Peterborough Natural Areas: The net gains and losses in natural heritage features from 1996 – 2016

Final Report

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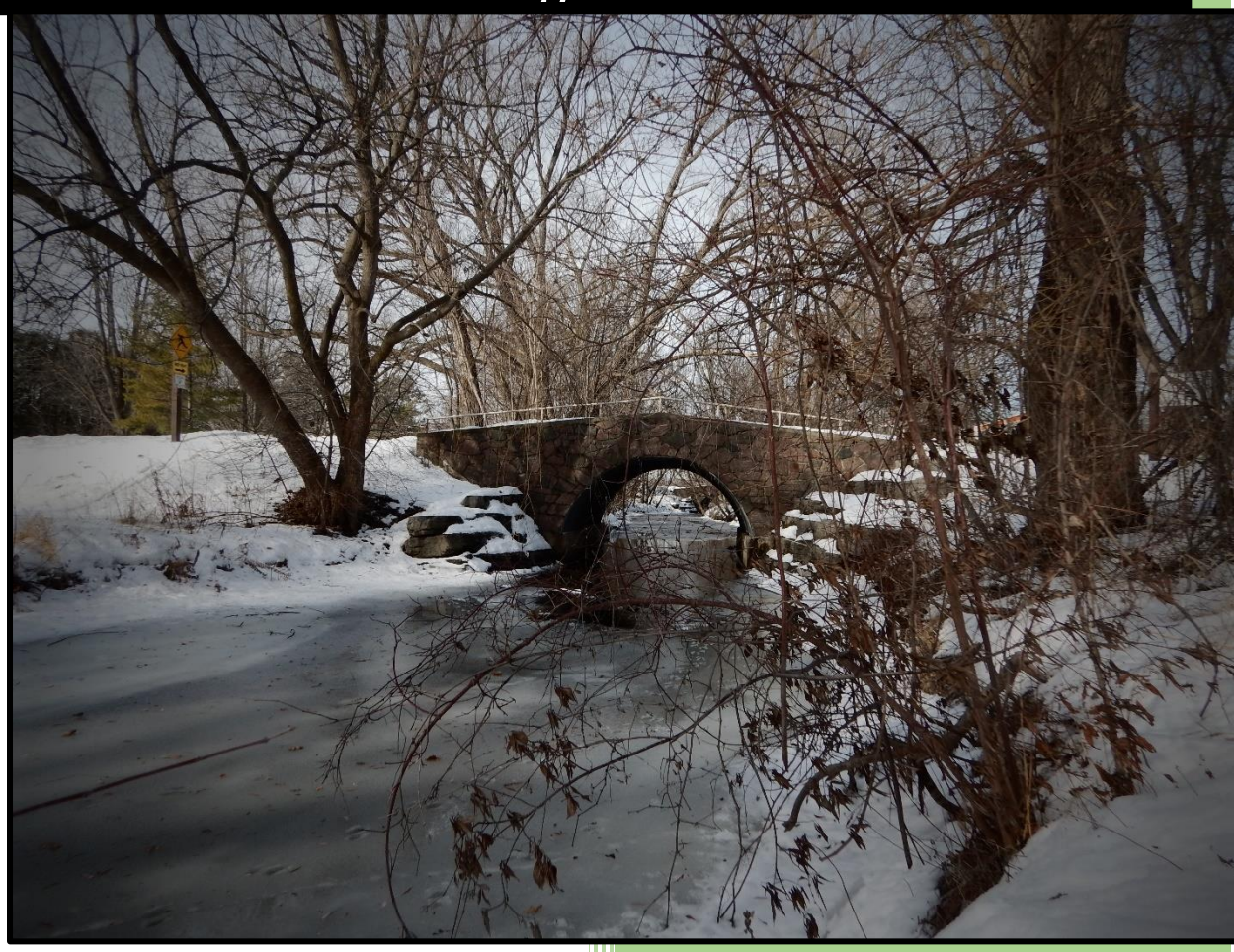

Vanessa Potvin

Honours Thesis – Final Report

Thursday, March 30th, 2017

Presented to Professor **H. Nicol** of Trent University & **K. Zippel** of the Peterborough Field Naturalists

Preface

The research paper presented reflects the work of a Trent University student within the Environmental Science and Resource Studies Program. As part of the degree, an honours thesis course was undertaken, in partnership with the Peterborough Field Naturalists and the Centre for Community-Based Research. The purpose of the project was to determine the net gains and losses in the natural heritage features of Peterborough. Three research questions were proposed: **(1)** What are the changes that have occurred over the last 20 years in the natural heritage features throughout the Peterborough natural areas? **(2)** Is it economically, environmentally, and financially viable to create a natural areas corridor through the city of Peterborough? **(3)** Is a staff position needed to manage and monitor the ecology and biodiversity of the natural areas on a continuous basis?

Both interesting - and quite possibly controversial - the natural areas of 1996 and 2016 were mapped using ArcGIS, with a total of 52 points ground-truthed. The original maps were computer-aided design (CAD) files that briefly outlined the boundaries of the 10 natural areas. The result is therefore not an accurate depiction of the natural limits of the areas. While this could be seen as somewhat controversial, the actual differences may not be particularly large. However, the best effort was put forward to properly map out the natural areas using ArcGIS, in hopes to limit the uncertainty, and thus controversy. However, while reading this research paper there are some things the reader needs to take into consideration regarding the information and data provided.

This research paper was overseen by Heather Nicol, the Trent University honours thesis supervisor, David Tough of the Trent Community Research Centre, and Kim Zippel of the Peterborough Field Naturalists which was the host organization. The program ran for 8 months, although access to maps was not granted until November 25th, 2016 – three months into the project. With that in mind, the time frame allotted to complete such a detailed paper would have fell short. As a result, the study became more limited than originally intended. Some methods were changed and some material was thus omitted from the final report. Interviews were undertaken, but not to the extent that would have been advantageous. Interviews would have allowed for further research and a more in-depth analysis and understanding of the natural areas, and how they have changed over time – for better or for worse. Due to time limitations, a site species inventory and the mapping out of the natural area boundaries was not viable. With that being said, these aspects of the project have the potential to be further researched.

In addition, it would have been useful to contact several corporations. This includes Otonabee Region Conservation Authority (ORCA), an environmental agency that works to manage and restore natural resources within the Otonabee Region watershed. The perspective of this particular organization would have been interesting to help balance this research paper and produce a more holistic conclusion. Specifically, in regards to the waterways, ORCA would have been able to provide a better understanding of its quality, and other attributes important to its health.

Lastly, it is important to note that this paper is not an expert opinion, and the studies were not undertaken by a professional. However, it has been done to the best of one's ability with a certain level of knowledge to show the broad changes in the Peterborough natural areas.

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I. Key Terms

Adapted from the *Natural Heritage Reference Manual, 2nd Edition* (Ontario Ministry of Natural Resources, 2010):

Adjacent Lands – those lands contiguous to a specific natural heritage feature or area where it is likely that development or site alteration would have a negative impacts on the feature or area.

Development – the creation of a new lots, a change in land use, or the construction of buildings and structures, requiring approval under the Planning Act (*excludes* infrastructure that has passed an environmental assessment)

Ecological function – the natural processes, products or services that living and nonliving environments provide or perform within or between species, ecosystems.

Ecosystem health – can be characterized as a measure of the level of distress in the ecosystem, its resilience and adaptability, the ability to sustain itself, the degree to which adjacent ecosystems are affects and the extent to which the ecosystem supports healthy human communities.

Ecosystem services – ecosystem services are the benefits that people gain from ecological systems. These services are the basis for human well-being and the economic value of our landscape and economy. Natural heritage systems deliver essential ecosystem services such as clean water and air, productive soils and flood attenuation.

Natural heritage features & areas – features and areas, significant: wetlands, coastal wetlands, woodlands/valleylands south and east of the Canadian Shield, habitat of endangered/threatened species, wildlife habitat, areas of natural and scientific interest; fish habitat. All of which are important for their environmental and social values as a legacy of the natural landscape of an area.

Natural heritage system – an ecologically based delineation of nature and natural function – a system of connected or to be connected green and natural areas that provide ecological functions over a longer period of time and enable movement of species. Natural heritage systems encompass or incorporate natural features, functions and linkages as component parts within them and across the landscape. They also enable the linking of different landscapes.

Negative impacts – degradation that threatens the health and integrity of the natural features of ecological functions for which an area is identified due to single, multiple or successive development or site alteration activities.

Significant – it is ecologically important in terms of features, functions, representation or amount, and contributing to the quality and diversity of an identifiable geographic area or natural heritage system

Site alteration – activities, such as grading, excavation and the placement of fill that would change the landform and natural vegetative characteristics of a site.

II. Abstract

The Peterborough Natural Areas Strategy was developed in 1996 to establish a natural areas corridor for the citizens of Peterborough. Ten natural areas were mapped. Within each site, core areas were identified for a total of 24 natural areas throughout the city. The environmental status of the areas has not been assessed since the development of the original strategy. This report examines each natural heritage area to determine the net gains and losses in ecological features over the past twenty years. ArcGIS was used to digitize the maps, and map analysis tools were used to determine the net gains and losses in natural heritage features. As a result of this study, it was determined that there has been no statistically significant change in the natural areas since 1996. However, an assertive conclusion cannot be made, due to the variety of limitations that pertained to this study. Instead, further studies should take place to support the claim of this research.

III. Introduction

Development of the Peterborough Natural Areas Strategy (PNAS) was guided by a multi-stakeholder Steering Committee in 1996. The plan was developed to "protect, restore and enhance [Peterborough's] natural heritage" (Peterborough Steering Committee [PSC], 1996, p. 1). The development of such a plan "allows for advance decision-making about important ecological features in the city" (PSC, p. 1). The goal of the natural areas strategy was to create a natural heritage corridor for the citizens of Peterborough to use for outdoor recreational activities. The interest in a natural areas strategy was sparked by a number of initiatives previously undertaken in Peterborough, to enhance its' natural heritage. These include, but are not limited to: shoreline restoration projects at Little Lake; the reclamation of railways into multi-use corridors; and Beavermead Parks' Green-up Ecology Program.

The original Strategy launched in 1996, identified ten natural areas within Peterborough that are considered to be ecologically important. Within each of the sites are core areas, making a total of 24 different sites for analysis allowing for a good degree of specificity in regards to defining what is ecologically important in each natural area. It has been twenty years since the plan was created, thus the current environmental status of each of these areas is now uncertain. Therefore, all 24 sites required reassessment and new maps needed to be created from aerial photography, to determine any net gains or losses in any of the key natural heritage features of each individual site.

This Peterborough Field Naturalists' (PFN) project was undertaken by a student at Trent University through the Trent Community Research Center (TCRC). It is intended to re-map and re-survey the areas along with an update of the strategy to include more current knowledge and to determine the net gains and losses in the key natural heritage features. A net loss would support the need for a comprehensive natural heritage management plan, and therefore, the creation of a City/staff position, citizen advisory board, or other authoritative body to monitor and manage these areas.

IV. Hypothesis

Null Hypothesis: there is not a significant difference in the natural areas between 1996 and 2016.
Alternate Hypothesis: there is a significant difference in the natural areas between 1996 and 2016.

V. Background Information

Natural heritage systems are composed of natural heritage features, that, according to Wise et. al., (2014, p.2) are "intended to provide connectivity and support natural processes, biological and geological diversity, natural functions, viable populations of indigenous species, and ecosystems." Natural heritage systems are thus composed of different natural features, areas and linkages. Municipal governments play a key role in protecting natural heritage features, but often struggle due to the lack of resources and expertise (Wise et. al., 2014). Not only that but management is challenging and complicated as strategies vary from site-to-site within the same type of natural heritage system (Ababnah et. al., 2016). Carter and Grimade (1997, p.45) point out that "conservation involves an inherit dilemma. It embraces both use and preservation. Yet, use can lead to destruction.

Peterborough is extremely fortunate to have an abundance of natural areas. Efforts to protect and manage such areas dates back to 1978 (PSC, 1996). The majority of natural areas are located on valley slopes, drumlins, or on saturated low areas making it challenging for development. The largest natural areas are located in the periphery of the City, while the smaller areas are located in the core. However, as urbanization is encroaching on the natural areas of Peterborough, it is important to (PSC, 1996, P#):

- Protect what we've already got for the benefit of the future
- To build on Peterborough's inheritance by completing the natural areas corridor, enhancing both natural and human values within that system
- To plan for future natural areas as urban settlements expand

Unfortunately, many natural areas are under pressure for development. Consequently, Peterborough is starting to suffer the environmental ills of major cities like Toronto, Montreal and Vancouver (PSC, 1996). The Jacksons Creek System and Bears Creek System are the only natural, connecting watercourses through the city, while all others are ecologically isolated. Thus, it is vital to protect them. But, why are natural heritage systems highly important to protect? This will now be discussed.

V.I Ecosystem Services

Ecosystem services are the functions of ecosystems that are beneficial to humans, either through the criticality to survive, or enhances the quality of life (Kremen, 2005). Ecosystem services contribute to public health and have to ability to increase the quality of life (Bolund & Hunhammar, 1999). Such features can range from sole street trees, to lawns and parks, to lakes and streams (Bolund & Hunhammar, 1999). Unfortunately, there is increasing threats to ecosystems situated in urban areas due to developmental pressures.

Natural heritage systems provide ecosystems services that are vital to human health, well-being, and safety (Wise, et. al., 2014). These ecosystem services include: flood control; soil retention; water purification; improved air quality; pollination; climate change mitigation and provision of wildlife habitat; forests and freshwater foods; and places for outdoor recreation and activities (Wise, et. al., 2014). It is important to understand such services, as they can contribute to a more resource efficient city structure and design (Bolund & Hunhammar, 1999).

V.II Sustainable Economic Development

The natural heritage areas of Peterborough are a defining element of the City's character. Many people often refer to it as a 'city in the country' (PSC, 1996). The ecosystem services which they provide, contribute to the development of a sustainable economy (Scottish Natural Heritage [SNH], 2015). Such areas provide jobs through management, farming and parks (SNH, 2015). In fact, natural heritage areas have the potential to save economic costs as they sequester carbon, mitigate pollution, and provide flood control, which in turn, limit the amount of money that needs to be provided to develop programs or infrastructure to deal with these issues (SNH, 2015). Natural heritage systems bring the tourism industry into the city, attracting a variety of visitors. Indirectly, the resulting tourism industry will allow other city businesses to increase their profit as visitors will need food, a place to stay, and of course other activities to participate in when they are not enjoying the natural areas. Natural areas have the potential to brand Peterborough as a city of 'high quality,' if they can be protected

V.III Nature Deficit Disorder & Biophilia

With the current attraction society has towards technology, and increasing urbanization, more and more humans are becoming disconnected from nature (Capaldi *et. al.*, 2015). This disconnection extends beyond the sole physical association one has with nature, but also the psychological impact that nature has on humans (Capaldi *et. al.*, 2015). In fact, according to Maller *et. al.*, (2015), humans have never been so disconnected from the environment. As a result, the nature-deficit disorder has developed, which coincides with the theory of biophilia.

Nature-deficit disorder, Louv (2008) argues, is the price that humans pay – physically, mentally, and health wise – when lacking in nature. These symptoms include but are not limited to "diminished use of senses, attention difficulties, and higher rates of physical and emotional illnesses" (p. 36). The disorder can affect individuals, families, populations, and even cities. On the other hand, biophilia is an evolutionary theory that suggests humans have an inherent connection to nature and all living organisms (Capaldi *et. al.*, 2015; MacKerron & Mourato, 2013). This is due in-part, to the reliance humans have had on the natural environment for survival over the last 10,000 years. As a result of this strong, innate affiliation, the natural environment is thought to have positive impacts on a person's health, wellbeing, and happiness (MacKerron & Mourato, 2013). Thus, nature-deficit disorder and biophilia go hand-in-hand as scientific evidence proves the importance of nature for human wellbeing.

Researchers are beginning to recognize the benefits gained when in presence of the natural world. In fact, exposure to nature can reduce symptoms of Attention Deficit Hyperactive Disorder (ADHD), and improve children's cognitive abilities and their resistance to anxiety and

depression. Studies show that those who have a connection to nature will spend more time outside, and therefore, are happier (Nisbet & Zelenski, 2011). Even brief periods – as short as fifteen minutes – can turn an emotional state from negative to positive (Capaldi *et. al.*, 2015; Nisbet & Zelenski, 2011). In fact, the phrases "I am going to clear my head" and "I need some fresh air" relate to the brains ability to relieve excess activity that is occurring, reducing stress, and restoring harmony back to the brain while in outdoor environments (Maller *et. al.*, (2015). According to Ryan *et. al.*, (2010, p.159) "natural elements bestow a sense of wellness and energy." Many observational and experimental studies that research the link between wellbeing and the natural environment have been conducted, concluding that a statistically significant relationship exists (MacKerron & Mourato, 2013). Some studies reveal that patients undergoing surgery have a more rapid recovery when they are provided with a natural rather than an urban view (Maller *et. al.*, 2015). Muscle tension and heart rate have also been shown to improve when one is viewing or immersed in nature – either physically or virtually. Therefore, as Maller *et. al.*, (2015, p.49) clearly states "nature and natural environments relate to human health and well-being," in a positive way. Due to the number of benefits natural environments provide for human well-being, it is not only important to protect such areas for species and the environment, but also for the benefit of humans.

Overall, natural areas are of extreme value to both the environment, the economy, and human health. In fact, many cities have developed, or are in the process of developing natural heritage management plans. Cities such as Edmonton, Alberta or Port Hope, Brampton and the Halton Region of Ontario support the case to develop a management plan.

VI. Case Studies

VI.I Edmonton, Alberta

Edmonton is one of Canada's largest, and fastest growing municipalities, where environmental issues, quality of life, and economic necessity are all intertwined (Edmonton, 2007). Thus, a balance needs to be found. The natural areas of Edmonton are part of its' distinguishing features, and needs to be protected. Edmonton has created a Natural Connections conservation plan to integrate planning and protection measures for natural areas within municipal boundaries (Edmonton, 2007). The main idea behind the plan is to strengthen the connections between natural areas and people. Like most Canadian cities, Edmonton includes both natural and man-made features and environments. It is thought that if they are properly managed, they can complement one another (Edmonton, 2007).

There are many recreational activities that take place within Edmonton's natural areas. These include, but are not limited to, cycling, running, hiking, cross country skiing, and bird watching (Edmonton, 2007). Due to the popularity of such natural areas, the municipality decided to improve its' conservation efforts. In 1990, the Office of the Environment was established, where one of its' ten strategies was the City's conservation of natural area systems. In 2001, the conservation coordinator position underwent expansion and was reestablished as the Office of Natural Areas (Edmonton, 2007). The intent of this management office was to coordinate conservation function, bringing other branches together to ensure sound planning and

operation. Subsequently, in 2006, the Urban Parks Management Plan decided to include a Natural Area Park designation to educate citizens about their structure, function, and value (Edmonton, 2007).

Unfortunately, many of the natural areas throughout Edmonton are under increasing pressure due to urbanization (Edmonton, 2007). Many of the areas have already been degraded, fragmented, or even lost altogether. As of 1993, 23% of natural areas has been lost to development, and 21% has been protected under a specific law. With that being said, the other 54% remains unprotected and is subjected to increasing development pressures (Edmonton, 2007).

Through open houses, surveys, facilitated workshops, and focus groups, citizens were given the opportunity to express whether they felt that Edmonton's natural areas should be protected, and if so, how they should be managed (Edmonton, 2007). Over 1,500 citizens participated in the aforementioned activities, in which the majority supported the efforts to protect the natural areas – it is something which many people are passionate about. The general consensus was as follows (Edmonton, 2007):

- Acquire privately owned nature areas
- Improve current protection methods
- Make conservation part of the planning process
- Work with developers to provide incentives
- Develop partnerships with stakeholder groups and the general public.

Subsequent surveys conducted all revealed the same results (Edmonton, 2007). Subsequently, it was determined that it is time to protect the natural areas from development, as it continuously increases. If action is not taken, there will be a higher risk of losing the ecological network. Figure 1 shows a systems approach to conservation planning, which transitions from the conventional approach to planning (Edmonton, 2007).

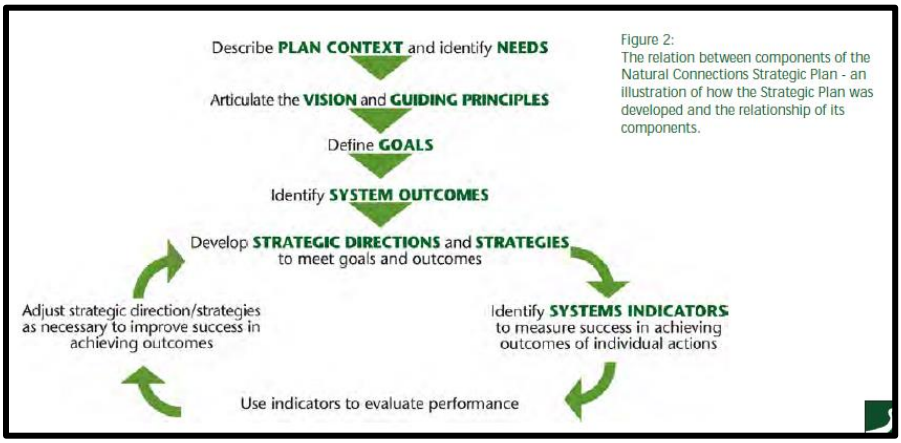


Figure 1 Illustrates the strategic plan and the relationships between its components.

A systems approach focuses on the measurement of outcomes, rather than outputs. It also identifies the output and system indicators (Edmonton, 2007). To ensure longevity of the ecological network, it had been decided to keep the following 4 features when planning and developing:

- Large patches of natural vegetation

- Wide vegetation corridors along major water courses
- Connectivity for the movement of key species
- Heterogeneous bits of nature throughout developed areas

It is also important to understand that such areas are connected to larger, regional or even continental systems increasing the importance to protect (Edmonton, 2007). Throughout the Plan it was noted that conservation should be integrated into all of the city's decision making processes. The systems approach plan intends to secure, manage, and engage with several different outcomes. The plan aims to achieve a variety of goals (Edmonton, 2007). This includes maximizing the protection of natural areas, which includes the restoration of damaged lands. Subsequently, it aims to create a natural heritage network, connecting the variety of natural areas throughout the city. This will be accomplished through effective management, increased knowledge of the natural areas, and partnerships created to conserve these areas (Edmonton, 2007). The strategies that will be used to achieve the aforementioned outcomes are as follows (Edmonton, 2007):

- Expansion of the ecological network through securement and restoration
- Increase the city's capacity for conservation planning
- Increase the capacity for the management of natural areas
- Build a well-connected network of conservation partners
- Support a system of shared conservation education
- Enhance Edmonton's culture of ecological innovation and excellence
- Increase accessibility and integration of information

VI.II Port Hope, Ontario

The Municipality of Port Hope Official Plan of 2009 states 'council shall protect lands classified as Natural Heritage form incompatible development.' The current natural heritage system of Port Hope is composed of fish habitat, valleylands, wetlands, woodlands, and the adjacent linkages that join them together (Ganaraska Region Conservation Authority [GRCA], 2014). Many of these features are not included in the Environmental Protection land use designation maps C and C-1, but are only found in Schedules B and B-1. As a result, a proposal has been made to create a new schedule for maps in the system, delineated Natural Heritage System (GRCA, 2014). A number of recommendations have been made, to amend the current Official Plan Policies:

- Outline the importance of a Natural Heritage System
- Update definitions that Natural Heritage Systems are composed of
- Adjust existing policy to include natural heritage areas that reside outside of the system, that should be protected
- Limit the types and longevity of activities that take place in natural areas
- Protect the natural heritage system areas from infrastructure projects, when possible
- Consider developing policies that allow restoration projects to occur within urban settlement areas

- Ensure that policies recognize natural heritage targets, and take such into consideration when areas undergo land use changes
- Update existing policy language

The Municipality of Port Hope believes that a combined Natural Heritage system is the most robust approach to protecting the valued features. It allows for restoration and enhancement for features naturally linked in the system and those located in the exterior (GRCA, 2014).

VI.III Brampton, Ontario

The City of Brampton, Ontario is made up of natural and built environments that are mutually supportive and overlapping (North-South Environmental & Lura Consulting [NSE & LC], 2015). Unfortunately, alongside rapid urbanization and population growth are many environmental impacts and threats to the City's natural areas. As Brampton is known for its "quality natural, open and built spaces" it is critical to find a balance between natural and built areas to create a complete, healthy and livable community" (NSE & LC, 2015, p.2)

During the initial development of the City of Brampton, many forests and wetlands were clear cut to create agricultural lands (NSE & LC, 2015). Subsequently, these lands were destroyed through urbanization, leaving the natural areas in dire need of care and management (NSE & LC, 2015). Through innovative programs led by a spirited and proud community, the Natural Heritage and Environmental Management Strategy (NHEMS) was developed. It provides an environmental framework to geared towards conservation (Figure 2) (NSE & LC, 2015). The NHEMS is Brampton's "first comprehensive framework to conserve, restore and enhance the ecological services of its natural heritage and open space systems" (NSE & LC, 2015, p. 65). This plan is required to be updated every five years to remain current and relevant. This is a proactive approach, developed to ensure that the natural heritage and built greenspaces found in the city are conserved to support health and diversity. Thus, goals must be integrated across several municipal departments including conservation partners, residents, businesses and stakeholders (NSE & LC, 2015).

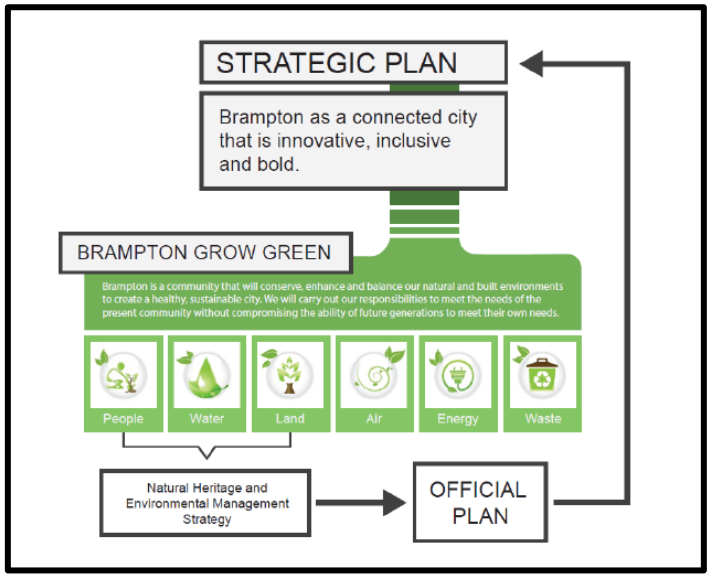


Figure 2 shows the relationship between the NHEMS and the strategic plan of the City.

The NHEMS had two phases. The first phase involved the development of a Natural Heritage System based science approach to conservation (NSE & LC, 2015). This was led by Credit Valley Conservation (CVC) and Toronto Region Conservation Authority (TRCA), alongside city staff and the Ontario Ministry of Natural Resources and Forestry (MNRF). The second phase involved the City of Brampton with North-South Environmental Inc. and Lura Consulting where a background report and action plan were compiled (NSE & LC, 2015). Current plans and policies, and the health status of natural areas and similar features were reviewed to develop best practices. The success of the plan, however, is based upon three key activities and a broader understanding of conservation needs (NSE & LC, 2015):

NHEMS Mission Statement

"Brampton will protect, restore, connect and enhance the health and biodiversity of our natural heritage and urban forest system. We will look for opportunities to integrate natural heritage within open space systems and green infrastructure [areas]. We will develop creative and feasible solutions centered on collaboration, partnership and stewardship that contribute to a healthy, sustainable city."

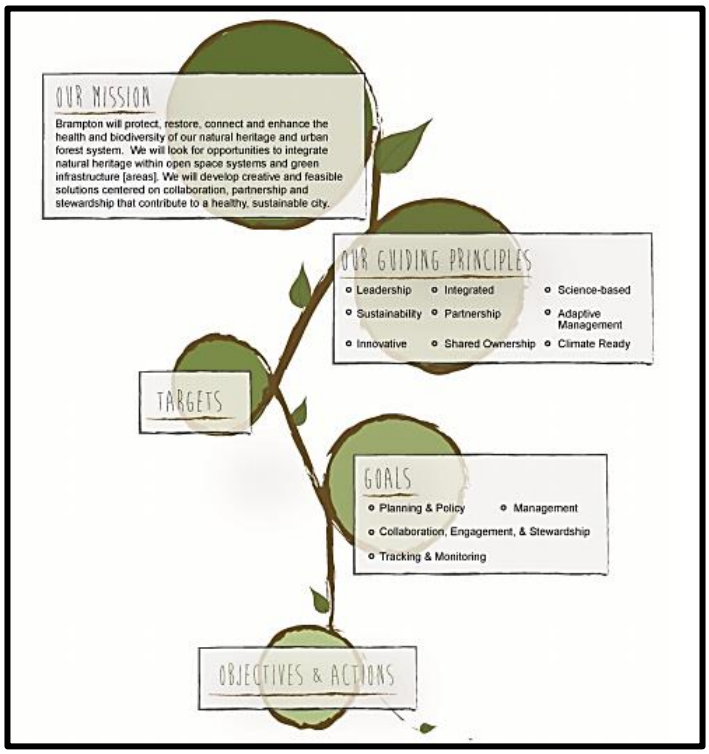


Figure 3 shows the components of the NHEMS framework.

- Education and awareness
- Collaboration and partnerships
- Performance monitoring and reporting

A variety of principles were chosen to help guide the implementation of the NHEMS from leadership to climate ready actions (Figure 3) (NSE & LC, 2015). People, water, and land are the three main targets of the strategy, to reach the four main goals outlined:

1. Establish an effective policy and planning framework for the NHEMS
2. Manage natural heritage, urban forests, open space and green infrastructure to maximize ecosystem services
3. Collaborate, engage and create partnerships with all interested stakeholders in the implementation of NHEMS actions
4. Track and monitor the performance of the NHEMS

Subsequently, dissemination of findings will be communicated using the tools identified by the Brampton Grow Green initiative (NSE & LC, 2015). Results will be relayed through environmental initiatives and an annual 'report card' to council, as well as through the sustainable Brampton report (NSE & LC, 2015).

VI.IV Halton Region, Ontario

The Halton Region includes the cities of Burlington, Oakville, Milton, and Halton Hills (North-South Environmental Consulting Inc [NSEC Inc], 2007). Unlike the previous case studies, the Halton Region of Ontario has taken a different path as it tries to plan for urban expansion, while protecting natural heritage features and functions. Growth targets for 2031 require the exploration of new urban areas and employment lands, with the least minimal impact to the natural heritage features (NSEC Inc, 2009). There were three options proposed to develop a natural heritage systems management plan.

1. Minimum policy standards
2. Systems-based approach
3. Enhanced ecological integrity

Option Three provided much greater assurance that biodiversity and ecological function can be preserved, and thus it was chosen (NSEC Inc, 2007). In order to establish the best management plan, data sets of maps, aerial photographs, and natural heritage information was compiled. The planning vision which has been articulated for Halton identified the need to "maintain Halton as a desirable and identifiable place" for future generations. It also asserts that "certain landforms within Halton must be preserved permanently" (NSEC Inc, 2009, p.2).

In order to have a successful Sustainable Halton Natural Heritage System, a systems-approach to planning has been developed and the following steps in its development are to:

Step 1 – Identify natural heritage features
Step 2 – Identify core areas, centers for biodiversity, and enhancement areas
Step 3 – Identify ecological linkages and buffers

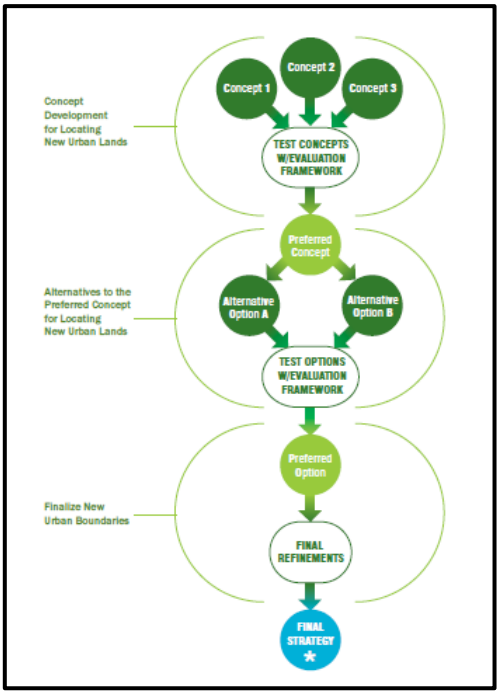


Figure 4 displays the Sustainable Halton approach to develop a comprehensive plan for urban development, outside the urban boundary.

Halton Region Official Plan (ROP) wants to ensure that a comprehensive plan is in place to manage the growth expected to occur (Figure 4). Divided into four phases, the first phase began in 2006, and the fourth phase was completed in 2016. Thus, it is obvious the amount of work, and research that is required to amend public policies to include those on natural heritage systems is quite large. Multiple stakeholder workshops took place, and a draft and final NHS report to determine the next steps of the strategy, and amendments to the Region Official Plan resulted (Dillon Consulting *et. al.*, 2016).

VI.V Common Themes

There are common themes throughout all of these case studies. The mission statements of each municipality discuss the importance of the environment, and the sustainability of their natural heritage systems. Pressure from urbanization is clearly a common factor. The increasing pressure on natural heritage features results from the want to develop. The natural heritage features are recognized to have great importance and all municipalities have, or are, in the process of incorporating natural heritage protection into the official plan. A systems approach has been another commonality throughout all studies. Such considers ecosystems as a whole, allowing them to be secured, managed and allows for community involvement.

VII. Methods

VII.I Digitizing

For the most part, this research was focused upon mapping of the ten natural areas. ArcGIS was used to digitize orthographic imagery of the city of Peterborough in 1996 and 2016. The aerial photographs were obtained from the City of Peterborough's GIS/Mapping Department. Each of the core areas residing within each natural area were outlined, in which a variety of features were identified. For example, the natural heritage site of the Otonabee River System has three core areas and therefore, had three individual maps created for 1996. The same process took place for 2016. Features identified include deciduous and coniferous trees and forests, wetlands, water, and open space/agricultural land.

VII.II Ground Truthing

According to ESRI (n.d.), ground truthing is "the accuracy of remotely sensed data based on data actually measured in the field." In this particular project, ground truthing was used to properly classify a feature (such as a wetland) in a specific area, and to a certain extent, define the boundary. As the digitization of the maps did not provide 100% accuracy, the site visits allowed for confirmation of what the aerial photography revealed. There were 52 UTM points scattered throughout the city that were ground truthed. Each location was visited to determine if the classification given to that particular location through digitization, was correct. If it was not, then the map would be adjusted accordingly.

Ground truthing took place during the month of February, 2017. At this time, photographs of the areas were also taken to be used in the final report. It is important to note, however, that the ground was snow covered, and some areas were inaccessible and viewed from afar.

VII.III Map Analysis

In order to ensure the most accurate size values of the natural areas, the *erase* tool was used to ensure none of the polygon layers overlapped one another. If this was not done, an inaccurate representation of the size of a specific layer would result. A new *field class* was then created as a *text* type. Subsequently, the *field calculator* was used, allowing each polygon of the same feature to become one layer. All of the polygon layers (excluding development) were then

joined using the *merge* tool. This allowed for the difference in total natural area size to be calculated from 1996 to 2016. Subsequently, in order to determine the difference in natural area over the twenty-year period, the total sum of each individual natural area was determined in hectares using the *statistics* tool (Table 1). These values were exported to *Excel* and a *paired sample t-test* (Appendix 1) was used to determine if a significant difference existed.

VI.IV Interviews

Interviews were arranged to take place in late January and February 2017. The interviewees were categorized into one of three groups: **(a)** member of the original steering committee, **(b)** a professional familiar with the natural areas, and **(c)** an employee of an organization who works with one or more of the natural areas (ie. Otonabee River Conservation Authority (ORCA)). Unfortunately, due to time constraints, only two professionals were actually interviewed for the project. As a result, the interviews will not be included in this report. However, it is important to note that the primary goal of the interviews was to identify commonalities among the responses from the interviewees to develop a succinct reasoning to if and why a management position needs to be developed; and what areas are the most critical to manage.

VIII. Results

The main results are displayed in 10 individual maps (Appendix 1 & 2) in 1996 and 2016 depicting the changes that have occurred over the last twenty years. Shown in the results section is an overview of the City of Peterborough Natural Areas in 1996 (Figure 6), and 2016 (Figure 7). These maps clearly show the development that has occurred, decreasing the natural area. For a closer look at the changes, please refer to Appendices 1 and 2. Each map has an associated legend, like the one shown in Figure 5. Each of these features are defined as follows:

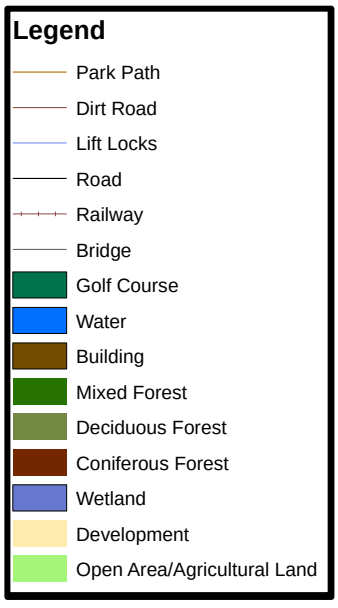


Figure 5 depicts the legend associated with each map.

Park Path – road, paved or dirt, that is within the boundaries of one of the natural areas that can be distinguished from the orthographic imagery.

Dirt Road – surface that is not paved, but still accessible; used for transportation purposes; most dirt roads lead to rural areas; identified through the use of orthographic imagery

Lift Locks – the locks located across the canal, allowing the flow of water.

Road – paved surface, used for transportation throughout Peterborough.

Railway – where the old railroad tracks used to exist, identified through orthographic imagery.

Bridge – roadway that crosses over the canal to get from the west side to the east side of the city, or vice versa.

Golf Course – all areas where the game of golf can be played.

Water – this includes all water systems: lakes, rivers, ponds, streams, creeks, canals, etc.

Building – all major buildings, as identified through orthographic imagery, to delineate development. Houses are not included in this.

Mixed Forest – forest in which both coniferous and deciduous trees grow.

Deciduous Forest – forest in which the majority of trees are deciduous.

Coniferous Forest – forest in which the majority of trees are coniferous.

Wetland – this could be a marsh, swamp, bog, fen, or a shallow open water wetland.

Development – this is classified as subdivisions either already existing or being constructed, as well as major developments. This includes anything with impervious surfaces.

Open Area/Agricultural Land – areas of open fields, or farm fields. Majority are the latter.

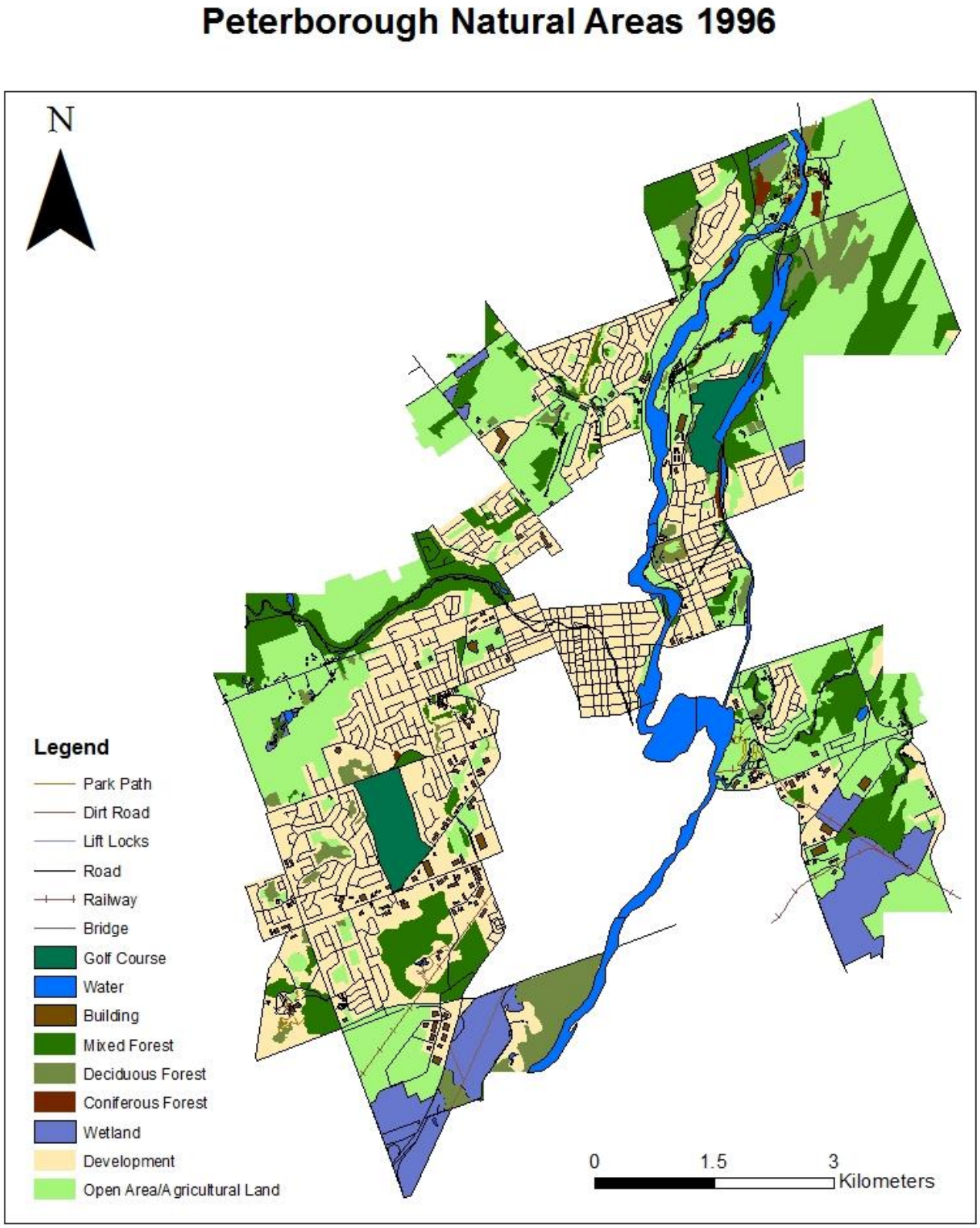


Figure 6 displays the final map of the Peterborough Natural Areas in 1996.

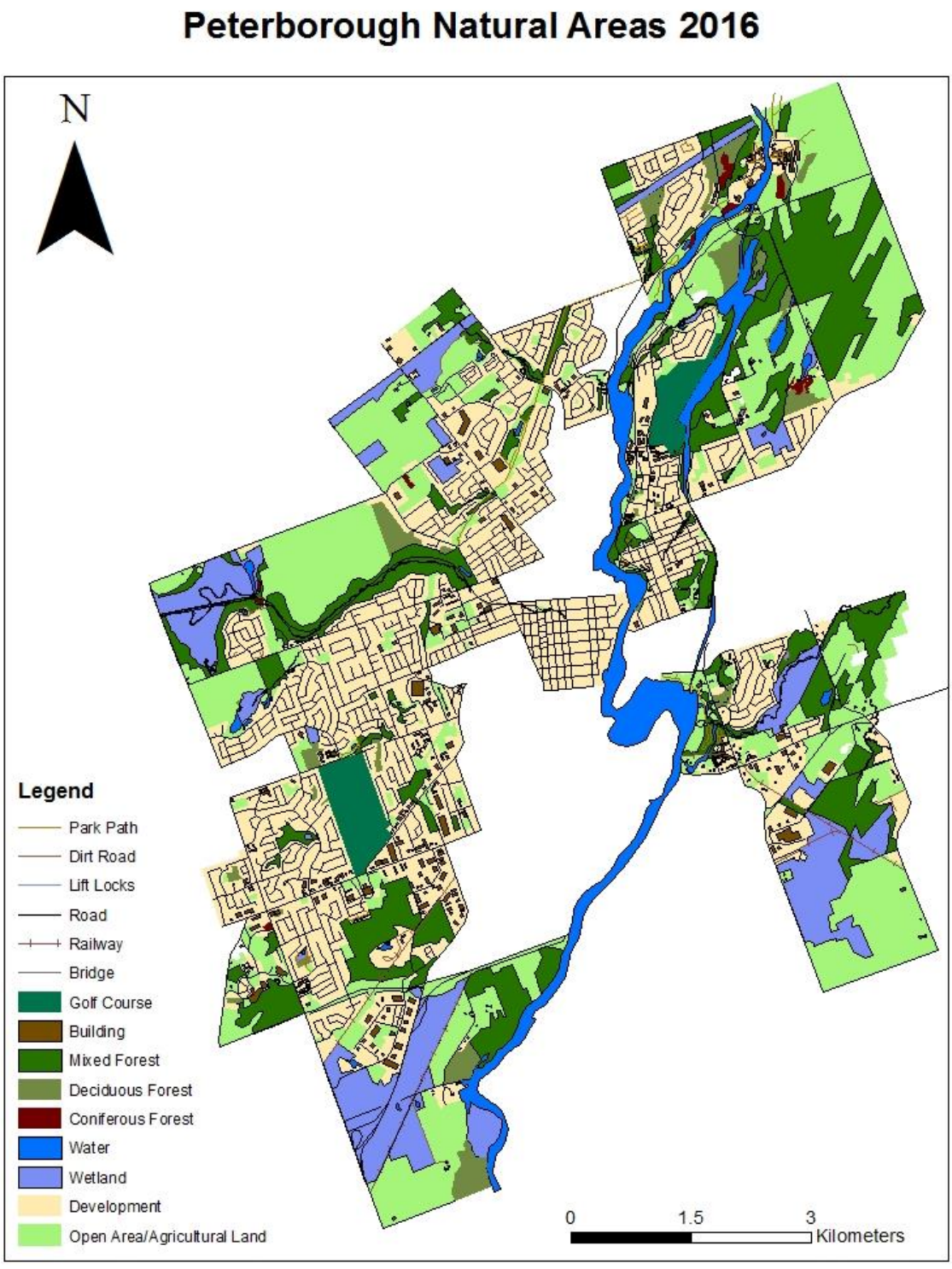


Figure 7 displays the final map of the Peterborough Natural Areas in 2016.

Table 1 Shows the total area of the polygon features in 1996 and 2016, in hectares. Values were calculated using ArcGIS statistics tool.

Feature	1996 Area (ha)	2016 Area (ha)
Wetland	305.64	556.09
Water	299.17	352.32
Mixed Forest	714.91	934.29
Coniferous Forest	19.21	18.21
Deciduous Forest	240.25	145.39
Total Forest	974.37	1097.89
Development	1740.68	2211.67
Open Area/Agricultural Land	1692.73	1559.05

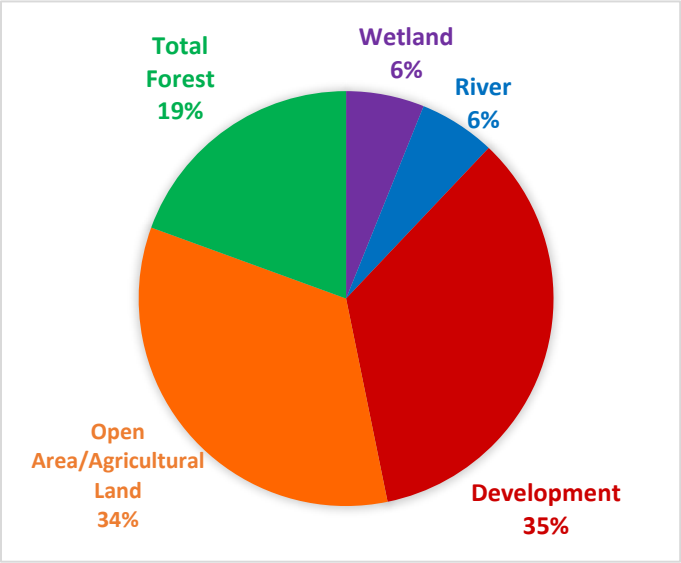


Figure 8 Displays the percentage that each features occupies of the city of Peterborough in 1996.

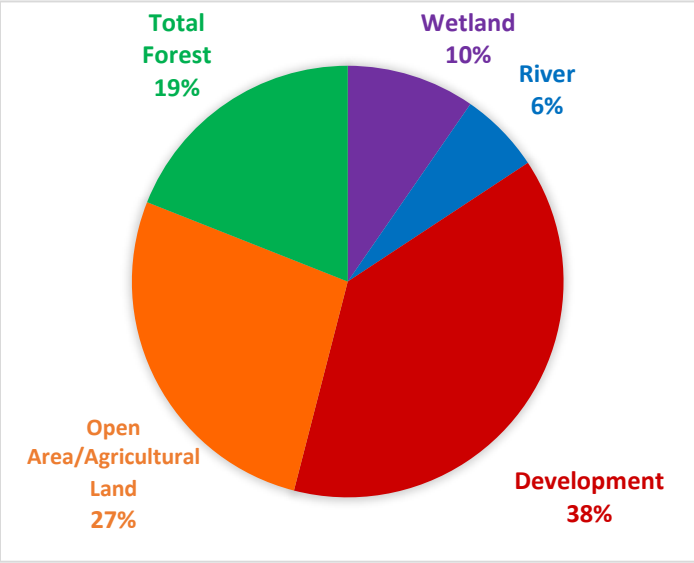


Figure 9 Displays the percentage that each features occupies of the city of Peterborough in 2016.

The map analysis took into account the main polygon features that would best represent the difference in natural area from 1996 to 2016. These features include deciduous, coniferous, and mixed forest (which were summed for simplicity), wetlands, water, open area/agricultural land, and development. Golf courses and buildings were omitted from the comparison. The biggest difference shown is associated with development, as it expanded 470.99 ha since 1996. Agricultural land decreased by 133.68 ha, whereas the total forest increased by 123.52 ha over the twenty year period. A visual representation of the changes in natural area cover can be seen in Figures 8 and 9.

IX. Discussion

The statistical results support the null hypothesis which states that there has been no significant difference in natural heritage features from 1996 to 2016. However, when looking at the maps, it is highly noticeable that there has been increasing urbanization, taking away from the natural areas. For example, when looking at the Jackson Creek System map of 1996, the south-western portion is surrounded by open area. However, when you look to the 2016 map, you can see how the development has encroached upon the creek system, taking away much of the existing green space. Again, if you examine the Trent-Severn Waterway System, to the west the natural area was surrounded by forests and open area in 1996. But in 2016, development has occurred adjacent to the waterway system. These are just two examples to note that depict a decrease in the natural areas since 1996. Although the maps represent such changes, the differences are not large enough to be considered significant.

The entirety of the natural areas as a whole, have not been altered a great amount. The majority of the areas have stayed the same over the last twenty years. As shown in the tables, development has increased, decreasing open areas and agricultural land. However total forest, water, and wetland area has increased. The increase in forest we see, may be due to one of two factors: **(A)** vegetation has flourished since 1996, or **(B)** those areas classified as open area in 1996 may have been replanted, also accounting for the decrease in open space. In fact, overall, there has been an increase in natural area when it is viewed as a whole - rather than individual spaces. This increase, however, is only 294 ha. Development on the other hand, increased almost twice that amount at 470 ha. Thus resulting in a net loss of only 176 ha of natural area over twenty years. Considering the growth throughout the city, Peterborough has been able to develop without much impact to the green spaces.

It has been made clear through the amount of benefits that the natural areas provide, that creating a management position to further protect the natural heritage areas would be great for the city economically, environmentally, financially, and for human health. With increasing urbanization, it is important to be prepared with planning systems to deal with an increasing population as learned from the case studies discussed. It is also important to review City documents in order to gain a better understanding of where natural areas stand, in terms of City management. Thus, a variety of city documents were reviewed.

IX.I City Documents

Many city documents were reviewed to examine the policies in place and responsibility that the city has in regards to the protection and management of the natural heritage areas. As Peterborough continues to grow, proper management of the natural areas should be required so that the city does not lose its defining features. It is thus, of great importance to review, what the city has done – if anything, to manage and protect the natural areas from development. As the results show that there has been a small net loss in the hectares of natural areas, such documents may explain why.

IX.I.I Sustainable Peterborough

Over the course of 18 months, an Integrated Community Sustainability Plan, known commonly as *Sustainable Peterborough,* had been developed (Sustainable Peterborough, 2012). This shared vision was not developed for the City of Peterborough itself, but also for the other eleven communities within the Greater Peterborough Area. As sustainability cannot be pursued in isolation, collaborative action and continued teamwork led to the creation of the sustainability plan for the city (Sustainable Peterborough, 2012).

It is the commitment of Sustainable Peterborough to identify threats to our community, and mitigate them to preserve what has been adored for by the public for years (Sustainable Peterborough, 2012). Peterborough is blessed with natural assets that are under threat due to development pressures, diminishing biodiversity, climate change, and invasive species. The 25 year goal is to "preserve, enhance and restore our natural assets to maintain ecological health." In order to achieve this goal, strategic directions have been outlined, alongside priority actions in the Sustainable Peterborough plan (2012, p.34):

- Adopt the Natural Heritage System practices from Kawarthas Naturally Connected, into the City's official plan
- Identify and help access financial incentives for environmentally sound land stewardship practices
    - Through the design and management of natural systems, maximize the functions which they offer
    - Conserve, manage, and enhance the natural areas so they are unique and diverse
    - Develop an understanding and appreciation of the natural assets, and their importance
    - Maintain and enhance the quality of our air

IX.I.II Vision 2020

Plan It Peterborough was launched to review the official plan, with references to the Planning Act, over a five year period (Plan It Peterborough, 2012). Many workshops and open houses took place, while a number of focus groups and surveys were developed to determine the public's vision for how they would like the city to grow. The majority of Peterborough residents supported the vision to promote environmentally sustainable growth that enhances the City's natural, social and economic environment (Plan It Peterborough, 2012). Thus, in order to achieve this vision, there have been five over-arching and interconnected themes that have resulted from the community meetings:

1. Complete, Healthy Communities
2. Environmental Sustainability

3. Economic Strength
4. Unique and Vibrant Places and Spaces
5. Connectivity and Mobility

Figure 10 displays the *Plan It Peterborough* logo.

These five themes will be used to guide, and influence decision makers in terms of future developments and planning policy (Plan It Peterborough, 2012). Falling under the theme for Environmental Sustainability is the policy to *Protect, Enhance and Expand Natural Areas/Green Spaces,* to maintain ecological health (Plan It Peterborough, 2012). The natural areas are an integral part of the city, adding to the quality of life that exists throughout (Vision 2020). There have been 17 policy directions developed, in the Vision plan, and they are summarized below as (Plan It Peterborough, 2012):

- Adjust policies to ensure protection of natural areas is priority
- Design and manage green spaces to maximize natural system functions. Increase area of already existing green spaces. Ensure green spaces are accessible to passive and active users.
- Conserve natural areas to foster a diversity of species
- Maintain and enhance the quality of the air
- Encourage environmental conservation and stewardship. Integrate Kawarthas Naturally Connected Natural Heritage Strategy into the Official Plan
- Continue to connect green spaces to create an interconnected trail network
- Create and/or update parks according to the needs of the community. An increase in the creation of new parks and sports fields, throughout neighborhoods.
- Provide policy support and protection for endangered species, and sensitive lands
- Review opportunities for the shared use of the natural areas between the city and school boards

IX.I.III The City of Peterborough Official Plan

The Official Plan of the City of Peterborough section 2.4.10.1 states “significant natural features and areas shall be protected for the long term” (The City of Peterborough, 2015, p. 50). Any significant area is protected from development and site alteration. The development of a natural corridor is supported in Section 3.3.1 stating that connecting links can “accommodate surface water drainage, landscaped open space strips, access or recreational trail connections or preserve[d] treed fence lines” (The City of Peterborough, 2015, p. 55). Schedule C shows the natural core areas, corridors, and connecting links throughout the City of Peterborough. The Official Plan outlines six ways which the City can assist in the protection of natural areas.

1. Through zoning and land designation for activities that would not compromise the natural area(s)
2. Development of agreements with landowners to secure land from further developments
3. Co-operation with Conservation Authorities (ORCA) and interested parties, and develop agreement involving voluntary stewardship efforts for the natural areas
4. Acquire (if not already done so) ownership or partial rights to natural areas in order to rehabilitate all, or significant portions of the area
5. Regulate deforestation (small scale – tree removal) from properties through the requirement of a permit
6. Permitting the alteration of sites, on the basis approval has been received for development.

Section 3.3.5 goes on to state that "no adjustment of boundaries or removal of the identification of Natural Areas will be considered by council if the environmental features on the property identified in the Natural Areas Strategy are willfully altered, damaged, or destroyed as determined by council" (The City of Peterborough, 2015, p. 57-58). As such, it is highly apparent that the city supports the protection of the Natural Areas through the Official Plan.

IX.II Limitations

IX.II.I Mapping Expertise

The original maps developed for the Natural Areas Strategy of 1996 were 2-dimensional, using a program besides that of GIS. The City of Peterborough's GIS/Mapping Department was contacted to find the original files. However, they were nonexistent. Subsequently, the MaDGIC Department at Trent University was contacted to find layers, or aerial photographs of Peterborough from 1996 and 2016. The site *eMaps Peterborough* was discovered, and is run by the City of Peterborough's GIS/Mapping Department, in which they were contacted once again to gain the imagery. It was not long before the aerial photographs of Peterborough were made available and were able to be digitized. However, as many different features were outlined such as trees and water systems, not all were able to be accurately mapped. Some features were more of an estimate. For example, it was hard to determine if the trees were coniferous, deciduous or of mixed species.

IX.II.II Time Constraints

There is much potential for this project to be taken further, but with the time allotted it was not possible. For example, the boundaries could have been defined using a GPS with the coordinates inputted into ArcGIS to obtain a more accurate depiction of the boundaries. Not only that, but more areas could have been ground truthed for classification purposes. Sites could also have been visited to inventory the different species that exist at each site. However, as this was not doable as a result of the time allotted to complete this project, another student can continue on the research and take part in one or more of the aforementioned activities.

IX.II.III Obscured Results

The natural areas were outlined as accurately as possible. However, boundaries of specific features such as mixed forest varies from one map to the next. Although it may not have changed, it may have been mapped otherwise, thus obscuring the results. Also, since1996 much vegetation could have flourished, which may be the reasoning as to why total forest cover has increased. Therefore, it is important to note that results should not be taken at face value, and should be further researched to determine a more exact change, and reasoning for such.

IX.III Conclusion

The maps show that there has been a change in natural heritage areas since 1996. However, the changes are not significant enough to support the claim for a natural heritage areas management position. But, it would be in the City's best interest to create one. It is apparent that the natural heritage features are an important part of what makes Peterborough what it is and adds to the quality of life – as noted in the above policies. Natural heritage systems exist in a variety of other cities, where a management position has or is in the process of being created as shown in the case studies. Not only that, but after reviewing many city documents, it is with the best interest of residents of Peterborough to protect and manage these areas – as it is also said in Official Plan. As stated throughout the many City documents examined for this research, such as Vision 2020, it would only make sense to establish and Natural Heritage System coordinator to:

- Ensure future damage does not occur to the natural areas of Peterborough
- Oversee that the steps taken to accomplish preservation, enhancement and restoration are appropriate
- Establish a natural heritage corridor

X. Acknowledgements

I would like to thank Heather Nicol, for her continuous support throughout this project and my entire university career. Kim Zippel and Ian Attridge have also been of great help in determining the scope of the project, and helping identify contacts important for the success of this research. Their support was also unlimited. I would also like to thank Mike McLean, Martin Parker, Mike McMurtry, Don Mcleod, and Bill Crins for their help with multiple portion of the project. Jennifer Bontje and Liam Kennedy-Slaney were also very helpful in regards to mapping advice.

XI. References

Ababneh, A., Darabseh, F.M., & Aloudat, A.S. (2016). The management of natural and cultural heritage: a comparative study from Jordan. *The Historic Environment: Policy & Practice, 7,* 3-24.

Bolund, P., & Hunhammar, S. (1999). Ecosystem services in urban areas. *Ecological Economics, 29,* 293-301.

Capaldi, C.A., Passmore, H-A., Nisbet, E.K., Zelenski, J.M., & Dopko, R.L. (2015). Flourishing in nature: A review of the benefits of connecting with nature and its application as a wellbeing intervention. *International Journal of Wellbeing, 5,* 1-16.

Carter, B., Grimwade, G. (2017). Balancing Use and Preservation in Cultural Heritage Management. *International Journal of Heritage Studies, 3,* 45-53.

Dillon Consulting., Watson & Associates., LURA Consulting., & Curtis Planning. (2016). The Regional Municipality of Halton – Directions Report. PDF. Available from http://webap-.halton.ca/Planning/LPS11016_Attachment01_DirectorsReport.pdf.

Edmonton. (2007). Natural Connections – Strategic Plan 2007. PDF. Available from https://www.edmonton.ca/city_government/documents/PDF/Natural_Connections_-_Strategic_Plan_JUNE_09.pdf.

ESRI. (n.d.). GIS Dictionary. Web. Available from http://support.esri.com/other-resources/gis-dictionary/search/ground%20truth.

Ganaraska Region Conservation Authority. (2014). Municipality of Port Hope Official Plan Review 2014. PDF. Available from www.porthope.ca/file-download/id/ZiUGLQVwr-WW514Xcwprexw.

Kremen, C. (2005). Managing ecosystem services: what do we need to know about their ecology? *Ecology Letters, 8,* 468-479.

Louv, R. (2008). Last Child in the Woods: Saving our Children from nature-Deficit Disorder. Print. New York: Algonquin Books.

MacKerron, G., & Mourato, S. (2013). Happiness is greater in natural environments. *Global Environmental Change,* 1-24.

Maller, C., Townsend, M., Pryor, A., Brown, P., & St Leger, L. (2005). Healthy nature healthy people: 'contact with nature' as an upstream health promotion intervention for populations. *Health Promotion International, 21,* 45-54.

Nisbet, E.K., & Zelenski, J.M. (2011). Underestimating Nearby Nature: Affective Forecasting Errors Obscure the Happy Path to Sustainability. *Psychological Science, 22,* 1101-1106.

North-South Environmental Inc. (2007). Sustainable Halton: Options for A Natural Heritage System in Halton. PDF. Available from www.halton.ca › ... › Sustainable Halton › Technical Reports - Phases One to Four.

North-South Environmental Inc. (2009). Natural Heritage System Definition & Implementation. PDF. Available from https://www.halton.ca/common/pages/UserFile.aspx?fileId=18611.

North-South Environmental & Lura Consulting. (2015). Natural Heritage & Environmental Management Strategy. PDF. Available from https://www.brampton.ca/EN/residents-/Environment/Documents/Brampton%20NHEMS%20Background%20Report%20_FINAL%20(Dec%202015)v2.pdf.

Ontario Ministry of Natural Resources. 2010. Natural Heritage Reference Manual for Natural Heritage Policies of the Provincial Policy Statement, 2005. Second Edition. Print. Toronto: Queen's Printer for Ontario.

Peterborough Steering Committee. (1996). Peterborough Natural Areas Strategy: Final Report – September 1996. PDF. Available from http://peterboroughnature.org/wp-content/-uploads/sites/7/2016/03/Peterborough-NaturalAreaStrategy.pdf.

Plan It Peterborough. (2012). Official Plan Review: Draft Policy Directions Report. PDF. Available from http://www.peterborough.ca/Assets/City+Assets/Planning/Documents/-OP+Review+Draft+Policy+Directions+Report.pdf.

Ryan, R.M., Weinstein, N., Bernstein, J., Brown, K.W., Mistretta, L., & Gagne, M. (2010). Vitalizing effects of being outdoors and in nature. *Journal of Environmental Psychology, 30,* 159-168.

Scottish Natural Heritage. 2015. Natural Benefits: The contribution of the natural environment to Community Planning Partnership priorities. PDF. Available from http://www.snh.org.uk-/pdfs/publications/heritagemanagement/natural%20benefits.pdf.

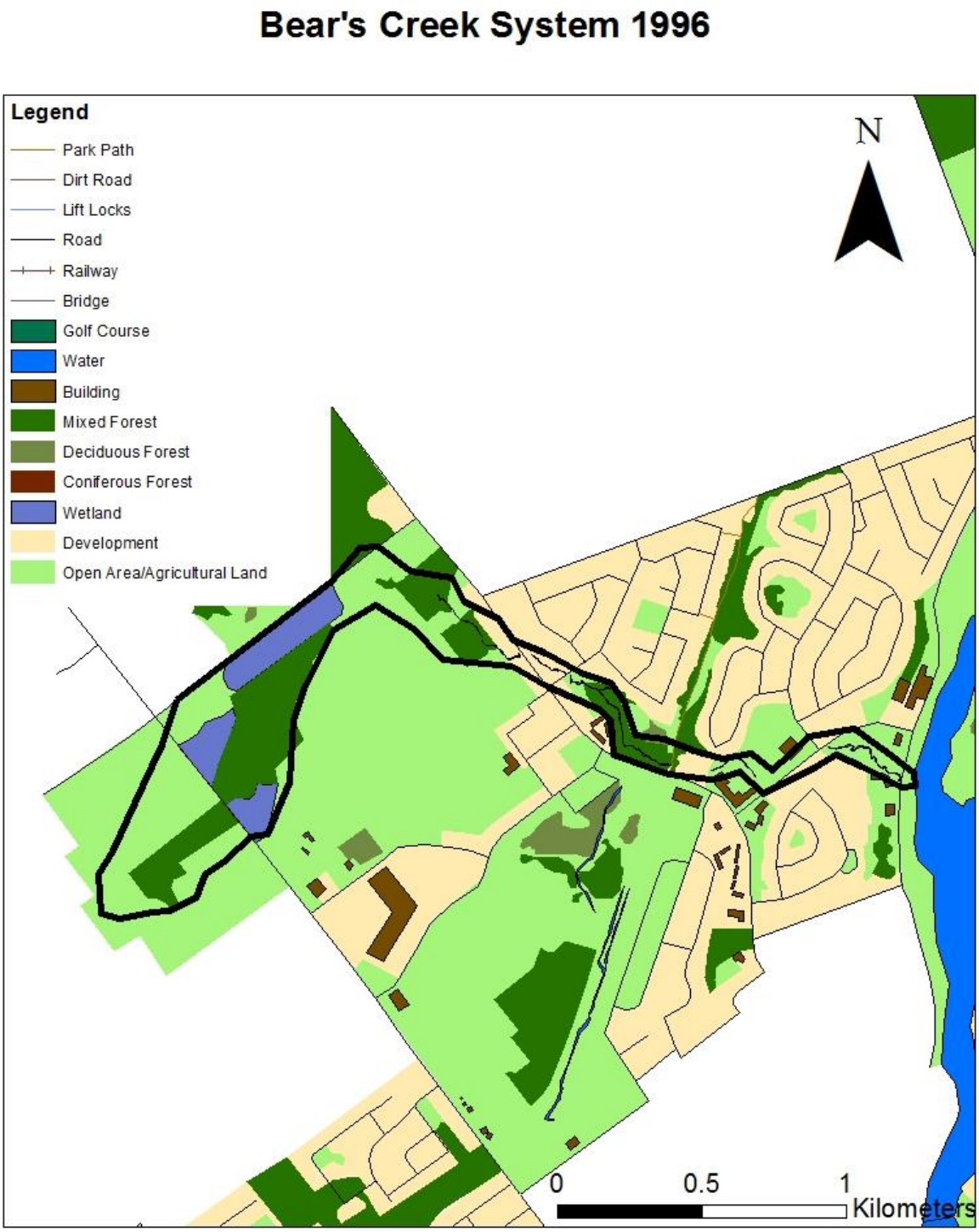
Sustainable Peterborough. (2012). Greater Peterborough Area Community Sustainability Plan. PDF. Available from http://sustainablepeterborough.ca/wp-content/uploads/2015/01/-SP_Plan_Final_Plan.pdf.

The City of Peterborough. (2015). The Official Plan of the City of Peterborough. PDF. Available from http://www.peterborough.ca/Assets/City+Assets/Planning/Documents/Official+Plan.pdf?method=1.

Wise, J., Wynia, M., & Bell, A. (2014). Best Practices Guide to Natural Heritage Systems Planning. PDF. Available from https://www.ontarionature.org/discover/resources/-PDFs/reports/nhs-guide-web.pdf.

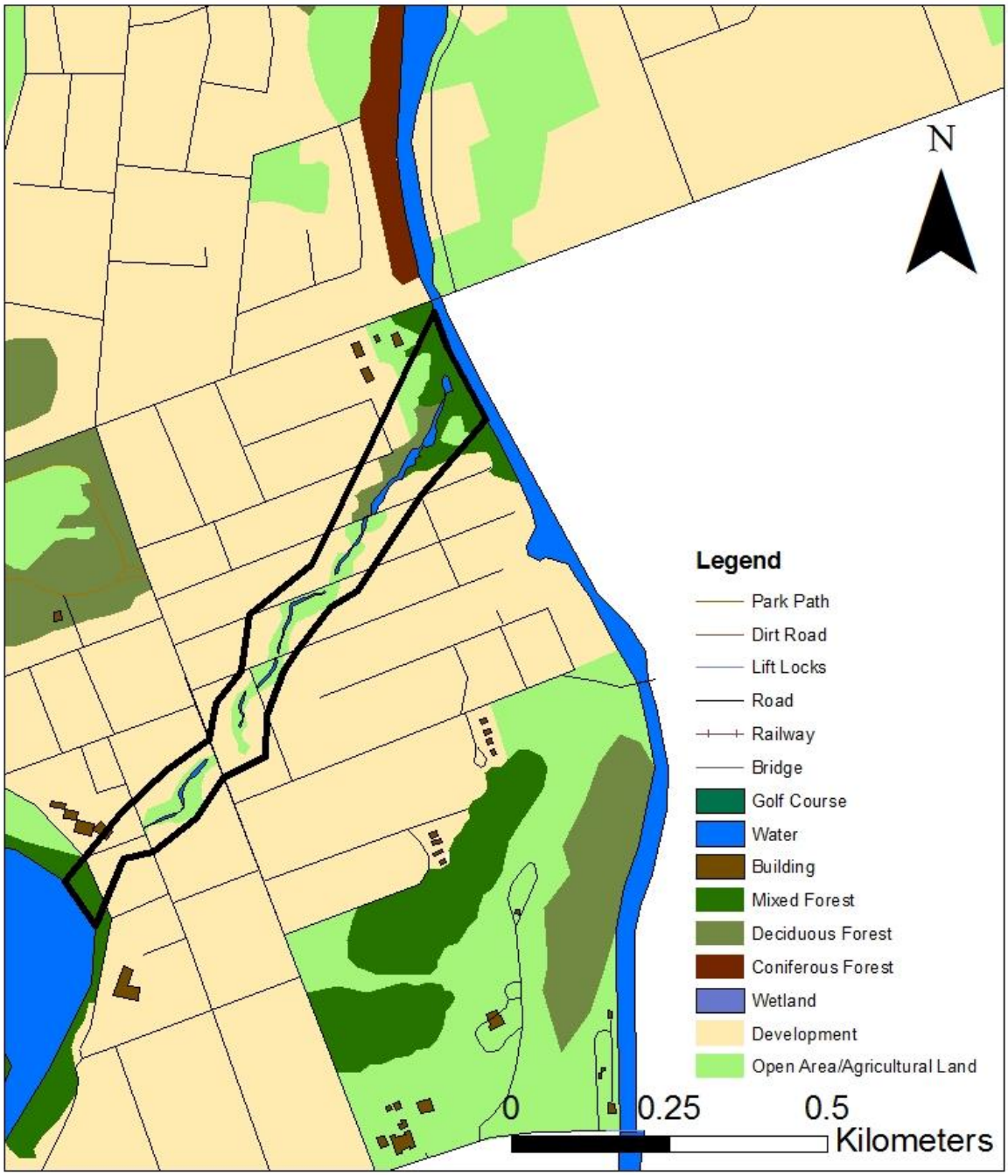
Appendix

Appendix 1 - Maps 1996

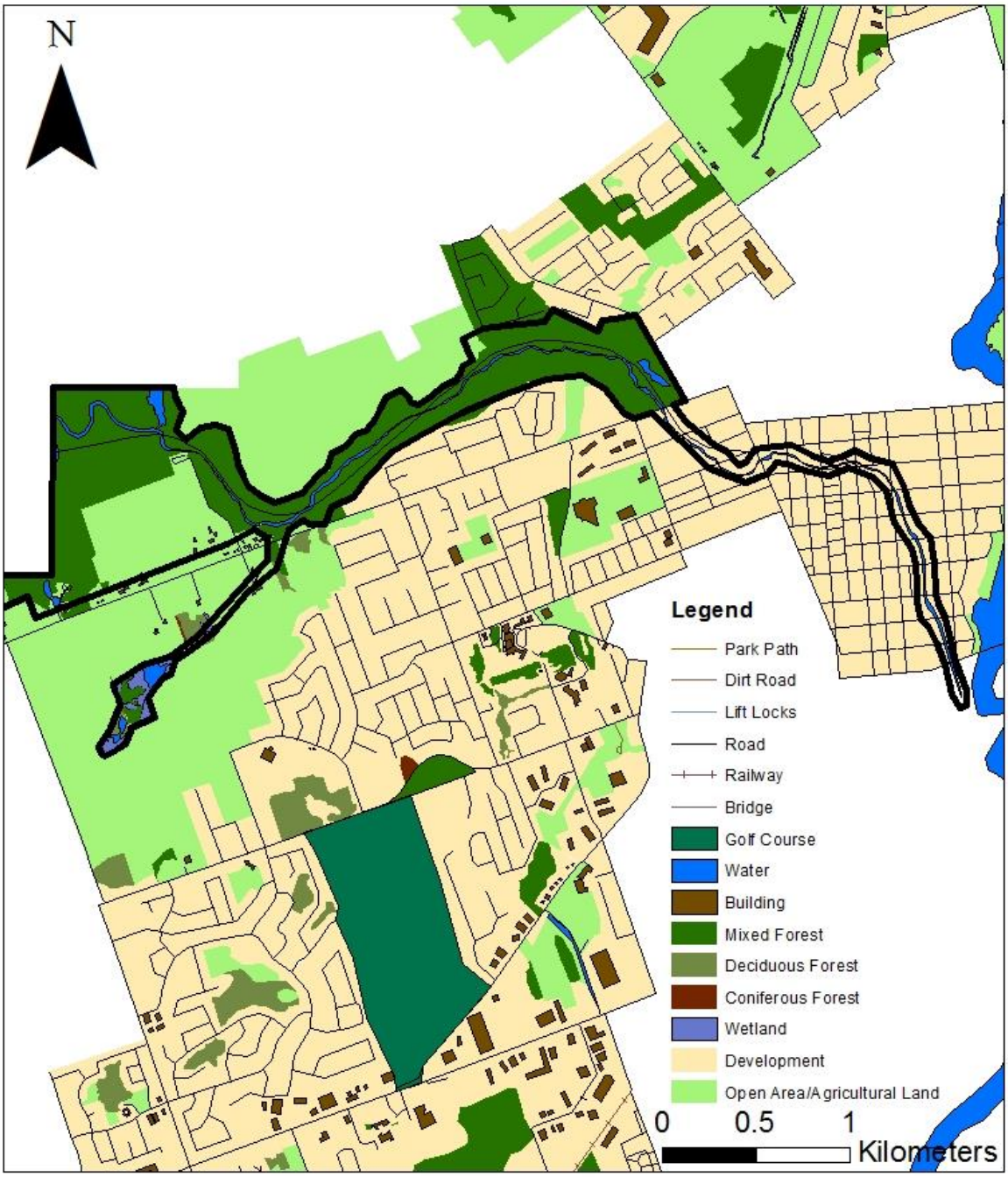


Byserville Creek System 1996

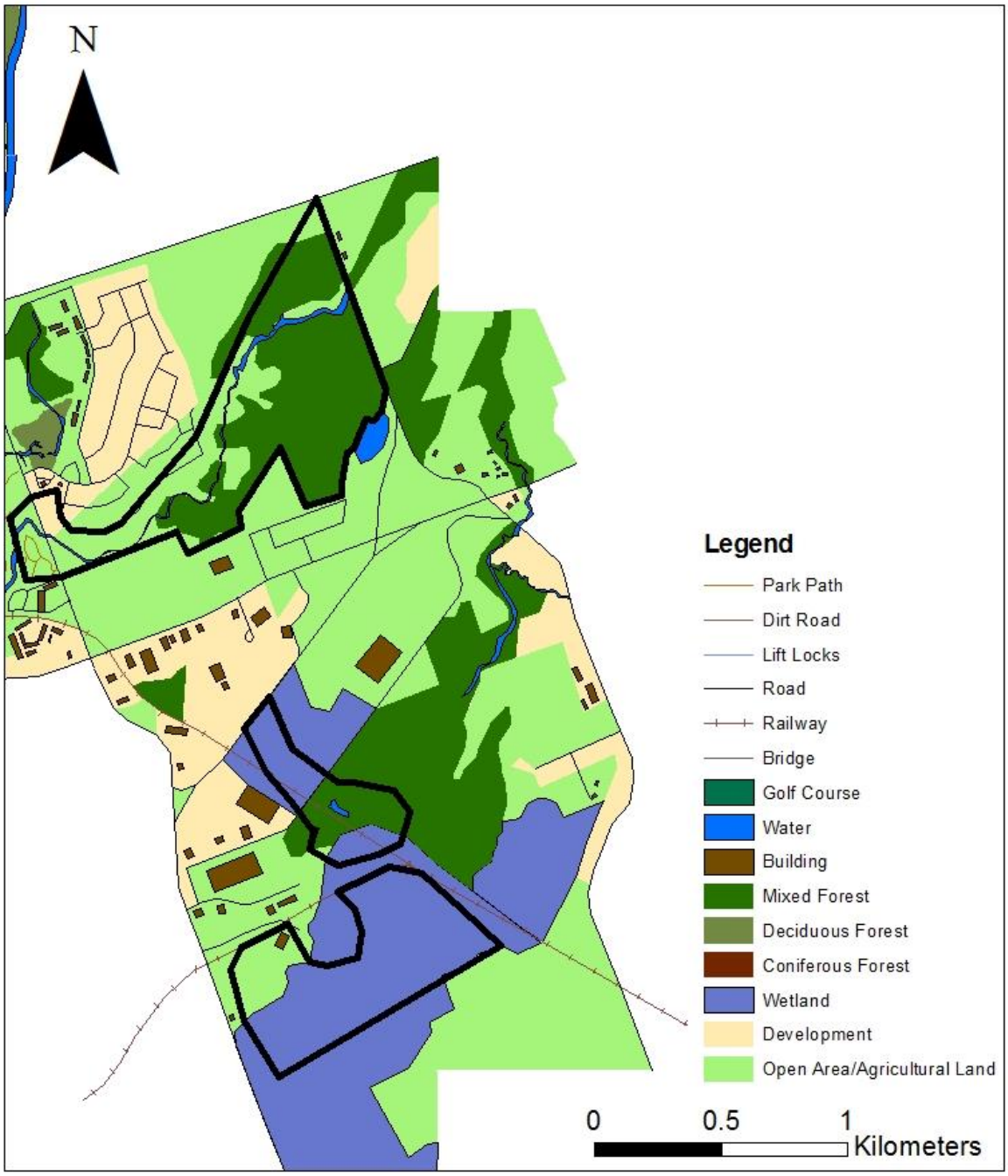
Curtis Creek System 1996



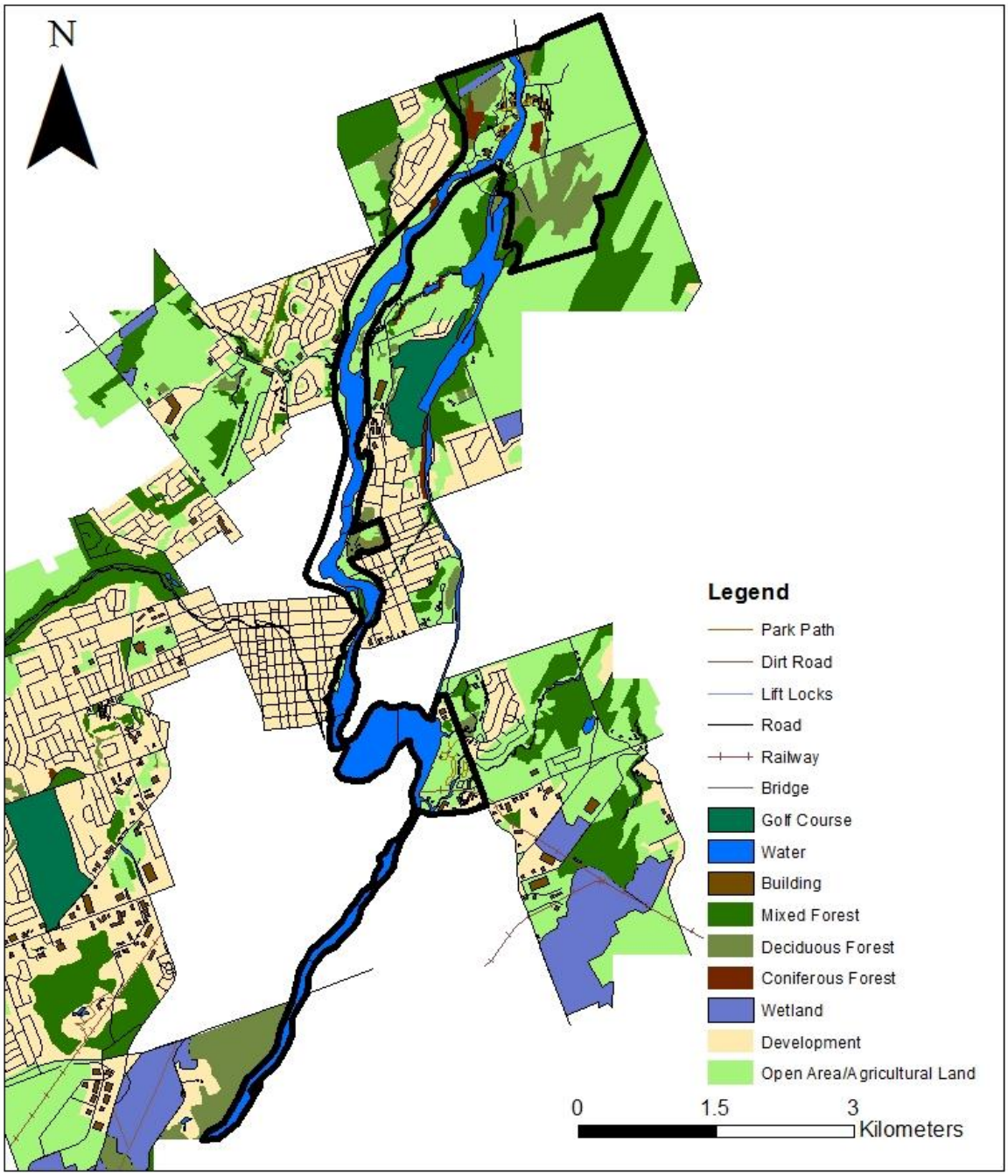
Jackson Creek System 1996



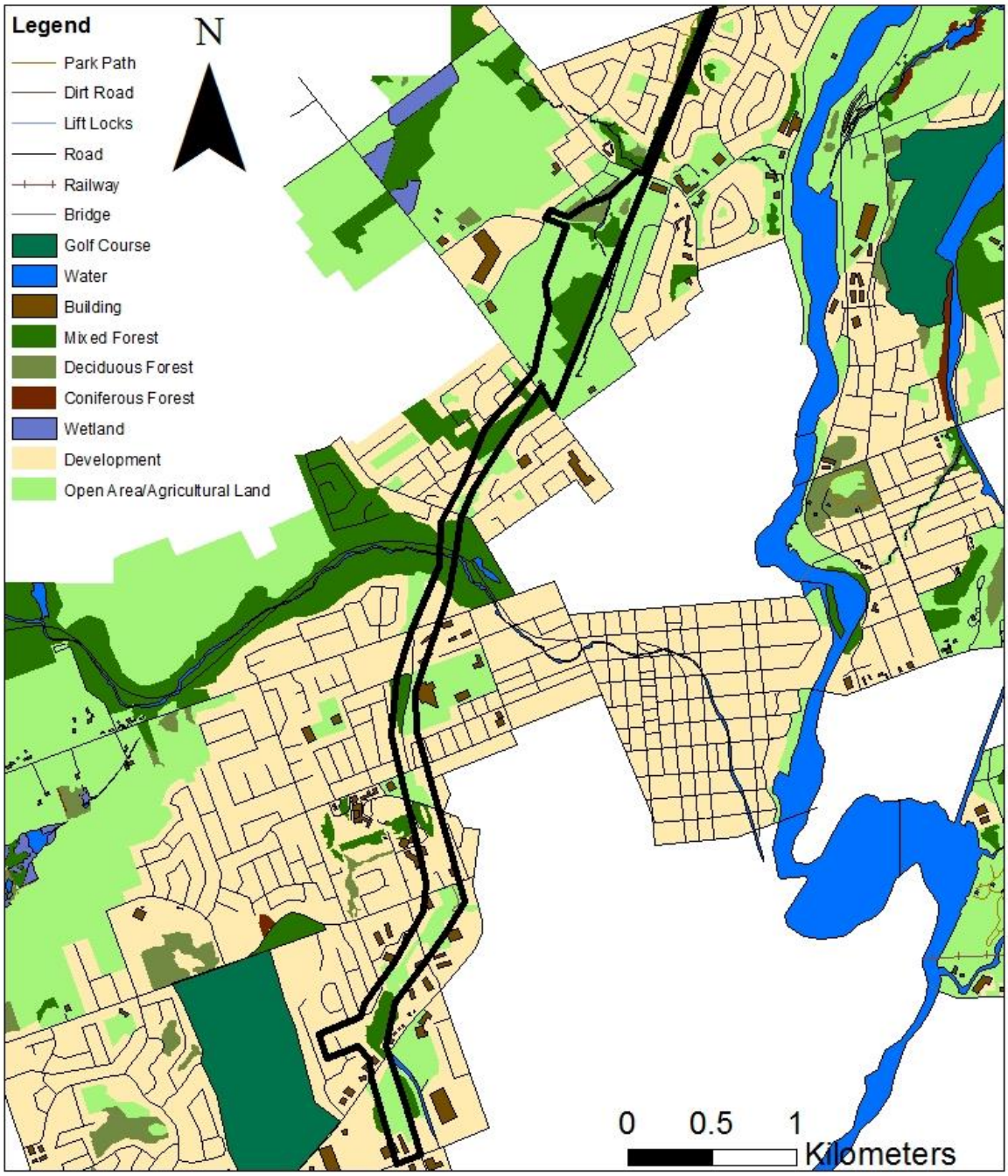
Meade Creek System 1996



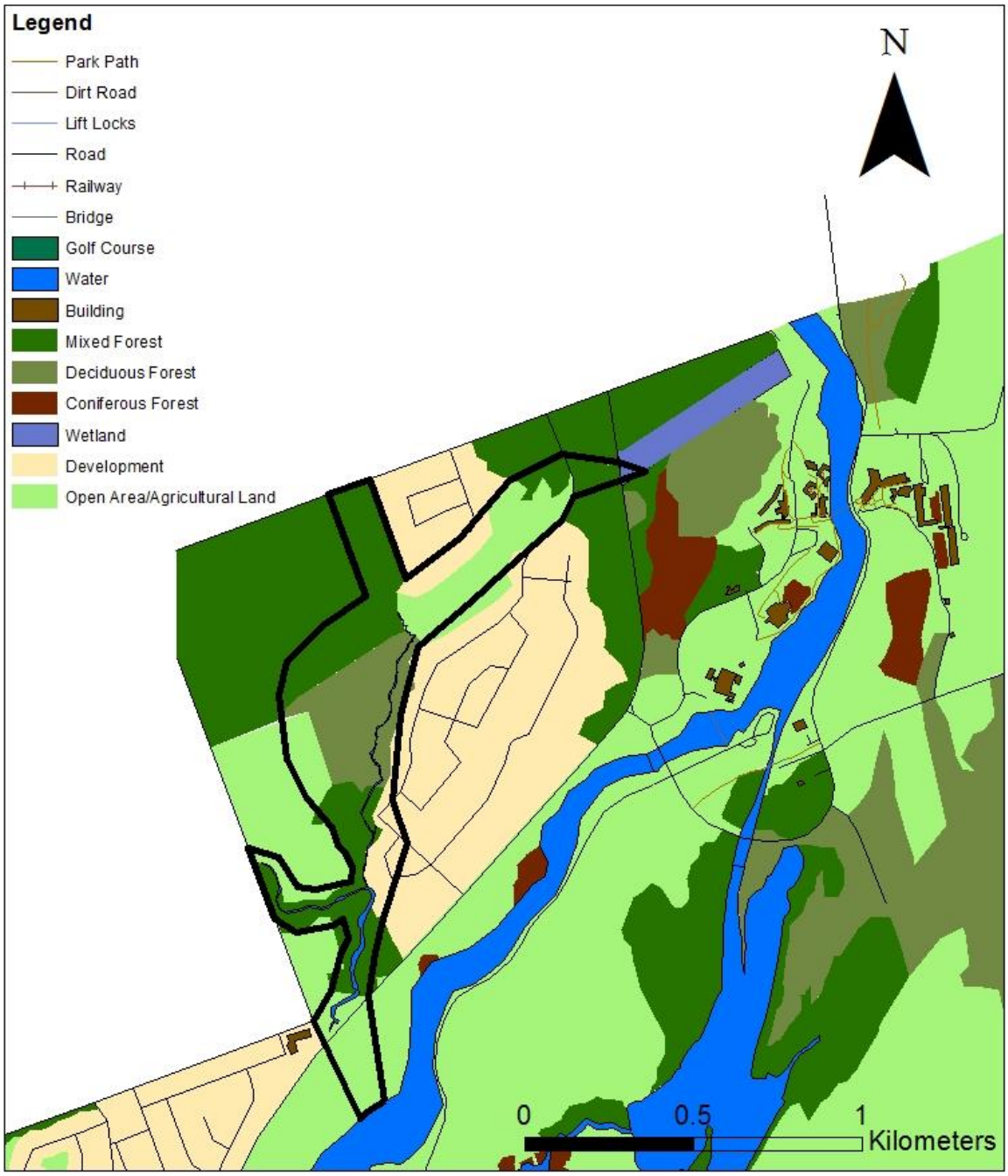
Otonabee River System 1996



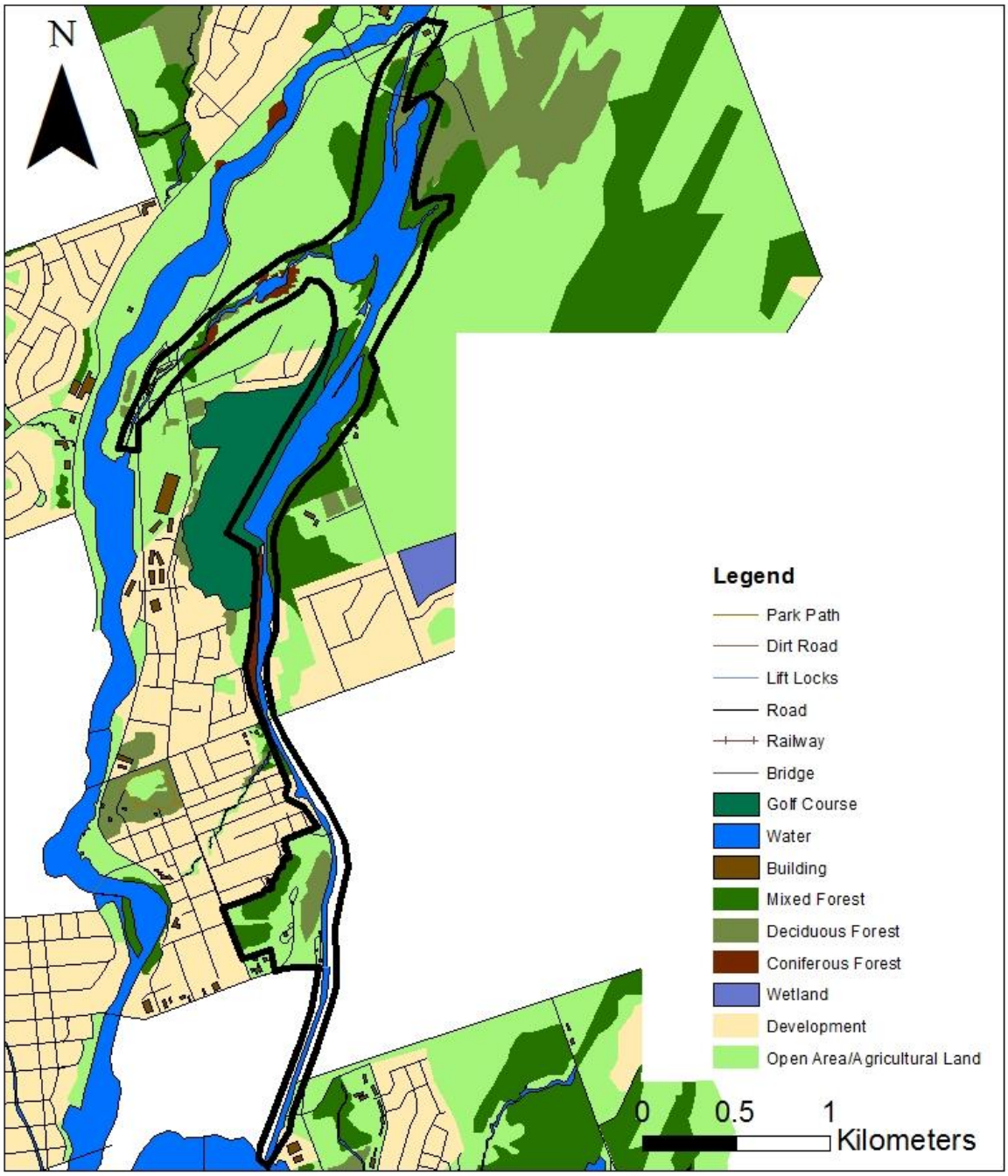
Parkway Belt System 1996



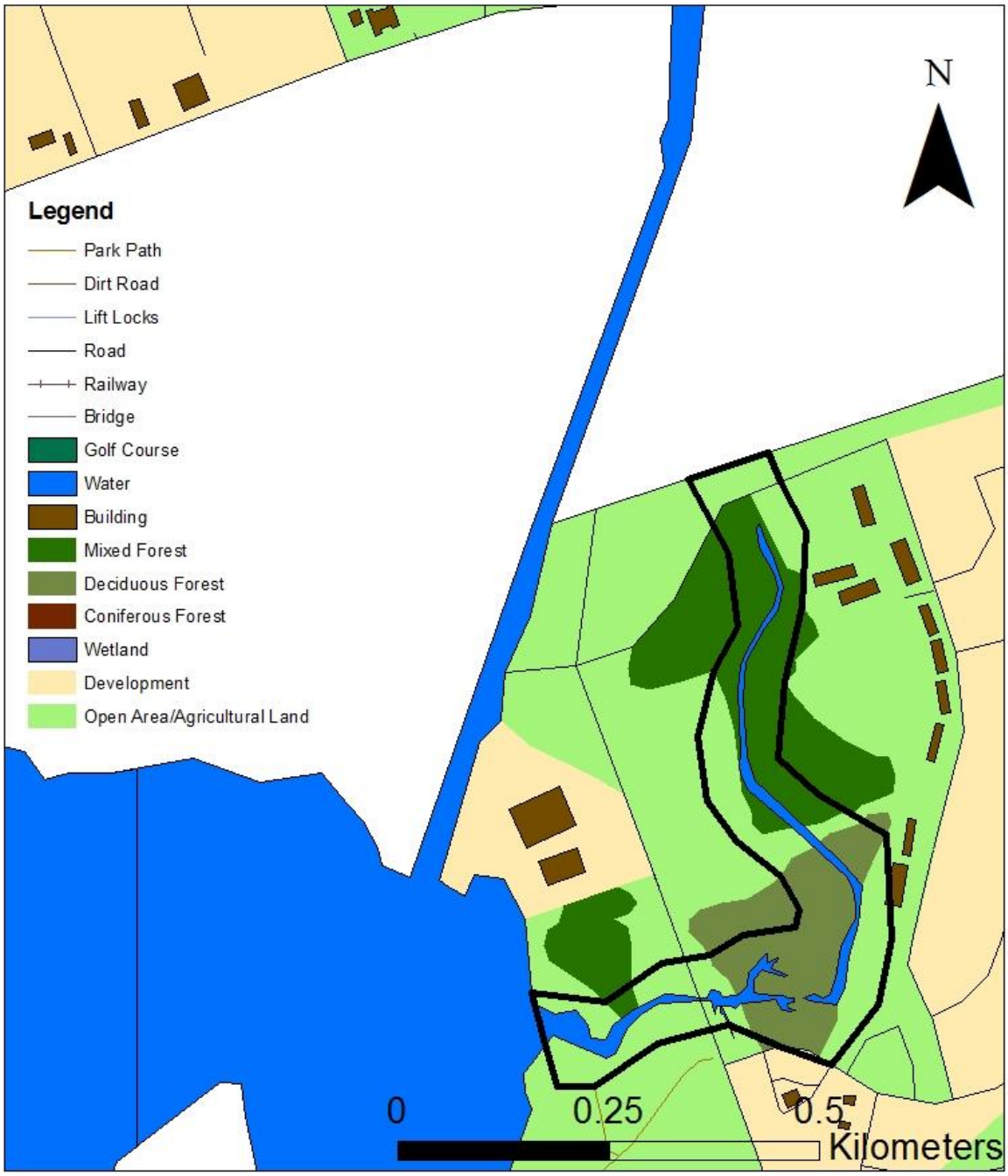
Riverview Creek System 1996



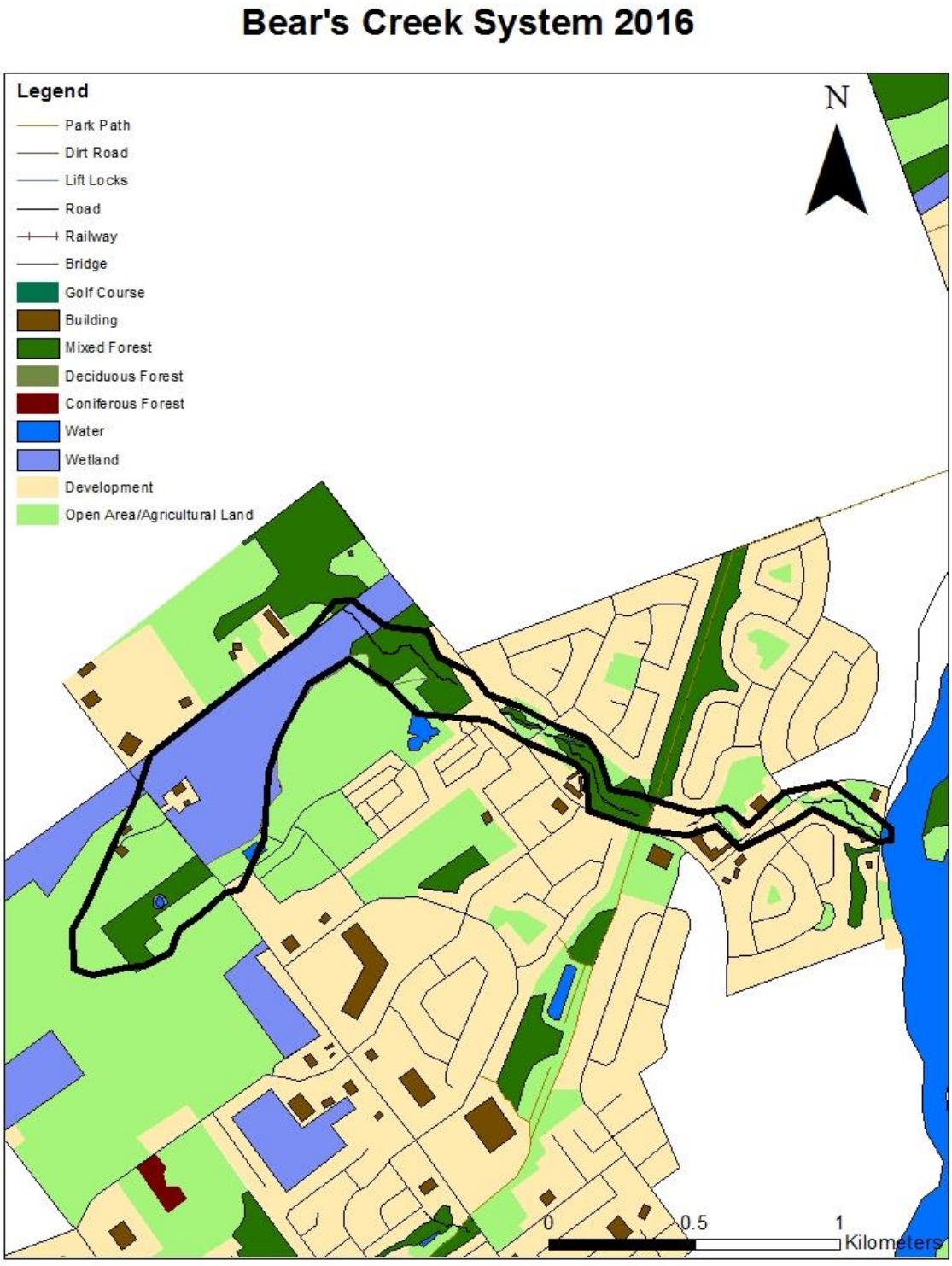
Trent-Severn Waterway System 1996



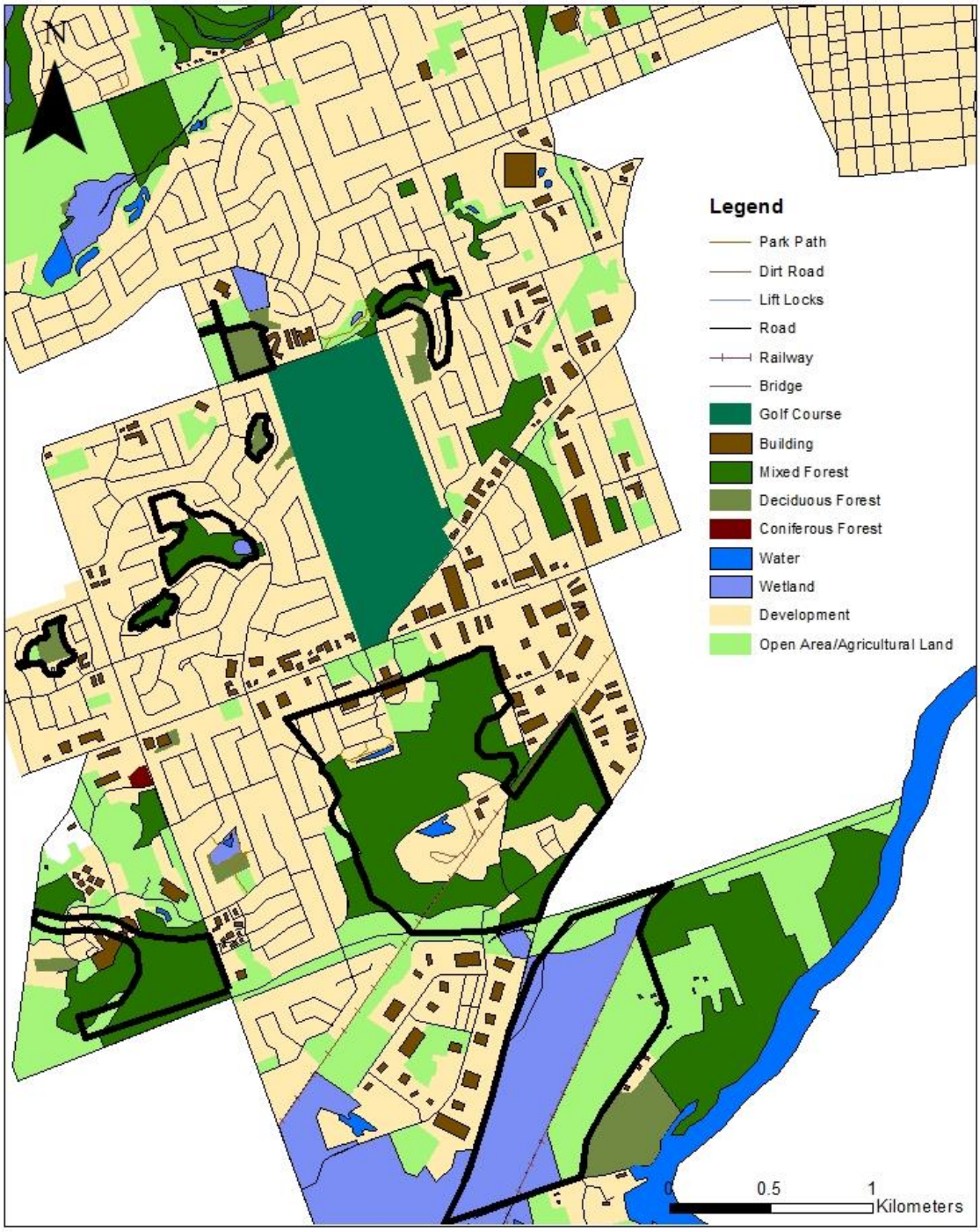
Whitlaw Creek System 1996



Appendix 2 – Maps 2016



Byserville Creek System 2016



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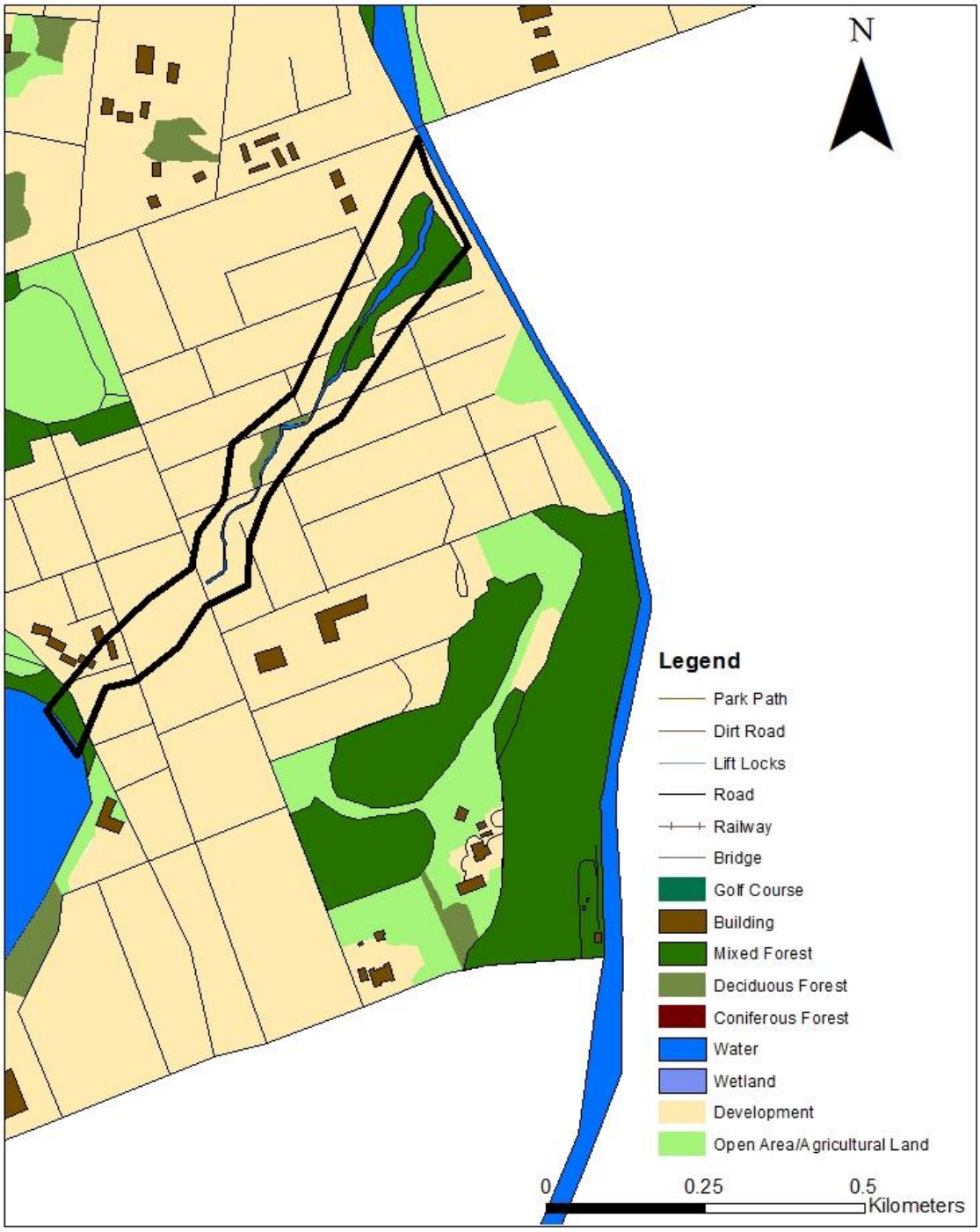
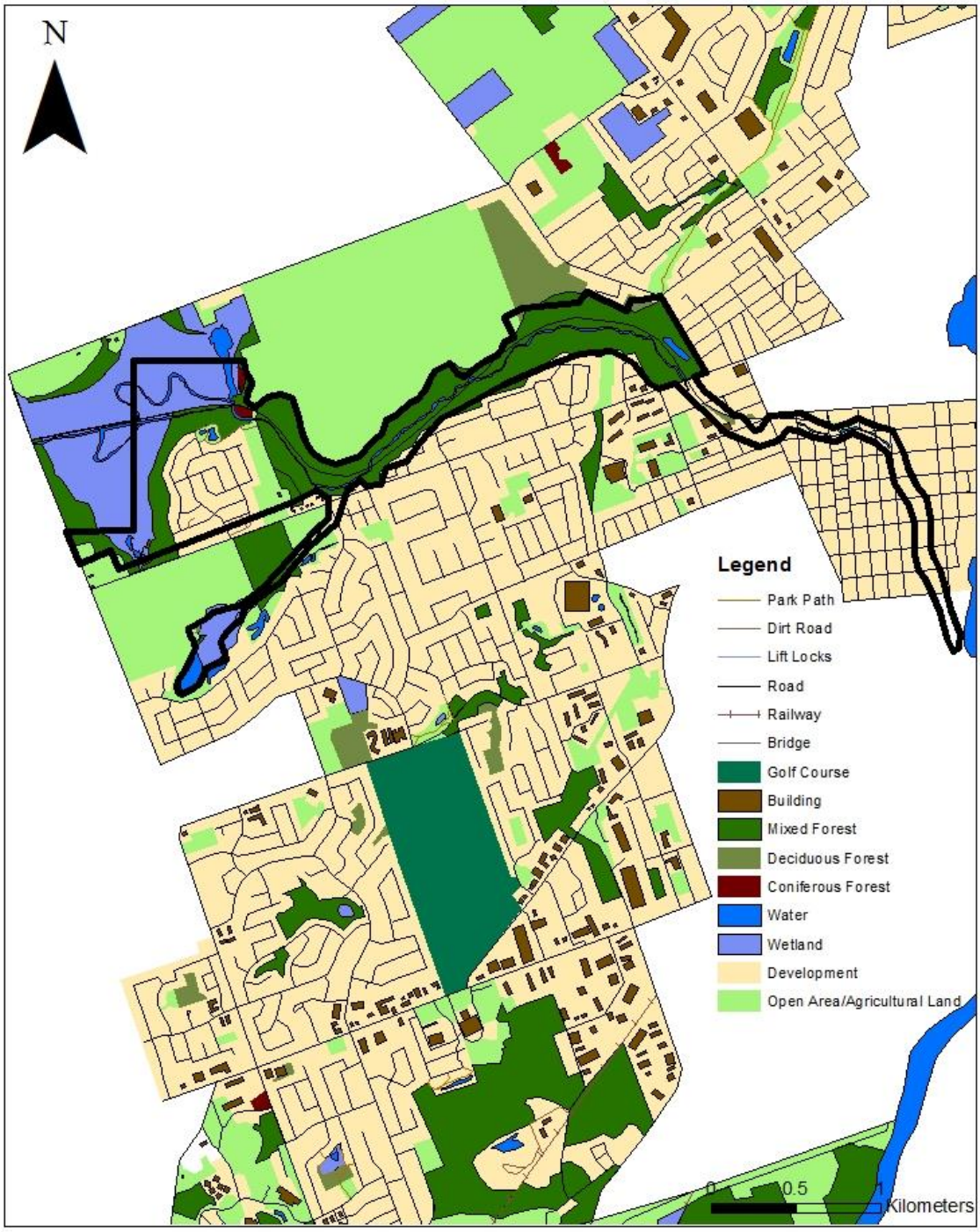
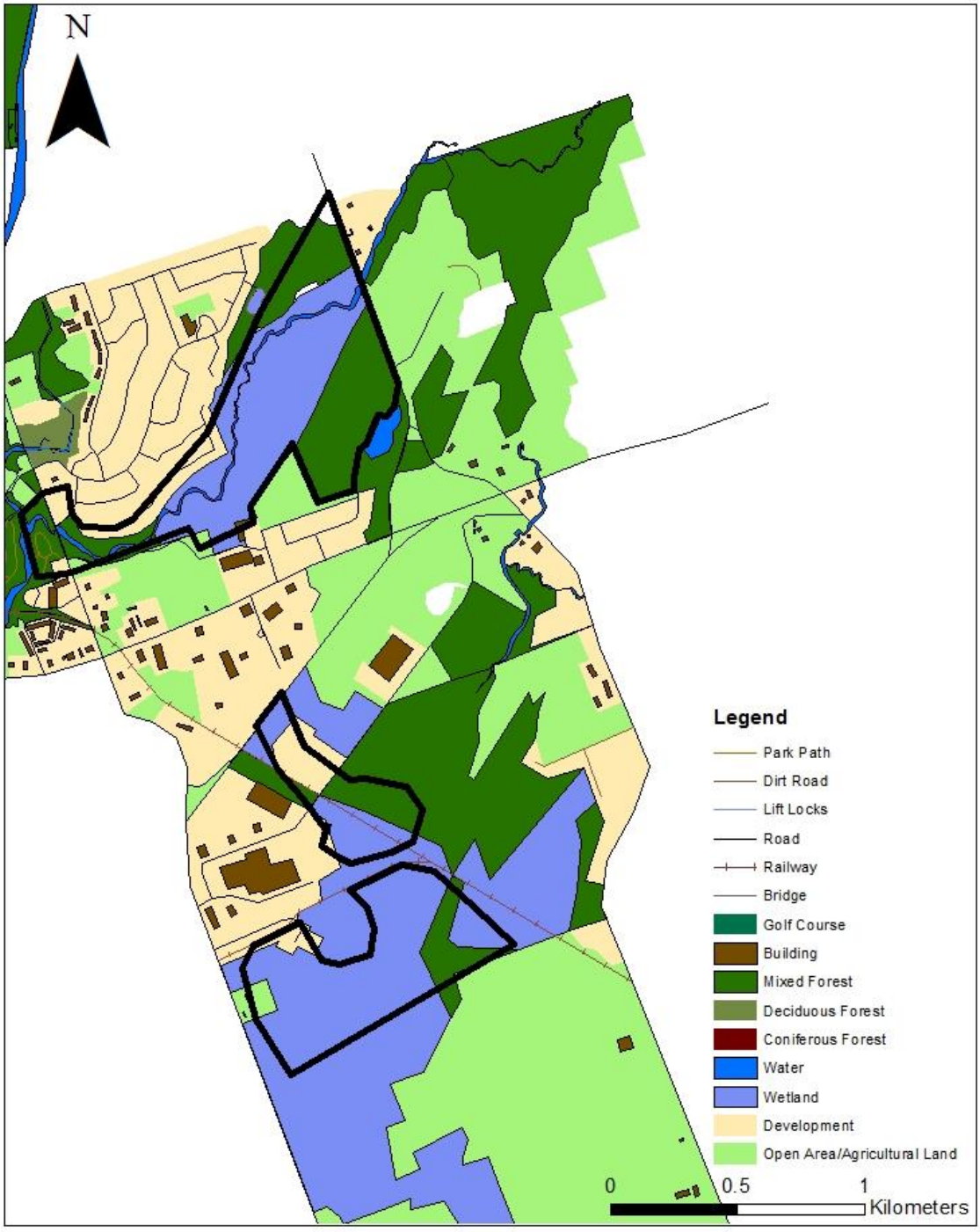


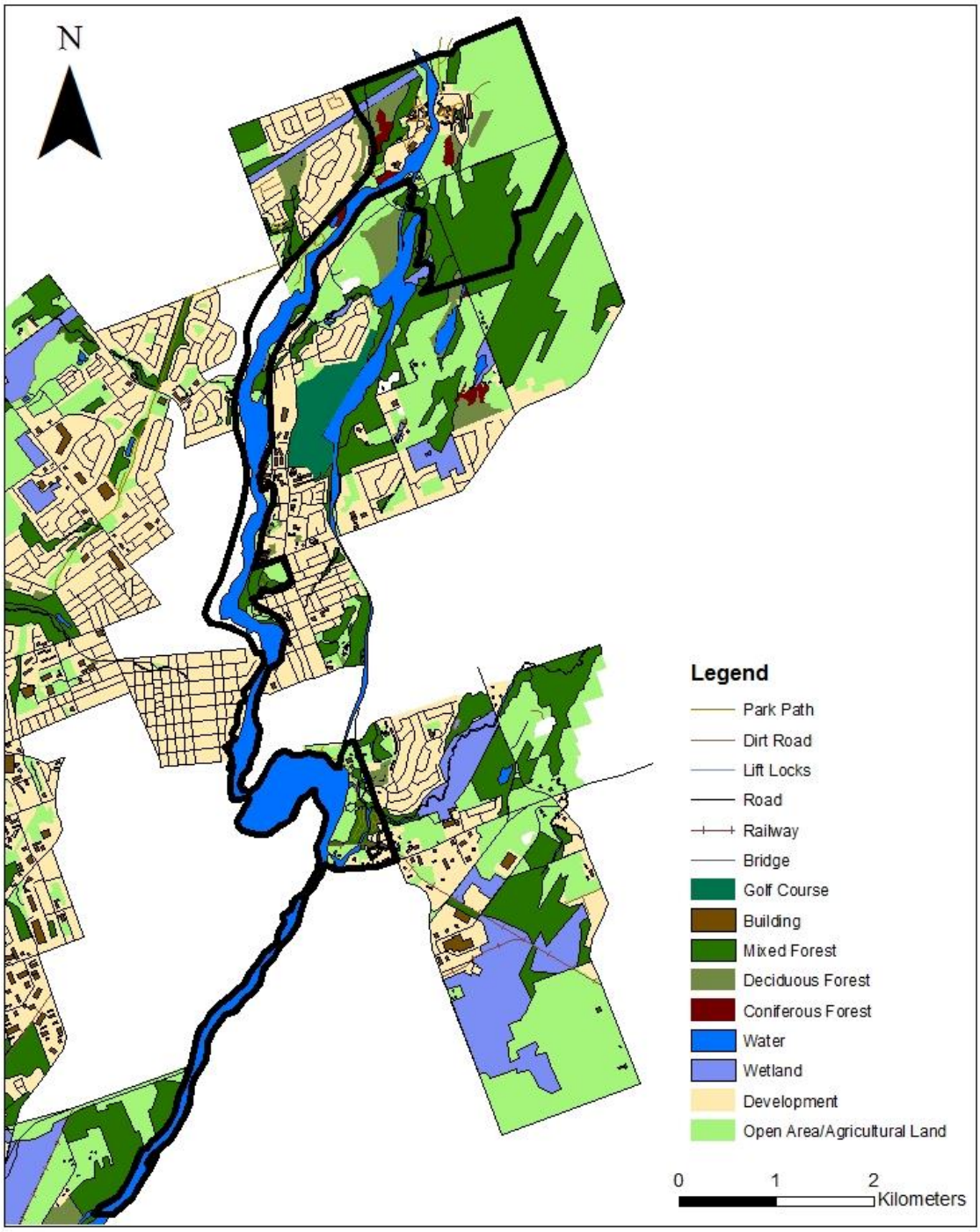
Jackson Creek System 2016



Meade Creek System 2016

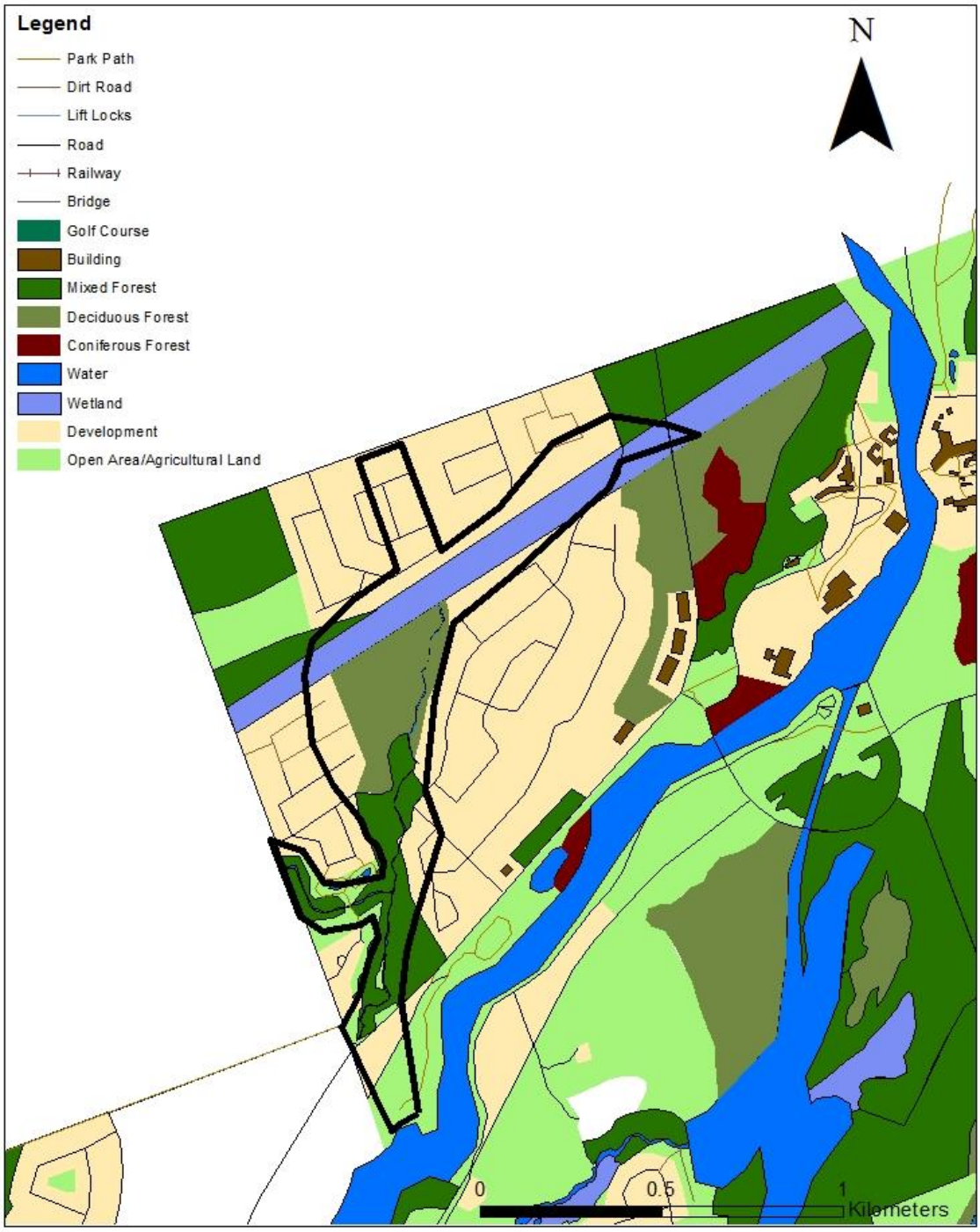


Otonabee River System 2016

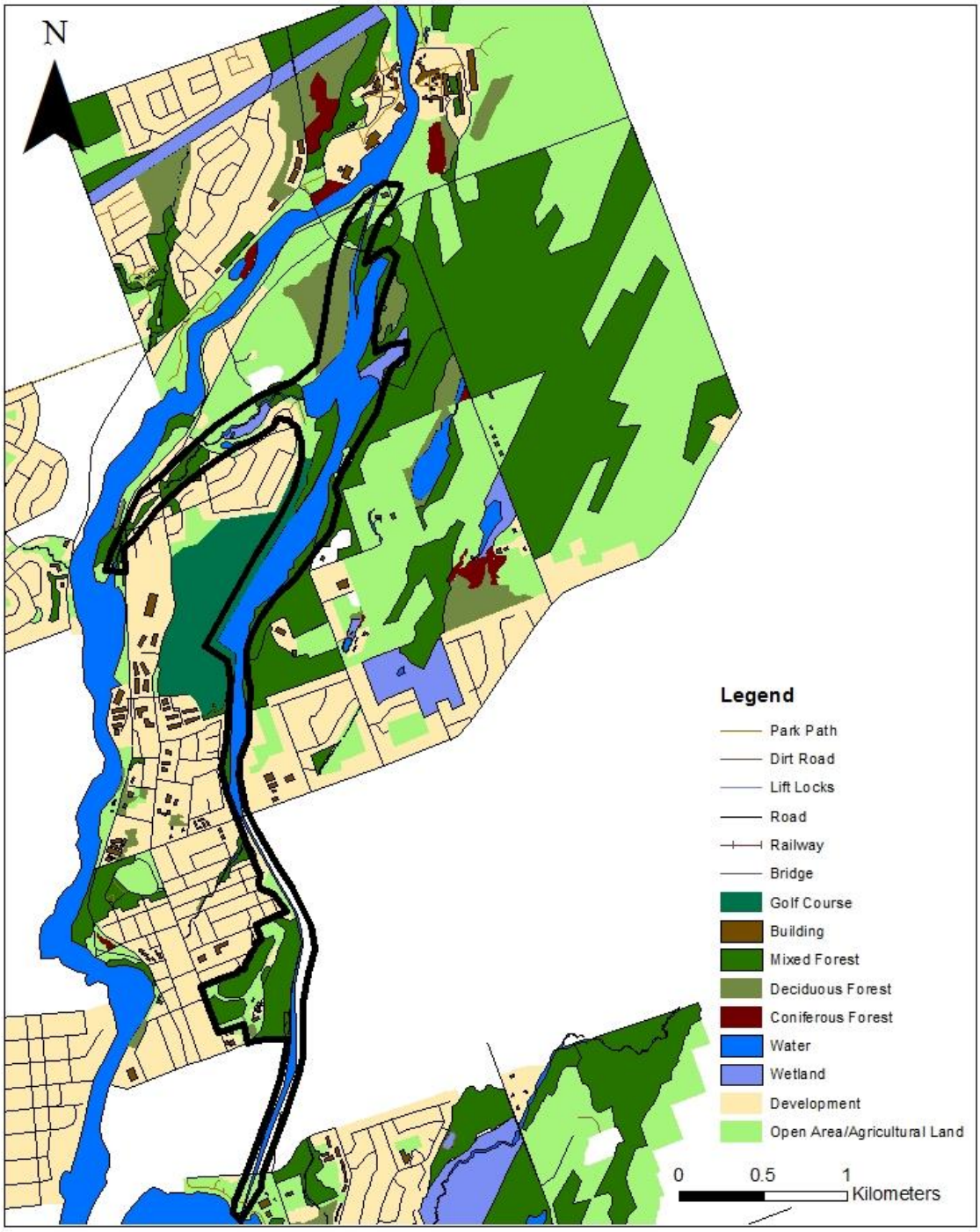


Parkway Belt System 2016

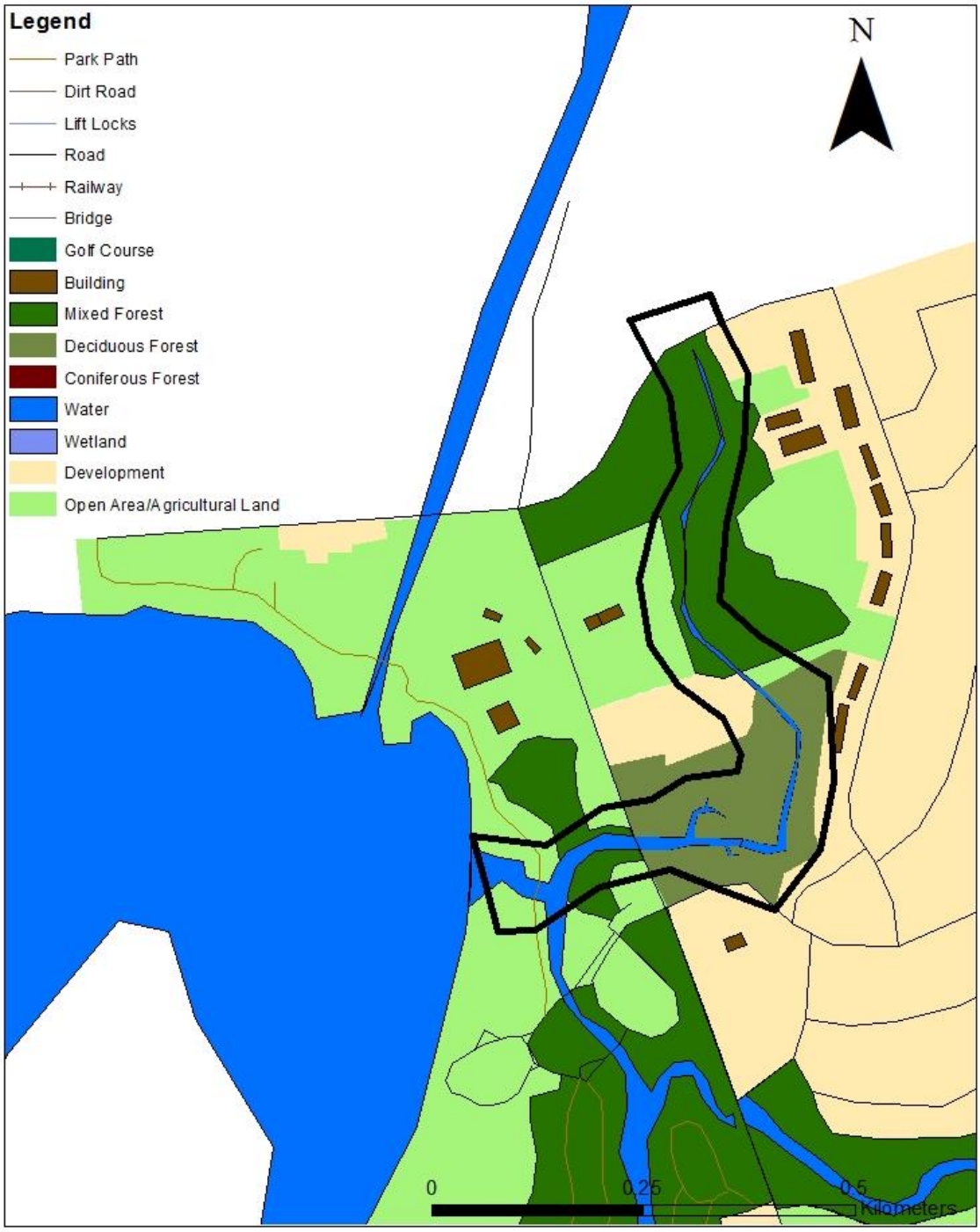
Riverview Creek System 2016



Trent-Severn Waterway System 2016



Whitlaw Creek System 2016



Appendix 3 – t-Test Results

It is important to note, that the mean is not accurate as multiple polygons could have been used to create a single layer. This would result in several measurements for a single area.

	Variable 1	*Variable 2*
~~Mean~~	~~577.8834444~~	~~666.536~~
~~Variance~~	~~457694.3872~~	~~584579.2317~~
Observations	9	9
Pearson Correlation	0.972138297	
Hypothesized Mean Difference	0	
df	8	
t Stat	-1.390643888	
P(T<=t) one-tail	0.100897299	
t Critical one-tail	1.859548038	
P(T<=t) two-tail	0.201794598	
t Critical two-tail	2.306004135	