Kettle Creek Watershed Characterization Report

DRAFT

January 2008

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Lake Erie Source Protection Region

Technical Team

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These maps are for information purposes only and the Kettle Creek Conservation Authority takes no responsibility for, nor guarantees, the accuracy of all the information contained within these maps.

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.

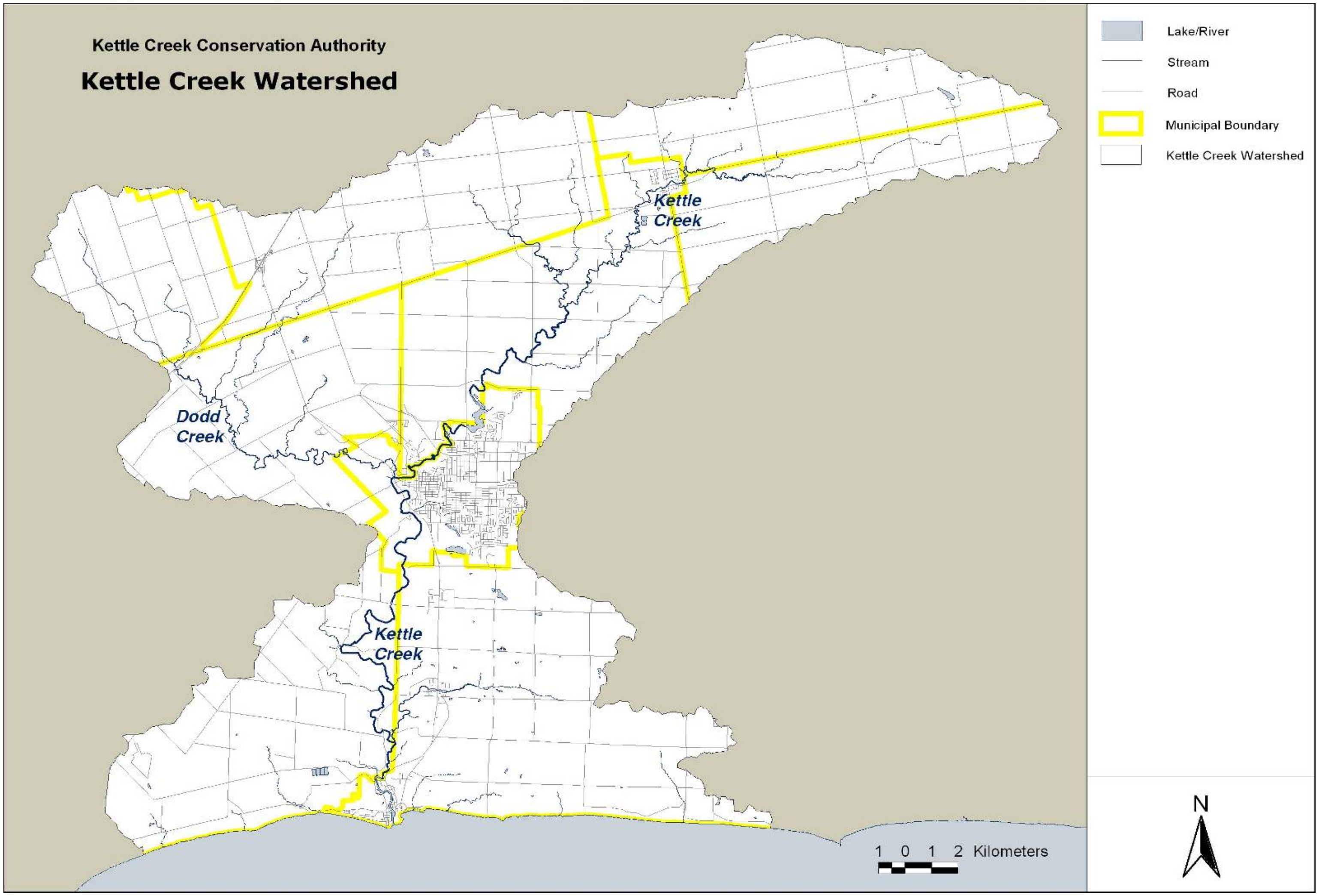
The first step in the development of the plan is to describe the physical and human characteristics of the watershed. The Watershed Characterization Report provides information ranging from geology, hydrology and hydrogeology, groundwater and surface water quality, population distribution, land uses, 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 Kettle Creek Source Protection Area

The Kettle Creek watershed is situated in the heart of the Carolinian Life Zone on the north shore of Lake Erie. As shown on **Map 1.1** (Appendix A), the watershed is hourglass in shape and drains 520 square kilometres of land which includes the south-central portion of Middlesex County/City of London and the central portion of Elgin County, including the City of St. Thomas.

Map 1.1: The Kettle Creek Watershed



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The northwest quadrant of the watershed, reaches well north of the intersection of Highway 401 and Highway 4, and makes up the headwaters of Dodd Creek, a major tributary of Kettle Creek. These headwaters originate at elevations ranging from 307 to 250 metres above sea level. This relatively flat clay plain has little vegetation cover or wetland. As a result, little continuous base flow is provided by Dodd Creek to the main branch of Kettle Creek in St. Thomas.

The northeast quadrant of the Kettle Creek watershed, extending just south of the Avon-Putnam exchange on Highway 401, is the headwater source for the Upper Kettle subwatershed. Sandwiched between the Westminster Moraine to the north and the St. Thomas Moraine to the south, the main branch of Kettle Creek originates at Lake Whittaker. A till plain along with some forest and wetland features provides a moderate base flow in all but severe drought conditions.

The southeast quadrant of the Kettle Creek watershed, which reaches almost to Port Bruce, is the headwater source for the Beaver Creek subwatershed. Fed from groundwater sources within the Sparta Moraine, Beaver Creek is located within the western remnants of the Norfolk Sand Plain. The creek originates at Corners Pond and maintains a good deal of forest and wetland features throughout its course. The Little Creek subwatershed, sourced within the same geographic features as Beaver Creek, flows directly into Lake Erie at Port Stanley. Both subwatersheds have moderate base flows in all conditions, forming cold to cool water stream features.

The southwest quadrant of the Kettle Creek watershed is comprised of clay plain. Many streams sourced from this quadrant flow directly to Lake Erie. The exception, Mill Creek, is a cold to cool water stream that enters Kettle Creek just north of Port Stanley. Base flows are generally moderate in all conditions, due to constant groundwater seepage from deeply incised valley walls.

Kettle Creek outlets to Lake Erie at Port Stanley at an elevation of 166 metres above sea level. This represents an elevation drop of about 141 metres from its watershed height to the average Lake Erie water level, approximately 1.75 metres per kilometre.

This steep elevation drop results in flash flooding and a high degree of erosion. In many instances the bed of the stream is more than 30 metres below the level of the surrounding land (Barnes, 1967). In addition, considerable evidence of glacial action and glacio-fluvial deposition exist.

Kettle Creek also has the fastest eroding shoreline in the Great Lakes basin and the largest lake-induced flood damage centre on the Canadian side of Lake Erie. Other than beach and low lying bluff at Port Stanley, the bluffs along the watershed's entire length of Lake Erie are 38 metres high. The shoreline has an average rate of recession of over two metres per year, averaged over 100 years.

A siltation study was undertaken for the Federal Government in 1987 to determine requirements for maintaining the harbour at commercial shipping depths. The study concluded that 55,000 cubic metres of sediment was annually dredged from Port Stanley harbour. Of this volume, 25 percent was attributed to siltation of the harbour mouth originating from Lake Erie. Therefore, over 41,000 cubic metres of harbour sediments were projected as being sourced from the Kettle Creek watershed, per annum.

The overall erosion rate in the watershed is compounded by the fact that 83 percent of the watershed lands are in agricultural use. Roughly 86 percent of these lands are considered ‘open’ and have soils suitable for cultivation (Class I, II, or III); 15 percent of land is forested or marginal and five percent is designated urban use.

The primary agricultural land use is cash crop, and a moderate amount of specialty cropping also exists. Crop rotation and minimum till is commonly practiced in the agricultural community, as are a number of other land conservation measures. Livestock operations are intensifying but declining in total number to below historical total number of animals. Most agricultural lands are systematically tile drained, which along with municipal drains, has reduced wetland features in the watershed landscape by 80 percent over historical records.

The population of the watershed is 44,406 people (2001), with a forecasted growth of 30 percent by 2031. A large, as yet unsettled or developed, portion of the City of London is located in the northern headwaters of the watershed.

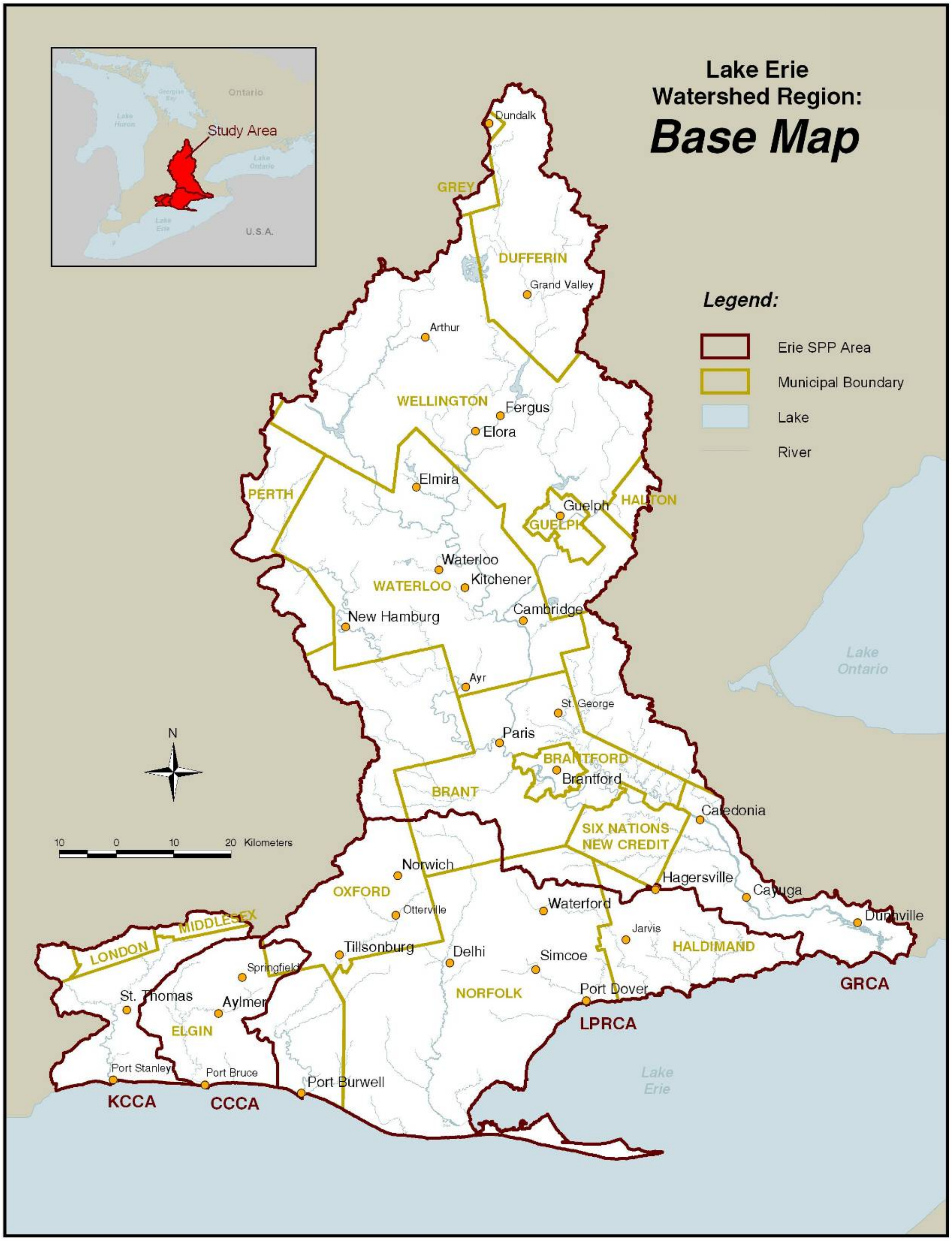
1.2 Lake Erie Source Protection Region

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 drinking water sources. Key partners included in the process are municipalities and conservation authorities. Conservation authorities will coordinate the development of technical and scientific knowledge in source water protection, and facilitate the planning process. Municipalities will develop the plan collaboratively with watershed stakeholders 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 to form the Lake Erie Source Protection Region. The GRCA acts as the lead authority for the region. **Map 1.2** shows the territory covered by the Lake Erie Source Protection 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 partnerships 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.

Map 1.2: Lake Erie Source Protection Region



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1.3 Watershed Partners and Stakeholders

1.3.1 Municipalities

Elgin County comprises about 60 percent of the southern portion of the Kettle Creek watershed, including portions of the municipalities of Southwold, Central Elgin, and Malahide. Middlesex County comprises about 20 percent of the northern portion of the watershed, including portions of the Municipalities of Middlesex Centre and Thames Centre. In the north central area of the watershed, rural lands within the City of London comprise 15 percent of the watershed landscape, while the remaining five percent are attributed to the City of St. Thomas.

The Upper Tier municipalities of Elgin and Middlesex Counties lead in major arterial roadwork, long-term health care facilities, library, and ambulance. These municipalities also perform limited planning functions and cultural services to member municipalities. Each municipality leads in roadwork, primary emergency response including fire and police services, a full range of municipal planning functions, and a variety of other local functions.

The Cities of London and St. Thomas provide a full range of services, and cooperate in joint ventures with both upper and lower tier municipalities adjacent to their jurisdiction.

1.3.2 Kettle Creek Conservation Authority

Kettle Creek Conservation Authority (KCCA) was incorporated in 1965 by a Provincial Order of Council (OC-1116/65). The Authority was formed due to municipal concerns regarding deforestation, erosion and sedimentation of watercourses, wetland loss, and declining quality and quantity of water resources. These resource management issues had developed due to the intensification of cash crop agricultural combined with the natural characteristics of the watershed including a steep descending watercourse.

In partnership with its member municipalities – City of London, Municipality of Central Elgin, City of St. Thomas, Southwold Township, Malahide Township, Thames Centre and Middlesex Centre – KCCA manages the natural resources of the watershed and devotes itself to water and land conservation projects. The Full Authority, or Board of Directors, makes program decisions and allocates funds. This body is comprised of ten representatives from municipalities within the watershed. The Board develops programs that further the conservation, restoration, development and management of the natural resources of the Kettle Creek watershed.

In 1994, a strategic planning exercise was undertaken in conjunction with a multitude of community stakeholders. The resulting “Conservation Strategy” included over 100 recommendations in support of the community’s vision of, “people in harmony with nature.” In support of this vision, KCCA adopted the mission statement, “to guide the conservation of ecosystem on a watershed basis.”

KCCA is devoted to building partnerships with watershed agencies that have an interest in the environment. Joint rehabilitative projects have been conducted between KCCA and the Elgin Hiking Trail Club, Elgin Stewardship Council, Ford CAW Environmental Committee, Presstran Industries, Ontario Geologic Society, Elgin Area Primary Water Supply System, and the Elgin Federation of Agriculture.

A list of KCCA's key partners in water conservation and source protection is included in **Table 1.1**.

A synopsis of KCCA's programs and services as they relate to source water protection is included in **Table 1.2**.

Table 1.1: Summary of Stakeholders and Partners in the Kettle Creek Watershed

Stakeholder	Affiliation	Mandate
Member Municipalities	Represented on KCCA Board and primary funder of KCCA programs.	Planning, regulatory and development controls relating to environmental conservation and provision of safe drinking water to the public.
Elgin Area Primary Water Supply System	Current stewardship program funder for source water protection.	To collect, treat and discharge safe drinking water within a primary system serving area municipalities
Boards of Health	Elgin-St. Thomas and London-Middlesex	Public health promotion and prevention, as well as emergency response in many programs and services that can relate to water at source to tap
Province of Ontario	MNR, MOE, OMAFRA, MMAH, Stewardship Councils	Environmental conservation, protection, and enhancement programs and services that positively impact water sources. Roles are divided as water quantity (MNR), water quality (MOE), rural services (OMAFRA), and planning services (MMAH).
Other Conservation Authorities	GRCA, LPRCA, CCCA, UTRCA	Program and services cooperation and integration at services delivery level, primarily in stewardship programs and source water protection planning.
Federal Government	Environment Canada, Lake Erie Bi-national Public Forum, Department of Fisheries and Oceans	Maintenance services for streamflow monitoring stations, LAMP and Lake Erie water source conservation, and community conservation strategies (Env. Canada); and conservation of water and fish habitat (DFO).
Other Stakeholders	St. Thomas Field Naturalists, McIlwraith Field Naturalists, Elgin Hiking Trail Club, Hawk Cliff Foundation, University of Guelph, University of Western Ontario, Elgin Federation of Agriculture, Lake Erie Salmon and Trout Club	Environmental monitoring, research, and management expertise is available related to specific areas of interest that can often affect or impact water conservation.
Private Industry	Green Lane Environmental,	Funding and volunteer support of

Table 1.1: Summary of Stakeholders and Partners in the Kettle Creek Watershed

Stakeholder	Affiliation	Mandate
	Ford CAW Local 1520, Presstran, Ontario Power Generation	a number of environmental conservation initiatives that directly benefit water conservation.
Local Foundations and Trusts	Timken Foundation, Kettle Creek Conservation Trust, Elgin Community Foundation, Friends of the Environment	Provision of funding for environmental works that often directly benefit water conservation
Ontario First Nations	No OFN organizations are found in the KCCA watershed.	

Table 1.2: Kettle Creek Conservation Authority Source Protection Water Management Program

Existing Program	Function	Comments
Section 28 Regulations	Environmental Regulations govern placement of fill, construction of buildings, or alteration of watercourses in a regulated area. Regulated areas include: streams, municipal drains, valleylands, wetlands, shoreline. Program typically protects environmental features in the watershed that are or convey water sources.	Program delivered at KCCA since 1973. Increasing success in public recognition and acceptance. Proactive program for prevention of resource concerns before they develop. Most regulatory zones are included in municipal planning documents in KCCA watershed.
Municipal Plan Input	Municipal Plan Input and Review according to Hazard Land policies and Natural Heritage policies of province. KCCA only local commenting agency, although ministerial comment on special matters may be solicited in process.	Program delivered at KCCA since 1970. Increasing involvement by KCCA, who now has sole comment status for natural hazards. Natural Heritage comments framed by subwatershed plans and Environmental Impact Studies.
Flood Warning and Forecasting	A public safety program. KCCA monitors weather forecasts and stream levels by computerized monitoring stations. Model is activated when combination of forecast rain, snow melt, thaw are tallied with existing ice and streamflow conditions. Public warnings and advice to municipalities follows. Municipalities are responsible for activating emergency response plans.	Program delivered at KCCA since 1969. Primary function of water management. The watershed's watercourses are short and steep, requiring a combination of real time (field) monitoring and fast-track forecasting / modeling. KCCA has forecasting and monitoring system for both riverine and lakeshore environments.
Dam Management	Originally set-up as a program to control surface water flows / floods or supplement low-flows.	Both Union and Dalewood Dams were acquired by KCCA for low-flow and flood control purposes in the early 1970's.

Table 1.2: Kettle Creek Conservation Authority Source Protection Water Management Program

Existing Program	Function	Comments
Education and Information	Local priorities for water quality include: Kettle Creek – Lake Erie Water Conservation Task Force; & KCCA local spills response.	KCCA role developed to date includes: public education; lobbying for remedial dollars; E-coli monitoring of Port Stanley beach waters and of Kettle Creek; promotion of remedial measures by user.
Private Land Stewardship	Tree planting, fencing of livestock access from streams, erosion control, wetland creation, and landowner advice and information.	Benefits of program will grow in future. Stewardship Coordinator position has been created and filled for 2 years.
Headwater Source Protection	The protection of regionally significant lands for overall watershed benefit, including: ANSI's, Wetlands, Habitat for rare or endangered species. Protection of lands that either recharge to groundwater or discharge to surface water is main purpose of the program.	Includes major headwater source protection such as Lake Whittaker and wetland complex plus upper Dalewood reservoir lands. Recharge and discharge areas are now mapped in subwatershed planning projects.
Low Flow Monitoring And Low Water Response	Three KCCA streamflow gauges are set to monitor low flow levels and volumes. Once critical low flow stages are met, water conservation promotions are enhanced. Water taking allocations could result.	Combined with upcoming water budget information, KCCA will be able to comment on water uses proposals subject to MOE's Permit to Take Water.
Benthic Monitoring (surface water quality)	Water Quality Monitoring system recently developed in conjunction with U of G.(Griffiths) Benthic monitoring is basis of assessment through BioMap. Water quality potential mapped and correlated to vegetation along watercourses. Satellite imagery used to track forest cover and target tree planting for optimum H2O results. Twenty-four monitoring stations are found throughout the watershed.	Broad range of surface water quality parameters are monitored through benthics: nutrient enrichment; organic enrichment; sedimentation; industrial effluents; thermal effects; and reduced flow conditions. Report shows 25% watercourses have unimpaired water quality potential, 67% impaired water quality potential, and 8% indeterminate. Indeterminate watercourses are targeted for remedial works.
Biota Monitoring	KCCA monitors flora and fauna populations as indicators to environmental stress and to guide remedial actions. Aquatic species are particularly vulnerable in the watershed.	Undertaken in conjunction with MNR, MOE, Environment Canada, local universities, naturalist clubs, and other partners having specific species interest.
Ground Water Monitoring Network (water q and q)	Monitor ground water quality and quantity for long-term trends. KCCA participates in this provincially based program managed by MOE.	Serves as an early warning system for groundwater conditions. Seven monitoring wells are located throughout the watershed.

Table 1.2: Kettle Creek Conservation Authority Source Protection Water Management Program

Existing Program	Function	Comments
Surface Water Monitoring Network	In partnership with MOE, the purpose of the program is to characterize the chemical and physical aspects of surface water quality within the Kettle Creek watershed.	Nine sampling stations are found throughout the watershed.
Sediment Monitoring (quality and quantity)	In partnership with the Elgin Area Primary Water Board and the University of Western Ontario, the purpose of the program is to monitor sediment quantity and quality in both the water column and bed sediments.	Eight sampling stations are found throughout the watershed. Specific interest in decreasing volume of sedimentation as well as to assess where contaminants are entering the watercourse for remedial action.
Watershed Plan and Subwatershed Plans	Examines land uses and resources present in the watershed and reconciles these with resource consumers and demands. Critical emphasis on ID and protecting water sources.	Since 1990, seven subwatershed plans have been completed. Well over half of the KCCA watershed has been subwatershed planned.

2.0 PHYSICAL DESCRIPTION

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

The bedrock geology across the Kettle Creek watershed consists of Middle Devonian Michigan Basin (Dundee Formation and Hamilton Group) and Appalachian Basin (Marcellus Formation) sedimentary rocks. Bedrock does not outcrop within the watershed since a thick layer of Quaternary sediments (40 metres to 140 metres) covers this area. Bedrock geology across the Kettle Creek watershed is shown on **Map 2.1**.

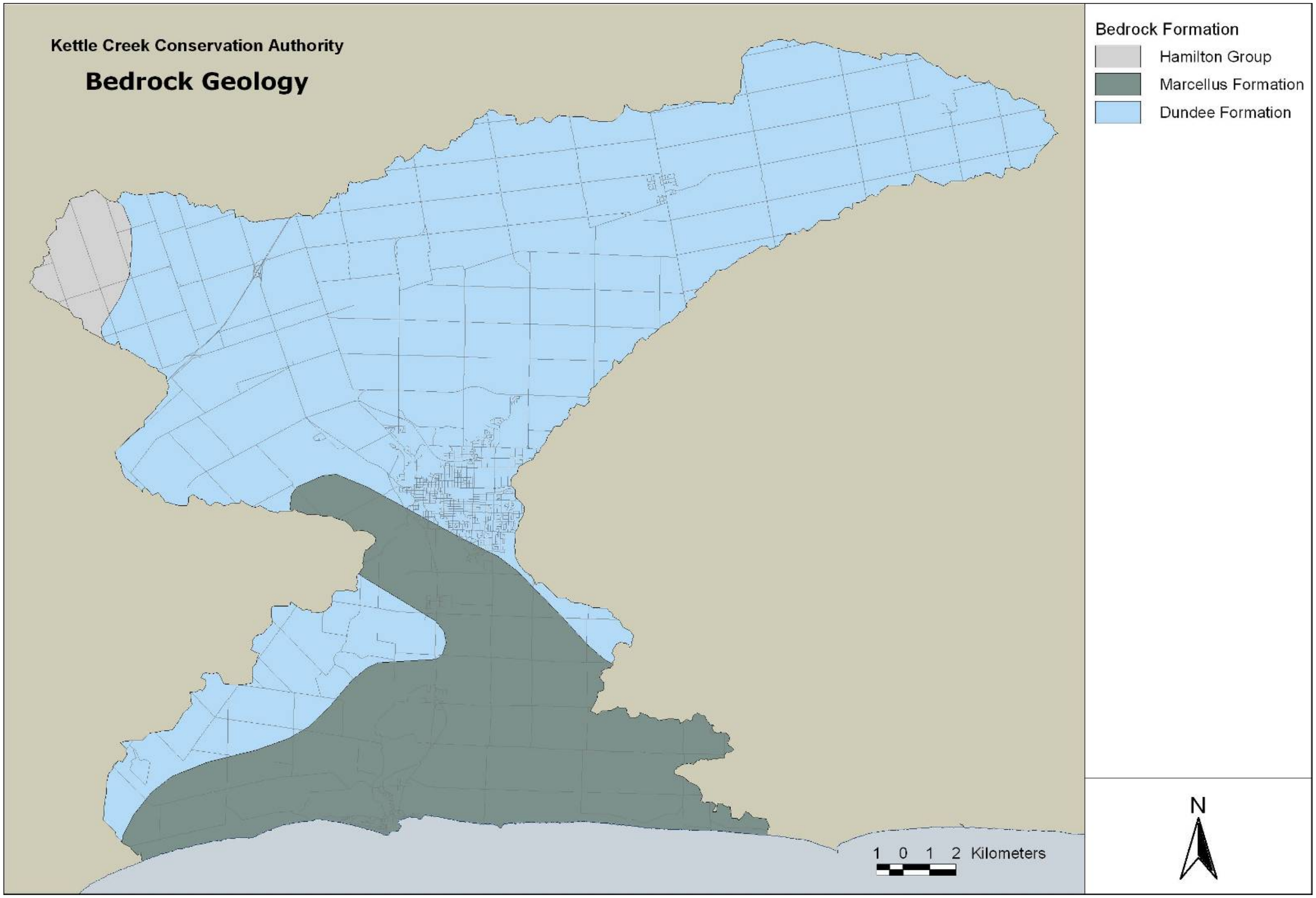
The Dundee Formation, the oldest bedrock formation within the study area, subcrops throughout most of the watershed. This formation is overlain by the Hamilton Group along the western edge of the Kettle Creek watershed boundary. There is a sharp, erosional contact between these two units. The Marcellus Formation conformably overlays the Dundee Formation along the southern boundary of the watershed, between St. Thomas and Lake Erie.

The Dundee Formation is characterized as a fossiliferous limestone with bituminous partings and chert nodules (Johnson et al., 1992). The rocks are interpreted to have formed in depositional environments ranging from lagoonal to open shelf and deep water (Johnson et al., 1992). In Ontario, the average thickness of the Dundee Formation ranges from 35 to 45 metres. Both Singer et al. (1997) and MacRitchie et al. (1994) identified the Dundee Formation as a major hydrogeologic unit stretching across Ontario. As a regional aquifer, well yields depend on secondary permeability, created through enhanced porosity resulting from fracturing, dissolution, dolomitization, etc. Relatively high well yields observed in the top 1.5 metres of the Dundee Formation suggest that flow is confined to joint and fracture zones developed as a result of differential glacial stresses (Schwartz, 1974). Transmissivity values determined by Singer, Cheng and Scafe (1997) suggest this formation has a very good water-yielding capability

Within southwestern Ontario, the Hamilton Group is comprised of six distinct units which primarily consist of mudstone and shale with thin, impure, lateral carbonate horizons (Johnson et al., 1992). The overall thickness of the Hamilton Group can reach up to 80 metres (Dillon, 2004). Distribution of transmissivity values determined by Singer, Cheng and Scafe (1997) in southern Ontario suggest that the Hamilton Group rocks have a moderate water-yielding capability.

The Marcellus Formation within southwestern Ontario has been characterized as a black, organic-rich shale with grey shale interbeds and sparse fossils. The Formation was deposited in a marine environment with a stratified water column (Johnson et al., 1992). The overall formation can range up to 12 metres in thickness (Dillon, 2004; Johnson et al., 1992).

Map 2.1: Bedrock Geology of the Kettle Creek Watershed



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Ontario Geological Survey, 1993. Bedrock geology, seamless coverage of the province of Ontario; Ontario Geological Survey, Data Set 6.

2.2 Physiography and Quaternary Geology

The watershed's current physiography was shaped by glacial processes during the Wisconsin glacier which occurred some 10,000 to 15,000 years ago during the "Pleistocene Era". This vast glacier covered southern Ontario as well as parts of Michigan, Indiana, Illinois and Ohio.

This tremendous layer of ice had the power to lift, shove, deposit and rearrange existing rock materials. As the glacier retreated from the Kettle Creek watershed it left behind ridges and massive amounts of glacial debris called till, which is a mixture of stones, rocks, sand and clay. The manner in which this till material was deposited gave rise to various land forms such as flat clay plains and moraine areas in the Kettle Creek watershed.

There are three distinct physiographic regions within the Kettle Creek watershed: the Mount Elgin Ridges; the Ekfird Clay Plain, and the Norfolk Sand Plain.

2.2.1 Mount Elgin Ridges

Located between the Thames River Valley and the sand plains of Norfolk and Elgin counties, the Mount Elgin Ridges cover approximately 270 square kilometres in the northern third of the Kettle Creek watershed. This distinct physiographic region is made up of two prominent topographic features, the St. Thomas and Westminster Moraines.

The St. Thomas Moraine was built by a submerged ice front. At St. Thomas a gap occurs in the ridge so the name for the moraine is not particularly apt. However, it is the strongest moraine of the series, varying in width of up to five kilometres between London and Tillsonburg and is prominent as far as Wallacetown (Barnes, 1967).

The Westminster moraine trends east to west and is approximately five kilometres wide. It passes about 12 kilometres south of the City of London's centre and is flanked on the north by the parallel Ingersoll Moraine. To the south, the Westminister Moraine is flanked by the parallel St. Thomas Moraine. Like most temperate lacustrine moraines, the Westminister Moraine consists of heavy clay deposited over coarser materials such as sand, gravel and extensive boulder beds (Dewdney, 2000). The succession of ridges and valleys in the Mount Elgin Ridges is characterized by clay or silty clay ridges and valleys with alluvium of gravel, sand or silt.

The divides between the Thames River and the several smaller rivers that run south to Lake Erie are found in this region. The broad "Belmont Vale" is occupied by the main branch of the Kettle Creek which, working headward from Lake Erie, has entrenched itself deeply into the till.

2.2.2 Ekfird Clay Plain

The Ekfird Clay Plain comprises a fairly large area in the Lake Erie region and approximately 110 square kilometres in the central portion of the Kettle Creek watershed. The flat lying area is characterized by clay and silt deposits providing little relief and poor drainage.

2.2.3 Norfolk Sand Plain

The Norfolk Sand Plain is an extensive 120 square kilometres and encompasses the southern third of the Kettle Creek watershed and extends to the Lake Erie shoreline. It is wedge shaped with a broad curved base along the shore of Lake Erie tapering northward to a point at Brantford on the Grand River. The sands and silts of this region were deposited as a delta in glacial Lake Whittlesey and Warren. The great discharge of meltwater from the Grand River area entered the lake between the ice front and the moraines to the north-west, building the delta from west to east as the glacier withdrew. Thus it covered most of the area west of the “Galt Moraine.” From observations in exposed river valleys and along the very steep bluffs of Lake Erie there are records of sand beds up to 23 metres deep but usually silt or clay strata or beds of boulder clay occur within nine metres of the surface (Barnes, 1967).

2.2.4 Quaternary Geology

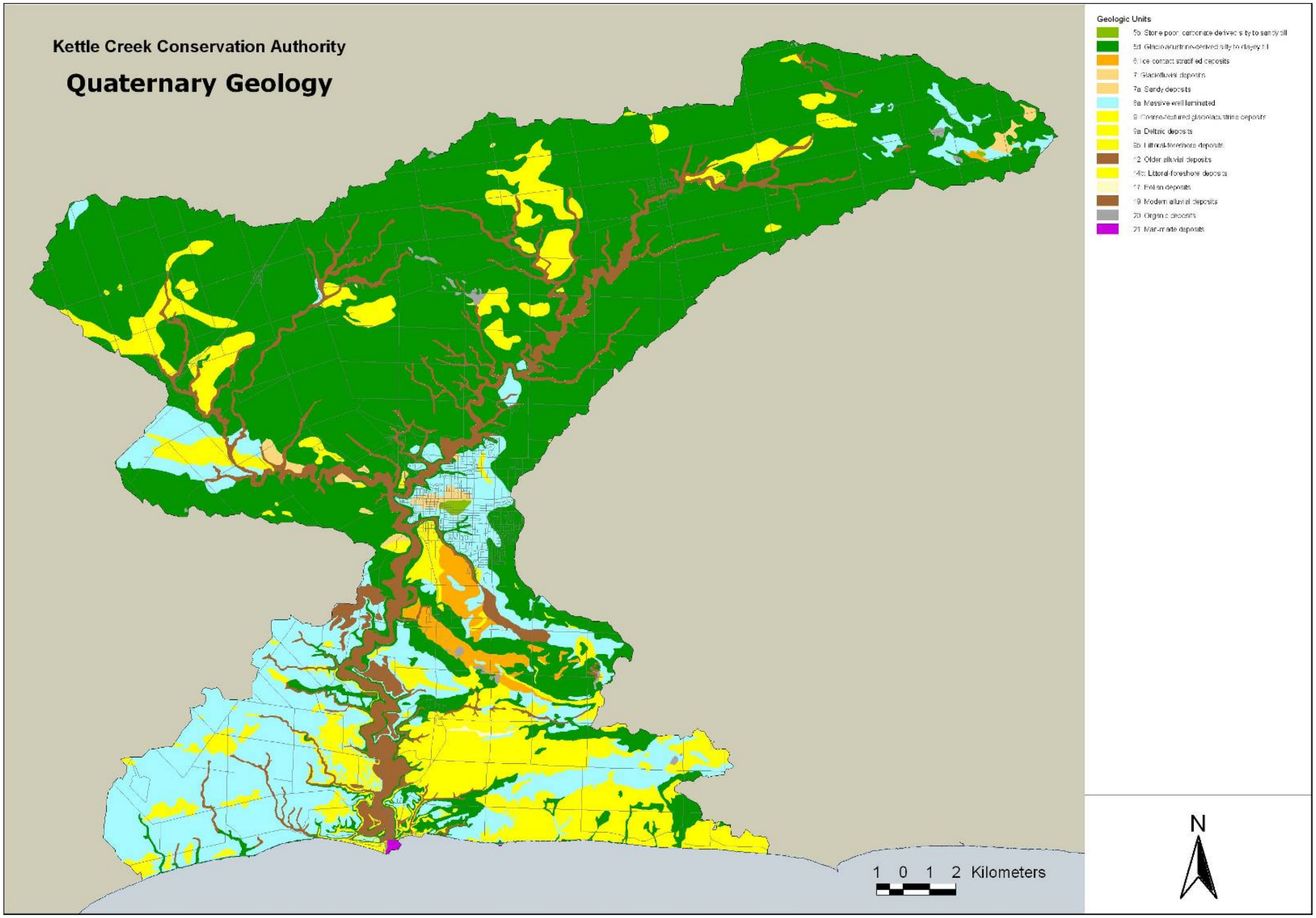
The Quaternary Period, which began about 1.8 million years ago, is the youngest period of the Earth’s history. The beginning of the Quaternary Period is generally considered to be a time when the Earth’s climate was cool and much of North America and Europe were intermittently covered by continental ice sheets. In Ontario, Quaternary deposits represent the last 190, 000 years. This time span covers two main glacial stages, the Illinoian and Wisconsinan, the interglacial Sangamonian Stage, and the Holocene (Recent Epoch). The Illinoian glacial stage was followed by the warmer Sangamonian interglacial stage where the ice retreated. This warmer period was followed by the Wisconsinan glacial stage, which began approximately 115, 000 years before present and ended approximately 10, 000 years ago. At a point during the Wisconsinan stage, approximately twenty thousand years ago, the Laurentide Ice Sheet completely covered Ontario. This ice sheet was a part of a larger continental glacier complex that covered much of Canada and extended into the northern parts of the United States (Johnson et al., 1992).

During the Late Wisconsinan stage, three significant periods of ice advance (stades) affected the lower Great Lakes region; the Nissouri, Port Bruce, and Port Huron Stades. These stades were separated by two periods of ice retreat (interstades); the Erie and Mackinaw Interstades. In addition to the glacial stades and interstades during the Late Wisconsinan, the Laurentide ice sheet broke into two distinct lobes; the Erie and Huron lobes. The Erie lobe advanced from the northeast and receded to the east while the Huron lobe advanced from Lake Huron and moved southwards across the watershed. The advance and retreat of the glacial lobes resulted in sediment deposits characteristic to these lobes, as well as the glacial stades and interstades (Johnson et al., 1992).Surficial Quaternary geology across the watershed is illustrated on **Map 2.2**.

2.2.5 Nissouri Stade

During the Late Wisconsinan, the Nissouri Stade occurred approximately 16,000 to 23,000 years before present (Barnett, 1998). In Ontario during this time, the Erie lobe of the Laurentide ice sheet advanced from the north-northeast towards the Lake Erie basin.

Map 2.2: Quaternary Geology of the Kettle Creek Watershed



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Ontario Geological Survey 2003. Surficial geology of Southern Ontario; Ontario Geological Survey, Miscellaneous Release--Data 128.

Sediments deposited during the Nissouri Stade are represented by the Catfish Creek Till, which is present across all of southern Ontario (Barnett, 1992). Within the Kettle Creek watershed, Catfish Creek Till outcrops near the community of Sparta and within the Lake Erie bluffs near Port Talbot. The till is composed of several layers of subglacial till, stratified sediments of glaciofluvial and glaciolacustrine origin, and supraglacial till layers and lenses (Barnett, 1992). Very sandy till beds are mainly supraglacial tills or ice-marginal subaquatic flow tills (Dreimanis and Barnett, 1985). In subglacial tills, a higher sand content may be due to glacial entrainment of lacustrine sands (Dreimanis and Barnett, 1985). Catfish Creek Till represents a complex interlobate depositional sequence of stratified till facies laterally interfingered with massive subglacial till (Dreimanis and Barnett, 1985). Within the Kettle Creek watershed, Catfish Creek Till has a reported thickness of 15 to 61 m (Schwartz, 1974). The unit is a moderately stony to very stony, very compact, highly calcareous, sandy silt to silty till (Barnett, 1992). In outcrop, Catfish Creek Till does not appear to exhibit any fracturing (Schwartz, 1974). Catfish Creek Till is often referred to as 'hardpan' by water well drillers because of its stiff nature (Schwartz, 1974).

The interlobate Sparta moraine, located along the central drainage divide between Catfish Creek and Kettle Creek watersheds, is an end moraine formed by the oscillatory retreat of the Erie lobe (Dreimanis and Barnett, 1985). The moraine is cored by Catfish Creek Till and two generations of ice-contact drift have been found within the moraine; the older drift is associated with Catfish Creek Till and the younger drift with the Port Stanley Till. (Dreimanis and Barnett, 1985).

2.2.6 Erie Interstadial

Approximately 15,500 years before present, the Erie ice lobe retreated towards the Lake Erie basin. At this time, several high level lakes occupied the uncovered parts of the Lake Erie basin and glacial Lake Leverett was believed to have existed in the Lake Erie basin (Barnett, 1998). Subsequently, fine-grained glaciolacustrine sediments were deposited. These sediments were later overridden and incorporated into later till units during the Bruce Stade as the glacier readvanced out of the Lake Erie basin (Barnett, 1998).

2.2.7 Bruce Stade

The glacial advance that marked the beginning of the Bruce Stade was controlled by the Lake Erie basin and flow was outward from the basin (Barnett, 1998). The advancing glacier overrode the Erie Interstadial glaciolacustrine deposts, incorporating them into the base of the glacier. This resulted in the deposition of the fine-grained Port Stanley till in southern Ontario (Barnett, 1998).

During the Bruce Stade, the oscillatory retreat of the Erie lobe toward the southeast into the Lake Erie and Ontario basins resulted in the formation of a series of end moraines including the Ingersoll Moraine, which marks the farthest northward extent of the Erie lobe during the Port Bruce Stade. The Westminster, St. Thomas, Norwich and Tillsonburg moraines mark either positions of standstill or minor readvances of the ice margin.

Within the watershed, Port Stanley Till forms the dominant surface cover and has been characterized as a strongly calcareous, clayey silt to silty clay till with low plasticity (Barnett, 1992). The Port Stanley Till and underlying Catfish Creek Till are separated stratigraphically by a discontinuous layer of glaciolacustrine sediments that are up to 4 m thick and texturally vary from well-sorted sand to clay (Schwartz, 1974).

Up to 3 till beds interbedded with lacustrine sands, and silts and clays have been found in the region (Dreimanis and Barnett, 1985). The older, basal portion of the Port Stanley Till was deposited during the initial advances of the Erie Lobe. Previously deposited glaciofluvial sand and gravel and bedrock were incorporated into the till and the base of the lowermost till bed is often marked by a boulder pavement (Dreimanis and Barnett, 1985). The younger overlying till units were deposited during oscillatory retreat cycles of the Erie Lobe, which resulted in the formation of a series of end moraines (discussed above). This generated a depositional environment of sub-aquatic flow in glaciolacustrine conditions and produced some lacustrine silt and sand interbeds within the Port Stanley Till (Dillon, 2004).

Vertical dessication fractures and joints have been observed in shallow (< 6 m) outcrops of the Port Stanley Till and are likely a result of stress release related to deglaciation and post-glacial erosion (Dreimanis and Barnett, 1985; Schwartz, 1974). However, the development of this secondary porosity is not as likely to occur at depth because of relatively high overburden pressure (Schwartz, 1974).

2.2.8 Mackinaw Interstade

The Mackinaw Interstade marked the retreat of the Erie lobe into the Lake Erie basin. During the initial eastward withdrawal of the ice margin, a series of high-level proglacial lakes (glacial lakes Maumee I to IV) occupied the western end of the Lake Erie basin. The silts, silty clays, and clays located along the southern portion of the watershed overlie Port Stanley Till and were deposited as lake bottom deposits by glacial Lake Maumee (Dreimanis and Barnett, 1985). Further recession of the ice margin resulted in a series of progressively lower lake levels (glacial Lake Arkona) in the Lake Erie basin (Barnett, 1998). Glacial Lake Arkona occupied the Tillsonburg area until approximately 13,600 years before present (Barnett, 1982).

2.2.9 Huron Stade

About 13,000 years before present, the Lake Erie basin was occuped by glacial Lake Whittlesey and, and part of the large expanse of the deltaic sands of the Norfolk Sand Plain was deposited (Chapman and Putman, 1984; Barnett, 1982). Today, the Norfolk Sand Plain is an important unconfined aquifer for the area and is extensively used for private groundwater supply.

After the final glacial retreat, the entire area was exposted to soil development, erosion, vegetational changes and settlement, which has given rise to the present day landscape.

2.3 Soils

The soils of the Kettle Creek watershed are highly susceptible to erosion. The most common soils series are described in **Table 2.1** below.

The mix of poorly drained clay soils with glacial till parent material overlying deep clay sub soils explains the need for upstream agricultural drainage. It also explains the ‘flushing action’ of the creek during run-off and the high degree of erosion. It is reasonable that, given existing land uses, significant erosion rates will continue.

As evidenced by the sediment load calculated for dredging of the Port Stanley harbour, erosion of both shoreline and upstream lands continues to be a significant concern. Intensive row crop production in over 70 percent of the watershed land base, combined with an extensive system of municipal drains, mean that ongoing sediment flushing will occur.

Table 2.1: Summary of Soils in the Kettle Creek Watershed.

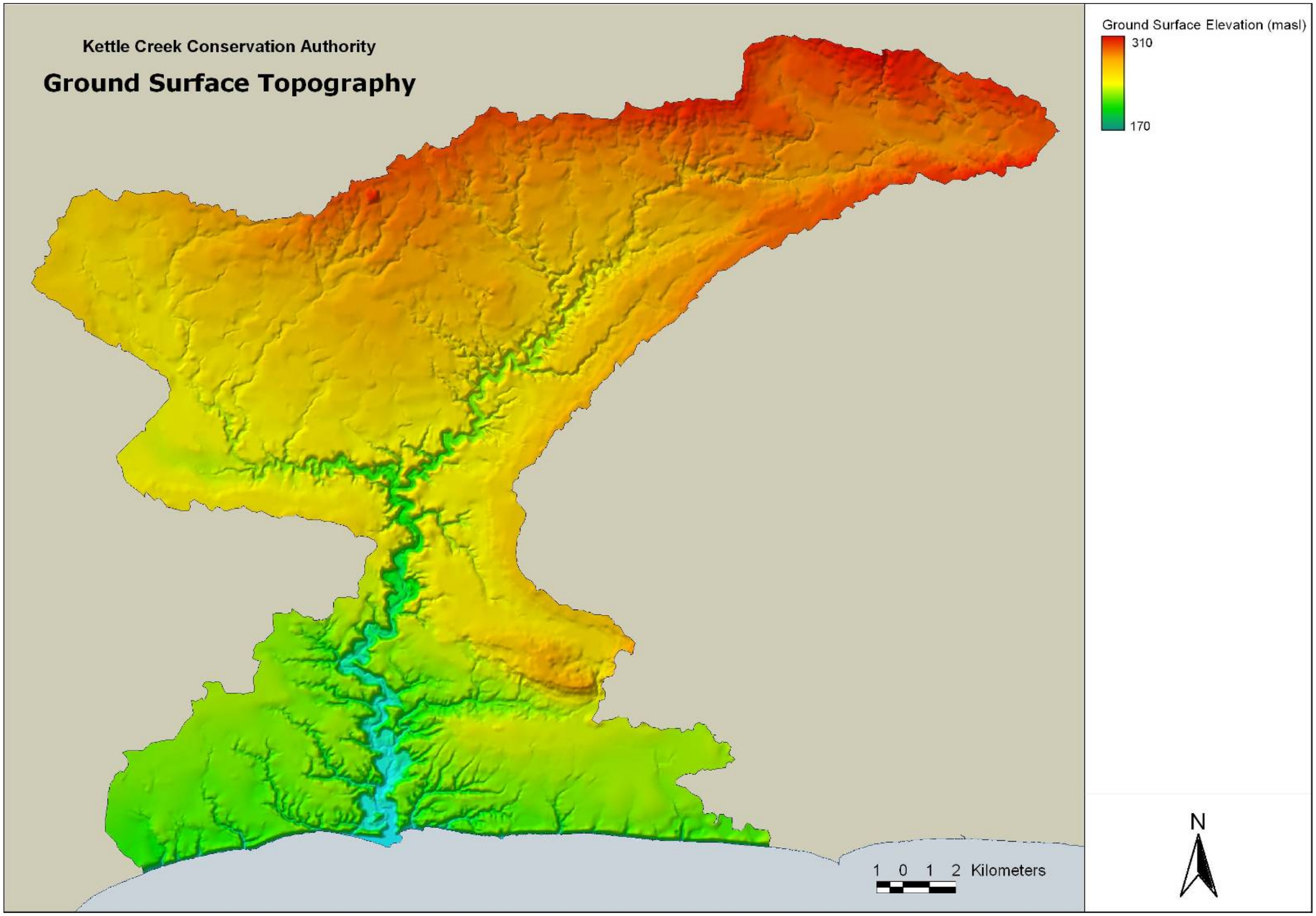
Series	% Watershed	Characteristics
Huron	35%	Clay and silt loams, well drained, rolling topography
London	20%	Silty loam, imperfectly drained, rolling to undulating
Guelph	17%	Clay till, well drained, rolling topography
Perth	11%	Loam and clay loam, imperfectly drained, level topography, need drainage
Brookston	9%	Clay to sandy clay, poor drainage, level land
Fox	5%	Sandy loam, well drained, level topography
Haldimand Series	3%	imperfectly drained soils composed of silt loams and clay loams, poor drainage

2.4 Topography

The topography of the Kettle Creek watershed was initially shaped during the regression of the last glaciation and is continuing to be reshaped by current fluvial processes that are taking place in the watershed on a daily basis. **Map 2.3** shows the topography of the Kettle Creek watershed. The topographic heights that exist within the watershed can be identified as the northerly St. Thomas and Westminster Moraines and the southerly Sparta Moraine. The topographic lows in the watershed occur as incised river valleys, created by glaciofluvial processes and continue to evolve as a result of current stream morphology (Dillon Consulting Ltd., 2004).

The Kettle Creek watershed drains 520 square kilometres of land situated in the heart of Elgin County and southern Middlesex County. The watershed is characterized by deeply incised valley systems and a steep descent of watercourses from headwater areas to Kettle Creek's outlet at Port Stanley. Kettle Creek and its tributaries decrease in elevation at an average of 1.75 metres per kilometre of watercourse. Given the predominance of moderately impermeable clay soils found throughout the watershed, rainfall and snowmelt quickly runs-off to nearby drains and streams. Accordingly, the watershed's primary natural resource management issues include: low base flows, 'flash' flooding and run-off, erosion and sedimentation, and degrading quality and quantity of water resources.

Map 2.3: Topography of the Kettle Creek Watershed



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2.5 Natural Heritage

2.5.1 Valley Lands

Kettle Creek's extensive valley lands are an important component of the region's natural heritage. Woodlots and shoreline vegetation included in the valley lands serve as buffers, protecting the land against erosion and the impact of adjacent agriculture or industry. At the same time, the valley lands offer habitat for species that normally would not be found near the creek. Many species use the streambank areas and forested buffers as wildlife corridors between other existing woodlots and environmentally significant areas.

Kettle Creek enters Lake Erie at Port Stanley where the bluff is about 38 metres high. Consequently, the valley itself is unique in that it is deeply cut into the landscape between St. Thomas and the Lake Erie shore. Although very steep sided, the valley is flat-floored and the creek meanders widely as far upstream as St. Thomas.

In some places, the bed of the creek is more than 30 metres below the level of the surrounding land, and the valley is still over 23 metres in depth (Barnes, Kettle Creek Conservation Report, 1967). The stream channel cuts through surficial and shallow intermediate aquifers which are suspected to contribute base flow to Lower Kettle Creek during dry weather conditions. The depth of this mantel of sediment and the presence of underlying clays allow a high water table and good general drainage, which are important to the conservation of water resources in the area.

The depth of the valley offers an array of ecosystems and habitats providing a high biodiversity of wildlife communities on all levels. Aside from the creek itself, this includes shoreline vegetation, clay or sand bluffs, forested uplands, lowlands, and wetlands. The valley acts as a natural water collection system, as it collects run-off from groundwater seepage. The depths of the valley also provide short-term storage of storm and melt waters, offering creek recharge, and flood control.

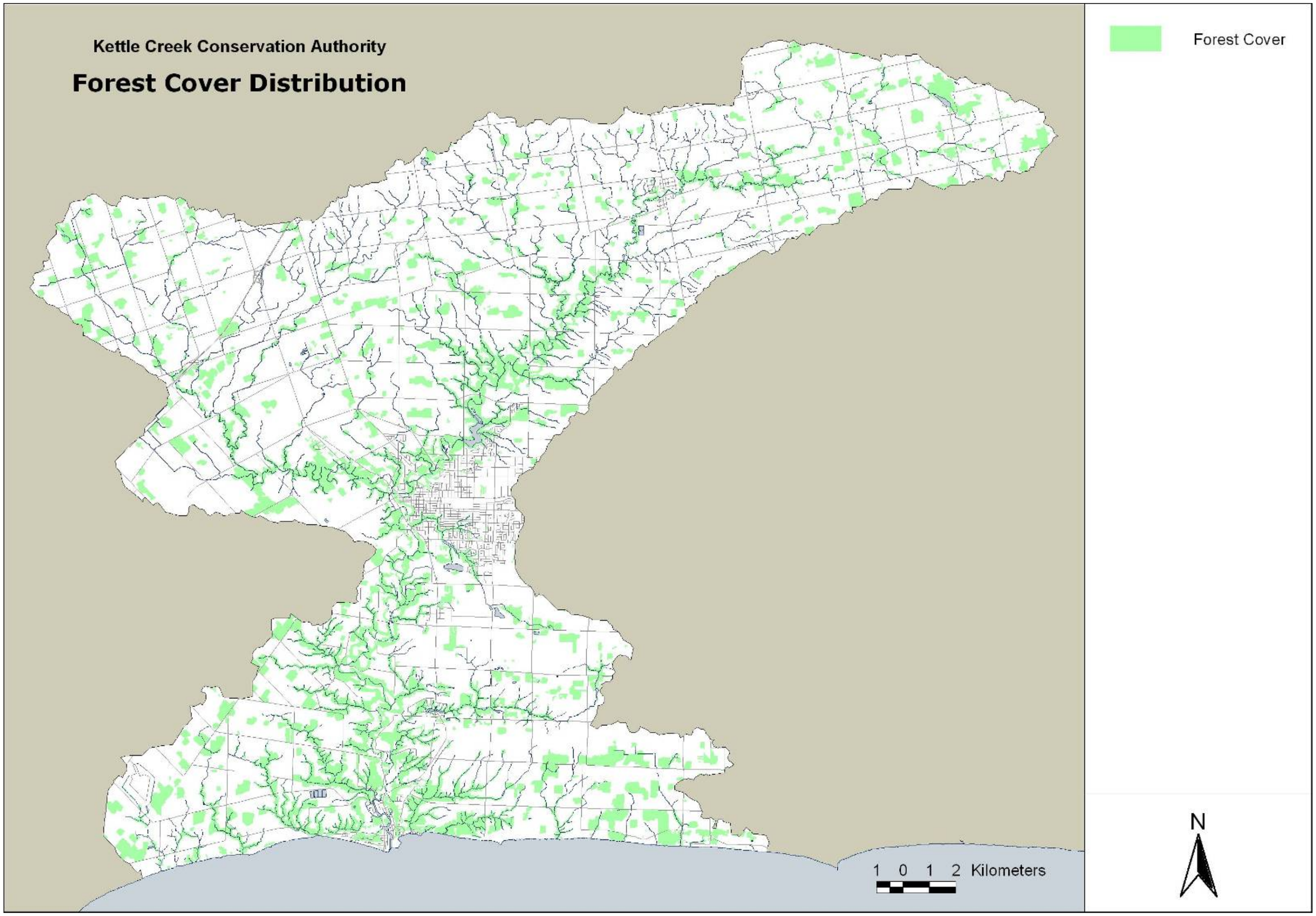
Moreover, small riverine wetlands contained within the valley lands also provide nutrients, control erosion and offer flow augmentation to the creek. The scarcity of wetlands in the watershed makes them a valuable resource for that reason alone. Other ecological functions served by the valley include nutrient and sediment transport, wildlife habitat and migration routes, and maintenance of a genetic pool for native flora and fauna (Bester, 1993).

2.5.2 Woodlands and Vegetated Riparian Areas

The forest cover in the Kettle Creek watershed, shown in **Map 2.4**, is estimated at 15 percent. The most common woodlots in the watershed are generally less than four hectares in size and are often fragmented from other forest tracts.

As a result, forest interior is only at one percent. This is extremely low, indicating that most of the woodlots are too small and/or narrow to support sensitive species that require large habitats within a significant core area.

Map 2.4: Forest Cover of the Kettle Creek Watershed



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In 2005, the Kettle Creek Conservation Authority (KCCA) received a $350,000 grant from Ontario Power Generation to plant a total of 200,000 trees throughout the watershed in 2006 and 2007. Using a circle analysis and a woodland buffer, planting sites were identified that could increase interior forest. A 100 metre external buffer was mapped around all woodlands greater than three hectares in size.

In addition, the watershed's forest cover has benefited from the Ministry of Natural Resources (MNR) Managed Forest Tax Incentive Program, which promotes the wise use of forested lands. All KCCA owned land in the watershed (754.83 acres) are recognized by the program. A further 47 acres of land were set aside by KCCA for reforestation in 2005. These lands will also be added to the program.

2.5.3 Wetlands

In the past, agriculture has had a devastating impact on wetlands in the Kettle Creek watershed. In the 1960's and 1970's farming changed in the watershed from mixed farming to cash crop. The result was more intensive agriculture with the removal of hedgerows and the claiming of marginal lands to make larger fields. Tile and drainage was also established as a common practice to create drier, workable parcels of land.

In the early 1980's the conservation community became concerned about the loss of wildlife habitat, specifically wetlands. KCCA undertook a number of studies in the early 1980's to determine the cause of wetland loss and develop rehabilitation plans. A wetland inventory was conducted in 1982 and again in 1984. Of the wetlands identified in 1982, almost one square kilometre or 98 hectares were lost by 1984.

Historically, the northwest quadrant of the watershed was scattered with wetlands. Today there are only two natural wetlands remaining: White's wetland and Sloan's wetland. The total percentage of wetlands left in the entire Kettle creek watershed is approximately half of one percent, the locations of which are shown in **Map 2.5**.

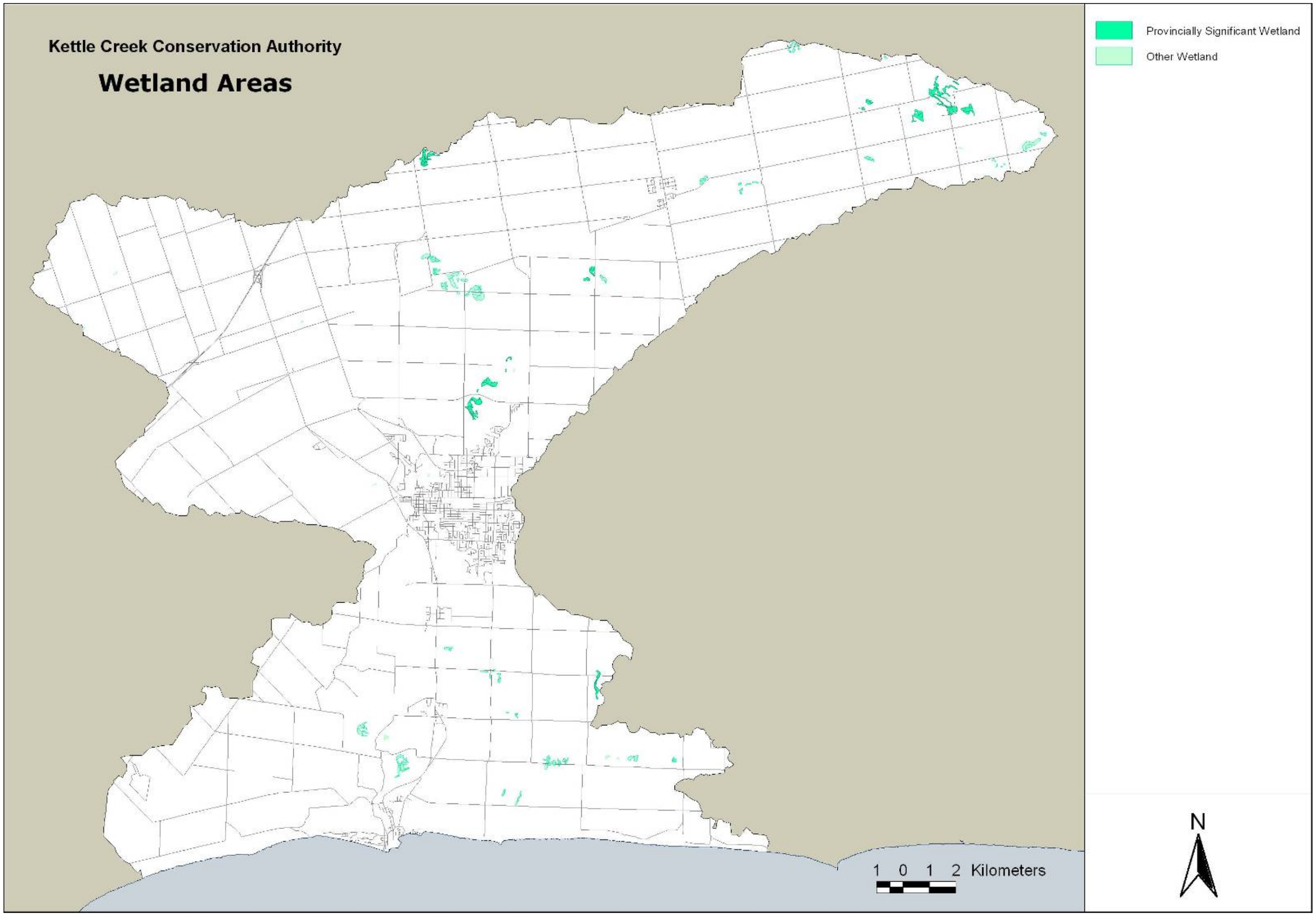
However, wetland rehabilitation is occurring. In the early 1990's the agricultural community embraced conservation practices such as no till and crop rotation. Moreover in 2005, KCCA engineered a small wetland complex near the crux of Highway 401 and County Road 15 in the northwest portion of the Dodd Creek basin. The $50,000 project was a partnership between KCCA, Green Lane Environmental Ltd., and Greenlane Community Trust Fund. Features such as the new wetland complex will help retain water from the spring snow melt to augment summer flows.

2.5.4 Environmentally Significant Areas

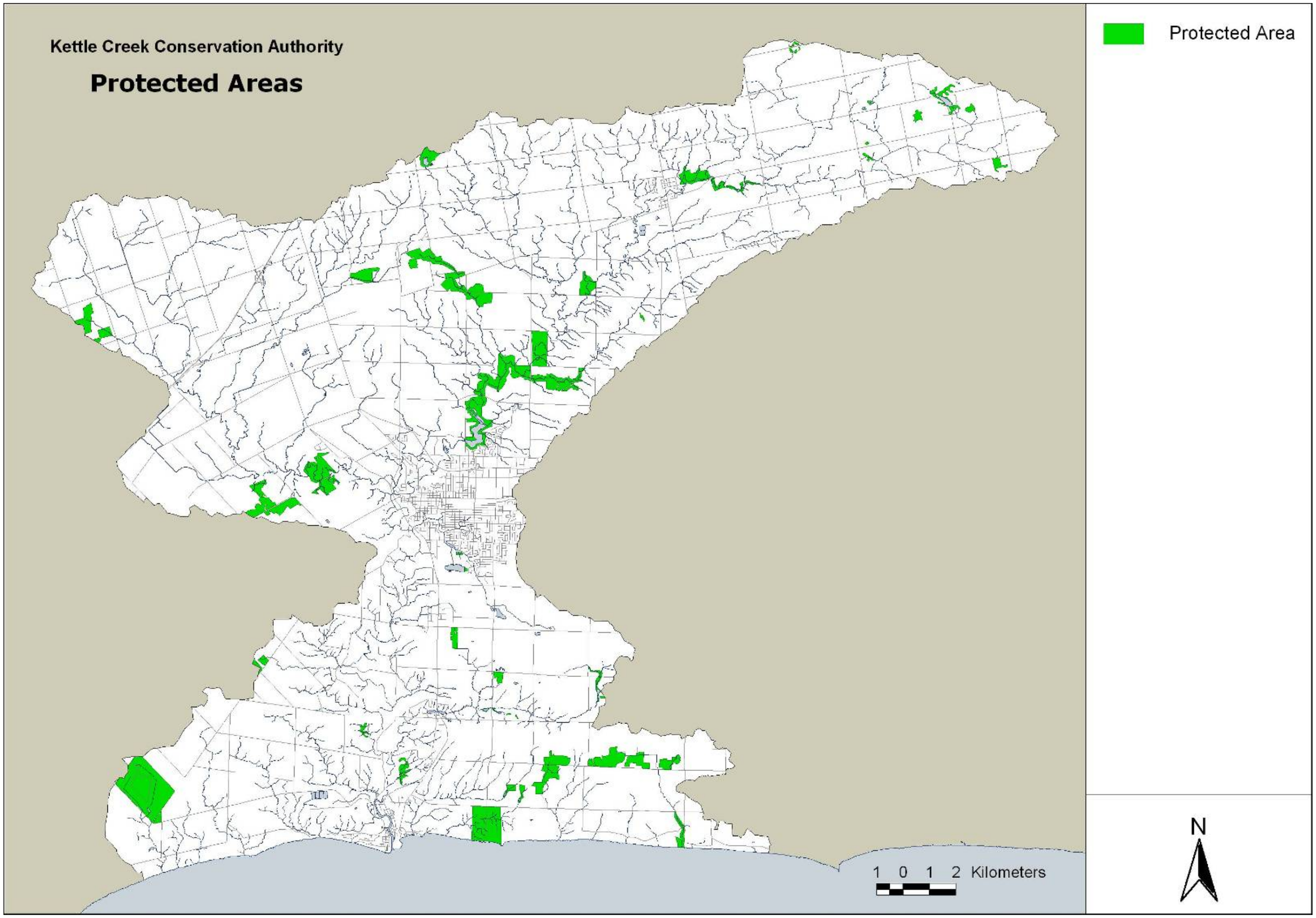
In 1993 KCCA undertook a study to identify Environmentally Significant Areas (ESAs) in the watershed. The study aimed to identify all the areas that had an inherent biological sensitivity in need of protection as representative of the region's natural heritage or distinct environmental function. This section provides a brief outline of each of those areas. **Map 2.6** shows the location of the ESAs in the Kettle Creek watershed.

Many additional wetlands and woodlots in the watershed that are not mentioned as ESAs serve either as buffers or flow regulators for those sections of the Kettle Creek bottomland in which they are located.

Map 2.5: Wetland Areas in the Kettle Creek Watershed



Map 2.6: Environmentally Significant Areas in the Kettle Creek Watershed



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Southwold Station Woodlot, Middlesex County
Total Area: 60.7 hectares

This is a relatively small woodlot on basically flat topography that contains both wet lowland and dry upland sections. The central area of the woodlot contains standing water, while the woodlot is surrounded by agricultural land. Natural drainage of the soil is poor due to the presence of clay loam.

The woodlot is disturbed by grazing, logging and logging trails. The wetter lowland areas contain silver and red maple while the dryer upland section is dominated by maple, beech and ash. The woodlot is excellent deer habitat. The present condition of the site is good, but the area is sensitive to any drainage activities.

St. Clair Junction Woodlot, Elgin County
Total Area: 113.2 hectares

This is one of the largest woodlots in the watershed. This site is located on a till moraine with soils of clay loam and sand. Standing water exists in the central portion of the woodlot and no running water has been observed. Good drainage exists in the upland areas. There is a diverse community of vegetation dominated by sugar maple and beech. Adjacent land uses are mostly agricultural with a railroad track running along the northern limit. The woodlot represents a large remnant area of the natural heritage of the watershed.

Middlemarch Forest, Elgin County
Total Area: 78.7 hectares

This forest complex is uncommonly well-sized for this watershed. Although little information could be compiled, Dodd Creek winds through the upper portion of the forest, giving it status as a part of the valley land system, possibly as a wildlife corridor. Further study is recommended for this site.

Futcher Woods, Elgin County
Total Area: 66.0 hectares

Situated on undulating terrain of rich loamy soil, one of Kettle Creek's tributaries runs through the northern most section of the woodlot feeding the sugar maple dominated stand. Mature white elm, ash, hickory, silver maple and beech dominate the remaining woodlot, however, logging is evident. Agricultural land and concession roads border this site. More study is recommended.

Fingal Wildlife Management Area, Elgin County
Total Area: 292.7 hectares

The Fingal Wildlife Management Area is a property managed by the Ministry of Natural Resources to produce quality wildlife, demonstrate techniques to conserve renewable resources and offer wildlife related recreational activities. This valuable program was created to demonstrate the compatibility of farming and wildlife management and is an excellent example of conservation education within the Kettle Creek watershed. There is also a large tall grass prairie feature.

This site hosts numerous land uses including agricultural lands of row crops and pasture as well as deciduous and coniferous forests, fence rows, open fields, wetland areas, walking paths and a sanctuary pond.

The site provides a good interpretation of the practices that demonstrate to the public the basic elements of upland wildlife habitat management. These practices maintain the properties attraction for migrating waterfowl and furbearers as well as provide an area for monitoring any progression and processes.

Moore's Water Garden, Elgin County
Total Area: 13.4 hectares
Wetland Class: 3
Wetland Type: swamp 60 percent; marsh 40 percent

This is a large single riverine wetland located near Port Stanley on the Lake Erie Plain. Adjacent land uses include row crops, pasture, abandoned agricultural land, and deciduous forest. Kettle Creek runs through the southern part of the wetland. The present owners utilize the marsh to supply wetland plants for their water garden business. Vegetation communities are not diverse but are well interspersed. These communities mainly consist of willows and cattails, with jewelweed and bur reeds common. The continued existence of the marsh is important for it provides suitable and significant local waterfowl staging habitat. Other species present include bullfrogs, snapping turtles, muskrats, raccoons and mink. The area is also within a migratory corridor for such species as the bald eagle, peregrine falcon and the northern harrier. The wetland is used by school groups and bird watchers for nature appreciation.

Hawk's Cliff, Elgin County
Total Area: 142 hectares

Hawk's Cliff lies within the Norfolk Sand Plain, with sandy loam on predominantly rolling topography. Hawk's Cliff is quite susceptible to erosion on the steeper slopes of 45 degrees and a height of 100 metres. Consequently, gullies have cut down into the underlying strata. The property fronts on Lake Erie for about 1,980 metres.

Hawk's Cliff has been recognized as one of the first hawk migration observation points in North America. The area is also a focal point for many other migratory bird species as it is not unusual to see thousands of Blue Jays in a single day during their migration. Other birds of interest in the forested area include the pileated woodpecker, ruffled grouse, and great blue heron, all of which are now uncommon in southern Ontario, but represent the remnant of populations which once occupied the area.

Other wildlife observed include: cottontails; jackrabbits; raccoons; brush wolves; white tailed deer; black squirrel; red fox, and woodchuck. The property has a very high wildlife potential because of the large area of cover and wide variety of habitats provided.

Salt Creek Woodlot, Elgin County
Total Area: 36.4 hectares

This site is located on generally flat topography with Salt Creek running through the middle. Adjacent land use is mainly agricultural. This site is excellent habitat for songbirds and other wildlife. Birdlife is abundant with over fifteen different species existing. Although none are uncommon to the watershed, the presence of Salt Creek attracts a wider array than most areas in the watershed. Silver maple and beech dominate with ferns, hawthorn, raspberries and jack-in-the-pulpit present. The woodlot is not used for commercial or recreational activities. It represents a large remnant area of the natural heritage of the watershed that should be protected.

Dexter's Woodlot, Elgin County
Total Area: 135 hectares
Wetland Class: 3
Wetland Type: swamp 90 percent; marsh 10 percent

This site is a complex of five small individual wetlands, surrounded by a relatively large woodlot. It is a riverine site with organic soils and is moderately effective as a short-term nutrient trap. The entire site is largely surrounded by agricultural land, row crops and pasture and is located adjacent to a rural road.

Vegetative communities are varied but poorly interspersed. Deciduous trees such as black ash, sugar maple and beech dominate, with jewelweed, sedges, grasses, duckweeds and mosses present. More than half of the trees in the complex are mature and timber is harvested from the area. The varied vegetative communities provide habitat for such species as bullfrogs, snapping turtles and raccoons. The area is also breeding and feeding habitat for the northern harrier as well as the bald eagle and peregrine falcon, both of which are endangered animal species. Human disturbance is limited to the effects of the harvesting of timber and the moderate amount of hunting that occurs. This woodlot is large for the watershed and has an unusually high biodiversity of communities.

Barnum's Gully, Elgin County
Total Area: 169 hectares

Barnum's Gully is situated on the north shore of Lake Erie and extends inland in a northerly direction for a distance of 850 metres. The gully varies in width and generally drains approximately 780 hectares of primarily agricultural land. At the northern limit of the gully a number of residential dwellings, various farm buildings and two township roads are in close proximity to the gully slopes. The gully invert consists generally of a "V" shaped channel with side slopes inclined at 30 to 40 degrees to the horizontal. Barnum's Gully is approximately 30 metres in depth. The small, three metre wide creek at the bottom of the gully is actively down-cutting the base of the channel. The side slopes are generally bare of vegetation and actively eroding. A woodlot, primarily maple and beech, exists along the gully and portions of the upland. The upland also contains small standing ponds approximately 4.5 metres around and 1.7 metres deep.

Barnum's Gully is an excellent example of natural mass wasting and other geomorphological processes. Although the gully's' expansion is threatening the upland woodlot, it is a natural process that is a good representation of a distinctive and rare landform in the Kettle Creek watershed.

EY-9, Elgin County
Total Area: 17 hectares
Wetland Class: 3
Wetland Type: swamp 62 percent; marsh 38 percent

This site is situated on a palustrine site with entirely mineral soils. It consists of a woodlot and a wetland that feeds the surroundings; row crops, pasture, deciduous forest and creeks. Vegetation is somewhat diverse with mixed communities of burreeds, spike-rush, dog willow, duckweed, jewelweed and other herbs. Showy Orchids have also been observed in the woodlot. The site also lies within a migratory corridor and is occasionally used by the migrating peregrine falcon.

The area is relatively free of disturbances although a drainage ditch runs close to the wetland which has already been partially drained by the owner to stop hunting. The area has acted as a locally significant waterfowl area in the past.

EY-9 is located within one kilometre of EY-10 but they are not connected hydrologically by surface water.

EY-10, Elgin County
Total Area: 126.6 hectares
Wetland Class: 3
Wetland Type: swamp 100 percent

This site is palustrine with mineral soils. Adjacent land uses include row crops, pasture, abandoned agricultural land, deciduous forest, fence rows as well as a stream running through. Other wetlands are nearby, but not hydrologically connected. Communities of soft maples, black ash and grasses are present. This wetland provides habitat for such species as snapping turtles and raccoons as well as the provincially significant peregrine falcon during migration. This class three wetland is hydrologically important to the lower half of the watershed and hosts a variety of species.

Corner's Pond, Elgin County
Total Area: 74.39 hectares
Wetland Class: 3
Wetland Type: swamp 70 percent; marsh 30 percent

This wetland is located in the fertile agricultural area southeast of St. Thomas. It is a riverine site, which provides some water quality improvement and erosion control, although open water is present in a single central area. A spring empties into the pond which is a crucial water source needed for the re-establishment of cold water fisheries along Beaver Creek. At present, the pond is used for irrigation purposes, wildlife habitat and a plantation site. It is threatened by water pollution and continued siltation. The pond will eventually turn from pond to marsh to meadow.

This site is surrounded by rural roads, field crops, pasture and deciduous forests. Vegetative communities are not very diverse but are moderately interspersed. Dense cover of dogwood, willow and bush honeysuckle dominate. These communities provide habitat for bullfrogs, snapping turtles, muskrats, raccoons, mink, red fox and the regionally significant beaver. The area provides a breeding and feeding habitat for the marsh wren and northern harrier as well as being migratory habitat for the endangered bald eagle and peregrine falcon. It is also nesting habitat for the great blue heron.

Jolley's Swamp, Elgin County
Total Area: 15 hectares
Wetland Class: 3
Wetland Type: swamp 44.5 percent; marsh 55.5 percent

Jolley's Swamp is composed of five small wetlands located on a westward extending plain. Glacial till moraine barely reaches the edge; small traces of it entering the swamp are seen in the form of low knolls. While this palustrine site is situated on organic and mineral soils, from 30 – 60 centimetres of organic peat overlies white marl throughout the swamp.

Due to the high water table, the presence of a spring and records of flowing artesian wells, Jolley's Swamp is in a groundwater discharge area. This feature is relatively significant to the Kettle Creek watershed in terms of flow augmentation and minimized flood peaks. Springs associated to the wetland are important for the establishment and maintenance of cold water fisheries in Beaver Creek which relies on the swamp as its source.

Cattails, duckweed and beggars ticks dominate in the marsh areas; while maple, ash and dogwood dominate in the swamp. These areas also host the locally rare crested wood fern and several rare species of moss including the second occurrence of sphagnum tenerum moss in Ontario. White cedar peat soil, ladies slippers and tamarack are all threatened in the swamp.

Bullfrogs, snapping turtles, muskrats and raccoons can be found in Jolley's Swamp. Jolley's Swamp is significant as it is located in the migratory corridor that provides habitat during migration for the bald eagle and the peregrine falcon. It is also a feeding area for the great blue heron.

Wiener's Woodlot, Elgin County
Total Area: 14.1 hectares
Wetland: Class 3
Wetland Type: swamp 100 percent

This small palustrine site lies mainly on organic soils. It is surrounded by agricultural land, and urban development. Most of the area is covered by open water. Vegetative communities primarily consist of dead trees, shrubs and young maples which occur over much of the area. Waterfowl staging and production of local significance has been observed. This site is located within a migratory corridor for the endangered bald eagle and peregrine falcon. Timber harvesting has occurred and the owner at one time wished to drain the man-made pond along one side. This wetland hosts a high biodiversity of communities and is habitat for rare or endangered indigenous species.

Kettle Creek Woods/Dalewood Wetlands, Elgin County
Total Area: 242.8 hectares
Wetland Class: 1
Wetland Type: swamp 71.5 percent; marsh 28.5 percent **

Kettle Creek Woods or the Dalewood Wetlands consists of twelve individual wetlands. The site type is mainly riverine although some palustrine and lacustrine areas are present. Soils are mainly clay and silt loams with good drainage. The Kettle Creek Woods facilitates erosion control as well as flood control and flow stabilization due to size and location. Water levels are affected by a nearby reservoir. Adjacent land uses include row crops, pasture, abandoned agricultural land, deciduous and coniferous forest and some residential.

Vegetation communities are diverse. In the woodlot areas, sugar maple, black maple, red maple and beech dominate. Cattails, sedges, willows and grasses occur in mixed communities.

Due to the high diversity and relatively undisturbed environment, Kettle Creek Woods provide excellent wildlife habitat. Bullfrogs, snapping turtles, muskrats, raccoons, red foxes and weasels are present. The area is also a regionally significant staging and breeding habitat for such waterfowl as the great blue heron, great egret, northern harrier, osprey and the sharp-shinned hawk. Other significant species include the milk snake, pickerel frog and the northern ribbon snake.

Kettle Creek Woods is used for some educational and recreational activities. Hunting is not allowed.

**Since this information was collected in 1993 the wetland has actually shown growth, and is now considered provincially significant. For more information refer to section 2.9 Aquatic Ecology (Hall, 2006).

Glanworth Complex, Middlesex and Elgin Counties
Total Area: 38.2 hectares
Wetland Class: 2
Wetland Type: swamp 85 percent marsh 15 percent

This is a palustrine site located on gently rolling to flat topography that acts as an important water source area for Kettle Creek. Open water, in the form of small ponds and channels is abundant in the complex, although drainage ranges from average to poor. Surrounding habitats include agricultural land, pasture, urban and industrial development and deciduous forest. Some logging has occurred. Vegetative communities are diverse with communities of trees, shrubs, floating plants, emergents and submergents existing. Beech and maple dominate. This biological diversity enables the area to support a wide variety of wildlife. Bullfrogs, snapping turtles, muskrats, raccoons as well as the regionally significant beaver are present. The provincially significant pied-billed grebe and northern harrier are found in the complex. The area also provides feeding habitat for the great blue heron. The wetland is located on the Lake Erie Plain, a region in which wetlands are scarce. Drainage of the area would cause major habitat change and alteration of vegetation. This wetland is classified as provincially significant.

Glanworth Woods Extended, Elgin County
Total Area: 52.5 hectares
Wetland Class: 2
Wetland Type: swamp 85 percent; marsh 15 percent

This site, located just south-east of Glanworth Complex is composed of a large swamp area, a woodlot and a gravel pit. This site has the potential to be rehabilitated into a healthy, productive wetland. Adjacent land uses include farmland for grain crops, pasture for cattle grazing and rural roads. This site is a possible area of groundwater discharge and may contribute to flood peak reduction as it is fairly large. Collectively, Glanworth Complex and this extended site are considered to be the most important wetland complex in the Kettle Creek watershed. The wetlands act as a water source and water storage area for Kettle Creek. Logging, drainage of the ponds and the extension of the gravel pit are all existing dangers to this site. Beech and maple dominate the vegetative community. This community provides habitat for the provincially significant pied-billed grebe and northern harrier as well as the regionally significant beaver.

Pitcher Plant Bog, Elgin County
Total Area: 9 hectares
Wetland Class: 3
Wetland Type: fen 37 percent; swamp 43 percent; marsh 20 percent

This unique botanical area is located on a section of the Mount Elgin Ridges. The bog is palustrine and probably formed in an old kettle lake. It also represents an acidic bog habitat that is in a present state of advanced succession. A floating mat of sedge and grass has developed over the bog so that any open ponding of water has been eliminated. This mat covers the entire area except for the wet trench surrounding the bog. Vegetation consists mainly of willows, cattails and sensitive fern, while the actual bog mat is composed of Canada bluegrass, sphagnum moss, bog cotton and the provincially significant pitcher plant. The mat in the bog supports the only known stand in the watershed of the pitcher plant.

Significant bird species include the northern harrier and the marsh wren. From an educational point of view, the bog is typical of the natural process of succession in nature and according to naturalists is the only representation of this in the watershed. It has still not been determined if it is a true bog.

Kirk Cousins Management Area, City of London
Total Area: 80.9 hectares
Wetland Class: 3
Wetland Type: 100 percent swamp

The Kirk Cousins Management Area is a diverse complex of wetlands ranging in size from 0.3 hectares to 13 hectares. It is primarily a palustrine site but a small portion is isolated.

Open water in the wetland occurs in scattered ponds of various sizes but is not abundant. The area is connected by surface water to other wetlands providing habitat linkage for wildlife and is an important source area for Kettle Creek. Hills, creeks, crops and pasture land and deciduous and coniferous forests surround the area. Vegetative communities in the wetland are quite diverse and are moderately interspersed.

Buttonbush, dead trees, elms, maples, beech, oak, willows and dogwoods are common and cattails, duckweeds and submergents dominate the marsh areas. Grasses, sedges and herbs are also abundant. More unique species include tamarack, pitcher plants and leather leaf.

The wide array of wooded swamps and marshes provide a locally significant waterfowl staging and breeding habitat. Muskrats, raccoons as well as the regionally significant beaver are also present.

The natural quality of the area has been disrupted to a moderate extent, mainly by water pollution. Adjacent land uses include agricultural and school grounds.

Of note, the main pond in this complex is being used as tertiary sewage treatment facility for the Regina Mundi College. As a result, the pond is heavily laden with phosphorous and nitrates and fish are stunted. Rehabilitative work on this property can only begin when a sewer is installed and the pond is no longer used as a treatment facility.

ESD 8, Wetland 1 -11, Elgin County
Total Area: 6.6 hectares
Wetland Class: 6
Wetland Type: swamp 49 percent; marsh 51 percent

This site is comprised of individual wetlands surrounded by woodlots, along the upper reach of Kettle Creek on the Lake Erie Plain. The site is palustrine with permanent or intermittent outflow. Surrounding habitat includes row crops, pasture as well as ravines leading to Kettle Creek. Vegetative communities include grasses, sedges, herbs, cattails, dogwood, willow and other deciduous trees. These communities provide habitat for such species as bullfrogs, raccoons and muskrats as well as the regionally significant beaver. This site is also an active feeding area for the great blue heron. This clearly distinct landscape is relatively absent of human disturbance. This is a wetland area providing flow regulation and wetland community components.

MN-4,5, Middlesex County
Total Area: 6.75 hectares
Wetland Class: 7
Wetland Type: swamp 80 percent; marsh 20 percent

These sites compose a complex of wetlands and woodlots. Adjacent land uses vary, including row crops, pasture, fence rows, deciduous forests, urban development as well as a major highway. This highway, which is fairly close to MN-4, is placing stress on the wetland. Cattle grazing, logging and garbage are also threatening the preservation of these wetlands.

These sites provide breeding and feeding habitat for the northern harrier. Tall shrubs and narrow-leaved emergents exist in this complex as well as burreeds, willows, dogwood and tamarack. These vegetative communities provide habitat for bullfrogs, snapping turtles, raccoons and muskrats. These wetlands provide diverse communities and base flow regulation.

ESD 4,5, Middlesex County
Total Area: 2.25 hectares
Wetland Class: 6
Wetland Type: swamp 70 percent; marsh 30 percent

This distinct area consists of four individual palustrine wetlands, all of which are of soils of clay, loam or silt. Adjacent land use includes row crops, pasture, abandoned agricultural land, fence rows, deciduous forest as well as the creek which feed the wetlands.

Vegetative communities include tall to mixed shrubs, grass, deciduous trees, jewelweed, mixed ground cover and duckweed. This diverse community provides habitat for such species as snapping turtle, muskrat, as well as the regionally significant beaver. The site also provides breeding and feeding habitat for the northern harrier.

The danger of drainage exists, and stress is being placed on the wetland because it is close to a road. This wetland area provides maintenance of vital ecological processes such as base flow regulation.

Lake Whittaker Swamp, Middlesex County
Total Area: 29.5 hectares
Wetland Class: 2
Wetland Type: swamp 79 percent; marsh 21 percent

This is a complex of three individual wetlands. The dominant site types are lacustrine and palustrine and a small proportion are riverine. Surrounding land uses are highly diverse, including cropland, pasture as well as deciduous and coniferous forest and deep water areas. As a headwater of Kettle Creek, this wetland provides an important function in maintaining summer stream flow augmentation.

There is little open water in this wetland, but because it is widely dispersed, the water edge area is high. The presence of a kettle lake gives this wetland some geological interest.

Vegetative communities here are diverse and moderately well interspersed. Areas of submergents, narrow-leaved emergents and floating plants are interspersed with communities of tall shrubs, robust emergents and herbs in both swamp and marsh areas of the wetland. Dominant species include jewelweed, waterweeds, sedges, duckweeds, dogwoods and cattails.

Lake Whittaker Swamp is habitat for such species as bullfrogs, snapping turtles, muskrats, raccoons, beavers and mink. The area is used extensively for fishing and boating and fish are abundant for at least part of the year. Both the pied-billed grebe and the northern harrier can be found in the area, which is also a feeding area for colonial waterbirds.

Hearns Woodlot, Middlesex County
Total Area: 9.6 hectares
Wetland Class: 3
Wetland Type: swamp 78 percent; marsh 22 percent

This woodlot and wetland are located on a palustrine site with mixed soils on gently rolling topography. Moderately diverse surroundings of abandoned fields, and crop and pasture land exist. Open water occupies much of the area and is well distributed through the swamp. The area acts as a source for Kettle Creek augmenting low flows. Vegetative communities in the wetland are diverse but poorly interspersed. Dominant varieties of vegetation include sugar maple, beech, cattails, duckweed and waterlilies.

Hearns Woodlot is a sustainable wildlife habitat where bullfrogs, snapping turtles, muskrats, raccoons, mink as well as the regionally significant beaver can be found. The area is also important for waterfowl staging and production. Significant species include the pied-billed grebe, black-crowned night heron, northern harrier, short-eared owl and marsh wren.

White's Wetland, City of London
Total Area: 14.2 hectares
Wetland Class: not ranked

This woodlot is a swamp with predominantly seasonal standing water. Adjacent land uses are mainly agricultural land and rural roads. Vegetative communities are dominated by silver maple, red maple, spicebush, yellow birch and skunk cabbage. This area is a significant contributor to base flow in Dodd Creek. Further study is strongly recommended due to the fact that little information has been compiled on the area.

Lake Margaret, Elgin County
Total Area: 42 hectares

Lake Margaret is a retired gravel pit that is filled in with natural groundwater. The lake is privately owned. This lake is significant because surrounding soils are predominately gravel and afford for predominately clear waters within the lake (as opposed to most water systems in this area which are murky due to high clay contents in surrounding soil.) This lake provides recharge to Mill Creek. There are significant bass populations within the lake and general habitat of the lake would be suitable for trout stocking.

Pinafore Wetland, Elgin County
Total Area: 2 hectares

This small two hectare wetland is situated at the southern terminus of Pinafore Lake. Despite its small size the wetland contains numerous forms and remains relatively undisturbed. The wetland is predominately swamp in nature with some marsh components and open lake areas.

2.5.5 Flora and Fauna

The Kettle Creek watershed's diverse flora and fauna is due in large part to its geographic location within the Carolinian Life Zone. This zone is affectionately known as the "banana belt" of Canada due to warm annual temperatures and mild winters (Baron, 2003).

Tree species such as maple, beech, birch, white and red oak, walnut, elm and ash predominate in the watershed with a few remnant stands of hemlock, cedar, tamarack and white pine.

Elgin County was among the earliest settlements in the area to come under the influence of the axe with most original stands cleared by 1880 (Stewart, 1992). Today forest cover in the County is estimated at 17 percent. This is continuously bolstered by the Elgin County Tree By-law's "no net loss policy". In addition, KCCA plants on average, 60,000 trees per year with the help of local landowners. In 2006, KCCA secured a $350,000 grant from Ontario Power Generation to plant a total of 200,000 trees in the watershed from 2006 – 2007.

The occurrence and distribution of mammal species in the watershed is influenced by the availability of habitat and natural food sources (Baron, 2003). Early records describe sightings of cougars and bears (Stewart, 1982). In 1982, William G. Stewart wrote in a study of mammals in Elgin County that the opossum was still a rare visitor to the region. At the time Stewart believed, "the geographical and climatic boundary formed by the Great Lakes waterway creat[ed] a physical barrier to species of more northern or southern distribution or species from east to west."

Today bear in the watershed is unheard of and the opossum an all too regular sighting.

William G. Stewart has done an extensive inventory of flora and fauna in the watershed. For a complete listing of species please see his series of publications listed in the Bibliography.

Species at risk, rare and/or endangered in the Kettle Creek Conservation Authority watershed as reported by the Natural Heritage Information Centre website are summarized in **Table 2.2** and **Table 2.3**.

Table 2.2: Summary of Endangered, At Risk or Rare Flora in the Kettle Creek Watershed.

A Moss	American Ginseng	Azure Bluet
Blue Ash	Brainerd's Hawthorn	Broad Beech Fern
Bulbostylis	Burning Bush	Bushy Cinquefoil
Colicroot	Cream Violet	Crooked-stem Aster
Double-striped Bluet	Eastern Few-fruited	Erect Knotweed
False Rue-Anemone	Fall Witch Grass	Forked Blue Curls
Frank's Sedge	Goose-foot Corn-salad	Green Dragon
Hairy Pinweed	Halloween Pennant	Hill's Pondweed
Eastern Prickly Pear Cactus	Lechea villosa	Long-styled Cdn. Snakeroot
Lowland Brittle Fern	Nebraska Sedge	Purple Love Grass
Rayed Bean	Red-root Flatsedge	Schweinitz's Flatsedge
Shinners Three-awned Grass	Slender Bluet	Slender Eight-flowered Fescu
Small-flower Groovebur	Southern Tickseed	Spoon-leaved Moss
Stiff Gentian	Stiff Goldenrod	Sullivant's Milkweed
Swamp Darner	Swamp Rose-mallow	Swan's Sedge
Toadflax	Yellow Screwstem	White-hair witch Grass
Wild Bean		

Table 2.3: Summary of Endangered, At Risk or Rare Fauna in the Kettle Creek Watershed

Acadian Flycatcher	Amber-winged Spreadwing	American Badger
Bald Eagle	Blanding's Turtle	Canvasback
Eastern Amberwing	Eastern Hog-nosed Snake	Eastern Red Damsel
Eastern Ribbonsnake	Gravel Chub	Greater Redhorse
Greenside Darter	Golden Redhorse	Henslow's Sparrow
Least Bittern	Loggerhead Shrike	Milksnake
Monarch Butterfly	Northern Bobwhite	Painted Skimmer
Pronghorn Clubtail	Red-headed Woodpecker Ruddy Duck	Ruddy Duck
Sharp-fruit Rush	Silver Chub	Small-footed Bat
Spiny softshell turtle	Variegated Meadowhawk	White-eyed Vireo
Wood-vetch	Woodland Vole	Yellow-breasted Chat

2.5.6 Birds

Volunteers with the Ontario Breeding Bird Atlas conducted a survey at three sites in the Kettle Creek watershed (Kirk-Cousins Management Area, Dan Patterson Conservation Area, Dalewood Conservation Area Trail) for five consecutive years from 2001 to 2005. Seventy-nine species were observed at Kirk-Cousins, 43 species at Dan Patterson, and 44 species at Dalewood Trail. Confirmed to be breeding species at each site are summarized in **Table 2.4, Table 2.5, and Table 2.6**.

Table 2.4: Breeding Bird Species at Kirk Cousins Management Area.

American Robin	American Woodcock	Bobolink
Canada Goose	Cedar Waxwing	Common Grackle
Eastern Meadowlark	European Starling	Great Horned Owl
Green Heron	Killdeer	Mallard
Northern Flicker	Red-winged Blackbird	Savannah Sparrow
Willow Flycatcher	Wood Duck	

Table 2.5: Breeding Bird Species at Dan Patterson Conservation Area.

American Robin	Baltimore Oriole	Black-capped Chickadee
Blue-gray Gnatcatcher	Chipping Sparrow	Eastern Phoebe
Eastern Towhee	Field Sparrow	Gray Catbird
House Wren	Warbling Vireo	Wood Duck
Sharp-shinned Hawk	Sharp-tailed Grouse	Yellow Warbler

Table 2.6: Breeding Bird Species at Dalewood Conservation Area Trail.

Black-capped Chickadee	Hairy Woodpecker	House Wren
Indigo Bunting	Northern Cardinal	Red-eyed Vireo
Yellow-billed Cuckoo	Yellow Warbler	Wood Thrush

A Christmas Bird Count has been conducted in the watershed since 1949 by the St. Thomas Field Naturalist Club. These statistics are compiled on the Audubon Christmas Bird Count Database web site (www.audubon.org/bird/cbc/). On average this yearly bird count is conducted by over 30 volunteers at different venues in a 24 kilometre radius around the city of St. Thomas.

The following chart is the results of the 2005 Christmas Bird Count as conducted by the St. Thomas Field Naturalists.

2.6 Climate

The Kettle Creek watershed enjoys a temperate climate compared to other parts of Southern Ontario. Lake Erie moderates the climate by absorbing heat from the sun during the summer months and releasing it slowly throughout the winter months. Winds coming across the lake are warmer in winter and cooler in summer than the land. This results in a temperate climate with a longer frost-free growing season.

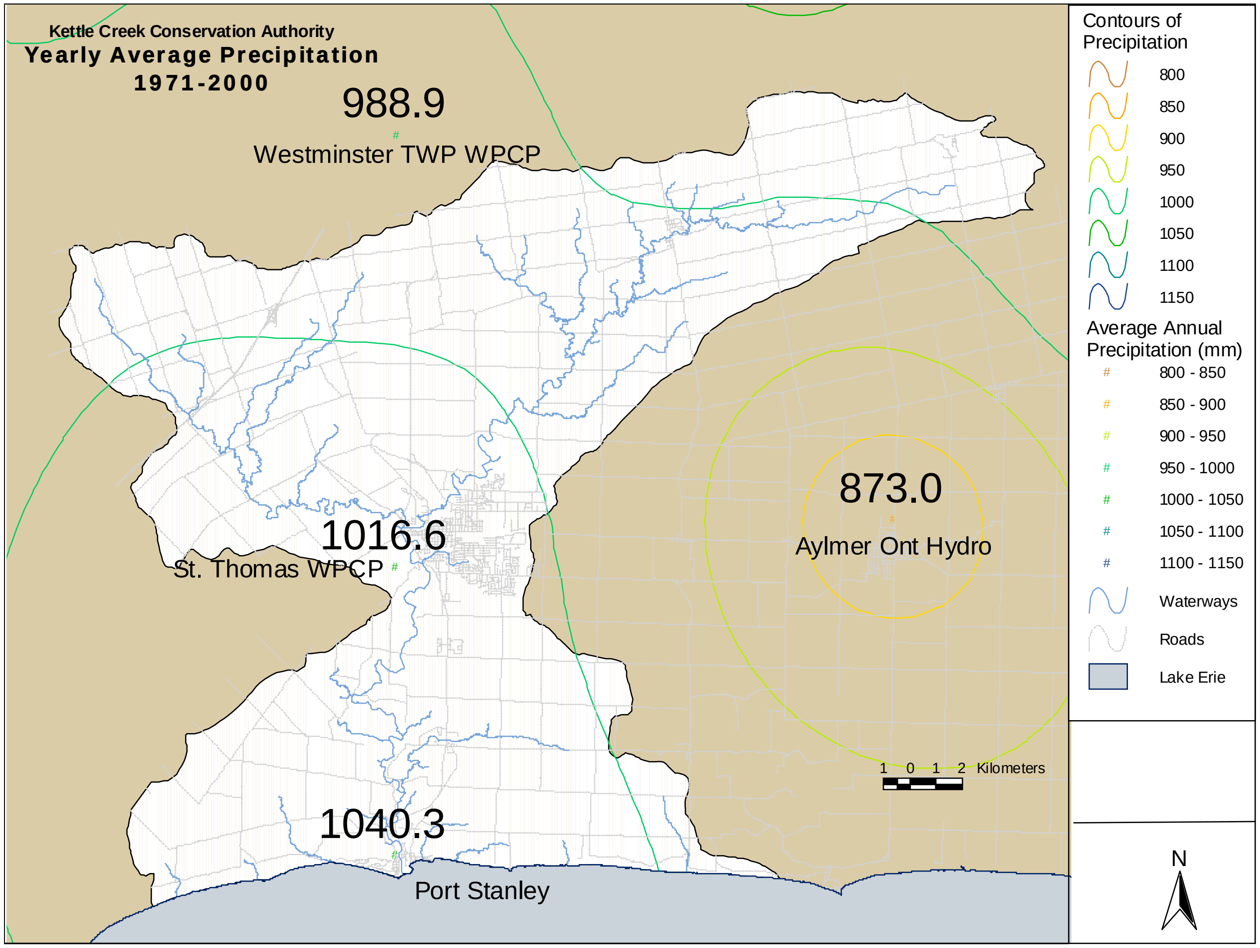
General weather patterns in this region consist of four distinct seasons. Winter is generally considered to have temperatures lower than zero degrees Celsius, beginning in December and lasting until late February or early March. Spring is generally only two months, followed by four months (June to September) of summer and two months of autumn (Sanderson, 1998). The average annual temperature is about 7.5 to 8.5 degrees Celsius. Extreme temperatures in this region have been known to reach as low as -32 degrees Celsius in January and as high as 38 degrees Celsius in July (see **Table 2.7**).

Annual average precipitation over the watershed is generally between 950 millimetres to 1,075 millimetres, as seen in **Map 2.7**. A majority of precipitation in the winter falls as rain. Even in January, generally the coldest month of the winter, more than half the precipitation falls as rain. Snowfall across the watershed is between 115 millimetres to 150 millimetres combined over the months of November to April. Precipitation is monitored at various locations throughout the watershed, as shown in **Map 2.8**.

Precipitation is fairly evenly distributed throughout the year, although the intensity, duration and frequency of precipitation events are quite different among the seasons. The accumulation of snow in the winter months makes the effects of the precipitation longer, as infiltration is delayed until a thaw. The spring thaw 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 quite evenly distributed throughout the year despite the perception of wetter and drier seasons in this region.

Map 2.7: Annual Average Precipitation in the Kettle Creek Watershed



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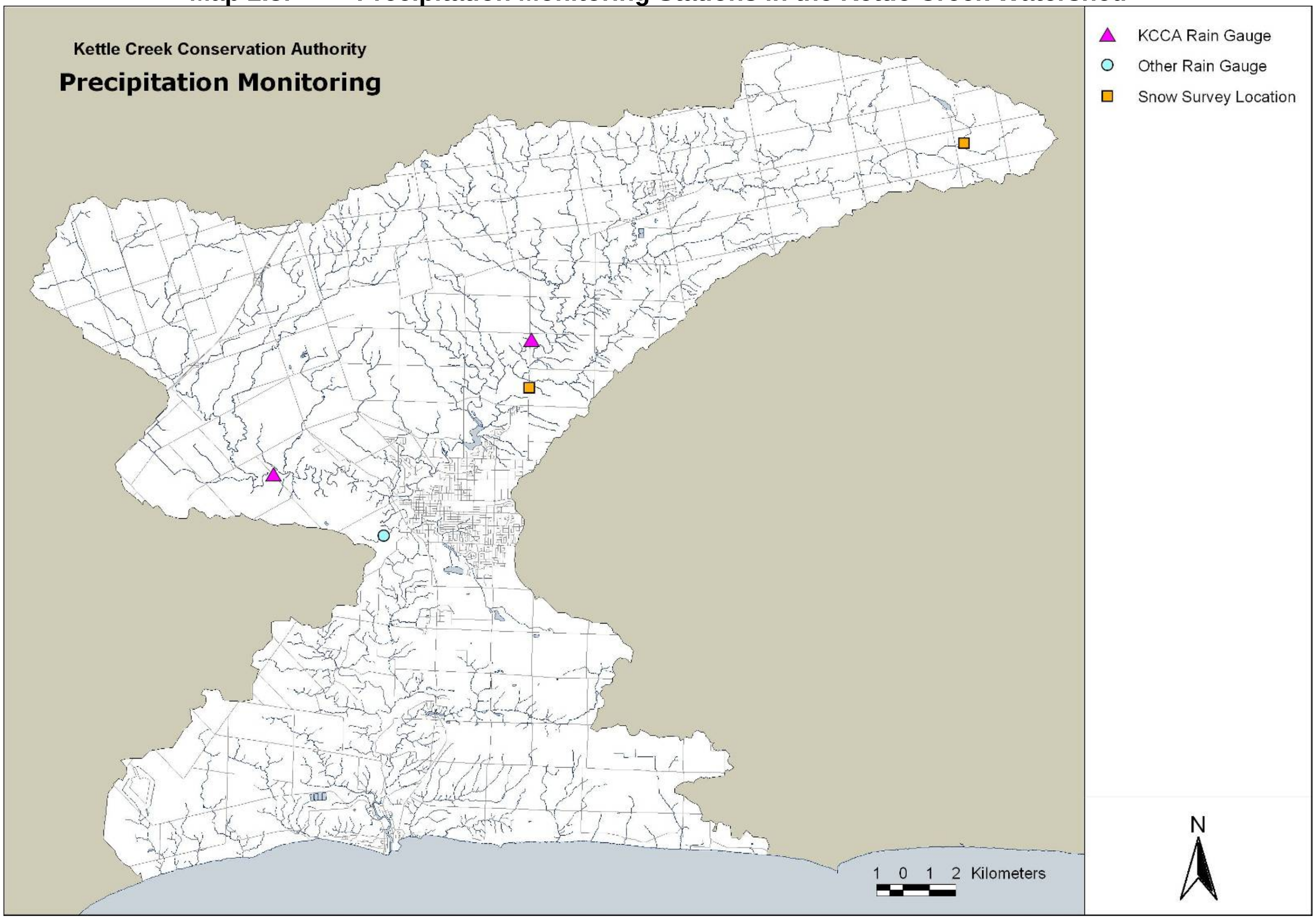
Environment Canada. "Canadian Climate Normals 1971-2000." 18 April, 2006. http://www.climate.weatheroffice.ec.gc.ca/climate_normals/index_e.html

Map 2.8: Precipitation Monitoring Stations in the Kettle Creek Watershed



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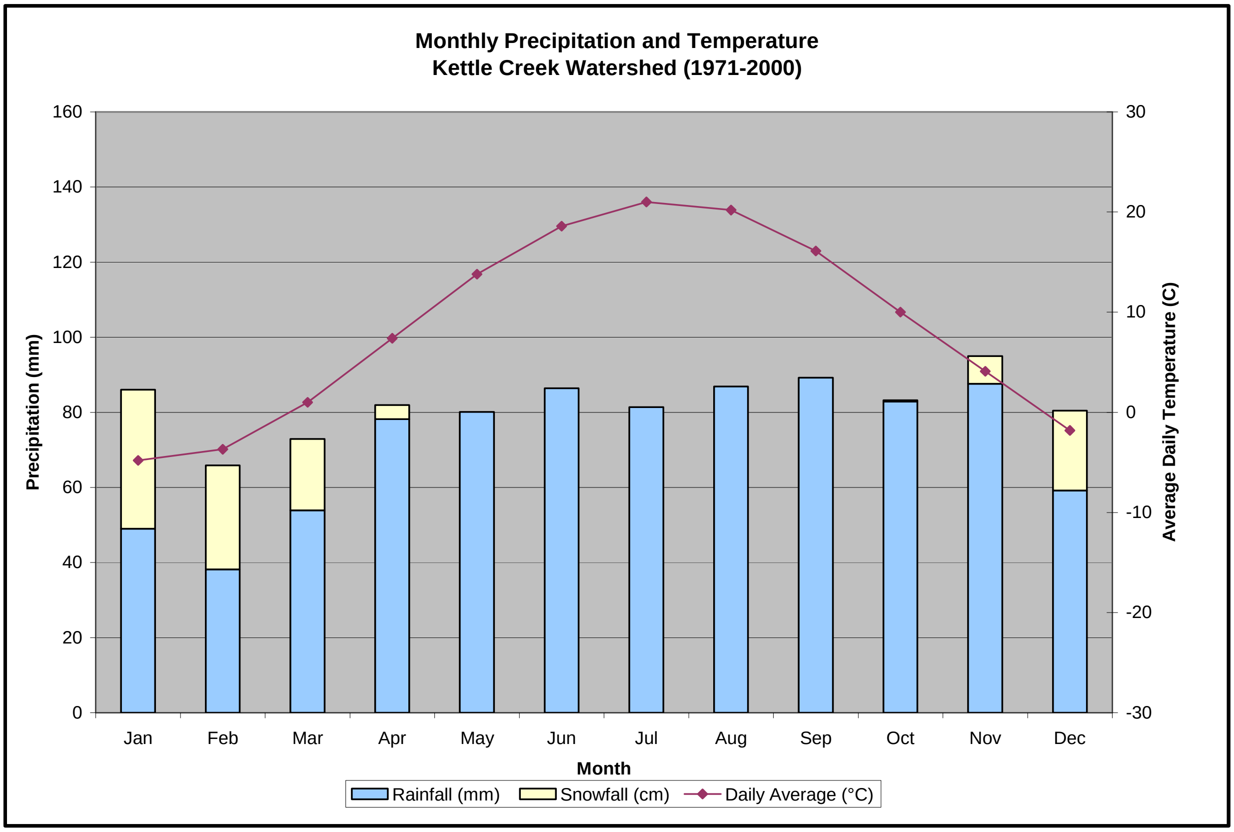
Mapping based partially on data contained within Environment Canada's Inventory of Climate Observing Networks in Ontario (ICONO) database.

Table 2.7: Temperature Characteristics in the Kettle Creek Watershed

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		
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	
St. Thomas WPCP	Daily Average (°C)	-4.8	-3.7	1	7.4	13.8	18.6	21	20.2	16.1	10	4.1	-1.8	8.5
	Standard Deviation	2.7	2.6	1.9	1.4	2.1	1.3	1.1	1.3	0.8	1.5	1.4	3	1
	Daily Maximum (°C)	-0.9	0.6	5.6	12.9	19.9	24.5	26.8	25.8	21.5	15.1	7.8	1.7	13.4
	Daily Minimum (°C)	-8.6	-7.9	-3.7	2	7.8	12.6	15.2	14.6	10.7	4.9	0.3	-5.3	3.5
	Extreme Maximum (°C)	14.5	18.5	24.5	29.5	32.5	38	37	34.5	32.5	26	21.5	18.5	
	Extreme Minimum (°C)	-31	-30	-23.5	-16	-3	1	6	0	-2	-7	-13.5	-27.5	
Westminster TWC WPCP	Daily Average (°C)	-6.3	-5.7	-0.1	6.7	13.2	18	20.7	19.7	15.5	9.2	3.3	-2.8	7.6
	Standard Deviation	2.9	2.7	2.1	1.6	1.9	1.3	0.9	1.1	1	1.8	1.5	2.5	1.2
	Daily Maximum (°C)	-2.7	-1.8	4	11.8	19.1	23.8	26.5	25.4	20.8	14	7	0.6	12.4
	Daily Minimum (°C)	-9.9	-9.7	-4.2	1.6	7.3	12.1	14.7	14	10.1	4.4	-0.3	-6.1	2.8
	Extreme Maximum (°C)	13.9	14	24	29	31.7	37	37	35	32.5	29.4	22.2	18.5	
	Extreme Minimum (°C)	**-32.2**	-30.6	-27	-13	-5.6	-1.1	3.3	1	-3.9	-9.4	-13.5	-28.9	
London A	Daily Average (°C)	-6.3	-5.5	-0.3	6.3	13	18	20.5	19.5	15.3	9	3.1	-3	7.5
	Standard Deviation	2.8	2.9	2.3	1.7	2.1	1.4	1.1	1.2	1.1	1.7	1.6	2.7	0.8
	Daily Maximum (°C)	-2.4	-1.4	4.2	11.6	19	23.8	26.3	25.2	20.9	14	6.9	0.6	12.4
	Daily Minimum (°C)	-10.1	-9.7	-4.7	1	7	12.1	14.6	13.7	9.6	4	-0.7	-6.5	2.5
	Extreme Maximum (°C)	16.7	17.8	24.8	29.4	32.4	**38.2**	36.7	37	34.4	30	24.4	18.5	
	Extreme Minimum (°C)	-31.7	-29.5	-24.8	-12.2	-5	-0.6	5	1.5	-3.3	-11.1	-18.3	-26.9	

The water requirements for human and environmental purposes over the course of the year, however, are quite variable. Often during the summer months, the climate can not replenish the streams and groundwater aquifers. However, there is often a surplus of water for human and environmental needs in the winter and spring.

Figure 2.1: Normal Average Precipitation and Temperature for the Kettle Creek Watershed



2.6.1 Climate Data Gaps

Climate trends for precipitation and temperature are limited by the sparse coverage of weather stations. There are fewer than 550 stations currently collecting data in the entire Province of Ontario and not all of these stations collect the same information. It is difficult to accurately assess the climate of an area that is lacking a weather station as weather can be very localized.

Precipitation data is especially difficult to map, since it can vary drastically across a small area and it is often not uniformly distributed. Unless there are several precipitation gauges directly underneath a storm cell, it will not accurately capture the storm's variability and area of influence. For example, weather fronts and convection storms create distinct boundaries of precipitation so interpolating results between weather stations will not derive accurate results.

Temperature is much less variable across an area and generally is more accurate to estimate between weather stations that are further apart.

There is a need to have provincial maps for both precipitation and temperature for seasonal and longer term trends. Standardizing the methods used to create isolines of either precipitation or temperature for the province could provide some consistency to estimates between climate stations. Restoring some of the many weather stations that were previously in use (there were more than 1,100 weather stations in the province between 1960 and 1980) would provide better coverage.

2.7 Hydrology

2.7.1 Water Quantity Monitoring

The flow monitoring network in the Kettle Creek watershed consists of three Water Survey of Canada (WSC) stream gauges, as shown on **Map 2.9**. The first gauge is on Dodd Creek below Payne's Mill and covers a drainage area of approximately 95 square kilometres. It has been in continuous operation since 1987. The other two gauges are on Kettle Creek, one above St. Thomas and the other at St. Thomas. The stream gauge above St. Thomas captures a drainage area of 135 square kilometres and has been in operation since 1985. The stream gauge at St. Thomas is the oldest in the watershed. It is located past the confluence of Dodd and Kettle Creeks and captures a drainage area of 330 square kilometres or 75 percent of the watershed. This gauge has been in operation since 1945. Real time stream flow information is available from all three gauges.

2.7.2 Surface Water Hydrology

The Kettle Creek watershed drains approximately 520 square kilometres. Kettle Creek originates at Lake Whittaker, a kettle lake, in the northeastern portion of the watershed. The upper portion of Kettle Creek flows in a southwesterly direction to the City of St. Thomas where it is joined by a major tributary, Dodd Creek. Kettle Creek then flows predominately southward towards Lake Erie being joined by the tributaries of Beaver and Mill Creeks before emptying into Lake Erie at Port Stanley.

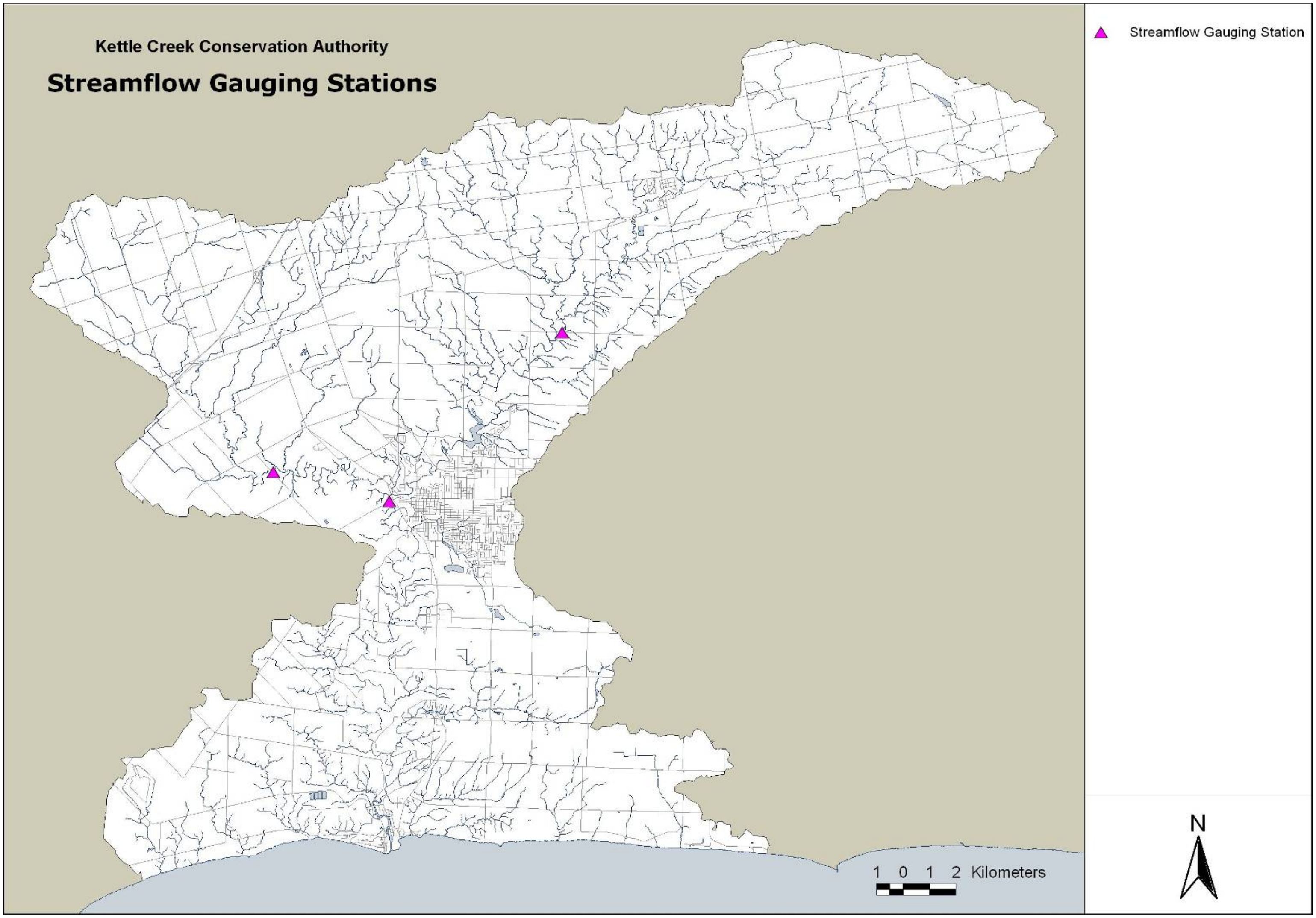
The creek drops approximately 141 metres over its 80 kilometre length. This steep elevation drop causes flash flooding and a high degree of erosion. The creek valley is well defined with steep slopes, in some instances the stream bed is 30 metres below the level of the surrounding landscape (Barnes, 1967). Numerous small watercourses border Kettle Creek in its southerly reaches that all drain directly into Lake Erie.

Upper Kettle Creek

The main branch of Kettle Creek originates at Lake Whittaker in the northeast corner of the watershed. The lake is an 11 hectare, groundwater fed kettle lake that provides moderate base flows to Kettle Creek in all but severe drought conditions. The subwatershed is comprised of clay and silt till, which has been cleared and drained for agriculture. The landscape produces high runoff and low infiltration. Agricultural drainage has further increased runoff to the creek and decreased water available for groundwater recharge.

The Upper Kettle Creek watershed contains the largest water storage reservoir in the watershed, Dalewood Reservoir. The reservoir's original purpose was to supply water to the City of St. Thomas, but has since been acquired by KCCA and is used for flood control and low flow augmentation.

Map 2.9: Locations of Streamflow Gauging Stations in the Kettle Creek Watershed



There is a stream gauge located above St. Thomas on Kettle Creek. It captures a drainage area of 135 kilometres and has been in operation since 1985. The Upper Kettle Creek subwatershed drains an area of approximately 200 square kilometres before it joins with Dodd creek near St. Thomas.

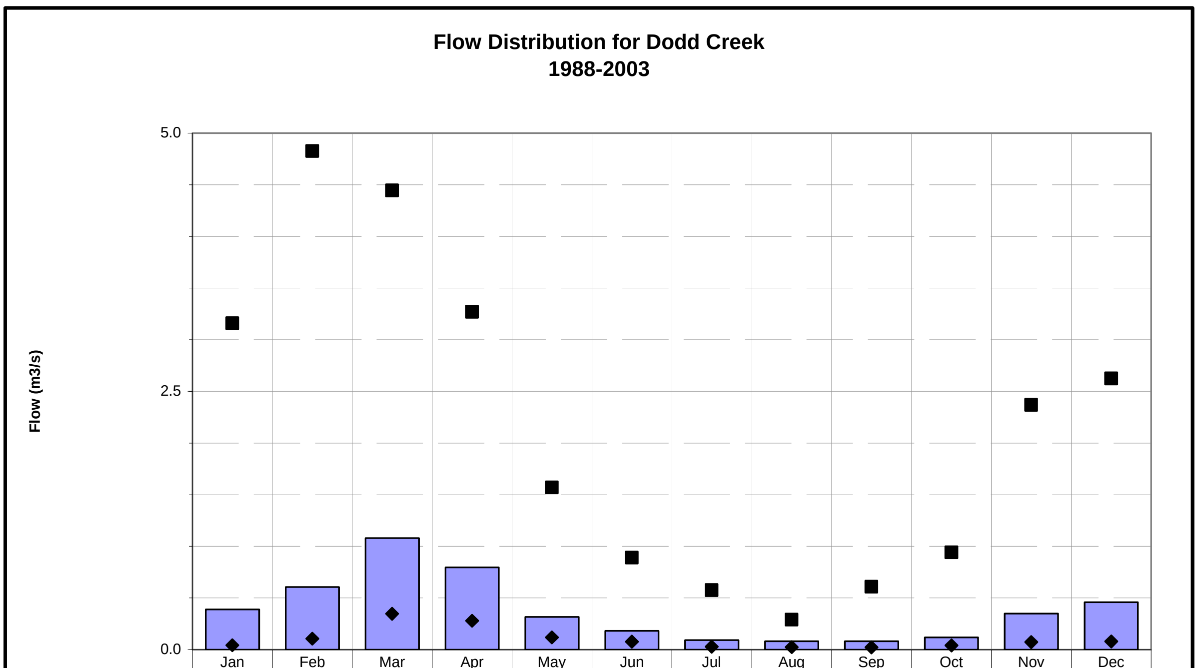
Dodd Creek

Dodd Creek is Kettle Creek's largest tributary, with a drainage area of approximately 130 square kilometres. The headwaters of Dodd Creek are in the northwest corner of the watershed. The creek flows south and west until it joins with Kettle Creek near the City of St. Thomas. Land use in the subwatershed is primarily agricultural. This relatively flat clay plain has little vegetation cover and few wetland features. The subwatershed is characterized by high runoff and little groundwater recharge. As a result, there is little continuous base flow.

There is one stream gauge located on Dodd Creek. The gauge is located below Payne's Mill and covers a drainage area of approximately 95 square kilometres. The Water Survey of Canada has used the gauge since 1987. The gauge's flow distribution is provided in **Figure 2.2**.

High flows are very flashy as shown by the difference between median and 90th percentile flows and the low median flows. Baseflows, as shown with 10th percentile flows, are extremely low and variable throughout the year. This distribution is typical of a non-regulated, runoff dominated system.

Figure 2.2: Flow Distribution of the Dodd Creek Gauge Showing Median, 10th Percentile, and 90th Percentile Monthly Flows.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Median	0.39	0.61	1.08	0.80	0.32	0.18	0.09	0.08	0.08	0.12	0.35	0.46
10th Percentile Flow	0.04	0.11	0.35	0.28	0.12	0.08	0.03	0.03	0.02	0.04	0.07	0.08
90th Percentile Flow	3.16	4.83	4.45	3.27	1.57	0.89	0.58	0.29	0.61	0.94	2.37	2.63

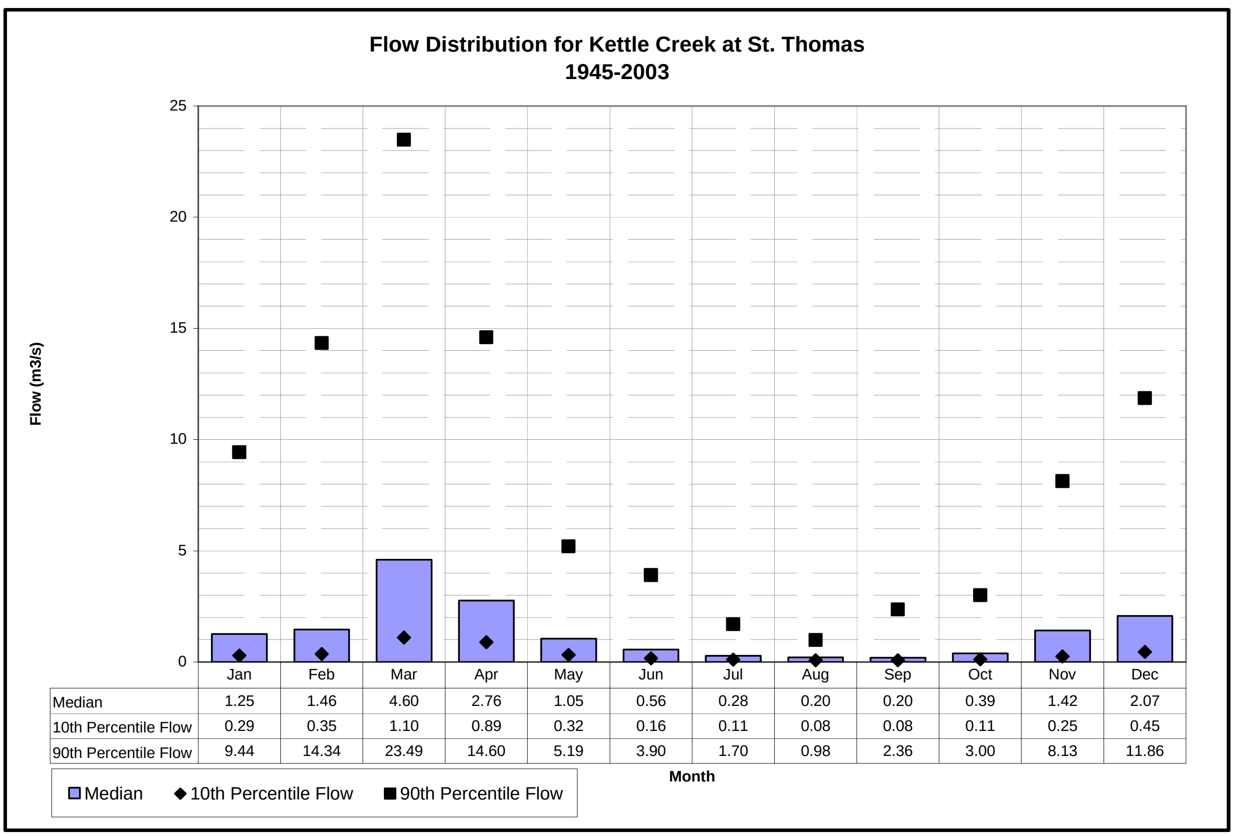
Lower Kettle Creek

The Lower Kettle Creek subwatershed begins at the confluence of Kettle Creek and Dodd Creek. The most southerly gauge on Kettle Creek is located near St. Thomas just downstream of the confluence of Dodd Creek and Kettle Creek. It has been in operation since 1945, and captures a drainage area of approximately 330 square kilometres or 66 percent of the Kettle Creek watershed. The flow distribution for the Kettle Creek at St. Thomas gauge is shown in **Figure 2.3**.

High flows are flashy as shown by the difference between median and 90th percentile flows and the low median flows. Baseflows, as shown with 10th percentile flows, are very low throughout the year. This distribution is typical of a runoff dominated system and drainage characteristics of till plain.

Unlike the upper part of the watershed the lower portion of the Kettle Creek watershed contains more sandy soils. This part of the watershed has higher infiltration and lower runoff than the silt and clay tills of the upper portions. One example is Beaver Creek, a tributary of Kettle Creek which drains an area on the eastern side of the watershed. Beaver Creek is a cool water fishery supported by forest cover, wetland features, and relatively high baseflows.

Figure 2.3: Flow Distribution for the Kettle Creek at St. Thomas Gauge Showing Median, 10th Percentile, and 90th Percentile Monthly Flows



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Median	1.25	1.46	4.60	2.76	1.05	0.56	0.28	0.20	0.20	0.39	1.42	2.07
10th Percentile Flow	0.29	0.35	1.10	0.89	0.32	0.16	0.11	0.08	0.08	0.11	0.25	0.45
90th Percentile Flow	9.44	14.34	23.49	14.60	5.19	3.90	1.70	0.98	2.36	3.00	8.13	11.86

Kettle Creek flows southward to Port Stanley where it drains into Lake Erie. At the outlet to Lake Erie Kettle Creek has a total drainage area of approximately 440 square kilometres.

Lake Erie Shoreline

Numerous small watercourses along the Lake Erie shoreline drain directly into Lake Erie. They drain a total area of approximately 80 square kilometres with the largest draining 11.5 square kilometres and the smallest less than 0.5 square kilometres. These watercourses are extremely steep with well defined valley sections. There are no flow gauges located on any of these small watercourses.

Key Hydrologic Processes

Kettle Creek is predominantly a surface water driven system with a clay-rich till plain covering the majority of the watershed. The low permeability of the till cover tends to inhibit infiltration and produces large quantities of runoff during rain events. Flows in the creek, which pass quickly through the watershed due in part to the steep elevation drop between the headwaters in the north and the outlet to Lake Erie and the nature of the till cover, tends to result in low baseflows and flashy flood events. Groundwater has little influence on the surface water system except in the headwaters where Kettle Creek is fed by a groundwater maintained kettle lake and in the southeast corner where a shallow groundwater system contributes to a cool water fishery in Beaver Creek.

2.7.3 Hydrogeology

Within the Kettle Creek watershed, groundwater has largely been characterized through the use of the MOE's Water Well Information System (WWIS).

An assessment of water well records within the Kettle Creek watershed indicates that approximately 90 percent of the water wells are completed within the overburden sediments. This is not unexpected as the overburden cover within the watershed is quite thick, ranging up to approximately 120 metres near the community of Sparta. Overburden cover tends to thin along Kettle Creek to approximately 40 metre deep.

Aquifers within the Kettle Creek watershed can be characterized as three relatively simple hydrostratigraphic units. The primary aquifer complex is comprised of broad unconfined sand and gravel units located between St. Thomas and Lake Erie with smaller sand and gravel aquifers occurring to the south of London and in the far northeastern extents of the watershed. Typically, this primary aquifer complex is located within the upper 20 metres of sediments. Deeper confined overburden aquifers, generally located at depths of greater than 20 metres, are found within the central parts of the watershed within the basal portions of the Port Stanley Till as discontinuous lenses of sand and gravel. These hydrostratigraphic units were defined through work completed by Strynatka et al. (2006), Dillon (2004) and Waterloo Hydrogeologic Incorporated (2003). The Dundee Formation, which forms the bedrock aquifer in the watershed, is largely untapped as a result of adequate groundwater resources within the overburden.

Shallow Groundwater Resources

In general, a water table surface represents groundwater conditions within the shallow aquifer under unconfined conditions. The water table surface can be used to identify shallow groundwater divides and the general flow direction of groundwater within the shallow overburden. Within the Kettle Creek watershed, the water table was generated from the static water level elevations of only those overburden wells that are less than 20 metres deep. **Map 2.10** shows the location of wells interpreted to be representative of the upper primary aquifer unit (upper 20 metres of overburden) superimposed on the Quaternary geology of the watershed, and **Map 2.11** shows the location of the water table which has been derived from the reported static water levels within those wells. **Map 2.12** indicates that shallow wells are generally associated with the surficial sand deposits located throughout the Kettle Creek watershed. Shallow wells are generally not utilized in the central portion of the watershed and across the boundary with the Catfish Creek watershed to the east as the upper primary aquifer complex is absent in this area. The surficial geological unit in this area is the Port Stanley Till which, due to its clay-rich nature, does not have the capability to produce significant quantities of water. This is supported by the water well records in this central area which indicate predominantly clay deposits within the upper 20 to 30 metres of overburden. As a result of the lack of data across the watershed boundaries between Catfish Creek and Kettle Creek, it is not possible to determine whether a shallow groundwater divide exists between the two watersheds in this area.

Map 2.11 indicates that water table elevations vary from approximately 290 metres above sea level across the north of the watershed to lows of 170 metres above sea level along Kettle Creek and the Lake Erie shoreline. Regional shallow groundwater flow is predominantly from the north, flowing south towards Lake Erie. Flow is influenced by Kettle Creek with local shallow groundwater flow directed towards the main branch of the creek.

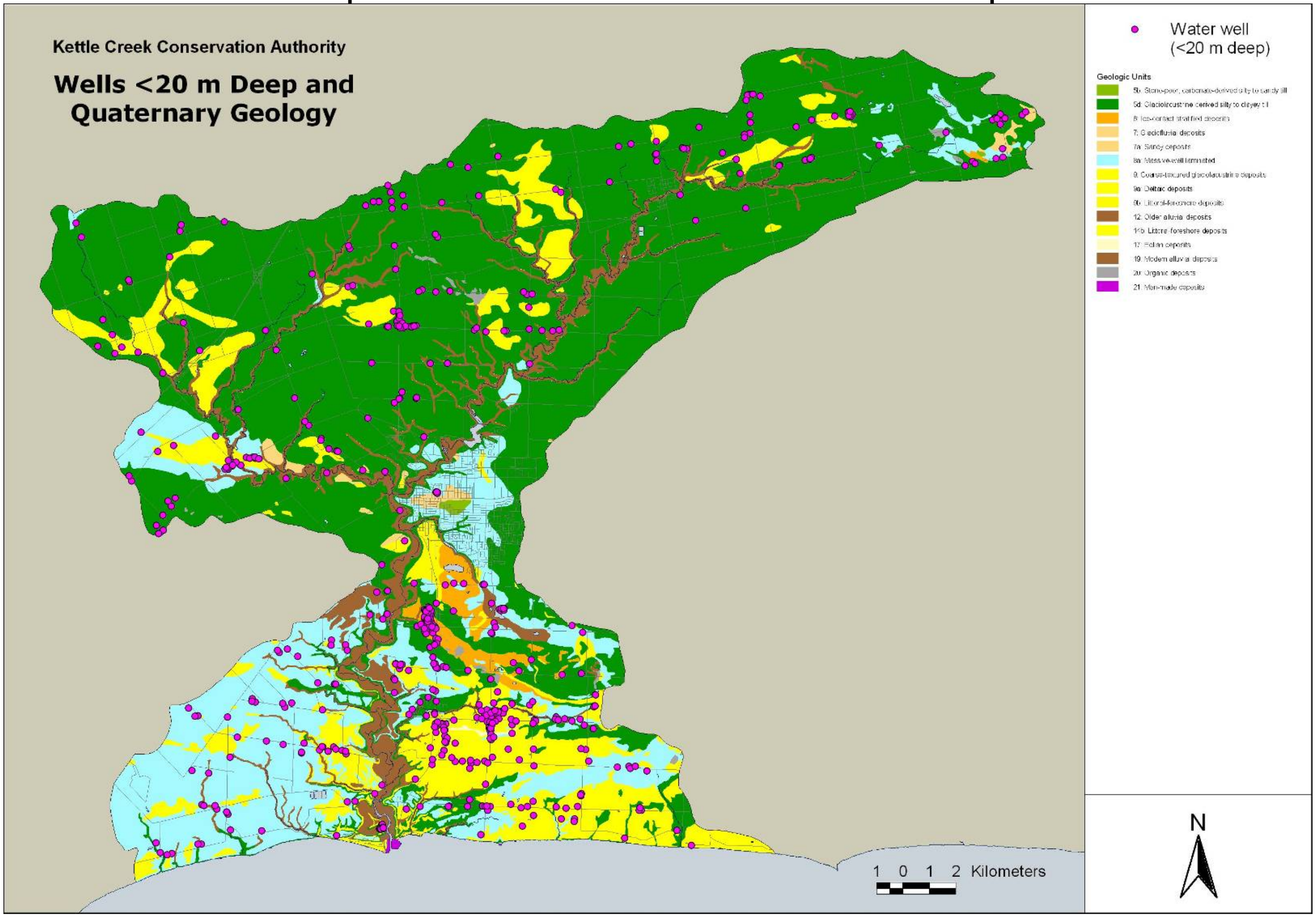
Primary groundwater resources within the shallow overburden are located between St. Thomas and Lake Erie. Shallow wells are clustered in these areas, and sand and gravel deposits with a cumulative thickness greater than two metres (**Map 2.12**) also commonly occur in these areas.

Deeper Overburden Groundwater Resources

Static groundwater elevations within the deep overburden sediments can be used to generate a potentiometric surface for that hydrostratigraphic unit. From this surface, general groundwater flow directions and groundwater divides within the deep overburden can be inferred. The deep overburden potentiometric surface was generated by kriging a surface of all static water levels in wells greater than 20 metres completed within the overburden sediments. **Map 2.13** shows the position of the deeper overburden potentiometric surface. From review of the well log data, the overburden potentiometric surface exists under semi-confined to confined conditions within the overburden, as the potentiometric surface tends to be above the top of the aquifer unit. The general regioanl groundwater flow directions inferred by this potentiometric surface are very similar to the water table surface where the dominant flow direction is from the north, southwards towards Lake Erie. As well, flow directions within the southern half of the watershed are locally influenced by Kettle Creek. There is also some evidence of a groundwater divide in the southeast portion of the Kettle Creek watershed along between the border of the Kettle and Catfish watersheds.

As shown on **Map 2.13**, overburden potentiometric surface elevations vary from approximately 290 metres above sea level across the north of the study area to lows of 150 metres above sea level along Kettle Creek and the Lake Erie shoreline.

Map 2.10: Location of Wells Less than 20 metres Deep



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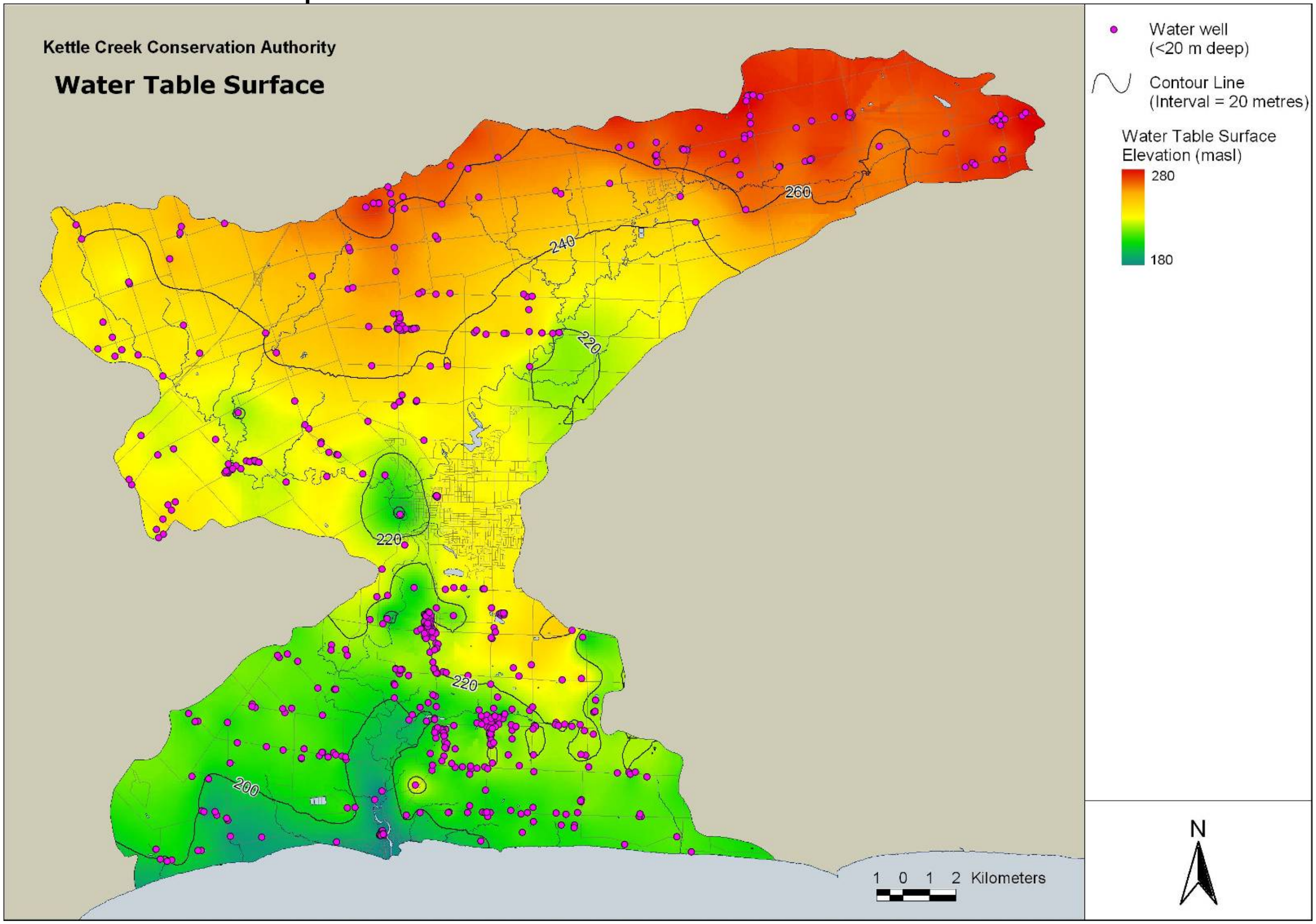
Mapping based partially on data contained within the Ontario Ministry of the Environment's electronic water well database.

Map 2.11: Water Table Surface in the Kettle Creek Watershed



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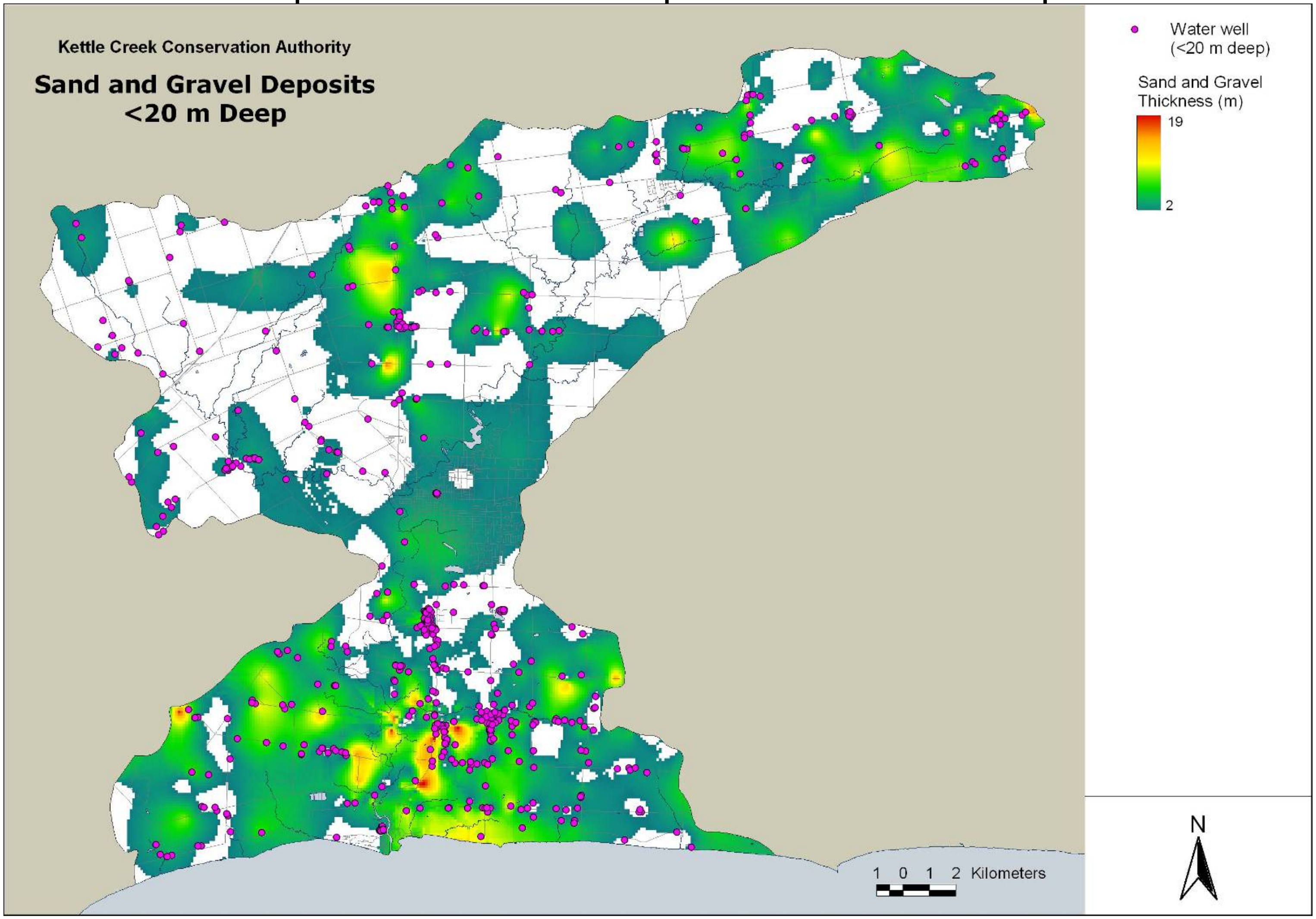
Strynatka, S., Pitcher, J., and Dragunas, P. 2006. *Draft Report* on the Groundwater Resources of the Catfish Creek Conservation Authority and Kettle Creek Conservation Authority. Ontario Geological Survey.
Mapping based partially on data contained within the Ontario Ministry of the Environment's electronic water well database.

Map 2.12: Sand and Gravel Deposits Less than 20 metres Deep



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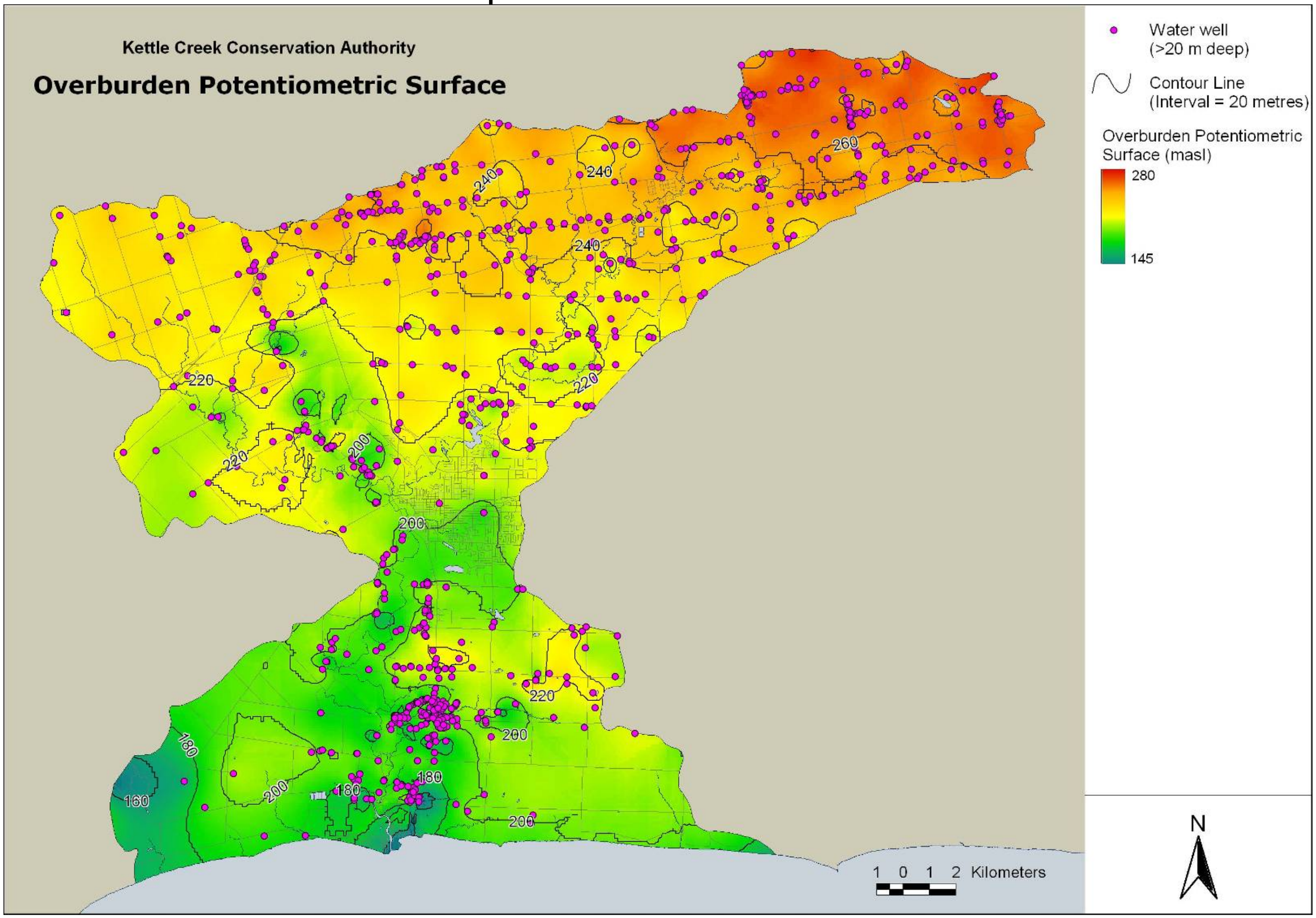
Mapping based partially on data contained within the Ontario Ministry of the Environment's electronic water well database.

Map 2.13: Overburden Potentiometric Surface



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Strynatka, S., Pitcher, J., and Dragunas, P. 2006. *Draft Report* on the Groundwater Resources of the Catfish Creek Conservation Authority and Kettle Creek Conservation Authority. Ontario Geological Survey.
Mapping based partially on data contained within the Ontario Ministry of the Environment's electronic water well database.

The deeper overburden hydrostratigraphic unit consists of discontinuous sand and gravel deposits related to individual till sheets associated with the Port Stanley Till and possibly the underlying Catfish Creek Till. Sand and gravel accumulations at depths greater than 20 metres are generally less than five metres thick, as illustrated on **Map 2.14**. Deposits of sand and gravel roughly coincide with the St. Thomas Moraine.

Bedrock Groundwater Resources

Static groundwater elevations measured within the bedrock water wells were used to develop the bedrock potentiometric surface. This surface, similar to the overburden potentiometric surface and water table surface, can be used to determine regional groundwater flow directions within the bedrock. Within the Kettle Creek watershed, the bedrock potentiometric surface, shown on **Map 2.15**, was generated using the static water levels for all water wells terminating below the bedrock surface. The bedrock potentiometric surface has a similar, but more subdued, character when compared to the overburden potentiometric surface. General flow is from the northeast towards the Lake Erie shoreline in the south. Surface water features do not appear to have any impact on local groundwater flow directions within the bedrock. Bedrock groundwater elevations range from approximately 270 metres above sea level in the northeast of the watershed, to lows along the Lake Erie shoreline, where bedrock groundwater elevations range from approximately 170 to 190 metres above sea level.

Significant Recharge Areas

The nature of the Quaternary geology is the driving force behind recharge in the watershed. Recharge is limited in much of the watershed because of the fine-grained clay till which has a low permeability as illustrated in **Map 2.16**. This till plain covers the northern portion of the watershed. Pockets of sand deposits coincide with higher recharge rates. An area of higher recharge, located in the southeast corner of the watershed is characterised by coarser-grained materials which have a higher permeability. The recharge in this area most likely contributes to the shallow groundwater system located in this area.

Data Gaps

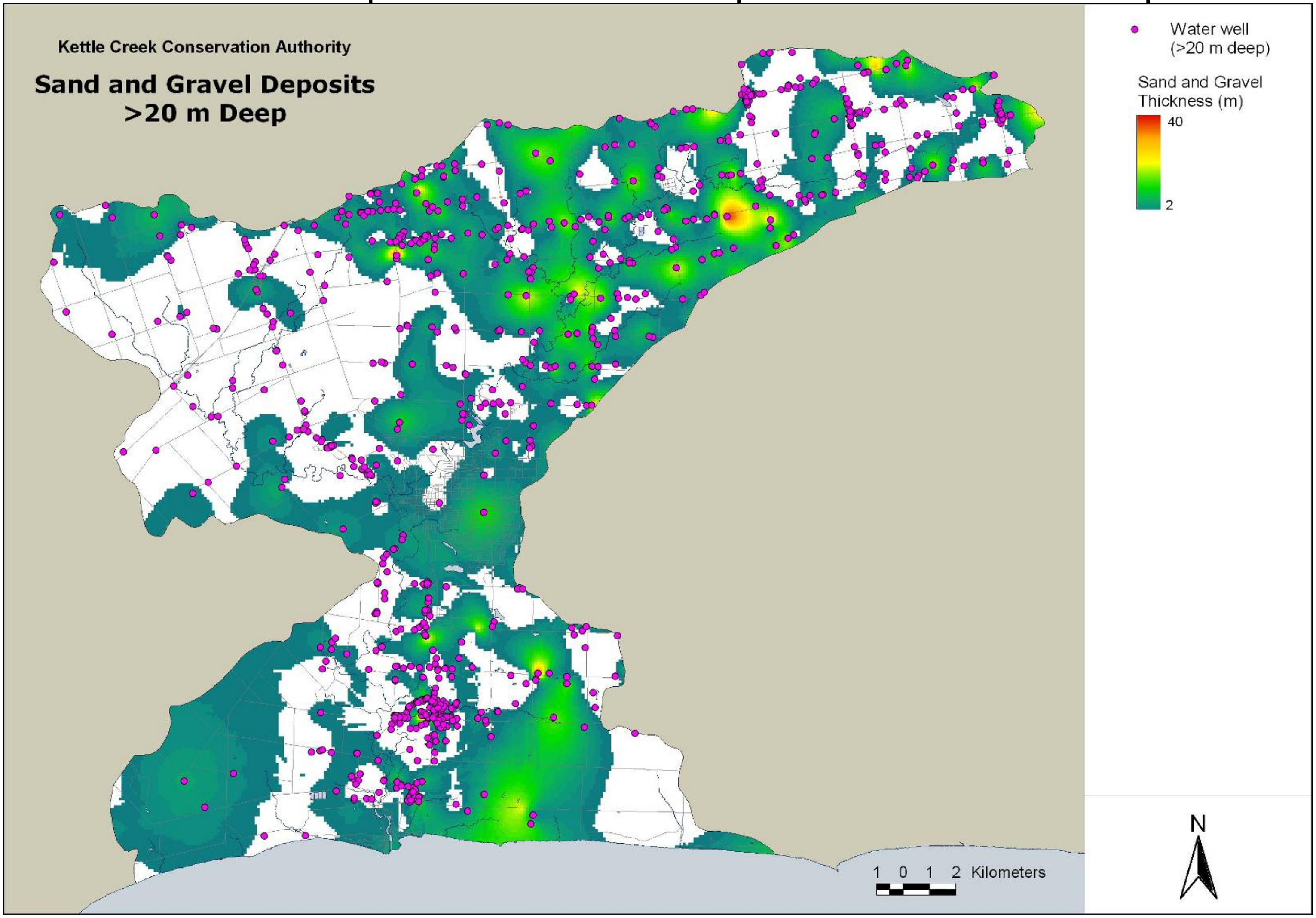
Currently the source of recharge for Lake Whittaker is unknown. A project is underway to extend a groundwater model to the Kettle Creek watershed, as part of the water budget process. When completed, the model may provide insight into the source of the recharge for Lake Whittaker.

A municipal study under source protection planning is underway to help determine the source of recharge for the aquifer supplying the Town of Belmont's municipal wells.

2.7.4 Surface and Groundwater Interactions

In the majority of the Kettle Creek watershed, the thick fine-grained overburden with an overall low permeability inhibits a large degree of interaction between the groundwater and surface water systems. Groundwater influences the surface water system in the headwaters of Kettle Creek by feeding Lake Whittaker which in turn produces baseflows for the creek. As well Beaver Creek in the south of the watershed is influenced by shallow groundwater as it passes through sandy deposits creating a cool water fishery. Additional information on groundwater and surface water interactions will be determined through the water budget process.

Map 2.14: Sand and Gravel Deposits Greater than 20 metres Deep



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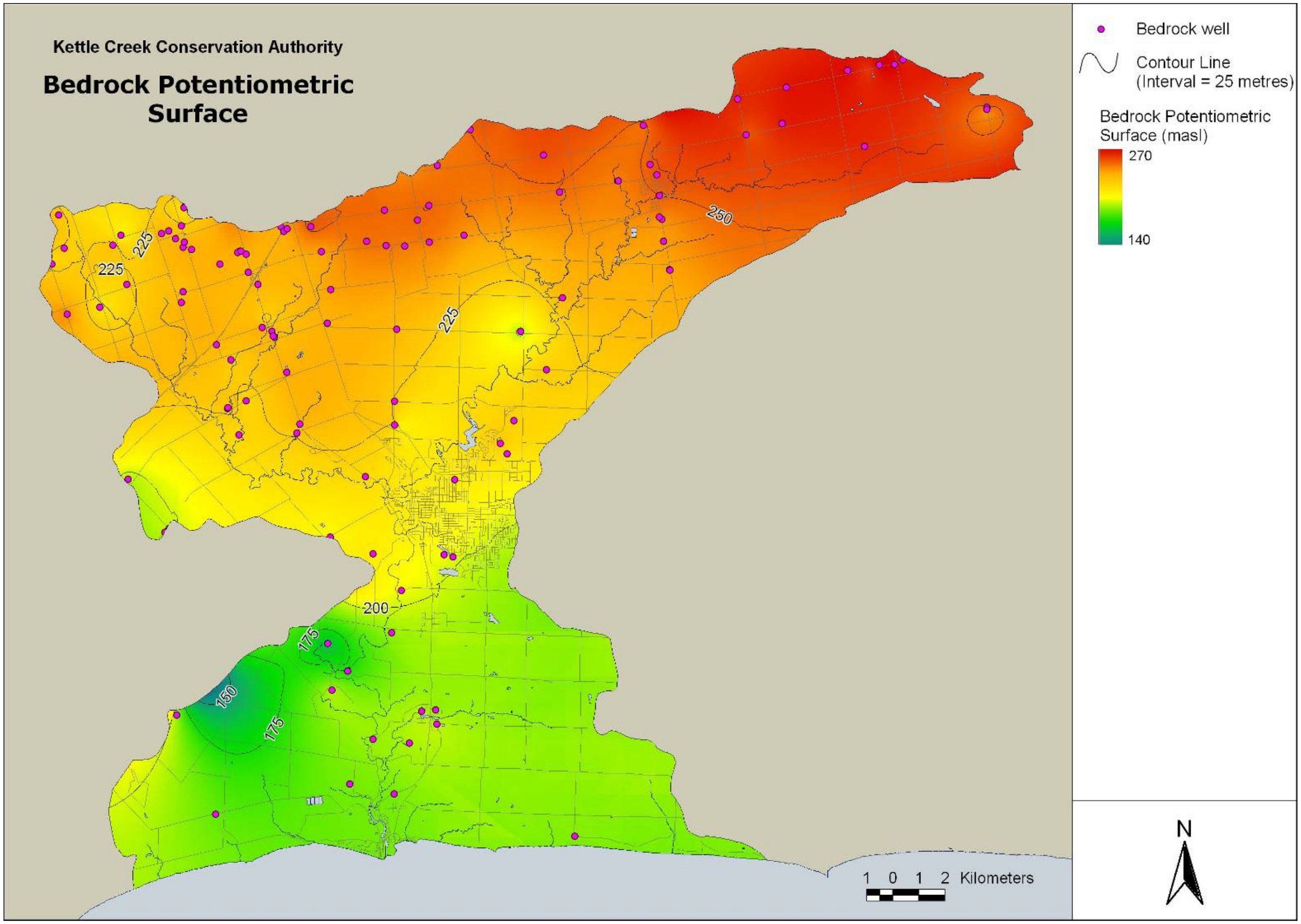
Mapping based partially on data contained within the Ontario Ministry of the Environment's electronic water well database.

Map 2.15: Bedrock Potentiometric Surface in the Kettle Creek Watershed



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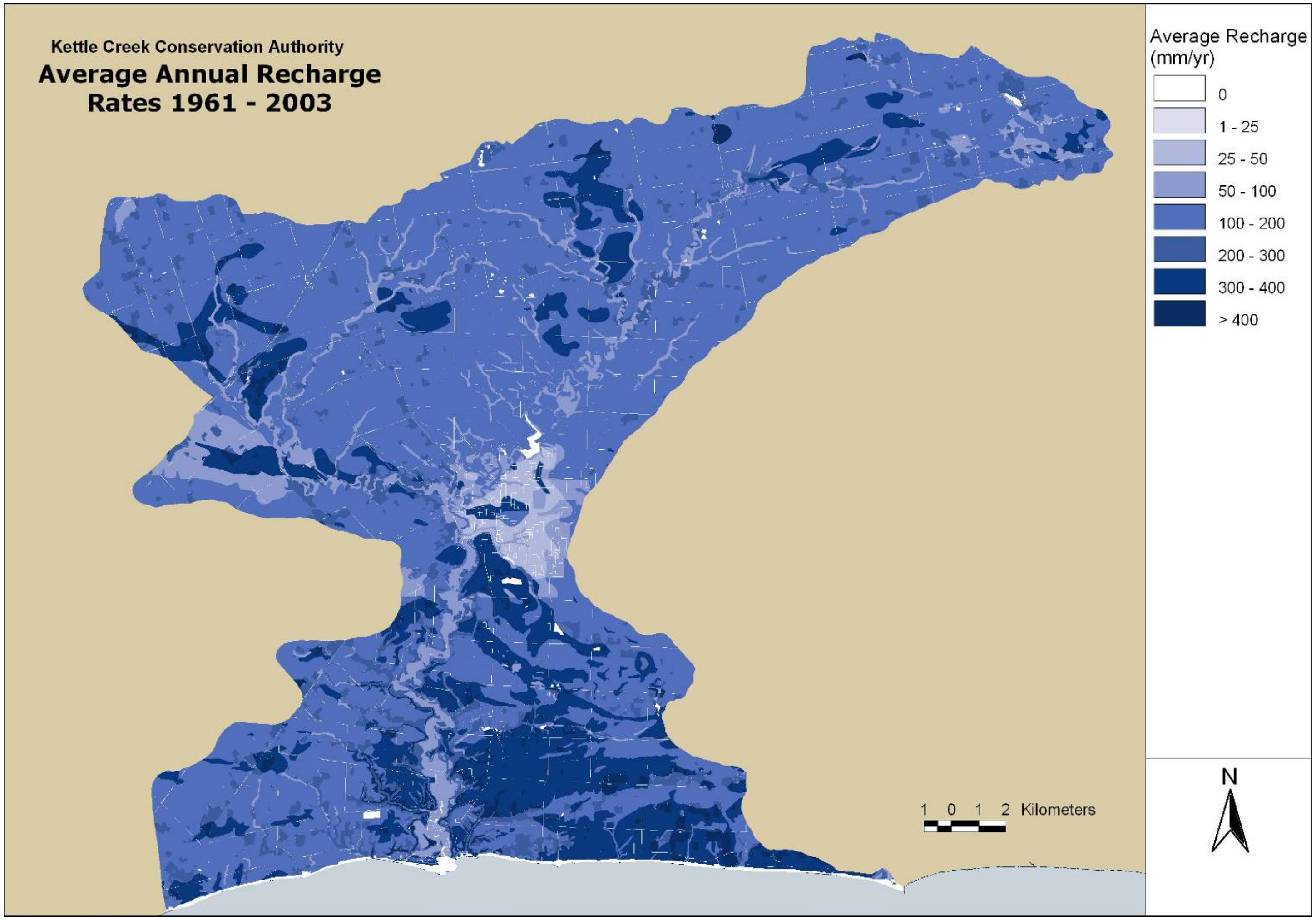
Strynatka, S., Pitcher, J., and Dragunas, P. 2006. *Draft Report* on the Groundwater Resources of the Catfish Creek Conservation Authority and Kettle Creek Conservation Authority. Ontario Geological Survey.
Mapping based partially on data contained within the Ontario Ministry of the Environment's electronic water well database.

Map 2.16: Average Annual Groundwater Recharge Rates in the Kettle Creek Watershed



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2.8 Water Quality Summary

2.8.1 Water Quality Monitoring

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 conservation authorities are responsible for collecting the samples. In the Kettle Creek watershed, the number of monitoring sites fell from a high of 12 in 1975 to a low of zero from 1996 to 2003. In 1996 when the MOE cut funding to the PWQMN program, Kettle Creek Conservation Authority (KCCA) did not have the internal capacity to continue monitoring on its own leaving an eight year data gap for watershed wide sampling from 1996 to 2003. However, in 2004 two years after the MOE started re-building the PWQMN, KCCA resumed sampling.

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 of the sites. 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 (ECO, 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 Maybeck 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.

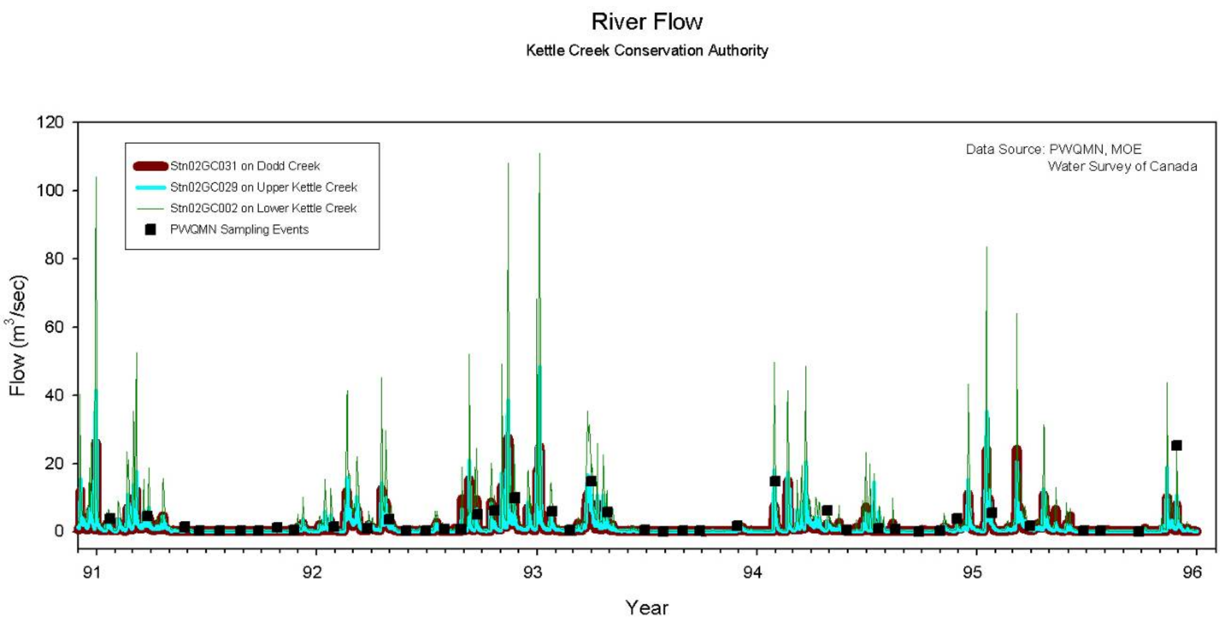
Generally, water quality samples collected at sites in the Kettle Creek watershed were collected during low to moderate flows (**Figure 2.4**). This was likely a result of limited manpower and logistical challenges associated with sampling high flow events. However, starting in 2005 there has been an attempt to characterize high flow events.

Under the current PWQMN program, the KCCA monitors four sites, which have all been historically sampled. In addition to these sites, five monitoring sites were added as part of the KCCA's capacity building in 2005 of which three sites were historically monitored as part of the PWQMN program. Samples from these new sites are analysed by a private laboratory. Each of the nine sites within the current monitoring network are sampled between eight to ten times per year to be consistent with the PWQMN program.

Map 2.17 illustrates the location of the PWQMN and new 2005 sites currently being monitored by the KCCA.

Current water quality samples are analyzed for routine chemistry, nutrients and metals (**Table 2.8**). For more information on laboratory methods and detection limits refer to MOE (1994). 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 they 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.

Figure 2.4: Water Quality Sampling Events as they relate to Stream Flow at Three Locations within the Kettle Creek Watershed.



Dissolved oxygen, conductivity, pH and temperature were monitored in the field at the time of sample collection, historically using titration kits and more recently using handheld data sondes.

Pesticides were only monitored at one PWQMN site, 16008701002 (near Sparta Line on lower Kettle Creek), sporadically from 1981 to 1992 and during the 1994 and 1995 sampling seasons. Water samples were also collected using the procedure previously described.

Map 2.17: Current Surface Water Monitoring Network in the Kettle Creek Watershed

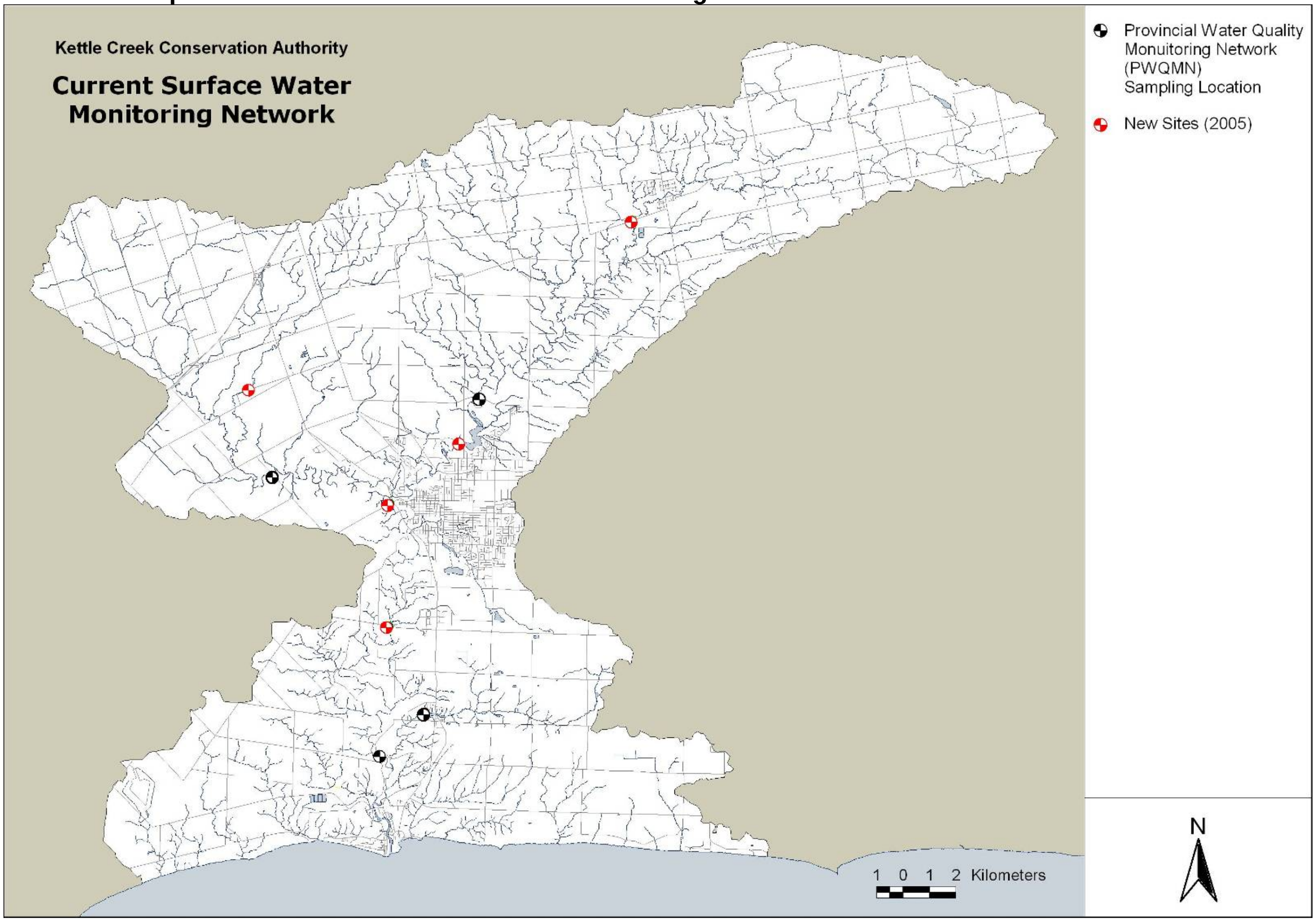


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Table 2.8: List of Water Quality Variables Analyzed in PWQMN Stream/River Samples

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

Historically, no routine monitoring of the major reservoirs within the Kettle Creek watershed has been carried out. However, in 1993 water and sediment samples from the Dalewood Reservoir were collected and analysed to evaluate water quality (Hawkins, 1993).

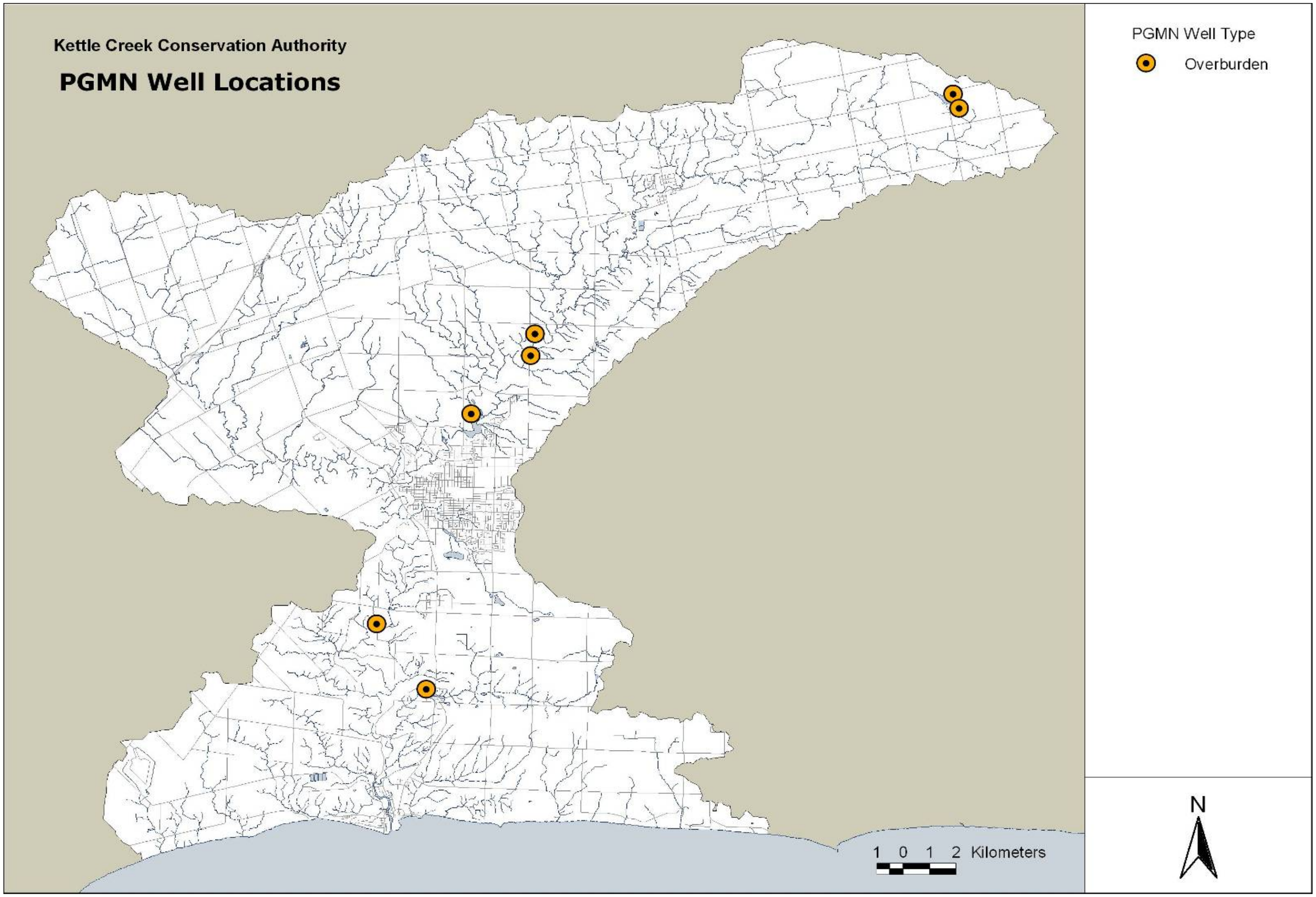
Samples for bacteria or pathogens were not routinely collected as part of the long-term PWQMN monitoring program. Significant variability in sampling and analysis methodologies provides for some hesitation when including these parameters as part of a long-term monitoring program. Historically, sporadic sampling for Fecal Coliform and *E.Coli* occurred at a subset of PWQMN sites from 1991-1995.

Groundwater Quality Monitoring

Groundwater is primarily monitored in the Kettle Creek watershed 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. **Map 2.18** shows the location of the PGMN monitoring wells in the watershed. The monitors are typically sited so that they are reflective of broad hydrogeologic conditions, away from areas where pumping or contamination may impact the 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 seven PGMN wells at seven locations within the Kettle Creek watershed. The wells are usually located in close proximity to Kettle Creek or one of its tributaries (**Map 2.18**) and each of the wells is completed within the overburden. 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. To date, water samples for quality monitoring have been obtained from five of the seven wells.

Map 2.18: Provincial Groundwater Monitoring Network (PGMN) Monitoring Well Locations



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2.8.2 Surface Water Quality Conditions and Trends

The following summary is based on findings from the Water Quality Technical Assessment Report for the Kettle Creek Watershed, which examined the most recent contiguous five year set of data in an attempt to identify the water quality conditions and trends found within the watershed (Evans and Lanthier, 2006).

Water quality sampling within the Kettle Creek 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 2.8.1, Figure 2.4**). Generally, sampling was performed across a range of flow events; 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 that occur during high flow events.

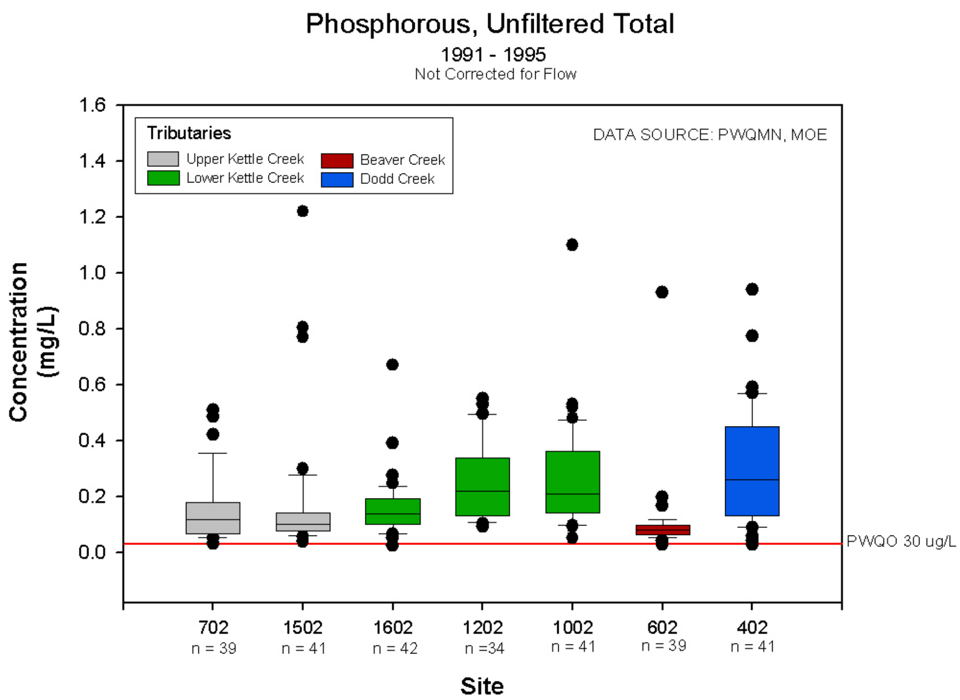
Surface water quality within the Kettle Creek watershed appears to be negatively affected by increasing summer temperatures, decreasing baseflows, potentially low levels of dissolved oxygen, and extensive nutrient and sediment concentrations.

The lower Kettle Creek and Dodd Creek sub-basins are the most impaired regions within the watershed where water quality appears to progressively deteriorate from upstream to downstream. Located on the Norfolk Sand Plain, Beaver Creek was found to be the least impaired region within the watershed. This is likely due to the natural characteristics of that sub-basin, primarily the sandy soils and groundwater-sourced stream baseflow.

Nutrient levels, primarily phosphorus (**Figure 2.5**) and nitrate (**Figure 2.6**), are high throughout the watershed. Nitrate concentrations are significantly higher within Lower Kettle Creek relative to the rest of the watershed. Phosphorus concentrations, although highest in Lower Kettle Creek and Dodd Creek, are consistently high throughout the watershed, and typically exceed the provincial water quality objective of 0.03 milligram per litre. Due to the importance of these nutrients for plant growth, there is a clear indication that these levels could lead to an increase in degradation of water resources across the watershed. Generally high phosphorus concentrations are seen in areas that drain highly intensive agricultural lands situated on till or clay plains, which is the case for both Dodd and Kettle Creek. However, there are also urban sources entering the creek, such as wastewater treatment plant effluent, that could also be elevating phosphorus levels found below St. Thomas.

Non-filterable residue (NFR) levels appear to be of more concern along Kettle Creek compared to the other tributaries within the watershed (**Figure 2.7**). NFR levels are routinely above the 25 milligram per litre general criteria within Kettle Creek and progressively increased from upstream to downstream. High levels of non-filterable residues can increase turbidity and restrict light penetration thus disrupting plant growth. High NFR can also damage fish gills and interfere with drinking water treatment processes. The discharge from the St. Thomas Wastewater Treatment Plant (WWTP), the bank erosion caused by livestock access to streams, the sediment deposition occurring in Dalewood Reservoir and the general steepness of the watershed topography could all be contributing to the high NFR levels found along Lower Kettle Creek.

Figure 2.5: Total Phosphorus Concentrations at Seven PWQMN Monitoring Sites in the Kettle Creek Watershed from 1991-1995.



Both the nutrient and sediment issues within the Kettle Creek watershed are primarily the result of runoff and erosion. These conditions are amplified by land-use practices, such as agriculture and urbanization, and the dramatic elevation change within the watershed. Nutrient and sediment concentrations are typically linked as nutrients readily bind to clayey and silty sediments (Hairston and Stribling, 1995).

Chloride is an important ion to metabolic processes of aquatic organisms as it influences osmotic balance and ion exchange. Usually excess chloride within streams is attributed to road salting in urban areas. Within Kettle Creek's watershed chloride is not a water quality concern as levels do not appear to be approaching the 250 milligram per litre Canadian Guideline (**Figure 2.8**).

Figure 2.6: Total Nitrate Concentrations at Seven PWQMN Monitoring Sites in the Kettle Creek Watershed from 1991-1995.

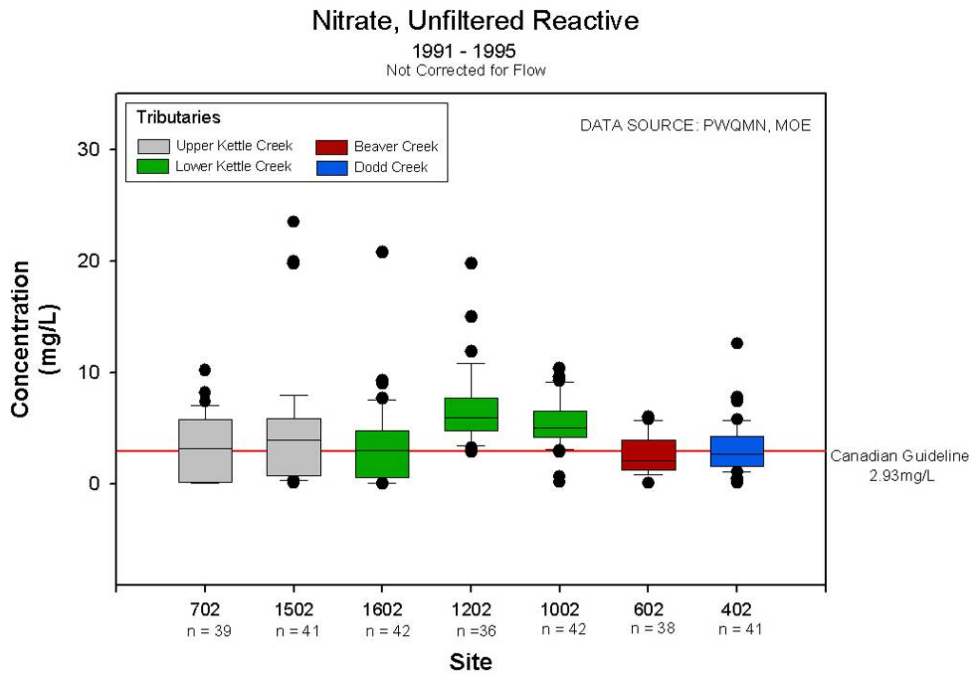


Figure 2.7: Non-Filterable Residue Concentrations at Seven PWQMN Monitoring Sites in the Kettle Creek Watershed from 1991-1995.

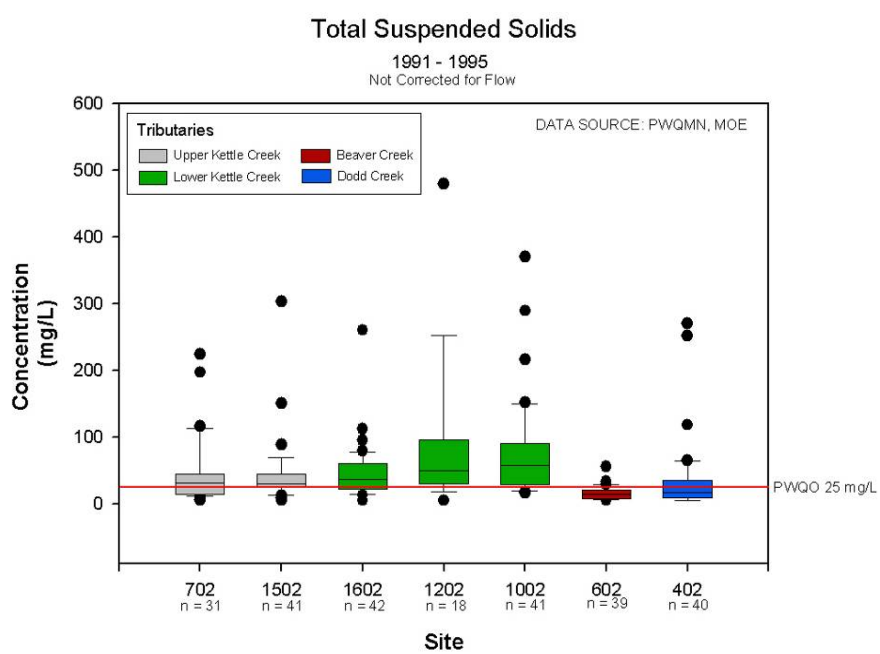
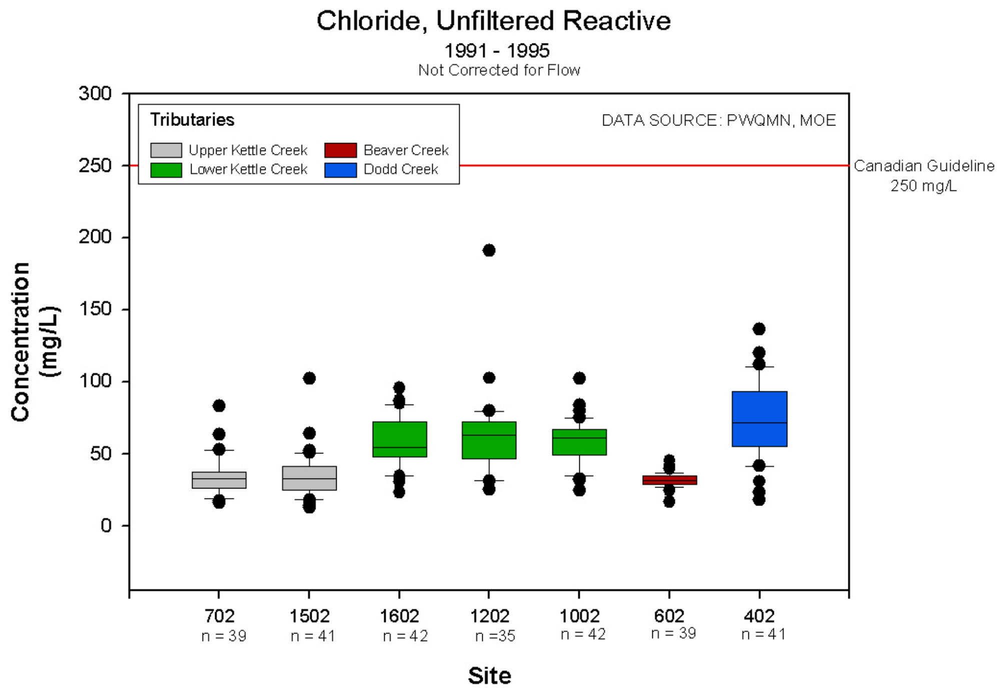


Figure 2.8: Total Chloride Concentrations at Seven PWQMN Monitoring Sites in the Kettle Creek Watershed from 1991-1995.



Most of the tributaries within the Kettle Creek watershed are thermally stressed. As summer temperatures continue to increase this has become a primary water quality concern. High water temperatures can limit the diversity of aquatic species present as well as impact dissolved oxygen saturations. For the period between 1991 and 1995 summer water temperatures were consistently above 20°C and reached as high as 26°C. Currently water temperatures have been reported as high as 28°C, which is approaching the upper threshold for many warm water species. These higher summer water temperatures are amplified in the upper Kettle and Dodd Creek sub-basins by the relatively low natural base-flows that tend to be intermittent during the dry season. Future investigations into possible ways to manage these very high summer temperatures should be examined.

Within the Kettle Creek watershed dissolved oxygen levels were rarely observed to dip below eight milligrams per litre which is well above the four milligrams per litre lower threshold for cold water biota. While this value is considered to be adequate for aquatic life, 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 Kettle Creek watershed was limiting to aquatic organisms can not be accurately assessed with the 1991 - 1995 sampling regime and diurnal monitoring should be employed as part of future monitoring programs.

Also associated with the low natural base flow is the limited assimilative capacity of Kettle Creek. Several studies assessing the assimilative capacity of the tributaries within the Kettle Creek watershed (McTavish, 1976; Mohring, 1995; KCCA, 1967) have indicated that there is inadequate streamflow to sufficiently dilute municipal and industrial waste discharged during the summer low flow period. KCCA (1967) indicated that the

Ford Plant and the St. Thomas WWTP make up most of the baseflow within Dodd and Lower Kettle Creek during the summer low flow season.

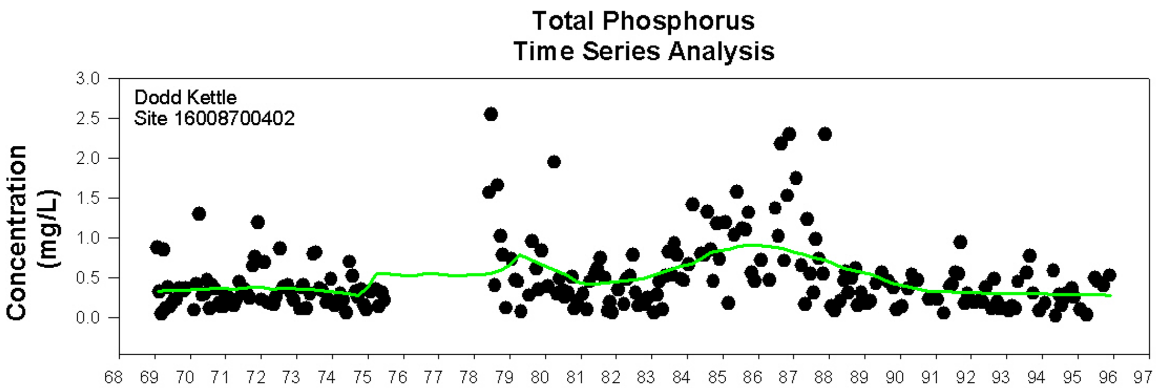
Bacteria and pathogens in the Kettle Creek watershed tend to be highly variable likely as a result of the land-use within the watershed. Dorner (2004) identified both agricultural and urban watersheds as areas that have a high occurrence of pathogens. Depuydt (1994) suggested that the primary sources of rural fecal coliform concentrations to the Kettle Creek were faulty septic systems, urban runoff and livestock access to streams.

A major contamination issue affecting water quality within Lower Kettle Creek at Port Stanley is the presence of Polynuclear Aromatic Hydrocarbons (PAHs) within the bed sediments. Two main areas within Lower Kettle Creek downstream of the George Street Drain in Port Stanley and adjacent to former petroleum tank farms have been identified as containing contaminated sediments. Several studies (Griffiths, 1988; Riggs Engineering, 2004; Acres and Associates, 2001) have investigated the extent and severity of the contamination. These studies have shown that the area furthest downstream is significantly contaminated and will continue to be a chronic source of pollution for the waterway if clean-up measures are not taken. PAHs are extremely toxic and can lead to odour problems and habitat degradation for aquatic life. Cumming Cockburn and Associates Limited (1987) determined that Kettle Creek deposits approximately 40,000 cubic metres of silty sediment into the Port Stanley harbour every year. This plume of sediment from Kettle Creek into Lake Erie was later identified by the Elgin Area Primary Water Supply System as a significant potential point source of contaminant laden sediments (Riggs, 2004).

Spills and wastewater treatment plant bypasses are a significant threat to downstream water users in the Kettle Creek watershed. They represent an acute and immediate impairment to water quality that can compromise drinking water treatment at the Elgin Area Primary Water Supply System as well as interfere with recreation occurring at Port Stanley beaches. Therefore, it is imperative to have an effective spills response protocol and accurate stream information for timely response.

Preliminary trend assessment yields variable results with respect to whether nutrients levels are decreasing or increasing over time. Nitrate concentrations appear to be slightly decreasing within Upper Kettle Creek but increasing within the downstream sites. Total phosphorus concentrations appear to be decreasing throughout Dodd Creek since the 1980's (**Figure 2.9**) but remained fairly constant at all other sites within the watershed (Evans and Lanthier, 2006). Re-assessing these trends in the future with current data would be beneficial in evaluating if new trends are emerging.

Figure 2.9: Time Series Analysis for Total Phosphorus at PWQMN Site 16008700402, Dodd Creek.



Water Quality Data Gaps

The current sampling frequency does not allow for the characterization of flow events. This limits the ability to properly calculate loads or statistically analyze for trends.

Recent studies have identified the sediment plume coming form Kettle Creek to be a point source of contamination to the Elgin Area Primary Water Supply System. More intensive sediment studies are required to understand the cause of this sediment loading to Lake Erie.

The assimilative capacity of Kettle Creek to continue receiving wastewater effluent from the St. Thomas wastewater treatment plant is not well known and further monitoring is required to understand the extent to which the wastewater treatment plant impacts Kettle Creek. Further monitoring is also required to understand the extent that the Port Stanley sewage lagoon effluent impacts the Lake Erie nearshore.

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

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 KCCA and increase the 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 subwatershed or basin specific targets within the Kettle Creek watershed has not been thoroughly investigated. Additional 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 and to understand the influence of these creeks on the near shore with respect to public health (e.g. drinking water intakes and beaches).

2.8.3 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 entirely to natural geochemical processes. For instance, some industrial processes are very sensitive to scaling issues, which may eliminate the use of groundwater high in hardness. Groundwater may have attained naturally high concentrations of arsenic or total dissolved solids that 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 snow or rain 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 reacting 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. From there it may finally be dominated by the anion chloride and 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).

In Ontario at the time a well is drilled, a well driller will classify groundwater through odour and taste. This information is included in the well record. Aside from the well driller’s classification of water type, there is limited information available regarding the groundwater quality within the Kettle Creek watershed. Groundwater probability maps for the County of Elgin were published in 1972 (MOE, 1972), and there are several research papers that characterize the groundwater chemistry within the Upper Kettle Creek watershed (Schwartz and Domenico, 1973; Schwartz, 1974; Strynatka, 1998). More recently, monitoring wells that are a part of the MOE-funded Provincial Groundwater Monitoring Network (PGMN) were sampled for a full suite of organic and inorganic chemical parameters.

The well driller will use taste and smell to classify the water as fresh, salty, sulphur or mineral. This method of classification provides a crude estimate of groundwater quality at the time the well is drilled. Upon examination of the distribution of wells with water quality problems within the Kettle Creek watershed, there is a general bias towards the sulphur classification within wells completed in the bedrock, likely because the sulphur odour is such a strong distinguishing feature. The distribution of groundwater quality, as identified by the water driller, is shown in **Table 2.9**. Groundwater was classified as fresh water in the majority (98 percent) of the overburden wells. Of the wells completed in the bedrock, 54 percent of the wells were classified as having fresh water, 38 percent were reported to have sulphurous water, and the remaining eight percent were a combination of mineral and iron water types.

Groundwater probability maps developed for the County of Elgin cover a portion of the Kettle Creek watershed and also extend into the adjacent Catfish Creek watershed located to the east (MOE, 1972). Samples collected from shallow, intermediate and deep aquifer units (there was no documentation to delineate these aquifers) underwent both field and lab analysis for a suite of inorganic ions and selected chemical properties. Two maps were produced from this data showing sample locations with associated major ion diagrams (stiff diagrams), geologic cross-sections through the overburden deposits and delineation of sand units located less than 7.5 metres (25 feet) from the ground surface. **Table 2.10**, **Table 2.11**, and **Table 2.12** summarize the lab analyses from these maps for each aquifer unit along with the Aesthetic Objective or Operation Guideline, Maximum Allowable Concentration or Interim Maximum Allowable Concentration as defined by the Ontario Ministry of the Environment in the Ontario Drinking Water Quality Standards (MOE, 2006).

Table 2.9: Groundwater Quality Classifications for Overburden and Bedrock Wells as Identified by Water Well Drillers.

Groundwater Quality Classification	Percentage of Overburden Wells	Percentage of Bedrock Wells
Fresh	98%	54%
Salty	0.1%	0%
Sulphur	0.5%	38%
Mineral	0.2%	2%
Iron	0.8%	6%
Gas	0%	0%
Unknown	0%	0%

From **Table 2.10**, the only parameters within the shallow aquifer which exceed MOE aesthetic objectives are Fe and hardness. None of the mean or median concentrations for parameters shown in **Table 2.10** exceed their respective MAC or IMAC.

Groundwater in the intermediate aquifer was identified to be of the best quality `when compared to the shallow and deep aquifers. While the shallow aquifer commonly yields very hard water, samples appeared to be reasonably dilute where Ca and HCO_3 were the dominate ions. Groundwater within the shallow aquifer also appeared to be impacted by nitrate, with concentrations reaching as high as 29 milligrams per litre.

Within the deeper aquifers, groundwater becomes less influenced by surficial sources, and more affected by natural processes such as ion exchange and mineral dissolution. This is reflected in the elevated sodium (> 100 milligrams per litre) and fluoride (< 1.0 milligrams per litre) concentrations as well as the general migration away from the Ca-HCO_3 water type. The deep aquifer sometimes yields water containing H_2S (MOE, 1972).

Similar to **Table 2.10**, the only parameters within the intermediate aquifer (**Table 2.11**) which exceed MOE aesthetic objectives are Fe and hardness. None of the parameters from **Table 2.11** exceed the MAC or IMAC.

Table 2.10: Summary of Analyses for Samples Collected from the Shallow Aquifer from County of Elgin. (*Data is in mg/L unless otherwise stated.)*

	Number of Samples	Mean	Median	Standard Deviation	Maximum	Minimum	AO or OG	MAC or IMAC
Lab pH	17	7.8	7.8	0.3	8.4	7.2	6.5-8.5	-
Fe	22	0.62	0.10	1.17	4.40	0.02	0.3	
Ca	19	90	87	38	152	8	-	-
Mg	19	15	15	5	28	6	-	-
Na	18	28	9	56	231	2	200	
K	18	4.3	1.6	7.1	29.0	0.8	-	-
B	12	0.12	0.10	0.08	0.35	0.06		5.0
HCO_3	22	274	253	90	459	117	-	-
SO_4	19	65	64	32	140	2	500	
Cl	22	36	16	64	280	6	250	
F	13	0.2	0.1	0.3	0.9	0.1		1.5
NO_3	19	7.45	2.40	10.02	29.00	0.01		10.0
Sodium Adsorption Ratio	18	1.28	0.20	3.38	14.34	0.06	-	-
Alkalinity (mg $CaCO_3$/L)	22	229	207	80	390	96	30-500	
Hardness (mg $CaCO_3$/L)	22	292	300	110	460	48	80-100	
Total Dissolved Solids	17	474	450	167	850	242	500	
Specific Conductivity (micromhos at 25 deg. C)	17	614	568	211	1190	290	-	-

Table 2.11: Summary of analyses for Samples Collected from the Intermediate Aquifer from County of Elgin *(Data is in mg/L unless otherwise stated)*

	Number of Samples	Mean	Median	Standard Deviation	Maximum	Minimum	AO or OG	MAC or IMAC
Lab pH	33	8.0	8.0	0.3	8.4	7.5	6.5-8.5	-
Fe	31	1.10	0.45	1.73	8.50	0.10	0.3	
Ca	26	39	25	32	110	9	-	-
Mg	26	14	14	8	30	3	-	-
Na	23	48	43	37	129	4	200	
K	23	1.2	1.1	0.5	2.7	0.6	-	-
B	18	0.29	0.29	0.11	0.46	0.14		5.0
HCO_3	33	230	222	81	435	78	-	-
SO_4	29	25	13	36	182	1	500	
Cl	31	24	8	43	227	1	250	
F	20	1.0	1.2	0.4	1.5	0.1		1.5
NO_3	23	0.16	0.01	0.56	2.70	0.01		10.0
Sodium Adsorption Ratio	23	2.35	2.24	1.97	5.93	0.09	-	-
Alkalinity (mg $CaCO_3$/L)	33	189	182	67	357		30-500	
Hardness (mg $CaCO_3$/L)	34	143	120	91	336		80-100	
Total Dissolved Solids	23	287	300	101	490		500	
Specific Conductivity (micromhos at 25 deg. C)	22	461	432	152	888		-	-

Within the deep aquifer, as shown on **Table 2.12**, geochemical results show exceedances of MOE aesthetic objectives for iron, hardness, and total dissolved solids.

More recently, monitoring wells that are a part of the Provincial Groundwater Monitoring Network within the watershed have been sampled for general groundwater chemistry; however, a complete set of results were not available at the time of this report.

Table 2.12: Summary of Analyses for Samples Collected from the Deep Aquifer from County of Elgin *(Data is in mg/L unless otherwise stated.)*

	Number of Samples	Mean	Median	Standard Deviation	Maximum	Minimum	AO or OG	MAC or IMAC
Lab pH	30	7.9	8.0	0.4	8.6	7.2	6.5-8.5	-
Fe	29	3.08	0.55	7.03	36.00	0.05	0.3	
Ca	25	45	30	33	111	11	-	-
Mg	25	19	15	11	46	5	-	-
Na	24	125	109	77	280	6	200	
K	24	8.2	1.9	27.1	135.0	0.9	-	-
B	17	0.83	0.66	0.77	3.40	0.10		5.0
HCO_3	30	268	239	127	734	107	-	-
SO_4	25	25	3	41	174	1	500	
Cl	29	151	107	144	450	2	250	
F	18	1.0	1.1	0.5	1.9	0.1		1.5
NO_3	23	0.62	0.01	1.77	8.00	0.01		10.0
Sodium Adsorption Ratio	24	4.33	4.44	2.59	10.78	0.14	-	-
Alkalinity (mg $CaCO_3$/L)	30	220	196	106	610	88	30-500	
Hardness (mg $CaCO_3$/L)	30	177	145	110	424		80-100	
Total Dissolved Solids	24	561	508	290	1064		500	
Specific Conductivity (micromhos at 25 deg. C)	22	880	768	437	1660		-	-

2.9 Aquatic Ecology

2.9.1 Fisheries

While a fish inventory was undertaken in 1993, KCCA does not have a comprehensive fisheries management plan. In fact the streams within the watershed have not been evaluated in over ten years, which is significant considering the number of years the watershed has experienced low flow or drought conditions.

The following is a synopsis of information gathered for each watershed stream during the 1993 inventory, with more current information added where available.

Little Creek

This stream produced through groundwater seepage supply is designated as a cold water stream. The creek ranges in depth from 0.1 to one metre and has a sandy bottom with the upper regions of the creek consisting of gravel and stone. Plant types on shore include grass, willow, and mature hardwoods with the cover in the water including overhanging shrubs and rocks.

Rainbow trout and suckers were observed in a 1993 electroshocking inventory.

Mill Creek

Mill Creek is a cool, clear water stream and ranges from 0.2 to 0.4 metres in depth. The creek is characterized primarily by a silt bottom which changes to a combination of silt and muck upstream. The entire stream exists due to groundwater seepage. The shore is comprised of grass, willow and dogwood with overhanging shrubs.

Suckers, chubs and sticklebacks inhabit this stream (Wardle, 1993).

Rainbow trout are also found in this creek. The Lake Erie Salmon and Trout Club is integral in sustaining this population.

Beaver Creek

This stream, established by groundwater seepage and wetlands, is designated a cold water stream. However, due to agricultural practices in the area, the habitat is less ideal for cold water species because of increased temperatures, low flow, sedimentation and siltation. Sections of the stream have gravel or muck substrate. The shoreline is populated with grasses and some willow, dogwood, mint, and arrowhead. Large hardwoods are also present. In the water, filamentous algae, stones, logs and duckweed can be seen.

Other than largemouth bass, only darters, minnows, shiners, suckers, chub and stonecats were observed in the 1993 inventory (Wardle, 1993). Remnant brook trout are evident in the downstream reaches (Hall, Personal, March 2006).

Pinafore Creek

Flows for Pinafore Creek are primarily due to surface runoff and groundwater seepage. Pinafore is a clear, warm water stream with a depth ranging from 0.05 metres to 0.5 metres. The cover on shore is approaching 100 percent and includes grass, mature hardwoods, and various shrubs. The cover in the water drops to 50 percent and includes filamentous algae and shrub overcropping. The creek is primarily a gravel substrate but does have sections of clay and muck.

No sport fish were observed in the 1993 inventory. However, darters, minnows, suckers, rock bass, and chub were found.

Dodd Creek

This warm water stream is very murky with a bottom type ranging from gravel to muck depending on the location. The source of this stream is surface runoff with small amounts of wetland components. The depth of this creek runs from 0.2 to 0.75 metres in all locations of the stream. The cover on shore fluctuates from 60 to 80 percent and consists of grass, wild grape, willow, bulrushes, and mature hardwoods. The cover in the water is approximately 70 perecent and consists of overcropping willow at most locations.

The upper reaches of Dodd Creek rely entirely on shallow water tables and surface runoff for water supply. Because the upper reaches of Dodd Creek do not cut deeply into the overburden, (and there are no wetlands or zones of saturation available) the creek flow relies entirely on thee availability of moisture from adjacent overburden. The soils in this area are generally described as loams and clay loams with gentle rolling topography of less than five percent gradients.

Dodd Creek drains an area of approximately 132 square kilometres with an approximate fall of 50 metres. Stream flow in the west areas of the Dodd Creek watershed is often intermittent and very reactive to periods of rain. The eastern portion of the watershed appears to be drawing its water from White's Wetland and other groundwater seep sources. In dry conditions, it would appear that the Ford Plant is a significant contributor to Dodd Creek's stream flow. From the data in the 1995 Stream Base Flow Hydrology Report, the main branch and western sections of Dodd Creek have very poor recharge ability.

Historically there is no flow in sections of Dodd Creek for July, August, and September except during major precipitation events. Deep water pools do not exceed 1.2 metres for this branch. Mid summer temperatures ranch from 22 to 27 degrees Celsius.

Darters, minnows, shiners, suckers, chub, stonecat and rock bass were inventoried in 1993 (Wardle, 1993). Historically, this stream had an active population of northern pike.

Salt Creek

The main water source for this creek is agricultural drainage systems with some groundwater seepage. The depth ranges from 0.2 to 1.25 metres with a bottom substrate built of rock and silt sediments. The cover on shore is 100 percent and consists of willow grass, sumack and dogwood. The water cover includes stone and overcropping shrub.

While Salt Creek is designated a cold water stream, no cold water species were inventoried in 1993 (Wardle, 1993). Minnows, shiners, suckers, rock bass, dace and chub were observed.

Vessie Creek

Vessie Creek is a deep stream originating from agricultural drainage with a maximum depth of 1.5 metres. The stream bottom consists of gravel and sand. Vegetative cover includes mature tree branches, rocks and overcropping willows. Vessie Creek is designated a warm water stream with fish species consisting of darters, minnows, suckers, shiners, chub, rock bass, and sticklebacks.

Spring Creek

Spring Creek is a clear, cool water stream located in North and South Dorchester Townships. Agricultural drainage and wetlands both contribute equally to this stream. The creek bottom consists of gravel and silt. Water cover includes rocks and mature tree branches. Suckers, chub and sticklebacks are evident.

Dalewood Reservoir

KCCA obtained the reservoir from the City of St. Thomas in 1975 as it was no longer needed for drinking water purposes. Dalewood is impaired as a reservoir, but KCCA manages it today as a flood control structure and provincially significant wetlands.

Intensive upstream agricultural land use and tile drainage has caused the reservoir to silt in at an alarming rate. A 1981 report by Ecologistics Ltd. documents the conditions of the reservoir and proposed several potential solutions for rehabilitation. The report describes the general state of the reservoir as poor based on decreased water quantity, poor water quality, and a decrease in the diversity of aquatic life.

While this increased sediment has caused the main waters of the reservoir to become turbid and poorly oxygenated (Hawkins, Dalewood Resevoir, 2003) it has also created a growth in wetlands surrounding the reservoir. The result is a more biologically diverse area (Hall, Personal Interview, March 2006). In recent biological inventories of these wetlands, a nesting pair of the endangered Least Bittern was observed.

In 1980, the Dalewood Reservoir surface area measured 51 hectares. By 2005, almost 30 percent of the reservoir surface area, or 16 hectares, had silted in and has formed a new, provincially significant wooded wetland. The University of Western Ontario recently calculated that the Dalewood Reservoir has reached its equilibrium, and is now a net source of sediment to downstream portions of the watershed.

The wetlands surrounding the reservoir are now capable of supporting a wider variety of fish species than previously thought. The reservoir, itself is smaller, however it does provide fish retrieve during long dry spells in the summer (Hall, Personal, March 2006).

Lake Whittaker

The water resources of the Lake Whittaker Conservation Area consist of a 10.5 hectare lake and approximately 30 hectares of low-lying wetlands. The lake is a source of the main stream of Kettle Creek, which drains out of the southeast corner of the property. It was purchased by KCCA in 1982.

Lake Whittaker is a natural inland lake, which extends over an area of approximately 10.5 hectares reaching a depth of 11 metres. Fed by several springs, the lake is the nucleus of the property and the focal point of the Lake Whittaker campground.

The flow of water within the lake is fairly slow and this, coupled with the extreme depths creates pockets of stagnant water at the base of the lake. A study in 1982 indicated that dissolved oxygen levels at the bottom of the lake were virtually non-existent. Since the lake is spring fed, no oxygenated water passes through it and decaying organic material rapidly uses up any available oxygen. As a result, no living organisms can currently exist on the lake bottom.

Drainage of the lake is currently regulated by a small weir, which controls the flow into the creek and maintains a more constant level of water in the lake throughout the year. By controlling the water level, the protection of fish and waterfowl habitat, as well as the provision of a recreation facility is ensured.

The conservation area retains an extensive system of wetlands covering approximately 30 hectares. Close to 80 percent of the wetland is wooded-swamp, located primarily in an area north of the lake. An evaluation conducted in 1984 placed the wetland within the Class Two category, indicating a wetland of provincial significance. This environment benefits the hydrological regime by acting as a storage basin and purifier by providing habitat for a variety of plant and animal species.

The wetland also extends into the southern part of the lake, adjacent to the outlet into Kettle Creek. The latter is a relatively small watercourse at this point, approximately 1 to 1.5 metres in width with depths varying from 0.3 to 1.5 metres. Although water flow within this part of the stream is marginal throughout the year, substantial increases in flow are experienced in spring, enabling many fish species in the lake to escape downstream.

Northern pike and yellow perch can be found in the lake in addition to large-mouth bass and rainbow trout. The trout have been stocked in the lake during the past few years. Although there are some limiting conditions such as low oxygen levels, high temperatures, alkalinity and algae growth in the lake, the lake itself is still able to host a variety of sport fish species.

Studies in the past by the Ontario Ministries of Natural Resources (MNR) and the Environment (MOE) indicated that due to the physical characteristics of the lake, an active fish management program could be developed only through considerable expense. An aerator was installed in 1989 on a test basis by the MOE in hopes of improving oxygen levels in the lake and thereby creating better habitat for sport fish. The personal accounts of fishermen and campers suggest the aerator is a success in boosting fish populations. This aerator was re-built and re-installed in 2006.

A 1971 water survey by the Department of Lands and Forests indicated that Lake Whittaker was in an advanced state of eutrification and in the stages of succession leading to a marsh lake. To date a marsh has developed in two locations at the north end of the lake and adjacent to the outlet of Kettle Creek, in the south end. These marshes and other wetlands at Lake Whittaker Conservation Area are limited in their development potential due to their inherent fragility. Development should be restricted to permit only compatible uses that would have a negligible effect on the wetlands. These include developments such as boardwalks or other types of raised trails, which would allow for passive recreational and educational uses that minimize the negative effects on the environment.

While trout and bass have been stocked in the lake in the past, the bass are managing to reproduce. A 2006 survey of fish populations revealed a significant number of large mouth bass of varying age classes. The placement of gravel boxes would continue to promote the reproduction of bass and hopefully improve the lake for other species. Pike and perch continue to be found in the lake along with a few other species.

Lake Margaret

Lake Margaret is a man-made lake as a result of gravel extraction that ceased in the 1980's. The 14 hectare lake is now a centerpiece for an upscale housing development. The developer, Doug Tarry Ltd., has undertaken a number of initiatives to protect and enhance the lake's environmental features.

Biological monitoring of the lake indicates that it supports a warm water fishery and is occasionally used for sport fishing. Benthic invertebrates in the bottom substrate consist primarily of aquatic worms, an indicator of nutrient rich and /or low oxygen conditions.

Two factors are likely contributing to the low level of dissolved oxygen: the lake is influenced by groundwater inputs, which are low in dissolved oxygen; biomass in the lake is consuming oxygen, both because of its presence and its decomposition.

2.9.2 Aquatic Macroinvertebrates

Benthic macroinvertebrates are excellent ‘integrators’ of the many different environmental stressors such as low dissolved oxygen, contaminant spills or chronic low pollutant levels that can impact or impair aquatic health. Although physical-chemical sampling is useful in identifying specific contaminants in a stream, these samples only show the results of a specific point in time. It is not practical to monitor these parameters at all times, and the toxicological effects of many chemicals are unknown. Since these organisms spend a large portion of their lifecycle in the stream channel, they are constantly exposed to all levels of stresses placed on the stream. Therefore, benthic monitoring allows a big picture review of the total effects of water quality on living organisms.

One of the most important factors in the use of benthic monitoring is that these organisms are a true indication of the effects of environmental stressors. The Ontario Water Resources Act (OWRA) states that water quality is deemed to be impaired if:

> *the material discharged or caused or permitted to be discharged or any derivative of such material causes or may cause injury to any person, animal, bird, or other living things as a result of the use or consumption of any plant, fish or other living matter or thing in the water or in the soil in contact with the water.*
> (R.S.O. 1990, c. O.40, s.28)

Thus, an impairment of the benthic community translates directly into an impairment of the water quality of the stream.

Several kinds of biotic indices can be used as a water quality assessment tool for a specific geographic location. A large population of many different kinds of benthic macroinvertebrates is a good indicator of a healthy stream and good water quality. The system KCCA employs is a biological index, known as BioMAP, developed by Dr. Ronald Griffiths for use in southern Ontario streams (Griffiths, 1993; Griffiths, 1996; Griffiths, 1998; Griffiths, 1999).

Griffiths noted that water courses are typically classified as excellent, good, fair, or poor, which may be deemed a “value” judgment. Thus, a cold water creek might be deemed good or excellent whereas, an equally healthy warm water river might be deemed fair or poor. The OWRA states that water is either impaired or unimpaired.

The basic concept behind BioMAP is that every species is assigned a sensitivity value based on the type of watercourse within which it would typically reside. Sites are assigned a BioMAP score based on a formula which incorporates species’ presence, density, sensitivity, and diversity. These scores are compared against a water quality index based on the sampling site location. Therefore, a BioMAP score of ten at a creek location would suggest impairment, but the same score at a river location would be considered unimpaired.

In 2003, Griffiths examined the use of riparian stream cover as a surrogate for water quality by determining if there was a positive correlation between results from the BioMAP benthic water quality index and the level of riparian stream cover present (Griffiths, 2003). Griffiths showed that a positive correlation does exist.

In total, 925 kilometres of stream channel were mapped in the Kettle Creek watershed, as shown in **Map 2.19**. The study determined that 25.4 percent of the watercourses within the watershed showed unimpaired conditions, while 66.6 percent were deemed to be impaired. Griffiths concludes that the high proportion of agricultural lands surrounding watercourses likely accounts for the water quality conditions. The remaining eight percent of watercourse is considered to be indeterminate.

Indeterminate ratings are given to stream channels with BioMAP scores between ten and 12. These areas typically exist immediately downstream of unimpaired areas. These indeterminate zones are prime target areas for stewardship projects because the rehabilitation process will be encouraged by the unimpaired upstream water quality.

2.9.3 Species at Risk

Kettle Creek Conservation Authority (KCCA) is participating in the Essex-Erie Aquatic Species at Risk Recovery Strategy. The goal of this program is to maintain and restore ecosystem quality and function in the Essex-Erie region to support viable populations of fish species at risk in their current and former range.

The study area encompasses the entire drainage area of four Conservation Authorities (Essex Region, Kettle Creek, Catfish Creek, and Long Point Region) and the portion of the Lower Thames Valley Conservation Authority that drains directly into Lake Erie. This area covers approximately 6,300 square kilometres of land in southwestern Ontario.

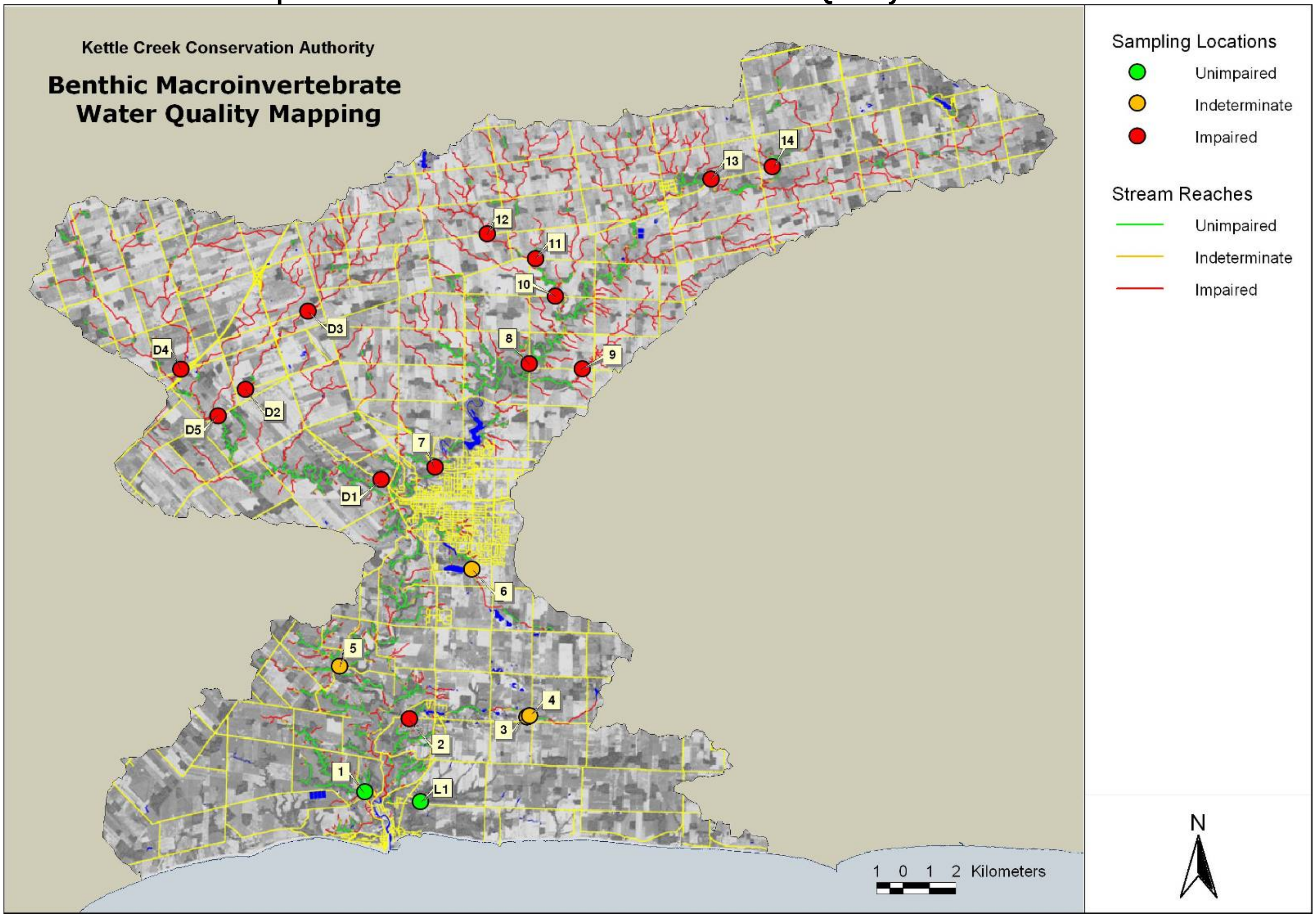
The recovery team is currently focusing on the aquatic species at risk that are known to inhabit inland waters, coastal wetlands, and the nearshore, unvegetated zone of Lake Erie, the Detroit River, and Lake St. Clair that are within the jurisdictional area of the five conservation authorities noted above. The primary focus of the recovery strategy will be on endangered (northern madtom and pugnose shiner) and threatened (black redhorse, channel darter, eastern sand darter, lake chubsucker, and spotted gar) fish species. However, it is anticipated that by taking a watershed-approach, benefits to many other aquatic species will result.

A complete list of species of animals and plants known to be at risk, rare or endangered in the Kettle Creek watershed is included in section 2.5.5 “Flora and Fauna”.

2.9.4 Invasive Species

The information available on invasive aquatics in the Kettle Creek watershed is limited. Much of the information collected by the Ministry of Natural Resources (MNR) is restricted to sightings reported by the general public. For the purposes of this report, species listed will be broadened to include not only species sighted within the watershed, but also those species which may, or are likely to exist within the watershed.

Map 2.19: Benthic Macroinvertebrate Water Quality in the Kettle Creek Watershed



Griffiths, R.W. Mapping the Water Quality of Kettle Creek. Kettle Creek Conservation Authority, St. Thomas Ontario, 2003.

Fauna

Zebra Mussels (Dreissena polymorpha)

Zebra mussels are small freshwater mollusks. These mussels are typically brown in colour, with white or yellow stripes. Originally discovered in Canada in Lake St. Clair in 1988, zebra mussels were introduced to Canadian waters through ballast water from a transatlantic vessel (Zebra Mussels, GLIN, 2006).

Living in large colonies, zebra mussels have caused extensive damage and disruption on both anthropogenic and ecological scales within Ontario. Zebra mussels are living in the Kettle Creek watershed (Harmful, MNR, 2006).

Quagga Mussels (Dreissena bugensis)

Similar to Zebra mussels, quagga mussels are slightly smaller and more oval. Unfortunately for both the ecosystem and the economy, quagga mussels are expected to compound the damage done by zebra mussels, because quagga mussels can take advantage of a wider variety of habitats (Invasive, MNR, 2006).

Quagga Mussels are confirmed in the Kettle Creek watershed (Sucee, 2006).

Chinese Mitten Crab (Eriocheir sinensis)

According to the MNR database, the Chinese Mitten Crab was spotted in the Port Stanley harbour in 1973 (Sucee, 2006). No sighting has been reported since; therefore, it is likely that this species is no longer present within the watershed.

Common Carp (Cyprinus carpio)

Now considered common in the Great Lakes and their tributaries, *Cyprinus carpio* was originally introduced to North America in the late 1800's by the U.S. Fish Commission. Since then the carp population has steadily grown (Wisconsin Sea Grant, 2006).

Carp have disrupted the local environment by uprooting plants and destroying vegetative food and cover required by other fish species.

Round Goby (Neogobius melanostomus)

This small bottom-dwelling fish was introduced to Canadian waters in the late 1980's. Originally from Eastern Europe, it is believed the round goby was introduced via ballast water.

Although not yet reported in the Kettle Creek watershed, these fish have been sighted in Lake Erie and neighbouring watersheds (Sucee, 2006). The round goby is an aggressive fish which spawns several times a year, and competes for resources with native fish species. It is expected that round goby will be harmful to the Great Lakes and inland fisheries (Harmful, MNR, 2006).

Sea Lamprey (Petromyzon marinus)

Sea lampreys, also known as lamprey eels, first appeared in Lake Erie in 1921. These eel-like fish accessed the Upper Great Lakes via the Welland Canal. An aggressive parasite, the sea lamprey latches on to its prey with circular rows of teeth and rasps out a hole with its tongue (Wisconsin Sea Grant, 2006).

Although not listed in the MNR's invasive species list for Elgin County, sea lampreys are believed to spawn in Kettle Creek (Hall, 2006).

Flora

Flowering-Rush (Butomus umbellatus L.)

Originating in Europe and Asia, flowering-rush was first discovered in North America along the St. Lawrence River in Quebec around 1897. Observation of this plant in southwestern Ontario occurred around 1955 (Environment Canada, 2006).

Although the effects of this plant on local wetland environments are not known, it is believed that this plant is capable of aggressively displacing native vegetation (Environment Canada, 2006).

Purple Loosestrife (Lythrum salicaria L.)

Believed to be introduced from Europe and Asia via ship ballast, purple loosestrife was first discovered in North America in the early 1800's. Purple loosestrife is described by Environment Canada as an herbaceous perennial with a prolific seed production of up to 2.7 million seeds per plant per year. This prolific seed production, in addition to the plants ability to spread through shoots and roots has led to purple loosestrife being regarded as one of the worst invasive alien species in Ontario wetlands (Environment Canada, 2006).

Although purple loosestrife is present throughout the Kettle Creek watershed, it is not currently considered to constitute a major threat to the local environment. Primary sightings are around Lake Whittaker and the Dalewood Reservoir, in the floodplain near John Wise Line, and in municipal drains throughout the watershed. The slow progression of purple loosestrife colonization in the Kettle Creek watershed is likely due to lack of preferred habitat. The combination of deeply incised shady valleys, watercourse erosion and seed bank washouts during spring thaw is believed to be responsible for limiting the spread of this plant (Hall, 2006).

Despite the relatively slow progression of the plant within the watershed, KCCA conducted a purple loosestrife removal project in 2001. The project was conducted around the Dalewood Reservoir and was considered very successful in reducing populations in the area.

Common Reed (Phragmites australis)

Common Reed is well established in the Kettle Creek watershed, and in some areas threatens to choke out native non-invasive species. Both native and European varieties of *Phragmites australis* exist in southern Ontario (Canadian Nature Federation, 2006). It is unknown which variety constitutes the community present in the Kettle Creek watershed. These plants are evident in and around the Dalewood Reservoir and in many municipal drains and ditches throughout the watershed.

Reed Canary Grass (Phalaris arundinacia L.)

Like *Phragmites autralis*, native and introduced varieties of *Phalaris arundinacia L.* exist within southern Ontario. Since these varieties are very difficult to distinguish between, it should be considered that either variety poses a threat to native wetland plants (Environment Canada, 2006).

Currently, no studies show a definite presence of this species in the Kettle Creek watershed. However, distribution mapping from Environment Canada suggests that it is present.

Reed Canary Grass is a vigorously competitive species capable of inhibiting and eliminating competing species. Once established, this plant species creates persistent, monotypic stands that dominate the local seed bank (Environment Canada, 2006).

Eurasian Watermilfoil (Myriophyllum spicatum L.)

Originally a native of Europe, Asia, and Northern Africa, it is believed that Eurasian watermilfoil was introduced to North America around 1940 via ballast water. First discovered in Ontario in the 1960s, by the 1970's the plant was considered a troublesome weed, and by 1985 was considered a major problem (Environment Canada, 2006).

Prominent in all watersheds in southern Ontario, Eurasian watermilfoil typically grows profusely in shallow to moderately deep waters forming a dense canopy. This species' ability to quickly colonize has caused widespread impacts including displacement of native species, interference with fish spawning, and limitation of recreational use of waters (Environment Canada, 2006).

Found within the Kettle Creek watershed, Environment Canada notes this species as "one of five invasive alien plants that have had a major impact on natural ecosystems in Canada" (Environment Canada, 2006).

3.0 HUMAN CHARACTERISTICS

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 impact on the watershed. This section describes the history of human settlement in the Kettle Creek watershed, the current land uses, patterns of human settlement, and provides future population growth projections.

3.1 Settlement History

Natives have inhabited the landscape of the Kettle Creek watershed for thousands of years. Settlement began in the Paleo-Indian and Archaic periods. The Neutral or Attawandaron natives occupied many villages in the area until 1651, when the Iroquois drove the Neutrals from southwestern Ontario. The region remained uninhabited until the early 1800s when the Europeans began to settle (Baron, 2001).

On August 21st, 1803, Lt. Colonel Thomas Talbot commenced settlement of the Talbot Settlement, landing and cutting the first tree at Port Talbot. The lands subsequently settled under his superintendence embraced 34 townships, and now form the whole of Elgin County and parts of four other counties (Baron, 2001).

Elgin County was part of Middlesex County from 1837 to 1851. Prior to that, Elgin was part of the London District. In 1851 legislation was passed to separate Middlesex and Elgin Counties. Elgin County was named for the Governor-General of the time, Lord Elgin.

3.1.1 Avon

Avon is a dispersed rural community situated on the border separating Middlesex and Elgin counties. It is located approximately eight kilometres south of Highway 401 and 18 miles northeast of St. Thomas (Mika, 1977).

The first European settler was William Baker, who arrived in 1820, after he had blazed a trail all the way from Brownsville (Mika, 1977).

3.1.2 Belmont

Belmont was known as Plymouth in 1849 and Kettle Creek in 1832. The village developed on the farm lands owned by Joshua Odell and Thomas Nugent. In 1840, Odell divided his farm into village lots. A decade later, Nugent severed part of his farm into lots and added them to Odell's village. Belmont was officially named as a post office in 1854 (Mika, 1977).

Belmont was originally part of Middlesex County. Final approval was given to annexation by South Dorchester April 6, 1948 (Mika, 1977).

3.1.3 Central Elgin (Yarmouth)

Colonel Thomas Talbot is said to have considered Yarmouth as the choice township among all the lakefront townships he helped settle from Long Point to the Detroit River. Established in 1792, it was named after Yarmouth in Norfolkshire, England. Most of the settlers arrived around 1810 (Mika, 1983).

Yarmouth Township, the Village of Belmont and the Village of Port Stanley amalgamated to form the Municipality of Central Elgin on January 1, 1998.

3.1.4 Harrietsville

This dispersed rural community was named in 1847 by Captain McMillen, an early settler, after his wife Harriet. The first settlers arrived in the 1830s, although land grants had been made as early as 1816. A post office was established in 1856 with McMillen as postmaster (Mika 1981).

3.1.5 London

Westminister, now part of the City of London, was surveyed as part of the north branch of Talbot Road by Col. Mahlon Burwell and the remaining part of the township was surveyed by Col. Bostwick in 1820. The first settler, Archibald McMillan, arrived prior to 1810. Land was granted and settled under Colonel Talbot. Unlike neighbouring townships, land was not granted to speculators or absentee owners. As a result, settlers flocked to Westminster to clear the land and establish their homes (Mika, 1983).

3.1.6 Malahide

The township of Malahide was named by Colonel Thomas Talbot, the founder of the Talbot Settlement in southwestern Ontario, in remembrance of the baronial castle of Malahide in Ireland where he was born (Mika, 1981).

The earliest settlers were the Davis brothers who came to the area from New York around 1810 (Mika, 1981).

3.1.7 Middlesex Centre

Delaware, presently called the Municipality of Middlesex Centre, was the first township to be settled in Middlesex County in 1798. Delaware was named after the Native tribe that settled in the area along the Thames River after being driven out of the United States.

3.1.8 Paynes Mills

William Sells settled in 1818 on Lot 33 on the south side of the North Branch of the Talbot Road, in what is now called Paynes Mills. He moved there after the War of 1812 and was the first and only blacksmith in the area for years (Sims, 1986).

Henry Payne spearheaded the establishment of flour mills in the area. For many years water was so plentiful in the swamps and woods that the three mills situated on Dodd Creek, at Payne, could run by waterpower all summer (Sims, 1986).

3.1.9 Port Stanley

Port Stanley was originally founded by Colonel Thomas Talbot. Colonel Bostwick was a friend to Colonel Talbot and as such was the first resident to be granted land. In 1804, Bostwick moved his family to Port Stanley. The village's name was adopted in 1823 in honour of Lord Stanley following his visit to the area (Mika, 1983).

Although Port Stanley would become a primary shipping port for the area, there were no stores in the Talbot Settlement until 1817. In this year, James Hamilton brought in goods and became the settlements first merchant (Baron, 2001). A road built in 1823 connected the village with London.

A village that served the Port was constructed on the present location of C. Griegel's property, some two miles upstream of the Port. In the mid 1800's, a very large flood completely destroyed the village; it was never rebuilt. Settlement thereafter concentrated on lands of higher elevation at Port Stanley (Hall, 2006).

Construction of the Port Stanley harbour generally occurred between 1833 and 1856. During this time, $190,000 was spent on the harbour resulting in the construction of two piers and a draw bridge which spanned Kettle Creek (Baron, 2001). In 1844 a lighthouse was built, and in 1846 the Federal Board of Public Works assumed supervision of the harbour (Mika, 1983).

Port Stanley's booming shipping industry suffered a blow with the construction of the London and Port Stanley Railroad in 1856 (Mika, 1983).

The summer tourism industry that Port Stanley enjoys today originally started to take off around the turn of the twentieth century (Mika, 1983).

3.1.10 Southwold

Southwold was part of the region of the Talbot Settlement. The name Southwold is derived from an Anglo-Saxon term "wold" or "weald", meaning forest or open country. The first settlers arrived in approximately 1809. Many of the settlers of Southwold were United Empire Loyalists, and a great number were involved in the War of 1812 and the Rebellion of 1837 (Mika, 1983).

3.1.11 St. Thomas

The first settlers arrived in St. Thomas in 1810 and within ten years a nucleus of a village had formed at the Kettle Creek crossing. Originally named Kettle Creek Village, the village was considered the "capital" of the Talbot Settlement. Later named St. Thomas after Colonel Thomas Talbot, the "Saint" prefix was added as an euphony (Mika, 1983). In 1853, with 1,200 residents, St. Thomas was incorporated.

Most of the business district of St. Thomas was ravaged by fire in 1870. However, the area soon recovered thanks in part to the construction of both the Great Western and the Canada Southern railway lines. The positioning of the stations for both lines outside of the boundaries of the village led to the expansion of the village. Between 1871 and 1876 the population of St. Thomas tripled (Mika, 1983).

Near the turn of the twentieth century industry was quickly expanding. With a staff of only four ladies and a doctor, St. Thomas' first hospital opened in 1892. By the middle of the twentieth century Ford Motor Company of Canada had established an assembly plant north of the city, and many other industries including aircraft and automotive parts, clothing, and plastics manufacturers were introduced (Mika, 1983).

3.1.12 Talbotville

Talbotville originated in 1811 when Colonel Mahlon Burwell completed the survey of North Street (Highway 4) and the Military Road (Highway 3), then known as Talbot St. North. At this point he had his survey party drive five stakes in the ground to mark the junction of five roads in Southwold Twp. After that it became known as "Five Stakes" (Sims, 1988).

For many years this area remained wilderness with only a trail blazed through the woods. The first group of settlers arrived in 1818. The group consisted of: David Gilbert, Jacob Lemon, Charles Hannon, Samuel Smith, Issa Reilley, John Mathies, Daniel Boughner, James Bowlby and Squire William Millard (Sims, 1988).

Before the introduction of the London and Port Stanley Railroad, Talbotville was an important transportation centre. The railroad took away the importance of Talbotville (Sims, 1988).

3.2 Municipalities and Municipal Structure

The Kettle Creek watershed spans central Elgin County, including the City of St. Thomas, and the south-central County of Middlesex, including the City of London.

Hourglass in shape, the watershed reaches from well north of the intersection of Highway 401 and Highway 4 to the northwest, to just south of the Avon-Putnam exchange on Highway 401 to the northeast, and from near Port Talbot on the southwest to Port Bruce on the southeast (see **Map 3.1**). The watershed constricts at its middle to include most of the City of St. Thomas.

Elgin County comprises about 60 percent of the southern portion of the watershed, including portions of the Municipalities of Southwold, Central Elgin, and Malahide. Middlesex County comprises about 20 percent of the northern portion of the watershed, including portions of the Municipalities of Middlesex Centre and Thames Centre.

In the north central area of the watershed, rural lands within the City of London comprise15 percent of the watershed landscape, while the remaining five percent is attributed to the City of St. Thomas.

The Upper Tier municipalities of Elgin and Middlesex Counties lead in major arterial roadwork, long-term health care facilities, library, and ambulance. They also perform limited planning functions and cultural services to their member municipalities. Each municipality leads in roadwork, primary emergency response including fire and police services, a full range of municipal planning functions, and a variety of other local functions.

The Cities of London and St. Thomas provide a full range of services, and cooperate in joint ventures with both upper and lower tier municipalities adjacent to their jurisdiction. **Table 3.1** provides a summary of the municipal structure and responsibilities in the Kettle Creek watershed.

Map 3.1: Municipalities in the Kettle Creek Watershed

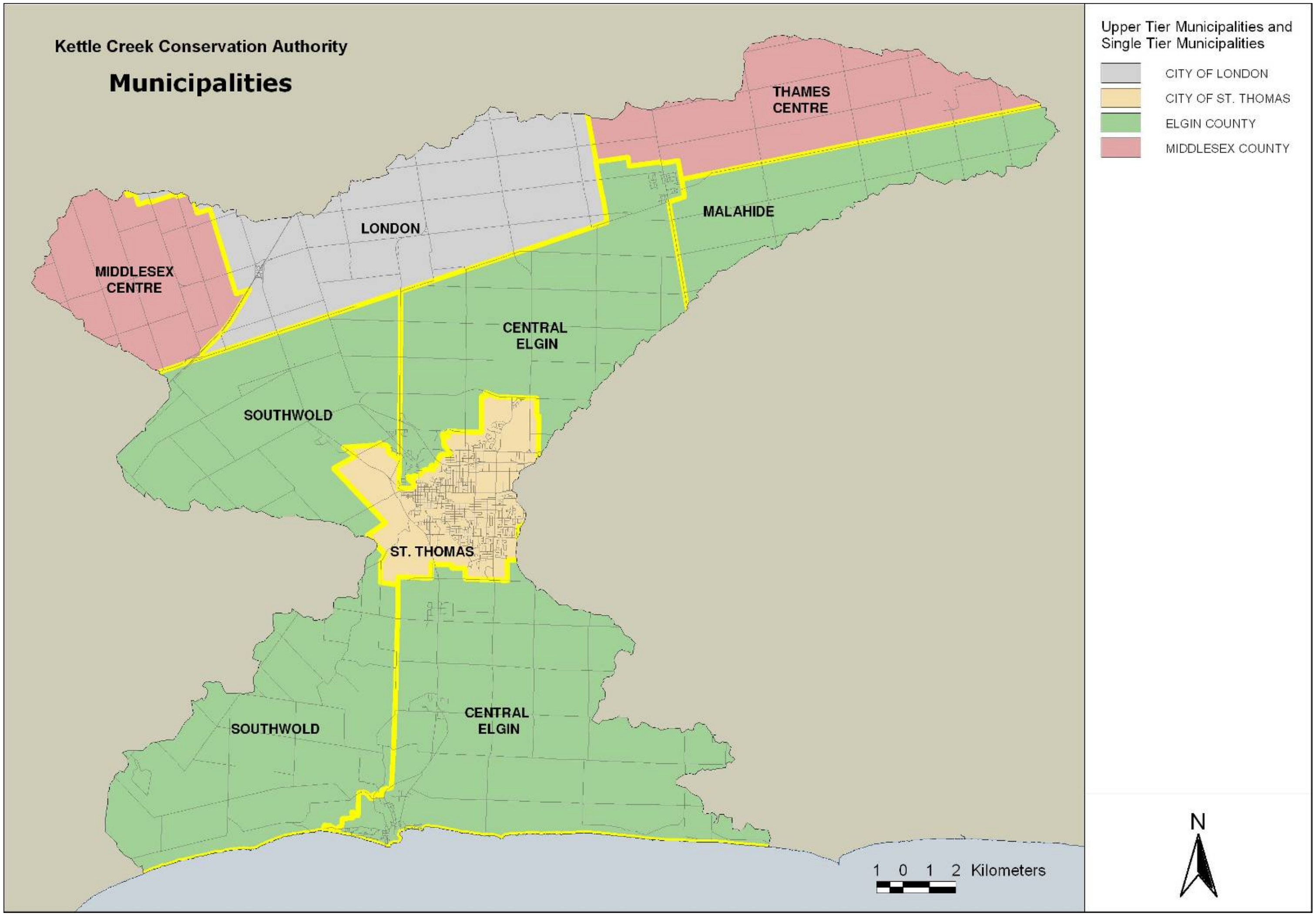


Table 3.1: Municipal Structure of the Kettle Creek Watershed.

Municipality	Elgin County	Municipality of Central Elgin	Southwold Township	Malahide Township	City of St. Thomas	Middlesex County	Municipality of Middlesex Centre	Municipality of Thames Centre	City of London
Level	Upper Tier	Lower Tier	Lower Tier	Lower Tier	Separated City	Upper Tier	Lower Tier	Lower Tier	Incorporated City
Official Plan	No	Yes**	Yes	Yes	Yes	Yes	Yes	Yes	Yes
By-laws	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Consents	Yes	No	No	No	Yes	No	Yes	Yes	Yes
Variances	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Subdivisions	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Homes for the Aged	Yes	No	No	No	Yes	Yes	No	No	Yes
Fire	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Police	No	OPP	OPP	OPP	City	No	OPP	OPP	City
Ambulance	Yes	No	No	No	Yes	Yes	No	No	Yes
Roads	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Culture	Yes	No	No	No	Yes	Yes	No	No	Yes
Recreation	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Drinking Water	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Wastewater	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes

** Currently Combination of Former Township of Yarmouth and Villages of Port Stanley and Belmont
Note: Partnerships often exist between various municipal levels.

3.3 Population Trends in the Kettle Creek Watershed

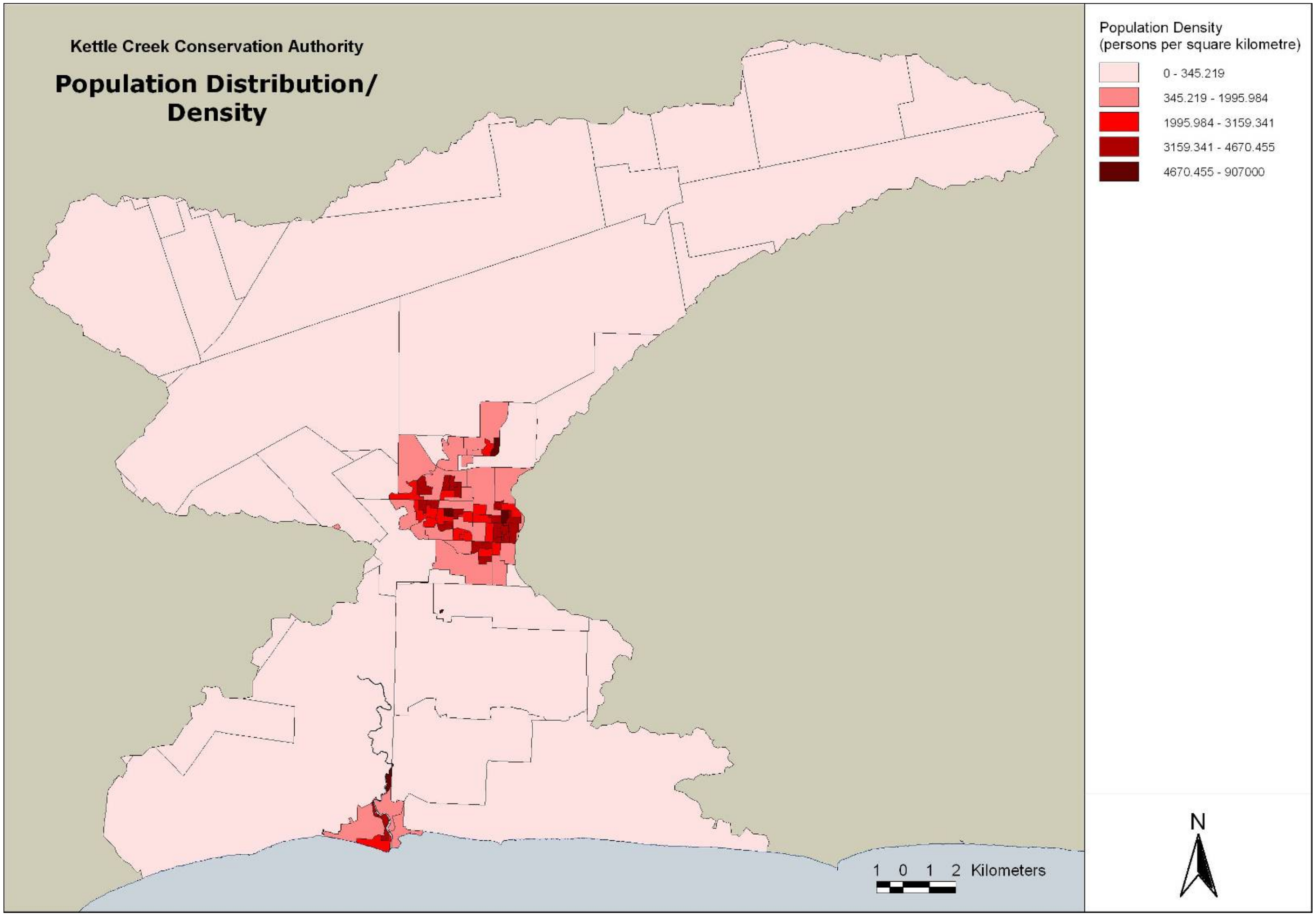
The population of the Kettle Creek watershed in 2001 was approximately 44,406, distributed between an urban core in the City of St. Thomas and a rural periphery in the Township of Malahide, Municipality of Central Elgin, Township of Southwold, Township of Middlesex Centre and Township of Thames Centre, and the southern, mostly rural portion of the City of London.

3.3.1 Population Distribution

The main population centre in the Kettle Creek watershed is the City of St. Thomas, representing a significant majority of the population (roughly 71 percent of 2001 watershed population) (LaPointe Consulting Inc. et al., 2004). However, the City of London sits on the watershed's northern boundary and strongly impacts both the economic and population growth of the area, although almost all of London's population is located outside of the Kettle Creek's watershed boundary (City of London Planning Department, 2003).

The remaining 29 percent of the population in the Kettle Creek watershed is relatively evenly distributed through rural townships in Elgin and Middlesex Counties, as seen in **Map 3.2**.

Map 3.2: Population Density and Distribution in the Kettle Creek Watershed, 2001



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

Serviced areas in the watershed include St. Thomas, Belmont and Port Stanley. The village of Talbotville may become serviced in the future, which may provide additional population growth to the area.

3.3.2 Population Forecasts

Population forecasts for the municipalities in the Kettle Creek watershed have been prepared for local municipal official plans and other planning documents ranging from 1995 to 2004.

As summarized in **Table 3.2**, forecasts indicate that the population of the watershed will grow by approximately 14,000 people by 2031. The majority of this growth will be centred in the serviced area of the City of St. Thomas, which is expected to increase by over 9,000 people by 2031 (LaPointe Consulting Inc. et al., 2004). St. Thomas's proximity to Highway 401 and the City of London, make it an attractive location for new home buyers.

Table 3.2: Population, Forecasts and Average Annual Growth Rates for the Kettle Creek Watershed

Municipality	Population 2001	Population Forecast 2031	Average Annual Growth 2001-2031 (ppl/yr)	% Population in Kettle Creek Watershed
Malahide Township	664*	930*	8.9	8%*
Central Elgin	8,272*	11,610*	111.3	67%*
City of St. Thomas	31,574*	40,893*	310.6	95%*
Township of Southwold	2,030	3,011	32.7	40.4%
City of London	789	1003	7.1	0.2%†
Middlesex Centre	360	360	0	5%
Thames Centre	720	757	1.2	5%
Total	**44,406**	**58,564**	**471.8/yr**	

* Estimate of total population of area in the Kettle Creek watershed.
† Represents percentage of population in three southernmost Planning Districts in London (those that fall into the Kettle Creek watershed).

The remaining growth will occur predominantly in the Municipality of Central Elgin, and in particular, in the serviced towns of Belmont and Port Stanley (LaPointe Consulting Inc. et al., 2004). More conservative growth is forecast for the mainly rural, unserviced townships of Southwold, Malahide, Middlesex Centre and Thames Centre (LaPointe Condulting Inc, 1995, Cumming Cockburn Limited, 2001, Marshal, Macklin, Monoghan, 2003, and Thames Centre, 2002).

Although the City of London plays an important role in attracting growth to the watershed, the portion of the city that lies in the Kettle Creek watershed consists of the rural planning districts of Tempo, Brockley and Glanworth, and therefore only a small portion of London's population. Growth is not expected to increase significantly in these planning districts, but rather in the north and west of the city, outside of the Kettle Creek watershed.

Current Population and Population Forecast Data Gaps

Current population totals used for this report are based on 2001 census data. The 2006 census data would provide more accurate population estimates for the watershed, but was unavailable at the time of this report.

Population forecasts cited in this report were gathered as part of a population forecast consolidation project in 2005. In some cases, municipalities are undertaking official plan reviews and comprehensive population forecast studies resulting from the new *Places to Grow Act* (2006) and associated planning policy changes in Ontario. Many municipalities have not yet incorporated the impact of *Places to Grow* in their population forecasts.

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 Kettle Creek watershed are characterized by an urban commercial, industrial and residential centre, surrounded by less-populated rural land used for intensive agricultural production. **Map 3.3** shows the distribution of land uses across the watershed. The map illustrates the dominance of agricultural land uses in rural areas of the watershed.

3.4.1 Settlement Areas

The primary settlement areas in the Kettle Creek watershed are the City of St. Thomas, Belmont and Port Stanley, in addition to several smaller, unserviced villages and rural settlement areas spread throughout the watershed.

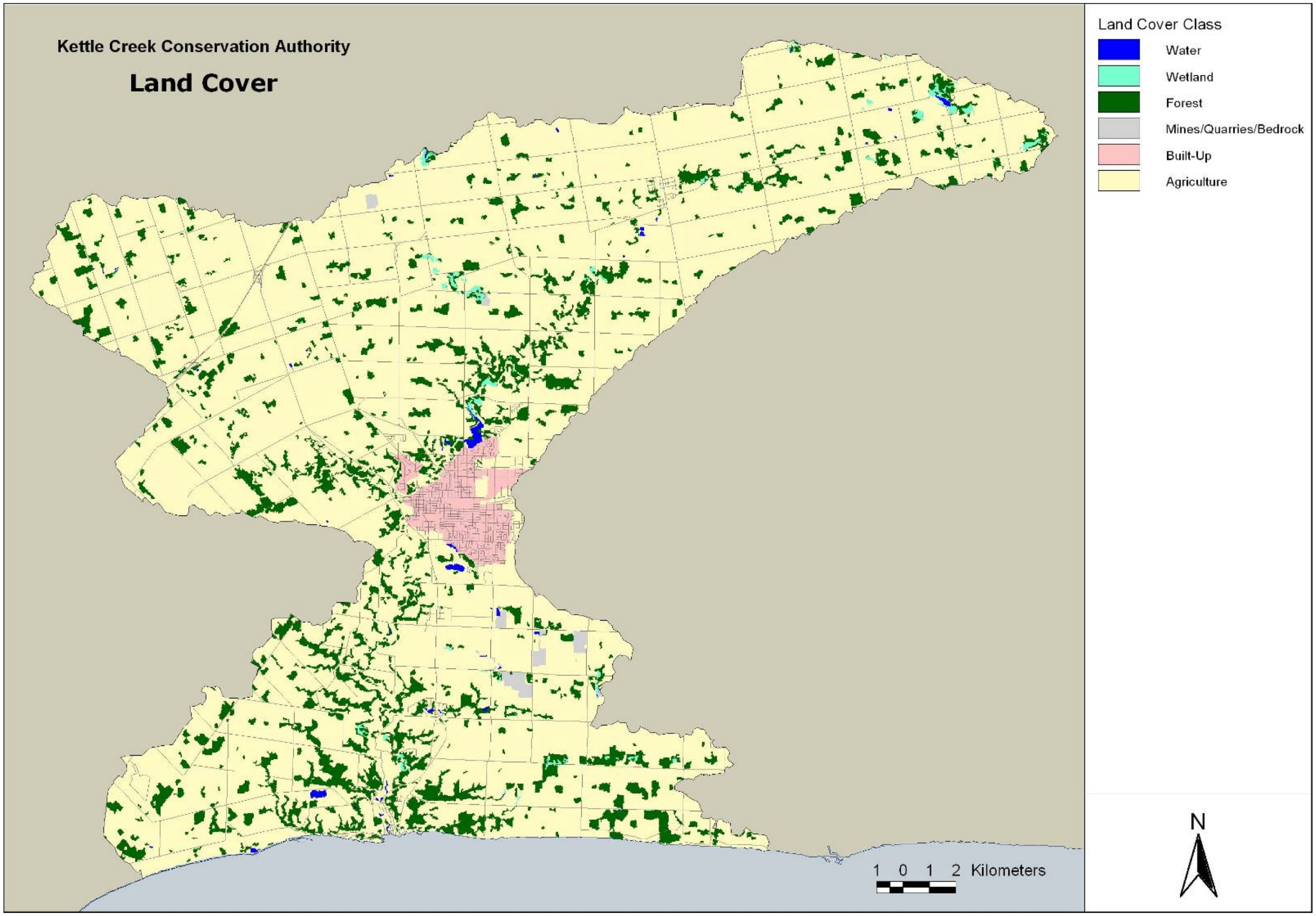
Serviced and Non-Serviced Areas

Approximately 98 percent of the watershed is supplied with water from Lake Erie by means of the Elgin Area Primary Water Supply System. Although such a large portion of the watershed area is on municipal water, only about six percent of the watershed area is serviced by municipal wastewater treatment facilities, as shown on **Map 3.4**.

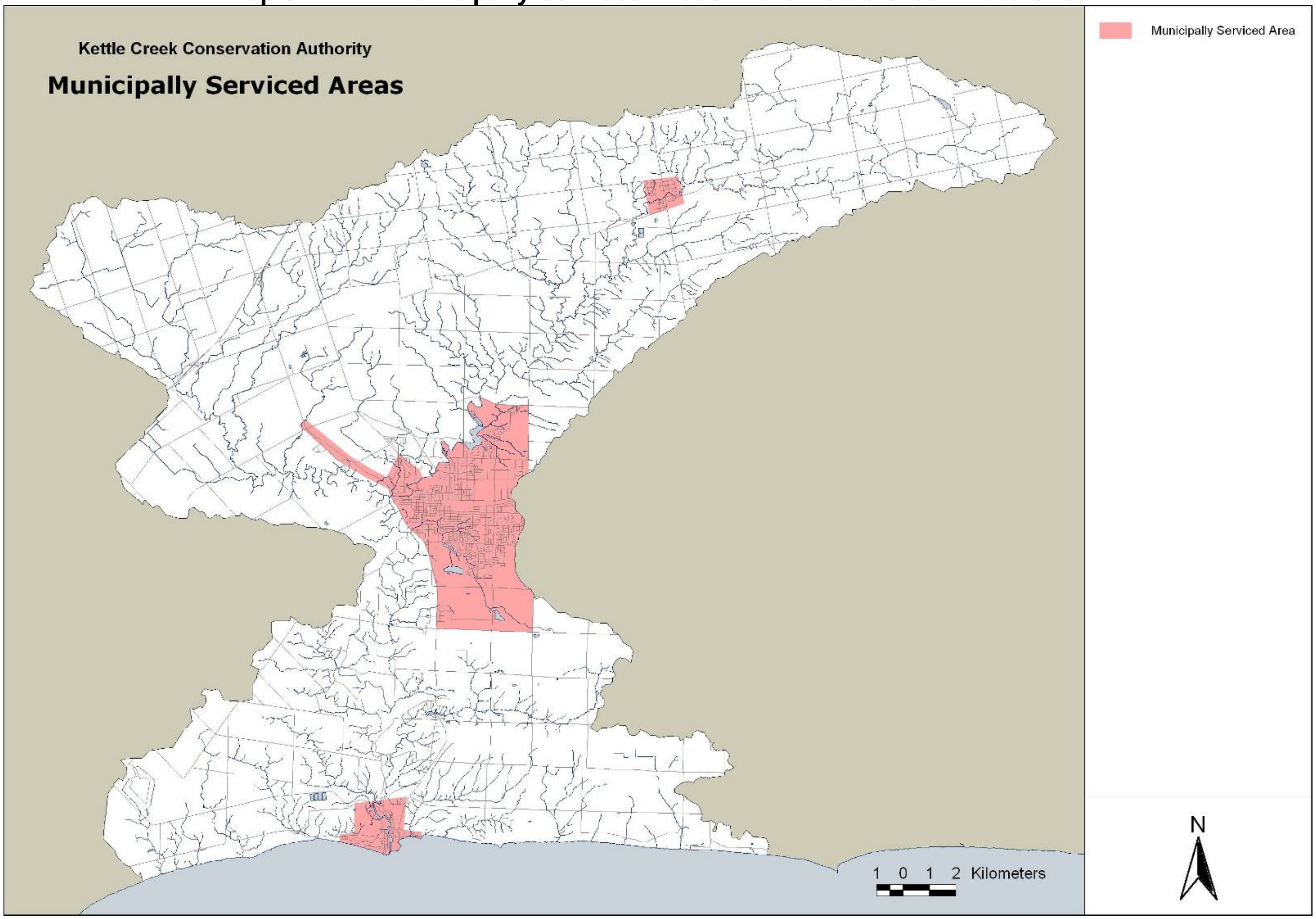
The City of St. Thomas and the villages of Belmont and Port Stanley offer municipal wastewater treatment facilities. Wastewater in the remaining 94 percent of the watershed is discharged to private septic systems.

There are approximately 4,000 homes on septic systems in the Municipality of Central Elgin. All the septage from these homes is hauled to London where it is incinerated in the Greenway Pollution Control Plant (Perrin, 2005).

Map 3.3: Land Use Distribution in the Kettle Creek Watershed



Map 3.4: Municipally Serviced Areas in the Kettle Creek Watershed



3.4.2 Industrial and Commercial Sectors Distribution

The primary industries in the Kettle Creek watershed are agriculture and manufacturing. In 2001, the manufacturing industry employed approximately 5,000 people in the City of St. Thomas alone, in which the predominant industry is auto manufacturing (Statistics Canada, Census of Labour Force 2001).

Outside of St. Thomas, agricultural production is the main land use and employer.

3.4.3 Forestry

According to records obtained from the Elgin County Tree Commissioner, there were approximately 250 hectares of forested lands selectively harvested in 2005 within Elgin County's portion of the Kettle Creek watershed.

This is considered to be representative of an average year, with the majority of logging occurring in the southern portion of the watershed. The 250 hectare estimate refers solely to selective harvesting as no land clearing has occurred in the watershed for at least two years.

In recent years, the City of London, Elgin and Middlesex counties have adopted new Woodlands Conservation By-laws to protect and enhance the woodlands within their jurisdictions. One of the goals of the new by-law is to promote the improvement of the overall health of the woodland. This is achieved through a practice known as Good Forestry, which requires that a residual basal area be left after the harvest operation.

3.4.4 Brownfields

Brownfields are defined by the American Heritage Dictionary as, "a piece of industrial or commercial property that is abandoned or underused and often environmentally contaminated, especially one considered as a potential site for redevelopment" (American Heritage Dictionary, 2000).

Currently, all of the suspected or potential brownfield locations in the Kettle Creek watershed are within the City of St. Thomas and the Village of Port Stanley. These areas are noted on **Map 3.5**. The areas identified as brownfields in the map are railway corridors and abandoned industrial sites or landfills.

The brownfield areas of most immediate concern in the watershed are those related to the coal tar deposits in the Village of Port Stanley. Several reports show that the Kettle Creek bed sediments in Port Stanley are highly contaminated with Polynuclear Aromatic Hydrocarbons (PAH's). In addition to the existence of this contamination, research shows that these contaminated sediments are mobile. Transported by water currents, these sediments were identified in the Elgin Area Water Supply Treatment Plant intake pipe, 1.5 kilometres east of Port Stanley (Riggs, 2004).

3.4.5 Mining and Aggregate Extraction

The surficial geology of the Kettle Creek watershed is primarily defined by the vast clay and till plains that cover most of the watershed. Consequently, aggregate extraction operations are primarily confined to the sand plains in the southeastern quadrant of the watershed.

Within the Kettle Creek watershed there are currently eight aggregate pits in operation (see **Map 3.6**), with a total land area of approximately 150 hectares (MNR, 2006). Licenses currently issued to these operations allow for a total extraction of approximately 910,000 tonnes of material (MNR, 2006), 72 percent of which comes from the area surrounding the Sparta Moraine.

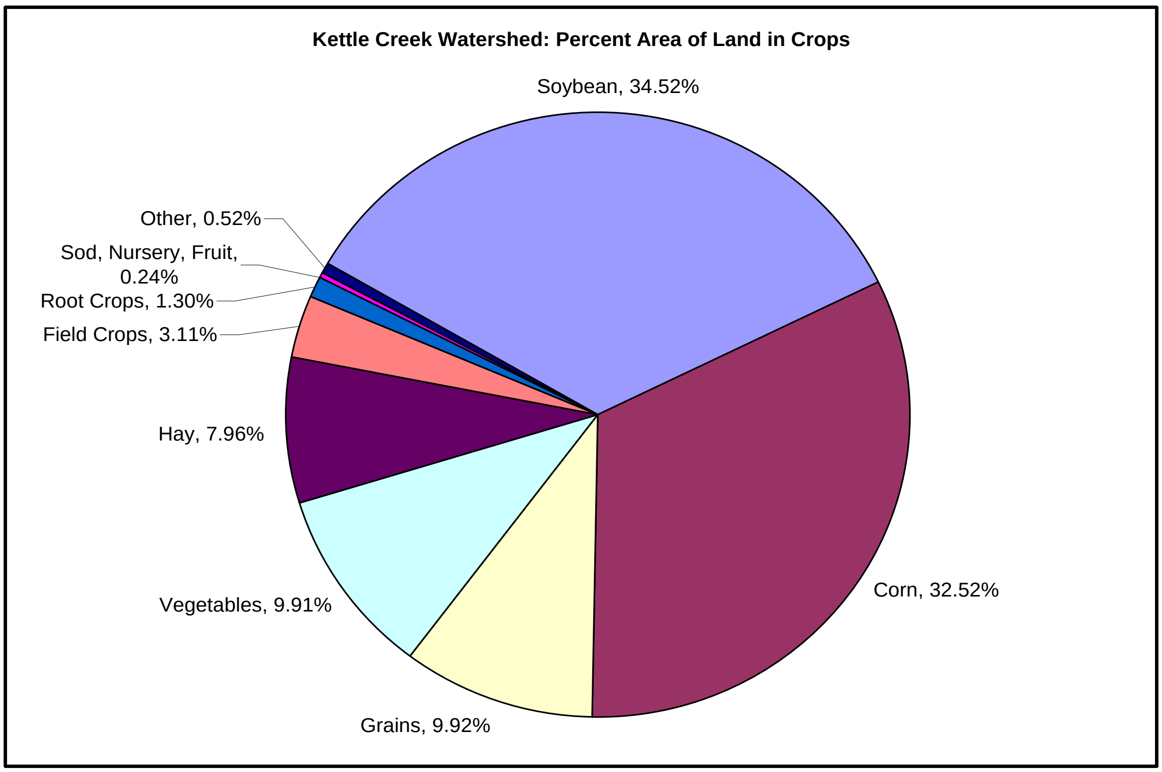
Historically, most of the aggregate operations were also on or near the Sparta Moraine, with the exception of some smaller operations near Port Stanley and Lake Whittaker.

The Sparta Moraine is the dividing point between the Mill Creek and Beaver Creek subwatersheds. Believed to be the primary provider of groundwater seepage to these Creek's, depletion of this moraine may have serious consequences to base flows in these basins.

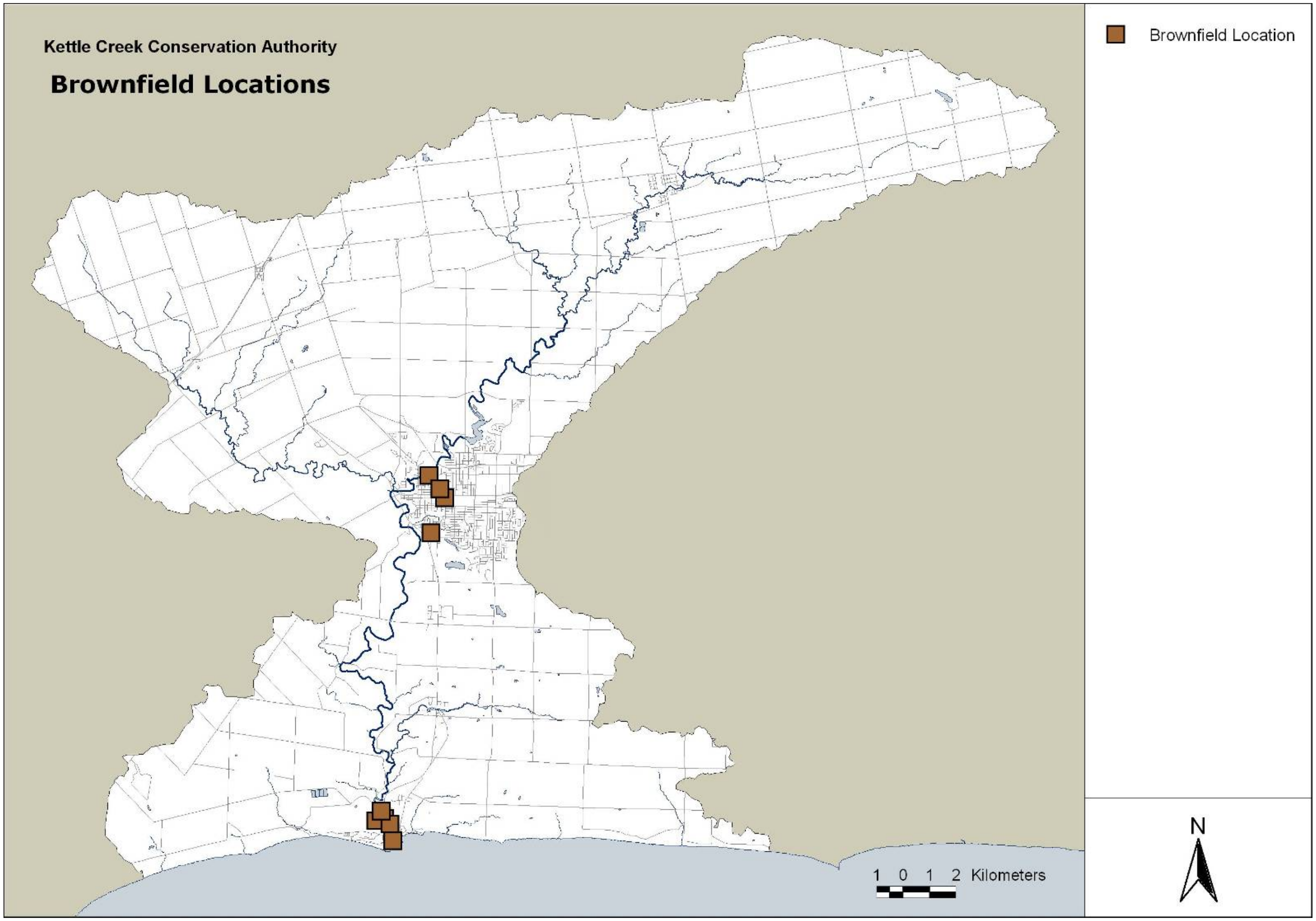
3.4.6 Agricultural Sector Distribution

Agriculture is a large part of the Kettle Creek watershed, as 83 percent of the land area is designated and used for agricultural purposes. Both livestock and agricultural crops are prominent practices, with 70 percent overall in cropped agricultural use. There are a total of 8,900 head of cattle, 14,800 head of swine and 200,000 head of poultry across the watershed. The majority of crops grown in the watershed are soybean (34.5 percent) and corn (32.5 percent), with vegetables and grains both at 9.9 percent (see **Figure 3.1**).

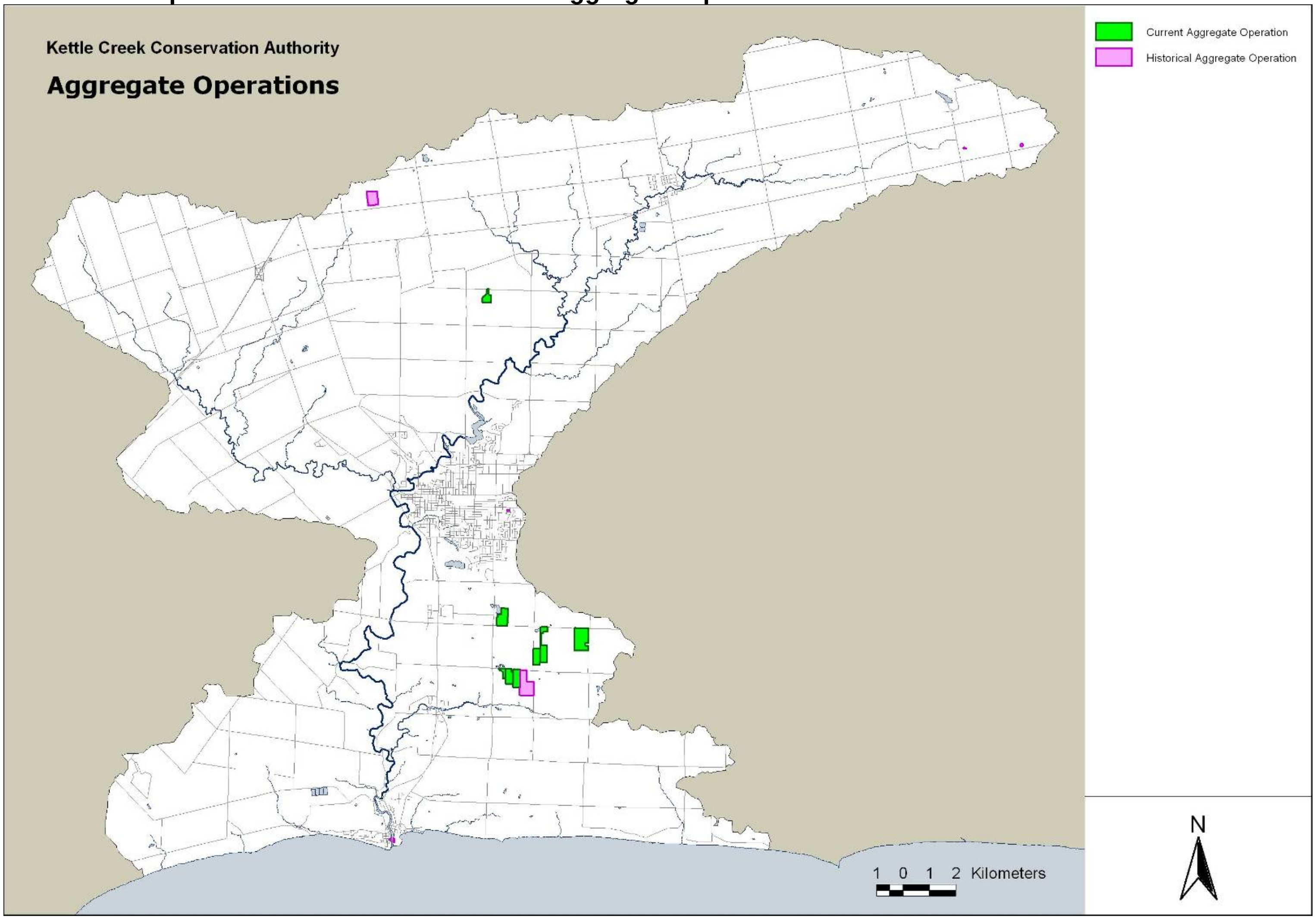
Figure 3.1: Distribution of Cropped Agricultural Lands in the Kettle Creek Watershed.



Map 3.5: Brownfield Locations in the Kettle Creek Watershed



Map 3.6: Historic and Current Aggregate Operations in the Kettle Creek Watershed



Cropping Characteristics in the Kettle Creek

Agricultural crops are quite diverse in the Kettle Creek watershed due to the different soil types and quaternary geology of the area. However, cropping patterns are evident when the watershed is divided into three subwatersheds. The Dodd Creek subwatershed is located to the north and west of St. Thomas while the Upper Kettle Creek subwatershed is located to the north and east. The Lower Kettle Creek subwatershed includes lands from St. Thomas, southward to Port Stanley.

The Dodd and Upper Kettle Creek subwatersheds are in the till plain while the The Lower Kettle subwatershed is characterized by clay and sand. Consequently, root crops such as tobacco and potatoes, which have high water requirements, are only found in the Lower Kettle subwatershed.

As seen in **Figure 3.1**, soybean and corn crops occupy the largest land area. However, vegetable production is prominent throughout the entire watershed and should be considered significant due to the crops' higher water requirements.

Livestock

Livestock farming can be divided into three categories: cattle, swine and poultry. Cattle are the most prominent of livestock farm types, while there are not as many poultry and only a few swine farms across the basin. For the purposes of this report, the term 'cattle' is used to describe livestock including all dairy and non-dairy cows, steers, calves and heifers.

Cattle were reported on almost a third of all the farms in the basin, and are fairly evenly spread out across the Kettle Creek watershed. Swine were only reported on five percent of all farms, and were mainly found in the Upper Kettle basin. Poultry were only slightly more prominent at 15 percent of farms. However, poultry is not a significant farming practice in the Dodd Creek subbasin, with only half the amount of farms producing poultry as in each of the other two subbasins. The Dodd Creek subbasin supported only one fifth the number of poultry as the Lower Kettle basin, which reported more than the combined number of poultry of the other two subbasins. The Upper Kettle basin has the greatest number of cattle and swine (see **Table 3.3**).

Watersheds with a high proportion of livestock farming may have higher nutrient loading due to the concentration of livestock. Manure spreading could be a function of the impact of the livestock in this area. Runoff into the creeks and surface water systems could be an issue in these watersheds. In addition, livestock may introduce bacteria and silt from stream banks directly into the waterways if proper fencing and buffering is not in place.

Table 3.3: Livestock Farming in the Kettle Creek Watershed.

Livestock	**Total Numbers**			**Average No. Per Farm**			**Per Hectare Farmed Land**		
Subbasin	**Cattle**	**Pigs**	**Poultry**	**Cattle**	**Pigs**	**Poultry**	**Cattle**	**Pigs**	**Poultry**
Lower Kettle	1,800	1,020	119,160	52	227	7,730	0.12	0.07	7.7
Dodd Creek	2,640	3,790	25,830	64	932	3,363	0.24	0.35	2.4
Upper Kettle	4,470	9,990	55,110	77	791	3,225	0.27	0.61	3.4
All KCCA	**8,910**	**14,800**	**200,100**	**65**	**650**	**4,770**	**0.21**	**0.34**	**4.48**

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, 42.9 percent of farms reported using grassed waterways, 6.6 percent use contour cultivation and six percent use strip cropping, while 29.5 percent use winter cover crops and 27.7 percent use windbreaks or shelter belts to help prevent the removal of topsoil by wind. Crop rotation is the most widely used conservation practice, with over 60.8 percent of farms reporting. This increases the longevity, productivity and environmental quality of farmland by replacing nutrients into the soil.

Use of Irrigation

The use of irrigation in the watershed is not extensive, and is generally only applied onto specialty crops such as vegetables, sod, fruit and root crops including tobacco, potatoes and ginseng. It is rare that other crops are irrigated unless it is for sweet corn or in dry years. Irrigation use is concentrated mostly in the Norfolk Sand Plain area in the southeast portion of the watershed, where a higher percentage of specialty crops are grown in well drained soils. Agricultural irrigation in the Kettle Creek watershed is concentrated in the summer months of July and August with some exceptions earlier or later in the growing season. The concentration of large water takings during warmer and often dryer periods, in a limited area, poses problems to water quantity in both groundwater and surface water sources.

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.

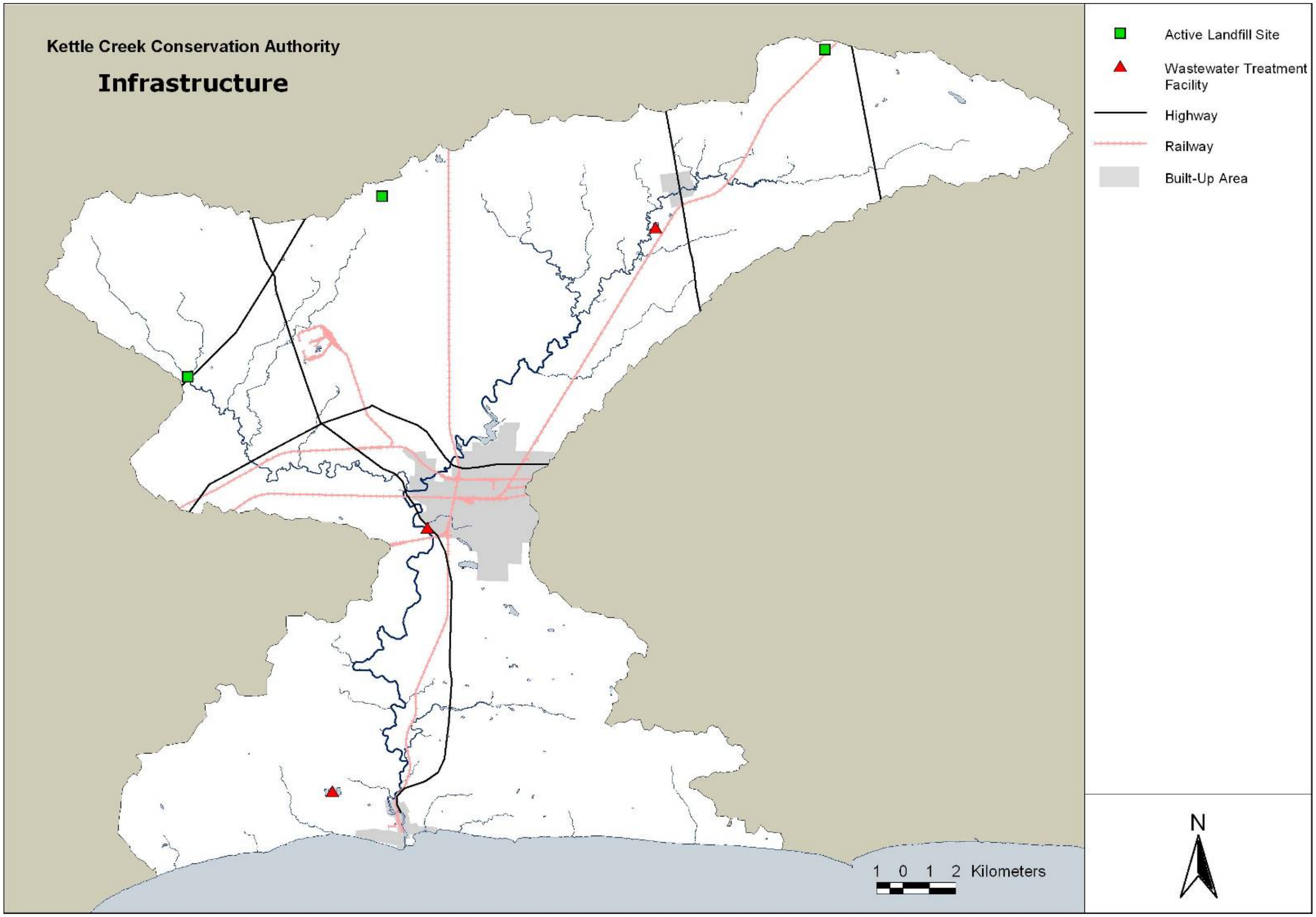
The quality and adaptability of infrastructure systems ultimately determines long-term sustainability of not only municipal drinking water services, but also drinking water sources.

The following sections briefly describe infrastructure systems currently in place in the Kettle Creek watershed, including landfills, transportation, wastewater and stormwater systems. Locations of selected infrastructure systems are shown on **Map 3.7**.

3.5.1 Landfills

There are three active landfills within the Kettle Creek watershed. These are the Green Lane Landfill, the W12A Landfill, and the Thames Centre Landfill, all of which are in the Creek's headwaters.

Map 3.7: Infrastructure in the Kettle Creek Watershed



Green Lane Landfill

Green Lane Landfill is located in Southwold Township near the crux of Highway 401 and Southminster Bourne. Set on a 129.7 hectare site, to date the landfill operations have covered approximately 43.9 hectares (Conestoga-Rover, 2004). The Green Lane Landfill is a privately owned landfill which services the City of St. Thomas, the Municipality of Central Elgin, and the Township of Southwold. Though not entirely in the Kettle Creek watershed, all surface water including leachate from the landfill is re-directed from the Lower Thames watershed into Dodd Creek via the leachate treatment facility.

Environmental monitoring is carried out in and around the Green Lane Landfill site on a regular basis as part of their Certificate of Approval from the Ministry of the Environment (MOE). Green Lane has 39 groundwater monitoring wells that are monitored quarterly for water level elevation. 23 of these wells are sampled annually in May for a suite of parameters including general chemistry, nutrients, major ions, metals, and volatile organic compounds (VOC's). Eight of the wells are sampled annually in November for general chemistry, nutrients, and major ions. The landfill is also required to carry out surface water quality sampling, leachate quality sampling, and benthic macroinvertebrate monitoring. MOE requires that a report on these monitoring events be prepared on an annual basis (Conestoga-Rovers, 2004).

An MOE-ordered mediation to Green Lane's recent Environmental Assessment for Optimization of the landfill resulted in additional monitoring, reporting and emergency response requirements for this operation.

W12A Landfill

The W12A covers 147 hectare of land in South London near the corner of White Oak Road and Manning Drive. This landfill services the City of London and receives approximately 200,000 tonnes of garbage annually. With over five million tonnes of waste already deposited in the landfill, the City of London expects that the W12A can accommodate an additional four million tonnes. As with Green Lane, the W12A landfill is equipped with a leachate collection system. The City of London estimates that in 2006, 10 million litres of leachate was collected and treated (City of London, personal communication, February 2007).

To ensure that the environmental impact of the landfill is kept to a minimum, the City of London has six surface water monitoring stations and over 30 groundwater monitoring wells in place. As part of their Certificate of Approval from the MOE, the results from these monitoring sites are recorded throughout the year and reported annually.

Thames Centre Landfill

The Thames Centre Landfill is located on Crampton Drive in the far northeastern section of the Kettle Creek watershed. As its name suggests, this landfill services the Municipality of Thames Centre. Waste accepted by this site includes household waste, construction debris, scrap metal, compost, brush, and tires (Landfill, Thames Centre, 2006).

The municipality has adopted a “bag tag” system requiring residence to “tag” their garbage bags for pick-up. These tags are available at various locations for a price of $2.50/tag. It is presumed this practice is in place to reduce the volume of waste being landfilled (Landfill, Thames Centre, 2006).

Abandoned Landfill Sites

There are two primary landfills within the Kettle Creek watershed that are no longer in operation. These are the landfills that formerly serviced the City of St. Thomas and the Village of Port Stanley.

The former St. Thomas landfill is located on Bush Line, adjacent to Kettle Creek, opposite the Water Pollution Control Plant. This landfill is identified as a Class A8 landfill (OMOE, Regional Inventory, n.d.). Class A landfills are those that have the potential to be a hazard to human health. Class A8 suggests this landfill contained municipal/domestic wastes, was situated in a rural setting, and was closed more than twenty years ago. Although closed in 1965, this landfill is still a potential concern due to its proximity to Kettle Creek (Closed Waste Disposal, Lake Ontario Waterkeeper, 2006).

The abandoned Port Stanley Landfill is located near the east end of Hill St. This landfill was closed in 1974.

3.5.2 Transportation

All of the primary modes of transportation are represented within the Kettle Creek watershed including: a major harbour in Port Stanley; a section of the 401 corridor; numerous railway lines, and an airport.

Port Stanley harbour is the largest natural harbour on the north side of Lake Erie. The Port Stanley harbour currently accommodates commercial and recreational fishing vessels, as well as a large variety of pleasure crafts, such as sailboats. The Municipality of Central Elgin is considering a proposal to introduce a ferry service between Port Stanley and Cleveland, Ohio.

The Kettle Creek watershed is centrally located in southern Ontario, approximately equidistance from Toronto, Detroit/Windsor, and Buffalo, NY. Travel by road to these destinations is approximately two hours.

The primary auto routes within the watershed are Highway 401, Highway 4, Highway 3, Wellington Road and Highbury Avenue. The section of Highway 401, within the northwest section of the watershed, is the primary access route to Toronto and Windsor. Highway 4, Wellington Road and Highbury Avenue, all of which connect to the 401, are the primary routes of travel between London and St. Thomas.

Highway 4 continues south past St. Thomas to connect to the Village of Port Stanley. Should the ferry service to Port Stanley commence, Highway 4 would be the probable route for the increased traffic. Highway 3, commencing in St. Thomas, connects the population within Kettle Creek to the Niagara Region.

The City of St. Thomas is the Railway Capital of Canada. Although it is no longer on mainline routes, this area receives regular service due to the large number of industrial customers. The primary rail providers in the watershed are Canadian National (CN), Canadian Pacific (CP), Norfolk and Southern, and the Trillium Railway Corporation (Transportation, EDC, 2006).

St. Thomas Airport, located four kilometres outside the eastern border of the Kettle Creek watershed, serves as a major transportation option for local residents.

3.5.3 Wastewater Treatment

Within the Kettle Creek watershed there are five active wastewater treatment facilities. Four of these systems are communal or municipal treatment systems, and the fifth is classified as an industrial sewage treatment system. The three municipal systems service the City of St. Thomas and the villages of Belmont and Port Stanley. The fourth facility is located at the Ford Motor Company in Talbotville. Allowable effluent concentrations as per the certificates of approval of the three municipal treatment systems are summarized in **Table 3.4**.

St. Thomas Water Pollution Control Plant

The St. Thomas Water Pollution Control Plant is a tertiary sewage treatment system that provides service for the City's 35,000 residents. Prior to 2002, this treatment plant was a considerable source of bacterial loading to Kettle Creek. Treatment plant bypasses during events of moderate precipitation were the source of the problem (CURB, 1994). To counter this issue the City constructed a Combined Sewer Overflow (CSO) holding tank. This holding tank enables the plant to contain combined sewer water and process it through the treatment plant after the rain event has passed. This addition to the facility has reduced plant bypasses by 94 percent (MOE, May 2004).

A review of the Ministry of the Environment's most recent inspection report for this facility indicates no non-compliance issues since the commencement of operation of the CSO.

Table 3.4: Allowable Average Monthly Effluent Concentrations as per Certificates of Approval

	Average Monthly Concentrations					
	Port Stanley		**St. Thomas**		**Belmont**	
Certificate Number	3-0833-94-006		5276-5M9JW7		9670-5VSMVJ	
Discharge Period	April - November		Continuous		Continuous	
	Objective	**Maximum**	**Objective**	**Maximum**	**Objective**	**Maximum**
$CBOD_5$ (mg/L)						
Non-Freezing Period	5.0	10.0	10.0	15.0	5.0	10.0
Freezing Period	10.0	15.0	10.0	15.0	10.0	15.0
Suspended Solids (mg/L)						
Non-Freezing Period	5.0	10.0	15.0	20.0	5.0	10.0
Freezing Period	10.0	15.0	15.0	20.0	10.0	15.0
Total Phosphorus as P (mg/L)						
Non-Freezing Period	0.3	0.5	0.8	1.0	0.3	0.5
Freezing Period	0.8	1.0	0.8	1.0	0.8	1.0
Total Ammonia Nitrogen as N (mg/L)						
Non-Freezing Period	2.0	3.0	1.0	5.0	1.0	3.0
Freezing Period	4.0	5.0	3.0		3.0	5.0

Table 3.4: Allowable Average Monthly Effluent Concentrations as per Certificates of Approval

	Average Monthly Concentrations					
	Port Stanley		St. Thomas		Belmont	
Certificate Number	3-0833-94-006		5276-5M9JW7		9670-5VSMVJ	
Discharge Period	April - November		Continuous		Continuous	
	Objective	**Maximum**	**Objective**	**Maximum**	**Objective**	**Maximum**
Un-ionized Ammonia Nitrogen	N/A	N/A			N/A	0.1
Dissolved Oxygen (mg/L)	>5	0.01			N/A	5
E. Coli (Organisms per 100ml)	150	200	200	200	150	200
Total Residual Chlorine (when in use)	N/A	0.01			0	0

Biosolids produced by the treatment plant are disposed of at the Green Lane Landfill site at the northwestern end of the watershed. St. Thomas' master plan for sewage treatment is currently outdated; however it is approved for updating in 2006 (Fiddy, 2005).

Belmont and Port Stanley Sewage Lagoons

The villages of Belmont and Port Stanley, within the Municipality of Central Elgin, are both serviced by communal sewage lagoons. Both systems are designed according to the "New Hamburg Process." This is a tertiary treatment process consisting of aerobic treatment and waste stabilization in lagoons. After the lagoon process, waste is treated through slow sand filters (MOE, Nov. 2004).

The treatment facility in Belmont was cleaned out, reconstructed, and upgraded to a "New Hamburg" style facility in 2004. At this time a self-contained engineered wetland feature was constructed to accept the sludge produced by this clean out process. The municipality expects that this lagoon system will not require sludge removal again for approximately 25 - 30 years. At that time, the sludge will again be deposited in the engineered wetland (Perrin, 2005).

The most recent MOE Inspection Report for the Belmont facility was conducted in 2004. A review of this report showed that the facility had some minor non-compliance issues in 2003 and 2004, but these caused no detrimental environmental effects.

As previously stated, the treatment facility servicing the Village of Port Stanley is also a tertiary lagoon system. The Port Stanley facility was cleaned out and reconstructed in 1996. These lagoons are not expected to require sludge removal again for approximately 25 years. At that time, the Municipality of Central Elgin expects that the wetland at the Belmont plant will be able to accommodate the sludge (Perrin, 2005).

A recent inspection report was not acquired for the Port Stanley facility because the MOE is not scheduled to inspect the facility until sometime in 2006.

Regina Mundi Catholic College

The wastewater treatment system at the Regina Mundi Catholic College is a tertiary treatment facility to specifically handle waste produced by the college. This system uses Regina Mundi Pond as part of the treatment process. This particular pond is part of the

Kirk-Cousins wetland complex which straddles the Upper Thames River and Kettle Creek Conservation Authority boundaries. There is evidence that nutrient and BOD levels produced by this treatment system have a negative effect on the wetland.

Ford Motor Company of Canada, St. Thomas Assembly Plant

The Ford Motor Company St. Thomas Assembly Plant is located on Highway 4 between Talbotville and Highway 401. This plant contains the only industrial sewage treatment facility in the Kettle Creek watershed. The facility treats both the domestic and industrial wastes produced at the plant. The final effluent from this facility is discharged into Dodd Creek at the northwestern corner of the Ford property.

Table 3.5: Certificate of Approval Effluent Requirements for Ford Motor Company, St. Thomas.

Effluent Requirements		
Effluent Quality Parameter	**Maximum Daily Concentration (mg/L)**	**Average Monthly Concentration (mg/L)**
Ammonia plus Ammonium*	4.5	3.0
Ammonia plus Ammonium**	7.5	5.0
$CBOD_5$*	10	3
$CBOD_5$**	20	7
Chromium (Total)		0.5
Chromium (Hexavalent - Cr+6)		0.05
E. coli (organisms per 100ml)	1000	200
Iron (total)		3.0
Lead (total)		0.25
Nickel (total)		0.25
pH	9.0	
Phenolics		0.005
Total Phosphorus *	1.0	0.05
Total Phosphorus **	1.5	1.0
Total Suspended Solids	20	10
Zinc (total)		0.3
Effluent Quality Parameter	**Minimum Daily Concentration (mg/L)**	**Average Monthly Concentration (mg/L)**
Dissolved Oxygen*	3.0	4.0
Dissolved Oxygen**	4.0	5.0
pH	6.0	

Notes:
* for water temperatures in the impounding basin greater than 5ºC
** for water temperature in the impounding basin equal to or less than 5ºC

A review of the most recent MOE inspection report indicates the facility had some minor effluent requirement exceedances. These exceedances were reported to the MOE and no detrimental environmental effects were noted. Otherwise, the Ford Industrial Sewage Treatment facility appears to be operating in compliance with its Certificate of Approval (MOE, 2005). Requirements of the Certificate of Approval are summarized in **Table 3.5.**

3.5.4 Stormwater Management

Stormwater quality is of increasing concern within the urbanizing areas of the watershed. Construction activities have the potential to add sediment loadings to streams. Moreover, post construction storm sewerage is increasingly seen as a source of sediment-borne pollutants. The Ministry of the Environment (MOE) has prepared interim guidelines on stormwater quality that are continually being upgraded and revised due to the expanding knowledge in this area of water management.

Water quantity concerns associated with urban runoff are just as important as water quality concerns. As land uses change, the surface runoff associated with that land area also changes. With urbanized land uses there is typically a dramatic increase in surface runoff as the water can no longer infiltrate the soil. It is very important for flood control purposes that these runoff levels be controlled to remain consistent with pre-development flows. Appropriate post development flows are typically determined using a one in 20 year storm.

In 2003, the MOE produced a guidance document entitled the Stormwater Management Planning and Design Manual. This document, which is used by the vast majority of the municipalities within the Kettle Creek watershed, stresses the importance of watershed-based planning as an effective means of ensuring no negative environmental impacts occur because of land use change. Even more effective are subwatershed studies, which review potential land-use changes on a smaller scale.

Subwatershed studies exist for nearly 70 percent of the Kettle Creek watershed. These studies provide very detailed information on the areas reviewed, including the modeling of watercourses to determine the potential effects of development on the relevant area. Each subwatershed plan reviews stormwater management goals and requires these goals to be incorporated into municipal development proposals.

In addition to stormwater management planning for new developments, some municipalities are working towards reducing stormwater flows from existing developments. Many municipalities in Ontario have combined storm and sanitary sewer lines and/or downspout connections to sanitary lines. This requires all the water in these lines to pass through the municipal water treatment facilities. However, the treatment facilities are typically not large enough to handle the volume of water delivered during a storm event.

As a result, many water treatment facilities allow the combined sewer water to bypass the treatment facility directly into the receiving water body. This results in spikes of nutrient and bacteriological loads in the receiving water body, and ultimately increases the potential for water quality issues. In recent years, many municipalities have required new developments to use other means, such as stormwater management ponds, to deal with stormwater run-off during rain events. However, the problem of the existing combined sewer systems still persists, and needs to be addressed.

Historically, the City of St. Thomas was believed to be a prime contributor of nutrients and bacteria into the Lower Kettle Creek system because of these bypass occurrences. Bacteria loadings from the Kettle Creek system were linked to frequent beach postings in Port Stanley. The Clean Up Rural Beaches (CURB) studies released in 1994 stated that approximately 4.6 percent of the bacterial loading in Kettle Creek was produced by the St. Thomas Water Pollution Control Plant.

The City of St. Thomas addressed these concerns by attempting to reduce the number of bypass events that occurred at the treatment facility. In 1998 the City of St. Thomas initiated a program to disconnect downspouts from sanitary lines, thereby attempting to reduce the amount of storm water being needlessly delivered to the treatment plant. Through this program the City was able to reduce residential downspout connections by 64 percent (St. Thomas Engineering Division, 2001).

In 2000, the City of St. Thomas completed the construction of a combined sewer overflow (CSO) facility. This facility is essentially a 4,000 cubic metre holding tank intended to minimize the number of treatment plant bypasses due to storm events. As of July 2004, the CSO facility had reduced the number of bypass events by 94 percent (MOE, May 2004).

The City of London has two by-laws which look specifically at the issue of stormwater management. The first is the "Drainage By-law" which covers the development of stormwater management systems. The second is the "Waste Discharge By-law" which sets out regulations for the use of storm and sanitary sewers, and affords the City a tool by which to control and regulate what is discharged into these systems. Although the portion of the City encompassed by KCCA's boundaries currently represents rural London, these by-laws will affect the Kettle Creek basin as urban development in the City expands.

3.6 Implications of Geology and Land Use for Source Water 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. As described earlier, the mix of clay and till materials covering most of the Kettle Creek watershed drives much of the precipitation to run off into the creek and its tributaries. Clearing and draining of land for agricultural use throughout the watershed has increased the rate of runoff and created a flushing effect where soils and contaminants are carried overland and downstream to the outlet of the creek into Lake Erie. This runoff may impact downstream water users, including the Lake Erie water intake for the Elgin Area Primary Water Supply System.

Conversely, the tight till and clay deposits in the northern portion of the watershed provide significant protection from land uses to the groundwater sources for both the municipal supply for the Town of Belmont and private wells. The clay and till materials of the Ekfird Clay Plain and Mount Elgin Ridges reduces infiltration of surface water and contaminants to the drinking water supply aquifer.

4.0 WATERSHED MANAGEMENT PLAN

Since its inception in 1965, the Kettle Creek Conservation Authority (KCCA) has undertaken a number of inventories, studies, plans and strategies that investigate and respond to the following water resource management issues facing the watershed:

- Flash flooding and run-off, and low base flows;
- Erosion and sedimentation of watercourses;
- Degrading quality and quantity of water resources;
- Habitat fragmentation, degradation, and loss, and
- Hazard land management.

Both riverine and lakeshore environments within the watershed present specific challenges to water and related land management activities by KCCA.

In consideration of: the magnitude of resource management issues facing the watershed; funding limitations for studies and remedial measures to address those issues; changing and fragmented roles of all levels of government; the speed of change in and intensification of land use, and gaps in local capacity, no one comprehensive water management plan has been prepared that encompasses all aspects of a water management plan.

However, specific plans were and continue to be undertaken to guide the development of water management programs, which are in some instances well developed components of a water management plan for the watershed.

4.1 Comprehensive Strategies and Watershed Plans

4.1.1 The 1967 Conservation Report and Water Resources Report

The 1967 Conservation Report and Water Resources Report are the founding documents upon which KCCA organized its initial resource management programs. The report highlights the 'flash flooding' and related erosion and sedimentation issues inherent to the watershed. It recognizes the need for enhanced base flow in watercourses, the protection of source areas that supply base flow, and a comprehensive hazard land management program to mitigate the impact of those issues upon the watershed community.

The Water Resources Report further examines the various aspects of water resources planning, concentrating on hydrology, flood and erosion hazard control measures, and recommendations for remedial measures. The report concludes with recommendations on flood protection, flood control measures, flood line mapping, floodplain zoning and acquisition, streambank erosion control measures and the development of a reservoirs system for flood protection. Of note, wetland conservation and protection was not identified as a critical component of maintaining base flow. Rather, management of surface water flows resulting from precipitation was addressed.

Accordingly, the KCCA Board of Directors pursued the development of the following primarily reactive programs: streamflow monitoring; flood forecasting and warning; dam acquisition and maintenance; watercourse soil erosion and sediment control; surface water quality monitoring; reforestation, and environmental planning and regulations. Most of the report recommendations were and continue to be implemented.

By 1977, KCCA had acquired four reservoirs and floodplain properties to partially meet the goals of headwater source protection and base flow supplement. These four reservoirs are shown in **Map 4.1** and described below.

4.1.2 Dalewood Reservoir

The Dalewood Reservoir was originally owned by the City of St. Thomas and was known as St. Thomas Waterworks Reservoir. The main purpose of the reservoir was to supply the City's drinking water supply. However, insufficient surface water flows in Kettle Creek prompted the province to place a moratorium on the growth of the City. Consequently, in 1967 the City connected to the Elgin Area Primary Water Supply system. By 1970 the City was exclusively using this water system, sourced from Lake Erie.

KCCA purchased this reservoir and the surrounding lands (243 hectares) from the City of St. Thomas in 1976. The Authority was interested in the reservoir in order to meet the recommendations of the 1967 reports on water resources for the watershed.

The Dalewood Dam, which was constructed in 1928, was subject to extensive maintenance and rehabilitation. It is still used today to augment stream flows and control flood events. Utilizing stop logs, floodwater can be backed up seven kilometres upstream to Highbury Avenue.

4.1.3 Union Pond

The Union Dam was built prior to 1900 and consists of an earthen embankment with a concrete spillway. The dam backs up water in a series of online ponds along Beaver Creek in the village of Union. The primary use of this reservoir is flood control, and base flow supplement. Until the 1940's the Union Dam was used for gristmill operation. KCCA acquired the dam and pond in 1972.

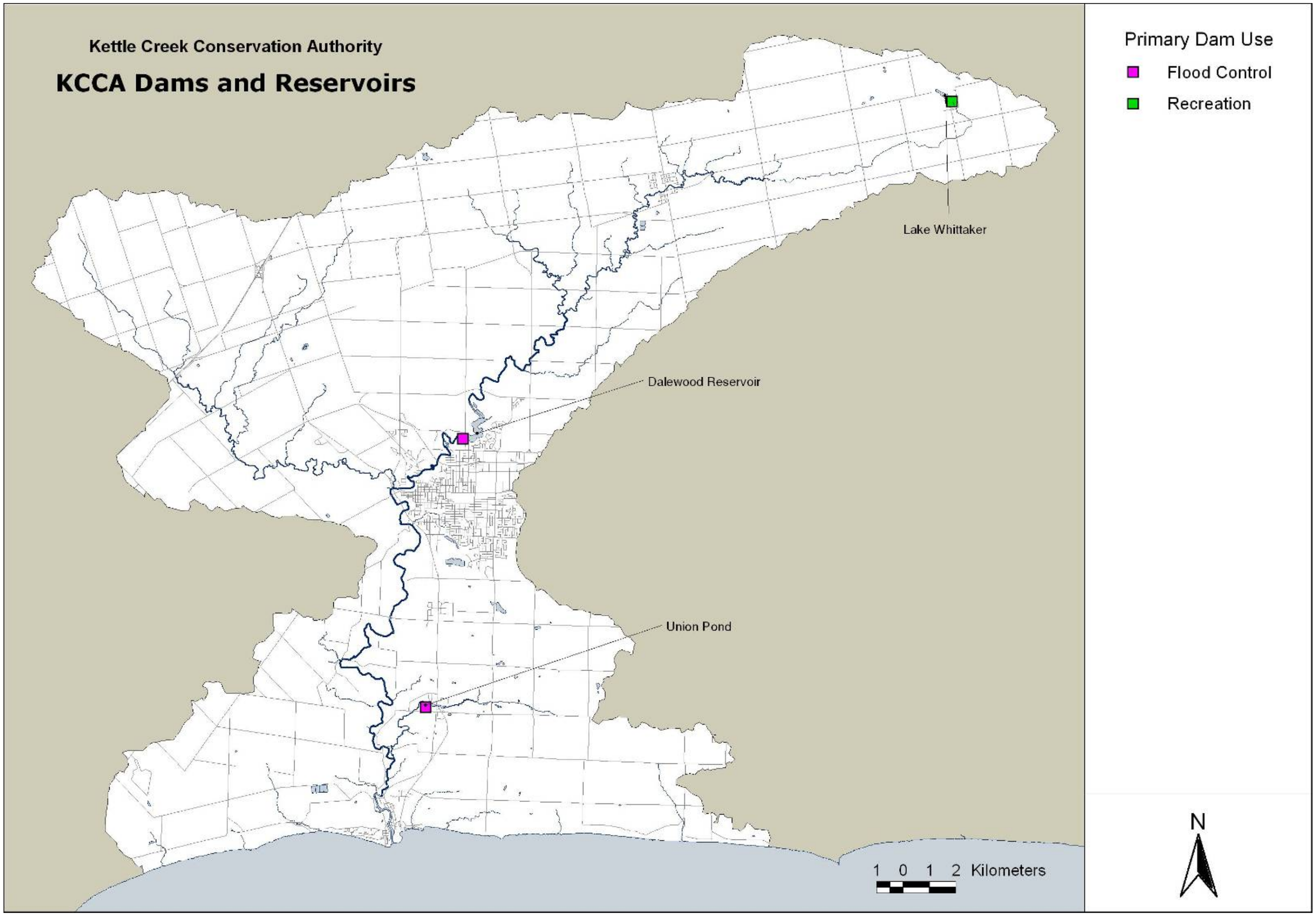
In 2002, Riggs Engineering determined the dam was at imminent risk of failure. KCCA was faced with the options of replacing, repairing or removing the dam. The decision was reached to repair the dam based on the water management benefits and lower costs.

In 2003, the dam was upgraded to meet provincial maintenance and operations standards. The reservoir itself is approximately 13 hectares in area with a holding capacity of approximately 8,000 metres cubed (Riggs, 2002). The reservoir is gradually silting-in, with most deposition of silt occurring in upstream ponds.

To date there are no studies investigating the water quality of the Union Pond. However, Union Pond is sourced from headwaters within the western portion of the Norfolk Sand Plain. Beaver Creek is a cool water stream with a remnant brook trout population in the lower reaches. A water quality monitoring station located immediately downstream of Union Pond suggests that although there were some nutrient exceedances, Beaver Creek, in general, is one of the least impaired sections within the Kettle Creek watershed.

Currently, there are no stream gauge stations on Beaver Creek. The reservoir is lowered in response to expected heavy rain events, and allowed to rise in the interim.

Map 4.1: Dams and Reservoirs in the Kettle Creek Watershed



4.1.4 Lake Whittaker

This 11 hectare kettle lake is the main headwater source for Kettle Creek. Lake Whittaker is located at the uppermost height of land in the watershed. Various parcels of property around the lake were purchased by the Authority from 1972 to 1995. A small, one metre concrete weir serves to maintain static water levels in the lake while permitting continual base flow. The lake waters are sourced primarily from ground waters surfacing in adjacent wetlands and within the lake itself. Virtually all lands surrounding the lake are naturalized, which limits the threat of contamination by nutrients and sediments.

Lake Whittaker itself is about 12 metres deep at its widest location. The lake is gradually eutrophying, but the presence of a lake aerator virtually stalls this successional trend. Algal blooms have not been observed on the lake. The water quality still supports native populations of largemouth bass and northern pike. Rainbow trout are annually stocked in the lake, and due to the aerator, can over-winter.

4.1.5 Kirk-Cousins Pond

This 12 hectare pond, formed initially as a 'kettle' lake, is found at the uppermost portion of the Kettle Creek watershed in south central London. From 1976 to 1989, KCCA assembled a number of parcels of land around the pond to form the Kirk-Cousins Management Area.

The pond is fed by overland flow from adjacent fields and woodlands as well as from groundwater seepage areas. Pond levels are maintained by groundwater flows and overland storm flows cause the pond levels to then increase – draining both southward into a tributary of Kettle Creek and northward into Dingman Creek.

The Kirk-Cousins pond has traditionally be used as a tertiary sewage treatment facility by the adjacent high school. The pond waters are highly nutrient laden, and often exceed water temperatures save for all but the most tolerant of fish species.

The pond offers little benefit to watershed base flows. However, with urbanization and servicing of southern London, it is anticipated that opportunities will arise to rehabilitate this water resource.

Due to the location of this pond at the watershed crest, no risk to sedimentation of the pond exists.

4.1.6 Other Watershed Reservoir Facilities

As outlined within the *2004 Inventory of Watershed Dams*, a large number of privately-owned reservoirs and ponds supplement base flow in the watershed. Those located in headwater reaches are of highest value, including: Lake Margaret, Mill Creek Pond, Corners Pond, and Sandam Pond.

About 27 other dams and associated reservoirs can be found throughout the watershed, which have been constructed to collect and retain surface water flows. All of these reservoirs have a more localized low flow augmentation benefit and are serving as sediment catches. Base flow in most of the Kettle Creek subwatersheds would otherwise be virtually non-existent except during precipitation events.

It should also be emphasized that these reservoirs have proven beneficial in providing refuges for aquatic and terrestrial life in times of low base flow or drought. During such intervals, base flows in the watershed can drop well below the "Level III" designation within the provincial Low Water Response Program.

Due to the topography and physiography of the watershed, combined with intensive agricultural land use and wetland loss, low base flows are a primary water management concern. Although the Conservation Report and Water Resources Report recommended a system of reservoirs designed to provide a continuous flow of surface water for municipal water supply purposes, base flows are too low to make implementation of the recommendation practical. Further, the primary causes of watercourse siltation – intensification of upstream agricultural land management practices - were not understood or recognized.

4.2 The 1983 KCCA Watershed Plan

Utilizing MNR guidelines, the KCCA prepared a watershed plan for the purpose of identifying resource management issues and solutions to those issues. The plan proposed a 20 year life-span and contained 86 recommendations – 42 of which pertained to some aspect of a water management plan. Of those 42 recommendations, 31 were or are currently being implemented as part of KCCA's existing programs and services.

The 11 unfulfilled recommendations have either been disregarded in program development, or were activities previously undertaken and eliminated due to financial restraint by upper levels of government. These recommendations typically involved municipal drainage, erosion and sedimentation from agricultural lands, and private land stewardship programs.

While the plan assisted KCCA in better organizing and delivering programs and services of the day, it did little to set overarching or comprehensive water management planning goals and targets for the watershed.

Continual provincial fiscal restraint to conservation authorities over the next decade continued to focus KCCA's attention upon the recommendations of the watershed plan. Emphasis was placed on development and improvements to protective management programs such as flood warning and forecasting, dam maintenance, streambank erosion control and environmental regulations. Other work in preventative program development, such as plan input and review, private lands stewardship, wetland protection, habitat enhancement, and water quality were de-emphasized by provincial funding withdrawal.

4.3 The 1994 Conservation Strategy

As local, municipal funding of conservation authorities increased to partially accommodate local program needs, KCCA completed a conservation strategy for the watershed in 1994.

The strategy identified key priorities of public awareness and education, partnership building, one-window streamlining of service delivery, private land stewardship, water quantity and quality improvements, and fiscal independence. It also identified fiscal restraint, lack of funding for local environmental priorities, lack of public participation in policy and program development, and duplication of programs and services as key obstacles to success.

Within a year, the provincial government introduced serious restraint upon conservation authority programs and funding. The Ministry of Natural Resources continued its emphasis on 'core' surface water management programs such as flood warning and operations, dam maintenance, and plan input providing a 50 percent grant toward the costs of those programs. In addition, environmental regulations, plan review, subwatershed planning, technical studies, and environmentally significant areas management continued as a 'core' responsibility but without any provincial funding.

The province had determined that conservation authorities were essentially of local municipal interest and concern. Nonetheless, local funding to support local resource management priorities outlined in the strategy quickly evaporated as all funding was concentrated in 'core' program areas required by the province.

As KCCA adjusted to these circumstances over the next decade, it undertook structural, organizational, program and funding reviews. Significant strides in developing alternate revenue sources combined with modest increases to municipal levies, together with leaps in automated efficiencies, facilitated achievement of many strategy goals.

As of 2006, the following summarizes KCCA's implementation of the strategy recommendations:

Recommendation Topic	Total #	# Implemented
Watershed Management	14	14
Water Quality and Quantity	24	22
Private Land Management*	19	12
Hazard Land Management	9	9
Community Awareness*	23	18
Community Participation*	15	11
IRM Policy Development	14	12
Watershed Planning*	17	16
Organizational Efficiency	24	24
Funding Efficiency	15	15
Property Management*	15	9

* Key priorities yet needing attention are focused within private land stewardship program development, community awareness of and participation within such programs, preparation of an overall Watershed Plan, and improvements to KCCA property management planning. Of note, attention to these areas would greatly assist KCCA in pursuing improvements to base flow supplement, wetland and watercourse rehabilitation and erosion and sediment control. Coincidentally, these improvements are suspected as closely tied to source protection planning goals for the watershed.

4.4 Subwatershed Planning

Throughout the 1990's, much of the Kettle Creek watershed was subwatershed planned. Six subwatershed planning studies were completed that cover at least 70 percent of the watershed. A firm foundation exists to environmentally assess future municipal development proposals over the next 20 years.

All development plans must recognize and adhere to the recommendations of the subwatershed plans, as required by municipal planning authorities. Development proposals are subject to Environmental Impact Study, according to the contents of each subwatershed plan. A good assessment of natural hazard and natural heritage features within the watershed is included in each plan.

However, these subwatershed plans do not adequately address rural watershed rehabilitation needs, and require the integration of those needs into municipal development considerations. Moreover, the plans do not adequately address rural land management practices, including benefits to base flow supplement, wetland and watercourse rehabilitation and erosion and sediment control.

4.5 The Dodd Creek Community-based Watershed Strategy

In 2003, as part of its LaMP initiatives, the Lake Erie Bi-national Public Forum undertake a comparison of land use issues that affect Lake Erie water quality. Both Canadian (Environment Canada) and US (Environmental Protection Agency) governments had determined that watersheds feeding directly into Lake Erie were directly and negatively impacting the success of Lake Erie restoration activities. The Black Creek (Ohio) subwatershed and the Dodd Creek (Ontario) subwatershed were selected for a paired comparison.

Community perceptions of resource management issues and potential solutions to those issues were studied. Simultaneously, projects to overcome those issues were selected and implemented. Through a community-driven process, it became apparent that watershed residents were well aware of the issues and restoration needs for the Dodd Creek watershed. The issues as jointly prioritized by the community, a technical advisory group, and KCCA staff are listed below:

1. Agricultural Erosion / Sediment Delivery Control
2. Wellhead Protection Areas Conservation
3. Watercourse Buffers Creation
4. Groundwater Infiltration Enhancement
5. Wetland Restoration
6. Natural Heritage Corridor Restoration
7. Woodlands Enhancement

Specific action plans were developed accordingly as they relate to:

1. Streambank and Agricultural Land Erosion Control
2. Source Water Protection
3. Wetland Creation and Restoration
4. Reforestation and Forest Cover Enhancement
5. Improvements to Municipal Drain Maintenance Practice

The Dodd Creek Community Based Watershed Strategy is being replicated in other subwatersheds within the Kettle Creek basin. Similar issues are being identified by those local communities. Support for the priorities and actions noted above are growing.

By the lack of any related issue identification, the Dodd Creek Strategy confirms that KCCA's efforts in protective water management programs dealing with flood forecasting and warning, hazard land management, dam maintenance and environmental regulations have been effective. However, while the Strategy confirms KCCA's awareness of the need for preventative water management programs dealing with water quality and quantity improvement, wetland conservation and restoration, and improvements to agricultural land management practices, KCCA's response to those issues remains lacking.

4.6 Riverine Water Management Programs

In response to recommendations of the *Watershed Conservation Report*, the KCCA undertook the 1976 Rural Fill Line Mapping Study. Since the character of the watershed involved significant erosion of streambank and valleylands, KCCA moved to map the entire watershed with "Fill, Construction and Alteration to Waterways" regulations. These regulations typically controlled or prohibited activities in floodplain, valleylands, wetlands and watercourses all with a view to protecting life and property from the threat of flooding and erosion.

The regulation governed:

- Placement or removal of fill in a regulated area;
- Construction or reconstruction in a floodplain;
- Alteration to a watercourse;
- Development of significant or eroding slopes, and
- Interference with wetlands.

While wetlands were regulated, little could be done to moderate the impact of agricultural land drainage. Public awareness of wetland values, and their mitigation of flooding and erosion in the watershed, was virtually non-existent.

Floodplain mapping was also undertaken in the Village of Belmont by the mid 1970's. However, KCCA shortly after moved to control floodplain development within that municipality by acquiring all of its floodplain lands.

In the late 1970's, KCCA also undertook a strategic review of the watershed in order to establish streamflow monitoring stations. The stations were situated specifically to monitor flows from the Dodd Creek and Upper Kettle subwatersheds and their impact upon the main branch of Kettle Creek in St. Thomas. The monitoring data gathered became instrumental in modeling flows in preparation for generating floodplain maps for flood damage centres throughout the watershed. By the mid 1980's, the stations were outfitted to monitor precipitation, automated, and adjusted to monitor low flows as well.

In the mid 1980's KCCA modeled and mapped flood damage centres in St. Thomas and Port Stanley in order to better meet flood warning and forecasting duties, and municipal plan input and review responsibilities. This was followed with an assessment of the two-zone concept of floodplain management for both municipalities.

In 1986, the St. Thomas Flood Damage Centre Analysis and Environmental Impact Statement was completed. That report concluded that in consideration of: the steep sloped valleys that restrict, deepen and accelerate regional flood flows; the very limited amount of developable land (between the 1:100 year line and the regional line); and the limited accessibility to those fringe lands; the application of the two zone concept was not recommended by Lathem for application in St. Thomas. The report indicated that there may well be places within the watershed where the application of the two zone concept might be applicable.

Also in 1986, in Port Stanley, another study was undertaken to determine the 1:100 and Regional Storm lines. This study was completed at the prompting of the Village of Port Stanley, who envisioned waterfront development along Kettle Creek. The Central Elgin Planning Office, which at the time provided planning services to St. Thomas, Yarmouth Twp., Port Stanley, Belmont, and Southwold Twp., supported the study as well.

The result was that four distinct, broad, and accessible areas of floodfringe, involving a total of some 20 acres, could be developed in Port Stanley. KCCA staff then prepared a summary document on the applicability of the two zone concept, and that document was approved at the November, 1986 Full Authority meeting of the KCCA Board of Directors. The KCCA floodplain management policy was then changed, and the practice adopted for Port Stanley alone.

Again in response to municipal development visions in 1988, KCCA studied and with provincial MNR approval, implemented the hydraulic floodway two zone concept in Port Stanley. Certain infilling of floodfringe was studied for impact upon regional or regulatory flood levels. With no impact according to revised, hydraulic flood way lines, some floodfringe development proceeded.

In response to the 'flash' flooding character of the watershed, KCCA had also prepared a flood forecast model. Completed by Dr. Harold Schroeder, the model utilized historical flood flow data and was field tested and fine tuned to subsequent flow events. The model has since been updated twice, and provides a good prediction of anticipated flood flows in timely fashion. Again, accurate flow predictions in a timely manner are required since the watershed passes the peak of a flood event within 24 hours into Lake Erie.

Due to the significant annual cost of dredging the Port Stanley harbour for commercial shipping purposes, Public Works Canada completed a harbour dredging study in 1987. They had determined that over 41,000 cubic metres per year of harbour sediments were sourced upstream of Port Stanley in the Kettle Creek watershed.

The impact of significant sedimentation of Kettle Creek in commercial marina basins upstream of the harbour, prompted the KCCA to undertake maintenance dredging in order to maintain hyrdraulic capacity and outlet of Kettle Creek. However, due to the existence of a coal tar deposit within the bed of Kettle Creek upstream of the harbour, maintenance dredging in that location was prohibited. The KCCA then undertook an assessment of that coal tar deposit in 2001. The Kettle Creek Sediment Sampling Report concluded that numerous provincial and federal government sediment quality exceedances were evident, and that the deposit was slowly moving downstream toward the harbour, within the creek bed sediments.

In recognition of Canadian government plans to divest the Port Stanley harbour, and to cease all dredging of the harbour, KCCA undertook the Port Stanley Hydraulics Study in 2005. Concerned about maintaining the hydraulic capacity of Kettle Creek's outlet, in order to avoid exacerbated flood levels upstream in Port Stanley, KCCA assessed the impacts of harbour divestiture and the cessation of dredging. The hydraulic capacity study determined that, while regional flood elevations had increased up to one half of a metre over those predicted in 1988, the overall cessation of dredging would have minimal impact upon those flood levels. However, the impact of increased flood levels due to ice jamming caused by increased sedimentation is now under review.

Also in 2005, and in response to MNR's directive to ensure conformity of all Conservation Authority environmental regulations, KCCA undertook a detailed modeling exercise of the entire watershed. Reasonable floodplain estimations were completed throughout the watershed, and new rural-based flood damage centres were identified. It was also established that certain dams and primary roadways were likely to flood or collapse, creating the need for enhanced emergency response planning.

KCCA's riverine water management plans and management programs, from a quantitative viewpoint, have been kept up to date for the purpose of protecting lives and property from the threat of flooding and erosion or natural hazards. However, additional work needs to be done to better understand and respond to low flow management and rehabilitation.

4.7 Lakeshore Management Programs

From 1983 to 1987, high lake levels were experienced throughout the Great Lakes, with notable concern for lake induced erosion and flooding of communities along the Lake Erie lakeshore. Within the Kettle Creek watershed, the 1:100 year lake storm was experienced in December of 1985, with similar flood events in 1986.

The provincial government responded to calls for assistance in shoreline erosion protection by providing grants for protective works and by preparing a provincial shoreline policy. The policy addressed both preventative and protective measures.

Due to an actively eroding shoreline, the susceptibility of large, low lying portions of the Village of Port Stanley to lake flooding, and the desire to better manage lakeshore hazards, KCCA took advantage of a number of provincial subsidies for lakeshore study. A multitude of related studies had recently been completed by the Canadian government, in response to court action involving lakeshore erosion in the Port Burwell area.

The 1986 Port Stanley Shoreline Protection Plan examined erosion and optimum protection measures relating to the lakeshore environments of that community: high bluff (over 30 metres), low bluff (under 15 metres) and low lying beach. Measures required to protect shoreline environments from the 1:100 year erosion rate or the 1:100 year lake storm were identified. Erosion protection standards and setbacks were incorporated into local municipal bylaws. Of note, KCCA's shoreline is the most actively eroding shoreline within the Great Lakes – having an average rate of recession of two metres per year, averaged over 100 years.

In 1989, the KCCA commissioned a Shoreline Management Plan for its entire shoreline. The purpose of the plan was to balance the options of shoreline prevention, protection, environmental impact, monitoring, emergency response and public education in an overall management plan of shoreline resources. The 1:100 year erosion rate and setback was calculated and mapped for the entire shoreline length. The suitability of existing low bluff erosion protection was confirmed to the 1:100 year erosion standard. The 1:100 year lake storm and surge floodplain was modeled and mapped. Recommendations for overcoming lake induced inland flooding were also made. Both preventative solutions such as establishing regulatory zones with development restrictions and protective solutions such as flood berms and floodproofing techniques were established.

A Beach Management Study was completed in 1996, which provided more detailed information and implementation guidelines on zones of development, restricted development, or development prohibition. All completed in accordance to provincial shoreline policy, the flooding and erosion hazards of the Port Stanley beach were quantified and incorporated into local municipal planning documents.

In response to KCCA's need for better modeling information for the 1:100 year regulatory lake storm, and for improved flood forecasting and warning for this flood damage centre, KCCA completed the Lakeshore Flooding Look Up Tables in 1992. The model was calibrated to wind direction, speed, duration, and lake level and wave set-up. A chart was prepared to allow KCCA staff quick reference for the issuance of accurate flood warnings.

KCCA continues to fully meet its responsibilities to protect lives and property from the threat of flooding and erosion relative to Lake Erie shorelands. It was through these studies, and a focus upon the Lake Erie environment, that KCCA became much more aware of the impact of the outlet of Kettle Creek's poor water quality upon Lake Erie, and the community's water source.

Since the existence and movement of the coal tar deposit in Kettle Creek at Port Stanley was documented, and in consideration of the need to monitor sediment and water quality in Lake Erie, the Elgin Area Primary Water Supply System undertook a study of sediment quality at its intake pipe. The Water Board identified Kettle Creek's plume as a significant potential point source of sediments laden with nutrients, mercury, and PAH's – all measurable out in Lake Erie at one kilometre south and two kilometres east and downdrift of Kettle Creek's outlet.

In response to this, the KCCA designed and implemented a comprehensive environmental monitoring system for the watershed in 2005 and 2006, in consultation with a number of experts in the field. Surface water quality and quantity, ground water quality and quantity, sediment quality and quantity, biota, and benthic monitoring program components will be activated in 2006. This information will be utilized for comparison purposes to monitoring information in Lake Erie. The purpose of the comparison will be for sourcing of contaminant inputs and their elimination upstream in the KCCA watershed.

5.0 WATER USES AND VALUES

5.1 Water Uses

Water use in the Kettle Creek watershed is documented in a separate technical water use report, entitled Water Uses in the Kettle Creek Watershed (Wong and Bellamy, 2006). The report is an initial summary of the present-day water uses, broken down into four subgroups including municipal supply, agricultural, unserviced domestic population and other permitted takings (greater than 50,000 litres per day). **Map 5.1** shows the location of permits to take water in the Kettle Creek watershed by water use.

The water use estimates in the report, 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. The Permit to Take Water (PTTW) database was used to quantify any water uses that did not fall into the previous three categories. A phone survey of the permit holders was completed to refine water use estimates based on their records, with a 50 percent response rate. The analysis of all water use data identified the following water uses within the basin:

1. Municipal Water Supply;
2. Rural Domestic;
3. Agricultural Irrigation;
4. Agriculture;
5. Golf Course Irrigation;
6. Dewatering;
7. Commercial Mall/Business; and
8. Miscellaneous.

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. While agricultural irrigation is the third largest water user on an annual basis, their water takings are concentrated during the months of June to August. Agricultural irrigation is actually the second highest water taking and is more than the combined total of all non-municipal water takings during these summer months. During an extreme dry year, which requires more irrigation than an average year, this demand for water is much more pronounced.

The bottom four water use categories on the list were derived from the PTTW database information and phone survey. The PTTW database is a collection of permits that are applied for through the MOE when a user requires more than 50,000 litres of water per day (animal watering, domestic usage and fire fighting are excluded). Users apply for a permit and declare the maximum volume of water they may require to take on any given day of the year. Reporting of the maximum permitted rate, but not the actual water use, in the database limits its usability in determining the volume of water extracted from groundwater and surface water sources, as the quantity may be far more than the users would actually take on an average day. However, in absence of accurate data, the PTTW database gives a crude estimate of the types of water uses and distribution of water takings throughout the watershed. The MOE has begun to require certain permit holder categories to submit annual reports on their actual water takings in an attempt to address this shortcoming. In lieu of this information, the PTTW database information was queried to determine the maximum amount of water required for each category and some of these uses are described in the following sections.

Additional uses of water are described in the following sections. These additional in-stream and recreational uses do not require a permit as water is not removed from the source.

Industrial uses are limited to pipeline water takers in the Kettle Creek watershed, and thus there are no permits issued in this region for industrial uses. Therefore, it is very difficult to quantify the number of water takers and the amount of water used for industrial purposes. However, one automotive plant is known to be a major industrial water user.

Dewatering permits, the sixth largest user in the Kettle Creek watershed, can be considered industrial uses as generally these permits are for extracting water from pits, quarries, mines and construction areas. Dewatering accounts for less than one percent of the total water uses in the watershed.

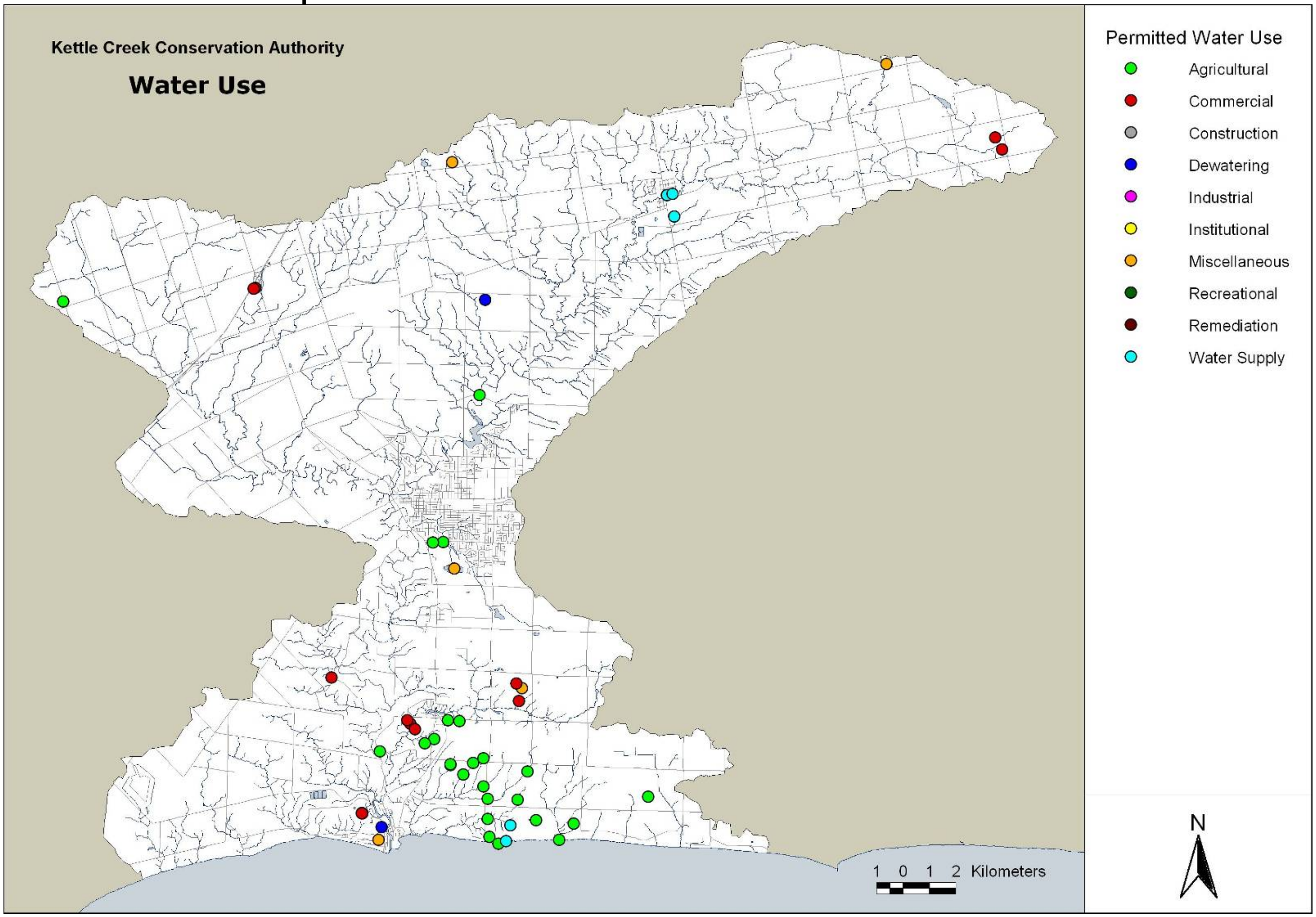
Commercial water uses include both golf courses and commercial businesses in the KCCA. Golf courses require permits to irrigate their greens and fairways on a seasonal basis, generally between April and September. Golf course irrigation accounts for 2.5 percent of total water use in the watershed. Commercial malls or businesses account for a very small percentage (less than 0.02 percent) of the water uses and are likely for sanitary purposes.

Agriculture is a large aspect of the Kettle Creek watershed, divided into crop irrigation uses and other agricultural water uses including washing and livestock watering. Livestock require water year round to provide drinking and washing water for the animals, while crop irrigation is only required during the summer months of the growing season of July and August. Only certain crops require irrigation and these are generally tobacco, root and vegetable crops.

Ecological water uses are for water to stay in the environment for fish and wildlife. These are needs of the environment for river levels and instream flows to sustain full natural ranges of life for all aquatic organisms. Ecological water uses are important for the maintenance of environmental integrity in a watershed and cannot be overlooked. Different aquatic organisms, including fish and invertebrates, have varying requirements for water levels in rivers during the year. A series of flows need to be maintained to ensure the quality of the environment such as stream structure or geomorphology, to function properly to support the organisms.

The concept of instream flow needs is still fairly new, and much research still is needed to grasp the complex relationships that aquatic organisms have to their physical, chemical and biological environments. Ecological flow requirements differ from site to site, from reach to reach along the entire length of any river and its tributaries. Studies have found that not only minimum flows were required to maintain healthy aquatic organism communities, but high flows and a variety of other requirements such as water temperature and groundwater contributions can also be a part of ecological flow requirements. The ecological flow needs in the Kettle Creek watershed include maintaining flows for different fish species, invertebrates and other wildlife, while maintaining flows for human uses as well.

Map 5.1: Permitted Water Use in the Kettle Creek Watershed



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Mapping based partially on data contained within Permits To Take Water issued by the Ontario Ministry of the Environment.

5.1.1 Recreational Water Uses

There are a number of water-related recreational facilities in the Kettle Creek watershed but all pale in comparison in size and economics to Lake Erie.

The historic village of Port Stanley is economically dependent on the water-based recreational activities surrounding Lake Erie. The Port Stanley harbour is the largest natural harbour on the north shore of Lake Erie. The size and depth of the harbour still attracts commercial and recreational fishing opportunities.

Consequently, the village has developed as a fishing and tourist community. Businesses such as marinas, marina suppliers, inns and shops predominately target summer tourists who are looking to spend a couple of relaxing hours on sandy, clean beaches.

Beyond Lake Erie, Lake Margaret, Pinafore Lake and Lake Whittaker also offer limited water-related recreational activities to the public. Both Lake Margaret and Pinafore Lake are economically tied to the community for aesthetic values. Pinafore Lake is the focal point of the City of St. Thomas' largest community park, while Lake Margaret is the focal point of a new up-scale residential development. The water quality of both lakes must be sustained and/or improved to maintain adjoining property values. Fishing is not permitted on Lake Margaret and Pinafore Lake, although area walking trails encompass the complex. While personal watercrafts is are not permitted on Lake Margaret, the local high school rowing community does use it as a practice facility.

Lake Whittaker is the focal point of a KCCA owned campground. Non-motorized boating is allowed. Fishing is permitted at Lake Whittaker and, of significant attraction to the sport fishermen; the lake is stocked annually with rainbow trout.

Dalewood Reservoir and Kirk Cousins Management Area are notable water-related attractions more so for aesthetic reasons than water-related activities. While the reservoir was once used by sail boats it is now too shallow to support any type of boating activity. Nature appreciation via bordering hiking trails is now the most common recreational activity at the Reservoir and the Kirk Cousins Management Area. Located adjacent to Regina Mundi College, Kirk Cousins is also frequented by students and teachers for educational purposes.

Finally, there are six golf courses in the Kettle Creek watershed that rely on ground or surface water to maintain healthy greens. The six golf courses include:

Belmont Golf Club 45809 Ferguson Line 18 holes	**Kettle Creek Golf and Country Club** 320 Carlow Rd., Port Stanley 18 holes	**Red Tail Golf Club** 6716 Mill Road, Southwold 18 holes
St. Thomas Golf and Country Club 42325 Sparta Line, Union 18 holes	**Tarandowah** 15125 Yorke Line, Avon 18 holes	**The Bluffs of Port Stanley** 35593 Lake Line, Port Stanley 9 holes

A seventh golf course, which draws from groundwater supplies, is located just outside of the watershed boundary:

Westminster Trails
2465 Westminster Drive
London
18 holes.

5.1.2 Data Gaps in Water Use Report

The Water Use in the Kettle Creek Watershed (GRCA, 2005) identified a number of issues with the current water use information, specifically using the PTTW database to determine actual water use estimates. Water managers who employ the PTTW database to quantify the amount of water use within a specific area may not be using the program for what it was intended. Until the current reporting requirements are made available to conservation authorities, the PTTW database does not contain sufficient detail to determine the actual amount of water used, or the seasonal or annual variability of takings. The estimates of the amount of water used, as determined from the PTTW database, are conservative estimates and should be treated as such. It should also be noted that probable low compliance within the PTTW program with certain sectors, further reduces the effectiveness of using the database to determine actual water use.

In an attempt to address these shortcomings and increase the accuracy of water use estimates further, the Water Use Report made the following recommendations:

1. That information gathered from the municipal sector be separated into industrial, commercial, institutional and residential components;

2. That consumptive ratios of all major water sectors be determined, as well as the occurrence of water diversions;

3. That development of a central database of water use in the watershed continues. This database would house recent information on municipal water systems as well as information gathered from permitted water users; and

4. That the information gathered in the new PTTW reporting requirements be made available for water managers as soon as possible, for use in technical studies for water budget and water use information.

5.2 Water Use Inventory

This section is an initial summary of the water uses within the Kettle Creek watershed for 2005, as found in a report entitled Water Use in the Kettle Creek Watershed (GRCA, 2005). Water use estimates are broken down into four subgroups: Municipal Supply, Agricultural, Un-serviced Population and Other Permitted Takings (larger than 50,000 litres per day). The water use estimates were determined using the best available data, including Census of Population, Census of Agriculture, municipalities, and the Permit to Take Water (PTTW) database. A phone survey of the permit holders was completed to refine water use estimates based on their records, with a 50 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.

5.2.1 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.

Belmont (approximately 1,800 residents) has the only groundwater source for municipal water takings in the Kettle Creek watershed. All other municipalities receive their water from Lake Erie from either primary or secondary water systems from an intake in Lake Erie off Port Stanley. These communities include St. Thomas (approx. 40,000 residents), and smaller communities in both Central Elgin and Southwold (approximately 9,000 residents). The water that is distributed via pipelines running through Elgin County also supplies approximately 25-30 percent of the rural and urban districts of the City of London both within and outside of the watershed region. Municipal water use totaled six million cubic metres in 2004 in this region.

Figure 5.1: Major Water Use on an Annual Basis in the Kettle Creek Watershed.

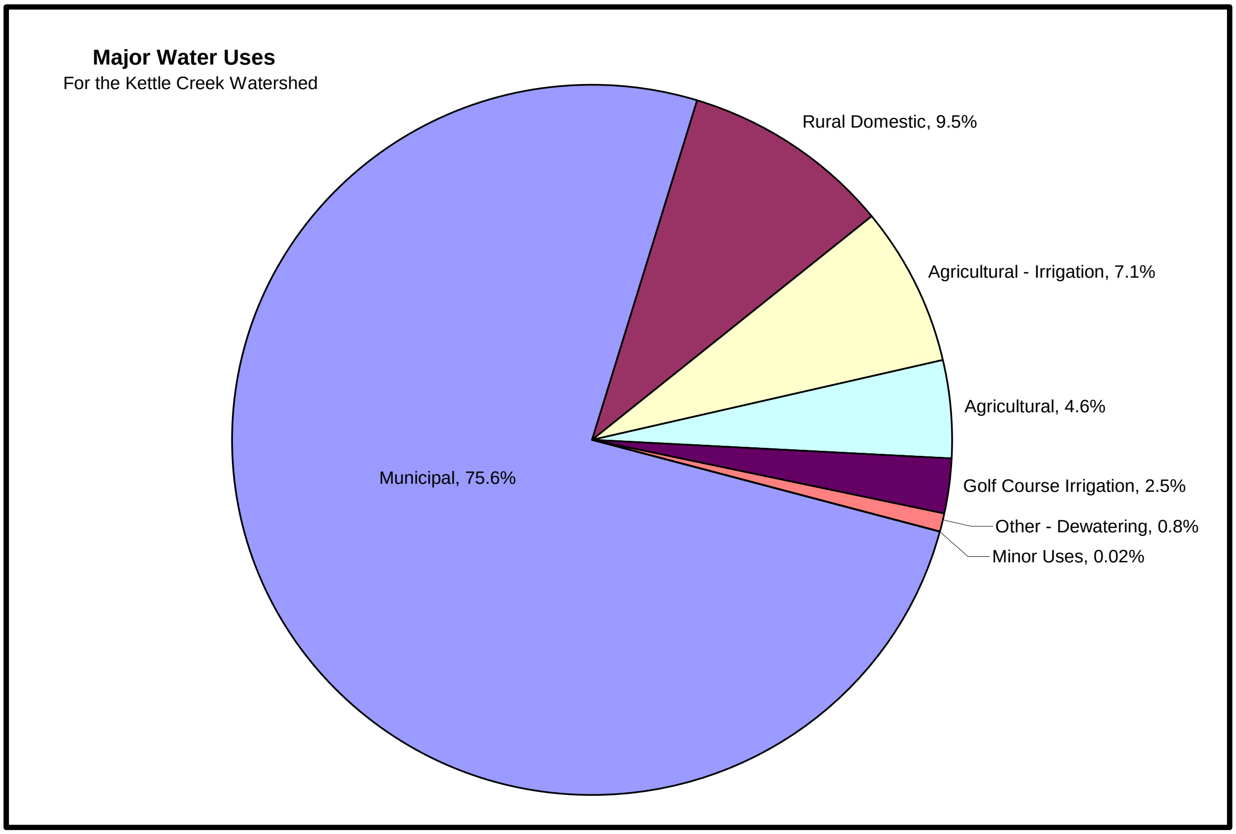


Table 5.1: Total Water Use Comparison (in cubic metres).

	Use Category	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	TOTAL
1	Municipal	518,250	492,320	511,650	495,070	520,290	573,430	580,580	491,370	524,250	452,620	403,890	480,420	6,044,150
2	Rural Domestic	64,530	58,285	64,530	62,448	64,530	62,448	64,530	64,530	62,448	64,530	62,448	64,530	759,784
3	Agricultural - Irrigation						141,250	282,500	141,250					565,000
4	Agricultural	21,520	19,440	21,520	20,830	21,520	20,830	58,340	58,340	57,640	21,520	20,830	21,520	363,840
5	Golf Course Irrigation	-	-	-	-	33,160	33,160	33,160	33,160	33,160	33,160	-	-	198,960
6	Other - Dewatering	5,140	5,140	5,140	5,140	5,140	5,140	5,140	5,140	5,140	5,140	5,140	5,140	61,680
7	Mall / Business	102	92	102	99	102	99	102	102	99	102	99	102	1,200
8	Other - Miscellaneous	2	2	2	2	2	2	2	2	2	2	2	2	25
	TOTAL	609,540	575,280	602,940	583,590	644,740	836,360	1,024,350	793,890	682,740	577,070	492,410	571,710	7,994,640

5.2.2 Agricultural Water Use

Agricultural water use was divided into two categories; livestock/farming operation water use and crop irrigation 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 considered in this water use category include greenhouse operations.

Livestock water demands were estimated using a water use coefficient for daily water requirements and the number of livestock in the watershed. The volume of livestock and other year-round agricultural water requirements, excluding irrigation water, is relatively small, accounting for 0.4 million cubic metres per year.

Crop irrigation is the application 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 for the Kettle Creek watershed. The irrigation demand model only considers irrigation events meant for maintaining soil moisture at adequate levels for plant growth. 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 25 agricultural irrigation sources, ten were supplied by groundwater and 15 were supplied from surface water. Irrigated crops in the watershed include tobacco, ginseng, potatoes and vegetables. The water used for all irrigation activity totals 0.6 million cubic metres per year.

5.2.3 Agricultural Water Use Data Gaps

Agricultural water use in the Province of Ontario is still lacking in accurate research into actual water requirements. There have been a few studies done (Ecologistics, 1993; Kreutzwiser and de Loe, 1999; and XGC Consultants, 2003), however there is still a lack of understanding into the irrigation water needs for Ontario’s crops. This is a provincewide gap in the study of irrigation water requirements for agricultural crops. It is suggested that investigations into more accurate estimates of irrigated land continue, including assessing the use of alternative methodologies such as remote sensing and crop specific water uses.

5.2.4 Un-Serviced Domestic Water Use

Un-serviced domestic water use includes all water used for domestic (indoor and outdoor residential water use) use that is not supplied by a municipal distribution system. Generally, these are rural communities where water is taken from private wells. The estimation of un-serviced 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, approximately 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 Kettle Creek watershed is estimated to be 13,000, drawing approximately 0.76 million cubic metres of water per year.

5.2.5 Other Permitted Water Takings

For water uses in the watershed that did not fall into the three previously mentioned categories (municipal, agricultural and rural un-serviced), the Ontario Ministry of the Environment 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. This includes many industrial and larger commercial operations, as well as many agricultural water requirements, such as irrigation.

Excluding the permits that have been expired for over ten years, cancelled, temporary, agricultural or municipal water supply permits, eight Permits to Take Water remain in the Kettle Creek watershed. These eight permits have a total of 15 sources associated with them. Of the 15 sources, 12 rely on groundwater, and three draw from surface water bodies, relating to 80 percent and 20 percent, respectively. The water takings were listed as uses for golf course irrigation, dewatering, commercial and miscellaneous.

A phone survey of the water takers in the Kettle Creek watershed 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 four of the eight permits (50 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 these permits in 2005 was 0.3 million cubic metres, with golf courses taking the bulk of this volume at 0.2 million cubic metres and dewatering accounting for 0.06 million cubic metres per year.

5.2.6 Summary and Data Gaps

Municipal water use is the largest user in the Kettle Creek watershed. The data is provided by the municipalities and is the only sector that consistently has reports on actual water takings. The only gap in municipal water taking values is the data that is reported 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 most municipalities lack the capacity to separate these uses. Also, aggregations from the Elgin Area Primary Water Supply System makes per capita estimates especially difficult as the number of users is unavailable. It is also hard to determine if there are large ICI users in the system.

Agricultural irrigation is the second largest water use sector, with water needs only during the summer growing season. 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.

Other permitted water uses in the watershed are few, from sectors such as dewatering, golf course irrigation and commercial businesses. Each sector has different timing and volume requirements and to fully understand their individual needs, it is suggested that the development of a central database of water use in the watershed continues. This database would house 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 watershed is comprised of a number of tightly knit farming and urban centres that take pride in their agricultural roots and small town appeal. Consequently, communities recognize the importance of water and the local environment primarily as it relates to their own growth and prosperity.

Historically, the creek was valued both by the native and European communities which settled on its banks. For the early pioneers Kettle Creek was the life blood of their community. Back then it was called the Tonto River, after the great explorer and devoted lieutenant of La Salle. The harbour was of great importance to navigators in those early days, because of the portage route extending from its mouth to the Thames River. The French and Iroquois later settled along Kettle Creek's banks. The creek provided them with transportation, a source of drinking water and food.

Kettle Creek has become, for many people, simply a backdrop to their fast paced lives. The watershed itself is not recognized as a management unit. Communities in the watershed such as Port Stanley in the south, Belmont in the north and urban centres like St. Thomas, define themselves and their local environment by municipal boundaries.

This fragmented view of the watershed is accentuated because the creek itself is not a major attraction. The creek is hidden in deep valleys except in its southern reaches as it empties into Lake Erie at Port Stanley. In the northern reaches of the watershed the creek is barely visible and only valued for aesthetic purposes or what limited recreational activities it can afford. As a result Port Stanley is the only community in the watershed where the creek is valued for more than its recreational or aesthetic qualities.

Port Stanley, the only deep water harbour/shipping facility on Lake Erie's north shore, is a focal point of recreation and industry. This quaint fishing village, with a population of 2,385, is also responsible for generating significant tourist revenue every year. Residents have always been acutely aware that the water quality and water quantity of Lake Erie and Kettle Creek has a direct correlation to their economic prosperity.

In 1995 the Kettle Creek Lake Erie Task Force was created as a result of public concern about a number of beach postings in Port Stanley during the summer of 1994. The Task Force was initiated by a group of concerned residents, Kettle Creek Conservation Authority, various municipal representatives and the Elgin St. Thomas Health Unit.

This grass roots organization commissioned a study to investigate possible bacterial contributors from Kettle Creek to the Port Stanley beaches. The results showed elevated bacterial loadings to Kettle Creek during storm events. The study concluded that St. Thomas was a major bacterial contributor to Kettle Creek. The community had shown a direct impact to what was happening upstream to their water quality. This led to improvements at St. Thomas Pollution Control Plant and in subsequent years a reduction in the number of beach postings in Port Stanley.

If the connection between water quality and quality of life is not made directly, the rest of the watershed community usually shows little interest. The larger watershed community views their water supply as limitless.

Urban based organizations like the Elgin - St. Thomas Health Unit and the Tourist Association have shown interest in working with environmental organizations like Kettle Creek Conservation Authority. However, in most cases these projects are routed in active recreational promotion such as hiking trail maps.

Collaborative stewardship projects beyond trail maps have to show a significant economic benefit to entice buy-in from local landowners. The success of Kettle Creek Conservation Authority's tree planting program depends heavily on the price per seedling. When funding is available trees are offered for free resulting in a very successful response rate. However, raising the price of seedlings, and offering them for as little as 25 cents per seedling can see a rapid decrease in interest.

Environmental stewardship comes second to other uses of the land like development, agriculture or recreation. In 1984, Kettle Creek Conservation Authority's own Watershed Plan promoted the drainage of land for agricultural purposes. The community valued drainage so much that the watershed subsequently lost one square kilometre or 98 hectares of wetlands.

The preservation of natural and historical sites also hedges on a communities ability to prove their value. In the watershed, only those features which were connected or supported by a prominent family have been protected. The City of St. Thomas bought all the land surrounding the Dalewood Reservoir to protect this drinking water source. This land was later sold to the Kettle Creek Conservation Authority when the City joined the Lake Erie pipe line as a drinking water source. The Dan Patterson Conservation Area was the homestead of the Patterson family and later passed to KCCA. Even such significant areas like Hawk's Cliff have a community foundation established to protect it. Those features not valued by families or communities are generally compromised.

6.0 DRINKING WATER SOURCES IN THE KETTLE CREEK WATERSHED

6.1 Summary of Municipal Drinking Water Systems

Within the Kettle Creek watershed, the only community with a groundwater-based municipal supply system is the village of Belmont, located in the Municipality of Central Elgin. The remainder of Central Elgin and surrounding municipalities rely upon Lake Erie water provided by the Elgin Area Primary Water Supply System, as well as private wells in un-serviced rural areas of the watershed. **Map 6.1** shows the location of municipal and known private wells in the Kettle Creek watershed.

There are no surface water intakes related to drinking water that take water directly from any of the tributaries within the Kettle Creek watershed. Most of the communities within the Kettle Creek watershed are supplied by the Elgin Area Primary Water Supply System (EAPWSS) whose intake is located in Lake Erie, into which Kettle Creek empties (shown on **Map 6.2**). The EAPWSS also provides water to communities within the Catfish Creek and Long Point Region watersheds.

6.2 Summary of Private Drinking Water Uses

Within the Kettle Creek watershed there are no known private surface drinking water intakes. Since there is no reporting mechanism in place, obtaining quantitative information about private intakes is difficult. Further information from the County of Elgin or the local health units may be able to provide more detailed information on the number of private surface water supplies within the region.

Many rural residents in the Kettle Creek watershed are reliant on private wells as a 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 also 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 to other water sources. 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 1,427 domestic wells are located in the KCCA official boundaries, with 54 (3.8 percent) of these wells being classified as bedrock wells and 1,349 (94.5 percent) as overburden wells. These wells date back to 1944 and it is unknown how many are still in domestic use today. It is possible that some wells were drilled to replace abandoned or decommissioned wells.

The lifetime of a well is dependent on its specific capacity to draw water. 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 Kettle Creek watershed.

There are few bedrock wells in the Kettle Creek watershed; most are found along the very top of the watershed, as shown in **Map 6.3**. Most bedrock wells were drilled in the City of London and Thames Centre Township. Bedrock wells range in depth from about 40 metres to almost 103 metres in this region, with the median depth being 79.9 metres. The depth of the wells may be an indication as to why there are not many bedrock wells in this region.

Domestic overburden wells, shown in **Map 6.4**, are much more common as they are generally much shallower wells, ranging from 2.75 metres to 97 metres in depth with a median depth of 24.4 metres. The range of overburden well depths indicates a thick overburden layer, and the ability to draw water from this layer without having to tap into the bedrock aquifer. Overburden wells were drilled throughout the watershed, with some wells clustered along the divide between Central Elgin and Southwold Townships. There are virtually no wells found in the City of St. Thomas, as the Lake Erie pipeline services this region.

There are few private domestic wells located in the town of Belmont, which is the only community in the Kettle Creek watershed serviced from groundwater wells. Wells drilled in groundwater serviced areas may be a concern if they are located within the capture zone of municipal wells, as they are potential pathways for surface contaminants to reach the aquifer that the municipal well is drawing upon. 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. The greater number of wells located in these capture zones increases the risks to contaminate municipal wells.

6.3 Municipal Drinking Water Systems Descriptions

6.3.1 Municipal Groundwater Systems Descriptions

Central Elgin, Town of Belmont

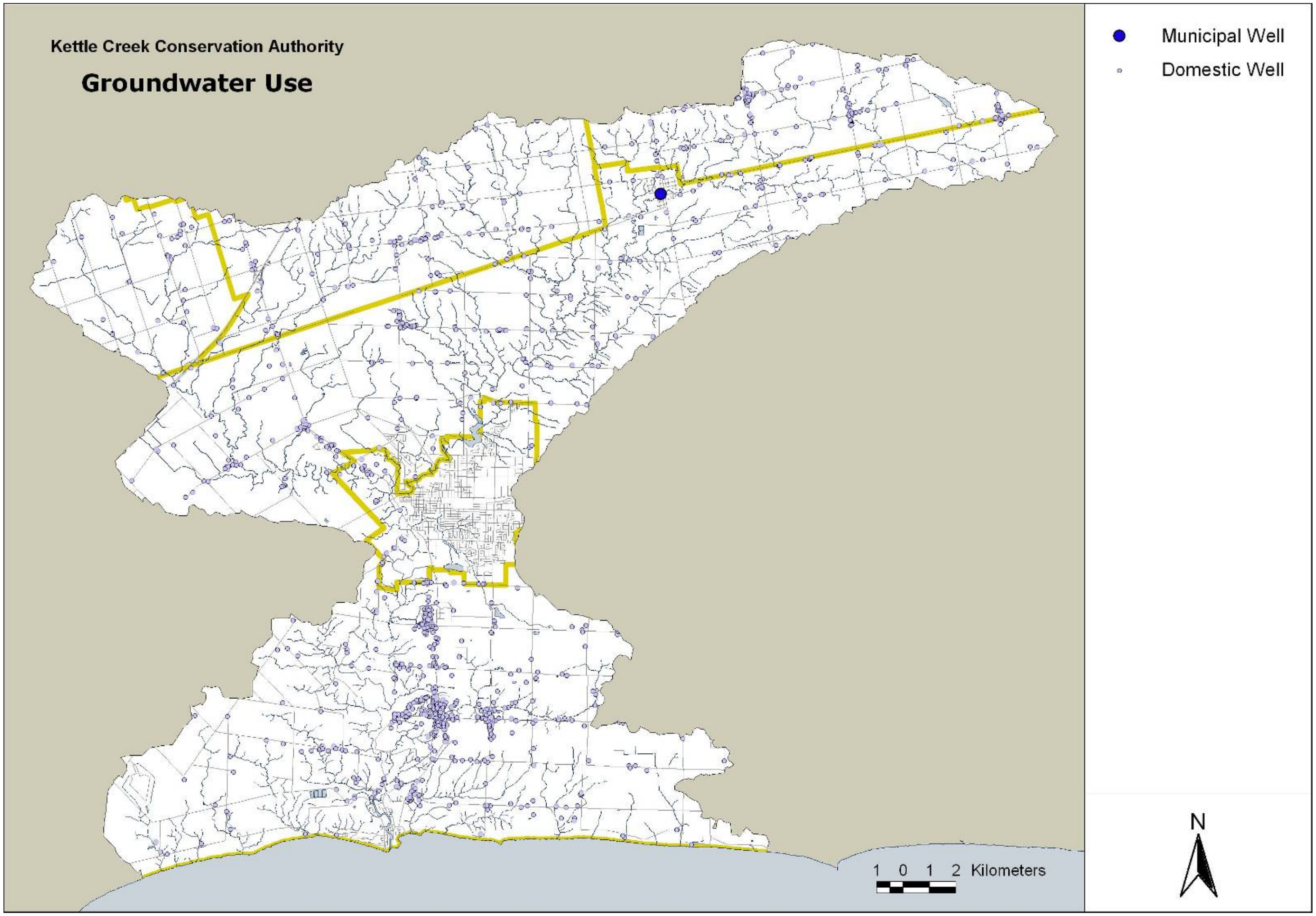
System Description and Hydrogeologic Setting

The drinking water supply system for the Town of Belmont consists of two deep artesian wells, a pumphouse, underground reservoir and distribution system. The overburden aquifer is sand and gravel and is confined by a thick layer of clay.

Municipal Groundwater Quality

No information regarding groundwater quality for the Belmont municipal supply was available at the time of this report, however results from monitoring reports identified no exceedances. Discussions with Central Elgin staff identified some concerns with hardness and current treatment for iron with sodium silicate.

Map 6.1: Groundwater Use in the Kettle Creek Watershed



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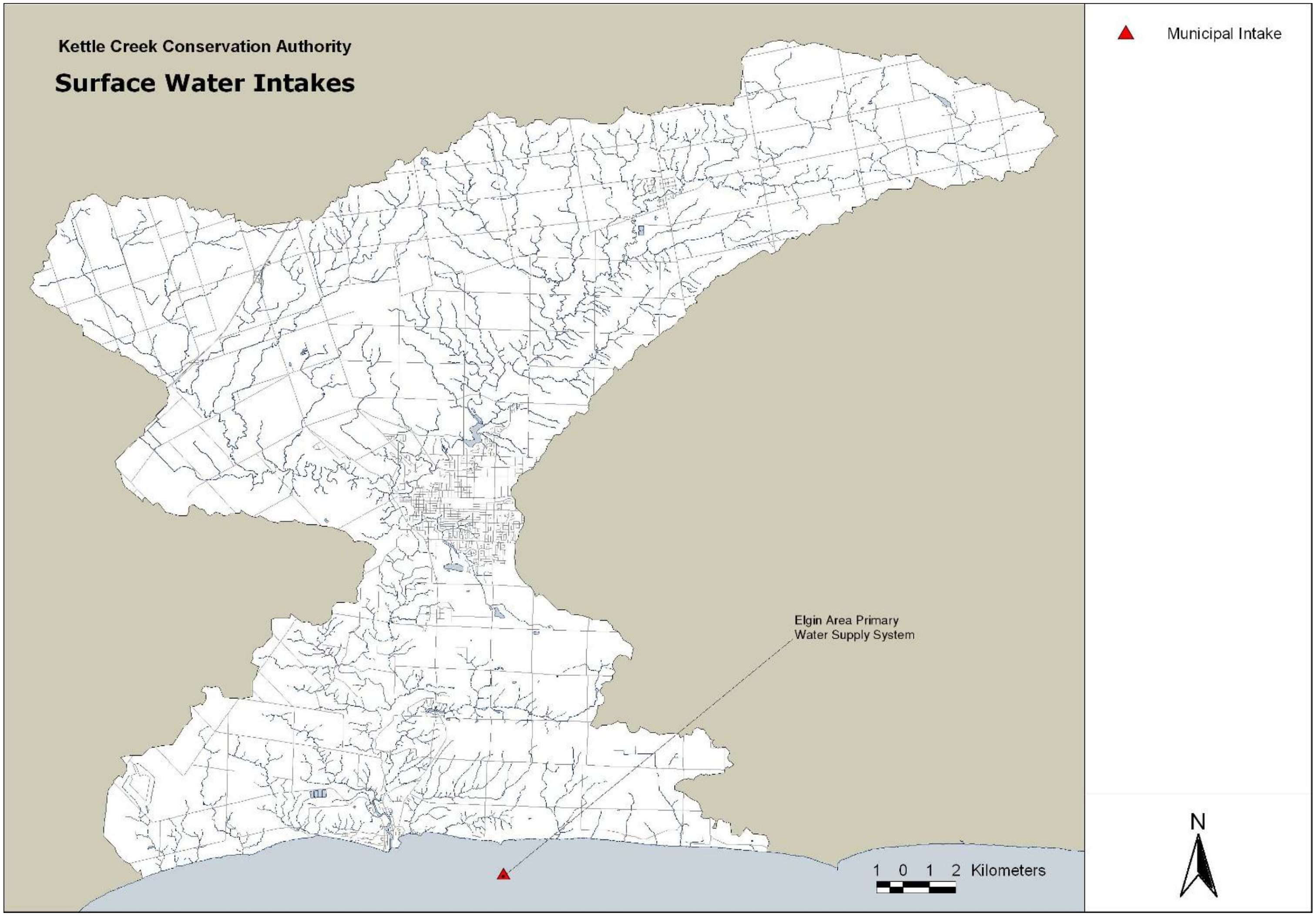
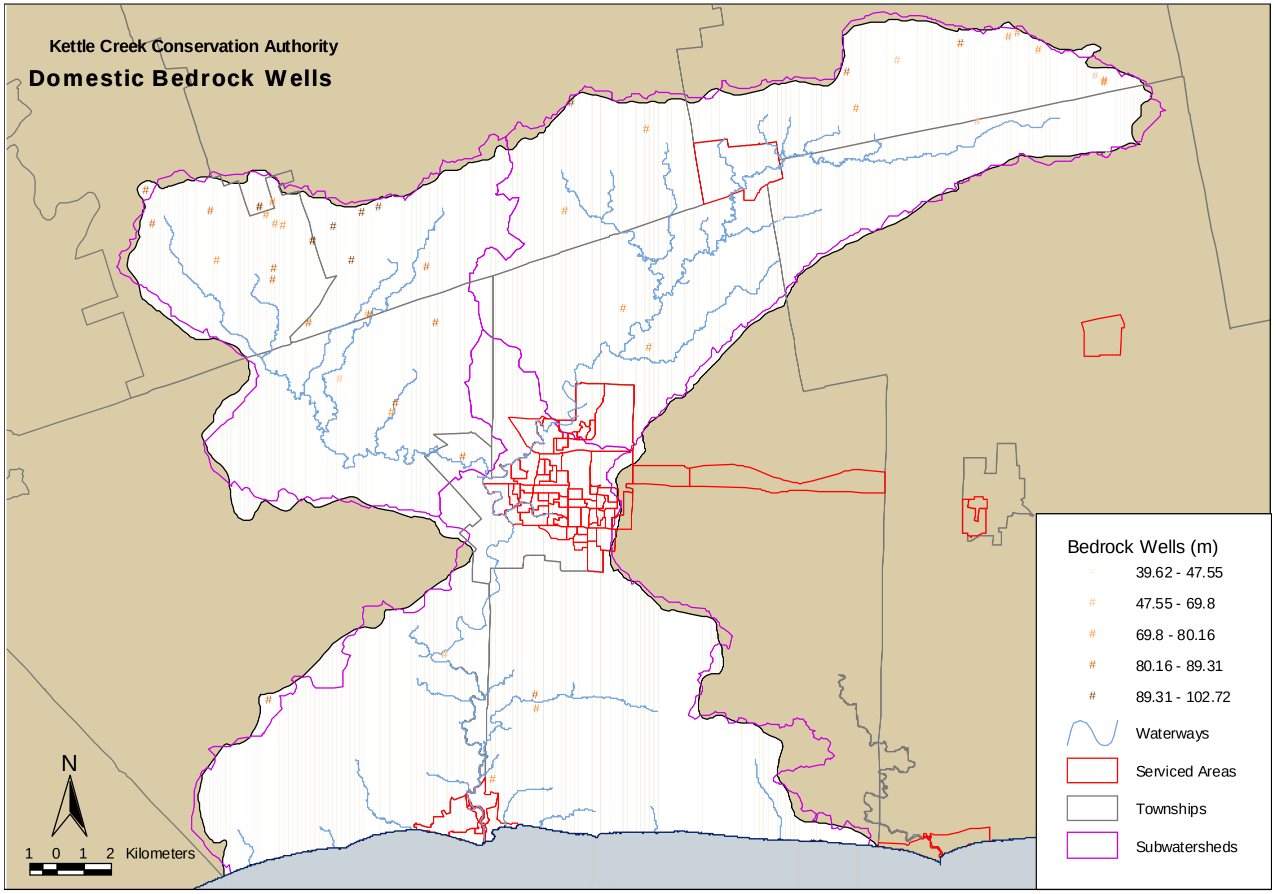
Map 6.2: Surface Water Intakes in the Kettle Creek Watershed



Map 6.3: Domestic Bedrock Wells in the Kettle Creek Watershed



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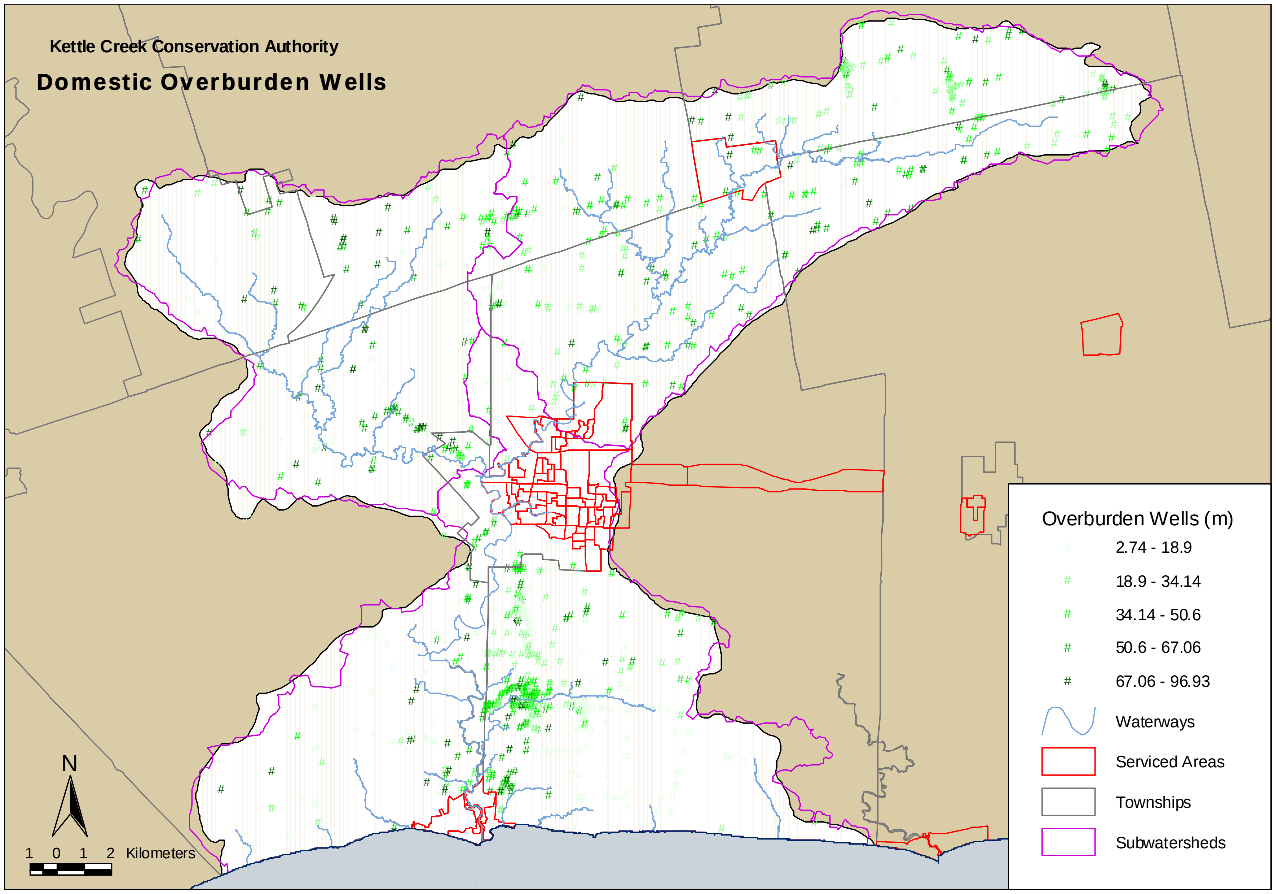
Mapping based partially on data contained within the Ontario Ministry of the Environment's electronic water well database.

Map 6.4: Domestic Overburden Wells in the Kettle Creek Watershed



Mapping based partially on data contained within the Ontario Ministry of the Environment's electronic water well database.

Description of Capture Zones

In 2002, the Municipality of Central Elgin completed a hydrogeological study for the Belmont groundwater system. This project included the development of two-, five- and ten-year time of travel capture zones for the wellfield (Dillon, 2002) shown in **Map 6.5**. Since the completion of the 2002 capture zones for the Belmont system, additional pumping tests have been completed and new flow rates for long-term build out of system have been developed. Therefore, a study funded by MOE and managed by the Municipality of Central Elgin is currently underway to model two-, five-, ten-, and 25-year capture zones for Belmont's municipal wells using these new data.

Vulnerable Areas within the 25-year Capture Zone

As a part of the Middlesex-Elgin Groundwater Protection Study, vulnerable areas for the uppermost aquifer were mapped using the Intrinsic Vulnerability Index for the Belmont area (Dillon Consulting and Golder Associates, 2004). Belmont is located in an area that was identified as having low Aquifer Intrinsic Susceptibility. A study is currently underway (managed by the Municipality of Central Elgin) to update the vulnerability mapping within the 25-year capture zones for the uppermost aquifer as well as the deeper municipal supply aquifer.

Threats within the 25-year Capture Zone

To date, a threats inventory has not been completed within the Belmont area. **Table 6.1** outlines a summary of high level threats identified in an interview with Central Elgin staff.

Table 6.1: High Level Threats

	Groundwater
Direct Introduction	
Water treatment plant wastewater discharge	None
Sewage treatment plant effluent	None (Aerated primary lagoons south of village drain sand filtered effluent to Kettle Creek)
Sewage treatment plant by-passes	None (3 lift stations in the village)
Industrial effluents	None
Landscape Activities	
Road salt application	Very low chloride levels in raw water (pre-wetting used)
De-icing activities	Bridge over Kettle Creek (next to wells) is de-iced using brine
Snow storage	None
Cemeteries	One inactive cemetery N/E of the wells
Stormwater management systems	New park pond being constructed immediately adjacent to well site Belmont residential dry SWM pond located to N/W of wells
Landfills	Waste trucked to Greenlane Landfill west of St. Thomas
Organic soil-conditioning	None
Septage application	Not aware of any septage application permits Pumped out septics treated at London WWTP
Hazardous waste disposal	None
Liquid industrial waste	None

Table 6.1: High Level Threats

	Groundwater
Mine tailings	None
Biosolids application	WWTP biosolids disposed in engineered wetland on site London & St. Thomas landfill their sludge Alymer land applies in Malahide Township
Manure application Fertilizer application Pesticide / herbicide application	Village surrounded by agricultural operations applying manure, fertilizer and pesticides Central Elgin has mainly cash crops (corn, beans, wheat, vegetables) Some livestock operations north and east of Central Elgin
Historical activities – contaminated lands	Old Borden Ice Cream Plant south of village closed 25 year ago, lagoons still not decommissioned
Storage of Potential Contaminants	
Fuels / hydrocarbons Pesticides (of concern to drinking water) Fertilizers	Farm supply outlet stores fuel, pesticides and fertilizers for agricultural operations Old gas stations decommissioned and sites remediated
DNAPL's (dense non-aqueous phase liquids)	None
Organic solvents	None
Manure	None

The interview identified that most high risk activities are not a threat to Belmont's well head protection area and that further work should assess the risk of agricultural activities around the village and the status of historic well sites. A study managed by Central Elgin is currently underway to identify threats in delineated vulnerable areas within the 25-year capture zone of the municipal wells. The following process will be followed to complete the potential contaminant sources inventory within the Belmont area:

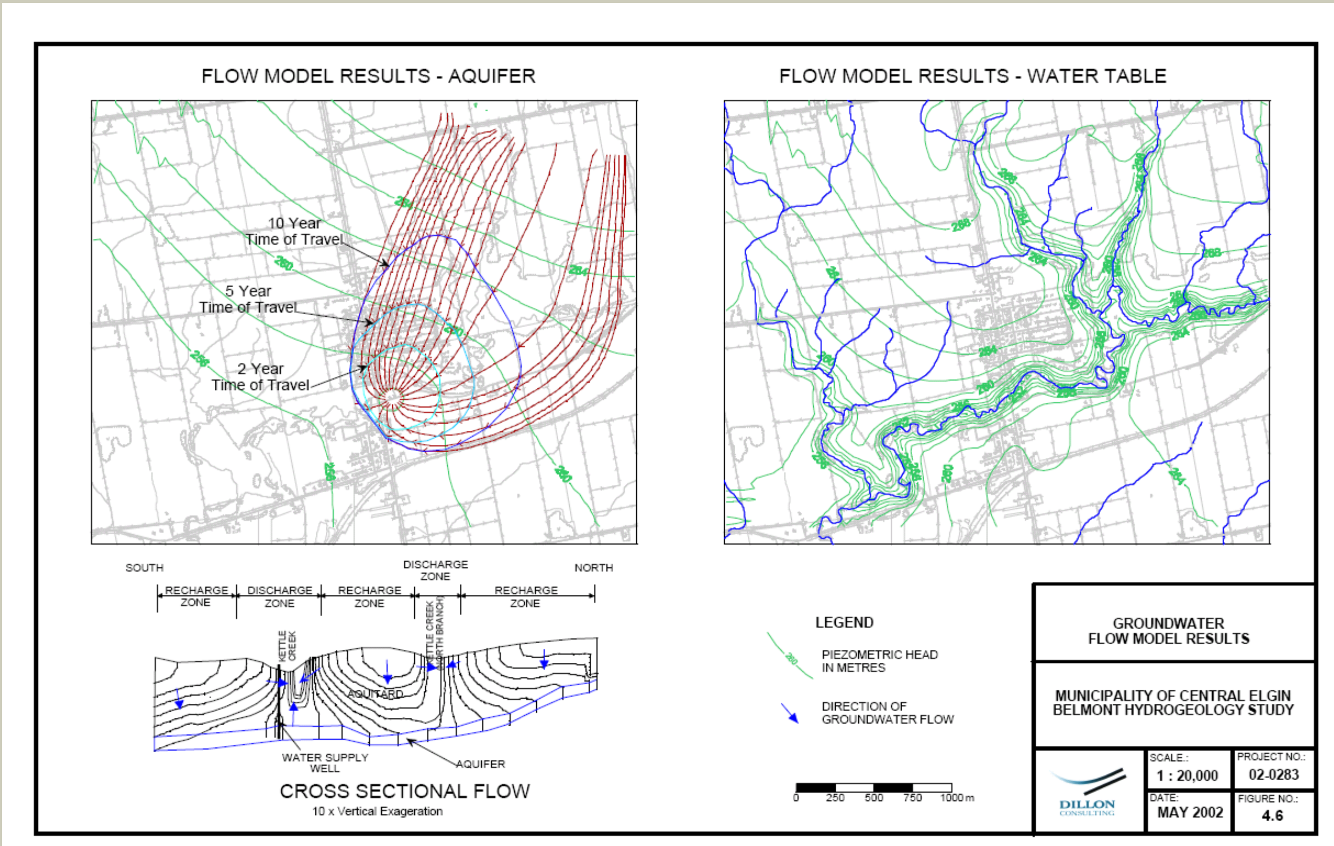
A. Desktop Study

- A review of historical aerial photographs and examination of land use changes in the vicinity of the wells;
- A review of the most current aerial photographs to identify high risk activities (i.e. landfills, cemeteries, gas stations etc.);
- A review of available provincial, federal and private environmental databases through Ecolog ERIS;
- A review of land use patterns in the vicinity of the site based upon available planning documentation, and
- A review of water well records and Permits To Take Water.

B. Field Verification

- A drive-by roadside verification program will be completed to confirm the results of the desktop study.

Map 6.5: Municipal Wellhead Capture Zones for the Town of Belmont



Kettle Creek Watershed Characterization Report

Wellhead Capture Zones

Study: Municipality of Central Elgin, Belmont Hydrogeology Study
Area: Belmont
Consultant(s): Dillon Consulting
Date: 2002

C. Interview Process

An interview process involving representatives of Belmont and landowners will be completed to confirm the findings of Steps A and B.

Summary

The groundwater source for Belmont has a low susceptibility to contamination due to a thick aquitard. Possible threats may relate to historical wells, which may be preferential pathways from agricultural land uses that should be investigated. Central Elgin has identified sufficient water supply exists for up to 25 years. The Municipality has implemented programs like pre-wetting of salt to protect the quality of recharge, although chlorides are not an issue in raw water. The Municipality has also completed several groundwater studies to quantify existing supplies, develop new supplies and identify wellhead areas for protection.

6.3.2 Municipal Surface Water Systems Descriptions

Elgin Area Primary Water Supply System - Southwold, London, St. Thomas, Central Elgin

System Description

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 Systems

The Elgin Area water treatment plant has four 700 horsepower high-lift discharge pumps. These pumps drive water from the plant at an average pressure of 600 kilopascals (85 PSI) through the 15 kilometre-long 750 millimetre (30 inch) pipeline to a Terminal Reservoir northeast of the City of St. Thomas. From this terminal reservoir the water is then re-pumped to Southwold, St. Thomas, London, Central Elgin, Malahide and Aylmer. The primary transmission pipeline which supplies water from the treatment plant to the Terminal Reservoir, also supplies water to the village of Port Stanley and the municipalities of Central Elgin, Malahide and Bayham along County Road 24 (Dexter Line).

During the 2004 reporting period there was a single occurrence where bacterial counts and residual chlorine were both exceeded. For each incident re-sampling and corrective measures were taken.

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 EAPWSS (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 & Lake Huron Water Supply System website (http://www.watersupply.london.ca).

Issues & 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 in this report. 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 EAPWSS. 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. 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.

6.3.3 Long-Term Municipal Water Supply Capacity Strategies

The municipal water system for Belmont in Central Elgin has capacity to service the community for the next 25 years based on available population projections and current water use trends. There are no known plans to expand the water system within the next 25 years.

With the exception of private well systems, the remainder of the serviced population in the Kettle Creek watershed receives their water from the EAPWSS through the Cities of St. Thomas and London, as well as the Municipalities of Southwold, Central Elgin, Malahide, Bayham and the Town of Aylmer. 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. For example, based on available information, the City of St. Thomas' current capacity for their distribution system is not large enough to handle the increase in water demand that the projected population of the community requires by 2031. Projected population numbers were not available for the serviced populations in the Townships of Southwold and Central Elgin.

7.0 SUMMARY OF IDENTIFIED POTENTIAL ISSUES

7.1 Known Drinking Water Issues

There are no known issues impacting the groundwater source for the Town of Belmont. The Belmont supply has a low susceptibility to contamination due to a thick aquitard. The municipality has implemented programs like pre-wetting of salt to protect the quality of recharge, although chlorides are not an issue in raw water.

As discussed in the previous section, there are known issues with respect to the Elgin Area Primary Water Supply System (EAPWSS) raw water supply. 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 EAPWSS. 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. There is the potential for these contaminated suspended sediments to be taken up by the intake pipe.

7.2 Data and Knowledge Gaps

Possible threats to the Town of Belmont groundwater supply 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.

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 studies that are currently underway.

8.0 CURRENT SOURCE PROTECTION ACTIVITIES

8.1 Spills Early Warning

Generally, the Ontario Ministry of the Environment (MOE) 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 MOE is responsible for providing support during these types of emergencies, which is provided through the Spills Action Centre (SAC) (Ontario Ministry of the Environment 1994a). 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 1994b).

The KCCA has also recently drafted an internal spills communication protocol which will provide guidance to KCCA staff on how to effectively respond to spills reported to their office.

8.2 Point Source Load Reductions

Currently there are no comprehensive point source load reduction programs operated by the municipalities or KCCA in the watershed.

8.3 Contaminated Sites and Brownfields Rehabilitation

No municipal programs regarding rehabilitation of brownfields or contaminated sites in the Kettle Creek watershed were identified at the time of writing this report.

8.4 Rural Non-Point Source Load Reduction

Rural non-point source load management refers to efforts within the rural community to alleviate the stress of contaminant loading on rural waterways. This can be achieved through a variety of means, including, but not limited to, curbing runoff, reducing erosion, and the development of Environmental Farm Plans.

Within the Kettle Creek watershed, many groups are actively participating in efforts to manage non-point source loads.

Environmental Farm Plans

Environmental Farm Plans (EFP) are assessments voluntarily prepared by farm families to increase their environmental awareness in up to 23 different areas on their farm. Through the EFP local workshop process, farmers highlight their farm’s environmental strengths, identify areas of environmental concern, and set realistic action plans with time tables to improve environmental conditions. Environmental cost-share programs are available to assist in implementing projects.

Although unable to acquire specific EFP numbers for the Kettle Creek watershed it is estimated that 2,000 EFP's were completed in Elgin and Middlesex counties in the past 13 years. The numbers for the County of Elgin are slightly below average based on other counties in the province, while the uptake in Middlesex County is slightly above average (Ontario Soil and Crop).

Canada-Ontario Farm Stewardship Program (COFSP)

The Canada-Ontario Farm Stewardship Program (COFSP) is a voluntary cost-share program that encourages producers to improve management of agricultural land. Through the adoption of Beneficial Management Practices farmers 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 $30,000.

Greencover Canada

This is an initiative to help producers improve land management practices, promote sustainable land use, protect water quality, reduce greenhouse gas emissions, enhance biodiversity and wildlife habitat, and expand the land base covered with perennial forest and trees. Elements of Greencover include: critical area management (i.e. enhancing riparian areas), shelterbelts, technical assistance, and conversion (i.e. converting marginal agricultural land to permanent cover). The cost share for Greencover Beneficial Management Practices categories is set at 50 percent, up to the category caps. The maximum federal contribution per legal farm entity with a unique FBRN is $20,000. The maximum contribution for COFSP and GC combined is $30,000.

The Clean Water Project

The Clean Water Project (CWP) is a rural water quality initiative that provides landowners with technical and financial assistance to improve and protect water quality. This program is available to eligible landowners within the Counties of Perth, Oxford, and Middlesex and the City of London.

These local municipalities together with the Ontario Ministry of Agriculture, Food and Rural Affairs are offering cost-sharing grants to qualified landowners for best management practices that improve ground and surface water quality. Financial assistance ranges from 50 to 70 percent, depending on the project. Maximum grants range from $500 for decommissioning an unused well to $10,000 for an erosion control project.

Since 2001, nine CWP's have been undertaken in the Kettle Creek watershed. One erosion control project, one nutrient management plan, two tree planting projects, two septic system upgrades, and three manure spreading equipment modifications. Of these, two of the projects have been carried out in Thames Centre, two in Middlesex Centre, and five in the City of London (email from Brad Glasman, UTRCA).

The Municipality of Central Elgin

The Municipality of Central Elgin, although primarily rural, encompasses both urban and rural areas. Thus, many of the load reduction initiatives mentioned in the *Urban Non-Point Source Load Reduction* section also apply to rural reductions. In addition to the efforts already mentioned, Central Elgin also implemented a reduction in mowing of ditches and roadsides. This is a win-win effort as it reduces the effects of runoff while lowering the maintenance costs for the municipality.

Forest Cover Initiatives

One of the primary issues regarding rural non-point contaminant loading is runoff reaching the creek directly without any buffers. In an attempt to alleviate this problem, several stakeholders throughout the watershed have participated in tree planting efforts to increase forest cover. This increased vegetative cover retains water during storm events to be released more slowly into the creek. This slower release of stormwater minimizes erosion, increases water quality, reduces peak flows, and improves baseflows.

Fifty landowners helped to boost forest cover in the watershed by planting 45,000 trees in 2005. Between 2001 and 2005, nearly 200,000 trees were planted in the Kettle Creek watershed through financial assistance from Ontario Power Generation's (OPG) Carbon Sequestration/Biodiversity Management Program. OPG has designated an additional $350,000 to plant another 200,000 trees within the Kettle Creek watershed in 2006 and 2007.

The County of Elgin has recently passed a woodland conservation by-law which was adopted by the Municipality of Central Elgin. This by-law regulates the harvest, destruction and/or injuring of trees within the municipality. The by-law stipulates that anyone harvesting, destroying or injuring trees must do so in accordance with Good Forestry Practices. It also employs a minimum circumference limit for which each tree species that may be harvested. There is a no-net loss policy for clearing of land for which people must replant the equivalent area or donate the equivalent in cash to a conservation organization. Around Environmental Significant Areas (ESAs) good forestry practices are the only way a harvest application can occur.

The Audubon Cooperative Sanctuary Program (ACSP) for Golf Courses

The ACSP is an award winning education and certification program that helps golf courses protect the environment and preserve the natural heritage of the game of golf. By helping people enhance the valuable natural areas and wildlife habitats that golf courses provide, improve efficiency, and minimize potentially harmful impacts of golf operations, the ACSP serves as a vital resource for golf courses.

The St. Thomas Golf and Country Club in Union, Ontario began working towards its designation as a Certified Audubon Cooperative Sanctuary in 1995. In 2001, St. Thomas Golf and Country Club achieved this goal. In recognition of this feat they received the Kettle Creek Conservation Authority Annual Stewardship Award and a letter of congratulations from Jean Chretien, former Prime Minister of Canada.

Designation as a *Certified Audubon Cooperative Sanctuary* is awarded to a golf course upon meeting environmental management standards in the following five areas: Wildlife and Habitat Management, Chemical Use Reduction and Safety, Water Conservation, Water Quality Management, and Outreach and Education.

There are currently 33 golf courses in Ontario, and 61 in Canada that have received designation as a *Certified Audubon Cooperative Sanctuary*.

Dodd and Upper Kettle Creek Community Based Watershed Strategies

The goal of these projects is to build a partnership of community stakeholders to identify local environmental concerns and develop action plans to address these issues. These strategies focus on two components: a technical summary and action plans. The summary of watershed features provides a snapshot of the available information on the two watersheds. The action plan presents priority issues and a strategy for addressing those issues.

The action plan was developed with input from the Dodd Creek and Upper Kettle Creek watershed communities and the Kettle Creek Conservation Authority. These plans are intended to act as tools to guide stewardship initiatives.

To date, two wetland projects, and various tree planting projects have been completed on private and public land under the guidance of these documents.

8.5 Urban Non-Point Source Load Reduction

Urban non-point source contaminant loading, or urban runoff, is a pressing issue in any watershed containing an urban landscape. Runoff is defined as a non-point source of contamination because the loading comes from many locations and thus cannot be linked to any specific source. Urban runoff reaches waterways through storm sewers, open swales and ditches, and directly from roads and parking lots.

Urban runoff is a serious concern as a non-point source contaminant load due to the association of a wide variety of contaminants. These contaminants range from industrial and household chemical compounds and petroleum products to fecal waste and sediments. These contaminants foul waterways and provide risks to downstream water users. Therefore, recognizing and dealing with these issues is becoming a priority for many municipalities.

One method municipalities are using in new development areas is to require stormwater management ponds to help filter out some of the contaminants before water reaches a creek or river. However, there is still the looming issue of dealing with areas which were developed prior to the advent of stormwater management ponds. Many different and innovative approaches are being proposed and carried out to help deal with this issue.

Within the Kettle Creek watershed, several municipalities are implementing measures to deal with the effects of contaminant loading from urban runoff.

The City of London

Although the entire Kettle Creek watershed within the City of London is rural agricultural land use and is outside the Urban Growth Boundary for the anticipated growth of the City, a summary of the City's urban non-point source load reduction programs is provided. The City of London actively promotes and participates in stewardship programs in the predominantly rural portion of the City that falls within the Kettle Creek watershed. As mentioned above, the City participates in the Clean Water Project, having completed five projects to date.

In 2003, the City of London's Steering Committee on Pesticide Management prepared a Community Plan entitled Community Plant Health Care – Integrated Pest Management Plan (PHC-IPM). The purpose of this plan was, "to help foster growing awareness in

London about PHC-IPM and alternatives to pesticides, which in turn will result in pesticide reductions and more informed purchasing decisions". The goals of the plan were, "to see a significant reduction in the use of urban pesticides, and target a complete phase-out of pesticide use for non-essential purposes by the year 2007".

The City of London has recently passed a by-law which bans the non-essential use of pesticides within the city. This ban will take effect in September 2008, and is hoped to effectively reduce the urban loading of chemicals into urban waterways.

Other by-laws in effect within the City of London which further this cause are the Drainage By-Law, the Dog Licensing and Control By-Law, and the Animal Control By-Law. The first prohibits the discharge of anything short of rain water into storm sewers. The Dog Licensing and Control By-Law and the Animal Control By-Law help to reduce fecal waste contamination from entering waterways by requiring the control and removal of such waste.

The City of St. Thomas

During the last 15 years, the City of St. Thomas has made major strides in the implementation of various projects relating to urban non-point source load reductions and the protection of sources of drinking water. These projects include the preparation and implementation of subwatershed studies and master drainage plans, stormwater management measures, water quality enhancement, Combined Sewer Overflow (CSO) control, Water Pollution Control Plant (WPCP) optimization, industrial discharge control, and various public education initiatives.

The following is a brief summary of the City of St. Thomas' efforts to reduce urban non-point contaminant loading:

- Operation and maintenance of stormwater management facilities. Most of the stormwater management facilities satisfy the following criteria:

  - The creation of a passive and active water quality storage enhancement volume with a constructed wetland component for a level 1 creek protection in accordance with the MOE Stormwater Management Planning and Design Manual Guidelines;

  - Two-year frequency storm peak detention to the pre-development levels for velocity and stream bank erosion control;

  - Five-year frequency storm peak detention to the pre-development level;

  - Major storm peak flow detention as required or in compliance with previously prepared master drainage plans.

- Installation of Stormwater Treatment Units/Quality Control Devices in strategic locations to include;

  - First Ave/Expressway – Stormceptor
  - Bennett Place – Stormceptor
  - Sanders Court – Stormceptor
  - Huntington Terrace – Stormceptor

- Triple M (245 Edward St.) – Stormceptor
- Canadian Tire – Stormceptor
- Walmart – Stormceptor
- Central Package LT (Curtis St.) – Stormceptor
- First Ave/Joseph St. – Stormceptor
- Hiawatha St. Parking Lot – Stormceptor
- Hemlock/Elmina – Stormceptor
- Maple/East End – Env 21 water quality enhancement unit
- Maple/Ross – Env 21 water quality enhancement unit
- Elmina/Dunkirk – Stormceptor
- Balaclava St. North of Talbot St. – Stormceptor

- Public Information Pamplets;
- Sub-Watershed Studies/Water Quality Enhancements and Master Drainage Plans for:
  - Lands of Dalewood
  - Mill Creek – South Block Area
  - Lynhurst Area
- Salt Management Plan;
- CSO Control Facility upstream of the WPCP, combined with many sewer separation projects;
- Spill Response Procedures;
- Development and implementation of a Supervisory Control And Data Acquisition System (SCADA) construction (winter '07) to improve the monitoring of flows at sewage pumping stations;
- Employment of a full time Waste Water Inspector;
- All construction to MOE standards at a minimum;
- Environmental Storm/Sanitary public education pamphlets

(Provided by the City of St. Thomas)

St. Thomas does not currently have a summer use watering by-law. However, the City has received an OWWA award for its water conservation initiatives, awarded on the merit of the extensive public education initiatives including pamphlets, and brochure.

In addition to these efforts the City of St. Thomas participates in the local Environmental Fair and in the Elgin Area Water Supply System Conservation Committee; has a by-law to control waste discharges into municipal sewers; and has an Animal Control By-Law which requires the removal of fecal waste daily from kennels, and immediately from any public location, thus helping to reduce fecal pathogen loadings to waterways.

The Municipality of Central Elgin

The *Communities in Bloom Community Profile Binder* describes the Municipality of Central Elgin's commitment to the environment. In an effort to reduce non-point source loading to streams Central Elgin has incorporated several initiatives into their operation procedures.

The municipality has an integrated pest management plan in place, including a "no spray" policy for all municipal properties and roadsides. Also, the municipality is working towards alternate ground covers on hillsides.

As described in the *Wastewater Treatment* section of this report, both the Village of Port Stanley and the Village of Belmont, within the Municipality of Central Elgin, employ tertiary sewage treatment processes. The sludge collected from these facilities is disposed of in an onsite constructed wetland. This wetland process breaks down the sludge, and provides a disposal alternative to land-filling or land application, thereby reducing contaminant loading to the creek system.

Yellow Fish Program

Yellow Fish Road™ volunteers paint "yellow fish" symbols next to storm drains and distribute fish-shaped brochures to nearby households, to remind people that anything that enters the storm drain system ends up in the local water course.

In the spring of 2006, Sparks, Brownies, Guides, and Pathfinders in the Village of Port Stanley participated in this program to remind local residents that anything that reaches the storm sewers also reaches the creek. This point is especially important in the Kettle Creek watershed, due to the link between the creek's outflow and the municipal intake pipe.

Kettle Creek / Lake Erie Water Quality Task Force

In response to frequent beach postings in Port Stanley, residents and government representatives within the Kettle Creek watershed formed the Kettle Creek / Lake Erie Water Quality Task Force. It was the mandate of this committee to determine what sources of contamination within the Kettle Creek watershed were causing the high bacteria levels in Port Stanley leading to beach postings.

The committee set forth the following action plan to address these issues:

Dredging:

1. That all dredging activities undertaken within the inner (upstream of the lift bridge) and outer (downstream of the lift bridge) harbour be subject to bacterial testing prior to the actual dredging;

2. That all dredging activities take place in late summer to early fall;

3. Assess dredging techniques for optimum impact reduction, and

4. Confirm in-lake dredgate locations and eliminate any possible contamination.

Natural Impacts:

1. Investigate the benefits and costs of on-stream wetland creation and natural treatment along Kettle Creek;

2. Investigate the benefits of a Canada Goose and Gull control program, which could include food control, beach garbage containers with lids, and beach signage stating "don't feed the gulls", and

3. In order to reduce sediment stirring, license and better control jet skis and boats - possibly through the provisions of the Bill 26 regulations.

Information and Education:

1. Promote the message "Water Quality is Everyone's Responsibility" and the recommendations of the Water Quality Task Force. Develop public support and lobbying by drawing parallels between health and environment: a healthy environment means better health. Institute an Environmental Watch program, perhaps through an existing watch group and by erecting signs;

2. Seek partnerships in the promotion of the Task Forces' recommendations through education and promotion, funding and cost sharing, problem solving, information and expertise, involvement and actual works implementation in projects and material sharing. List and share task force member information and education support materials, equipment, displays and expertise;

3. Advance public understanding of the beach sign postings. Promote available activities beyond swimming and Port Stanley beach as a good, clean place to visit. Develop a "public promos tip" program - in terms of a positive - do this activity, which could be used in a free PSA format, and

4. Promote any existing, applicable environmental regulations in order to foster stewardship of Kettle Creek and its watershed. Highlight the costs and affects of rural dumping.

Boating:

1. Educate boaters on water quality problems and their need to use marina facilities. Erect signage along boating corridors to advise boaters on key messages determined through the above;

2. Promote Regulation 343 (Discharge of Sewage from Pleasure Boats) and 351 (Operation of Pump-out Facility at Commercial Marinas) and enforcement of the same;

3. Investigate marina pump out facilities and procedures and promote any necessary modifications. Application for boat slips should include information and boat features, and

4. Investigate and remediate lake freighter sewage/bilge dumping impacts on local water quality. Investigate and remediate commercial fishing activities and

procedures that have either a direct or indirect impact upon water quality and public perception.

Rural Impacts:

1. Review all approved septage sites that are in the Kettle Creek watershed area and field inspect to identify any potential adverse effects on surface water;

2. Contact all local septic tank haulers and update information on disposal from septic systems they pump that are located within the watershed area;

3. Investigate and remediate any impacts of Port Stanley septic tank systems along George Street and upstream of Grand Canyon and review pumping station records in Port Stanley;

4. Review municipal plans for upcoming input conversion from septic to sewage treatment plant. Contact all municipalities on the Kettle Creek watershed and fact-find the information;

5. Promote the use of sewage treatment plants for disposal of septage;

6. Promote values of good agricultural practices to landowners. Promote and enforce Best Management Practices for agriculture, such as cattle fencing, manure management, and milk house waste. Investigate funding alternatives available for landowners to implement improvements as suggested by Best Management Practices;

7. Lobby Provincial and local agriculture associations and individuals to identify and eliminate watercourse pollution practices. Lobby provincial government to reinstate CURB program;

8. Investigate alternatives for septic system maintenance enforcement;

9. Integrate water quality interests into municipal drain programs where applicable;

10. Investigate alternative types of septic systems, manure storage, watercourse fencing and innovative milkhouse waste treatment and demonstrate potential benefits to public, and

11. Investigate any wildlife bacterial inputs upstream in Kettle Creek.

Water Sampling:

1. Revise Health Unit beach signage protocols;

2. More frequent beach water sampling after a beach is posted;

3. Investigate alternative sources for timely test results, perhaps at cost;

4. Investigate alternative water sampling analysis techniques which may be more cost effective or timely;

5. Hire a summer student to take beach water samples for cost savings;

6. Consolidate task force member water sampling needs, protocols, and costs and information dissemination, all for efficiency purposes;

7. Ensure beach water sampling protocols are understood and utilized, and

8. Consider undertaking off-season water quality sampling.

Sewage Treatment Facilities:

1. Include recommendations for the improvement of infrastructure (capital needs improvement) of the sewage treatment plants;

2. Investigate opportunities for combined sewage holding facilities;

3. Eliminate downspout/basement drain tile connections to sanitary sewers in St. Thomas and Port Stanley and disconnect all sump-pump connections from sanitary sewers and separate combined sewers;

4. Install UV treatment of Plant Discharge;

5. Determine feasibility, cost and scheduling of sewer separation;

6. Task Force members should educate themselves on the operation of the St. Thomas, Port Stanley and Belmont facilities, and

7. Support sales campaign to promote sewer rate and possible homeowner money savings.

To date, many of these actions have been implemented. This action plan is currently under review to determine which issues still need to be address, or which issues need to be readdressed.

8.6 Private Well Protection

Since the Walkerton tragedy in 2000, stringent guidelines have come into place dealing with large and small scale municipal groundwater systems. However, private water wells are equally susceptible to contamination, and with thousands of private wells provincewide, the aquifers which they access are also susceptible. In light of this fact, it becomes increasingly apparent that private landowners need the knowledge and capabilities to maintain their wells in a safe and healthy manner for themselves and their neighbours.

A variety of water testing and education programs exist throughout the province to ensure that private well owners have access to safe drinking water. Within the Kettle Creek watershed, both the municipalities and the local health units are taking action to ensure these programs are available.

The Municipality of Central Elgin has taken the initiative to distribute Well Aware™ booklets with building permits. These booklets are produced through a partnership between the Green Communities Association, the Ontario Ground Water Association, and the Ontario Ministry of the Environment. The booklet covers the basics on groundwater, well location and construction, and well decommissioning. It also provides information on well maintenance and water quality testing.

The Elgin - St. Thomas Health Unit and the Middlesex - London Health Unit provide sample bottles and laboratory testing for total coliforms and E. coli free of charge to local residents. The health units also provide residents with informative literature regarding well maintenance, water quality testing, and dealing with contaminant exceedances in their wells.

In addition to these local initiatives, many of the programs described in the Rural Non-Point Source Load Management section of this report provide funding to landowners looking to decommission an old well, or to protect an existing well from surface water contamination.

These types of public awareness campaigns help ensure that local residents have clean, safe drinking water, and also aid in keeping local aquifers clean and safe.

8.7 Water Conservation and Demand Management

The Kettle Creek watershed is a unique situation in which the community draws its drinking water from what seems like a limitless resource: Lake Erie. Municipalities are not solely concentrating on education and outreach to help the community value their water sources. Most of the municipalities within the Kettle Creek watershed have established water rates, which deter residents from using water frivolously. Still other municipalities have tried to curb overuse during drought conditions by introducing by-laws that restrict water use.

Table 8.1 summarizes by-laws and water charges currently employed in the Kettle Creek watershed.

Table 8.1: Water Rate Charges and By-laws in Municipalities in the Kettle Creek Watershed.

Municipality	Water Rate Charges (2006)	Water By-Law
St. Thomas	TBD	N/A
City of London	$1.12/m^3$ for first 16.990 m3 $1.18/m^3$ for next 39.644 m3 $1.23 for all additional m^3 Minimum monthly charge of $5.00 Plus a fixed charged based on metre size	During the months of June, July and August the external use of water is restricted based on street address. Engineer is also able to in his discretion completely ban the external use of water
Central Elgin	Monthly Service Charge $13.50 Per Cubic Metre $1.63	N/A
Malahide Township	Every 13 week period monthly bill from $30 to $62.10 for 27 cubic metres plus all additional water will cost $1.00 - $2.30 per cubic metre based on address	Lawn watering restrictions based on street address yearly from June 1 – September 15
Middlesex Centre	First 90 cubic metres $1.15 Next 60 cubic metres $1.28	Outdoor watering for lawn and gardening is restricted during the

Table 8.1: Water Rate Charges and By-laws in Municipalities in the Kettle Creek Watershed.

Municipality	Water Rate Charges (2006)	Water By-Law
	Next 60 cubic metres $1.42 Next 60 cubic metres $1.55 Next 60 cubic metres $1.71 Next 60 cubic metres $1.88 Next 60 cubic metres $2.08 Next 60 cubic metres $2.28 Next 60 cubic metres $2.51 Next 60 cubic metres $2.76 Minimum charge $43.47	period of June 1 to September 15 each year based on street addresses. Gardens, flower beds, trees and shrubs may be watered daily with a hand held hose only. Newly sodded and/or seeded lawns may be watered daily for a 2 week period.
Thames Centre	0-14 cubic metres $20.83 minimum bi-monthly charge 15 – 50 cubic metres $1.14 per cubic metre Over 50 cubic metres $1.56 per cubic metre	Non-essential water use is limited to the odd/even system during the months of May, June, July, August and September based on street address. Non-essential water use refers to lawn watering, filling pools, washing vehicles etc.
Southwold	$1.25 per cubic metre plus a base charge of $25 charged quarterly	A water by-law 2005-18 is in place but includes no watering restrictions. There are no other current water use management programs.

8.8 Protection of Key Hydrologic Processes

The protection of key hydrological processes is vital for the protection of source water. The issues which threaten these processes are many, and without a proactive approach to resource management the damage may be irreparable. Examples of proactive approaches to protection include: land acquisitions by all levels of government, conservation authorities, and NGOs; municipal, provincial and federal land designations; and, naturalization projects implemented by local stakeholders.

Wetlands are a vital part of the hydrological process, and as such several policies have been developed to protect these areas. The Ontario Ministry of Natural Resources (MNR) defines wetlands as:

> *Lands that are seasonally or permanently covered by shallow water, as well as lands where the water table is close to or at the surface. In either case the presence of abundant water has caused the formation of hydric soils and has favoured the dominance of either hydrophytic or water tolerant plants. The four major types of wetlands are swamps, marshes, bogs, and fens (MNR, 1999).*

The Provincial Policy Statement states that water and natural heritage features are an integral part of Ontario's environmental and social well-being. Sections 2.1 and 2.2 of the Provincial Policy Statement provide a basis for conservation authority regulations and municipal planning documents to protect these areas.

Within the Kettle Creek watershed, wetlands are regulated by the Kettle Creek Conservation Authority (KCCA). Sections 7.2 and 7.3 of KCCA's Development, Interference with Wetlands and Alterations to Shorelines and Watercourses regulations set out specific rules for development in and around wetlands. Although the Provincial

Policy Statement refers specifically to provincially significant wetlands, KCCA's policies incorporate all existing wetland features.

In addition to regulating existing wetlands, KCCA has recently created some new wetlands with funding from the Green Lane Community Trust Fund, Green Lane Environmental and Environment Canada's EcoAction Community Funding Program. Examples of these wetlands can be seen on Southminster Bourne near the Green Lane landfill, and in the Dan Patterson Conservation Area.

Forests and vegetated areas also play a key role in the protection of hydrological processes by slowing the flow of water across the landscape and allowing the water to infiltrate the soils. This process is vital to the replenishment of aquifers and to maintaining healthy baseflows in streams.

KCCA, working in conjunction with many local stakeholders, land owners, and funding partners have succeeded in reforesting approximately 400 ha of land, over 1,000,000 trees, within the last 20 years (Rob Lindsay, pers. comm). With continued funding from Ontario Power Generation, and the continued support of local landowners, KCCA plans to plant an additional 100,000 trees in 2007.

In addition to creating and protecting wetlands, and reforesting the landscape, subwatershed studies exist for approximately 70 percent of the Kettle Creek watershed (Bryan Hall, pers. comm). These studies provide management strategies for protecting, maintaining, and enhancing key, or significant, environmental features within the study areas. These strategies are in place to ensure the integration of viable urban development with sustainable environmental health.

8.9 Education and Outreach

Various municipalities in the watershed are actively promoting water conservation and best management practices for source protection.

The Community of London Environmental Awareness Reporting (CLEAR) Network was launched in May of 2006. This web site www.clear.london.ca is maintained by the City of London and a host of municipal partners. The site provides information to the public on how well London as a community is responding to environmental concerns such as – drinking water, air quality, sewage treatment and urban planning. The network is still evolving but it is a valuable resource to inform residents about how their day-to-day activities impact the environment and how various agencies are working to mitigate those impacts.

The City of London has also launched a poster campaign which explains in easy to understand terms the storm water drainage system and the wastewater system. The posters include tips on how to keep our water clean, conservation efforts and flush fact, what not to flush.

The City of St. Thomas has a similar water conservation literature campaign. The city has produced a series of pamphlets on water efficiency including healthy lawn care, a water efficient plant list, water efficiency in the laundry room, bathroom and a complete guide to indoor water efficiency. The guides include information on how to reduce, retrofit and repair items in your house to save water. The guides were placed in water bills and are still available to the public.

The Lake Huron Primary Water Supply System and Elgin Area Primary Water Supply System (Water Boards), in partnership, have established a region-wide water conservation and public education committee that promotes water conservation in the various communities, which includes pamphlets on water conservation tips in the yard, bathroom and kitchen. The Water Boards have also partnered with a variety of community organizations to hold a London-Middlesex Children's Water Festival. The goal of the London-Middlesex Children's Water Festival is to provide a hands-on learning environment in which students in grades three to five from the City of London, Middlesex County and surrounding areas discover the importance of water in their lives and communities. It is proposed that the Children's Water Festival will be expanded in future years to include the other areas supplied by the Water Boards, including Elgin County, Middlesex County, Lambton County and Huron County.

There will be approximately 40 hands-on activity stations linked to the Ontario Curriculum. These activity stations are grouped around five themes: water conservation, water attitude, water technology, water protection and water science.

The Festival will take place in London in June 2007 and it is anticipated that a similar festival will be brought to Elgin County in 2008.

In addition to its own water conservation messages, the Elgin - St. Thomas Health Unit provides the public with information on how to test their well water and what responsibilities they have as a well owner.

Kettle Creek Conservation Authority (KCCA) is constantly working to improve community awareness about the environment. KCCA was among the first authorities in the province to hire a full-time communication professional to develop an outreach program. In 1984 KCCA invited a variety of stakeholders, including the Health Unit, service clubs and municipal representatives to the table to develop a watershed strategy. The resulting document outlined the beliefs and values that the partners shared, as well as clear priorities for the Authority to guide conservation efforts in the years to come.

Today, KCCA in cooperation with The Lake Huron and Lake Erie Water Supply System are developing watershed conservation strategies. The premise behind these strategies is to approach the community and find out what they consider to be the environmental priorities in the watershed. Once these priorities are identified, KCCA will attempt to find funding for a stewardship project. The strategies have not only increased the awareness of the community but local politicians as well. The work KCCA and the Water Board have completed with the watershed strategies showed a direct need to have a comprehensive environmental monitoring program in the watershed. With the community behind the effort local municipalities supported a 25 percent increase in funding levy to KCCA to initialize the monitoring program.

Other non-governmental/municipal organizations have their own environmental outreach programs in the community. The St. Thomas Golf and Country Club offers a junior golf environment program. Young golfers help green staff with environmental activities such as building bluebird boxes or planting trees.

Similarly, The Hawk Cliff Foundation offers banding days each year during the fall migration. Children and adults alike have the opportunity to come to the cliff to see the raptors and are given an opportunity to see birds being banded.

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