likely to occur only during the months of May through October, while commercial water uses are year-round water takings. These adjustments were included where available in the calculation of the water use estimate for large permitted water takings. The total volume of water takings for all the permits was 9.7 million cubic metres in 2005.

5.2.5 Summary and Data Gaps

Section 5.1 (water use), reported that agriculture use of water for irrigation was the number one and most considerable water use within the watershed. However, data concerning the exact amount of water being used for irrigation is not known. The PTTW database provides only a crude estimate of the maximum daily amounts that the irrigator is allowed to use, but the requirements of irrigation are variable on a seasonal and yearly basis. Continued work into actual water uses is needed to further refine the estimates of water use in agricultural water use and for permitted takers. The new required reporting structure of the MOE PTTW program could provide beneficial information to water managers for water budgets and water use calculations.

Water use in relation to ecological flow requirements is a new area that needs research in terms of how it affects aquatic organisms. A pilot project was carried out within the watershed which revealed that water takings affect aquatic organisms, however the exact effects and amount of flow needed in-stream are not precisely known. Further studies into ecological flow requirements are suggested to help better understand the effects of water takings on the ecological integrity of the watershed and on aquatic organisms.

Municipal water use is the second largest user in the LPRCA. Water use data is provided by the municipalities and is the only sector that consistently has reports on actual water takings. The only shortcoming in municipal water taking values is the data is reported by several municipalities in an aggregated format for all water uses in the municipality. Information gathered from the municipal sector would be more beneficial if it could be separated into industrial, commercial, institutional (ICI) and residential components of water use; however many municipalities lack the capacity to separate these uses. Also, aggregations of several communities in the Elgin Area distribution system makes per capita estimates especially difficult as the number of users is unknown.

Other permitted water uses in the watershed are varied, from many ICI sectors such as aquaculture, aggregate washing, dewatering and golf course irrigation to other uses such as sanitary needs of campgrounds and schools. Each sector has different timing and volume requirements for water. A phone study of PTTW permit holders was carried out in order to acquire more accurate water taking estimates but it resulted in response rate of only 53 percent. It is suggested that the surveying continues, and be housed in a central database of water use in the watershed. This database would include recent information on actual water needs information gathered from permitted water users. Finally, a gap in the data is the lack of consumptive ratios of all major water sectors, as well as the occurrence of water diversions.

5.3 Community Water Quality Objectives and Values

The values that a community hold of their natural surroundings often shape the way the natural resources are accessed and managed. One community value that drives conservation in the watershed is the protection of recreational opportunities in regards to fishing and wildlife observation. The many cold and warm water streams and lakes create diverse habitat providing high quality fishing opportunities. In addition, the vast habitats along the streams, lakes, and within the many natural areas offer great viewing prospects for bird or wildlife watching. Conservation and park areas within the watershed include Backus Heritage Conservation Area, Deer Creek Conservation Area, Haldimand Conservation Area, Norfolk Conservation Area, Brook Conservation Area, Lee Brown Waterfowl Management Area and Charles Sauriol Carolinian Forest.

Another chief value that compels conservation in the watershed is the protection of water. Communities generally enjoy the aesthetics of water and also the idea that the water systems are full of fish for excellent fishing opportunities of recreational value.

Heritage features within the watershed include two main dams: the John C. Backhouse Mill, and the Quance Dam. The John C. Backhouse Mill, built in 1798, is located in the Backus Heritage Conservation Area. The Backus (Backhouse) family operated the mill until 1955 when the mill and surrounding area was purchased by the Big Creek Region Conservation Authority. The Backus Mill is currently operational and provides a popular tourist spot and a visible representation of the power and historic use of water.

6.0 DRINKING WATER SOURCES

6.1 Summary of Municipal Drinking Water Systems

There are eight municipal groundwater supply systems within the Long Point Region watersheds which rely on groundwater as a drinking water source; five systems (Dereham Centre, Norwich, Otterville-Springford, Mount Elgin and Tillsonburg) are located within the County of Oxford, and three systems (Delhi, Simcoe, and Waterford) are located within Norfolk County. **Map 6.1** shows the location of municipal groundwater wells, as well as known private wells in the Long Point Region watersheds.

Within the Long Point Region, two Ministry of the Environment municipal groundwater studies have been completed; *the County of Oxford Phase II Groundwater Protection Study* (Golder Associates Ltd., 2001), and *the Norfolk Municipal Groundwater Study* (Waterloo Hydrogeologic Inc. et al., 2003). Since the completion of the Oxford County study, several additional reports have been completed, which build upon Golder Associates Ltd. (2001) original work. These reports include *the Additional Aquifer Vulnerability Mapping, Oxford County* (Golder Associates Ltd., 2003) and *the County of Oxford Vulnerability (SWAT) Pilot Study* (Golder Associates Ltd., 2005).

There is only one drinking water intake which takes surface water either directly from a reservoir or tributary within the Long Point Region: Delhi Water Treatment Plant. The remaining eight surface drinking water intakes servicing the Long Point Region take water directly from Lake Erie into which the 14 watersheds of the Long Point Region empty. **Map 6.2** shows the location of municipal and private surface water intakes in the Long Point Region watersheds.

6.2 Summary of Private Drinking Water Supplies

6.2.1 Private Surface Water Intakes

There is only one drinking water intake which takes surface water either directly from a reservoir or tributary within the Long Point Region: Deer Creek Conservation Area. The remaining private surface drinking water intakes servicing the Long Point Region take water directly from Lake Erie into which the watersheds of the Long Point Region empty.

Since there is no reporting mechanism in place, obtaining quantitative information for private intakes is difficult. Further information from County or local health units may be able to provide more detailed information on the number of private surface water supplies within the region.

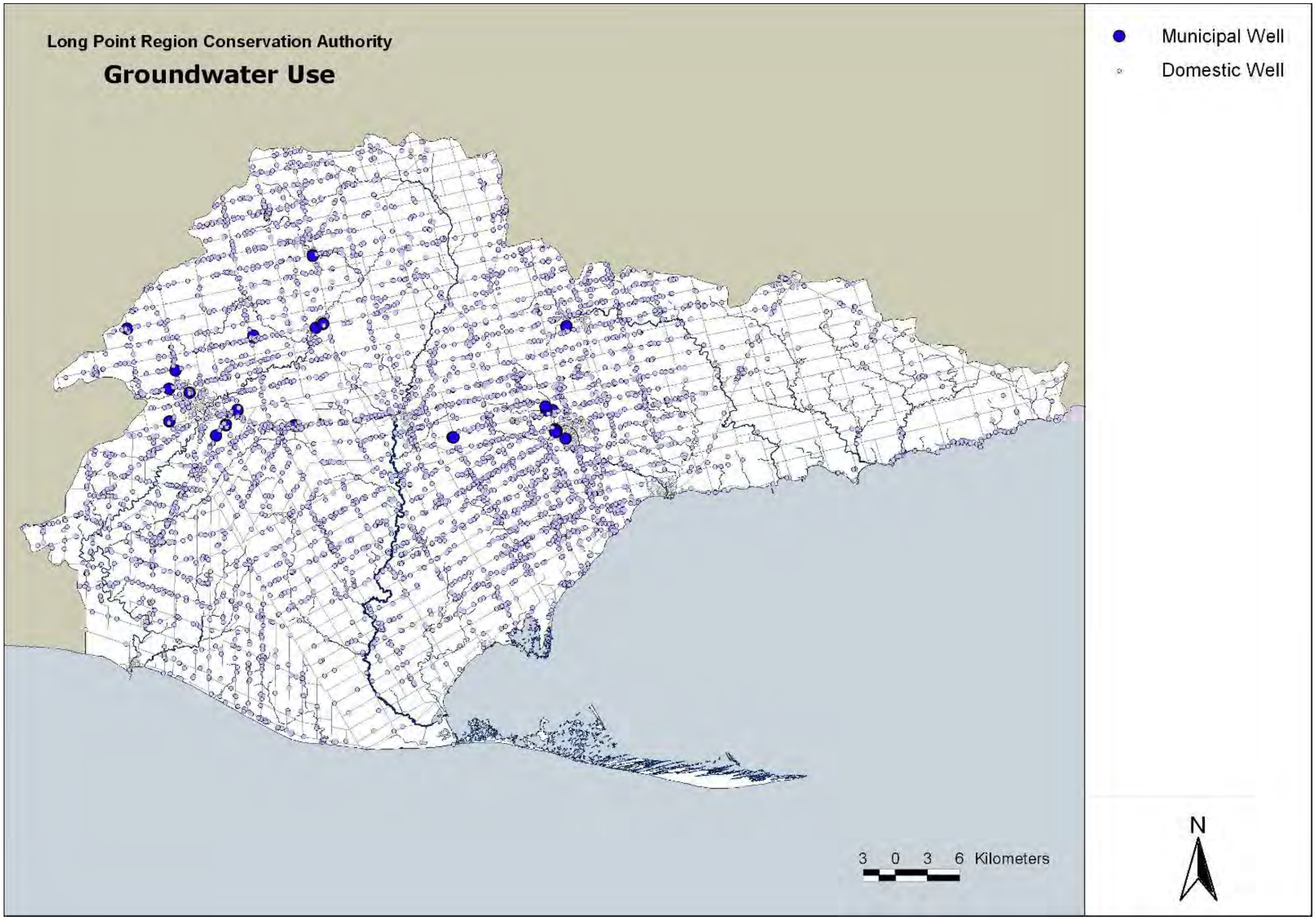
6.2.1.1 Deer Creek Conservation Area

System Description

The Deer Creek Conservation Area is a small non-municipal seasonal drinking water plant and thus is regulated under the Safe Drinking Water Act through O. Reg. 252.

It is privately owned and operated by the Long Point Region Conservation Authority (LPRCA). It draws drinking water out of the Deer Creek Reservoir (an 80 plus acre water body resulting from the construction of the Deer Creek Dam) and distributes it only to the drinking water facilities within the Conservation Area. The treatment process consists of filtration and disinfection through chlorination.

Map 6.1 Municipal and Private Groundwater Use in Long Point Region



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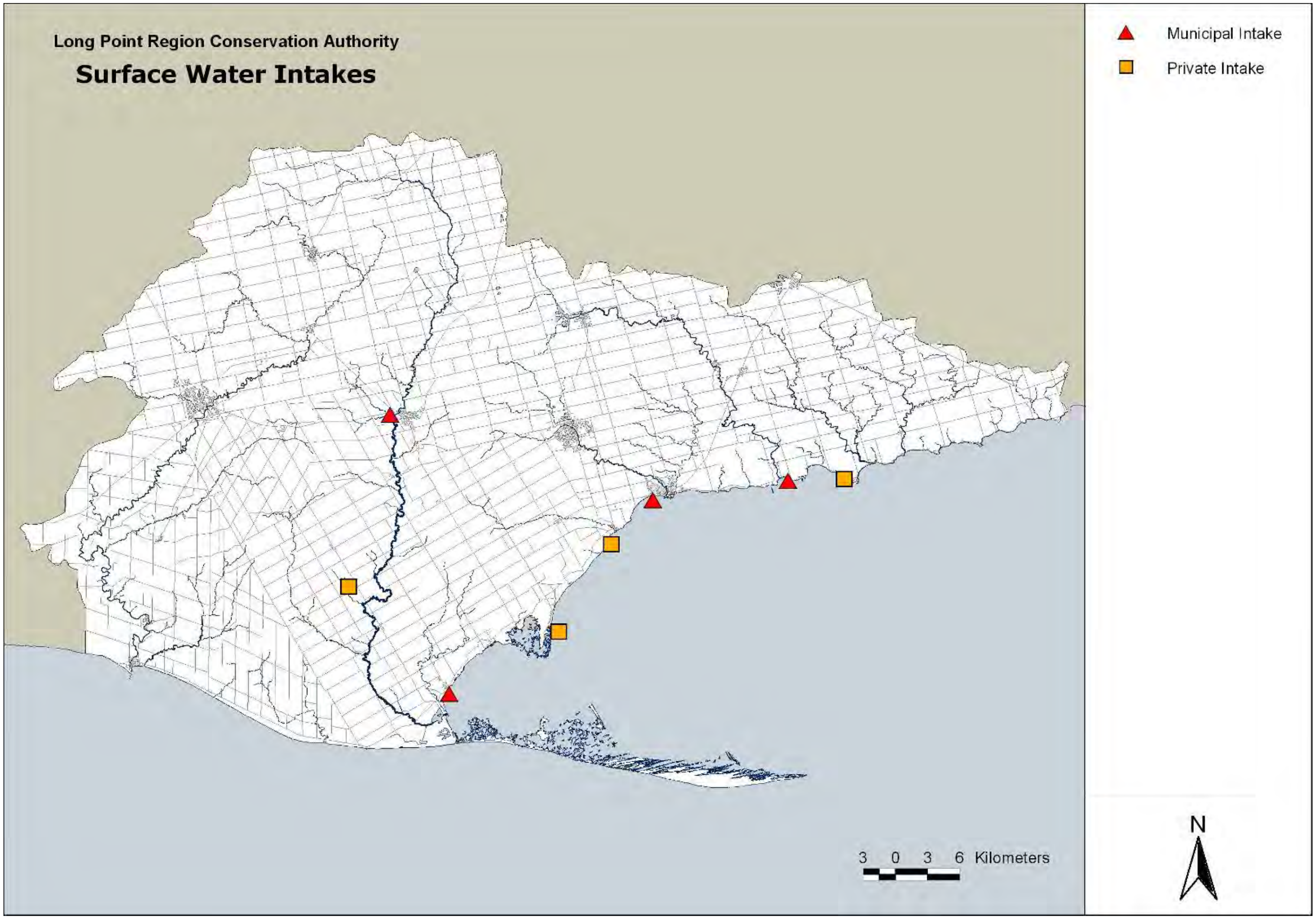
Map 6.2: Municipal and Private Surface Water Intakes in Long Point Region



Distribution System

More information required.

Treated Water Quality

Under Ontario Regulation 252, small non-municipal seasonal drinking water treatment facilities are not required to submit annual reports to the Ministry of Environment (MOE). However, they are required to report any adverse water quality results to the local health units and the MOE.

Issues and Concerns

More information required.

6.2.1.2 Lakeview Water Systems (Turkey Point)

System Description

The Lakeview Water System is privately owned by Tom Bowen Sr. and operated by Tom Bowen Jr. This facility is located within the village of Turkey Point, has a capacity of 210 gallons per minute and supplies treated drinking water to approximately 650 Turkey Point residents.

The Lakeview Water System is a conventional treatment plant and was upgraded in 2004. Raw water is pumped directly from Lake Erie into a reservoir for clarification (settling of particulate matter). The treatment process consists of meida filers, catridge filtration, UV for primary disinfection and chlorination for secondary disinfection and through the distribution system.

Distribution System

More information required.

Treated Water Quality

During the 2005 year there were two occurrences of background coliform levels above the Ontario drinking water standards. However, immediate re-testing found no adverse results.

Annual Reports describing the treatment plant's operations and water quality monitoring results can be obtained by contacting Tom Bowen (519) 429-3122 or the Hamilton MOE district office.

Issues and Concerns

More information required.

6.2.1.3 Rockpoint and Long Point Provincial Parks

System Description

Two provincial parks operate private drinking water intakes from Lake Erie to service park staff and visitors: Rockpoint and Long Point Provincial Parks.

Distribution System

More information required.

Treated Water Quality

More information required.

Issues and Concerns

More information required.

6.2.1.4 Norfolk Conservation Area

System Description

The Norfolk Conservation Area has an intake pipe pumping water directly from Lake Erie which is owned and operated by the Long Point Region Conservation Authority. This water is pumped directly into two large tanks below the beach. Water from these tanks is then pumped into the parks treatment facility. The treatment process includes filtration and chlorination for disinfection. The treated water is then stored above ground in a 5,000 gallon tank from which it is distributed throughout the park.

Distribution System

More information required.

Treated Water Quality

The drinking water treatment facility at the Norfolk Conservation Area is classified as a seasonal non-municipal small water treatment facility. Therefore no annual report is required. However, any adverse quality must be reported to the local Public Health Units.

Treated water is sampled twice a day for residual chloride, once a day for turbidity and once a week for bacteria. Monitoring for facilities within this category is regulated under O.Reg. 252/05 rather than O.Reg. 170/03.

Issues and Concerns

More information required.

6.2.1.5 Haldimand Conservation Area

System Description

The Haldimand Conservation Area has an intake pipe pumping water directly from Lake Erie which is owned and operated by the Long Point Region Conservation Authority. This water is pumped directly into two large tanks below the beach. Water from these tanks is then pumped into the parks treatment facility. The treatment process includes filtration and chlorination for disinfection. The treated water is then stored above ground in a 5,000 gallon tank from which it is distributed throughout the park.

Distribution System

More information required.

Treated Water Quality

The drinking water treatment facility at the Haldimand Conservation Area is classified as a seasonal non-municipal small water treatment facility. Therefore no annual report is required. However, any adverse quality must be reported to the local Public Health Units.

Treated water is sampled twice a day for residual chloride, once a day for turbidity and once a week for bacteria. Monitoring of facilities within this category is regulated under O.Reg. 252/05 rather than O.Reg. 170/03.

Issues and Concerns

More information required.

6.2.1.6 Peacock Point Private Water System (Cottagers Association)

System Description

Intake pipe placed in Lake Erie on a seasonal basis.

Distribution System

More information required.

Treated Water Quality (This information needs to be confirmed)

The drinking water treatment facility at Peacock Point is classified as a seasonal non-municipal small water treatment facility. Therefore no annual report is required. However, any adverse quality must be reported to the local Public Health Units.

Treated water is sampled twice a day for residual chloride, once a day for turbidity and once a week for bacteria. Monitoring of facilities within this category is regulated under O.Reg. 252/05 rather than O.Reg. 170/03.

Issues and Concerns

More information required.

6.2.2. Summary of Private Groundwater Uses

Many rural residents in the Long Point Region watersheds are reliant on private wells and cisterns as their source of drinking water, since rural populations live outside of municipally serviced water supply systems. The locations and depths of these private domestic wells are useful for understanding the reliance on either a regional overburden aquifer or a bedrock aquifer. It is beneficial to understand the number of people using these sources of drinking water, in case of groundwater aquifer contamination, or as potential pathways for contamination from private wells. The MOE well log database was queried to locate all the domestic wells in the watershed to characterize the private groundwater sources.

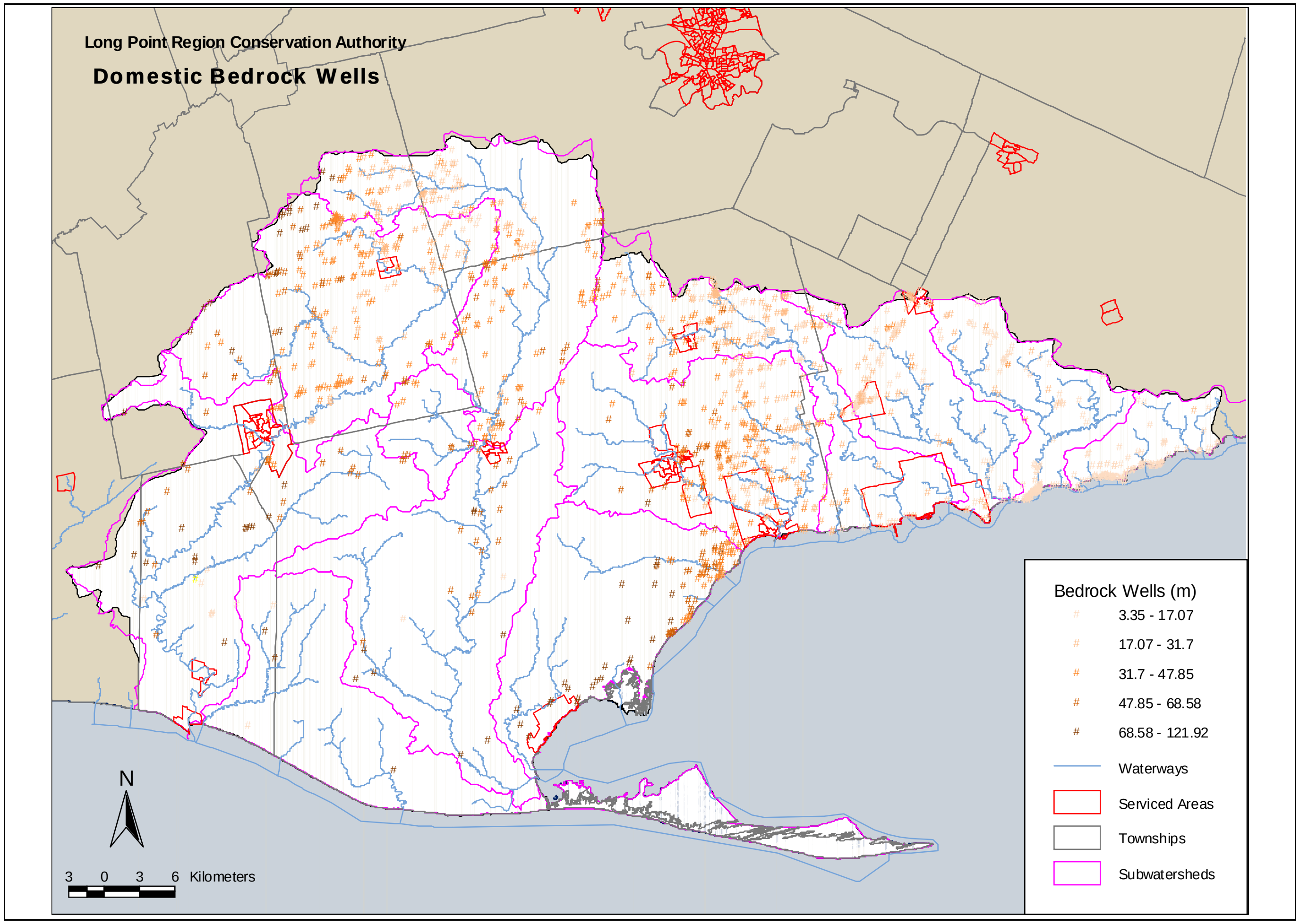
A total of 7,613 domestic wells are located in the Long Point Region official boundaries, with 1,531 (20.1 percent) of these wells being classified as bedrock wells and 5,922 (77.8 percent) as overburden wells. These wells date back to 1939 and it is unknown how many are still in operation for domestic use today. It is possible that some wells drilled at this time have been drilled to replace abandoned or decommissioned wells that were previously used. However, there is no information given in the well log to remove these wells from the database once they are no longer in use. This can be a concern as wells may have been left open or have been improperly closed which can lead to groundwater contamination concerns. The lifetime of a well is dependent on its specific capacity – the ability to draw water – and as wells age and deteriorate or if water levels are not being replenished, new wells will be drilled and old ones abandoned. There is no way of knowing how many wells are still in operation and which ones are not being used as this information is not documented in the database. Thus, all the wells in the database are used for consideration to characterize private groundwater wells in the Long Point Region watersheds.

Bedrock wells for domestic use are predominantly located on the eastern and northern watersheds of the Long Point Region, and along the shore of Lake Erie (**Map 6.3**). These regions of the watershed are located on the clay plain and the till plain where drilling down to bedrock would be needed to find productive groundwater sources. The wells range in depth from 3.4 metres down to 112.9 metres with a median well depth of 25.9 metres, indicating that there are some deep bedrock wells, but the majority of wells are within 30 metres of the surface.

Overburden wells dominate in the western portion of the central region, where the Norfolk Sand Plain is dominant and drilling into this will provide sufficient water resources for domestic purposes (**Map 6.4**). There are virtually no overburden wells in some of the eastern subwatersheds, as clay plains have very low porosity and ability to supply water. Overburden wells are evenly spread out across the central and western subwatersheds, which also coincide with the Norfolk Sand Plain. This central and western region is also where the shallowest overburden wells are located, as it is not necessary to drill deep into the earth to get a productive water well. Overburden wells can also be found in the till plain, but generally these wells need to be drilled deeper to get sufficient groundwater for domestic or other purposes. Overburden wells in this region range from 1.8 to 83.8 metres in depth, but the median is 11.9 metres, indicating that many wells need not go too deep to supply their water needs.

Private wells drilled in urban areas may pose a threat to municipal drinking water sources if they are located within the capture zone of municipal wells, as they may act as potential pathways for surface contaminants to reach the aquifer supplying municipal well. This is especially true for abandoned or active wells that are improperly sealed, or wells that are located in the vicinity of nutrient loads such as a septic tank or manure storage.

Map 6.3: Bedrock Wells for Domestic Use in Long Point Region



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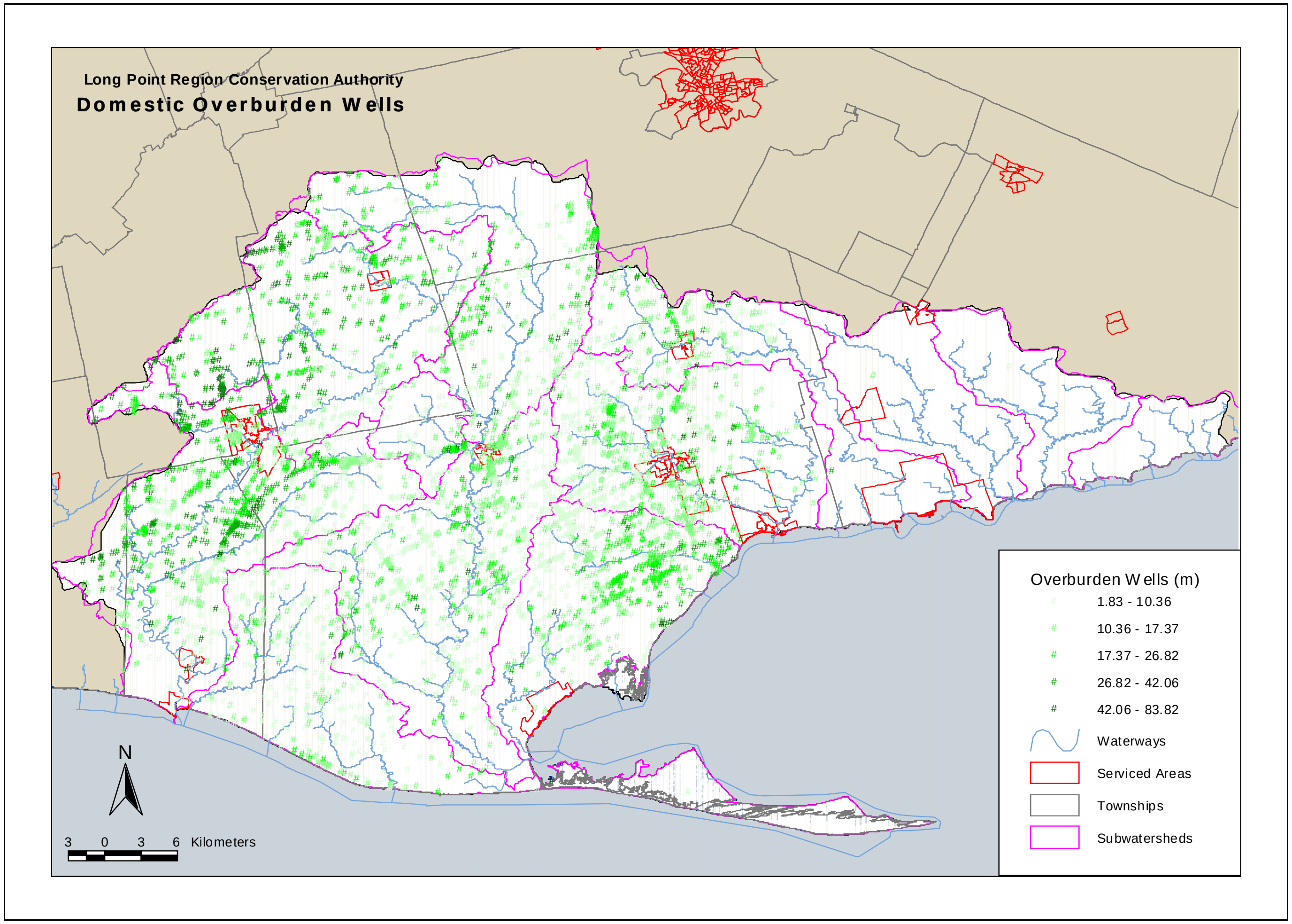
Map 6.4: Overburden Wells for Domestic Use in Long Point Region



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6.3 Municipal Drinking Water Systems Descriptions

6.3.1 Municipal Groundwater Systems Descriptions

6.3.1.1 County of Oxford

The County of Oxford Phase II Groundwater Protection Study (Golder Associates Ltd., 2001) completed a number of tasks including wellhead protection area (WHPA) delineation, vulnerability mapping and the compilation of a regional threats inventory.

MODFLOW was used to develop well field-scale groundwater models to delineate two-, five-, ten-, and 25-year capture zones for each of the County's municipal well fields. The pumping rates used were dependent on the municipality as to whether current average flows or projected flows were used to model the capture zones. The uncertainty in the capture zone delineation was addressed though the use of two correction factors; an expansion of the capture zone by five degrees from the centerline and an increase of 20 percent from the centerline of the capture zone.

In *The County of Oxford's Phase II Groundwater Protection Study*, a vulnerability assessment was completed for each of the four aquifer units in the study area. For each major aquifer, a numerical score related to the hydraulic conductivity of the material in the stratum overlying the aquifer was multiplied by the thickness of the stratum to which it was assigned. The resulting products for each of the strata overlying the aquifer were summed to give the vulnerability score for that well location. Following the calculation of the vulnerability scores, the scores were classed according to high (< 30), moderate (30 – 80) and low vulnerability (> 80). These results were then interpolated across the study area to create four vulnerability maps for the shallow overburden aquifer, intermediate overburden aquifer, deep overburden aquifer and bedrock aquifer.

From these four maps, a composite groundwater vulnerability map was generated by mapping the first aquifer encountered at each well location. For much of the County, this was the shallow aquifer. In areas where the shallow aquifer was not present, the vulnerability for the next aquifer encountered was mapped. If no overburden aquifers were present, the vulnerability rating for the composite map was derived from the bedrock aquifer.

Additionally a potential contaminant sources inventory was compiled on a regional basis using existing databases. The County also completed a detailed inspection and land use inventory within municipal well capture zones which involved field inspections and the identification of various land uses and potential sources of contaminations associated with the various land uses. Each land use was mapped according to its risk rating adapted from the USEPA and was provided to the County for internal use. Intensive livestock operations were also mapped County-wide using existing Nutrient Management Plans.

Since the completion of the *Phase II Groundwater Protection Study*, a second vulnerability map was generated (Golder Associates Ltd., 2003) using the MOE's ISI methodology (refer to Land Use Policy Branch, 2001). The approach used the 'first significant aquifer' only and the resulting map was less conservative than the mapping completed as a part of the *Phase II Groundwater Protection Study*.

In 2005, the County of Oxford completed a pilot surface to well advection time (SWAT) analysis for the Ingersoll, Woodstock, Tillsonburg and Norwich wellfields (Note however that only the Tillsonburg and Norwich wells are located within the LPRCA boundaries) (Golder Associates

Ltd., 2005). The conclusions of this study found the SWAT calculations provided a reasonable means of quantifying the relative vulnerability of the supply aquifers. In July of 2006 staff from the GRCA met with County of Oxford staff to discuss high level threats to the municipal groundwater supply as summarized in **Table 6.1.** As a component of Source Protection Planning, the County of Oxford is currently undertaking a project to update the threats inventory within all County WHPAs. This project is expected to take 12 months to complete.

Table 6.1: High Level Drinking Water Threats in the County of Oxford

	Groundwater
Direct Introduction	
Water treatment plant wastewater discharge	None
Sewage treatment plant effluent	Tillsonburg WWTP outlets to Big Otter Creek Norwich sewage lagoons outlet to Otter Creek
Sewage treatment plant by-passes	Any by-pass is reported in accordance with MOE requirements
Industrial effluents	Commercial/industrial activities within Tillsonburg and Otterville
Landscape Activities	
Road salt application	County salt storage facility in Dereham Centre is not within the WHPA. The County applies salt/sand to County roadways as required
De-icing activities	Commercial airport north of Tillsonburg outside of WHPAs
Snow storage	None
Cemeteries	No cemeteries likely within WHPAs
Stormwater management systems	No SWM ponds within WHPAs
Landfills	Abandoned landfill sites identified in County Official Plan No active landfills within LPRCA boundary
Organic soil-conditioning	None
Septage application	Private haulers mostly delivering septage to WWTP's
Hazardous waste disposal	Rotating HHW programs for residential collection
Liquid industrial waste	There is some liquid waste from food processors in Tillsonburg
Mine tailings	None
Biosolids application	No application allowed within any 2-yr TOT for a municipal well
Manure application Fertilizer application Pesticide / herbicide application	Agricultural applications are used widely in the County Nutrient Management Act dictates manure control for some livestock operations Crop activities predominate in the southern sand plains Livestock operations typically in north end of the County Some hog operations are moving into the sand plain
Historical activities – contaminated Lands	Official Plan identifies some historical activities Tillsonburg has some brownfield sites
Storage of Potential Contaminants	
Fuels / hydrocarbons	No bulk fuel stations within the WHPAs
DNAPL's (dense non-aqueous phase liquids) Organic solvents Pesticides (of concern to drinking water) Fertilizers Manure	Source Protection Study will focus on property level threats Ag Co-op in Springford

Village of Mount Elgin

Summary

The Village of Mount Elgin is groundwater dependant. The village is situated on the drainage divide between the Long Point Region watershed and the Upper Thames River watershed. The County of Oxford WHPA mapping for the water supply shows the groundwater source originating within the Upper Thames watershed. The current water use records for the village indicate that additional water supplies will be required to meet the future needs of the community.

Village of Dereham Centre

System Description

The Dereham Centre system services a population of approximately 48 people. A new well and treatment facility were constructed during fall 2004 and began operating in January, 2005. A new well, reservoir, pumphouse, all controls and monitoring equipment, standby power and distribution system mains and curb stops were installed. Water is treated with sodium hypochlorite for disinfection and sodium silicate for iron sequestration.

Municipal Groundwater Quality

According to the 2005 Drinking Water Systems Regulations Annual Report for Dereham Centre, no exceedances were reported in 2005.

Description of Capture Zones

Since a new well has been brought on-line for Dereham Centre a revision of capture zones formulated as a part of *Phase II Groundwater Protection Study* was undertaken. The new WHPAs were not available at the time of this report.

The older capture zones modelled as a part of the *Phase II Study*, shown on **Map 6.5**, extend northeast of the well through a few residential properties and agricultural land.

Vulnerable Areas within the 25-year Capture Zone

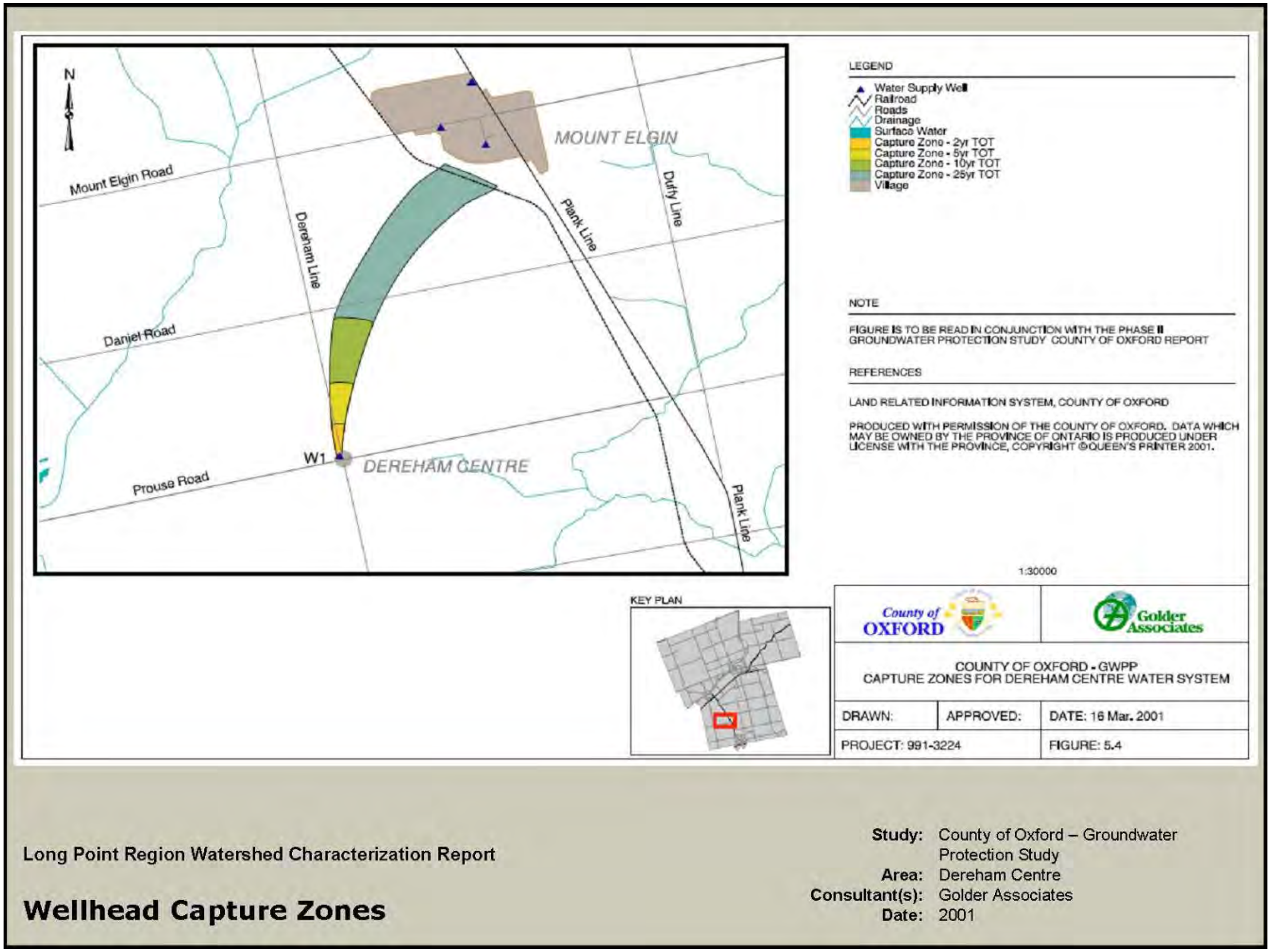
The municipal supply aquifer for Dereham Centre was identified as the Intermediate Aquifer by Golder Associates Ltd (2001). The vulnerability of the Intermediate Aquifer across the County of Oxford is shown on **Map 6.6**. In the vicinity of Dereham Centre, the vulnerability of the Intermediate Aquifer has been mapped as low to medium susceptibility to contamination.

Threats within the 25-year Capture Zone

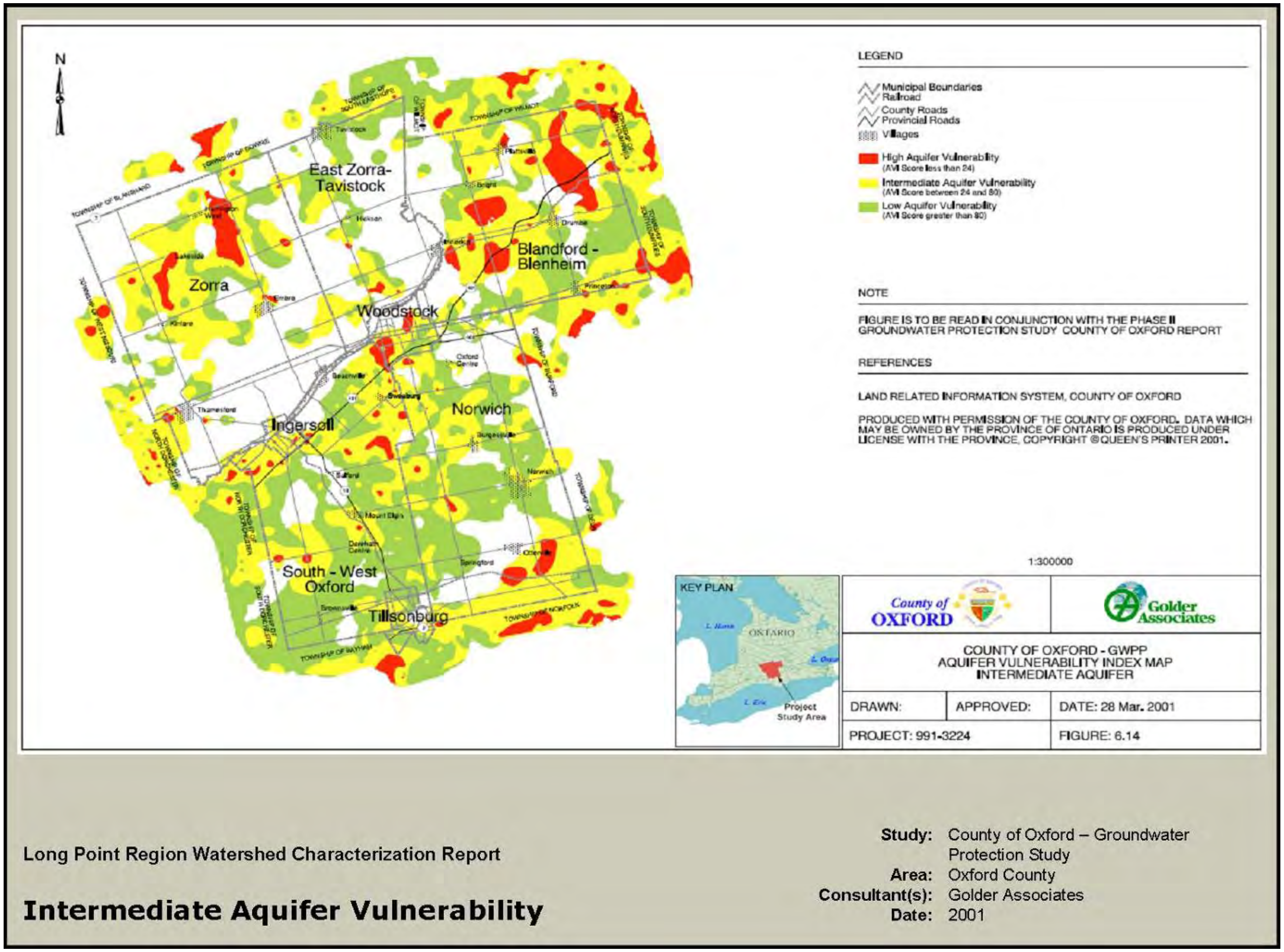
Threats that were mapped on a County-wide basis are shown on **Map 6.7**. Within Dereham Centre's capture zone, a municipal patrol yard containing two identified USTs, an AST and a salt dome were identified. The patrol yard was located northwest of the former municipal well, on the adjacent property.

The County of Oxford is currently managing a study to inventory threats within Dereham Centre's 25-year capture zone.

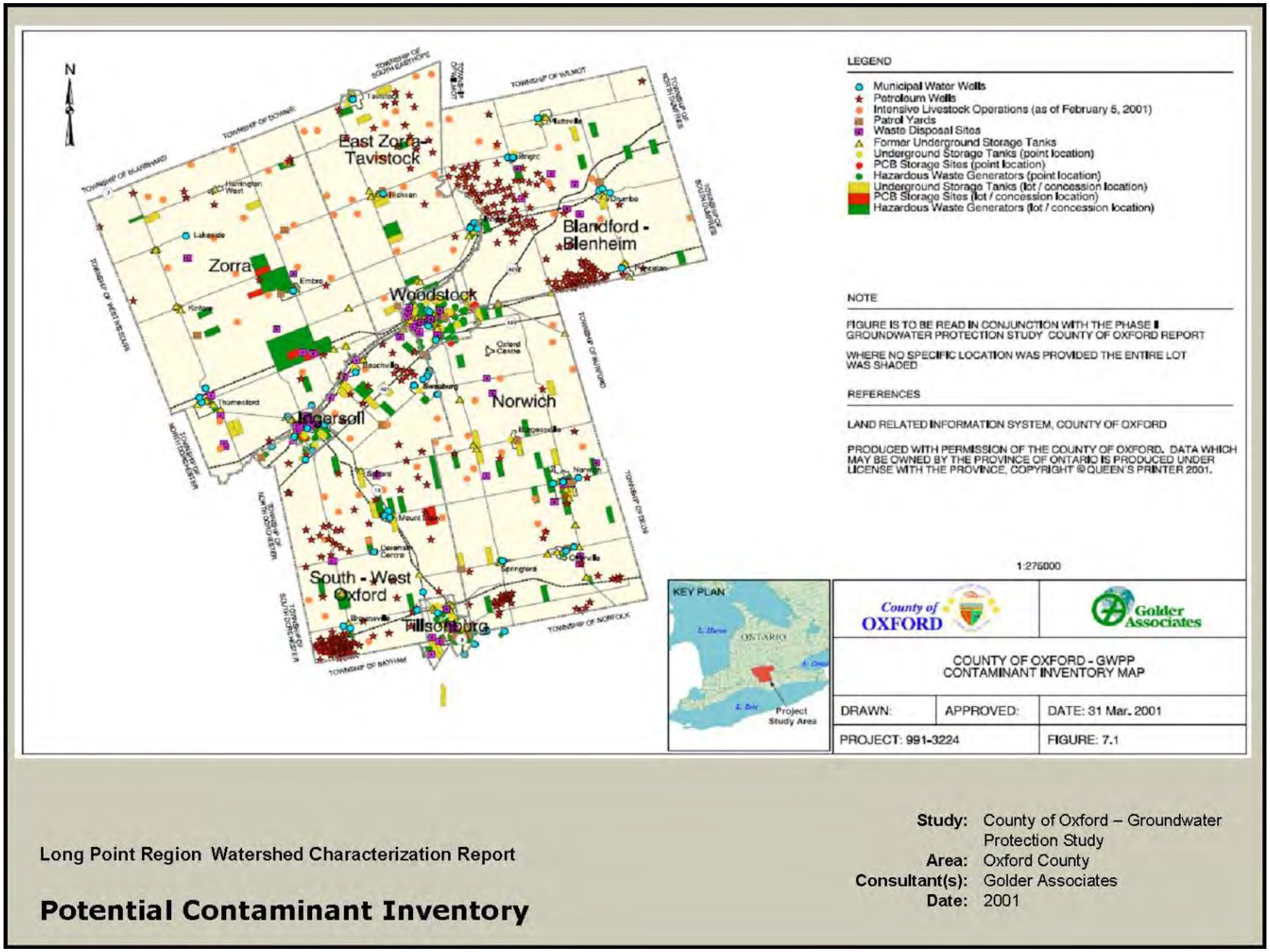
Map 6.5: Wellhead Capture Zones for Dereham Centre, Oxford County



Map 6.6: Intermediate Aquifer Vulnerability for Oxford County



Map 6.7: Potential Contaminant Inventory for Oxford County



Summary

The Village of Dereham Centre is groundwater dependant. Threats range from natural characteristics (arsenic) to rural land use activities (septic systems, agriculture) and a patrol yard in the village with salt and fuel storage. The vulnerability of the source in the Intermediate Aquifer has been mapped as low to medium susceptibility to contamination. The village well has sufficient capacity for existing population and future expansion is anticipated to be very limited. The County of Oxford is considered a leader in well head protection and has conducted a number of provincial pilot studies. They have completed a variety of groundwater studies to map well head protection areas, identify regional threats to existing water supplies and develop strategies for well head protection.

Town of Norwich

System Description

The Norwich water supply consists of three existing wells (Wells 1, 2 and 4) and a 1,818 cubic metres elevated water tower. Former Well 3 was taken off-line in the late 1990's due to poor water quality. Well 1 will be abandoned in 2007 due to its age and relatively poor condition. A Class Environmental Assessment and Hydrogeological Study was completed in December 2006 and included the rehabilitation of Well 2 and construction of a new well (Well 5) to replace Well 1. The treatment works, including filtration for iron removal for Wells 2 & 5, will be constructed in 2007. This system services approximately 2,595 people. Well 4 is treated with sodium silicate to sequester iron.

Municipal Groundwater Quality

In June of 2005, several instances of background bacteria counts greater than 200 colonies/ 100 millilitres were reported in the 2005 Drinking Water Systems Annual Report for the Norwich system.

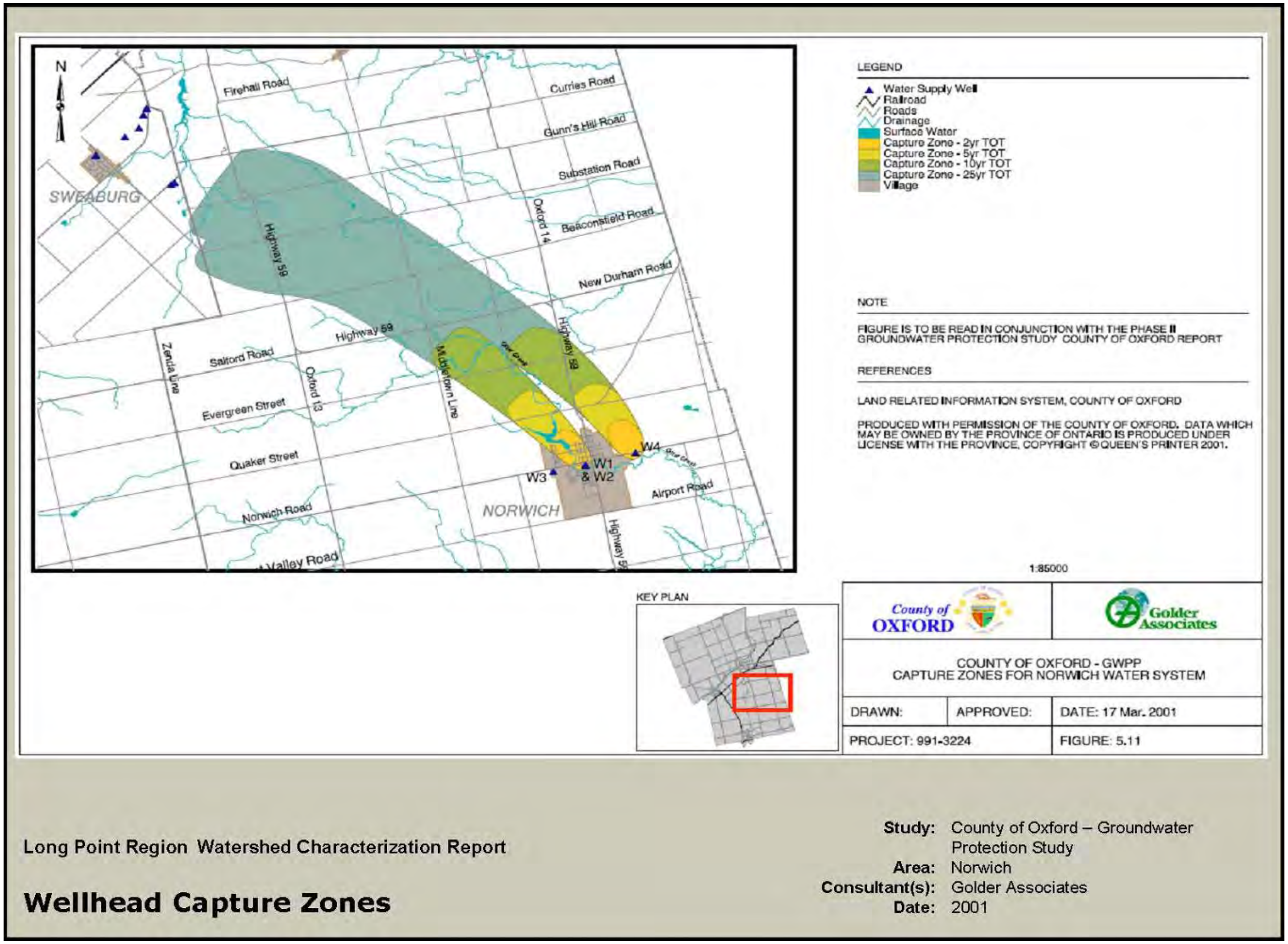
Description of Capture Zones

The Norwich capture zones, which were modelled as a part of the County's 2001 Phase II Groundwater Study, are shown on **Map 6.8**. The two-, five-, ten-, and 25-year capture zones extend to the northwest, through the central and northern developed areas of the town into agricultural properties, towards the community of Sweaburg. Otter Creek flows through the capture zones; however, it was assumed in the Phase II Study that there was no hydraulic connection between the creek and the bedrock municipal supply aquifer. Since the projected population growth in the Norwich area is 25 percent, the pumping rate for the Norwich water supply wells used to forecast the time-related capture zones was increased by 25 percent compared to 1999 values. The total pumping rate from any one of the wells is not to exceed the capacity of Well 2.

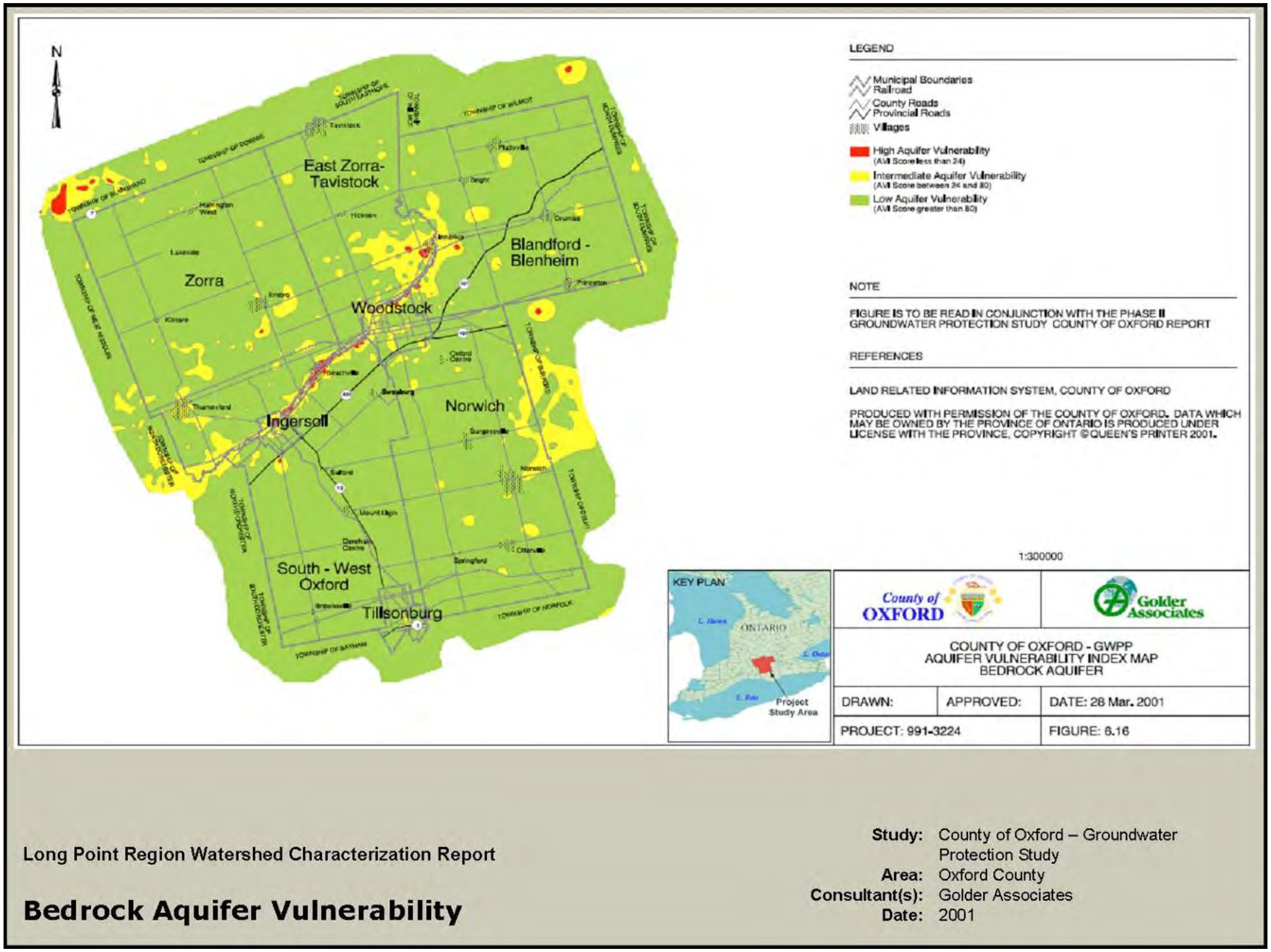
Vulnerable Areas within the 25-year Capture Zone

Regional vulnerability of the bedrock aquifer, which is the municipal supply aquifer for Norwich, is shown on **Map 6.9**. In the vicinity of the Norwich capture zones, the bedrock aquifer has been mapped as having a low vulnerability to contamination.

Map 6.8: Wellhead Capture Zones for Norwich, Oxford County



Map 6.9: Bedrock Aquifer Vulnerability for Oxford County



Threats within the 25-year Capture Zone
Threats that were mapped on a County-wide basis are shown on **Map 6.7**. Land uses identified by Golder Associates Ltd. (2001) within the capture zones for Wells 1 and 2 included office and commercial properties, schools, a nursing home, churches, a fire station, industrial facilities, a gas station, automotive service stations, agricultural products distributor and residential and agricultural properties. A gas station and furniture manufacturer were identified within the capture zone for Well 4. The County of Oxford is currently managing a study to inventory threats within Norwich's 25-year capture zone.

Summary
The Village of Norwich is groundwater dependant. Threats range from rural land use activities (septic systems, agriculture) to historic urban activities (industry, fuel storage tanks, municipal patrol yard). The County of Oxford's WHPA mapping for the water supply shows the upper limits of the 25-year capture zone originating within the Upper Thames watershed. In the vicinity of the Norwich capture zones, the bedrock aquifer has been mapped as having a low vulnerability to contamination. A previous high bacteria count lead to the decommissioning of a former municipal well. The village's water supply needs to be expanded. A Class EA was completed in 2006 to expand the supply through increased pumping of existing wells. The County of Oxford is considered a leader in well head protection and has conducted a number of provincial pilot studies. They have completed a variety of groundwater studies to map well head protection areas, identify regional threats to existing water supplies and develop strategies for well head protection.

Villages of Otterville and Springford

System Description
The Otterville – Springford Well supply consists of four groundwater wells. Springford and Otterville each have two wells and a treatment/pumping facility. A 1,440 cubic metre water tower is located in Otterville. The communities are connected by a 3.3 kilometre water main with no service connections between the communities.

Municipal Groundwater Quality
In November of 2005, one incidence of a fluoride concentration slightly greater than the MAC of one and a half milligrams per litre was reported in the 2005 Drinking Water Systems Annual Report for the Norwich system.

Description of Capture Zones
The Springford and Otterville supply systems were recently connected by a watermain, and two new wells have been brought on-line at Springford since the completion of the County's *Phase II Groundwater Study*. The Springford wells presented in the *Phase II Groundwater Study* have been since taken off-line from the community's water supply. Otterville's supply wells however have remained the same since the completion of the *Phase II Groundwater Study* with the exception of one well that has been decommissioned (presently two wells are on-line versus the three wells documented in the *Groundwater Study*). Capture zones for Otterville's wells are shown on **Map 6.10** (Golder Associates Ltd., 2001). The capture zones extend east of the wells into agricultural lands.

Vulnerable Areas within the 25-year Capture Zone
Otterville's supply wells have been identified as being completed in the Shallow Overburden Aquifer which is unconfined in the areas surrounding Otterville (Golder Associates Ltd., 2001). The groundwater vulnerability map for the Shallow Overburden Aquifer is presented on **Map 6.11**. In the vicinity surrounding the community of Otterville, the vulnerability of the supply

aquifer has been rated as highly susceptible to contamination since it is a shallow, unconfined aquifer with little protection from surficial land uses.

Threats within the 25-year Capture Zone
Threats that were mapped on a County-wide basis are shown on **Map 6.7**. Land uses identified by Golder Associates Ltd. (2001) within Otterville's capture zones included mainly residential and agricultural properties. An automotive service station was also identified within the capture zone for Wells 3 and 4.

The County of Oxford is currently managing a study to inventory threats within Springford and Otterville's 25-year capture zones.

Summary
The Villages of Otterville and Springford are groundwater dependant, serviced by wells on an integrated system. Threats range from natural characteristics (arsenic in Springford) to rural land use activities (septic systems, agriculture). In the vicinity of Otterville, the vulnerability of the supply aquifer has been rated as highly susceptible to contamination since it is a shallow, unconfined aquifer with little protection from surficial land uses. The village's water supplies have sufficient capacity for future expansion. The County of Oxford is considered a leader in well head protection and has conducted a number of provincial pilot studies. They have completed a variety of groundwater studies to map well head protection areas, identify regional threats to existing water supplies develop strategies for well head protection.

Town of Tillsonburg

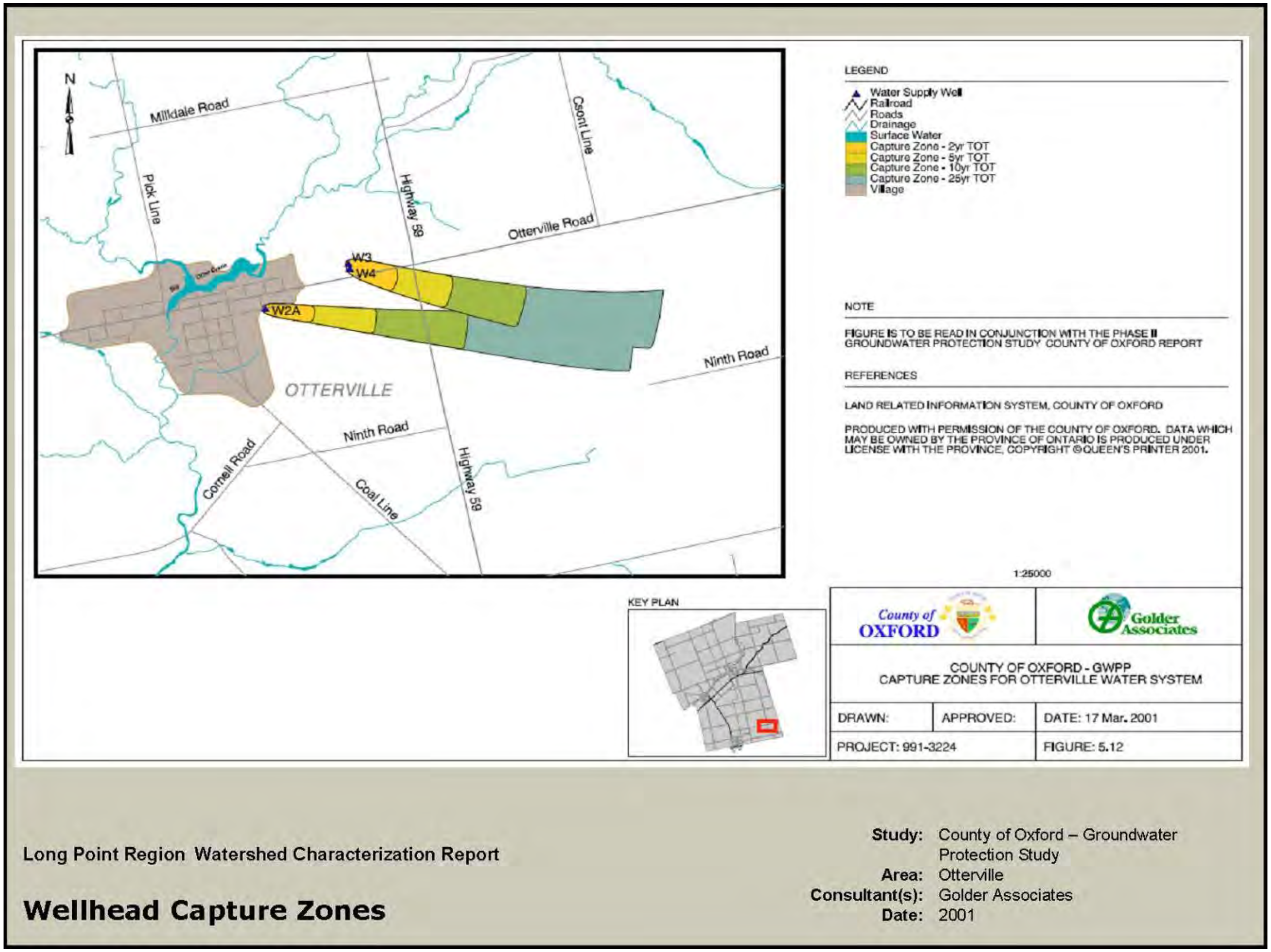
System Description
The Tillsonburg Well Supply consists of ten raw water wells treated at six different pumphouse/treatment facilities located within and surrounding the community of Tillsonburg. The system supplies drinking water to a population of approximately 13,972 people. Each pumphouse has one to three wells for supply, a contact reservoir on site, disinfection and monitoring equipment. Each pumphouse can supply the distribution system directly and storage is provided by a 9,100 cubic metre reservoir. Sodium silicate for sequestering iron is added at the Broadway, Bell Mill and Mall Road pumphouses. All water is treated with chlorine gas and sodium hypochlorite for disinfection.

The facilities are set up as follows:

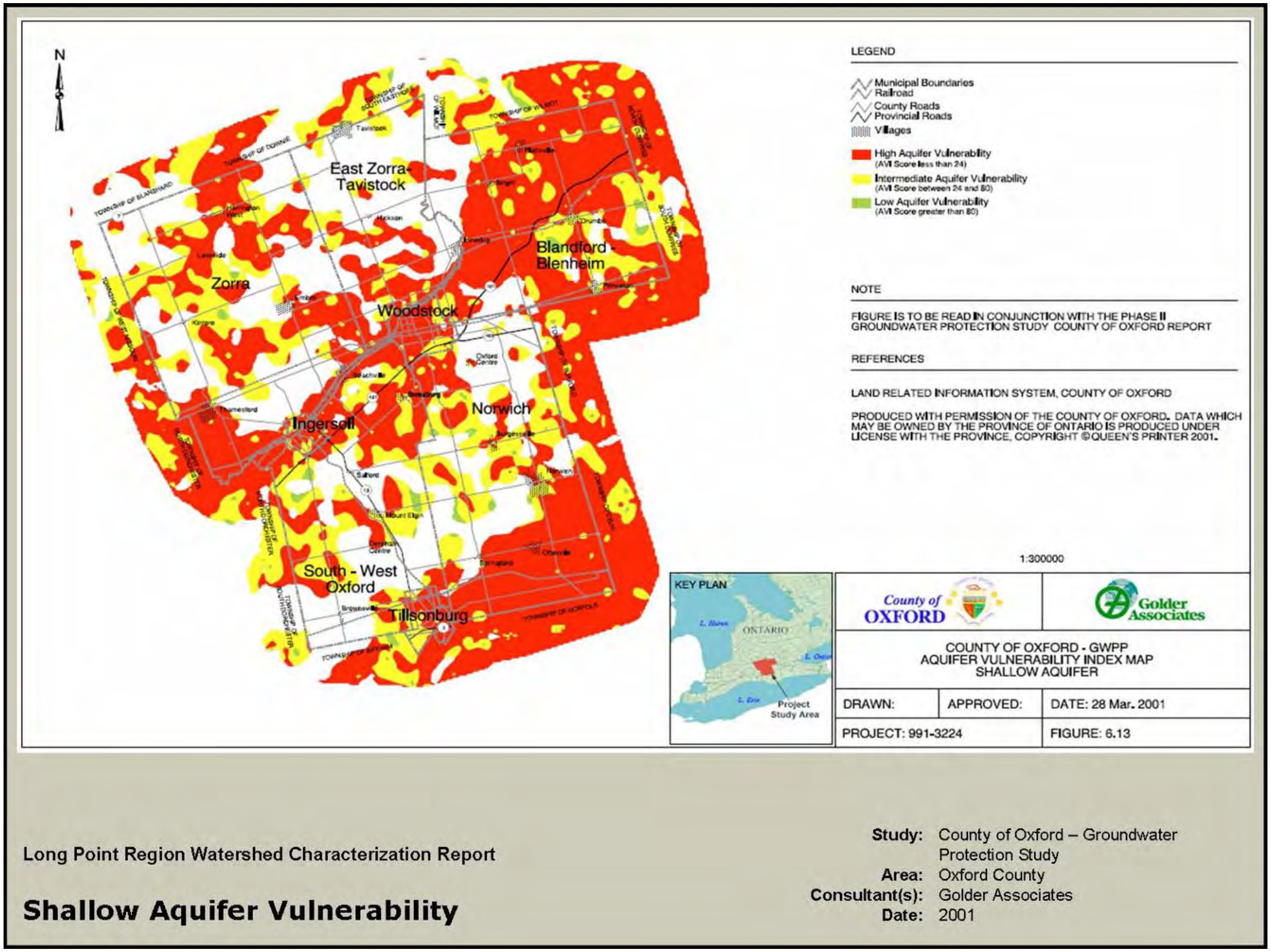
- Mall Road Pumphouse – Wells 1A and 2
- North Street West Pumphouse – Wells 4 and 5
- Plank Line Pumphouse – Well 6A
- Broadway Street Pumphouse – Well 7
- Bell Mill Sideroad Pumphouse – Wells 9, 10 and 11
- Rokeby Road Pumphouse - Well 12

Wells 1A, 2, 4, 5, 7, 9 and 10 have been identified as GUDI wells (Groundwater Under the Direct Influence of Surface Water) whereas Wells 6, 11 and 12 are secure groundwater wells.

Map 6.10: Wellhead Capture Zones for Otterville, Oxford County



Map 6.11: Shallow Aquifer Vulnerability for Oxford County



The following treatment upgrades are either currently under construction or planned fro construction in 2007:

- Mall Road Pumphouse – a new treatment facility with iron filtration and UV disinfection for wells 1 & 2
- North Tillsonburg Treatment facility and booster pumping station – UV disinfection for wells 4, 5 & 7
- Plank Line pumphouse will be connected directly to the Tillsonburg reservoir for chlorine contact time
- Bell Mill Sideroad – new treatment facility with iron filtration and UV disinfection for wells 9, 10 & 11

Wells 1A, 2, 9, 10, 11 and 12 lie to the southeast of Tillsonburg in the Norfolk Sand Plain. Wells 4, 5, 6 and 7 are located in the Township of South-West Oxford, to the north of Big Otter Creek and Stony Creek. All of the wells are completed in the overburden. Overburden aquifers in the Tillsonburg area are generally unconfined (Golder Associates Ltd., 2001).

Municipal Groundwater Quality
According to the 2005 Drinking Water Systems Annual Report for Tillsonburg, the following exceedances occurred over the course of the year:

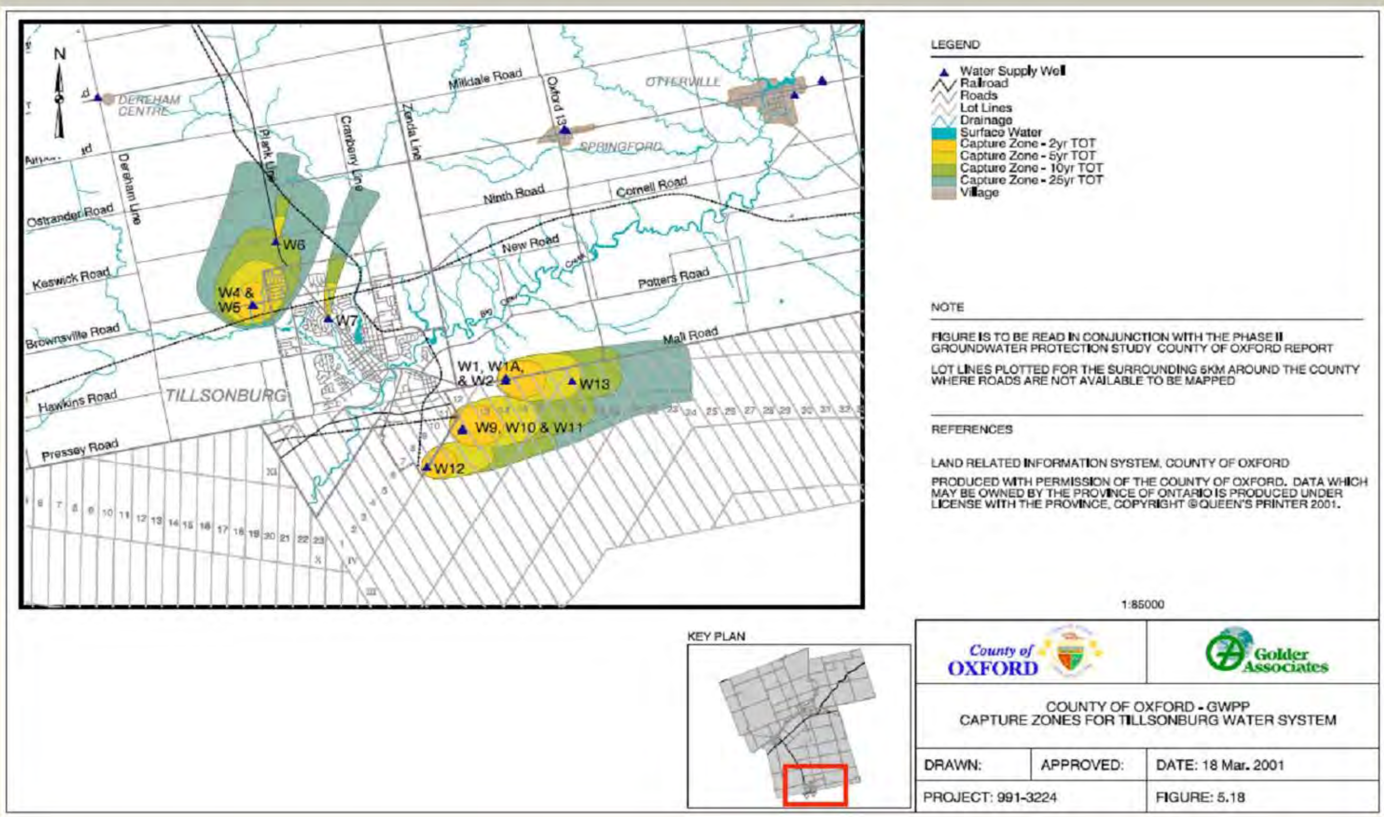
- In January, 2005, nitrate at the North Street West pumphouse exceeded the MAC of ten milligrams per litre with a concentration of 10.2 milligrams per litre;
- In May, 2005, background bacteria at the Broadway pumphouse exceeded the MAC of 200 colonies/100 millilitres with a count of 360 colonies/100millilitres; and
- In August, 2005, the background bacteria in the distribution system was greater than 200 colonies/100 millilitres with a count of 1,140 colonies/100 millilitres, and one total coliform colony/100 millilitres was found in a second sampling event following a watermain break.

Description of WHPAs
Capture zones for Tillsonburg's municipal wells, completed as a part of the *Phase II Groundwater Study*, are shown on **Map 6.12**.

The capture zone for Wells 1, 1A and 2 extend east of the wells and include mainly residential and agricultural properties. The capture zone for Wells 4 and 5 extends outward from the wells, mainly to the northeast. The capture zone for Well 6 extends north-northeast from the well into agricultural lands. The capture zone for Well 7 extends north-northeast from the well, through residential properties and into agricultural lands. The capture zones for Wells 9, 10 and 11 extends east from the wells into agricultural lands. The capture zone for Well 12 extends east of the wells into agricultural lands.

Vulnerable Areas within the 25-year Capture Zone
All but three of Tillsonburg's municipal wells have been identified as GUDI. This indicates that these wells are under the influence of surface water and are therefore more susceptible to contamination by surface waters.

Map 6.12: Wellhead Capture Zones for Tillsonburg, Oxford County



Long Point Region Watershed Characterization Report

Wellhead Capture Zones

Study: County of Oxford – Groundwater Protection Study
Area: Tillsonburg
Consultant(s): Golder Associates
Date: 2001

Threats within the 25-year Capture Zone
Threats that were mapped on a County-wide basis are shown on Map 6.7 (Golder Associates Ltd., 2001). The capture zone for Wells 4 and 5 includes agricultural and residential properties. A contractor's yard located west of Wells 4 and 5 contained three identified fuel ASTs. A contractor's yard and a multi-commercial/industrial unit were also located within the capture zone for Well 7. Land uses other than agricultural within the capture zones for Wells 9, 10 and 11 include an automotive dealership, a manufacturing plant, a lumber mill and a feed mill.

The County of Oxford is currently managing a study to inventory threats within Tillsonburg's 25-year capture zones.

Summary
The Town of Tillsonburg is groundwater dependant. Water taking is divided between wells to the northwest of the town with sources in the County of Oxford and wells to the southeast with sources in Norfolk County within the Norfolk Sand Plain. The wells are completed in unconfined overburden aquifers, the majority identified as groundwater under the direct influence of surface water (GUDI). Threats range from natural characteristics (arsenic) to urban and rural land use activities (industry, fuel storage tanks, septic systems, agriculture). The County has identified the need to expand its long-term water supply due to growth projections and potential loss of existing supplies to contamination in Tillsonburg but has not yet completed a long-term water supply strategy. The County of Oxford is considered a leader in well head protection and has conducted a number of provincial pilot studies. They have completed a variety of groundwater studies to map well head protection areas, identify regional threats to existing water supplies develop strategies for well head protection.

6.3.1.2 Norfolk County

The Norfolk Municipal Groundwater Study (Waterloo Hydrogeologic Inc. et al., 2003) completed a number of tasks including: WHPA delineation, vulnerability mapping and compilation of a threats inventory.

The Norfolk County Groundwater Study used MODFLOW to develop a regional groundwater model and with additional modelling at each of the well fields with the exception of Waterford. Capture zones were delineated using 50-day, two-, ten-, and 25-year and steady state saturated times of travel. Although not explicitly stated in the study, it is assumed that average flow rates were used in developing the capture zones. An uncertainty analysis was carried out by adjusting the hydraulic conductivity, recharge rates and porosity values for each aquifer / aquitard unit.

The intrinsic susceptibility analysis for *the Norfolk Municipal Groundwater Study* was completed to evaluate the groundwater vulnerability for the 'first significant aquifer'. To complete this, both the water table surface and the bedrock potentiometric surface maps were used in the analysis, resulting in two vulnerability maps. ISI values were calculated for both the depth to the water table and the bedrock potentiometric surface and classified according to high vulnerability (< 30), moderate vulnerability (30 – 80) and low vulnerability (> 80) at each well. Results were then kriged to create an interpolated vulnerability across the study area and two groundwater vulnerability maps were generated; one utilizing the water table surface and the second using the bedrock potentiometric surface as reference in determining the 'first significant aquifer'.

Additionally a potential contaminant sources inventory was compiled within municipal WHPAs using existing databases and agricultural data from the 2001 Census of Agriculture was obtained. Intensive livestock operations were mapped on the basis of building permits. In June of 2006 staff from the GRCA met with Norfolk County staff to discuss high level threats to the municipal groundwater supply as summarized in **Table 6.2**.

As a component of source protection planning, Norfolk County is currently undertaking a project to update WHPAs within the community of Simcoe and model WHPAs for newly established wells in Port Rowan using the existing regional groundwater flow model. Additionally, this project will also update the threats inventory within all County WHPAs.

Table 6.2: High Level Threats in Norfolk County

	Groundwater
Direct Introduction	
Water treatment plant wastewater discharge	None
Sewage treatment plant effluent	None
Sewage treatment plant by-passes	None
Industrial effluents	None
Landscape Activities	
Road salt application	Cedar Street wellfield in Simcoe is experiencing higher chloride levels County has action plan to reduce salt use (pre-wetting using molasses and beet juice)
De-icing activities	None
Snow storage	Snow dumps being investigated to determine possible impact on capture zones
Cemeteries	14th Street cemetery in Simcoe adjacent to well properties
Stormwater management systems	County using naturalized wet ponds in Simcoe and Port Dover
Landfills	Norfolk and Haldimand Counties share a landfill site west of Hagersville Simcoe MRF is in WHPA
Organic soil-conditioning	Soil/manure blending operation in Waterford
Septage application	Simcoe, Port Dover and Port Rowan receive septage
Hazardous waste disposal	None
Liquid industrial waste	None
Mine tailings	None
Biosolids application	Significant land application in the north and east clay plains Ginseng requires imported biosolids to rejuvenate removed nutrients
Manure application	Very few livestock operations mean manure is imported Tobacco and ginseng demand lots of manure
Fertilizer application	High agricultural use Some storage on farms
Pesticide / herbicide application	
Historical activities – contaminated lands	Some old factory sites in Simcoe, Delhi, Waterford and Port Dover Old coal gas site located in Simcoe
Storage of Potential Contaminants	
Fuels / hydrocarbons	Storage leaks shut down First Avenue well 10 year ago Fuel storage in Langton and Delhi
DNAPL's (dense non-aqueous phase liquids)	None
Organic solvents	Automotive parts manufacturers in Simcoe
Pesticides (of concern to drinking water)	None
Fertilizers	Industry NW of Delhi (mixes and blends fertilizers) Food processor on the edge of Delhi in WHPA
Manure	Large piles imported and sometimes windrows sit through winter

Town of Delhi and Village of Courtland

System Description and Hydrogeologic Setting

The Delhi water supply is a combination well and surface water, which services the communities of Delhi and Courtland. The municipal water supply consists of two raw water well sources, a surface water filtration plant, and a water standpipe. Water is treated with the following chemicals: sodium hypochlorite, sodium silicate, hydrofluorosilicic acid, and polyaluminum chloride.

Overburden in the area consists of glaciolacustrine silt and clay, glaciofluvial outwash sand and gravel, and glaciofluvial ice-contact deposits consisting of sand and gravel as well as some till and silt. The primary aquifer for the Delhi municipal wells is the sand and gravel deposits which are intercalated with clay material. The thickness of the aquifer varies from five to 35 metres and clay/till units form aquitards of varying thickness up to 30 metres. Both municipal wells are completed at 39.32 metres depth with screen depths from 30.02 to 39.00 metres.

Groundwater Quality

Groundwater quality within the Delhi municipal wells characterized as a part of *the Norfolk Municipal Groundwater Study* (Waterloo Hydrogeologic Inc. et al., 2003). This characterization was completed by a review geochemical and isotopic data collected from the shallow and deep groundwater systems compiled from Norfolk GUDI studies and literature reviews.

The Delhi wells are completed in the shallow, unconfined overburden aquifer. Geochemical and isotopic data shows the water to be bicarbonate normal alkaline-earth water (Ca-Mg-HCO3), similar to the surface water chemistry. These findings are indicative of a dynamic system that is recharged by modern day precipitation and recharge.

The Delhi Drinking Water Systems Annual report for 2005 summarized exceedances and corrective action as shown in **Table 6.3**.

Description of Capture Zones

50 day, two-, ten-, and 25-year time of travel capture zones for the Delhi municipal wells were modelled using MODFLOW as a part of the Norfolk municipal groundwater study (Waterloo Hydrogeologic Inc. et al., 2003). These capture zones are presented on **Map 6.13** Although not explicitly stated in the study, it is assumed that average flow rates were used in developing the capture zones. An uncertainty analysis was carried out by adjusting the hydraulic conductivity, recharge rates and porosity values for each aquifer / aquitard unit.

The capture zones illustrated on **Map 6.13** indicate the groundwater flow is from the east towards Big Creek to the west.

Table 6.3: Reported Exceedances for the Delhi Municipal Water Supply System

Incident Date	Parameter	Result	Unit of Measure	Corrective Action	Corrective Action Date
27/01/05	Total Coliforms Total Coliforms	2 1	cfu/100 mL	Flush, chlorine increased and resampled	02/02/05
30/03/05	Total Coliforms	1	cfu/100 mL	Flush, chlorine increased and resampled	04/04/05
28/04/05	Total Coliforms	1	cfu/100 mL	Flush, chlorine increased and resampled	02/05/05
07/06/05	Lead	0.012	mg/L	Resample	29/06/05
20/07/05	Total Coliforms	2	cfu/100 mL	Flush, chlorine increased and resampled	25/07/05
02/11/05	Total Coliforms	2	cfu/100 mL	Flush, chlorine increased and resampled	07/11/05

Vulnerable Areas within the 25-year Capture Zone

Intrinsic susceptibility mapping within the Delhi area, as shown on **Map 6.13**, has used the uppermost shallow aquifer as the 'first significant aquifer' (refer to Land Use Policy Branch, 2001). Throughout all of the Delhi capture zones, the shallow aquifer, which is also the municipal supply aquifer, has been mapped as highly susceptible.

Threats within the 25-year Capture Zone

Threats are fairly limited throughout the Delhi capture zones, as illustrated on **Map 6.13**. One automotive site (a farm with abandoned automobiles) within the ten-year capture zone and two fuel storage sites are within the 50-day capture zone for Well 1.

Summary

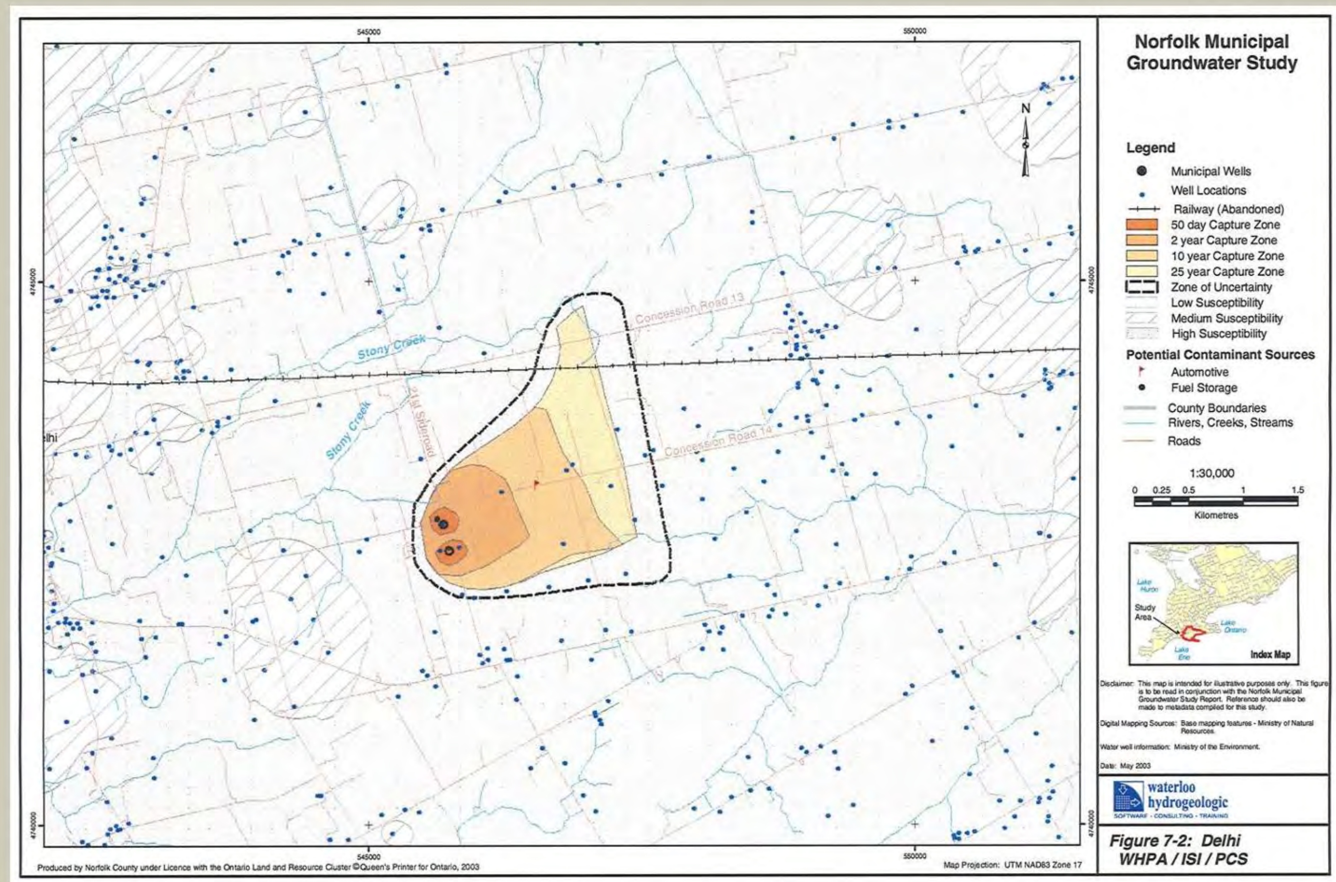
The Town of Delhi and Village of Courtland are supplied water from a combination of two groundwater wells and surface water from the Lehman Reservoir in Delhi. The two wells in Delhi are completed in the shallow aquifer which has been mapped as highly susceptible. The primary threat to groundwater relates to agricultural land uses surrounding the town, however there are fuel storage sites and an abandoned vehicle yard within the well capture zones. Norfolk County is currently reviewing long-term plans to expand its water supply to meet 25-50 year growth projections. The County will rely upon several groundwater studies, historical land use records and a dye trace study to quantify existing water quality issues and determine the vulnerability of the water supply.

Town of Simcoe

System Description and Hydrogeologic Setting

The Simcoe municipal water supply is a well-based system which consists of nine raw water well sources, an infiltration gallery, two reservoirs and an elevated water storage tower. Water treatment consists of the addition of the following chemicals: sodium hypochlorite, sodium silicate, and hydrofluorosilicic acid.

Map 6.13: Wellhead Capture Zones, Vulnerability and Potential Threats in Delhi, Norfolk County



Long Point Region Watershed Characterization Report

Wellhead Capture Zones, Vulnerability and Potential Threats

Study: Norfolk Municipal Groundwater Study
Area: Delhi, Norfolk County
Consultant(s): Waterloo Hydrogeologic Inc.
Date: 2003

The primary aquifer for the Simcoe municipal wells are the sand and gravel deposits surrounding the area, which are often intercalated with silty clay soils. The thickness of these aquifers varies from five to 25 metres. Till units in the area form aquitards of varying thicknesses (up to 50 metres), however, they are generally discontinuous.

Municipal Groundwater Quality

According to the 2005 Drinking Water Systems Regulations Annual Report for Simcoe, no water quality exceedances were reported for 2005.

Description of Capture Zones

Within the community of Simcoe, the WHPA model domain encompassed three municipal wellfields, as shown on **Map 6.14**. All the well fields are located within the community's limits. The Chapel Street wellfield consists of one well, the Cedar Street wellfield consists of five wells, and the Northwest Area wellfield consists of three wells.

50 day, two-, ten-, and 25-year time of travel capture zones for the Simcoe municipal wells were modelled using MODFLOW as a part of the Norfolk municipal groundwater study (Waterloo Hydrogeologic Inc. et al., 2003). Although not explicitly stated in the study, it is assumed that average flow rates were used in developing the capture zones. An uncertainty analysis was carried out by adjusting the hydraulic conductivity, recharge rates and porosity values for each aquifer / aquitard unit.

With Source Water Protection funding, WHPAs are currently being developed for new Simcoe municipal wells.

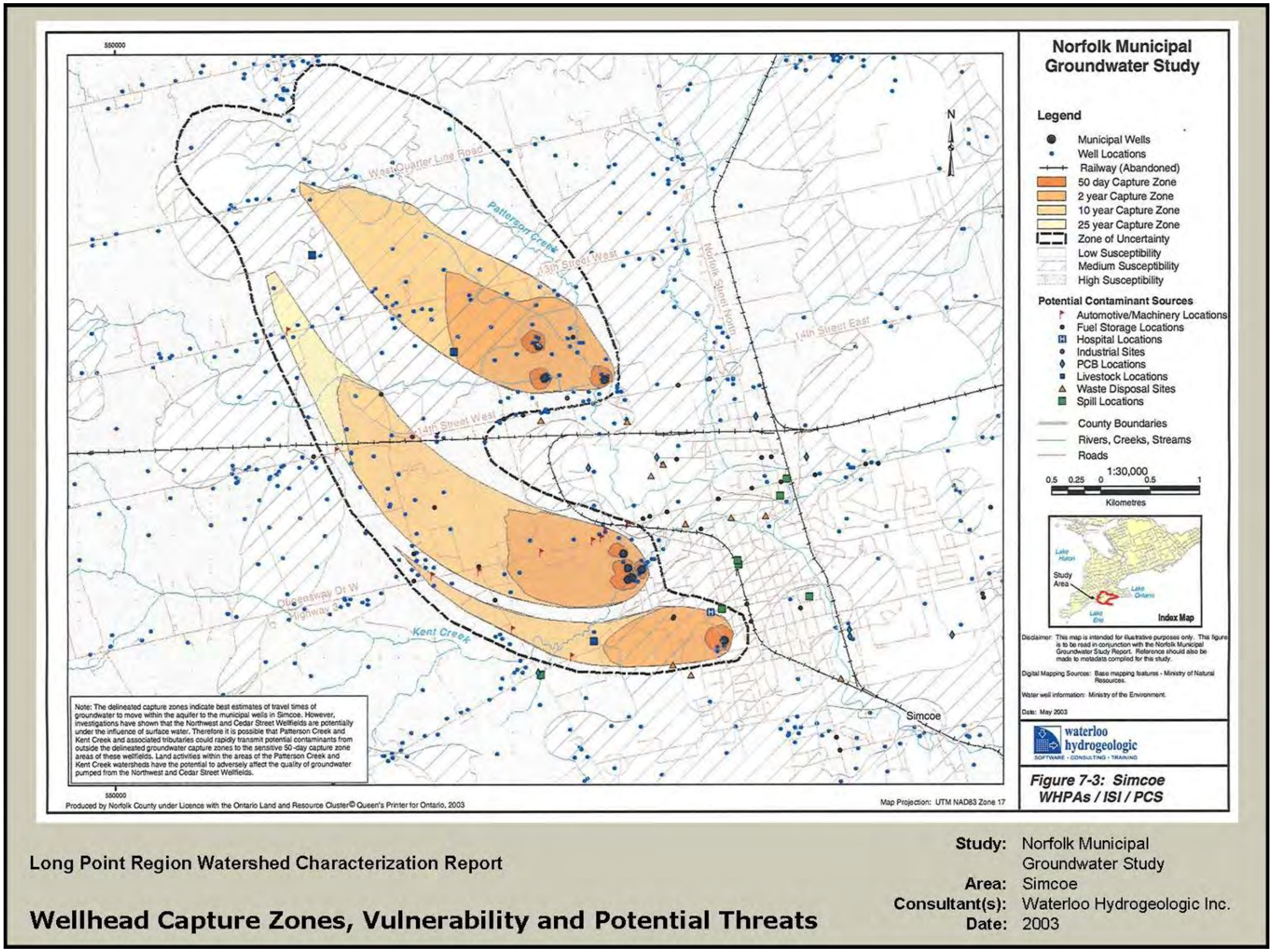
Vulnerable Areas within the 25-year Capture Zone

Within the Simcoe capture zones, the vulnerability of the first significant aquifer ranges from areas of low to high susceptibility, as shown on **Map 6.14**. In the Northwest wellfield capture zones, the overburden aquifer was mapped as medium to high susceptibility. Throughout most of the Cedar Street capture zones, the overburden aquifer has been mapped as highly susceptible. In the Chapel Street capture zones, the overburden aquifer has been mapped as low to medium susceptibility in the two-year capture zone and highly susceptible in the ten-year capture zone.

Additionally, previous investigations have shown the Northwest and Cedar Street wellfields to be potentially under the influence of surface water (Waterloo Hydrogeologic Inc. et al., 2003). It is therefore possible that Patterson Creek and Kent Creek and their associated tributaries could transmit potential contaminants from outside the delineated capture zones to the 50-day capture zones. Therefore land activities within the areas of the Patterson Creek and the Kent Creek watersheds have the potential to adversely affect the quality of water pumped from the Northwest and Cedar Street wellfields (Waterloo Hydrogeologic Inc. et al., 2003).

The WHPAs currently being developed for the new Simcoe supply wells will be assigned vulnerability scores using either SAAT or SWAT methods.

Map 6.14: Wellhead Capture Zones, Vulnerability and Potential Threats in Simcoe, Norfolk County



Threats within the 25-year Capture Zone

An inventory of potential groundwater threats was compiled as a component of *the Norfolk Municipal Groundwater Study* (Waterloo Hydrogeologic Inc. et al., 2003). The mapped threats are shown on **Map 6.14**.

Within the Northwest wellfield's two-year capture zone, there is a fuel storage location to the northeast of the wells and a livestock operation to the west of the wells. Within Cedar Street wellfield's two-year capture zone, there are four automotive or machinery locations and within the ten-year capture zone, there is one automotive/machinery location, three fuel storage locations and one industrial site. Within the Chapel Street two-year capture zone, there is one hospital, one gasoline station and one fuel storage site.

Upon completion of the WHPAs for the new Simcoe supply wells, a threats inventory and issues evaluation will be completed within the 25-year capture zone.

Summary

The Town of Simcoe is supplied groundwater from capture zones mapped predominantly as medium to high susceptibility. The major threats are related to municipal land uses (fuel storage, industrial and institutional uses) surrounding the municipal wells in NW Simcoe and the protection from GUDI sources. Norfolk County is currently reviewing long-term plans to expand its water supply to meet 25-50 year growth projections. The County will rely upon several groundwater studies and historical land use records to quantify existing water quality issues, determine the vulnerability of the water supply, and develop new supplies to replace sources at risk in Simcoe.

Town of Waterford

System Description and Hydrogeologic Setting

The Waterford supply is a well-based municipal system which consists of two raw water well sources (Well 3 and Well 4), a manganese and iron removal plant, a reservoir and a water standpipe. Water treatment consists of the addition of the following chemicals: sodium hypochlorite, sodium permanganate, and polyaluminum chloride.

The primary aquifer for the Waterford municipal wells consists of fine gravel and sand deposits (glaciolacustrine sands) surrounding the community. The thickness of the aquifer ranges from four to eight metres. Well 3 terminates at a depth of 10.66 metres with the screen top set at 7.62 metres depth and screen bottom at 10.66 metres depth while Well 4 is completed at a depth of 13.08 metres with the screen top set at 10.05 metres depth and the screen bottom set at 13.08 metres depth.

Municipal Groundwater Quality

According to the 2005 Drinking Water Systems Annual Report for Waterford, one sample exceeded the MAC for fluoride of one and a half milligrams per litre and was resampled as a corrective action.

Description of WHPAs

The WHPA model domain for the community of Waterford encompassed one municipal wellfield as shown on **Map 6.15**. The wellfield consists of two wells, both located within Waterford's limits. The regional groundwater FEFLOW model was used to complete the WHPA modelling for Waterford's municipal wells.

50 day, two-, ten-, and 25-year time of travel capture zones for the Waterford municipal wells were modelled as a part of *the Norfolk Municipal Groundwater Study* (Waterloo Hydrogeologic Inc. et al., 2003). Although not explicitly stated in the study, it is assumed that average flow rates were used in developing the capture zones. An uncertainty analysis was carried out by adjusting the hydraulic conductivity, recharge rates and porosity values for each aquifer/aquitard unit.

Vulnerable Areas within the 25-year Capture Zone

Within Waterford's capture zones, the vulnerability of the first significant aquifer ranges from areas of medium to high susceptibility as shown on **Map 6.15**. The overburden aquifer has been assigned a high susceptibility along the western half of the capture zones, and medium to low susceptibility on the eastern half.

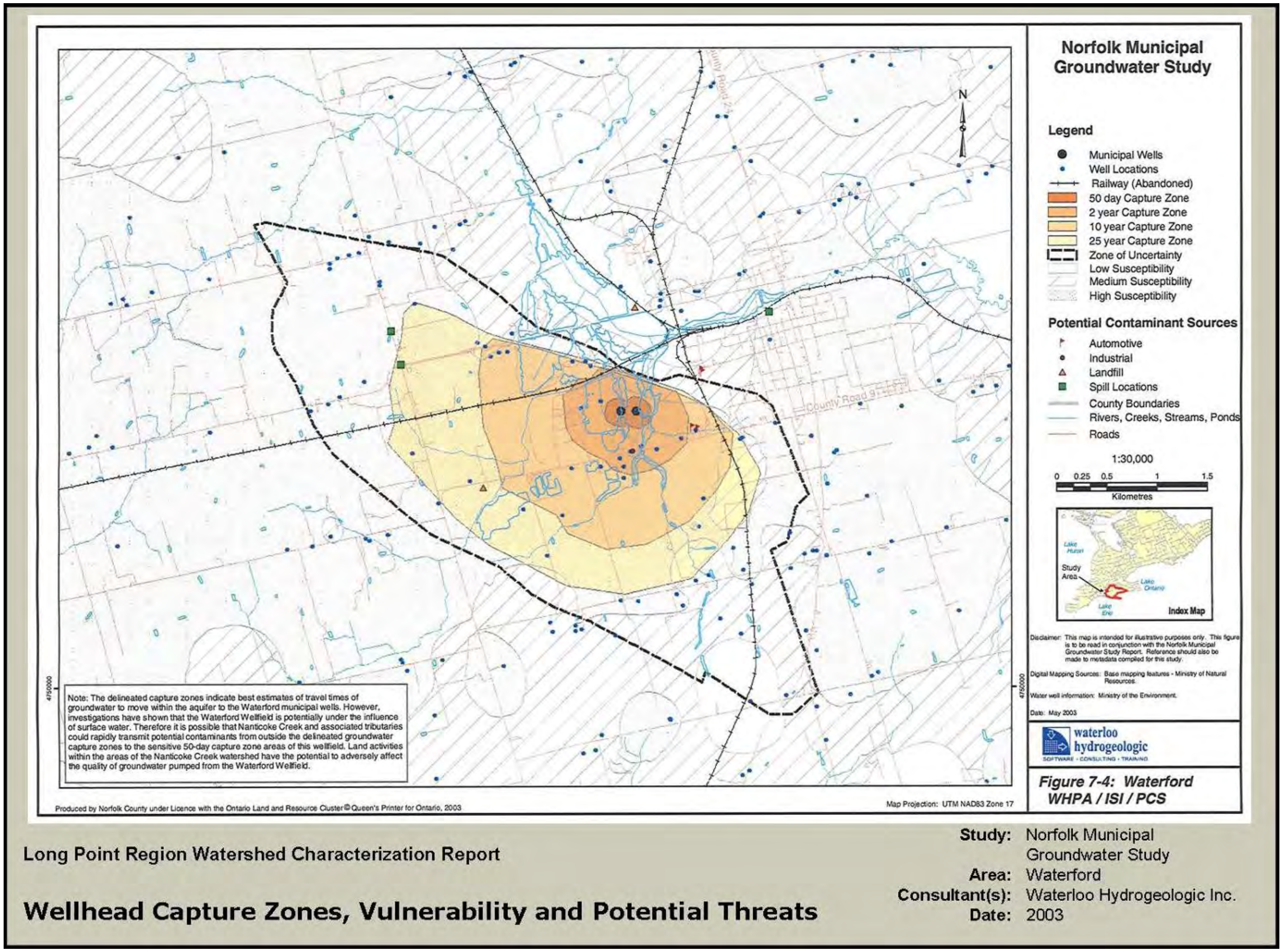
Threats within the 25-year Capture Zone

Threats mapped as a part of *the Norfolk Municipal Groundwater Study* (Waterloo Hydrogeologic Inc. et al., 2003) are shown on Map 42. From this figure, one industrial site is located within the two-year capture zone to the south of the wells, two automotive locations are located in the ten-year capture zone to the east of the wells, and one landfill and one spill location are located within the 25-year capture zone to the southwest and northwest respectfully of the wells.

Summary

The Town of Waterford is supplied groundwater from capture zones mapped predominantly as high susceptibility. The major threats are related to municipal land uses (fuel storage, industrial) and some agricultural applications surrounding the municipal wells in southwest Waterford. Norfolk County is currently reviewing long-term plans to expand its water supply to meet 25-50 year growth projections. The County will rely upon several groundwater studies and historical land use records to quantify existing water quality issues and determine the vulnerability of the water supply in Waterford.

Map 6.15: Wellhead Capture Zones, Vulnerability and Potential Threats in Waterford, Norfolk County



6.3.2 Municipal Surface Water Systems Descriptions

6.3.2.1 Municipality of Bayham

Elgin Area Primary Water Supply System (Port Burwell and Area)

System Description and Hydrogeologic Setting

The Elgin Area Primary Water Supply System (EAPWSS) is owned by the EAPWSS Joint Board of Management but operated and maintained by American Water Canada Corp. under contract. This main treatment facility is located in the Municipality of Central Elgin along the north shore of Lake Erie, two kilometres east of the village of Port Stanley. Treated water from the EAPWSS is distributed to seven member municipalities (Aylmer, Bayham, Central Elgin, London, Malahide, Southwold and St. Thomas) through a trunk transmission main owned by the EAPWSS and distribution systems owned and operated by the receiving municipalities. This water treatment plant has a current rated capacity of 91,000 cubic metres per day and serves an estimated population of approximately 100,000 people.

The EAPWSS intake pipe extends approximately 1,290 metres off the northern shore of Lake Erie to an intake crib approximately ten metres below the water surface. The raw water taken from Lake Erie is treated through a conventional treatment process consisting of coagulation, flocculation, sedimentation, filtration, fluoridation and disinfection. Powder activated carbon is used for taste and odour control during summer months. Ultraviolet disinfection has been installed at this facility as a backup primary disinfection system during high volume demand periods. Sodium hypochlorite is applied at the intake crib during the summer months for zebra mussel control.

Distribution System

Within the Long Point Region treated water from the EAPWSS is pumped to Port Burwell and the town of Vienna via the EAPWSS Distribution System.

Treated Water Quality

Monitoring of both raw and treated water is done in compliance with the Safe Drinking Water Act (SDWA) and the Drinking Water Systems Regulation O.Reg. 170. The Safe Drinking Water Act requires that flow, residual chloride, turbidity and fluoride be continuously monitored at different stages throughout the treatment process (raw-treated). The EAPWSS also continuously monitors for pH, conductivity, and temperature within the raw water supply for operational requirements to maintain the treatment process efficiency.

Other chemical and bacterial parameters are monitored at frequencies in compliance with the SDWA. The Drinking Water Surveillance Program reported no adverse water quality results for the treated water from the Elgin Area Primary Water Supply System (2000-2002, www.ene.gov.on.ca/envision/water/dwsp/0002/). However, the 2004 annual compliance report indicated there were three occurrences of HPC (heterotrophic plate count) levels above the drinking water standard upon which corrective action was taken. Annual Reports describing the treatment plant's operations and water quality monitoring results can be found on the Elgin Area and Lake Huron Water Supply System website (http://www.watersupply.london.ca).

Issues and Concerns

To date no formal threats inventory or delineation of vulnerable areas has been performed for the EAPWSS. This data gap is intended to be filled upon completion of the intake protection zone study and vulnerability assessments that are currently underway.

However, there are known issues and concerns with respect to the EAPWSS raw water supply that can be discussed here. The sediment plume originating from the Kettle Creek outfall has been reported to be contaminated with PAHs (Polynuclear Aromatic Hydrocarbons) (Riggs Engineering Ltd., 2004). Riggs Engineering Ltd (2004) found evidence that the PAH contamination within Kettle Creek could be directly impacting the quality of the raw water taken up by the Elgin Area Primary Water Supply System. Chemical analysis of the sediment accumulation within the intake pipe revealed high levels of phosphorus and nitrogen as well as trace levels of PAH contamination. These findings are of potential concern for two reasons: elevated sediment accumulation within the intake pipe could impede the effectiveness of the treatment facility and there is the potential for these contaminated suspended sediments to be taken up by the intake pipe.

Summary
The EAPWSS provides treated potable drinking water to seven municipalities along the north shore of Lake Erie. The system provides consistently high quality treated lake water to its customers. The long-term water supply needs of the seven municipalities are not clear at this time, but the intake crib is designed for twice the current capacity of the treatment plant and expansion of the plant is expected by 2015. To date no formal threats inventory or delineation of vulnerable areas has been performed for the EAPWSS. This data gap is intended to be filled upon completion of the intake protection zone and vulnerability assessment studies that are currently underway. Known issues and concerns with respect to the EAPWSS raw water supply that require additional study include possible impacts from the Kettle Creek sediment plume entering Lake Erie just west of the intake crib.

6.3.2.2 Norfolk County

Port Dover Water Supply System (Port Dover)

System Description and Hydrogeologic Setting
The Port Dover Water Supply System is owned and operated by the Corporation of Norfolk County and located in the town of Port Dover Ontario. The Port Dover Water Supply System consists of two conventional water treatment plants which treat water from Lake Erie, has a design capacity of 9,676 cubic metres per day and serves a population of approximately 5,800.

The treatment process at both plants consists of coagulation, flocculation, sedimentation, filtration and disinfection. The main difference between the two facilities is that the newer plant uses dual media filters consisting of silica sand and activated carbon. Also, there is a post-chlorination step at the newer plant as well. Chlorine is added at the mouth of the intake structure for Zebra Mussel control when the raw water temperature rises above 12 degrees Celsius.

Distribution System
With the use of three high-lift pumps, the treated water is supplied to the distribution systems servicing the Village. Within the system there is further storage capacity at the 5,400 cubic metre elevated water tower.

Treated Water Quality
During the 2004 reporting period there were no adverse water quality conditions reported. Additional monitoring information acquired through the Drinking Water Surveillance Program (summary from 2000-2002, www.ene.gov.on.ca/envision/water/dwsp/0002/) also reported no adverse water quality results for the treated water. Annual Reports describing the treatment plant's operations and water quality monitoring results can be found on the Norfolk County

website (http://www.norfolkcounty.on.ca).

The raw water supply for the Port Dover Water Supply System has not formally been characterized. This gap will be eliminated upon completion of the IPZ analyses currently underway.

Issues and Concerns
To date no formal threats inventory or delineation of vulnerable areas has been performed for the Port Dover surface water intake. This data gap is intended to be filled upon completion of the intake protection zone studies that are currently underway.

The major threats for the Port Dover Water Treatment plant are also related to the quality of the raw water supplying the treatment plant. The primary treatment issues appear to be taste and odour problems caused by algae blooms and increased temperatures. There is also the potential for the intake to be susceptible to contamination from nearby marinas or the numerous cottage lot septic systems along the shore.

Summary
The Village of Port Dover receives its water supply from Lake Erie surface water. The major threats are related to taste, odour, algae and temperature concerns at the intake. At this time, Norfolk County has no firm plans to expand its long-term water supply to meet 25-50 year growth projections. The County will rely upon intake protection zone studies to quantify existing water quality issues and determine the vulnerability of the existing supply.

Port Rowan Treatment Plant (Port Rowan and St. Williams)

System Description and Hydrogeologic Setting
The Port Rowan Water Treatment Plant, owned and operated by the Corporation of Norfolk County, is a package plant which uses conventional treatment and treats water taken from the Long Point inner bay on Lake Erie. This is a relatively new plant commissioned in the summer of 1992 which has a design capacity of 3,000 cubic metres per day that serves a population of approximately 1,280 from the towns of Port Rowan and St. Williams.

The treatment process consists of coagulation, flocculation, sedimentation, filtration, and disinfection. Granular activated carbon (GAC) contactors are used in addition to the dual media filters during the summer months.

Distribution System
Upon treatment drinking water is distributed to the town of Port Rowan and to the St. Williams Booster Station. Water from this booster station is then distributed to the town of St. Williams. The combined system includes a 1,800 cubic metre standpipe, which acts as a reservoir when the system requires larger amounts of water than the sources can supply (such as fire fighting or high demand).

Treated Water Quality
During the 2004 reporting period there was one sample with total coliform counts above the drinking water quality standards. Flushing and increased disinfection were undertaken upon which re-sampling found no adverse coliform counts. Annual Reports describing the treatment plant's operations and water quality monitoring results can be found on the Norfolk County website (http://www.norfolkcounty.on.ca). Additional monitoring information acquired through the Drinking Water Surveillance Program (summary from 2000-2002, www.ene.gov.on.ca/envision/water/dwsp/0002/) reported that treated water from the Port

Rowan Water Treatment Plant did not have any occurrences of samples with adverse water quality.

The raw water supply for the Port Rowan Water Supply System has not formally been characterized. This gap will likely be filled with the completion of the IPZ analyses currently proposed.

Issues and Concerns

To date no formal threats inventory or delineation of vulnerable areas has been performed for the Port Rowan surface water intake. This data gap will be eliminated upon completion of the intake protection zone studies.

The major threats for the Port Rowan Water Treatment plant are related to the quality of the raw water supplying the treatment plant. The intake pipe is extremely shallow and as such is more susceptible to taste and odour problems caused by algae blooms and increased temperatures. The shallow nature of the intake and its close proximity to the Lake Erie shore also make it potentially susceptible to contamination from the nearby marina or the numerous cottage lot septic systems along the shore.

Summary

The villages of Port Rowan and St. Williams receive their water supply from a relatively shallow Lake Erie surface water intake. The major threats are related to taste, odour, algae and temperature concerns at the Long Point Inner Bay intake. At this time, Norfolk County has no firm plans to expand its long-term water supply to meet 25-50 year growth projections. The County will rely upon intake protection zone studies to quantify existing water quality issues, determine the vulnerability of supplies, and develop new supplies to replace the source at risk in Port Rowan.

Delhi Water Treatment Plant (Delhi and Courtland)

System Description and Hydrogeologic Setting

The Delhi Water Supply is owned and operated by the Corporation of Norfolk County and is situated within the Town of Delhi. This plant is a combination well and surface water municipal water supply consisting of two raw water well sources, a surface water filtration plant and a water standpipe. The Delhi Surface Water Treatment Plant treats raw water from the Lehman Dam Reservoir (a surface water impoundment on North Creek, a tributary to Big Creek). The filtration plant has a rated capacity of 4,543 cubic metres per day which, in combination with the groundwater sources, services approximately 6,000 people including the community of Courtland. The treatment process consists of coagulation, filtration, fluoridation and disinfection. Disinfection is achieved through ultraviolet (UV) irradiation followed by chlorination.

Distribution System

The Delhi distribution system provides treated surface and groundwater to the residents of Delhi and was recently connected to the treated municipal groundwater supply system in Courtland servicing an additional 1,000 residents. The combined system includes a 3,950 cubic metre standpipe, which acts as a reservoir when the system requires larger amounts of water than the sources can supply (such as fire fighting).

Treated Water Quality

Monitoring of both raw and treated water is done in compliance with the Safe Drinking Water Act (SDWA) and the Drinking Water Systems Regulation O.Reg. 170. The Safe Drinking Water Act requires that flow, residual chloride and turbidity be continuously monitored at different stages throughout the treatment process. Other chemical parameters such as nitrate, nitrite, volatile organics, pesticides, THMs are monitored quarterly; Inorganics are monitored annually; however, bacterial samples are monitored weekly in both the raw and treated water.

The 2000-2002 Drinking Water Surveillance Program found no adverse water quality results for the Delhi Water Treatment Plant (www.ene.gov.on.ca/envision/water/dwsp/0002/). However, the 2004 annual compliance report indicated there were two occurrences of inadequate disinfection and one occurrence where background bacterial counts were above the standard. Subsequent corrective action and re-sampling was performed. Annual Reports describing the treatment plant's operations and water quality monitoring results can be found on the Norfolk County website (http://www.norfolkcounty.on.ca).

The raw surface water supply for the Delhi Water Treatment Plant has not formally been characterized. This gap will likely be filled by the IPZ analysis currently underway.

Issues and Concerns

The primary threats to the surface water component of the Delhi Water Supply System relates to agricultural land uses surrounding the Lehman Reservoir. However, to date no formal threats inventory or delineation of vulnerable areas has been performed for the Delhi surface water intake. This data gap is intended to be filled upon completion of the intake protection zone studies that are currently underway. Dye tracer studies upstream of the Lehman Reservoir are being completed to determine the range of upstream contamination threats to the Delhi surface water supply.

Summary

The Town of Delhi obtains part of its municipal water supply from surface water taken from the Lehman Reservoir in Delhi. The primary threat to this source relates to agricultural land uses surrounding the town in addition to the Highway 3 transportation corridor that transects the reservoir and concerns about the level of protection afforded to the surface water intake at the Lehman Reservoir. At this time, Norfolk County has no firm plans to expand its long-term water supply to meet 25-50 year growth projections. The County will rely upon several groundwater studies, historical land use records and a dye trace study to quantify existing water quality issues and determine the of vulnerability of the water supply.

6.3.2.3 Haldimand County

Nanticoke Water Treatment Plant (Nanticoke, Hagersville, Jarvis and Townsend)

System Description and Hydrogeologic Setting

The Nanticoke Water Treatment Plant (WTP), built in the 1970's, is owned by the Corporation of Haldimand County but operated and maintained by the Ontario Clean Water Agency (OCWA). This facility is located southwest of the Hamlet of Nanticoke and distributes treated water to the communities of Hagersville, Jarvis and Townsend, the Ontario Power Generation (OPG) Nanticoke Plant and the Lake Erie Industrial Park and raw chlorinated water to the Steel Company of Canada (Stelco) Lake Erie Works and the Imperial Oil Refinery through distribution systems owned and operated by the County. This water treatment plant has a rated capacity of 440,100 cubic metres per day for chlorinated industrial water usage and current potable water capacity of 13,625 cubic metres per day with a potential for 1,360,000 cubic metres per day and a Permit to Take Water rated at 1,820,000 cubic metres per day.

The Nanticoke WTP is a conventional treatment plant (package plant) that receives raw water from Lake Erie. The treatment process consists of pre-screening and chlorination, coagulation, flocculation, sedimentation, filtration, and disinfection. Powder activated carbon is added for taste and odour control when necessary.

Distribution System
With the use of four high lift pumps, the treated water is supplied to the distribution system servicing Hagersville, Jarvis, Townsend, OPG, and the Lake Erie Industrial Park. Separate raw water lines supply Stelco and Imperial Oil. Within the system there is further storage capacity at the Hagersville standpipe (4,600 cubic metres) and the Townsend elevated tank (2,300 cubic metres).

Treated Water Quality
No occurrences of adverse water quality conditions were reported in the 2004 Annual Report or the 2000-2002 Drinking Water Surveillance Program Report (www.ene.gov.on.ca/envision/water/dwsp/0002/). However, during the 2004 reporting period there was one occurrence of elevated *E.Coli* levels in the Jarvis Distribution System, which on resampling was found to be satisfactory. This was one sample out of 156 samples and had a count of 1/100 millilitres. Counts this low normally represent either a sampling error or lab error. There were also two occurrences of background bacterial counts above the standard in the Townsend Distribution System. Background counts, as with HPC counts, are not necessarily health related. Their purpose is to make the Operator aware of possible deteriorating conditions within the system. These were two samples out of a total of 262 samples. Annual Reports describing the treatment plant's operations and water quality monitoring results can be found on the Haldimand County website (http://www.haldimandcounty.on.ca).

The raw water supply for the Nanticoke WTP was likely characterized as part of the environmental assessment completed as part of the plant upgrade. However this information is not presently available. The Nanticoke WTP EA for the potable system is available for viewing on the County's web site.

Issues and Concerns
To date no formal threats inventory or delineation of vulnerable areas has been performed for the Nanticoke intake. This data gap is intended to be filled upon completion of the intake protection zone studies that are currently underway.

The majority of threats are related to the background quality of lake water, which is generally good. However, there are concerns about possible localized impacts from turbidity, algae growth, septic systems and potential contamination from the nearby Nanticoke Industrial Park wastewater effluent. With the exception of intermittent taste and odour issues with late summer algae blooms, localized impacts from turbidity and septic systems are not a concern due to the length and depth of the intake. In a recent assimilation study of the stream that receives the Lake Erie Industrial Park lagoon effluent it was concluded that the effluent was of superior quality to water upstream and the effluent from the lagoons improved the water quality in the stream.

Summary
Haldimand County's urban centres are predominantly surface water dependant. The majority of threats are related to the background quality of Lake Erie water; however there are concerns about possible localized impacts from turbidity, algae growth and numerous septic systems along the Lake Erie shoreline. There have been a few incidents of algae taste in water due to the late summer algae blooms, but this is only sporadic and does not occur every summer. The County has sufficient capacity in its pipeline systems for future growth. Plans to conduct intake

protection zone studies to quantify risks to the Lake Erie source are also underway.

6.3.3 Long-Term Municipal Water Supply Capacity Strategies

There are four municipalities who operate water systems in the Long Point Region; Oxford County, Norfolk County, Haldimand County, and the Municipality of Bayham. Oxford County has five groundwater systems within including one system bordering the Long Point Region. Based on available population projections and current water use Tillsonburg within the Region, and Mount Elgin, on the border of the Region, may have difficulty meeting projected water demand in 25 years. The County-wide Long Term Water Supply Strategy will be initiated in 2007.

Norfolk County owns and operates two groundwater systems, two Lake Erie supplied systems and one groundwater-surface water combined water system in the Long Point Region. Based on available population projections and current water use trends the combined groundwater-surface water system serving the communities of Courtland and Delhi may have difficulty meeting demand in 25 years. A study is currently underway to examine the water supply and wastewater systems for the next 25 years for all of the serviced communities in Norfolk County.

Haldimand County owns and operates the Nanticoke Water Treatment Plant, which services the communities of Hagersville, Jarvis, and Townsend and additional industries adjacent to the treatment plant. The plant has capacity to supply the presently serviced communities for the next 25 years based on available population projections and current water use trends. Haldimand County recently completed an Environmental Assessment on the expansion of the plant to service additional communities.

Serviced communities within the Municipality of Bayham receive water from the EAPWSS through the Municipality of Bayham. The EAPWSS has a Water Supply Master Plan with plans to 2026. It is projected that the treatment plant will require an expansion to increase capacity by 2015. Distribution systems connected to the EAPWSS may eventually need to increase their distribution works to take advantage of the increase in supply capability. Projected population numbers were not available for the serviced population in the Township of Bayham.

7.0 SUMMARY OF IDENTIFIED POTENTIAL ISSUES

7.1 Known Drinking Water Issues

7.1.1 Groundwater Issues

County of Oxford

- Naturally occurring arsenic in Tillsonburg, Springford and Dereham Centre
- Nitrates in Tillsonburg
- High bacteria count in Norwich (wells closed)

The County of Oxford has established awareness programs to inform water users of best practices for water protection and provide connections to program assistance from other government departments and agencies. Federal guidelines dictate that the limit for arsenic is dropping from 0.025 milligrams per litre to 0.010 milligrams per litre. Ion exchange treatment is proposed for Tillsonburg Well 7, Springford and Dereham Centre. A Class EA has been completed for a proposed water treatment plant in Tillsonburg to address the nitrates in Wells 4 and 5. The plant is expected to be on line in late 2007. The bacteria problem in Norwich was addressed in 2005 when Well 3 was closed.

Norfolk County

- Benzene in Simcoe (well decommissioned)
- TCE in Delhi (well decommissioned)
- Chlorides in Simcoe

The 1st Avenue Well in Simcoe was decommissioned in the mid 90's to address hydrocarbon contamination. A former well in Delhi was decommissioned due to TCE contamination. Concerns with the infiltration gallery at the deer park in Waterford resulted in the abandonment of the gallery. Municipal operations in the NW quadrant of Simcoe appear to impacting upon the wellhead protection areas of the NW well. Chlorides are appearing in raw water samples which may be connected to municipal salt dome operations. Norfolk County has an action plan to reduce salt use in Simcoe.

7.1.2 Surface Water Issues

Elgin Area Primary Water Supply System

- PAH contaminated sediment from Kettle Creek

Riggs Engineering Ltd. (2004) found evidence that the PAH contamination within Kettle Creek could be directly impacting the quality of the raw water taken up by the Elgin Area Primary Water Supply System. Chemical analysis of the sediment accumulation within the intake pipe revealed high levels of phosphorus and nitrogen as well as trace levels of PAH contamination. These findings are of potential concern for two reasons: elevated sediment accumulation within the intake pipe could impede the effectiveness of the treatment facility and there is the potential for these contaminated suspended sediments to be taken up by the intake pipe.

Norfolk County

- TCE in a spring in Delhi (source decommissioned)
- Taste, odour and algae in Lake Erie source water at Port Rowan

Norfolk County decommissioned a spring water supply in Delhi due to TCE contamination. The surface water intake for Port Rowan sits in relatively shallow waters in Lower Long Point Bay which get quite warm in the summer resulting in aesthetic issues with this supply. The County is considering a switch to a groundwater source in Port Rowan to replace the Lake Erie supply.

Haldimand County

- Turbidity in Lake Erie source water at Nanticoke intake

Turbidity counts increase during seasonal Lake Erie turnover and after storm events creating an aesthetic water quality issue. Water treatment plant uses alum to control turbidity.

7.2 Sources for Identifying Potential Issues

7.2.1 Groundwater Concerns

County of Oxford

- Nitrates in Tillsonburg

Nitrates in Tillsonburg groundwater are probably agricultural, but there is a need to qualify the source (pers. comm. Marg Misek-Evans and Deb Goudreau, July 25, 2006).

7.2.2 Surface Water Concerns

Norfolk County

- Surface water vulnerability in Delhi

Norfolk County is currently undertaking intake protection zone studies to accurately determine the vulnerability of the reservoir.

Haldimand County

- Aesthetic water quality from Nanticoke water treatment plant

Haldimand County received phone calls in 2003 complaining about taste and odour concerns with treated lake water. The County also has concerns with the density of cottage lots on questionable septic systems along the Lake Erie shoreline (pers. comm. Brian Pett, July 27, 2006).

7.3 Data and Knowledge Gaps

7.3.1 Groundwater Gaps

County of Oxford

Possible threats to groundwater supplies may relate to historical wells. These wells may act as preferential pathways for contamination to enter the aquifer. Preferential pathways and the land uses surrounding them should be investigated further to determine the potential risk to groundwater quality. The County is currently updating the threats inventory, identifying hazards at a property scale and establishing time of travel to sources of supply. The County has also identified the need to get better coordination of data collection with provincial ministries.

Norfolk County

Property specific information relative to current site use, historic use and past practices is needed for all properties adjacent to municipal groundwater supplies.

7.3.2 Surface Water

Elgin Area Primary Water Supply System

To date no formal threats inventory or delineation of vulnerable areas has been performed for the Elgin Area Primary Water Supply System. This data gap is intended to be filled upon completion of the intake protection zone studies that are currently underway.

Norfolk County

Intake protection zone dye testing upstream of the Lehman Reservoir is being completed. IPZ testing is also needed for the other Lake Erie intakes.

Haldimand County

Haldimand County is studying cottage lot use to generally identify the potential for septic systems to impact raw surface water quality. There is also the need for biological assessments of the Lake Erie shoreline to measure algae. IPZ studies will be conducted to identify Lake Erie currents and consider TSS impacts to source waters.

8.0 CURRENT SOURCE WATER PROTECTION ACTIVITIES

8.1 Spills Early Warning

Generally, the Ministry of the Environment is the lead regulatory agency for spills occurring in the Province. Exceptions to this include ship-source and international boundary water spills, for which the Canadian Coast Guard assumes the lead, and spills at federally regulated facilities, for which Environment Canada assumes the lead. Police, fire or health officials normally provide the lead for incidents involving threats to human health, safety, life and property. The Ministry is responsible for providing support during these types of emergencies which is provided through the Spills Action Centre (SAC) (Ontario Ministry of the Environment, 1994b). The SAC was established to a) maintain a province-wide, toll-free service for receiving, evaluating and initiating responses to notifications of spills and other urgent environmental matters on a 24-hour basis; (b) serve as a provincial focal point for activities dealing with spills and related emergencies; (c) liaise with other agencies on spills and related emergencies; (d) maintain a provincial spill database for the Ministry; and,(e) provide contingency planning functions and related spill response training (Ontario Ministry of the Environment, 1994c).

Long Point Region Conservation Authority does not have any internal protocols developed.

8.2 Point Source Load Reductions

Currently within the Long Point Region several municipalities have point source load reduction programs in place.

Norfolk County, which includes Waterford, Port Dover, Simcoe, Delhi and Port Rowan, initiated a water and wastewater master plan in July 2006. The town of Simcoe has recently begun upgrading their wastewater treatment plant to reduce the impact its effluent on the Lynn River.

Within Haldimand County, the Hagersville Water Pollution Control Plant has been through an environmental assessment in light of the projected growth within the area. This investigation has evaluated design options for upgrading the plant to reduce potential loads to the Sandusk Creek Watershed.

The Lake Erie Industrial Park has also undergone an environmental assessment to identify and evaluate alternative solutions with respect to providing wastewater treatment services to the Lake Erie Industrial Area, the Stelco Lake Erie Industrial Park and potentially to surrounding urban areas.

The County of Haldimand is presently assessing its wastewater treatment plant capacity in the community of Caledonia.

Oxford County does not have any comprehensive point source load reduction management plan currently in place.

Bayham Township does not have any comprehensive point source reduction management plans in place but are currently updating their official plan which may include a section on point source reduction.

8.3 Rural Non-Point Source Load Reductions

Non-point source load management is an important tool in protecting water quality. Rural non-point best management practices include many initiatives which can involve buffering, conservation tillage, crop rotation, and grazing systems.

Buffering provides protection against sediment and runoff from entering a water system as the vegetation traps sediment and slows and stores runoff from agricultural land. Vegetation can also be used for wind breaks thus decreasing erosion of the soil and sediment travelling into a water system. Buffering also provides shore/bank stability, creates habitat for fish and wildlife, and aides flood protection (Ontario Cattlemen's Association). Conservation Tillage is described as "any tillage or planting system that maintains at least 30 percent of the soil surface covered by residue after planting" (McGauley, p14, 2004). The term includes no-till, mulch tillage, minimum till or reduced till. No-till involves leaving the field practically undisturbed where the field is not plowed and narrow seed banks are often created to get the most production out of the seed. Conservation tillage is an important best management tool as the residue left on the surface collects water which then infiltrates into the soil. This in turn increases the soil moisture and also reduces wind and water erosion which lessons the amount of sediment going into water ways (Agriculture and Agri-Food Canada, 1997). Crop rotation aides the soil in nutrient replenishment creating a healthy soil that lessens its erodibility factor which in turn decreases the amount of sediment moving into the water. Implementing a grazing system can involve moving and creating small areas for livestock around agricultural land which decreases the damage inflicted by grazing. Grazing management systems also entails controlling access points to water from livestock and using alternate water sources. Having no control over the livestock around water ways leads to the destruction of riparian areas, erosion of the banks and manure polluting the water. Alternate water sources include seepage troughs, water supplied inside a barn, windmill, solar powered pumps and ram pumps (Ontario Cattlemen's Association).

8.3.1 Available Funding and Projects for Non-Point Source Management

Programs available to aid in the financing and education of best management practises in regards to water quality include various incentives. Long Point Region Conservation Authority offers the Erosion Control Assistance Program which provides land owners technical advice and limited financial assistance in regards to erosion control. The program provides funding for up to 50 percent of the project costs to a maximum of $1,000. In addition the authority offers the Private Land Tree Planting Program where staff provides assistance in the design plans, plant species and the acquiring of trees or shrubs for the landowner. The program is important to water quality as planting will aide in the control of wind erosion, increase quality of runoff and decrease surface runoff. In addition schools in the watershed help in tree and prairie species planting which include Valley Heights, Delhi High School and the Annandale and Glendale schools in Tillsonburg which take part in the trees-for-tomorrow program which is offered through the Ministry of Natural Resources.

The Brant Rural Water Quality Program was formed for landowners in Brant County and is funded through the County of Brant and the City of Brantford. The initiative provides financial assistance for selected projects geared at improving and protecting water quality. Examples of projects include manure storage, fertilizer/chemical storage and handling, nutrient management, tree planting and clean water diversion.

Governmental incentives can be obtained through the Canada-Ontario Environmental Farm Plan where the three programs include: Canada-Ontario Farm Stewardship Program (COFSP), Greencover Canada (GC), and the Canada-Ontario Water Supply Expansion Program (COWSEP).

COFSP is "a voluntary cost-share program to encourage producers to improve management of agricultural land through the adoption of beneficial management practices (BMP) to reduce risk to water and air quality, improve soil productivity and enhance wildlife habitat. Cost-share for specific COFSP categories is set at either 30 percent or 50 percent, up to the category caps. The maximum federal contribution per legal farm entity with a unique Farm Business Registration Number (FBRN) is up to $30,000" (Ontario Soil and Crop Improvement Assoc., 2006). Examples of projects include manure land application, barn improvements, product and waste management, and water well management.

Greencover Canada (GC) is a program that aides "producers improve land management practises, promote sustainable land use, protect water quality, reduce greenhouse gas emissions, enhance biodiversity and wildlife habitat, and expand the land base covered with perennial forage and trees" (Ontario Soil and Crop Improvement Assoc., 2006). Projects include Riparian area management, erosion control structures and shelterbelt establishment.

COWSEP is a "voluntary cost-share program to improve the capacity of agricultural producers to deal with low water situations through expanded water supplies" (Ontario Soil and Crop Improvement Assoc., 2006). Examples include new water wells for agricultural purposes, ponds for storing water for agricultural purposes and water supply expansion planning.

8.4 Urban Non-Point Source Load Reductions

Urban non-point source management is important for water quality protection as the process reduces the chance of pollutants moving into a water system. Practices that towns and cities within the watershed follow include street sweeping which can prevent possible contaminants on the road from going into water ways through particulates and oils. In addition the clean up of catch basins is regularly carried out which can inhibit particles from getting into water ways and from plugging the basin which can prohibit runoff from entering the catch basin. Sediment fences are also used, mainly at construction areas and are key best management practises as the fences catch sediment, which can contain contaminants, preventing it from being blown from the site or running off into storm water. However, new best management practices are focusing on wet ponds, wetlands, extended detention ponds, infiltration techniques, vegetation filters and planning techniques in order to aide storm water management and improve the water quality which may travel into drinking water systems (Marshall Macklin Monaghan Limited, 1991). Many storm water management systems within the watershed use more natural storm water management strategies which focus on the creation of wet ponds where many have evolved into wetland habitat. Examples include the Evergreen Hill site in Simcoe and the wet pond in Port Dover (Sommerset).

Another way of controlling urban non-point sources is by limiting or eliminating pesticide and herbicide usage. The chemicals can be washed into storm water which may lead to rivers and lakes and may create possible environmental problems for aquatic life and vegetation. However, currently there are no by-laws in place concerning limiting or prohibiting pesticide use within the watershed.

8.5 Groundwater Protection Programs

The municipalities throughout the Long Point Region consist of predominantly rural/agricultural land uses. As a result, groundwater protection programs have focused mainly on rural strategies. Section 8.4 outlines a number of government funding programs that have been developed at the federal and provincial levels that encourage best management practices around nutrient management, product storage and handling, septic maintenance and well decommissioning. The GRCA and UTRCA administer rural water quality programs leveraging federal, provincial and municipal funding to deliver best management programs that cross over into the Long Point Region in Oxford, Brant and Haldimand counties.

At the municipal level, Norfolk, Oxford, and Brant counties have incorporated the results of their municipal groundwater studies to establish well head protection areas for integration with their Official Plans. This allows for protection of water supplies from the start of the land use development process and sets the stage for future administration of programs by planners and provides tools for by-law officers to check compliance. Municipalities also serve on the front line of informing land owners about their opportunities to get involved in groundwater protection. For example, the County of Oxford has established awareness programs to inform water users of best practices for water protection and provide connections to program assistance from other government departments and agencies.

8.6 Private Well Protection

Protecting groundwater wells is imperative in protecting groundwater quality and quantity. One of the best approaches in maintaining the health of a well is for landowners to carry out a regular maintenance program that includes three main steps. The first step is for landowners to protect the ground surface by lessoning or eliminating contaminants that may potentially travel into the well water, which can include pesticides, animal wastes, gasoline, de-icers and other hazardous chemicals (Green Communities Association, 2003). The second step involves inspecting the well regularly and maintaining the upkeep of the well. Lastly the well water should be tested regularly, which, in the Long Point Region is undertaken by the Haldimand Norfolk Health Unit, Oxford County Board of Health and Brant County Health Unit free of charge to landowners. The program for testing well water has always been a priority of the health units which started when each health unit was formed.

Information regarding the importance of well protection is outlined in an informational booklet *Well Aware* (Green Communities Association, 2003) that is displayed within the Conservation Authority for well owners to read about. In addition, the Haldimand Norfolk Health Unit, County of Brant Health Unit and the Oxford Health Unit provide information on their website in regards to well basics, what you need for testing of water and what the results of water testing represent. Also under the *Ontario Water Resources Act*, regulation 903 'wells' outlines the legal responsibility that landowners must follow in protecting groundwater.

The location of the well is important for protecting the wellhead zone as the well must be a safe distance from possible contamination sources. Potential sources of contamination include fuel storage tanks, stockpiles of contaminants (road salt, pesticides), septic systems, gardens, manure piles, roads and driveways (Green Communities Association, 2003). New well construction or upgrading of an old well is another means of protecting drinking water as new barriers and techniques are implemented. New wells should be lined with water tight casings that prevent contaminants from entering a well, the annual seal must be filled with a water tight sealant such as bentonite and the well cap must be commercially manufactured so that the cap prevents vermin from entering (Green Communities Association, 2003). Well pits are no longer considered safe as over time they tend to crack letting in vermin, surface water and precipitation. Upgrading of a pit well is recommended to prevent contamination and the work needs to be handled by a licensed well contractor which is outlined under regulation 903. In addition under regulation 903 wells that are abandoned or unused must be properly sealed and plugged, which also must be completed by a licensed well contractor. Unused wells pose a threat to groundwater as the upkeep of the unused well is usually not monitored, leading to contaminants moving into the well or groundwater. Following the above steps and continuing the maintenance and upkeep of a well will aid in the prevention of possible contamination of drinking water.

8.7 Water Conservation and Demand Management

In Norfolk County a by-law was put in place for a watering ban starting May 1 and continuing until September 30. The by-law was put in place in order to conserve water during the summer months which is when precipitation levels are low and irrigation practises are high. The details of the by-law entails that no person is allowed to 'cause or permit the use of water externally through a hose, pipe or other watering device or mechanism" (Norfolk County By-Law NO. 2003-63). The exception to the law is that people may water on even or odd days that correspond to their premise number in times between nine and 11 am and seven and 11 pm. Brant County also has a by-law in regards to a watering ban which encompasses a small part of the watershed. In addition, another means of conserving water is through education and providing examples of practices that people can follow. Norfolk County provides rain barrels to residents in the watershed and presents water conservation information on their website for inhabitants to follow in order to decrease the amount of water being wasted.

Another means of water conservation and demand management in the watershed is the creation of irrigation committees. The committees provide information and assistance to rural land owners in regards to water conservation and provide demand management as best irrigation methods are talked about and conflict issues are addressed. In 2001 *the Big Creek Irrigation Peer Review and Assistance Project* (Long Point Region Conservation Authority, 2003) was created in order to deal with water shortages and use conflicts in the Big Creek watershed. The project was a success and the irrigation committee is currently still functioning. In addition, as part of *Big Otter/Catfish Watersheds Irrigation Options Project 2002-2004 Final Report* (2002) one objective of the project was to create two irrigation advisory committees. The Big Otter irrigation committee was formed in 2003 and is currently running.

The LPRCA administers the Ontario Low Water Response (OLWR) program for the Long Point Region watersheds. Three Water Response Teams have been established to provide a forum for review and discussion of the low water conditions and for providing recommendations for water conservation measures. These teams also recommend moving from one level of low water (drought) to another in accordance with the provincial OLWR guidelines. The Water Response Teams are made up of representatives of provincial water management ministries and the major water user groups, including the agriculture and municipal sectors.

8.8 Protection of Key Hydrologic Processes

8.8.1 Significant Wetlands

Wetlands are vital areas that should be protected as the vegetation absorbs contaminants, which enhances the water quality around the wetland and the water leaving the wetland. Wetlands hold precipitation and runoff, and release water slowly thus decreasing possible erosion issues and aiding in recharging groundwater supplies. The most significant wetland in the Long Point Region watershed is found along Long Point and at the mouth of Big Creek which encompasses an area of 75 square kilometres. The area is protected and is recognized under the Ramsar Convention and as the Long Point Biosphere Reserve. The area provides habitat to many bird, mammal, fish and reptile species.

Protection of wetlands can be accomplished through a variety of means, including creating protected areas through legislation (i.e. Official Plans, Zoning By-Laws C.A. Regulations) and providing financial assistance and education for residents to create and enhance wetlands. One incentive for landowners in the watershed is through the Ontario Wetland Habitat Fund. The program provides financial assistance to southern Ontario land owners in conjunction with technical advice. Wildlife Habitat Canada co-ordinates and supports the program in partnership with the Ministry of Natural Resources, Canadian Wildlife Service, U.S Fish and Wildlife Service, and other supporters. Long Point Region Conservation Authority provides many project opportunities in regards to reforestation and wetland creation which aid/protect headwater and recharge/discharge areas. Financial assistance relating to reforestation projects primarily comes from Ontario Power Generation. In addition projects relating to wetland creation are able to be funded through a variety of initiatives relating to LPRCA. An example of a significant area that needs to be protected for its key hydrological processes is the Norfolk Sand Plain. The region contains many recharge areas as there is a low aquifer which can be considered head waters for the sand plain. Examples of projects that are protecting wetland areas include the wetland drain project and the South Creek reforestation project.

8.8.2 Groundwater Areas of Concern

Knowing potential areas where groundwater contamination may occur can aid in the prevention of groundwater contamination as precautionary measures may be implemented. The municipality of Norfolk carried out a groundwater study which was completed in 2003 by Waterloo Hydrogeologic Inc. (Waterloo Hydrogeologic Inc. et al., 2003). Data was compiled of known spills as well as locations of potential contaminant sources which were used to identify possible areas of concern. The existing data that was obtained from the Ontario Ministry of Environment looked at fuel storage, PCB storage, contaminant spills and certificate of approvals for waste disposal sites. Fuel storage systems are a concern since they often contain gasoline, fuel oil and diesel and are located above or below ground. Underground storage poses a higher risk since groundwater can corrode the tank and the ground setting above or below the tank can cause corrosive effects that can lead to holes and cracks. A total of 172 locations of fuel storage sites were identified in the study. PCBs used in transformers and electrical capacitors are banned in Canada; however, PCBs are very resilient and persist in the environment which is why they are a concern. 19 PCB storage sites were found in the study area, which may lead to contamination of groundwater if any leakages occur. Certificates of approval that were given in the area totalled 63 waste disposal and waste generation sites. One of the main concerns with disposal and generation sites is the possibility of seepage into waterways and groundwater.

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