Municipality of Clarington

Robinson Creek & Tooley Creek – Watershed Plan Existing Conditions Report

Report

Environmental

Municipality of Clarington

Robinson Creek & Tooley Creek – Watershed Plan Existing Conditions Report

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Executive Summary

The Robinson Creek and Tooley Creek - Watershed Plan Existing Conditions Report documents and summarizes the natural environment within the Robinson Creek and Tooley Creek watersheds. The Tooley Creek and Robinson Creek watersheds are located in the Regional Municipality of Durham, entirely within the local Municipality of Clarington, and are under the jurisdiction of CLOCA. They are among the smallest watersheds within the jurisdiction of the Municipality of Clarington, with the Robinson Creek Watershed draining an area of approximately 578 ha and the Tooley Creek Watershed draining an area of approximately 1,040 ha in size.

This report provides an assessment of policy and land use, hydrology and hydraulics, groundwater quality and quantity, aquatic habitat and fisheries, surface water quality and quantity, and terrestrial natural heritage. The existing conditions presented in this document will provide the basis for creating the Robinson Creek and Tooley Creek Watershed Management Plan, which will help to conserve, enhance, and manage these watersheds and their resources for future generations.

The Tooley Creek Watershed originates near the Lake Iroquois Shoreline at Nash Road, and outlets into Lake Ontario through the Tooley Creek Coastal Marsh. The headwaters of Tooley Creek are located within the Provincially Significant Maple Grove Wetland Complex. The northern portion of this watershed rests on the sandy Iroquois Plain Shallow Aquifer, while the remaining portions of the watershed are characterized by silty-sand till deposits of the Newmarket Till Formation. The area covered by the sandy Iroquois Plain Shallow Aquifer, is a significant groundwater recharge area within the watershed. The Robinson Creek Watershed originates to the north of Bloor Street, and outlets into Lake Ontario within the boundaries of Darlington Provincial Park and in the McLaughlin Bay Wetland. The headwaters of Robinson Creek are located in a small wetland area located north of Bloor Street. The majority of the watershed rests on low permeability silty-sand till deposits of the Newmarket Till Formation. Robinson Creek is primarily fed by surface water inputs, but localized areas of groundwater discharge provide important contributions to baseflow.

Both the Robinson Creek and Tooley Creek watersheds have similar fisheries and aquatic habitat characteristics in that they generally support warm/cool water fish communities that are typical of surface water driven streams. Both have some groundwater contribution within their headwaters which are considered critical to the annual flow regimes of the systems. These groundwater contributions create a habitat that can support cold water fish species such as rainbow trout, which were found in small numbers in both creeks. In general, the fish species existing within Robinson Creek and Tooley Creek are generalists in their habitat requirements, are relatively tolerant to environmental change and perturbation, and are widespread in their southern Ontario distribution. Both Robinson Creek and Tooley Creek can be thermally classified as coolwater streams.

Land use throughout the Robinson and Tooley Creek watersheds is dominated by agricultural use, with relatively small proportions of natural and naturalized cover. The most common remnant natural features include shoreline bluffs and beaches, rivermouth marshes, stream valleys and riparian corridors, and isolated upland forests. It was found that 22% of the Robinson Creek Watershed and 19% of the Tooley Creek Watershed have natural or naturalized cover. The forest bird community, as a result, is poorly developed in both the Robinson Creek and Tooley watersheds due to the very small and patchy amount of remaining forest. The most frequently observed bird species are those that are common in southern Ontario typical of edges, shrub habitats and disturbed areas. Wetlands and amphibian breeding habitat in both watersheds have also been impacted by human disturbance.

Both the Robinson Creek Watershed and the Tooley Creek Watershed are under development pressure and there is a need to protect the aquatic, terrestrial and groundwater features within the watersheds. Based upon the results of the Existing Conditions Report, a final Watershed Management Plan will be prepared, and will identify the final set of management goals, objectives and targets, which will be used to evaluate the acceptability of future land use decisions, future resource use proposals and to track progress in implementation of applicable policies and guidelines.

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1. Introduction

1.1 Background

There is a need to manage and plan for the appropriate use of our natural environment and its resources Throughout the Province of Ontario. As development pressures continue within the province, sustainable management and planning of human settlement is required to ensure that current and future actions do not degrade, alter or destroy the natural environment. Within Robinson Creek and Tooley Creek Watersheds development pressure, requires that a comprehensive understanding of the ecological, hydrologic and hydrogeological features and processes be undertaken at a watershed scale; and a watershed-wide ecosystem approach to watershed management be developed to effectively protect, rehabilitate and enhance natural features in the context of the needs of the community.

Watershed planning provides a broad-based understanding of the inter-related natural heritage and groundwater functions of a watershed, as well as human influences. The result of this planning is the creation of a management plan that provides a solid foundation upon which to make planning decisions while having regard for potential cumulative impacts of change on all components of the ecosystem.

> *A Watershed Management Plan is a document developed co-operatively by government agencies and other stakeholders to manage the water, land/water interactions, aquatic life and aquatic resources within a particular watershed, in order to protect the health of the ecosystem as land uses change. It recommends how water resources are to be protected and enhanced in relation to changing land uses (MNR and MOE, 1993)*

1.2 Scope

The Watershed Management Plan for Robinson Creek and Tooley Creek watersheds will be prepared in three phases. The first phase, the Existing Conditions Report (contained herein), provides an assessment of the watersheds by examining the following components: policy and land use, hydrology and hydraulics, groundwater quality and quantity, aquatic habitat and fisheries, surface water quality and quantity, and terrestrial natural heritage.

The second phase will be the development, analysis and evaluation of alternative future land or resource use scenarios, management approaches and monitoring initiatives. The purpose of this phase is to understand how the watershed will respond to future stresses, determine whether management objectives will be compromised and, if so, identify the effectiveness of various management approaches. Evaluation criteria will be developed through input from the community, and will be the basis upon which a preferred management approach is recommended.

The final Watershed Management Plan will be prepared in Phase Three, and will identify the final set of management goals, objectives and targets, which is to be used to evaluate the acceptability of future land use changes, future resource use proposals and track progress in implementation.

1.3 Participation

The Municipality of Clarington is working in partnership with CLOCA and other stakeholders, to complete the watershed planning process for the watersheds of Robinson Creek and Tooley Creek. AECOM has been retained by the Municipality of Clarington to prepare the Phase One- Existing Conditions Report for these watersheds. The Municipality of Clarington, CLOCA and AECOM staff are working in co-operation with a Technical Review Committee, the public and stakeholders through this process, which will strengthen the project product at each phase and ultimate implementation of the Plan.

2. Study Area

This Section provides an overview of the study area. Sections 4.3, 4.4, 5.2, 6.2 and 7.1, provide more detailed and discipline-specific descriptions of the study area from hydrogeologic, hydrologic/ hydraulic, aquatic habitat and terrestrial perspectives.

The Tooley Creek and Robinson Creek watersheds are located in the Regional Municipality of Durham, entirely within the local Municipality of Clarington, and are under the jurisdiction of CLOCA (**Figure 2.1).** They are among the smallest watersheds within the jurisdiction of the Municipality of Clarington, with the Robinson Creek Watershed measuring approximately 578 ha and the Tooley Creek Watershed measuring approximately 1,040 ha in size. There is a concern that by virtue of their size, these watersheds are especially vulnerable to the effects of changing land use and the impact of development.

<u>Tooley Creek</u>

The Tooley Creek Watershed originates near the Lake Iroquois Shoreline at Nash Road, and outlets into Lake Ontario through the Tooley Creek Coastal Marsh. The northern portion of the watershed occurs on Lake Iroquois Plain deposits (silt and sand), while the remainder of the watershed is characterized by silty-sand till deposits of the Newmarket Till Formation. Erodible, high bluffs are found along the Lake Ontario shoreline, between the mouths of Robinson Creek and Tooley Creek. A portion of the Tooley Creek Watershed north of Highway 2 falls within the Green Belt (refer to Section 3.1.2.2 for a description of the Green Belt Plan) and contains a portion of the provincially significant Maple Grove Wetland Complex. Existing land use within the Tooley Creek Watershed is predominately agricultural with some rural residential use. The community of Courtice encroaches into the northwestern edge of the watershed, which is primary source of development pressure.

<u>Robinson Creek</u>

The headwaters of Robinson Creek originate to the north of Bloor Street, where a defined stream channel first appears. Robinson Creek drains into Lake Ontario through a portion of the provincially significant McLaughlin Bay Wetland Complex and Darlington Provincial Park. The watershed is predominately characterized by silty-sand till deposits of the Newmarket Till Formation, with areas of glaciolacustrine silty-clay deposits present near the Robinson Creek channel. Land use within the Robinson Creek Watershed is predominately agricultural, however there are urban and developing urban areas associated with the community of Courtice, present along the northern and western limits of the watershed.

2.1 Climate Change and Existing Conditions

The concept of climate change on a local, regional and global scale is a well studied field (Millenium Ecosystem Assessment, 2005), and one that must be considered when undertaking a planning processes such as a watershed management plan. Climate change, as defined by McCarthy *et al.*(2006) is considered to be any change in climate over time whether due to natural variability or anthropogenic activity.

With this in mind, and in addition to phenomena already observed worldwide (i.e., rising atmospheric temperatures, loss of biodiversity, rising sea levels etc) (Fischlin et al., 2007), evidence of impacts as a result of climate change are also being observed in Canada. One such study notes an observed increase in average air temperatures of 1.4°C in Ontario since 1948 (Chiotti and Lavender, 2008). Further to this, the same study also notes other observations/variations related to climate change including: the duration of ice cover on the Great Lakes has shortened by approximately 1 to 2 months over the last 100+ years, near shore lake temperatures (littoral zones) have shown to be increasing in numerous locations since the 1920s, and range expansions of native and non-native fish species is expected and is occurring throughout the Great Lakes Basin, while at the same time, a range reduction for coldwater species is occurring. **Table 2.1** (Chiotti and Lavender 2008) lists potential/anticipated effects of climate change on the Great Lakes Basin.

Table 2.1 Anticipated Effects of Climate Change in the Great Lakes Basin (from Chiotti and Lavender, 2008)

Hydrological parameter	Expected changes in the 21st century, Great Lakes basin
Runoff	• Decreased annual runoff, but increased winter runoff • Earlier and lower spring freshet (the flow resulting from melting snow and ice) • Lower summer and fall low flows • Longer duration low flow periods • Increased frequency of high flows due to extreme precipitation events
Lake levels	• Lower net basin supplies and declining levels due to increased evaporation and timing of precipitation • Increased frequency of low water levels
Groundwater recharge	• Decreased groundwater recharge, with shallow aquifers being especially sensitive
Groundwater discharge	• Changes in amount and timing of baseflow to streams, lakes and wetlands
Ice cover	• Ice cover season reduced, or eliminated completely
Snow cover	• Reduced snow cover (depth, areas, and duration)
Water temperature	• Increased water temperatures in surface water bodies
Soil moisture	• Soil moisture may increase by as much as 80 percent during winter in the basin, but decrease by as much as 30 percent in the summer and fall

The overriding theme from these predicted changes is that change (in some form and magnitude) will occur in the future within the Robinson and Tooley Creek watersheds. As a result of this, the ecosystem functions of the systems are constantly in a state of flux and adaptation. With the effects of climate change already being seen in the Great Lakes Basin, the ability and resiliency of these systems to adapt to changes and stressors is paramount. Therefore, by preserving and enhancing the existing habitat and functions of the natural environment in the Robinson and Tooley Creek watersheds, these ecosystems will be better equipped to adapt to predicted and unforeseen stressors as a result of climate change. With the potential stressors in mind, appropriate considerations and potential scenarios should permeate throughout the watershed management planning process for Robinson and Tooley Creek.

Further to an appreciation of potential climate change on a global and regional scale, the following discussion is provided for the purpose of understanding the local climate context in which the watersheds were characterized in 2009. Climate statistics for 2009 were obtained from Environment Canada‟s Oshawa‟s WPCP climate station (station ID 6155878) and compared to climate norms for the same location (1971 to 2000; **Table 2.2** and **Table 2.3**). In general, 2009 can be considered an average year for monthly mean air temperature, with only the January air temperature showing any notable deviation from the normal. Of significance though, is the low maximum air temperature measured in July 2009, of 21.8°C, when the 1971 to 2000 average is 25°C. This will have implications on the stream temperature measurements collected over this time period and will be further discussed in Section 4.

Table 2.2 Comparison of Air Temperature Climate Normals to Observed Conditions

Average Monthly Air Temperature (°C)[1]				Climate Normals (1971 – 2000)[2]			
Date	*Maximum*	*Minimum*	*Mean*	*Date*	*Maximum*	*Minimum*	*Mean*
January	0.3	-20.0	-9.3	**January**	-1.4	-9.2	-5.3
February	5.3	-13.5	-3.3	**February**	-0.6	-8.2	-4.4
March	7.5	-11.3	0.3	**March**	4.1	-3.8	0.1
April	13.8	-2.0	6.8	**April**	10.5	2.0	6.3
May	17.8	6.0	12.1	**May**	17.0	7.6	12.3
June	23.0	10.0	16.7	**June**	21.9	12.4	17.2
July	21.8	15.3	18.4	**July**	25.0	15.5	20.3
August	25.0	13.5	20.1	**August**	24.0	15.2	19.6
September	21.8	9.3	16.1	**September**	19.7	11.2	15.5
October	13.0	2.5	8.7	**October**	13.1	5.2	9.2
November	9.8	2.0	6.4	**November**	7.2	0.7	4.0
December	6.0	-12.0	-2.0	**December**	1.5	-5.4	-2.0

Notes: 1. Source: www.climate.weatheroffice.ec.gc.ca/ClimateData
2. Source: www.climate.weatheroffice.ec.gc.ca/climatenormals

Overall, the total precipitation for January to December 2009 (867.6 mm) was comparable to the historical total precipitation (877.9 mm), but the monthly precipitation amount differed significantly (**Table 2.3**).

Table 2.3 Comparison of Precipitation Climate Normals to Observed Conditions

Average Monthly Precipitation (mm)[1]				Climate Normals (1971 – 2000)[2]			
Date	*Rain*	*Snow*	*Total*	*Date*	*Rain*	*Snow*	*Total*
January	0.0	65.5	65.5	**January**	32.1	38.9	71.0
February	44.0	6.5	50.5	**February**	29.5	23.2	52.7
March	47.3	1.0	48.3	**March**	46.8	15.5	62.3
April	128.5	0.0	128.5	**April**	70.1	3.1	73.2
May	124.7	0.0	124.7	**May**	74.7	0.0	74.7
June	52.7	0.0	52.7	**June**	80.6	0.0	80.6
July	62.7	0.0	62.7	**July**	67.3	0.0	67.3
August	82.5	0.0	82.5	**August**	83.3	0.0	83.3
September	41.2	0.0	41.2	**September**	87.9	0.0	87.9
October	85.7	0.0	85.7	**October**	66.2	0.1	66.3
November	27.1	0.0	27.1	**November**	74.2	5.7	79.9
December	89.7	8.5	98.2	**December**	46.8	31.9	78.7
Total	**786.1**	**81.5**	**867.6**	**Total**	**759.5**	**118.4**	**877.9**

Notes: 1. Source: www.climate.weatheroffice.ec.gc.ca/ClimateData
2. Source: www.climate.weatheroffice.ec.gc.ca/climatenormals
3. 1 cm of snow equals 1 mm of precipitation

Basemapping from Ontario Ministry of Natural Resources
Orthophotography: 2005

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UTM Zone 17N, NAD 83

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Legend

- Watershed
- Railway
- Intermittent Stream
- Permanent Stream
- Waterbody Segment
- Wetland Area, Permanent

Robinson Creek and Tooley Creek Watershed Plan

Study Area

September 2009
Project 112956

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Figure 2.1

Map Document: (N:\projects\0-aecom\112956\2009\Final\GISSpatial\MXDs\ReportMXDs\112956StudyArea.mxd)
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3. Existing Policy and Land Use

3.1 Policy Context

The following section provides an overview of the applicable legislation and policy related to natural heritage features.

3.1.1 Federal

3.1.1.1 Federal Fisheries Act – Department of Fisheries and Oceans

The key national legislation for the protection of fish habitat is the *Fisheries Act*. The primary goal of this Act is to protect fish habitat from 1) biological 2) physical 3) or chemical alterations that are harmful or destructive. The Department of Fisheries and Oceans Canada (DFO) is responsible for the enforcement and management of fisheries resources according to the *Fisheries Act*. DFO works in conjunction with a variety of other agencies (Environment Canada, Ontario Ministry of Natural Resources (OMNR), Ontario Ministry of the Environment and Conservation Authorities) for administration of various portions of the *Fisheries Act*. The two significant components of this legislation in relation to watercourse crossings are briefly discussed below:

> *Section 35(1):*
> *"No person shall carry on any work or undertaking that result in the harmful alteration, disruption or destruction of fish habitat."*

The guiding principle for Section 35(1) is "no net loss" of productive capacity of fish habitat in relation to project proposals. The DFO is ultimately responsible for the review and analysis process to identify the mitigation measures required to minimize or eliminate the adverse effects of projects on habitat or the compensation measures that apply in order to achieve no net loss in the productive capacity of fish habitat.

> *Section 36(3):*
> *"No person shall deposit or permit the deposit of a deleterious substance of any type in water frequented by fish or in any place under any conditions where the deleterious substance or any other deleterious substance that results from the deposit of the deleterious substance may enter such water."*

A substance is deleterious if it is harmful to fish, if it limits the use of fish by humans, or if by going through some process of degradation, it harms the water quality (for example, oxygen-depleting wastes). The Ministry of the Environment is responsible for governing this legislation, except when the deleterious substance is suspended solids; in which case the OMNR is responsible.

3.1.1.2 Species at Risk Act – Environment Canada

The federal *Species at Risk Act* (SARA) was created to prevent wildlife species from becoming extinct. The federal Act protects species at risk and their critical habitats. The Act became law in June 2003. It includes prohibitions against killing, harming, harassing, capturing or taking species at risk, and makes it illegal to destroy their critical habitats and can impose restrictions on development and construction projects.

Species are designated „at risk‟ by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), an independent body of experts that assesses wildlife according to a broad range of scientific data. The committee meets annually to review status reports on species suspected of being at risk and provides assessments to government and the public. The federal Cabinet then decides whether those species should get legal protection under the Act. These decisions are made after consultations with affected stakeholders and other groups.

Once a species is added to the list and protected officially under SARA, a recovery strategy must be developed. For endangered species, this strategy must be developed within a year of the listing; for threatened or extirpated (extinct in Canada) species, it must be developed within two years.

Recovery strategies and action plans for species listed as endangered or threatened will be developed in consultation with stakeholders. These recovery strategies and action plans will detail the specific steps that need to be taken to protect identified species.

3.1.2 Provincial

3.1.2.1 The Planning Act – Ministry of Municipal Affairs and Housing

The Provincial Policy Statement (PPS) has a strong focus on the long-term prosperity and environmental health of Ontario. It states that Natural features and areas shall be protected for the long-term. This policy, established under Section 3.0 of Ontario"s *Planning Act*, prescribes the extent to which natural features are protected when development is proposed. The PPS includes social and economic components and should be read in its entirety. Although the PPS is provincial legislation, it is implemented by the Municipality of Clarington through their Official Plan.

The PPS provides direction on the protection of the Natural Heritage System by not permitting development and site alteration in a number of circumstances:

"2.1.3 Development and site alteration shall not be permitted in,

a. significant habitat of endangered species and threatened species;
b. significant wetlands in Ecoregions 5E, 6E and 7E; and
c. significant coastal wetlands.

2.1.4 Development and site alteration shall not be permitted in,

a. significant wetlands in the Canadian Shield north of Ecoregions 5E, 6E and 7E;
b. significant woodlands south and east of the Canadian Shield;
c. significant valleylands south and east of the Canadian Shield;
d. significant wildlife habitat; and
e. significant areas of natural and scientific interest.

unless it has been demonstrated that there will be no negative impacts on the natural features or their ecological functions.

2.1.5 Development and site alteration shall not be permitted in fish habitat except in accordance with provincial and federal requirements.

2.1.6 Development and site alteration shall not be permitted on adjacent lands to the natural heritage features and areas identified in policies 2.1.3, 2.1.4 and 2.1.5 unless the ecological function of the adjacent lands has been evaluated and it has been demonstrated that there will be no negative impacts on the natural features or on their ecological functions."

3.1.2.2 The Greenbelt Act – Ministry of Municipal Affairs and Housing

Ontario"s Greenbelt is 1.8 million acres of permanently protected green space, farmland, communities, forests, wetlands, and watersheds. The Greenbelt covers lands south of the Oak Ridges Moraine (ORM), surrounding Clarington"s urban boundaries. The Greenbelt Plan contains policies for providing permanent agricultural and environmental protection as well as providing for a wide range of recreation, tourism and cultural opportunities in the area. The Greenbelt Plan encompasses lands within the Niagara Escarpment Plan (NEP) and the Oak Ridges Moraine Conservation Plan (ORMCP), while building upon the foundation of ecological protections provided by these two Plans. The Protected Countryside comprises of an Agricultural System and a Natural System, together with a number of settlement areas, and is intended to improve linkages among these areas and surrounding systems.

The Natural System identifies lands that support both natural heritage and hydrologic features and functions. The Natural System policies protect areas of natural heritage, hydrologic and/or landform features, which are often functionally inter-related and which collectively support biodiversity and overall ecological integrity. This Natural System is made up of a Natural Heritage System and a Water Resource System that often coincides given ecological linkages between terrestrial and water based functions. The Natural Heritage System includes areas of the Protected Countryside with the highest concentration of the most sensitive and/or *significant* natural features and functions. The Water Resource System is made up of both ground and surface water features and their associated functions, which provide the water resources necessary to sustain healthy aquatic and terrestrial ecosystems and human water consumption.

Approximately 59 ha of the Tooley Creek Watershed area are within the Greenbelt (5.7% of the watershed). The area of Greenbelt within the Tooley Creek Watershed extends from Highway 2 to the northern limit of the watershed, within which there are Greenbelt designations of *Protected Countryside* and *Natural Heritage System.* The Greenbelt does not extent into the Robinson Creek Watershed.

3.1.2.3 Ontario Endangered Species Act – Ministry of Natural Resources

The new *Endangered Species Act*, 2007 received Royal Assent on May 17, 2007. This legislation is the first in Canada to combine mandatory habitat protection with a science-based approach to listing species for protection. Species thought to be at risk are assessed by The Committee on the Status of Species at Risk in Ontario (COSSARO). COSSARO is an independent body that reviews species based on the best available science, including community knowledge, and Aboriginal Traditional Knowledge.

Once species are classified "at risk", they are added to the Species at Risk in Ontario (SARO) list in one of three categories. Endangered, threatened and extirpated species on this list automatically receive legal protection under the ESA 2007. Providing legal protection to threatened species is a change from the original Act which only applied to endangered species.

The new Act provides protection for species and their habitats. When a species is classified endangered or threatened, the habitat of that species is protected under a general definition.

The ESA 2007 calls for the creation of recovery strategies for endangered and threatened species, and management plans for special species of concern. These documents provide advice to the government on steps to take to protect and recover species at risk to healthy population levels.

3.1.2.4 Ontario Water Resources Act (O. Reg. 128/03) – Ministry of the Environment

The Ontario *Water Resources Act* regulates both groundwater and surface water resources throughout the province. The *Water Resources Act* regulates sewage disposal and waste facilities. It prohibits the discharge of pollutants that may impair water quality and regulates water takings from ground or surface water sources. The *Water Resources Act* regulates well construction, operation and abandonment. A few pertinent sections of the Ontario *Water Resources Act* are discussed below.

- *Ontario Water Resources Act (s.34) – Permit-To-Take-Water*

  Under the Ontario *Water Resources Act* (O. Reg. 128/03), a Permit-To-Take-Water (PTTW) from the Ministry of the Environment shall be obtained for the taking of water over 50,000 L/day from any given source (surface water or groundwater), whether temporary or permanent for any purpose including but not limited to: diversion, potable water supply, cleaning, flushing and dewatering.

- *Ontario Water Resources Act (s.53)*

  Under the Ontario *Water Resources Act* (O. Reg. 128/03), a Certificate of Approval shall be acquired from the Ontario Ministry of the Environment prior to construction, for any surface water conveyance or management works not being constructed under either the *Drainage Act* or the *Public Transportation and Highway Improvement Act*. This applies to discharge of stormwater management facilities.

- *Ontario Water Resources Act (Wells Regulation 903)*

  Under the Ontario *Water Resources Act* (O. Reg. 128/03), Regulation 903 covers all wells including public and private, municipal and rural, agricultural, commercial and industrial, as well as test holes, dewatering wells, and monitoring wells. It sets out minimum standards for sighting, constructing, tagging and reporting, maintaining and decommissioning wells. The regulation also sets out the licensing requirements for businesses and individuals engaged in well construction, pump and other equipment installation, and standards for the design, construction, maintenance and abandonment (or decommissioning) of wells.

3.1.2.5 Environmental Protection Act – Ministry of the Environment

The *Environmental Protection Act* is the primary pollution control legislation in Ontario and can be used interchangeably with the *Water Resources Act*. The legislation prohibits discharge of any contaminants in to the environment that cause or are likely to cause adverse effects. Amounts of approved contaminants must not exceed limits prescribed by the regulations. The Act also requires that spills of pollutants are reported and cleaned up promptly.

3.1.2.6 Nutrient Management Act – Ministry of Environment & Ministry of Agriculture & Food

As part of Ontario"s Clean Water Strategy, the *Nutrient Management Act*, 2002 was designed to reduce the potential for water and environmental contamination from some agricultural practices. The Act establishes the framework for best practices regarding nutrient management (particularly manure). The *Nutrient Management Act* also provides standards for nutrient storage and how nutrients are applied to farmland, in order to reduce the likelihood of ground or surface water contamination.

3.1.2.7 Clean Water Act – Ministry of the Environment

The *Clean Water Act* is an outcome of the Walkerton Inquiry and is designed to support Justice O"Connor"s recommendation for protection of drinking water at its source. The legislation sets the basic framework for communities to follow in developing an approach to protect their water resources by identifying and assessing risks, developing source protection plans, and implementing these plans.

3.1.2.8 Safe Drinking Water Act – Ministry of the Environment

Like the *Clean Water Act*, the *Safe Drinking Water Act* was initiated by the Walkerton Inquiry. As a result of the Act, all municipal drinking water systems must obtain an approval from the Director of the Ministry of the Environment in order to operate, and operators must be trained and certified to provincial standards. The Act also provides a framework for testing with standards for contaminants in drinking water and the mandatory use of licensed and accredited laboratories for drinking water testing.

3.1.3 Central Lake Ontario Conservation Authority - Regulation and Policy

One of the roles of the Central Lake Ontario Conservation Authority (CLOCA) is as a commenting agency on development applications under the *Planning Act* based on regulations approved by their Board of Directors and the province. CLOCA has agreements with partnering municipalities to provide advisory services regarding matters associated with natural heritage protection, hazardous land management and water resources (e.g., stormwater management).

In addition, CLOCA has the delegated responsibility from the Ministries of Natural Resources and Municipal Affairs and Housing to implement Section 3.1 of the Provincial Policy Statement (PPS), consistent with the Provincial one window planning initiative.

CLOCA also administers Regulation 42/06 (Regulation of Development, Interference with Wetlands and Alteration to Shorelines and Watercourses) under Section 28 of the *Conservation Authorities Act*. In general this regulation prohibits altering a watercourse, wetland or shoreline and prohibits development in areas adjacent to river and stream valleys, hazardous lands and wetlands, without prior written approval from the Conservation Authority.

Finally, CLOCA has a Level III agreement with Fisheries and Oceans Canada (DFO) under Section 35(1) of the *Fisheries Act*. Under this agreement CLOCA conducts initial reviews of proposed projects on behalf of DFO to determine if there is a potential risk to fish habitat. If a potential risk to fish habitat exists, CLOCA‟s agreement permits them to work with the proponent to mitigate or eliminate the potential risks or impacts. If the potential risk can be mitigated, CLOCA may issue a Letter of Advice (LoA) for the works to proceed. If the potential risk cannot be mitigated, CLOCA may work with the proponent and DFO in order to minimise the risk and prepare a fish habitat compensation plan, which DFO then may authorize under the *Fisheries Act*.

3.2 Regional and Municipal Planning

3.2.1 Regional Municipality of Durham

Durham Region‟s Official Plan is the overarching policy document guiding land use within the Region. These policies implement provincial legislation and provide planning context to lower tier municipalities, such as Clarington.

The Regional Official Plan (Office Consolidation 2008) for Durham defines a Greenlands System for which it prescribes goals and general policies (Section 10 of the Official Plan). Section 10.2.3 of the Official Plan states that:

> *"The Greenlands System includes areas with the highest concentration of sensitive and/or significant natural features and functions. These areas are to be managed as a connected and integrated natural heritage system recognizing the functional inter-relationships between them. The main features of the Greenlands System, particularly the Oak Ridges Moraine, valley systems and the Waterfronts, shall be protected for their special natural and scenic features, their roles as predominant landscape elements in the Region and the recreational opportunities they facilitate. Further, linking the waterfronts with the Oak Ridges Moraine through the connecting valley systems shall be a primary objective of the continuous Greenlands System, as is linking of the valley systems themselves. The Greenlands System also contains agricultural and agricultural-related and secondary uses which shall be protected as integral components of the System."*

3.2.1.1 Growing Durham

In July 2007, Durham Region initiated a "Growing Durham Study", which built on the Region‟s Official Plan review work and provides comprehensive analysis of the implications of growth in the Region, including a review and evaluation of alternate growth scenarios. The recently completed Study addresses Growth Plan population and employment forecasts to 2031.

3.2.2 Municipality of Clarington

The Municipality of Clarington‟s Official Plan includes policies that ensure land use planning decisions are in conformity with both provincial and regional policies. Policies within municipal official plans are typically more detailed to better reflect local conditions and growth patterns. Section 4.4 of the Official Plan, defines and describes the Clarington‟s Natural Heritage System. The municipality‟s Natural Heritage System is comprised of natural heritage features together with their ecological functions. Section 4.4.11 of the Official Plan states that:

> *"The following areas in the Municipality are particularly important to the natural heritage system of the Municipality:*
> 1. *the Oak Ridges Moraine;*
> 2. *the Lake Iroquois Beach; and*
> 3. *the Lake Ontario Waterfront."*

3.3 Land Use Designations

Land use designations reflected in the Clarington Official Plan are depicted for Robinson and Tooley Creek on **Figures 3.1** and **3.2** respectively.

The ROPA 128 OP Amendment has been submitted and a DRAFT decision was made by the Ministry of Municipal Affairs and Housing (MMAH). Subsequent revisions/submissions and dialogue are anticipated and the approved land use layer was not finalized in time for this report.

3.3.1 Robinson Creek Watershed

3.3.1.1 Municipality of Clarington

Much of the land within the Robinson Creek Watershed is within the area designated as *Urban Residential*. An area north of Bloor Street and along the western tributary of Robinson Creek are designated as *Future Urban Residential*. South of Bloor Street, lands are predominately designated as *Light Industrial* and *General Industrial.* Special Policy Area D has been designated east of Robinson Creek, north of Highway 401. The policy for this area describes the Municipality‟s long term goal to encourage the relocation of the existing use as an automobile parts yard, to allow the eventual redevelopment of this property for industrial purposes. An area on the north side of the rail line, west of Robinson Creek, is designated as *Prestige Employment*.

The Official Plan designates lands along and adjacent to Robinson Creek and its tributaries and McLaughlin Bay as Environmental Protection Area. On either side of Highway 401 is a linear strip of land designated as *Green Space*. Lands south of the CN rail line to the Lake Ontario Shoreline are designated as *Waterfront Greenway*. There is an area south of Bloor Street, on the west side of Robinson Creek that is designated under the Official Plan as a *Community Park*.

Clarington"s Natural Heritage System (shown on **Figure 3.1**) includes the McLaughlin Bay Wetland complex on the shoreline of Lake Ontario. The Official Plan identifies areas of *Significant Woodland* within Darlington Provincial Park in the southern portion of the watershed (south of Highway 401) and along the main branch of Robinson Creek and its Western Tributary. Lands along and adjacent to Robinson Creek and its tributaries are designated *Significant Valleylands*. North of Highway 2, there is some overlap between future urban residential and significant valleylands.

3.3.1.2 Regional Municipality of Durham

At the regional level, most of the Robinson Creek Watershed is designated as Living Areas (Durham Official Plan – Schedule A). The policies of the Official Plan state that Living Areas shall be used predominately for housing purposes and incorporate the widest possible variety of housing types.

The Official Plan designates lands south of Bloor Street and east of Robinson Creek as Employment Areas. Lands along and adjacent to Robinson Creek are designated as part of the Greenlands System as Major Open Space Areas. As defined in the Official Plan, Major Open Space Areas include key natural heritage and hydrological features, prime agricultural lands as well as lands of lesser agricultural significance. The predominant use of lands in the Major Open Space Areas shall be conservation, and a full range of agricultural, agricultural-related and secondary uses.

The area south of Highway 401, within the Robinson Creek Watershed, is designated as part of the Regional Greenlands System, as Waterfront Area. According to the Official Plan, *waterfronts of Lake Ontario shall generally be developed as "people places" with the exception of significant natural areas, which will be protected in their natural states.*

The majority of the Robinson Creek Watershed is within the urban boundary and is planned for development. As such, development pressures will continue throughout the watershed.

3.3.2 Tooley Creek Watershed

3.3.2.1 Municipality of Clarington

The portion of the Tooley Creek Watershed west of Courtice Road is designated for urban (*Urban Residential* and *Future Urban Residential*) and industrial (*General Industrial* and *Light Industrial*) uses. A small area west of Courtice Road is designated for *Prestige Employment*. East of Courtice Road, lands have been designated predominately as *General Agricultural,* with an area of *Green Space*, within the northern portion and along the eastern edge of the watershed.

The Official Plan designates lands along and adjacent to Tooley Creek and its tributaries as *Environmental Protection Area* as well as an isolated area located south of Bloor Street, between Trulls Road and Courtice Road. East of Tooley Creek, south of Highway 401, lands are designated *Green Space*. Lands south of the CN rail line to the Lake Ontario Shoreline are designated as *Waterfront Greenway*. The Clarington Energy Park is reflected in the Official Plan land use mapping, in the area south of Highway 401 designated as *Business Park*.

Clarington"s Natural Heritage System (shown on **Figure 3.2**) includes areas of wetland in the northernmost portion of the watershed, north of Highway 2, reflecting the provincially significant Maple Grove Wetland Complex and the locally significant Tooley Creek Coastal Marsh at Lake Ontario. The Official Plan identifies areas of *Significant Woodland* predominately through the middle and northern portions of the watershed (**Figure 3.2**). Lands along and adjacent to Tooley Creek and its tributaries are designated *Significant Valleylands*.

Potential for development in the 59 ha in the northern portion of Tooley Creek Watershed is determined by the Greenbelt Plan. The majority of watersheds located outside of the Greenbelt, will likely experience pressures for urban expansion. Under the current Official Plan, most of the watershed is proposed primarily for conservation, agricultural and active and passive recreational uses through the *Green Space* and *Waterfront Greenway* designations.

3.3.2.2 Regional Municipality of Durham

Lands within the Tooley Creek Watershed are predominately designated in the regional Official Plan as part of the Greenlands System as Major Open Space Areas. The Official Plan designates a rectangular area of land, east of Courtice Road, as Prime Agricultural Area. Prime Agricultural Areas consist of areas where prime agricultural lands predominate. As prescribed by the Official Plan, Agricultural areas shall be used primarily for agriculture and farm-related uses.

Lands south of the CN rail line to the Lake Ontario Shoreline are designated as part of the Regional Greenlands System, as Waterfront Area.

3.3.2.3 407 East Corridor

An extension of Highway 407 (called 407 East) through Durham Region was first shown on regional and municipal Official Plans in the 1970s. Since this time, planning decisions related to land use and transportation in the Greater Golden Horseshoe have included the 407 East corridor as part of future existing conditions.

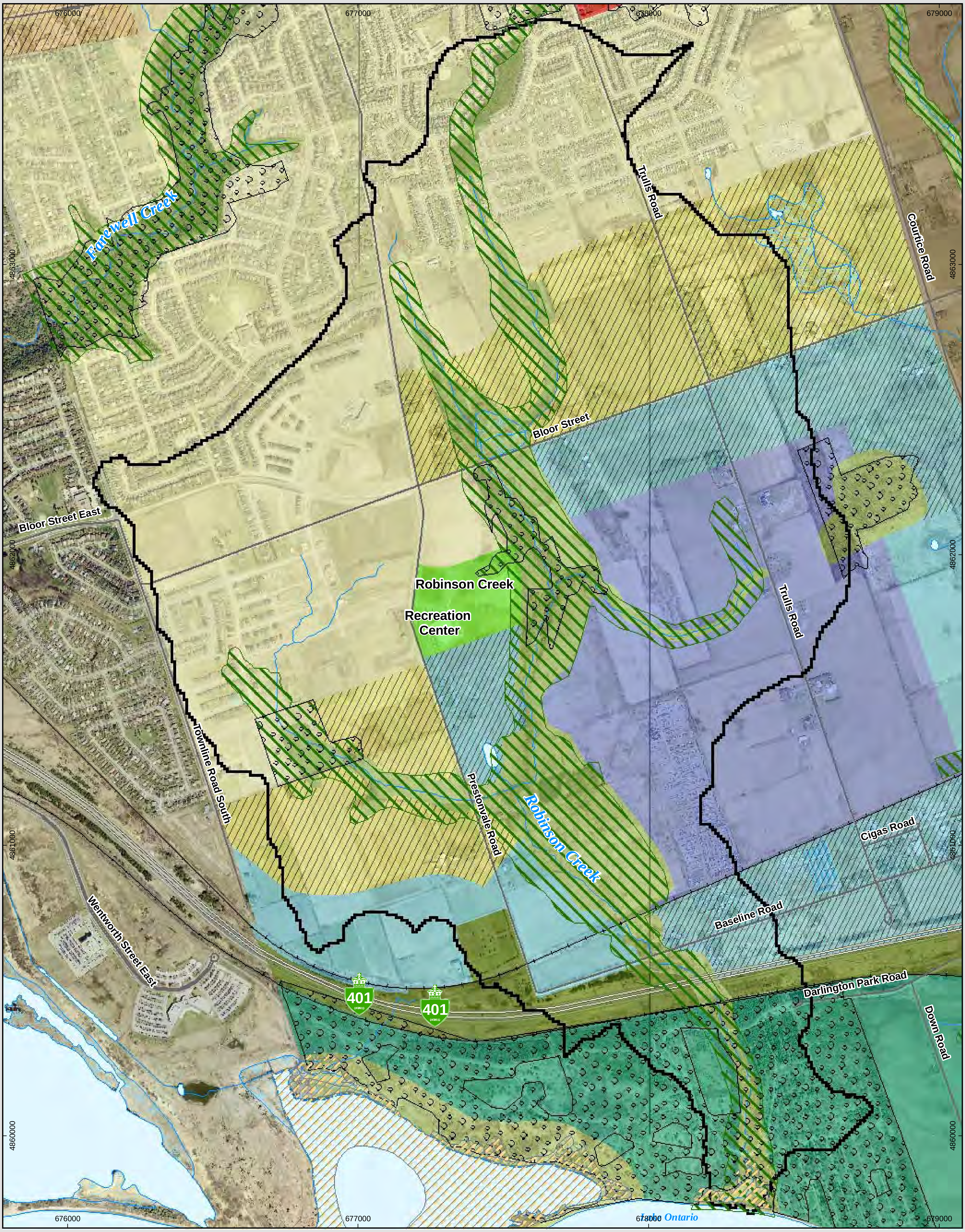
The Ontario Ministry of Transportation (MTO) in consultation with Durham Region, its constituents and surrounding municipalities, undertook an individual Environmental Assessment (EA) study to address the long-term transportation needs in the Region of Durham and surrounding area. The EA was initiated in January 2005, after approval of the Terms of Reference by the Minister of the Environment.

The proposed 407 East corridor, identified through the EA process includes a transportation corridor, consisting of a highway and a transitway, and the associated support facilities. The transportation corridor includes:

- Mainline section from Brock Road to Highway 35/115;
- Two north-south freeway links connecting the proposed 407 East extension to Highway 401, one in Whitby (West Durham Link) and the other in Clarington (East Durham Link); and
- Protection of a dedicated transitway corridor.

The 407 East corridor crosses the eastern portion of the Tooley Creek Watershed from north of Highway 2 to Highway 401, between Hancock and Solina Road.

The 407 East Environment Assessment (EA) was submitted in August, 2009 to the Minister of the Environment for approval. Approval of EA, along with the conditions of approval, was granted on July 3, 2010. The targeted date for the completion of the construction of the proposed 407 East is 2013.



Basemapping from Ontario Ministry of Natural Resources
Orthophotography: 2005
Land Use from Clarington Offical Plan, 2007

N
W E
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m

0 60 120 240 360 480

1:12,500

UTM Zone 17N, NAD 83

Legend

Watershed

Clarington Official Plan, 2007 - Natural Heritage System

- Significant Valleyland
- Significant Woodlands
- Wetland

Clarington Official Plan, 2007 - Land Use

- Community Park
- Courtice West Shopping Distric
- Environmental Protection
- Future Urban Residential
- General Agricultural
- General Industrial
- Green Space
- Light Industrial
- Prestige Employment
- Prime Agricultural
- Town Centre
- Urban Residential
- Waterfront Greenway

Robinson Creek and Tooley Creek Watershed Plan

Robinson Creek Watershed Landuse

October 2009
Project 112956

AECOM

Figure 3.1

Map Document: (N:\projects\0-aecom\112956\2009\Final\GISSpatial\MXDs\ReportMXDs\112956RobinsonLandUse.mxd)
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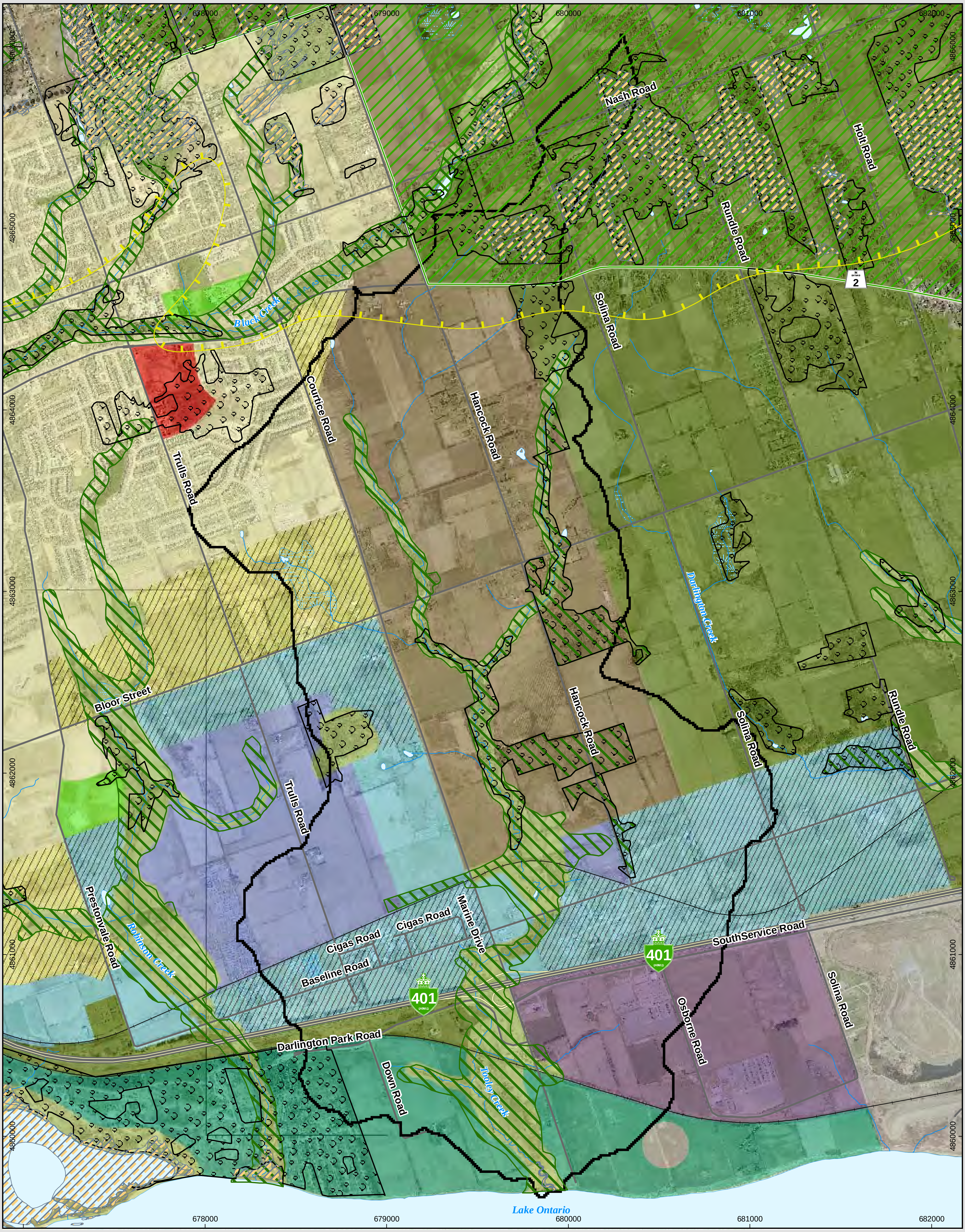

Basemapping from Ontario Ministry of Natural Resources
Orthophotography: 2005
Land Use from Clarington Offical Plan, 2007

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UTM Zone 17N, NAD 83

Legend

Watershed
Greenbelt

Clarington Official Plan, 2007 - Natural Heritage System

Significant Valleyland
Lake Iroquois Beach
Significant Woodlands
Wetland

Clarington Official Plan, 2007 - Land Use

Business Park
Community Park
Environmental Protection
Future Urban Residential
General Agricultural
General Industrial
Green Space
Light Industrial
Prestige Employment
Special Study Areas 5 and 6
Town Centre
Urban Residential
Utility
Waterfront Greenway

Robinson Creek and Tooley Creek Watershed Plan

Tooley Creek Watershed Land Use

October 2009
Project 112956

AECOM

Figure 3.2

Map Document: (N:\projects\0-aecom\112956\2009\Final\GISSpatial\MXDs\ReportMXDs\112956TooleyLandUse.mxd)
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4. Hydrogeology

4.1 Introduction

Groundwater plays an important role in the *hydrologic cycle*, which controls the global distribution of water. On the watershed scale, groundwater recharge and discharge control the baseflow to streams and help support aquatic and terrestrial habitats. Groundwater *recharge* refers to the infiltration of surface water downwards to the water table. Groundwater *discharge* refers to the movement of groundwater from below the water table to the surface water system. Groundwater discharge most often occurs in low-lying areas such as rivers, stream and lakes, but can also occur as springs where confined aquifers discharge to surface. Groundwater discharge provides the baseflow to many streams and helps support important aquatic species and aquatic habitat. Groundwater recharge can occur locally (i.e., within the watershed boundaries) or regionally (i.e., from an upgradient source outside the watershed).

4.2 Methodology

To assess the hydrogeological conditions of the Robinson Creek and the Tooley Creek watersheds, hydrogeological information was first gathered through a secondary source review. The key reports referenced include: Groundwater Modelling of the Oak Ridges Moraine (York, Peel, Durham, Toronto – Conservation Authority Moraine Coalition (YPDT-CAMC) Technical Report #01-06), Hydrologic and Hydraulic Modelling for Tooley Creek (October 2007 – Revised March 2008), the 407 East Environmental Assessment (MTO, 2009), and the Natural Environment (Hydrogeology) Impact Assessment of the 407 East Recommended Design (MTO, 2009). Surficial geology and bedrock mapping were obtained from the Ontario Ministry of Natural Resources base mapping.

The 407 East Environmental Assessment (MTO, 2009), and the Natural Environment (Hydrogeology) Impact Assessment of the 407 East Recommended Design (MTO, 2009) investigations, herein referred to as the 407 East EA Reports were conducted within the Tooley Creek Watershed to assess the impacts of the proposed development. These investigations included borehole drilling at two sites, mini-piezometer[1] installations at two sites, and chemical analysis of groundwater samples from the monitoring wells. This public document provided information on historical groundwater levels, the hydraulic properties of local hydrogeological units, and groundwater chemical results that are considered representative of the Robinson and Tooley Creek watersheds. Although the information contained in these reports are available to the public, some of the figures and data have been used and modified, with permission from the MTO, as part of this study.

CLOCA has provided mapping from a regional groundwater model that shows areas of potential groundwater discharge by highlighting areas where the water table was identified in MOE water well records as being with 1 m of the ground surface. This method of identifying groundwater discharge areas is useful when characterizing discharge areas on a regional scale, but may not be representative at the small scale. For this reason, field investigations for this project focused on identifying the specific areas that contribute groundwater baseflow to Robinson and Tooley creeks. Areas that were not identified as groundwater discharge areas by CLOCA‟s mapping were assumed to be groundwater recharge areas.

A search of the MOE water well record database, along with the information contained in the 407 East EA Reports provided the information necessary to characterize the subsurface geological and hydrogeological conditions of the watershed. Analysis of the stratigraphy provided in water well records allowed delineation of aquifer and aquitard materials and where groundwater resources are generally obtained. A regional north-south cross-section is provided along Oshawa-Clarington Townline Road to show the geology watersheds in a regional context. Information on the water table depth and the presence of artesian groundwater conditions are also provided in the MOE well records and were utilized in characterizing groundwater flow directions within the watershed.

1. *Mini-piezometers are small diameter (1/2"- inside diameter) steel wells that are hand driven into streams and wetlands. They are used to measure groundwater levels below surface water bodies to quality groundwater/ surface water interactions.*

4.2.1 Field Investigations

Hydrogeology field investigations were conducted and focused on understanding the geological and hydrogeological conditions of the Tooley Creek and Robinson Creek Watersheds, specifically related to characterization of groundwater flow and groundwater recharge and discharge areas. These investigations include the installation of mini-piezometers in streams and wetlands, the measurement of stream water temperatures, and the visual observation and characterization of groundwater springs and seeps.

Visual investigations that focused on indentifying groundwater discharge/ recharge areas were conducted within the two watersheds. All roadside watercourse crossings and wetland areas were visited to observe signs of groundwater discharge (as identified by watercress or iron sheen) or a high groundwater table (as identified by jewel weed, mottled surface texture, etc.). The majority of Robinson Creek and Tooley Creek and their tributaries were walked by AECOM staff, again to delineate potential areas of groundwater discharge. To confirm the shallow geological conditions as shown in the Provincial Mapping, shallow hand auger samples were collected at various points in the watersheds.

4.2.2 Groundwater Monitors

No groundwater monitoring wells were installed as part of this study. The 407 East EA, presents information on two groundwater monitoring well nests that were installed in the Tooley Creek Watershed and consist of a shallow (s) and deep (d) groundwater monitor (**Figure 4.9**). No groundwater monitors are installed in the Robinson Creek Watershed. The two well nests in the Tooley Creek Watershed have been relabelled as TC-BH1 and TC-BH2, to be consistent with the nomenclature of this project. Information regarding the hydraulic conductivity of the soils surrounding the well screen and groundwater chemistry from these wells is also presented in the 407 East EA, and will be referenced as part of this study. Groundwater monitors TC-BH1s and TC-BH1d were instrumented with Solinst Gold © Leveloggers (Solinst Instruments, Georgetown, Ontario) to continually record groundwater level data over the study period.

4.2.3 Mini-Piezometers

A total of 11 mini-piezometers (MP) were installed in Robinson Creek (RC-MP1s/d, RC-MP2, RC-MP3, RC-MP4, RC-MP5) and Tooley Creek (TC-MP1, TC-MP2, TC-MP3, TC-MP4s/d, TC-MP5, TC-MP6s/d) watersheds to establish the hydraulic relationship between shallow groundwater and surface water. Mini-piezometers installed as part of this study area shown on **Figure 4.1** for Robinson Creek and **Figure 4.9** for Tooley Creek. Mini-piezometers were installed either as a single piezometer (in flowing streams) or as a piezometer nest consisting of 2 mini-piezometers, each installed at different depths (**see Photographs 1 to 3**). Each mini-piezometer consists of a length of 12.7 mm diameter (1/2-inch ID) galvanized steel pipe with a slotted and screened drivepoint tip on the end. The surrounding geologic formation was allowed to collapse around the piezometer to seal the annular space around the pipe. Mini-piezometers were installed by hand using a post driver. Single mini-piezometer installations were installed to a depth of approximately 1.5 m below the bottom of the streambed, where permitted by subsurface conditions. Mini-piezometer nests consist of one piezometer installed to a depth of approximately 1.5 m below the bottom of the streambed or ground surface and one piezometer installed deeper so that there was at least 1.0 m separating the bottom of the drivepoint in the shallow piezometer and the top of drivepoint in the deep piezometer. Plastic caps were placed on each piezometer to prevent any rainwater inputs. Each piezometer was surveyed using a GPS unit for horizontal position. An estimate of vertical control was based on existing topographic mapping.

Photo 1. Mini- piezometer Wetland Pair at RC-MP1

Photo 2. Mini-piezometer Stream Single at RC-MP2

Photo 3. Mini-piezometer Stream Single at TC-MP3

Mini-piezometer nests were primarily installed in wetland areas to characterize the vertical direction and magnitude of the hydraulic gradient within the subsurface (i.e., between mini-piezometers) to establish the relationship between shallow groundwater and surface water in the wetland. That is, to determine if the wetland groundwater fed, or surface water fed. Wetland mini-piezometers include RC-MP1s/d, TC-MP4s/d, and TC-MP6s/d.

Through analysis of the direction and magnitude of the hydraulic gradient between groundwater and surface water, areas of groundwater discharge can be specifically delineated. This information is not only utilized for understanding the hydrogeology of the watershed, but is also a valuable piece of information to aid in the understanding of aquatic species and habitat.

4.2.4 Temperature Logging

In Robinson Creek, the watercourse was instrumented at mini-piezometer locations RC-MP2, RC-MP3, RC-MP4, and RC-MP5, with an OnSet TidbiT (Solinst Instruments, Georgetown, Ontario) continuous temperature recorder and data logger. In Tooley Creek, the watercourse at mini-piezometers TC-MP1, TC-MP2, TC-MP3, and TC-MP5, were instrumented with Tidbit loggers. The TidbiT loggers were installed below the water surface to measure the temperature of the water on hourly intervals. Air temperature records were also obtained from the Oshawa"s WPCP climate station (Environment Canada, 2009) to provide mean daily air temperature information. Groundwater temperatures generally fluctuate in a narrow band of 5°C to 15°C, depending upon depth and season, whereas air temperature changes significantly on a daily and seasonal basis. A difference of greater than 5°C between the air temperature and the surface water temperature is an indication that the stream is fed by groundwater discharge. Streams that are fed by groundwater inputs are more likely to support cold water fish habitat and are more sensitive to potential changes in baseflow possibly as a result of future development within the watershed.

Although temperature logging was only conducted for the period between June 2009 and March 2010, the timing of these data collection was optimal to identify differences between groundwater, surface water and air temperature. During the peak summer and winter months the difference in temperature between groundwater and air are the greatest and therefore identification of groundwater temperature buffering in surface water can be the most easily identified. It is difficult to distinguish groundwater influenced surface water features from runoff influenced surface water features in the spring and fall due to the natural similarities between groundwater and air temperature.

4.3 Robinson Creek Watershed

This chapter focuses on the geological and hydrogeological conditions within the watershed and how they relate to its overall natural function. This analysis includes a discussion of the surface and subsurface geological materials in watershed, descriptions and hydraulic characteristics of the aquifer and aquitard materials, and the patterns of groundwater flow. A water balance is presented to quantitatively assess the significance of groundwater recharge and surface runoff and its contributions to stream flow and groundwater recharge. No groundwater monitoring wells are present in this watershed and therefore, information on the groundwater table elevation and groundwater flow, as well as groundwater use, will be derived from Ministry of the Environment (MOE) Water Well Records and from representative information from outside the watershed, but in a similar geoenvironmental setting (e.g., Tooley Creek Watershed).

4.3.1 Results and Discussion

4.3.1.1 Geology and Physiography

An understanding of the geological conditions in the watershed provides the basis for further analysis of the natural function of the watershed.

The Robinson Creek Watershed is located within Iroquois Plain physiographic region, which is a gently sloping lowland area extending from the edge of the till plain of the South Slope region (located to the north of the study area) down to Lake Ontario (Chapman and Putnam, 1984). The geology of the Robinson Creek Watershed consists of Quaternary sediments that overlie Ordovician bedrock. The base soil in the area is a stony, sandy, silt till known as the Newmarket Till (**Figures 4.3 and 4.21**). This unit is very dense and restricts groundwater flow and infiltration.

The Iroquois Plain is generally covered in shallow lake deposits of fine sand, silt and clay. These deposits were deposited by glacial melt water discharging into Glacial Lake Iroquois and can be classified as glaciolacustrine. The shoreline of Lake Iroquois is characterized by raised sand and gravel beach deposits and can be found to the north and east of the watershed. Raised beach features are not present in the Robinson Creek Watershed. Fine sand deposits were deposited close to the former shoreline, with subsequent deposits of silts and clays being deposited farther south (closer to present day Lake Ontario). Some minor deposits of glaciolacustrine sand, silt and clay are present within the Robinson Creek Watershed but the Newmarket Till dominates the surficial materials. On **Figure 4.3,** the sand deposits are shown in yellow and the silts and clays are shown in blue. The Newmarket Till is shown in green.

The bedrock that underlies the Quaternary sediments ranges in depth of between ~45 m near the north end of the watershed and ~25 m near Lake Ontario, as estimated from MOE water well records (**Appendix E.1**). The bedrock is comprised of flat-lying Palaeozoic limestones and shales that are upper Ordovician in age (Liberty, 1969). The northern portion of the watershed is underlain by the blue-grey shales of the Blue Mountain Formation (**Figure 4.2**). This unit is also referred to locally as the Whitby Formation. The southern portion is underlain by the Lindsay Formation limestone. No bedrock outcrops are known to exist in the watershed.

4.3.1.2 Hydrogeology

The presence of thick deposits of Newmarket Till at surface within the watershed controls the groundwater conditions in the Robinson Creek Watershed (**Figure 4.21**). This unit is very dense and restricts groundwater flow and infiltration. The Newmarket Till is a major regional aquitard for the area. Based upon previous studies, the Newmarket Till Aquitard has a hydraulic conductivity that ranges from 10^{-6} to 10^{-9} m/s depending upon the degree of weathering the till has undergone (YPDT-CAMC Technical Report #01-06). The results of the 407 East EA have shown that the Newmarket Till in the vicinity of the study area has an average hydraulic conductivity of 3.2×10^{-07} m/s. When weathered, the hydraulic conductivity was shown to increase by approximately an order of magnitude and has an average value of 2.0×10^{-06} m/s. Borehole TC-BH2s, which is in the Tooley Creek Watershed, and is screened in the weathered till has a hydraulic conductivity of 2.7×10^{-06} m/s, which fits within the regional range. Due to its low permeability, groundwater flow within the till is generally downwards towards more permeable bedrock aquifers, but a minor lateral component likely bends towards the river valleys. Groundwater flow in the upper weathered zone (generally assumed to represent the upper ~3.0 m) is lateral towards the creeks. Diffuse groundwater discharge to Robinson Creek from the Newmarket Till will likely contribute to stream flow, although due to the low permeability of the material, this input is expected to be minor. Surface runoff via overland flow is anticipated to contribute the most significant component to stream flow in Robinson Creek due to poor infiltration though the Newmarket Till. That is, the water tends to runoff as there is not enough time for it to soak into the low permeability till in any given rainfall event. The small areas of glaciolacustrine sands are too small in extent to constitute significant surficial aquifer units and only contribute locally to groundwater recharge.

The Newmarket Till Aquitard is regionally known to contain isolated deposits (lenses) of sand and gravel, created by small outwash features below the glaciers. These deposits are often utilized as aquifers for residential groundwater use. Where a surficial feature such as Robinson Creek has cut deep enough into the Newmarket Till, these lenses may become exposed and form groundwater springs. These springs are isolated but may contribute to stream flow at discrete locations.

The southern extent of the major regional aquifer units such as the Thorncliffe Aquifer and the Oak Ridged Moraine Aquifer, pinch out to the north of the Robinson Creek Watershed (YPDT-CAMC Technical Report #01-06) (**Figure 4.21**). These units do not contribute to groundwater flow in the watershed. It is therefore likely that any groundwater discharge occurring in Robinson Creek and its tributaries is derived locally, rather than from deep regional groundwater flow. A minor portion of the Scarborough Formation is present below thick deposits of Newmarket Till in the northern portion of the watershed. The aquifer materials are made up of a deltaic sequence often beginning with a lower clay member overlying sands, silts and fluvial gravels. The spatial extent and nature of this aquifer is highly variable and typically is present in topographic bedrock lows such as bedrock depressions and valleys. Due to its depth and the presence of a thick confining unit above, the Scarborough Formation is not anticipated to contribute to groundwater discharge in the watershed.

4.3.1.3 Water Wells

A search of the Ministry of the Environment (MOE) water well database was conducted for the Robinson Creek Watershed. The number of wells located within the watershed was estimated by a query of the 2002 version of the MOE water well database. Using reliability codes, the results from MOE database were filtered for accuracy. A total of 27 wells were identified in the Robinson Creek Watershed by this method although it is recognized that this may be an underestimation (**Table 4.1**). These wells are shown on **Figure 4.4** and the corresponding MOE water well records are included in **Appendix E.1**.

Potable water in the Robinson Creek Watershed is generally derived from wells dug to permeable sand and gravel lenses in the Newmarket Till (**Table 4.1**). Some wells are drilled to bedrock aquifers, although these appear to be uncommon. Experience has shown that bedrock wells in the Whitby formation outside of the Robinson Creek Watershed generally have poor water quality due to elevated levels of iron and sulphur. It is likely that the bedrock wells in the Robinson Creek Watershed also would have poor groundwater quality.

A portion of the Scarborough Formation Aquifer has been identified in regional cross-section (**Figure 4.21**) and is identified in a small number of MOE well records from within the Robinson Creek Watershed. However, its extent and thickness is limited in the Robinson Creek Watershed, and therefore, it does not appear to be commonly utilized as a target aquifer for private wells.

As municipal development continues to increase within the watershed, more residences will obtain potable water from municipal servicing (derived from Lake Ontario) rather than groundwater.

Table 4.1 Summary of MOE Water Well Database

# MOE Water Wells	Drilled Wells	Dug Wells	Screened in Overburden Aquifer	Screened in Bedrock Aquifer
27	8	19	23	4

4.3.1.4 Groundwater Flow

No groundwater monitors were constructed as part of this study of the Robinson Creek Watershed. The interpretation of potentiometric level and groundwater flow is based upon analysis of the water levels of the wells in the MOE Water Well database and is presented on **Figure 4.5**. The potentiometric levels are based upon the wells screened in the overburden. The potentiometric level of wells completed in the bedrock were not included in the potentiometric level contours. The horizontal component of groundwater flow in the watershed has a gradient of approximately 0.015 m/m. The gradient increases to approximately 0.03 m/m near the centre of the watershed where topography is steepest. The lateral flow in the weathered till zone is not captured by the water table contour mapping as very few if any wells are screened in this unit. The vertical gradients through the till soils are downwards to the bedrock and stronger than the horizontal gradient at around 0.1 to 0.2 m/m based upon groundwater monitors in the neighbouring Tooley Creek Watershed (407 East EA).

Water table contours and groundwater flow directions subtly reflect the topographic contours in the study area and generally flow from north to south, indicating the influence of topography and soil type on the shallow groundwater flow system. Although the contours show a southwards groundwater flow direction, the presence of low permeability till within the watershed will cause downwards groundwater flow to dominate overall. Downwards flow occurs in the till because the shortest path to the permeable bedrock aquifer unit is downwards (~40 m) as opposed to laterally towards Lake Ontario (up to 5 km). Groundwater flow in higher permeability zones within the Ordovician bedrock is likely southwards towards Lake Ontario. Lateral groundwater flow likely occurs in the shallow weather till zone and discharges into Robinson Creek. As shown on **Figure 4.5,** groundwater flow paths bend slightly into river valleys and isolated topographic depressions, but generally flow southwards towards Lake Ontario.

4.3.1.5 General Field Observations

Field investigations were conducted between July 2009 and March 2010. The primary focus of the field observations was to qualitatively determine areas of groundwater discharge. During the study period, all tributaries of Robinson Creek were flowing, although it is recognized that the western tributary that crosses Prestonville Road receives inputs from a stormwater management pond that may keep it artificially flowing year round. The months of July and August experienced above average rainfall which made delineating baseflow conditions more difficult (see **Section 2.0**). However, September experienced little to no rainfall, which provided an optimal time to observe the characteristics of Robinson Creek under baseflow conditions (i.e., no surface water inputs, only groundwater). A hand auger was used at various locations within the watershed to characterize the shallow subsurface geology.

The field investigations have confirmed that the base of Robinson Creek rests on unweathered Newmarket Till deposits, which restricts infiltration and prevents loss of stream flow over the length of the creek. These soils are the foundations for the entire watershed and are found either at surface or just below surface. Based upon our investigations at a large cut slope to the north of Baseline Road and using a shallow hand auger along the length of Robinson Creek, it is apparent that the Newmarket Till makes up the base of the creek along its entire length. It appears that Robinson Creek has incised through the thin deposits of glaciolacustrine silts and clays that are shown to be present adjacent to the creek on **Figure 4.3** and exposed the Newmarket Till.

Minor groundwater seepage though the stream bank was observed over much of Robinson Creek which is believed to be derived primarily from lateral groundwater inputs from the weathered till zone and or shallow alluvial sediments. One spring was observed along the western bank of the creek to the east of the Recreation Centre off Prestonville Road (**Photographs 4 and 5**). Jewel weed was present around the spring. Plants such as watercress and marsh marigold are adapted to the constant temperature and low nutrient content of groundwater and may also be considered as indicators of groundwater discharge. These were observed at specific points within Robinson Creek were groundwater discharge was found to occur (**Figure 4.8**).

Photo 4. Seepage on the West Bank of Robinson Creek to the East of the Rec Centre
←

Photo 5. Close-up of Seepage on the West Bank of Robinson Creek
→

4.3.1.6 Mini-Piezometers

A total of 6 mini-piezometers were installed at 5 locations within the Robinson Creek Watershed (**Figure 4.1**). The groundwater level measurements are presented in **Appendix E.4**. The vertical hydraulic gradient between the deep and shallow mini-piezometer or the surface water level and the mini-piezometer is presented in **Figure 4.6**. When an upwards or positive hydraulic gradient is measured, then groundwater may be discharging in the creek at that point. When a downwards or negative hydraulic gradient is measured, the creek may be losing water to the ground at that point. Whether or not groundwater is entering or leaving the watercourse it highly dependent upon the permeability of the soils below the stream bed. For example, a strong upwards gradient may exist below a stream bed, but if the stream rests on a low permeability till base, groundwater discharge into the creek will be very small. It is also important to note that the first water level measurement in a mini-piezometer does not usually provide an accurate measurement of the groundwater table level as the groundwater has not reached a new equilibrium within the piezometer. When analyzed with subsequent observations of groundwater level, it does help provide an indication of the permeability of the surrounding soil. A fast recovery suggests permeable soil, whereas a slow recovery suggests low permeability soil. Mini-piezometers generally need to be measured for an entire year to establish the yearly trend of the hydraulic gradient. However, do to the time limitations of this project, only seven months of data could be collected, which gives an indication of the direction of the hydraulic gradients. Future seasonal monitoring will be required to confirm the results.

A summary of the mini-piezometer results are presented in **Table 4.2**.

Table 4.2 Mini-piezometer Summary

Mini-Piezometer	Location	Geological Unit	Average Gradient*	Groundwater Flow
RC-MP1 Nest	wetland south of Bloor Street	Weathered Till (shallow); Till (deep)	-1.09	Downwards
RC-MP2	Robinson Creek tributary near Prestonville Road	Unknown (potentially weathered Till)	0.10	Upwards
RC-MP3	Robinson Creek north of Baseline Road and railway culvert	Unknown (Likely Till)	-0.45	Downwards
RC-MP4	Robinson Creek south of Bloor Street	Not Functioning Properly		
RC-MP5	Robinson Creek east of Rec Centre	Unknown (Likely Till)	-0.39	Downwards

*Notes: * average since piezometer reached equilibrium*

- **<u>RC-MP1</u>**
  Mini-piezometer RC-MP1 was installed as a mini-piezometer nest within a wetland area to the east of Robinson Creek and to the south of Bloor Street. Since it was suspected that this wetland may not have any standing water during dry periods, both a shallow and a deep piezometer were installed at this location to help delineate the vertical gradient between the shallow and the deep groundwater. The groundwater level measured in the deep piezometer (RC-MP1d) was lower than that of the water level in the shallow piezometer (RC-MP1s). This suggests that the deep groundwater pressure is less than the shallow groundwater pressure and since groundwater flows from high to low pressure, the flow direction will be downwards. The hydraulic gradient between the water level in the shallow (RC-MP1s) and deep (RC-MP1d) piezometers showed an overall average downwards gradient of -1.09 (**Figure 4.6**). Further monitoring is recommended to obtain a yearlong data set.

- **<u>RC-MP2</u>**
  Mini-piezometer RC-MP2 was installed in a tributary to Robinson Creek on the east side of Prestonville Road. The groundwater level in the piezometer is higher than the stream water level, indicating that the groundwater pressure is greater than the surface water pressure. This indicates upwards groundwater flow or groundwater discharge (**Figure 4.6**). No obvious ecological indicators of groundwater discharge were observed at this location.

- **<u>RC-MP3</u>**
  The location of RC-MP3 was selected to determine if groundwater discharge was contributing to stream flow in a large pool located north of a railway culvert, north of Baseline Road. The groundwater levels in RC-MP3 show a downwards hydraulic gradient, suggesting groundwater recharge (**Figure 4.6**).

- **<u>RC-MP4</u>**
  Mini-piezometer RC-MP4 was installed in September 2009 to determine the nature of groundwater inputs to a small pool in Robinson Creek just south of Bloor Street. RC-MP4 was dry on all three monitoring events suggesting that the mini-piezometer is not functioning properly.

- **<u>RC-MP5</u>**
  Mini-piezometer RC-MP5 was also installed in September 2009 to specifically characterize an area where a groundwater spring and significant groundwater seepage were observed. It was installed on the stream bank, but the screened interval was placed below the base of Robinson Creek. The purpose of this mini-piezometer was to determine if groundwater seepage was a result of lateral groundwater flow or groundwater upwelling. The groundwater levels and hydraulic gradients in RC-MP5 show a downwards hydraulic gradient which supports the lateral groundwater seepage hypothesis at this location rather than groundwater upwelling.

In summary, the water levels measured in the mini-piezometers in Robinson Creek suggest that significant groundwater upwelling from buried aquifers is not occurring in the creek. This observation is consistent with the regional geological model that does not identify any shallow confined aquifer in the Robinson Creek Watershed. The observation of minor shallow groundwater discharge, sidebank seepage and isolated groundwater springs fits the conceptual model of lateral groundwater inputs from the upper weathered till zone and possibly from small isolated permeable lenses within the till. Although all of the groundwater levels in the mini-piezometers reached equilibrium over the seven months of monitoring (with the exception of RC-MP4), continued monitoring for at least one full year is recommended to confirm some of the results and assumptions presented.

4.3.1.7 Stream Temperature Logging

Tidbit continuous temperature loggers were installed below the surface water level at 3 mini-piezometer locations within Robinson Creek (RC-MP2, RC-MP3, RC-MP4; **Figure 4.1**). The hourly temperature results from the Tidbit loggers were compared against hourly temperature measured that the Oshawa Meteorological Station (Environment Canada, 2009) to determine the difference between the surface water temperature and the air temperature (**Figure 4.7**). A difference of greater than 5°C between the surface water temperature and the air temperature is a good indicator of groundwater discharge as groundwater generally maintains an average yearly temperature of between 5°C and 15°C, whereas air temperatures can reach 25°C to 30°C in the summer. Although stream temperature measurements were only collected for a seven month period, they were collected during the summer and winter months, when the difference between the air temperature and the groundwater temperature is the greatest.

A summary of the stream temperature results are presented in **Table 4.3**.

Table 4.3 Stream Temperature Summary

Temperature Logger Location	Location	Minimum Temperature	Maximum Temperature	Mean Temperature
Air	Oshawa Meteorological Station	-18.3	25.0	5.3
RC-MP4*	Robinson Creek south of Bloor Street	-2.8	18.4	4.4
RC-MP2	Robinson Creek tributary near Prestonville Road	0.0	26.6	9.7
RC-MP3	Robinson Creek north of Baseline Road and railway culvert	-0.1	25.3	8.8

*Notes: * temperature monitoring at RC-MP4 was conducted between September 9th 2009 and March 9th 2010. The others were measured between July 10th 2009 and March 9th 2010.*

- **<u>RC-MP2</u>**
  A stream temperature logger was installed at RC-MP2 in a tributary to Robinson Creek near where it crosses Prestonville Road. The surface water temperature between July 2009 and March 2010 generally mimicked the air temperature and did not show any indications of thermal buffering by groundwater (**Figure 4.7**). As shown in **Table 4.3**, the maximum stream temperature measured was 26.6°C and the mean water temperature was 9.7°C. Over the winter months (December to March), Robinson Creek did not freeze at this location as shown by the consistently above freezing water temperatures (**Figure 4.7**). This observation is indicative of groundwater inputs. It should be noted that a stormwater management pond discharges upstream of this location and may influence surface water temperatures. The hydraulic gradients measured at RC-MP2 show an upwards hydraulic gradient, suggesting groundwater discharge. Although upwards gradients were identified at this point, the low permeability of the Newmarket Till, which makes up the base of the creek, will only contribute a small volume of water to the creek. This small volume may not have the capacity for significant thermal buffering of the stream during the summer months, but may prevent the watercourse from freezing during the winter.

- **<u>RC-MP3</u>**
  A stream water temperature monitoring station was established here to determine the stream temperature in the lower reaches of the Robinson Creek Watershed. The surface water temperature between July 2009 and March 2010, mimicked the air temperature and did not show any thermal indications of temperature buffering by groundwater (**Figure 4.7**). As shown in **Table 4.3**, the maximum stream temperature measured was 25.3°C and the mean water temperature was 8.8°C. These surface water temperatures are indicative of a surface water fed system, which is consistent with the creek travelling several kilometres over a till base with only minor groundwater inputs..

- **<u>RC-MP4</u>**
  A stream temperature logger was installed at RC-MP4 in the upper reaches of Robinson Creek on September 9, 2009. The surface water temperature between September 2009 and March 2010 mimicked the air temperature and did not show any thermal indications of temperature buffering by groundwater (**Figure 4.8**). As shown in **Table 4.3**, the maximum stream temperature measured was 18.4°C and the mean temperature was 4.4°C. In the same period the average air temperature was 5.3°C and the maximum temperature was 21.5°C. Because these measurements were not taken during the peak summer conduction, it is difficult to classify Robinson Creek as a groundwater fed or surface water fed system based upon these data. However, it was observed that the average stream temperature of RC-MP4 was always above the average air temperature and the stream temperatures of the other two downstream monitoring locations. The sharp drop to -2.8°C over the winter further indicates that groundwater discharge is not occurring here. These data suggest that groundwater discharge is not occurring at RC-MP4 even though this area is near the headwaters of Robinson Creek and some groundwater inputs are expected.

In summary, as Robinson Creek flows a southward over the Newmarket Till, the stream temperature becomes warmer during the summer months due to limited thermal buffering by groundwater and significant surface water inputs. However, it is expected that groundwater discharge is occurring in the headwaters of the stream and potentially at specific point along its length. Lateral groundwater seepage along the banks contributes to flow along much of its length. Groundwater inputs may be relatively minor, but are sufficient to provide a cool water function and classification for Robinson Creek..

4.3.1.8 Creek Baseflow

Stream flow was measured during September 2009 at three locations in Robinson Creek: R1, R2, and R3 (**Figure 6.3**). These streamflow measurements was taken after a prolonged period of time without rainfall, however it should be noted that the summer of 2009 experienced above average rainfall amounts that may contribute groundwater inputs to streamflow for longer periods of time than are generally expected. That being said, the streamflow measurements taken in September 2009 are considered to represent baseflow in Robinson Creek.

Table 4.4 presents the stream flow measurements collected at R1, R2 and R3 in L/s. The pattern shows that stream flow increases downstream from 1.4 to 6.0 L/s during baseflow conditions Flow in the creek is expected to be dominated by surface water inputs, and the overall yearly stream flow rate will be largely controlled by “event” based flows such as rainfalls and the spring snow melt. Based upon the difficulties measuring small flow rates, it is anticipated that there is an error of between 10 and 20% for the stream flow values.

Table 4.4 Stream Flow Summary

Stream Flow Location	R1	R2	R3
September 2009	6.0 L/s	4.7 L/s	1.4 L/s
	South of Darlington Park Road	North of Baseline Road	South of Bloor Street

4.3.1.9 Groundwater Recharge

The purpose of this section is to provide a general discussion of recharge conditions that occur in the various areas and through the various geological units of the Robinson Creek Watershed. The predominant land use in the Robinson Creek Watershed continues to be agriculture, in the form of grains and soybeans. Developed areas of housing subdivisions are found in the north and western portions of the watershed. A review of the water well records and the MOE Permit to Take Water database reveals that there are no substantive takings (irrigation or municipal) from groundwater sources in this watershed.

Greater than 90% of the study area is covered by a layer of low permeability till or glaciolacustrine silt and clay (**Figure 4.3**). The majority of this watershed can be considered a groundwater recharge area, although the groundwater recharge rates are generally very low through till and silty clay soils. Surface runoff is expected to exceed infiltration. Estimates made by Gerber and Howard (2000) suggest that infiltration rates through till soils in the vicinity of the Oak Ridges Moraine may be as high as 150 mm/year, but are generally expected to be less. A small area of surficial sand is shown on the surficial geological mapping, but it is believed to be too small in extent and thickness to significantly contribute to the overall groundwater recharge rate in the watershed.

Groundwater recharge through the upper weathered Newmarket Till surface likely contributes in a small way to stream baseflow. Due to the presence of unweathered till below, groundwater flow is horizontal to discharge areas located at topographical lows such as Robinson Creek and its tributaries. This discharge has been observed in the field with diffuse seepage areas along the banks of the creek and the occasional spring. Mini-piezometers generally show a downwards hydraulic gradient, suggesting that Robinson Creek is losing water to the ground over most of its length. This loss is small, due to the stream base resting on Newmarket Till.

The infiltration rate through the unweathered Newmarket Till is what controls the overall groundwater recharge rate in the watershed. The water the infiltrates through this unit flows downwards towards bedrock aquifers and sand lenses within the till. Due to the low permeability of this unit, surface runoff of precipitation is expected to dominate over groundwater recharge and contribute more significantly to streamflow.

4.3.1.10 Groundwater Discharge

In general, groundwater discharge, or the upwards movement of water from the saturated zone to surface, sustains stream baseflow and wetlands that, in turn, may provide habitat for aquatic ecosystems or vegetation communities.

Groundwater discharge may also occur where the groundwater table is intersected by the land surface as sidebank seepage. The amount of discharge depends upon the soil‟s ability to convey the water, which as the following paragraphs identify, may not be very high in Robinson Creek. **Table 4.5** provides a summary of groundwater discharge observations.

Table 4.5 Summary of Groundwater Discharge Observations

	Observations
Surface Water Flow	a) The main branch of Robinson Creek and all of its tributaries were flowing under baseflow conditions. The headwaters of Robinson Creek, that are located to the north of Bloor Street, were flowing though a perched culvert at Bloor Street to the south.
Vertical Groundwater Gradients	b) RC-MP2, located in a tributary near Prestonville Road, had an upward gradient indicating the upwards movement of groundwater (***Section 4.3.1.6***). Piezometer RC-MP1s installed in a wetland area south of Bloor St., showed upwards gradients on the August 24th monitoring event and showed neutral gradients during the other monitoring events.
Vegetation	c) Plants that occur where groundwater is discharging to the surface such as watercress, were seen to the north of Bloor Street and where the Prestonville Road Tributary meets the main branch of Robinson Creek. Jewel Weed was identified near groundwater seeps behind the Rec Centre off Prestonville Road. Large areas of cattails can be found both north and south of Bloor Street and on the west side of Prestonville Road.
Seepage and Springs	d) Groundwater seepage was observed in two distinct areas 1) along the eastern and western slope of the Robinson Creek Valley between Bloor Street and the Prestonville Road tributary (**Photographs 4 and 5**) and 2) north of Bloor Street in the wetland area. A groundwater spring was identified east of the Rec Centre off Prestonville Road (**Figure 4.8**), which is likely derived from a sand lens within the till.

Similar to the discussion for groundwater recharge, groundwater discharge is also closely correlated to the surficial geological conditions, with the greatest discharge associated with permeable sediments and high water tables. Groundwater discharge area mapping provided by CLOCA provided a basis for which to begin to understand groundwater discharge relationships within the watershed. This mapping was simplified and is shown in **Figure 4.8**. The groundwater discharge area mapping provided by CLOCA was derived from a regional groundwater model that showed areas of potential groundwater discharge by highlighting areas where the water table was identified in MOE water well records as being within 1 m of the ground surface. This method of identifying groundwater discharge areas is usefully when characterizing discharge areas on a regional scale, but may not be representative at the small scale. A summary of all groundwater discharge observations made by the project team was overlain on the CLOCA groundwater discharge mapping and is presented on **Figure 4.8.**

4.3.1.11 Summary of Groundwater Supported Flow in Robinson Creek

Based upon the results of groundwater monitoring at 6 mini-piezometers, stream temperature logging, stream flow measurements, visual seepage observations, and analysis of the hydrostratigraphy of the watershed, it can be concluded that Robinson Creek is primarily a surface water fed stream that does not receive significant groundwater contributions from buried regional aquifers. Vertical hydraulic gradients are generally downwards and the low permeability of the basal till soils minimize groundwater/ surface water interactions.

However, baseflow measurements indicate that at distinct locations, minor groundwater discharge and sidebank seepage contribute to flow and help to provide a thermal buffer in Robinson Creek. Groundwater discharge occurs in the headwaters area located near Bloor Street and at specific locations were sand lenses in the Newmarket Till have been encountered (i.e., near the Rec Centre). These groundwater inputs are sufficient enough to sustain year-round flow and create a coolwater thermal regime for Robinson Creek.

4.3.2 Water Budget

4.3.2.1 Purpose and Objectives

A *water budget* is used to describe the movement of water in a watershed. The total *precipitation* accounts for the water that falls both as rainfall and as snow, and constitutes the total amount of water available in a watershed. A large portion of the precipitation (often up to 60%) is returned to the atmosphere by *evaporation* or plant *transpiration*. The combined process of evaporation and transpiration is called *evapotranspiration (ET)*. The remaining water (~40%) comprises what is known as the *water surplus*. This is the water that is available to *runoff* to the stream system or *infiltrate* to the groundwater.

The proportion of the water surplus that is infiltrated depends upon the characteristics of the soils in the watershed, the topography, the land use and the vegetative cover that is present. This concept is based upon the fact that water will infiltrate more easily though flat lying, high permeability soils than it will though steep slopes or low permeability soils. Naturally vegetated cover accepts infiltration more readily than urban developments. Water the infiltrates to the ground recharges the water table. This water may flow downwards towards deep aquifers or it may flow laterally towards river valleys and contribute cold, groundwater discharge. The travel time though the soil creates a long time lag (often ranging from weeks to many years) between when the water infiltrated and when it is exposed at surface again.

Surface runoff on the other hand generally coincides with rainfall events. As the surficial soil layers become saturated by rainfall, water may runoff to low lying areas. The amount of runoff depends on a large number of factors such as soils type, slope gradients, vegetative cover and the soil moisture prior to the rainfall. Runoff contributes water to stream flow at a much faster rate than groundwater will, and often at a much greater volume. The runoff water will have a temperature that mimics the air temperature and can be identified from groundwater in stream flow by a difference in temperature.

For the Robinson Creek Watershed, a water budget has been prepared to characterize the relative importance of the various components of water movement. This will not only help confirm some of the conclusions from the previous sections, but will also allow for a qualitative assessment of future conditions.

Meteorological data from the Oshawa Meteorological Station (Environment Canada, 2009) is used to calculate the precipitation and evapotranspiration components of the water budget. Runoff and infiltration components are estimated using site specific information about the soils, topography, vegetative cover, and stream baseflow conditions. A water budget has been prepared for the existing conditions of the Robinson Creek Watershed.

4.3.2.2 Meteorological Data and the Water Balance

Long term meteorological data from 1971 – 2000 average was obtained from Environment Canada for the Bowmanville Mostert Meteorological Station (Environment Canada, 2009), to be used to calculate the total precipitation and ET. The mean annual water surplus was calculated using the method described in Thornthwaite and Mather (1957), using a monthly time step and assuming a soil moisture of 150 mm. The soil moisture was estimated according to Thornthwaite and Mather, through analysis of soil type and vegetation in the watershed. The overall water surplus (the difference between the mean annual precipitation and ET) was then calculated and consists of the water available for runoff and infiltration.

A summary of the monthly mean precipitation rate, average daily air temperature, actual evapotranspiration and the generated water balance surplus is presented in **Table 4.6**. The long term average annual mean precipitation at the Bowmanville Mostert Meteorological Station was 857.8 mm/yr. There is obviously some variation from year to year, but this value constitutes a reasonable average value for the Robinson Creek Watershed given its similar elevation and proximity to Lake Ontario. The mean annual evapotranspiration is calculated to be 493.7 mm/yr. The mean annual water surplus is therefore calculated to be the difference, which is 364.1.mm.

Table 4.6 Monthly Water Budget Summary

Month	Mean Monthly Temperature (°C)[1]	Mean Monthly Precipitation (mm) [1]	Actual Evapotranspiration[2] (mm)	Water Balance – Surplus (mm)
January	-6.3	63.1	0.0	63.1
February	-5.3	47.2	0.0	47.2
March	-0.5	60.7	0.0	60.7
April	6	72.9	28.3	44.6
May	12.2	73.7	59.6	14.1
June	17.1	81.5	85.1	-3.6
July	19.8	63.7	99.2	-35.5
August	18.9	81.0	94.5	-13.5
September	14.7	90.5	72.6	17.9
October	8.4	67.9	40.3	27.6
November	3.1	84.0	14.1	69.9
December	-2.7	71.6	0.0	71.6
Year (mm/yr)		**857.8**	**493.7**	**364.1**

Notes: 1. Data obtained from the 1971 – 2000 average at the Bowmanville Mostert Meteorological Station.
2. Evapotranspiration calculated using the Thornthwaite and Mather (1957) method.

4.3.2.3 Infiltration Factors

The partitioning of the water surplus between runoff and infiltration depends on a number of physical properties of the watershed including, soils, topography, and cover. Water will infiltrate more easily through sand than it will through clay or till, and more easily on flat slopes than on steep slopes. The infiltration factors range between 0 and 1. An infiltration factor of 0.6 would mean that 60% of the water surplus is expected to infiltrate and 40% will therefore become runoff.

Infiltration factors were calculated using a method developed by Bernard (1932) and accepted by the MOE (1995). The total infiltration factors are calculated by summing the individual subfactors that are dependent upon the topography, soil, and cover at the site.

Table 4.7 presents a breakdown of the infiltration factors for the various soil types in the watershed. The three dominate soil types are glaciolacustrine silt and clay, Newmarket Till and glaciolacustrine fine sand.

The topography of the watershed can be described as rolling, generally with low gradients. The watershed slopes in general, range between approximately 0.15% in the tableland areas to approximately 6% near the Robinson Creek valley; however this makes up a very small portion of the watershed. The dominate land use in the watershed is agriculture, although urban developments are quickly becoming a more dominant land use category. To assess the existing conditions, it was assumed that cultivated cropland dominated the infiltration subfactors.

Table 4.7 Infiltration Factor Calculations (from MOE 1995)

Subfactor	Glaciolacustrine Silt and Clay		Newmarket Till		Glaciolacustrine Fine Sand	
	Description	*Factor*	*Description*	*Factor*	*Description*	*Factor*
Topography	rolling	0.15	rolling	0.15	rolling	0.15
Soil	silt and clay	0.1	weathered till	0.15	fine sands	0.3
Cover	cultivated	0.1	cultivated	0.1	cultivated	0.1
Total Factor	**0.35**		**0.40**		**0.55**	

The results of this exercise yields infiltration subfactors that range from 0.35 to 0.55 (**Table 4.7**) depending upon soil type. Each infiltration subfactor was applied to the area of the representative soil type to determine the amount of recharge.

4.3.2.4 Water Budget for Existing Conditions

Using the calculated water surplus and the infiltration subfactor for each soil type, a water balance was completed for the existing conditions of the Robinson Creek Watershed (**Table 4.8**). This was calculated by first measuring the area (in m^2) of each of the surficial soil types in the Robinson Creek Watershed. The Newmarket Till covers 4,236,130 m^2 (73% of Robinson Creek Watershed), Glaciolacustrine silt and clay covers 1,297,902 m^2 (22% of watershed) and Glaciolacustrine sand covers 246,368 m^2 (5% of watershed). The yearly contribution to infiltration and runoff from each area was then calculated by multiplying the area (in m^2) by the surplus [in m/yr (1 m = 1,000 mm)].

Table 4.8 Water Budget for Existing Conditions

Soil Type	Area (m^2)	Precipitation		Evapotranspiration		Surplus		Infiltration		Runoff	
		(m^3/yr)	(mm/yr)	(m^3/yr)	(mm/yr)	(m^3/yr)	(mm/yr)	(m^3/yr)	(mm/yr)	(m^3/yr)	(mm/yr)
Newmarket Till	4,236,130	3,633,752	857.8	2,091,377	493.7	1,542,375	364.1	616,950	145.6	925,425	218.5
Glaciolacustrine Silt and Clay	1,297,902	1,113,340	857.8	640,774	493.7	472,566	364.1	165,398	127.4	307,168	236.7
Glaciolacustrine fine Sand	246,368	211,334	857.8	121,632	493.7	89,702	364.1	49,336	200.3	40,366	163.8
Total	**5,780,400**	**4,958,427**	**857.8**	**2,853,783**	**493.7**	**2,104,644**	**364.1**	**831,684**	**143.9**	**1,272,959**	**220.2**

Evapotranspiration accounts for approximately 58% of the mean annual precipitation. Of the remaining 42% of water (the Surplus), approximately 40% infiltrates to the groundwater as recharge and 60% becomes runoff and supports stream flow in Robinson Creek. Of the total precipitation that falls on the watershed, only 40% becomes groundwater recharge, which is not unexpected given the thick deposits of low permeability soils at surface. Runoff dominates infiltration in the Robinson Creek Watershed by a ratio of 1.5:1.

Due to the tight nature of the surficial soils in the watershed, it makes sense that runoff contributes more to stream flow than groundwater. If it is assumed that all runoff contributes to stream flow in Robinson Creek then the average yearly flow rate would be 40.4 L/s. This value is much greater than the 6.0 L/s measured at Station R1 (**Figure 6.3**) under baseflow conditions. Although storm flows have not been measured, it is likely that flows in the creek peak quite dramatically after a precipitation event or during snow melt. An average flow rate of 40.4 L/s is reasonable for a creek of this size, although this average is highly dependent upon event based flows.

A Darcy Flux was calculated as a second, independent determination of the groundwater infiltration rate to confirm the results of the MOE (1995) method. A Darcy flux is a volume per time per area calculation that is standard in hydrogeology and as written as follows:

$$Q = \frac{k * (dH_v/dL_v)}{A}$$

Although no groundwater monitors are present in the Robinson Creek Watershed, the 407 East EA provides a summary table of the average hydraulic conductivity of each of the hydrostratigraphic units present in the Tooley Creek Study area based upon a regional dataset. The geological and hydrogeological conditions presented in these dataset are considered to be a reasonable surrogate for the conditions in the Robinson Creek Watershed for the purpose of this calculation. A total vertical Darcy Flux of 846,422 m^3/yr was calculated as the yearly infiltration rate in the Robinson Creek Watershed (**Table 4.9**).

Table 4.9 Darcy Flux Infiltration Rate

Soil Type	K (m/s)	dHv/dLv	Area	Infiltration (m^3/s)	Infiltration (m^3/yr)
Newmarket Till	3.2×10^{-08}	0.13	4,236,130	0.018	555,737
Glaciolacustrine Silt and Clay	4.4×10^{-08}	0.13	1,297,902	0.0074	234,123
Glaciolacustrine fine Sand	5.6×10^{-06}	0.0013	246,368	0.002	56,562
Estimated From the Darcy Flux					846,422
Estimated From Water Balance					831,684
Percent Difference					2%

Since the unweathered Newmarket Till controls the overall groundwater recharge in the watershed, a hydraulic conductivity for this unit was used. The average horizontal hydraulic conductivity (K) for the Newmarket Till was determined to be 3.2×10^{-7} m/s (407 East EA). The presence of fractures and sand lenses in the Newmarket Till are known to increase the horizontal hydraulic conductivity, which may cause k-values obtained by slug testing to overestimate the hydraulic conductivity of the till. Previous studies have assumed that $K_h = 10K_v$ for the Newmarket Till (CAMC/YPDT 01-06; Gerber and Howard, 2002; and Martin and Frind, 1998). Therefore, for the purpose of calculating vertical infiltration through the Newmarket Till as part of this study, a value of 3.2×10^{-8} m/s will be used. The K value of glaciolacustrine silt and clay was found to average 4.4×10^{-8} m/s and glaciolacustrine sand was found to average 5.6×10^{-06} m/s (407 East EA). These values were used to calculate the Darcy Flux for the individual units.

A vertical hydraulic gradient (dH_v/dL_v) was estimated from the TC-BH1 well nest in the Tooley Creek Watershed from the difference between the water level in TC-BH1S and TC-BH1D over the difference in length of their well screens. An average vertical hydraulic gradient of 0.13 was calculated between January 2008 and September 2009. This gradient is considered to be representative for vertical flow in low permeability units such as the Newmarket Till and the glaciolacustrine silt and clay. Experience has shown that vertical hydraulic gradients are considerably less in high permeability materials such as silts and sands because of the ease at which water can move through the material. Therefore, an average vertical hydraulic gradient of 0.0013 m/m was considered to be representative for infiltration through the glaciolacustrine sand in the watershed (two orders of magnitude less). This gradient is also consistent with the assumption that horizontal flow dominates over vertical flow in the surficial sand aquifer.

The average volume of infiltration through the Newmarket Till was determined to be 846,422 m^3/yr. This represents a 2% variation from the infiltration rate estimated from the water balance using the MOE 1995 and the Thornthwaite and Mather (1957) method presented in Section 4.3.2.4. The similarity of these two results lends confidence that the assumptions made when calculating the water balance were reasonable.

4.3.2.5 Groundwater Inputs to Robinson Creek

In **Section 4.2.2.10**, it was concluded that lateral groundwater inputs from the weathered till unit contributed to baseflow in Robinson Creek. This was based upon observations of sidebank seepage. The horizontal groundwater flow towards the creek can be calculated by using the Darcy principal. Using this basic hydrogeological approach, we can estimate what the weathered till zone could contribute to the baseflow of the creek. This value can be compared against the measured baseflow values in Robinson Creek as measured at Station R1 and presented in **Table 4.4**.

A hydraulic conductivity value of 2.7×10^{-6} ms/ was obtained from TC-BH2S which is screened in the weathered Newmarket Till in the Tooley Creek Watershed and is used to represent the weathered till in the Robinson Creek Watershed. Because this unit is weathered, this value is considered representative for both the vertical and horizontal hydraulic conductivity. The land surface slopes sharply towards the Robinson Creek Valley at a slope of approximately 6% (0.06 m/m). This value is assumed to be equal to the hydraulic gradient of groundwater flow towards the creek. An area of approximately 30,000 m^2 was estimated to be the contributing area from the weathered till to Robinson Creek assuming a saturated thickness of the weathered till of 2.0 m and a cumulative length of stream (both sides) of 15 km.

As shown in **Table 4.10**, the calculated discharge from the weathered till zone is 4.9 L/s, which is less than the stream flow measured at R1 of 6.0 L/s. However, this value does not account for the contribution from groundwater springs and other minor sources of water in the watershed. Given that this independent calculation is of the same order of magnitude as the measured value, it provides some level of confidence in the estimated water balance

Table 4.10 Groundwater Contribution to Baseflow from the Weathered Till Zone

K (m/s)	dH/dL	Area (m^2)	Discharge (m^3/s)	Discharge (L/s)
2.7 x 10^{-06}	0.06	30,000	0.0049	4.9
Measured at Station R1				6.0
Percent Difference				19%

It can therefore be concluded that Robinson Creek flows permanently due to a small contribution from groundwater from the weathered till zone and from minor groundwater springs, even during long periods of little to no precipitation. Previously infiltrated water contributes to stream baseflow. The soils in the watershed are tight and relatively impermeable, which results in a low infiltration capacity and an overall low recharge function.

4.3.3 Conclusions and Recommendations

A detailed understanding of the geological and hydrogeological conditions in the Robinson Creek Watershed is critical to understanding the ecological function of the watershed. The presence of groundwater discharge or a shallow water table can support specific plant communities. The nature and location of groundwater inputs to the watercourses can be used to help understand the pattern of fish and aquatic communities that rely on the thermal regime created by groundwater inputs for habitat. For these reasons, it is important for local managers to have an understanding of the groundwater conditions within a watershed to avoid or mitigate for developments which may disturb the quantity and quality of local groundwater and its relationship with the natural environment.

The Robinson Creek Watershed is primarily underlain by low permeability, Newmarket Till soils, which restricts groundwater recharge and promotes surface runoff. Water budget calculations show that runoff exceeded infiltration by approximately 1.5:1. Minor amounts of groundwater recharge occurs in the weathered till soils and flows laterally towards discharge areas in the Robinson Creek valley. Groundwater discharge from the weathered till zone is sufficient to sustain baseflow in Robinson Creek during periods with limited precipitation. No significant regional confined aquifers were identified within the watershed and therefore groundwater that is recharged locally supports groundwater discharge and baseflow in Robinson Creek.

Stream temperature measurements confirm that Robinson Creek and its tributaries are predominantly surface water fed. Although a few significant areas of groundwater discharge were identified, the small volume of groundwater inputs does not appear to have a significant enough buffering capacity to dominate the temperature of Robinson Creek. Protection of the headwaters area to the north of Bloor Street will be critical to maintain the small amounts of groundwater inputs into Robinson Creek.

There is no municipal supply wells located in the Watershed and domestic water users have traditionally utilized groundwater for potable water use. These wells generally derive their water from lenses within the Newmarket Till. With increasing urban development in the Watershed, more domestic users are obtaining water from municipal systems that derive water from Lake Ontario.

No groundwater samples were collected as part of this study, but owing to the Newmarket Till aquitard at surface, it is anticipated that groundwater quality in the watershed is likely generally good. Surface water samples collected as part of the Aquatic Study (***Section 6.0***) found that the water quality of Robinson Creek has been impacted by local farming activities (e.g., elevated concentrations of ammonium and phosphorus). Due to the significant amount of surface runoff in the watershed, these concentrations area likely derived from a surficial source and are not reflective of the groundwater quality.

It is recommended that the instrumentation used for this study continue to be monitored to establish long-term trends (at least seasonal and annual trends).

The average annual precipitation in the Robinson Creek Watershed is 857.8 mm/yr. 493.7 mm/yr is lost to evaporation and transpiration by plants. The presence of dense till soils limit infiltration to only 143.9 mm/yr and the remainder (220.2 mm/yr) is lost to runoff. An average of 143.9 mm/yr of infiltration serves to recharge the water table, provides some minor baseflow to Robinson Creek and replenishes small aquifer units within the till. Because of the low permeability soils in the watershed, opportunities to enhance infiltration in the watershed are limited. However, this also means that impacts to infiltration due to changes in land use will also be limited. Losses of some infiltration in the watershed due to development will not have an adverse impact on the overall water balance. However, a target of 143.9 mm/yr of infiltration should generally be maintained in the vicinity of Robinson Creek and its tributaries to maintain the existing baseflow conditions.

4.4 Tooley Creek Watershed

4.4.1 Study Area and Scope

This chapter focuses on the geological and hydrogeological conditions within the watershed and how they relate to its overall natural function. This analysis includes a discussion of the surface and subsurface geological materials in watershed, descriptions and hydraulic characteristics of the aquifer and aquitard materials, and the patterns of groundwater flow. A water balance is presented to quantitatively assess the significance of groundwater recharge and surface runoff and its contributions to stream flow and groundwater recharge. No groundwater monitoring wells were installed as part of this project, although 2 monitoring well nests are present in the watershed that were installed as part of the 407 East EA. Information on the groundwater table elevation and groundwater flow, as well as groundwater use, will be derived from these two monitoring wells, from the Ministry of the Environment (MOE) Water Well Records and from representative information in similar geoenvironmental settings, contained in secondary source information.

4.4.2 Results and Discussion

4.4.2.1 Geology and Physiography

As with the neighbouring Robinson Creek Watershed, an understanding of the geological conditions in the Tooley Creek Watershed provides the basis for further analysis of the natural function of the watershed.

The Tooley Creek Watershed is located within Iroquois Plain physiographic region, which is a gently sloping lowland area extending from the edge of the till plain of the South Slope region (located to the north of the study area) down to Lake Ontario (Chapman and Putnam, 1984). It is important to know that this feature is an extensive east to west feature extending from Burlington to Trenton, and hosts many interesting natural heritage features that rely on shallow groundwater conditions. Much of it has been developed and the remnants provide pathways for wildlife movement (Section 7.0). The Tooley Creek Watershed hosts an undeveloped portion of this unique geologic feature, something the Robinson Creek Watershed does not. The geology of the Tooley Creek Watershed consists of Quaternary sediments that overlie Ordovician bedrock. The base soil in the area is the stony, sandy, silt Newmarket Till (**Figure 4.9**). This unit is very dense and restricts groundwater flow and infiltration.

The Iroquois Plain is generally covered by shallow lake deposits of fine sand, silt and clay. These deposits were deposited by glacial melt water discharging into Glacial Lake Iroquois and can be classified as glaciolacustrine. A portion of the Iroquois Plain Shallow Aquifer is present at surface in the northern portion of the watershed (**Figure 4.11**). The shoreline of Lake Iroquois is characterized by raised sand and gravel beach deposits and can be found to the north and east of the watershed. Fine sand deposits were deposited close to the former shoreline (shown in yellow on Figure 4.11), with subsequent deposits of silts and clays being deposited farther south (closer to present day Lake Ontario). Some minor deposits of glaciolacustrine sand, silt and clay are present within the Tooley Creek Watershed but the Newmarket Till dominates the surficial materials. On **Figure 4.11,** the sand deposits are shown in yellow and the silts and clays are shown in blue. The Newmarket Till is shown in green.

The bedrock that underlies the Quaternary sediments ranges in depth of between ~55 metres above sea level (mASL) near the north end of the watershed and ~29 mASL near Lake Ontario, as estimated from MOE water well records (**Appendix E.2**). The bedrock is comprised of flat-lying Palaeozoic limestones and shales that are upper Ordovician in age (Liberty, 1969). The northern portion of the watershed is underlain by the blue-grey shales of the Blue Mountain Formation (**Figure 4.10**). This unit is also referred to locally as the Whitby Formation. The southern portion is underlain by the Lindsay Formation limestone. No bedrock outcrops are known to exist in the Tooley Creek Watershed.

4.4.2.2 Hydrogeology

The presence of thick deposits of Newmarket Till at surface within the watershed controls the groundwater conditions in the Tooley Creek Watershed (**Figures 4.11 and 4.21**). This unit is very dense and restricts groundwater flow and infiltration. The Newmarket Till is a major regional aquitard for the area. Based upon previous studies, the Newmarket Till Aquitard has a hydraulic conductivity that ranges from 10^{-6} to 10^{-9} m/s depending upon the degree of weathering the till has undergone (YPDT-CAMC Technical Report #01-06). The results of the 407 East EA have shown that the Newmarket Till within the study area has an average hydraulic conductivity of 3.2×10^{-07} m/s. When weathered, the hydraulic conductivity was shown to increase by approximately an order of magnitude and has an average value of 2.0×10^{-06} m/s. Borehole TC-BH2s, which is in the Tooley Creek Watershed, and is screened in the weathered till has a hydraulic conductivity of 2.7×10^{-06} m/s, which fits within the regional range. Due to its low permeability, groundwater flow within the till is generally downwards towards more permeable bedrock aquifers, but a minor lateral component likely bends towards the river valleys. Groundwater flow in the upper weathered zone (generally assumed to represent the upper ~3.0 m) is lateral towards the creeks.

The high permeability of the sandy near shore deposits of the Iroquois Plain Shallow Aquifer, which can be found at the north end of the watershed, provides a pathway for local groundwater recharge and discharge. The results of the 407 East EA have shown that the Iroquois Plain Aquifer in the vicinity of the study area has an average hydraulic conductivity of 5.6×10^{-06} m/s. The water table is typically near surface because the low permeability of the underlying Newmarket Till restricts drainage to depth. Significant groundwater discharge to Tooley Creek from the Iroquois Plain Shallow Aquifer is occurring and contributes to stream flow. Diffuse groundwater discharge to Tooley Creek from the weathered Newmarket Till will also contribute to stream flow, although due to the low permeability of the material, this input is expected to be minor.

The Newmarket Till Aquitard is regionally known to contain isolated deposits (lenses) of sand and gravel, created by small outwash features below the glaciers. These deposits are often utilized as aquifers for residential groundwater use. Where a surficial feature such as Tooley Creek has cut deep enough into the Newmarket Till, these lenses may become exposed and form groundwater springs. These springs are isolated but contribute to stream flow at discrete locations.

The southern extent of the major regional aquifer units such as the Thorncliffe Aquifer and the Oak Ridges Moraine Aquifer, pinch out to the north of the Tooley Creek Watershed (YPDT-CAMC Technical Report #01-06) (**Figure 4.21**). These units do not contribute to groundwater flow in the watershed. It is therefore likely that any groundwater discharge occurring in Tooley Creek and its tributaries is derived locally (i.e., from the Iroquois Plain Shallow Aquifer or the weathered till), rather than from deep regional groundwater flow. A minor portion of the Scarborough Formation is present below thick deposits of Newmarket Till in the northern portion of the watershed. The aquifer materials are made up of a deltaic sequence often beginning with a lower clay member overlying sands, silts and fluvial gravels. The spatial extent and nature of this aquifer is highly variable and typically is present in topographic bedrock lows such as bedrock depressions and valleys. Due to its depth and the presence of a thick confining unit above, the Scarborough Formation is not anticipated to contribute to groundwater discharge in the watershed.

4.4.2.3 Water Wells

A search of the Ministry of the Environment (MOE) water well database was conducted for the Tooley Creek Watershed. The number of wells located within the watershed was estimated by a query of the 2002 version of the MOE water well database. Using reliability codes, the results from MOE database were filtered for accuracy. A total of 88 wells were identified in the Tooley Creek Watershed by this method, although it is recognized that this may be an underestimation (**Table 4.11**). These wells are shown on **Figure 4.12** and the corresponding MOE water well records are included in **Appendix E.2**.

Depending upon the location in the Tooley Creek Watershed, potable water is generally derived from wells dug to permeable sand of the Iroquois Plain Aquifer or into sand and gravel lenses in the Newmarket Till (**Table 4.11**). Some wells are drilled to bedrock aquifers, although these appear to be uncommon. Experience has shown that bedrock wells in the Whitby Formation bedrock generally have poor water quality due to elevated levels of iron and sulphur. It is likely that the bedrock wells in the Tooley Creek Watershed also would have poor groundwater quality.

A portion of the Scarborough Formation Aquifer has been identified in regional cross-section (**Figure 4.21**) and is identified in a small number of MOE well records from within the Tooley Creek Watershed. However, its extent and thickness is limited in the watershed, and therefore, it does not appear to be commonly utilized as a target aquifer for private wells.

The highest concentration of wells is located in the northern portion of the study area, where glaciolacustrine sands from the Iroquois Plain Shallow Aquifer form a water-bearing unconfined aquifer. Bedrock wells are most common in the southern portion of the study area where the Newmarket Till Aquitard is most thin.

Table 4.11 Summary of MOE Water Well Database

# MOE Water Wells	Drilled Wells	Dug Wells	Screened in Overburden Aquifer	Screened in Bedrock Aquifer
88	40	38	72	16

4.4.2.4 Groundwater Flow

The interpretation of potentiometric level and groundwater flow is based upon analysis of the water levels of the wells in the MOE Water Well database and is presented on **Figure 4.13**. The potentiometric levels are based upon the wells screened in the overburden. The potentiometric level of wells completed in the bedrock were not included in the potentiometric level contours. Two groundwater monitoring well nests are located within the Tooley Creek Watershed but were not used to determine the groundwater flow contours for the watershed. Rather, they were used as an independent check of the contouring results. The groundwater level in groundwater monitor TC-BH1s ranged between ~137.45 and 136.75 mASL over the study period (**Figure 4.15**) and predictably fell between the 135 and 140 mASL contours. The groundwater level in groundwater monitor TC-BH2s ranged between ~145.8 and 144.2 mASL over the study period and was significantly different than the 120 to 125 mASL contours near its position. The elevation of this well is under review and therefore it could not be used to verify the results of the contouring.

The horizontal component of groundwater flow in the watershed varies depending upon the surficial geology. Where the Iroquois Plain Aquifer is present at surface, the horizontal gradient is approximately 0.007 m/m. This small gradient reflects the flat surface topography of the area. Where the surficial sand is absent and Newmarket Till is found at surface, the horizontal gradient increases to approximately 0.013 m/m. The topography is steepest in this portion of the watershed. The lateral flow in the weathered till zone is not captured by the water table contour mapping as very few if any wells are screened in this unit. The vertical gradients through the till soils are downwards to the bedrock and stronger than the horizontal gradients at around 0.1 to 0.2 m/m based upon groundwater levels in groundwater monitor TC-BH1 (407 East EA).

Potentiometric level contours and groundwater flow directions subtly reflect the topographic contours in the study area and, similar to Robinson Creek Watershed, generally flow from north to south, indicating the influence of topography and soil type on the shallow groundwater flow system. Although the contours show a southwards groundwater flow direction, groundwater flow in the Newmarket Till is predominantly downwards. Downwards flow occurs in the till because the shortest path to the permeable bedrock aquifer unit is downwards (~40 m) as opposed to laterally towards Lake Ontario (up to 5 km). Groundwater flow in higher permeability zones within the Ordovician bedrock is likely southwards towards Lake Ontario. Lateral groundwater flow will dominate in the Iroquois Plain Aquifer due to poor drainage through the Newmarket Till below.

Lateral groundwater flow will also occur in the shallow weather till zone and discharge into Tooley Creek. As shown on **Figure 4.13,** groundwater flow paths bend slightly into river valleys and isolated topographic depressions, but generally flow southwards towards Lake Ontario.

4.4.2.5 General Field Observations

Field investigations were conducted between July 2009 and March 2010. During the study period, all but one of the significant tributaries to Tooley Creek was flowing. The tributary that crosses Courtice Road just south of Bloor Street was not flowing in July 2009, although rainfall had been recorded over the previous few days.

The months of July and August experienced above average rainfall which made delineating baseflow conditions more difficult (see **Section 2.1**). However, September experienced little to no rainfall, which provided an optimal time to observe the characteristics of Tooley Creek under baseflow conditions (i.e., no surface water inputs, only groundwater). A hand auger was used at various locations within the watershed to characterize the shallow subsurface geology.

Field investigations have confirmed that the headwaters of Tooley Creek begin near the Maple Grove Wetland Complex north of Highway #2. As the stream flows southward it passes over the southern extent of the Iroquois

Plain Shallow aquifer. To the south of Bloor Street, Tooley Creek generally rests on unweathered Newmarket Till deposits, which restricts infiltration and prevents loss of stream flow over the length of the creek. These soils are the foundation for the entire watershed and are found either at surface or just below surface throughout the watershed. Minor lateral groundwater seepage was observed along the bank of Tooley Creek to the south of Bloor Street, where there is a small pocket of glaciolacustrine sand. Between Bloor Street and Baseline Road groundwater seeps were identified and presumably are derived from exposed sand lenses within the till or from seepage from the lower contact of the fine-textured glaciolacustrine deposits with the underlying till (**Figure 4.20**). A spring was observed in the eastern tributary to Tooley Creek to the south of Bloor Street. South of Baseline Road Tooley Creek again rests on Newmarket Till deposits and minor lateral groundwater seepage can be observed from the weathered till.

4.4.2.6 Groundwater Monitors

Two groundwater monitoring well nests, TC-BH1 and TC-BH2, are present in the Tooley Creek Watershed and were installed as part of the 407 East Environmental Assessment. These wells were monitored as part of this study. The dataset collected as part of this study was combined with the data from the 407 East EA and was used to assess the long term trends of water levels in the watershed.

TC-BH1 is located on the north side of Highway #2 near the Maple Grove Wetland Complex. This groundwater monitor nest consists of deep (TC-BH1s) and shallow (TC-BH1d) monitors that are screened in the surficial Iroquois Plain Shallow Aquifer and the underlying Newmarket Till deposit, respectively. According to the 407 East EA, the thickness of the Iroquois Plain Aquifer is 3.1 m at TC-BH1s.

Between December 2007 and March 2010, the water table depth in the glaciolacustrine deposit, as measured in TC-BH1s, ranged from 137.63 mASL (2.06 mbgs) to 139.46 mASL (0.23 mbgs) (**Figure 4.14**). Over the same period, the piezometeric head in TC-BH1d ranged from 136.51 mASL (3.18 mbgs) to 138.17 mASL (1.52 mbgs). **Figure 4.15** shows the manual water level data and the continuous water level data as measured with Solinst™ Leveloggers between July 2009 and March 2010. The shallow water levels in the surficial sand aquifer respond to precipitation events, which confirms that groundwater recharge is derived from local infiltration. The water levels in the deep monitor also respond to precipitation events by responding to changes in hydraulic pressure by the higher water table. The magnitude of the water level response in the deeper well is therefore subdued relative to the shallow monitor and there is a distinct, but small time lag before a response is observed in the deep compared to the shallow monitor. These results are expected given that TC-BH1d is screened at a deeper depth and in a lower permeability unit than TC-BH1s. A consistent downwards hydraulic gradient of approximately 0.13 m/m exists between the surficial glaciolacustrine aquifer and the deeper Newmarket Till aquitard, indicating a groundwater recharge area.

TC-BH2 is located on the north side of Bloor Street near the Tooley Creek Watershed boundary in the east. This groundwater monitor nest consists of deep (TC-BH2d) and shallow (TC-BH2s) monitors that are both screened in the Newmarket Till. However, TC-BH2s is screened in the upper weathered zone and TC-BH2d is screened in the unweathered till below. The Iroquois Plain Shallow Aquifer is absent from this area. According to the 407 East EA, borehole TC-BH2 encountered 11.3 m of silty sand Newmarket Till. A thin sand layer was encountered between 7.7 and 8.1 mbgs and is interpreted to be a sand lens within the till. A layer of gravelly sand till was found at the base of the borehole between 11.3 and 12.1 mbgs.

The water table elevation in TC-BH2s ranged from 144.11 mASL (1.90 mbgs) to 145.85 mASL (0.16 mbgs) between April 2008 and March 2010 (**Figure 4.16**). Over the same time period, the piezometric head in TC-BH2d ranged from 144.17 mASL (1.78 mbgs) to 146.22 mASL (0.27 m above ground surface). The thin sand layer encountered in TC-BH2d may be the source of the minor artesian pressure. A small upwards hydraulic gradient exists between the shallow and deep till indicating upwards groundwater movement (albeit minor). These groundwater levels also indicate that the shallow water table in the weathered till is at or near surface because drainage is restricted by the more competent till below. Both the shallow and the deep water levels respond to seasonal changes in precipitation and therefore, water is likely derived from local infiltration.

4.4.2.7 Groundwater Quality

Groundwater chemistry results were obtained from the 407 East EA Report for groundwater monitors within the Tooley Creek Watershed and were analyzed as part of this report. The results are presented in **Appendix E.3**. Samples TC-BH1d, TC-BH2d, and TC-BH2s are all from the Newmarket Till aquitard, whereas sample TC-BH1s is from the Iroquois Plain Shallow Aquifer. Typical to groundwater in southern Ontario, each of the samples would be described as hard with high concentration of anions and cations such as calcium, magnesium, sodium, and bicarbonate.

The groundwater chemistry from TC-BH1s is reflective of the unconfined, sandy aquifer, from which the water was derived. Relative to the samples from the Newmarket Till, it has elevated concentrations of most major anions and cations, as well as conductivity and alkalinity. Nitrate and sodium were detected in TC-BH1s at concentrations higher than the other samples collected, but still at levels well below Ontario Drinking Water Standards (ODWS), which reflects the unconfined nature of this aquifer. **Figure 4.17** presents a piper plot of the four groundwater samples collected in the Tooley Creek Watershed. Samples TC-BH2d and TC-BH2s have very similar chemistry and very similar anion/ cation ratios confirming that they are derived from the same source. The anion/cation ratios and the elevated concentration of nitrate and sodium in TC-BH1s are indicative minor impacts from road salt and local fertilizer use. TC-BH1d contains uncharacteristically low concentrations of calcium and magnesium and therefore plots in a different location than the other samples collected from the Newmarket Till Aquitard.

4.4.2.8 Mini-Piezometers

A total of 8 mini-piezometers were installed at 6 locations within the Tooley Creek Watershed (**Figure 4.9**). Some of the mini-piezometers have been in place since August 2008 (TC-MP4 and TC-MP5), when they were installed as part of the 407 East EA. The vertical hydraulic gradient between the deep and shallow mini-piezometer or the surface water level and the mini-piezometer is presented in **Figure 4.18**.

A summary of the mini-piezometer results is presented in **Table 4.12**.

Table 4.12 Summary of Tooley Creek Mini-Piezometer Observations

Mini-Piezometer	Location	Geological Unit	Average Gradient*	Groundwater Flow
TC-MP1	Tooley Creek South of Bloor Street	Weathered Till	0.03	Upwards
TC-MP2	Tooley Creek South of Baseline Road	Weathered Till	0.32	Upwards
TC-MP3	Tooley Creek South of Darlington Park Road	Weathered Till	0.10	Upwards
TC-MP4 Nest	Maple Grove Wetland Complex (PSW)	Glaciolacustrine Sand	0.36	Upwards
TC-MP5	Tooley Creek south of Highway #2	Glaciolacustrine Sand	0.05	Upwards
TC-MP6 Nest	Wetland to South of Bloor Street near Eastern Tributary to Tooley Creek	Glaciolacustrine silty fine sand (shallow); Till (deep)	0.01**	Upwards

*Note: * average from when piezometer reached equilibrium*
*** TC-MP6 reached equilibrium by the March 2010 monitoring event*

- <u>*TC-MP1*</u>
  Mini-piezometer TC-MP1 was installed in July 2009 south of Bloor Street within the main branch of Tooley Creek. The water level in the piezometer increased between July and August 2009 and reached equilibrium in late August (**Figure 4.18**). A positive average hydraulic gradient was measured in the August, September, and

March measurements (**Table 4.12**). Observations made during installation indicate that Tooley Creek is perched on unweathered Newmarket Till deposits over this reach and that groundwater seepage occurs along the bank of the creek from the weathered Till. A spring was also observed near this location (**Figure 4.20**).

- *TC-MP2*
  Mini-piezometer RC-MP2 was installed south of Baseline Road in Tooley Creek. With the exception of the measurement taken following construction, the groundwater level in the piezometer is higher than the stream water level, indicating upwards groundwater flow or groundwater discharge (**Figure 4.18**). Observations made during installation indicate that Tooley Creek is perched on Newmarket Till deposits over this reach and that minor groundwater seepage occurs along the bank on the east side of the creek.

- *TC-MP3*
  This location was selected to determine if groundwater discharge was contributing to stream flow in the lower reaches of Tooley Creek to the south of Darlington Park Road. With the exception of the measurement taken following construction, the groundwater level in the piezometer is higher than the stream water level, indicating upwards hydraulic gradient (**Figure 4.18**). Observations made during installation indicate that Tooley Creek is perched on Newmarket Till deposits over this reach. No obvious indications of groundwater discharge or seepage were noted nearby the installation.

- *TC-MP4*
  TC-MP4 was installed as a mini-piezometer nest in August 2008, as part of the 407 East EA, in the Maple Grove Wetland Complex north of Highway #2. The Maple Grove Wetland Complex is a Provincially Significant Wetland (PSW) that provides the groundwater source for the headwaters of Tooley Creek. Data presented on **Figure 4.18** between August 2008 and January 2009, were derived from the 407 East EA dataset. Monitoring for this study began in June 2009. Because of the larger dataset, additional discussion will be provided on this mini-piezometer.

  Glaciolacustrine sand deposits are present at surface and groundwater levels are anticipated to vary with seasonal precipitation rates. No standing water is present at TC-MP4s, but the ground can generally be described as moist. The water level measured in TC-MP4s has varied between 1.22 mbgs and 0.22 m above ground surface, between August 2008 and March 2010. The water level in TC-MP4d has varied between 0.19 mbgs and 0.52 m above ground surface (mags), over the same time period. There is a positive upwards hydraulic gradient between the shallow and deep mini-piezometers at TC-MP4, which indicated upwards groundwater movement (**Table 4.12**).

- *TC-MP5*
  TC-MP5 was installed south of Highway #2 in Tooley Creek for the 407 East EA. This mini-piezometer is located in Iroquois Plain Shallow Aquifer and measures the groundwater contribution to Tooley Creek from this unit. Data presented on **Figure 4.18** between August 2008 and January 2009, were derived from the 407 East EA dataset. Monitoring for this study began in June 2009. **Figure 4.18** indicates that it took between August 2008 and January 2009 for the piezometer to reach equilibrium, but when it did, a clear pattern of slow groundwater gradient increase was observed. This result may suggest that the underlying soils at this mini-piezometer have a low hydraulic conductivity, and therefore, do not contribute significant volumes of groundwater to Tooley Creek, even though there is an upwards hydraulic gradient,

- *TC-MP6*
  TC-MP6 was installed as a mini-piezometer nest in a small wetland area south of Bloor Street near the eastern tributary to Tooley Creek. Significant groundwater discharge from seepage and groundwater upwelling was observed during the field visit on July 10th, 2009. The ground surface at the piezometers is wet due to groundwater seepage, but it was not installed directly in the stream, so no standing water can be measured.

Although a spring was observed near the piezometer and upwards hydraulic gradients were anticipated, the majority of measurements indicate a downwards hydraulic gradient. The pattern of water level recovery at TC-MP6d suggests that equilibrium was not met in this piezometer until March 2010 (**Figure 4.18**). The March 2010 measurement showed an upwards hydraulic gradient at the piezometer nest. These results may indicate that the deep mini-piezometer may not be functioning properly or that it was installed below the unit that is the source of the observed spring seepage. Based upon the slow pattern of recovery, it is most likely that the deep mini-piezometer was installed in the low permeability till unit below the Iroquois sands.

4.4.2.9 Stream Temperature Logging

Tidbit continuous temperature loggers were installed below the surface water level at 4 mini-piezometer locations within Tooley Creek. The temperature results from the Tidbit loggers were compared against the mean daily air temperature measured that the Oshawa Meteorological Station (Environment Canada, 2009) to determine the difference between the surface water temperature and the air temperature (**Figure 4.19**). A difference of greater than 5°C between the surface water temperature and the air temperature is a good indicator of groundwater discharge as groundwater generally maintains an average yearly temperature of between 5°C and 15°C, whereas air temperatures can reach 25°C to 30°C in the summer. Although stream temperature measurements were only collected for a short period of time, they were collected during the summer and winter months, when the difference between the air temperature and the groundwater temperature is the greatest. These are the best times of the year to use the difference in temperature to determine groundwater inputs.

A summary of the stream temperature measurements is presented in **Table 4.13**.

Table 4.13 Summary of Stream Temperature Measurements

Temperature Logger Location	Location	Minimum Temperature	Maximum Temperature	Mean Temperature
Air	Oshawa Meteorological Station	-18.8	25.0	5.3
TC-MP1	Tooley Creek south of Bloor Street*	8.6	21.5	14.5
TC-MP2	Tooley Creek south of Baseline Road	0.0	22.5	7.7
TC-MP3	Tooley Creek south of Darlington Park Road	-0.2	23.1	7.6
TC-MP5	Tooley Creek south of Highway 2	0.0	21.2	7.7

*Note: * Temperature logger at TC-MP1 was lost on September 30, 2009. Temperature values reflect the period from July to September 2009.*

- <u>*TC-MP1*</u>
  A stream temperature logger was installed at TC-MP1 in Tooley Creek south of Bloor Street. The surface water temperature measured between July and September was significantly lower than the air temperature, indicating thermal buffering by cold groundwater inputs (**Figure 4.19**). No data was collected past September 30, 2009 as the temperature logger was lost in the creek. There was often a > 5°C difference between the air temperature and the stream temperature, suggesting groundwater discharge. The upward hydraulic gradient consistently measured in the mini-piezometer installed at this location is also indicative of groundwater discharge. The contact between the Iroquois Plain Shallow Aquifer and the Newmarket Till is located approximately 500 m north of Bloor Street, which is an area where cold groundwater discharge was observed (**Figure 4.20**). As shown in **Table 4.13**, the maximum stream temperature measured was 21.5°C and the mean temperature was 14.5°C. These surface water temperatures are indicative of a cool water stream that is buffered by groundwater inputs, but still has a significant surface water contribution.

- <u>*TC-MP2*</u>
  A stream temperature logger was installed at TC-MP2 in Tooley Creek south of Baseline Road. The surface water temperatures at this location measured between July 2009 and March 2010 were sufficiently different from air temperatures to indicate that thermal buffering by groundwater inputs is occurring (**Figure 4.19**). As shown in

Table 4.13, the maximum stream temperature measured was 22.5°C and the mean temperature was 7.7°C. These surface water temperatures are indicative of a cool water stream. The surface water at this location has a higher temperature than was measured upstream at TC-MP1. This suggests that Tooley Creek is warming up as it flows over the Newmarket Till plain and the contribution to stream flow from groundwater becomes less relative to surface runoff. It is likely that the groundwater discharge from the Iroquois Plain Aquifer is buffering the stream temperature downstream.

- *TC-MP3*
  A stream temperature logger was installed at TC-MP3 in Tooley Creek south of Darlington Park Road. The surface water temperatures at this location measured between July 2009 and March 2010 were sufficiently different from air temperatures to indicate that thermal buffering by groundwater inputs is occurring (**Figure 4.19**). As shown in **Table 4.6**, the maximum stream temperature measured was 23.1°C and the mean temperature was 7.6°C. These surface water temperatures are again indicative of a cool water stream. The surface water at this location has a higher temperature than was measured upstream at TC-MP1 and is similar to that of TC-MP2. This suggests that Tooley Creek is warming up as it flows over the Newmarket Till plain and the contribution to stream flow from groundwater becomes less relative to surface runoff. It is likely that the groundwater discharge from the Iroquois Plain Aquifer is buffering the stream temperature downstream. Some minor groundwater inputs are likely, between Baseline Road (TC-MP2) and Darlington Park Road (TC-MP3).

- *TC-MP5*
  A stream temperature logger was installed at TC-MP5 near the headwaters of Tooley Creek south of Highway 2 and the Maple grove Wetland Complex. The surface water temperature measured between July 2009 and September 2009 was significantly lower than the air temperature, indicating thermal buffering by groundwater inputs (**Figure 4.19**). Between September 2009 and March 2010, the surface water temperature was significantly higher than air temperature, again indicating thermal buffering by groundwater. This area is located within the Iroquois Plain Aquifer, where cold groundwater inputs are anticipated. The hydraulic gradient at the mini-piezometer installed at this location is also indicative of groundwater discharge. As shown in **Table 4.13**, the maximum stream temperature measured was 21.2°C and the mean temperature was 7.7°C. These surface water temperatures are indicative of a cool water stream that is constantly fed by groundwater discharge.

Overall, the thermal regime for Tooley Creek is indicative of a coolwater stream, which is consistent with Ministry of Natural Resources Mapping. It appears that the majority of the cold groundwater discharge occurs in the upper reaches of the watershed where contributions from the Iroquois Plain Shallow Aquifer are significant. The stream warms up as it flows over the Newmarket Till plain south towards Lake Ontario. Runoff is the most significant contribution to stream flow south of the Iroquois Plain Aquifer. Minor groundwater inputs along the entire length of Tooley Creek may help to buffer the stream temperature lower down in the watershed, but overall, surface water inputs dominate.

4.4.2.10 Creek Baseflow

Stream flow was measured during September 2009 at three locations progressively upstream in Tooley Creek: T2, T3, and T5 (**Figure 6.7**). These streamflow measurements was taken after a prolonged period of time without rainfall, however it should be noted that the summer of 2009 experienced above average rainfall amounts that may contribute groundwater inputs to streamflow for longer periods of time than are generally expected. That being said, the streamflow measurements taken in September 2009 are considered to best represent baseflow in Tooley Creek.

Table 4.14 presents the stream flow measurements collected at T2, T3 and T5 in L/s. The pattern shows that stream flow increases downstream between T5 (at Bloor Street) and T3 (at Baseline Road), but decreases downstream between T3 and T2 (Darlington Park Road).

Because flow in the creek is expected to be dominated by surface water inputs, the overall yearly stream flow rate will be largely controlled by “event” based flows such as rainfalls and the spring snow melt.

Table 4.14 Stream Flow Summary

Stream Flow Location	T2	T3	T5
September 2009	1.4 L/s	2.9 L/s	0.7 L/s
	South of Darlington Park Road	North of Baseline Road	South of Bloor Street

4.4.2.11 Groundwater Recharge

The purpose of this section is to provide a general discussion of recharge conditions that occur in the various areas and through the various geological units of the Tooley Creek Watershed. The predominant land use in the Tooley Creek Watershed continues to be agriculture, in the form of grains and soybeans. Developed areas of housing subdivisions are found to the north and to the west of the watershed. A review of the water well records and the MOE Permit to Take Water database reveals that there are no substantive takings (irrigation or municipal) from groundwater sources in this watershed.

Approximately 75% of the study area is covered by a layer of low permeability till or glaciolacustrine silt and clay (**Figure 4.11**). The remaining 25% is underlain by the more permeable Iroquois Plain Shallow Sand Aquifer. The majority of this watershed can be considered a groundwater recharge area, although the groundwater recharge rates are generally very low through till and silty clay soils, and recharge through the sand aquifer will contribute significantly to the water balance (**Section 4.4.3**). Generally, surface runoff is expected to exceed infiltration throughout the watershed, especially where till soils are present at surface. Runoff can still occur on the Iroquois Plain Aquifer if the intensity of the precipitation event is enough to fill the available pore space of the shallow aquifer sediments.

Groundwater recharge through the Iroquois Plain Aquifer contributes to stream baseflow as shown by the cool water thermal regime of the watercourse. Groundwater recharge through the upper weathered Newmarket Till surface near the creek also contributes, but in a smaller way to stream baseflow. Due to the presence of unweathered till below, groundwater flow through high permeability units such as glaciolacustrine sand and weathered till is horizontal. This shallow subsurface flow migrates to discharge areas located at topographical lows such as Tooley Creek and its tributaries. This discharge has been observed in the field as diffuse seepage areas along the banks of the creek and the occasional spring.
The infiltration rate through the unweathered Newmarket Till is what controls the overall groundwater recharge rate in the watershed. The water that infiltrates through this unit flows downwards towards bedrock aquifers and sand lenses within the till. The groundwater recharge capacity of the Iroquois sands is limited due to the low permeability till deposits below restricting drainage to depth. This unit does however provide significant storage of groundwater within the watershed.

4.4.2.12 Groundwater Discharge

The purpose of this section is to discuss, in general, the groundwater discharge areas and their relative contributions to stream baseflow in the Tooley Creek Watershed. **Table 4.15** provides a summary of groundwater discharge observations from the watershed.

Table 4.15 Summary of Groundwater Discharge Observations – Tooley Creek

	Observations
Surface Water Flow	a) The main branch of Tooley Creek and all but one of its tributaries were flowing under baseflow conditions. The headwaters of Tooley Creek, that are located to the north and south of Highway 2, showed signs of groundwater discharge.
Vertical Groundwater Gradients	b) All of the mini-piezometers installed within the Tooley Creek Watershed showed upwards hydraulic gradients.. TC-MP1, TC-MP2, TC-MP3, and TC-MP5 were all installed in the stream bed of Tooley Creek. The nest at TC-MP4, showed a strong upwards gradient between the shallow and deep piezometers.
Vegetation	c) Plants that occur where groundwater is discharging to the surface such as watercress were not observed it the watershed. Jewel Weed was identified near groundwater seeps found in wetland areas identified near the southeast corner of Courtice Road and Highway 2, and south of Bloor Street at TC-MP6.
Seepage	d) Groundwater seepage was observed in a number of distinct locations: (1) The Maple Grove Wetland Complex; (2) the wetland area near the southeast corner of Courtice Road and Highway 2; (3) a wetland area in the eastern tributary to Tooley Creek, south of Bloor Street; (4) at a spring located approx. 750 m north of Baseline Road in the main branch of Tooley Creek on the east bank; and (5) as minor seepage along the bank of Tooley Creek along much of its length (**Figure 4.20**).

Groundwater discharge area mapping provided by CLOCA provided a basis for which to begin to understand groundwater discharge relationships within the watershed. This mapping was simplified and is shown in **Figure 4.20**. The groundwater discharge area mapping provided by CLOCA was derived from a regional groundwater model that showed areas of potential groundwater discharge by highlighting areas where the water table was identified in MOE water well records as being within 1 m of the ground surface. This method of identifying groundwater discharge areas is useful when characterizing discharge areas on a regional scale, but may not be representative at the small scale. The results of this analysis indicate that groundwater discharge was most likely to occur where Tooley Creek and its tributaries intersect the water table in their river valleys as well as the contact between the Iroquois Plain Aquifer and the Newmarket Till Plain. A summary of all groundwater discharge observations made by the project team was overlain on the CLOCA groundwater discharge mapping and is presented on **Figure 4.20.**

Newmarket Till is primarily found at surface throughout the watershed. Till deposits are poorly suited for infiltration, which subsequently limits groundwater recharge to the water table and therefore does not provide a significant source of groundwater that may ultimately become discharge. Because the Newmarket Till is present at surface over most of the watershed, it is likely that surface runoff provides the most significant contribution to stream flow in Tooley Creek.

No significant confined aquifers were identified in the Tooley Creek Watershed and therefore there is likely no source for regional groundwater discharge. A small portion of the Scarborough Formation Aquifer is present in the northern portion, directly overlying the bedrock, but due to its depth and the fact that it"s confined below the Newmarket Till, it does not significantly affect the hydrogeologic conditions in the watershed. Sand lenses within the till may provide a minor source of groundwater discharge where exposed in cuts or incised valleys, such as the one identified north of Baseline Road on the east side of Tooley Creek.

The majority of the groundwater discharge occurs in the northern portion of the watershed where glaciolacustrine sand deposits are found at surface. This area was identified as an important groundwater recharge area in the previous section. Stream temperature measurements confirm that cold groundwater discharge is occurring in the area north of Bloor Street. These deposits are well suited for infiltration, which subsequently increases groundwater recharge to the water table and therefore provides a significant source of groundwater that may ultimately become discharge. . No significant confined aquifers were identified in the Tooley Creek Watershed and therefore there is likely no significant source for regional groundwater discharge.

Although Tooley Creek is primarily surface water fed (as will be shown in the Water Balance calculated in the following Section), it would appear that baseflow in Tooley Creek and its tributaries are supported by groundwater inputs. The cumulative baseflow for the entire creek was found to range between 1.4 and 2.9 L/s in September 2009, although the seasonal nature of this value still requires assessment.

4.4.3 Water Budget

4.4.3.1 Purpose and Objectives

For the Tooley Creek Watershed, a water budget has been prepared in the same fashion as Robinson Creek Watershed, to characterize the relative importance of the various components of water movement. This will not only help confirm some of the conclusions from the previous sections, but will also allow for a qualitative assessment of future conditions.

Meteorological data from the Oshawa Meteorological Station (Environment Canada, 2009) is used to calculate the precipitation and evapotranspiration components of the water budget. Runoff and infiltration components are estimated using site specific information about the soils, topography, vegetative cover, and stream baseflow conditions. A water budget has been prepared for the existing conditions of the Tooley Creek Watershed.

4.4.3.2 Meteorological Data and the Water Balance

Long term meteorological data from 1971 – 2000 average was obtained from Environment Canada for the Oshawa Meteorological Station (Environment Canada, 2009), to be used to calculate the total precipitation and ET. The same water budget prepared for Robinson Creek in Section 4.3.1.2 has been used here. Please refer to **Table 4.6.**

By way of review, the long term average annual mean precipitation at the Oshawa Meteorological Station was 857.8 mm/yr. The mean annual evapotranspiration is calculated to be 493.7 mm/yr. The mean annual water surplus is therefore calculated to be the difference, that is, 364.1.mm.

4.4.3.3 Infiltration Factors

The partitioning of the water surplus between runoff and infiltration depends on a number of physical properties of the watershed including, soils, topography, and cover, as previously described. Infiltration factors were calculated using these factors with the method developed by Bernard (1932) and accepted by the MOE (1995). The total infiltration factors are calculated by summing the individual subfactors that are dependent upon the topography, soil, and cover at the site. **Table 4.16** presents a breakdown of the infiltration factors for the various soil types in the watershed. The three dominate soil types are glaciolacustrine silt and clay, Newmarket Till and glaciolacustrine sand of the Iroquois Plain Aquifer.

Table 4.16 Infiltration Factor Calculations (from MOE 1995) – Tooley Creek

Subfactor	Glaciolacustrine Silt and Clay		Newmarket Till		Glaciolacustrine Sand	
	Description	*Factor*	*Description*	*Factor*	*Description*	*Factor*
Topography	rolling	0.15	rolling	0.15	Flat	0.20
Soil	silt and clay	0.10	weathered till	0.15	sand	0.35
Cover	cultivated	0.10	cultivated	0.10	cultivated	0.10
Total Factor	**0.35**		**0.40**		**0.65**	

The topography of the watershed can be described as rolling, generally with low gradients. The watershed slopes in general, range between approximately 0.15% in the tableland areas to approximately 6% near the Tooley Creek valley; however this makes up a very small portion of the watershed. The dominate land use in the watershed is agriculture, as urban development has not significantly begun. To assess the existing conditions, it was assumed that cultivated cropland dominated the infiltration subfactors.

The results of this exercise yields infiltration subfactors that range from 0.35 to 0.65 (**Table 4.16**) depending primarily upon soil type. Each infiltration subfactor was applied to the area (in m^2) of the representative soil type, and multiplied by the surplus to determine the amount of recharge.

4.4.3.4 Water Budget for Existing Conditions

Using the calculated water surplus and the infiltration subfactor for each soil type, a water balance was completed for the existing conditions of the Tooley Creek Watershed (**Table 4.17**). This was calculated by first measuring the area (in m^2) of each of the surficial soil types in the Tooley Creek Watershed:

- The Newmarket Till covers 6,207,824 m^2 (59% of Tooley Creek Watershed),;
- Glaciolacustrine silt and clay covers 1,632,399 m^2 (16% of watershed) and; and
- Glaciolacustrine sand covers 2,601,277 m^2 (25% of watershed).

The yearly contribution to infiltration and runoff from each area was then calculated by multiplying the area (in m^2) by the surplus [in m/yr (1 m = 1,000 mm)].

Table 4.17 Water Budget for Existing Conditions – Tooley Creek

Soil Type	Area (m^2)	Precipitation		Evapotranspiration		Surplus		Infiltration		Runoff	
		(m^3/yr)	*(mm/yr)*	*(m^3/yr)*	*(mm/yr)*	*(m^3/yr)*	*(mm/yr)*	*(m^3/yr)*	*(mm/yr)*	*(m^3/yr)*	*(mm/yr)*
Newmarket Till	6,207,824	5,325,072	857.8	3,064,803	493.7	2,260,269	364.1	904,108	145.6	1,356,161	218.5
Glaciolacustrine Silt and Clay	1,632,399	1,400,272	857.8	805,915	493.7	594,356	364.1	208,025	127.4	386,332	236.7
Glaciolacustrine Fine Sand	2,601,277	2,231,375	857.8	1,284,250	493.7	947,125	364.1	615,631	236.7	331,494	127.4
Total	10,441,500	8,956,719	857.8	5,154,969	493.7	3,801,750	364.1	1,727,763	165.5	2,073,987	198.6

Evapotranspiration accounts for approximately 58% of the mean annual precipitation. Of the remaining 42% of water (the Surplus), approximately 45% infiltrates to the groundwater as recharge and 55% becomes runoff and supports stream flow in Tooley Creek. Groundwater infiltration through the Newmarket Till contributes the largest portion of recharge to the water table because it represents the largest surface area in the watershed. Although infiltration is rapid through the Iroquois Plain Sands, their extent is limited and they have a minor influence on the overall water balance. (This does not down play their local importance, and the 65% infiltration in just the glaciolacustrine sand is reflected in the greater relative baseflow to the watercourses in the headwaters of Tooley Creek). Of the total precipitation that falls on the entire watershed, only 45% becomes groundwater recharge, which is not unexpected given the thick deposits of low permeability soils at surface. Runoff dominates over infiltration in the Tooley Creek Watershed by a ratio of 1.2:1.

Due to the tight nature of the surficial soils in the watershed, it makes sense that runoff contributes more to stream flow than groundwater, although the contributions from the glaciolacustrine sands are important. If it is assumed that all runoff contributes to stream flow in Tooley Creek then the average yearly flow rate would be 65.8 L/s. This value is of course much greater than the 1.4 – 2.9 L/s measured at Stations T2 and T3 (**Figure 6.7**) under baseflow conditions. Although storm flow has not been measured, it is likely that flow in the creek peaks quite dramatically after a precipitation event or during snow melt. An average flow rate of 65.8 L/s is reasonable for a creek of this size, although this average is highly dependent upon event based flow.

A Darcy Flux was calculated as a second, independent determination of the groundwater infiltration rate to assess (and to confirm) the results of the MOE (1995) method. A Darcy flux is a volume per time per area calculation that is standard in hydrogeology and is written as follows:

$$Q = \frac{k * (dH_v/dL_v)}{A}$$

Two groundwater monitors are present in the Tooley Creek Watershed. The 407 East EA provides a summary table of the average hydraulic conductivity of each of the hydrostratigraphic units present in the study area based upon a regional dataset (which includes the two groundwater monitors). The geological and hydrogeological conditions presented in these dataset are considered to be a reasonable surrogate for the conditions in the Tooley Creek Watershed for the purpose of this calculation. A total vertical Darcy Flux of 1,706,071 m^3/yr was calculated as the yearly infiltration rate in the Tooley Creek Watershed (**Table 4.18**)

Table 4.18 Darcy Flux Infiltration Rate – Tooley Creek

Soil Type	K (m/s)	dHv/dLv	Area	Infiltration (Q) (m^3/s)	Infiltration (Q) (m^3/yr)
Newmarket Till	3.2 x 10^{-08}	0.13	6,207,824	0.026	814,403
Glaciolacustrine Silt and Clay	4.4 x 10^{-08}	0.13	1,632,399	0.0093	294,462
Glaciolacustrine fine Sand	5.6 x 10^{-06}	0.0013	2,601,277	0.019	597,207
Estimated From the Darcy Flux					1,706,071
Estimated From Water Balance					1,727,763
Percent Difference					1.3%

Just as in the Robinson Creek Watershed, the unweathered Newmarket Till controls the largest portion of groundwater recharge to depth in the watershed. Following the same logic as was used to determine the vertical hydraulic conductivity of the Newmarket Till in the Robinson Creek Watershed (Section 4.3.2.4), the vertical hydraulic conductivity of the Newmarket Till was determined to be 3.2 x 10^{-8} m/s. The K value of glaciolacustrine silt and clay was found to average 4.4 x 10^{-8} m/s and glaciolacustrine sand was found to average 5.6 x 10^{-06} m/s (407 East EA, MTO 2009). These regional values were used to calculate the Darcy Flux for the individual units within this watershed.

A vertical hydraulic gradient (dH_v/dL_v) was estimated from the TC-BH1 well nest in the Tooley Creek Watershed from the difference between the water level in TC-BH1S and TC-BH1D over the difference in the distance between their well screens. An average vertical hydraulic gradient of 0.13 was calculated between January 2008 and March 2010. This gradient is considered to be representative for vertical flow in low permeability units such as the Newmarket Till and the glaciolacustrine silt and clay. Experience has shown that vertical hydraulic gradients are considerably less in high permeability materials such as silts and sands because of the ease at which water can move laterally through the material. Because no direct measurements of the vertical gradient could be calculated for the Iroquois Plain Aquifer, a value that is 100 times less than that of the vertical hydraulic gradient within the Newmarket Till (0.13 m/s) was used. An average vertical hydraulic gradient of 0.0013 was considered to be representative for infiltration through the glaciolacustrine sand of the Iroquois Plain Aquifer in the watershed.

The average volume of infiltration in the watershed was determined to be 1,706,071 m^3/yr (**Table 4.18)**. This represents a 1.3% variation from the infiltration rate estimated from the water balance using the MOE 1995 and the Thornthwaite and Mather (1957) method for the watershed. The similarity of these two results lends confidence that the assumptions made when calculating the water balance were reasonable.

4.4.3.5 Groundwater Discharge to Tooley Creek

In **Section 4.2.2.10**, it was concluded that groundwater discharge from the Iroquois Plain Aquifer as well as lateral groundwater inputs from the weathered till unit contributed to baseflow in Tooley Creek.

A horizontal hydraulic conductivity of 2.7 x 10^{-6} m/s was obtained from TC-BH2S which is screened in the weathered Newmarket Till in the Tooley Creek Watershed and because it is weathered, is considered representative for both the vertical and horizontal hydraulic conductivity values. Over the area covered by the Iroquois Aquifer, the land surface is relatively flat and has a slope of approximately 2.5% (0.025 m/m). This value is assumed to equal the hydraulic gradient of groundwater flow towards the creek in the Iroquois Plain Aquifer. Over the remainder of the watershed, the land surface slopes more sharply towards the Tooley Creek Valley at a slope of approximately 1% (0.1 m/m). This value is assumed to be equal to the hydraulic gradient of groundwater flow towards the creek from the weathered till zone.

An area of approximately 25,600 m^2 was estimated to be the contributing area from the weathered till to Tooley Creek assuming a saturated thickness of the weathered till of 2.0 m and a cumulative length of stream (both sides) of 12.8 km. An area of approximately 13,600 m^2 was estimated to be the contributing area from the Iroquois Plain Aquifer, again assuming a saturated thickness of the aquifer of 2.0 m (the aquifer thickness is ~3.1 m) and a cumulative length of stream (both sides) of 6.8 km.

As shown in **Table 4.19**, the calculated discharge from the weathered till zone is 8.8 L/s, which is greater than the stream flow measured at T3 of 2.9 L/s. Given that this independent calculation is of the same order of magnitude as the measured value, it provides some level of confidence in the estimated water balance. The hydraulic conductivity may over estimate discharge from the till. In addition, loss of water though recharge at the base of creek may be a factor. It can however, be concluded that baseflow in Tooley Creek is permanently derived from groundwater inputs from the weathered till zone, and the Iroquois Plain Aquifer. As noted the hydraulic conductivity value assumed for the weathered till is conservative and it is likely lower in many places along Tooley Creek. However, localized areas of higher permeability, such as sand lenses within the till, will act to increase the bulk hydraulic conductivity of this unit and contribute additional water to baseflow at discrete locations.

Table 4.19 Groundwater Contribution to Baseflow from the Weathered Till Zone

Soil Type	K (m/s)	dH/dL	Area (m^2)	Discharge (m^3/s)	Discharge (L/s)
Weathered Till	2.7 x 10^{-06}	0.1	25,600	0.0069	6.9
Iroquois Sand	5.6 x 10^{-06}	0.025	13,600	0.0019	1.9
Total Stream Flow					8.8
Measured at Station T3					2.9

4.4.4 Conclusions and Recommendations

The Tooley Creek Watershed is primarily underlain by low permeability Newmarket Till soils at surface, which restricts groundwater recharge and promotes surface runoff, as shown by the water budget calculations. Groundwater infiltration through the Iroquois Plain Aquifer located at the north end of the watershed contributes groundwater recharge in the watershed and is the most sensitive to change in land use.

Minor amounts of groundwater recharge also occur in the weathered till soils and alluvial sediments, which flows laterally towards discharge areas in the Tooley Creek river valley.

Stream temperature measurements confirm that Tooley Creek and its tributaries can be classified as a coolwater stream. Cold groundwater inputs from the Iroquois Plain Aquifer and isolated locations downstream of this aquifer, are sufficient to buffer the temperature of the warm surface water inputs during the summer months and vice versa in the winter months.

There are no municipal supply wells located in the Watershed and domestic water users have traditionally utilized groundwater for potable water use. Where the Iroquois Plain Aquifer is present at surface, the majority of wells are wide bore shallow dug wells. In other parts of the watershed, wells generally derive their water from lenses within the Newmarket Till or from bedrock aquifers. With increasing urban development in the Watershed, more domestic users are obtaining water from municipal systems that derive water from Lake Ontario.

No groundwater samples were collected as part of this study, but analysis of the data contained in the 407 East EA Report shows that the groundwater quality is generally good, with minor indications of impacts from surficial land use activities in the groundwater of the unconfined Iroquois Plain Aquifer. These are typified by small concentrations of nitrate and sodium, likely derived from fertilizers and road salt.

It is recommended that the instrumentation used for this study continue to be monitored to establish long-term trends.

The average annual precipitation in the Tooley Creek Watershed is 857.8 mm/yr. On average, 493.7 mm/yr is lost to evaporation and transpiration by plants. A combination of dense till soils and surficial sands means that infiltration accounts for 165.5 mm/yr and the remainder (198.6 mm/yr) is lost to runoff. The average annual infiltration of 165.5 mm/yr serves to recharge the water table, ultimately provides baseflow to Tooley Creek and replenishes small aquifer units within the till.

Losses of some infiltration in the watershed due to development may have an adverse impact on the overall water balance. The area covered by the Iroquois Plain Shallow aquifer (25% of watershed) is more susceptible to changes in infiltration caused by development.. This area functions as a groundwater recharge area for the watershed and contributes groundwater discharge to Tooley Creek. A target of 236.7 mm/yr of infiltration should be maintained in the area covered by the glaciolacustrine aquifer to maintain its recharge and discharge functions. A target of between 127.4 and 145.6 mm/yr should generally be maintained over the remainder of the watershed to sustain baseflow conditions in Tooley Creek.

Basemapping from Ontario Ministry of Natural Resources
Orthophotography: 2005

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UTM Zone 17N, NAD 83

Legend

Monitors

- Groundwater Monitor Nest
- MIni-Piezometer
- Watershed
- Railway
- Intermittent Stream
- Permanent Stream
- Waterbody Segment
- Wetland Area, Permanent

Robinson Creek and Tooley Creek Watershed Plan

Robinson Creek Watershed Groundwater Monitoring Locations

September 2009
Project 112956

AECOM

Figure 4.1

Map Document: (N:\projects\0-aecom\112956\2009\Final\GISSpatial\MXDs\ReportMXDs\112956RobinsonGWmonitorLoc.mxd)
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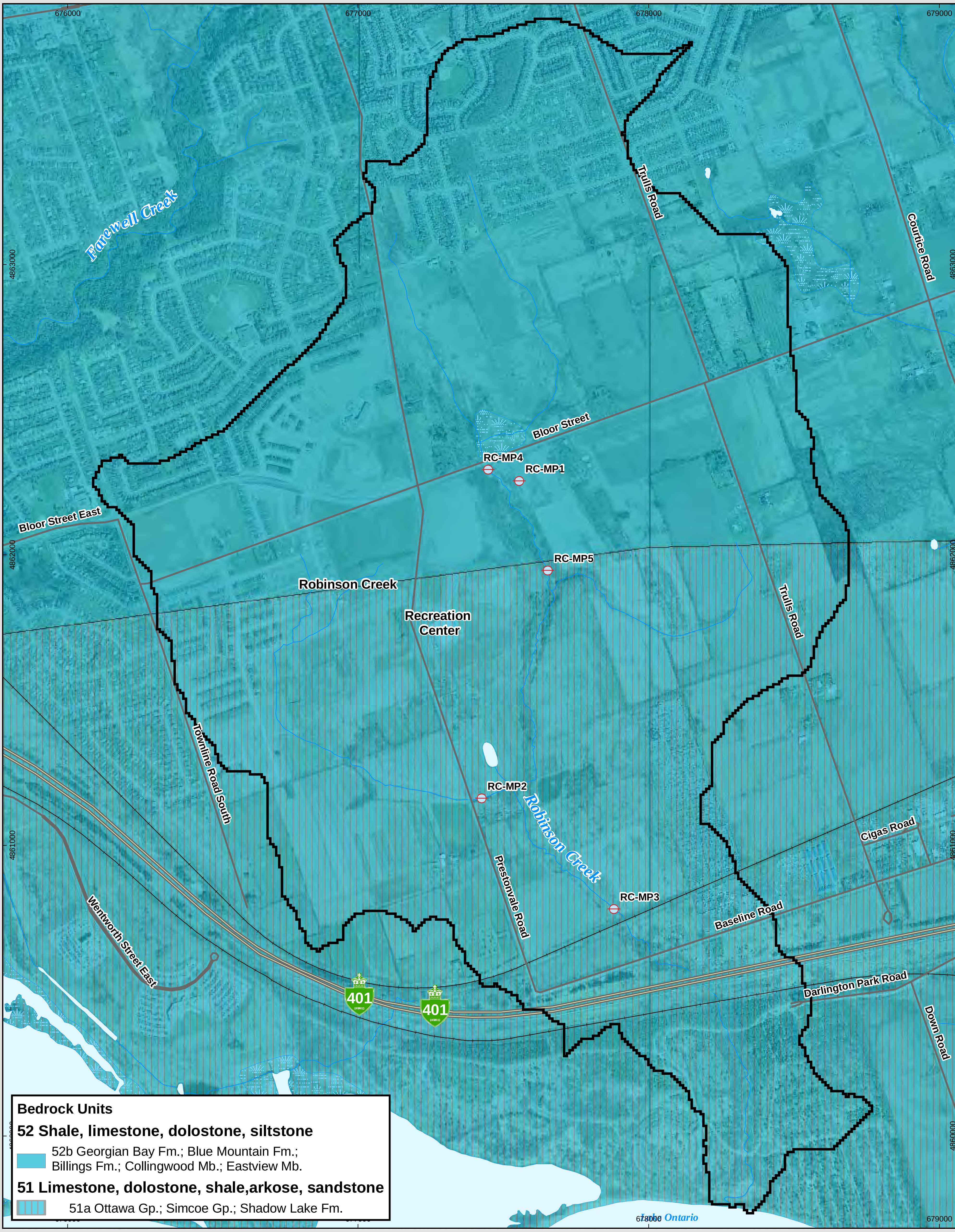

Basemapping from Ontario Ministry of Natural Resources
Orthophotography: 2005

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UTM Zone 17N, NAD 83

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Legend

Monitors

- Groundwater Monitor Nest
- MIni-Piezometer
- Watershed
- Railway
- Intermittent Stream
- Permanent Stream
- Waterbody Segment
- Wetland Area, Permanent

Robinson Creek and Tooley Creek Watershed Plan

Robinson Creek Watershed Bedrock Geology

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Figure 4.2

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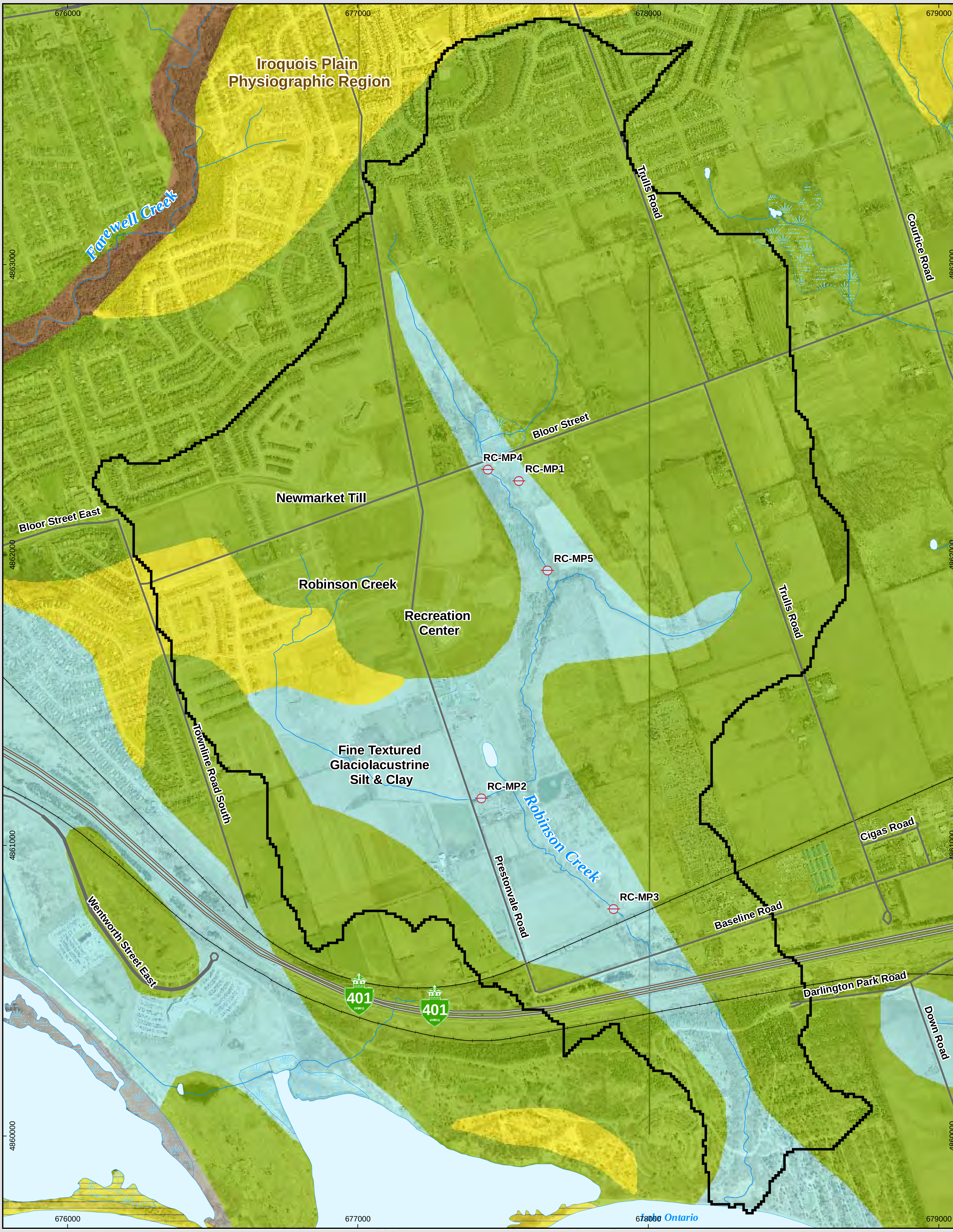

Basemapping from Ontario Ministry of Natural Resources
Orthophotography: 2005

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UTM Zone 17N, NAD 83

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Legend

Monitors

- Groundwater Monitor Nest
- MIni-Piezometer
- Watershed
- Railway
- Intermittent Stream
- Permanent Stream
- Waterbody Segment
- Wetland Area, Permanent

Surficial Geology

- 20: Organic deposits
- 19: Modern alluvial deposits (Silt, Sand and Gravel)
- 14b: Littoral-foreshore deposits (Sand)
- 9c: Foreshore-basinal deposits (Silt and Sand)
- 8a: Massive-well laminated (Silt and Clay)
- 5b: Stone-poor, carbonate-derived silty to sandy till (Newmarket Till)

Robinson Creek and Tooley Creek
Watershed Plan

Robinson Creek Watershed Surficial Geology

September 2009
Project 112956

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Figure 4.3

Map Document: (N:\projects\0-aecom\112956\2009\Final\GISSpatial\MXDs\ReportMXDs\112956RobinsonGWmonitorLoc.mxd)
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Basemapping from Ontario Ministry of Natural Resources
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Legend

Monitors

- Groundwater Monitor Nest
- MIni-Piezometer
- Watershed
- Railway
- Intermittent Stream
- Permanent Stream
- Waterbody Segment
- Wetland Area, Permanent

Robinson Creek and Tooley Creek Watershed Plan

Robinson Creek Watershed MOE Water Wells

September 2009
Project 112956

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Figure 4.4

Map Document: (N:\projects\0-aecom\112956\2009\Final\GISSpatial\MXDs\ReportMXDs\112956RobinsonGWmonitorLoc.mxd)
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Basemapping from Ontario Ministry of Natural Resources
Orthophotography: 2005

Legend

- Equipotential Lines
- MOE Water Wells and Static Groundwater Level
- Watershed

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UTM Zone 17N, NAD 83

Tooley/Robinson Creek

Robinson Creek Equipotential Map

October 2009
Project 112956

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Figure 4.5

Map Document: (N:\projects\0-aecom\112956\2009\Final\GISSpatial\MXDs\ReportMXDs\112956RobinsonStaticGWLevel.mxd)
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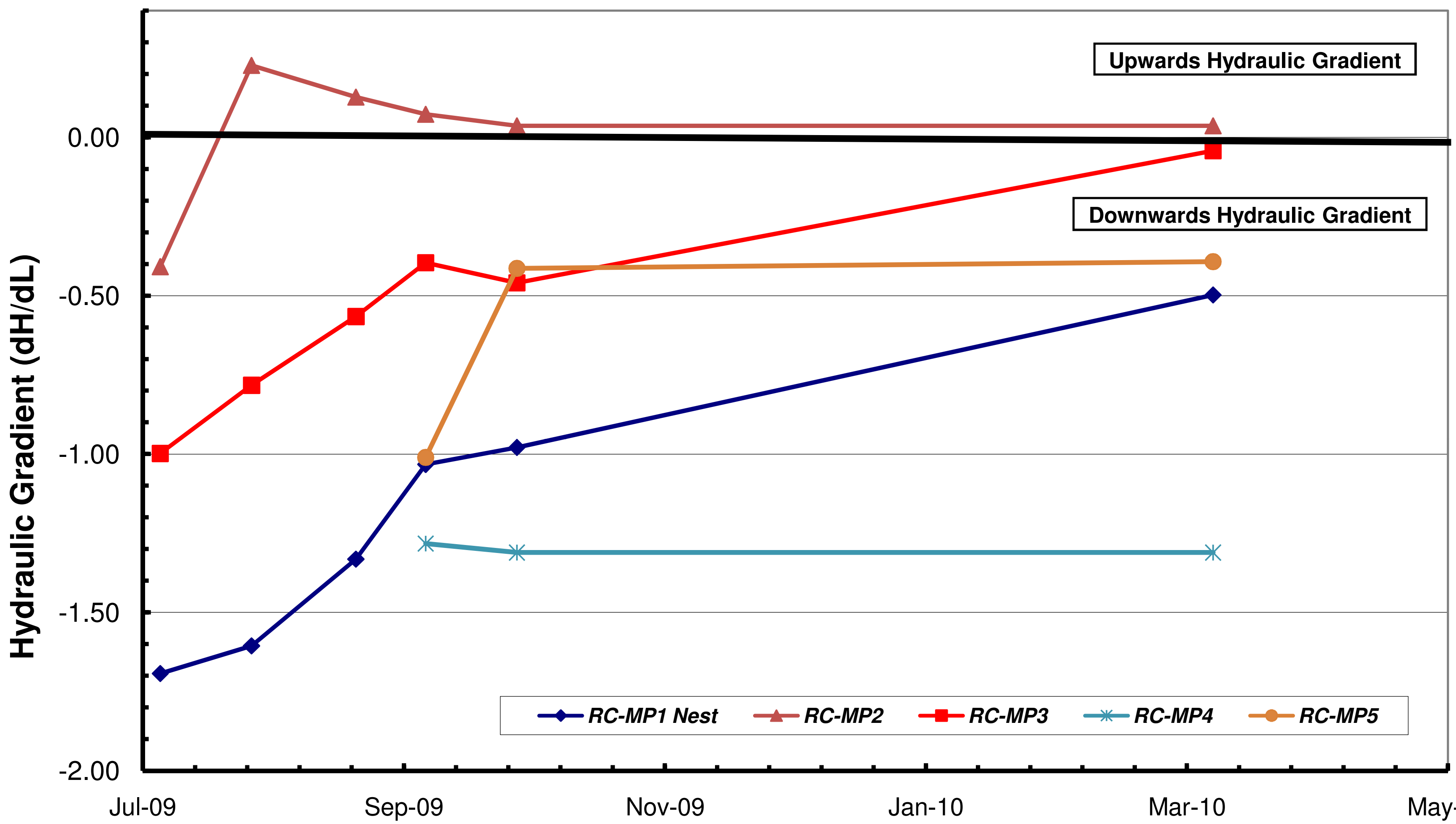
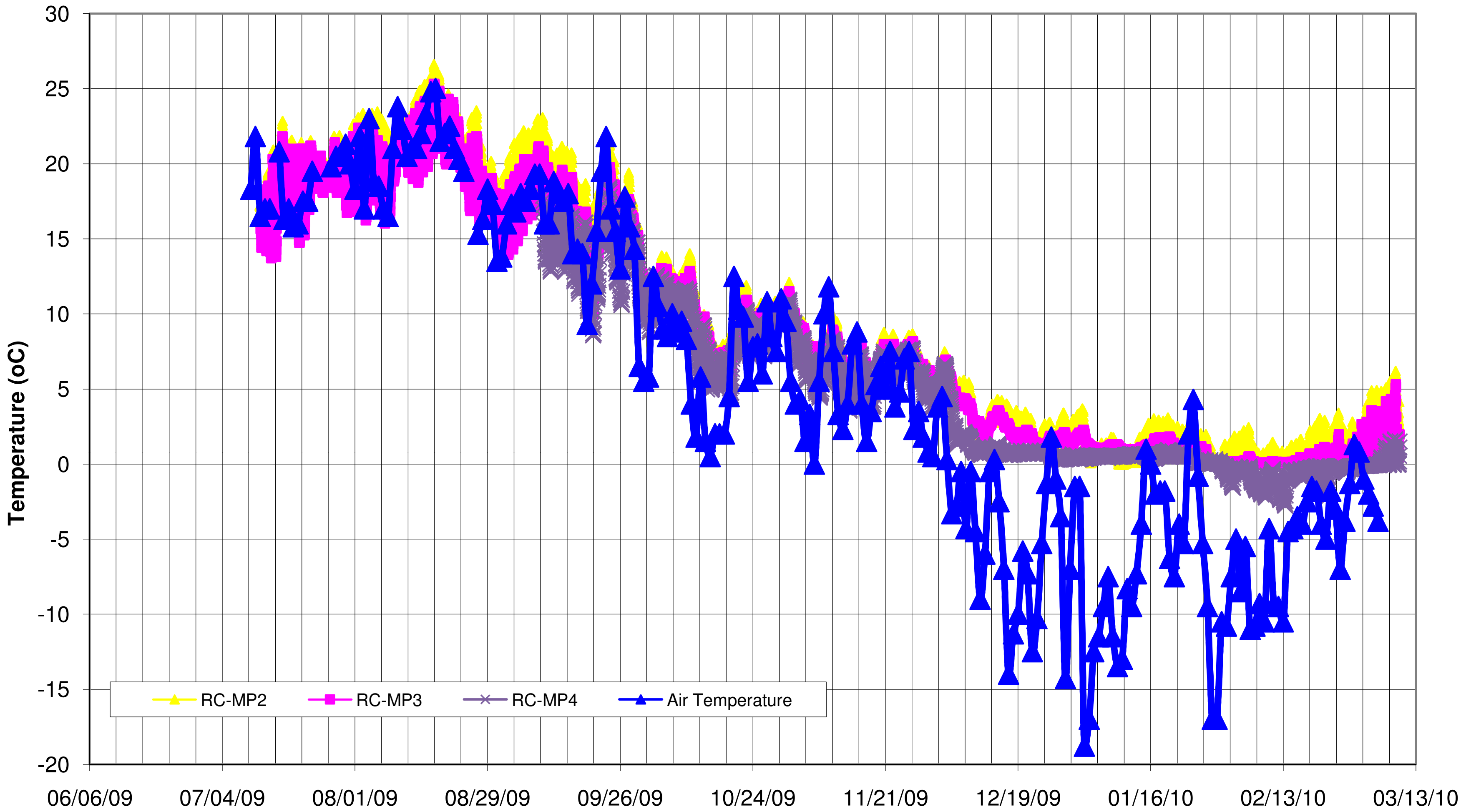
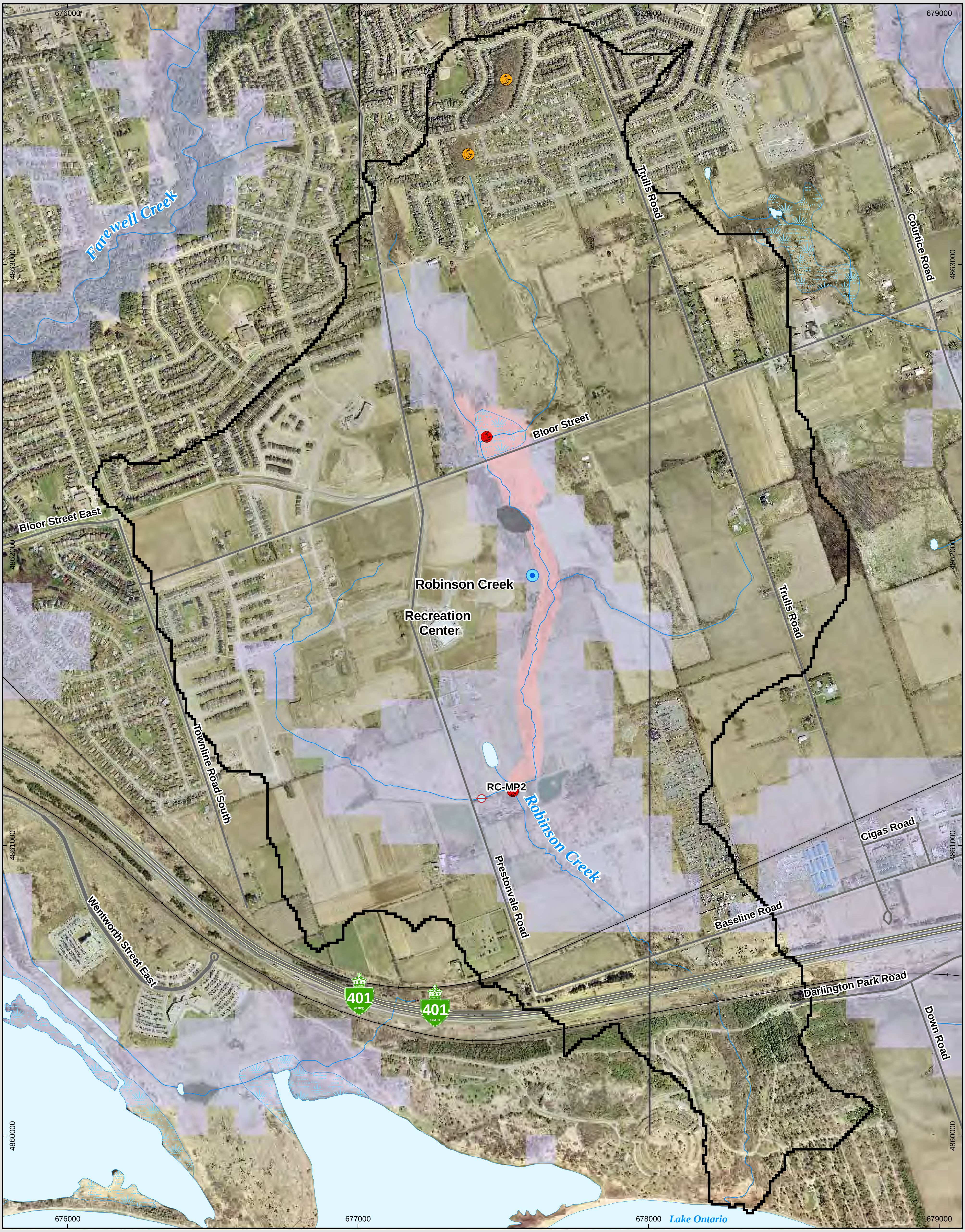


Hydraulic Gradients in Mini-Piezometers (Robinson Creek Watershed)	**FIGURE 4.6**
CLOCA - Tooley Creek / Robinson Creek Watershed Study	Project 112956



Stream Temperature (Robinson Creek Watershed)	**FIGURE 4.7**
CLOCA - Tooley Creek / Robinson Creek Watershed Study	Project 112956



Basemapping from Ontario Ministry of Natural Resources
Orthophotography: 2005

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Legend

Seepage Indicating Plant Species
- Marsh Marigold (Calthaa palustris)
- Water-cress (Nasturtium officinale)

Upwards Hydraulic Gradients: Groundwater Monitors
- Mini-piezometer

Visual Seepage Observations
- Spring
- Seepage

Soil Type
- Organic Soil

- Modelled Groundwater Discharge Areas(CLOCA)
- Watershed
- Railway
- Intermittent Stream
- Permanent Stream
- Waterbody Segment
- Wetland Area, Permanent

Robinson Creek and Tooley Creek Watershed Plan

Robinson Creek Watershed Groundwater Discharge Observations

October 2009
Project 112956

AECOM

Figure 4.8

Map Document: (N:\projects\0-aecom\112956\2009\Final\GISSpatial\MXDs\ReportMXDs\112956RobinsonDischarge.mxd)
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Basemapping from Ontario Ministry of Natural Resources
Orthophotography: 2005

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UTM Zone 17N, NAD 83

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Legend

Monitors

- Groundwater Monitor Nest
- MIni-Piezometer
- Watershed
- Railway
- Intermittent Stream
- Permanent Stream
- Waterbody Segment
- Wetland Area, Permanent

Robinson Creek and Tooley Creek Watershed Plan

Tooley Creek Watershed Groundwater Monitor Location

September 2009
Project 112956

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Figure 4.9

Map Document: (N:\projects\0-aecom\112956\2009\Final\GISSpatial\MXDs\ReportMXDs\112956TooleyGWmonitorLoc.mxd)
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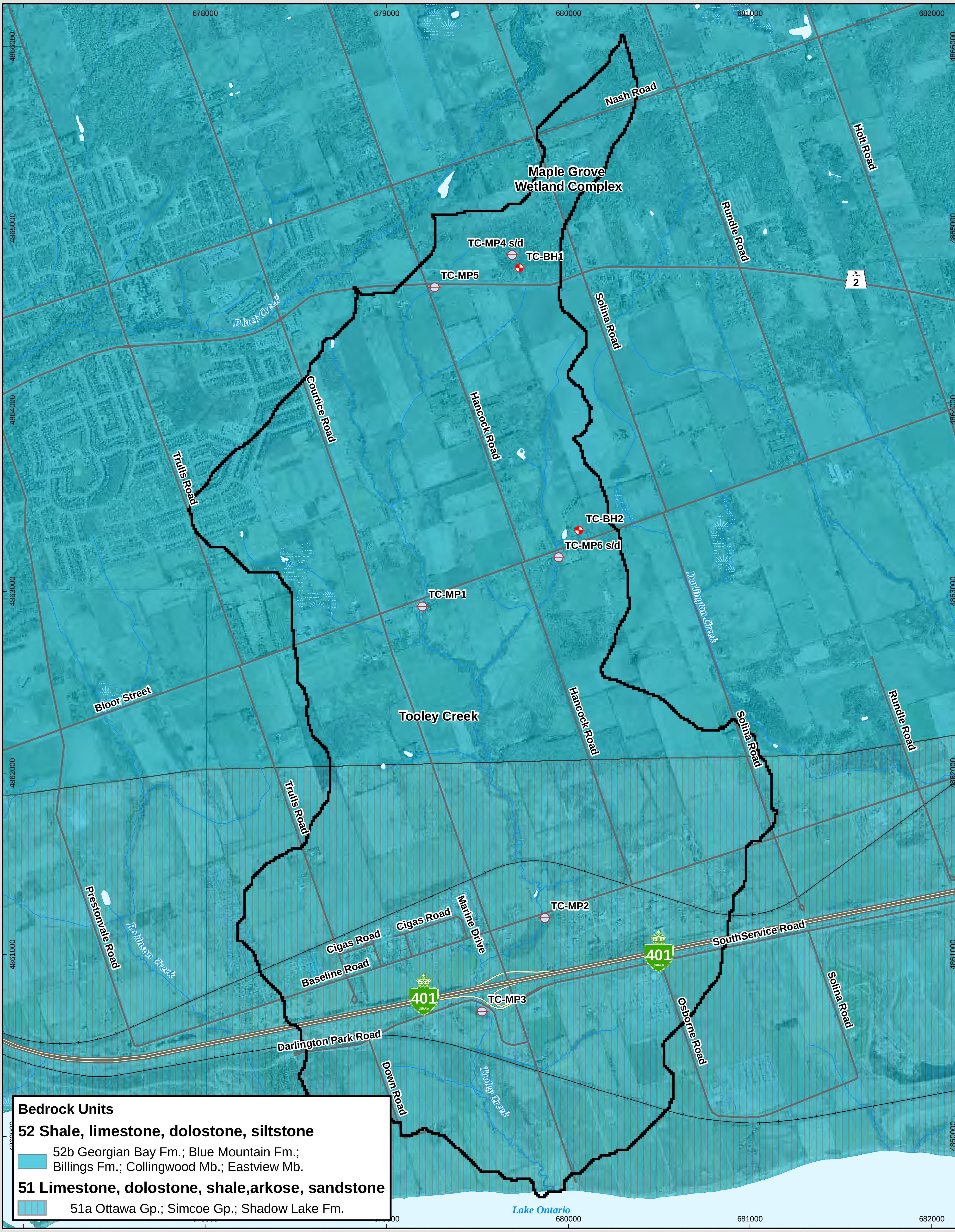

Basemapping from Ontario Ministry of Natural Resources
Orthophotography: 2005

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UTM Zone 17N, NAD 83

Legend

Monitors

- Groundwater Monitor Nest
- MIni-Piezometer
- Watershed
- Railway
- Intermittent Stream
- Permanent Stream
- Waterbody Segment
- Wetland Area, Permanent

Robinson Creek and Tooley Creek Watershed Plan

Tooley Creek Watershed Bedrock Geology

October 2009
Project 112956

AECOM

Figure 4.10

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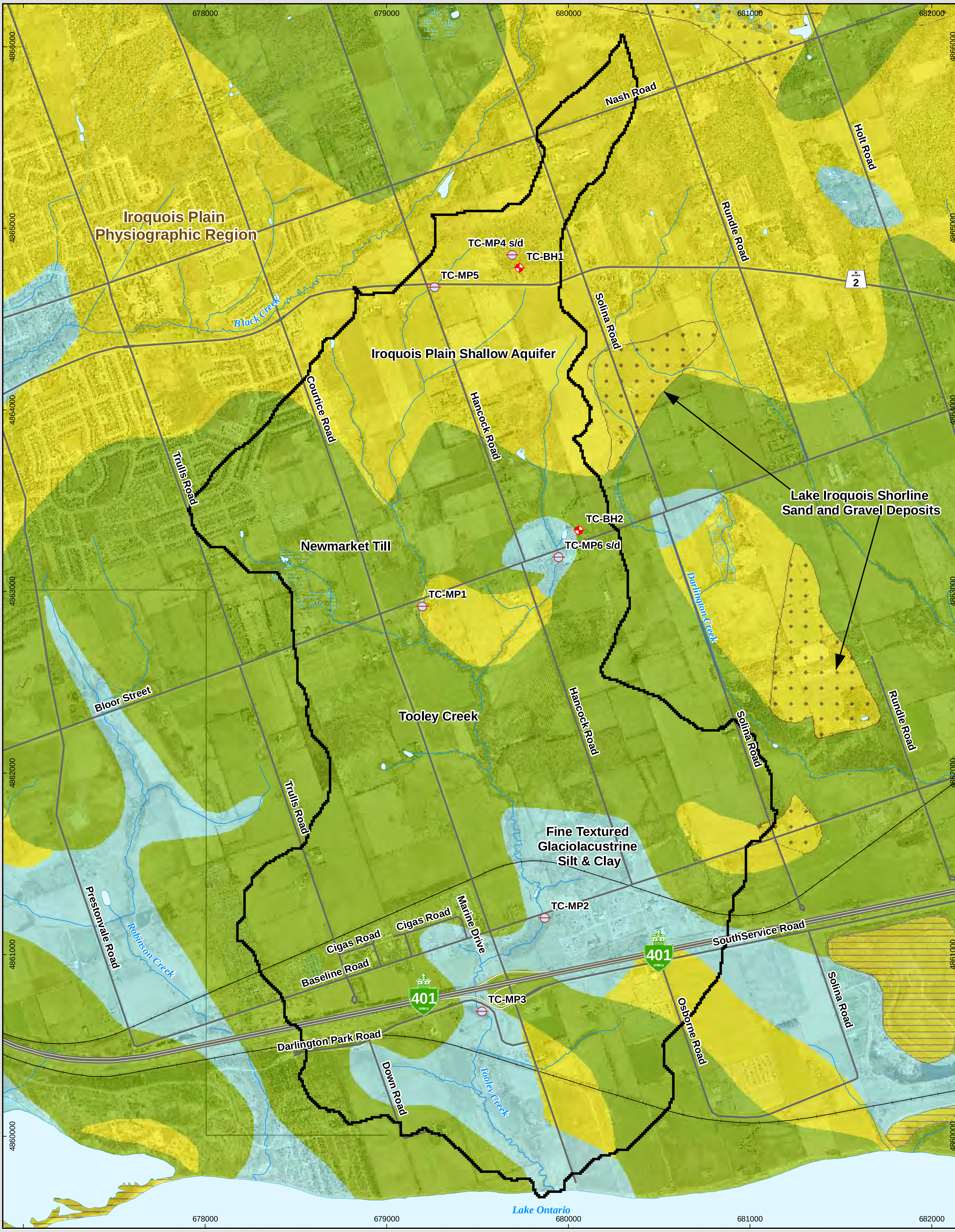

Basemapping from Ontario Ministry of Natural Resources
Orthophotography: 2005

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0 100 200 400 600 800

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UTM Zone 17N, NAD 83

Legend

Monitors

- Groundwater Monitor Nest
- MIni-Piezometer
- Watershed
- Railway
- Intermittent Stream
- Permanent Stream
- Waterbody Segment
- Wetland Area, Permanent

Surficial Geology

- 20: Organic deposits
- 19: Modern alluvial deposits (Silt, Sand and Gravel)
- 14b: Littoral-foreshore deposits (Sand)
- 9b: Littoral-foreshore deposits (Sand and Gravel)
- 9c: Foreshore-basinal deposits (Silt and Clay)
- 8a: Massive-well laminated (Silt and Clay)
- 5b: Stone-poor, carbonate-derived silty to sandy till (Newmarket Till)

Robinson Creek and Tooley Creek Watershed Plan

Tooley Creek Watershed Surficial Geology

September 2009
Project 112956

AECOM

Figure 4.11

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UTM Zone 17N, NAD 83

Legend

Monitors

- Groundwater Monitor Nest
- MIni-Piezometer
- Watershed
- Railway
- Intermittent Stream
- Permanent Stream
- Waterbody Segment
- Wetland Area, Permanent

Robinson Creek and Tooley Creek Watershed Plan

Tooley Creek Watershed MOE Water Wells

September 2009
Project 112956

AECOM

Figure 4.12

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Basemapping from Ontario Ministry of Natural Resources
Orthophotography: 2005

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UTM Zone 17N, NAD 83

Legend

- Equipotential Lines
- MOE Water Wells and Static Groundwater Level
- Watershed

Tooley/Robinson Creek

Tooley Creek Equipotential Map

October 2009
Project 112956

AECOM

Figure 4.13

Map Document: (N:\projects\0-aecom\112956\2009\Final\GISSpatial\MXDs\ReportMXDs\112956TooleyStaticGWLevel.mxd)
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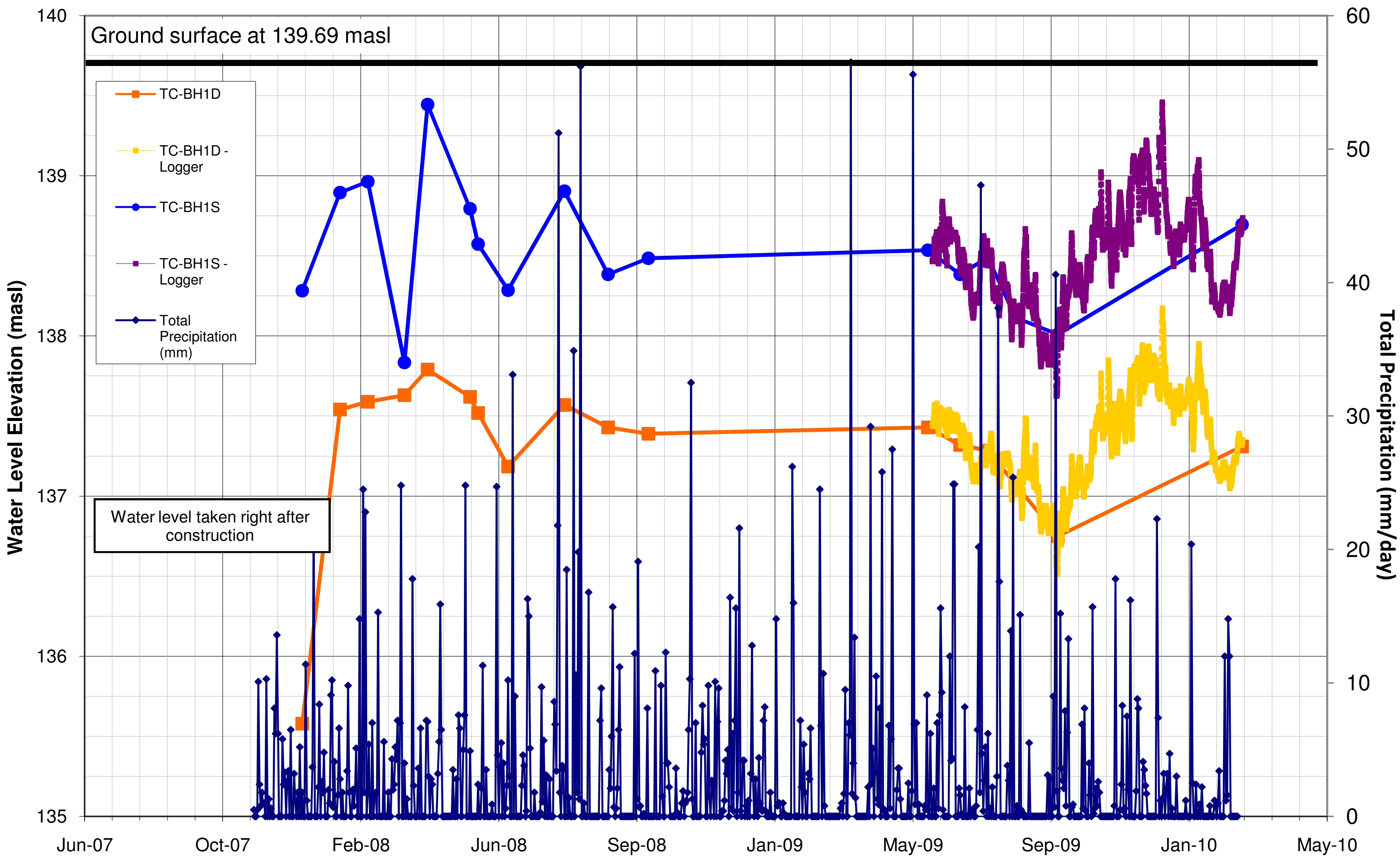


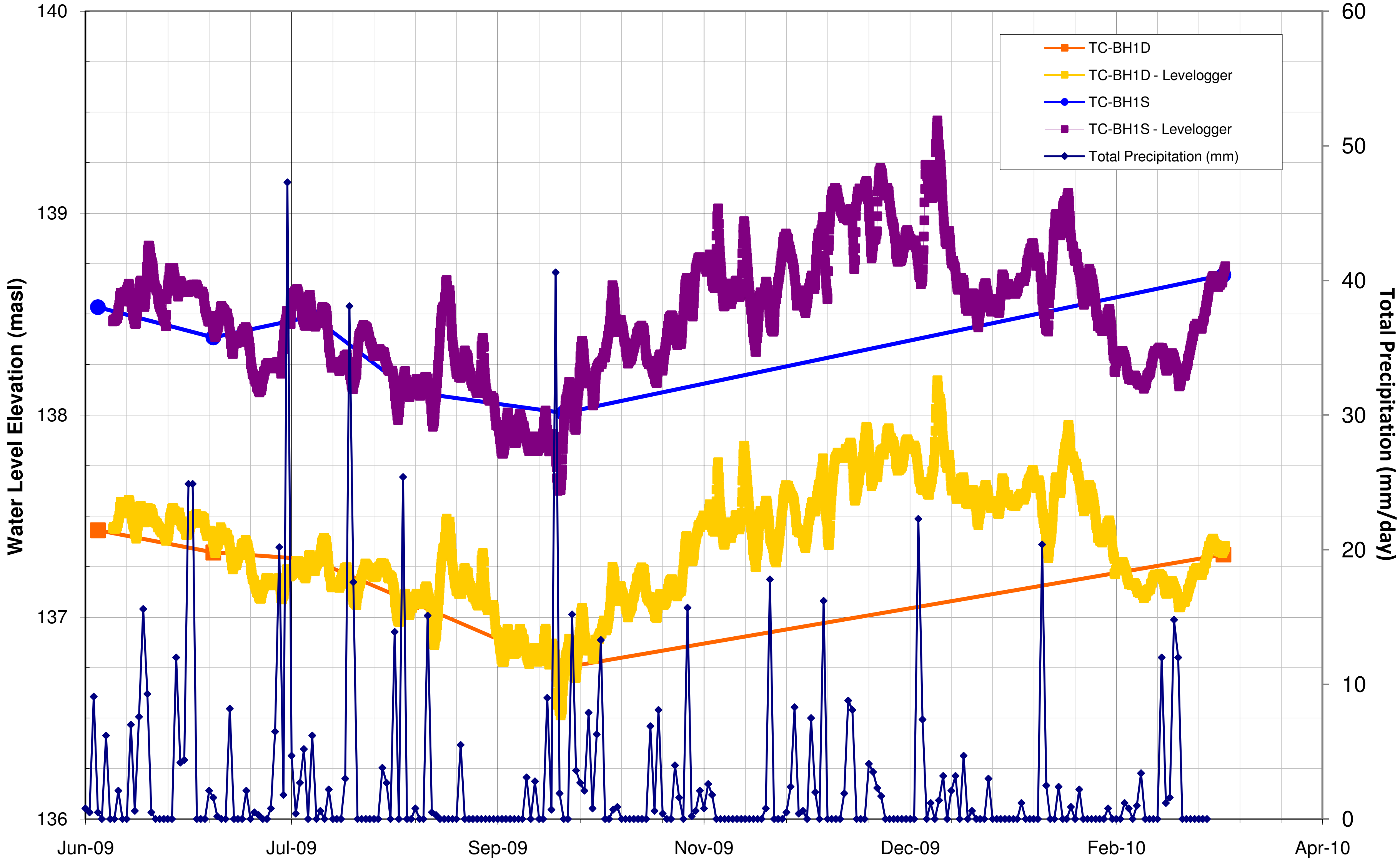
Water Levels TC-BH-1

CLOCA - Tooley Creek / Robinson Creek Watershed Study

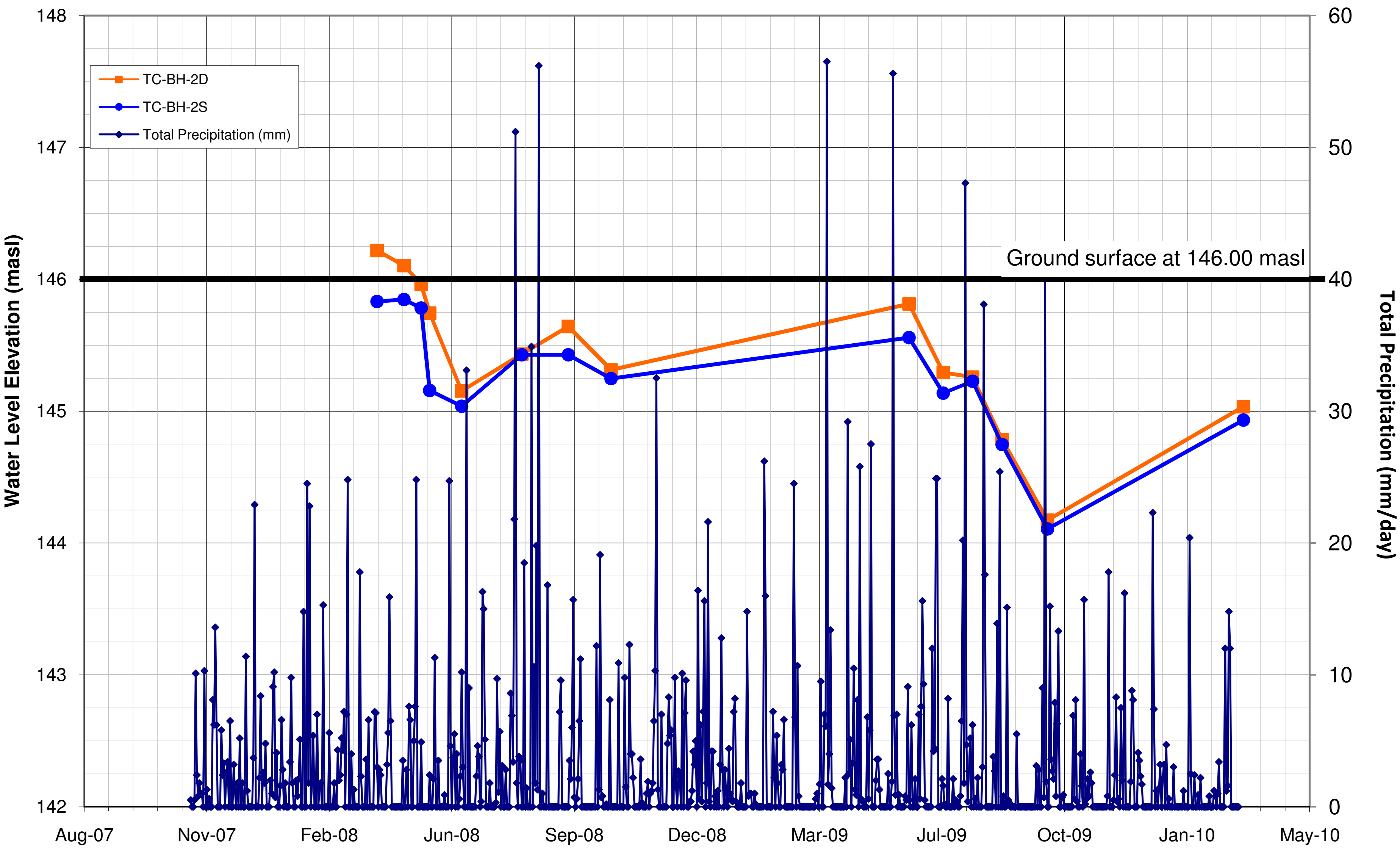
* Figure modfied from 407 East EA (MTO,2009).

FIGURE 4.14

Project 112956



Water Levels TC-BH-1	**FIGURE 4.15**
CLOCA - Tooley Creek / Robinson Creek Watershed Study	Project 112956



Water Levels TC-BH-2

FIGURE 4.16

CLOCA - Tooley Creek / Robinson Creek Watershed Study

Project 112956

* Figure modfied from 407 East EA (MTO,2009).

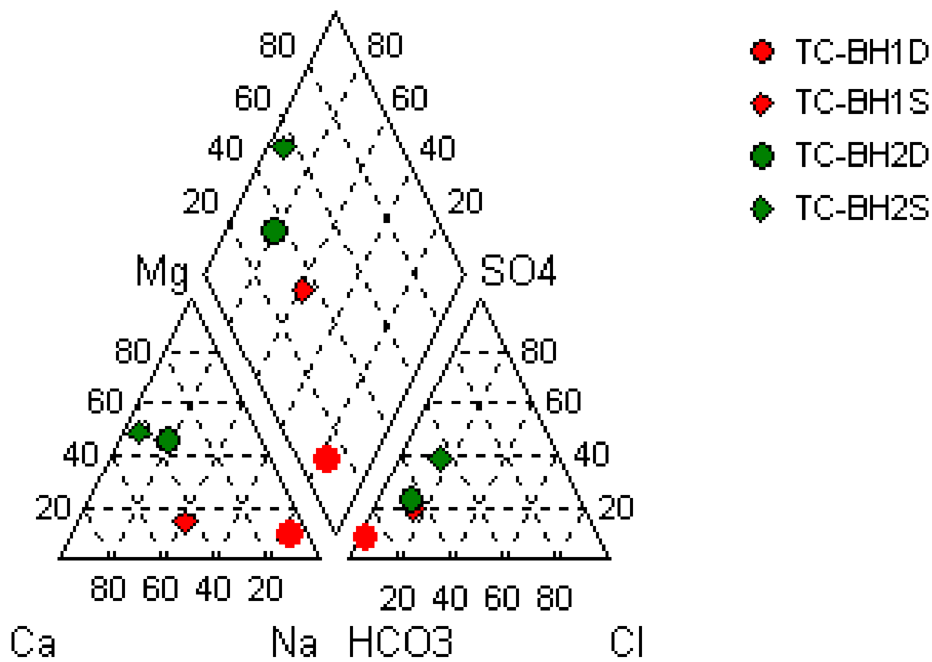
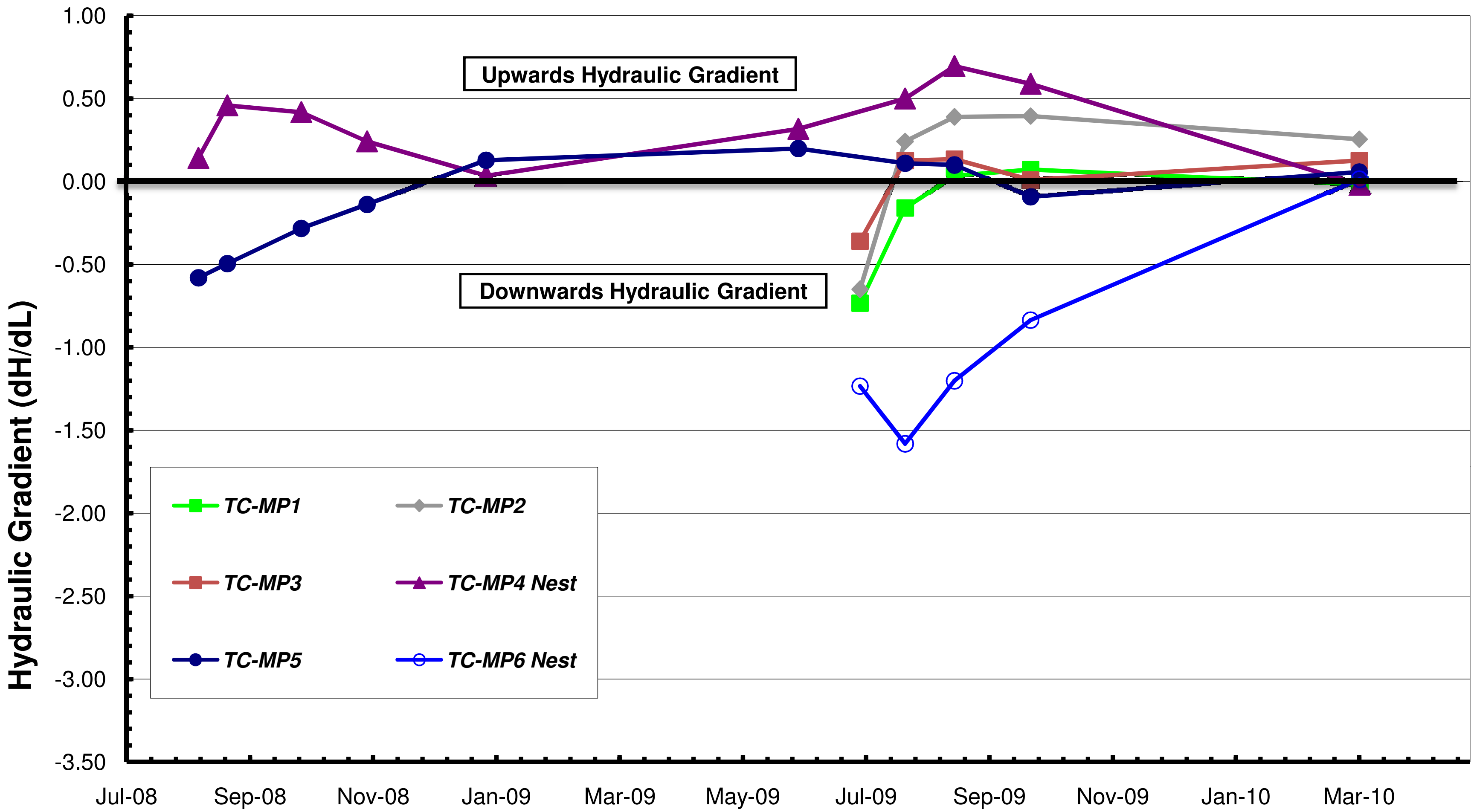


Figure 4.17 Piper Plot of Major Anions and Cations



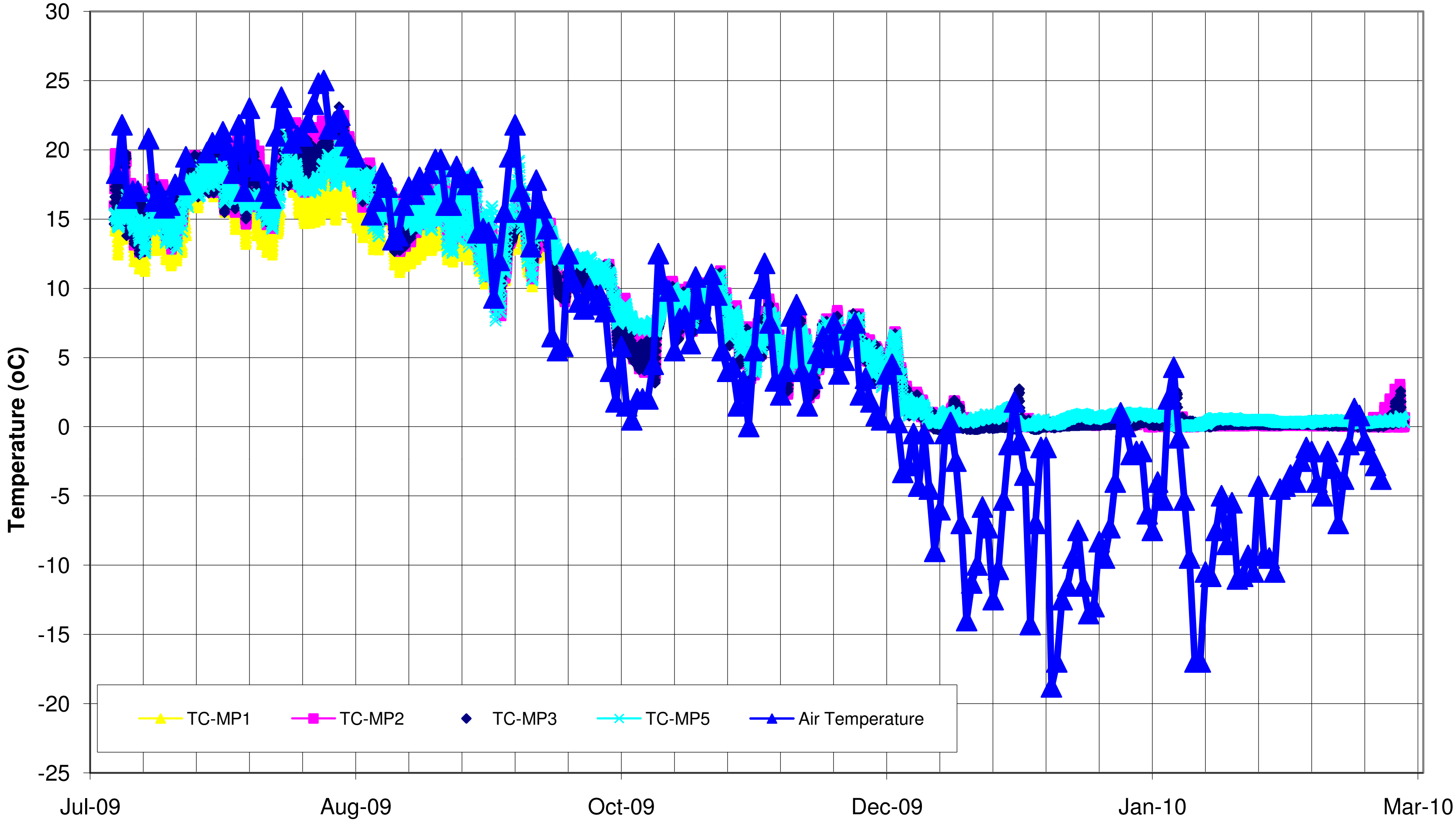
Hydraulic Gradients in Mini-Piezometers (Tooley Creek Watershed)

CLOCA - Tooley Creek / Robinson Creek Watershed Study

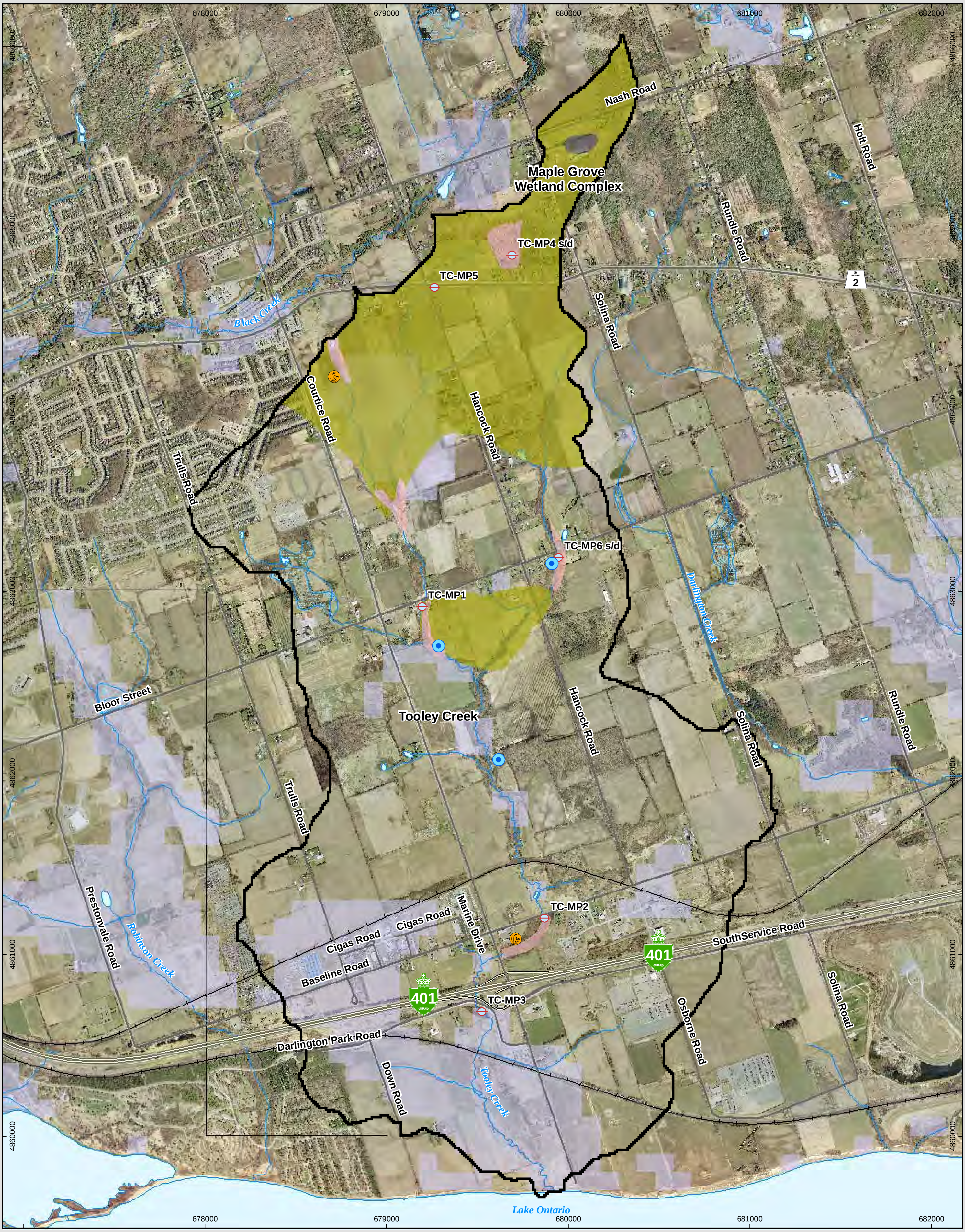
* Figure modfied from 407 East EA (MTO 2009).

FIGURE 4.18

Project 112956



Stream Temperature (Tooley Creek Watershed)	FIGURE 4.19
CLOCA - Tooley Creek / Robinson Creek Watershed Study	Project 112956



Basemapping from Ontario Ministry of Natural Resources
Orthophotography: 2005

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0 100 200 400 600 800

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UTM Zone 17N, NAD 83

Legend

Seepage Indicating Plant Species
- Marsh Marigold (Calthaa palustris)

Upwards Hydraulic Gradients: Groundwater Monitors
- Mini-piezometer

Visual Seepage Observations
- Spring
- Seepage

Soil Type
- Organic Soil
- Iroquois Plain Shallow Aquifer

- Modelled Groundwater Discharge Areas(CLOCA)
- Watershed
- Railway
- Intermittent Stream
- Permanent Stream
- Waterbody Segment
- Wetland Area, Permanent

Robinson Creek and Tooley Creek Watershed Plan

Tooley Creek Watershed Groundwater Discharge Observations

October 2009
Project 112956

AECOM

Figure 4.20

Map Document: (N:\projects\0-aecom\112956\2009\Final\GISSpatial\MXDs\ReportMXDs\112956TooleyDischarge.mxd)
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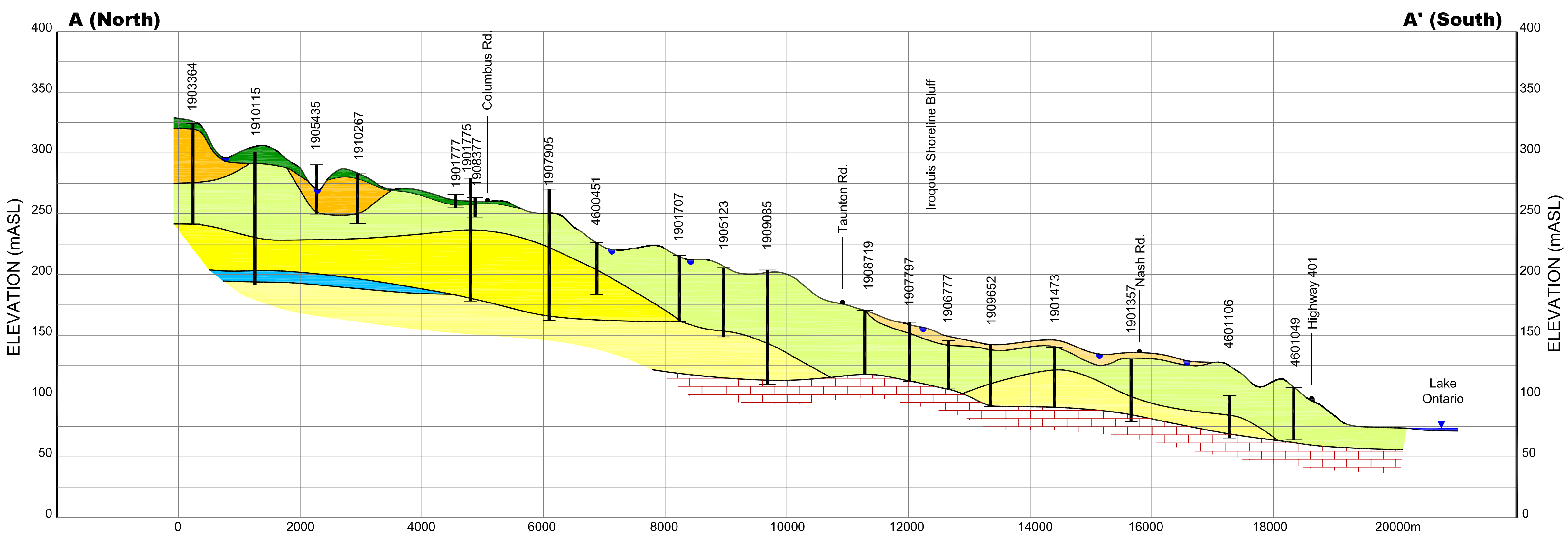

CROSS SECTION ALONG OSHAWA-CLARINGTON TOWNLINE

Legend

- Iroquois Sediments
- Halton Till
- Oak Ridges Moraine
- Newmarket Till
- Thorncliffe Formation
- Sunnybrook Drift
- Scarborough Formation
- Bedrock

4601873 — Water Well Location and Identification
— Original Ground
— Creek
— Inferred Stratigraphic Contact
— Water Level

Horizontal 1 : 80000
0 400 800 1600 2400 3200 m
0 20 40 80 120 160 m
Vertical 1 : 4000

NOTE:
Stratigraphy inferred from MOE water well borehole logs within 1km of cross–section line and refined from the Ontario Geological Survey's regional geological model.

DO NOT SCALE THIS DOCUMENT.
ALL MEASUREMENTS MUST BE OBTAINED FROM STATED DIMENSIONS

AECOM

Robinson and Tooley Creek Watershed Study

Geological Cross-Section

PROJECT NUMBER	DATE	FIGURE
60119359	August 2010	4.21

5. Hydrologic and Hydraulic Modelling

5.1 Robinson Creek Hydrologic and Hydraulic Modelling

The first hydrologic and hydraulic models for the Robinson Creek Watershed were prepared by M.M. Dillon Consulting Engineers Ltd. in 1974 (Whitby Bowmanville Area Floodplain Mapping). This study terminates approximately 600 m north of Bloor Street. The portion of Robinson Creek above this study area was modelled by G.M. Sernas and Associates in 1991 (Robinson Creek Master Drainage Study).

In February 2010, CLOCA produced updated hydrologic and hydraulic models for the Robinson Creek Watershed in a report entitled, “Hydrologic and Hydraulic Modelling for Robinson Creek”. This report takes into account the most recent land use classes, flow characteristics, and watershed/subwatershed boundaries. Updated floodplain mapping was also completed as part of this report. The hydrologic and hydraulic report prepared by CLOCA (2010a) is included in its entirely in **Appendix A** of this report, and where appropriate, is referenced.

5.2 Tooley Creek Hydrologic and Hydraulic Modelling

The original hydrologic and hydraulic models for the Tooley Creek Watershed were prepared by M.M. Dillon Consulting Engineers Ltd. in 1974 (Whitby Bowmanville Area Floodplain Mapping).

In October 2007, revised in March 2008, CLOCA produced updated hydrologic and hydraulic models for the Tooley Creek Watershed in a report entitled, “Hydrologic and Hydraulic Modelling for Tooley Creek”. This report takes into account the most recent land use classes, flow characteristics, and watershed/subwatershed boundaries. The revision in March 2008 was to include additional HEC-RAS modelling of the Courtice Road Subway. The hydrologic and hydraulic report prepared by CLOCA (2010b) is included in its entirely in **Appendix B** of this report, and where appropriate, is referenced.

6. Fisheries and Aquatic Habitat

6.1 Introduction

The aquatic environment and fish communities found within the Robinson Creek and Tooley Creek watersheds are largely influenced by numerous contributing factors including:

- Hydrology;
- Hydrogeology;
- Land use and land cover (including wetlands and riparian vegetation); and
- Local climate, geography, physiographic and surficial geology.

Many of these influencing factors are discussed in detail relative to the existing condition of the aquatic resources and each will be discussed in relation to the Fisheries and Aquatic resources of the Robinson Creek and Tooley Creek watersheds throughout this report.

6.2 Study Area and Scope

As described above, Robinson Creek and Tooley Creek occur within the Municipality of Clarington, and flow drains into Lake Ontario. Although the watersheds are geographically close, they are vastly different in their physiographic characteristics, hydrology and resulting aquatic features. Consequently, each watershed will be discussed separately in this report.

For each watercourse, this report will summarizes the current existing condition of the fisheries communities/resources and aquatic habitat present in both the Robinson Creek and Tooley Creek watersheds Within this summary, a relevant historical synopsis of the resources will be provided to the extent that such information is from existing secondary source data or discussions with local and former residents of the watersheds.

Additionally, specific indicators of aquatic habitat condition and health are described in relation to the local environment including, Strahler stream order, instream barriers to fish migration/isolation, riparian vegetation, thermal regimes and land use/cover. In addition to these environmental indicators and conditions, fish species and benthic invertebrate composition and distribution within the watersheds will also be discussed as they relate and respond to these contributing influences.

6.3 Methodology

Secondary source information was comprehensively compiled and analyzed to develop a general understanding of the aquatic ecosystems and fish communities within the watersheds.

Secondary source information was reviewed and gathered from the following sources:

- CLOCA 2009, 2008, 2007, and 2006 Aquatic Monitoring Reports;
- Information gathered from previous 407 Environmental Assessment studies (1989-1994);
- Existing fish community and habitat mapping collected for 407 EA (2001, 2005-2008));
- 1:50,000 NTS maps and aerial photography and digital orthoimagery;
- 1:10,000 Ontario Base Maps (OBM);
- Ministry of Natural Resources (MNR) Natural Resource Values Systems (NRVIS) mapping; and
- Existing information residing with MNR, CLOCA, and local field naturalists, including those from Darlington Provincial Park.

In addition to secondary source information, field investigations were undertaken during the spring/summer and fall of 2009 to augment existing data and support the understanding of the existing conditions within each watershed for planning purposes.

6.3.1 Habitat Surveys

Tributaries of the creek systems having the potential to support fish and fish habitat were identified through air photo interpretation and available secondary source information prior to conducting field surveys,. Confirmatory aquatic habitat field investigations were conducted by AECOM in June, August and September 2009 (sample locations are identified in **Figure 6.3** and **6.7**).

Primary fisheries data were gathered from both watersheds in 2009. Specifically, fish community sampling and fish habitat assessments were conducted in June 2009 and August/September 2009 (**Figure 6.3** and **6.7** in order to capture migrating spring spawning fish species and to determine which habitats and stream reaches fish utilize during the spring freshet. This approach permits for the sampling of streams when they are most likely flowing, thus optimizing the likelihood of observing the presence of fish in the watercourses. Fish sampling was conducted using a Model 12 backpack electrofisher and dip nets or minnow traps depending on the habitat present. AECOM selected each sampling location based on air photo interpretation and property access, in order to get uniform sampling effort throughout the watersheds. In addition to the existing fish sampling locations monitored by regularly by CLOCA, AECOM sampled five additional locations within the Robinson Creek Watershed, and five additional locations within the Tooley Creek Watershed during 2009. Fish sampling locations were originally identified in upper reaches of the watercourses, and primarily in the headwaters of the watersheds but on field inspection these areas lacked permanent flow or suitable refuge habitat for complete analysis. In these instances, only the potential for habitat from a fisheries resource perspective was characterized.

A qualitative fish habitat assessment was conducted at each sampling station, (where applicable) using a modified version of the Rapid Assessment Methodology for Channel Structure (RAM) module (section 4, module 2) from the Ontario Stream Assessment Protocol (OSAP 2003; version 5.1). The RAM tool is designed to provide visual estimates of common attributes of channel structure such as;

- general channel dimensions and flow conditions
- substrate
- instream and riparian vegetation
- instream/bank cover
- morphology (riffle, run, pool, flat)
- evidence of groundwater discharge and general water quality indicators
- evidence of previous channel disturbance (e.g., channelization, straightening, realignment); and
- fish barriers and connectivity

For each of the habitat sampling reaches a specific site was identified according to the OSAP protocol. A sampling site was defined as a section of stream with a minimum length of 40 m with a beginning and ending at crossover points and inclusion of at least one riffle-pool sequence. The OSAP "Site Identification Form" and "Site Features Form" were completed for each station.

The RAM module recommends that surveys be completed using:

> *"visual transects across the stream at the appropriate distances along the channel (i.e., about 10 transects, one every 4 to 5 m for a 40 m station)";, and with "6 or more point observations along each transect".*

It is AECOM‟s experience that greater amount of variability in the characterization of stream attributes is associated with the visual transect method rather than with the Point-Transect method, also described in the OSAP manual. To reduce attribute measurement variability, both the transect and the point layout for the Point–Transect module (Section 4, Module 2) were used. AECOM‟s applied the number of transects and points per transect dependent on stream width, as provided in **Table 6.1**. A RAM field sheet was completed for each sampling site.

Table 6.1 Transect and Point Layout (OSAP, Section 4, Module 2)

Minimum Width (m)	Number of Transects	Points per Transect
>3.0	10	6
1.5 – 3.0	12	5
1.0 – 1.49	15	3
<1.0	20	2

When physical characteristics permitted (i.e., sufficient water depth), sampling sites were electrofished using a single pass survey according to OSAP methodologies (Section 3, Module 1). (Note: block nets are optional and were not used in this study). In situations where electrofishing was not possible (habitat was overly confined for suitable access of two people), minnow traps were deployed and left overnight in order to identify and enumerate the fish community at the sampling location.

Electrofishing was generally undertaken on the same day as the RAM survey. However there were occasions when this was not possible. When the two modules were conducted on the same day, electrofishing was conducted first and the RAM conducted post electrofishing. Efforts were taken to minimize the disturbance to in-stream habitat while electrofishing in order to maintain the integrity of the subsequent habitat survey.

6.3.2 Biological Water Quality Assessments

Benthic invertebrates are excellent indictors of environmental condition because they are continually exposed to the full rigor of their environment over long periods of time. Quantitative benthic invertebrate samples were collected on June 24, 2009 from three locations and on September 3, 2009, from two additional locations in Robinson Creek. Furthermore, benthic invertebrate samples were also collected on June 25, 2009, from three locations within Tooley Creek (**Figures 6.4** and **6.8**) using the Ontario Stream Assessment Protocol approved kick and sweep method. This sampling technique generates a composite sample of the invertebrate community present in both pool and riffle habitats by establishing collection areas (transects) along a meander sequence, with representation of at least one pool and two riffles (Stanfield, 2005). At each site, a 10 m by 0.5 m area of the stream was sampled except those cases where the stream was less than 10 m in width. In these instances multiple transects were sampled, each one being the full stream width at that location). All samples were collected with a D framed net with a standardized mesh (500 µm) and completed within a standardized time (10 minutes). All the samples were submitted to a qualified taxonomist for identification and enumeration (ZEAS, Nobleton, ON). The following benthic invertebrate community descriptors were calculated:

- Organism abundance;
- Organism density;
- Species richness;
- Relative abundance of taxonomic groups;
- Ephemeroptera, Plecoptera, and Trichoptera (EPT) Index;
- Simpson‟s Index of Diversity;
- Hilsenhoff Biotic Index; and
- BioMap Water Quality Index (WQI).

6.3.3 Chemical Water Quality Assessments

To collect and characterize surface water quality in Robinson and Tooley Creek, field chemistry and water quality samples were collected on June 24-25, August 24 and September 3, 2009, from flowing water at specific locations south of Bloor Street within the Creek, (**Figure 6.4 and Figure 6.8**). Samples north of Bloor Street were not obtained due to insufficient water or stagnant (standing) water conditions. Field measurements (water temperature, pH and conductivity) were measured at the time of each water quality sample. Chemical analyses of the surface water grab samples were analyzed for: total ammonia, total phosphorus, total suspended solids (TSS), dissolved chloride and biological oxygen demand (BOD) by an accredited laboratory (Maxxam). Where possible, un-ionized ammonia was calculated using field measurements (pH and water temperature) and the laboratory result for total ammonia.

6.4 Robinson Creek Results

6.4.1 Watershed Context

6.4.1.1 Strahler Stream Order

Stream order provides a method of grouping streams of a similar size, depth and flow, as well as suggesting a level of sensitivity a watercourse may have to disturbance or development. In general, as stream order increases, so does watercourse depth and width. To this end, stream order may be directly attributable to other morphometric and fluvial characteristics of a watershed, and can therefore be used in the determination/classification of fish habitat. Strahler"s (1952) stream order classification was used to classify stream segments in the watersheds at a scale of 1:10,000 based on the number of tributaries upstream. A stream with no tributaries (headwater stream) is considered a first order stream. The confluence of two first order streams represents the forming of a second order stream and so on. As stream orders increase, stream gradients generally decrease. This can be observed in first and second order streams generally characterised as having narrow banks with eroding substrates, while fourth and fifth order streams are generally wider, slower moving with large pool/riffle sections and contain both erosional and depositional zones.

Table 6.2 below shows stream order classifications within the Robinson Creek Watershed. Robinson Creek flows for approximately 6.7 km (north to south) before out letting into Lake Ontario at the south end of Darlington Provincial Park (**Figure 6.1**). Robinson Creek is classified as a warm water system according to MNR Natural Resources, Natural Value Information System (NRVIS) mapping (MNR, 2008). However, results collected as part of this study and through analysis of data provided by CLOCA, conclude that Robinson Creek should be thermally classified as a coolwater system (**Figure 6.3**). This will be discussed further in section 6.4.2.

Table 6.2 Strahler Stream Order Designations for Robinson Creek

Watershed	Strahler Stream Order	Length
Robinson Creek	1	4.0 km
	2	2.7 km
	Total	**6.7 km**

6.4.1.2 Instream Barriers

In stream barriers can arise from a variety of causes including man-made devices such as water control structures (i.e., dams, weirs and culverts) or natural obstacles such as log jams or debris weirs that prevent/deter/obstruct fish movement. The presence of barriers in watercourses can cause localized stress to fish throughout the year, but are particularly detrimental during spawning migrations or (in the case of the Robinson and Tooley Creek watersheds) during periods of low flow condition when migration upstream and downstream for fish is critical to finding adequate refuge habitat.

Instream barriers can affect water quality and habitat conditions within a watershed. Of particular importance is the potential for standing water behind barriers to warm more than flowing segments as a result of increased solar absorption (Wetzel 2001). Barriers can also act as sediment traps and in some cases have been shown to decrease downstream turbidity and sediment loading (Liu and Yu 1992). Stagnant or standing water behind a barrier allows for increased sediment to settle out from the flowing water. In these instances, large amounts of sediment can build up behind barriers and lead to dissolved oxygen depletion through increased biological oxygen demand (BOD) in the sediments as rates of decay may increase. Change in hydraulic head and stream channel dimensions can also result in flow changes, and specifically increased water velocities. Increased velocities have been associated with increased rates of bank and substrate erosion downstream that interfere with natural morphological processes as well as physical fish habitat conditions. Instream barriers such as beaver dams and weirs also have the potential for large sediment releases and flushing as the ponded areas become increasingly full of sediment. Large releases of sediment to downstream reaches of a system may lead to the smothering of fish spawning habitat and the infilling of refuge pools and other important habitat features.

In stream barriers within Robinson Creek were assessed during spring and summer field surveys in 2009 by AECOM staff and were supplemented by Hydrologic and Hydraulic Modelling results for Robinson Creek provided by CLOCA (2010) and presented in **Appendix A**. Moving upstream within the watershed from Lake Ontario, the first impediment to fish migration is located at the railway crossing of Robinson Creek upstream of Baseline Road (**Figure 6.2**). The railway crossing is best described as a closed bottom, concrete arch culvert that conveys flow for approximately 20 m beneath the railway. Within the archway the watercourse is confined within an engineered concrete channel with laminar flow and little instream cover or flow variability. In terms of fish migration through the culvert, movement may be limited by velocity barriers during periods of peak flow through the archway culvert. However, during periods of low flow, movement through the culvert may likewise impeded because of a lack of refuge or holding structures resulting from the otherwise laminar and uniform sill within the underpass.

A second barrier to fish movement was located on the south side of Bloor Street (**Figure 6.2**) and is associated with a perched culvert. At this location the physical barrier created by the disconnection of the culvert to the stream bed likely limits the upstream passage of certain species into upstream habitats or possible the headwaters of the watershed. It is noteworthy that in regard to the perched culver, an abundance of fish were captured on the downstream side of the perched culvert in late August (2009), while no fish were captured upstream of this location (nor was suitable fish habitat observed) during 2009 fish community sampling.

6.4.1.3 Riparian Vegetation and Landscape Influences

The relationship between riparian vegetation, water quality and aquatic life is well documented and studied (Mackie, 2001). Riparian vegetation serves as natural filtration for overland surface water flow and aids in minimizing sedimentation within streams. Riparian vegetation also functions to provide allochthonous inputs into streams such as leaf and woody debris, which creates habitat cover and provides shade cover over streams contributing to the buffering of water temperatures. Environment Canada guidelines state that 75% of a stream length should be buffered by 30 m of riparian cover to maintain a healthy state (EC, 2004).

Within the Robinson Creek Watershed many of the first order streams are devoid of adequate riparian vegetation and generally consist of scrublands and highly disturbed construction areas or outlets from stormwater or irrigation ponds (**Figure 6.1**). Some vegetated areas within the headwaters exist north of Bloor Street in the western tributary, however large reaches of first order tributaries throughout the watershed are highly disturbed, altered or have been eliminated through recent developments. **Figure 6.1** depicts some of the recent and ongoing development within the watershed and illustrates the lack of riparian vegetation surrounding first order tributaries. In total approximately 72% of first order streams lack sufficient riparian vegetation while only 28% maintain some riparian vegetation cover.

In contrast to first order streams, the majority of second order stream reaches within the Robinson Creek Watershed are surrounded by large naturalised riparian buffers that are relatively undisturbed from development or local agriculture. **Figure 6.1** (south of Bloor Street) contains the details of a large contiguous riparian corridor bordering one of two second order tributaries of the watershed throughout most of its drainage downstream to Lake Ontario. The riparian cover is also shown on **Figure 7.2**, of Section 7. Coincidently, these reaches of the watershed also represent some of the highest quality and most productive fish habitat areas within the watershed. In total approximately 70% of second order streams maintain adequate riparian buffer vegetation while 30% of second order streams are limited in riparian cover.

The majority of the third order stream reaches within the Robinson Creek Watershed also maintain adequate riparian vegetation. Specifically, roughly 79% of the stream length from the confluence of the two second order tributaries upstream of the railway crossing north of Baseline Road (**Figure 6.1**) downstream to the outlet into Lake Ontario, the Robinson Creek main branch maintains good riparian cover with only a fifth of the stream associated with Darlington Provincial Park lacking well established riparian cover.

6.4.2 Fisheries and Aquatic Habitat

The following section provides a brief discussion on the fish community present within Robinson Creek. A complete list of fish species captured at each sampling location (**Figure 6.3**) within the Robinson Creek Watershed is also located in **Appendix C** (only sites where fish were captured are included in the table). Historic fish community data obtained from the MNR, from CLOCA‟s 2009 Aquatic Monitoring Report, and fish captured during AECOM‟s 2009 field investigations, are presented in **Table 6.3**.

Table 6.3 Known Fish Community Composition – Robinson Creek Watershed

Family	Common Name	Scientific Name	Abundance (% of total captured)	Thermal Class	COSEWIC Status	COSSARO Status
Catostomidae	White Sucker	*Catostomus commersoni*	<1%	Cool	NAR	NAR
Centrarchidae	Pumpkinseed	*Lepomis gibbosus*	3%	Warm	NAR	NAR
Cyprinidae	Fathead Minnow	*Pimephales notatus*	36%	Warm	NAR	NAR
	Creek Chub	*Semotilus atromaculauts*	25%	Cool	NAR	NAR
	Blacknose Dace	*Rhinichthys atratulus*	30%	Warm	NAR	NAR
	Longnose Dace	*Rhinichthys cataractae*	<1%	Cool	NAR	NAR
	Northern Redbelly Dace	*Phoximus eos*	3%	Cool/Warm	NAR	NAR
Gasterosteidae	Brook Stickleback	*Culaea inconstans*	2%	Cool	NAR	NAR
Percidae	Johnny Darter	*Etheostoma nigrum*	<1%	Warm	NAR	NAR
Salmonidae	Rainbow Trout	*Oncorhynchus mykiss*	<1%	Cold	NAR	NAR
Cyprinodontidae	Banded Killifish	*Fundulus diaphanus*	<1%	Cool	NAR	NAR

AECOM‟s fish community sampling for the Robinson Creek Watershed identified 11 known species, representing seven families. Given the sampling frequencies employed it is possible that a small number of additional species inhabiting the watershed on a seasonal/permanent basis were not identified in the efforts of this study. Regardless, in comparison to the 73 species known to reside in CLOCA‟s jurisdiction (CLOCA, 2008), the fish community of the Robinson Creek watershed is poorly represented.

Of the 11 fish species caught, Blacknose Dace (*Rhinichthys atratulus*), Creek Chub (*Semotilus atromaculauts*) and Fathead Minnow (*Pimephales promelas*), where the most common species captured, and were all captured in similar amounts within Robinson Creek (**Table 6.3**). These fish species represent a warm to coolwater community and are each widespread in their southern Ontario distribution. Rainbow Trout (*Oncorhynchus mykiss*), which is a coldwater species, represented less than 1% of all fish captured.

The location and timing of migratory fish species, such as rainbow trout (a cold/cool water fish species) and white sucker, collections from Robinson Creek are shown on **Figure 6.3**. AECOM identified young-of-the-year rainbow trout upstream of the barrier at the railway crossing of Robinson Creek, upstream of Baseline Road, suggesting that the railway crossing north of Baseline Road is not a significant barrier to rainbow trout migration. These data are consistent with CLOCA reports confirming young-of-the-year rainbow trout in Robinson Creek in 2003, however, it should also be noted that CLOCA was not able to capture migratory species from the same areas in 2008 and 2009.

The confirmed occurrence of rainbow trout, both in 2009 (AECOM) and 2003 (CLOCA) suggests that limited runs of migratory rainbow trout exist in the watershed, and furthermore, the middle reaches of the watershed provide tolerable, cool water conditions for moderately tolerant fish species, including rainbow trout (a cold/cool water fish species).

White sucker were caught by AECOM in 2009, upstream of the railway crossing barrier, but below the perched culvert at Bloor Street. A local resident reports historical runs of longnose sucker (*Catostomus catostomus*) and white sucker within the watershed, however these runs declined or disappeared seasonally since the 1980s. On further investigation, AECOM confirmed that there are no records of longnose sucker within MNR or CLOCA databases/reports, and the mention of longnose sucker is not substantiated.

The spawning migration of white sucker (although locally reported to be severely reduced from the 1990s), still occurs annually within the watershed, as indicated by the white sucker caught all along Robinson Creek (**Figure 6.3**). This indicates that upstream and downstream movement of white sucker occurs within the watershed, as some juvenile white sucker were captured above the railway crossing barrier north of Baseline Road. However, none were captured upstream of the perched culvert at Bloor St., indicating that this is a significant barrier to fish movement.

The presence of cool water species within the watershed also speaks to the thermal regime of the watershed as displayed in **Table 6.4**. Water temperatures generally mimicked the fluctuating air temperature on a daily basis indicating primarily warm water conditions but as noted in **Section 4.3.2**, **Figure 4.7**, some shallow groundwater inputs occur within the upstream reaches of the watershed and likely aid in creating suitable/tolerable conditions for species such as creek chub, longnose dace, northern redbelly dace, and brook stickleback.

Table 6.4 Stream Temperature Monitoring within Robinson Creek

Temperature Logger Location	Period of Record	Days within Mean Daily Temperature Range				Min Temp (°C)	Max Temp (°C)	Classification
		Cold (<19°C)	*Cool (19 – 25°C)*	*Warm (>25°C)*	*Lethal Limit for Rainbow Trout (>26°C)*			
RC-WT2 (MP2)	July 12 – August 31, 2009	8	42	1	0	16.2	25.1	Coolwater
RC-WT3 (MP3)	July 12 – August 31, 2009	21	30	0	0	15.7	23.8	Coolwater

Stream temperatures collected between July and August 2009 suggest that the thermal regime is generally coolwater rather than warmwater (as shown in the MNR database), and supports a coolwater classification for this system. AECOM"s conclusion is consistent with CLOCA"s thermal data collected between 2005 and 2009, and generally matches the thermal class of the fish community, with the exception of the presence of rainbow trout; which are most often associated with coldwater systems. Despite AECOM and CLOCA data (including fish collections) in support of a coolwater thermal regime, CLOCA reported in 2006 that the thermal regime of the Robinson Creek tributary at Prestonville Road (CLOCA‟s sampling location was near AECOM sampling location R5) was characteristic of a warmwater system. The disagreement in findings between study years suggests that the thermal regime of Robinson Creek is variable from year-to-year or from segment to segment. In addition, it is noteworthy that July 2009 was a relatively cool month relative to the climatic norms (**Table 2.2**) and given the seasonally dependent sampling events undertaken, AECOM‟s dataset is probably slightly bias towards lower stream temperatures. In light of the point-in-time nature of most field studies, the extension of such data to defining a thermal regime may not be of practical use. In actuality, a multi-year sampling is best suited to the determination of thermal characteristics of a system.

Based on AECOM‟s findings fish community within the Robinson Creek Watershed contains a range of warm to cold water fish species that are widespread in distribution and are moderately to highly tolerant of environmental change and perturbation. With the exception of rainbow trout, the fish community of Robinson Creek is typical of a coolwater system with the distribution of species primarily dependant on flow regime within the watershed and less onwater temperatures. Therefore, AECOM‟s conclusion the fish community most consistent with a coolwater fish community comprised of generalist species that are not highly dependent on specific habitat requirements for spawning or life history processes.

To this end, flow regime within Robinson Creek is a primary factor of fish species distribution and habitat potential. As illustrated in **Figure 6.3** seasonal fish habitat within intermittent reaches of Robinson Creek does exist within some of the first and second order stream reaches and the majority of permanent fish habitat exists within the second and third order stream reaches.

6.4.2.1 Biological Water Quality Assessments

A taxonomic list showing all benthic macro-invertebrate species collected at all stations (following the sampling methods described in section 6.3.2) is included in **Appendix C**.

Organism abundance is the total number of organisms collected from each site and each respective density was calculated as the total number of individuals of all taxonomic categories collected at each site expressed per unit area (numbers/m^2). Species richness is the total number of different species collected at each site.

The EPT index is the total number of individuals counted from within the taxonomic orders, Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) compared to the total number of individuals counted in the whole sample. Since these taxa are typically sensitive to environmental stressors, a higher EPT index is typically associated with better environmental quality.

The Simpson‟s Index of Diversity (D) accounts for both the abundance patterns and taxonomic richness of the community. This is calculated by determining for each taxonomic group at a site, the proportion of individuals that it contributes to the total in the site. The Simpson‟s Diversity Index is calculated as:

$$D = 1 – (\Sigma (n_i/N)^2)$$

Where: D = Simpson‟s Index of Diversity;
n_i = the number of individuals of the i^{th} taxon; and
N = the total number of organisms in the sample.

The value of this index ranges between 0 and almost 1, the greater the value, the greater the species diversity at the site.

Benthic invertebrates were categorized into major taxonomic groups, which include Isopoda (sowbugs), Amphipods (side swimmers) and chironomids (midges). The relative percentage of the total sample comprised by each major taxonomic group indicates general water quality at the sampling site.

The Hilsenhoff Biotic Index (HBI) uses benthic invertebrates to provide an indication of water quality based on published tolerance values for individual species. Tolerance values range from 0 to 10, with 0 being intolerant and 10 being very tolerant. The HBI is an average of tolerance values for all individual species collected from a site; therefore a lower HBI suggests better water quality. These values are then translated into descriptive rankings which indicate the water quality type at that station. HBI is calculated as:

$$HBI = \Sigma (x_i t_i/N)$$

Where: HBI = Hilsenhoff Biotic Index;
x_i = the number of individuals of the ith taxon;
t_i = the tolerance value of the ith taxon; and
N = the total number of organisms in the sample.

BioMAP is a biological index used to provide a bioassessment of water quality using benthic invertebrates and their associated sensitivity values. These values range from 0 – 4, where 0 is the most sensitive and 4 is most tolerant, and these values are based on the reach in which they commonly occur (headwaters (4), streams (3), rivers and rocky nearshore areas of lakes (2), large rivers and riverine marshes (1) and lentic systems (0). The BioMAP water quality index (WQI) is calculated as:

$$WQI = \frac{[\sum (e^{SVi} * \ln (x_i+1))]}{[\sum \ln ((x_i+1)]}$$

Where: WQI = BioMAP Water Quality Index;
SV_i = the sensitivity value of the ith taxon; and
x_i = the density of individuals of the ith taxon.

A summary of results from all the applied indices are presented in **Table 6.5.**

Table 6.5 Robinson Creek Benthic Invertebrate Community Summary Indices, 2009

Indices	R1	R2	R3	R4	R5
Organism Abundance	12192	6456	1263	1398	725
Organism Density (#/m^2)	2438	1291	253	-	-
Species Richness	24	32	17	8	11
% Isopoda	18%	30%	32%	55%	71%
% Amphipods	45%	23%	37%	34%	9%
% Chironomidae	25%	26%	24%	5%	11%
% EPT	1%	2%	1%	1%	0%
Simpson's Index of Diversity	0.78	0.86	0.75	0.58	0.52
HBI	6.54	6.67	6.85	6.41	7.34
BioMap WQI	8.6	7.5	10.1	-	-

Overall, abundance ranged from 1263 (Site R3) to 12192 (Site R1) individuals with densities ranging from 253 (Site R3) to 2438 (Site R1) individuals/m^2 (**Table 6.5**). Please note that densities for Sites R4 and R5 cannot be calculated due to a change in sampling protocol. Sites R1 and R3 were numerically dominated by *Gammarus*; and Sites R2, R4 and R5 were dominated by the Isopod family Asellidae (*Caecidotea*). Species richness was highest at Site R2 (32), Site R1 was lower (24) and with a much lower richness was Site R3 (17), Site R5 (11) and Site R4 (8) (**Table 6.5**).

For streams in southwestern Ontario, sites with an EPT value less than two are considered severely impacted, whereas sites with EPT values greater than ten are considered non-impacted (Mackie, 2004). The EPT index was very low (0 - 2%) for all sites monitored on Robinson Creek in 2009 and therefore all sites are considered severely impacted using the EPT index.

For the Simpson"s Index of Diversity, higher values (D) represent more diverse and healthier communities. Overall the Simpson"s D values on Robinson Creek were moderate, Sites R2, R1 and R3 were the highest, and Sites R4 and R5 were the lowest and therefore associated with a less diverse community than at Sites R1 – R3 (**Table 6.5**).

HBI ratings are associated with a descriptive ranking system that can be used to characterize the water quality of the sampled site. These rankings are provided in **Table 6.6**

Table 6.6 Hilsenhoff Biotic Index Values and Descriptive Rankings (Bode, 1993)

HBI Value	Descriptive Ranking
0 – 3.50	Excellent
3.51 – 4.50	Very Good
4.51 – 5.50	Good
5.51 – 6.50	Fair
6.51 – 7.5	Fairly Poor
7.51 – 8.50	Poor
8.51 - 10	Very Poor

The highest ranking site on Robinson Creek was R4 (Fair), with all other sampled sites on receiving a water quality rating of fairly poor. These higher HBIs can be attributed to the large number of Isopods and Gammarids that dominated these sites, and their associated high HBI tolerance values (8 and 4-6, respectively).

Like HBI ratings, BioMAP WQIs can be translated into three classifications (Unimpaired, Impaired and Inconclusive) which can be used to describe the water quality of the sampled site. The classification categories are provided in **Table 6.7**.

Table 6.7 Classification of Water Quality for Creeks based on BioMAP WQI Values (Griffiths, 1999)

WQI	Classification
<14.0	Impaired
14.1 – 16.0	Inconclusive
>16.1	Unimpaired

All sites on Robinson Creek received a water quality rating of impaired (It is important to note that WQIs could not be calculated for Sites R4 and R5 due to a lack of density estimates). Like the HBI, these WQI values can be attributed to the large number of *Caecidotea* (Isopod), *Gammarus* (sideswimmer) *Stictochironomus* (midge) that dominated these sites and their associated low sensitivity values.

6.4.2.2 Chemical Water Quality Assessments

Field parameters and results from the laboratory analyses are presented in **Table 6.8**. A comparison to the Provincial Water Quality Objective (PWQO) is made where applicable.

Table 6.8 Robinson Creek Surface Water Quality

Parameters	Units	PWQO	June 24 – 25/09			August 24/09			September 3/09	
			R1	***R2***	***R3***	***R1****	***R2****	***R3****	***R4***	***R5***
Water Temperature	°C	-	21.1	23.4	19.6	14	16.7	16.8	17.7	20.1
pH	-	6.5 - 8.5	7.77	7.85	7.56	8.25	7.95	8.21	8.04	8.04
Conductivity	µS/cm	-	637	610	664	625	586	736	894	600
Total Ammonia	mg/L	-	0.08	0.22	0.07	0.06	0.06	0.07	0.09	0.07
Un-ionized Ammonia	mg/L	0.02	0.002	0.005	0.008	NA	NA	NA	NA	0.003
Total Phosphorus	mg/L	0.03	**0.076**	**0.064**	**0.037**	**0.050**	**0.058**	**0.11**	**0.048**	**0.067**
TSS	mg/L	-	34	27	17	17	21	61	23	61
Chloride	mg/L	150**	88	84	74	95	88	54	**180**	130
BOD	mg/L	-	ND	ND	ND	ND	ND	ND	ND	ND

*Notes: *water temperature, pH and conductivity collected on September 4, 2009*
*** Currently there is no PWQO for chloride, however, 150 mg/L is used as a protection of freshwater biota criteria by the Toronto Region Conservation Authority, Ontario MOE - Environmental Monitoring and Reporting Branch and the BC Ministry of the Environment*
ND = Not Detectable
NA = Not Available, due to missing data required for calculation
***Bold numbers** are above their respective PWQO*

All measured field parameters fell within typical ranges for urban watersheds. The increase in conductivity measured at Site R4 in September 2009 may be due to the increased concentration of chloride at this same location. Overall, the chloride concentrations in Robinson Creek are generally low, with only Site R4 exceeding the 150 mg/L criteria. Due to the conservative nature of chloride, the increase noted here may be due to the adjacent wetland, which may be accumulating chloride derived from the road salt application to Bloor Street immediately north of Site R4 and then slowly discharging it. The PWQO for total phosphorus (0.03 mg/L) was exceeded at all Robinson Creek monitoring locations during all monitoring events in 2009. In June, total phosphorus increased downstream, while the concentrations decreased downstream in August 2009. This suggests that in June 2009, small non-point source(s) of total phosphorus occurred in Robinson Creek. Due to the small incremental concentration increases observed from R3 to R1, locating specific areas of total phosphorus loading would be difficult. Total phosphorus concentrations are probably associated with TSS (and therefore overland flow) as the highest total phosphorus concentrations in 2009 coincide with the highest TSS concentrations. For example, at Site R3 in August 2009, there was increased turbidity and a thin layer of recent sediment deposition. This was restricted to the main branch of Robinson Creek at this location as the incoming water from the upstream tributary was clear (**Figure 6.4**). Where available, un-ionized ammonia was less than the PWQO and the biological oxygen demand was not detected at any of the Robinson Creek monitoring locations during all monitoring events in 2009.

6.5 Tooley Creek Results

6.5.1 Watershed Context

6.5.1.1 Strahler Stream Order

Table 6.9 below shows stream order classifications within the Tooley Creek Watershed. Tooley Creek flows for approximately 15.7 km (north to southeast) before out letting into Lake Ontario (**Figure 6.5**). According to MNR NRVIS layer mapping, much of the Tooley Creek Watershed is undetermined with regard to thermal regime, with some reaches within the watershed classified as coolwater and equal approximately 5.9 km of its length. Results collected as part of this study and through analysis of data provided by CLOCA, conclude that Tooley Creek should be thermally classified as a coolwater system, with a portion of its headwaters thermally consistent with a coldwater system (**Figure 6.7**). Thermal classifications will be discussed further in section 6.5.2.

Table 6.9 Strahler Stream Order Designations for Tooley Creek

Watershed	Strahler Stream Order	Length (km)
Tooley Creek	1	7.8
	2	3.8
	3	4.1
	Total	**15.7**

6.5.1.2 Instream Barriers

In stream barriers within Tooley Creek were assessed during spring and summer field surveys by AECOM staff in 2009 and were supplemented by Hydrologic and Hydraulic Modelling for Tooley Creek provided by CLOCA (CLOCA, 2009) and presented in **Appendix B**. A total of three potential barriers to fish movement were identified **(Figure 6.6**). Moving upstream within the watershed from Lake Ontario, there are two impediments to fish migration that are located at both railway crossings of Tooley Creek (**Figure 6.6**). The first railway crossing of Tooley Creek is located south of Highway 401 and the second is located north of Baseline Road, east of Courtice Road. The railway crossings are best described as closed bottom, concrete arch culverts that convey flow for approximately 20 m beneath the railways. Within the archways the watercourse is confined within an engineered concrete channel with laminar flow and little or no instream cover or flow variability. Within the archway, the watercourse is confined within an engineered concrete channel with laminar flow and little instream cover or flow variability. In terms of fish migration through the culvert, movement may be limited by velocity barriers during periods of peak flow through the archway culvert. However, during periods of low flow, movement through the culvert may likewise impeded because of a lack of refuge or holding structures resulting from the otherwise laminar and uniform sill within the underpass.

The third and primary impediment to fish migration is a closed bottom box culvert located at the downstream end of the Highway 401 underpass (**Figure 6.6**). The outlet of this box culvert is perched by approximately 0.45 m. Although most fish can jump small vertical distances, this culvert likely serves as a barrier to most species present within the creek. In this regard, it is noteworthy that white sucker were not observed upstream of the box culvert during AECOM‟s 2009 field sampling nor have they been captured by CLOCA upstream of the 401 in previous studies. This is important since historically evidence suggests that white sucker have existed upstream of this location. It is possible that some upstream migration is possible overt the perched culvert during appropriate flows, but not consistently. Other species of fish such as rainbow trout were observed upstream of this location in 1997 and 2003 by CLOCA, and in 2009 by AECOM. Therefore, rainbow trout are known to pass this barrier during periods of appropriate flow.

6.5.1.3 Riparian Vegetation and Landscape Influences

Many of the Tooley Creek first order streams maintain riparian vegetated areas composed of forested cover or at a minimum naturalised scrublands (**Figure 6.5**). The riparian cover is also shown on **Figure 7.6**, of Section 7. There are some instances where headwater tributaries have been highly disturbed, altered or there has been out-letting from stormwater/irrigation ponds. Within the headwaters north of Bloor Street and Highway #2, there are remaining areas of relatively undisturbed naturalised areas as discussed in Section 7.4. **Figure 6.5** depicts the existing conditions of the first order tributaries within the watershed and illustrates the relative abundance of naturalised areas within the headwaters of Tooley Creek. In total approximately 65% of first order streams maintain some/adequate riparian vegetation while 35% lack sufficient riparian vegetation.

The majority of second order stream reaches within the Tooley Creek Watershed are also surrounded by large naturalised riparian buffers that are relatively undisturbed from development or local agriculture. **Figures 6.5** and **7.6** depict relatively large contiguous riparian corridors bordering both second order tributaries of the watershed throughout most of their reaches. These large intact areas comprise approximately 84% of second order streams while only 16% of second order streams are limited in riparian cover.

Although many upstream portions of the third order reaches (main branch) of Tooley Creek maintain adequate riparian vegetation, far less of the lower section of the watershed (near Lake Ontario) contains suitable riparian cover. In these areas Tooley Creek flows through pasture fields where riparian cover has been depleted by unrestricted cattle access to the creek. From the confluence of the two primary second order tributaries (**Figure 6.5**) to the outlet into Lake Ontario Tooley Creek maintains well intact riparian cover for about half of its length, with remaining areas possessing degraded riparian habitat or lacking such features altogether.

6.5.2 Fisheries and Aquatic Habitat

The following section provides a brief discussion on the fish community and fish habitat present within Tooley Creek. A complete list of fish species captured at each sampling location (**Figure 6.7**) within the Tooley Creek Watershed is also located in **Appendix C.1** (only sites where fish were captured are included in the table). Historic fish community data obtained from the MNR, from CLOCA‟s 2009 Aquatic Monitoring Report, and fish captured during AECOM‟s 2009 field investigations are presented in **Table 6.10**.

Table 6.10 Known Fish Community Composition – Tooley Creek Watershed

Family	Common Name	Scientific Name	Abundance *(% of total captured)*	Thermal Class	COSEWIC Status	COSSARO Status
Catostomidae	White Sucker	*Catostomus commersoni*	1%	Cool	NAR	NAR
Centrarchidae	Pumpkinseed	*Lepomis gibbosus*	<1%	Warm	NAR	NAR
Cyprinidae	Fathead Minnow	*Pimephales promelas*	8%	Warm	NAR	NAR
	Creek Chub	*Semotilus atromaculauts*	13%	Cool	NAR	NAR
	Blacknose Dace	*Rhinichthys atratulus*	61%	Warm	NAR	NAR
	Northern Redbelly Dace	*Phoximus eos*	<1%	Cool/Warm	NAR	NAR
	Bluntnose Minnow	*Pimephales notatus*	<1%	Warm	NAR	NAR
	Longnose Dace	*Rhinichthys cataractae*	<1%	Cool	NAR	NAR
	Common Shiner	*Luxilus cornutus*	<1%	Warm	NAR	NAR
Gasterosteidae	Brook Stickleback	*Culaea inconstans*	14%	Cool	NAR	NAR
	Threespine Stickleback	*Gasterosteus aculeatus*	<1%	Cool	NAR	NAR
Percidae	Johnny Darter	*Etheostoma nigrum*	<1%	Warm	NAR	NAR
Salmonidae	Rainbow Trout	*Oncorhynchus mykiss*	1%	Cold	NAR	NAR

AECOM identified the fish community of the Tooley Creek Watershed consisting of 13 fish species, representing six families. Similar to Robinson Creek, there may be a sampling bias on the collection of some species due to the limits of the study design. However, it is not expected that a large number of additional species would occur in Tooley Creek given secondary source information for this system. Consequently, it can be stated that the diversity of fish within Tooley Creek represents a small percentage of the 73 species known to reside in CLOCA‟s jurisdiction (CLOCA, 2008).

Of the 13 fish species caught, Blacknose Dace (*Rhinichthys atratulus*) was by far the most common, consisting of 61% of all fish captured (**Table 6.10**). Blacknose Dace is a warmwater fish species that is highly tolerant to environmental change and perturbation and is widespread in their southern Ontario distribution. The other most common fish species were Brook Stickleback (*Culaea inconstans*), Creek Chub (*Semotilus atromaculauts*) and Fathead Minnow (*Pimephales promelas*), all of which represent a warm to coolwater community and are widespread in their southern Ontario distribution. Rainbow Trout (*Oncorhynchus mykiss*), which is a coldwater species, represented only 1% of all fish captured.

The presence of migratory fish species, such as rainbow trout (a cold/cool water fish species) and white sucker is limited to the southernmost reaches of the watercourse (**Figure 6.7**). Indeed, historical sampling conducted by CLOCA caught rainbow trout in 2008, 2003, and 1997, however, all were captured south of the 401. There is a potential that a lack of flow in the middle and upper reaches of Tooley Creek may contribute to the lack of migratory rainbow trout caught near the headwaters. It is unlikely that the railway crossing barrier north of Baseline Road interferes with fish passage, particularly rainbow trout, since young-of-the-year rainbow trout was caught upstream of the barrier at Highway 401. No rainbow trout were caught upstream of the railway crossing barrier north of Baseline Road, indicating that this feature is a barrier to migrational species,

The presence of rainbow trout (a cold/cool water fish species) within the lower reaches of the watershed demonstrates tolerable, coolwater conditions for moderately tolerant fish species in this section of the creek. However, more importantly, the occurrence of rainbow trout, in 2009, 2003, and 1997 indicates that limited runs of migratory rainbow trout may occur throughout the watershed.

White sucker were caught by AECOM in 2009, downstream of the 401 underpass barrier (**Figures 6.6 and 6.7**). Historic reports of runs of longnose sucker and white sucker have been noted by local residences within the watershed, however these runs have been in decline since the 1980s. No records of longnose sucker exist within MNR or CLOCA records, nor were any captured during 2009 field sampling. For this reason the record of longnose sucker is considered anecdotal and unconfirmed. The spawning migration of white sucker, although locally reported to be severely reduced from the 1990s, still occurs annually within Tooley Creek.

The spawning migration of white sucker has been impacted by instream barriers within Tooley Creek (**Figures 6.6 and 6.7**). White sucker were captured south of the 401 by AECOM in 2009 and by CLOCA in 2008, indicating that this is a significant impediment to white sucker migration.

The thermal preferences of other species observed in Tooley Creek in 2009 (in particular cool water species) is consistent with the dominant thermal regime of the watershed as displayed in **Table 6.11**. Water temperatures were consistently observed to be slightly lower than the mean daily air temperature, as shown in **Table 4.13**, suggesting some thermal buffering of water temperatures from groundwater contributions. Some shallow groundwater inputs do exist within the upstream reaches of the watershed (north of Bloor Street within the Iroquois Plain Shallow Aquifer), and are responsible for creating a coldwater thermal system over this reach (**Figure 6.7**). These groundwater inputs are also likely responsible for creating suitable/tolerable conditions for cool water species such as creek chub, longnose dace, northern red belly dace, and brook stickleback observed throughout the watershed in 2009. Similar to Robinson Creek, the presence of rainbow trout, within the lower reaches of the watershed, suggests suitable conditions for some tolerant cold/cool water species. Juvenile rainbow trout were observed at T2 (**Figure 6.7)** in spring sampling of 2009 when the daily air temperature was 28°C and the water temperature was 19°C (**Figure 4.19**). Although no rainbow trout were observed in September 2009 (rainbow trout were caught in June 2009), conditions are such that suggest thermal buffering from groundwater contributions could support rainbow trout throughout the year, especially in the upper regions where a coldwater thermal regime was identified. No rainbow trout were observed upstream of T2 within the Tooley Creek Watershed in 2009 or by CLOCA in 2008, 2003, and 1997; however, historic runs of rainbow trout upstream of this location are reported by local residences.

Table 6.11 Stream Temperature Monitoring within Tooley Creek

Temperature Logger Location	Period of Record	Days within Mean Daily Temperature Range				Min Temp (°C)	Max Temp (°C)	Classification
		Cold (<19°C)	*Cool (19 – 25°C)*	*Warm (>25°C)*	*Lethal Limit for Rainbow Trout (>26°C)*			
TC-WT3 (MP1)	July 10 – August 31, 2009	52	1	0	0	12.8	19.9	**Coldwater**
TC-WT2 (MP2)	July 10 – August 31, 2009	41	12	0	0	14.7	21.2	Coolwater
TC-WT1 (MP3)	July 10 – August 31, 2009	43	10	0	0	14.3	20.9	Coolwater
TC-WT4 (MP5)	July 10 – August 31, 2009	51	2	0	0	13.8	19.2	**Coldwater**

Stream temperature data collected between July and August 2009 indicates that the thermal regime can be classified as coolwater. This result is consistent with CLOCA"s thermal data collected between 2005 and 2009, and generally matches the thermal class of the fish community, with the exception of rainbow trout. The upper reaches of Tooley Creek were deemed to be a coldwater system due to significant groundwater inputs from the Iroquois Plain Shallow Aquifer and the Maple grove Wetland Complex. The upper reaches have never been thermally characterized before and therefore, a multi-year sampling approach is needed to gain an accurate picture of the system on a year-to-year basis. In this regard, it is noteworthy that July 2009 was a relatively cool month relative to the climatic norms (**Table 2.2**) and that the maximum mean daily temperature recorded was 21.8°C, and well below the typical thermal range for warmwater classified streams. Therefore, it is believed that the 2009 dataset is slightly bias towards lower stream temperatures.

In general, the species assemblage in Tooley Creek is typical of a warm to cold water urban fish community. All of the species present within the watershed are moderately/highly tolerant to environmental change and perturbation and all are widespread in their southern Ontario distribution. The fish community present is composed of generalist species that are not highly dependent on specific habitat requirements for spawning or life history processes. With the exception of rainbow trout, which are moderately sensitive to increased water temperatures for habitat suitability, the fish community is typical of warm/cool water conditions, the distribution of which is primarily dependant on flow regime within the watershed and to a lesser extent water temperatures.

6.5.3 Biological Water Quality Assessments

A taxonomic list showing all benthic macro-invertebrate species collected at all stations (following the sampling methods described in section 6.3.2) is included in **Appendix C**.

Organism abundance is the total number of organisms collected from each site and each respective density was calculated as the total number of individuals of all taxonomic categories collected at each site expressed per unit area (numbers/m^2). Species richness is the total number of different species collected at each site.

The EPT index is the total number of individuals counted from within the taxonomic orders, Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) compared to the total number of individuals counted in the whole sample. Since these taxa are typically sensitive to environmental stressors, a higher EPT index is typically associated with better environmental quality.

The Simpson"s Index of Diversity (D) accounts for both the abundance patterns and taxonomic richness of the community. This is calculated by determining for each taxonomic group at a site, the proportion of individuals that it contributes to the total in the site. The Simpson"s Diversity Index is calculated as:

$$D = 1 – (\Sigma (n_i/N)^2)$$

Where: D = Simpson"s Index of Diversity;
n_i = the number of individuals of the i^{th} taxon; and
N = the total number of organisms in the sample.

The value of this index ranges between 0 and almost 1, the greater the value, the greater the species diversity at the site.

Benthic invertebrates were categorized into major taxonomic groups, which include Isopoda (sowbugs), Amphipods (side swimmers) and chironomids (midges). The relative percentage of the total sample comprised by each major taxonomic group indicates general water quality at the sampling site.

The Hilsenhoff Biotic Index (HBI) uses benthic invertebrates to provide an indication of water quality based on published tolerance values for individual species. Tolerance values range from 0 to 10, with 0 being intolerant and 10 being very tolerant. The HBI is an average of tolerance values for all individual species collected from a site; therefore a lower HBI suggests better water quality. These values are then translated into descriptive rankings which indicate the water quality type at that station. HBI is calculated as:

$$HBI = \Sigma (x_i t_i/N)$$

Where: HBI = Hilsenhoff Biotic Index;
x_i = the number of individuals of the ith taxon;
t_i = the tolerance value of the ith taxon; and
N = the total number of organisms in the sample.

BioMAP is a biological index used to provide a bioassessment of water quality using benthic invertebrates and their associated sensitivity values. These values range from 0 – 4, where 0 is the most sensitive and 4 is most tolerant, and these values are based on the reach in which they commonly occur (headwaters (4), streams (3), rivers and rocky nearshore areas of lakes (2), large rivers and riverine marshes (1) and lentic systems (0). The BioMAP water quality index (WQI) is calculated as:

$$WQI = \frac{[\sum (e^{SVi} * \ln (x_i+1))]}{[\sum \ln ((x_i+1)]}$$

Where: WQI = BioMAP Water Quality Index;
SV_i = the sensitivity value of the ith taxon; and
x_i = the density of individuals of the ith taxon.

A summary of all the indices are presented in **Table 6.12**.

Table 6.12 Tooley Creek Benthic Invertebrate Community Summary Indices, 2009

Indices	T1	T2	T5
Organism Abundance	953	3861	3656
Organism Density (#/m^2)	191	772	731
Species Richness	24	29	12
% Isopoda	7%	73%	74%
% Amphipods	10%	3%	7%
% Chironomidae	57%	16%	11%
% EPT	0%	0%	0%
Simpson's Index of Diversity	0.26	0.54	0.56
HBI	6.67	7.53	7.71
BioMap WQI	5.5	7.2	6.4

Overall, abundance ranged from 953 (Site T1) to 3861 (Site T2) individuals with densities ranging from 191 (Site T1) to 772 (Site T2) individuals/m^2 (**Table 6.12**). Site T1 was numerically dominated by the midge family, Chironomidae; and Sites T2 and T5 were dominated by the Isopod family Asellidae (*Caecidotea*). Species richness was highest at Site T2 (29), Site T1 was slightly lower (24), and at half the richness was Site T5 (12) (**Table 6.12**).

For streams in southwestern Ontario, sites with an EPT value less than two are considered severely impacted, whereas site with EPT values greater than ten are considered non-impacted (Mackie, 2004). The EPT index was very low (0%) for all sites monitored on Tooley Creek in 2009 and therefore it is considered severely impacted.

CLOCA‟s 2009 Aquatic Monitoring Report presents some historical ETP values collected from south of the 401 in Tooley Creek. The EPT values range from approximately 15 to less than 1, with results generally around 2. These data are therefore consistent with AECOM‟s findings, however, no date describing when CLOCA‟s samples were collected was found in the report.

For the Simpson‟s Index of Diversity, higher values represent more diverse and healthier communities. Simpson‟s D values were similar between Sites T2 and T5, with Site T1 having the lowest value of the sites sampled on Tooley Creek and therefore the lowest diversity and associated community health (**Table 6.12**).

HBI ratings are associated with a descriptive ranking system that can be used to characterize the water quality of the sampled site. These rankings are provided in **Table 6.13**.

Table 6.13 Hilsenhoff Biotic Index Values and Descriptive Rankings (Bode, 1993)

HBI Value	Descriptive Ranking
0 – 3.50	Excellent
3.51 – 4.50	Very Good
4.51 – 5.50	Good
5.51 – 6.50	Fair
6.51 – 7.5	Fairly Poor
7.51 – 8.50	Poor
8.51 - 10	Very Poor

With exception of Site T1 that received an HBI of 6.67 (fairly poor water quality), all other sites received a water quality rating of poor. The higher HBIs observed at Sites T2 and T5 (and therefore poorer water quality) can be attributed to the large number of Isopods that dominated these sites, and they have high HBI tolerance values (8), which corresponds to poor water quality.

Similar to HBI ratings, BioMAP WQIs can be translated into three classifications (Unimpaired, Impaired and Inconclusive) which can be used to describe the water quality of the sampled site. The classification categories are provided in **Table 6.14**.

Table 6.14 Classification of Water Quality for Streams based on BioMAP WQI Values (Griffiths, 1999)

WQI	Classification
<14.0	Impaired
14.1 – 16.0	Inconclusive
>16.1	Unimpaired

All sites on Tooley Creek received a water quality rating of impaired. Like the HBI, these WQI values can be attributed to the large number of *Caecidotea* (Isopod) and *Gammarus* (sideswimmer) that dominated these sites and their associated low sensitivity values.

6.5.4 Chemical Water Quality Assessments

Field parameters and results from the laboratory analyses are presented in **Table 6.15**. A comparison to the Provincial Water Quality Objective (PWQO) is made where applicable.

Table 6.15 Tooley Creek Surface Water Quality

Parameters	Units	PWQO	June 25/09			August 24/09		
			T1	T2	T5	T1*	T2*	T5*
Water Temperature	°C	-	25.5	19	14.9	20.6	15.1	11.5
pH	-	6.5 - 8.5	7.52	7.83	7.56	7.85	7.92	7.92
Conductivity	µS/cm	-	697	577	472	662	610	292
Total Ammonia	mg/L	-	0.09	0.21	0.16	0.07	0.11	0.05
Un-ionized Ammonia	mg/L	0.02	0.002	0.003	0.002	NA	NA	NA
Total Phosphorus	mg/L	0.03	0.027	**0.038**	**0.31**	**0.036**	**0.068**	**0.051**
TSS	mg/L	-	4	2	80	4	2	5
Chloride	mg/L	150**	120	50	45	120	33	53
BOD	mg/L	-	ND	ND	ND	ND	ND	ND

Notes: **water temperature, pH and conductivity collected on September 4, 2009*
***Currently there is no PWQO for chloride, however, 150 mg/L is used as a protection of freshwater biota criteria by the Toronto Region Conservation Authority, Ontario MOE - Environmental Monitoring and Reporting Branch and the BC Ministry of the Environment*
ND = Not Detectable
NA = Not Available, due to missing data required for calculation ***Bold numbers*** *are above their respective PWQO*

All measured field parameters were within typical ranges for urban watersheds. The decrease in conductivity measured at Site T5 in August 2009 is likely due to groundwater input at this location. Hydrological monitoring at this location indicates upwelling in this area of Tooley Creek (TC-MP1 - **Figure 4.20**). With the exception of Site T1 in June 2009, the PWQO for total phosphorus (0.03 mg/L) was exceeded at all Tooley Creek monitoring locations during all monitoring events in 2009. In both June and August 2009, the concentration of total phosphorus increased at Site T2, compared to the upstream monitoring location at Site T5. This suggests that there may be a source of total phosphorus entering Tooley Creek between Site T5 and Site T2. This increase in total phosphorus may be related to agricultural runoff, as there is a significant amount of farmland between Site T5 and Site T2. Overall, the chloride concentrations in Tooley Creek are generally low. The increased concentrations measured at Site T1 are likely due to its proximity to Lake Ontario or immediate agricultural influence (cattle were noted in the stream approximately 150 m from Site T1). Where available, un-ionized ammonia was less than the PWQO and the biological oxygen demand was not detected at any Tooley Creek monitoring locations during all monitoring events in 2009.

6.6 Conclusions

Both the Robinson Creek and Tooley Creek watersheds have similar characteristics in that they support warm/cool water fish communities that are typical of surface water driven streams. Both have some groundwater contribution within their headwaters which are considered critical to the annual flow regimes of the systems. These groundwater contributions create a habitat that can support cold water fish species such as rainbow trout. The distribution of species within these watersheds is largely dependent on flow regime, barriers/impediments to fish movement and to a lesser extent water temperature. In general, the fish species existing within Robinson and Tooley Creek are generalists in their habitat requirements, are relatively tolerant to environmental change and perturbation, and are widespread in their southern Ontario distribution.

Data collected as part of the 2009 field investigations was generally consistent with the data presented in CLOCA‟s annual Aquatic Monitoring Reports between 2006 and 2009, with some variation. The variations in results over the monitoring period, further exemplifies the need to long-term monitoring to accurately characterize the thermal regime and the species present in Robinson and Tooley Creeks.

Habitat conditions within both watersheds vary based on the occurrence and quality of intact riparian cover. In Robinson Creek, first order streams are generally lacking adequate riparian vegetation while second and third order streams maintain continuous vegetated cover. In contrast, first and second order streams within the Tooley Creek Watershed, in general, maintain adequate riparian cover, however, within the lower reaches of the main branch of the watershed, riparian cover is lacking as the creek flows through cattle pastures and open fields.

Overall, these systems have the ability to support cool/coldwater fish species. The long-term survival of migratory lake-run rainbow trout and coolwater white sucker is highly dependent on maintaining groundwater inputs, riparian vegetation and flow within the headwaters of the watersheds. If these contributing elements are maintained, the fish community appears to be highly adaptable and displays some tolerance to other physical habitat alterations that have occurred within these systems.

The benthic communities in both watersheds had little to no sensitive species and were dominated by tolerant species such as Midges, Gammarids and Isopods. Indices showed that the impacts to habitat quality in both Robinson and Tooley Creek were moderate, and showed the effects of non-point source pollution.

Total phosphorus concentrations were high throughout both watersheds, especially within agricultural areas. Chloride concentrations were high in areas adjacent to high traffic roads. Long term exposure to high levels of chloride may negatively affect both benthic and fish communities.

6.7 Recommendations and Discussions

Based on the existing conditions as well as potential for future development within the watershed, the following discusses some general recommendations for maintaining and enhancing the integrity and function of Tooley and Robinson Creek from a fisheries and aquatic resource perspective. It is intended that through adherence and judicious implementation of these recommendations, the Robinson and Tooley Creek watersheds will be better equipped to adapt to future land use changes as well as an ever changing climate.

The maintenance of existing riparian vegetation corridors through appropriately sized buffers and the enhancement of headwater riparian vegetation throughout both the Robinson and Tooley Creek watersheds (with specific emphasis on the Robinson Creek headwaters) is considered a key strategy for maintaining the integrity and function of the watersheds. Further to this, the protection of headwaters within both Robinson and Tooley Creek is considered to be vital for the maintenance of base flow and associated water quality, fish community composition, fish habitat and ecological function. Increasing riparian cover on 1st order streams in the Robinson Creek Watershed should be a priority. Maintaining and/or increasing vegetative riparian cover would benefit both Tooley and Robinson Creek, and should be considered moving forward with the overall Watershed Management Plan.

The maintenance of base flow also supports life history requirements for migratory species within the watersheds such as White Sucker and Rainbow Trout. With this in mind, removal/enhancement of in-stream barriers/impediments to fish movement identified in this study is encouraged as part of any new development or road construction upgrades.

Agricultural Best Management Practices (BMPs) should be encouraged throughout both watersheds to minimize/reduce the amount of non-point source pollutants entering the groundwater and surface water systems. This will help to improve surface water quality.

Finally, the development of a Salt Management Plan (SMP) is also recommended in advance of project growth or development within the watersheds. The objective of a SMP (is to ensure that roadside operations provide for public safety while at the same time minimizing the impacts on the environment from chloride applications. Additionally, a SMP will ensure legislated responsibilities with respect to road salts are being met, and will work as a communication tool for environmental policy, objectives and targets to winter maintenance staff and contractors. A SMP provides a long-term, prioritized strategy that will guide staff in evaluating and facilitating appropriate adjustments to the winter maintenance program on an annual basis. In particular, application of a SMP for the Municipality of Clarington could be used at specific locations (as identified in Section 6.4.2 and 6.5.2) to address high concentrations of chloride near Bloor Street. If a SMP does not already exist for the Municipality, then strong efforts should be made to develop one.

Basemapping from Ontario Ministry of Natural Resources
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Legend

Strahler Stream Order

- 1
- 2
- 3
- Railway
- Watershed
- Waterbody Segment
- Wetland Area, Permanent

Robinson Creek and Tooley Creek Watershed Plan

Robinson Creek Watershed Strahler Stream Order

September 2009
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Figure 6.1

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Legend

- Instream Barrier
- Railway
- Watershed
- Intermittent Stream
- Permanent Stream
- Waterbody Segment
- Wetland Area, Permanent

Robinson Creek and Tooley Creek Watershed Plan

Robinson Creek Watershed Instream Barriers

October 2009
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Figure 6.2

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Legend

MigratoryFishSpecies
- Rainbow Trout, June 2009
- Rainbow Trout, Sept 2009
- White Sucker, June 2009
- White Sucker, Sept 2009
- Water Temperature Monitoring Station
- Fisheries & Habitat Assesment
- CLOCA Sample Locations
- Habitat Assesment
- Watershed

- Railway
- Intermittent Stream
- Permanent Stream
- Waterbody Segment
- Wetland Area, Permanent

Stream Type & Thermal Assessment
- Intermittent, No data
- Intermittent, Unassigned
- Permanent, No data
- Permanent, Coolwater

Robinson Creek and Tooley Creek Watershed Plan

Robinson Creek Watershed Fishery and Habitat Assessment

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Figure 6.3

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Legend

- Benthic Invertebrate Survey and Surface Water Quality Sample Location (% EPT Shown)
- Watershed
- Railway
- Intermittent Stream
- Permanent Stream
- Waterbody Segment
- Wetland Area, Permanent

Stream Type & Thermal Assessment

- Intermittent, No data
- Intermittent, Unassigned
- Permanent, No data
- Permanent, Coolwater

Robinson Creek and Tooley Creek Watershed Plan

Robinson Creek Watershed Water Qualitiy and Benthic Sites

October 2009
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AECOM

Figure 6.4

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Strahler Stream Order

- 1
- 2
- 3
- Railway
- Watershed
- Waterbody Segment
- Wetland Area, Permanent

Robinson Creek and Tooley Creek Watershed Plan

Tooley Creek Watershed Strahler Stream Order

October 2009
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AECOM

Figure 6.5

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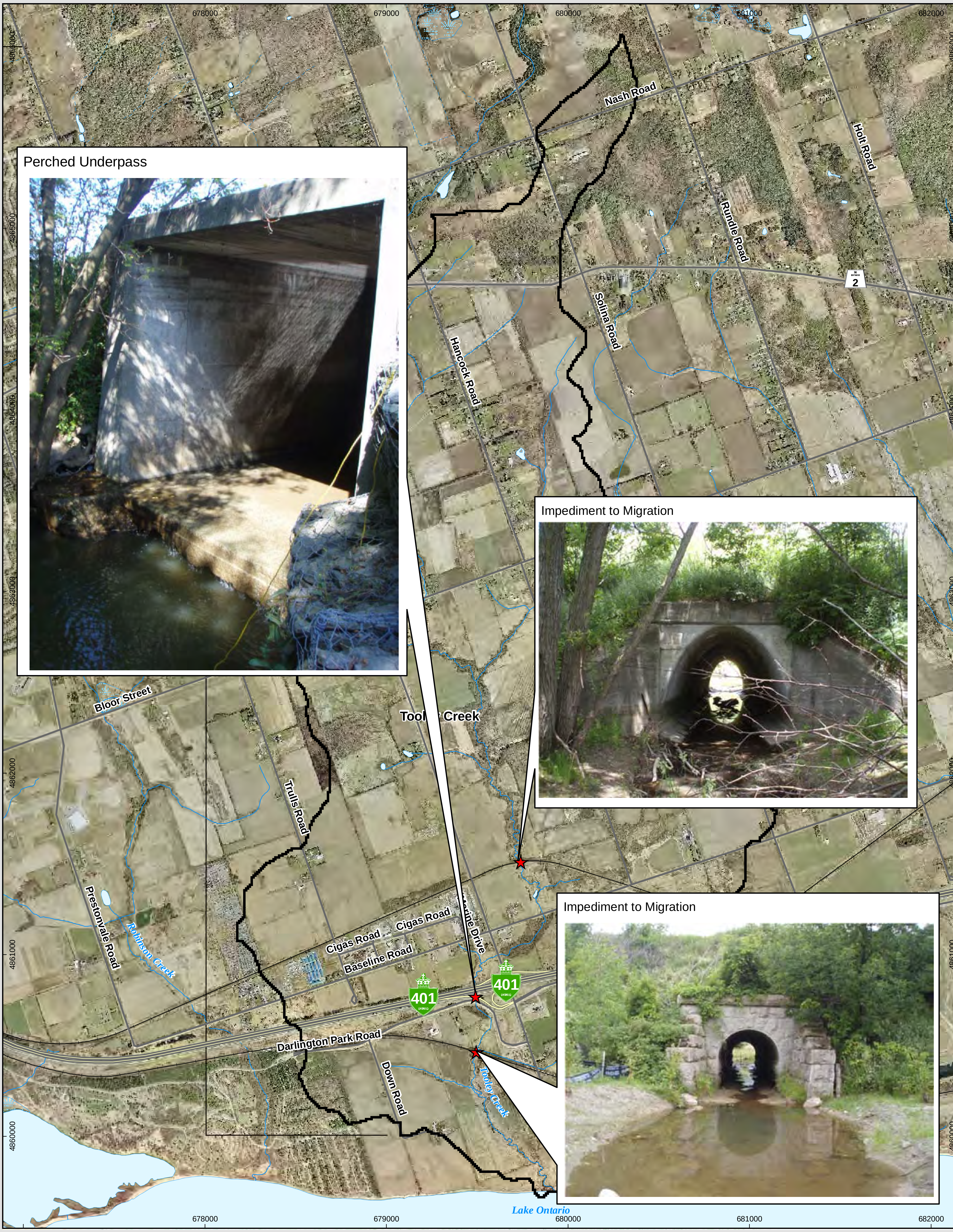

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UTM Zone 17N, NAD 83

Legend

- Instream Barrier
- Railway
- Watershed
- Intermittent Stream
- Permanent Stream
- Waterbody Segment
- Wetland Area, Permanent

Robinson Creek and Tooley Creek Watershed Plan

Tooley Creek Watershed Instream Barriers

October 2009
Project 112956

AECOM

Figure 6.6

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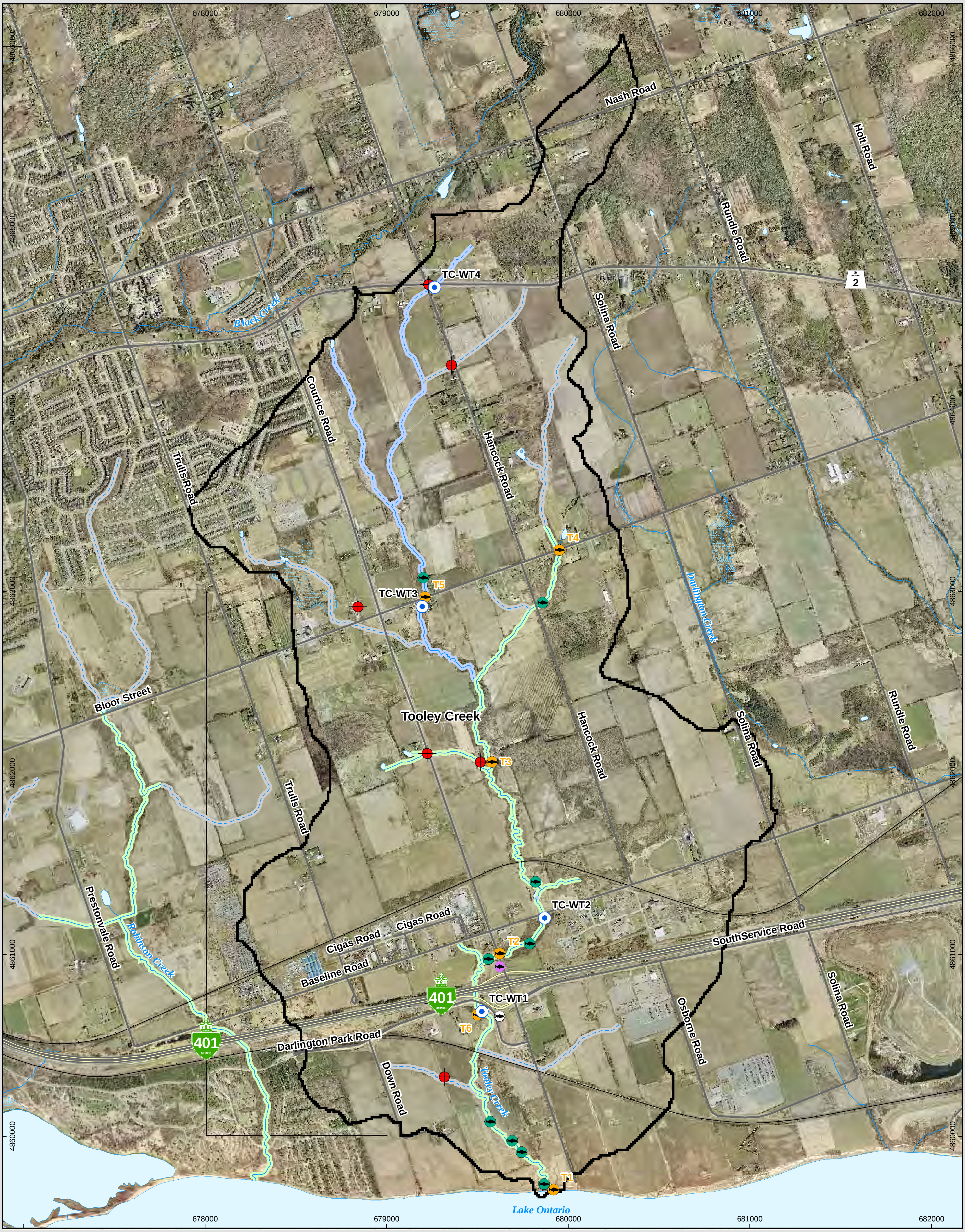

Basemapping from Ontario Ministry of Natural Resources
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MigratoryFishSpecies
- Rainbow Trout, June 2009
- Rainbow Trout, Sept 2009
- White Sucker, June 2009
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- Water Temperature Monitoring Station
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- CLOCA Sample Locations
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- Railway

- Intermittent Stream
- Permanent Stream
- Waterbody Segment
- Wetland Area, Permanent

Stream Type & Thermal Assessment
- Intermittent, Coldwater
- Intermittent, No data
- Intermittent, Unassigned
- Permanent, No data
- Permanent, Coolwater
- Permanent, Coldwater

Robinson Creek and Tooley Creek Watershed Plan

Tooley Creek Watershed Fisheries & Habitat Assessment

October 2009
Project 112956

AECOM

Figure 6.7

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- Benthic Invertebrate Survey and Surface Water Quality Sample Location (% EPT Shown)
- Watershed
- Railway
- Intermittent Stream
- Permanent Stream
- Waterbody Segment
- Wetland Area, Permanent

Stream Type & Thermal Assessment

- Intermittent, Coldwater
- Intermittent, No data
- Intermittent, Unassigned
- Permanent, No data
- Permanent, Coolwater
- Permanent, Coldwater

Robinson Creek and Tooley Creek Watershed Plan

Tooley Creek Watershed Water Qualitiy and Benthic Sites

October 2009
Project 112956

AECOM

Figure 6.8

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7. Terrestrial Natural Heritage

7.1 Introduction and Study Area

The Robinson Creek and Tooley Creek watersheds are located along the north shore of Lake Ontario within Ontario Ministry of Natural Resources Site District 6-13. The site district is further divided by Chapman and Putnam (1984) into the Iroquois Plain and the Oak Ridges Moraine South Slope physiographic regions. Both watersheds occur below the South Slope and historic Lake Iroquois shoreline, and are entirely located within the Lake Iroquois Plain physiographic region. The Iroquois Plain is an east-west trending feature that consists of sandy to silty deposits, usually saturated, that give rise to extensive swamps. Low permeability till soils located below the sandy to silty soils can restrict deep groundwater flow and promote local discharge. Discharge from this feature is important for maintenance of baseflow to streams, and help support wetlands and cool water fisheries.

Land use throughout the Robinson and Tooley Creek watersheds is dominated by agricultural use, with relatively small proportions of natural and naturalized cover. In 1984, OMNR found approximately five to ten percent of Site District 6-13 to be in relatively natural and undisturbed state. The most common remnant natural features include shoreline bluffs and beaches, rivermouth marshes, stream valleys and riparian corridors, and isolated upland forests. In recent years, urban residential development has encroached on the Robinson Creek and Tooley Creek watersheds, particularly from the northwest (i.e., west of Prestonvale Road and north of Bloor in the Robinson Creek Watershed, and northwest of the Bloor Street – Courtice Road intersection in the Tooley Creek Watershed). Findings presented in the subsequent sections report natural and naturalized cover (i.e., vegetation communities mapped according to Ecological Land Classification protocols, excluding Agricultural and Constructed Community Classes) of 22% and 19% for Robinson and Tooley Creek watersheds, respectively.

Young deciduous forest and thicket communities are the most common community types in both watersheds, with Green Ash (*Fraxinus pennsylvanica*) abundant throughout. Common associates include, American Elm (*Ulmus americana*) and Manitoba Maple (*Acer negundo*), the later is particularly common in lowlands and floodplains. Mid-age and mature forest cover is rare in both watersheds. Where these communities do occur, Sugar Maple (*Acer saccharum*) forms associations with White Ash (*Fraxinus americana*), Red Oak (*Quercus rubra*), American Beech (*Fagus grandifolia*), and/or Eastern Hemlock (*Tsuga canadensis*). Coniferous and mixed forests comprise a relatively small component of forest cover, with White Pine (*Pinus strobus*), Red Pine (*Pinus resinosa*) and White Spruce (*Picea glauca*) occurring in upland situations (commonly as remnant plantations), and Eastern White Cedar (*Thuja occidentalis*) occurring in the floodplains. Upland meadows occur throughout both watersheds, particularly as abandoned agriculture fields. These meadows are typically dominated by varying degrees of cool-season grasses, Canada Goldenrod (*Solidago canadensis*), Heath Aster (*Aster ericoides*) and New England Aster (*Aster novae-angliae*).

Low permeability soils at or near ground surface restrict drainage of surface water and promotes the occasional occurrence of perched wetland features in the region. Deciduous swamp communities are the most common wetland types, with Green Ash and Swamp Maple (*Acer freemanii*) abundant throughout treed types, and Red-osier Dogwood (*Cornus stolonifera*) and willow species (*Salix sp.)* dominating the thicket swamps. Mixed Eastern White Cedar swamps occur in the upper reaches of the Tooley Creek Watershed, (north of Highway 2). Marsh communities are present in smaller portions in both Robinson and Tooley Creek watersheds, with Reed-canary Grass (*Phalarus aurundinacea*) and forb meadow marshes the most common types, followed by shallow Cattail (*Typha sp.*) marshes. Seepage wetlands are rare throughout both watersheds. Occurrence of seepage wetlands is associated with areas where stream valleys have exposed shallow localized groundwater flow, predominately along the main branches of the Robinson and Tooley Creek valleys.

7.2 Methodology

7.2.1 Secondary Source Review

Secondary source information was compiled and reviewed in preparing this document to develop a general understanding of the terrestrial features and functions within the Robinson and Tooley Creek watersheds. Secondary source information was reviewed from the following sources:

- Ministry of Natural Resources Natural Heritage Information Centre (NHIC) – Natural Area Records;
- Ministry of Natural Resources Natural Heritage Information Centre (NHIC) – Sensitive Species Records;
- MNR Wetland Evaluations;
- MNR Life Science Areas of Natural and Scientific Interest (ANSI) in Site District 6-13 report;
- Durham Region Coastal Wetlands Study;
- CLOCA"s Environmental Sensitivity Mapping Project;
- CLOCA"s baseline Ecological Land Classification mapping;
- Documentation prepared in support of the 407 East Environmental Assessment (EA);
- Ministry of Natural Resources (MNR) Natural Resource Values Systems (NRVIS) mapping;
- Ontario Geological Survey/MNR (Chapman and Putnam, 1984) Physiography of Southern Ontario text;
- Biological Inventories of Darlington Provincial Park; and
- Digital Orthoimagery.

7.2.2 Vegetation

The secondary source review (**Section 7.2.1** above) provided the basis for field investigations by establishing the physical setting and providing baseline vegetation community delineations, particularly MNR ANSI reports for site district 6-13 (Hanna, 1984), The Physiography of Southern Ontario (Chapman and Putnam, 1984), ELC data provided by CLOCA, documentation prepared in support of the 407 East EA, and to a lesser extent, the MNR Wetland Evaluation reports. These data were reviewed in concert with an interpretation of digital orthoimagery to delineate preliminary broad level (Community Series) ELC polygons. The secondary source review also compiled a list a rare vascular flora species known to occur within either the Tooley Creek or Robinson Creek watersheds, or proximate lands, to provide the field collector with a flora species list.

Field investigations were completed on the following eight dates in 2009: July 23-24, July 29-31, August 4, and August 18-19. Investigations classified vegetation communities to the Vegetation Type where possible according to the Ecological Land Classification (ELC) protocols (Lee *et al.* 1998), using the draft 2nd updated hierarchy community descriptions (OMNR, 2008) for all mature and naturalized areas. Data regarding the structure and composition of vegetation units were collected, including information describing soil types, dominant species, cover, community structure, community disturbance, and other notable features including the presence of groundwater seeps and noting seepage indicator plant species.

Investigations focused on lands west of Hancock Road (i.e., the area not covered by 407 East EA documentation). Where 407 East EA documentation provided ELC classification to Vegetation Type, as part of this study, field investigations were completed at a reconnaissance level to confirm the accuracy of community classification and delineation.

A systematic survey of vascular plants was not completed, however all species encountered were recorded. All rare flora, including regionally rare species, were located on field maps.

Swallow-wort (also known as Dog-strangling Vine) species (*Cynanchum sp.*) were assigned an occurrence code according to Lee et al. (1998) for each polygon visited during field investigations (i.e., dominant, abundant, occasional and rare). The *Cynanchum* genus includes two species of aggressive, non-native plants known to occur in the Greater Toronto Area: the White Swallow-wort (*C. rossicum*) and the Black Swallow-wort (*C. cynanchum*). White Swallow-wort is the only species known to occur in Durham Region (Varga et al., 2000), and was the only species observed during field investigations. This species can quickly invade a variety habits including upland forest, thicket and meadow communities, and to a lesser extent, wetland communities. Existing distribution and abundance data of White Swallow-wort may be important to broad natural heritage management plans and smaller scale site planning; however these data are not presented as part of this report, but are available upon request.

Post-field investigations, field data and secondary source information were compiled to evaluate the natural features and compile lists of vascular plant species known to occur in the Tooley and Robinson Creek watersheds. Vegetation field data were refined and synthesized to create the vegetation community maps (**Figures 7.2 and 7.6**). Provincial rarity of vegetation communities was assessed according to the provincial rankings provided on the Natural Heritage Information Centre (NHIC) website. Provincial rarity of flora was determined using the NHIC list of *Rare Vascular Plants of Ontario* (Oldham and Brinker, 2009). Regional rarity of plants was determined according to the *Distribution and Status of the Vascular Plants of the Greater Toronto Area* (Varga et al. 2000).

7.2.3 Wildlife Habitat

For purpose of describing terrestrial wildlife and wildlife habitat, background sources (listed in **Section 7.2.1**) were consulted and field investigations were conducted. Two groups, breeding birds and calling amphibians, were selected for systematic field survey. These two groups can be surveyed fairly readily, and birds in particular represent a diverse group of species that are present in all habitats, thus they serve as surrogates to generally represent terrestrial wildlife.

Bird surveys were conducted on nine days between May 28 and June 26, 2009 in the early morning before 11:00 am and under low wind and no precipitation conditions. All birds heard or observed were recorded on maps in their approximate location. Lists of bird species were compiled by watershed, however field notes containing information on bird species recorded at each site are on file at AECOM and are available upon request. There is a small piece of land along the Lake Ontario shoreline that is between the Robinson Creek and Tooley Creek watersheds. Bird observations from the west side of this piece that are continuous with Darlington Provincial Park are included in the Robinson Creek Watershed bird list. Bird observations from the east side, primarily along the lakeshore are included in the Tooley Creek Watershed bird list.

Records from AECOM breeding bird surveys of 2003 and 2006 from the Highway 407 East EA were included in the results. These surveys covered most natural areas east of Hancock Road within the Tooley Creek Watershed. Some of these areas were re-surveyed for breeding birds during this study, as was practical during the breeding season. The regional status of Durham Region birds is based on Bain and Henshaw (1993). Although this reference is becoming outdated, and some species have increased in occurrence since it was written, it still provides insight for the regional rarity of species.

Amphibian roadside calling surveys occurred on July 3, 2009. Frog species and the number heard were recorded, as was the assumed breeding location. This survey occurred after dark, under low wind conditions. No amphibian calling surveys occurred in April, when different species call, as the project had not been initiated. Anecdotal information from land-owners was documented when available. Field surveys and air photography were used to assess ponds and wetland habitat for their potential to contain breeding amphibian habitat.

Mammal and herptile observations were recorded while conducting field surveys. Historical wildlife observations from Darlington Provincial Park were also used (G. Vogg and T. Hoar, pers. comm. 2009).

7.2.3.1 Forest Habitat and Landscape Connectivity

The following serves as an introduction to landscape connectivity and describes the methods used for the associated analysis for both Robinson and Tooley Creek watersheds.

With increasing rates of habitat loss and fragmentation in southern Ontario, landscape connectivity (which includes the concept of „wildlife corridors") has become recognized as an important part of natural heritage planning. Corridors have become popular tools in efforts to mitigate fragmentation and conserve biodiversity. Generally speaking, a poorly connected landscape is one where there are relatively small quantities of natural habitat (forest, wetland, thicket, etc.) separated by larger areas of agricultural lands, urban areas and or roads. A highly connected landscape is one where the landscape is mostly natural habitat, with minimum quantities of agriculture or development breaking up the landscape and where the roads are not major highways or commuter roads. It is characterized by more core areas and interior forest habitat.

Movement corridors serve to increase local species richness and biodiversity, provide more immigration and movement opportunities for individuals among core natural areas, and provide greater likelihood of seed dispersal and exchange of other genetic material between populations. This is thought to generally outweigh negative effects, such as pathways for invasive plant dispersal.

7.2.3.2 Core Areas and Interior Habitat

A core area, due to its size and/or shape, provides a sufficiently large area of natural habitat that an increases the probability for enhanced wildlife function (e.g., sensitive breeding birds and/or complex habitat). A minimum of 25 ha was used to identify large or core habitat areas for the purposes of assessing effects to landscape connectivity and wildlife movement opportunities at the landscape level. If forested, this minimum size will also contain some forest interior habitat; up to 9 ha if the area were an ideal square.

Core areas for this landscape connectivity analysis, are comprised of wetland, forest and woodland communities. It should be noted that early successional habitats, such as thickets and meadows, although not included in the core area analysis, do provide habitat for thicket, meadow and other open country species. For the purposes of the assessment, gaps between vegetation communities greater than 20 m are considered to form a break in a contiguous core area. Long linear features (less than about 150 m wide), were not considered to be core areas but still offer opportunities for wildlife movement.

Interior habitat refers to the area protected from the effects of sun, wind, invasive plants, and soil desiccation, providing conditions suitable for the persistence of shade- tolerant native forest flora. For wildlife, particularly forest birds, edge effect zones have been identified as extending at least 100 m in from the forest edge (Riley and Mohr, 1994). For this study, interior forest habitat is defined as the forest and treed swamp habitat which is 100 m or more from an edge. Deep forest interior is generally identified as being at least 200 m from the forest edge. Based upon the current land use in both the Robinson and Tooley Creek watersheds, the presence of deep interior forest it not anticipated.

7.2.3.3 Corridors

Corridors serve a number of functions and operate at varying scales. In the context of the Robinson Creek and Tooley Creek watersheds, they have been categorized into two types: landscape corridors and local corridors. Landscape corridors are major movement routes within the watershed that connect core areas and/or are sufficiently robust to supply key habitat requirements for wildlife inhabiting the watershed. They typically follow linear features such as creeks and valleys, and can be composed of a continuous series of independent habitats. Local corridors are minor movement routes within a landscape that connect small to moderate sized habitat units into a continuous series. They are usually associated with tributary valleys. These corridor definitions are based on those within the Oshawa Creek Watershed Management Plan (CLOCA, 2002).

7.3 Robinson Creek Watershed: Results and Findings

7.3.1 Significant Features

This section lists and describes the significant features that occur within the Robinson Creek Watershed. The locations and aerial extent of the features described below are shown on **Figure 7.1.**

7.3.1.1 Provincially Significant Wetlands

McLaughlin Bay Wetland (also known as Darlington Bay or Oshawa Third Marsh) is a 43.9 ha provincially significant coastal wetland, and is composed of two wetland types: 13% swamp and 87% marsh (NHIC Natural Areas Record, 2009). The McLaughlin Bay Wetland occurs almost entirely outside of the Robinson Creek Watershed, with the exception of the southwest corner of the watershed, and surrounding the outlet of Robinson Creek to Lake Ontario (**Figure 7.1**).

The wetland historically was open to Lake Ontario, but shoreline processes have created a substantial barrier beach across the wetland. The wetland water levels remain perched above Lake Ontario with some seepage from the wetland to the lake through the barrier beach (Environment Canada, 2004). The barrier occasionally blows out when lake levels are high during violent storm events (Leadbeater, Pers. Comm., 2009).

McLaughlin Bay Wetland is surrounded predominately by abandoned agricultural lands and Darlington Provincial Park and as a result has few sources of agricultural and urban pollution, although CLOCA reports that runoff from the nearby Highway 401 and the General Motors Plant, enter the wetland. According to the *Durham Region Coastal Wetland Monitoring Project: Year 2 Technical Report*, produced by Environment Canada and CLOCA staff (Environment Canada and CLOCA, 2004), the McLaughlin Bay Wetland generally has good quality sediment and water, and can support high numbers of disturbance-sensitive aquatic macroinvertebrates. Submerged aquatic plant communities are limited by wind and wave action and activities of invasive species including Common Carp and Mute Swan. The wetland complex supports nesting, breeding, staging and feeding habitat for waterbirds. This area is considered an important migratory passerine and shorebird stopover area (OMNR 1984).

7.3.1.2 Darlington Provincial Park

A portion of Darlington Provincial Park occurs within the Robinson Creek Watershed. The park is located along the north shore of Lake Ontario in the Town of Newcastle. The park is separated into two zones; a development zone (76 ha) and a natural environment zone (95 ha of land and water). The park includes a portion of the stream valley of Robinson Creek, the eastern edge of Mclaughlin Bay and its associated wetland, sandpits and backshore areas (NHIC Natural Areas Record, 2009).

7.3.1.3 Environmentally Sensitive Areas (ESA)

The Robinson Creek Valley ESA occurs entirely within the Robinson Creek Watershed. This ESA acts a conveyor of local surface drainage and exhibits low to moderate sensitivity (Gartner Lee, 1978).

7.3.2 Vegetation

7.3.2.1 Vegetation Communities

Vegetation community investigations documented 23 distinct Community Series in 10 broad classifications or Community Classes within the Robinson Creek Watershed as described in **Table 7.1** below. Community Classes are illustrated in **Figure 7.2**; unmapped portions are predominantly Crop Agriculture (OAGM1, OAGM2, and OAGM3) and Constructed (CVI, CVR, and CVC) classifications.

Table 7.1 Vegetation Community Class and Series Classifications within Robinson Creek Watershed (Updated ELC Hierarchy, 2008)

		Area (ha)
Terrestrial System – Natural and Naturalized Communities		**105.34**
Shoreline Community Class		**0.01**
SHO	Open Shoreline Community Series	0.01
Forest Community Class		**36.52**
FOC	Coniferous Forest Community Series	9.70
FOD	Deciduous Forest Community Series	23.36
FOM	Mixed Forest Community Series	3.46
Meadow Community Class		**24.18**
MEF	Forb Meadow Community Series	10.60
MEG	Graminoid Meadow Community Series	5.00
MEM	Mixed Meadow Community Series	8.58
Thicket Community Class		**38.33**
THD	Deciduous Thicket Community Series	38.33
Woodland Community Class		**6.30**
WOD	Deciduous Woodland Community Series	5.91
WOM	Mixed Woodland Community Series	0.39
Terrestrial System – Cultural Communities		**56.52**
Agricultural Community Class		**26.89**
AGO	Open Agriculture Community Series	2.34
SAG	Shrub Agriculture Community Series	24.55
Constructed Community Class		**29.63**
CGL	Green Lands Community Series	29.63
Wetland System		**22.83**
Marsh Community Class		**9.38**
MAM	Meadow Marsh Community Series	6.03
MAS	Shallow Marsh Community Series	3.35
Swamp Community Class		**13.45**
SWC	Coniferous Swamp Community Series	1.28
SWD	Deciduous Swamp Community Series	6.85
SWM	Mixed Swamp Community Series	1.56
SWT	Thicket Swamp Community Series	3.76
Aquatic System		**0.68**
Open Water Community Class		**0.68**
OAO	Open Aquatic Community Series	0.68
Total		**185.37**

Vegetation communities were further classified to categories of Ecosite and Vegetation Type based on soil characteristics and dominant plant species present. Ecosite and Vegetation Type units are mapped on **Figure 7.3**.

All vegetation communities documented are considered common and widespread throughout southern Ontario according to the NHIC website. A Fresh-Moist Deciduous Woodland classification was used to describe a stand of approximately 15 young Butternut trees located along the main branch of Robinson Creek, immediately south of Bloor Street, as indicated on **Figure 7.3**. Butternut (*Juglans* cinerea) is a nationally endangered species threatened throughout its North American range by a non-native fungus, *Sirococcus clavigignenti-juglandacearum*. Although an official health assessment was not completed for individual Butternut trees all trees appeared healthy, although exhibiting some symptoms of disease.

Poorly-drained silt and clay soils occur throughout the Iroquois Plain physiographic region, particularly near the shore of Lake Ontario (OMNR, 1994). The presence of these soils, underlying more permeable sandy soils, can lead to the rare occurrence of groundwater seepage and seepage wetlands. This trend was observed throughout the Robinson Creek Watershed. Field investigates mapped seepage indicators on **Figure 4.8**, including vegetation communities with organic soil development (i.e., organics greater than >40 cm as defined by Lee et al. (1998)), observed seeps, and plant indicator species that are associated with cold groundwater discharge (i.e., watercress). One organic swamp (SWMO1-1) was documented in the main Robinson Creek valley, south of Bloor Street, and three locations of groundwater indicators (one of *Nasturtium microphyllum* and two of *Caltha palustris*) were noted (**Figure 4.8**) These areas should be considered uncommon in the Robinson Creek Watershed, as well as within the broader physiographic region.

7.3.2.2 Flora

The background review and field investigations identified a total of 193 species of vascular plants with the Robinson Creek Watershed (**Appendix D.1**). Forty-six of the species indentified are non-native occurrences, representing approximately 24% of all species recorded. The high proportion of non-native species is largely attributed to the fragmented nature of the vegetation throughout the watershed, which is typical of southern Ontario.

Eleven species are considered regionally significant (uncommon to rare in Durham Region according to Varga et al., 2000) and are listed in **Table 7.2** below. Butternut (*Juglans cinerea*) was located along the main branch of Robinson Creek, between Bloor Street and Baseline Road, and within Darlington Provincial Park, as indicated on **Figure 7.3**. Butternut (*Juglans* cinerea) is a nationally endangered species threatened throughout its North American range by a non-native fungus, *Sirococcus clavigignenti-juglandacearum*.

Table 7.2 Regionally Significant Vascular Plants of Robinson Creek Watershed

Scientific Name	Common Name	Community Class
Cakile edentula	Sea-rocket	SHO
Carex blanda	Woodland Sedge	FOD
Crataegus chrysocarpa	Round-leaved Hawthorn	FOD
Elymus virginicus	Virginia Wild-rye	SWD
Gentiana andrewsii	Closed Gentian	MAM
*Juglans cinerea**	Butternut	WOD, FOD
Juncus balticus	Baltic Rush	SHO
Lilium michiganese	Canada Lily	FOD
Lobelia siphilitica	Great Lobelia	MAM
Potentilla anserina	Silverweed	SHO
Solidago juncea	Early Goldenrod	MEM
Viola Canadensis	Canada Violet	FOD

*Note: * Juglans cinerea is nationally endangered.*

7.3.3 Wildlife Habitat

7.3.3.1 Birds

Fifty-five breeding season species were recorded in the Robinson Creek Watershed (see **Appendix D.3** for annotated checklist). This number is relatively low given the size of the area, however it reflects the low quality of habitat available. The most frequently observed bird species are those that are common in southern Ontario typical of edges, shrub habitats and disturbed areas. The most abundant species recorded included: Blue Jay (*Cyanocitta cristata*), House Wren (*Troglodytes aedon*), Gray Catbird (*Dumetella carolinensis*), Yellow Warbler (*Dendroica petechia*), Northern Cardinal (*Cardinalis cardinalis*), Song Sparrow (*Melospiza melodia*), Red-winged Blackbird (*Agelaius phoeniceus*), and American Goldfinch (*Cardeulis tristis*). A large thicket area northeast of Bloor Street and Prestonvale Road contained a particularly diverse number of early successional species that included the only locations in the watershed for Field Sparrow, regionally scarce Clay-coloured Sparrow and regionally rare Orchard Oriole (see **Figure 7.4**). Both of the latter two species, although rare, are found mainly in human-created habitats (the former in open shrub lands and the latter in habitats such as hedgerows and open woodlands).

The forest bird community is very poorly developed in the Robinson Creek Watershed due to the very small and patchy amount of remaining forest. Even usually common forest birds such as Downy Woodpecker (*Picoides pubescens*), Black-capped Chickadee (*Poecile atricapillus*), Rose-breasted Grosbeak (*Pheucticus ludovicianus*) and Great-crested Flycatcher (*Myiarchus crinitus*), were not frequently seen. Negligible numbers of area-sensitive forest bird species were recorded (**Figure 7.4**). These are species that whose breeding success is correlated to forest patch size and breed more successfully or in greater densities, or in larger patches. Within the Robinson Creek Watershed, five individuals of three forest area-sensitive species were recorded: White-breasted Nuthatch (*Sitta carolinensis*), Black-throated Green Warbler (*Dendroica virens*) and Blue-gray Gnatcatcher (*Polioptila caerulea*). The Black-throated Green Warbler was in a very small patch of suitable habitat and was not heard on subsequent visits to the site. It is not likely a regular or successful breeder. The Blue-gray Gnatcatcher, also regionally rare, is regularly recorded in Darlington Provincial Park north of the mouth of the creek. American Redstart (*Setophaga ruticilla*), another area-sensitive forest species was recorded in Darlington Provincial Park, but were thought to be in migration. Golden-crowned Kinglet (*Regulus satrapa*) may have bred in the conifers at Darlington Provincial Park (Vogg G. pers. comm. 2009).

A few grassland or open land area-sensitive species were recorded and are primarily species which breed in habitat very influenced by people. Only Savannah Sparrow (*Passerculus sandwichensis*) was recorded in any significant numbers. Savannah Sparrow will breed in many types of open field habitat including cultivated fields, thus this is not considered unusual. There is limited wetland habitat within the watershed to support marsh breeding birds. Hence only a few Swamp Sparrows (*Melospiza georgiana*) were recorded in limited locations. The newer stormwater pond at the south end of Fenning Drive, located to the west of Presonville Road, provides the only habitat for breeding waterfowl in the watershed, except for breeding Mallards seen in one or two other locations (**Figure 7.4**). The stormwater pond provided breeding habitat (young were observed) for at least three waterfowl species, including the regionally scarce Green-winged Teal, as well as feeding habitat for Great Blue Heron (*Ardea herodias*). No breeding bird Species at Risk were recorded in the watershed. Regionally rare species have been discussed above.

Information on migrant birds can be gathered from existing sources and are difficult to field survey without an intensive program. Due to its location bordering Lake Ontario, Darlington Provincial Park is a very important migrant stop-over location for songbirds in particular, but also for shorebirds and waterfowl. The Darlington Provincial Park Checklist of Birds (T. Hoar 1997), lists the 264 bird species which have occurred in the park. Note that only half the park is within the watershed. The majority of these would have been observed during migration seasons, including some species that have probably only been observed once or twice. This list includes waterfowl and shorebird migrants which utilize the beach, McLaughlin Bay and Lake Ontario itself. The list of songbirds for the park is also extensive. Many of the bird features, for which McLaughlin Bay Wetland is known for, are associated with the part of the wetland that is outside of the Robinson Creek Watershed.

The Fenning Drive stormwater pond also provides some habitat for migrant shorebirds and waterfowl. A few late migrant birds were observed during breeding bird surveys and additional species would be expected in spring and fall.

7.3.3.2 Amphibians and Other Wildlife

There appears to be little high quality amphibian breeding habitat in the watershed. No frogs were heard during the July roadside calling survey, but it is possible that some sites could not be heard from the road. Also, some species may have stopped calling as a result of the timing of the surveys. However, it is likely that small to moderate numbers of at least five species are present in the watershed. Three of these are species that are most tolerant of human disturbance. Several locations where Green Frog (*Rana clamitans*) and Leopard Frog (*Rana pipiens*) may occur have been shown on **Figure 7.4** as potential amphibian breeding habitat. A third species, American Toad (*Bufo americanus*) is also likely present as it will breed in tiny human-created pools or puddles of water. Tadpoles of this species were recorded approximately 300 m to the east of the Robinson Creek Watershed, but within the Tooley Creek Watershed. A fourth amphibian species, the Wood Frog, has been observed in Darlington Provincial Park. A Wood Frog (*Rana* *sylvatica*) was observed in the wooded ravine, outside of its breeding season (G. Vogg pers. comm. 2009), and they are known to occur at Oshawa Second Marsh to the west (Kamstra, Pers. Comm., 2009). This species is not expected to be common in the watershed. The fifth and final species is the Gray Treefrog (*Hyla versicolor*). An individual was heard calling during the non-breeding season about 250 m east of Prestonvale Road and 600 m north of the railway. This species may breed in either of the two large ponds near this location, but like the Wood Frog is not likely to be common in the watershed due to a lack of good quality, non-breeding (woodland) habitat.

There appears to be only poor habitat available for turtles in the watershed, although three species likely occur. See Species at Risk Section (**Section 7.3.4**) for a discussion on the presence of Snapping Turtle (*Chelydra serpentina*) and Blanding"s Turtle (*Emys blandingii*). A third species, Painted Turtle (*Chrysemys picta*) the most common Ontario species, may occur in the watershed, although it was not recorded during field surveys in 2009. The three larger ponds, including the Fenning Drive stormwater pond, may contain this species.

Like turtles, snakes can be difficult to observe. No snakes were recorded during field work for this study, but it is likely that at least one or more of the common species occur in the watershed. A discussion of the presence of Milksnake (*Lampropeltis triangulum*), a Species a Risk, can be found under **Section 7.3.4**.

No rare mammals are known to occur in the watershed. Several species common to southern Ontario were observed during field surveys, including: Coyote (*Canis latrans*), Striped Skunk (*Mehpitis mephitis*), White-tailed Deer (*Odocoileus virginianus*), Eastern Cottontail (*Sylvilagus floridanus*), and Grey Squirrel (*Sciurus carolinensis*). Other species undoubtedly occur including small mammal and bat species which are difficult to observe without a targetted study.

7.3.3.3 Forests and Landscape Connectivity

The Robinson Creek Watershed is poorly connected. See **Section 7.2.3** for an introduction to this section and the methods used in the analysis. To the north and west of the watershed, the area is fully developed with residential housing, and as a result, impedes most movement for wildlife and provides little habitat. To the south, Lake Ontario is a barrier for many species, with the exception of specific aquatic species. Within the watershed, the six-lane Highway 401 is also a major barrier for the movement of most terrestrial species. To the east there are movement possibilities for a small number of wildlife species which can function within a landscape that is mainly agricultural. Two specific corridors were identified and are presented on **Figure 7.4**. A landscape level corridor was identified from Darlington Provincial Park westward, but not eastward due to the agricultural lands in that direction. A second, local corridor was identified, that moves along the main branch of Robinson Creek. As mentioned previously, this corridor ends in the south at Highway 401 and in the north at a location where development occurs approximately 400 m north of Bloor St.

No forested or wetland areas are large enough to be considered core areas, nor is there any forest interior within the watershed. This concurs with the lack of area-sensitive wildlife data recorded and the low diversity of breeding species.

7.3.4 Species at Risk

Species at Risk are those species with status under the Federal *Species at Risk Act* (SARA) and/or the Provincial *Endangered Species Act*. Species at Risk are identified federally by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), and provincially by the Committee on the Status of Species at Risk in Ontario (COSSARO).

Each of the Species at Risk recorded in the Robinson Creek Watershed are described below, and are listed in **Table 7.3** below. These records have been compiled through field investigations conducted by the project team, records from the OMNR, from Darlington Provincial Park staff and through the review of secondary source information.

Table 7.3 Species at Risk in the Robinson Creek Watershed*

	Common Name	Scientific Name	Federal Status	Provincial Status (COSSARO)	Provincial S-Rank (NHIC)
Birds	Piping Plover	*Charadrius melodus*	Endangered	Endangered	S1 (Critically Imperiled)
Reptiles	Blanding"s Turtle	*Emydoidea blandingii*	Threatened	Threatened	S3 (Vulnerable)
	Snapping Turtle	*Chelydra serpentina*	Special Concern	Special Concern	S3 (Vulnerable)
	Milksnake	*Lampropeltis triangulum triangulum*	Special Concern	Special Concern	S3 (Vulnerable)
Vegetation	Butternut	*Juglans cinerea*	Endangered	Endangered	S3? (Vulnerable – rank uncertain)

*Note: * Listed as Endangered, Threatened or Special Concern with federally or provincially, or appear on Schedule 1 of the Species at Risk Act*

Piping Plover (*Charadrius melodus*)

Piping Plover was recorded by Darlington Provincial Park staff in May 2009. This species was recorded along an area of beach just outside of the Robinson Creek Watershed, and was not breeding. The preferred habitat of this species does not occur within the watershed, so it is unlikely that this species will occur within the boundary of the watershed. The numbers of Piping Plovers have been decreasing everywhere; however, the most dramatic long-term declines have occurred in the Great Lakes region (Government of Canada, 2009). However, there has been at least one breeding record of Piping Plover from lower Great Lakes shorelines. The most important limiting factor for the Piping Plover (*circumcinctus* subspecies) is loss of habitat due to human use of beaches, and the consequent disturbance of nesting sites (Government of Canada, 2009).

Blanding's Turtle (*Emydoidea blandingii)*

Blanding"s Turtle has been recorded within the Robinson Creek Watershed. The same individual was reported by Darlington Provincial Park staff in 2000 and 2006. This species predominately inhabits the McLaughlin Bay Wetland and is unlikely to be recorded elsewhere in the watershed. The Great Lakes/St. Lawrence population of this species, although widespread and fairly numerous, is declining (COSEWIC, 2005).

Snapping Turtle *(Chelydra serpentine)*

Snapping Turtle was recently recorded within the watershed by Darlington Provincial Park staff, at the southern tip of the watershed. It is likely that these individuals are predominately associated with the McLaughlin Bay Wetland. It is likely that this species is present elsewhere in the watershed, particularly in ponds and in the main channel of Robinson Creek. According to COSEWIC"s assessment, although this species is widespread and still somewhat abundant, its life history and dependence on long warm summers to complete incubation successfully, make it unusually susceptible to anthropogenic threats (COSEWIC, 2008).

Milksnake (*Lampropeltis triangulum triangulum)*

According to NHIC records, Milksnake was last recorded in 1989 within the Robinson Creek Watershed. The Milksnake inhabits a wide variety of habitats including field, swamp and open woodlots. This snake is more common in heavily forested areas (deciduous, evergreen and mixed) than in areas of low forest cover. However, Eastern Milksnakes are also common in rural pastures and hayfields, as well as in and around barns, sheds and houses (COSEWIC 2002). This species is still widespread in Ontario, but anecdotal information indicates that it occurs in small numbers (COSEWIC 2002).

Butternut *(Juglans cinerea)*

Butternut was recorded in the watershed during 2009 field investigations (Figure 7.3). In three locations, one or two butternut trees were recorded including: within an area of campground of Darlington Provincial Park, south of Darlington Park Road, and in two locations within deciduous forest communities near the main branch of Robinson Creek. A deciduous woodlot dominated by Butternut was identified and delineated east of Prestonvale Road, south of Bloor Street. Butternut is a widespread tree found as single trees or small groups in deciduous and mixed forests of southern Ontario, Quebec, and New Brunswick. High rates of infection and mortality by Butternut canker have been observed in parts of Ontario (COSEWIC, 2003).

7.4 Tooley Creek Results and Findings

7.4.1 Significant Features

This section lists and describes the significant features that occur within the Tooley Creek Watershed. The locations and aerial extent of the features described below are shown on **Figure 7.5.**

Provincially Significant Wetland

The western portion of the provincially significant Maple Grove Wetland Complex occurs within the headwaters of the Tooley Creek Watershed (**Figure 7.5**). Wetland units as part of the complex also cross the headwaters of Darlington Creek and two subwatersheds of Bowmanville Creek. The complex was evaluated in 2004 and is entirely within private ownership (OMNR, 2004).

The Maple Grove complex is comprised of 17 wetlands covering a total of 149 ha. The complex is predominately swamp (97%), with a small representation of marsh communities. All of the wetlands units are classified as palustrine, with 97% situated in headwaters with no inflows and another 3%, further downstream with some inflow (OMNR, 2004). Seventeen significant plant species has been identified within the complex, 14 of which are locally rare and 3 that are regionally rare. The mixed, coniferous and deciduous swamps are locally significant for wintering deer (OMNR, 2004).

Wetlands such as Maple Grove are rare on the Lake Iroquois Plain due to development. Maple Grove, along with the adjacent Black Farewell Wetland Complex, supports the largest wetland complexes and largest swamps on the Iroquois Plain in the GTA (OMNR, 2004).

Darlington Provincial Park

A small portion of Darlington Provincial Park occurs within the Tooley Creek Watershed, south of Highway 401 and west of Down Road. The park is located along the north shore of Lake Ontario in the Town of Newcastle. The park is separated into two zones; a development zone (76 ha) and a natural environment zone (95 ha of land and water).

Locally Significant Wetlands

The locally significant Tooley Creek Coastal Wetland is located at the mouth of Tooley Creek, occurring entirely within the Tooley Creek Watershed. The Tooley Creek wetland is only 0.35 ha in size and sustains three marsh vegetation communities and an aquatic community that covers 50% of the wetland. This wetland supports two locally rare plant species, Leafy Pondweed (*Potamogeton foliosus*) and Common Three-square (*Scripus pungens*). The Tooley Creek Wetland supports fish habitat that is considered locally significant, as it provides nursery and spawning areas for Lake Ontario fish. The open waters areas are also a staging area for waterfowl (OMNR, 2006).

Environmentally Sensitive Areas (ESA)

The Tooley Creek Valley ESA has been delineated along the main branch of Tooley Creek (Gartner Lee, 1978), from the outlet at Lake Ontario, north to just south of Highway 2. This ESA has been designated on the basis that Tooley Creek conveys surface drainage. The sensitivity has been classified as moderately low (Gartner Lee, 1978).

7.4.2 Vegetation

7.4.2.1 Vegetation Communities

Vegetation community investigations documented 23 distinct Community Series in 10 broad classifications or Community Classes within the Tooley Creek Watershed as described in **Table 7.4** below. Community Classes are illustrated in **Figure 7.6**; unmapped portions are predominantly Crop Agriculture (OAGM1, OAGM2, and OAGM3) and Constructed (CVI, CVR, and CVC) classifications.

Table 7.4 Vegetation Community Class and Series Classifications within Tooley Creek Watershed

		Area (ha)
Terrestrial System – Natural and Naturalized Communities		**152.71**
Shoreline Community Class		**1.64**
SHO	Open Shoreline Community Series	1.64
Bluff Community Class		**0.03**
BLO	Open Bluff	0.03
Forest Community Class		**80.77**
FOC	Coniferous Forest Community Series	8.52
FOD	Deciduous Forest Community Series	68.41
FOM	Mixed Forest Community Series	3.84
Meadow Community Class		**12.97**
MEF	Forb Meadow Community Series	7.48
MEM	Mixed Meadow Community Series	5.49
Thicket Community Class		**33.39**
THD	Deciduous Thicket Community Series	33.39
Woodland Community Class		**23.91**
WOD	Deciduous Woodland Community Series	9.78
WOM	Mixed Woodland Community Series	14.13
Terrestrial System – Cultural Communities		**60.08**
Agricultural Community Class		**56.99**
OAG	Open Agriculture Community Series	31.05
SAG	Shrub Agriculture Community Series	19.24
TAG	Treed Agriculture Community Series	6.70
Constructed Community Class		**3.09**
CGL	Green Lands Community Series	3.09
Wetland System		**43.41**
Marsh Community Class		**6.26**
MAM	Meadow Marsh Community Series	4.63
MAS	Shallow Marsh Community Series	1.63
Swamp Community Class		**37.15**
SWD	Deciduous Swamp Community Series	21.84
SWM	Mixed Swamp Community Series	10
SWT	Thicket Swamp Community Series	5.31
Aquatic System		**0.19**
Open Water Community Class		**0.19**
SAS	Submerged Shallow Aquatic Community Series	0.19
Total		**256.39**

Vegetation communities were further classified to categories of Ecosite and Vegetation Type based on soil characteristics and dominant plant species present. Ecosite and Vegetation Type units are mapped on **Figure 7.3**. All vegetation communities documented are considered common and widespread throughout southern Ontario according to the NHIC website.

Poorly-drained silt and clay soils occur throughout the Iroquois Plain physiographic region, particularly near the shore of Lake Ontario (OMNR, 1994). The presence of these soils, underlying more permeable sandy soils, can lead to the rare occurrence of groundwater seepage and seepage wetlands. This trend was observed throughout Tooley Creek Watershed. Field investigates mapped seepage indicators on **Figure 4.20**, including vegetation communities with organic soil development (i.e., organics greater than >40 cm as defined by Lee et al. (1998)), observed seeps, and plant indicator species that are associated with cold groundwater discharge (i.e., watercress). One organic swamp (SWMO3-2) was documented in the Maple Grove Wetland Complex, north of Highway 2 and east of Solina Road, and two locations of groundwater indicators (*Caltha palustris*) were noted. These areas should be considered uncommon in the Tooley Creek Watershed as well as within the broader physiographic region.

7.4.2.2 Flora

The background review and field investigations identified a total of 212 species of vascular plants with the Tooley Creek Watershed (**Appendix D.3**). Forty-eight species indentified are non-native occurrences, representing approximately 23% of all species recorded. The high proportion of non-native species is largely attributed to the fragmented natural of vegetation throughout the watershed.

Seventeen species are considered regionally significant (uncommon to rare in Durham Region according to Varga et al., 2000) as listed in **Table 7.5** below. Additionally, two Butternut (*Juglans cinerea*) were located at one location along the main branch of Tooley Creek, approximately 500 m north of Bloor Street, as indicated on **Figure 7.3**. Butternut (*Juglans* cinerea) is a nationally endangered species threatened throughout its North American range by a non-native fungus, *Sirococcus clavigignenti-juglandacearum*. Although an official health assessment was not completed for the Butternut trees, evidence of the fungus was present, although both trees appeared healthy.

Table 7.5 Regionally Significant Vascular Plants of the Robinson Creek Watershed

Scientific Name	Common Name	Community Class
Agalinus tenuifolia	Slender Gerardia	SWD
Carex albursina	Bear Sedge	FOD
Carex blanda	Woodland Sedge	FOD
Carex laxiflora	Loose-flowered Sedge	FOD
Carex rosea	Rose-like Sedge	FOD
Carex trisperma	Three-seeded Sedge	SWD
Crataegus chrysocarpa	Round-leaved Hawthorn	FOD
Cypripedium calceolus	Yellow Lady-slipper	SWD
Hydrophyllum canadense	Canada Waterleaf	FOD
*Juglans cinerea**	Butternut	FOD
Osmunda regalis	American Royal Fern	SWM
Polygonum hydropiperoides	Mild Waterpepper	SAS
Potamogeton foliosus	Leafy Pondweed	SAS
Rubus hispidus	Swamp Dewberry	SWM
Sagittaria cuneata	Floating-leaved Arrowhead	SAS
Scirpus pungens	Common Three-square	SAS
Solidago juncea	Early Goldenrod	MEM
Solidago uliginosa	Bog Goldenrod	SWM

*Note: * Juglans cinerea is nationally endangered.*

7.4.3 Wildlife Habitat

7.4.3.1 Birds

Seventy-two breeding season species were recorded in the Tooley Creek Watershed (see **Appendix D.4** for the annotated checklist). The most frequently observed bird species are those that are common in southern Ontario and which are found in edges, shrub habitats and disturbed areas. These most abundant species recorded included: Blue Jay (*Cyanocitta cristata*), House Wren (*Troglodytes aedon*), Gray Catbird (*Dumetella carolinensis*), Yellow Warbler (*Dendroica petechia*), Northern Cardinal (*Cardinalis cardinalis*), Song Sparrow (*Melospiza melodia*), Red-winged Blackbird (*Agelaius phoeniceus*), and American Goldfinch (*Cardeulis tristis*).

The forest bird community is poorly developed in the Tooley Creek Watershed due to the very small and patchy amount of forest remaining. Usually common forest birds such as Downy Woodpecker, Black-capped Chickadee, Rose-breasted Grosbeak and Great-crested Flycatcher, were not frequently seen in most of the watershed. A notable exception to this is the northeastern portion of the watershed (north of Highway 2 and east of Hancock Road). Numerous area-sensitive forest bird species were recorded in this area, mainly forest warblers and Veery (**Figure 7.7**). Area-sensitive species either require larger patches of forest in which to breed, or breed more successfully, or in greater densities in larger patches. Within the Tooley Creek Watershed, 36 individuals of nine forest area-sensitive species were recorded (**Figure 7.7, Appendix D.4**), and most of these were in the northeastern portion. Three of these species are also regionally rare. These forests were the only location where Northern Waterthrush was recorded. A few of the areas-sensitive individuals that were recorded within the two forest areas east of Solina Road, were recorded during the Highway 407 East EA surveys, which were conducted throughout forest area in the Tooley Creek Watershed and also included forest areas outside of the watershed. Because precise observation location of these individuals was not recorded, not all of these birds may actually occur within Tooley Creek Watershed, but they at least occur nearby.

A few grassland or open land area-sensitive species were recorded and are primarily species which breed in habitat very influenced by people. Only one Savannah Sparrow (*Passerculus sandwichensis*) was recorded, in significant numbers. Savannah Sparrow will breed in many types of open field habitat including cultivated fields, thus this is not considered unusual. There is almost no open wetland habitat within the watershed within which marsh birds or waterfowl might breed. Hence only a few Swamp Sparrows (*Melospiza georgiana*) and Mallards were recorded in limited locations.

One Species at Risk breeding bird was recorded in the watershed. Canada Warbler (*Wilsonia canadensis*), is designated Threatened nationally and Special Concern provincially. It was recorded in suitable habitat in a large forest southeast of Nash and Solina Roads. The species is probably not present every year. See **Section 7.4.4** for descriptions of other species at risk, including: Black Tern (*Chlidonias niger*) (Special Concern provincially), and Least Bittern (*Ixobrychus exilis*) (Threatened nationally and provincially). Both of these species were recorded during an Environmental Impact Study (EIS) undertaken for the Courtice Water Pollution Control Plant (CLOCA, 2009), which is now situated at the base of the lakeshore east of Courtice Road. Neither was recorded during their breeding season, and there was no appropriate breeding habitat present before the plant was built. It is assumed that these two species were observed moving along the lakeshore.

Regionally rare species includes those listed in Bain and Henshaw (1994) as scarce, rare or very rare. These included some forest species as mentioned above as well as a Red-bellied Woodpecker (*Melanerpes carolinus*) in the forest north of the compost facility on Hancock Road, and a Hairy Woodpecker southeast of Bloor and Hancock Roads. Other regionally rare species are those usually found in habitats strongly influenced or created by people. This includes: Black-billed Cuckoo (*Coccyzus erythropthalmus*), Northern Mockingbird (*Mimus polyglottus*), Eastern Bluebird (*Siala sialis*), and Orchard Oriole (**Figure 7.7**). The occurrence of some of these species is not surprising given the degree of human activity on the landscape. Both Northern Mockingbird and Orchard Oriole have increased in numbers in southern Ontario (Cadman *et al.,* 2007), since the Durham status list was created.

Two Bank Swallow colonies were observed in the banks along Lake Ontario. Although not technically in the Tooley or Robinson Creek watersheds, these colonies have been included to highlight their occurrence and sensitivity. They are shown on **Figure 7.7** and are about 30 nests and 14 nests in size. This species is quite common in southern Ontario, but its breeding habitat is so specific that its colonies are quite localized.

Information on migrant birds is difficult to field survey without an intensive program, but can be gathered from existing sources. The shoreline on both sides of the Tooley Creek mouth is not naturally vegetated, and thus does not provide good habitat for landbird migrants that might otherwise concentrate along the lakeshore. The beach shoreline and the nearshore waters of Lake Ontario are also used by migrant waterbirds, although numbers of these migrants are not as high here as other parts of the Lake Ontario shoreline, where the habitat is more diverse. On June 2, 2009, a few migrant or non-breeding waterbirds were observed along the lakeshore. These included Semi-palmated Sandpiper (*Calidris pusilla*), Red-breasted Merganser (*Mergus serrator*) and Ring-billed Gull (*Larus delawarensis*).

7.4.3.2 Amphibians and Other Wildlife

There appears to be little high quality amphibian breeding habitat in the watershed. No frogs were heard during the roadside calling survey in July, but it is possible that some sites could not be heard from the road. Also, some species may have stopped calling as a result of the timing of the surveys. However, it is likely that small to moderate numbers of several species are present in the watershed. Three of these are species that are most tolerant of human disturbance including: Green Frog (*Rana clamitans*) and Leopard Frog (*Rana pipiens*). Leopard Frog has been recorded at the Tooley Creek outlet into Lake Ontario (OMNR, 2006), and is likely present elsewhere. A third species, American Toad (*Bufo americanus*) is likely present in numerous locations as it will breed in tiny human-created pools or puddles of water. Over a thousand toad tadpoles were recorded in a pond in a pasture southwest of Bloor and Courtice Roads (**Figure 7.7**). This species is very prolific and not all of the tadpoles are expected to transform. Other species, such as Wood Frog, Gray Treefrog, and Spring Peeper (*Pseudacris crucifer*), that usually require woodlands in the non-breeding season, may also occur in small numbers. The former two have been recorded in the Robinson Creek Watershed, a watershed with an even smaller amount of forest cover. Spring Peeper has been recorded in the Maple Grove Wetland although this may have been at a location just outside the watershed (OMNR, 2004).

There is one area that appears to have good potential for larger numbers of breeding amphibians. This is the area, primarily pastured, that is situated west of Courtice Road, north of Bloor St., east of Trulls Road and south of the high school (shown as a wetland on **Figure 7.6**). Although this area is now partly developed, the area appears to have once been a wetland, that been partially drained. It now contains swamp thicket, deciduous swamp with relatively deep standing water in early summer, a cattail marsh and several ponds. A local resident has heard many frogs calling here in the early spring and the habitat looks suitable for potentially several species. Potential amphibian breeding habitat is shown on **Figure 7.7** and it includes numerous ponds that appear to have been originally created as farm ponds.

There appears to be only poor habitat available for turtles in the watershed, although likely two species occur. See Species at Risk Section (**Section 7.4.4**) for a discussion on the presence of Snapping Turtle (*Chelydra serpentina*). A second species, Painted Turtle (*Chrysemys picta*) the most common Ontario species, may occur in the watershed, although it was not recorded during surveys conducted for this project in 2009.

Like turtles, snakes can be difficult to observe. No snakes were recorded during field work for this study, but it is likely that at least one or more of the common species occur in the watershed. A discussion of the presence of Milksnake (*Lampropeltis triangulum*), a Species a Risk, can be found under **Section 7.4.4.**

No rare mammals are known to occur in the watershed. Several species common to southern Ontario were observed, including: Coyote (*Canis latrans*), Striped Skunk (*Mehpitis mephitis*), White-tailed Deer (*Odocoileus virginianus*), Eastern Cottontail (*Sylvilagus floridanus*), and Grey Squirrel (*Sciurus carolinensis*). Other species undoubtedly occur including, small mammal and bat species. These species are difficult to observe without an in-depth study. A farmer within the watershed noted that coyotes are eating both deer and cow calves. He also noted that within the last decade there have been two records of Black Bear (*Ursus americanus*). Bear have been seen in increasing frequency within southern Ontario within this time period, but are not expected to be a permanent resident in the watershed within the foreseeable future.

7.4.3.3 Forests and Landscape Connectivity

The Tooley Creek Watershed is poorly connected. See **Section 7.2.3** for an introduction to this section and the methods used in the analysis. To the east and west of the watershed, the landscape is dominated by agricultural uses and forested areas tend to be patchy and disconnected. To the south, Lake Ontario is a barrier for terrestrial species. To the northwest, residential housing blocks most potential wildlife movement. Within the watershed, the six-lane Highway 401 is also a major barrier for the movement of most terrestrial species. Three significant corridors were identified (**Figure 7.7**). Two landscape level corridors were identified and both occur in the northeast corner of the watershed in the Maple Grove Wetland Complex. This landscape level corridor forms a connection between the relatively large forest and swamp in this area, which are separated usually by small roads and possible a line of rural houses or patches of early successional habitat. Only one forested area has been identified as a core area within the watershed and it is part of the Maple Grove Wetland Complex (**Figure 7.7**). A forested area located on both the east and west side of Hancock Road, south of Bloor Street, exhibited many properties of a core area, but was not quite large enough to contain sufficient interior habitat. A local corridor was identified that provides movement along the main branch of Tooley Creek. As mentioned, this corridor ends in the south at Highway 401. To the north, there are poor connections along tributaries to areas to the northeast.

Larger amounts of forest interior are only found within the northeastern forests within the watershed (**Figure 7.7**). This concurs with the lack of area-sensitive wildlife data recorded in the most of the watershed.

7.4.4 Species at Risk

Species at Risk are those species with status under the Federal *Species at Risk Act* (SARA) and/or the *Provincial Endangered Species Act*. Species at Risk are identified federally by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and provincially by the Committee on the Status of Species at Risk in Ontario (COSSARO).

Each of the Species at Risk recorded in the Tooley Creek Watershed are described below and those recorded during project field investigations are listed in **Table 7.6**. These records have been compiled through field investigations conducted by the project team, records from the OMNR, from Darlington Provincial Park staff and through the review of secondary source information.

Red-headed Woodpecker (*Melanerpes erythrocephalus*)

A nesting Red-headed Woodpecker was recorded in 1998 by Darlington Provincial Park staff, between the eastern boundary of the park and Courtice Road, south of Highway 401. This species was also recorded as part of the Courtice Water Pollution Control EIS. This species was not recorded during 2009 field investigations. As a result of the significant decline of the population of this species across Canada (COSEWIC 2007), it is not likely to re-occur within the watershed.

Canada Warbler (*Wilsonia canadensis*)

Canada Warbler was recorded in 2009 during project team field investigations within the moist mixed forest/swamp communities within the Maple Grove Wetland Complex, in the northern portion of the watershed. This species was recorded within its preferred habitat, characterized as moist forest communities with well developed, dense understorey. This species has not previously been recorded during multi-year field investigations in this area (between 2003 and 2008) and this, coupled with the nation-wide population decline, it is unlikely that this species will occur within the watershed every year. While regional trends may vary, overall the species has experienced a significant long-term decline (COSEWIC, 2008). The Provincial SRank for this species is S4 (Apparently Secure).

Butternut (Juglans cinerea)

Butternut was recorded in one location within the watershed during 2009 field investigations. Butternut was identified at the edge a mineral meadow marsh community along the main branch of Tooley Creek, east of Courtice Road, north of Bloor Street. Butternut is widely distributed, found as single trees or small groups in deciduous and mixed forests of southern Ontario, Quebec, and New Brunswick. High rates of infection and mortality by Butternut canker have been observed in parts of Ontario (COSEWIC, 2003).

Snapping Turtle (Chelydra serpentine)

Snapping turtle inhabits a variety of aquatic habitats including ponds, swamps, marshes and streams. According to COSEWIC"s assessment, although this species is widespread and still somewhat abundant, its life history and dependence on long warms summers to complete incubation successfully make it unusually susceptible to anthropogenic threats (COSEWIC, 2008).

Milksnake (Lampropeltis triangulum triangulum)

There are no known records of Milksnake within the Tooley Creek Watershed, however there is potential for this species to occur within the watershed boundaries. The Milksnake inhabits a wide variety of habitats including field, swamp and open woodlots. This snake is more common in heavily forested areas (deciduous, evergreen and mixed) than in areas of low forest cover. However, Milksnakes are also common in rural pastures and hayfields, as well as in and around barns, sheds and houses (COSEWIC 2002). This species is still widespread in Ontario, but anecdotal information indicates that it occurs in small numbers (COSEWIC, 2002).

Table 7.6 Species at Risk in the Tooley Creek Watershed*

	Common Name	Scientific Name	Federal Status	Provincial Status (COSSARO)	Provincial S-Rank (NHIC)
Birds	Red-headed Woodpecker	*Melanerpes erythrocephalus*	Special Concern	Threatened	S4 (Apparently Secure)
	Canada Warbler	*Wilsonia canadensis*	Special Concern	Threatened	S4 (Apparently Secure)
Vegetation	Butternut	*Juglans cinerea*	Endangered	Endangered	S3? (Vulnerable – rank uncertain)

*Note: * Listed as Endangered, Threatened or Special Concern with federally or provincially, or appear on Schedule 1 of the Species at Risk Act*

For discussion of records of Black Tern (*Chlidonias niger*) and Least Bittern (*Ixobrychus exilis*) documented as part of the Courtice Water Pollution Control Plant, refer to **Section 7.4.3.1**.

7.5 Summary of Terrestrial Features and Functions

The Robinson Creek and Tooley Creek watersheds are typical of those in the rural GTA, in that they are currently predominately agricultural, but becoming increasingly urban. The Robinson Creek Watershed in particular, is rapidly becoming more urban especially parts west of Prestonvale Road and north of Bloor Street. South of Highway 401 in the Robinson Creek Watershed, land is wholly Darlington Provincial Park and protected from urbanization.

Conversely, in the Tooley Creek Watershed, this land is mainly agricultural. Some industry is situated near Highway 401 in both watersheds and these areas have been identified as areas of future growth. Forest cover is considered low in both watersheds, with Tooley Watershed supporting a slightly higher portion mainly due to the presence of the Maple Grove Wetland Complex. The following summarizes some of the primary terrestrial natural heritage findings:

a) Each watershed includes a portion of a provincially significant wetland (Maple Grove in Tooley and McLaughlin Bay in Robinson). One locally significant wetland also occurs in the Tooley Creek Watershed (Tooley Creek Coastal Marsh);

b) There is one Environmentally Sensitive Area in each watershed, found along each of the main branches of the creeks;

c) Darlington Provincial Park is situated along the lakeshore, mainly within Robinson Creek Watershed. It provides very important habitat for migrant landbirds;

d) Much of the natural vegetation communities within both watersheds are early successional communities;

e) Forested communities are uncommon. The most common forest community types are young Green Ash – hardwood associations, with Willow and Manitoba Maple common in riparian situations;

f) Upland forests are very infrequent. Some small associates of mature Sugar Maple with mature White Ash, Red Oak and/or Eastern Hemlock are present;

g) The northeastern portion of Tooley Creek Watershed is the only portion of both watersheds where larger forests and swamps occur;

h) Most forests are young to mid-aged, however there are a few locations where mature trees are present;

i) Groundwater seepage is rare throughout both watersheds, with one organic Eastern Cedar – Black Ash swamp in the Robinson Creek Watershed, and one organic Poplar – Eastern Cedar swamp in the Tooley Creek Watershed. Additionally seepage indicator flora was observed at three locations in the Robinson Creek Watershed and at two locations in the Tooley Creek Watershed;

j) One plant Species at Risk, Butternut, is present in both watersheds, with the highest concentration along the main branch of Robinson Creek, between Bloor Street and Baseline Road;

k) 25 regionally rare plant species were identified (11 in Robinson and 17 in Tooley, with three rare species common to both watersheds);

l) Bird communities are predominately those of young vegetation communities and edges;

m) Very few forest area-sensitive bird species and individuals are present in both watersheds with the exception of three forest blocks near Nash and Solina Roads;

n) One Species at Risk breeding bird was observed in 2009 (Canada Warbler) and another has bred in the past (Red-headed Woodpecker);

o) Two small Bank Swallow colonies are found along the lakeshore, and are the only known bird colonies of this species in either watershed;

p) Amphibian habitat and diversity appears to be relatively low in amount;

q) Other wildlife Species at Risk that have or are presumed to occur in the watersheds are: Snapping Turtle, Blanding"s Turtle and Milksnake;

r) Core areas and forest interior habitat are not present in the Robinson Creek Watershed, but are present in the Tooley Creek Watershed, specifically in the northeastern portion of the watershed, within the Maple Grove Wetland Complex; and

s) Landscape connectivity and opportunities for wildlife movement are poor in both watersheds, due to the low forest cover and high degree of development/agriculture.

7.6 Evaluation of Function

There is a need to protect the terrestrial features and functions identified in the Robinson Creek and Tooley Creek watersheds, particularly in light of the significant development pressure experienced by these areas.

The intent of this section is to describe the process by which the terrestrial resources within these watersheds were classified and assigned a habitat quality rating. It is this classification that serves as the basis for the development of some preliminary general recommendations, included below, with respect to the future management of these watersheds. These preliminary recommendations will be further developed during subsequent stages of the final watershed management plan.

Using a combination of all of the information gathered both in the field and from background sources, areas have been assessed as having:

- High quality terrestrial characteristics or features; and/ or
- Moderate quality terrestrial characteristics or features.

The rating is a qualitative assessment based on consideration of the following factors:

- Habitat for area-sensitive forest birds;
- Amphibian breeding habitat;
- Forest size;
- Species at Risk presence;
- Habitat for migratory birds;
- Breeding bird species richness and diversity;
- Regionally rare species; and
- Forest characteristics.

The high and moderate categories have been mapped on **Figures 7.8** and **7.9**. The rationale for the classification of each area is included on the map.

High Quality Terrestrial Habitat

Areas that are shown as high quality terrestrial habitat should be retained and protected from new development. Environmental setbacks/buffers should be implemented to afford protection to these features from potential impact from proposed or future development. Buffer size may vary depending on the feature type.

Moderate Quality Terrestrial Habitat

Areas that are shown as moderate quality terrestrial habitat should be considered for retention and protection from development. The boundaries of the features in this category and buffer requirements should be determined on a site-specific basis.

Additional Habitat Features and Functions

In addition to the specific areas identified and mapped on **Figures 7.8** and **7.9,** there are others areas that fall within the moderate and high quality classifications. These areas include:

1. Natural areas within about 2 km of Lake Ontario (for migrant landbirds);
2. Natural habitat within a 100 m or more of major creeks (for wildlife movement); and
3. Ponds or other wetlands that provide amphibian breeding habitat once this function can be confirmed.

These areas have not been mapped, as part of this stage of the Watershed Plan. The delineation of these more generalized areas and habitats will be developed following the confirmation of these general recommendations and the determination of specific recommendations that will be prepared during subsequent stages in the development of the final Watershed Plan. A discussion of each of these areas in provided below:

- **Migrant Landbirds**
  During migration, landbirds tend to concentrate within a few kilometres of the Lake Ontario shoreline in the spring after crossing the lake, and in the fall as they approach the lake and need to feed before crossing. Natural habitat along Lake Ontario is especially limited due to the high degree of development. There are some patchy natural areas in the Tooley Creek Watershed north of Highway 401, but little to the south. It is for these reasons that a portion of the Lake Ontario Shoreline is recommended for naturalization. The naturalization of a strip of land at least 250 m wide and ideally 0.5 km or more wide along the Lake Ontario shoreline would provide some of the natural habitat that is currently limited in this area.

- **Natural Habitat along Creeks**
  The retention and protection of natural habitat along the major creeks and minor tributaries is recommended to facilitate wildlife movement (also refer to recommendations in **Section 6.7**).

- **Amphibian Breeding Habitat**
  If development is to occur within or adjacent to any of the areas shown as known or potential amphibian breeding habitat on **Figures 7.4** and **7.7**, then a more intensive amphibian calling survey program should be undertaken. Three visits that are conducted within or adjacent to suitable habitat (e.g., not conducted solely from the roadside), during the appropriate season will provide greater information on the importance of these habitat features to amphibians. Following that, a determination can be made as to whether the feature is retained or not.

Basemapping from Ontario Ministry of Natural Resources
Orthophotography: 2005

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UTM Zone 17N, NAD 83

Legend

- Watershed
- Railway
- Intermittent Stream
- Permanent Stream
- Waterbody Segment
- Wetland Area, Permanent
- Provincially Significant Wetland
- ESA
- Darlington Provincial Park

Robinson Creek and Tooley Creek Watershed Plan

Robinson Creek Watershed Significant Features

October 2009
Project 112956

AECOM

Figure 7.1

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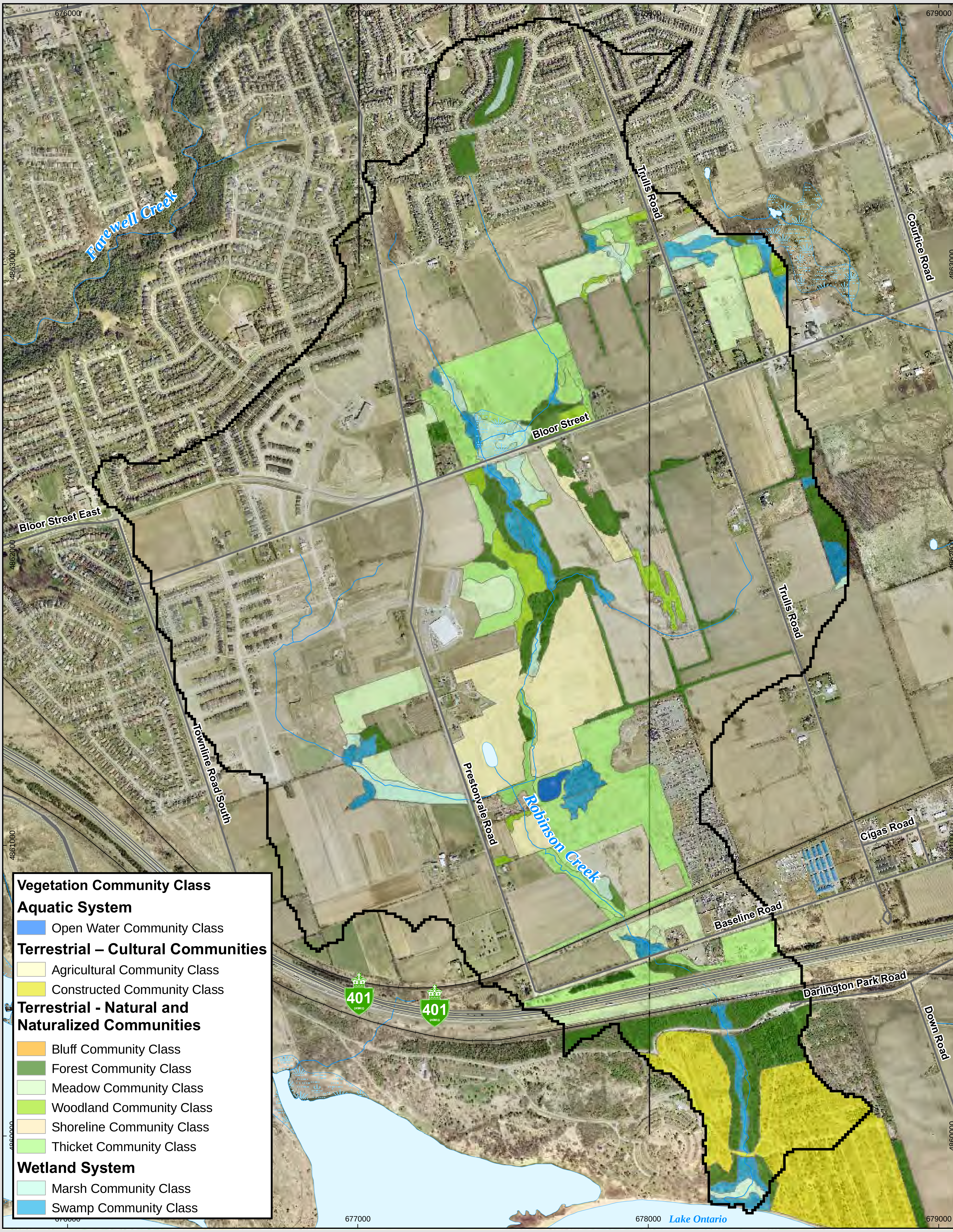

Basemapping from Ontario Ministry of Natural Resources
Orthophotography: 2005

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UTM Zone 17N, NAD 83

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Legend

- Watershed
- Railway
- Intermittent Stream
- Permanent Stream
- Waterbody Segment
- Wetland Area, Permanent

Robinson Creek and Tooley Creek Watershed Plan

Robinson Creek Watershed Vegetation Communities

October 2009
Project 112956

AECOM

Figure 7.2

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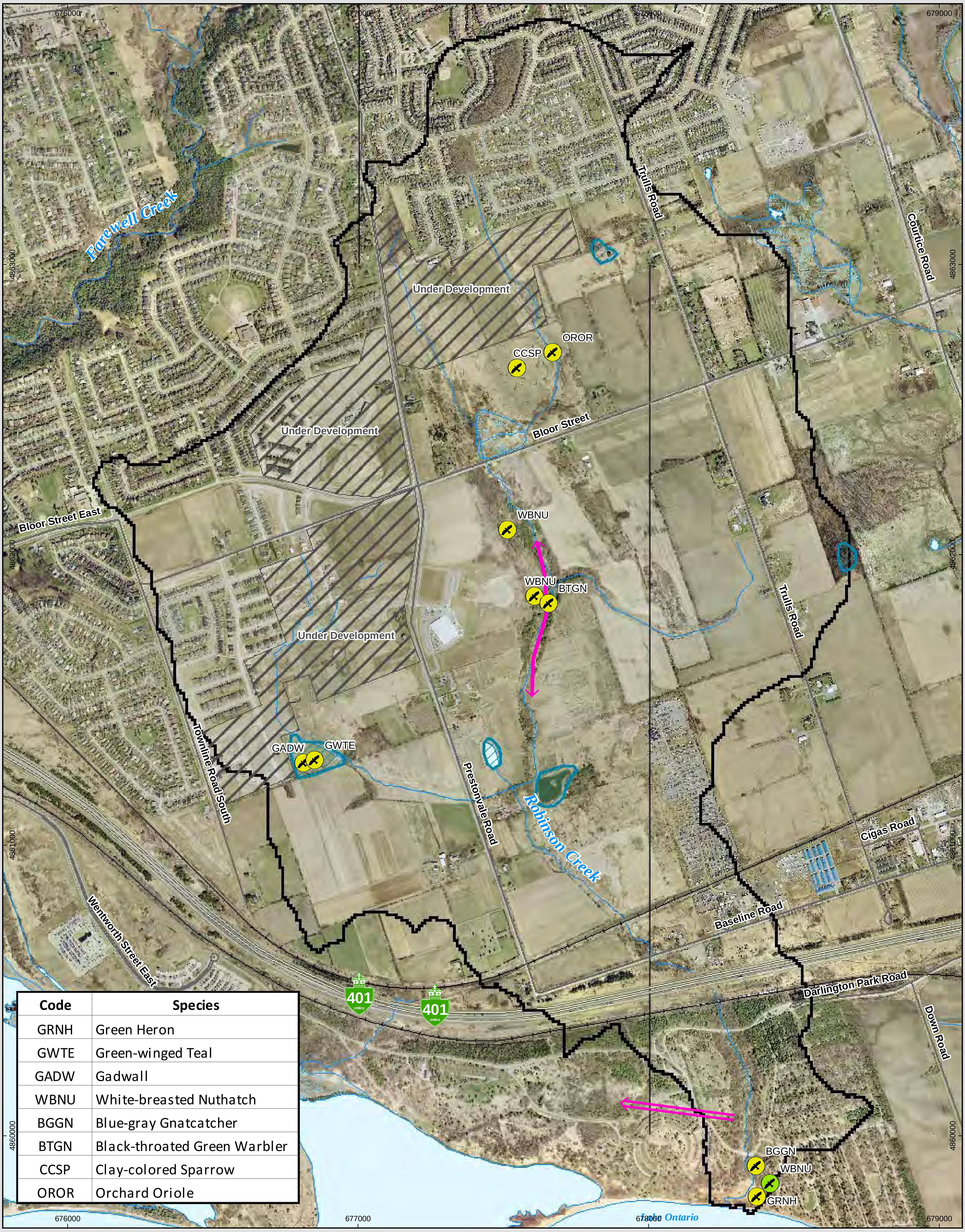

Code	Species
GRNH	Green Heron
GWTE	Green-winged Teal
GADW	Gadwall
WBNU	White-breasted Nuthatch
BGGN	Blue-gray Gnatcatcher
BTGN	Black-throated Green Warbler
CCSP	Clay-colored Sparrow
OROR	Orchard Oriole

Basemapping from Ontario Ministry of Natural Resources
Orthophotography: 2005

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UTM Zone 17N, NAD 83

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Legend

- Bank Swallow Colony
- Forest Area-sensitive Species
- Regionally Scarce, Rare or Very Rare Species
- Landscape Corridor
- Local Corridor
- Under Development
- Potential Amphibian Breeding Habitat
- Interior Forest
- Core Areas
- Watershed
- Railway
- Intermittent Stream
- Permanent Stream
- Waterbody Segment
- Wetland Area, Permanent

Robinson Creek and Tooley Creek Watershed Plan

Robinson Creek Watershed Wildlife Features

October 2009
Project 112956

AECOM

Figure 7.4

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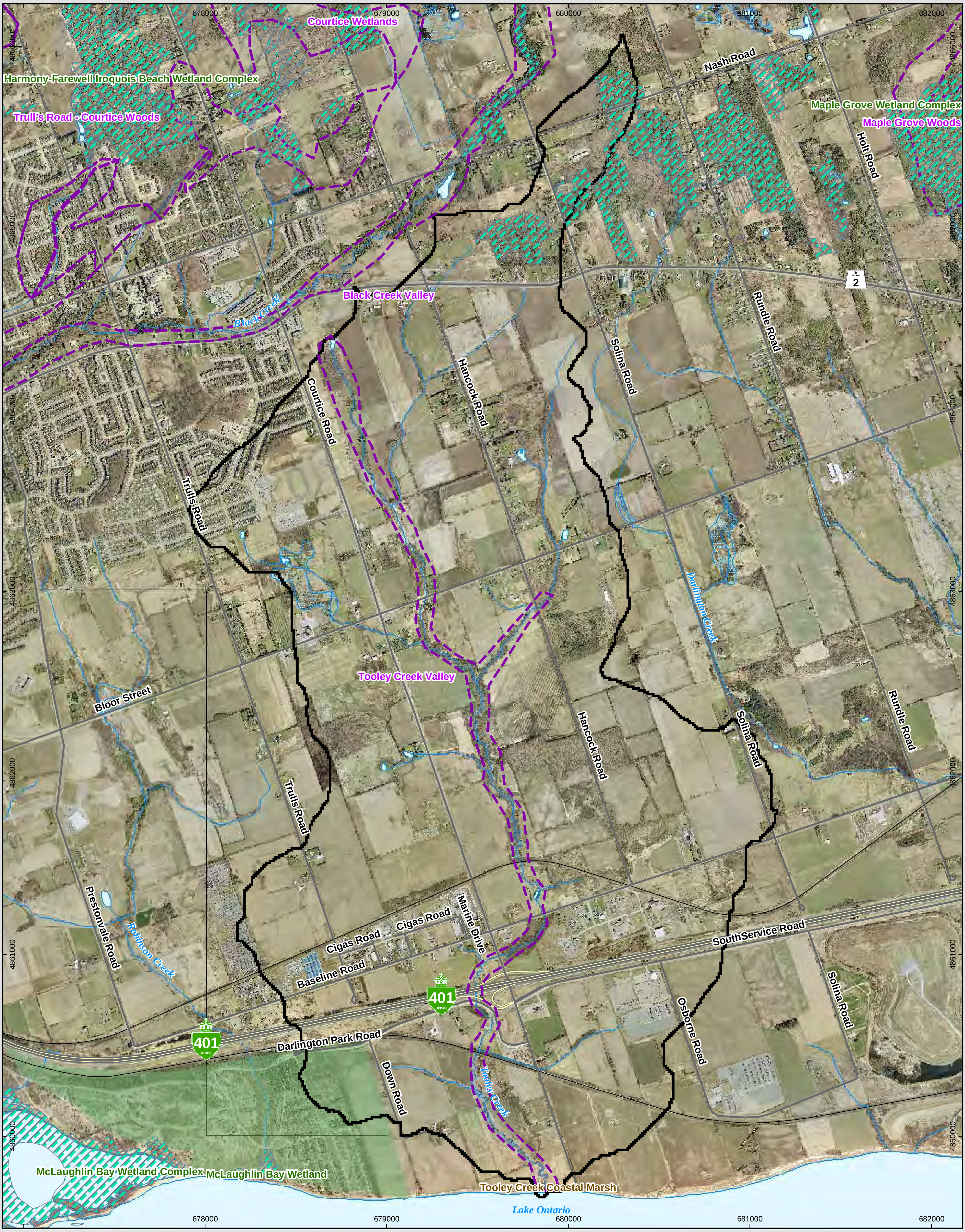

Basemapping from Ontario Ministry of Natural Resources
Orthophotography: 2005

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UTM Zone 17N, NAD 83

Legend

- Watershed
- Railway
- Intermittent Stream
- Permanent Stream
- Waterbody Segment
- Wetland Area, Permanent
- Provincially Significant Wetland
- Locally Significant Wetland
- ESA
- Darlington Provincial Park

Robinson Creek and Tooley Creek Watershed Plan

Tooley Creek Watershed Significant Features

October 2009
Project 112956

AECOM

Figure 7.5

Map Document: (N:\projects\0-aecom\112956\2009\Final\GISSpatial\MXDs\ReportMXDs\112956TooleySignificantFeatures.mxd)
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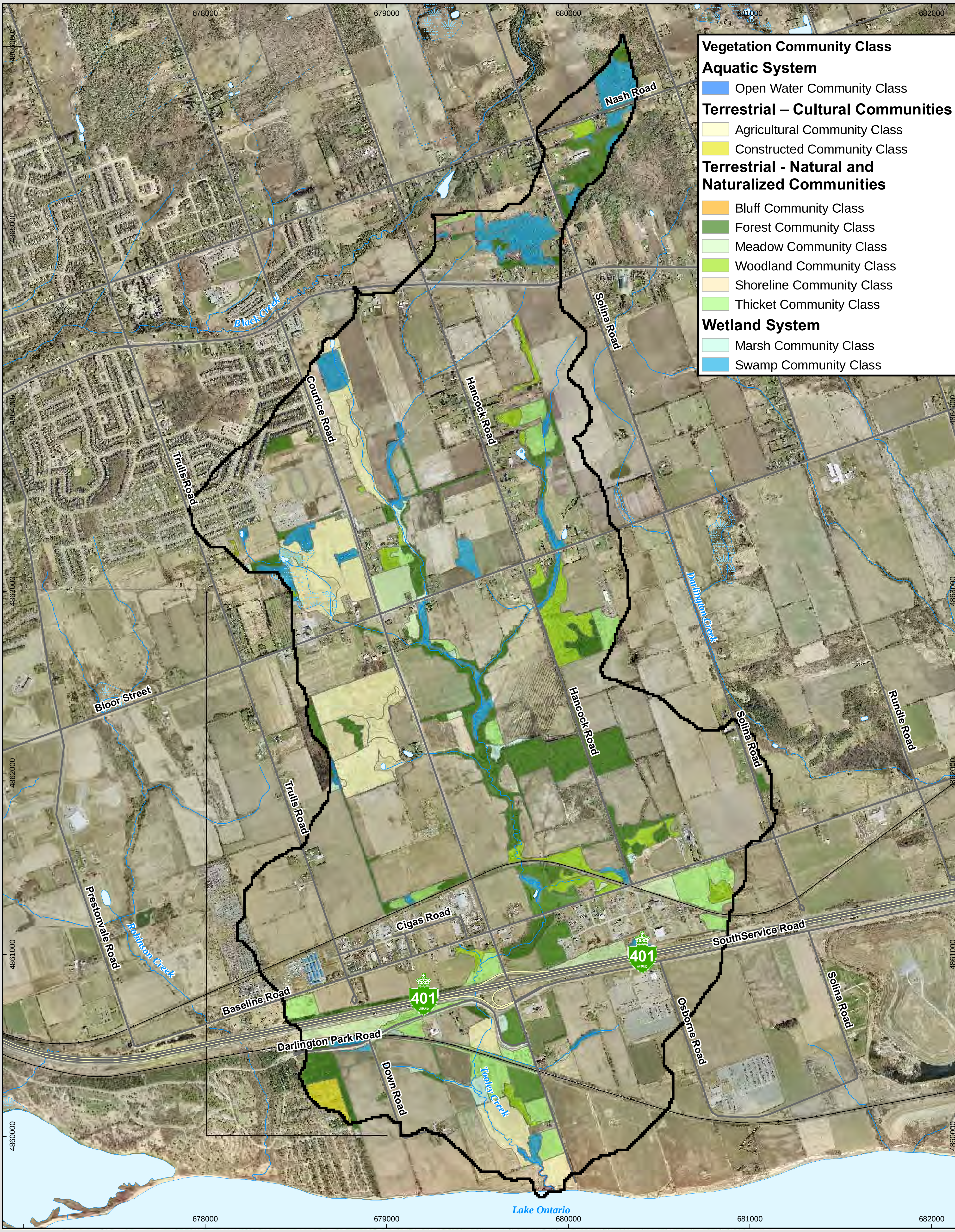

Basemapping from Ontario Ministry of Natural Resources
Orthophotography: 2005

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Legend

- Watershed
- Railway
- Intermittent Stream
- Permanent Stream
- Waterbody Segment
- Wetland Area, Permanent

Robinson Creek and Tooley Creek Watershed Plan

Tooley Creek Vegetation Communities

October 2009
Project 112956

AECOM

Figure 7.6

Map Document: (N:\projects\0-aecom\112956\2009\Final\GISSpatial\MXDs\ReportMXDs\112956TooleyVegetation.mxd)
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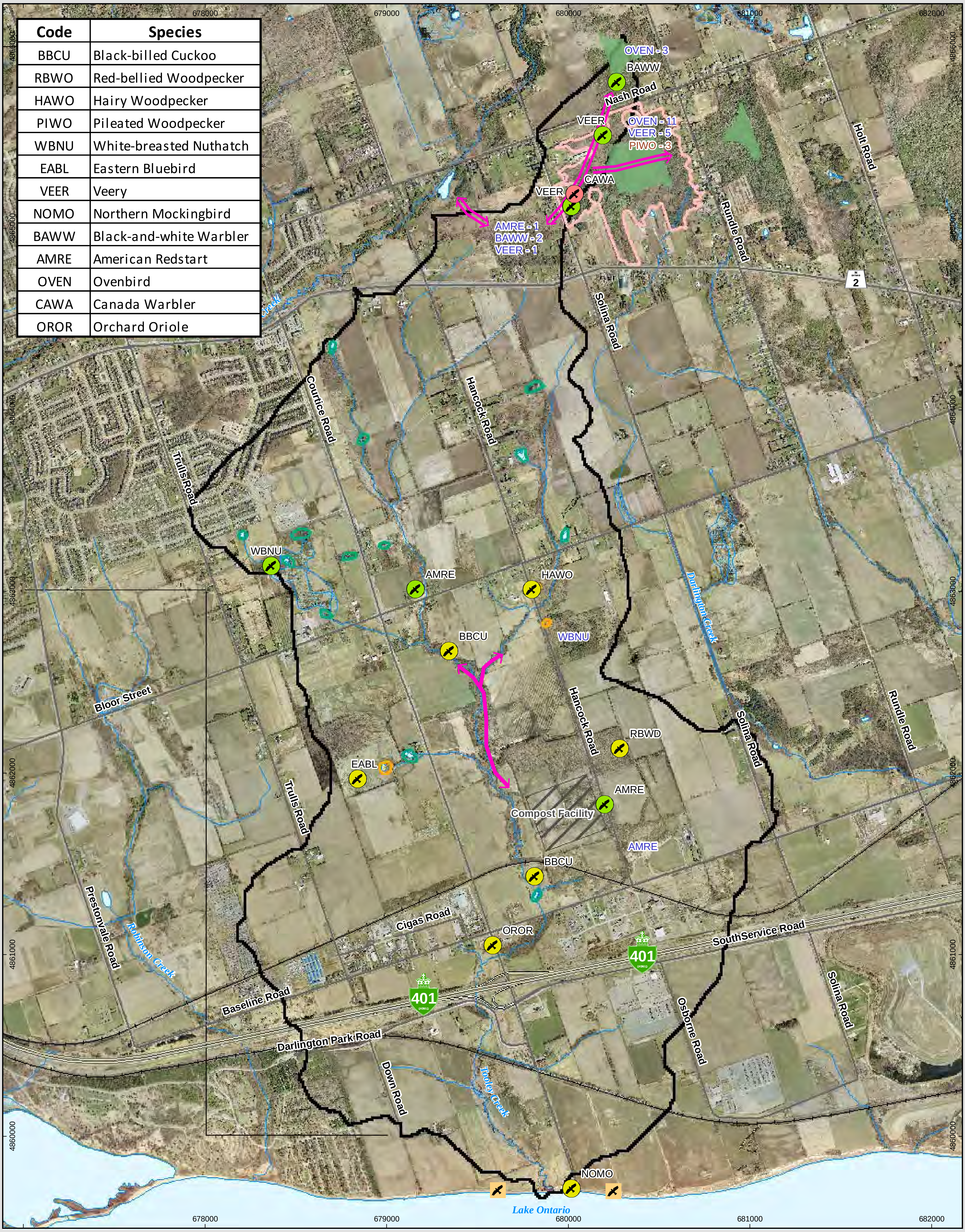

Basemapping from Ontario Ministry of Natural Resources
Orthophotography: 2005

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UTM Zone 17N, NAD 83

Legend

- Bank Swallow Colony
- Forest Area-sensitive Species AMRE
- Species at Risk
- Regionally Scarce, Rare or Very Rare Species PIWO
- Landscape Corridor
- Local Corridor
- Compost Facility
- Potential Amphibian Breeding Habitat
- Known Amphibian Breeding Habitat
- Interior Forest
- Core Areas
- Watershed
- Railway
- Intermittent Stream
- Permanent Stream
- Waterbody Segment
- Wetland Area, Permanent

Robinson Creek and Tooley Creek Watershed Plan

Tooley Creek Watershed Wildlife Features

October 2009
Project 112956

AECOM

Figure 7.7

Map Document: (N:\projects\0-aecom\112956\2009\Final\GISSpatial\MXDs\ReportMXDs\112956TooleyWildlifeFeature.mxd)
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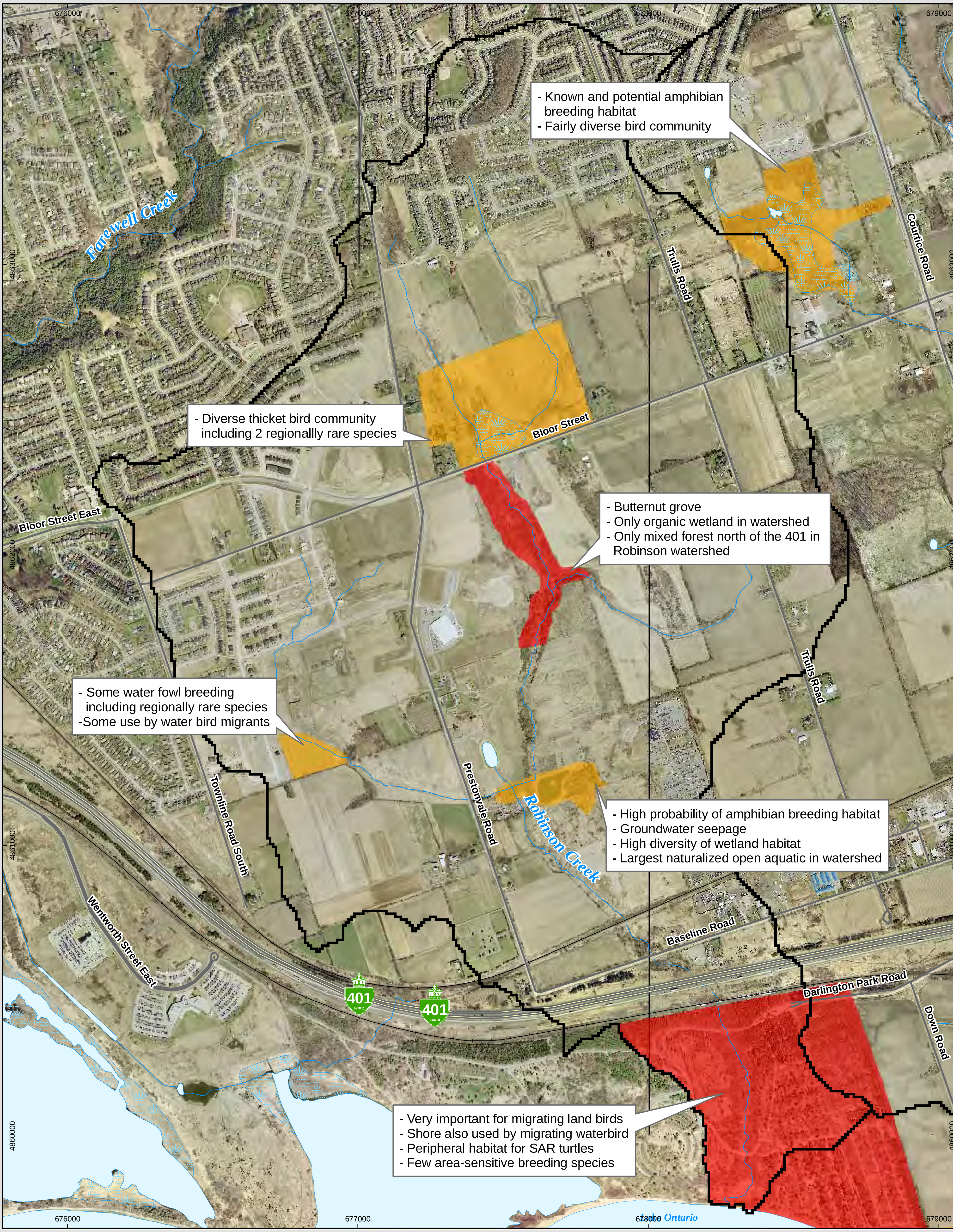

Basemapping from Ontario Ministry of Natural Resources
Orthophotography: 2005

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UTM Zone 17N, NAD 83

Legend

- Highest Quality Terrestrial Habitat (Reasons Listed)
- Moderate Quality Terrestrial Habitat (Reasons Listed)
- Watershed
- Railway
- Intermittent Stream
- Permanent Stream
- Waterbody Segment
- Wetland Area, Permanent

Note: Other areas provide habitat for wildlife, especially: 1) natural areas within about 2 km of Lake Ontario (for migrant land birds), 2) natural habitat within 100 m or more of major creeks (for wildlife movement), 3) ponds and other potential habitat for breeding amphibians, if this is confirmed, and 4) given low forest cover throughout either watershed, consideration should be given to all moderate sized treed areas.

Robinson Creek and Tooley Creek Watershed Plan

Robinson Creek Watershed Terrestrial Habitat Quality

October 2009
Project 112956

AECOM

Figure 7.8

Map Document: (N:\projects\0-aecom\112956\2009\Final\GISSpatial\MXDs\ReportMXDs\112956RobinsonHabitatQuality.mxd)
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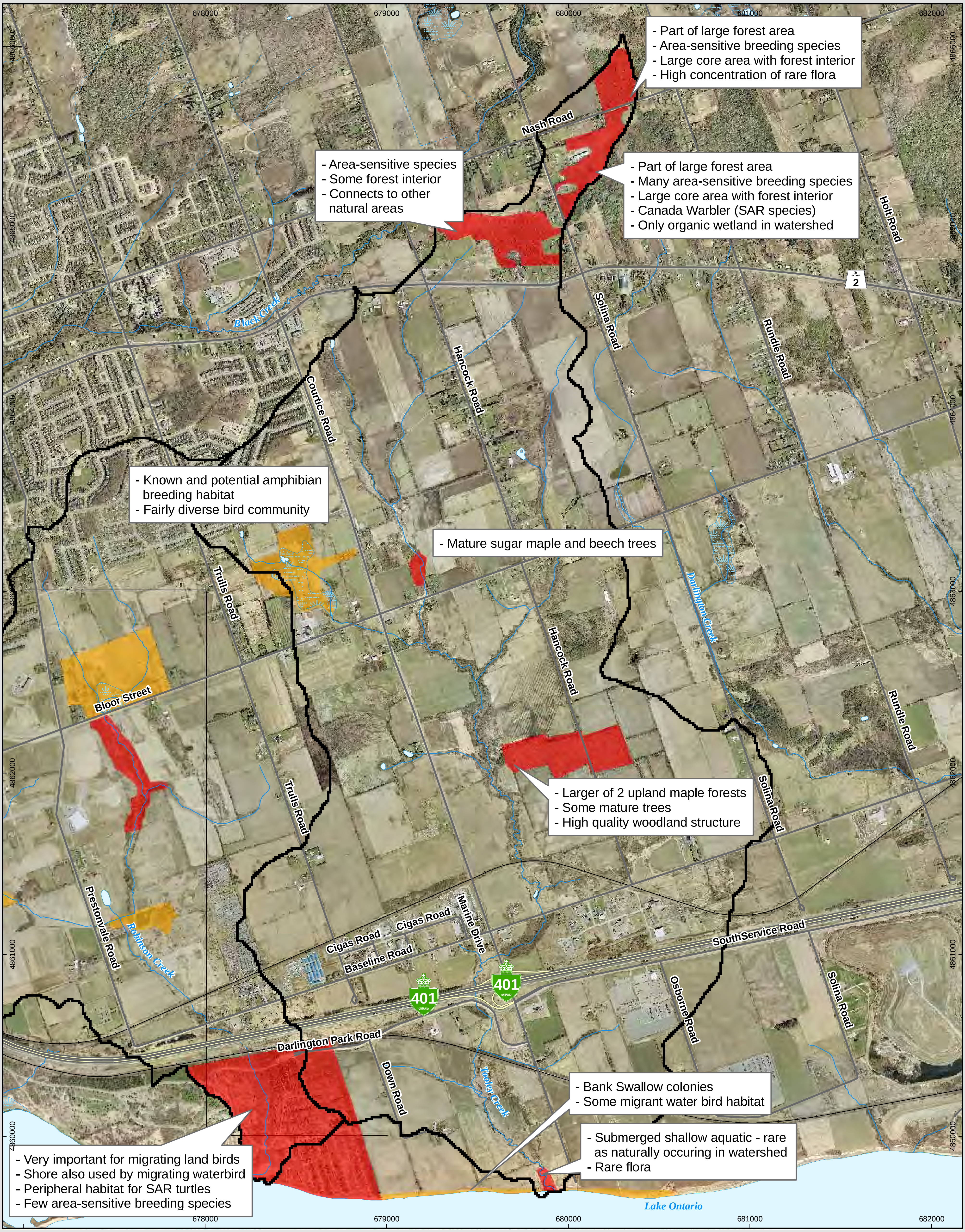

Basemapping from Ontario Ministry of Natural Resources
Orthophotography: 2005

Legend

Highest Quality Terrestrial Habitat (Reasons Listed)	Railway
Moderate Quality Terrestrial Habitat (Reasons Listed)	Intermittent Stream
Watershed	Permanent Stream
	Waterbody Segment
	Wetland Area, Permanent

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UTM Zone 17N, NAD 83

Note: Other areas provide habitat for wildlife, especially: 1) natural areas within about 2 km of Lake Ontario (for migrant land birds), 2) natural habitat within 100 m or more of major creeks (for wildlife movement), 3) ponds and other potential habitat for breeding amphibians, if this is confirmed, and 4) given low forest cover throughout either watershed, consideration should be given to all moderate sized treed areas.

Robinson Creek and Tooley Creek Watershed Plan

Tooley Creek Watershed Terrestrial Habitat Quality

October 2009
Project 112956

AECOM

Figure 7.9

Map Document: (N:\projects\0-aecom\112956\2009\Final\GISSpatial\MXDs\ReportMXDs\112956TooleyHabitatQuality.mxd)
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8. Future Considerations (Next Steps)

The purpose of this Existing Conditions Report is to characterize the Robinson and Tooley Creek watersheds, and as such, provide the basis for the development of a management plan to effectively protect, rehabilitate and enhance the natural features in the context of the needs of the community. Further analysis of the interconnections of the Iroquois Plain with natural heritage features and functions will be conducted in subsequent phases. In addition, landscape connectivity analysis, while conducted as part of this report within the boundaries of the Robinson and Tooley Creek watersheds, will be assessed within a regional context in later phases of the study.

Subsequent phases in the development of the final Watershed Management Plan include the development, analysis and evaluation of alternative future land or resource use scenarios, management approaches and monitoring initiatives. The purpose of this phase is to understand how the watershed will respond to future stresses, determine whether management objectives will be compromised and, if so, identify the effectiveness of various management approaches. Evaluation criteria will be developed through input from the community and will be the basis upon which a preferred management approach is recommended.

The final Watershed Management Plan will then be prepared, and will identify the final set of management goals, objectives and targets, which is to be used to evaluate the acceptability of future land use decisions, future resource use proposals and to track progress in implementation of applicable policies and guidelines.

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Appendix A

Hydrologic and Hydraulic Modelling for Robinson Creek (CLOCA, 2010)

Hydrologic and Hydraulic Modeling for Robinson Creek

Documentation

February 2010

Central Lake Ontario Conservation

TABLE OF CONTENTS

TABLE OF APPENDICES

1.0 INTRODUCTION

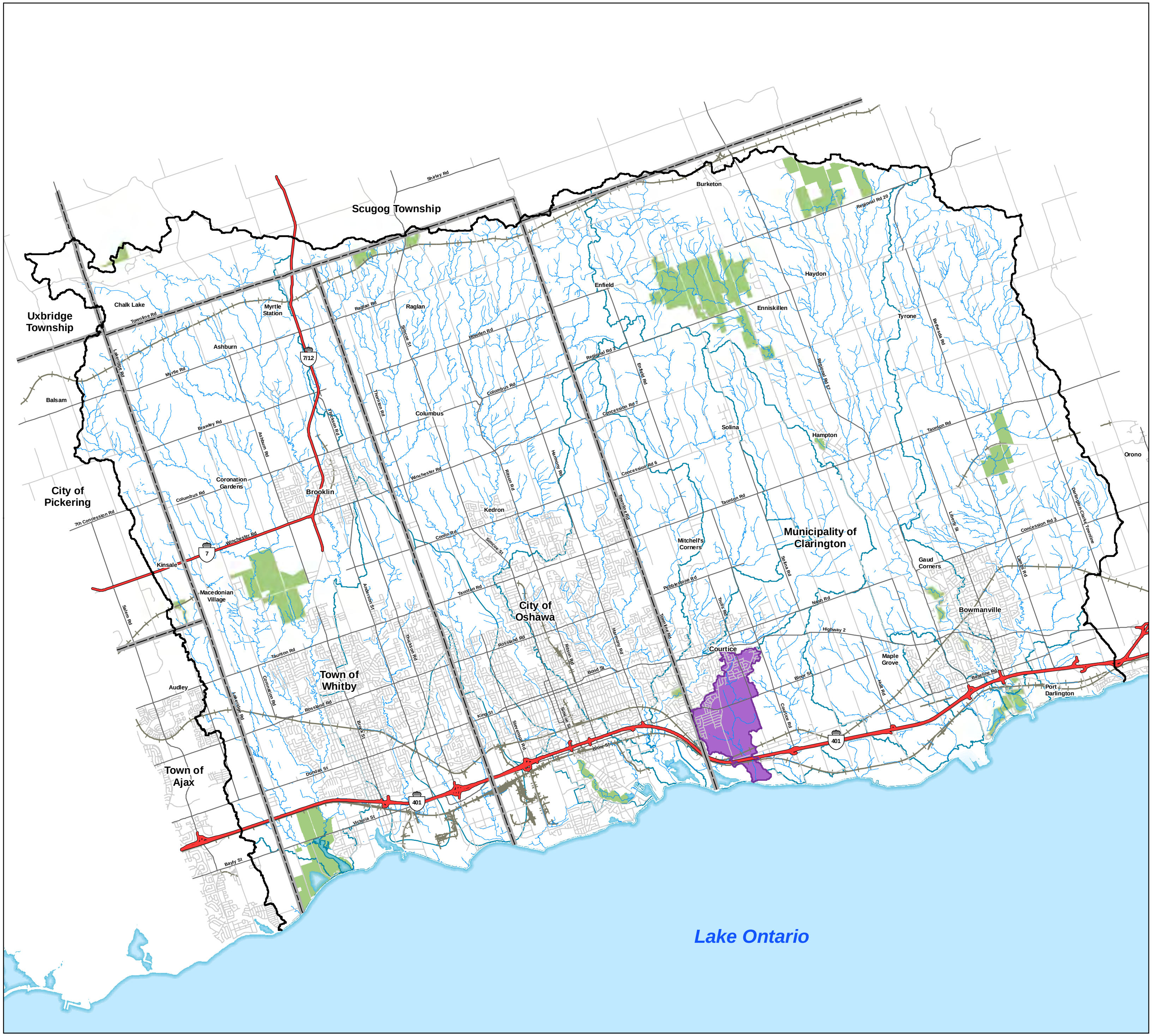
The existing hydrologic and hydraulic models for the Robinson Creek watershed were prepared by M.M. Dillon Consulting Engineers Ltd in 1974 (Whitby Bowmanville Area Floodplain Mapping). This study terminates approximately 600m north of Bloor Street. The portion of Robinson Creek above this study was modeled by G.M. Sernas and Associates in 1991 (Robinson Creek Master Drainage Study). Although this work is still useful, the model versions are now antiquated and no longer available in digital format.

2.0 STUDY AREA

Robinson Creek is located in the Municipality of Clarington and is bounded by Townline Road on the west and Courtice Road on the East. The headwaters of Robinson Creek begin to the south of Nash Road. Figure 1 shows the location of Robinson Creek. The Robinson Creek watershed has a drainage area of approximately 592 hectares, and has approximately 6.9 kilometers of creek with a drainage area over 125 hectares.

The Central Lake Ontario Conservation Authority

Figure 1 - Location Plan



Legend

- Robinson Creek Watershed

Transportation Network

- Provincial Highway
- Major Road
- Minor Road
- Railway
- CLOCA Watershed
- Municipal Boundary
- Drainage
- Lake
- CLOCA Property

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Source: CLOCA, 2010; DMTI Spatial, 2009; MNR, 2009;
Regional Municipality of Durham, 2009.

Map Compiled by the Central Lake Ontario Conservation Authority:
100 Whiting Ave., Oshawa, Ontario, L1H 3T3

This map is for information purposes only and the Central Lake Ontario Conservation Authority takes no responsibility for, nor guarantees, the accuracy of all the information contained within the map.

Central Lake Ontario Conservation

3.0 METHODOLOGY

3.1 Base Mapping

Base mapping for the project was compiled from First Base Solutions Digital Ortho Mapping and Digital Elevation Modeling Mapping derived from aerial photography. The First Base Solutions Digital Ortho Mapping specifications are:

- 20cm pixel resolution,
- Projected and referenced in NAD83, 6 Degree Universal Transverse Mercator (UTM), Zone 17, Central Meridian 81 Degrees West Longitude
- 1km by 1km GeoTif format

3.2 Hydrology

The hydrology for Robinson Creek was created at the same time the hydraulics were and is not available in either digital or paper format. It was therefore determined that the creation of a new section of hydrology would be advantageous. A hydrology model was created in Visual Otthymo 2. The model was not calibrated, as there are no gauges within the Robinson Creek watershed.

Twenty-two (22) subwatersheds were delineated for Robinson Creek. The subwatersheds were determined based on the DEM provided by First Base Solutions and are shown on Figure 2.

Subwatersheds with 20% or more total imperviousness are modeled as urban all others were modeled as rural.

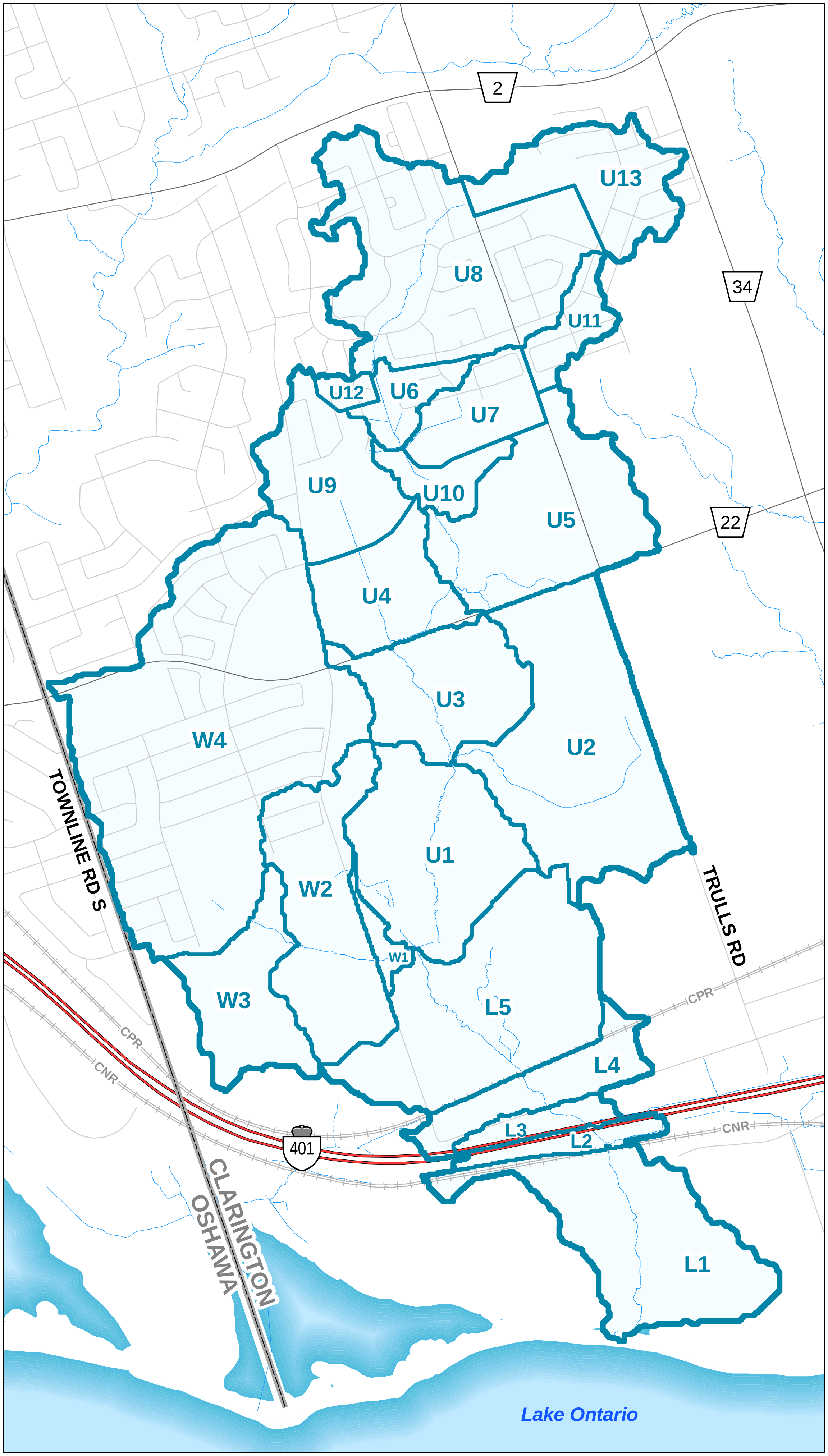
The rural subwatersheds were modeled using the Nashyd command. Within this command, the CN parameter reflects the soil types, topography, vegetation cover and land use of each subwatershed. Initial abstraction, Ia, a weighted value was computed based on land use. Tables for CN, Ia, Soils Group Classification, C, and Imperviousness have been compiled and is included in Appendix A.

The urban subwatersheds were modeled using the Standhyd command. CN and Ia values were used for the pervious areas of the units and the Ximp (directly connected impervious area) and Timp (total impervious area) values are used to define the amount of imperviousness within each urban unit.

Model parameters were determined independently of the model using GIS queries, topographic mapping and published values. The required parameters and the method used for their determination is included in Appendix A.

The Central Lake Ontario Conservation Authority

Figure 2: Subwatersheds



Legend

- Robinson Creek Watershed
- Subwatershed Boundary

Transportation Network

- Provincial Highway
- Major Road
- Minor Road
- Railway
- Municipal Boundary
- Drainage

250 125 0 250 500

Metres

N

Source: CLOCA, 2010; DMTI Spatial, 2009; MNR, 2009; Regional Municipality of Durham, 2009.

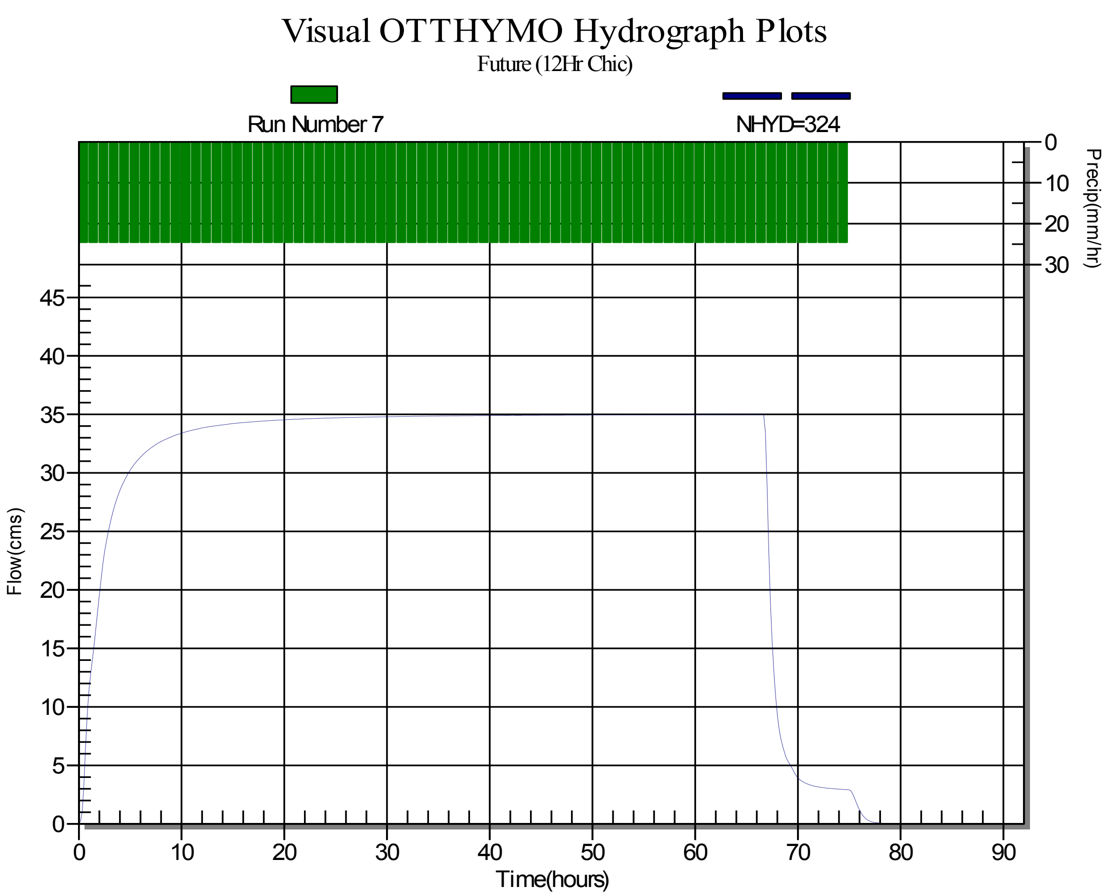
Map Compiled by the Central Lake Ontario Conservation Authority: 100 Whiting Ave., Oshawa, Ontario, L1H 3T3

Central Lake Ontario Conservation

The hydrologic modeling has been completed in two (2) stages. The first stage involved creating an existing land use model and the associated parameters for Visual Otthymo. The existing model uses the land use from 1980, when the only development within the watershed was the Courtice Heights Neighborhood. The second stage involved editing the parameters within the existing land use model, to create a future land use model using land use from the Municipality of Clarington's Official Plans. The two models are then compared based on their input parameters and resulting peak flows.

To ensure that the entire watershed is contributing to the peak flow a long duration storm with a constant intensity of 25mm/hr was tested on the watershed. The resulting hydrograph is shown in the figure below. It can be seen that the entire watershed is contributing during the 22nd hour. After twelve (12) hours approximately 95% of the watershed is contributing.

Figure 3 – Watershed Response to a Constant Intensity Storm



This indicates that a storm distribution with a 12 hour duration would be appropriate for the Robinson Creek watershed. The previous Master Drainage Plan for Robinson Creek used a 6 hour Chicago Storm. To ensure that the selected storm distribution accurately represents the response from Robinson Creek, the model was run, under future conditions for three (3) different storm distributions; 12 hour Chicago, 6 Hour Chicago and 12 hour SCS. The 12 hour Chicago storm produced the greatest peak flows, therefore it was selected as the design storm for Robinson Creek.

The 12 hour Chicago distribution will be used for the 2, 5, 10, 25, 50 and 100 year return period storms for both the existing future and future controlled land use scenarios. The Regional Storm (Hurricane Hazel) was also modeled for both existing and future land use scenarios. CN values were increased to reflect Antecedent Moisture Condition III for the regional storm event.

The results of the hydrologic model were used to examine peak flows within the watershed. Table 1 shows the peak flows for the Regional Storm for the existing and future land use conditions at the hydrologic reference points.

Table 1 – Peak Flows

NHYD	Subwatershed	Peak Flows (m3/s)			
		Existing		Future	
		100 Year	Regional	100 Year (Uncontrolled)	Regional
101	L1	2.41	4.57	2.41	4.57
102	L2	1.75	0.82	1.75	0.82
103	L3	1.09	0.48	1.68	0.79
104	L4	2.51	1.00	6.64	2.09
105	L5	7.88	7.11	20.33	7.21
201	U1	2.70	4.46	14.70	5.11
202	U2	6.31	7.30	22.04	7.73
203	U3	4.55	3.39	5.18	3.43
204	U4	0.64	1.71	6.61	2.70
205	U5	1.77	3.79	10.03	5.21
206	U6	0.39	0.78	2.64	1.05
207	U7	0.62	1.35	4.90	1.86
208	U8	2.33	5.54	13.22	7.72
209	U9	1.09	2.37	8.06	3.28
210	U10	0.28	0.69	2.28	0.99
211	U11	0.41	0.80	2.92	1.09
212	U12	0.13	0.25	0.88	0.33
250	W1	5.58	0.31	1.40	0.43
301	W2	0.15	3.56	12.10	4.78
302	W3	1.81	2.19	8.38	2.93
303	W4	1.13	10.88	27.49	15.14

A review of Table 1 indicates that there are some very significant increases in peak flows between the existing and future land use conditions. In addition, the future 100 year uncontrolled peak flows exceed the future Regional peak flows.

3.3 Hydraulics

3.3.1 Field Survey

To ensure that the model was constructed as an accurate representation of the area a field survey component was conducted. Using aerial photographs all the road crossings were identified. Twelve (12) crossings on the sections of the creek with a drainage area greater than 125 hectares were identified. The crossing locations are shown in Figure 3. Each crossing was then surveyed, photographed and documented. Surveys for each crossing consisted of two (2) surveyed cross sections: one upstream and one downstream, each at a point where the natural valley shape is represented. The crossings length, size and material was measured and recorded. The details for each culvert are included in Appendix B.

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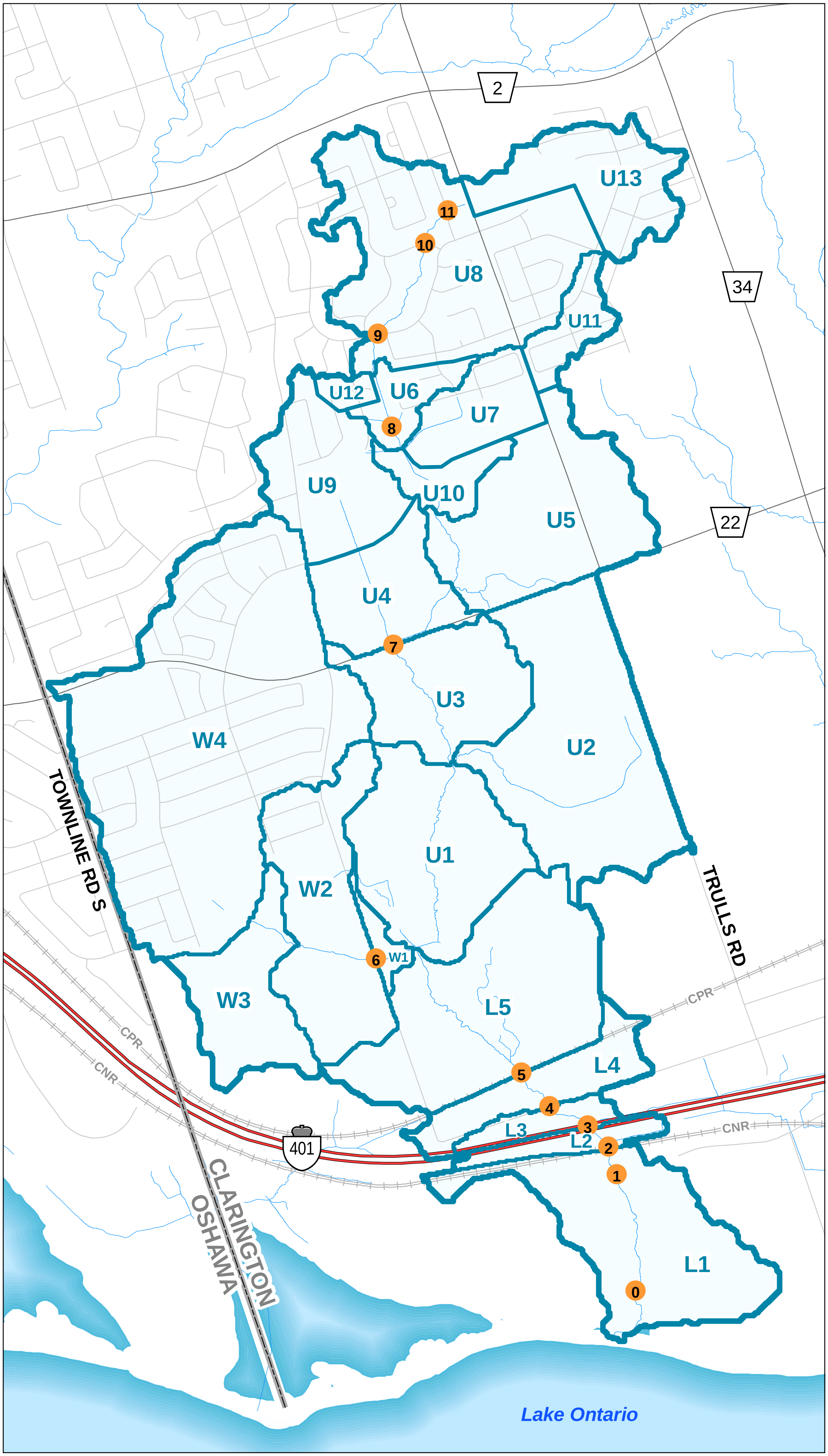
Figure 3: Water Crossing Locations



Legend

Crossing Location

Transportation Network

Provincial Highway

Major Road

Minor Road

Railway

Robinson Creek Watershed

Subwatershed Boundary

Municipal Boundary

Drainage

250 125 0 250 500

Metres

N

Source: CLOCA, 2010; DMTI Spatial, 2009; MNR, 2009; Regional Municipality of Durham, 2009.

Map Compiled by the Central Lake Ontario Conservation Authority: 100 Whiting Ave., Oshawa, Ontario, L1H 3T3

This map is for information purposes only and the Central Lake Ontario Conservation Authority takes no responsibility for, nor guarantees, the accuracy of all the information contained within the map.

Central Lake Ontario Conservation

3.3.2 Model Set Up

A new hydraulic model for the watershed was prepared using the US Army Corp of Engineer's Hec-GeoRAS version 4.0. HEC-GeoRAS uses spatially referenced attributes including stream centre line, bank lines, and, road crossings. Typically only streams with drainage areas greater than 125 hectares are modeled, however interest was expressed by planning staff in the section of the creek extending to Trulls Road. The spatially referenced attributes were already a part of CLOCA's spatial data repository, but required some modifications to meet the requirements of HEC-GeoRAS (refer to the Hec-GeoRAS manual for detailed descriptions). In addition HEC-GeoRAS uses a Triangular Irregular Network to extract the cross section profiles.

A new Hec-RAS project was set up and documented; the GIS data was then imported into the model. Each cross section that was imported was then inspected to ensure that they accurately reflected the topography. The layout of the hydraulic model, including cross section locations is shown in Figure 4.

The field survey information was added to the model as bridge or culvert elements. The cross sections immediately upstream and downstream of the crossings were edited to reflect the surveyed information. In some cases additional cross sections were added.

Flows from the hydrology were assigned to the appropriate reaches of the Hec-RAS model. After all the information was added to the model it was run under a steady state analysis.

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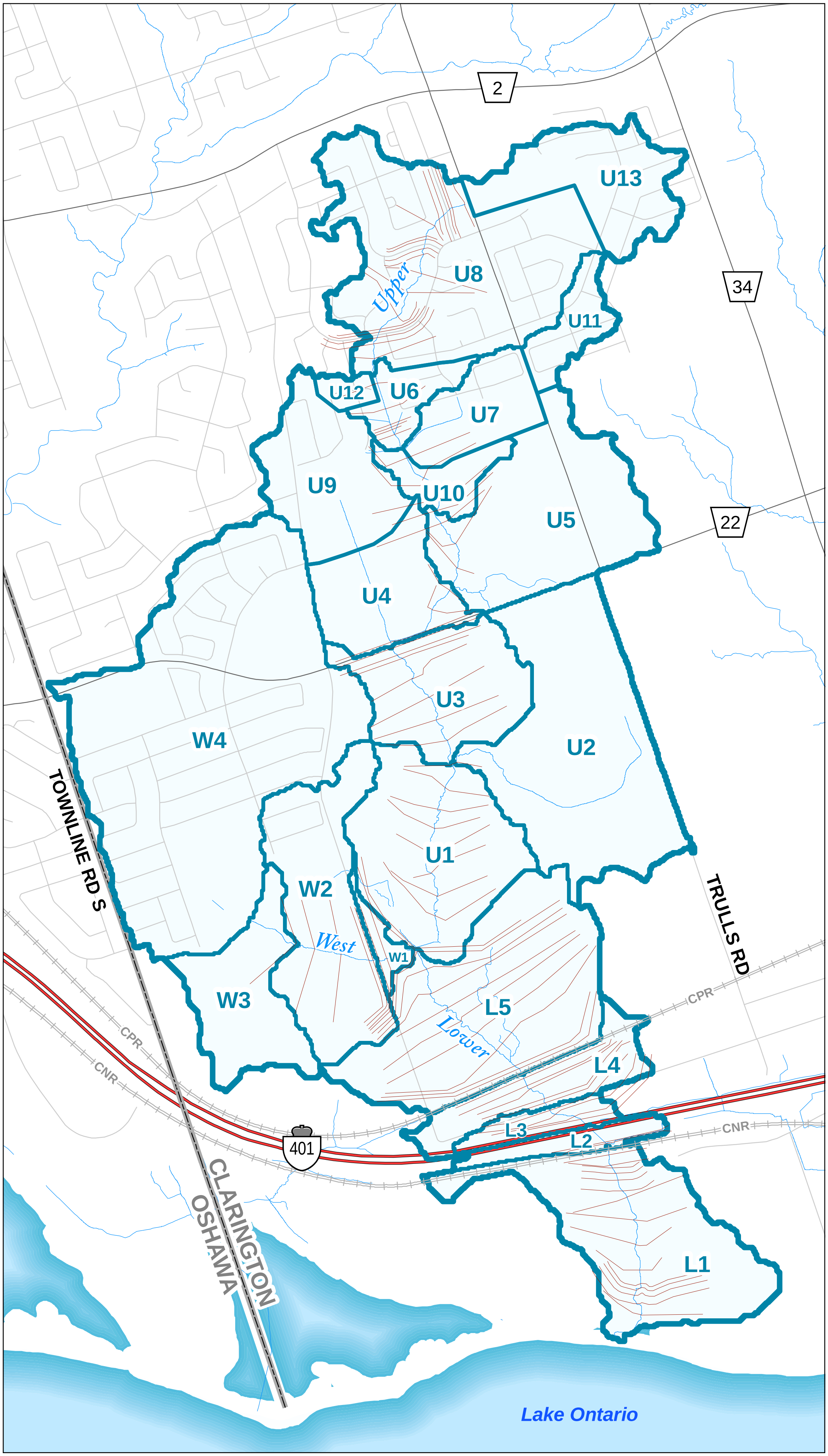
Figure 4: Hydraulic Model Layout



Legend

Cross Section

Transportation Network

Provincial Highway

Major Road

Minor Road

Railway

Robinson Creek Watershed

Subwatershed Boundary

Municipal Boundary

Drainage

250 125 0 250 500

Metres

N

Source: CLOCA, 2010; DMTI Spatial, 2009; MNR, 2009; Regional Municipality of Durham, 2009.

Map Compiled by the Central Lake Ontario Conservation Authority: 100 Whiting Ave., Oshawa, Ontario, L1H 3T3

Central Lake Ontario Conservation

3.3.3 Highway 401 Spills Analysis

The current modeling (2009) identified a large spill over the 401 in an easterly direction where the 1980 modeling did not. The 2009 modeling originally identified and labeled the spill, but did not attempt to analyze the spill. In an effort to define the limits of this spill a spills analysis was performed.

A complementary model was created for the 401 ditch (North side of the highway) that extends from the centre line of Robinson Creek, at section 1050, to a small tributary on Tooley Creek. This model will be referred to as the "Spill" model. The model contains approximately 520m of channel and 21 cross sections. The last cross section is identical to the cross section 1050 from the Robinson mode.

Flow data for each model was compiled in excel. Only the 100 year uncontrolled storm event was analyzed as it is the only event in which a spill occurs. The flow data was added into each HEC-RAS model as multiple profiles. The sum of the flow from each model equaled the total flow within the Robinson Creek (91.47m3/s). Table 2 shows the flow distribution iterations used in HEC-RAS.

Table 2 – Spills Analysis; Flow Distribution

Iteration	Robinson Flow (m^3/s)	Spill Flow (m^3/s)
1	91.47	0.00
2	73.47	18.00
3	72.47	19.00
4	72.37	19.10
5	72.27	19.20
6	72.17	19.30
7	72.07	19.40
8	71.97	19.50
9	71.47	20.00
10	70.47	21.00

Two new flow change locations were added in the Robinson HEC-RAS model. The first flow change location was added at cross section 1050, where the spill begins. The flows shown in the above table, under the Robinson heading, were applied at this location. The second flow change location was added at cross section 876, this is where the floodline returns to being contained within the valley. At this cross section the flows were returned to the original (pre-spill) values. Each model was run with their respective flow profiles.

The resulting water surface elevations at the common cross section, 1050, are presented in Table 3. It is found that when the flow in the Robinson model was 72.37 m^3/s and the flow in the Spill model is 19.10 m^3/s (Profile 4) the water surface elevations at the common cross section are equal, thus the model is considered to be balanced.

Table 3 – Spills Analysis Results

Run	**Robinson Flow (m^3/s)**	**Spill Flow (m^3/s)**	**Robinson WSEL (m)**	**Spill WSEL (m)**
1	91.47	0.00	97.33	84.72
2	73.47	18.00	95.46	95.2
3	72.47	19.00	95.25	95.22
4	72.37	19.10	95.23	95.23
5	72.27	19.20	95.21	95.23
6	72.17	19.30	95.19	95.23
7	72.07	19.40	95.17	95.23
8	71.97	19.50	95.15	95.23
9	71.47	20.00	95.04	95.24
10	70.47	21.00	94.83	95.26

Table 4 summarizes the resulting water surface elevations upstream of the 401 for the 1980 and the 2009 analyses.

Table 4 – Spills Analysis Results Comparason

Study	**Scenario**	**Resulting Water Surface Elevation**
TSH, 1980	No Spills Analysis Required	90.82
CLOCA, 2009	No Spills Analysis	97.34
	With Spills Analysis	95.23

A review of the resulting floodline indicates that the floodplain is significantly lower when the spills analysis was performed. The majority of the spill is contained within the highway 401 ditch, however approximately 300 m east of the Robinson Creek centerline, the westbound lanes of the 401 become inundated. It should be noted that a small spill still occurs where the 401 ditch converges with the Tooley Creek Tributary.

3.3.4 Storage Consideration Upstream of the CPR

The area located north of the CPR is characterized by a wide, deep floodplain that is restricted by the CPR culvert. The 1980 floodplain mapping performed by TSH modeled this area using two separate methods. The first analysis was performed without considering the storage north of the CPR, where the second analysis did. The current (2009) modeling followed suit, and also modeled the area using two separate methods. The process for considering the storage upstream of the CPR involves several steps which are outlined in the following paragraphs.

The results from the 2009 HEC-RAS model were analyzed and the tailwater elevation, just downstream of the CPR culvert was obtained for both the 100 year uncontrolled and the Regional storm (100 Yr = 95.44, Regional Storm = 94.07). The 2005 contours were used to calculate the storage volume from the tailwater elevation to the spill point at the top of the railway (99.0m). A rating curve was created in culvert master using the culvert and tailwater information. The storage volume calculations are combined with the rating curve to create a stage-storage-discharge table that describes the CPR culvert and its storage capacity.

A Route Reservoir was added to the VO2 model, using the stage-storage-discharge table that is discussed above. It is important to note that this scenario of the VO2 model will not be used to determine flows for the HEC-RAS model, it is used solely for the purpose of determining the maximum storage used for each storm event, and the corresponding water surface elevation. The maximum storage used in each of the 100 year and regional storms is 19.7 and 57.1 ham respectively.

The maximum storage volume is used in combination with the stage-storage-discharge table to determine the corresponding starting water surface elevation immediately upstream of the CPR (100 Yr = 96.08, Regional = 96.23). The starting water surface elevation is input into the HEC-RAS model as an internal change in water surface elevation. Table 5 summarizes the different analyses and their results.

Table 5 – Storage Consideration Upstream of CPR; Results

Study	Scenario	Resulting Water Surface Elevation
TSH, 1980	Without storage (Reg)	99.5
	With storage (Reg)	94.1
CLOCA, 2009	Without storage (Reg)	99.55
	With storage (Reg)	96.28
	Without storage (100)	99.58
	With storage (100)	96.19

A review of Table 5 indicates that the difference between the two analyses performed in 1980 is significant, approximately 5.4m. The analyses performed in 2009 still results in a noticeable difference, although it is not as drastic as the 1980's analyses. Both the 1980 and the 2009 analysis that did not consider storage produced similar results, within 0.1m. However, the 1980 and the 2009 analyses that do consider storage result in elevations that are appreciably different. The difference between the 1980 and 2009 analyses that consider storage is likely attributed to the large increase in peak flows, a direct result of an increase in impervious area. This change of land use has also led to the change of the critical storm for the Regulatory Event. The 1980 study used the Regional storm in its analysis, as at the time the flows produced by this event were the largest. The 2009 study uses the 100 year storm in its analysis, as it now produces flows that are greater than the Regional storm.

3.3.5 Model Results

A summary of the flow and water surface elevation at each crossing is shown in Table 6. The regulatory flows listed in table 5 are all a result of the 100 year uncontrolled event.

Table 6 – Road Crossing Details

Description	Reach	River Station	Q Total (m^3/s)	W.S. US. (m)
Darlington Park Rd	Lower	302	91.20	77.56
Darlington Park Rd	Lower	787	92.05	87.70
Railway	Lower	899	72.37	92.60
Highway 401	Lower	994	72.37	95.23
Baseline Rd	Lower	1186	91.04	95.43
Railway	Lower	1370	89.88	96.08
Prestonvale Rd	West	165	44.26	96.18
Bloor St	Upper	1466	35.59	111.89
Sandringham Rd	Upper	2894	7.05	130.60
Stuart Rd	Upper	3316	2.02	132.75
Bushford Rd	Upper	3469	2.02	133.18

4.0 FLOOD PLAIN MAPPING

The Hec-RAS was exported to the GIS environment through a series of complex steps.

The output was converted into a dataset representing the floodlines. The quality control aspect of this process is very important. The generated floodlines were mapped with the old floodlines, identified wetland features, 1m interval contours and the aerial photographs. These datasets were examined in relation to each other to ensure that the generated floodlines made sense. Upon initial examination several areas were identified that deviated from the expected. These areas were adjusted, having additional cross sections added, adding levees or revising the cross sectional information. The revised areas were re-imported into Hec-RAS and the model was run again and exported to GIS. The quality control process began again.

To create the final product the resulting floodlines were mapped together with existing base data and aerial photographs and arranged onto 1:2000 map sheets. The cross sections were labeled with the river stations and the floodline elevations.

WHAT WE DO ON THE LAND IS MIRRORED IN THE WATER

5.0 CONCLUSIONS

At the completion of the Robinson Creek Floodplain Update Study the following can be concluded:

- CLOCA now has up to date floodplain mapping for the Robinson Creek watershed that replaces the 1980 and the 1974 mapping.
- The new floodlines are in most cases in close proximity to the superseded floodline with two exceptions; upstream of the CPR and upstream of Highway 401.
- A spills analysis was conducted on the 401 to define the limits of the floodplain.
- Storage was considered upstream of the CPR to refine the limits of the floodplain.
- The Robinson Creek watershed was predominantly rural, and future urban development will see the watershed undergo significant development, the development will significantly affect the watershed.
- The use of HecGEO-RAS as a hydraulic modeling and mapping tool saved a considerable amount of time during the data collection and mapping phase. It must be noted that a significant amount of quality control is still required.
- The modeling and accompanying maps should be updated to reflect any significant land use changes should they occur.
- The new Robinson Creek regional floodline should be used to update CLOCA's Regulated Area (Ont Reg 42/06)

APPENDIX A
Hydrology

Robinson Creek
Hydrologic Soils Groups
February 13, 2008

Soils	Hydrologic Soil Group
Bondhead Fine Sandy Loam	AB
Bondhead Loam	B
Bondhead Sandy Loam	AB
Bottom Land	C
Bridgeman Sands	A
Brighton Gravelly Sand	A
Brighton Sand	A
Brighton Sandy Loam	AB
Darlington Loam	C
Darlington Sandy Loam	B
Dundonald Sandy Loam	AB
Granby Sandy Loam	B
Guerin Loam	B
Lyons Loam	B
Muck	B
Newcastle Clay Loam	C
Newcastle Loam	BC
Otonabee Loam Steep	B
Ponty Pool Sand	A
Pontypool Sandy Loam	AB
Smithfield Clay Loam	CD
Tecumseth Sandy Loam	AB
Whitby	BC

Source: MTO Drainage Manual (Included in References Section)

Robinson Creek
Subcatchment Parameters
February 13, 2008

Land Use Curve Numbers (CN) for NasHyd

Land Use	Hydrologic Soils Group							
	A	AB	B	BC	C	CD	D	
Crop & Improved	66	70	74	78	82	84	86	
Pasture & Unimproved	58	62	65	71	76	79	81	
Urban Residential	77	81	85	88	90	91	92	
Rural Residential	51	60	68	74	79	82	84	
Industrial & Commercial	85	88	90	92	93	94	94	
Wetland	50	50	50	50	50	50	50	
Woodlot & Forrest	36	48	60	67	73	76	79	
Manicured Greenspace	39	50	61	68	74	77	80	
Landfill and Aggregate	50	50	50	50	50	50	50	*
Transportation & Utility	98	98	98	98	98	98	98	

Land Use Curve Numbers (CN) for StandHyd

(pervious parts only)

Land Use	Hydrologic Soils Group						
	A	AB	B	BC	C	CD	D
Crop & Improved	66	70	74	78	82	84	86
Pasture & Unimproved	58	62	65	71	76	79	81
Urban Residential	39	50	61	68	74	77	80
Rural Residential	39	50	61	68	74	77	80
Industrial & Commercial	58	62	65	71	76	78	80
Wetland	50	50	50	50	50	50	50
Woodlot & Forrest	50	54	58	65	71	74	79
Manicured Greenspace	39	50	61	68	74	77	80
Landfill and Aggregate	50	50	50	50	50	50	50
Transportation & Utility	58	62	65	71	76	79	81

Note: Values for Landfill and Aggregate were chosen to be similar to a wetland as runoff is stored on site
Source: US Soil Conservation Services, US Department of Agriculture, MTO Drainage Manual (Included in Reference Section)

Runoff Coefficients

Land Use	Hydrologic Soils Group							
	A	AB	B	BC	C	CD	D	
Crop & Improved	0.30	0.39	0.48	0.57	0.65	0.71	0.76	
Pasture & Unimproved	0.09	0.15	0.20	0.25	0.29	0.32	0.34	
Urban Residential	0.45	0.45	0.45	0.45	0.45	0.45	0.45	
Rural Residential	0.19	0.20	0.21	0.23	0.25	0.27	0.29	
Industrial & Commercial	0.70	0.70	0.70	0.71	0.71	0.71	0.71	
Lakes and Wetlands	0.05	0.05	0.05	0.05	0.05	0.05	0.05	
Woodlot & Forrest	0.07	0.09	0.11	0.12	0.13	0.14	0.15	
Manicured Greenspace	0.12	0.14	0.16	0.18	0.19	0.22	0.24	
Landfill and Aggregate	0.05	0.05	0.05	0.05	0.05	0.05	0.05	*
Transportation & Utility	0.90	0.90	0.90	0.90	0.90	0.90	0.90	

Note: Values for Landfill and Aggregate were chosen to be similar to a wetland as runoff is stored on site
Source: MTO Drainge Manual, Maryland State Highway Administration (Included in Reference Section)

Initial Abstractions

Soil Type	Initial Abstractions
Crop & Improved	7
Pasture & Unimproved	8
Urban Residential	1.5
Rural Residential	1.5
Industrial & Commercial	1.5
Lakes and Wetlands	0
Woodlot & Forrest	10
Manicured Greenspace	5
Landfill and Aggregate	10
Transportation & Utility	1.5

Percent Impervious

Land Use	Total (%)	Connected (%)
Crop & Improved	0	0
Pasture & Unimproved	0	0
Urban Residential	45	35
Rural Residential	20	10
Industrial & Commercial	85	85
Lakes and Wetlands	0	0
Woodlot & Forrest	0	0
Manicured Greenspace	0	0
Landfill and Aggregate	50	0
Transportation & Utility	50	25

Landuse Classification

Dissolved Lanuse	GIS Classification	
	Cloca Landuse	ELC
Crop & Improved	Agricultural Facility Crop Field Nursery	
Pasture & Unimproved	Pature Transportation Greenspace Treed Field (Orchard)	Cultural Meadow Cultural Savanah Cultural Thicket
Urban Residential	Urban Residential	
Rural Residential	Rural Residential	
Industrial & Commercial	Commercial Industrial Institutional Building	
Lakes and Wetlands	Stormwater Pond Water Feature	Open Fen Meadow Marsh Shallow Marsh Open Aquatic Submerged shallow aquatic Floating leaves shallow aquatic Deciduous Swamp Coniferous Swamp Mixed Swamp Thicket Swamp
Woodlot & Forrest		Cultural Plantation Cultural Woodland Coniferous Forest Deciduous Forest Mixed Forest
Manicured Greenspace	Athletic field Golf facility Institutional greenspace Park Skihill	
Landfill and Aggregate	Aggregate Landfill	
Transportation & Utility	Transportation Corridor Utility Corridor Utility Transfer Station	

Note: Landuse was taken from the September 2002 ELC layer

Robinson Creek
Subcatchment Soil Group Coverage
June 13, 2008

Sub Catchment No.	Area (ha)	Mean Hydrologic Soil Group
L1	40.35	C
L2	5.83	C
L3	5.61	C
L4	14.5	C
L5	50.67	C
U1	35.74	C
U2	54.13	C
U3	24.97	C
U4	18.95	C
U5	36.93	C
U6	7.38	C
U7	13.04	C
U8	57.16	B
U9	23.24	C
U10	7.07	C
U11	7.69	C
U12	2.32	C
U13	21.55	AB
W1	2.96	C
W2	33.61	C
W3	20.48	C
W4	107.78	C

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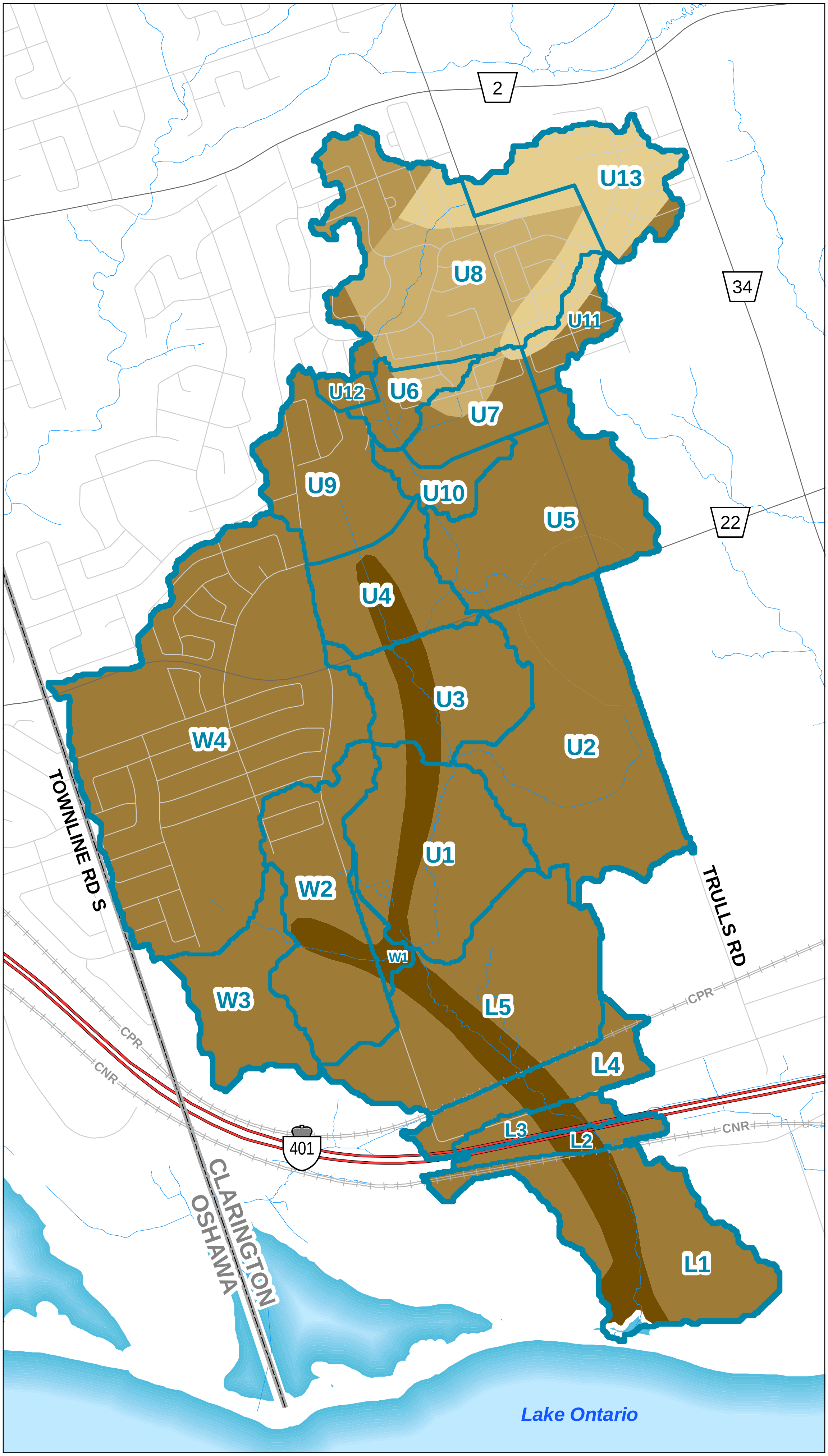
Hydrologic Soils Group



Legend

Hydrologic Soils Group

- A
- AB
- B
- BC
- C
- CD
- D

Transportation Network

- Provincial Highway
- Major Road
- Minor Road
- Railway
- Robinson Creek Watershed
- Subwatershed Boundary
- Municipal Boundary
- Drainage

250 125 0 250 500

Metres

N

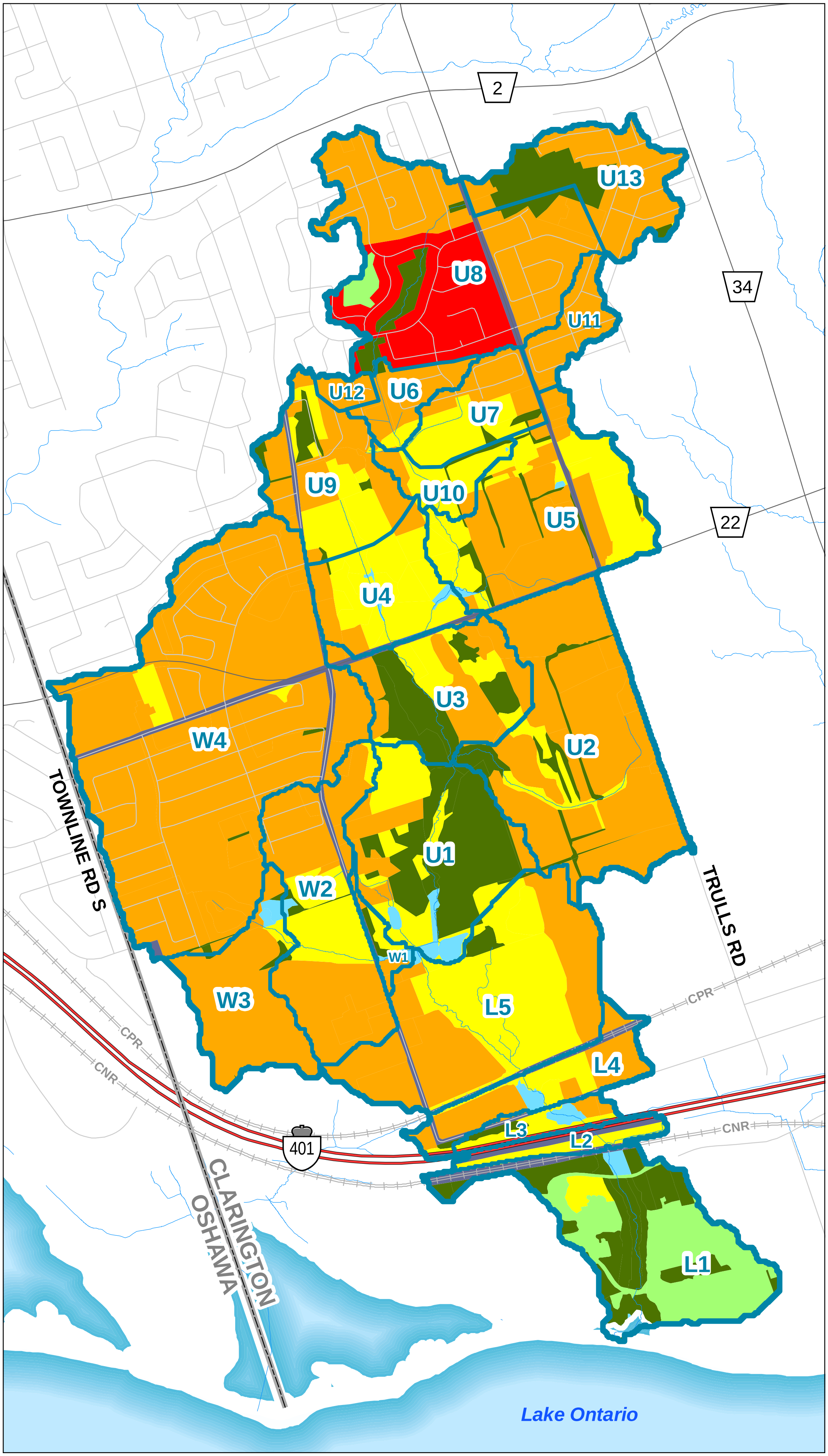
Source: CLOCA, 2010; DMTI Spatial, 2009; MNR, 2009; Regional Municipality of Durham, 2009.

Map Compiled by the Central Lake Ontario Conservation Authority: 100 Whiting Ave., Oshawa, Ontario, L1H 3T3

Central Lake Ontario Conservation

Robinson Creek
Existing Land Use - Based on 1980 Condition (Courtice Heights Only)
June 13, 2008

Sub Area No.	Area (ha)	% Landuse Coverage									
		CI	PU	UR	RR	IC	LW	WF	MG	LA	TU
L1	40.35	0.02%	4.22%	0.00%	0.00%	0.00%	3.35%	37.32%	49.73%	0.00%	5.36%
L2	5.83	0.00%	48.48%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	51.52%
L3	5.61	19.40%	34.41%	0.00%	0.00%	0.00%	12.75%	10.90%	0.00%	0.00%	22.54%
L4	14.50	57.76%	22.04%	0.00%	0.00%	0.00%	4.36%	1.28%	0.00%	0.00%	14.56%
L5	50.67	48.26%	46.22%	0.00%	0.00%	0.00%	0.36%	2.06%	0.00%	0.00%	3.10%
U1	35.74	15.91%	27.17%	0.00%	0.00%	0.00%	5.18%	51.74%	0.00%	0.00%	0.00%
U2	54.13	83.76%	5.56%	0.00%	0.00%	0.00%	0.00%	8.22%	0.00%	0.00%	2.46%
U3	24.97	43.24%	18.87%	0.00%	0.00%	0.00%	0.00%	35.18%	0.00%	0.00%	2.71%
U4	18.95	19.83%	72.49%	0.00%	0.00%	0.00%	2.73%	0.29%	0.00%	0.00%	4.66%
U5	36.93	55.55%	33.84%	0.00%	0.00%	0.00%	0.68%	5.50%	0.00%	0.00%	4.43%
U6	7.38	86.86%	10.99%	0.00%	0.00%	0.00%	0.00%	2.15%	0.00%	0.00%	0.00%
U7	13.04	42.06%	51.15%	0.00%	0.00%	0.00%	0.00%	4.63%	0.00%	0.00%	2.16%
U8	57.16	49.79%	0.00%	37.09%	0.00%	0.00%	0.00%	7.94%	2.68%	0.00%	2.50%
U9	23.24	51.15%	35.95%	0.00%	0.00%	0.00%	0.00%	8.90%	0.00%	0.00%	4.00%
U10	7.07	23.84%	68.18%	0.00%	0.00%	0.00%	0.19%	7.79%	0.00%	0.00%	0.00%
U11	7.69	97.84%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	2.16%
U12	2.32	98.68%	0.00%	0.00%	0.00%	0.00%	0.00%	1.32%	0.00%	0.00%	0.00%
U13	21.55	68.08%	0.14%	0.02%	0.00%	0.00%	0.00%	31.22%	0.00%	0.00%	0.56%
W1	2.96	34.97%	27.48%	0.00%	0.00%	0.00%	9.74%	14.52%	0.00%	0.00%	13.29%
W2	33.61	68.46%	26.05%	0.00%	0.00%	0.00%	0.63%	1.37%	0.00%	0.00%	3.49%
W3	20.48	91.29%	2.95%	0.00%	0.00%	0.00%	3.27%	2.49%	0.00%	0.00%	0.00%
W4	107.78	93.96%	1.78%	0.00%	0.00%	0.00%	0.00%	0.47%	0.00%	0.00%	3.79%



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Existing Landuse

Legend

Existing Land Use Category

- Crop & Improved
- Industrial & Commercial
- Landfill & Aggregate
- Lakes & Wetland
- Manicured Greenspace
- Pasture & Unimproved
- Rural Residential
- Transportation & Utility
- Urban Residential
- Woodlots & Forest

Transportation Network

- Provincial Highway
- Major Road
- Minor Road
- Railway
- Robinson Creek Watershed
- Subwatershed Boundary
- Municipal Boundary
- Drainage

250 125 0 250 500

Metres

N

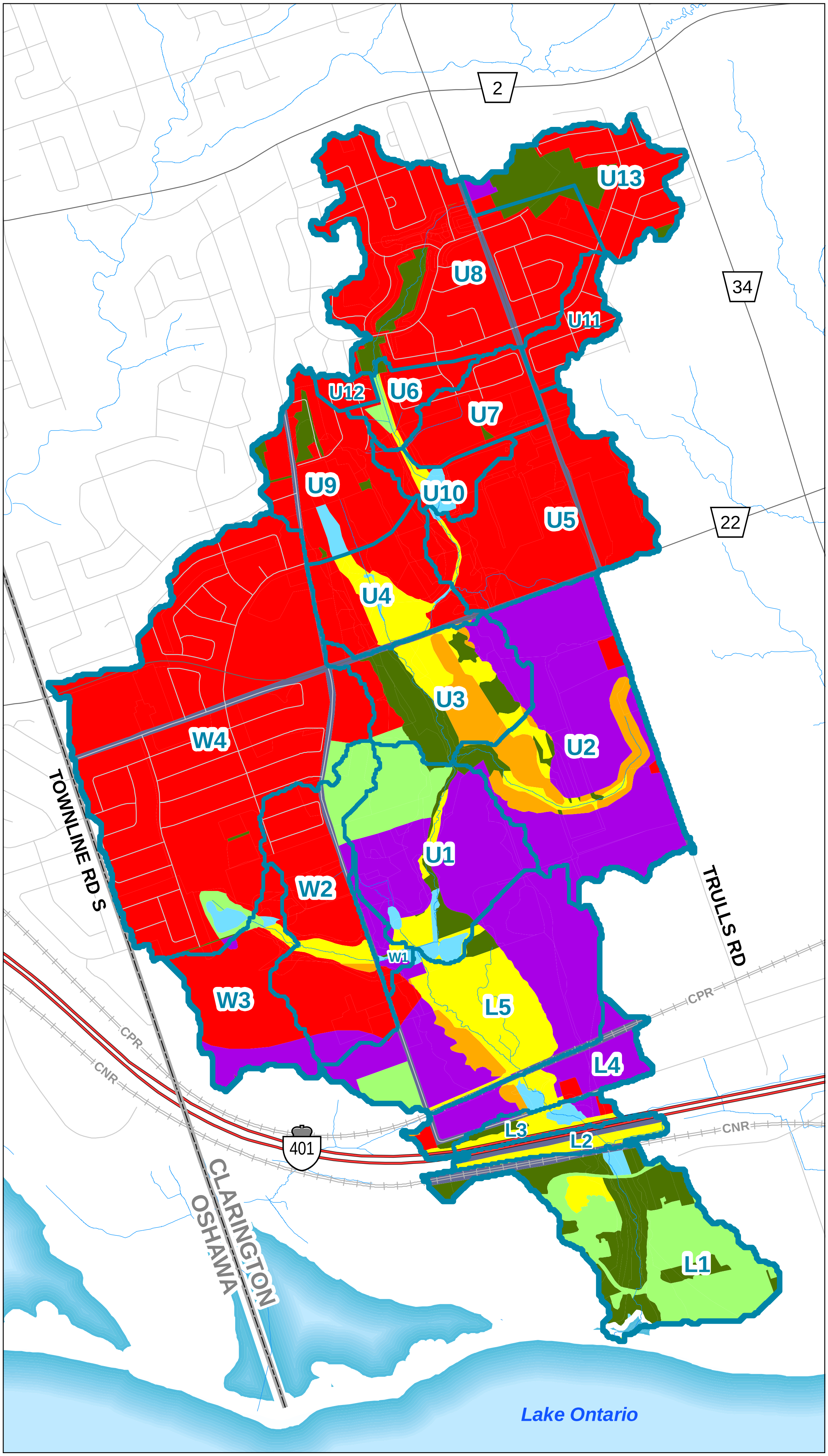
Source: CLOCA, 2010; DMTI Spatial, 2009; MNR, 2009; Regional Municipality of Durham, 2009.

Map Compiled by the Central Lake Ontario Conservation Authority: 100 Whiting Ave., Oshawa, Ontario, L1H 3T3

Central Lake Ontario Conservation

Robinson Creek
Future Land Use
June 13, 2008

Sub Area No.	Area (ha)	% Landuse Coverage									
		CI	PU	UR	RR	IC	LW	WF	MG	LA	TU
L1	40.35	0.02%	4.22%	0.00%	0.00%	0.00%	3.35%	37.32%	49.73%	0.00%	5.36%
L2	5.83	0.00%	48.48%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	51.52%
L3	5.61	0.45%	34.41%	6.11%	0.00%	12.84%	12.75%	10.90%	0.00%	0.00%	22.54%
L4	14.50	4.54%	9.15%	6.95%	0.00%	59.16%	4.36%	1.28%	0.00%	0.00%	14.56%
L5	50.67	4.00%	27.97%	2.54%	0.00%	55.20%	0.36%	1.50%	5.33%	0.00%	3.10%
U1	35.74	0.00%	6.92%	0.00%	0.00%	58.99%	5.07%	6.79%	22.23%	0.00%	0.00%
U2	54.13	14.47%	4.31%	1.69%	0.00%	73.64%	0.00%	3.43%	0.00%	0.00%	2.46%
U3	24.97	20.95%	16.21%	10.64%	0.00%	15.22%	0.00%	31.64%	2.63%	0.00%	2.71%
U4	18.95	0.28%	27.37%	66.22%	0.00%	0.28%	1.19%	0.00%	0.00%	0.00%	4.66%
U5	36.93	0.00%	1.00%	94.25%	0.00%	0.00%	0.32%	0.00%	0.00%	0.00%	4.43%
U6	7.38	0.00%	3.54%	82.67%	0.00%	0.00%	0.00%	2.15%	11.64%	0.00%	0.00%
U7	13.04	0.00%	0.34%	96.26%	0.00%	0.00%	0.00%	1.24%	0.00%	0.00%	2.16%
U8	57.16	0.00%	0.00%	89.72%	0.00%	0.00%	0.00%	7.77%	0.01%	0.00%	2.50%
U9	23.24	0.00%	0.00%	82.76%	0.00%	0.00%	4.50%	8.74%	0.00%	0.00%	4.00%
U10	7.07	0.00%	7.02%	74.24%	0.00%	0.00%	18.74%	0.00%	0.00%	0.00%	0.00%
U11	7.69	0.00%	0.00%	97.84%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	2.16%
U12	2.32	0.00%	0.00%	98.68%	0.00%	0.00%	0.00%	1.32%	0.00%	0.00%	0.00%
U13	21.55	0.00%	0.00%	65.27%	0.00%	2.95%	0.00%	31.22%	0.00%	0.00%	0.56%
W1	2.96	0.00%	6.49%	9.46%	0.00%	59.49%	9.74%	1.53%	0.00%	0.00%	13.29%
W2	33.61	0.77%	5.28%	71.52%	0.00%	7.19%	0.00%	0.00%	11.75%	0.00%	3.49%
W3	20.48	0.00%	2.10%	74.93%	0.00%	20.77%	0.84%	0.13%	1.23%	0.00%	0.00%
W4	107.78	0.00%	0.00%	93.18%	0.00%	0.08%	0.87%	0.21%	1.87%	0.00%	3.79%



The Central Lake Ontario Conservation Authority

Future Landuse

Legend

Future Land Use Category

- Crop & Improved
- Industrial & Commercial
- Landfill & Aggregate
- Lakes & Wetland
- Manicured Greenspace
- Pasture & Unimproved
- Rural Residential
- Transportation & Utility
- Urban Residential
- Woodlots & Forest

Transportation Network

- Provincial Highway
- Major Road
- Minor Road
- Railway
- Robinson Creek Watershed
- Subwatershed Boundary
- Municipal Boundary
- Drainage

250 125 0 250 500

Metres

N

Source: CLOCA, 2010; DMTI Spatial, 2009; MNR, 2009;
Regional Municipality of Durham, 2009.

Map Compiled by the Central Lake Ontario Conservation Authority:
100 Whiting Ave., Oshawa, Ontario, L1H 3T3

This map is for information purposes only and the Central Lake Ontario Conservation Authority takes no responsibility for, nor guarantees, the accuracy of all the information contained within the map.

Central Lake Ontario Conservation

Robinson Creek

Existing Parameters - Based on 1980 Condition (Courtice Heights Only)

June 13, 2008

Sub Watershed No.	NHYD	Command	Sub-Watershed Information												
			Area (ha)	HSG	CN AMC II	CN AMC III	C	IA (mm)	Length (m)	Width (m)	Slope (%)	TC (min)	TP (hr)	TIMP (%)	XIMP (%)
L1	101	NasHYD	40.35	C	74	87	0.21	6.64	918	500	2.90	62.19	0.69	3	1
L2	102	StandHYD	5.83	C	76	88	0.60	4.65	105	500	1.30	4.76	0.05	26	13
L3	103	NasHYD	5.61	C	78	89	0.45	5.54	176	500	2.60	6.97	0.08	11	6
L4	104	NasHYD	14.50	C	81	91	0.57	6.15	178	500	2.60	6.41	0.07	7	4
L5	105	NasHYD	50.67	C	79	90	0.48	7.33	703	900	3.60	20.95	0.23	2	1
U1	201	NasHYD	35.74	C	74	87	0.25	8.46	850	600	6.70	43.02	0.48	0	0
U2	202	NasHYD	54.13	C	81	91	0.59	7.17	900	600	1.00	34.42	0.38	1	1
U3	203	NasHYD	24.97	C	78	89	0.41	8.10	544	600	6.40	15.51	0.17	1	1
U4	204	NasHYD	18.95	C	77	89	0.38	7.29	900	400	10.00	32.81	1.48	2	1
U5	205	NasHYD	36.93	C	80	90	0.51	7.21	500	900	1.50	18.32	1.09	2	1
U6	206	NasHYD	7.38	C	81	91	0.60	7.17	300	400	2.10	12.07	1.02	0	0
U7	207	NasHYD	13.04	C	79	90	0.45	7.53	400	100	2.00	15.35	1.05	1	1
U8	208	NasHYD	57.16	B	77	89	0.44	5.01	1000	500	2.00	33.11	1.25	18	14
U9	209	NasHYD	23.24	C	80	90	0.48	7.41	600	400	2.60	20.63	1.11	2	1
U10	210	NasHYD	7.07	C	77	89	0.36	7.90	224	200	2.00	28.61	1.20	0	0
U11	211	NasHYD	7.69	C	82	91	0.66	6.88	350	100	1.30	15.44	1.05	1	1
U12	212	NasHYD	2.32	C	82	91	0.64	7.04	200	100	1.00	10.48	1.00	0	0
U13	213	NasHYD	21.55	AB	63	80	0.30	7.91	800	200	2.00	58.76	1.54	0	0
W1	301	NasHYD	2.96	C	78	89	0.45	6.30	149	200	3.10	6.08	0.95	7	3
W2	302	NasHYD	33.61	C	81	91	0.55	7.07	326	900	5.10	9.44	0.99	2	1
W3	303	NasHYD	20.48	C	81	91	0.61	6.88	200	500	3.20	6.68	0.96	0	0
W4	304	NasHYD	107.78	C	82	92	0.65	6.82	900	1500	3.00	25.79	1.17	2	1

Robinson Creek
Future Parameters
June 13, 2008

Sub Watershed No.	NHYD	Command	Sub-Watershed Information												
			Area (ha)	HSG	CN AMC II	CN AMC III	C	IA (mm)	Length (m)	Width (m)	Slope (%)	TC (min)	TP (hr)	TIMP (%)	XIMP (%)
L1	101	NasHYD	40.35	C	74	87	0.21	6.64	918	500	2.90	62.19	0.69	3	1
L2	102	StandHYD	5.83	C	76	88	0.60	4.65	105	500	1.30	4.76	0.05	26	13
L3	103	StandHYD	5.61	C	72	86	0.44	4.50	176	500	2.60	6.97	0.08	25	19
L4	104	StandHYD	14.50	C	75	87	0.64	2.39	178	500	2.60	6.41	0.07	61	56
L5	105	StandHYD	50.67	C	76	88	0.55	3.85	703	900	3.60	20.95	0.23	50	49
U1	201	StandHYD	35.74	C	74	87	0.49	3.23	850	600	6.70	23.16	0.26	50	50
U2	202	StandHYD	54.13	C	77	88	0.66	2.87	900	600	1.00	34.42	0.38	65	64
U3	203	NasHYD	24.97	C	81	91	0.41	6.49	544	600	6.40	15.51	0.17	19	17
U4	204	StandHYD	18.95	C	74	87	0.42	3.28	900	400	10.00	24.12	0.27	32	25
U5	205	StandHYD	36.93	C	74	87	0.47	1.56	500	900	1.50	18.32	0.20	45	34
U6	206	StandHYD	7.38	C	74	87	0.41	2.32	300	400	2.10	12.07	0.13	37	29
U7	207	StandHYD	13.04	C	74	87	0.46	1.63	400	100	2.00	15.35	0.17	44	34
U8	208	StandHYD	57.16	B	61	78	0.43	2.16	1000	500	2	33.11	0.37	42	32
U9	209	StandHYD	23.24	C	73	86	0.42	2.18	600	400	2.60	20.63	0.23	39	30
U10	210	StandHYD	7.07	C	70	84	0.36	1.68	224	200	2.00	28.58	0.32	33	26
U11	211	StandHYD	7.69	C	74	87	0.46	1.50	350	100	1.30	15.44	0.17	45	35
U12	212	StandHYD	2.32	C	74	87	0.45	1.61	200	100	1.00	10.48	0.12	44	35
U13	301	StandHYD	21.55	AB	52	71	0.35	4.15	800	200	2	55.20	0.62	32	25
W1	301	StandHYD	2.96	C	73	86	0.61	1.91	149	200	3.10	6.08	0.07	61	57
W2	302	StandHYD	33.61	C	74	87	0.45	2.30	326	900	5.10	9.44	0.11	40	32
W3	303	StandHYD	20.48	C	74	87	0.49	1.68	200	500	3.20	6.68	0.07	51	44
W4	304	StandHYD	107.78	C	74	87	0.46	1.57	900	1500	3.00	25.79	0.29	44	34

Robinson Creek
Route Channel Parameters
June 13, 2008

RC	Length	Channel S	Floodplain S	Channel n	Floodplain n
L1	918	2	3	0.03	0.05
L2	105	4	1	0.03	0.05
L3	176	-1	3	0.03	0.05
L4	178	2	3	0.03	0.05
L5	703	0	4	0.03	0.05
U1	850	1	7	0.03	0.05
U2	n/a				
U3	544	1	6	0.03	0.05
U4	360	2	10	0.03	0.05
U5	500	4	2	0.03	0.05
U6	300	2	2	0.03	0.05
U7	n/a				
U8	1000	1	2	0.03	0.05
U9	n/a				
U10	224	1	2	0.03	0.05
U11	n/a				
U12	n/a				
U13	n/a				
W1	149	1	3	0.03	0.05
W2	326	1	5	0.03	0.05
W3	200	2	3	0.03	0.05
W4	n/a				

L1	
Sta	Elev
94.77	84
108.83	83
119.34	80
121.93	79
141.49	78
145.24	77
147.87	78
162.81	79
167.5	80
181.04	83
182.65	84

L2	
Sta	Elev
29.69	92
44.83	91
50.05	89
56.68	87
58.65	86
62.83	87
77.49	88
117.33	89
142.02	90
153.99	91

L3	
Sta	Elev
14.38	91
18.58	90
26.98	88
31.41	87
49.24	86
52.04	85
58.82	86
64.4	87
66.56	88
74.52	90
80.03	91

L4	
Sta	Elev
2.31	93
20.2	92
29.15	91
34.53	90
56.99	89
66.88	88
73.89	89
82.83	90
94.16	91
97.04	92
100.23	93

L5	
Sta	Elev
33.59	92
78.31	91
95.7	91
98.18	90
110.11	90.5
118.43	91
123.52	92
132.53	93

U1	
Sta	Elev
0	106
32.22	105
38.65	104
52.88	101
61.43	100
65.26	99
71.09	99
84.2	100
91.97	102
103.36	106

U3	
Sta	Elev
31.56	121
69.23	114
132.77	109
201.56	106
228.41	105.5
269.05	106
282.86	108
323.42	112
348.44	117
380.79	120
423.36	121

U5	
Sta	Elev
25.29	127
37.67	126
55.91	124
60.49	125
69.49	126
80.06	127

W2	
Sta	Elev
20.14	97
75.4	96
104.37	95
106.22	94.5
110.99	95
140.86	96
167.05	97

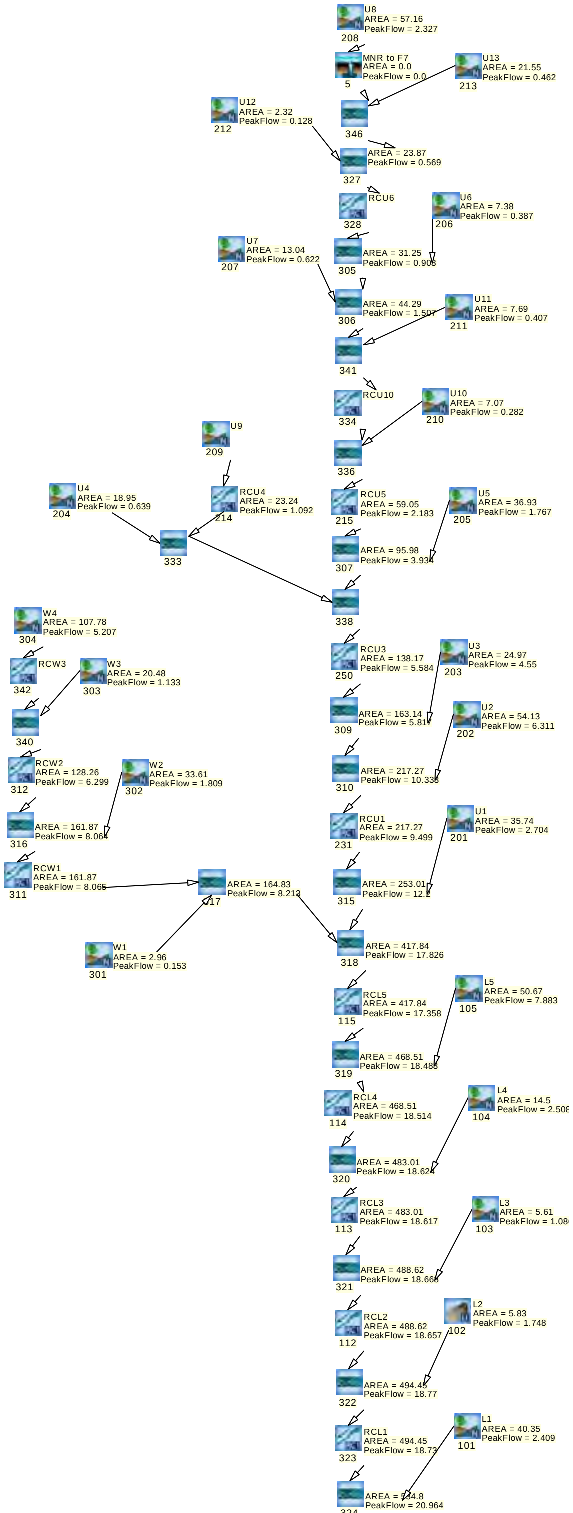
U4	
Sta	Elev
29.14	123
34.71	121
42.28	119
54.45	116
63.51	114
70.59	116
72.63	117
82.31	121
91.49	125

U6	
Sta	Elev
19.75	132
43.6	131
57.54	130
60.16	128
71.54	127.5
78.77	128
82.62	129
107.45	130

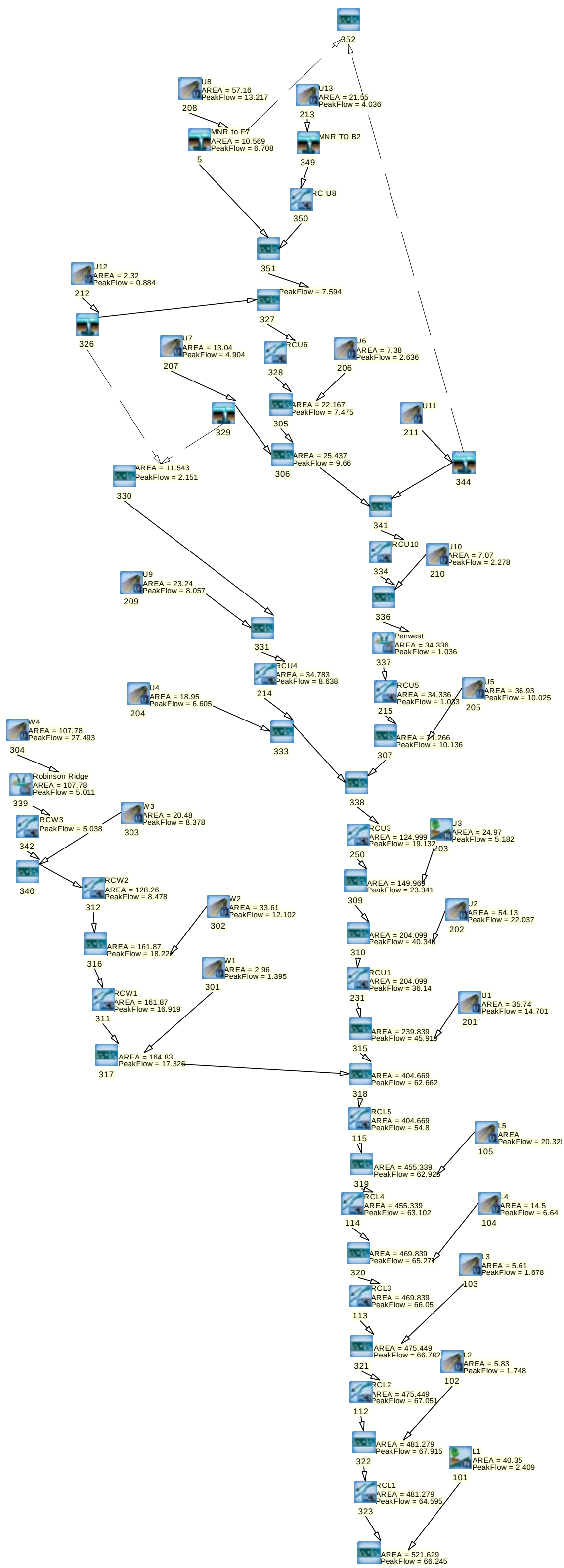
W1	
Sta	Elev
18.47	95
84.19	94.5
100.34	94
108.83	94
113.56	93.5
121.74	95

U8	
Sta	Elev
82	131.6
91.1	131.4
102.7	131
121.2	130.9
123.9	130.7
124.3	130.6
125.3	130.8
136.3	131
153.3	131.8

Existing Conditions



Future Conditions



Robinson Creek
Chicago Peak Flows
June 18, 2009

NHYD	Sub-watershed	Peak Flow (m3/s)																	
		2 Year			5 Year			10 Year			25 Year			50 Year			100 Year		
		Existing	Future	Change	Existing	Future	Change	Existing	Future	Change	Existing	Future	Change	Existing	Future	Change	Existing	Future	Change
5	mnr to Blk	0.57	4.18	632.86%	0.97	6.51	569.66%	1.27	6.51	412.02%	1.68	6.51	287.56%	2.00	6.51	225.72%	2.33	6.51	179.75%
5	mjr to Blk	0.00	0.00		0.00	0.00			1.58			3.58			5.13			6.71	
101	L1	0.52	0.52	0.00%	0.94	0.94	0.00%	1.26	1.26	0.00%	1.70	1.70	0.00%	2.05	2.05	0.00%	2.41	2.41	0.00%
102	L2	0.29	0.29	0.00%	0.47	0.47	0.00%	0.61	0.61	0.00%	0.83	0.83	0.00%	1.49	1.49	0.00%	1.75	1.75	0.00%
103	L3	0.24	0.34	39.06%	0.43	0.52	21.10%	0.58	0.65	13.59%	0.77	1.20	56.30%	0.93	1.44	55.14%	1.09	1.68	54.47%
104	L4	0.57	2.09	266.33%	1.01	3.04	199.20%	1.35	3.67	173.19%	1.79	5.10	184.70%	2.14	5.87	173.59%	2.51	6.64	164.79%
105	L5	1.71	5.85	241.55%	3.11	8.70	179.92%	4.16	10.65	156.15%	5.60	13.18	135.56%	6.72	15.12	124.93%	7.88	20.33	157.83%
112		4.14	18.16	338.87%	7.36	27.76	277.31%	9.71	36.34	274.16%	12.90	47.72	270.09%	15.71	57.85	268.23%	18.66	67.05	259.39%
113		4.12	17.82	332.06%	7.34	27.51	274.95%	9.69	35.94	270.94%	12.86	47.27	267.56%	15.67	57.28	265.55%	18.62	66.05	254.77%
114		4.10	16.51	302.93%	7.29	26.68	265.91%	9.63	34.75	260.71%	12.79	45.71	257.53%	15.58	55.32	255.03%	18.51	63.10	240.83%
115		3.88	13.57	249.42%	6.91	22.84	230.37%	9.12	29.86	227.27%	12.17	38.86	219.28%	14.73	47.03	219.26%	17.36	54.80	215.70%
201	U1	0.54	4.33	703.88%	1.01	6.40	533.33%	1.37	7.80	468.17%	1.88	11.14	492.56%	2.28	12.91	465.68%	2.70	14.70	443.62%
202	U2	1.44	7.67	434.13%	2.56	11.44	347.64%	3.39	13.97	312.04%	4.52	17.16	279.36%	5.41	19.60	262.51%	6.31	22.04	249.21%
203	U3	0.89	1.15	29.51%	1.69	2.07	22.08%	2.31	2.75	19.18%	3.16	3.68	16.60%	3.84	4.42	15.12%	4.55	5.18	13.89%
204	U4	0.15	1.43	882.06%	0.26	2.91	1037.51%	0.34	3.72	997.14%	0.45	4.83	961.17%	0.55	5.70	945.75%	0.64	6.61	934.17%
205	U5	0.41	3.29	697.50%	0.72	4.99	590.07%	0.96	6.15	543.97%	1.27	7.67	503.62%	1.52	8.84	483.37%	1.77	10.03	467.32%
206	U6	0.09	0.64	599.79%	0.16	0.96	503.21%	0.21	1.18	461.34%	0.28	1.95	600.44%	0.33	2.29	589.42%	0.39	2.64	581.70%
207	U7	0.14	1.25	787.39%	0.25	1.88	651.40%	0.33	2.30	594.05%	0.44	3.66	724.91%	0.53	4.27	703.90%	0.62	4.90	687.93%
208	U8	0.57	4.18	632.86%	0.97	6.51	569.66%	1.27	8.08	535.93%	1.68	10.08	500.45%	2.00	11.64	482.47%	2.33	13.22	468.03%
209	U9	0.25	1.95	672.02%	0.45	2.93	559.03%	0.59	3.62	514.55%	0.78	4.52	475.97%	0.94	6.99	646.06%	1.09	8.06	637.41%
210	U10	0.06	0.54	778.61%	0.11	0.82	639.18%	0.15	1.01	580.96%	0.20	1.26	530.62%	0.24	1.97	721.62%	0.28	2.28	708.29%
211	U11	0.10	0.77	681.54%	0.17	1.15	575.28%	0.22	1.40	528.35%	0.29	1.73	486.63%	0.35	2.55	627.95%	0.41	2.92	617.20%
212	U12	0.03	0.24	680.92%	0.05	0.35	554.11%	0.07	0.43	512.39%	0.09	0.53	469.55%	0.11	0.77	603.16%	0.13	0.88	592.15%
213		0.09	1.32	1358.40%	0.17	2.01	1096.86%	0.23	2.47	973.54%	0.32	3.09	874.53%	0.39	3.56	818.33%	0.46	4.04	773.45%
214		0.25	2.84	1027.24%	0.44	4.44	903.24%	0.59	5.40	821.25%	0.78	6.50	731.49%	0.93	7.76	729.79%	1.09	8.64	691.24%
215		0.48	0.15	-68.59%	0.86	0.23	-73.30%	1.15	0.39	-66.34%	1.54	0.65	-58.01%	1.86	0.90	-51.46%	2.18	1.03	-52.71%
231		2.06	10.26	399.16%	3.68	16.89	359.44%	4.89	21.70	343.40%	6.66	26.98	305.01%	8.05	31.65	292.95%	9.50	36.14	280.48%
250	W1	1.26	6.04	378.35%	2.24	9.16	308.50%	2.98	11.25	277.84%	3.98	14.00	252.06%	4.76	16.85	253.59%	5.58	19.13	242.62%
301	W2	0.04	0.46	1183.70%	0.06	0.66	951.88%	0.08	0.88	964.59%	0.11	1.08	885.60%	0.13	1.24	845.42%	0.15	1.40	813.60%
302	W3	0.43	2.92	585.56%	0.75	4.41	491.02%	0.98	5.44	453.58%	1.30	8.95	586.12%	1.55	10.50	576.06%	1.81	12.10	568.91%
303	W4	0.27	2.37	778.22%	0.47	3.49	643.81%	0.62	4.26	589.49%	0.82	6.33	673.91%	0.97	7.35	654.34%	1.13	8.38	639.30%
304		1.27	8.79	592.44%	2.18	13.38	513.19%	2.86	16.60	480.57%	3.77	20.85	452.34%	4.48	24.15	438.68%	5.21	27.49	427.96%
305		0.19	0.64	232.27%	0.35	0.96	174.97%	0.47	1.97	322.72%	0.63	3.91	518.20%	0.77	5.69	643.23%	0.90	7.48	727.89%
306		0.33	0.64	93.74%	0.59	1.03	73.67%	0.79	2.22	181.62%	1.06	5.48	415.29%	1.28	7.55	489.43%	1.51	9.66	540.89%
307		0.88	3.32	277.43%	1.57	5.03	220.89%	2.09	6.20	197.28%	2.79	7.74	177.34%	3.35	8.93	166.82%	3.93	10.14	157.67%
309		1.34	7.05	426.76%	2.36	10.91	362.54%	3.12	13.55	334.42%	4.16	17.05	310.26%	4.97	20.47	311.68%	5.82	23.34	301.24%
310		2.20	12.50	466.88%	4.03	19.73	389.32%	5.41	24.31	349.21%	7.30	30.31	314.91%	8.80	35.56	304.25%	10.33	40.35	290.48%
311		1.94	5.08	161.36%	3.35	7.70	129.91%	4.41	9.63	118.61%	5.85	12.77	118.46%	6.94	14.82	113.49%	8.07	16.92	109.78%
312		1.53	2.55	66.78%	2.63	3.81	45.03%	3.45	4.77	38.34%	4.57	6.35	38.98%	5.41	7.39	36.49%	6.30	8.48	34.59%
315		2.59	12.43	379.27%	4.69	20.55	338.57%	6.26	26.07	316.30%	8.54	33.57	293.34%	10.33	39.99	286.96%	12.20	45.92	276.38%
316		1.94	4.63	138.53%	3.36	6.94	106.67%	4.42	8.57	94.07%	5.85	13.53	131.38%	6.93	15.85	128.59%	8.06	18.22	125.95%
317		1.98	5.24	165.01%	3.41	7.94	132.81%	4.49	9.89	120.51%	5.95	13.09	119.95%	7.07	15.18	114.82%	8.21	17.33	110.96%
318		4.07	17.67	334.69%	7.20	28.02	289.16%	9.54	35.52	272.46%	12.75	46.08	261.49%	15.28	54.59	257.32%	17.83	62.66	251.53%
319		4.10	15.66	282.21%	7.30	26.39	261.73%	9.63	34.22	255.37%	12.79	46.05	260.11%	15.60	55.35	254.73%	18.48	62.93	240.45%

Robinson Creek
Chicago Peak Flows
June 18, 2009

NHYD	Sub-watershed	Peak Flow (m3/s)																	
		2 Year			5 Year			10 Year			25 Year			50 Year			100 Year		
		Existing	Future	Change	Existing	Future	Change	Existing	Future	Change	Existing	Future	Change	Existing	Future	Change	Existing	Future	Change
320		4.12	17.39	321.72%	7.34	27.65	276.94%	9.69	35.94	270.83%	12.85	47.44	269.12%	15.67	57.28	265.50%	18.62	65.28	250.50%
321		4.14	18.03	335.94%	7.36	27.82	278.19%	9.71	36.35	274.19%	12.89	47.82	270.95%	15.71	57.92	268.67%	18.67	66.78	257.74%
322		4.17	18.40	340.78%	7.41	28.14	279.56%	9.79	36.84	276.39%	12.97	48.55	274.34%	15.80	58.61	270.88%	18.77	67.92	261.84%
323		4.16	17.77	326.80%	7.41	27.34	269.23%	9.79	35.24	260.01%	12.93	46.91	262.86%	15.75	56.13	256.28%	18.73	64.59	244.88%
324		4.55	18.17	299.06%	8.19	28.09	242.87%	10.90	36.24	232.39%	14.31	48.06	235.91%	17.54	57.52	227.87%	20.96	66.24	215.99%
326	mnr to Qual		0.24			0.34			0.34			0.34			0.34			0.34	
326	mjr to Qual					0.00			0.08			0.18			0.43			0.54	
327		0.12	0.00	-100.00%	0.21	0.00	-97.88%	0.29	1.73	498.63%	0.39	3.93	897.64%	0.48	5.82	1113.59%	0.57	7.59	1235.23%
328		0.11	0.00	-100.00%	0.21	0.00	-99.60%	0.28	1.00	254.67%	0.39	2.54	554.63%	0.47	4.08	764.95%	0.56	5.63	905.08%
329	mnr to Qual		1.25			1.81			1.81			1.81			1.81			1.81	
329	mjr to Qual					0.07			0.49			1.85			2.47			3.10	
330			1.49			2.15			2.15			2.15			2.15			2.15	
331			3.44			5.08			5.77			6.67			9.14			10.21	
333		0.39	3.83	876.92%	0.69	6.34	817.20%	0.92	7.68	738.68%	1.22	9.52	679.24%	1.46	12.18	734.03%	1.71	13.91	715.06%
334		0.42	0.47	10.86%	0.76	0.83	10.10%	1.01	2.30	127.87%	1.35	6.17	356.66%	1.62	9.35	476.12%	1.90	12.31	546.42%
336	U/S Penwest	0.48	0.85	76.78%	0.87	1.50	72.49%	1.16	3.13	170.78%	1.55	7.23	366.56%	1.86	10.74	476.99%	2.19	13.92	536.75%
337	Penwest		0.15			0.23			0.39			0.65			0.91			1.04	
338		1.27	7.03	452.76%	2.26	11.37	403.22%	3.00	13.88	362.87%	4.01	17.26	330.77%	4.80	21.11	339.60%	5.63	24.04	327.14%
339	Rob Ridge		1.17			2.05			2.66			3.61			4.33			5.01	
340		1.53	2.74	79.68%	2.64	4.02	52.21%	3.46	4.89	41.42%	4.57	7.11	55.56%	5.42	8.23	51.77%	6.30	9.38	48.82%
341		0.42	0.64	49.74%	0.76	1.06	39.67%	1.01	2.49	147.52%	1.36	6.09	349.23%	1.63	8.98	451.71%	1.91	11.46	500.07%
342		1.27	1.17	-8.32%	2.18	2.06	-5.70%	2.86	2.65	-7.07%	3.77	3.62	-4.00%	4.48	4.35	-2.91%	5.21	5.04	-3.28%
344			0.77			1.11			1.11			1.11			1.11			1.11	
344						0.03			0.28			0.61			1.43			1.80	
346		0.09			0.17			0.23			0.32			0.39			0.46		
349	mnr to Blk		1.32			2.01			2.01			2.01			2.01			2.01	
349	mjr to Blk		0.00			0.00			0.45			1.08			1.55			2.02	
350			0.00			0.00			0.13			0.32			0.46			0.64	
351			0.00			0.00			1.64			3.75			5.39			7.05	
352			4.95			7.62			7.62			7.62			7.62			7.62	

Robinson Creek
100 Year Chicago, Uncontrolled Peak Flows
July 23, 2009

NHYD	Sub-watershed	Peak Flow (m3/s)
5	mnr to Blk	6.51
5	mjr to Blk	6.71
101	L1	2.41
102	L2	1.75
103	L3	1.68
104	L4	6.64
105	L5	20.33
112		91.40
113		90.74
114		88.86
115		81.75
201	U1	14.70
202	U2	22.04
203	U3	5.18
204	U4	6.61
205	U5	10.03
206	U6	2.64
207	U7	4.90
208	U8	13.22
209	U9	8.06
210	U10	2.28
211	U11	2.92
212	U12	0.88
213		4.04
214		8.64
215		11.45
231		42.50
250		27.59
301	W1	1.40
302	W2	12.10
303	W3	8.38
304	W4	27.49
305		7.48
306		9.66
307		19.99
309		31.80
310		44.23
311		43.85
312		34.85
315		49.08
316		39.92
317		44.26
318		92.18
319		89.88
320		91.04
321		91.47
322		92.05

Robinson Creek

100 Year Chicago, Uncontrolled Peak Flows

July 23, 2009

NHYD	Sub-watershed	Peak Flow (m3/s)
323		89.55
324		91.20
326	mnr to Qua	0.34
326	mjr to Qual	0.54
327		7.59
328		5.63
329	mnr to Qua	1.81
329	mjr to Qual	3.10
330		2.15
331		10.21
333		13.91
334		12.31
336		13.92
338		32.59
340		31.30
341		11.46
342		26.46
344		1.11
344		1.80
349	mnr to Blk	2.01
349	mjr to Blk	2.02
350		0.64
351		7.05
352		7.62

Robinson Creek
Regional Peak Flows
June 18, 2009

NHYD	Sub-watershed	Peak Flow (m3/s)		
		Existing	Future	Change
5	mjr to Blk	0.00	1.21	-
5	mnr to Blk	5.54	6.51	17.39%
101	L1	4.57	4.57	0.00%
102	L2	0.82	0.82	0.00%
103	L3	0.48	0.79	64.89%
104	L4	1.00	2.09	108.95%
105	L5	7.11	7.21	1.39%
112		46.93	63.79	35.94%
113		46.61	63.00	35.17%
114		45.95	60.93	32.60%
115		41.02	54.03	31.71%
201	U1	4.46	5.11	14.41%
202	U2	7.30	7.73	5.94%
203	U3	3.39	3.43	1.09%
204	U4	1.71	2.70	57.26%
205	U5	3.79	5.21	37.77%
206	U6	0.78	1.05	35.14%
207	U7	1.35	1.86	37.30%
208	U8	5.54	7.72	39.19%
209	U9	2.37	3.28	38.62%
210	U10	0.69	0.99	42.26%
211	U11	0.80	1.09	36.46%
212	U12	0.25	0.33	34.73%
213		1.77	2.74	54.24%
214		2.36	5.42	129.30%
215		5.54	2.97	-46.38%
231		20.74	26.48	27.67%
250		13.29	15.83	19.09%
301	W1	0.31	0.43	35.63%
302	W2	3.56	4.78	34.11%
303	W3	2.19	2.93	33.66%
304	W4	10.88	15.14	39.19%
305		2.73	2.07	-23.93%
306		4.06	2.12	-47.64%
307		9.28	8.06	-13.16%
309		15.18	19.14	26.13%
310		20.94	26.87	28.31%
311		16.58	22.76	37.25%
312		13.03	17.99	38.06%
315		24.59	31.54	28.25%
316		16.59	22.77	37.23%
317		16.89	23.18	37.23%
318		41.24	54.72	32.68%
319		45.99	61.05	32.75%

Robinson Creek
Regional Peak Flows
June 18, 2009

NHYD	Sub-watershed	Peak Flow (m3/s)		
		Existing	Future	Change
320		46.68	63.01	35.00%
321		46.95	63.75	35.78%
322		47.54	64.58	35.86%
323		47.33	64.19	35.62%
324		51.71	68.31	32.10%
326	mjr to Blk		0.00	
326	mnr to Blk		0.33	
327		2.01	1.21	-39.70%
328		1.99	1.03	-48.52%
329	mjr to Blk		0.05	
329	mnr to Blk		1.81	
330			2.14	
331			5.42	
333		4.06	8.11	99.73%
334		4.85	2.07	-57.39%
336		5.54	3.01	-45.63%
338		13.34	16.17	21.20%
340		13.06	18.07	38.37%
341		4.85	2.12	-56.18%
342		10.87	15.14	39.23%
344	mjr to Blk		0.00	
344	mnr to Blk		1.09	
349	mjr to Blk		0.72	
	mnr to Blk		2.01	
350			0.00	
351			1.21	
352			7.60	

Robinson Creek
Comparison to Other Studies
June 18, 2009

Location	NHYD	2			5			10		
		2008	1993	Change	2008	1993	Change	2008	1993	Change
Lake Ontario	324	18.17	12.40	-31.77%	28.09	18.70	-33.42%	36.24	26.40	-27.16%
S.Service Rd	322	18.40	11.80	-35.86%	28.14	17.60	-37.45%	36.84	24.80	-32.67%
401	321	18.03	11.80	-34.57%	27.82	17.60	-36.74%	36.35	24.80	-31.77%
Baseline Rd	320	17.39	10.60	-39.06%	27.65	16.00	-42.14%	35.94	22.70	-36.84%
CPR	319	15.66	10.60	-32.32%	26.39	16.00	-39.38%	34.22	22.70	-33.66%
Bloor	338	7.03	1.90	-72.98%	11.37	2.80	-75.38%	13.88	4.60	-66.86%

Location	NHYD	25			50			100		
		2008	1993	Change	2008	1993	Change	2008	1993	Change
Lake Ontario	324	48.06	32.80	-31.75%	57.52	34.00	-40.89%	66.24	44.40	-32.98%
S.Service Rd	322	48.55	30.70	-36.77%	58.61	31.90	-45.57%	67.92	41.40	-39.04%
401	321	47.82	30.70	-35.80%	57.92	31.90	-44.92%	66.78	41.40	-38.01%
Baseline Rd	320	47.44	28.30	-40.35%	57.28	29.30	-48.84%	65.28	38.30	-41.33%
CPR	319	46.05	28.30	-38.55%	55.35	29.30	-47.07%	62.93	38.30	-39.13%
Bloor	338	17.26	6.10	-64.65%	21.11	6.40	-69.69%	24.04	9.20	-61.73%

Location	Reg		
	2008	1993	Change
Lake Ontario	68.31	67.50	-1.19%
S.Service Rd	64.58	61.30	-5.09%
401	63.75	61.30	-3.85%
Baseline Rd	63.01	57.10	-9.38%
CPR	61.05	57.10	-6.47%
Bloor	18.07	13.00	-28.04%

1993 refers to the Robinson Creek Master Drainage Study prepared by G.M.Sernas & Associates Ltd in 1993. Flows are taken from the Future condition which uses a Chicago Distribution.
2008 refers to the CLOCA 2008 Robinson Creek Master Drainage Study Update (?). Flows are taken from the Future condition, using a Chicago Distribution.

APPENDIX B
Crossing Details

HYDRAULIC STRUCTURE INVENTORY SHEET:
Site # 0

Watershed and Location Information	Structure Configuration and Dimensions	Current Flow Information
Date (mm/dd/yy): May 15th 2008	**Structure Type (Culvert/Bridge):** Culvert	**Flow Present (Y/N): Y**
Field Crew: Amber/Phil/Julie	**Number of Cells**: 1	**Approx. Depth (mm):** 35 mm
Watershed Name: Robinson	**Material (Concrete/Steel):** Steel	**Approx. Velocity (m/s):** 0.11m/sec
Subcatchment Area No: L1	**Open Footing (Yes/No):** no	**Upstream Erosion (Y/N):** Yes-Gabions
Tributary Name: Robinson Lower	**Height (m) x Width (m) (If Applicable):** N/A	**Downstream Erosion (Y/N):** N
Floodplain Map Sheet No.:	**Diameter (m) (If Applicable):** 1.77	**Additional Flow Information:**
Cross Section Range: 302	**Length (m):** 14.23	
Municipality: Clarington	**Inlet Type (Projecting/Mitered/Headwall):** Projecting	
Location (Road Name/Intersection): Darlington Park Rd	**Skew Angle of Crossing (Degrees):**	
	Height from Obvert to Top of Road (m): 0.31	
	Depth of Siltation (mm): None upstream 10cm deep on Downstream	
	Upstream Invert (m): 75.574	
	Downstream Invert (m): 75.499	
	Top of Road Elevation (m): 77.579	
	Benchmark Location: CL of Rd over Culvert	
	Benchmark Elevation (m): 77.579	

Site Photograph and Additional Field Notes

Additional Field Notes:
-Gabion Baskets present on upstream side.
-Fish present in stream

Upstream Photograph

Downstream Photograph

HYDRAULIC STRUCTURE INVENTORY SHEET:
Site # 1

Watershed and Location Information

Date (mm/dd/yy): May 8th 2008

Field Crew: Amber/Phil

Watershed Name: Robinson

Subcatchment Area No:

Tributary Name: Robinson Lower

Floodplain Map Sheet No.: L1

Cross Section Range: 787

Municipality: Clarington

Location (Road Name/Intersection):
Darlington Park Rd

Structure Configuration and Dimensions

Structure Type (Culvert/Bridge): Box / CSP

Number of Cells: 2

Material (Concrete/Steel): Concrete / Steel

Open Footing (Yes/No): No

Height (m) x Width (m) (If Applicable): 3.0 X 3.0 / NA

Diameter (m) (If Applicable): N/A / 3.0m

Length (m): 28.95 (8.23m to bend)

Inlet Type (Projecting/Mitered/Headwall): Headwall / projecting

Skew Angle of Crossing (Degrees):

Height from Obvert to Top of Road (m):

Depth of Siltation (mm): NA / 0.50

Upstream Invert (m): 80.637 / 81.50

Downstream Invert (m): 80.476 / 81.30

Top of Road Elevation (m): 87.70

Benchmark Location: CL of Rd over Culvert

Benchmark Elevation (m): 87.70

Current Flow Information

Flow Present (Y/N): Y

Approx. Depth (mm): 0.15m/ 0

Approx. Velocity (m/s): 0.25m/sec

Upstream Erosion (Y/N): N

Downstream Erosion (Y/N): N

Additional Flow Information:

Site Photograph and Additional Field Notes

Additional Field Notes:
Dist b/w culverts
U/S = 2.95 m
D/S = 15.75 m

Upstream Photograph

Downstream Photograph

HYDRAULIC STRUCTURE INVENTORY SHEET:
Site # 2

Watershed and Location Information	Structure Configuration and Dimensions	Current Flow Information
Date (mm/dd/yy): 05/16/08	**Structure Type (Culvert/Bridge):** Culvert	**Flow Present (Y/N):** Y
Field Crew: Phil/Julie	**Number of Cells**: 1	**Approx. Depth (mm):** 0.11 m
Watershed Name:_ Robinson	**Material (Concrete/Steel):** Concrete	**Approx. Velocity (m/s):** 0.17m/s
Subcatchment Area No: L2	**Open Footing (Yes/No):** No	**Upstream Erosion (Y/N):** N
Tributary Name: Robinson Lower	**Height (m) x Width (m) (If Applicable):** 2.6 X 3.6	**Downstream Erosion (Y/N): N**
Floodplain Map Sheet No.:	**Diameter (m) (If Applicable):** N/A	**Additional Flow Information:** Heavy bedload –Large rounded cobbles
Cross Section Range: 899	**Length (m):** 34.87	
Municipality: Clarington	**Inlet Type (Projecting/Mitered/Headwall):** Projecting/Mitered	
Location (Road Name/Intersection): North of Darlington Park Rd. Culvert under train tracks	**Skew Angle of Crossing (Degrees):**	
	Height from Obvert to Top of Road (m):	
	Depth of Siltation (mm): 70mm (avg (11+3)/2)	
	Upstream Invert (m): 83.04	
	Downstream Invert (m): 82.669	
	Top of Road Elevation (m): 95.028	
	Benchmark Location: CL Culvert, top of rail	
	Benchmark Elevation (m): 95.028	

Site Photograph and Additional Field Notes

Additional Field Notes:

Upstream Photograph

Downstream Photograph

HYDRAULIC STRUCTURE INVENTORY SHEET:
Site # 3

Watershed and Location Information	Structure Configuration and Dimensions	Current Flow Information
Date (mm/dd/yy): 05/21/08	**Structure Type (Culvert/Bridge):** Culvert	**Flow Present (Y/N):** Y
Field Crew: Phil/Julie	**Number of Cells**: 1	**Approx. Depth (mm):** 5
Watershed Name: Robinson	**Material (Concrete/Steel):** Concrete	**Approx. Velocity (m/s):** .33m/sec
Subcatchment Area No: L2	**Open Footing (Yes/No):** No	**Upstream Erosion (Y/N):** N
Tributary Name: Robinson Lower	**Height (m) x Width (m) (If Applicable):** 2.97 X 4.7	**Downstream Erosion (Y/N): N**
Floodplain Map Sheet No.:	**Diameter (m) (If Applicable):** N/A	**Additional Flow Information:** Heavy bedload: Large rounded cobbles
Cross Section Range: 994	**Length (m):** 119.6	
Municipality: Clarington	**Inlet Type (Projecting/Mitered/Headwall):** Projecting	
Location (Road Name/Intersection): North of Darlington Park Rd. Culvert at 401.	**Skew Angle of Crossing (Degrees):** 85°	
	Height from Obvert to Top of Road (m):	
	Depth of Siltation (mm): 0	
	Upstream Invert (m): 84.967	
	Downstream Invert (m): 83.421	
	Top of Road Elevation (m): 95.80	
	Benchmark Location: CL of railway over culvert	
	Benchmark Elevation (m): 95.028	

Site Photograph and Additional Field Notes

Additional Field Notes:

Upstream Photograph

Downstream Photograph

HYDRAULIC STRUCTURE INVENTORY SHEET:
Site # 4

Central Lake Ontario Conservation

Watershed and Location Information	Structure Configuration and Dimensions	Current Flow Information
Date (mm/dd/yy): 05/22/08	**Structure Type (Culvert/Bridge):** Culvert	**Flow Present (Y/N):** Y
Field Crew: Julie/Phil	**Number of Cells**: 1	**Approx. Depth (mm):** 110
Watershed Name: Robinson	**Material (Concrete/Steel):** Concrete	**Approx. Velocity (m/s):** 0.33m/s
Subcatchment Area No: L4	**Open Footing (Yes/No):** No	**Upstream Erosion (Y/N):** N
Tributary Name: Robinson Lower	**Height (m) x Width (m) (If Applicable):** 2.85 X 4.8	**Downstream Erosion (Y/N): Y**
Floodplain Map Sheet No.:	**Diameter (m) (If Applicable):** N/A	**Additional Flow Information:** Mixed bedload: some cobles, mostly large gravel with sand/silt Downstream: far less cobbles
Cross Section Range: 1186	**Length (m):** 36.7	
Municipality: Clarington	**Inlet Type (Projecting/Mitered/Headwall):** Projecting	
Location (Road Name/Intersection): Baseline Rd. West of Courtice Rd	**Skew Angle of Crossing (Degrees):**	
	Height from Obvert to Top of Road (m): 4.698 m	
	Depth of Siltation (mm): 75mm	
	Upstream Invert (m): 86.53	
	Downstream Invert (m): 86.355	
	Top of Road Elevation (m): 93.874 m	
	Benchmark Location: CL of Rd over Culvert	
	Benchmark Elevation (m): 93.874 m	

Site Photograph and Additional Field Notes

Additional Field Notes:

Surrounding slopes heavily eroded

Small drainage/creek on east side of upstream culvert

Upstream Photograph

Downstream Photograph

HYDRAULIC STRUCTURE INVENTORY SHEET:
Site # 5

Watershed and Location Information	Structure Configuration and Dimensions	Current Flow Information
Date (mm/dd/yy): 27/05/08	**Structure Type (Culvert/Bridge):** Culvert	**Flow Present (Y/N):** Yes
Field Crew: Phil/Julie	**Number of Cells**: 1	**Approx. Depth (mm):** 200mm
Watershed Name: Robinson	**Material (Concrete/Steel):** Concrete/Steel	**Approx. Velocity (m/s):** 0.24m/sec
Subcatchment Area No: L5	**Open Footing (Yes/No):** No	**Upstream Erosion (Y/N):** Yes
Tributary Name: Robinson Lower	**Height (m) x Width (m) (If Applicable):** 2.3 * 2.45	**Downstream Erosion (Y/N):** No
Floodplain Map Sheet No.:	**Diameter (m) (If Applicable):**	**Additional Flow Information:** Large Boulders Downstream. Beaver Dam Upstream which is 0.60meters above culvert with +/- 0.5meters of mud.
Cross Section Range: 1370	**Length (m):** 32.9meters	
Municipality: Clarington	**Inlet Type (Projecting/Mitered/Headwall):** projecting	
Location (Road Name/Intersection): Baseline Rd & Train Track (One set)	**Skew Angle of Crossing (Degrees):**	
	Height from Obvert to Top of Road (m):	
	Depth of Siltation (mm): 0mm	
	Upstream Invert (m): 89.09	
	Downstream Invert (m): 88.71	
	Top of Road Elevation (m): 99.53	
	Benchmark Location: BM CL of tracks over culvert	
	Benchmark Elevation (m): 99.53	

Site Photograph and Additional Field Notes

Additional Field Notes:

Also upstream was a CSP pipe, this was flowing from a farmer's field which created a stream to the culvert.

The Culvert had a CSP support inside which was 18.5meters from downstream, and stopped at 27.7meters before the end of the upstream entrance of the culvert.

Culvert was an oval shape.

Upstream Photograph

Downstream Photograph

HYDRAULIC STRUCTURE INVENTORY SHEET:
Site # 6

Watershed and Location Information

Date (mm/dd/yy):	05/23/08
Field Crew:	Julie/Phil
Watershed Name:	Robinson
Subcatchment Area No:	W2
Tributary Name:	Robinson West
Floodplain Map Sheet No.:	
Cross Section Range:	165
Municipality:	Clarington
Location (Road Name/Intersection):	Prestonvale Rd between Bloor St. and Baseline Rd.

Structure Configuration and Dimensions

Structure Type (Culvert/Bridge):	Culvert
Number of Cells:	2
Material (Concrete/Steel):	CSP
Open Footing (Yes/No):	No
Height (m) x Width (m) (If Applicable):	N/A
Diameter (m) (If Applicable):	1.25/.56
Length (m):	15.91/ 12.5
Inlet Type (Projecting/Mitered/Headwall):	Projecting
Skew Angle of Crossing (Degrees):	
Height from Obvert to Top of Road (m):	1.457 m
Depth of Siltation (mm):	0/0
Upstream Invert (m):	93.145 / 93.802
Downstream Invert (m):	92.99 / 93.647
Top of Road Elevation (m):	95.347
Benchmark Location:	BM CL of Road over culvert
Benchmark Elevation (m):	95.347

Current Flow Information

Flow Present (Y/N):	Y/N
Approx. Depth (mm):	0.4/0.0
Approx. Velocity (m/s):	0.05m/s
Upstream Erosion (Y/N):	Y
Downstream Erosion (Y/N): Y	
Additional Flow Information:	Bedload- Silt with Medium Sand

Site Photograph and Additional Field Notes

Additional Field Notes:

2 Culverts

Upstream 7.05m apart

Downstream 1.00m apart

Spring on south side of smaller culvert on downstream side of road

Upstream Photograph

Downstream Photograph

HYDRAULIC STRUCTURE INVENTORY SHEET:
Site # 7

Watershed and Location Information

Date (mm/dd/yy): 05/27/08
Field Crew: Phil/Julie
Watershed Name: Robinson
Subcatchment Area No: U4
Tributary Name: Robinson Upper
Floodplain Map Sheet No.:
Cross Section Range: 1466
Municipality: Clarington
Location (Road Name/Intersection):
Bloor St. between Prestonvale Rd. and Trulls Rd.

Structure Configuration and Dimensions

Structure Type (Culvert/Bridge): Culvert
Number of Cells: 1
Material (Concrete/Steel): CSP
Open Footing (Yes/No): No
Height (m) x Width (m) (If Applicable): N/A
Diameter (m) (If Applicable): 1.46 m
Length (m): 21.62 m
Inlet Type (Projecting/Mitered/Headwall): Projecting
Skew Angle of Crossing (Degrees):
Height from Obvert to Top of Road (m): 2.741 m
Depth of Siltation (mm): 0
Upstream Invert (m): 107.571 m
Downstream Invert (m): 107.363 m
Top of Road Elevation (m): 111.642 m
Benchmark Location: CL of Rd over Culvert
Benchmark Elevation (m): 111.642 m

Current Flow Information

Flow Present (Y/N): Y
Approx. Depth (mm): 40mm
Approx. Velocity (m/s): 0.40m/s
Upstream Erosion (Y/N): N
Downstream Erosion (Y/N): Y
Additional Flow Information:

Site Photograph and Additional Field Notes

Additional Field Notes:

Silt

Bed Load with large Gravel

Upstream Photograph

Downstream Photograph

HYDRAULIC STRUCTURE INVENTORY SHEET:
Site # 8

Watershed and Location Information	Structure Configuration and Dimensions	Current Flow Information
Date (mm/dd/yy): 05/28/08	**Structure Type (Culvert/Bridge):** Bridge	**Flow Present (Y/N):** N
Field Crew: Julie/Phil	**Number of Cells**: 1	**Approx. Depth (mm):** 200mm
Watershed Name: Robinson	**Material (Concrete/Steel):** Concrete footings with Steel Bridge	**Approx. Velocity (m/s):** 0
Subcatchment Area No: U6	**Open Footing (Yes/No):** yes	**Upstream Erosion (Y/N):** N
Tributary Name: Robinson Upper	**Height (m) x Width (m) (If Applicable):** 2.2m above WL	**Downstream Erosion (Y/N):** N
Floodplain Map Sheet No.:	**Diameter (m) (If Applicable):**	**Additional Flow Information:** Cattails and grasses obstruct flow
Cross Section Range: 2524	**Length (m):** 24.4 m	
Municipality: Clarington	**Inlet Type (Projecting/Mitered/Headwall):** N/A	
Location (Road Name/Intersection): Oke Rd Near a park	**Skew Angle of Crossing (Degrees):**	
	Height from Obvert to Top of Road (m): N/A	
	Depth of Siltation (mm): N/A	
	Upstream Invert (m): N/A	
	Downstream Invert (m): N/A	
	Top of Road Elevation (m): N/A	
	Benchmark Location: CL over Bridge	
	Benchmark Elevation (m): 128.906 m	

Site Photograph and Additional Field Notes

Additional Field Notes:

Construction Site South west of this Bridge

Upstream Photograph

Downstream Photograph

HYDRAULIC STRUCTURE INVENTORY SHEET:
Site # 9

Watershed and Location Information

Date (mm/dd/yy): 28/05/08

Field Crew: Julie/Phil

Watershed Name: Robinson

Subcatchment Area No: U8

Tributary Name: Robinson Upper

Floodplain Map Sheet No.:

Cross Section Range: 2894

Municipality: Clarington

Location (Road Name/Intersection):

Sandringham Rd

Structure Configuration and Dimensions

Structure Type (Culvert/Bridge): Culvert

Number of Cells: 1

Material (Concrete/Steel): Concrete

Open Footing (Yes/No): No

Height (m) x Width (m) (If Applicable): 0.25 * 1.75

Diameter (m) (If Applicable):

Length (m): 36.65

Inlet Type (Projecting/Mitered/Headwall): Projecting

Skew Angle of Crossing (Degrees): 45º

Height from Obvert to Top of Road (m): 0.535 m

Depth of Siltation (mm): 240mm (mostly leaf debris)

Upstream Invert (m): 129.668 m

Downstream Invert (m): 129.538 m

Top of Road Elevation (m): 130.944 m

Benchmark Location: CL of Rd over Culvert

Benchmark Elevation (m): 130.944 m

Current Flow Information

Flow Present (Y/N): N

Approx. Depth (mm): 0

Approx. Velocity (m/s): 0

Upstream Erosion (Y/N): N

Downstream Erosion (Y/N): N

Additional Flow Information:

Dry vegetative bed

Site Photograph and Additional Field Notes

Additional Field Notes:

A lot of wood debris

Gabion baskets before culverts on both upstream and downstream

Upstream Photograph

Downstream Photograph

HYDRAULIC STRUCTURE INVENTORY SHEET:
Site # 10

Watershed and Location Information	Structure Configuration and Dimensions	Current Flow Information
Date (mm/dd/yy): 05/28/08	**Structure Type (Culvert/Bridge):** Culvert	**Flow Present (Y/N):** N
Field Crew: Phil/Julie	**Number of Cells**: 1	**Approx. Depth (mm):** 0
Watershed Name: Robinson	**Material (Concrete/Steel):** Concrete	**Approx. Velocity (m/s):** 0
Subcatchment Area No: U8	**Open Footing (Yes/No):** No	**Upstream Erosion (Y/N):** N
Tributary Name: Robinson Upper	**Height (m) x Width (m) (If Applicable):** 0.53 X 1.72	**Downstream Erosion (Y/N):**N
Floodplain Map Sheet No.:	**Diameter (m) (If Applicable):** N/A	**Additional Flow Information:** Dry vegetative Bed with lots of soil deposits.
Cross Section Range: 3316	**Length (m):** 34m	
Municipality: Clarington	**Inlet Type (Projecting/Mitered/Headwall):** projecting	
Location (Road Name/Intersection): Stuart Rd	**Skew Angle of Crossing (Degrees):**	
	Height from Obvert to Top of Road (m): 0.857 m	
	Depth of Siltation (mm): 500mm	
	Upstream Invert (m): 131.691 m	
	Downstream Invert (m): 131.642 m	
	Top of Road Elevation (m): 133.221 m	
	Benchmark Location: CL of Rd over Culvert	
	Benchmark Elevation (m): 133.221 m	

Site Photograph and Additional Field Notes

Additional Field Notes:

Upstream Photograph

Downstream Photograph

HYDRAULIC STRUCTURE INVENTORY SHEET:
Site # 11

Watershed and Location Information	Structure Configuration and Dimensions	Current Flow Information
Date (mm/dd/yy): 07/04/08	**Structure Type (Culvert/Bridge):** Culvert	**Flow Present (Y/N):** N
Field Crew: Phil/Julie	**Number of Cells**: 2	**Approx. Depth (mm):** 0
Watershed Name: Robinson	**Material (Concrete/Steel):** CSP	**Approx. Velocity (m/s):** 0
Subcatchment Area No: U8	**Open Footing (Yes/No):** No	**Upstream Erosion (Y/N):** N
Tributary Name: Robinson Upper	**Height (m) x Width (m) (If Applicable):** N/A	**Downstream Erosion (Y/N):**N
Floodplain Map Sheet No.:	**Diameter (m) (If Applicable):** 1.72 / 1.72	**Additional Flow Information:** Dry bed / No flow
Cross Section Range: 3469	**Length (m):** 31.14	
Municipality: Clarington	**Inlet Type (Projecting/Mitered/Headwall):** projecting and grated	
Location (Road Name/Intersection): Bushford Rd./Sandringham	**Skew Angle of Crossing (Degrees):** 45º	
	Height from Obvert to Top of Road (m):	
	Depth of Siltation (mm): 50 mm	
	Upstream Invert (m): 132.036 / 132.05	
	Downstream Invert (m): 132.116 / 131.996	
	Top of Road Elevation (m): 133.08	
	Benchmark Location: CL of Rd over Culvert	
	Benchmark Elevation (m): 133.08	

Site Photograph and Additional Field Notes

Additional Field Notes:

Heavily vegetated on downstream side

Upstream Photograph

Downstream Photograph

APPENDIX C
Hydraulics

Expansion and Contraction Lengths
Robinson Creek
July 2, 2008

The exercise of determining the expansion and contraction lengths using the newest method, detailed in the Hydraulic Reference Manual was completed for Tooley Creek. It was consistantly found that all of the variables used in determining the expansion reach for each crossing were identical. Subsequently the resulting expantion ratios were also identical. As a result of this excersize it was determined that the ratios were also identical. As a result of this excersize it was determined that the determined ratio, of 2 will be used for all crossings within Robinson Creek.

Bridge Section:	302 - Robinson Lower
Description:	Darlington Park Road
Structure:	0

Average Obstruction Length

A to B:	15.0
C to D:	15.0
Average:	15.0

Expansion Reach Length = 30

Contraction Reach Length = 15.0

Bridge Section:	787 - Robinson Lower
Description:	Darlington Park Road
Structure:	1

Average Obstruction Length

A to B:	20.0
C to D:	20.0
Average:	20.0

Expansion Reach Length = 40

Contraction Reach Length = 20.0

Bridge Section:	899 - Robinson Lower
Description:	Railway
Structure:	2

Average Obstruction Length

A to B:	20.0
C to D:	20.0
Average:	20.0

Expansion Reach Length = 40

Contraction Reach Length = 20.0

Bridge Section:	994 - Robinson Lower
Description:	Highway 401
Structure:	3

Average Obstruction Length

A to B:	20.0
C to D:	20.0
Average:	20.0

Expansion Reach Length = 40

Contraction Reach Length = 20.0

Bridge Section:	1186 - Robinson Lower
Description:	Baseline Road
Structure:	4

Average Obstruction Length

A to B:	15.0
C to D:	15.0
Average:	15.0

Expansion Reach Length = 30

Contraction Reach Length = 15.0

Bridge Section:	1370 - Robinson Lower
Description:	Railway
Structure:	5

Average Obstruction Length

A to B:	15.0
C to D:	15.0
Average:	15.0

Expansion Reach Length = 30

Contraction Reach Length = 15.0

Bridge Section:	165 - Robinson West
Description:	Prestonvale Road
Structure:	6

Average Obstruction Length

A to B:	15.0
C to D:	15.0
Average:	15.0

Expansion Reach Length = 30

Contraction Reach Length = 15.0

Bridge Section:	1466 - Robinson Upper
Description:	Bloor Street
Structure:	7

Average Obstruction Length

A to B:	15.0
C to D:	15.0
Average:	15.0

Expansion Reach Length = 30

Contraction Reach Length = 15.0

Bridge Section:	2524 - Robinson Upper
Description:	Walking Path
Structure:	8

Average Obstruction Length

A to B:	10.0
C to D:	10.0
Average:	10.0

Expansion Reach Length = **20**

Contraction Reach Length = **10.0**

Bridge Section:	2894 - Robinson Upper
Description:	Sandringham
Structure:	9

Average Obstruction Length

A to B:	10.0
C to D:	10.0
Average:	10.0

Expansion Reach Length = **20**

Contraction Reach Length = **10.0**

Bridge Section:	3316 - Robinson Upper
Description:	Stuart
Structure:	10

Average Obstruction Length

A to B:	10.0
C to D:	10.0
Average:	10.0

Expansion Reach Length = **20**

Contraction Reach Length = **10.0**

Bridge Section:	3469 - Robinson Upper
Description:	Bushford
Structure:	11

Average Obstruction Length

A to B:	10.0
C to D:	10.0
Average:	10.0

Expansion Reach Length = **20**

Contraction Reach Length = **10.0**

Channel Modification

STEPS:
1. Run the quality controled / de-bugged model
2. Create a summary table containing Min Ch El, Center Sta, Ch Sta L, and Ch Sta R.
3. Copy table to excell
4. Create new columns Top Width, Depth, Center Sta, Bottom Width, Invert El, Left Slope, Right Slope, and n.
5. Populate new columns
    - i) Top Width = from survey (average over reach)
    - ii) Depth = from survey (average over reach)
    - iii) Center Sta = from exported table
    - iv) Bottom Width = Top Width - 2 * Depth * Side Slope
    - v) Invert El = Min Ch El - Depth
    - vi) Left Slope = 3 (typical)
    - vii) Right Slope = 3 (typical)
    - viii) n = 0.035 (typical)
6. Copy the new column into the Channel Modification Editor

Reach	Structure	US Width	US Depth	DS Width	DS Depth	Avg US Width	Avg US Depth	Avg DS Width	Avg DS Depth	Avg Width	Avg Depth
Lower	0	1.95	0.11	1.80	0.07	6.07	0.23	2.49	0.21	4.28	0.22
	1	2.67	0.17	3.16	0.29						
	2	2.16	0.28	2.51	0.14						
	3	2.13	0.31	3.07	0.37						
	4	1.17	0.05	2.99	0.22						
	5	26.34	0.47	1.43	0.18						
Upper	7	0.87	0.17	2.15	0.14	1.00	0.08	1.34	0.09	1.17	0.08
	8	4.15	0.21	4.55	0.29						
	9	0.00	0.00	0.00	0.00						
	10	0.00	0.00	0.00	0.00						
	11	0.00	0.00	0.00	0.00						
West	6	1.94	0.36	2.03	0.06	1.94	0.36	2.03	0.06	1.99	0.21

HEC-RAS Plan:								Channel Modification Parameters							
River	Reach	River Sta	Profile	Min Ch El (m)	Center Station (m)	Ch Sta L (m)	Ch Sta R (m)	Top Width (m)	Depth (m)	Center Station (m)	Bottom Width (m)	Invert Elev (m)	Left Slope	Right Slope	n
RobinsonWest	West	486.4874	PF 1	96.37	190.27	189.76	190.78	1.99	0.21	190.27	0.73	96.16	3	3	0.035
RobinsonWest	West	400	PF 1	95.41	221.11	220.61	221.60	1.99	0.21	221.11	0.73	95.20	3	3	0.035
RobinsonWest	West	300	PF 1	94.23	233.04	232.53	233.54	1.99	0.21	233.04	0.73	94.02	3	3	0.035
RobinsonWest	West	193.175	PF 1	93.85	188.66	188.05	189.28	1.99	0.21	188.66	0.73	93.64	3	3	0.035
RobinsonWest	West	176.2835	PF 1	92.92	194.82	193.85	195.79	1.99	0.21	194.82	0.73	92.71	3	3	0.035
RobinsonWest	West	154.4447	PF 1	92.88	202.76	201.74	203.77	1.99	0.21	202.76	0.73	92.67	3	3	0.035
RobinsonWest	West	122.0857	PF 1	93.24	205.09	204.56	205.61	1.99	0.21	205.09	0.73	93.03	3	3	0.035
RobinsonWest	West	7.527757	PF 1	91.84	385.66	385.17	386.16	1.99	0.21	385.66	0.73	91.63	3	3	0.035
RobinsonUpper	Upper	3542.466	PF 1	132.18	89.58	89.09	90.08	1.17	0.08	89.58	0.69	132.10	3	3	0.035
RobinsonUpper	Upper	3494.811	PF 1	131.96	115.48	114.97	115.98	1.17	0.08	115.48	0.69	131.88	3	3	0.035
RobinsonUpper	Upper	3484.383	PF 1	132.03	115.01	113.23	116.78	1.17	0.08	115.01	0.69	131.95	3	3	0.035
RobinsonUpper	Upper	3454.014	PF 1	132.13	102.28	99.01	105.56	1.17	0.08	102.28	0.69	132.05	3	3	0.035
RobinsonUpper	Upper	3430.442	PF 1	131.94	93.62	93.08	94.15	1.17	0.08	93.62	0.69	131.86	3	3	0.035
RobinsonUpper	Upper	3400	PF 1	131.86	63.30	62.81	63.79	1.17	0.08	63.30	0.69	131.78	3	3	0.035
RobinsonUpper	Upper	3344.928	PF 1	131.68	73.89	73.37	74.41	1.17	0.08	73.89	0.69	131.60	3	3	0.035
RobinsonUpper	Upper	3334.47	PF 1	131.49	68.76	67.99	69.53	1.17	0.08	68.76	0.69	131.41	3	3	0.035
RobinsonUpper	Upper	3298.848	PF 1	131.61	58.36	56.17	60.54	1.17	0.08	58.36	0.69	131.53	3	3	0.035
RobinsonUpper	Upper	3274.914	PF 1	131.34	48.27	47.76	48.79	1.17	0.08	48.27	0.69	131.26	3	3	0.035
RobinsonUpper	Upper	3200	PF 1	130.94	250.01	249.49	250.52	1.17	0.08	250.01	0.69	130.86	3	3	0.035
RobinsonUpper	Upper	3100	PF 1	130.69	246.68	246.19	247.17	1.17	0.08	246.68	0.69	130.61	3	3	0.035
RobinsonUpper	Upper	3000	PF 1	130.40	52.21	51.71	52.71	1.17	0.08	52.21	0.69	130.32	3	3	0.035
RobinsonUpper	Upper	2917.452	PF 1	130.04	191.33	190.62	192.03	1.17	0.08	191.33	0.69	129.96	3	3	0.035
RobinsonUpper	Upper	2906.009	PF 1	129.59	151.17	149.30	153.04	1.17	0.08	151.17	0.69	129.51	3	3	0.035
RobinsonUpper	Upper	2882.851	PF 1	129.58	205.67	202.72	208.61	1.17	0.08	205.67	0.69	129.50	3	3	0.035
RobinsonUpper	Upper	2855.66	PF 1	129.96	274.48	273.99	274.98	1.17	0.08	274.48	0.69	129.88	3	3	0.035
RobinsonUpper	Upper	2800	PF 1	129.56	238.96	238.46	239.45	1.17	0.08	238.96	0.69	129.48	3	3	0.035
RobinsonUpper	Upper	2700	PF 1	128.23	177.07	176.56	177.58	1.17	0.08	177.07	0.69	128.15	3	3	0.035
RobinsonUpper	Upper	2600	PF 1	126.94	172.02	171.51	172.53	1.17	0.08	172.02	0.69	126.86	3	3	0.035
RobinsonUpper	Upper	2539.354	PF 1	126.73	21.95	21.45	22.45	1.17	0.08	21.95	0.69	126.65	3	3	0.035
RobinsonUpper	Upper	2529.293	PF 1	126.63	22.85	22.34	23.35	1.17	0.08	22.85	0.69	126.55	3	3	0.035
RobinsonUpper	Upper	2519.291	PF 1	126.83	22.71	22.21	23.22	1.17	0.08	22.71	0.69	126.75	3	3	0.035
RobinsonUpper	Upper	2499.168	PF 1	126.52	21.06	20.54	21.58	1.17	0.08	21.06	0.69	126.44	3	3	0.035
RobinsonUpper	Upper	2400	PF 1	126.32	250.00	249.50	250.49	1.17	0.08	250.00	0.69	126.24	3	3	0.035
RobinsonUpper	Upper	2300	PF 1	125.67	237.20	236.69	237.71	1.17	0.08	237.20	0.69	125.59	3	3	0.035
RobinsonUpper	Upper	2200	PF 1	124.99	219.13	218.61	219.64	1.17	0.08	219.13	0.69	124.91	3	3	0.035
RobinsonUpper	Upper	2154.378	PF 1	124.76	258.28	257.64	258.92	1.17	0.08	258.28	0.69	124.68	3	3	0.035
RobinsonUpper	Upper	2100	PF 1	124.18	215.51	215.03	216.00	1.17	0.08	215.51	0.69	124.10	3	3	0.035
RobinsonUpper	Upper	2000	PF 1	122.01	250.02	249.50	250.53	1.17	0.08	250.02	0.69	121.93	3	3	0.035
RobinsonUpper	Upper	1900	PF 1	118.62	65.74	65.25	66.23	1.17	0.08	65.74	0.69	118.54	3	3	0.035
RobinsonUpper	Upper	1800	PF 1	115.28	102.48	101.98	102.97	1.17	0.08	102.48	0.69	115.20	3	3	0.035
RobinsonUpper	Upper	1700	PF 1	112.39	143.76	143.26	144.26	1.17	0.08	143.76	0.69	112.31	3	3	0.035
RobinsonUpper	Upper	1478.247	PF 1	107.45	333.04	332.61	333.48	1.17	0.08	333.04	0.69	107.37	3	3	0.035
RobinsonUpper	Upper	1454.188	PF 1	106.90	332.97	331.90	334.04	1.17	0.08	332.97	0.69	106.82	3	3	0.035
RobinsonUpper	Upper	1421.456	PF 1	106.83	325.27	324.78	325.76	1.17	0.08	325.27	0.69	106.75	3	3	0.035
RobinsonUpper	Upper	1400	PF 1	106.50	259.70	259.20	260.20	1.17	0.08	259.70	0.69	106.42	3	3	0.035
RobinsonUpper	Upper	1300	PF 1	105.67	249.38	248.90	249.87	1.17	0.08	249.38	0.69	105.59	3	3	0.035
RobinsonUpper	Upper	1200	PF 1	104.86	233.56	233.08	234.04	1.17	0.08	233.56	0.69	104.78	3	3	0.035

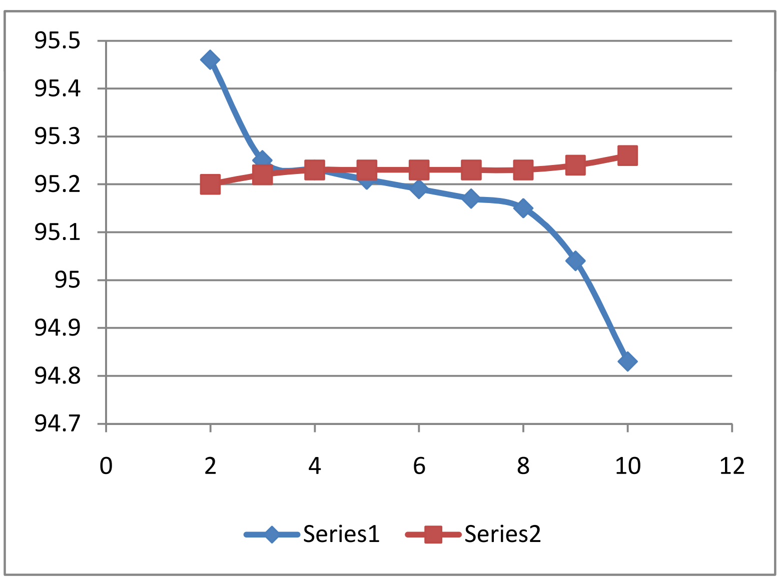
RobinsonUpper	Upper	1100	PF 1	103.83	244.98	244.47	245.49	1.17	0.08	244.98	0.69	103.75	3	3	0.035
RobinsonUpper	Upper	1000	PF 1	103.12	252.59	252.08	253.09	1.17	0.08	252.59	0.69	103.04	3	3	0.035
RobinsonUpper	Upper	900	PF 1	102.11	115.50	115.00	115.99	1.17	0.08	115.50	0.69	102.03	3	3	0.035
RobinsonUpper	Upper	800	PF 1	100.92	165.71	165.21	166.20	1.17	0.08	165.71	0.69	100.84	3	3	0.035
RobinsonUpper	Upper	700	PF 1	99.45	190.21	189.71	190.71	1.17	0.08	190.21	0.69	99.37	3	3	0.035
RobinsonUpper	Upper	600	PF 1	97.72	171.80	171.29	172.31	1.17	0.08	171.80	0.69	97.64	3	3	0.035
RobinsonUpper	Upper	500	PF 1	96.59	256.14	255.64	256.64	1.17	0.08	256.14	0.69	96.51	3	3	0.035
RobinsonUpper	Upper	400	PF 1	94.83	229.62	229.13	230.11	1.17	0.08	229.62	0.69	94.75	3	3	0.035
RobinsonUpper	Upper	300	PF 1	93.89	213.46	212.97	213.95	1.17	0.08	213.46	0.69	93.81	3	3	0.035
RobinsonUpper	Upper	200	PF 1	92.78	260.23	259.74	260.72	1.17	0.08	260.23	0.69	92.70	3	3	0.035
RobinsonUpper	Upper	11.06822	PF 1	91.89	571.67	571.13	572.21	1.17	0.08	571.67	0.69	91.81	3	3	0.035
RobinsonLower	Lower	2075.481	PF 1	91.69	578.96	578.43	579.49	4.28	0.22	578.96	2.95	91.47	3	3	0.035
RobinsonLower	Lower	2000	PF 1	91.35	562.33	561.83	562.83	4.28	0.22	562.33	2.95	91.13	3	3	0.035
RobinsonLower	Lower	1900	PF 1	90.90	582.97	582.46	583.47	4.28	0.22	582.97	2.95	90.68	3	3	0.035
RobinsonLower	Lower	1800	PF 1	90.33	550.45	549.95	550.94	4.28	0.22	550.45	2.95	90.11	3	3	0.035
RobinsonLower	Lower	1700	PF 1	90.15	546.24	545.75	546.72	4.28	0.22	546.24	2.95	89.93	3	3	0.035
RobinsonLower	Lower	1600	PF 1	89.36	520.79	520.29	521.28	4.28	0.22	520.79	2.95	89.14	3	3	0.035
RobinsonLower	Lower	1500	PF 1	89.27	540.45	539.94	540.96	4.28	0.22	540.45	2.95	89.05	3	3	0.035
RobinsonLower	Lower	1408.42	PF 1	89.26	425.55	424.98	426.12	4.28	0.22	425.55	2.95	89.04	3	3	0.035
RobinsonLower	Lower	1389.432	PF 1	89.23	449.36	448.24	450.47	4.28	0.22	449.36	2.95	89.01	3	3	0.035
RobinsonLower	Lower	1349.056	PF 1	88.42	235.20	234.20	236.20	4.28	0.22	235.20	2.95	88.20	3	3	0.035
RobinsonLower	Lower	1318.902	PF 1	88.02	234.40	233.89	234.91	4.28	0.22	234.40	2.95	87.80	3	3	0.035
RobinsonLower	Lower	1300	PF 1	87.95	267.52	267.03	268.00	4.28	0.22	267.52	2.95	87.73	3	3	0.035
RobinsonLower	Lower	1225.673	PF 1	86.98	168.38	167.85	168.92	4.28	0.22	168.38	2.95	86.76	3	3	0.035
RobinsonLower	Lower	1208.394	PF 1	86.55	171.17	169.38	172.96	4.28	0.22	171.17	2.95	86.33	3	3	0.035
RobinsonLower	Lower	1174.573	PF 1	86.39	162.95	161.45	164.44	4.28	0.22	162.95	2.95	86.17	3	3	0.035
RobinsonLower	Lower	1170.69	PF 1	86.36	162.95	161.45	164.44	4.28	0.22	162.95	2.95	86.14	3	3	0.035
RobinsonLower	Lower	1146.689	PF 1	85.74	149.40	148.71	150.08	4.28	0.22	149.40	2.95	85.52	3	3	0.035
RobinsonLower	Lower	1076.022	PF 1	85.08	153.86	153.27	154.45	4.28	0.22	153.86	2.95	84.86	3	3	0.035
RobinsonLower	Lower	1050.327	PF 1	84.72	132.05	130.62	133.48	4.28	0.22	132.05	2.95	84.50	3	3	0.035
RobinsonLower	Lower	928.2293	PF 1	82.86	63.09	61.12	65.06	4.28	0.22	63.09	2.95	82.64	3	3	0.035
RobinsonLower	Lower	918.8482	PF 1	82.75	127.08	125.07	129.09	4.28	0.22	127.08	2.95	82.53	3	3	0.035
RobinsonLower	Lower	876.9869	PF 1	82.53	140.42	139.17	141.68	4.28	0.22	140.42	2.95	82.31	3	3	0.035
RobinsonLower	Lower	834.4676	PF 1	82.59	140.45	139.79	141.10	4.28	0.22	140.45	2.95	82.37	3	3	0.035
RobinsonLower	Lower	823.6441	PF 1	82.51	105.73	105.19	106.26	4.28	0.22	105.73	2.95	82.29	3	3	0.035
RobinsonLower	Lower	800.6076	PF 1	80.77	107.2	106.72	107.68	4.28	0.22	107.20	2.95	80.55	3	3	0.035
RobinsonLower	Lower	772.9675	PF 1	80.04	114.94	114.06	115.82	4.28	0.22	114.94	2.95	79.82	3	3	0.035
RobinsonLower	Lower	728.9347	PF 1	81.08	125.34	124.72	125.97	4.28	0.22	125.34	2.95	80.86	3	3	0.035
RobinsonLower	Lower	700	PF 1	80.98	223.44	222.95	223.94	4.28	0.22	223.44	2.95	80.76	3	3	0.035
RobinsonLower	Lower	600	PF 1	79.32	203.39	202.89	203.89	4.28	0.22	203.39	2.95	79.10	3	3	0.035
RobinsonLower	Lower	500	PF 1	77.35	154.62	154.11	155.13	4.28	0.22	154.62	2.95	77.13	3	3	0.035
RobinsonLower	Lower	400	PF 1	76.75	104.33	103.84	104.82	4.28	0.22	104.33	2.95	76.53	3	3	0.035
RobinsonLower	Lower	349.8643	PF 1	76.52	249.65	249.13	250.17	4.28	0.22	249.65	2.95	76.30	3	3	0.035
RobinsonLower	Lower	310.5079	PF 1	75.81	270.6	270.05	271.14	4.28	0.22	270.60	2.95	75.59	3	3	0.035
RobinsonLower	Lower	289.6513	PF 1	75.83	283.14	282.56	283.71	4.28	0.22	283.14	2.95	75.61	3	3	0.035
RobinsonLower	Lower	254.9745	PF 1	75.68	278.86	278.31	279.4	4.28	0.22	278.86	2.95	75.46	3	3	0.035
RobinsonLower	Lower	200	PF 1	75.5	228.26	227.76	228.75	4.28	0.22	228.26	2.95	75.28	3	3	0.035

Robinson Creek Floodplain Mapping
Flow Split - Spill Analysis
November 13, 2009

100 Year Storm

Run	Robinson Flow (m^3/s)	Spill Flow (m^3/s)	Robinson WSEL (m)	Spill WSEL (m)
1	91.47	0.00	97.33	84.72
2	73.47	18.00	95.46	95.2
3	72.47	19.00	95.25	95.22
4	72.37	19.10	95.23	95.23
5	72.27	19.20	95.21	95.23
6	72.17	19.30	95.19	95.23
7	72.07	19.40	95.17	95.23
8	71.97	19.50	95.15	95.23
9	71.47	20.00	95.04	95.24
10	70.47	21.00	94.83	95.26

Notes:
1 XS Lower 1050 was included in both models and the resulting WSEL from each model were compared.



Robinson Creek Floodplain Mapping

Stage-Storage-Discharge Upstream of Baseline Road

December 18, 2009

Total Storage 100 Year

Elevation	Surface Area	Incremental Volume	Cummulative Volume		Storage Above 100 Yr Tailwater Elev (95.44)	Discharge 100Yr
(m)	(m2)	(m3)	(m3)	(ham)		(m3/s)
89.09	0	0.00	0.00	0	0	
90	2242	1020.05	1020.05	0.1020	0	
91	20761	11501.56	12521.61	1.2522	0	
92	53323	37042.13	49563.74	4.9564	0	
93	121251	87286.88	136850.62	13.6851	0	
94	193632	157441.41	294292.02	29.4292	0	
95	248409	221020.44	515312.47	51.5312	0	
95.44	279464	116131.96	631444.42	63.1444	0	0
96	318988	167566.50	799010.92	79.9011	16.76	6.60
97	387079	353033.73	1152044.65	115.2045	52.06	11.01
98	452010	419544.45	1571589.11	157.1589	94.01	14.10
99	509960	480984.91	2052574.01	205.2574	142.11	16.63

Tailwater Elevation 100 Year

Scenario	Storm Event	Max Storage	E1	S1	E2	S2	E
		(ham)	(m)	(ham)	(m)	(ham)	(m)
Fut Uncont	100	19.74	96	16.7567	97	52.0600	96.08

NOTES:

1 Surface area calculted in GIS using contour shapefiles

2 Discharge calculated using Culvert Master

3 Structure ID 5

4 Surface area for tailwater elevation was interpolated between contours.

Total Storage Regional

Elevation	Surface Area	Incremental Volume	Cummulative Volume		Storage Above Regional Tailwater Elev (94.07)	Discharge Regional
(m)	(m2)	(m3)	(m3)	(ham)		(m3/s)
89.09	0	0.00	0.00	0	0	
90	2242	1020.05	1020.05	0.1020	0	
91	20761	11501.56	12521.61	1.2522	0	
92	53323	37042.13	49563.74	4.9564	0	
93	121251	87286.88	136850.62	13.6851	0	
94	193632	157441.41	294292.02	29.4292	0	
94.07	197466.4382	13688.45	307980.47	30.7980	0	0
95	248409	207332.00	515312.47	51.5312	20.7332	8.50
96	318988	283698.46	799010.92	79.9011	49.1030	12.25
97	387079	353033.73	1152044.65	115.2045	84.4064	15.09
98	452010	419544.45	1571589.11	157.1589	126.3609	17.48
99	509960	480984.91	2052574.01	205.2574	174.4594	19.57

Tailwater Elevation Regional

Scenario		Max Storage	E1	S1	E2	S2	E
	Storm Event	(ham)	(m)	(ham)	(m)	(ham)	(m)
Fut Uncont	Regional	57.13	96	49.1030	97	84.4064	96.23

Total Storage 50 Year

Elevation	Surface Area	Incremental Volume	Cummulative Volume		Storage Above 50 Yr Tailwater Elev (92.37)	Discharge Regional
(m)	(m2)	(m3)	(m3)	(ham)		(m3/s)
89.09	0	0.00	0.00	0	0	
90	2242	1020.05	1020.05	0.1020	0	
91	20761	11501.56	12521.61	1.2522	0	
92	53323	37042.13	49563.74	4.9564	0	
92.37	78456.26807	24379.16	73942.91	7.3943	0	0.00
93	121251	62907.71	136850.62	13.6851	6.29	7.00
94	193632	157441.41	294292.02	29.4292	22.03	11.25
95	248409	221020.44	515312.47	51.5312	44.14	14.30
96	318988	283698.46	799010.92	79.9011	72.51	16.80
97	387079	353033.73	1152044.65	115.2045	107.81	18.97
98	452010	419544.45	1571589.11	157.1589	149.76	20.92
99	509960	480984.91	2052574.01	205.2574	197.86	22.57

Tailwater Elevation 50 Year

Scenario		Max Storage	E1	S1	E2	S2	E
	Storm Event	(ham)	(m)	(ham)	(m)	(ham)	(m)
Fut	50 Yr	11.85	93	6.2908	94	22.0349	93.35

Total Storage 25 Year

Elevation	Surface Area	Incremental Volume	Cummulative Volume		Storage Above 25 Yr Tailwater Elev (90.57)	Discharge Regional
(m)	(m2)	(m3)	(m3)	(ham)		(m3/s)
89.09	0	0.00	0.00	0	0	
90	2242	1020.05	1020.05	0.1020	0	
90.57	12797.92059	4286.34	5306.38	0.5306	0	0.00
91	20761	7215.23	12521.61	1.2522	0.7215	6.94
92	53323	37042.13	49563.74	4.9564	4.4257	9.32
93	121251	87286.88	136850.62	13.6851	13.1544	12.03
94	193632	157441.41	294292.02	29.4292	28.8986	14.3361
95	248409	221020.44	515312.47	51.5312	51.0006	16.32
96	318988	283698.46	799010.92	79.9011	79.3705	18.08
97	387079	353033.73	1152044.65	115.2045	114.6738	19.69
98	452010	419544.45	1571589.11	157.1589	156.6283	21.18
99	509960	480984.91	2052574.01	205.2574	204.7268	22.57

Tailwater Elevation 25 Year

Scenario	Storm Event	Max Storage (ham)	E1 (m)	S1 (ham)	E2 (m)	S2 (ham)	E (m)
Fut	25 Yr	7.74	92	4.4257	93	13.1544	92.38

Total Storage 10 Year

Elevation	Surface Area	Incremental Volume	Cummulative Volume		Storage Above 10 Yr Tailwater Elev (89.85)	Discharge Regional
(m)	(m2)	(m3)	(m3)	(ham)		(m3/s)
89.09	0	0.00	0.00	0	0	0.00
89.85	1872.321171	711.48	711.48	0.0711	0	0.00
90	2242	308.56	1020.05	0.1020	0.0309	2.73
91	20761	11501.56	12521.61	1.2522	1.1502	6.75
92	53323	37042.13	49563.74	4.9564	4.8544	9.32
93	121251	87286.88	136850.62	13.6851	13.5831	12.03
94	193632	157441.41	294292.02	29.4292	29.3272	14.34
95	248409	221020.44	515312.47	51.5312	51.4292	16.32
96	318988	283698.46	799010.92	79.9011	79.7991	18.08
97	387079	353033.73	1152044.65	115.2045	115.1025	19.69
98	452010	419544.45	1571589.11	157.1589	157.0569	21.18
99	509960	480984.91	2052574.01	205.2574	205.1554	22.57

Tailwater Elevation 10 Year

Scenario	Storm Event	Max Storage (ham)	E1 (m)	S1 (ham)	E2 (m)	S2 (ham)	E (m)
Fut	10 Yr	5.54	92	4.8544	93	13.5831	92.08

Total Storage 5Year

Elevation	Surface Area	Incremental Volume	Cummulative Volume		Storage Above 5Yr Tailwater	Discharge Regional
(m)	(m2)	(m3)	(m3)	(ham)		(m3/s)
89.09	0	0.00	0.00	0	0	
89.48	960.7964	187.36	187.36	0.0187	0	0.00
90	2242	832.69	1020.05	0.1020	0.0833	2.85
91	20761	11501.56	12521.61	1.2522	1.1502	6.75
92	53323	37042.13	49563.74	4.9564	4.8544	9.32
93	121251	87286.88	136850.62	13.6851	13.5831	12.03
94	193632	157441.41	294292.02	29.4292	29.3272	14.34
95	248409	221020.44	515312.47	51.5312	51.4292	16.32
96	318988	283698.46	799010.92	79.9011	79.7991	18.08
97	387079	353033.73	1152044.65	115.2045	115.1025	19.69
98	452010	419544.45	1571589.11	157.1589	157.0569	21.18
99	509960	480984.91	2052574.01	205.2574	205.1554	22.57

Tailwater Elevation 5 Year

Scenario	Storm Event	Max Storage (ham)	E1 (m)	S1 (ham)	E2 (m)	S2 (ham)	E (m)
Fut	5 Yr	4.08	91	1.1502	92	4.8544	91.79

Total Storage 2Year

Elevation	Surface Area	Incremental Volume	Cummulative Volume		Storage Above 2Yr Tailwater Elev (89.26)	Discharge Regional
(m)	(m2)	(m3)	(m3)	(ham)		(m3/s)
89.09	0	0.00	0.00	0	0	0.00
89.26	418.8087	35.60	35.60	0.0036	0	0.00
90	2242	984.45	1020.05	0.1020	0.0984	2.85
91	20761	11501.56	12521.61	1.2522	1.1502	6.75
92	53323	37042.13	49563.74	4.9564	4.8544	9.31
93	121251	87286.88	136850.62	13.6851	13.5831	12.03
94	193632	157441.41	294292.02	29.4292	29.3272	14.34
95	248409	221020.44	515312.47	51.5312	51.4292	16.32
96	318988	283698.46	799010.92	79.9011	79.7991	18.08
97	387079	353033.73	1152044.65	115.2045	115.1025	19.69
98	452010	419544.45	1571589.11	157.1589	157.0569	21.18
99	509960	480984.91	2052574.01	205.2574	205.1554	22.57

Tailwater Elevation 2 Year

Scenario	Storm Event	Max Storage (ham)	E1 (m)	S1 (ham)	E2 (m)	S2 (ham)	E (m)
Fut	2 Yr	2.19	91	1.1502	92	4.8544	91.28

HEC-RAS Plan: Robinson

River	Reach	River Sta	Profile	Q Total	W.S. Elev
				(m3/s)	(m)
RobinsonWest	West	486.4874	100 Year	31.30	97.64
RobinsonWest	West	486.4874	Regional	18.07	97.44
RobinsonWest	West	486.4874	2 Year	2.74	96.83
RobinsonWest	West	486.4874	5 Year	4.02	96.93
RobinsonWest	West	486.4874	10 Year	4.89	96.99
RobinsonWest	West	486.4874	25 Year	7.11	97.11
RobinsonWest	West	486.4874	50 Year	8.23	97.16
RobinsonWest	West	400	100 Year	31.30	96.83
RobinsonWest	West	400	Regional	18.07	96.70
RobinsonWest	West	400	2 Year	2.74	95.79
RobinsonWest	West	400	5 Year	4.02	95.90
RobinsonWest	West	400	10 Year	4.89	95.97
RobinsonWest	West	400	25 Year	7.11	96.12
RobinsonWest	West	400	50 Year	8.23	96.18
RobinsonWest	West	300	100 Year	44.26	96.22
RobinsonWest	West	300	Regional	23.18	96.28
RobinsonWest	West	300	2 Year	5.24	95.44
RobinsonWest	West	300	5 Year	7.94	95.53
RobinsonWest	West	300	10 Year	9.89	95.57
RobinsonWest	West	300	25 Year	13.09	95.64
RobinsonWest	West	300	50 Year	15.18	95.67
RobinsonWest	West	193.1750	100 Year	44.26	96.20
RobinsonWest	West	193.1750	Regional	23.18	96.28
RobinsonWest	West	193.1750	2 Year	5.24	95.44
RobinsonWest	West	193.1750	5 Year	7.94	95.52
RobinsonWest	West	193.1750	10 Year	9.89	95.56
RobinsonWest	West	193.1750	25 Year	13.09	95.63
RobinsonWest	West	193.1750	50 Year	15.18	95.66
RobinsonWest	West	176.2835	100 Year	44.26	96.19
RobinsonWest	West	176.2835	Regional	23.18	96.28
RobinsonWest	West	176.2835	2 Year	5.24	95.44
RobinsonWest	West	176.2835	5 Year	7.94	95.52
RobinsonWest	West	176.2835	10 Year	9.89	95.56
RobinsonWest	West	176.2835	25 Year	13.09	95.62
RobinsonWest	West	176.2835	50 Year	15.18	95.65
RobinsonWest	West	165.6963		Mult Open	
RobinsonWest	West	154.4447	100 Year	44.26	96.19
RobinsonWest	West	154.4447	Regional	23.18	96.28
RobinsonWest	West	154.4447	2 Year	5.24	94.07
RobinsonWest	West	154.4447	5 Year	7.94	94.20
RobinsonWest	West	154.4447	10 Year	9.89	94.26
RobinsonWest	West	154.4447	25 Year	13.09	94.33
RobinsonWest	West	154.4447	50 Year	15.18	94.37
RobinsonWest	West	122.0857	100 Year	44.26	96.19

HEC-RAS Plan: Robinson (Continued)

River	Reach	River Sta	Profile	Q Total	W.S. Elev
				(m3/s)	(m)
RobinsonWest	West	122.0857	Regional	23.18	96.28
RobinsonWest	West	122.0857	2 Year	5.24	93.83
RobinsonWest	West	122.0857	5 Year	7.94	94.03
RobinsonWest	West	122.0857	10 Year	9.89	94.11
RobinsonWest	West	122.0857	25 Year	13.09	94.21
RobinsonWest	West	122.0857	50 Year	15.18	94.26
RobinsonWest	West	7.527757	100 Year	44.26	96.19
RobinsonWest	West	7.527757	Regional	23.18	96.28
RobinsonWest	West	7.527757	2 Year	5.24	92.78
RobinsonWest	West	7.527757	5 Year	7.94	92.92
RobinsonWest	West	7.527757	10 Year	9.89	92.99
RobinsonWest	West	7.527757	25 Year	13.09	93.07
RobinsonWest	West	7.527757	50 Year	15.18	93.50
RobinsonUpper	Upper	3542.466	100 Year	2.02	133.20
RobinsonUpper	Upper	3542.466	Regional	0.72	132.79
RobinsonUpper	Upper	3542.466	2 Year	0.10	132.34
RobinsonUpper	Upper	3542.466	5 Year	0.10	132.34
RobinsonUpper	Upper	3542.466	10 Year	0.45	132.62
RobinsonUpper	Upper	3542.466	25 Year	1.08	133.09
RobinsonUpper	Upper	3542.466	50 Year	1.55	133.16
RobinsonUpper	Upper	3494.811	100 Year	2.02	133.20
RobinsonUpper	Upper	3494.811	Regional	0.72	132.79
RobinsonUpper	Upper	3494.811	2 Year	0.10	132.34
RobinsonUpper	Upper	3494.811	5 Year	0.10	132.34
RobinsonUpper	Upper	3494.811	10 Year	0.45	132.61
RobinsonUpper	Upper	3494.811	25 Year	1.08	133.09
RobinsonUpper	Upper	3494.811	50 Year	1.55	133.15
RobinsonUpper	Upper	3484.383	100 Year	2.02	133.18
RobinsonUpper	Upper	3484.383	Regional	0.72	132.78
RobinsonUpper	Upper	3484.383	2 Year	0.10	132.33
RobinsonUpper	Upper	3484.383	5 Year	0.10	132.33
RobinsonUpper	Upper	3484.383	10 Year	0.45	132.61
RobinsonUpper	Upper	3484.383	25 Year	1.08	133.08
RobinsonUpper	Upper	3484.383	50 Year	1.55	133.14
RobinsonUpper	Upper	3469.744		Mult Open	
RobinsonUpper	Upper	3454.014	100 Year	2.02	132.81
RobinsonUpper	Upper	3454.014	Regional	0.72	132.40
RobinsonUpper	Upper	3454.014	2 Year	0.10	132.24
RobinsonUpper	Upper	3454.014	5 Year	0.10	132.24
RobinsonUpper	Upper	3454.014	10 Year	0.45	132.33
RobinsonUpper	Upper	3454.014	25 Year	1.08	132.48
RobinsonUpper	Upper	3454.014	50 Year	1.55	132.59
RobinsonUpper	Upper	3430.442	100 Year	2.02	132.81
RobinsonUpper	Upper	3430.442	Regional	0.72	132.32

HEC-RAS Plan: Robinson (Continued)

River	Reach	River Sta	Profile	Q Total	W.S. Elev
				(m3/s)	(m)
RobinsonUpper	Upper	3430.442	2 Year	0.10	132.06
RobinsonUpper	Upper	3430.442	5 Year	0.10	132.06
RobinsonUpper	Upper	3430.442	10 Year	0.45	132.23
RobinsonUpper	Upper	3430.442	25 Year	1.08	132.43
RobinsonUpper	Upper	3430.442	50 Year	1.55	132.56
RobinsonUpper	Upper	3400	100 Year	2.02	132.80
RobinsonUpper	Upper	3400	Regional	0.72	132.25
RobinsonUpper	Upper	3400	2 Year	0.10	131.96
RobinsonUpper	Upper	3400	5 Year	0.10	131.96
RobinsonUpper	Upper	3400	10 Year	0.45	132.15
RobinsonUpper	Upper	3400	25 Year	1.08	132.37
RobinsonUpper	Upper	3400	50 Year	1.55	132.53
RobinsonUpper	Upper	3344.928	100 Year	2.02	132.78
RobinsonUpper	Upper	3344.928	Regional	0.72	132.16
RobinsonUpper	Upper	3344.928	2 Year	0.10	131.83
RobinsonUpper	Upper	3344.928	5 Year	0.10	131.83
RobinsonUpper	Upper	3344.928	10 Year	0.45	132.04
RobinsonUpper	Upper	3344.928	25 Year	1.08	132.30
RobinsonUpper	Upper	3344.928	50 Year	1.55	132.47
RobinsonUpper	Upper	3334.470	100 Year	2.02	132.75
RobinsonUpper	Upper	3334.470	Regional	0.72	132.12
RobinsonUpper	Upper	3334.470	2 Year	0.10	131.81
RobinsonUpper	Upper	3334.470	5 Year	0.10	131.81
RobinsonUpper	Upper	3334.470	10 Year	0.45	132.00
RobinsonUpper	Upper	3334.470	25 Year	1.08	132.26
RobinsonUpper	Upper	3334.470	50 Year	1.55	132.43
RobinsonUpper	Upper	3316.727		Culvert	
RobinsonUpper	Upper	3298.848	100 Year	2.02	132.01
RobinsonUpper	Upper	3298.848	Regional	0.72	131.85
RobinsonUpper	Upper	3298.848	2 Year	0.10	131.71
RobinsonUpper	Upper	3298.848	5 Year	0.10	131.71
RobinsonUpper	Upper	3298.848	10 Year	0.45	131.77
RobinsonUpper	Upper	3298.848	25 Year	1.08	131.88
RobinsonUpper	Upper	3298.848	50 Year	1.55	131.95
RobinsonUpper	Upper	3274.914	100 Year	2.02	131.82
RobinsonUpper	Upper	3274.914	Regional	0.72	131.63
RobinsonUpper	Upper	3274.914	2 Year	0.10	131.38
RobinsonUpper	Upper	3274.914	5 Year	0.10	131.38
RobinsonUpper	Upper	3274.914	10 Year	0.45	131.62
RobinsonUpper	Upper	3274.914	25 Year	1.08	131.74
RobinsonUpper	Upper	3274.914	50 Year	1.55	131.78
RobinsonUpper	Upper	3200	100 Year	7.05	131.59
RobinsonUpper	Upper	3200	Regional	1.21	131.26
RobinsonUpper	Upper	3200	2 Year	0.10	131.05

HEC-RAS Plan: Robinson (Continued)

River	Reach	River Sta	Profile	Q Total	W.S. Elev
				(m3/s)	(m)
RobinsonUpper	Upper	3200	5 Year	0.10	131.05
RobinsonUpper	Upper	3200	10 Year	1.64	131.31
RobinsonUpper	Upper	3200	25 Year	3.75	131.45
RobinsonUpper	Upper	3200	50 Year	5.39	131.53
RobinsonUpper	Upper	3100	100 Year	7.05	131.32
RobinsonUpper	Upper	3100	Regional	1.21	131.01
RobinsonUpper	Upper	3100	2 Year	0.10	130.79
RobinsonUpper	Upper	3100	5 Year	0.10	130.79
RobinsonUpper	Upper	3100	10 Year	1.64	131.05
RobinsonUpper	Upper	3100	25 Year	3.75	131.18
RobinsonUpper	Upper	3100	50 Year	5.39	131.26
RobinsonUpper	Upper	3000	100 Year	7.05	131.18
RobinsonUpper	Upper	3000	Regional	1.21	130.96
RobinsonUpper	Upper	3000	2 Year	0.10	130.53
RobinsonUpper	Upper	3000	5 Year	0.10	130.53
RobinsonUpper	Upper	3000	10 Year	1.64	130.98
RobinsonUpper	Upper	3000	25 Year	3.75	131.04
RobinsonUpper	Upper	3000	50 Year	5.39	131.11
RobinsonUpper	Upper	2917.452	100 Year	7.05	131.18
RobinsonUpper	Upper	2917.452	Regional	1.21	130.96
RobinsonUpper	Upper	2917.452	2 Year	0.10	130.07
RobinsonUpper	Upper	2917.452	5 Year	0.10	130.07
RobinsonUpper	Upper	2917.452	10 Year	1.64	130.98
RobinsonUpper	Upper	2917.452	25 Year	3.75	131.04
RobinsonUpper	Upper	2917.452	50 Year	5.39	131.11
RobinsonUpper	Upper	2906.009	100 Year	7.05	131.09
RobinsonUpper	Upper	2906.009	Regional	1.21	130.94
RobinsonUpper	Upper	2906.009	2 Year	0.10	130.07
RobinsonUpper	Upper	2906.009	5 Year	0.10	130.07
RobinsonUpper	Upper	2906.009	10 Year	1.64	130.96
RobinsonUpper	Upper	2906.009	25 Year	3.75	130.90
RobinsonUpper	Upper	2906.009	50 Year	5.39	130.64
RobinsonUpper	Upper	2894.430		Culvert	
RobinsonUpper	Upper	2882.851	100 Year	7.05	130.60
RobinsonUpper	Upper	2882.851	Regional	1.21	130.30
RobinsonUpper	Upper	2882.851	2 Year	0.10	130.06
RobinsonUpper	Upper	2882.851	5 Year	0.10	130.06
RobinsonUpper	Upper	2882.851	10 Year	1.64	130.39
RobinsonUpper	Upper	2882.851	25 Year	3.75	130.49
RobinsonUpper	Upper	2882.851	50 Year	5.39	130.55
RobinsonUpper	Upper	2855.660	100 Year	7.05	130.50
RobinsonUpper	Upper	2855.660	Regional	1.21	130.27
RobinsonUpper	Upper	2855.660	2 Year	0.10	130.04
RobinsonUpper	Upper	2855.660	5 Year	0.10	130.04

HEC-RAS Plan: Robinson (Continued)

River	Reach	River Sta	Profile	Q Total	W.S. Elev
				(m3/s)	(m)
RobinsonUpper	Upper	2855.660	10 Year	1.64	130.31
RobinsonUpper	Upper	2855.660	25 Year	3.75	130.40
RobinsonUpper	Upper	2855.660	50 Year	5.39	130.45
RobinsonUpper	Upper	2800	100 Year	7.05	130.11
RobinsonUpper	Upper	2800	Regional	1.21	129.91
RobinsonUpper	Upper	2800	2 Year	0.10	129.63
RobinsonUpper	Upper	2800	5 Year	0.10	129.63
RobinsonUpper	Upper	2800	10 Year	1.64	129.96
RobinsonUpper	Upper	2800	25 Year	3.75	130.06
RobinsonUpper	Upper	2800	50 Year	5.39	130.09
RobinsonUpper	Upper	2700	100 Year	7.05	128.72
RobinsonUpper	Upper	2700	Regional	1.21	128.50
RobinsonUpper	Upper	2700	2 Year	0.10	128.26
RobinsonUpper	Upper	2700	5 Year	0.10	128.26
RobinsonUpper	Upper	2700	10 Year	1.64	128.53
RobinsonUpper	Upper	2700	25 Year	3.75	128.64
RobinsonUpper	Upper	2700	50 Year	5.39	128.68
RobinsonUpper	Upper	2600	100 Year	7.48	127.69
RobinsonUpper	Upper	2600	Regional	2.07	127.41
RobinsonUpper	Upper	2600	2 Year	0.64	127.24
RobinsonUpper	Upper	2600	5 Year	0.96	127.30
RobinsonUpper	Upper	2600	10 Year	1.97	127.40
RobinsonUpper	Upper	2600	25 Year	3.91	127.53
RobinsonUpper	Upper	2600	50 Year	5.69	127.61
RobinsonUpper	Upper	2539.354	100 Year	7.48	127.47
RobinsonUpper	Upper	2539.354	Regional	2.07	127.18
RobinsonUpper	Upper	2539.354	2 Year	0.64	127.04
RobinsonUpper	Upper	2539.354	5 Year	0.96	127.08
RobinsonUpper	Upper	2539.354	10 Year	1.97	127.17
RobinsonUpper	Upper	2539.354	25 Year	3.91	127.30
RobinsonUpper	Upper	2539.354	50 Year	5.69	127.39
RobinsonUpper	Upper	2529.293	100 Year	7.48	127.47
RobinsonUpper	Upper	2529.293	Regional	2.07	127.18
RobinsonUpper	Upper	2529.293	2 Year	0.64	127.03
RobinsonUpper	Upper	2529.293	5 Year	0.96	127.08
RobinsonUpper	Upper	2529.293	10 Year	1.97	127.17
RobinsonUpper	Upper	2529.293	25 Year	3.91	127.30
RobinsonUpper	Upper	2529.293	50 Year	5.69	127.39
RobinsonUpper	Upper	2519.291	100 Year	7.48	127.44
RobinsonUpper	Upper	2519.291	Regional	2.07	127.14
RobinsonUpper	Upper	2519.291	2 Year	0.64	126.99
RobinsonUpper	Upper	2519.291	5 Year	0.96	127.04
RobinsonUpper	Upper	2519.291	10 Year	1.97	127.14
RobinsonUpper	Upper	2519.291	25 Year	3.91	127.26
RobinsonUpper	Upper	2519.291	50 Year	5.69	127.36

HEC-RAS Plan: Robinson (Continued)

River	Reach	River Sta	Profile	Q Total	W.S. Elev
				(m3/s)	(m)
RobinsonUpper	Upper	2499.168	100 Year	7.48	127.27
RobinsonUpper	Upper	2499.168	Regional	2.07	126.98
RobinsonUpper	Upper	2499.168	2 Year	0.64	126.80
RobinsonUpper	Upper	2499.168	5 Year	0.96	126.84
RobinsonUpper	Upper	2499.168	10 Year	1.97	126.97
RobinsonUpper	Upper	2499.168	25 Year	3.91	127.13
RobinsonUpper	Upper	2499.168	50 Year	5.69	127.21
RobinsonUpper	Upper	2400	100 Year	7.48	126.87
RobinsonUpper	Upper	2400	Regional	2.07	126.53
RobinsonUpper	Upper	2400	2 Year	0.64	126.39
RobinsonUpper	Upper	2400	5 Year	0.96	126.44
RobinsonUpper	Upper	2400	10 Year	1.97	126.53
RobinsonUpper	Upper	2400	25 Year	3.91	126.63
RobinsonUpper	Upper	2400	50 Year	5.69	126.74
RobinsonUpper	Upper	2300	100 Year	13.92	126.20
RobinsonUpper	Upper	2300	Regional	3.01	126.03
RobinsonUpper	Upper	2300	2 Year	0.85	125.94
RobinsonUpper	Upper	2300	5 Year	1.50	125.97
RobinsonUpper	Upper	2300	10 Year	3.13	126.04
RobinsonUpper	Upper	2300	25 Year	7.23	126.15
RobinsonUpper	Upper	2300	50 Year	10.74	126.20
RobinsonUpper	Upper	2200	100 Year	13.92	125.62
RobinsonUpper	Upper	2200	Regional	3.01	125.44
RobinsonUpper	Upper	2200	2 Year	0.85	125.29
RobinsonUpper	Upper	2200	5 Year	1.50	125.38
RobinsonUpper	Upper	2200	10 Year	3.13	125.44
RobinsonUpper	Upper	2200	25 Year	7.23	125.49
RobinsonUpper	Upper	2200	50 Year	10.74	125.55
RobinsonUpper	Upper	2154.378	100 Year	13.92	125.57
RobinsonUpper	Upper	2154.378	Regional	3.01	125.22
RobinsonUpper	Upper	2154.378	2 Year	0.85	125.03
RobinsonUpper	Upper	2154.378	5 Year	1.50	125.12
RobinsonUpper	Upper	2154.378	10 Year	3.13	125.23
RobinsonUpper	Upper	2154.378	25 Year	7.23	125.37
RobinsonUpper	Upper	2154.378	50 Year	10.74	125.48
RobinsonUpper	Upper	2100	100 Year	13.92	125.22
RobinsonUpper	Upper	2100	Regional	3.01	124.70
RobinsonUpper	Upper	2100	2 Year	0.85	124.45
RobinsonUpper	Upper	2100	5 Year	1.50	124.55
RobinsonUpper	Upper	2100	10 Year	3.13	124.72
RobinsonUpper	Upper	2100	25 Year	7.23	124.97
RobinsonUpper	Upper	2100	50 Year	10.74	125.13
RobinsonUpper	Upper	2000	100 Year	19.99	123.04
RobinsonUpper	Upper	2000	Regional	8.06	122.67

HEC-RAS Plan: Robinson (Continued)

River	Reach	River Sta	Profile	Q Total	W.S. Elev
				(m3/s)	(m)
RobinsonUpper	Upper	2000	2 Year	3.32	122.45
RobinsonUpper	Upper	2000	5 Year	5.03	122.54
RobinsonUpper	Upper	2000	10 Year	6.20	122.60
RobinsonUpper	Upper	2000	25 Year	7.74	122.66
RobinsonUpper	Upper	2000	50 Year	8.93	122.70
RobinsonUpper	Upper	1900	100 Year	19.99	119.77
RobinsonUpper	Upper	1900	Regional	8.06	119.37
RobinsonUpper	Upper	1900	2 Year	3.32	119.12
RobinsonUpper	Upper	1900	5 Year	5.03	119.22
RobinsonUpper	Upper	1900	10 Year	6.20	119.29
RobinsonUpper	Upper	1900	25 Year	7.74	119.35
RobinsonUpper	Upper	1900	50 Year	8.93	119.41
RobinsonUpper	Upper	1800	100 Year	19.99	116.50
RobinsonUpper	Upper	1800	Regional	8.06	116.07
RobinsonUpper	Upper	1800	2 Year	3.32	115.78
RobinsonUpper	Upper	1800	5 Year	5.03	115.90
RobinsonUpper	Upper	1800	10 Year	6.20	115.97
RobinsonUpper	Upper	1800	25 Year	7.74	116.05
RobinsonUpper	Upper	1800	50 Year	8.93	116.11
RobinsonUpper	Upper	1700	100 Year	32.59	112.88
RobinsonUpper	Upper	1700	Regional	16.17	112.70
RobinsonUpper	Upper	1700	2 Year	7.03	112.56
RobinsonUpper	Upper	1700	5 Year	11.37	112.63
RobinsonUpper	Upper	1700	10 Year	13.88	112.67
RobinsonUpper	Upper	1700	25 Year	17.26	112.71
RobinsonUpper	Upper	1700	50 Year	21.11	112.76
RobinsonUpper	Upper	1478.247	100 Year	32.59	111.89
RobinsonUpper	Upper	1478.247	Regional	16.17	111.64
RobinsonUpper	Upper	1478.247	2 Year	7.03	111.31
RobinsonUpper	Upper	1478.247	5 Year	11.37	111.64
RobinsonUpper	Upper	1478.247	10 Year	13.88	111.64
RobinsonUpper	Upper	1478.247	25 Year	17.26	111.64
RobinsonUpper	Upper	1478.247	50 Year	21.11	111.76
RobinsonUpper	Upper	1466.204		Culvert	
RobinsonUpper	Upper	1454.188	100 Year	32.59	109.56
RobinsonUpper	Upper	1454.188	Regional	16.17	108.58
RobinsonUpper	Upper	1454.188	2 Year	7.03	107.89
RobinsonUpper	Upper	1454.188	5 Year	11.37	108.24
RobinsonUpper	Upper	1454.188	10 Year	13.88	108.43
RobinsonUpper	Upper	1454.188	25 Year	17.26	108.65
RobinsonUpper	Upper	1454.188	50 Year	21.11	108.90
RobinsonUpper	Upper	1421.456	100 Year	32.59	107.87
RobinsonUpper	Upper	1421.456	Regional	16.17	107.63
RobinsonUpper	Upper	1421.456	2 Year	7.03	107.42

HEC-RAS Plan: Robinson (Continued)

River	Reach	River Sta	Profile	Q Total	W.S. Elev
				(m3/s)	(m)
RobinsonUpper	Upper	1421.456	5 Year	11.37	107.53
RobinsonUpper	Upper	1421.456	10 Year	13.88	107.59
RobinsonUpper	Upper	1421.456	25 Year	17.26	107.65
RobinsonUpper	Upper	1421.456	50 Year	21.11	107.71
RobinsonUpper	Upper	1400	100 Year	32.59	107.54
RobinsonUpper	Upper	1400	Regional	16.17	107.34
RobinsonUpper	Upper	1400	2 Year	7.03	107.16
RobinsonUpper	Upper	1400	5 Year	11.37	107.26
RobinsonUpper	Upper	1400	10 Year	13.88	107.30
RobinsonUpper	Upper	1400	25 Year	17.26	107.35
RobinsonUpper	Upper	1400	50 Year	21.11	107.41
RobinsonUpper	Upper	1300	100 Year	32.59	106.58
RobinsonUpper	Upper	1300	Regional	16.17	106.36
RobinsonUpper	Upper	1300	2 Year	7.03	106.14
RobinsonUpper	Upper	1300	5 Year	11.37	106.24
RobinsonUpper	Upper	1300	10 Year	13.88	106.29
RobinsonUpper	Upper	1300	25 Year	17.26	106.36
RobinsonUpper	Upper	1300	50 Year	21.11	106.42
RobinsonUpper	Upper	1200	100 Year	31.80	105.82
RobinsonUpper	Upper	1200	Regional	19.14	105.68
RobinsonUpper	Upper	1200	2 Year	7.05	105.43
RobinsonUpper	Upper	1200	5 Year	10.91	105.52
RobinsonUpper	Upper	1200	10 Year	13.55	105.58
RobinsonUpper	Upper	1200	25 Year	17.05	105.64
RobinsonUpper	Upper	1200	50 Year	20.47	105.69
RobinsonUpper	Upper	1100	100 Year	31.80	105.14
RobinsonUpper	Upper	1100	Regional	19.14	104.89
RobinsonUpper	Upper	1100	2 Year	7.05	104.51
RobinsonUpper	Upper	1100	5 Year	10.91	104.65
RobinsonUpper	Upper	1100	10 Year	13.55	104.73
RobinsonUpper	Upper	1100	25 Year	17.05	104.82
RobinsonUpper	Upper	1100	50 Year	20.47	104.90
RobinsonUpper	Upper	1000	100 Year	31.80	104.36
RobinsonUpper	Upper	1000	Regional	19.14	104.10
RobinsonUpper	Upper	1000	2 Year	7.05	103.77
RobinsonUpper	Upper	1000	5 Year	10.91	103.92
RobinsonUpper	Upper	1000	10 Year	13.55	104.01
RobinsonUpper	Upper	1000	25 Year	17.05	104.11
RobinsonUpper	Upper	1000	50 Year	20.47	104.19
RobinsonUpper	Upper	900	100 Year	44.23	103.50
RobinsonUpper	Upper	900	Regional	26.87	103.23
RobinsonUpper	Upper	900	2 Year	12.50	102.92
RobinsonUpper	Upper	900	5 Year	19.73	103.09
RobinsonUpper	Upper	900	10 Year	24.31	103.18
RobinsonUpper	Upper	900	25 Year	30.31	103.28

HEC-RAS Plan: Robinson (Continued)

River	Reach	River Sta	Profile	Q Total	W.S. Elev
				(m3/s)	(m)
RobinsonUpper	Upper	900	50 Year	35.56	103.37
RobinsonUpper	Upper	800	100 Year	44.23	102.27
RobinsonUpper	Upper	800	Regional	26.87	102.01
RobinsonUpper	Upper	800	2 Year	12.50	101.70
RobinsonUpper	Upper	800	5 Year	19.73	101.88
RobinsonUpper	Upper	800	10 Year	24.31	101.97
RobinsonUpper	Upper	800	25 Year	30.31	102.07
RobinsonUpper	Upper	800	50 Year	35.56	102.15
RobinsonUpper	Upper	700	100 Year	44.23	100.63
RobinsonUpper	Upper	700	Regional	26.87	100.43
RobinsonUpper	Upper	700	2 Year	12.50	100.21
RobinsonUpper	Upper	700	5 Year	19.73	100.33
RobinsonUpper	Upper	700	10 Year	24.31	100.40
RobinsonUpper	Upper	700	25 Year	30.31	100.48
RobinsonUpper	Upper	700	50 Year	35.56	100.54
RobinsonUpper	Upper	600	100 Year	44.23	99.25
RobinsonUpper	Upper	600	Regional	26.87	98.99
RobinsonUpper	Upper	600	2 Year	12.50	98.61
RobinsonUpper	Upper	600	5 Year	19.73	98.83
RobinsonUpper	Upper	600	10 Year	24.31	98.91
RobinsonUpper	Upper	600	25 Year	30.31	99.03
RobinsonUpper	Upper	600	50 Year	35.56	99.13
RobinsonUpper	Upper	500	100 Year	49.08	98.33
RobinsonUpper	Upper	500	Regional	31.54	98.09
RobinsonUpper	Upper	500	2 Year	12.43	97.68
RobinsonUpper	Upper	500	5 Year	20.55	97.85
RobinsonUpper	Upper	500	10 Year	26.07	98.00
RobinsonUpper	Upper	500	25 Year	33.57	98.12
RobinsonUpper	Upper	500	50 Year	39.99	98.20
RobinsonUpper	Upper	400	100 Year	49.08	96.31
RobinsonUpper	Upper	400	Regional	31.54	96.31
RobinsonUpper	Upper	400	2 Year	12.43	95.78
RobinsonUpper	Upper	400	5 Year	20.55	96.07
RobinsonUpper	Upper	400	10 Year	26.07	96.10
RobinsonUpper	Upper	400	25 Year	33.57	96.23
RobinsonUpper	Upper	400	50 Year	39.99	96.33
RobinsonUpper	Upper	300	100 Year	49.08	96.16
RobinsonUpper	Upper	300	Regional	31.54	96.27
RobinsonUpper	Upper	300	2 Year	12.43	94.90
RobinsonUpper	Upper	300	5 Year	20.55	95.02
RobinsonUpper	Upper	300	10 Year	26.07	95.26
RobinsonUpper	Upper	300	25 Year	33.57	95.37
RobinsonUpper	Upper	300	50 Year	39.99	95.45
RobinsonUpper	Upper	200	100 Year	49.08	96.19

HEC-RAS Plan: Robinson (Continued)

River	Reach	River Sta	Profile	Q Total	W.S. Elev
				(m3/s)	(m)
RobinsonUpper	Upper	200	Regional	31.54	96.28
RobinsonUpper	Upper	200	2 Year	12.43	93.80
RobinsonUpper	Upper	200	5 Year	20.55	93.89
RobinsonUpper	Upper	200	10 Year	26.07	93.93
RobinsonUpper	Upper	200	25 Year	33.57	93.99
RobinsonUpper	Upper	200	50 Year	39.99	94.03
RobinsonUpper	Upper	11.06822	100 Year	49.08	96.19
RobinsonUpper	Upper	11.06822	Regional	31.54	96.28
RobinsonUpper	Upper	11.06822	2 Year	12.43	92.78
RobinsonUpper	Upper	11.06822	5 Year	20.55	92.92
RobinsonUpper	Upper	11.06822	10 Year	26.07	92.99
RobinsonUpper	Upper	11.06822	25 Year	33.57	93.07
RobinsonUpper	Upper	11.06822	50 Year	39.99	93.50
RobinsonLower	Lower	2075.481	100 Year	92.18	96.19
RobinsonLower	Lower	2075.481	Regional	54.72	96.28
RobinsonLower	Lower	2075.481	2 Year	17.67	92.77
RobinsonLower	Lower	2075.481	5 Year	28.02	92.91
RobinsonLower	Lower	2075.481	10 Year	35.52	92.98
RobinsonLower	Lower	2075.481	25 Year	46.08	93.06
RobinsonLower	Lower	2075.481	50 Year	54.59	93.50
RobinsonLower	Lower	2000	100 Year	92.18	96.19
RobinsonLower	Lower	2000	Regional	54.72	96.28
RobinsonLower	Lower	2000	2 Year	17.67	92.49
RobinsonLower	Lower	2000	5 Year	28.02	92.72
RobinsonLower	Lower	2000	10 Year	35.52	92.74
RobinsonLower	Lower	2000	25 Year	46.08	92.79
RobinsonLower	Lower	2000	50 Year	54.59	93.48
RobinsonLower	Lower	1900	100 Year	92.18	96.19
RobinsonLower	Lower	1900	Regional	54.72	96.28
RobinsonLower	Lower	1900	2 Year	17.67	91.76
RobinsonLower	Lower	1900	5 Year	28.02	91.90
RobinsonLower	Lower	1900	10 Year	35.52	92.23
RobinsonLower	Lower	1900	25 Year	46.08	92.60
RobinsonLower	Lower	1900	50 Year	54.59	93.48
RobinsonLower	Lower	1800	100 Year	92.18	96.19
RobinsonLower	Lower	1800	Regional	54.72	96.28
RobinsonLower	Lower	1800	2 Year	17.67	91.45
RobinsonLower	Lower	1800	5 Year	28.02	91.92
RobinsonLower	Lower	1800	10 Year	35.52	92.22
RobinsonLower	Lower	1800	25 Year	46.08	92.56
RobinsonLower	Lower	1800	50 Year	54.59	93.47
RobinsonLower	Lower	1700	100 Year	92.18	96.19
RobinsonLower	Lower	1700	Regional	54.72	96.28
RobinsonLower	Lower	1700	2 Year	17.67	91.36
RobinsonLower	Lower	1700	5 Year	28.02	91.89

HEC-RAS Plan: Robinson (Continued)

River	Reach	River Sta	Profile	Q Total	W.S. Elev
				(m3/s)	(m)
RobinsonLower	Lower	1700	10 Year	35.52	92.20
RobinsonLower	Lower	1700	25 Year	46.08	92.54
RobinsonLower	Lower	1700	50 Year	54.59	93.47
RobinsonLower	Lower	1600	100 Year	89.88	96.19
RobinsonLower	Lower	1600	Regional	61.05	96.28
RobinsonLower	Lower	1600	2 Year	15.66	91.33
RobinsonLower	Lower	1600	5 Year	26.39	91.87
RobinsonLower	Lower	1600	10 Year	34.22	92.18
RobinsonLower	Lower	1600	25 Year	46.05	92.53
RobinsonLower	Lower	1600	50 Year	55.35	93.47
RobinsonLower	Lower	1500	100 Year	89.88	96.19
RobinsonLower	Lower	1500	Regional	61.05	96.28
RobinsonLower	Lower	1500	2 Year	15.66	91.33
RobinsonLower	Lower	1500	5 Year	26.39	91.87
RobinsonLower	Lower	1500	10 Year	34.22	92.18
RobinsonLower	Lower	1500	25 Year	46.05	92.53
RobinsonLower	Lower	1500	50 Year	55.35	93.47
RobinsonLower	Lower	1408.420	100 Year	89.88	96.19
RobinsonLower	Lower	1408.420	Regional	61.05	96.28
RobinsonLower	Lower	1408.420	2 Year	15.66	91.32
RobinsonLower	Lower	1408.420	5 Year	26.39	91.86
RobinsonLower	Lower	1408.420	10 Year	34.22	92.18
RobinsonLower	Lower	1408.420	25 Year	46.05	92.52
RobinsonLower	Lower	1408.420	50 Year	55.35	93.47
RobinsonLower	Lower	1389.432	100 Year	89.88	96.08
RobinsonLower	Lower	1389.432	Regional	61.05	96.23
RobinsonLower	Lower	1389.432	2 Year	15.66	91.28
RobinsonLower	Lower	1389.432	5 Year	26.39	91.79
RobinsonLower	Lower	1389.432	10 Year	34.22	92.08
RobinsonLower	Lower	1389.432	25 Year	46.05	92.38
RobinsonLower	Lower	1389.432	50 Year	55.35	93.35
RobinsonLower	Lower	1370.068		Culvert	
RobinsonLower	Lower	1349.056	100 Year	89.88	95.30
RobinsonLower	Lower	1349.056	Regional	61.05	93.96
RobinsonLower	Lower	1349.056	2 Year	15.66	89.81
RobinsonLower	Lower	1349.056	5 Year	26.39	90.13
RobinsonLower	Lower	1349.056	10 Year	34.22	90.35
RobinsonLower	Lower	1349.056	25 Year	46.05	90.64
RobinsonLower	Lower	1349.056	50 Year	55.35	92.15
RobinsonLower	Lower	1318.902	100 Year	89.88	95.44
RobinsonLower	Lower	1318.902	Regional	61.05	94.07
RobinsonLower	Lower	1318.902	2 Year	15.66	89.26
RobinsonLower	Lower	1318.902	5 Year	26.39	89.48
RobinsonLower	Lower	1318.902	10 Year	34.22	89.85

HEC-RAS Plan: Robinson (Continued)

River	Reach	River Sta	Profile	Q Total	W.S. Elev
				(m3/s)	(m)
RobinsonLower	Lower	1318.902	25 Year	46.05	90.57
RobinsonLower	Lower	1318.902	50 Year	55.35	92.37
RobinsonLower	Lower	1300	100 Year	91.04	95.44
RobinsonLower	Lower	1300	Regional	63.01	94.07
RobinsonLower	Lower	1300	2 Year	17.39	88.99
RobinsonLower	Lower	1300	5 Year	27.65	89.26
RobinsonLower	Lower	1300	10 Year	35.94	89.81
RobinsonLower	Lower	1300	25 Year	47.44	90.57
RobinsonLower	Lower	1300	50 Year	57.28	92.37
RobinsonLower	Lower	1225.673	100 Year	91.04	95.44
RobinsonLower	Lower	1225.673	Regional	63.01	94.06
RobinsonLower	Lower	1225.673	2 Year	17.39	88.75
RobinsonLower	Lower	1225.673	5 Year	27.65	89.36
RobinsonLower	Lower	1225.673	10 Year	35.94	89.82
RobinsonLower	Lower	1225.673	25 Year	47.44	90.56
RobinsonLower	Lower	1225.673	50 Year	57.28	92.36
RobinsonLower	Lower	1208.394	100 Year	91.04	95.43
RobinsonLower	Lower	1208.394	Regional	63.01	93.87
RobinsonLower	Lower	1208.394	2 Year	17.39	88.16
RobinsonLower	Lower	1208.394	5 Year	27.65	88.56
RobinsonLower	Lower	1208.394	10 Year	35.94	89.11
RobinsonLower	Lower	1208.394	25 Year	47.44	89.94
RobinsonLower	Lower	1208.394	50 Year	57.28	92.07
RobinsonLower	Lower	1186.848		Culvert	
RobinsonLower	Lower	1174.573	100 Year	91.04	95.29
RobinsonLower	Lower	1174.573	Regional	63.01	92.44
RobinsonLower	Lower	1174.573	2 Year	17.39	87.71
RobinsonLower	Lower	1174.573	5 Year	27.65	88.17
RobinsonLower	Lower	1174.573	10 Year	35.94	88.54
RobinsonLower	Lower	1174.573	25 Year	47.44	88.94
RobinsonLower	Lower	1174.573	50 Year	57.28	90.88
RobinsonLower	Lower	1146.689	100 Year	91.04	95.29
RobinsonLower	Lower	1146.689	Regional	63.01	92.53
RobinsonLower	Lower	1146.689	2 Year	17.39	87.06
RobinsonLower	Lower	1146.689	5 Year	27.65	87.69
RobinsonLower	Lower	1146.689	10 Year	35.94	88.20
RobinsonLower	Lower	1146.689	25 Year	47.44	89.30
RobinsonLower	Lower	1146.689	50 Year	57.28	91.24
RobinsonLower	Lower	1076.022	100 Year	91.47	95.29
RobinsonLower	Lower	1076.022	Regional	63.75	92.53
RobinsonLower	Lower	1076.022	2 Year	18.03	87.00
RobinsonLower	Lower	1076.022	5 Year	27.82	87.66
RobinsonLower	Lower	1076.022	10 Year	36.35	88.18
RobinsonLower	Lower	1076.022	25 Year	47.82	89.29

HEC-RAS Plan: Robinson (Continued)

River	Reach	River Sta	Profile	Q Total	W.S. Elev
				(m3/s)	(m)
RobinsonLower	Lower	1076.022	50 Year	57.92	91.23
RobinsonLower	Lower	1050.327	100 Year	72.37	95.23
RobinsonLower	Lower	1050.327	Regional	63.75	92.44
RobinsonLower	Lower	1050.327	2 Year	18.03	86.76
RobinsonLower	Lower	1050.327	5 Year	27.82	87.43
RobinsonLower	Lower	1050.327	10 Year	36.35	87.94
RobinsonLower	Lower	1050.327	25 Year	47.82	89.10
RobinsonLower	Lower	1050.327	50 Year	57.92	91.12
RobinsonLower	Lower	994.6486		Culvert	
RobinsonLower	Lower	928.2293	100 Year	72.37	92.62
RobinsonLower	Lower	928.2293	Regional	63.75	90.45
RobinsonLower	Lower	928.2293	2 Year	18.03	85.26
RobinsonLower	Lower	928.2293	5 Year	27.82	86.01
RobinsonLower	Lower	928.2293	10 Year	36.35	86.85
RobinsonLower	Lower	928.2293	25 Year	47.82	88.11
RobinsonLower	Lower	928.2293	50 Year	57.92	89.52
RobinsonLower	Lower	918.8482	100 Year	72.37	92.60
RobinsonLower	Lower	918.8482	Regional	63.75	90.50
RobinsonLower	Lower	918.8482	2 Year	18.03	85.31
RobinsonLower	Lower	918.8482	5 Year	27.82	86.08
RobinsonLower	Lower	918.8482	10 Year	36.35	86.92
RobinsonLower	Lower	918.8482	25 Year	47.82	88.18
RobinsonLower	Lower	918.8482	50 Year	57.92	89.58
RobinsonLower	Lower	899.0165		Culvert	
RobinsonLower	Lower	876.9869	100 Year	92.05	87.85
RobinsonLower	Lower	876.9869	Regional	64.58	85.28
RobinsonLower	Lower	876.9869	2 Year	18.40	83.82
RobinsonLower	Lower	876.9869	5 Year	28.14	84.10
RobinsonLower	Lower	876.9869	10 Year	36.84	84.30
RobinsonLower	Lower	876.9869	25 Year	48.55	84.55
RobinsonLower	Lower	876.9869	50 Year	58.61	84.75
RobinsonLower	Lower	834.4676	100 Year	92.05	88.04
RobinsonLower	Lower	834.4676	Regional	64.58	85.69
RobinsonLower	Lower	834.4676	2 Year	18.40	83.00
RobinsonLower	Lower	834.4676	5 Year	28.14	83.59
RobinsonLower	Lower	834.4676	10 Year	36.84	84.06
RobinsonLower	Lower	834.4676	25 Year	48.55	84.69
RobinsonLower	Lower	834.4676	50 Year	58.61	85.29
RobinsonLower	Lower	823.6441	100 Year	92.05	88.04
RobinsonLower	Lower	823.6441	Regional	64.58	85.69
RobinsonLower	Lower	823.6441	2 Year	18.40	82.99
RobinsonLower	Lower	823.6441	5 Year	28.14	83.59
RobinsonLower	Lower	823.6441	10 Year	36.84	84.06

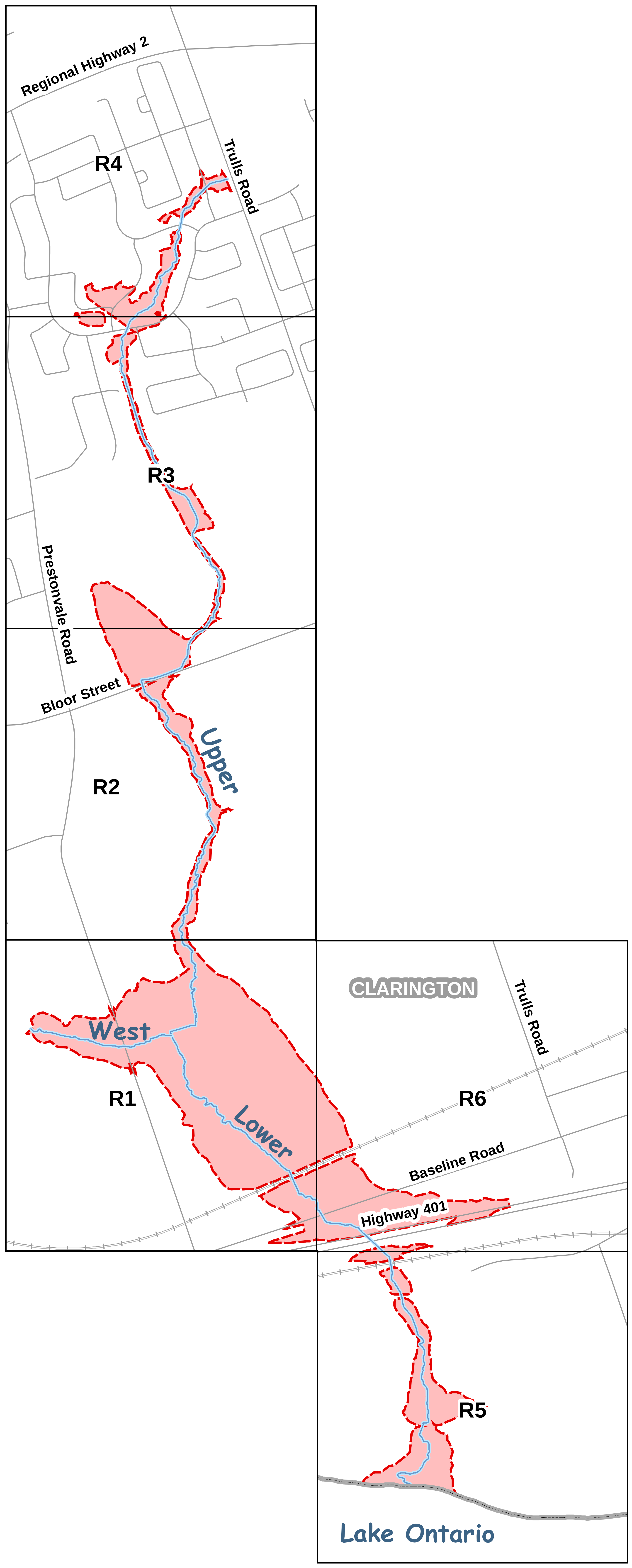
HEC-RAS Plan: Robinson (Continued)

River	Reach	River Sta	Profile	Q Total	W.S. Elev
				(m3/s)	(m)
RobinsonLower	Lower	823.6441	25 Year	48.55	84.69
RobinsonLower	Lower	823.6441	50 Year	58.61	85.30
RobinsonLower	Lower	800.6076	100 Year	92.05	87.70
RobinsonLower	Lower	800.6076	Regional	64.58	85.53
RobinsonLower	Lower	800.6076	2 Year	18.40	82.88
RobinsonLower	Lower	800.6076	5 Year	28.14	83.46
RobinsonLower	Lower	800.6076	10 Year	36.84	83.91
RobinsonLower	Lower	800.6076	25 Year	48.55	84.52
RobinsonLower	Lower	800.6076	50 Year	58.61	85.13
RobinsonLower	Lower	787.4796		Mult Open	
RobinsonLower	Lower	772.9675	100 Year	92.05	82.96
RobinsonLower	Lower	772.9675	Regional	64.58	82.67
RobinsonLower	Lower	772.9675	2 Year	18.40	82.04
RobinsonLower	Lower	772.9675	5 Year	28.14	82.18
RobinsonLower	Lower	772.9675	10 Year	36.84	82.24
RobinsonLower	Lower	772.9675	25 Year	48.55	82.46
RobinsonLower	Lower	772.9675	50 Year	58.61	82.60
RobinsonLower	Lower	728.9347	100 Year	92.05	82.89
RobinsonLower	Lower	728.9347	Regional	64.58	82.63
RobinsonLower	Lower	728.9347	2 Year	18.40	81.98
RobinsonLower	Lower	728.9347	5 Year	28.14	82.17
RobinsonLower	Lower	728.9347	10 Year	36.84	82.29
RobinsonLower	Lower	728.9347	25 Year	48.55	82.45
RobinsonLower	Lower	728.9347	50 Year	58.61	82.56
RobinsonLower	Lower	700	100 Year	92.05	82.38
RobinsonLower	Lower	700	Regional	64.58	82.19
RobinsonLower	Lower	700	2 Year	18.40	81.69
RobinsonLower	Lower	700	5 Year	28.14	81.84
RobinsonLower	Lower	700	10 Year	36.84	81.95
RobinsonLower	Lower	700	25 Year	48.55	82.06
RobinsonLower	Lower	700	50 Year	58.61	82.14
RobinsonLower	Lower	600	100 Year	92.05	82.36
RobinsonLower	Lower	600	Regional	64.58	80.76
RobinsonLower	Lower	600	2 Year	18.40	80.19
RobinsonLower	Lower	600	5 Year	28.14	80.37
RobinsonLower	Lower	600	10 Year	36.84	80.48
RobinsonLower	Lower	600	25 Year	48.55	80.61
RobinsonLower	Lower	600	50 Year	58.61	80.71
RobinsonLower	Lower	500	100 Year	91.20	82.36
RobinsonLower	Lower	500	Regional	68.31	80.32
RobinsonLower	Lower	500	2 Year	18.17	78.25
RobinsonLower	Lower	500	5 Year	28.09	78.49
RobinsonLower	Lower	500	10 Year	36.24	78.75
RobinsonLower	Lower	500	25 Year	48.06	78.98

HEC-RAS Plan: Robinson (Continued)

River	Reach	River Sta	Profile	Q Total	W.S. Elev
				(m3/s)	(m)
RobinsonLower	Lower	500	50 Year	57.52	79.53
RobinsonLower	Lower	400	100 Year	91.20	82.37
RobinsonLower	Lower	400	Regional	68.31	80.33
RobinsonLower	Lower	400	2 Year	18.17	77.90
RobinsonLower	Lower	400	5 Year	28.09	78.13
RobinsonLower	Lower	400	10 Year	36.24	78.34
RobinsonLower	Lower	400	25 Year	48.06	79.00
RobinsonLower	Lower	400	50 Year	57.52	79.57
RobinsonLower	Lower	349.8643	100 Year	91.20	82.37
RobinsonLower	Lower	349.8643	Regional	68.31	80.34
RobinsonLower	Lower	349.8643	2 Year	18.17	77.92
RobinsonLower	Lower	349.8643	5 Year	28.09	78.14
RobinsonLower	Lower	349.8643	10 Year	36.24	78.36
RobinsonLower	Lower	349.8643	25 Year	48.06	79.01
RobinsonLower	Lower	349.8643	50 Year	57.52	79.58
RobinsonLower	Lower	310.5079	100 Year	91.20	77.56
RobinsonLower	Lower	310.5079	Regional	68.31	77.54
RobinsonLower	Lower	310.5079	2 Year	18.17	77.88
RobinsonLower	Lower	310.5079	5 Year	28.09	78.12
RobinsonLower	Lower	310.5079	10 Year	36.24	77.53
RobinsonLower	Lower	310.5079	25 Year	48.06	77.50
RobinsonLower	Lower	310.5079	50 Year	57.52	77.52
RobinsonLower	Lower	302.0028		Culvert	
RobinsonLower	Lower	289.6513	100 Year	91.20	77.91
RobinsonLower	Lower	289.6513	Regional	68.31	77.82
RobinsonLower	Lower	289.6513	2 Year	18.17	77.16
RobinsonLower	Lower	289.6513	5 Year	28.09	77.38
RobinsonLower	Lower	289.6513	10 Year	36.24	77.70
RobinsonLower	Lower	289.6513	25 Year	48.06	77.75
RobinsonLower	Lower	289.6513	50 Year	57.52	77.79
RobinsonLower	Lower	254.9745	100 Year	91.20	77.21
RobinsonLower	Lower	254.9745	Regional	68.31	77.09
RobinsonLower	Lower	254.9745	2 Year	18.17	76.62
RobinsonLower	Lower	254.9745	5 Year	28.09	76.77
RobinsonLower	Lower	254.9745	10 Year	36.24	76.85
RobinsonLower	Lower	254.9745	25 Year	48.06	76.95
RobinsonLower	Lower	254.9745	50 Year	57.52	77.01
RobinsonLower	Lower	200	100 Year	91.20	76.79
RobinsonLower	Lower	200	Regional	68.31	76.70
RobinsonLower	Lower	200	2 Year	18.17	76.37
RobinsonLower	Lower	200	5 Year	28.09	76.46
RobinsonLower	Lower	200	10 Year	36.24	76.54
RobinsonLower	Lower	200	25 Year	48.06	76.61
RobinsonLower	Lower	200	50 Year	57.52	76.66

APPENDIX D
Floodplain Maps
(Reduced Scale)



Central Lake Ontario Conservation

This map is prepared for use in conjunction with the Hydrologic & Hydraulic modeling for Robinson Creek Documentation, 2010.

Floodplain modelling prepared by Engineering Department, CLOCA, using HECRAS 4.0, 2009. Input parameters were extracted from base mapping with the use of HEC-Geo RAS.

Base mapping compiled from First Base Solutions Digital Ortho Mapping & DEM Mapping derived from aerial photography (Spring 2005), carried out by Geomatics and Information Technology, CLOCA.

ROBINSON CREEK FLOODPLAIN MAPPING 2010

Drainage

Municipal Boundary

Regulatory Floodplain

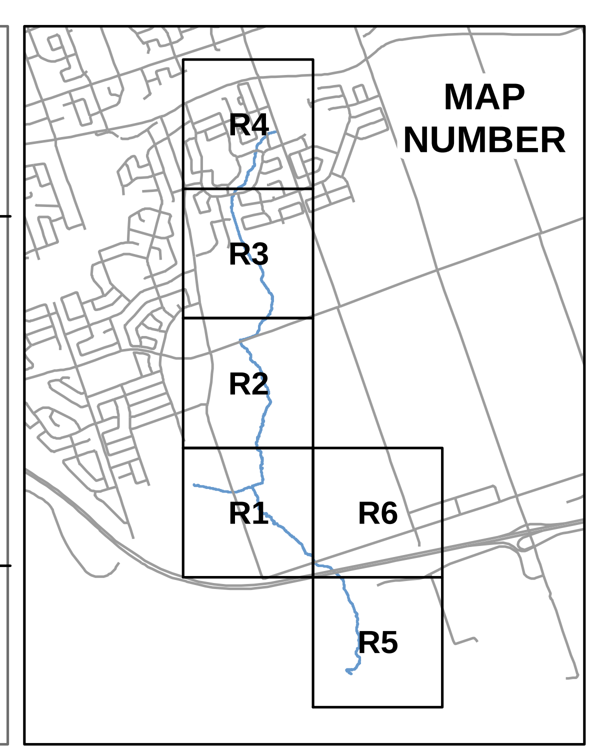
1:11,000

500 250 0 500 1,000

Metres

N

MAP NUMBER



REVISIONS AND UPDATES

NO.	DATE	REVISION

INDEX SHEET

Central Lake Ontario Conservation

This map is prepared for use in conjunction with the Hydrologic & Hydraulic modeling for Robinson Creek Documentation, 2010.

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ROBINSON CREEK
FLOODPLAIN MAPPING 2010

Regulatory Floodplain
Drainage
Study Limit
Lowest Weir Elevation
3800 Cross Section Number and Location
49.90 Regulatory Event Flood Elevation
Railway
Contour

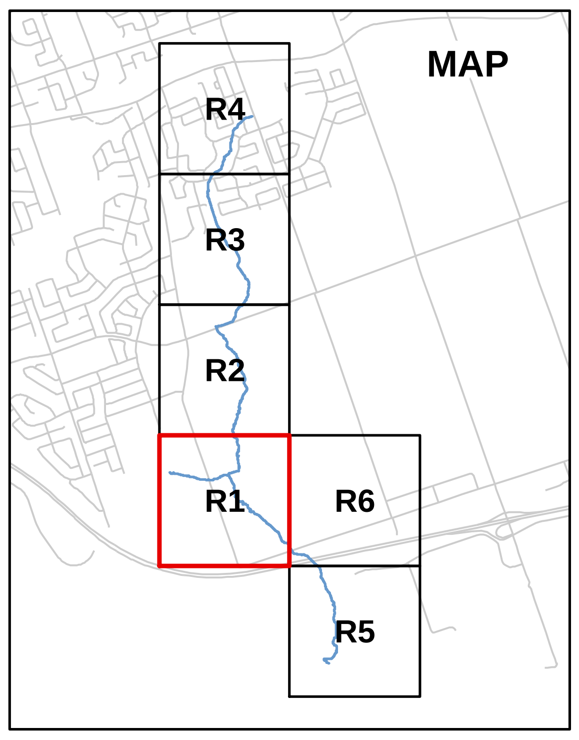
1:2,000

50 25 0 50 100 150 200 250 300

Metres

N

MAP



REVISIONS AND UPDATES

NO.	DATE	REVISION

SHEET NUMBER

6774861

MAP NUMBER

R1

Central Lake Ontario Conservation

This map is prepared for use in conjunction with the Hydrologic & Hydraulic modeling for Robinson Creek Documentation, 2010.

Floodplain modelling prepared by Engineering Department, CLOCA, using HECRAS 4.0, 2009. Input parameters were extracted from base mapping with the use of HEC-Geo RAS.

Base mapping compiled from First Base Solutions Digital Ortho Mapping & DEM Mapping derived from aerial photography (Spring 2005), carried out by Geomatics and Information Technology, CLOCA.

ROBINSON CREEK
FLOODPLAIN MAPPING 2010

- Regulatory Floodplain
- Drainage
- Study Limit
- Lowest Weir Elevation
- 3800 Cross Section Number and Location
- 49.90 Regulatory Event Flood Elevation
- Railway
- Contour

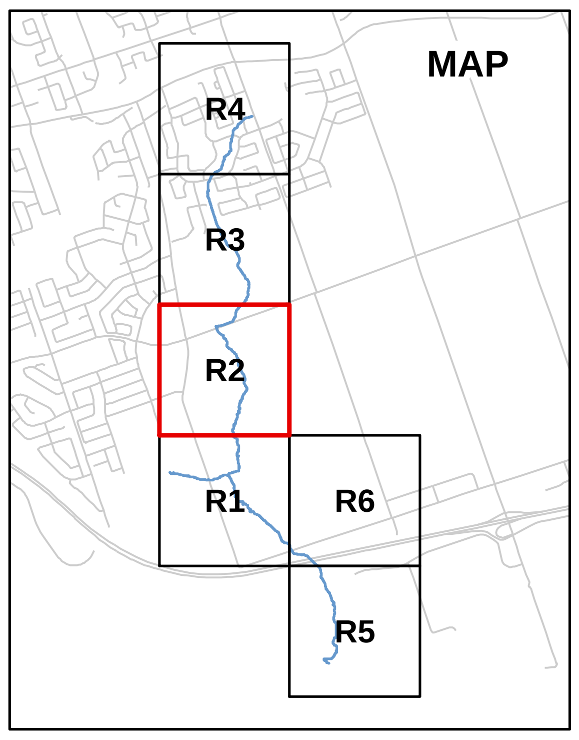
1:2,000

50 25 0 50 100 150 200 250 300

Metres

N

MAP



REVISIONS AND UPDATES

NO.	DATE	REVISION

SHEET NUMBER
6774862

MAP NUMBER
R2

R4

R2

Central Lake Ontario Conservation

This map is prepared for use in conjunction with the Hydrologic & Hydraulic modeling for Robinson Creek Documentation, 2010.

Floodplain modelling prepared by Engineering Department, CLOCA, using HECRAS 4.0, 2009. Input parameters were extracted from base mapping with the use of HEC-Geo RAS.

Base mapping compiled from First Base Solutions Digital Ortho Mapping & DEM Mapping derived from aerial photography (Spring 2005), carried out by Geomatics and Information Technology, CLOCA.

ROBINSON CREEK FLOODPLAIN MAPPING 2010

	Regulatory Floodplain	3800	Cross Section Number and Location
	Drainage	49.90	Regulatory Event Flood Elevation
	Study Limit		Railway
	Lowest Weir Elevation		Contour

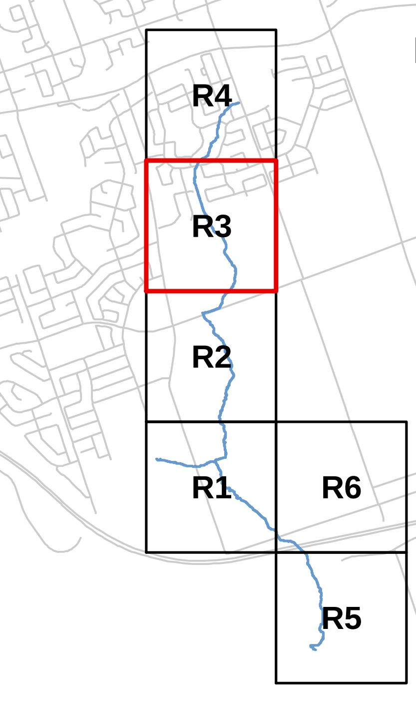
1:2,000

50 25 0 50 100 150 200 250 300

Metres

N

MAP



REVISIONS AND UPDATES

NO.	DATE	REVISION

SHEET NUMBER

6774863

MAP NUMBER

R3

This map is prepared for use in conjunction with the Hydrologic & Hydraulic modeling for Robinson Creek Documentation, 2010.

Floodplain modelling prepared by Engineering Department, CLOCA, using HECRAS 4.0, 2009. Input parameters were extracted from base mapping with the use of HEC-Geo RAS.

Base mapping compiled from First Base Solutions Digital Ortho Mapping & DEM Mapping derived from aerial photography (Spring 2005), carried out by Geomatics and Information Technology, CLOCA.

ROBINSON CREEK
FLOODPLAIN MAPPING 2010

- Regulatory Floodplain
- Drainage
- Study Limit
- Lowest Weir Elevation
- 3800 Cross Section Number and Location
- 49.90 Regulatory Event Flood Elevation
- Railway
- Contour

1:2,000

50 25 0 50 100 150 200 250 300

Metres

N

MAP

R4
R3
R2
R1
R6
R5

REVISIONS AND UPDATES

NO.	DATE	REVISION

SHEET NUMBER
6774864

MAP NUMBER
R4

Central Lake Ontario Conservation

This map is prepared for use in conjunction with the Hydrologic & Hydraulic modeling for Robinson Creek Documentation, 2010.

Floodplain modelling prepared by Engineering Department, CLOCA, using HECRAS 4.0, 2009. Input parameters were extracted from base mapping with the use of HEC-Geo RAS.

Base mapping compiled from First Base Solutions Digital Ortho Mapping & DEM Mapping derived from aerial photography (Spring 2005), carried out by Geomatics and Information Technology, CLOCA.

ROBINSON CREEK
FLOODPLAIN MAPPING 2010

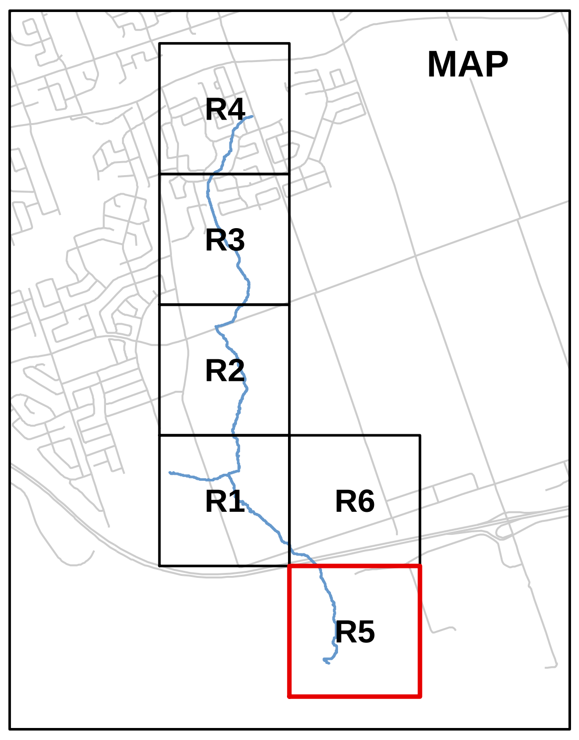
- Regulatory Floodplain
- Drainage
- Study Limit
- Lowest Weir Elevation
- 3800 Cross Section Number and Location
- 49.90 Regulatory Event Flood Elevation
- Railway
- Contour

1:2,000

50 25 0 50 100 150 200 250 300

Metres

N



REVISIONS AND UPDATES

NO.	DATE	REVISION

SHEET NUMBER
6784860

MAP NUMBER
R5

Central Lake Ontario Conservation

This map is prepared for use in conjunction with the Hydrologic & Hydraulic modeling for Robinson Creek Documentation, 2010.

Floodplain modelling prepared by Engineering Department, CLOCA, using HECRAS 4.0, 2009. Input parameters were extracted from base mapping with the use of HEC-Geo RAS.

Base mapping compiled from First Base Solutions Digital Ortho Mapping & DEM Mapping derived from aerial photography (Spring 2005), carried out by Geomatics and Information Technology, CLOCA.

ROBINSON CREEK
FLOODPLAIN MAPPING 2010

- Regulatory Floodplain
- Drainage
- Study Limit
- Lowest Weir Elevation
- 3800 Cross Section Number and Location
- 49.90 Regulatory Event Flood Elevation
- Railway
- Contour

1:2,000

50 25 0 50 100 150 200 250 300

Metres

N

MAP

R4
R3
R2
R1
R6
R5

REVISIONS AND UPDATES

NO.	DATE	REVISION

SHEET NUMBER
6784861

MAP NUMBER
R6

Appendix B

Hydrologic and Hydraulic Modelling for Tooley Creek (CLOCA, 2008, Revised, 2009)

HYDROLOGIC and HYDRAULIC MODELING FOR TOOLEY CREEK

DOCUMENTATION

Revised March 2008
October 2007

Central Lake Ontario Conservation

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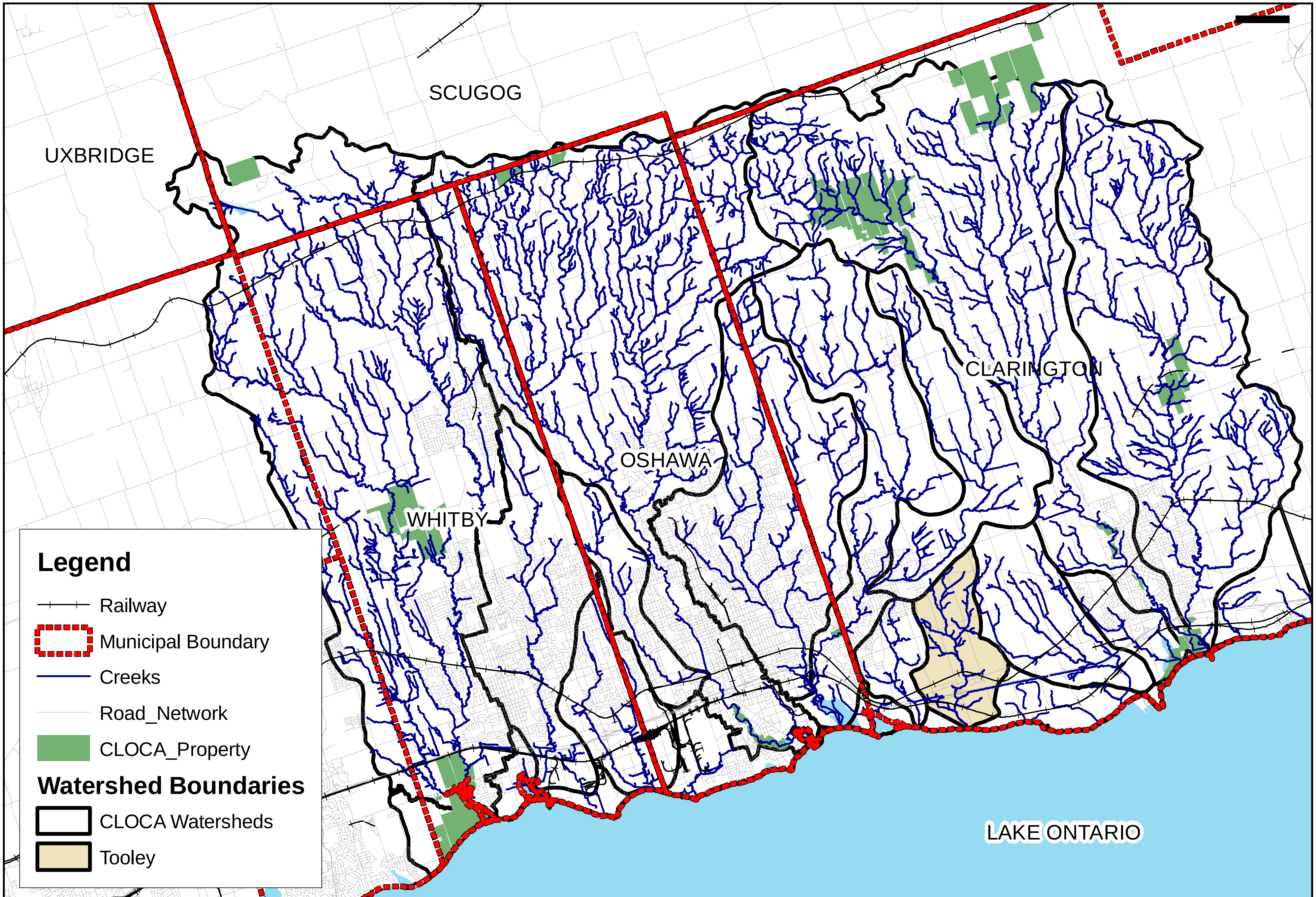
TABLE OF APPENDICES

1.0 INTRODUCTION

The existing hydrologic and hydraulic models for the Tooley Creek watershed were prepared by M.M. Dillon Consulting Engineers Ltd in 1974 (Whitby Bowmanville Area Floodplain Mapping). Although this work is still useful, the model versions are now antiquated and no longer available in digital format.

2.0 STUDY AREA

Tooley Creek is located in the Municipality of Clarington and is bounded by Trull's Road on the west and Solina Road on the East. The headwaters of Tooley Creek begin to the south of Nash Road. Figure 1 shows the location of Tooley Creek. The Tooley Creek watershed has a drainage area of approximately 1158 hectares, and has 6.5 kilometers of creek with a drainage area over 150 hectares.



Central Lake Ontario Conservation

Tooley Creek
Figure 1 - Location Plan

Date: October 26, 2007

3.0 METHODOLOGY

3.1 Base Mapping

Base mapping for the project was compiled from First Base Solutions Digital Ortho Mapping and Digital Elevation Modeling Mapping derived from aerial photography. The First Base Solutions Digital Ortho Mapping specifications are:

- 20cm pixel resolution,
- Projected and referenced in NAD83, 6 Degree Universal Transverse Mercator (UTM), Zone 17, Central Meridian 81 Degrees West Longitude
- 1km by 1km GeoTif format

3.2 Hydrology

The hydrology for Tooley Creek was created at the same time the hydraulics were and is not available in either digital or paper format. It was therefore determined that the creation of a new section of hydrology would be advantageous. A hydrology model was created in Visual Otthymo 2. The model was not calibrated, as there are no gauges within the Tooley Creek watershed.

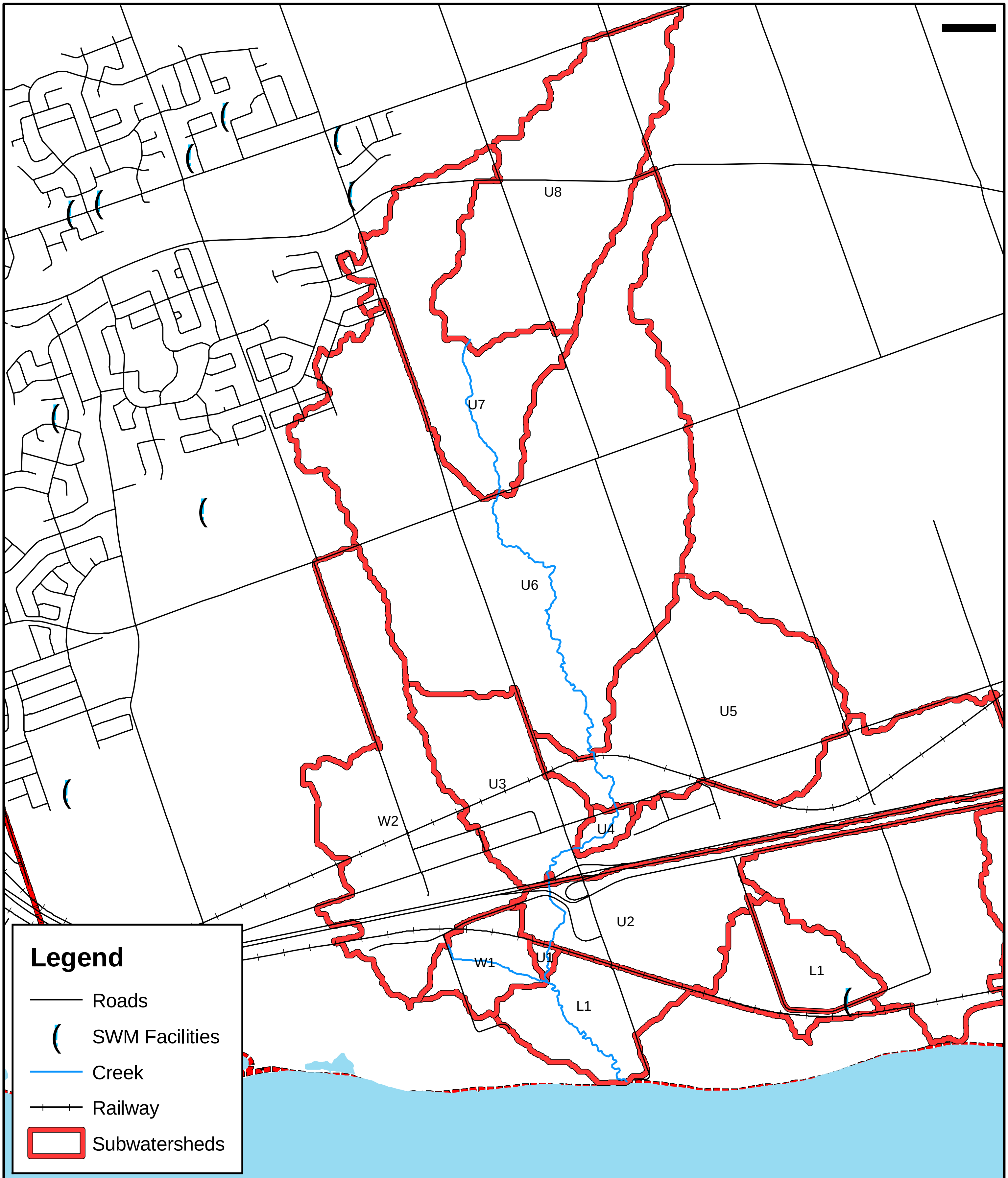
Twelve (12) subwatersheds were delineated for Tooley Creek. The subwatersheds were determined based on the DEM provided by First Base Solutions and are shown on Figure 2.

Subwatersheds with 20% or more total imperviousness are modeled as urban all others were modeled as rural.

The rural subwatersheds were modeled using the Nashyd command. Within this command, the CN parameter reflects the soil types, topography, vegetation cover and land use of each subwatershed. Initial abstraction, Ia, a weighted value was computed based on land use. Tables for CN, Ia, Soils Group Classification, C, and Imperviousness have been compiled and is included in Appendix A.

The urban subwatersheds were modeled using the Standhyd command. CN and Ia values were used for the pervious areas of the units and the Ximp (directly connected impervious area) and Timp (total impervious area) values are used to define the amount of imperviousness within each urban unit.

Model parameters were determined independently of the model using GIS queries, topographic mapping and published values. The required parameters and the method used for their determination is included in Appendix A.



Date: October 26, 2007

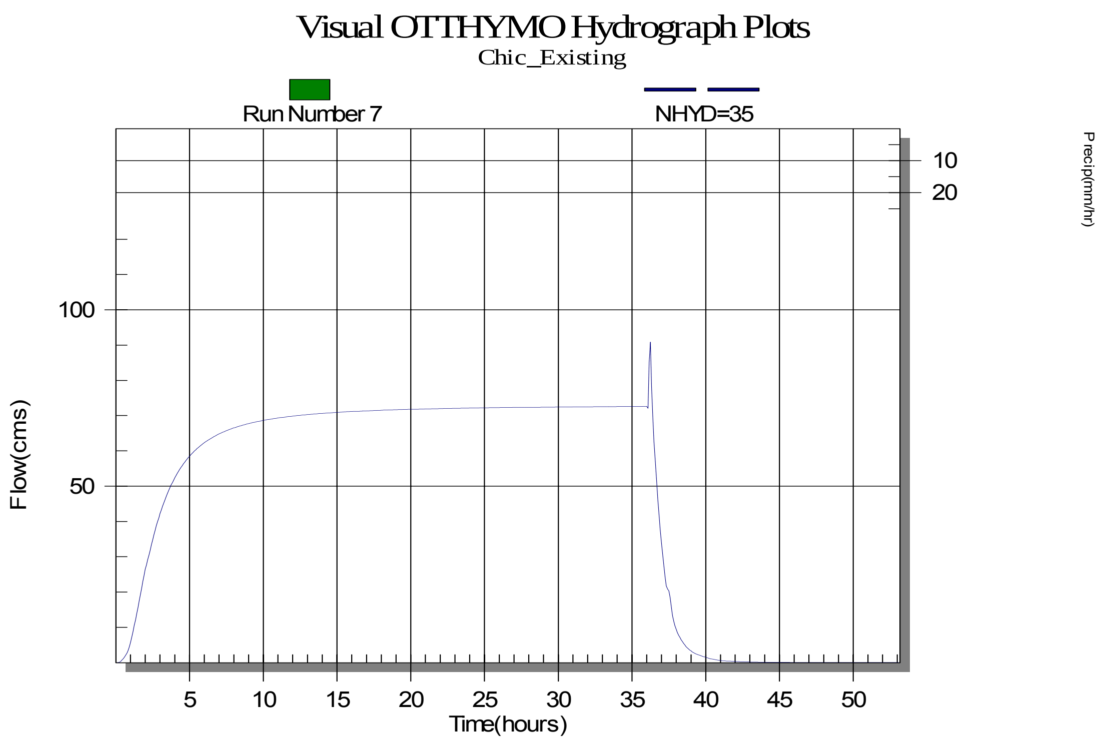
Central Lake Ontario Conservation

Tooley Creek
Figure 2 - Subwatersheds

The hydrologic modeling has been completed in two (2) stages. The first stage involved creating an existing, 2005 year land use model and the associated parameters for Visual Otthymo. The second stage involved editing the parameters within the existing 2005 land use model, to create a future land use model using land use from the Municipality of Clarington's Official Plans. The two models are then compared based on their input parameters and resulting peak flows.

To ensure that the entire watershed is contributing to the peak flow a long duration storm with a constant intensity of 25mm/hr was tested on the watershed. The resulting hydrograph is shown in the figure below. It can be seen that the entire watershed is contributing during the 20th hour. After eight (8) hours approximately 95% of the watershed is contributing. This indicates that a storm distribution with a 12 hour duration would be appropriate for the Tooley Creek watershed. A 12 hour Chicago and a 12 hour SCS distribution will be used for the 2, 5, 10, 25, 50 and 100 year return period storms for both the existing and future land use scenarios.

Figure 3 – Watershed Response to a Constant Intensity Storm



The Regional Storm (Hurricane Hazel) was also modeled for both existing and future land use scenarios. CN values were increased to reflect Antecedent Moisture Condition III for the regional storm event.

The results of the hydrologic model were used to examine peak flows within the watershed. Table 1 shows the peak flows for the Regional Storm for the existing 2005 and future land use conditions at the hydrologic reference points.

Table 1 – Peak Flows

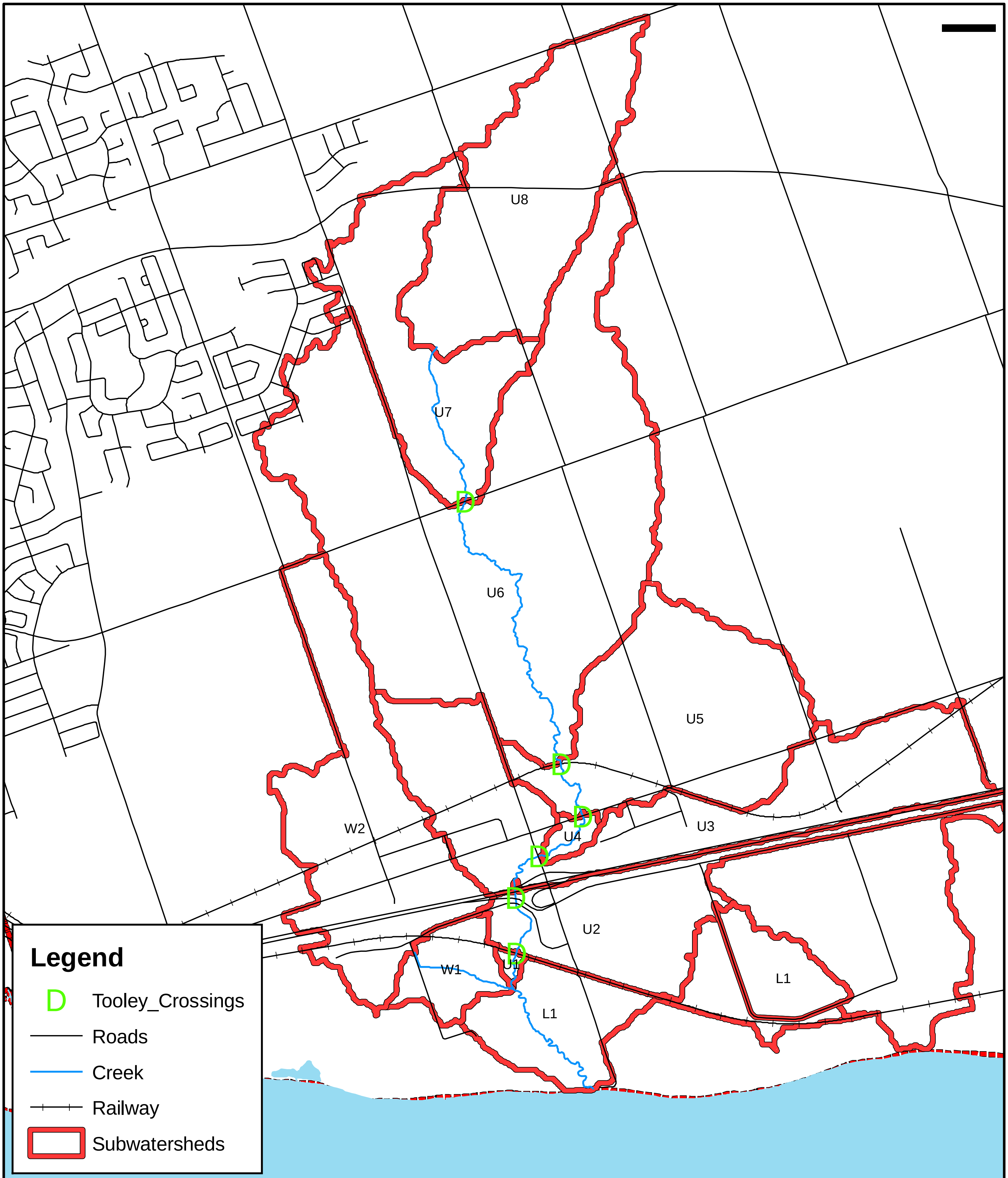
NHYD	Sub-watershed	Peak Flow (m3/s)		
		Regional		
		Existing	Future	Change
1	U8	12.41	12.41	0.00%
2	U7	11.64	11.70	0.58%
6	U6	39.17	39.40	0.60%
8	U5	16.62	16.62	0.00%
9	U4	0.76	0.76	0.00%
12	U1	0.06	0.06	0.00%
21	U3	21.16	21.16	0.00%
22	U2	10.79	10.79	0.00%
25	W2	3.40	3.40	0.00%
28	W1	3.38	3.38	0.00%
32	L1	8.42	8.42	0.00%
36	L2	3.51	3.51	0.00%

A review of Table 1 indicates that there is no or very little change in peak flows between the existing and future land use conditions.

3.3 Hydraulics

3.3.1 Field Survey

To ensure that the model was constructed as an accurate representation of the area a field survey component was conducted. Using aerial photographs all the road crossings were identified. Six (6) crossing on the sections of the creek with a drainage area greater than 125 hectares were identified. The crossing locations are shown in Figure 3. Each crossing was then surveyed, photographed and documented. Surveys for each crossing consisted of four (4) surveyed cross sections: 10 meters upstream, 10 meters downstream, immediately upstream of the culvert, and immediately downstream of the culvert. The crossings length, size and material was measured and recorded. The details for each culvert are included in Appendix B.



Date: October 26, 2007

Central Lake Ontario Conservation

Tooley Creek
Figure 4 - Creek Crossings

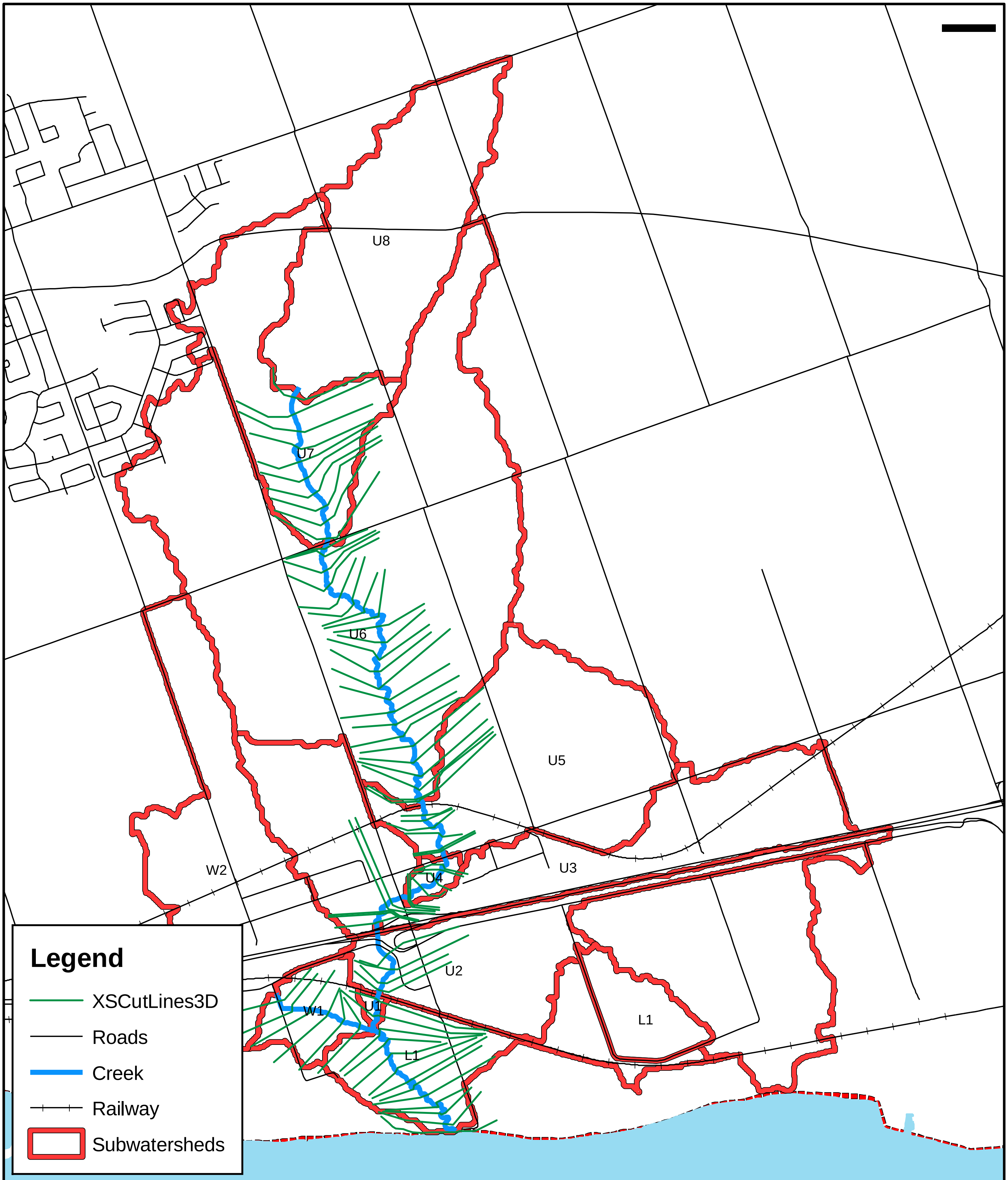
3.3.2 Model Set Up

A new hydraulic model for the watershed was prepared using the US Army Corp of Engineer's Hec-GeoRAS version 4.1.1. HEC-GeoRAS uses spatially referenced attributes including stream centre line (with drainage areas greater than 125 hectares), bank lines, and, road crossings. The spatially referenced attributes were already a part of CLOCA's spatial data repository, but required some modifications to meet the requirements of HEC-GeoRAS (refer to the Hec-GeoRAS manual for detailed descriptions). In addition HEC-GeoRAS uses a Triangular Irregular Network to extract the cross section profiles.

A new Hec-RAS project was set up and documented; the GIS data was then imported into the model. Each cross section that was imported was then inspected to ensure that they accurately reflected the topography. The layout of the hydraulic model, including cross section locations is shown in Figure 4.

The field survey information was added to the model as bridge or culvert elements. The cross sections immediately upstream and downstream of the crossings were edited to reflect the surveyed information. In some cases additional cross sections were added.

Flows from the hydrology were assigned to the appropriate reaches of the Hec-RAS model. After all the information was added to the model it was run under a steady state analysis. The first run identified many areas that required further editing; these included water surface elevations that exceeded cross section extents, incorrectly coded crossings and areas requiring additional cross sections. The model was run several times before all the errors were eliminated.



Date: October 26, 2007

Central Lake Ontario Conservation

Tooley Creek
Figure 5 - Hydraulic Modeling Setup

A summary of the flow and water surface elevation at each crossing is shown in Table 3.

Table 3 – Road Crossing Details

Description	River	Reach	River Station	Q Total (m^3/s)	W.S. US. (m)
Bloor St	Tooley	Upper	3884	22.08	120.30
Railway	Tooley	Upper	1779	59.94	105.57
Baseline Rd	Tooley	Upper	1376	74.24	98.66
Courtice Rd	Tooley	Upper	970.5	74.77	97.92
Highway 401	Tooley	Upper	705	91.51	97.63
Railway	Tooley	Upper	243	99.84	91.51

4.0 FLOOD PLAIN MAPPING

The Hec-RAS was exported to the GIS environment through a series of complex steps.

The output was converted into a dataset representing the floodlines. The quality control aspect of this process is very important. The generated floodlines were mapped with the old floodlines, identified wetland features, 1m interval contours and the aerial photographs. These datasets were examined in relation to each other to ensure that the generated floodlines made sense. Upon initial examination several areas were identified that deviated from the expected. These areas were adjusted, having additional cross sections added, adding levees or revising the cross sectional information. The revised areas were re-imported into Hec-RAS and the model was run again and exported to GIS. The quality control process began again.

To create the final product the resulting floodlines were mapped together with existing base data and aerial photographs and arranged onto 1:2000 map sheets. The cross sections were labeled with the river stations and the floodline elevations.

5.0 CONCLUSIONS

At the completion of the Tooley Creek Floodplain Update Study the following can be concluded:

- CLOCA now has up to date floodplain mapping for the Tooley Creek watershed that replaces the 1974 mapping.
- The new floodlines are in close proximity to the superseded floodline with noticeable improvements around crossings and wetland features.
- The Tooley Creek watershed is predominantly rural, and not significantly affected by future urbanization.
- The use of HecGEO-RAS as a hydraulic modeling and mapping tool saved a considerable amount of time during the data collection and mapping phase. It must be noted that a significant amount of quality control is still required.
- The modeling and accompanying maps should be updated to reflect any significant land use changes should they occur.
- The new Tooley Creek regional floodline should be used to update CLOCA's Regulated Area (Ont Reg 42/06)

APPENDIX A
Hydrology

Tooley Creek Watershed Hydrology
Hydrologic Soils Groups

Soils	Hydrologic Soil Group
Bondhead Fine Sandy Loam	AB
Bondhead Loam	B
Bondhead Sandy Loam	AB
Bottom Land	C
Bridgeman Sands	A
Brighton Gravelly Sand	A
Brighton Sand	A
Brighton Sandy Loam	AB
Darlington Loam	C
Darlington Sandy Loam	B
Dundonald Sandy Loam	AB
Granby Sandy Loam	B
Guerin Loam	B
Lyons Loam	B
Muck	B
Newcastle Clay Loam	C
Newcastle Loam	BC
Otonabee Loam Steep	B
Ponty Pool Sand	A
Pontypool Sandy Loam	AB
Smithfield Clay Loam	CD
Tecumseth Sandy Loam	AB
Whitby	BC

Source: MTO Drainage Manual (Included in References Section)

Tooley Creek Watershed Hydrology
Subcatchment Parameters

Land Use Curve Numbers (CN) for NasHyd

Land Use	Hydrologic Soils Group						
	A	AB	B	BC	C	CD	D
Crop & Improved	66	70	74	78	82	84	86
Pasture & Unimproved	58	62	65	71	76	79	81
Urban Residential	77	81	85	88	90	91	92
Rural Residential	51	60	68	74	79	82	84
Industrial & Commercial	85	88	90	92	93	94	94
Wetland	50	50	50	50	50	50	50
Woodlot & Forrest	36	48	60	67	73	76	79
Manicured Greenspace	39	50	61	68	74	77	80
Landfill and Aggregate	50	50	50	50	50	50	50 *
Transportation & Utility	98	98	98	98	98	98	98

Land Use Curve Numbers (CN) for StandHyd

(pervious parts only)

Land Use	Hydrologic Soils Group						
	A	AB	B	BC	C	CD	D
Crop & Improved	66	70	74	78	82	84	86
Pasture & Unimproved	58	62	65	71	76	79	81
Urban Residential	39	50	61	68	74	77	80
Rural Residential	39	50	61	68	74	77	80
Industrial & Commercial	58	62	65	71	76	78	80
Wetland	50	50	50	50	50	50	50
Woodlot & Forrest	50	54	58	65	71	74	79
Manicured Greenspace	39	50	61	68	74	77	80
Landfill and Aggregate	50	50	50	50	50	50	50
Transportation & Utility	58	62	65	71	76	79	81

Note: Values for Landfill and Aggregate were chosen to be similar to a wetland as runoff is stored on site
Source: US Soil Conservation Services, US Department of Agriculture, MTO Drainage Manual (Included in Reference Section)

Rational Method Constants (Runoff Coefficients)

Land Use	Hydrologic Soils Group							
	A	AB	B	BC	C	CD	D	
Crop & Improved	0.30	0.39	0.48	0.57	0.65	0.71	0.76	
Pasture & Unimproved	0.09	0.15	0.20	0.25	0.29	0.32	0.34	
Urban Residential	0.50	0.55	0.60	0.65	0.70	0.75	0.80	
Rural Residential	0.19	0.20	0.21	0.23	0.25	0.27	0.29	
Industrial & Commercial	0.70	0.70	0.70	0.71	0.71	0.71	0.71	
Lakes and Wetlands	0.05	0.05	0.05	0.05	0.05	0.05	0.05	
Woodlot & Forrest	0.07	0.09	0.11	0.12	0.13	0.14	0.15	
Manicured Greenspace	0.12	0.14	0.16	0.18	0.19	0.22	0.24	
Landfill and Aggregate	0.05	0.05	0.05	0.05	0.05	0.05	0.05	*
Transportation & Utility	0.90	0.90	0.90	0.90	0.90	0.90	0.90	

Note: Values for Landfill and Aggregate were chosen to be similar to a wetland as runoff is stored on site
Source: Based on MTO Drainge Manual, Maryland State Highway Administration (Included in Reference Section)

Initail Abstractions

Soil Type	Initial Abstractions
Crop & Improved	7
Pasture & Unimproved	8
Urban Residential	1.5
Rural Residential	1.5
Industrial & Commercial	1.5
Lakes and Wetlands	0
Woodlot & Forrest	10
Manicured Greenspace	5
Landfill and Aggregate	10
Transportation & Utility	1.5

Percent Impervious

Land Use	Total (%)	Connected (%)
Crop & Improved	0	0
Pasture & Unimproved	0	0
Urban Residential	45	35
Rural Residential	20	10
Industrial & Commercial	85	85
Lakes and Wetlands	0	0
Woodlot & Forrest	0	0
Manicured Greenspace	0	0
Landfill and Aggregate	50	0
Transportation & Utility	50	25

Landuse Classification

Dissolved Landuse	GIS Classification	
	Cloca Landuse	ELC
Crop & Improved	Agricultural Facility Crop Field Nursery	
Pasture & Unimproved	Pature Transportation Greenspace Treed Field (Orchard)	Cultural Meadow Cultural Savanah Cultural Thicket
Urban Residential	Urban Residential	
Rural Residential	Rural Residential	
Industrial & Commercial	Commercial Industrial Institutional Building	
Lakes and Wetlands	Stormwater Pond Water Feature	Open Fen Meadow Marsh Shallow Marsh Open Aquatic Submerged shallow aquatic Floating leaves shallow aquatic Deciduous Swamp Coniferous Swamp Mixed Swamp Thicket Swamp
Woodlot & Forrest		Cultural Plantation Cultural Woodland Coniferous Forest Deciduous Forest Mixed Forest
Manicured Greenspace	Athletic field Golf facility Institutional greenspace Park Skihill	
Landfill and Aggregate	Aggregate Landfill	
Transportation & Utility	Transportation Corridor Utility Corridor Utility Transfer Station	

Note: Landuse was taken from the 2007 ELC layer

Tooley Creek Watershed Hydrology

Subcatchment Soil Group Coverage

Sub Catchment No.	Area (ha)	Mean Hydrologic Soil Group
L1	62.85	C
L2	24.66	C
W1	23.96	C
W2	126.64	C
U1	2.04	D
U2	76.56	C
U3	152.46	C
U4	5.55	D
U5	126.36	C
U6	336.94	C
U7	92.91	C
U8	126.11	BC

Query From CLOCA soils layer

Tooley Creek Watershed Hydrology
2005 Existing Land Use Condition

Sub Area No.	Area (ha)	% Landuse Coverage CI	PU	UR	RR	IC	LW	WF	MG	LA	TU	Check
L1	62.85	45.92%	42.57%	2.13%	0.00%	0.00%	0.04%	0.59%	0.00%	0.00%	8.75%	1.0000
L2	24.66	78.27%	0.00%	0.37%	0.00%	17.64%	0.00%	0.00%	0.00%	0.00%	3.72%	1.0000
W1	23.96	69.41%	17.78%	0.25%	0.00%	0.00%	4.38%	0.29%	0.04%	0.00%	7.85%	1.0000
W2	126.64	47.62%	13.74%	3.40%	0.00%	12.15%	1.11%	6.98%	3.38%	0.00%	11.62%	1.0000
U1	2.04	0.00%	84.31%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	15.69%	1.0000
U2	76.56	41.32%	7.65%	3.17%	0.00%	11.70%	1.70%	3.03%	0.00%	0.00%	31.43%	1.0000
U3	152.46	44.06%	17.41%	1.13%	0.00%	19.41%	0.03%	3.98%	0.00%	0.00%	13.98%	1.0000
U4	5.55	3.24%	23.06%	0.00%	0.00%	14.59%	31.90%	20.90%	0.00%	0.00%	6.31%	1.0000
U5	126.36	57.60%	17.04%	1.90%	0.02%	1.09%	2.32%	13.56%	0.00%	0.00%	6.47%	1.0000
U6	336.94	41.55%	26.52%	2.38%	4.45%	3.48%	6.81%	10.52%	0.59%	0.00%	3.70%	1.0000
U7	92.91	59.68%	14.38%	3.44%	4.23%	0.15%	2.58%	8.30%	1.65%	0.00%	5.59%	1.0000
U8	126.11	32.70%	25.28%	0.00%	17.48%	1.17%	9.85%	5.53%	2.49%	0.00%	5.50%	1.0000

CI	Crop & Improved
PU	Pasture & Unimproved
UR	Urban Residential
RR	Rural Residential
IC	Industrial / Commercial
LW	Lakes & Wetlands
WF	Woodlot & Forest
MG	Manicured Greenspace
LA	Landfill and Aggrigate
TU	Transportation and Utilities

Tooley Creek Watershed Hydrology
Future Land Use Condition

Sub Area No.	Area (ha)	% Landuse Coverage										Check
		CI	PU	UR	RR	IC	LW	WF	MG	LA	TU	
L1	62.85	45.92%	42.57%	2.13%	0.00%	0.00%	0.04%	0.59%	0.00%	0.00%	8.75%	1.0000
L2	24.66	78.27%	0.00%	0.37%	0.00%	17.64%	0.00%	0.00%	0.00%	0.00%	3.72%	1.0000
W1	23.96	69.41%	17.78%	0.25%	0.00%	0.00%	4.38%	0.29%	0.04%	0.00%	7.85%	1.0000
W2	126.64	47.62%	13.74%	3.40%	0.00%	12.15%	1.11%	6.98%	3.38%	0.00%	11.62%	1.0000
U1	2.04	0.00%	84.31%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	15.69%	1.0000
U2	76.56	41.32%	7.65%	3.17%	0.00%	11.70%	1.70%	3.03%	0.00%	0.00%	31.43%	1.0000
U3	152.46	44.06%	17.41%	1.13%	0.00%	19.41%	0.03%	3.98%	0.00%	0.00%	13.98%	1.0000
U4	5.55	3.24%	23.06%	0.00%	0.00%	14.59%	31.90%	20.90%	0.00%	0.00%	6.31%	1.0000
U5	126.36	57.60%	17.04%	1.90%	0.02%	1.09%	2.32%	13.56%	0.00%	0.00%	6.47%	1.0000
U6	336.94	39.29%	17.83%	19.18%	4.45%	0.89%	6.05%	8.38%	0.23%	0.00%	3.70%	1.0000
U7	92.91	54.58%	12.36%	11.15%	4.23%	0.15%	2.52%	7.77%	1.65%	0.00%	5.59%	1.0000
U8	126.11	32.70%	25.28%	0.00%	17.48%	1.17%	9.85%	5.53%	2.49%	0.00%	5.50%	1.0000

CI Crop & Improved
PU Pasture & Unimproved
UR Urban Residential
RR Rural Residential
IC Industrial / Commercial
LW Lakes & Wetland
WF Woodlot & Forest
MG Manicured Greenspace
LA Landfill and Aggrigate
TU Transportation and Utilities

Tooley Creek Watershed Hydrology
Existing Parameters

Sub Watershed No.	NHYD	Command	DT	Sub-Watershed Information													
				Area (ha)	HSG	CN (II)	CN (III)	C	IA (mm)	N	Length (m)	Width (m)	Slope (%)	TC (min)	TP (hr)	TIMP (%)	XIMP (%)
L1	32	NasHYD	10	62.85	C	81	91	0.52	6.84	3	1000	700	1.50	34.74	0.39	5	1
L2	36	NasHYD	9	24.66	C	85	93	0.67	5.80	3	600	800	1.30	23.55	0.26	17	15
W1	28	NasHYD	10	23.96	C	81	91	0.58	6.43	3	600	800	1.30	23.62	0.26	4	0
W2	25	NasHYD	10	126.64	C	83	92	0.58	5.71	3	1000	400	2.30	29.74	0.33	18	12
U1	12	NasHYD	10	2.04	D	84	92	0.43	6.98	3	100	100	3.10	4.23	0.05	8	0
U2	22	StandHYD	10	76.56	C	78	89	0.68	4.50	3	1100	700	2.90	32.84	0.37	27	11
U3	21	StandHYD	10	152.46	C	78	89	0.61	5.39	3	2600	500	2.60	74.05	0.83	24	17
U4	9	NasHYD	10	5.55	D	74	87	0.31	4.48	3	300	200	20.00	16.58	0.19	16	12
U5	8	NasHYD	10	126.36	C	80	90	0.52	6.89	3	1300	600	3.10	36.42	0.41	5	2
U6	6	NasHYD	10	336.94	C	78	89	0.45	6.32	3	2400	1300	3.60	59.17	0.66	7	4
U7	2	NasHYD	10	92.91	C	80	90	0.53	6.44	3	1300	600	1.20	45.41	0.51	5	2
U8	1	NasHYD	10	126.11	BC	73	86	0.36	5.35	3	1800	700	1.00	102.27	1.14	7	3

Tooley Creek Watershed Hydrology
Future Parameters

Sub Watershed No.	NHYD	Command	DT	Sub-Watershed Information													
				Area (ha)	HSG	CN (II)	CN (III)	C	IA (mm)	N	Length (m)	Width (m)	Slope (%)	TC (min)	TP (hr)	TIMP (%)	XIMP (%)
L1	32	NasHYD	10	62.85	C	81	91	0.52	6.84	3	1000	700	2	34.74	0.39	5	1
L2	36	NasHYD	9	24.66	C	85	93	0.67	5.80	2	600	800	1	23.55	0.26	17	15
W1	28	NasHYD	10	23.96	C	81	91	0.58	6.43	3	600	800	1	23.62	0.26	4	0
W2	25	NasHYD	10	126.64	C	83	92	0.58	5.71	3	1000	400	2	29.74	0.33	18	12
U1	12	NasHYD	10	2.04	D	84	92	0.43	6.98	3	100	100	3	4.23	0.05	8	0
U2	22	StandHYD	10	76.56	C	78	89	0.68	4.50	3	1100	700	3	32.84	0.37	27	11
U3	21	StandHYD	10	152.46	C	78	89	0.61	5.39	3	2600	500	3	74.05	0.83	24	17
U4	9	NasHYD	10	5.55	D	74	87	0.31	4.48	3	300	200	20	16.58	0.19	16	12
U5	8	NasHYD	10	126.36	C	80	90	0.52	6.89	3	1300	600	3	36.42	0.41	5	2
U6	6	NasHYD	10	336.94	C	80	90	0.51	5.45	3	2400	1300	4	59.17	0.66	12	8
U7	2	NasHYD	10	92.91	C	81	91	0.55	5.99	3	1300	600	1	45.41	0.51	9	4
U8	1	NasHYD	10	126.11	BC	73	86	0.36	5.35	3	1800	700	1	102.27	1.14	7	3

Tooley Creek Watershed Hydrology
Channel Routing

RC	Length	Channel S	Floodplain S	XS used	Channel n	Floodplain n
L1	1009.52	0.60%	1.50	800	0.03	0.05
L2	N/A	-	-	-	-	-
W1	635.41	1.20%	1.30	300	0.03	0.05
W2	N/A	-	-	-	-	-
U1	232.12	1.87%	3.10	100	0.03	0.05
U2	453.78	0.23%	2.90	400	0.03	0.05
U3	286.75	1.58%	2.60	800	0.03	0.05
U4	394.44	1.50%	20.00	1200	0.03	0.05
U5	411.43	0.22%	3.10	1500	0.03	0.05
U6	2099.27	0.96%	3.60	2200	0.03	0.05
U7	949.00	1.01%	1.20	4200	0.03	0.05
U8	N/A	-	-	-	-	-

Tooley Creek Watershed Hydrology
12 Hour Chicago Storm - Peak Flows
29-Aug-07

NHYD	Sub-watershed	Peak Flow (m3/s) 2 Year			5 Year			10 Year			25 Year			50 Year			100 Year		
		Existing	Future	Change	Existing	Future	Change	Existing	Future	Change	Existing	Future	Change	Existing	Future	Change	Existing	Future	Change
1	U8	0.93	0.93	0.00%	1.69	1.69	0.00%	2.13	2.13	0.00%	3.00	3.00	0.00%	3.69	3.69	0.00%	4.24	4.24	0.00%
2	U7	1.50	1.62	8.23%	2.77	2.95	6.40%	3.49	3.69	5.78%	4.91	5.16	4.95%	6.01	6.28	4.49%	6.87	7.16	4.20%
3		1.87	1.98	5.95%	3.45	3.61	4.64%	4.39	4.56	3.94%	6.31	6.50	3.09%	7.81	8.04	3.06%	8.97	9.23	2.84%
4		0.90	0.90	0.00%	1.66	1.66	0.00%	2.12	2.12	0.00%	2.96	2.96	0.00%	3.65	3.65	0.00%	4.19	4.19	0.00%
5		1.48	1.55	4.50%	2.86	2.97	3.86%	3.69	3.81	3.30%	5.35	5.49	2.66%	6.62	6.81	2.88%	7.69	7.89	2.56%
6	U6	4.19	4.86	16.06%	7.75	8.73	12.67%	9.78	10.90	11.49%	13.82	15.18	9.87%	16.97	18.50	8.98%	19.44	21.07	8.41%
7		5.29	6.02	13.88%	9.94	11.00	10.64%	12.62	13.84	9.67%	18.08	19.55	8.15%	22.37	24.01	7.34%	25.72	27.48	6.84%
8	U5	2.25	2.25	0.00%	4.26	4.26	0.00%	5.40	5.40	0.00%	7.67	7.67	0.00%	9.43	9.43	0.00%	10.81	10.81	0.00%
9	U4	0.14	0.14	0.00%	0.25	0.25	0.00%	0.32	0.32	0.00%	0.45	0.45	0.00%	0.55	0.55	0.00%	0.63	0.63	0.00%
12	U1	0.02	0.02	0.00%	0.05	0.05	0.00%	0.06	0.06	0.00%	0.08	0.08	0.00%	0.10	0.10	0.00%	0.11	0.11	0.00%
13		5.27	5.99	13.72%	9.89	10.92	10.46%	12.55	13.76	9.60%	17.97	19.43	8.15%	22.22	23.89	7.53%	25.57	27.36	7.00%
14		6.91	7.66	10.83%	12.99	14.08	8.42%	16.47	17.75	7.81%	23.50	24.93	6.11%	28.89	30.61	5.97%	33.18	35.02	5.56%
15		6.93	7.69	10.90%	13.02	14.12	8.44%	16.53	17.83	7.83%	23.62	25.08	6.18%	29.03	30.76	5.97%	33.35	35.21	5.56%
16		9.30	10.05	8.07%	16.65	17.72	6.41%	20.98	22.22	5.90%	29.54	31.02	5.02%	36.21	37.67	4.05%	41.30	42.91	3.91%
17		6.92	7.68	10.88%	12.98	14.08	8.45%	16.44	17.72	7.78%	23.49	24.94	6.15%	28.87	30.60	5.99%	33.18	35.03	5.58%
18		6.95	7.70	10.82%	13.06	14.15	8.37%	16.55	17.84	7.77%	23.61	25.06	6.12%	29.03	30.75	5.95%	33.33	35.18	5.54%
19		9.34	10.09	8.11%	16.80	17.89	6.51%	21.14	22.39	5.91%	29.76	31.31	5.18%	36.54	37.95	3.86%	41.78	43.09	3.13%
20		10.58	11.27	6.53%	18.86	19.86	5.28%	23.85	24.90	4.41%	33.59	34.77	3.51%	41.48	42.81	3.22%	47.58	48.87	2.71%
21	U3	5.09	5.09	0.00%	9.40	9.40	0.00%	11.66	11.66	0.00%	16.21	16.21	0.00%	19.81	19.81	0.00%	22.65	22.65	0.00%
22	U2	2.82	2.82	0.00%	5.15	5.15	0.00%	6.42	6.42	0.00%	8.99	8.99	0.00%	11.00	11.00	0.00%	12.59	12.59	0.00%
23		10.56	11.26	6.55%	18.86	19.81	5.06%	23.85	24.88	4.33%	33.48	34.74	3.77%	41.36	42.62	3.05%	47.57	48.85	2.68%
24		10.57	11.26	6.54%	18.87	19.82	5.06%	23.86	24.89	4.32%	33.49	34.75	3.77%	41.38	42.64	3.05%	47.59	48.87	2.68%
25	W2	0.63	0.63	0.00%	1.17	1.17	0.00%	1.48	1.48	0.00%	2.09	2.09	0.00%	2.56	2.56	0.00%	2.92	2.92	0.00%
26		0.57	0.57	0.00%	1.10	1.10	0.00%	1.40	1.40	0.00%	1.96	1.96	0.00%	2.40	2.40	0.00%	2.74	2.74	0.00%
27		1.15	1.15	0.00%	2.14	2.14	0.00%	2.70	2.70	0.00%	3.76	3.76	0.00%	4.63	4.63	0.00%	5.33	5.33	0.00%
28	W1	0.63	0.63	0.00%	1.17	1.17	0.00%	1.48	1.48	0.00%	2.09	2.09	0.00%	2.56	2.56	0.00%	2.92	2.92	0.00%
29		11.47	12.02	4.81%	20.56	21.39	4.04%	26.08	27.00	3.54%	36.73	37.82	2.96%	45.44	46.70	2.78%	52.46	53.64	2.25%
31		0.56	0.56	0.00%	1.05	1.05	0.00%	1.32	1.32	0.00%	1.82	1.82	0.00%	2.20	2.20	0.00%	2.50	2.50	0.00%
32	L1	1.23	1.23	0.00%	2.31	2.31	0.00%	2.92	2.92	0.00%	4.12	4.12	0.00%	5.05	5.05	0.00%	5.77	5.77	0.00%
33		1.76	1.76	0.00%	3.28	3.28	0.00%	4.18	4.18	0.00%	5.90	5.90	0.00%	7.23	7.23	0.00%	8.26	8.26	0.00%
34		11.16	11.80	5.79%	20.22	21.10	4.34%	26.00	28.10	8.08%	34.89	36.13	3.54%	42.22	43.52	3.08%	48.61	50.00	2.86%
35		12.69	13.25	4.41%	23.23	24.05	3.50%	29.13	30.89	6.04%	39.83	40.93	2.76%	48.12	49.32	2.49%	55.64	56.90	2.26%
36	L2	0.83	0.83	0.00%	1.49	1.49	0.00%	1.85	1.85	0.00%	2.54	2.54	0.00%	3.08	3.08	0.00%	3.48	3.48	0.00%

Tooley Creek Watershed Hydrology
12 Hour SCS - Peak Flows
29-Aug-07

NHYD	Sub-watershed	Peak Flow (m3/s)																	
		2 Year			5 Year			10 Year			25 Year			50 Year			100 Year		
		Existing	Future	Change	Existing	Future	Change	Existing	Future	Change	Existing	Future	Change	Existing	Future	Change	Existing	Future	Change
1	U8	0.907613	0.907613	0.00%	1.53566	1.53566	0.00%	2.010826	2.010826	0.00%	2.66236	2.66236	0.00%	3.172983	3.172983	0.00%	3.706123	3.706123	0.00%
2	U7	1.246822	1.337371	7.26%	2.115182	2.243282	6.06%	2.771145	2.921235	5.42%	3.660201	3.833662	4.74%	4.348262	4.537243	4.35%	5.059593	5.262731	4.01%
3	0	1.729469	1.784698	3.19%	2.943557	3.026111	2.80%	3.8884	3.993766	2.71%	5.231024	5.354048	2.35%	6.258016	6.408417	2.40%	7.297215	7.45738	2.19%
4	0	0.879556	0.879556	0.00%	1.513754	1.513754	0.00%	2.005224	2.005224	0.00%	2.630368	2.630368	0.00%	3.138137	3.138137	0.00%	3.670619	3.670619	0.00%
5	0	1.511949	1.567484	3.67%	2.665029	2.745175	3.01%	3.56288	3.649945	2.44%	4.760169	4.876381	2.44%	5.688528	5.802454	2.00%	6.653865	6.777944	1.86%
6	U6	3.653128	4.190859	14.72%	6.263403	6.993707	11.66%	8.1985	9.045699	10.33%	10.82248	11.84239	9.42%	12.88591	14.02278	8.82%	15.04714	16.27674	8.17%
7	0	4.769265	5.330857	11.78%	8.300876	9.086298	9.46%	10.97187	11.88453	8.32%	14.67426	15.76134	7.41%	17.54835	18.79211	7.09%	20.6197	21.96817	6.54%
8	U5	1.8526	1.8526	0.00%	3.177306	3.177306	0.00%	4.149763	4.149763	0.00%	5.458102	5.458102	0.00%	6.466429	6.466429	0.00%	7.505577	7.505577	0.00%
9	U4	0.092609	0.092609	0.00%	0.15253	0.15253	0.00%	0.196817	0.196817	0.00%	0.256844	0.256844	0.00%	0.303433	0.303433	0.00%	0.351716	0.351716	0.00%
12	U1	0.010177	0.010177	0.00%	0.016198	0.016198	0.00%	0.020407	0.020407	0.00%	0.025878	0.025878	0.00%	0.029979	0.029979	0.00%	0.034124	0.034124	0.00%
13	0	4.763899	5.321323	11.70%	8.284692	9.069555	9.47%	10.94711	11.87476	8.47%	14.66069	15.75951	7.50%	17.55788	18.75319	6.81%	20.57761	21.90002	6.43%
14	0	6.118489	6.729448	9.99%	10.65536	11.51276	8.05%	14.09758	15.10101	7.12%	18.84153	20.00965	6.20%	22.55419	23.81139	5.57%	26.3336	27.74806	5.37%
15	0	6.150641	6.760371	9.91%	10.72255	11.57424	7.94%	14.16535	15.17971	7.16%	18.95414	20.13489	6.23%	22.69793	23.92118	5.39%	26.50448	27.90356	5.28%
16	0	8.273834	8.924535	7.86%	14.12864	14.99489	6.13%	18.59035	19.60221	5.44%	24.71624	25.90176	4.80%	29.47903	30.792	4.45%	34.28281	35.67205	4.05%
17	0	6.123931	6.734086	9.96%	10.66043	11.51461	8.01%	14.09145	15.09467	7.12%	18.84179	20.02755	6.29%	22.56675	23.79148	5.43%	26.35454	27.75976	5.33%
18	0	6.158663	6.770303	9.93%	10.72066	11.57935	8.01%	14.18235	15.18577	7.08%	18.9506	20.12345	6.19%	22.69396	23.95115	5.54%	26.49455	27.909	5.34%
19	0	8.306314	8.967746	7.96%	14.20149	15.07	6.12%	18.72724	19.73245	5.37%	24.89907	26.07718	4.73%	29.70669	31.03832	4.48%	34.53947	35.91887	3.99%
20	0	9.379845	10.03055	6.94%	16.07633	16.94254	5.39%	21.05402	22.06589	4.81%	27.46792	28.65211	4.31%	32.68224	34.00672	4.05%	38.01304	39.33914	3.49%
21	U3	2.74633	2.74633	0.00%	4.689264	4.689264	0.00%	5.966573	5.966573	0.00%	7.699875	7.699875	0.00%	9.046168	9.046168	0.00%	10.44193	10.44193	0.00%
22	U2	1.525394	1.525394	0.00%	2.450758	2.450758	0.00%	3.132004	3.132004	0.00%	4.326571	4.326571	0.00%	5.075027	5.075027	0.00%	5.836942	5.836942	0.00%
23	0	9.363907	10.02627	7.07%	16.05364	16.91723	5.38%	21.06162	22.07067	4.79%	27.46549	28.65082	4.32%	32.64841	33.96766	4.04%	37.98523	39.3049	3.47%
24	0	9.367794	10.03016	7.07%	16.05952	16.92311	5.38%	21.06894	22.07799	4.79%	27.47467	28.66	4.31%	32.65898	33.97823	4.04%	37.99712	39.3168	3.47%
25	W2	0.455675	0.455675	0.00%	0.761259	0.761259	0.00%	0.98285	0.98285	0.00%	1.278423	1.278423	0.00%	1.504639	1.504639	0.00%	1.736595	1.736595	0.00%
26	0	0.421586	0.421586	0.00%	0.706196	0.706196	0.00%	0.914794	0.914794	0.00%	1.187176	1.187176	0.00%	1.397236	1.397236	0.00%	1.617387	1.617387	0.00%
27	0	0.841044	0.841044	0.00%	1.436736	1.436736	0.00%	1.871887	1.871887	0.00%	2.449552	2.449552	0.00%	2.896926	2.896926	0.00%	3.353982	3.353982	0.00%
28	W1	0.455675	0.455675	0.00%	0.761259	0.761259	0.00%	0.98285	0.98285	0.00%	1.278423	1.278423	0.00%	1.504639	1.504639	0.00%	1.736595	1.736595	0.00%
29	0	9.900867	10.56323	6.69%	17.0758	17.93939	5.06%	22.35683	23.36589	4.51%	29.217	30.396	4.04%	34.75578	36.06643	3.77%	40.45203	41.7717	3.26%
31	0	0.448933	0.448933	0.00%	0.779273	0.779273	0.00%	1.007114	1.007114	0.00%	1.303656	1.303656	0.00%	1.5269	1.5269	0.00%	1.753589	1.753589	0.00%
32	L1	0.988911	0.988911	0.00%	1.678648	1.678648	0.00%	2.181284	2.181284	0.00%	2.853944	2.853944	0.00%	3.370117	3.370117	0.00%	3.900397	3.900397	0.00%
33	0	1.434249	1.434249	0.00%	2.457922	2.457922	0.00%	3.188398	3.188398	0.00%	4.1576	4.1576	0.00%	4.897017	4.897017	0.00%	5.653986	5.653986	0.00%
34	0	9.782181	10.42342	6.56%	16.79154	17.65808	5.16%	22.07442	23.07456	4.53%	28.59401	29.76152	4.08%	34.02555	35.3176	3.80%	39.56034	40.79613	3.12%
35	0	10.85832	11.49345	5.85%	18.76921	19.63575	4.62%	24.67191	25.65795	4.00%	31.85377	33.00368	3.61%	37.90901	39.18828	3.37%	44.11459	45.25496	2.59%
36	L2	0.583526	0.583526	0.00%	0.939741	0.939741	0.00%	1.191577	1.191577	0.00%	1.521538	1.521538	0.00%	1.770527	1.770527	0.00%	2.023301	2.023301	0.00%

Tooley Creek Watershed Hydrology
Regional Storm (Hurricane Hazel) - Peak Flows
08/29/2007

NHYD	Sub-watershed	Peak Flow (m3/s)		
		Existing	Regional Future	Change
1	U8	12.41	12.41	0.00%
2	U7	11.64	11.70	0.58%
3	0	22.04	22.08	0.19%
4	0	12.30	12.30	0.00%
5	0	21.72	21.77	0.20%
6	U6	39.17	39.40	0.60%
7	0	59.66	59.94	0.47%
8	U5	16.62	16.62	0.00%
9	U4	0.76	0.76	0.00%
12	U1	0.06	0.06	0.00%
13	0	59.62	59.90	0.46%
14	0	73.92	74.22	0.41%
15	0	74.47	74.76	0.39%
16	0	91.13	91.45	0.35%
17	0	73.95	74.24	0.40%
18	0	74.47	74.77	0.40%
19	0	91.20	91.51	0.33%
20	0	99.53	99.84	0.32%
21	U3	21.16	21.16	0.00%
22	U2	10.79	10.79	0.00%
23	0	99.52	99.84	0.32%
24	0	99.56	99.88	0.32%
25	W2	3.40	3.40	0.00%
26	0	3.37	3.37	0.00%
27	0	6.75	6.75	0.00%
28	W1	3.38	3.38	0.00%
29	0	104.85	105.18	0.31%
31	0	3.31	3.31	0.00%
32	L1	8.42	8.42	0.00%
33	0	11.67	11.67	0.00%
34	0	104.47	104.80	0.31%
35	0	114.50	114.85	0.30%
36	L2	3.51	3.51	0.00%

Tooley Creek Watershed Hydrology
HEC-RAS Flow Input

	River	Reach	RS	NHYD	Reg	2	5	10	25	50	100
1	Tooley_West	West	600	25	3.40	0.63	1.17	1.48	2.09	2.56	2.92
2	Tooley_West	West	300	27	6.75	1.15	2.14	2.70	3.76	4.63	5.33
3	Tooley_Lower	Lower	1000	29	105.18	12.02	21.39	27.00	37.82	46.70	53.64
4	Tooley_Lower	Lower	500	35	114.85	13.25	24.05	30.89	40.93	49.32	56.90
5	Tooley_Upper	Upper	4800	1	12.41	0.93	1.69	2.13	3.00	3.69	4.24
6	Tooley_Upper	Upper	4600	1+69%2	20.48	2.05	3.73	4.68	6.56	8.03	9.18
7	Tooley_Upper	Upper	4200	3	22.08	1.98	3.61	4.56	6.50	8.04	9.23
8	Tooley_Upper	Upper	3700	2+23%6	20.77	2.74	4.96	6.20	8.65	10.54	12.01
9	Tooley_Upper	Upper	3300	2+62%6	36.13	4.64	8.36	10.45	14.57	17.75	20.23
10	Tooley_Upper	Upper	2800	2+92%6	47.95	6.10	10.98	13.72	19.12	23.30	26.55
11	Tooley_Upper	Upper	2100	7	59.94	6.02	11.00	13.84	19.55	24.01	27.48
12	Tooley_Upper	Upper	1500	17	74.24	7.68	14.08	17.72	24.94	30.60	35.03
13	Tooley_Upper	Upper	1100	18	74.77	7.70	14.15	17.84	25.06	30.75	35.18
14	Tooley_Upper	Upper	800	19	91.51	10.09	17.89	22.39	31.31	37.95	43.09
15	Tooley_Upper	Upper	400	20	99.84	11.27	19.86	24.90	34.77	42.81	48.87
16	Tooley_Upper	Upper	200	24	99.88	11.26	19.82	24.89	34.75	42.64	48.87

APPENDIX B
Crossing Details

Holt
Courtice
Nash
Jane
Westmore
Fourth
Moyse
Living
Rundle
Regional Highway 2
Solina
Caleche
Sandringham
Fieldcrest
Hancock
Brownstone
Avondale
Weaver
Farmington
Inglis
Wilkins
Bloor
Wade
Trulls
Hancock
Solina
Trulls
Progress
Mcknight
401
Baseline
Cigas
South Service
Ramp
401
Solina
Darlington Park
Ramp
Osbourne
Down

HYDRAULIC STRUCTURE INVENTORY SHEET: SITE#0

Watershed and Location Information	Structure Configuration and Dimensions	Current Flow Information
Date (mm/dd/yy): 07/05/07	Structure Type (Culvert/Bridge): Bridge	Flow Present (Y/N): Y
Field Crew: Glenn Hendry & Ron Baker	Number of Cells: 1	Approx. Depth (mm):50
Watershed Name: Tooley	Material (Concrete/Steel): Concrete	Upstream Erosion (Y/N): N
Subcatchment Area No:	Open Footing (Yes/No): N	Downstream Erosion (Y/N):N
Tributary Name: Tooley Upper Tributary	Height (m) x Width (m) (If Applicable): 2.55x2.45	**Additional Field Notes**
Floodplain Map Sheet No.:	Diameter (m) (If Applicable):	-drive down and park at the end of the dirt road just south of train tracks south of 401 on Courtice Rd -barbed wire fence limits access to upstream side
Cross Section Range:	Length (m): 30	
Municipality: Clarington	Inlet Type (Projecting/Mitered/Headwall): N/A	
Location (Road Name/Intersection): Under southern train tracks just west of Courtice Rd	Height from Obvert to Top of Road (m): 9.028	
	Depth of Siltation (mm): 0	
	Upstream Invert (m): 82.32	
	Downstream Invert (m): 82.28	
	Top of Road Elevation (m): 91.298	
	Benchmark Location: Centre of South Train Tracks	**Structure is used in HEC-RAS Model**
	Benchmark Elevation (m): 91.298	

Site Photographs

Structure Photograph: Downstream

Upstream Photograph

Downstream Photograph

HYDRAULIC STRUCTURE INVENTORY SHEET: SITE#1&5

Central Lake Ontario Conservation

Watershed and Location Information

Date (mm/dd/yy): 07/11/07
Field Crew: Glenn Hendry & Ron Baker
Watershed Name: Tooley
Subcatchment Area No:
Tributary Name: Tooley West Tributary
Floodplain Map Sheet No.:
Cross Section Range:
Municipality: Clarington
Location (Road Name/Intersection):
On Darlington Park just east of where tracks cross the road.

Structure Configuration and Dimensions

Structure Type (Culvert/Bridge): Culvert
Number of Cells: 1
Material (Concrete/Steel): Steel
Open Footing (Yes/No): No
Height (m) x Width (m) (If Applicable):
Diameter (m) (If Applicable):0.55
Length (m): 26
Inlet Type (Projecting/Mitered/Headwall): Projecting
Height from Obvert to Top of Road (m): 0.826
Depth of Siltation (mm): 250
Upstream Invert (m): 89.80
Downstream Invert (m): 90.19
Top of Road Elevation (m): 91.546
Benchmark Location: Centreline of Darlington Park
Benchmark Elevation (m): 91.546

Current Flow Information

Flow Present (Y/N): N
Approx. Depth (mm):0
Upstream Erosion (Y/N):N
Downstream Erosion (Y/N):N

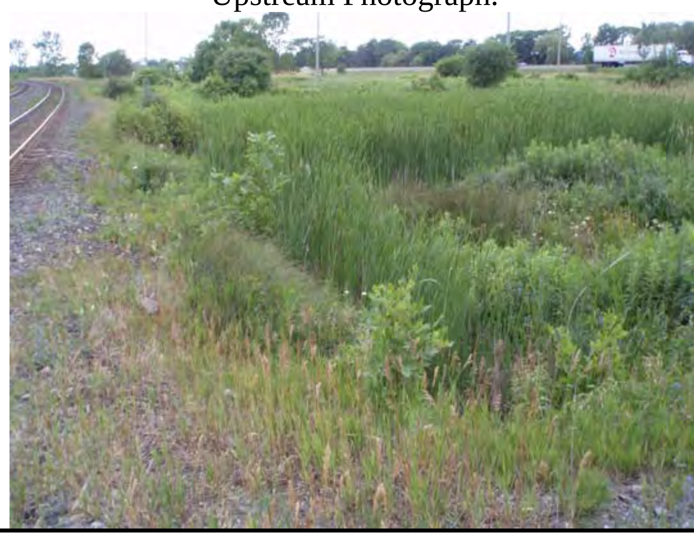
Additional Field Notes

-sites 1 and 5 are upstream and downstream of the same culvert

Site Photographs

Structure Photograph Upstream

Upstream Photograph.



Downstream Photograph

HYDRAULIC STRUCTURE INVENTORY SHEET: SITE#2&3

Central Lake Ontario Conservation

Watershed and Location Information	Structure Configuration and Dimensions	Current Flow Information
Date (mm/dd/yy): 07/05/07	Structure Type (Culvert/Bridge): Culvert	Flow Present (Y/N): N
Field Crew: Glenn Hendry & Ron Baker	Number of Cells: 1	Approx. Depth (mm):140
Watershed Name: Tooley Creek	Material (Concrete/Steel): Concrete	Upstream Erosion (Y/N): N
Subcatchment Area No:	Open Footing (Yes/No): N	Downstream Erosion (Y/N):N
Tributary Name: Tooley West Tributary-1	Height (m) x Width (m) (If Applicable): 1.12x1.23	**Additional Field Notes**
Floodplain Map Sheet No.:	Diameter (m) (If Applicable):52	-sites 2 and 3 are upstream and downstream of the same culvert -for site 3 park on Darlington Park Rd before Darlington Park, walk north towards 401 -for site 2 park in small driveway just west of blue storage garages and walk along edge of farmers field south of Baseline
Cross Section Range:	Length (m): 52	
Municipality: Clarington	Inlet Type (Projecting/Mitered/Headwall): Projecting	
Location (Road Name/Intersection): Under 401, North of Darlington Park Rd across the train tracks	Height from Obvert to Top of Road (m): N/A(Under 401)	
	Depth of Siltation (mm): 100	
	Upstream Invert (m): 91.08 (#3)	
	Downstream Invert (m): 91.27 (#2)	
	Top of Road Elevation (m): 93.152 (#2)	
	Benchmark Location: Centre of Train Tracks (#2) Top of Culvert (#3)	
	Benchmark Elevation (m): 93.152 (#2) 92.641 (#3)	

Site Photographs

Structure Photograph Downtream

Upstream Photograph

Downstream Photograph

HYDRAULIC STRUCTURE INVENTORY SHEET: SITE#4

Watershed and Location Information	Structure Configuration and Dimensions	Current Flow Information
Date (mm/dd/yy): 07/06/07	Structure Type (Culvert/Bridge): Culvert	Flow Present (Y/N): N
Field Crew: Ron Baker & Glenn Hendry	Number of Cells: 1	Approx. Depth (mm):0
Watershed Name: Tooley Creek	Material (Concrete/Steel): Steel	Upstream Erosion (Y/N): N
Subcatchment Area No:	Open Footing (Yes/No): N	Downstream Erosion (Y/N): N
Tributary Name: Tooley West Tributary	Height (m) x Width (m) (If Applicable):	**Additional Field Notes**
Floodplain Map Sheet No.:	Diameter (m) (If Applicable): 0.72	
Cross Section Range:	Length (m): 19	
Municipality: Clarington	Inlet Type (Projecting/Mitered/Headwall): Projecting	
Location (Road Name/Intersection): Darlington Park Rd & Down Rd South of 401. Culvert underneath Darlington Park Rd	Height from Obvert to Top of Road (m): 1.462	
	Depth of Siltation (mm): 0.3	
	Upstream Invert (m): 88.37	
	Downstream Invert (m): 88.84	
	Top of Road Elevation (m): 91.222	
	Benchmark Location: Centre of Darlington Park Rd	
	Benchmark Elevation (m): 91.222	

Site Photographs

Structure Photograph Downstream

Upstream Photograph

Downstream Photograph

HYDRAULIC STRUCTURE INVENTORY SHEET: SITE#6

Watershed and Location Information	Structure Configuration and Dimensions	Current Flow Information
Date (mm/dd/yy): 06/08/07	Structure Type (Culvert/Bridge): Culvert	Flow Present (Y/N): N
Field Crew: Glenn Hendry & Ron Baker	Number of Cells: 1	Approx. Depth (mm):120
Watershed Name: Tooley	Material (Concrete/Steel): Steel	Upstream Erosion (Y/N): N
Subcatchment Area No:	Open Footing (Yes/No): N	Downstream Erosion (Y/N): N
Tributary Name: Tooley Upper Tributary-1	Height (m) x Width (m) (If Applicable):	**Additional Field Notes**
Floodplain Map Sheet No.:	Diameter (m) (If Applicable):1.5	
Cross Section Range:	Length (m): 31.5	
Municipality: Clarington	Inlet Type (Projecting/Mitered/Headwall): Projecting	
Location (Road Name/Intersection): East most site on Darlington Park	Height from Obvert to Top of Road (m): 1.484	
	Depth of Siltation (mm): 0	
	Upstream Invert (m): 86.04	
	Downstream Invert (m): 85.13	
	Top of Road Elevation (m): 88.914	
	Benchmark Location: Centreline of Darlington Park Rd	
	Benchmark Elevation (m): 88.914	

Site Photographs

Structure Photograph Downstream

Upstream Photograph

Downstream Photograph

HYDRAULIC STRUCTURE INVENTORY SHEET: SITE#7

Central Lake Ontario Conservation

Watershed and Location Information	Structure Configuration and Dimensions	Current Flow Information
Date (mm/dd/yy): 07/06/07	Structure Type (Culvert/Bridge): Culvert	Flow Present (Y/N): N
Field Crew: Glenn Hendry & Ron Baker	Number of Cells: 1	Approx. Depth (mm):100
Watershed Name: Tooley	Material (Concrete/Steel): Concrete	Upstream Erosion (Y/N): N/A
Subcatchment Area No:	Open Footing (Yes/No): N	Downstream Erosion (Y/N): N
Tributary Name: Tooley West Tributary	Height (m) x Width (m) (If Applicable):	**Additional Field Notes**
Floodplain Map Sheet No.:	Diameter (m) (If Applicable): 0.5	-park on Darlington Park Rd and walk north towards 401
Cross Section Range:	Length (m): Upstream end not found	
Municipality: Clarington	Inlet Type (Projecting/Mitered/Headwall): Projecting	
Location (Road Name/Intersection): South of 401 North of Darlington Rd west of Courtice Rd	Height from Obvert to Top of Road (m): N/A (Under 401)	
	Depth of Siltation (mm): 160	
	Upstream Invert (m): U/S end not found	
	Downstream Invert (m): 93.48	
	Top of Road Elevation (m):	
	Benchmark Location: Top of Downstream Culvert opening(see picture below),	
	Benchmark Elevation (m): 93.811	

Site Photographs

Structure Photograph	Upstream Photograph	Downstream Photograph
	Could not find stream culvert	

HYDRAULIC STRUCTURE INVENTORY SHEET: SITE#8&10

Central Lake Ontario Conservation

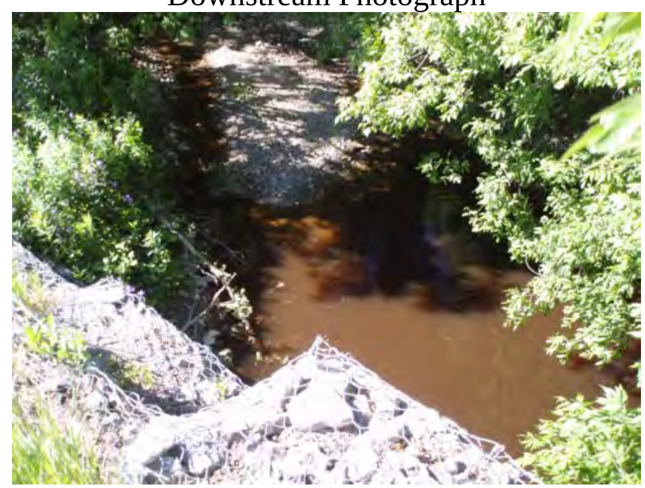
Watershed and Location Information	Structure Configuration and Dimensions	Current Flow Information
Date (mm/dd/yy): 07/06/07	Structure Type (Culvert/Bridge): Concrete box culvert	Flow Present (Y/N): Y
Field Crew: Ron Baker & Glenn Hendry	Number of Cells: 1	Approx. Depth (mm):40
Watershed Name: Tooley	Material (Concrete/Steel): Concrete	Upstream Erosion (Y/N): Y
Subcatchment Area No:	Open Footing (Yes/No): N	Downstream Erosion (Y/N): N
Tributary Name: Tooley Upper Tributary	Height (m) x Width (m) (If Applicable): 3.43x3.67	**Additional Field Notes**
Floodplain Map Sheet No.:	Diameter (m) (If Applicable):	-site 8 and 10 are downstream and upstream of the same culvert -for site 10 park on Courtice Rd by Site 14 and walk across field
Cross Section Range:	Length (m): 126	
Municipality: Clarington	Inlet Type (Projecting/Mitered/Headwall): Projecting	
Location (Road Name/Intersection): West of Courtice Rd under 401. Site 8 is just south of eastbound off ramp. Site 10 is just north of westbound on ramp.	Height from Obvert to Top of Road (m): 0.77	
	Depth of Siltation (mm): 0	
	Upstream Invert (m): 87.65	
	Downstream Invert (m): 85.22	
	Top of Road Elevation (m): 90.850 (#8) 95.521 (#10)	
	Benchmark Location: Centreline of Darlington Park above Bridge (#8) Top of bridge opening North of 401 (Upstream) (#10)	**Structure is used in HEC-RAS Model**
	Benchmark Elevation (m): 90.850 (#8) 91.45 (#10)	

Site Photographs

Structure Photograph Upstream

Upstream Photograph

Downstream Photograph



HYDRAULIC STRUCTURE INVENTORY SHEET
SITE#9:

Watershed and Location Information	Structure Configuration and Dimensions	Current Flow Information
Date (mm/dd/yy): 07/05/07	Structure Type (Culvert/Bridge): Culvert	Flow Present (Y/N): N
Field Crew: Glenn Hendry & Ron Baker	Number of Cells: 1	Approx. Depth (mm):2
Watershed Name: Tooley	Material (Concrete/Steel): Steel	Upstream Erosion (Y/N):N
Subcatchment Area No:	Open Footing (Yes/No): N	Downstream Erosion (Y/N):N
Tributary Name: Tooley Upper Tributary	Height (m) x Width (m) (If Applicable): 85cm(wide)x63cm(high)	**Additional Field Notes:**
Floodplain Map Sheet No.:	Diameter (m) (If Applicable):	-Site 9 drains into the site 8 and 10 culvert
Cross Section Range:	Length (m): Could not find D/S end	
Municipality: Clarington	Inlet Type (Projecting/Mitered/Headwall): Mitered	
Location (Road Name/Intersection): Left side of the Eastbound 401 on Courtice Rd Exit Ramp	Height from Obvert to Top of Road (m): 2.295	
	Depth of Siltation (mm): 0	
	Upstream Invert (m): 92.27	
	Downstream Invert (m): Could not find D/S end	
	Top of Road Elevation (m): 95.275	
	Benchmark Location: White line on North side of Ramp	
	Benchmark Elevation (m): 95.275	

Site Photographs

Structure Photograph

Upstream Photograph

Downstream Photograph

No downstream culvert available since it drains into sewer system

HYDRAULIC STRUCTURE INVENTORY SHEET: SITE#11

Watershed and Location Information	Structure Configuration and Dimensions	Current Flow Information
Date (mm/dd/yy): 06/20/07	Structure Type (Culvert/Bridge): Culvert	Flow Present (Y/N): Y
Field Crew: Glenn Hendry & Ron Baker	Number of Cells: 1	Approx. Depth (mm):25
Watershed Name: Tooley	Material (Concrete/Steel): Steel	Upstream Erosion (Y/N): N
Subcatchment Area No:	Open Footing (Yes/No): N	Downstream Erosion (Y/N):N
Tributary Name: Tooley Upper Tributary-1	Height (m) x Width (m) (If Applicable):	**Additional Field Notes**
Floodplain Map Sheet No.:	Diameter (m) (If Applicable):1.65	-park in driveway of abandoned building
Cross Section Range:	Length (m): 35	
Municipality: Clarington	Inlet Type (Projecting/Mitered/Headwall): Projecting	
Location (Road Name/Intersection): Under Courtice Rd South of Serviceline Rd	Height from Obvert to Top of Road (m): 1.95	
	Depth of Siltation (mm): 0	
	Upstream Invert (m): 93.05	
	Downstream Invert (m): 92.07	
	Top of Road Elevation (m): 95.750	
	Benchmark Location: Centerline of Courtice Rd above Culvert(south of South Service Rd)	
	Benchmark Elevation (m):95.750	

Site Photographs

Structure Photograph Downstream

Upstream Photograph

Downstream Photograph

HYDRAULIC STRUCTURE INVENTORY SHEET: SITE#12

Watershed and Location Information	Structure Configuration and Dimensions	Current Flow Information
Date (mm/dd/yy): 06/20/07	Structure Type (Culvert/Bridge): Culvert	Flow Present (Y/N): Y
Field Crew: Glenn Hendry & Ron Baker	Number of Cells: 1	Approx. Depth (mm):20
Watershed Name: Tooley	Material (Concrete/Steel): Steel	Upstream Erosion (Y/N): Y
Subcatchment Area No:	Open Footing (Yes/No): N	Downstream Erosion (Y/N): N
Tributary Name: Tooley Upper Tributary-1	Height (m) x Width (m) (If Applicable):	**Additional Field Notes:**
Floodplain Map Sheet No.:	Diameter (m) (If Applicable): 1.5	-park in driveway of abandoned building
Cross Section Range:	Length (m): 40	
Municipality: Clarington	Inlet Type (Projecting/Mitered/Headwall): Projecting	
Location (Road Name/Intersection): Under South Service Rd East of Courtice Rd	Height from Obvert to Top of Road (m): 0.816	
	Depth of Siltation (mm): 0	
	Upstream Invert (m): 99.35	
	Downstream Invert (m): 98.81	
	Top of Road Elevation (m): 100.726	
	Benchmark Location: White line on south side of South Service Rd	
	Benchmark Elevation (m):100.726	

Site Photographs

Structure Photograph Upstream

Upstream Photograph

Downstream Photograph

HYDRAULIC STRUCTURE INVENTORY SHEET: SITE#13

Watershed and Location Information	Structure Configuration and Dimensions	Current Flow Information
Date (mm/dd/yy): 06/21/2007	Structure Type (Culvert/Bridge): Culvert	Flow Present (Y/N): N
Field Crew: Glenn Hendry & Ron Baker	Number of Cells: 1	Approx. Depth (mm):50
Watershed Name: Tooley	Material (Concrete/Steel): Steel	Upstream Erosion (Y/N): N
Subcatchment Area No:	Open Footing (Yes/No): No	Downstream Erosion (Y/N):N
Tributary Name: Tooley Upper Tributary-1	Height (m) x Width (m) (If Applicable):	**Additional Field Notes**
Floodplain Map Sheet No.:	Diameter (m) (If Applicable):1.6	-park in driveway of abandoned building
Cross Section Range:	Length (m): 23	
Municipality: Clarington	Inlet Type (Projecting/Mitered/Headwall): Projecting	
Location (Road Name/Intersection): On South Service Rd. East of Courtice Parallel to South Service Rd.	Height from Obvert to Top of Road (m): 0.903	
	Depth of Siltation (mm): 230(Downstream)	
	Upstream Invert (m): 95.46	
	Downstream Invert (m): 95.40	
	Top of Road Elevation (m): 97.613	
	Benchmark Location: On white line on South side of South Service Rd at	
	Benchmark Elevation (m):97.613	

Site Photographs

Structure Photograph Upstream

Upstream Photograph

Downstream Photograph

HYDRAULIC STRUCTURE INVENTORY SHEET: SITE#14

Watershed and Location Information	Structure Configuration and Dimensions	Current Flow Information
Date (mm/dd/yy): 06/22/2007	Structure Type (Culvert/Bridge): Culvert	Flow Present (Y/N): Y
Field Crew: Glenn Hendry & Ron Baker	Number of Cells: 1	Approx. Depth (mm): 20
Watershed Name: Tooley	Material (Concrete/Steel): Concrete	Upstream Erosion (Y/N):N
Subcatchment Area No:	Open Footing (Yes/No): N	Downstream Erosion (Y/N): N
Tributary Name: Tooley Upper Tributary	Height (m) x Width (m) (If Applicable): 2.22X3.72	**Additional Field Notes**
Floodplain Map Sheet No.:	Diameter (m) (If Applicable):	
Cross Section Range:	Length (m): 24.95m	
Municipality: Clarington	Inlet Type (Projecting/Mitered/Headwall): Projecting	
Location (Road Name/Intersection): Courtice Rd south of Baseline Rd, north of 401	Height from Obvert to Top of Road (m): 1.686	
	Depth of Siltation (mm): 0	
	Upstream Invert (m): 89.66	
	Downstream Invert (m): 89.54	
	Top of Road Elevation (m): 94.108	
	Benchmark Location: White line on East side of Courtice Rd above Bridge	**Structure is used in HEC-RAS Model**
	Benchmark Elevation (m):94.108	

Site Photographs

Structure Photograph Downstream

Upstream Photograph

Downstream Photograph

Central Lake Ontario Conservation

HYDRAULIC STRUCTURE INVENTORY SHEET: SITE#15

Watershed and Location Information

Date (mm/dd/yy): 06/20/07

Field Crew: Glenn Hendry & Ron Baker

Watershed Name: Tooley

Subcatchment Area No:

Tributary Name: Tooley Upper Tributary-2

Floodplain Map Sheet No.:

Cross Section Range:

Municipality: Clarington

Location (Road Name/Intersection):
On Baseline west of Courtice Rd

Structure Configuration and Dimensions

Structure Type (Culvert/Bridge): 2 Culverts

Number of Cells: 1

Material (Concrete/Steel): Steel

Open Footing (Yes/No): N

Height (m) x Width (m) (If Applicable):

Diameter (m) (If Applicable):0.95

Length (m): 15

Inlet Type (Projecting/Mitered/Headwall): Projecting

Height from Obvert to Top of Road (m): 0.555

Depth of Siltation (mm): 0

Upstream Invert (m): East 94.86 West 94.63

Downstream Invert (m): East 93.68 West 93.65

Top of Road Elevation (m): 96.085

Benchmark Location: Center of Baseline Rd

Benchmark Elevation (m):96.085

Current Flow Information

Flow Present (Y/N): Y

Approx. Depth (mm):50

Upstream Erosion (Y/N): N

Downstream Erosion (Y/N): N

Additional Field Notes

Site Photographs

Structure Photograph Upstream

Upstream Photograph

Downstream Photograph

HYDRAULIC STRUCTURE INVENTORY SHEET: SITE#16

Watershed and Location Information	Structure Configuration and Dimensions	Current Flow Information
Date (mm/dd/yy):	Structure Type (Culvert/Bridge): Culvert	Flow Present (Y/N): N
Field Crew: Glenn Hendry & Ron Baker	Number of Cells: 1	Approx. Depth (mm):370
Watershed Name: Tooley	Material (Concrete/Steel): Steel	Upstream Erosion (Y/N): N
Subcatchment Area No:	Open Footing (Yes/No): N	Downstream Erosion (Y/N):N
Tributary Name: Tooley Upper Tributary	Height (m) x Width (m) (If Applicable):	**Additional Field Notes:**
Floodplain Map Sheet No.:	Diameter (m) (If Applicable):1.25	
Cross Section Range:	Length (m): 15.5	
Municipality: Clarington	Inlet Type (Projecting/Mitered/Headwall):Projecting	
Location (Road Name/Intersection): End of Courtice Rd South of 401. Stream is just north of the train tracks	Height from Obvert to Top of Road (m): 0.497	
	Depth of Siltation (mm): 600	
	Upstream Invert (m): 84.73	
	Downstream Invert (m): 84.78	
	Top of Road Elevation (m): 86.438	
	Benchmark Location: Centre of Courtice Rd above culvert	
	Benchmark Elevation (m):86.438	

Site Photographs

Structure Photograph Upstream

Upstream Photograph

Downstream Photograph

HYDRAULIC STRUCTURE INVENTORY SHEET: SITE#17

Central Lake Ontario Conservation

Watershed and Location Information	Structure Configuration and Dimensions	Current Flow Information
Date (mm/dd/yy): 06/08/07	Structure Type (Culvert/Bridge): Culvert	Flow Present (Y/N): Very Little
Field Crew: Glenn Hendry & Ron Baker	Number of Cells: 1	Approx. Depth (mm): 160
Watershed Name: Tooley	Material (Concrete/Steel): Concrete	Upstream Erosion (Y/N): N
Subcatchment Area No:	Open Footing (Yes/No): N	Downstream Erosion (Y/N): N
Tributary Name: Tooley Upper Tributary	Height (m) x Width (m) (If Applicable): 2.81 x 6.34	**Additional Field Notes**
Floodplain Map Sheet No.:	Diameter (m) (If Applicable):	
Cross Section Range:	Length (m): 31	
Municipality: Clarington	Inlet Type (Projecting/Mitered/Headwall): Projecting	
Location (Road Name/Intersection): Baseline East of Courtice	Height from Obvert to Top of Road (m): 3.718	
	Depth of Siltation (mm): 0	
	Upstream Invert (m): 94.05	
	Downstream Invert (m): 94.04	
	Top of Road Elevation (m): 100.639	
	Benchmark Location: Centre of Baseline	
	Benchmark Elevation (m):100.639	**Structure is used in HEC-RAS Model**

Site Photographs

Structure Photograph Upstream

Upstream Photograph

Downstream Photograph

HYDRAULIC STRUCTURE INVENTORY SHEET: SITE#18

Watershed and Location Information	Structure Configuration and Dimensions	Current Flow Information
Date (mm/dd/yy): 06/22/2007	Structure Type (Culvert/Bridge): Culvert	Flow Present (Y/N): N
Field Crew: Glenn, Ron, & Amber	Number of Cells: 1	Approx. Depth (mm):50
Watershed Name: Tooley	Material (Concrete/Steel): Concrete	Upstream Erosion (Y/N): N
Subcatchment Area No:	Open Footing (Yes/No): N	Downstream Erosion (Y/N): N
Tributary Name: Tooley Upper Tributary	Height (m) x Width (m) (If Applicable): 2.83X3.05	**Additional Field Notes:**
Floodplain Map Sheet No.:	Diameter (m) (If Applicable):	-park on Courtice Rd just north of the train tracks north of the 401, follow tracks east to site
Cross Section Range:	Length (m): 29	
Municipality: Clarington	Inlet Type (Projecting/Mitered/Headwall): N/A	
Location (Road Name/Intersection): Western most site between Courtice Rd and Hancock	Height from Obvert to Top of Road (m): 6.145	
	Depth of Siltation (mm):	
	Upstream Invert (m): 97.58	
	Downstream Invert (m): 97.53	
	Top of Road Elevation (m): 105.885(Tracks)	
	Benchmark Location: Centre of tracks above culvert	
	Benchmark Elevation (m):105.885	**Structure is used in HEC-RAS Model**

Site Photographs

Structure Photograph Upstream

Upstream Photograph

Downstream Photograph

Central Lake Ontario Conservation

HYDRAULIC STRUCTURE INVENTORY SHEET: SITE#19

Watershed and Location Information	Structure Configuration and Dimensions	Current Flow Information
Date (mm/dd/yy): 06/22/2007	Structure Type (Culvert/Bridge): Culvert	Flow Present (Y/N): N
Field Crew: Glenn, Ron, & Amber	Number of Cells: 1	Approx. Depth (mm):0
Watershed Name: Tooley	Material (Concrete/Steel): Steel	Upstream Erosion (Y/N): Y Construction
Subcatchment Area No:	Open Footing (Yes/No): N	Downstream Erosion (Y/N): N/A
Tributary Name: Tooley Upper Tributary-3	Height (m) x Width (m) (If Applicable):	**Additional Field Notes**
Floodplain Map Sheet No.:	Diameter (m) (If Applicable):0.85	-unable to find downstream culvert -park at base of Hancock Rd on Baseline and walk west along tracks to site
Cross Section Range:	Length (m): 22.5	
Municipality: Clarington	Inlet Type (Projecting/Mitered/Headwall): Headwall	
Location (Road Name/Intersection): First site on train tracks west of Hancock Rd, north of 401	Height from Obvert to Top of Road (m): 3.097	
	Depth of Siltation (mm): 0	
	Upstream Invert (m): 103.12	
	Downstream Invert (m): Unable to Locate	
	Top of Road Elevation (m): 107.087(Tracks)	
	Benchmark Location: Middle of North Tracks Above Culvert	
	Benchmark Elevation (m):107.087	

Site Photographs

Structure Photograph Upstream

Upstream Photograph

Downstream Photograph

Unable to locate downstream culvert

HYDRAULIC STRUCTURE INVENTORY SHEET: SITE#20

Watershed and Location Information	Structure Configuration and Dimensions	Current Flow Information
Date (mm/dd/yy): 07/11/07	Structure Type (Culvert/Bridge): Culvert	Flow Present (Y/N): N
Field Crew: Glenn Hendry & Ron Baker	Number of Cells: 2	Approx. Depth (mm):0
Watershed Name: Tooley	Material (Concrete/Steel): Steel	Upstream Erosion (Y/N):N
Subcatchment Area No:	Open Footing (Yes/No): N	Downstream Erosion (Y/N):N
Tributary Name: Tooley Upper Tributary-3	Height (m) x Width (m) (If Applicable):	**Additional Field Notes**
Floodplain Map Sheet No.:	Diameter (m) (If Applicable): 1.00	-area was under construction when surveyed
Cross Section Range:	Length (m): 10	
Municipality: Clarington	Inlet Type (Projecting/Mitered/Headwall): Projecting	
Location (Road Name/Intersection): On Hancock road just North of Baseline	Height from Obvert to Top of Road (m): 1.131	
	Depth of Siltation (mm): 0	
	Upstream Invert (m): South culvert 103.88 North culvert 103.90	
	Downstream Invert (m): South culvert 103.76 North culvert 103.75	
	Top of Road Elevation (m): 105.891	
	Benchmark Location: Centreline of Hancock Rd	
	Benchmark Elevation (m):105.891	

Site Photographs

Structure Photograph Downstream

Upstream Photograph

Downstream Photograph

HYDRAULIC STRUCTURE INVENTORY SHEET: SITE#21

Watershed and Location Information	Structure Configuration and Dimensions	Current Flow Information
Date (mm/dd/yy): 06/07/07	Structure Type (Culvert/Bridge): Culvert	Flow Present (Y/N): N
Field Crew: Glenn Hendry & Ron Baker	Number of Cells: 1	Approx. Depth (mm):very low
Watershed Name: Tooley	Material (Concrete/Steel): Steel	Upstream Erosion (Y/N): N
Subcatchment Area No:	Open Footing (Yes/No): N	Downstream Erosion (Y/N): N
Tributary Name: Tooley Upper Tributary-4	Height (m) x Width (m) (If Applicable):	**Additional Field Notes**
Floodplain Map Sheet No.:	Diameter (m) (If Applicable): 0.9	
Cross Section Range:	Length (m): 22	
Municipality: Clarington	Inlet Type (Projecting/Mitered/Headwall): Projecting	
Location (Road Name/Intersection): Courtice Rd South of Bloor North of Baseline	Height from Obvert to Top of Road (m): 0.907	
	Depth of Siltation (mm): 0	
	Upstream Invert (m): 114.45	
	Downstream Invert (m): 113.28	
	Top of Road Elevation (m): 116.397	
	Benchmark Location: White line of eastside of Courtice Rd	
	Benchmark Elevation (m):116.397	

Site Photographs

Structure Photograph Upstream

Upstream Photograph

Downstream Photograph

HYDRAULIC STRUCTURE INVENTORY SHEET: SITE#22

Watershed and Location Information

Date (mm/dd/yy): 06/07/07

Field Crew: Ron Baker & Glenn Hendry

Watershed Name: Tooley

Subcatchment Area No:

Tributary Name: Tooley Upper Tributary-5

Floodplain Map Sheet No.:

Cross Section Range:

Municipality: Clarington

Location (Road Name/Intersection):
Next to Cemetery @ Bloor Rd and Courtice Rd

Structure Configuration and Dimensions

Structure Type (Culvert/Bridge): Culvert

Number of Cells: 1

Material (Concrete/Steel): Steel

Open Footing (Yes/No): No

Height (m) x Width (m) (If Applicable):

Diameter (m) (If Applicable):1.4

Length (m): 24

Inlet Type (Projecting/Mitered/Headwall): Projecting

Height from Obvert to Top of Road (m): 0.893

Depth of Siltation (mm): 200

Upstream Invert (m): 121.59

Downstream Invert (m): 121.67

Top of Road Elevation (m): 123.753

Benchmark Location: White line on Eastside of Courtice Rd above culvert

Benchmark Elevation (m):123.753

Current Flow Information

Flow Present (Y/N): N

Approx. Depth (mm):100

Upstream Erosion (Y/N): N

Downstream Erosion (Y/N): N

Additional Field Notes:

Site Photographs

Structure Photograph Downstream

Upstream Photograph

Downstream Photograph

HYDRAULIC STRUCTURE INVENTORY SHEET: SITE#23

Watershed and Location Information	Structure Configuration and Dimensions	Current Flow Information
Date (mm/dd/yy): 06/07/07	Structure Type (Culvert/Bridge): Culvert	Flow Present (Y/N): Y
Field Crew: Glenn Hendry & Ron Baker	Number of Cells: 1	Approx. Depth (mm):100
Watershed Name: Tooley	Material (Concrete/Steel): Concrete	Upstream Erosion (Y/N): N
Subcatchment Area No:	Open Footing (Yes/No): N	Downstream Erosion (Y/N):N
Tributary Name: Tooley Upper Tributary	Height (m) x Width (m) (If Applicable): 1.22x3.7	**Additional Field Notes:**
Floodplain Map Sheet No.:	Diameter (m) (If Applicable):	
Cross Section Range:	Length (m): 16	
Municipality: Clarington	Inlet Type (Projecting/Mitered/Headwall): Projecting	
Location (Road Name/Intersection): Bloor just eat of Courtice Rd	Height from Obvert to Top of Road (m): 0.106	
	Depth of Siltation (mm): 0	
	Upstream Invert (m): 116.59	
	Downstream Invert (m): 116.80	
	Top of Road Elevation (m): 120.176	
	Benchmark Location: Centreline of Bloor	**Structure is used in HEC-RAS Model**
	Benchmark Elevation (m):120.176	

Site Photographs

Structure Photograph Downstream

Upstream Photograph

Downstream Photograph

HYDRAULIC STRUCTURE INVENTORY SHEET: SITE#24

Watershed and Location Information	Structure Configuration and Dimensions	Current Flow Information
Date (mm/dd/yy): 06/22/07	Structure Type (Culvert/Bridge): Culvert	Flow Present (Y/N): N
Field Crew: Glenn, Ron & Amber	Number of Cells: 1	Approx. Depth (mm):0
Watershed Name: Tooley	Material (Concrete/Steel): Steel	Upstream Erosion (Y/N): N
Subcatchment Area No:	Open Footing (Yes/No): N	Downstream Erosion (Y/N): N
Tributary Name: Tooley Upper Tributary-10	Height (m) x Width (m) (If Applicable):	**Additional Field Notes**
Floodplain Map Sheet No.:	Diameter (m) (If Applicable):0.45	-upstream culvert was buried, picture below is the culvert opening on the road -Park on Hancock just south of Bloor, at road blockage
Cross Section Range:	Length (m): 8	
Municipality: Clarington	Inlet Type (Projecting/Mitered/Headwall): Mitered	
Location (Road Name/Intersection): Second creek on Hancock south of Bloor	Height from Obvert to Top of Road (m): 0.196	
	Depth of Siltation (mm): 100	
	Upstream Invert (m): 117.41	
	Downstream Invert (m): 117.43	
	Top of Road Elevation (m): 118.116	
	Benchmark Location: Center of Hancock Rd	
	Benchmark Elevation (m):118.116	

Site Photographs

Structure Photograph Downstream

Upstream Photograph

Downstream Photograph

HYDRAULIC STRUCTURE INVENTORY SHEET: SITE#25

Watershed and Location Information	Structure Configuration and Dimensions	Current Flow Information
Date (mm/dd/yy): 06/22/07	Structure Type (Culvert/Bridge): Culvert	Flow Present (Y/N): N
Field Crew: Glenn, Ron, & Amber	Number of Cells: 1	Approx. Depth (mm):230
Watershed Name: Tooley	Material (Concrete/Steel): Steel	Upstream Erosion (Y/N): N
Subcatchment Area No:	Open Footing (Yes/No): N	Downstream Erosion (Y/N):N
Tributary Name: Tooley Upper Tributary-12	Height (m) x Width (m) (If Applicable):	**Additional Field Notes**
Floodplain Map Sheet No.:	Diameter (m) (If Applicable):0.45	-Park on Hancock just south of Bloor, at road blockage
Cross Section Range:	Length (m): 7	
Municipality: Clarington	Inlet Type (Projecting/Mitered/Headwall): Projecting	
Location (Road Name/Intersection): First creek on Hancock south of Bloor	Height from Obvert to Top of Road (m): 0.148	
	Depth of Siltation (mm): 100	
	Upstream Invert (m): 116.48	
	Downstream Invert (m): 116.72	
	Top of Road Elevation (m): 117.198	
	Benchmark Location: Center of Hancock Rd	
	Benchmark Elevation (m):117.198	

Site Photographs

Structure Photograph Upstream

Upstream Photograph

Downstream Photograph

HYDRAULIC STRUCTURE INVENTORY SHEET: SITE#26

Central Lake Ontario Conservation

Watershed and Location Information	Structure Configuration and Dimensions	Current Flow Information
Date (mm/dd/yy): 06/06/07	Structure Type (Culvert/Bridge): Culvert	Flow Present (Y/N): N
Field Crew: Glenn Hendry & Ron Baker	Number of Cells: 1	Approx. Depth (mm):250
Watershed Name: Tooley	Material (Concrete/Steel): Steel	Upstream Erosion (Y/N): N
Subcatchment Area No:	Open Footing (Yes/No): N	Downstream Erosion (Y/N): N
Tributary Name: Tooley Upper Tributary-5	Height (m) x Width (m) (If Applicable):	**Additional Field Notes**
Floodplain Map Sheet No.:	Diameter (m) (If Applicable): 1.07	
Cross Section Range:	Length (m): 20	
Municipality: Clarington	Inlet Type (Projecting/Mitered/Headwall): Projecting	
Location (Road Name/Intersection): Bloor Rd & Courtice Rd	Height from Obvert to Top of Road (m): 0.802	
	Depth of Siltation (mm): 40	
	Upstream Invert (m): 126.89	
	Downstream Invert (m):125.56	
	Top of Road Elevation (m): 127.842	
	Benchmark Location: Centre line of Bloor	
	Benchmark Elevation (m):127.842	

Site Photographs

Structure Photograph Upstream

Upstream Photograph

Downstream Photograph

HYDRAULIC STRUCTURE INVENTORY SHEET: SITE#27

Watershed and Location Information	Structure Configuration and Dimensions	Current Flow Information
Date (mm/dd/yy): 06/07/07	Structure Type (Culvert/Bridge): Culvert	Flow Present (Y/N): N
Field Crew: Glenn Hendry and Ron Baker	Number of Cells: 1	Approx. Depth (mm):50
Watershed Name: Tooley	Material (Concrete/Steel): Steel	Upstream Erosion (Y/N): Y
Subcatchment Area No:	Open Footing (Yes/No): No	Downstream Erosion (Y/N): N
Tributary Name: Tooley Upper Tributary-11	Height (m) x Width (m) (If Applicable):	**Additional Field Notes**
Floodplain Map Sheet No.:	Diameter (m) (If Applicable):0.96 (crushed)	
Cross Section Range:	Length (m): 11	
Municipality: Clarington	Inlet Type (Projecting/Mitered/Headwall): Projecting	
Location (Road Name/Intersection): Bloor St East of Courtice Rd	Height from Obvert to Top of Road (m): 0.884	
	Depth of Siltation (mm): 10	
	Upstream Invert (m): 121.35	
	Downstream Invert (m): 121.34	
	Top of Road Elevation (m): 122.884	
	Benchmark Location: Centreline of Bloor St. above Culvert	
	Benchmark Elevation (m):122.884	

Site Photographs

Structure Photograph Upstream

Upstream Photograph

Downstream Photograph

HYDRAULIC STRUCTURE INVENTORY SHEET: SITE#28

Watershed and Location Information	Structure Configuration and Dimensions	Current Flow Information
Date (mm/dd/yy): 06/06/07	Structure Type (Culvert/Bridge): Culvert	Flow Present (Y/N): Y
Field Crew: Glenn Hendry & Ron Baker	Number of Cells: 1	Approx. Depth (mm):50
Watershed Name: Tooley	Material (Concrete/Steel): Steel	Upstream Erosion (Y/N): N
Subcatchment Area No:	Open Footing (Yes/No): N	Downstream Erosion (Y/N): N
Tributary Name: Tooley Upper Tributary-12	Height (m) x Width (m) (If Applicable):	**Additional Field Notes**
Floodplain Map Sheet No.:	Diameter (m) (If Applicable):1.24	
Cross Section Range:	Length (m): 9	
Municipality: Clarington	Inlet Type (Projecting/Mitered/Headwall): Projecting	
Location (Road Name/Intersection): Bloor, East of Hancock	Height from Obvert to Top of Road (m): 1.238	
	Depth of Siltation (mm): 0	
	Upstream Invert (m):120.72	
	Downstream Invert (m): 120.7	
	Top of Road Elevation (m): 122.568	
	Benchmark Location: Centreline of Bloor	
	Benchmark Elevation (m):122.568	

Site Photographs

Structure Photograph Upstream	Upstream Photograph	Downstream Photograph
		

HYDRAULIC STRUCTURE INVENTORY SHEET: SITE#29

Watershed and Location Information	Structure Configuration and Dimensions	Current Flow Information
Date (mm/dd/yy): 06/01/07	Structure Type (Culvert/Bridge): Culvert	Flow Present (Y/N): N
Field Crew: Glenn Hendry & Ron Baker	Number of Cells: 1	Approx. Depth (mm):0
Watershed Name: Tooley	Material (Concrete/Steel): Steel	Upstream Erosion (Y/N):N
Subcatchment Area No:	Open Footing (Yes/No): N	Downstream Erosion (Y/N):N
Tributary Name: Tooley Upper Tributary-8	Height (m) x Width (m) (If Applicable):	**Additional Field Notes**
Floodplain Map Sheet No.:	Diameter (m) (If Applicable):0.62	
Cross Section Range:	Length (m): 12	
Municipality: Clarington	Inlet Type (Projecting/Mitered/Headwall): Projecting	
Location (Road Name/Intersection): Hancock between Hwy 2 and Bloor	Height from Obvert to Top of Road (m): 0.536	
	Depth of Siltation (mm): 50	
	Upstream Invert (m):133.3	
	Downstream Invert (m): 133.32	
	Top of Road Elevation (m): 134.396	
	Benchmark Location: Centre of Hancock Rd above culvert	
	Benchmark Elevation (m):134.396	

Site Photographs

Structure Photograph Downstream

Upstream Photograph

Downstream Photograph

HYDRAULIC STRUCTURE INVENTORY SHEET: SITE#30

Central Lake Ontario Conservation

Watershed and Location Information	Structure Configuration and Dimensions	Current Flow Information
Date (mm/dd/yy): 06/01/07	Structure Type (Culvert/Bridge): Culvert	Flow Present (Y/N): N
Field Crew: Ron Baker & Glenn Hendry	Number of Cells: 1	Approx. Depth (mm):200
Watershed Name: Tooley	Material (Concrete/Steel): Steel	Upstream Erosion (Y/N): N
Subcatchment Area No:	Open Footing (Yes/No): N	Downstream Erosion (Y/N):N
Tributary Name: Tooley Upper Tributary-8	Height (m) x Width (m) (If Applicable):	**Additional Field Notes:**
Floodplain Map Sheet No.:	Diameter (m) (If Applicable):0.85	-Park on Hancock Rd just south of Hwy2
Cross Section Range:	Length (m): 13	
Municipality: Clarington	Inlet Type (Projecting/Mitered/Headwall): Mitered	
Location (Road Name/Intersection): Under Hancock Rd. & Hwy 2	Height from Obvert to Top of Road (m): 0.938	
	Depth of Siltation (mm): 20	
	Upstream Invert (m): 135.41	
	Downstream Invert (m): 136.29	
	Top of Road Elevation (m): 137.708	
	Benchmark Location: Centre of Hancock Rd	
	Benchmark Elevation (m):137.708	

Site Photographs

Structure Photograph Downstream

Upstream Photograph

Downstream Photograph

HYDRAULIC STRUCTURE INVENTORY SHEET: SITE#31

Watershed and Location Information	Structure Configuration and Dimensions	Current Flow Information
Date (mm/dd/yy): 06/06/07	Structure Type (Culvert/Bridge): Culvert	Flow Present (Y/N): N
Field Crew: Glenn Hendry & Ron Baker	Number of Cells: 1	Approx. Depth (mm):160
Watershed Name: Tooley	Material (Concrete/Steel): Steel	Upstream Erosion (Y/N): N
Subcatchment Area No:	Open Footing (Yes/No): N	Downstream Erosion (Y/N): N
Tributary Name: Tooley Upper Tributary-8	Height (m) x Width (m) (If Applicable):	**Additional Field Notes**
Floodplain Map Sheet No.:	Diameter (m) (If Applicable): 1.0	
Cross Section Range:	Length (m): 43	
Municipality: Clarington	Inlet Type (Projecting/Mitered/Headwall): Projecting	
Location (Road Name/Intersection): Under Hwy 2 & Hancock	Height from Obvert to Top of Road (m): 1.32	
	Depth of Siltation (mm): 0	
	Upstream Invert (m): 136.51	
	Downstream Invert (m): 136.48	
	Top of Road Elevation (m): 138.420	
	Benchmark Location: White line on south edge of Hwy 2 above culvert	
	Benchmark Elevation (m):138.420	

Site Photographs

Structure Photograph Upstream

Upstream Photograph

Downstream Photograph

HYDRAULIC STRUCTURE INVENTORY SHEET: SITE#32

Central Lake Ontario Conservation

Watershed and Location Information	Structure Configuration and Dimensions	Current Flow Information
Date (mm/dd/yy): 06/22/2007	Structure Type (Culvert/Bridge): Culvert	Flow Present (Y/N): N
Field Crew: Glenn, Ron, & Amber	Number of Cells: 1	Approx. Depth (mm):0
Watershed Name: Tooley	Material (Concrete/Steel): Steel	Upstream Erosion (Y/N):N
Subcatchment Area No:	Open Footing (Yes/No): N	Downstream Erosion (Y/N):N
Tributary Name: Tooley Upper Tributary-8	Height (m) x Width (m) (If Applicable): N/A	**Additional Field Notes**
Floodplain Map Sheet No.:	Diameter (m) (If Applicable): 0.95	-downstream opening of culvert drains from a manhole
Cross Section Range:	Length (m): 40	
Municipality: Clarington	Inlet Type (Projecting/Mitered/Headwall): Projecting	
Location (Road Name/Intersection): East most site on Hwy 2	Skew Angle of Crossing (Degrees):	
	Height from Obvert to Top of Road (m): 1.184	
	Depth of Siltation (mm): 100	
	Upstream Invert (m): N/A	
	Downstream Invert (m):138.0	
	Top of Road Elevation (m): 139.649	
	Benchmark Location: South Side of Hwy 2	
	Benchmark Elevation (m):139.649	

Site Photographs

Structure Photograph Downstream

Upstream Photograph

Unable to get Upstream Photograph because it drains sewer system

Downstream Photograph

HYDRAULIC STRUCTURE INVENTORY SHEET: SITE#33

Central Lake Ontario Conservation

Watershed and Location Information	Structure Configuration and Dimensions	Current Flow Information
Date (mm/dd/yy): 07/06/07	Structure Type (Culvert/Bridge): Culvert	Flow Present (Y/N): N
Field Crew: Ron Baker & Glenn Hendry	Number of Cells: 1	Approx. Depth (mm):10
Watershed Name: Tooley	Material (Concrete/Steel): Steel	Upstream Erosion (Y/N):N
Subcatchment Area No:	Open Footing (Yes/No): N	Downstream Erosion (Y/N):N
Tributary Name: Tooley West Tributary-1	Height (m) x Width (m) (If Applicable):	**Additional Field Notes**
Floodplain Map Sheet No.:	Diameter (m) (If Applicable):0.75	
Cross Section Range:	Length (m): 18	
Municipality: Clarington	Inlet Type (Projecting/Mitered/Headwall): Projecting	
Location (Road Name/Intersection): Directly North of Intersection of Down Rd and Darlington Park Rd- Under tracks **Culvert not on map**	Height from Obvert to Top of Road (m): 1.032	
	Depth of Siltation (mm): 140	
	Upstream Invert (m): 89.74	
	Downstream Invert (m): 89.38	
	Top of Road Elevation (m): 91.222	
	Benchmark Location: Centre of Darlington Rd	
	Benchmark Elevation (m):91.222	

Site Photographs

Structure Photograph Upstream

Upstream Photograph

Downstream Photograph

APPENDIX C
Hydraulics

Bridge Section:	3875
Description:	Bloor St (Structure 23)

Bridge Opening to Floodplain Width Ratio

Bridge Opening:	3.7
Floodplain Width:	59
b/B:	0.06

Slope

U/S Section:	3900
U/S Elev:	117.56
D/S Section:	3800
D/S Elev:	116.82
Slope:	0.74

Manning's Overbank to Manning's Channel Ratio

Overbank:	0.05
Channel:	0.03
n_{ob}/n_c:	1.67

Ranges of Expansion Ratios

		n_{ob}/n_c=1	n_{ob}/n_c=2	n_{ob}/n_c=4
b/B = 0.10	S = 0.02%	1.4-3.6	1.3-3.0	1.2-2.1
	S = 0.10%	1.0-2.5	0.8-2.0	0.8-2.0
	S = 0.20%	1.0-2.2	0.8-2.0	0.8-2.0
b/B = 0.25	S = 0.02%	1.6-3.0	1.4-2.5	1.2-2.0
	S = 0.10%	1.5-2.5	1.3-2.0	1.3-2.0
	S = 0.20%	1.5-2.0	1.3-2.0	1.3-2.0
b/B = 0.50	S = 0.02%	1.4-2.6	1.3-1.9	1.2-1.4
	S = 0.10%	1.3-2.1	1.2-1.6	1.0-1.4
	S = 0.20%	1.3-2.0	1.2-1.5	1.0-1.4

Expansion Ratio: 2

Average Obstruction Length

A to B:	7.0
C to D:	18.0
Average:	12.5

Expansion Reach Length = 25

Contraction Reach Length = 12.5

Bridge Section: 1764
Description: Railway (Structure 18)

Bridge Opening to Floodplain Width Ratio

Bridge Opening: 3.05
Floodplain Width: 170
b/B: 0.02

Slope

U/S Section: 1800
U/S Elev: 98.45
D/S Section: 1700
D/S Elev: 97.51
Slope: 0.94

Manning's Overbank to Manning's Channel Ratio

Overbank: 0.05
Channel: 0.03
n_{ob}/n_c: 1.67

Ranges of Expansion Ratios

		n_{ob}/n_c=1	n_{ob}/n_c=2	n_{ob}/n_c=4
b/B = 0.10	S = 0.02%	1.4-3.6	1.3-3.0	1.2-2.1
	S = 0.10%	1.0-2.5	0.8-2.0	0.8-2.0
	S = 0.20%	1.0-2.2	0.8-2.0	0.8-2.0
b/B = 0.25	S = 0.02%	1.6-3.0	1.4-2.5	1.2-2.0
	S = 0.10%	1.5-2.5	1.3-2.0	1.3-2.0
	S = 0.20%	1.5-2.0	1.3-2.0	1.3-2.0
b/B = 0.50	S = 0.02%	1.4-2.6	1.3-1.9	1.2-1.4
	S = 0.10%	1.3-2.1	1.2-1.6	1.0-1.4
	S = 0.20%	1.3-2.0	1.2-1.5	1.0-1.4

Expansion Ratio: 2

Average Obstruction Length

A to B: 77.0
C to D: 1.0

Average: 39.0

Expansion Reach Length = **78**

Contraction Reach Length = **39**

Bridge Section: 1360
Description: Baseline (Structure 17)

Bridge Opening to Floodplain Width Ratio

Bridge Opening: 6.34
Floodplain Width: 79
b/B: 0.08

Slope

U/S Section: 1400
U/S Elev: 94.55
D/S Section: 1300
D/S Elev: 93.96
Slope: 0.59

Manning's Overbank to Manning's Channel Ratio

Overbank: 0.05
Channel: 0.03
n_{ob}/n_c: 1.67

Ranges of Expansion Ratios

		n_{ob}/n_c=1	n_{ob}/n_c=2	n_{ob}/n_c=4
b/B = 0.10	S = 0.02%	1.4-3.6	1.3-3.0	1.2-2.1
	S = 0.10%	1.0-2.5	0.8-2.0	0.8-2.0
	S = 0.20%	1.0-2.2	0.8-2.0	0.8-2.0
b/B = 0.25	S = 0.02%	1.6-3.0	1.4-2.5	1.2-2.0
	S = 0.10%	1.5-2.5	1.3-2.0	1.3-2.0
	S = 0.20%	1.5-2.0	1.3-2.0	1.3-2.0
b/B = 0.50	S = 0.02%	1.4-2.6	1.3-1.9	1.2-1.4
	S = 0.10%	1.3-2.1	1.2-1.6	1.0-1.4
	S = 0.20%	1.3-2.0	1.2-1.5	1.0-1.4

Expansion Ratio: 2

Average Obstruction Length

A to B: 62.0
C to D: 11.0

Average: 36.5

Expansion Reach Length = **73**

Contraction Reach Length = **36.5**

Bridge Section: 957
Description: Courtice Rd (Structure 14)

Bridge Opening to Floodplain Width Ratio

Bridge Opening: 3.72
Floodplain Width: 197
b/B: 0.02

Slope

U/S Section: 1000
U/S Elev: 90.39
D/S Section: 900
D/S Elev: 89.35
Slope: 1.04

Manning's Overbank to Manning's Channel Ratio

Overbank: 0.05
Channel: 0.03
n_{ob}/n_c: 1.67

Ranges of Expansion Ratios

		n_{ob}/n_c=1	n_{ob}/n_c=2	n_{ob}/n_c=4
b/B = 0.10	S = 0.02%	1.4-3.6	1.3-3.0	1.2-2.1
	S = 0.10%	1.0-2.5	0.8-2.0	0.8-2.0
	S = 0.20%	1.0-2.2	0.8-2.0	0.8-2.0
b/B = 0.25	S = 0.02%	1.6-3.0	1.4-2.5	1.2-2.0
	S = 0.10%	1.5-2.5	1.3-2.0	1.3-2.0
	S = 0.20%	1.5-2.0	1.3-2.0	1.3-2.0
b/B = 0.50	S = 0.02%	1.4-2.6	1.3-1.9	1.2-1.4
	S = 0.10%	1.3-2.1	1.2-1.6	1.0-1.4
	S = 0.20%	1.3-2.0	1.2-1.5	1.0-1.4

Expansion Ratio: 2

Average Obstruction Length

A to B: 1.0
C to D: 82.0

Average: 41.5

Expansion Reach Length = 83

Contraction Reach Length = 41.5

Bridge Section: 641
Description: 401 (Structure 10)

Bridge Opening to Floodplain Width Ratio

Bridge Opening: 3.67
Floodplain Width: 180
b/B: 0.02

Slope

U/S Section: 800
U/S Elev: 88.18
D/S Section: 500
D/S Elev: 85.19
Slope: 1.00

Manning's Overbank to Manning's Channel Ratio

Overbank: 0.05
Channel: 0.03
n_{ob}/n_c: 1.67

Ranges of Expansion Ratios

		n_{ob}/n_c=1	n_{ob}/n_c=2	n_{ob}/n_c=4
b/B = 0.10	S = 0.02%	1.4-3.6	1.3-3.0	1.2-2.1
	S = 0.10%	1.0-2.5	0.8-2.0	0.8-2.0
	S = 0.20%	1.0-2.2	0.8-2.0	0.8-2.0
b/B = 0.25	S = 0.02%	1.6-3.0	1.4-2.5	1.2-2.0
	S = 0.10%	1.5-2.5	1.3-2.0	1.3-2.0
	S = 0.20%	1.5-2.0	1.3-2.0	1.3-2.0
b/B = 0.50	S = 0.02%	1.4-2.6	1.3-1.9	1.2-1.4
	S = 0.10%	1.3-2.1	1.2-1.6	1.0-1.4
	S = 0.20%	1.3-2.0	1.2-1.5	1.0-1.4

Expansion Ratio: 2

Average Obstruction Length

A to B: 100.0
C to D: 76.0

Average: 88.0

Expansion Reach Length = **176**

Contraction Reach Length = **88**

Bridge Section: 227
Description: Railway (Structure 0)

Bridge Opening to Floodplain Width Ratio

Bridge Opening: 2.45
Floodplain Width: 246
b/B: 0.01

Slope

U/S Section: 300
U/S Elev: 83.11
D/S Section: 200
D/S Elev: 82.18
Slope: 0.93

Manning's Overbank to Manning's Channel Ratio

Overbank: 0.05
Channel: 0.03
n_{ob}/n_c: 1.67

Ranges of Expansion Ratios

		n_{ob}/n_c=1	n_{ob}/n_c=2	n_{ob}/n_c=4
b/B = 0.10	S = 0.02%	1.4-3.6	1.3-3.0	1.2-2.1
	S = 0.10%	1.0-2.5	0.8-2.0	0.8-2.0
	S = 0.20%	1.0-2.2	0.8-2.0	0.8-2.0
b/B = 0.25	S = 0.02%	1.6-3.0	1.4-2.5	1.2-2.0
	S = 0.10%	1.5-2.5	1.3-2.0	1.3-2.0
	S = 0.20%	1.5-2.0	1.3-2.0	1.3-2.0
b/B = 0.50	S = 0.02%	1.4-2.6	1.3-1.9	1.2-1.4
	S = 0.10%	1.3-2.1	1.2-1.6	1.0-1.4
	S = 0.20%	1.3-2.0	1.2-1.5	1.0-1.4

Expansion Ratio: 2

Average Obstruction Length

A to B: 1.0
C to D: 1.0

Average: 1.0

Expansion Reach Length = **2**

Contraction Reach Length = **1**

HEC-RAS

River	Reach	River Sta	Profile	Plan	Q Total	W.S. Elev
					(m3/s)	(m)
Tooley_West	West	600	2 Year	1	0.63	89.20
Tooley_West	West	600	Future Regional	Regional	3.40	89.50
Tooley_West	West	600	5 Year	1	1.17	89.25
Tooley_West	West	600	10 Year	1	1.48	89.27
Tooley_West	West	600	25 Year	1	2.09	89.29
Tooley_West	West	600	50 Year	1	2.56	89.30
Tooley_West	West	600	100 Year	1	2.92	89.41
Tooley_West	West	500	2 Year	1	0.63	88.84
Tooley_West	West	500	Future Regional	Regional	3.40	89.00
Tooley_West	West	500	5 Year	1	1.17	88.94
Tooley_West	West	500	10 Year	1	1.48	88.98
Tooley_West	West	500	25 Year	1	2.09	89.04
Tooley_West	West	500	50 Year	1	2.56	89.15
Tooley_West	West	500	100 Year	1	2.92	88.98
Tooley_West	West	400	2 Year	1	0.63	88.33
Tooley_West	West	400	Future Regional	Regional	3.40	88.72
Tooley_West	West	400	5 Year	1	1.17	88.43
Tooley_West	West	400	10 Year	1	1.48	88.47
Tooley_West	West	400	25 Year	1	2.09	88.55
Tooley_West	West	400	50 Year	1	2.56	88.60
Tooley_West	West	400	100 Year	1	2.92	88.63
Tooley_West	West	300	2 Year	1	0.63	86.61
Tooley_West	West	300	Future Regional	Regional	6.75	87.12
Tooley_West	West	300	5 Year	1	1.17	86.71
Tooley_West	West	300	10 Year	1	1.48	86.75
Tooley_West	West	300	25 Year	1	2.09	86.82
Tooley_West	West	300	50 Year	1	2.56	86.86
Tooley_West	West	300	100 Year	1	2.92	86.89
Tooley_West	West	200	2 Year	1	0.63	85.27
Tooley_West	West	200	Future Regional	Regional	6.75	85.79
Tooley_West	West	200	5 Year	1	1.17	85.36
Tooley_West	West	200	10 Year	1	1.48	85.39
Tooley_West	West	200	25 Year	1	2.09	85.46
Tooley_West	West	200	50 Year	1	2.56	85.50
Tooley_West	West	200	100 Year	1	2.92	85.53
Tooley_West	West	100	2 Year	1	0.63	82.87
Tooley_West	West	100	Future Regional	Regional	6.75	83.20
Tooley_West	West	100	5 Year	1	1.17	82.94
Tooley_West	West	100	10 Year	1	1.48	82.95
Tooley_West	West	100	25 Year	1	2.09	82.99
Tooley_West	West	100	50 Year	1	2.56	83.02
Tooley_West	West	100	100 Year	1	2.92	83.04
Tooley_Upper	Upper	4800	2 Year	1	0.93	128.70
Tooley_Upper	Upper	4800	Future Regional	Regional	12.41	129.00
Tooley_Upper	Upper	4800	5 Year	1	1.69	128.74

HEC-RAS (Continued)

River	Reach	River Sta	Profile	Plan	Q Total	W.S. Elev
					(m3/s)	(m)
Tooley_Upper	Upper	4800	10 Year	1	2.13	128.76
Tooley_Upper	Upper	4800	25 Year	1	3.00	128.81
Tooley_Upper	Upper	4800	50 Year	1	3.69	128.82
Tooley_Upper	Upper	4800	100 Year	1	4.24	128.83
Tooley_Upper	Upper	4700	2 Year	1	0.93	128.25
Tooley_Upper	Upper	4700	Future Regional	Regional	12.41	128.78
Tooley_Upper	Upper	4700	5 Year	1	1.69	128.34
Tooley_Upper	Upper	4700	10 Year	1	2.13	128.38
Tooley_Upper	Upper	4700	25 Year	1	3.00	128.45
Tooley_Upper	Upper	4700	50 Year	1	3.69	128.49
Tooley_Upper	Upper	4700	100 Year	1	4.24	128.53
Tooley_Upper	Upper	4600	2 Year	1	2.05	127.94
Tooley_Upper	Upper	4600	Future Regional	Regional	20.48	128.41
Tooley_Upper	Upper	4600	5 Year	1	3.73	128.04
Tooley_Upper	Upper	4600	10 Year	1	4.68	128.08
Tooley_Upper	Upper	4600	25 Year	1	6.56	128.14
Tooley_Upper	Upper	4600	50 Year	1	8.03	128.18
Tooley_Upper	Upper	4600	100 Year	1	9.18	128.22
Tooley_Upper	Upper	4500.017	2 Year	1	2.05	126.87
Tooley_Upper	Upper	4500.017	Future Regional	Regional	20.48	127.11
Tooley_Upper	Upper	4500.017	5 Year	1	3.73	126.91
Tooley_Upper	Upper	4500.017	10 Year	1	4.68	126.93
Tooley_Upper	Upper	4500.017	25 Year	1	6.56	126.96
Tooley_Upper	Upper	4500.017	50 Year	1	8.03	126.99
Tooley_Upper	Upper	4500.017	100 Year	1	9.18	126.99
Tooley_Upper	Upper	4400	2 Year	1	2.05	125.46
Tooley_Upper	Upper	4400	Future Regional	Regional	20.48	126.04
Tooley_Upper	Upper	4400	5 Year	1	3.73	125.57
Tooley_Upper	Upper	4400	10 Year	1	4.68	125.61
Tooley_Upper	Upper	4400	25 Year	1	6.56	125.67
Tooley_Upper	Upper	4400	50 Year	1	8.03	125.72
Tooley_Upper	Upper	4400	100 Year	1	9.18	125.76
Tooley_Upper	Upper	4300	2 Year	1	2.05	124.71
Tooley_Upper	Upper	4300	Future Regional	Regional	20.48	125.16
Tooley_Upper	Upper	4300	5 Year	1	3.73	124.79
Tooley_Upper	Upper	4300	10 Year	1	4.68	124.82
Tooley_Upper	Upper	4300	25 Year	1	6.56	124.90
Tooley_Upper	Upper	4300	50 Year	1	8.03	124.95
Tooley_Upper	Upper	4300	100 Year	1	9.18	124.98
Tooley_Upper	Upper	4200	2 Year	1	1.98	123.04
Tooley_Upper	Upper	4200	Future Regional	Regional	22.08	123.79
Tooley_Upper	Upper	4200	5 Year	1	3.61	123.14
Tooley_Upper	Upper	4200	10 Year	1	4.56	123.20
Tooley_Upper	Upper	4200	25 Year	1	6.50	123.24
Tooley_Upper	Upper	4200	50 Year	1	8.04	123.30

HEC-RAS (Continued)

River	Reach	River Sta	Profile	Plan	Q Total	W.S. Elev
					(m3/s)	(m)
Tooley_Upper	Upper	4200	100 Year	1	9.23	123.34
Tooley_Upper	Upper	4100	2 Year	1	1.98	120.93
Tooley_Upper	Upper	4100	Future Regional	Regional	22.08	121.26
Tooley_Upper	Upper	4100	5 Year	1	3.61	121.02
Tooley_Upper	Upper	4100	10 Year	1	4.56	121.05
Tooley_Upper	Upper	4100	25 Year	1	6.50	121.18
Tooley_Upper	Upper	4100	50 Year	1	8.04	121.23
Tooley_Upper	Upper	4100	100 Year	1	9.23	121.27
Tooley_Upper	Upper	4000	2 Year	1	1.98	119.02
Tooley_Upper	Upper	4000	Future Regional	Regional	22.08	120.34
Tooley_Upper	Upper	4000	5 Year	1	3.61	119.09
Tooley_Upper	Upper	4000	10 Year	1	4.56	119.14
Tooley_Upper	Upper	4000	25 Year	1	6.50	119.12
Tooley_Upper	Upper	4000	50 Year	1	8.04	119.16
Tooley_Upper	Upper	4000	100 Year	1	9.23	119.18
Tooley_Upper	Upper	3900	2 Year	1	1.98	117.95
Tooley_Upper	Upper	3900	Future Regional	Regional	22.08	120.34
Tooley_Upper	Upper	3900	5 Year	1	3.61	118.04
Tooley_Upper	Upper	3900	10 Year	1	4.56	118.08
Tooley_Upper	Upper	3900	25 Year	1	6.50	118.26
Tooley_Upper	Upper	3900	50 Year	1	8.04	118.42
Tooley_Upper	Upper	3900	100 Year	1	9.23	118.54
Tooley_Upper	Upper	3896.167	2 Year	1	1.98	117.88
Tooley_Upper	Upper	3896.167	Future Regional	Regional	22.08	120.34
Tooley_Upper	Upper	3896.167	5 Year	1	3.61	117.94
Tooley_Upper	Upper	3896.167	10 Year	1	4.56	118.02
Tooley_Upper	Upper	3896.167	25 Year	1	6.50	118.24
Tooley_Upper	Upper	3896.167	50 Year	1	8.04	118.41
Tooley_Upper	Upper	3896.167	100 Year	1	9.23	118.54
Tooley_Upper	Upper	3884	2 Year	1	1.98	117.75
Tooley_Upper	Upper	3884	Future Regional	Regional	22.08	120.30
Tooley_Upper	Upper	3884	5 Year	1	3.61	117.92
Tooley_Upper	Upper	3884	10 Year	1	4.56	118.00
Tooley_Upper	Upper	3884	25 Year	1	6.50	118.14
Tooley_Upper	Upper	3884	50 Year	1	8.04	118.28
Tooley_Upper	Upper	3884	100 Year	1	9.23	118.38
Tooley_Upper	Upper	3875.491			Culvert	
Tooley_Upper	Upper	3866	2 Year	1	1.98	117.71
Tooley_Upper	Upper	3866	Future Regional	Regional	22.08	118.58
Tooley_Upper	Upper	3866	5 Year	1	3.61	117.84
Tooley_Upper	Upper	3866	10 Year	1	4.56	117.88
Tooley_Upper	Upper	3866	25 Year	1	6.50	117.95
Tooley_Upper	Upper	3866	50 Year	1	8.04	117.99
Tooley_Upper	Upper	3866	100 Year	1	9.23	118.05

HEC-RAS (Continued)

River	Reach	River Sta	Profile	Plan	Q Total	W.S. Elev
					(m3/s)	(m)
Tooley_Upper	Upper	3840.997	2 Year	1	1.98	117.62
Tooley_Upper	Upper	3840.997	Future Regional	Regional	22.08	118.29
Tooley_Upper	Upper	3840.997	5 Year	1	3.61	117.73
Tooley_Upper	Upper	3840.997	10 Year	1	4.56	117.78
Tooley_Upper	Upper	3840.997	25 Year	1	6.50	117.86
Tooley_Upper	Upper	3840.997	50 Year	1	8.04	117.91
Tooley_Upper	Upper	3840.997	100 Year	1	9.23	117.96
Tooley_Upper	Upper	3800	2 Year	1	1.98	117.24
Tooley_Upper	Upper	3800	Future Regional	Regional	22.08	117.89
Tooley_Upper	Upper	3800	5 Year	1	3.61	117.36
Tooley_Upper	Upper	3800	10 Year	1	4.56	117.40
Tooley_Upper	Upper	3800	25 Year	1	6.50	117.51
Tooley_Upper	Upper	3800	50 Year	1	8.04	117.58
Tooley_Upper	Upper	3800	100 Year	1	9.23	117.63
Tooley_Upper	Upper	3700	2 Year	1	2.74	116.50
Tooley_Upper	Upper	3700	Future Regional	Regional	20.77	117.18
Tooley_Upper	Upper	3700	5 Year	1	4.96	116.65
Tooley_Upper	Upper	3700	10 Year	1	6.20	116.73
Tooley_Upper	Upper	3700	25 Year	1	8.65	116.83
Tooley_Upper	Upper	3700	50 Year	1	10.54	116.92
Tooley_Upper	Upper	3700	100 Year	1	12.01	116.96
Tooley_Upper	Upper	3600	2 Year	1	2.74	115.69
Tooley_Upper	Upper	3600	Future Regional	Regional	20.77	116.21
Tooley_Upper	Upper	3600	5 Year	1	4.96	115.81
Tooley_Upper	Upper	3600	10 Year	1	6.20	115.84
Tooley_Upper	Upper	3600	25 Year	1	8.65	115.94
Tooley_Upper	Upper	3600	50 Year	1	10.54	115.99
Tooley_Upper	Upper	3600	100 Year	1	12.01	116.03
Tooley_Upper	Upper	3500	2 Year	1	2.74	114.32
Tooley_Upper	Upper	3500	Future Regional	Regional	20.77	114.70
Tooley_Upper	Upper	3500	5 Year	1	4.96	114.40
Tooley_Upper	Upper	3500	10 Year	1	6.20	114.45
Tooley_Upper	Upper	3500	25 Year	1	8.65	114.50
Tooley_Upper	Upper	3500	50 Year	1	10.54	114.54
Tooley_Upper	Upper	3500	100 Year	1	12.01	114.56
Tooley_Upper	Upper	3400	2 Year	1	2.74	113.36
Tooley_Upper	Upper	3400	Future Regional	Regional	20.77	113.92
Tooley_Upper	Upper	3400	5 Year	1	4.96	113.49
Tooley_Upper	Upper	3400	10 Year	1	6.20	113.54
Tooley_Upper	Upper	3400	25 Year	1	8.65	113.63
Tooley_Upper	Upper	3400	50 Year	1	10.54	113.69
Tooley_Upper	Upper	3400	100 Year	1	12.01	113.73
Tooley_Upper	Upper	3300	2 Year	1	4.64	112.78
Tooley_Upper	Upper	3300	Future Regional	Regional	36.13	113.27

HEC-RAS (Continued)

River	Reach	River Sta	Profile	Plan	Q Total	W.S. Elev
					(m3/s)	(m)
Tooley_Upper	Upper	3300	5 Year	1	8.36	112.87
Tooley_Upper	Upper	3300	10 Year	1	10.45	112.92
Tooley_Upper	Upper	3300	25 Year	1	14.57	112.99
Tooley_Upper	Upper	3300	50 Year	1	17.75	113.04
Tooley_Upper	Upper	3300	100 Year	1	20.23	113.08
Tooley_Upper	Upper	3200	2 Year	1	4.64	111.95
Tooley_Upper	Upper	3200	Future Regional	Regional	36.13	112.43
Tooley_Upper	Upper	3200	5 Year	1	8.36	112.04
Tooley_Upper	Upper	3200	10 Year	1	10.45	112.09
Tooley_Upper	Upper	3200	25 Year	1	14.57	112.17
Tooley_Upper	Upper	3200	50 Year	1	17.75	112.21
Tooley_Upper	Upper	3200	100 Year	1	20.23	112.25
Tooley_Upper	Upper	3100	2 Year	1	4.64	110.94
Tooley_Upper	Upper	3100	Future Regional	Regional	36.13	111.35
Tooley_Upper	Upper	3100	5 Year	1	8.36	111.02
Tooley_Upper	Upper	3100	10 Year	1	10.45	111.05
Tooley_Upper	Upper	3100	25 Year	1	14.57	111.11
Tooley_Upper	Upper	3100	50 Year	1	17.75	111.15
Tooley_Upper	Upper	3100	100 Year	1	20.23	111.18
Tooley_Upper	Upper	3000	2 Year	1	4.64	109.83
Tooley_Upper	Upper	3000	Future Regional	Regional	36.13	110.25
Tooley_Upper	Upper	3000	5 Year	1	8.36	109.91
Tooley_Upper	Upper	3000	10 Year	1	10.45	109.95
Tooley_Upper	Upper	3000	25 Year	1	14.57	110.01
Tooley_Upper	Upper	3000	50 Year	1	17.75	110.06
Tooley_Upper	Upper	3000	100 Year	1	20.23	110.09
Tooley_Upper	Upper	2900	2 Year	1	4.64	109.23
Tooley_Upper	Upper	2900	Future Regional	Regional	36.13	109.70
Tooley_Upper	Upper	2900	5 Year	1	8.36	109.33
Tooley_Upper	Upper	2900	10 Year	1	10.45	109.37
Tooley_Upper	Upper	2900	25 Year	1	14.57	109.44
Tooley_Upper	Upper	2900	50 Year	1	17.75	109.49
Tooley_Upper	Upper	2900	100 Year	1	20.23	109.52
Tooley_Upper	Upper	2800	2 Year	1	6.10	108.29
Tooley_Upper	Upper	2800	Future Regional	Regional	47.95	108.73
Tooley_Upper	Upper	2800	5 Year	1	10.98	108.38
Tooley_Upper	Upper	2800	10 Year	1	13.72	108.42
Tooley_Upper	Upper	2800	25 Year	1	19.12	108.48
Tooley_Upper	Upper	2800	50 Year	1	23.30	108.53
Tooley_Upper	Upper	2800	100 Year	1	26.55	108.56
Tooley_Upper	Upper	2700	2 Year	1	6.10	107.26
Tooley_Upper	Upper	2700	Future Regional	Regional	47.95	107.77
Tooley_Upper	Upper	2700	5 Year	1	10.98	107.37
Tooley_Upper	Upper	2700	10 Year	1	13.72	107.41
Tooley_Upper	Upper	2700	25 Year	1	19.12	107.49

HEC-RAS (Continued)

River	Reach	River Sta	Profile	Plan	Q Total	W.S. Elev
					(m3/s)	(m)
Tooley_Upper	Upper	2700	50 Year	1	23.30	107.54
Tooley_Upper	Upper	2700	100 Year	1	26.55	107.58
Tooley_Upper	Upper	2593.810	2 Year	1	6.10	106.32
Tooley_Upper	Upper	2593.810	Future Regional	Regional	47.95	106.66
Tooley_Upper	Upper	2593.810	5 Year	1	10.98	106.37
Tooley_Upper	Upper	2593.810	10 Year	1	13.72	106.39
Tooley_Upper	Upper	2593.810	25 Year	1	19.12	106.45
Tooley_Upper	Upper	2593.810	50 Year	1	23.30	106.48
Tooley_Upper	Upper	2593.810	100 Year	1	26.55	106.51
Tooley_Upper	Upper	2500	2 Year	1	6.10	105.70
Tooley_Upper	Upper	2500	Future Regional	Regional	47.95	106.25
Tooley_Upper	Upper	2500	5 Year	1	10.98	105.81
Tooley_Upper	Upper	2500	10 Year	1	13.72	105.86
Tooley_Upper	Upper	2500	25 Year	1	19.12	105.95
Tooley_Upper	Upper	2500	50 Year	1	23.30	106.00
Tooley_Upper	Upper	2500	100 Year	1	26.55	106.04
Tooley_Upper	Upper	2400	2 Year	1	6.10	105.03
Tooley_Upper	Upper	2400	Future Regional	Regional	47.95	105.55
Tooley_Upper	Upper	2400	5 Year	1	10.98	105.14
Tooley_Upper	Upper	2400	10 Year	1	13.72	105.19
Tooley_Upper	Upper	2400	25 Year	1	19.12	105.28
Tooley_Upper	Upper	2400	50 Year	1	23.30	105.33
Tooley_Upper	Upper	2400	100 Year	1	26.55	105.37
Tooley_Upper	Upper	2300	2 Year	1	6.10	104.12
Tooley_Upper	Upper	2300	Future Regional	Regional	47.95	105.58
Tooley_Upper	Upper	2300	5 Year	1	10.98	104.24
Tooley_Upper	Upper	2300	10 Year	1	13.72	104.30
Tooley_Upper	Upper	2300	25 Year	1	19.12	104.38
Tooley_Upper	Upper	2300	50 Year	1	23.30	104.47
Tooley_Upper	Upper	2300	100 Year	1	26.55	104.51
Tooley_Upper	Upper	2200	2 Year	1	6.10	103.37
Tooley_Upper	Upper	2200	Future Regional	Regional	47.95	105.57
Tooley_Upper	Upper	2200	5 Year	1	10.98	103.47
Tooley_Upper	Upper	2200	10 Year	1	13.72	103.51
Tooley_Upper	Upper	2200	25 Year	1	19.12	103.59
Tooley_Upper	Upper	2200	50 Year	1	23.30	103.60
Tooley_Upper	Upper	2200	100 Year	1	26.55	103.63
Tooley_Upper	Upper	2100	2 Year	1	6.02	102.17
Tooley_Upper	Upper	2100	Future Regional	Regional	59.94	105.57
Tooley_Upper	Upper	2100	5 Year	1	11.00	102.29
Tooley_Upper	Upper	2100	10 Year	1	13.84	102.34
Tooley_Upper	Upper	2100	25 Year	1	19.55	102.43
Tooley_Upper	Upper	2100	50 Year	1	24.01	102.59
Tooley_Upper	Upper	2100	100 Year	1	27.48	102.63

HEC-RAS (Continued)

River	Reach	River Sta	Profile	Plan	Q Total	W.S. Elev
					(m3/s)	(m)
Tooley_Upper	Upper	2000	2 Year	1	6.02	101.45
Tooley_Upper	Upper	2000	Future Regional	Regional	59.94	105.57
Tooley_Upper	Upper	2000	5 Year	1	11.00	101.55
Tooley_Upper	Upper	2000	10 Year	1	13.84	101.59
Tooley_Upper	Upper	2000	25 Year	1	19.55	101.65
Tooley_Upper	Upper	2000	50 Year	1	24.01	101.59
Tooley_Upper	Upper	2000	100 Year	1	27.48	101.62
Tooley_Upper	Upper	1900	2 Year	1	6.02	100.37
Tooley_Upper	Upper	1900	Future Regional	Regional	59.94	105.57
Tooley_Upper	Upper	1900	5 Year	1	11.00	100.45
Tooley_Upper	Upper	1900	10 Year	1	13.84	100.49
Tooley_Upper	Upper	1900	25 Year	1	19.55	100.56
Tooley_Upper	Upper	1900	50 Year	1	24.01	100.75
Tooley_Upper	Upper	1900	100 Year	1	27.48	101.06
Tooley_Upper	Upper	1818.172	2 Year	1	6.02	99.16
Tooley_Upper	Upper	1818.172	Future Regional	Regional	59.94	105.57
Tooley_Upper	Upper	1818.172	5 Year	1	11.00	99.64
Tooley_Upper	Upper	1818.172	10 Year	1	13.84	99.91
Tooley_Upper	Upper	1818.172	25 Year	1	19.55	100.40
Tooley_Upper	Upper	1818.172	50 Year	1	24.01	100.77
Tooley_Upper	Upper	1818.172	100 Year	1	27.48	101.05
Tooley_Upper	Upper	1800	2 Year	1	6.02	99.14
Tooley_Upper	Upper	1800	Future Regional	Regional	59.94	105.57
Tooley_Upper	Upper	1800	5 Year	1	11.00	99.64
Tooley_Upper	Upper	1800	10 Year	1	13.84	99.90
Tooley_Upper	Upper	1800	25 Year	1	19.55	100.40
Tooley_Upper	Upper	1800	50 Year	1	24.01	100.77
Tooley_Upper	Upper	1800	100 Year	1	27.48	101.05
Tooley_Upper	Upper	1779	2 Year	1	6.02	98.90
Tooley_Upper	Upper	1779	Future Regional	Regional	59.94	105.57
Tooley_Upper	Upper	1779	5 Year	1	11.00	99.38
Tooley_Upper	Upper	1779	10 Year	1	13.84	99.62
Tooley_Upper	Upper	1779	25 Year	1	19.55	100.08
Tooley_Upper	Upper	1779	50 Year	1	24.01	100.42
Tooley_Upper	Upper	1779	100 Year	1	27.48	100.69
Tooley_Upper	Upper	1764.263			Culvert	
Tooley_Upper	Upper	1748	2 Year	1	6.02	98.70
Tooley_Upper	Upper	1748	Future Regional	Regional	59.94	100.89
Tooley_Upper	Upper	1748	5 Year	1	11.00	99.02
Tooley_Upper	Upper	1748	10 Year	1	13.84	99.17
Tooley_Upper	Upper	1748	25 Year	1	19.55	99.45
Tooley_Upper	Upper	1748	50 Year	1	24.01	99.64
Tooley_Upper	Upper	1748	100 Year	1	27.48	99.78
Tooley_Upper	Upper	1700	2 Year	1	6.02	98.04

HEC-RAS (Continued)

River	Reach	River Sta	Profile	Plan	Q Total	W.S. Elev
					(m3/s)	(m)
Tooley_Upper	Upper	1700	Future Regional	Regional	59.94	99.10
Tooley_Upper	Upper	1700	5 Year	1	11.00	98.18
Tooley_Upper	Upper	1700	10 Year	1	13.84	98.24
Tooley_Upper	Upper	1700	25 Year	1	19.55	98.32
Tooley_Upper	Upper	1700	50 Year	1	24.01	98.37
Tooley_Upper	Upper	1700	100 Year	1	27.48	98.41
Tooley_Upper	Upper	1670.175	2 Year	1	6.02	97.69
Tooley_Upper	Upper	1670.175	Future Regional	Regional	59.94	99.07
Tooley_Upper	Upper	1670.175	5 Year	1	11.00	97.78
Tooley_Upper	Upper	1670.175	10 Year	1	13.84	97.84
Tooley_Upper	Upper	1670.175	25 Year	1	19.55	97.95
Tooley_Upper	Upper	1670.175	50 Year	1	24.01	98.03
Tooley_Upper	Upper	1670.175	100 Year	1	27.48	98.08
Tooley_Upper	Upper	1600	2 Year	1	6.02	97.38
Tooley_Upper	Upper	1600	Future Regional	Regional	59.94	99.05
Tooley_Upper	Upper	1600	5 Year	1	11.00	97.56
Tooley_Upper	Upper	1600	10 Year	1	13.84	97.63
Tooley_Upper	Upper	1600	25 Year	1	19.55	97.77
Tooley_Upper	Upper	1600	50 Year	1	24.01	97.87
Tooley_Upper	Upper	1600	100 Year	1	27.48	97.92
Tooley_Upper	Upper	1500	2 Year	1	7.68	96.97
Tooley_Upper	Upper	1500	Future Regional	Regional	74.24	99.03
Tooley_Upper	Upper	1500	5 Year	1	14.08	97.01
Tooley_Upper	Upper	1500	10 Year	1	17.72	97.13
Tooley_Upper	Upper	1500	25 Year	1	24.94	97.17
Tooley_Upper	Upper	1500	50 Year	1	30.60	97.18
Tooley_Upper	Upper	1500	100 Year	1	35.03	97.29
Tooley_Upper	Upper	1412.393	2 Year	1	7.68	95.73
Tooley_Upper	Upper	1412.393	Future Regional	Regional	74.24	99.02
Tooley_Upper	Upper	1412.393	5 Year	1	14.08	96.22
Tooley_Upper	Upper	1412.393	10 Year	1	17.72	96.27
Tooley_Upper	Upper	1412.393	25 Year	1	24.94	96.51
Tooley_Upper	Upper	1412.393	50 Year	1	30.60	96.80
Tooley_Upper	Upper	1412.393	100 Year	1	35.03	97.00
Tooley_Upper	Upper	1400	2 Year	1	7.68	95.58
Tooley_Upper	Upper	1400	Future Regional	Regional	74.24	99.02
Tooley_Upper	Upper	1400	5 Year	1	14.08	95.81
Tooley_Upper	Upper	1400	10 Year	1	17.72	96.11
Tooley_Upper	Upper	1400	25 Year	1	24.94	96.51
Tooley_Upper	Upper	1400	50 Year	1	30.60	96.80
Tooley_Upper	Upper	1400	100 Year	1	35.03	97.00
Tooley_Upper	Upper	1376	2 Year	1	7.68	95.20
Tooley_Upper	Upper	1376	Future Regional	Regional	74.24	98.66
Tooley_Upper	Upper	1376	5 Year	1	14.08	95.68
Tooley_Upper	Upper	1376	10 Year	1	17.72	95.91

HEC-RAS (Continued)

River	Reach	River Sta	Profile	Plan	Q Total	W.S. Elev
					(m3/s)	(m)
Tooley_Upper	Upper	1376	25 Year	1	24.94	96.30
Tooley_Upper	Upper	1376	50 Year	1	30.60	96.53
Tooley_Upper	Upper	1376	100 Year	1	35.03	96.71
Tooley_Upper	Upper	1360.285			Culvert	
Tooley_Upper	Upper	1343.5	2 Year	1	7.68	94.94
Tooley_Upper	Upper	1343.5	Future Regional	Regional	74.24	97.57
Tooley_Upper	Upper	1343.5	5 Year	1	14.08	95.28
Tooley_Upper	Upper	1343.5	10 Year	1	17.72	95.45
Tooley_Upper	Upper	1343.5	25 Year	1	24.94	95.85
Tooley_Upper	Upper	1343.5	50 Year	1	30.60	96.02
Tooley_Upper	Upper	1343.5	100 Year	1	35.03	96.14
Tooley_Upper	Upper	1300	2 Year	1	7.68	94.70
Tooley_Upper	Upper	1300	Future Regional	Regional	74.24	97.92
Tooley_Upper	Upper	1300	5 Year	1	14.08	94.80
Tooley_Upper	Upper	1300	10 Year	1	17.72	94.92
Tooley_Upper	Upper	1300	25 Year	1	24.94	95.02
Tooley_Upper	Upper	1300	50 Year	1	30.60	95.05
Tooley_Upper	Upper	1300	100 Year	1	35.03	95.09
Tooley_Upper	Upper	1270.062	2 Year	1	7.68	94.41
Tooley_Upper	Upper	1270.062	Future Regional	Regional	74.24	97.92
Tooley_Upper	Upper	1270.062	5 Year	1	14.08	94.57
Tooley_Upper	Upper	1270.062	10 Year	1	17.72	94.62
Tooley_Upper	Upper	1270.062	25 Year	1	24.94	94.75
Tooley_Upper	Upper	1270.062	50 Year	1	30.60	94.83
Tooley_Upper	Upper	1270.062	100 Year	1	35.03	94.80
Tooley_Upper	Upper	1200	2 Year	1	7.68	93.69
Tooley_Upper	Upper	1200	Future Regional	Regional	74.24	97.92
Tooley_Upper	Upper	1200	5 Year	1	14.08	93.78
Tooley_Upper	Upper	1200	10 Year	1	17.72	93.84
Tooley_Upper	Upper	1200	25 Year	1	24.94	93.88
Tooley_Upper	Upper	1200	50 Year	1	30.60	93.94
Tooley_Upper	Upper	1200	100 Year	1	35.03	94.09
Tooley_Upper	Upper	1100	2 Year	1	7.70	92.29
Tooley_Upper	Upper	1100	Future Regional	Regional	74.77	97.92
Tooley_Upper	Upper	1100	5 Year	1	14.15	92.44
Tooley_Upper	Upper	1100	10 Year	1	17.84	92.48
Tooley_Upper	Upper	1100	25 Year	1	25.06	92.83
Tooley_Upper	Upper	1100	50 Year	1	30.75	93.37
Tooley_Upper	Upper	1100	100 Year	1	35.18	94.16
Tooley_Upper	Upper	1012.493	2 Year	1	7.70	91.70
Tooley_Upper	Upper	1012.493	Future Regional	Regional	74.77	97.92
Tooley_Upper	Upper	1012.493	5 Year	1	14.15	91.91
Tooley_Upper	Upper	1012.493	10 Year	1	17.84	92.15
Tooley_Upper	Upper	1012.493	25 Year	1	25.06	92.73

HEC-RAS (Continued)

River	Reach	River Sta	Profile	Plan	Q Total	W.S. Elev
					(m3/s)	(m)
Tooley_Upper	Upper	1012.493	50 Year	1	30.75	93.34
Tooley_Upper	Upper	1012.493	100 Year	1	35.18	94.15
Tooley_Upper	Upper	1000	2 Year	1	7.70	91.07
Tooley_Upper	Upper	1000	Future Regional	Regional	74.77	97.92
Tooley_Upper	Upper	1000	5 Year	1	14.15	91.71
Tooley_Upper	Upper	1000	10 Year	1	17.84	92.05
Tooley_Upper	Upper	1000	25 Year	1	25.06	92.69
Tooley_Upper	Upper	1000	50 Year	1	30.75	93.33
Tooley_Upper	Upper	1000	100 Year	1	35.18	94.15
Tooley_Upper	Upper	970.5	2 Year	1	7.70	90.85
Tooley_Upper	Upper	970.5	Future Regional	Regional	74.77	97.92
Tooley_Upper	Upper	970.5	5 Year	1	14.15	91.50
Tooley_Upper	Upper	970.5	10 Year	1	17.84	91.82
Tooley_Upper	Upper	970.5	25 Year	1	25.06	92.45
Tooley_Upper	Upper	970.5	50 Year	1	30.75	93.10
Tooley_Upper	Upper	970.5	100 Year	1	35.18	93.97
Tooley_Upper	Upper	957.6232			Culvert	
Tooley_Upper	Upper	943.5	2 Year	1	7.70	90.66
Tooley_Upper	Upper	943.5	Future Regional	Regional	74.77	97.91
Tooley_Upper	Upper	943.5	5 Year	1	14.15	90.92
Tooley_Upper	Upper	943.5	10 Year	1	17.84	91.06
Tooley_Upper	Upper	943.5	25 Year	1	25.06	91.33
Tooley_Upper	Upper	943.5	50 Year	1	30.75	91.74
Tooley_Upper	Upper	943.5	100 Year	1	35.18	92.62
Tooley_Upper	Upper	900	2 Year	1	7.70	90.35
Tooley_Upper	Upper	900	Future Regional	Regional	74.77	97.91
Tooley_Upper	Upper	900	5 Year	1	14.15	90.56
Tooley_Upper	Upper	900	10 Year	1	17.84	90.64
Tooley_Upper	Upper	900	25 Year	1	25.06	90.78
Tooley_Upper	Upper	900	50 Year	1	30.75	91.99
Tooley_Upper	Upper	900	100 Year	1	35.18	92.77
Tooley_Upper	Upper	863.4556	2 Year	1	7.70	89.78
Tooley_Upper	Upper	863.4556	Future Regional	Regional	74.77	97.91
Tooley_Upper	Upper	863.4556	5 Year	1	14.15	90.00
Tooley_Upper	Upper	863.4556	10 Year	1	17.84	90.10
Tooley_Upper	Upper	863.4556	25 Year	1	25.06	90.39
Tooley_Upper	Upper	863.4556	50 Year	1	30.75	91.98
Tooley_Upper	Upper	863.4556	100 Year	1	35.18	92.77
Tooley_Upper	Upper	800	2 Year	1	10.09	89.10
Tooley_Upper	Upper	800	Future Regional	Regional	91.51	97.91
Tooley_Upper	Upper	800	5 Year	1	17.89	89.45
Tooley_Upper	Upper	800	10 Year	1	22.39	89.80
Tooley_Upper	Upper	800	25 Year	1	31.31	90.47
Tooley_Upper	Upper	800	50 Year	1	37.95	91.98

HEC-RAS (Continued)

River	Reach	River Sta	Profile	Plan	Q Total	W.S. Elev
					(m3/s)	(m)
Tooley_Upper	Upper	800	100 Year	1	43.09	92.77
Tooley_Upper	Upper	784.2309	2 Year	1	10.09	88.95
Tooley_Upper	Upper	784.2309	Future Regional	Regional	91.51	97.91
Tooley_Upper	Upper	784.2309	5 Year	1	17.89	89.46
Tooley_Upper	Upper	784.2309	10 Year	1	22.39	89.80
Tooley_Upper	Upper	784.2309	25 Year	1	31.31	90.47
Tooley_Upper	Upper	784.2309	50 Year	1	37.95	91.98
Tooley_Upper	Upper	784.2309	100 Year	1	43.09	92.77
Tooley_Upper	Upper	705	2 Year	1	10.09	88.16
Tooley_Upper	Upper	705	Future Regional	Regional	91.51	97.63
Tooley_Upper	Upper	705	5 Year	1	17.89	88.96
Tooley_Upper	Upper	705	10 Year	1	22.39	89.33
Tooley_Upper	Upper	705	25 Year	1	31.31	89.98
Tooley_Upper	Upper	705	50 Year	1	37.95	91.72
Tooley_Upper	Upper	705	100 Year	1	43.09	92.53
Tooley_Upper	Upper	641.6027			Culvert	
Tooley_Upper	Upper	577	2 Year	1	10.09	86.76
Tooley_Upper	Upper	577	Future Regional	Regional	91.51	91.03
Tooley_Upper	Upper	577	5 Year	1	17.89	87.06
Tooley_Upper	Upper	577	10 Year	1	22.39	87.16
Tooley_Upper	Upper	577	25 Year	1	31.31	88.24
Tooley_Upper	Upper	577	50 Year	1	37.95	90.77
Tooley_Upper	Upper	577	100 Year	1	43.09	91.23
Tooley_Upper	Upper	500	2 Year	1	10.09	86.48
Tooley_Upper	Upper	500	Future Regional	Regional	91.51	91.50
Tooley_Upper	Upper	500	5 Year	1	17.89	86.82
Tooley_Upper	Upper	500	10 Year	1	22.39	86.94
Tooley_Upper	Upper	500	25 Year	1	31.31	88.43
Tooley_Upper	Upper	500	50 Year	1	37.95	90.86
Tooley_Upper	Upper	500	100 Year	1	43.09	91.32
Tooley_Upper	Upper	497	2 Year	1	10.09	86.23
Tooley_Upper	Upper	497	Future Regional	Regional	91.51	91.50
Tooley_Upper	Upper	497	5 Year	1	17.89	86.54
Tooley_Upper	Upper	497	10 Year	1	22.39	86.65
Tooley_Upper	Upper	497	25 Year	1	31.31	88.42
Tooley_Upper	Upper	497	50 Year	1	37.95	90.86
Tooley_Upper	Upper	497	100 Year	1	43.09	91.32
Tooley_Upper	Upper	400	2 Year	1	11.27	84.89
Tooley_Upper	Upper	400	Future Regional	Regional	99.84	91.50
Tooley_Upper	Upper	400	5 Year	1	19.86	85.58
Tooley_Upper	Upper	400	10 Year	1	24.90	86.16
Tooley_Upper	Upper	400	25 Year	1	34.77	88.43
Tooley_Upper	Upper	400	50 Year	1	42.81	90.86
Tooley_Upper	Upper	400	100 Year	1	48.87	91.32

HEC-RAS (Continued)

River	Reach	River Sta	Profile	Plan	Q Total	W.S. Elev
					(m3/s)	(m)
Tooley_Upper	Upper	300	2 Year	1	11.27	84.55
Tooley_Upper	Upper	300	Future Regional	Regional	99.84	91.50
Tooley_Upper	Upper	300	5 Year	1	19.86	85.57
Tooley_Upper	Upper	300	10 Year	1	24.90	86.16
Tooley_Upper	Upper	300	25 Year	1	34.77	88.43
Tooley_Upper	Upper	300	50 Year	1	42.81	90.86
Tooley_Upper	Upper	300	100 Year	1	48.87	91.32
Tooley_Upper	Upper	255.4727	2 Year	1	11.27	84.55
Tooley_Upper	Upper	255.4727	Future Regional	Regional	99.84	91.50
Tooley_Upper	Upper	255.4727	5 Year	1	19.86	85.57
Tooley_Upper	Upper	255.4727	10 Year	1	24.90	86.16
Tooley_Upper	Upper	255.4727	25 Year	1	34.77	88.43
Tooley_Upper	Upper	255.4727	50 Year	1	42.81	90.86
Tooley_Upper	Upper	255.4727	100 Year	1	48.87	91.32
Tooley_Upper	Upper	243	2 Year	1	11.27	84.44
Tooley_Upper	Upper	243	Future Regional	Regional	99.84	91.51
Tooley_Upper	Upper	243	5 Year	1	19.86	85.42
Tooley_Upper	Upper	243	10 Year	1	24.90	86.00
Tooley_Upper	Upper	243	25 Year	1	34.77	88.32
Tooley_Upper	Upper	243	50 Year	1	42.81	90.78
Tooley_Upper	Upper	243	100 Year	1	48.87	91.32
Tooley_Upper	Upper	227.3807			Mult Open	
Tooley_Upper	Upper	211	2 Year	1	11.27	83.10
Tooley_Upper	Upper	211	Future Regional	Regional	99.84	86.08
Tooley_Upper	Upper	211	5 Year	1	19.86	83.53
Tooley_Upper	Upper	211	10 Year	1	24.90	83.74
Tooley_Upper	Upper	211	25 Year	1	34.77	84.12
Tooley_Upper	Upper	211	50 Year	1	42.81	84.41
Tooley_Upper	Upper	211	100 Year	1	48.87	84.61
Tooley_Upper	Upper	200	2 Year	1	11.26	83.17
Tooley_Upper	Upper	200	Future Regional	Regional	99.88	84.06
Tooley_Upper	Upper	200	5 Year	1	19.82	83.39
Tooley_Upper	Upper	200	10 Year	1	24.89	83.47
Tooley_Upper	Upper	200	25 Year	1	34.75	83.62
Tooley_Upper	Upper	200	50 Year	1	42.64	83.71
Tooley_Upper	Upper	200	100 Year	1	48.87	83.78
Tooley_Upper	Upper	100	2 Year	1	11.26	82.44
Tooley_Upper	Upper	100	Future Regional	Regional	99.88	83.18
Tooley_Upper	Upper	100	5 Year	1	19.82	82.63
Tooley_Upper	Upper	100	10 Year	1	24.89	82.72
Tooley_Upper	Upper	100	25 Year	1	34.75	82.81
Tooley_Upper	Upper	100	50 Year	1	42.64	82.87
Tooley_Upper	Upper	100	100 Year	1	48.87	82.90

HEC-RAS (Continued)

River	Reach	River Sta	Profile	Plan	Q Total	W.S. Elev
					(m3/s)	(m)
Tooley_Lower	Lower	1000	2 Year	1	12.02	81.50
Tooley_Lower	Lower	1000	Future Regional	Regional	105.18	82.37
Tooley_Lower	Lower	1000	5 Year	1	21.39	81.63
Tooley_Lower	Lower	1000	10 Year	1	27.00	81.70
Tooley_Lower	Lower	1000	25 Year	1	37.82	81.81
Tooley_Lower	Lower	1000	50 Year	1	46.70	81.90
Tooley_Lower	Lower	1000	100 Year	1	53.64	81.96
Tooley_Lower	Lower	900	2 Year	1	12.02	80.82
Tooley_Lower	Lower	900	Future Regional	Regional	105.18	81.55
Tooley_Lower	Lower	900	5 Year	1	21.39	81.12
Tooley_Lower	Lower	900	10 Year	1	27.00	81.19
Tooley_Lower	Lower	900	25 Year	1	37.82	81.27
Tooley_Lower	Lower	900	50 Year	1	46.70	81.31
Tooley_Lower	Lower	900	100 Year	1	53.64	81.35
Tooley_Lower	Lower	800	2 Year	1	12.02	80.20
Tooley_Lower	Lower	800	Future Regional	Regional	105.18	80.95
Tooley_Lower	Lower	800	5 Year	1	21.39	80.52
Tooley_Lower	Lower	800	10 Year	1	27.00	80.58
Tooley_Lower	Lower	800	25 Year	1	37.82	80.66
Tooley_Lower	Lower	800	50 Year	1	46.70	80.72
Tooley_Lower	Lower	800	100 Year	1	53.64	80.76
Tooley_Lower	Lower	700	2 Year	1	12.02	79.34
Tooley_Lower	Lower	700	Future Regional	Regional	105.18	80.04
Tooley_Lower	Lower	700	5 Year	1	21.39	79.48
Tooley_Lower	Lower	700	10 Year	1	27.00	79.55
Tooley_Lower	Lower	700	25 Year	1	37.82	79.64
Tooley_Lower	Lower	700	50 Year	1	46.70	79.70
Tooley_Lower	Lower	700	100 Year	1	53.64	79.75
Tooley_Lower	Lower	600	2 Year	1	12.02	78.90
Tooley_Lower	Lower	600	Future Regional	Regional	105.18	79.60
Tooley_Lower	Lower	600	5 Year	1	21.39	79.03
Tooley_Lower	Lower	600	10 Year	1	27.00	79.08
Tooley_Lower	Lower	600	25 Year	1	37.82	79.17
Tooley_Lower	Lower	600	50 Year	1	46.70	79.24
Tooley_Lower	Lower	600	100 Year	1	53.64	79.29
Tooley_Lower	Lower	500	2 Year	1	13.25	78.42
Tooley_Lower	Lower	500	Future Regional	Regional	114.85	79.16
Tooley_Lower	Lower	500	5 Year	1	24.05	78.58
Tooley_Lower	Lower	500	10 Year	1	30.89	78.68
Tooley_Lower	Lower	500	25 Year	1	40.93	78.79
Tooley_Lower	Lower	500	50 Year	1	49.32	78.82
Tooley_Lower	Lower	500	100 Year	1	56.90	78.87
Tooley_Lower	Lower	400	2 Year	1	13.25	77.26
Tooley_Lower	Lower	400	Future Regional	Regional	114.85	78.15
Tooley_Lower	Lower	400	5 Year	1	24.05	77.46

HEC-RAS (Continued)

River	Reach	River Sta	Profile	Plan	Q Total	W.S. Elev
					(m3/s)	(m)
Tooley_Lower	Lower	400	10 Year	1	30.89	77.49
Tooley_Lower	Lower	400	25 Year	1	40.93	77.63
Tooley_Lower	Lower	400	50 Year	1	49.32	77.80
Tooley_Lower	Lower	400	100 Year	1	56.90	77.85
Tooley_Lower	Lower	300	2 Year	1	13.25	76.77
Tooley_Lower	Lower	300	Future Regional	Regional	114.85	77.64
Tooley_Lower	Lower	300	5 Year	1	24.05	76.96
Tooley_Lower	Lower	300	10 Year	1	30.89	77.09
Tooley_Lower	Lower	300	25 Year	1	40.93	77.16
Tooley_Lower	Lower	300	50 Year	1	49.32	77.23
Tooley_Lower	Lower	300	100 Year	1	56.90	77.30
Tooley_Lower	Lower	200	2 Year	1	13.25	76.24
Tooley_Lower	Lower	200	Future Regional	Regional	114.85	77.25
Tooley_Lower	Lower	200	5 Year	1	24.05	76.45
Tooley_Lower	Lower	200	10 Year	1	30.89	76.58
Tooley_Lower	Lower	200	25 Year	1	40.93	76.70
Tooley_Lower	Lower	200	50 Year	1	49.32	76.79
Tooley_Lower	Lower	200	100 Year	1	56.90	76.86
Tooley_Lower	Lower	100	2 Year	1	13.25	76.02
Tooley_Lower	Lower	100	Future Regional	Regional	114.85	76.94
Tooley_Lower	Lower	100	5 Year	1	24.05	76.24
Tooley_Lower	Lower	100	10 Year	1	30.89	76.33
Tooley_Lower	Lower	100	25 Year	1	40.93	76.45
Tooley_Lower	Lower	100	50 Year	1	49.32	76.52
Tooley_Lower	Lower	100	100 Year	1	56.90	76.59
Tooley_Lower	Lower	8.907429	2 Year	1	13.25	75.49
Tooley_Lower	Lower	8.907429	Future Regional	Regional	114.85	76.26
Tooley_Lower	Lower	8.907429	5 Year	1	24.05	75.67
Tooley_Lower	Lower	8.907429	10 Year	1	30.89	75.84
Tooley_Lower	Lower	8.907429	25 Year	1	40.93	75.90
Tooley_Lower	Lower	8.907429	50 Year	1	49.32	75.99
Tooley_Lower	Lower	8.907429	100 Year	1	56.90	76.02

REVISION SUMMARY

1. March 31, 2008 – Addition of the Courtice Road Subway to the HEC-RAS model. Maps 4, 5, 8 and 9 were revised.

Appendix C

Fisheries and Aquatic Habitat

C.1 Fish Sampling Records for Robinson and Tooley Creeks – 2009

C.2 Water Quality Data for Robinson and Tooley Creeks

C.3 Benthic Data for Robinson and Tooley Creeks

C.1 Fish Sampling Records for Robinson and Tooley Creeks – 2009

Appendix C-1 Fish Sampling Records for Robinson and Tooley Creek - 2009

Site Code	Watershed	Date	Easting	Northing	Species	Method
R1	Robinson Creek	23-Jun-09	678253	4860379	northern redbelly dace, brook stickleback, blacknose dace, johnny darter, pumpkinseed	Electrofishing
R1	Robinson Creek	3-Sep-09	678255	4860360	blacknose dace, creek chub, brook stickleback, banded killfish, rainbow trout, pumpkinseed, white sucker, fathead minnow, johnny darter	Electrofishing
R2	Robinson Creek	24-Jun-09	677903	4860760	creek chub, pimpkinseed, fathead minnow, bluntnose minnow, brook sickleback	Electrofishing
R2	Robinson Creek	3-Sep-09	677900	4860761	creek chub, blacknose dace, white sucker, pumpkinseed, rainbow trout, fathead minnow, johnny darter, brook stickleback	Electrofishing
R3	Robinson Creek	24-Jun-09	677678	4861866	creek chub, blacknose dace	Electrofishing
R3	Robinson Creek	3-Sep-09	677697	4861845	creek chub, blacknose dace, pumpkinseed	Electrofishing
R4	Robinson Creek	3-Sep-09	677445	4862310	creek chub, blacknose dace, fathead minnow, pumpkinseed, white sucker	Electrofishing
R5	Robinson Creek	23-Jun-09	677372	4861159	creek chub, fathead minnow, pumpkinseed, blacknose dace	Minnow Trap
R5	Robinson Creek	4-Sep-09	677451	4863115	creek chub, fathead minnow, pumpkinseed, blacknose dace, white sucker	Minnow Trap

Site Code	Watershed	Date	Easting	Northing	Species	Method
T1	Tooly Creek	4-Sep-09	679919	4859707	brook stickleback	Electrofishing
T2	Tooly Creek	25-Jun-09	679632	4861003	creek chub, brook stickleback, blacknose dace, rainbow trout	Electrofishing
T2	Tooly Creek	4-Sep-09	679632	4861003	creek chub, brook stickleback, blacknose dace	Electrofishing
T3	Tooly Creek	25-Jun-09	679580	4862062	brook stickleback	Electrofishing
T3	Tooly Creek	4-Sep-09	679580	4862062	creek chub, brook stickleback, blacknose dace	Electrofishing
T4	Tooly Creek	25-Jun-09			No Fish	Electrofishing
T5	Tooley Creek	25-Jun-09	679209	4862971	blacknose dace, creek chub, brook stickleback, fathead minnow	

T5	Tooley Creek	4-Sep-09	679209	4862971	blacknose dace, creek chub, brook stickleback, fathead minnow	
T6	Tooly Creek	4-Sep-09	679495	4860719	white sucker, blacknose dace, creek chub, fathead minnow, johny darter, pumpkinseed	Electrofishing

Appendix C-2. Fish Species Information

Family	Common Name	Scientific Name	Thermal Class	COSEWIC Status	COSSARO Status
Catostomidae	White Sucker	Catostomus commersoni	Cool	NAR	NAR
Centrarchidae	Pumpkinseed	Lepomis gibbosus	Warm	NAR	NAR
Cyprinidae	fathead minnow	Pimephales notatus	Warm	NAR	NAR
	creek chub	Semotilus atromaculauts	Cool	NAR	NAR
	blacknose dace	Rhinichthys atratulus	Warm	NAR	NAR
	northern redbelly dace	Phoximus eos	Cool/War m	NAR	NAR
Gasterosteidae	brook stickleback	Culaea inconstans	Cool	NAR	NAR
Percidae	johnny darter	Etheostoma nigrum	Warm	NAR	NAR
Salmonidae	rainbow trout	Oncorhynchus mykiss	Cold	NAR	NAR
Cyprinodontidae	banded killifish	fundulus diaphanus	Cool	NAR	NAR

C.2 Water Quality Data for Robinson and Tooley Creeks

Appendix C-3: Water Quality Data

Maxxam Job #: A9B0113
Report Date: 2009/08/31

AECOM Canada Ltd
Client Project #: 112956
Project name: ROBINSON/TOOLY
Sampler Initials:

RESULTS OF ANALYSES OF WATER

Maxxam ID		DM2949	DM2949	DM2950	DM2950	DM2952	DM2954	
Sampling Date		8/24/2009	8/24/2009	8/24/2009	8/24/2009	8/24/2009	8/24/2009	
COC Number		160972-0	160972-0	160972-0	160972-0	160972-0	160972-0	
	Units	**T1**	**T1 Lab-Dup**	**T5**	**T5 Lab-Dup**	**R1**	**R3**	**RDL**
Inorganics								
Total Ammonia-N	mg/L	0.07		0.11		0.06	0.07	0.05
Total BOD	mg/L	ND	ND	ND		ND	ND	2
Total Phosphorus	mg/L	0.036		0.068	0.071	0.050	0.11	0.002
Total Suspended Solids	mg/L	4		2		17	61	1
Dissolved Chloride (Cl)	mg/L	120		33		95	54	1

ND = Not detected
RDL = Reportable Detection Limit
Lab-Dup = Laboratory Initiated Duplicate
QC Batch = Quality Control Batch

Results relate only to the items tested.

Appendix C-3: Water Quality Data

Maxxam Job #: A9B8807
Report Date: 2009/09/17

AECOM Canada Ltd
Client Project #: 112956
Project name: ROBINSON TOOLY CREEK
Sampler Initials:

RESULTS OF ANALYSES OF WATER

Maxxam ID		DQ7686	DQ7686	DQ7687	
Sampling Date		9/8/2009	9/8/2009	9/8/2009	
COC Number		74038-06	74038-06	74038-06	
	Units	**R4**	**R4 Lab-Dup**	**PMT**	**RDL**
Inorganics					
Total Ammonia-N	mg/L	0.09		0.07	0.05
Total BOD	mg/L	ND	ND	ND	2
Total Phosphorus	mg/L	0.048		0.067	0.002
Total Suspended Solids	mg/L	23		61	1
Dissolved Chloride (Cl)	mg/L	180		130	1

ND = Not detected
RDL = Reportable Detection Limit
Lab-Dup = Laboratory Initiated Duplicate
QC Batch = Quality Control Batch

C.3 Benthic Data for Robinson and Tooley Creeks

APPENDIX C.4 BENTHIC MACROINVERTEBRATES COLLECTED FROM AECOM, 2009

Creek	Robinson Creek					Tooley Creek		
Station	1	2	3	4	5	1	2	5
ROUNDWORMS								
P. Nemata	-	-	-	-	-	-	16	-
ANNELIDS								
P. Annelida								
WORMS								
Cl. Oligochaeta								
F. Enchytraeidae	-	-	-	-	-	8	-	-
F. Naididae	64	48	-	-	-	4	-	-
F. Sparganophilidae	-	-	9	-	-	-	-	-
LEECHES								
Cl. Hirudinea								
F. Erpobdellidae	-	-	-	-	1	-	34	-
F. Glossiphoniidae	-	-	-	8	4	4	-	-
ARTHROPODS								
P. Arthropoda								
MITES								
Cl. Arachnida								
O. Acarina	-	16	-	8	-	-	16	-
SEED SHRIMPS								
Cl. Ostracoda	32	-	-	-	-	8	-	-
WATER SCUDS								
O. Amphipoda								
F. Gammaridae	5504	1457	468	469	64	96	123	240
AQUATIC SOW BUGS								
O. Isopoda								
F. Asellidae	2144	1936	402	769	514	69	2819	2704
INSECTS								
Cl. Insecta								
BEETLES								
F. Curculionidae	32	-	-	-	-	-	-	-
F. Dytiscidae	-	-	-	-	-	36	67	32
F. Elmidae	416	352	-	-	12	4	33	-
F. Haliplidae	-	-	-	-	-	4	-	-
MAYFLIES								
O. Ephemeroptera								
F. Baetidae	-	-	-	8	-	-	-	-
AQUATIC MOTHS								
O. Lepidoptera								
F. Pyralidae	-	-	-	-	-	4	-	-
O. Odonata								
DAMSELFLIES								
F. Coenagrionidae	-	-	-	-	16	-	-	-
DRAGONFLIES								
F. Aeshnidae	-	-	-	-	2	-	-	-
BUGS								
O. Hemiptera								
F. Corixidae	32	-	8	16	-	100	16	16
CADDISFLIES								
O. Trichoptera								
F. Hydropsychidae	64	96	-	-	-	-	-	-
F. Hydroptilidae	128	128	8	-	-	-	16	-
TRUE FLIES								
O. Diptera								
indeterminat	-	32	-	-	-	-	16	-
BITING-MIDGE								
F. Ceratopogonidae	-	-	8	-	-	-	-	-
MIDGES								
F. Chironomidae	3264	1936	312	72	80	548	640	424
F. Empididae	-	-	-	-	4	-	-	-
F. Ephydridae	32	-	-	-	-	-	-	-
F. Muscidae	-	-	-	-	-	-	1	-
F. Sciomyzidae	-	-	-	-	-	4	-	-
F. Simuliidae	32	256	16	-	-	-	-	-
F. Stratiomyiidae	-	-	16	-	-	-	-	-
F. Tipulidae	64	16	-	-	-	32	16	-

APPENDIX C.4 BENTHIC MACROINVERTEBRATES COLLECTED FROM AECOM, 2009

Creek	Robinson Creek					Tooley Creek		
Station	1	2	3	4	5	1	2	5
MOLLUSCS								
P. Mollusca								
SNAILS								
Cl. Gastropoda								
F. Lymnaeidae	-	19	-	-	12	20	32	-
F. Physidae	-	164	-	-	-	-	16	184
F. Planorbidae	-	-	-	-	-	4	-	-
CLAMS								
Cl. Bivalvia								
F. Sphaeriidae	384	-	16	48	16	8	-	56
TOTAL NUMBER OF ORGANISMS	12192	6456	1263	1398	725	953	3861	3656
TOTAL NUMBER OF FAMILIES	14	13	10	8	11	17	15	7

Appendix D

Terrestrial Natural Heritage

D.1 Plant Species List for Robinson Creek

D.2 Plant Species List for Tooley Creek

D.3 Breeding Bird Species List for Robinson Creek

D.4 Breeding Bird Species List for Tooley Creek

D.1 Plant Species List for Robinson Creek

Appendix D-1. Vascular Plant Species of Robinson Creek Watershed

Family / Species	Common Name	Status	Community* Forest	Swamp	Marsh	Cultural
PTERIDOPHYTA	***FERNS AND ALLIES***					
DRYOPTERIDACEAE	**WOOD FERN FAMILY**					
Cystopteris bulbifera (L.) Bern.	Bulblet Fern			X		
Dryopteris carthusiana (Vill.) H.P.Fuchs	Spinulose Wood Fern		X			
Dryopteris intermedia (Willd.)	Glandular Wood Fern		X			
Dryopteris marginalis (L.) Gray	Marginal Wood Fern		X			
Onoclea sensibilis L.	Sensitive Fern			X		
Polystichum acrostichoides (Michx.) Schoff	Christmas Fern			X		
EQUISETACEAE	**HORSETAIL FAMILY**					
Equisetum hyemale L.	Scouring-rush				X	
Equisetum variegatum Schleich.	Variegated Scouring-rush					X
THELYPTERIDACEAE	**BEECH FERN FAMILY**					
Thelypteris palustris (Salisb.) Schott	Marsh Fern			X		
GYMNOSPERMAE	***CONIFERS***					
CUPRESSACEAE	**CYPRESS FAMILY**					
Juniperus virginiana L.	Red Cedar					X
Thuja occidentalis L.	White Cedar			X		
PINACEAE	**PINE FAMILY**					
Picea glauca (Moench) Voss	White Spruce					X
Pinus strobus L.	White Pine		X			
Tsuga canadensis (L.)Carr.	Eastern Hemlock		X			
LILIOPSIDA	***MONOCOTS***					
ARACEAE	**ARUM FAMILY**					
Arisaema triphyllum (L.) Schott	Jack-in-the-pulpit		X			
BUTOMACEAE	**FLOWERING RUSH FAMILY**					
Butomus umbellatus L.	Flowering Rush	+			X	
CYPERACEAE	**SEDGE FAMILY**					
Carex arctata Boott	Drooping Wood Sedge		X			
Carex aurea Nutt.	Golden Fruited Sedge		X			
Carex bebbii (Bailey) Fern.	Bebb's Sedge				X	
Carex blanda Dew.	Woodland Sedge	RR	X			
Carex gracillima Schw.	Graceful Sedge			X		
Carex granularis Muhl. ex Willd	Sedge				X	X
Carex lupulina Muhl. ex Willd.	Hop Sedge		X			
Carex pedunculata Muhl. ex Willd.	Peduncled Sedge		X			
Carex pensylvanica Lam.	Pensylvanica Sedge		X			
Carex pseudocyperus L.	Cyperus-like Sedge				X	
Carex radiata	Radiating Sedge		X			
Carex spicata Huds.	Sedge	+				X
Carex stricta Lam.	Tussock Sedge				X	
Carex vulpinoidea Michx.	Fox Tail Sedge			X	X	
Eleocharis erythropoda Steud.	Spike-rush				X	
Scirpus atrovirens Willd.	Black Bulrush				X	
Scirpus cyperinus (L.) Kunth	Wool-grass				X	
Scirpus validus Vahl.	Softstem Bulrush				X	
IRIDACEAE	**IRIS FAMILY**					
Iris versicolor L.	Wild Blue Flag				X	
JUNCACEAE	**RUSH FAMILY**					
Juncus balticus Willd.	Baltic Rush	RR			X	
Juncus tenuis Willd.	Path Rush			X		X
Juncus torreyi Cov.	Rush				X	
Juncus sp.	Rush species			X	X	
LILIACEAE	**LILY FAMILY**					

Family / Species	Common Name	Status	Community* Forest	Swamp	Marsh	Cultural
Lilium michiganese Farw.	Canada Lily	RR		X		
Maianthemum stellatum (L.) Link	Starry False Solomon's-seal		X			
Trillium grandiflorum (Michx.) Salisb.	White Trillium		X			
ORCHIDACEAE	**ORCHID FAMILY**					
Epipactis helleborine (L.) Crantz	Helleborine	+	X			
POACEAE	**GRASS FAMILY**					
Agrostis gigantea Roth.	Redtop	+				X
Agrostis stolonifera L.	Creeping Bent Grass				X	
Bromus inermis Leyss.	Smooth Brome Grass	+				X
Calamagrostis canadensis (Michx.) Beauv.	Canada Blue-joint				X	
Elymus virginicus L.	Virginia Wild-rye	RR	X			
Glyceria grandis S. Wats.	Tall Manna Grass			X	X	
Glyceria striata (Lam.) A.S. Hitchc.	Fowl Manna Grass			X		
Phalaris arundinacea L.	Reed Canary Grass					X
Phleum pratense L.	Timothy	+				X
Phragmites australis (Cav.) Trin. ex Steud.	Common Reed	+			X	
Poa pratensis L.	Kentucky Blue Grass	+				X
MAGNOLIOPSIDA	***DICOTS***					
ACERACEAE	**MAPLE FAMILY**					
Acer negundo L.	Manitoba Maple		X			X
Acer saccharum Marsh.	Sugar Maple		X			
Acer freemani	Hybrid Maple		X			
ANACARDIACEAE	**CASHEW FAMILY**					
Rhus radicans L.	Poison-ivy		X			X
Rhus typhina L.	Staghorn Sumac					X
APIACEAE	**CARROT FAMILY**					
Cicuta maculata L.	Spotted Water-hemlock				X	
Daucus carota L.	Wild Carrot, Queen Anne's Lace	+				X
Sium suave Walt.	Water-parsnip			X		
APOCYNACEAE	**DOGBANE FAMILY**					
Apocynum androsaemifolium L.	Spreading Dogbane					X
ARALIACEAE	**GINSENG FAMILY**					
Aralia nudicaulis L.	Wild Sarsaparilla		X			
ASCLEPIADACEAE	**MILKWEED FAMILY**					
Asclepias syriaca L.	Common Milkweed					X
Cynanchum rossicum (Kleopov) Borh.	White Swallow-wort	+	X			X
ASTERACEAE	**ASTER FAMILY**					
Ambrosia artemisiifolia L.	Common Ragweed					X
Arctium minus (Hill) Bernh.	Common Burdock	+				X
Aster eriocoides L.	Heath Aster					X
Aster lanceolatus Willd.	Tall White Aster		X			
Aster lateriflorus (L.) Britt.	One-sided Aster		X			
Aster novae-angliae L.	New England Aster					X
Aster puniceus L.	Red-stemmed Aster			X	X	
Bidens cernua L.	Nodding Beggarticks				X	
Bidens frondosa L.	Devil's Beggarticks				X	
Carduus nutans L.	Nodding Thistle	+				X
Centaurea maculosa Lam.	Spotted Knapweed	+				X
Chrysanthemum leucanthemum L.	Ox-eye Daisy	+				X
Cirsium arvense (L.) Scop.	Canada Thistle	+				X
Cirsium vulgare (Savi) Tenore	Bull Thistle	+	X			
Conyza canadensis (L.) Cronq.	Horse-Weed					X
Erigeron philadelphicus L.	Philadelphia Fleabane		X			
Erigeron strigosus L.	Daisy Fleabane					X
Eupatorium maculatum L.	Spotted Joe-Pye Weed				X	
Eupatorium perfoliatum L.	Boneset				X	
Euthamia graminifolia (L.) Nutt.	Narrow-leaf Goldenrod					X
Inula helenium L.	Elecampane	+			X	
Prenanthes altissima L.	Tall White Lettuce		X	X		
Rudbeckia hirta L.	Black-eyed Susan					X
Solidago altissima L.	Tall Goldenrod					X

Family / Species	Common Name	Status	Community*			
			Forest	Swamp	Marsh	Cultural
Solidago canadensis L.	Canada Goldenrod					X
Solidago flexicaulis L.	Zig-zag Goldenrod		X			
Solidago gigantea Ait.	Late Goldenrod			X		
Solidago juncea Ait.	Early Goldenrod	RR				X
Solidago nemoralis Ait.	Gray Goldenrod					X
Solidago rugosa Ait.	Rough Goldenrod				X	
Taraxacum officinale Weber	Dandelion	+	X			X
BALSAMINACEAE	**TOUCH-ME-NOT-FAMILY**					
Impatiens capensis Meerb.	Spotted Jewelweed		X			
BERBERIDACEAE	**BARBERRY FAMILY**					
Berberis thunbergii DC.	Japanese Barberry	+	X			
Caulophyllum thalictroides (L.) Michx.	Blue Cohosh		X			
Podophyllum peltatum L.	May-apple		X			
BETULACEAE	**BIRCH FAMILY**					
Carpinus caroliniana Walt.	Blue Beech			X		
Ostrya virginiana (Mill.) K. Koch	Hop Hornbeam		X			
BORAGINACEAE	**BORAGE FAMILY**					
Echium vulgare L.	Viper's-bugloss	+				X
BRASSICACEAE	**MUSTARD FAMILY**					
Alliaria petiolata (Bieb.)Cavara & Grande	Garlic Mustard	+	X			
Cakile edentula (Bigel.) Hook	Sea-rocket	RR				X
Nasturtium microphyllum (Boenn.) Reichb.	Water Cress	+	X			
CAPRIFOLIACEAE	**HONEYSUCKLE FAMILY**					
Sambucus canadensis L.	Common Elder			X		
CARYOPHYLLACEAE	**PINK FAMILY**					
Saponaria officinalis L.	Bouncing-bet	+				X
CORNACEAE	**DOGWOOD FAMILY**					
Cornus alternifolia L.f.	Alternate-leaved Dogwood		X			
Cornus stolonifera Michx.	Red-osier Dogwood			X		
FABACEAE	**PEA FAMILY**					
Lotus corniculatus L.	Bird-foot Trefoil	+				X
Melilotus alba Medic.	White Sweet-clover	+				X
Trifolium pratense L.	Red Clover	+				X
Vicia cracca L.	Bird Vetch	+				X
GENTIANACEAE	**GENTIAN FAMILY**					
Gentiana andrewsii Griseb.	Closed Gentian	RR		X		
GROSSULARIACEAE	**GOOSEBERRY FAMILY**					
Ribes americanum Mill.	Wild Black Currant			X		
Ribes cynosbati L.	Prickly Gooseberry		X			
HYDROPHYLLACEAE	**WATERLEAF FAMILY**					
Hydrophyllum virginianum L.	Virginia Waterleaf		X			
HYPERICACEAE	**ST. JOHN'S-WORT FAMILY**					
Hypericum perforatum L.	Common St. John's-wort	+	X			X
Hypericum sp.	St.John's-wort			X		
JUGLANDACEAE	**WALNUT FAMILY**					
Juglans cinerea L.	Butternut	PR	X			
Juglans nigra L.	Black Walnut	+	X			X
LAMIACEAE	**MINT FAMILY**					
Mentha arvensis L.	Field or Common Mint			X		
Prunella vulgaris L.	Heal-all	+	X			
LOBELIACEAE	**LOBELIA FAMILY**					
Lobelia siphilitica L.	Great Lobelia	RR			X	
OLEACEAE	**OLIVE FAMILY**					
Fraxinus americana L.	White Ash		X			
Fraxinus nigra Marsh.	Black Ash			X		
Fraxinus pennsylvanica Marsh.	Red Ash		X			
Syringa vulgaris L.	Common Lilac	+				X
ONAGRACEAE	**EVENING-PRIMROSE FAMILY**					
Circaea lutetiana L.	Enchanter's Nightshade		X			
Epilobium angustifolium L.	Fireweed	RR			X	X
Epilobium ciliatum Raf.	Sticky Willowherb				X	

Family / Species	Common Name	Status	Community*			
			Forest	Swamp	Marsh	Cultural
Epilobium hirsutum L.	Hairy Willowherb	+			X	X
Oenothera biennis L.	Hairy Yellow Evening-primrose					X
PAPAVERACEAE	**POPPY FAMILY**					
Sanguinaria canadensis L.	Bloodroot		X			
POLYGONACEAE	**BUCKWHEAT FAMILY**					
Polygonum hydropiper L.	Marshpepper Smartweed				X	
Polygonum persicaria L.	Lady's Thumb	+				X
Rumex crispus L.	Curly Dock	+				X
PRIMULACEAE	**PRIMROSE FAMILY**					
Lysimachia ciliata L.	Fringed Loosestrife			X		
RANUNCULACEAE	**BUTTERCUP FAMILY**					
Actaea pachypoda Ell.	White Baneberry		X			
Actaea rubra (Ait.) Willd.	Red Baneberry		X			
Anemone virginiana L.	Thimbleweed					X
Caltha palustris L.	Marsh-marigold			X		
Ranunculus abortivus L.	Small-flowered Buttercup		X			
Ranunculus acris L.	Tall Buttercup	+	X			
Ranunculus hispidus Michx.	Swamp Buttercup			X		
Thalictrum dioicum L.	Early Meadow Rue				X	X
RHAMNACEAE	**BUCKTHORN FAMILY**					
Rhamnus cathartica L.	Common Buckthorn	+	X			
ROSACEAE	**ROSE FAMILY**					
Agrimonia gryposepala Wallr.	Agrimony		X			
Crataegus chrysocarpa Ashe.	Round-leaved Hawthorn	RR	X			
Crataegus pedicellata Sarg.	Scarlet Thorn		X			
Crataegus monogyna Jacq.	English Hawthorn	+				X
Crataegus punctata Jacq.	Dotted Hawthorn		X			X
Geum aleppicum Jacq.	Yellow Avens			X		
Geum canadense Jacq.	White Avens					X
Malus pumila Miller	Apple					X
Potentilla anserina L.	Silverweed	RR			X	
Potentilla norvegica L.	Rough Cinquefoil					X
Prunus virginiana L.	Choke Cherry		X			
Rubus odoratus L.	Flowering Raspberry		X			
Rubus pubescens Raf.	Dwarf Raspberry			X		
Sorbus aucuparia L.	European Mountain-ash	+	X		X	X
Spiraea alba DuRoi	Meadowsweet				X	X
RUBIACEAE	**MADDER FAMILY**					
Galium mollugo L.	Wild Madder	+				X
Galium palustre L.	Marsh Bedstraw				X	
Galium triflorum Michx.	Sweet-scented Bedstraw		X			
SALICACEAE	**WILLOW FAMILY**					
Populus balsamifera L.	Balsam Poplar			X		
Populus tremuloides Michx.	Trembling Aspen		X			X
Salix alba L.	White Willow	+				X
Salix bebbiana Sarg.	Bebb's Willow				X	
Salix discolor Muhl.	Pussy Willow			X		
Salix eriocephala Michx.	Missouri Willow			X		
Salix fragilis L.	Crack Willow	+	X		X	X
Salix x rubens Schrank.	Hybrid Crack Willow	+		X		X
SAXIFRAGACEAE	**SAXIFRAGE FAMILY**					
Tiarella cordifolia L.	Foam Flower			X		
SCROPHULARIACEAE	**FIGWORT FAMILY**					
Chelone glabra L.	Turtlehead				X	
Linaria vulgaris Mill.	Butter-and-eggs	+				X
Verbascum thapsus L.	Common Mullein	+				X
Veronica officinalis L.	Common Speedwell	+	X			
SOLANACEAE	**NIGHTSHADE FAMILY**					
Solanum dulcamara L.	Bittersweet Nightshade	+		X		
TILIACEAE	**LINDEN FAMILY**					
Tilia americana L.	Basswood		X			

Family / Species	Common Name	Status	Community*			
			Forest	Swamp	Marsh	Cultural
ULMACEAE	**ELM FAMILY**					
Ulmus americana L.	American Elm		X	X		X
URTICACEAE	**NETTLE FAMILY**					
Boehmeria cylindrica (L.) Sw.	False Nettle			X		
Pilea pumila (L.) Gray	Clearweed			X		
VERBENACEAE	**VERVAIN FAMILY**					
Verbena hastata L.	Blue Vervain					X
VIOLACEAE	**VIOLET FAMILY**					
Viola canadensis L.	Canada Violet	RR	X			
Viola conspersa Reich.	Dog Violet		X			
Viola cucullata Ait.	Marsh Violet				X	
Viola pubescens Ait.	Downy Yellow Violet		X			
Viola sororia Willd.	Common Blue Violet		X			
VITACEAE	**GRAPE FAMILY**					
Parthenocissus inserta (A. Kerner) Fritsch	Virginia Creeper		X	X		
Vitis riparia Michx.	Riverbank Grape					X

\+ Non-native species

RR Regionally Uncommon to Rare (Varga et al. 2000)

PR Provincially Rare (Oldham and Brinker 2009)

* ELC Communities follow Ecological Land Classification for Southern Ontario. First Approximation and Its Application 1998

D.2 Plant Species List for Tooley Creek

Appendix D-2. Vascular Plant Species of Tooley Creek Watershed

Family / Species	Common Name	Status	Community* Forest	Swamp	Marsh	Cultural
PTERIDOPHYTA	***FERNS AND ALLIES***					
DRYOPTERIDACEAE	**WOOD FERN FAMILY**					
Athyrium filix-femina (L.)Roth	Northeastern Lady Fern		X			
Dryopteris carthusiana (Vill.) H.P.Fuchs	Spinulose Wood Fern		X			
Dryopteris intermedia (Willd.)	Glandular Wood Fern		X			
Dryopteris marginalis (L.) Gray	Marginal Wood Fern		X			
Onoclea sensibilis L.	Sensitive Fern			X	X	
Polystichum acrostichoides (Michx.) Schoff	Christmas Fern		X			
EQUISETACEAE	**HORSETAIL FAMILY**					
Equisetum arvense L.	Field Horsetail				X	
Equisetum fluviatile L.	Water Horsetail				X	
Equisetum hyemale L.	Scouring-rush		X			
OSMUNDACEAE	**ROYAL FERN FAMILY**					
Osmunda cinnamomea L.	Cinnamon Fern			X		
Osmunda regalis L.	American Royal Fern	RR		X		
THELYPTERIDACEAE	**BEECH FERN FAMILY**					
Thelypteris palustris (Salisb.) Schott	Marsh Fern				X	
GYMNOSPERMAE	***CONIFERS***					
CUPRESSACEAE	**CYPRESS FAMILY**					
Thuja occidentalis L.	White Cedar		X	X		
PINACEAE	**PINE FAMILY**					
Pinus nigra	Austrian Pine					X
Pinus resinosa Ait.	Red Pine		X			
Pinus strobus L.	White Pine		X			
Pinus sylvestris L.	Scots Pine	+	X			
Tsuga canadensis (L.)Carr.	Eastern Hemlock		X			
LILIOPSIDA	***MONOCOTS***					
ALISMATACEAE	**WATER-PLANTAIN FAMILY**					
Alisma plantago-aquatica L.	Water-plantain				X	
Sagittaria cuneata Sheldon	Floating-leaved Arrowhead	RR			X	
Sagittaria latifolia Willd.	Broad-leaved Arrowhead				X	
ARACEAE	**ARUM FAMILY**					
Arisaema triphyllum (L.) Schott	Jack-in-the-pulpit		X			
CYPERACEAE	**SEDGE FAMILY**					
Carex albursina Sheldon	Bear Sedge	RR	X			
Carex arctata Boott	Drooping Wood Sedge		X			
Carex bebbii (Bailey) Fern.	Bebb's Sedge				X	
Carex blanda Dew.	Woodland Sedge	RR	X			
Carex communis Bailey	Fibrous Rooted Sedge			X		
Carex gracillima Schw.	Graceful Sedge			X		
Carex interior Bailey	Inland Sedge		X	X		
Carex laxiflora Lam.	Sedge	RR	X			
Carex pellita Muhl.	Wooly Sedge				X	
Carex pensylvanica Lam.	Pensylvanica Sedge		X			
Carex plantaginea Lam.	Plantain-leaved Sedge		X			
Carex radiata	Radiating Sedge		X	X		
Carex rosea Schk. ex Willd.	Rose-like Sedge	RR		X		
Carex spicata Huds.	Sedge	+				X
Carex stipata Muhl. ex Willd.	Awl-Fruited Sedge			X		
Carex trisperma Dew.	Three-seeded Sedge	RR		X		
Carex vulpinoidea Michx.	Fox Tail Sedge				X	
Eleocharis erythropoda Steud.	Spike-rush				X	
Scirpus atrovirens Willd.	Black Bulrush				X	
Scirpus pungens M. Vahl.	Common Three-square	RR			X	

Family / Species	Common Name	Status	Community* Forest	Swamp	Marsh	Cultural
Scirpus validus Vahl.	Softstem Bulrush				X	
HYDROCHARITACEAE	**FROG'S-BIT FAMILY**					
Elodea canadensis Michx.	Elodea				X	
JUNCACEAE	**RUSH FAMILY**					
Juncus articulatus L.	Rush				X	
Juncus dudleyi Wieg.	Dudley's Rush				X	
Juncus nodosus L.	Rush				X	
Juncus tenuis Willd.	Path Rush				X	
Juncus torreyi Cov.	Rush				X	
LILIACEAE	**LILY FAMILY**					
Allium tricoccum Ait.	Wild Leek; Ramps		X			
Clintonia borealis (Ait.) Raf.	Bluebead-lily		X			
Erythronium americanum Ker	Yellow Trout Lily		X			
Maianthemum canadense Desf.	Canada MayFlower		X			
Maianthemum racemosum (L.) Link	False Solomon's-seal		X			
Maianthemum stellatum (L.) Link	Starry False Solomon's-seal		X			
Trillium erectum L.	Purple Trillium		X			
Trillium grandiflorum (Michx.) Salisb.	White Trillium		X			
ORCHIDACEAE	**ORCHID FAMILY**					
Cypripedium calceolus L.	Yellow Lady-slipper	RR			X	
Epipactis helleborine (L.) Crantz	Helleborine	+	X			
POACEAE	**GRASS FAMILY**					
Agrostis gigantea Roth.	Redtop	+				X
Agrostis stolonifera L.	Creeping Bent Grass				X	
Bromus inermis Leyss.	Smooth Brome Grass	+				X
Danthonia spicata (L.) R. & S.	Poverty Oat Grass					X
Echinochloa crusgalli (L.) Beauv.	Barnyard Grass	+			X	
Elymus repens (L.) Gould	Quack Grass	+				X
Festuca pratensis Huds.	Meadow Fescue	+			X	
Glyceria grandis S. Wats.	Tall Manna Grass				X	
Glyceria striata (Lam.) A.S. Hitchc.	Fowl Manna Grass		X	X		
Leersia oryzoides (L.) Sw.	Cut Grass				X	
Muhlenbergia mexicana (L.) Trin.	Muhly Grass	+			X	
Phalaris arundinacea L.	Reed Canary Grass				X	
Poa annua L.	Annual Blue Grass	+				X
Poa palustris L.	Fowl Meadow Grass				X	
Poa pratensis L.	Kentucky Blue Grass	+				X
Setaria viridis (L.) Beauv.	Green Foxtail	+			X	
POTAMOGETONACEAE	**PONDWEED FAMILY**					
Potamogeton foliosus Raf.	Pondweed	RR			X	
Potamogeton pectinatus L.	Sago Pondweed				X	
Potamogeton pusillus	Small Pondweed				X	
SPARGANIACEAE	**BUR-REED FAMILY**					
Sparganium eurycarpum Engelm.	Giant Bur-reed				X	
MAGNOLIOPSIDA	*DICOTS*					
ACERACEAE	**MAPLE FAMILY**					
Acer negundo L.	Manitoba Maple		X	X		X
Acer saccharum Marsh.	Sugar Maple		X			X
Acer freemani	Hybrid Maple			X		
ANACARDIACEAE	**CASHEW FAMILY**					
Rhus radicans L.	Poison-ivy		X		X	X
Rhus typhina L.	Staghorn Sumac		X			X
APIACEAE	**CARROT FAMILY**					
Cicuta maculata L.	Spotted Water-hemlock				X	
Daucus carota L.	Wild Carrot, Queen Anne's Lace	+				X
Sium suave Walt.	Water-parsnip					X
APOCYNACEAE	**DOGBANE FAMILY**					
Apocynum androsaemifolium L.	Spreading Dogbane					X

Family / Species	Common Name	Status	Community*			
			Forest	Swamp	Marsh	Cultural
Apocynum cannabinum L.	Indian Hemp					X
ARALIACEAE	**GINSENG FAMILY**					
Aralia nudicaulis L.	Wild Sarsaparilla		X			
ASCLEPIADACEAE	**MILKWEED FAMILY**					
Asclepias syriaca L.	Common Milkweed					X
Cynanchum rossicum (Kleopov) Borh.	White Swallow-wort	+	X			X
ASTERACEAE	**ASTER FAMILY**					
Ambrosia artemisiifolia L.	Common Ragweed					X
Arctium minus (Hill) Bernh.	Common Burdock	+				X
Aster ericoides L.	Heath Aster					X
Aster lanceolatus Willd.	Tall White Aster				X	X
Aster lateriflorus (L.) Britt.	One-sided Aster		X			
Aster puniceus L.	Red-stemmed Aster				X	
Aster umbellatus Mill.	Flat-topped White Aster				X	
Bidens cernua L.	Nodding Beggarticks				X	
Bidens frondosa L.	Devil's Beggarticks				X	
Cirsium arvense (L.) Scop.	Canada Thistle	+				X
Cirsium vulgare (Savi) Tenore	Bull Thistle	+				X
Eupatorium maculatum L.	Spotted Joe-Pye Weed				X	
Eupatorium perfoliatum L.	Boneset				X	
Lactuca serriola L.	Prickly Lettuce	+				X
Rudbeckia hirta L.	Black-eyed Susan					X
Solidago caesia L.	Blue-stem Goldenrod		X			
Solidago flexicaulis L.	Zig-zag Goldenrod		X			
Solidago gigantea Ait.	Late Goldenrod			X	X	
Solidago juncea Ait.	Early Goldenrod	RR				X
Solidago nemoralis Ait.	Gray Goldenrod					X
Solidago uliginosa Nutt.	Bog Goldenrod	RR		X		
Taraxacum officinale Weber	Dandelion	+	X	X		
Tragopogon pratensis L.	Meadow Goat's-beard	+				X
Xanthium strumarium L.	Cocklebur				X	
BALSAMINACEAE	**TOUCH-ME-NOT-FAMILY**					
Impatiens capensis Meerb.	Spotted Jewelweed			X	X	
BERBERIDACEAE	**BARBERRY FAMILY**					
Berberis thunbergii DC.	Japanese Barberry	+	X			
Caulophyllum thalictroides (L.) Michx.	Blue Cohosh			X	X	
Podophyllum peltatum L.	May-apple		X			
BETULACEAE	**BIRCH FAMILY**					
Betula alleghaniensis Britt.	Yellow Birch		X			
Betula papyrifera Marsh.	Paper Birch		X			
Ostrya virginiana (Mill.) K. Koch	Hop Hornbeam		X			
BRASSICACEAE	**MUSTARD FAMILY**					
Barbarea vulgaris R. Br.	Yellow Rocket	+				X
CAPRIFOLIACEAE	**HONEYSUCKLE FAMILY**					
Lonicera tatarica L.	Tartarian Honeysuckle	+				X
Lonicera x bella Zabel	Hybrid Honeysuckle	+				X
Viburnum lentago L.	Nannyberry					X
Viburnum opulus L.	Guelder Rose	+				X
CHENOPODIACEAE	**SPINACH FAMILY**					
Chenopodium album L.	Lamb's-quarters	+				X
CONVOLVULACEAE	**MORNING GLORY FAMILY**					
Calystegia sepium (L.) R.Br.	Hedge Bindweed				X	
CORNACEAE	**DOGWOOD FAMILY**					
Cornus alternifolia L.f.	Alternate-leaved Dogwood		X			X
Cornus stolonifera Michx.	Red-osier Dogwood		X	X	X	X
CUCURBITACEAE	**GOURD FAMILY**					
Echinocystis lobata (Michx.) T. & G.	Wild Cucumber			X	X	X
ELAEAGNACEAE	**OLEASTER FAMILY**					

Family / Species	Common Name	Status	Community* Forest	Swamp	Marsh	Cultural
Elaeagnus angustifolia L.	Russian Olive	+				X
FAGACEAE	**BEECH FAMILY**					
Fagus grandifolia Ehrh.	American Beech		X			
Quercus rubra L.	Red Oak		X			
FABACEAE	**PEA FAMILY**					
Melilotus alba Medic.	White Sweet-clover	+				X
Trifolium pratense L.	Red Clover	+				X
Vicia cracca L.	Bird Vetch	+				X
GERANIACEAE	**GERANIUM FAMILY**					
Geranium robertianum L.	Herb Robert	+	X			
GROSSULARIACEAE	**GOOSEBERRY FAMILY**					
Ribes americanum Mill.	Wild Black Currant				X	
Ribes cynosbati L.	Prickly Gooseberry		X			
HYDROPHYLLACEAE	**WATERLEAF FAMILY**					
Hydrophyllum canadense L.	Canada Waterleaf	RR	X			
Hydrophyllum virginianum L.	Virginia Waterleaf		X			
Hypericum sp.	St.John's-wort					
JUGLANDACEAE	**WALNUT FAMILY**					
Carya cordiformis (Wang.) K.Koch	Bitternut Hickory		X			
Juglans cinerea L.	Butternut	PR	X			
Juglans nigra L.	Black Walnut	+	X			X
LAMIACEAE	**MINT FAMILY**					
Glechoma hederacea L.	Ground-ivy	+				X
Lycopus americanus Muhl.	American Water-horehound				X	
Lycopus uniflorus Michx.	Northern Water-horehound			X		
Mentha arvensis L.	Field or Common Mint				X	
Mentha X piperita L.	Peppermint	+			X	
Prunella vulgaris L.	Heal-all	+			X	
OLEACEAE	**OLIVE FAMILY**					
Fraxinus americana L.	White Ash		X			X
Fraxinus pennsylvanica Marsh.	Red Ash		X		X	X
ONAGRACEAE	**EVENING-PRIMROSE FAMILY**					
Epilobium parviflorum Schreb.	Small-flowered Willowherb	+			X	
Oenothera biennis L.	Hairy Yellow Evening-primrose					X
OROBANCHACEAE	**BROOM-RAPE FAMILY**					
Epifagus virginiana (L.) Bart.	Beech-drops		X			
PAPAVERACEAE	**POPPY FAMILY**					
Sanguinaria canadensis L.	Bloodroot		X			
POLYGONACEAE	**BUCKWHEAT FAMILY**					
Polygonum amphibium L.	Water Smartweed				X	
Polygonum hydropiper L.	Marshpepper Smartweed				X	
Polygonum hydropiperoides Michx.	Mild Waterpepper	RR		X		
Rumex crispus L.	Curly Dock	+				X
PRIMULACEAE	**PRIMROSE FAMILY**					
Lysimachia ciliata L.	Fringed Loosestrife		X	X		
RANUNCULACEAE	**BUTTERCUP FAMILY**					
Actaea pachypoda Ell.	White Baneberry		X			
Anemone virginiana L.	Thimbleweed					X
Caltha palustris L.	Marsh-marigold			X		
Ranunculus acris L.	Tall Buttercup	+				X
Ranunculus hispidus Michx.	Swamp Buttercup				X	
Thalictrum dioicum L.	Early Meadow Rue			X		
RHAMNACEAE	**BUCKTHORN FAMILY**					
Rhamnus cathartica L.	Common Buckthorn	+	X			X
Rhamnus frangula L.	Glossy Buckthorn	+		X		
ROSACEAE	**ROSE FAMILY**					
Amelanchier arborea (Michx. f.) Fern.	Serviceberry		X			
Amelanchier sp.	Serviceberry			X		X

Family / Species	Common Name	Status	Community* Forest	Swamp	Marsh	Cultural
Crataegus chrysocarpa Ashe.	Round-leaved Hawthorn	RR	X			
Crataegus pedicellata Sarg.	Scarlet Thorn		X			
Crataegus monogyna Jacq.	English Hawthorn	+				X
Crataegus punctata Jacq.	Dotted Hawthorn		X			X
Geum aleppicum Jacq.	Yellow Avens		X			
Geum canadense Jacq.	White Avens		X			
Potentilla norvegica L.	Rough Cinquefoil					X
Potentilla recta L.	Rough-fruited Cinquefoil	+				X
Prunus pensylvanica L. f.	Pin Cherry					X
Prunus serotina Ehrh.	Black Cherry					X
Prunus virginiana L.	Choke Cherry		X			X
Rosa multiflora Thumb.	Multiflora Rose	+				X
Rubus hispidus L.	Swamp Dewberry	RR		X		
Rubus idaeus L.	Wild Red Raspberry					X
Rubus occidentalis L.	Black Raspberry		X			
Rubus odoratus L.	Flowering Raspberry		X			
RUBIACEAE	**MADDER FAMILY**					
Galium triflorum Michx.	Sweet-scented Bedstraw		X			
Mitchella repens L.	Partridge berry		X			
SALICACEAE	**WILLOW FAMILY**					
Populus alba L.	White Poplar	+	X			X
Populus tremuloides Michx.	Trembling Aspen		X	X		X
Salix eriocephala Michx.	Missouri Willow			X	X	
Salix exigua Nutt.	Sandbar Willow				X	
Salix fragilis L.	Crack Willow	+	X	X	X	X
Salix x rubens Schrank.	Hybrid Crack Willow	+			X	X
SAXIFRAGACEAE	**SAXIFRAGE FAMILY**					
Mitella diphylla L.	Bishop's Cap			X		
SCROPHULARIACEAE	**FIGWORT FAMILY**					
Agalinus tenuifolia (Vahl) Raf.	Slender Gerardia	RR			X	
Mimulus ringens L.	Square-stemmed Monkeyflower				X	
Veronica anagallis-aquatica L.	Water-speedwell	+			X	
SOLANACEAE	**NIGHTSHADE FAMILY**					
Solanum dulcamara L.	Bittersweet Nightshade	+			X	
TILIACEAE	**LINDEN FAMILY**					
Tilia americana L.	Basswood		X			
ULMACEAE	**ELM FAMILY**					
Ulmus americana L.	American Elm		X		X	
URTICACEAE	**NETTLE FAMILY**					
Pilea pumila (L.) Gray	Clearweed			X		
Urtica dioica L. subsp. gracilis (Ait.)	American Stinging Nettle				X	
VERBENACEAE	**VERVAIN FAMILY**					
Verbena hastata L.	Blue Vervain				X	
VIOLACEAE	**VIOLET FAMILY**					
Viola canadensis L.	Canada Violet			X		
Viola pubescens Ait.	Downy Yellow Violet		X			
Viola sororia Willd.	Common Blue Violet		X			
VITACEAE	**GRAPE FAMILY**					
Vitis riparia Michx.	Riverbank Grape		X			

+ Non-native species
RR Regionally Uncommon to Rare (Varga et al. 2000)
PR Provincially Rare (Oldham and Brinker 2009)

* ELC Communities follow Ecological Land Classification for Southern Ontario. First Approximation and Its Application 1998

D.3 Breeding Bird Species List for Robinson Creek

Appendix D-3: Breeding Birds of Robinson Creek Watershed

Common Name	Scientific Name	Regional Status in Durham a	A = Area-sensitive Species (OMNR[c])	Comments - Includes Relative Abundance within Watershed
Great Blue Heron	*Ardea herodias*			feeding at Fenning Dr. Storm Water Pond (SWP); not breeding in watershed
Green Heron	*Butorides virescens*	S		near mouth of creek in Darlington P.P.
Canada Goose	*Branta canadensis*			with young at Fenning Dr. SWP; species probably feeds at numerous locations
Green-winged Teal	*Anas crecca*	S		breeding one location: Fenning Dr. Stormwater Pond (SWP)
Mallard	*Anas platyrhynchos*			
Gadwall	*Anas strepera*	S		at Fenning Dr. SWP - may not have bred
Red-tailed Hawk	*Buteo jamaicensis*			
Killdeer	*Charadrius vociferus*			
Spotted Sandpiper	*Actitis macularia*			
American Woodcock	*Scolopax minor*			
Mourning Dove	*Zenaida macroura*			
Downy Woodpecker	*Picoides pubescens*			
Northern Flicker	*Colaptes auratus*			
Eastern Wood-Pewee	*Contopus virens*			
Willow Flycatcher	*Empidonax traillii*			
Great Crested Flycatcher	*Myiarchus crinitus*			
Eastern Kingbird	*Tyrannus tyrannus*			
Tree Swallow	*Tachycineta bicolor*			
Barn Swallow	*Hirundo rustica*			
Blue Jay	*Cyanocitta cristata*			common
American Crow	*Corvus brachyrhynchos*			
Black-capped Chickadee	*Poecile atricapillus*			
White-breasted Nuthatch	*Sitta carolinensis*		A	3: 1at Darlington P.P.; 2 forest along main creek east of community centre
House Wren	*Troglodytes aedon*			common
Blue-gray Gnatcatcher	*Polioptila caerulea*	VR	A	1: near mouth of creek in Darlington P.P.
Wood Thrush	*Hylocichla mustelina*			2: 1at Darlington P.P.; another wetland northwest of BloorSt/ Courtice Rd.
American Robin	*Turdus migratorius*			common
Gray Catbird	*Dumetella carolinensis*			very common
Brown Thrasher	*Toxostoma rufum*			
Cedar Waxwing	*Bombycilla cedrorum*			
European Starling	*Sturnus vulgaris*			
Warbling Vireo	*Vireo gilvus*			
Red-eyed Vireo	*Vireo olivaceus*			
Yellow Warbler	*Dendroica petechia*			very common
Black-throated Green Warbler	*Dendroica virens*	S	A	1: in hemlock stand east of community centre on main Robinson Creek; likely unsucessful, not regular breeder
Mourning Warbler	*Oporornis philadelphia*			
Common Yellowthroat	*Geothlyphis trichas*			fairly common
Northern Cardinal	*Cardinalis cardinalis*			common
Rose-breasted Grosbeak	*Pheucticus ludovicianus*			
Indigo Bunting	*Passerina cyanea*			
Chipping Sparrow	*Spizella passerina*			
Clay-colored Sparrow	*Spizella pallida*	S		1- large thicket northeast Bloor/Prestonvale
Field Sparrow	*Spizella pusilla*			2 -large thicket northeast Bloor/Prestonvale
Savannah Sparrow	*Passerculus sandwichensis*		A	common
Song Sparrow	*Melospiza melodia*			very common
Swamp Sparrow	*Melospiza georgiana*			several locations in small numbers
Bobolink	*Dolichonyx oryzivorus*		A	1: east of community centre on Prestonvale
Red-winged Blackbird	*Agelaius phoeniceus*			abundant
Eastern Meadowlark	*Sturnella magna*		A	infrequent
Common Grackle	*Quiscalus quiscula*			
Brown-headed Cowbird	*Molothrus ater*			common
Orchard Oriole	*Icterus spurius*	VR		1- large thicket northeast Bloor/Prestonvale
Baltimore Oriole	*Icterus galbula*			
House Finch	*Carpodacus mexicanus*			
American Goldfinch	*Cardeulis tristis*			very common
House Sparrow	*Passer domesticus*			

Field Work Conducted Between: May 28 and June 26, 2009

Number of Species: 56
Number of (provincial and national) Species at Risk: 0
Number of S1 to S3 (provincially rare) Species: 0
Number of Regionally Scarce through Rare Species: 7
Number of Forest Area-sensitive Species: 3
Number of Open Lands Area-sensitive Species: 3

a Noted if Scarce (S), Rare (R) or Very Rare (VR) breeding status from Bain, M., and B. Henshaw. 1994. The Durham Region Natural History Report 1993. Funded by the Pickering Naturalists. Orchard Oriole populations have increased in southern Ontario since this source was written, thus status may no longer be accurate

b Area-sensitive source: Ontario Ministry of Natural Resources (OMNR). 2000. Significant Wildlife Habitat Technical Guide (Appendix G). 1 51 p plus appendices.

D.4 Breeding Bird Species List for Tooley Creek

Appendix D-4: Breeding Birds of Tooley Creek Watershed

Common Name	Scientific Name	Species at Risk (national) [a]	Species at Risk (provincial) [a]	Regional Status in Durham b	A = Area-sensitive Species (OMNR[c])	Water-shed Study	Hwy 407 Study	Comments - Includes Relative Abundance within Watershed
Great Blue Heron	*Ardea herodias*					X		observed flying over, may infrequently feed in area, but not breeding
Green Heron	*Butorides virescens*			S		X		1 observed flying over
Canada Goose	*Branta canadensis*						X	no breeding evidence found athough may breed and likely forages in area in breeding season
Mallard	*Anas platyrhynchos*					X		infrequent due to small amount of open wetlands
Turkey Vulture	*Cathartes aura*					X		observed flying over only; could breed
Red-tailed Hawk	*Buteo jamaicensis*					X		
Killdeer	*Charadrius vociferus*					X	X	
Spotted Sandpiper	*Actitis macularia*					X		
American Woodcock	*Scolopax minor*					X		
Rock Pigeon	*Columba livia*					X		
Mourning Dove	*Zenaida macroura*					X	X	common
Black-billed Cuckoo	*Coccyzus erythropthalmus*			S		X		2: main Tooley Creek between Baseline and Bloor St
Great Horned Owl	*Bubo virginianus*					X		
Ruby-throated Hummingbird	*Archilochus colubris*					X	X	1 location: maple forest north of compost facility
Red-bellied Woodpecker	*Melanerpes carolinus*			R [b]		X		1 location: maple forest north of compost facility
Downy Woodpecker	*Picoides pubescens*						X	very infrequent
Hairy Woodpecker	*Picoides villosus*			S	A	X		1: forest southeast of Hancock Rd./Bloor St.
Northern Flicker	*Colaptes auratus*					X	X	
Pileated Woodpecker	*Dryocopus pileatus*			S	A		X	Solina Rds; record may be from just outside watershed
Eastern Wood-Pewee	*Contopus virens*					X	X	common
Alder Flycatcher	*Empidonax alnorum*						X	
Willow Flycatcher	*Empidonax traillii*					X		common
Eastern Phoebe	*Sayornis phoebe*					X		two locations
Great Crested Flycatcher	*Myiarchus crinitus*					X	X	
Eastern Kingbird	*Tyrannus tyrannus*					X		common
Tree Swallow	*Tachycineta bicolor*					X		
N. Rough-winged Swallow	*Stelgidopteryx serripennis*					X		occasional forager; no observed breeding
Bank Swallow	*Riparia riparia*					X		2 colonies along lakeshore (each approx. 300 m east and west of mouth of creek); colony size~ 14 and 25 nests respectively
Barn Swallow	*Hirundo rustica*					X		
Blue Jay	*Cyanocitta cristata*					X	X	common
American Crow	*Corvus brachyrhynchos*					X	X	
Black-capped Chickadee	*Poecile atricapillus*					X	X	
White-breasted Nuthatch	*Sitta carolinensis*				A	X	X	Trullis Rd; forest southeast of Hancock Rd./ Bloor St.
House Wren	*Troglodytes aedon*					X	X	common
Marsh Wren	*Cistothorus palustris*					X		1: cattail patch in pasture northwest Bloor St./Courtice Rd; likely unsuccessful breeder and not usually present
Eastern Bluebird	*Sialia sialis*			S		X		1: pasture southwest Bloor St./Courtice Rd
Veery	*Catharus fuscescens*				A	X	X	only present in lowland forests in northeastern corner of watershed
Wood Thrush	*Hylocichla mustelina*					X	X	infrequent (about 7 recorded in subwatershed study)
American Robin	*Turdus migratorius*					X	X	
Northern Mockingbird	*Mimus polyglottus*			VR [b]		X		1: near mouth of Tooley Creek
Gray Catbird	*Dumetella carolinensis*					X	X	common
Brown Thrasher	*Toxostoma rufum*					X	X	
Cedar Waxwing	*Bombycilla cedrorum*					X	X	
European Starling	*Sturnus vulgaris*					X	X	common
Warbling Vireo	*Vireo gilvus*					X	X	
Red-eyed Vireo	*Vireo olivaceus*					X	X	common
Yellow Warbler	*Dendroica petechia*					X	X	abundant
Black-and-white Warbler	*Mniotilta varia*				A	X	X	3: only present in lowland forests in northeastern corner of watershed
American Redstart	*Setophaga ruticilla*				A	X	X	6 records: of these 2 probably migrants (not mapped), and two are young males that are likely unsucessful breeders
Ovenbird	*Seiurus aurocapillus*				A		X	only present in lowland forests in northeastern corner of watershed
Northern Waterthrush	*Seiurus noveboracensis*						X	several, but only in large lowland forest southeast of Nash and Solina Rds

Common Name	Scientific Name	Species at Risk (national) a	Species at Risk (provincial) a	Regional Status in Durham b	A = Area-sensitive Species (OMNR[c])	Water-shed Study	Hwy 407 Study	Comments - Includes Relative Abundance within Watershed
Mourning Warbler	*Oporornis philadelphia*					X	X	
Common Yellowthroat	*Geothlypis trichas*					X	X	
Canada Warbler	*Wilsonia canadensis*	THR	SC	R	A	X		1: in large lowland forest southeast of Nash and Solina Rds
Scarlet Tanager	*Piranga olivacea*				A		X	Solina Rds; record may be from just outside watershed
Northern Cardinal	*Cardinalis cardinalis*					X	X	common
Rose-breasted Grosbeak	*Pheucticus ludovicianus*					X	X	
Indigo Bunting	*Passerina cyanea*					X	X	
Chipping Sparrow	*Spizella passerina*					X	X	
Vesper Sparrow	*Pooecetes gramineus*						X	
Savannah Sparrow	*Passerculus sandwichensis*				A	X	X	common
Song Sparrow	*Melospiza melodia*					X	X	abundant
Swamp Sparrow	*Melospiza georgiana*					X		infrequent
Bobolink	*Dolichonyx oryzivorus*				A	X		
Red-winged Blackbird	*Agelaius phoeniceus*					X	X	abundant
Eastern Meadowlark	*Sturnella magna*				A	X		
Common Grackle	*Quiscalus quiscula*					X	X	
Brown-headed Cowbird	*Molothrus ater*					X	X	
Orchard Oriole	*Icterus spurius*			VR [b]		X		1: in garden near Basline Rd. and Courtice Rd/
Baltimore Oriole	*Icterus galbula*					X		
American Goldfinch	*Cardeulis tristis*					X	X	common
House Sparrow	*Passer domesticus*					X		

Field Work Conducted Between: May 28 and June 26, 2009 for this study; and breeding bird season in 2003 and 2006 for Hwy 407 study

Number of Species: 72
Number of (provincial and national) Species at Risk: 1
Number of S1 to S3 (provincially rare) Species: 0 (Canada Warbler is S4)
Number of Regionally Scarce through Rare Species: 9
Number of Forest Area-sensitive Species: 9
Number of Open Lands Area-sensitive Species: 3

a National Species at Risk are those listed by COSEWIC = Committee on the Status of Endangered Wildlife in Canada
Provincial Species at Risk are those listed by COSSARO = Committee on the Status of Species at Risk in Ontario
END = Endangered, THR = Threatened, SC = Special Concern

b Noted if Scarce (S), Rare (R) or Very Rare (VR) breeding status, but not abundant through uncommon from Bain, M., and B. Henshaw. 1994. The Durham Region Natural History Report 1993. Funded by the Pickering Naturalists. Red-bellied Woodpecker, N. Mockingbird and Orchard Oriole populations have increased in southern Ontario since this source was written, thus status may no longer be accurate

c Area-sensitive source: Ontario Ministry of Natural Resources (OMNR). 2000. Significant Wildlife Habitat Technical Guide (Appendix G). 151 p plus appendices.

Appendix E

Hydrogeology

E.1 MOE Water Well Records – Robinson Creek
E.2 MOE Water Well Records – Tooley Creek
E.3 Groundwater Monitor Sampling Results

E.1 MOE Water Well Records – Robinson Creek

MOE Water Well Records Report

112956 Robinson

Well Number 1901129 **Construction Date** 08-May-1960 **Primary Water Use** Public Supply **Well Type** Bedrock
Easting (NAD83) 678515 **Northing (NAD83)** 4860263 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 94.49
Lot 032 **Concession** Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 15.24 **Static Level (m)** 9.14 **Deepest Water Found** 32.31 **Well Depth** 32.31
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)** 25.60
Pump Rate(Igpm) 3.00 **Pump Time(h:m)** 2 : 0 **Depth (end of 60 min)** 30.48
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :** 100.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	0.61	Topsoil		fill (incl topsoil, waste)
2	0.61	25.60	Clay Stones		diamicton: si to sa/si matrix
3	25.60	32.31	Shale	Brown	shale

Well Number 1901130 **Construction Date** 08-Jun-1964 **Primary Water Use** Public Supply **Well Type** Overburden
Easting (NAD83) 678255 **Northing (NAD83)** 4859933 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 76.20
Lot 032 **Concession** Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 76.20 **Static Level (m)** 6.10 **Deepest Water Found** 9.75 **Well Depth** 10.67
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm) 8.00 **Pump Time(h:m)** : **Depth (end of 60 min)**
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :** 33.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	0.30	Topsoil		fill (incl topsoil, waste)
2	0.30	1.83	Clay	Brown	clay, silty clay
3	1.83	9.75	Clay	Blue	clay, silty clay
4	9.75	10.67	Coarse Sand		sand, silty sand

Well Number 1901187 **Construction Date** 05-Jun-1959 **Primary Water Use** Public Supply **Well Type** Overburden
Easting (NAD83) 678458 **Northing (NAD83)** 4862546 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 129.54
Lot 030 **Concession** 01 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 15.24 **Static Level (m)** 2.44 **Deepest Water Found** 10.67 **Well Depth** 42.67
Top of Screen (m): 10.67 **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm) 8.00 **Pump Time(h:m)** 6 : 0 **Depth (end of 60 min)** 10.67
Specific Capacity: 0.30 **Recommended Pump Setting (gpm) :**

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	0.30	Topsoil		fill (incl topsoil, waste)
2	0.30	15.24	Medium Sand Stones		gravel, gravelly sand
3	15.24	42.67	Medium Sand Clay	Grey	sand, silty sand

MOE Water Well Records Report

112956 Robinson

Well Number 1901190 **Construction Date** 29-May-1962 **Primary Water Use** Domestic **Well Type** Overburden
Easting (NAD83) 678021 **Northing (NAD83)** 4863092 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 132.59
Lot 031 **Concession** 01 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 76.20 **Static Level (m)** 6.10 **Deepest Water Found** 6.10 **Well Depth** 7.62
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm 5.00 **Pump Time(h:m)** : **Depth (end of 60 min)**
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :** 23.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	1.83	Clay	Brown	clay, silty clay
2	1.83	5.49	Clay	Blue	clay, silty clay
3	5.49	6.10	Gravel		gravel, gravelly sand
4	6.10	7.62	Clay	Blue	clay, silty clay

Well Number 1901191 **Construction Date** 14-Jan-1960 **Primary Water Use** Stock **Well Type** Overburden
Easting (NAD83) 677180 **Northing (NAD83)** 4861706 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 118.87
Lot 034 **Concession** 01 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 15.24 **Static Level (m)** 24.38 **Deepest Water Found** 44.20 **Well Depth** 44.20
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm 10.00 **Pump Time(h:m)** 4 : 0 **Depth (end of 60 min)** 30.48
Specific Capacity: 0.50 **Recommended Pump Setting (gpm) :** 100.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	12.19	Previously Dug		fill (incl topsoil, waste)
2	12.19	36.58	Medium Sand Stones	Brown	gravel, gravelly sand
3	36.58	43.59	Clay	Grey	clay, silty clay
4	43.59	44.20	Gravel		gravel, gravelly sand

Well Number 1901192 **Construction Date** 30-Sep-1960 **Primary Water Use** Domestic **Well Type** Overburden
Easting (NAD83) 676551 **Northing (NAD83)** 4861951 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 121.92
Lot 035 **Concession** 01 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 91.44 **Static Level (m)** 6.71 **Deepest Water Found** 5.49 **Well Depth** 7.92
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm 0.00 **Pump Time(h:m)** 12 : 0 **Depth (end of 60 min)**
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :**

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	0.91	Topsoil Clay		fill (incl topsoil, waste)
2	0.91	3.35	Clay Medium Sand	Brown	silt, sandy silt, clayey silt
3	3.35	4.57	Clay Medium Sand	Blue	silt, sandy silt, clayey silt
4	4.57	5.49	Hardpan		diamicton: si to sa/si matrix
5	5.49	5.79	Gravel		gravel, gravelly sand
6	5.79	7.92	Hardpan		diamicton: si to sa/si matrix

MOE Water Well Records Report

Well Number 1901193 **Construction Date** 10-Jan-1964 **Primary Water Use** Stock **Well Type** Bedrock
Easting (NAD83) 676469 **Northing (NAD83)** 4861956 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 120.40
Lot 035 **Concession** 01 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 15.24 **Static Level (m)** 19.81 **Deepest Water Found** 45.72 **Well Depth** 46.02
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)** 45.72
Pump Rate(Igpm) 4.00 **Pump Time(h:m)** 2 **:** 0 **Depth (end of 60 min)** 43.59
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :** 146.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	0.30	Topsoil		fill (incl topsoil, waste)
2	0.30	4.57	Clay Gravel Stones	Brown	diamicton: si to sa/si matrix
3	4.57	7.62	Sand	Brown	sand, silty sand
4	7.62	18.29	Sand Stones	Grey	gravel, gravelly sand
5	18.29	45.72	Sand Clay	Grey	sand, silty sand
6	45.72	46.02	Shale	Black	shale

Well Number 1901195 **Construction Date** 28-Jul-1967 **Primary Water Use** Domestic **Well Type** Overburden
Easting (NAD83) 676123 **Northing (NAD83)** 4862317 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 128.02
Lot 035 **Concession** 01 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 91.44 **Static Level (m)** 4.88 **Deepest Water Found** 8.84 **Well Depth** 10.97
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm) 15.00 **Pump Time(h:m)** **:** **Depth (end of 60 min)**
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :** 34.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	0.30	Topsoil Clay		fill (incl topsoil, waste)
2	0.30	3.96	Clay	Brown	clay, silty clay
3	3.96	8.84	Clay	Blue	clay, silty clay
4	8.84	10.97	Medium Sand		sand, silty sand

Well Number 1901309 **Construction Date** 24-Aug-1962 **Primary Water Use** Domestic **Well Type** Overburden
Easting (NAD83) 677902 **Northing (NAD83)** 4863530 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 134.11
Lot 030 **Concession** 02 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 76.20 **Static Level (m)** 2.74 **Deepest Water Found** 5.49 **Well Depth** 7.01
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm) 4.00 **Pump Time(h:m)** **:** **Depth (end of 60 min)**
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :** 20.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	2.74	Clay Stones	Brown	diamicton: si to sa/si matrix
2	2.74	3.66	Medium Sand		sand, silty sand
3	3.66	5.49	Clay Stones	Blue	diamicton: si to sa/si matrix
4	5.49	5.79	Medium Sand		sand, silty sand
5	5.79	7.01	Clay Stones	Blue	diamicton: si to sa/si matrix

MOE Water Well Records Report

112956 Robinson

Well Number 1901316 **Construction Date** 15-Jan-1959 **Primary Water Use** Domestic **Well Type** Overburden
Easting (NAD83) 677900 **Northing (NAD83)** 4863407 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 133.50
Lot 031 **Concession** 02 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 76.20 **Static Level (m)** **Deepest Water Found** 4.88 **Well Depth** 4.88
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm **Pump Time(h:m)** : **Depth (end of 60 min)**
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :**

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	4.57	Clay	Brown	clay, silty clay
2	4.57	4.88	Coarse Sand		sand, silty sand

Well Number 1901318 **Construction Date** 24-Mar-1960 **Primary Water Use** Domestic **Well Type** Overburden
Easting (NAD83) 677994 **Northing (NAD83)** 4863132 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 132.59
Lot 031 **Concession** 02 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 10.16 **Static Level (m)** 1.22 **Deepest Water Found** 18.29 **Well Depth** 19.20
Top of Screen (m): 18.59 **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm 4.00 **Pump Time(h:m)** 8 : 0 **Depth (end of 60 min)** 3.66
Specific Capacity: 0.50 **Recommended Pump Setting (gpm) :**

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	3.66	Clay	Brown	clay, silty clay
2	3.66	15.24	Clay Boulders	Blue	diamicton: si to sa/si matrix
3	15.24	18.29	Fine Sand		sand, silty sand
4	18.29	19.20	Gravel		gravel, gravelly sand

Well Number 1901323 **Construction Date** 24-Jun-1963 **Primary Water Use** Domestic **Well Type** Overburden
Easting (NAD83) 678005 **Northing (NAD83)** 4863113 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 132.59
Lot 031 **Concession** 02 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 76.20 **Static Level (m)** 3.05 **Deepest Water Found** 6.71 **Well Depth** 8.53
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm 2.00 **Pump Time(h:m)** : **Depth (end of 60 min)**
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :** 25.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	2.13	Clay Stones	Brown	diamicton: si to sa/si matrix
2	2.13	6.10	Clay Stones	Blue	diamicton: si to sa/si matrix
3	6.10	6.71	Clay	Blue	clay, silty clay
4	6.71	7.62	Medium Sand		sand, silty sand
5	7.62	8.53	Clay	Blue	clay, silty clay

MOE Water Well Records Report

Well Number 1901324 **Construction Date** 11-Jul-1963 **Primary Water Use** Domestic **Well Type** Overburden
Easting (NAD83) 677817 **Northing (NAD83)** 4863617 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 133.50
Lot 031 **Concession** 02 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 76.20 **Static Level (m)** 3.05 **Deepest Water Found** 5.49 **Well Depth** 7.62
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm 2.00 **Pump Time(h:m)** : **Depth (end of 60 min)**
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :** 24.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	2.44	Clay	Brown	clay, silty clay
2	2.44	3.35	Clay	Blue	clay, silty clay
3	3.35	5.49	Clay Stones	Blue	diamicton: si to sa/si matrix
4	5.49	5.79	Coarse Sand		sand, silty sand
5	5.79	7.62	Clay	Blue	clay, silty clay

Well Number 1901335 **Construction Date** 09-Aug-1962 **Primary Water Use** Stock **Well Type** Overburden
Easting (NAD83) 677746 **Northing (NAD83)** 4862457 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 122.83
Lot 032 **Concession** 02 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 76.20 **Static Level (m)** 3.66 **Deepest Water Found** 4.27 **Well Depth** 6.40
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm 2.00 **Pump Time(h:m)** : **Depth (end of 60 min)**
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :** 18.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	3.66	Clay	Brown	clay, silty clay
2	3.66	4.27	Clay Medium Sand	Brown	silt, sandy silt, clayey silt
3	4.27	6.10	Coarse Sand		sand, silty sand
4	6.10	6.40	Clay	Blue	clay, silty clay

Well Number 1901346 **Construction Date** 24-Aug-1964 **Primary Water Use** Domestic **Well Type** Overburden
Easting (NAD83) 677119 **Northing (NAD83)** 4862645 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 125.58
Lot 033 **Concession** 02 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 76.20 **Static Level (m)** 1.83 **Deepest Water Found** 5.79 **Well Depth** 15.24
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm 1.00 **Pump Time(h:m)** : **Depth (end of 60 min)**
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :**

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	0.30	Topsoil		fill (incl topsoil, waste)
2	0.30	3.96	Clay Stones	Brown	diamicton: si to sa/si matrix
3	3.96	15.24	Clay Stones	Blue	diamicton: si to sa/si matrix

MOE Water Well Records Report

112956 Robinson

Well Number 1901347 **Construction Date** 09-Oct-1964 **Primary Water Use** Domestic **Well Type** Overburden
Easting (NAD83) 677060 **Northing (NAD83)** 4862800 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 125.88
Lot 033 **Concession** 02 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 91.44 **Static Level (m)** 1.22 **Deepest Water Found** 15.24 **Well Depth** 16.46
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm 1.00 **Pump Time(h:m)** : **Depth (end of 60 min)**
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :** 52.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	1.22	Topsoil Clay		fill (incl topsoil, waste)
2	1.22	5.18	Clay	Brown	clay, silty clay
3	5.18	16.46	Clay Gravel	Blue	diamicton: si to sa/si matrix

Well Number 1901350 **Construction Date** 20-Jul-1966 **Primary Water Use** Domestic **Well Type** Overburden
Easting (NAD83) 677073 **Northing (NAD83)** 4863134 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 128.02
Lot 033 **Concession** 02 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 91.44 **Static Level (m)** 6.40 **Deepest Water Found** 6.10 **Well Depth** 8.53
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm 6.00 **Pump Time(h:m)** : **Depth (end of 60 min)**
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :** 26.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	0.30	Clay Topsoil		fill (incl topsoil, waste)
2	0.30	2.44	Clay	Brown	clay, silty clay
3	2.44	6.10	Clay	Blue	clay, silty clay
4	6.10	8.53	Clay Medium Sand	Blue	silt, sandy silt, clayey silt

Well Number 1901351 **Construction Date** 03-Nov-1966 **Primary Water Use** Domestic **Well Type** Overburden
Easting (NAD83) 676946 **Northing (NAD83)** 4862478 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 124.97
Lot 033 **Concession** 02 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 91.44 **Static Level (m)** 2.13 **Deepest Water Found** 7.62 **Well Depth** 8.23
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm 9.00 **Pump Time(h:m)** : **Depth (end of 60 min)**
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :** 25.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	0.30	Clay Topsoil		fill (incl topsoil, waste)
2	0.30	2.44	Clay	Brown	clay, silty clay
3	2.44	7.62	Clay	Blue	clay, silty clay
4	7.62	8.23	Clay Medium Sand	Blue	silt, sandy silt, clayey silt

MOE Water Well Records Report

Well Number 1902542 **Construction Date** 02-Jul-1968 **Primary Water Use** Domestic **Well Type** Overburden
Easting (NAD83) 678315 **Northing (NAD83)** 4862683 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 129.54
Lot 030 **Concession** 02 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 10.16 **Static Level (m)** 1.22 **Deepest Water Found** 37.19 **Well Depth** 39.62
Top of Screen (m): 9.14 **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm 2.00 **Pump Time(h:m)** 5 **:** 0 **Depth (end of 60 min)** 10.67
Specific Capacity: 0.10 **Recommended Pump Setting (gpm) :** 35.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	0.30	Topsoil		fill (incl topsoil, waste)
2	0.30	9.14	Clay	Brown	clay, silty clay
3	9.14	12.19	Gravel		gravel, gravelly sand
4	12.19	27.43	Clay	Blue	clay, silty clay
5	27.43	28.04	Medium Sand		sand, silty sand
6	28.04	37.19	Clay	Blue	clay, silty clay
7	37.19	38.10	Medium Sand		sand, silty sand
8	38.10	39.62	Clay	Blue	clay, silty clay

Well Number 1903047 **Construction Date** 13-Feb-1970 **Primary Water Use** Domestic **Well Type** Bedrock
Easting (NAD83) 677215 **Northing (NAD83)** 4861763 **UTM Zone** 17
Positional Reliability margin of error : 30 m - 100 m **Elevation(mASL)** 121.92
Lot 033 **Concession** 01 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 15.24 **Static Level (m)** 20.12 **Deepest Water Found** 46.94 **Well Depth** 46.94
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)** 46.63
Pump Rate(Igpm 5.00 **Pump Time(h:m)** 3 **:** 10 **Depth (end of 60 min)** 43.89
Specific Capacity: 0.10 **Recommended Pump Setting (gpm) :** 149.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	0.30	Topsoil	Brown	fill (incl topsoil, waste)
2	0.30	3.66	Clay	Brown	clay, silty clay
3	3.66	17.37	Gravel Medium Sand Clay	Brown	gravel, gravelly sand
4	17.37	46.63	Clay Medium Sand	Grey	silt, sandy silt, clayey silt
5	46.63	46.94	Shale Gravel	Black	gravel, gravelly sand

Well Number 1903130 **Construction Date** 28-Jul-1971 **Primary Water Use** Stock **Well Type** Overburden
Easting (NAD83) 678270 **Northing (NAD83)** 4862123 **UTM Zone** 17
Positional Reliability margin of error : 30 m - 100 m **Elevation(mASL)** 123.44
Lot 031 **Concession** 01 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 91.44 **Static Level (m)** 3.66 **Deepest Water Found** 5.18 **Well Depth** 7.32
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm 7.00 **Pump Time(h:m)** 3 **:** 0 **Depth (end of 60 min)** 6.40
Specific Capacity: 0.80 **Recommended Pump Setting (gpm) :** 22.00

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Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	0.30	Topsoil Clay		fill (incl topsoil, waste)
2	0.30	3.66	Clay	Brown	clay, silty clay
3	3.66	5.18	Clay Gravel	Brown	diamicton: si to sa/si matrix
4	5.18	7.32	Clay Gravel	Blue	diamicton: si to sa/si matrix

Well Number 1903745 **Construction Date** 01-Nov-1973 **Primary Water Use** Industrial **Well Type** Bedrock
Easting (NAD83) 678303 **Northing (NAD83)** 4860815 **UTM Zone** 17
Positional Reliability margin of error : 30 m - 100 m **Elevation(mASL)** 97.54
Lot 032 **Concession** 01 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 15.24 **Static Level (m)** 10.67 **Deepest Water Found** 32.00 **Well Depth** 32.92
Top of Screen (m): 31.70 **WaterKind** Fresh **Depth to Bedrock (m)** 32.61
Pump Rate(Igpm 2.00 **Pump Time(h:m)** 3 **:** 0 **Depth (end of 60 min)** 32.00
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :** 2.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	0.61	Topsoil	Brown	fill (incl topsoil, waste)
2	0.61	7.62	Sand Clay	Brown	sand, silty sand
3	7.62	8.23	Sand Gravel Clay	Brown	gravel, gravelly sand
4	8.23	32.00	Clay	Grey	clay, silty clay
5	32.00	32.61	Sand Gravel	Brown	gravel, gravelly sand
6	32.61	32.92	Limestone Rock	Brown	limestone

Well Number 1903969 **Construction Date** 24-Sep-1974 **Primary Water Use** Domestic **Well Type** Overburden
Easting (NAD83) 678437 **Northing (NAD83)** 4861999 **UTM Zone** 17
Positional Reliability margin of error : 30 m - 100 m **Elevation(mASL)** 123.75
Lot 030 **Concession** 01 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 76.20 **Static Level (m)** 4.88 **Deepest Water Found** 9.14 **Well Depth** 12.19
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm 3.00 **Pump Time(h:m)** 1 **:** 0 **Depth (end of 60 min)** 12.19
Specific Capacity: 0.10 **Recommended Pump Setting (gpm) :** 39.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	4.88	Clay Stones	Brown	diamicton: si to sa/si matrix
2	4.88	5.18	Clay Sand	Brown	silt, sandy silt, clayey silt
3	5.18	6.40	Clay Stones	Blue	diamicton: si to sa/si matrix
4	6.40	6.71	Clay Sand	Blue	silt, sandy silt, clayey silt
5	6.71	9.14	Clay Stones	Blue	diamicton: si to sa/si matrix
6	9.14	9.45	Clay Sand	Blue	silt, sandy silt, clayey silt
7	9.45	12.19	Clay Stones	Blue	diamicton: si to sa/si matrix

MOE Water Well Records Report

Well Number 1904372 **Construction Date** 20-Nov-1975 **Primary Water Use** Stock **Well Type** Overburden
Easting (NAD83) 677275 **Northing (NAD83)** 4860963 **UTM Zone** 17
Positional Reliability margin of error : 30 m - 100 m **Elevation(mASL)** 103.63
Lot 034 **Concession** 01 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 91.44 **Static Level (m)** 1.83 **Deepest Water Found** 1.52 **Well Depth** 2.74
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm 5.00 **Pump Time(h:m)** 3 **:** 0 **Depth (end of 60 min)** 2.74
Specific Capacity: 1.60 **Recommended Pump Setting (gpm) :** 9.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	0.30	Topsoil Clay	Black	fill (incl topsoil, waste)
2	0.30	1.52	Clay Soft	Brown	clay, silty clay
3	1.52	2.74	Clay Gravel Layered	Brown	diamicton: si to sa/si matrix

Well Number 1904517 **Construction Date** 16-Nov-1976 **Primary Water Use** Domestic **Well Type** Overburden
Easting (NAD83) 678235 **Northing (NAD83)** 4862743 **UTM Zone** 17
Positional Reliability margin of error : 30 m - 100 m **Elevation(mASL)** 129.84
Lot 030 **Concession** 02 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 76.20 **Static Level (m)** 3.05 **Deepest Water Found** 3.05 **Well Depth** 7.62
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm 4.00 **Pump Time(h:m)** 1 **:** 0 **Depth (end of 60 min)** 7.01
Specific Capacity: 0.30 **Recommended Pump Setting (gpm) :** 23.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	3.05	Clay Packed	Brown	clay, silty clay
2	3.05	3.35	Sand Water-bearing	Brown	sand, silty sand
3	3.35	7.62	Clay Stones Cemented	Blue	diamicton: si to sa/si matrix

Well Number 1907553 **Construction Date** 07-Dec-1985 **Primary Water Use** Domestic **Well Type** Overburden
Easting (NAD83) 678356 **Northing (NAD83)** 4862206 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 125.88
Lot 030 **Concession** 01 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 76.20 **Static Level (m)** 3.66 **Deepest Water Found** 3.66 **Well Depth** 8.23
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm 6.00 **Pump Time(h:m)** 0 **:** 30 **Depth (end of 60 min)** 4.57
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :** 25.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	3.66	Clay Stones Packed	Brown	diamicton: si to sa/si matrix
2	3.66	4.57	Clay Boulders Cemented	Blue	diamicton: si to sa/si matrix
3	4.57	5.18	Sand Water-bearing	Grey	sand, silty sand
4	5.18	7.32	Clay Packed	Grey	clay, silty clay
5	7.32	8.23	Sand Water-bearing	Grey	sand, silty sand

MOE Water Well Records Report

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Well Number 1909286 **Construction Date** 09-Aug-1988 **Primary Water Use** Domestic **Well Type** Overburden
Easting (NAD83) 677847 **Northing (NAD83)** 4863574 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 134.11
Lot 031 **Concession** 02 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 76.20 **Static Level (m)** 0.30 **Deepest Water Found** 4.57 **Well Depth** 7.62
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm 6.00 **Pump Time(h:m)** 1 **:** 0 **Depth (end of 60 min)** 7.62
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :** 24.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	0.91	Topsoil	Black	fill (incl topsoil, waste)
2	0.91	4.57	Clay	Brown	clay, silty clay
3	4.57	4.88	Sand Water-bearing	Brown	sand, silty sand
4	4.88	5.79	Clay	Brown	clay, silty clay
5	5.79	6.10	Sand Water-bearing	Brown	sand, silty sand
6	6.10	7.62	Clay Stones	Brown	diamicton: si to sa/si matrix

E.2 MOE Water Well Records – Tooley Creek

MOE Water Well Records Report

112956 Tooley

Well Number 1901126 **Construction Date** 03-Aug-1967 **Primary Water Use** Commercial **Well Type** Overburden
Easting (NAD83) 679255 **Northing (NAD83)** 4860613 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 92.96
Lot 029 **Concession** Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 91.44 **Static Level (m)** 1.22 **Deepest Water Found** 3.05 **Well Depth** 6.10
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm) 8.00 **Pump Time(h:m)** : **Depth (end of 60 min)**
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :** 19.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	3.05	Clay	Brown	clay, silty clay
2	3.05	3.66	Gravel		gravel, gravelly sand
3	3.66	6.10	Clay	Blue	clay, silty clay

Well Number 1901127 **Construction Date** 09-Jun-1964 **Primary Water Use** **Well Type** Overburden
Easting (NAD83) 678695 **Northing (NAD83)** 4860223 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 96.01
Lot 031 **Concession** Newcastle Town (Darlington) **Durham**
Well Diameter(cm) **Static Level (m)** **Deepest Water Found** **Well Depth** 16.76
Top of Screen (m): **WaterKind** **Depth to Bedrock (m)**
Pump Rate(Igpm) **Pump Time(h:m)** : **Depth (end of 60 min)**
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :**

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	0.30	Topsoil		fill (incl topsoil, waste)
2	0.30	2.74	Clay	Brown	clay, silty clay
3	2.74	16.76	Clay	Blue	clay, silty clay

Well Number 1901182 **Construction Date** 13-Mar-1963 **Primary Water Use** Domestic **Well Type** Overburden
Easting (NAD83) 679369 **Northing (NAD83)** 4863001 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 121.92
Lot 027 **Concession** 01 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 76.20 **Static Level (m)** 4.57 **Deepest Water Found** 7.62 **Well Depth** 9.45
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm) 0.00 **Pump Time(h:m)** : **Depth (end of 60 min)**
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :** 30.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	2.44	Clay	Brown	clay, silty clay
2	2.44	7.62	Clay	Blue	clay, silty clay
3	7.62	9.45	Clay Stones	Blue	diamicton: si to sa/si matrix

MOE Water Well Records Report

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Well Number 1901184 **Construction Date** 28-May-1966 **Primary Water Use** Domestic **Well Type** Overburden
Easting (NAD83) 678990 **Northing (NAD83)** 4862712 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 124.97
Lot 029 **Concession** 01 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 76.20 **Static Level (m)** 5.49 **Deepest Water Found** 3.96 **Well Depth** 9.14
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm 1.00 **Pump Time(h:m)** : **Depth (end of 60 min)**
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :** 28.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	0.30	Topsoil		fill (incl topsoil, waste)
2	0.30	1.83	Clay	Brown	clay, silty clay
3	1.83	6.10	Clay Medium Sand	Blue	silt, sandy silt, clayey silt
4	6.10	9.14	Clay	Blue	clay, silty clay

Well Number 1901185 **Construction Date** 16-Oct-1959 **Primary Water Use** Domestic **Well Type** Overburden
Easting (NAD83) 679198 **Northing (NAD83)** 4862917 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 117.35
Lot 028 **Concession** 01 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 91.44 **Static Level (m)** 1.22 **Deepest Water Found** 4.88 **Well Depth** 6.10
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm 9.00 **Pump Time(h:m)** 12 : 0 **Depth (end of 60 min)**
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :**

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	0.91	Clay	Brown	clay, silty clay
2	0.91	2.74	Clay Medium Sand	Brown	silt, sandy silt, clayey silt
3	2.74	4.88	Clay	Blue	clay, silty clay
4	4.88	5.49	Clay Gravel	Blue	diamicton: si to sa/si matrix
5	5.49	6.10	Clay	Blue	clay, silty clay

Well Number 1901186 **Construction Date** 11-Sep-1964 **Primary Water Use** Domestic **Well Type** Overburden
Easting (NAD83) 679050 **Northing (NAD83)** 4862680 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 121.92
Lot 028 **Concession** 01 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 15.24 **Static Level (m)** 0.00 **Deepest Water Found** 12.80 **Well Depth** 13.72
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm 5.00 **Pump Time(h:m)** 4 : 0 **Depth (end of 60 min)** 11.28
Specific Capacity: 0.10 **Recommended Pump Setting (gpm) :** 37.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	0.30	Topsoil		fill (incl topsoil, waste)
2	0.30	7.92	Clay	Brown	clay, silty clay
3	7.92	12.80	Clay	Grey	clay, silty clay
4	12.80	13.72	Clay Gravel	Grey	diamicton: si to sa/si matrix

MOE Water Well Records Report

Well Number 1901189 **Construction Date** 10-Dec-1959 **Primary Water Use** Stock **Well Type** Overburden
Easting (NAD83) 678446 **Northing (NAD83)** 4861420 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 117.35
Lot 031 **Concession** 01 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 91.44 **Static Level (m)** 2.74 **Deepest Water Found** 5.18 **Well Depth** 7.62
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm 1.00 **Pump Time(h:m)** : **Depth (end of 60 min)**
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :**

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	0.91	Topsoil Clay		fill (incl topsoil, waste)
2	0.91	2.44	Clay Stones	Brown	diamicton: si to sa/si matrix
3	2.44	5.18	Clay Stones	Blue	diamicton: si to sa/si matrix
4	5.18	7.62	Clay Gravel	Blue	diamicton: si to sa/si matrix

Well Number 1901280 **Construction Date** 05-Aug-1960 **Primary Water Use** Domestic **Well Type** Overburden
Easting (NAD83) 679117 **Northing (NAD83)** 4863851 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 140.21
Lot 025 **Concession** 02 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 76.20 **Static Level (m)** 0.91 **Deepest Water Found** 6.40 **Well Depth** 7.62
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm 1.00 **Pump Time(h:m)** : **Depth (end of 60 min)**
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :**

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	0.91	Topsoil		fill (incl topsoil, waste)
2	0.91	1.83	Gravel		gravel, gravelly sand
3	1.83	5.49	Clay	Grey	clay, silty clay
4	5.49	6.40	Clay Medium Sand		silt, sandy silt, clayey silt
5	6.40	7.62	Gravel		gravel, gravelly sand

Well Number 1901281 **Construction Date** 05-Nov-1963 **Primary Water Use** Domestic **Well Type** Overburden
Easting (NAD83) 679932 **Northing (NAD83)** 4864676 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 140.21
Lot 025 **Concession** 02 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 12.70 **Static Level (m)** 5.18 **Deepest Water Found** 16.76 **Well Depth** 16.76
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm 1.00 **Pump Time(h:m)** 1 : 30 **Depth (end of 60 min)** 5.79
Specific Capacity: 0.50 **Recommended Pump Setting (gpm) :** 21.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	6.71	Previously Dug		fill (incl topsoil, waste)
2	6.71	12.50	Clay Boulders	Blue	diamicton: si to sa/si matrix
3	12.50	16.46	Clay Medium Sand		silt, sandy silt, clayey silt
4	16.46	16.76	Gravel	Brown	gravel, gravelly sand

MOE Water Well Records Report

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Well Number 1901282 **Construction Date** 14-Oct-1966 **Primary Water Use** Domestic **Well Type** Overburden
Easting (NAD83) 679896 **Northing (NAD83)** 4864748 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 140.21
Lot 025 **Concession** 02 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 10.16 **Static Level (m)** 4.88 **Deepest Water Found** 14.63 **Well Depth** 15.85
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm) 1.00 **Pump Time(h:m)** : **Depth (end of 60 min)** 4.88
Specific Capacity: 2.00 **Recommended Pump Setting (gpm) :** 23.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	7.01	Previously Dug		fill (incl topsoil, waste)
2	7.01	9.14	Clay Boulders	Blue	diamicton: si to sa/si matrix
3	9.14	14.63	Gravel Medium Sand		gravel, gravelly sand
4	14.63	15.54	Gravel		gravel, gravelly sand
5	15.54	15.85	Clay		clay, silty clay

Well Number 1901283 **Construction Date** 11-Nov-1960 **Primary Water Use** Domestic **Well Type** Overburden
Easting (NAD83) 679639 **Northing (NAD83)** 4863638 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 134.11
Lot 026 **Concession** 02 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 10.16 **Static Level (m)** 3.05 **Deepest Water Found** 17.37 **Well Depth** 17.68
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm) 1.00 **Pump Time(h:m)** 2 : 0 **Depth (end of 60 min)** 5.49
Specific Capacity: 0.10 **Recommended Pump Setting (gpm) :** 18.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	5.49	Previously Dug		fill (incl topsoil, waste)
2	5.49	14.33	Clay	Blue	clay, silty clay
3	14.33	17.37	Fine Sand		sand, silty sand
4	17.37	17.68	Gravel		gravel, gravelly sand

Well Number 1901284 **Construction Date** 24-Mar-1963 **Primary Water Use** Domestic **Well Type** Overburden
Easting (NAD83) 679495 **Northing (NAD83)** 4863933 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 121.92
Lot 026 **Concession** 02 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 15.24 **Static Level (m)** 3.66 **Deepest Water Found** 17.37 **Well Depth** 17.68
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm) 5.00 **Pump Time(h:m)** 8 : 0 **Depth (end of 60 min)** 11.58
Specific Capacity: 0.20 **Recommended Pump Setting (gpm) :** 50.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	3.05	Previously Dug		fill (incl topsoil, waste)
2	3.05	4.57	Gravel Medium Sand		gravel, gravelly sand
3	4.57	17.37	Clay Medium Sand Stones	Blue	diamicton: si to sa/si matrix
4	17.37	17.68	Medium Sand	Brown	sand, silty sand

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Well Number 1901288 **Construction Date** 28-Jul-1964 **Primary Water Use** Domestic **Well Type** Overburden
Easting (NAD83) 679534 **Northing (NAD83)** 4863774 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 118.87
Lot 027 **Concession** 02 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 76.20 **Static Level (m)** 3.96 **Deepest Water Found** 3.66 **Well Depth** 6.71
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm 0.00 **Pump Time(h:m)** : **Depth (end of 60 min)** 3.96
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :** 21.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	1.52	Topsoil		fill (incl topsoil, waste)
2	1.52	2.74	Clay Medium Sand		silt, sandy silt, clayey silt
3	2.74	3.66	Clay	Brown	clay, silty clay
4	3.66	6.71	Clay Medium Sand	Blue	silt, sandy silt, clayey silt

Well Number 1901290 **Construction Date** 02-Nov-1955 **Primary Water Use** Domestic **Well Type** Overburden
Easting (NAD83) 678771 **Northing (NAD83)** 4863769 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 132.59
Lot 028 **Concession** 02 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 10.16 **Static Level (m)** 1.22 **Deepest Water Found** 15.24 **Well Depth** 15.54
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm 15.00 **Pump Time(h:m)** 10 : 0 **Depth (end of 60 min)** 2.44
Specific Capacity: 3.70 **Recommended Pump Setting (gpm) :**

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	8.23	Previously Dug		fill (incl topsoil, waste)
2	8.23	15.24	Clay	Grey	clay, silty clay
3	15.24	15.54	Coarse Sand		sand, silty sand

Well Number 1901291 **Construction Date** 20-Oct-1958 **Primary Water Use** Domestic **Well Type** Overburden
Easting (NAD83) 678822 **Northing (NAD83)** 4863459 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 118.87
Lot 028 **Concession** 02 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 91.44 **Static Level (m)** 7.62 **Deepest Water Found** 8.53 **Well Depth** 9.14
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm **Pump Time(h:m)** : **Depth (end of 60 min)**
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :**

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	0.91	Topsoil Clay		fill (incl topsoil, waste)
2	0.91	2.74	Clay	Brown	clay, silty clay
3	2.74	8.53	Clay	Blue	clay, silty clay
4	8.53	9.14	Gravel		gravel, gravelly sand

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Well Number 1901292 **Construction Date** 20-Apr-1959 **Primary Water Use** Domestic **Well Type** Overburden
Easting (NAD83) 678891 **Northing (NAD83)** 4863293 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 121.92
Lot 028 **Concession** 02 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 91.44 **Static Level (m)** 2.13 **Deepest Water Found** 3.66 **Well Depth** 5.49
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm **Pump Time(h:m)** : **Depth (end of 60 min)**
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :**

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	0.61	Topsoil Medium Sand		fill (incl topsoil, waste)
2	0.61	1.52	Medium Sand		sand, silty sand
3	1.52	3.66	Clay		clay, silty clay
4	3.66	5.49	Clay Medium Sand		silt, sandy silt, clayey silt

Well Number 1901293 **Construction Date** 28-Oct-1960 **Primary Water Use** Domestic **Well Type** Overburden
Easting (NAD83) 679306 **Northing (NAD83)** 4863053 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 121.92
Lot 028 **Concession** 02 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 91.44 **Static Level (m)** 2.13 **Deepest Water Found** 7.92 **Well Depth** 8.84
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm 2.00 **Pump Time(h:m)** : **Depth (end of 60 min)**
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :** 2.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	0.30	Topsoil Medium Sand		fill (incl topsoil, waste)
2	0.30	2.13	Medium Sand		sand, silty sand
3	2.13	3.05	Clay Medium Sand	Brown	silt, sandy silt, clayey silt
4	3.05	5.79	Clay Medium Sand	Blue	silt, sandy silt, clayey silt
5	5.79	6.10	Gravel Clay		gravel, gravelly sand
6	6.10	8.84	Medium Sand Clay		sand, silty sand

Well Number 1901305 **Construction Date** 15-Mar-1963 **Primary Water Use** Domestic **Well Type** Overburden
Easting (NAD83) 678785 **Northing (NAD83)** 4863358 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 131.67
Lot 029 **Concession** 02 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 15.24 **Static Level (m)** 4.88 **Deepest Water Found** 12.80 **Well Depth** 26.21
Top of Screen (m): 12.80 **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm 10.00 **Pump Time(h:m)** 1 : 30 **Depth (end of 60 min)** 7.92
Specific Capacity: 1.00 **Recommended Pump Setting (gpm) :** 35.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	9.45	Previously Dug		fill (incl topsoil, waste)
2	9.45	12.19	Clay	Blue	clay, silty clay
3	12.19	15.24	Gravel Medium Sand		gravel, gravelly sand
4	15.24	26.21	Medium Sand	Grey	sand, silty sand

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Well Number 1902672 **Construction Date** 11-Nov-1968 **Primary Water Use** Domestic **Well Type** Overburden
Easting (NAD83) 678985 **Northing (NAD83)** 4862973 **UTM Zone** 17
Positional Reliability margin of error : 30 m - 100 m **Elevation(mASL)** 126.49
Lot 028 **Concession** 02 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 91.44 **Static Level (m)** 2.44 **Deepest Water Found** 3.05 **Well Depth** 5.49
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm **Pump Time(h:m)** : **Depth (end of 60 min)**
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :** 16.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	0.91	Topsoil Medium Sand		fill (incl topsoil, waste)
2	0.91	3.05	Clay		clay, silty clay
3	3.05	4.57	Clay Medium Sand		silt, sandy silt, clayey silt
4	4.57	5.49	Clay		clay, silty clay

Well Number 1902695 **Construction Date** 30-May-1969 **Primary Water Use** Domestic **Well Type** Overburden
Easting (NAD83) 680855 **Northing (NAD83)** 4861993 **UTM Zone** 17
Positional Reliability margin of error : 30 m - 100 m **Elevation(mASL)** 121.92
Lot 025 **Concession** 01 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 91.44 **Static Level (m)** 2.44 **Deepest Water Found** 7.32 **Well Depth** 7.62
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm 6.00 **Pump Time(h:m)** 2 : 0 **Depth (end of 60 min)** 7.62
Specific Capacity: 0.40 **Recommended Pump Setting (gpm) :** 24.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	0.30	Clay Topsoil	Black	fill (incl topsoil, waste)
2	0.30	7.32	Clay Stones	Brown	diamicton: si to sa/si matrix
3	7.32	7.62	Clay Gravel	Brown	diamicton: si to sa/si matrix

Well Number 1902942 **Construction Date** 11-Sep-1970 **Primary Water Use** Domestic **Well Type** Overburden
Easting (NAD83) 679115 **Northing (NAD83)** 4863003 **UTM Zone** 17
Positional Reliability margin of error : 30 m - 100 m **Elevation(mASL)** 121.92
Lot 028 **Concession** 02 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 60.96 **Static Level (m)** 4.88 **Deepest Water Found** 9.14 **Well Depth** 10.06
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm **Pump Time(h:m)** : **Depth (end of 60 min)** 9.14
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :**

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	0.30	Topsoil	Black	fill (incl topsoil, waste)
2	0.30	4.57	Clay	Brown	clay, silty clay
3	4.57	9.14	Clay Boulders	Grey	diamicton: si to sa/si matrix
4	9.14	10.06	Medium Sand Gravel	Brown	gravel, gravelly sand

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Well Number 1903240 **Construction Date** 01-Dec-1971 **Primary Water Use** Stock **Well Type** Overburden
Easting (NAD83) 679415 **Northing (NAD83)** 4860653 **UTM Zone** 17
Positional Reliability margin of error : 30 m - 100 m **Elevation(mASL)** 99.06
Lot 030 **Concession** Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 91.44 **Static Level (m)** 4.88 **Deepest Water Found** 14.02 **Well Depth** 20.42
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm 5.00 **Pump Time(h:m)** 2 **:** 0 **Depth (end of 60 min)** 20.12
Specific Capacity: 0.10 **Recommended Pump Setting (gpm) :** 65.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	0.30	Topsoil	Black	fill (incl topsoil, waste)
2	0.30	2.44	Clay Medium Sand	Brown	silt, sandy silt, clayey silt
3	2.44	4.88	Clay	Brown	clay, silty clay
4	4.88	5.18	Medium Sand Gravel	Brown	gravel, gravelly sand
5	5.18	14.02	Clay	Blue	clay, silty clay
6	14.02	14.33	Medium Sand Clay	Blue	sand, silty sand
7	14.33	20.42	Clay	Blue	clay, silty clay

Well Number 1903518 **Construction Date** 15-Dec-1972 **Primary Water Use** Industrial **Well Type** Overburden
Easting (NAD83) 680615 **Northing (NAD83)** 4861583 **UTM Zone** 17
Positional Reliability margin of error : 30 m - 100 m **Elevation(mASL)** 111.25
Lot 026 **Concession** 01 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 76.20 **Static Level (m)** **Deepest Water Found** 6.10 **Well Depth** 12.19
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm 5.00 **Pump Time(h:m)** 1 **:** 0 **Depth (end of 60 min)** 6.10
Specific Capacity: 0.20 **Recommended Pump Setting (gpm) :** 35.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	0.30	Topsoil		fill (incl topsoil, waste)
2	0.30	6.10	Clay Stones	Blue	diamicton: si to sa/si matrix
3	6.10	9.14	Clay Sand	Grey	silt, sandy silt, clayey silt
4	9.14	12.19	Clay	Blue	clay, silty clay

Well Number 1903527 **Construction Date** 20-Dec-1972 **Primary Water Use** Domestic **Well Type** Overburden
Easting (NAD83) 678515 **Northing (NAD83)** 4861373 **UTM Zone** 17
Positional Reliability margin of error : 30 m - 100 m **Elevation(mASL)** 114.30
Lot 031 **Concession** 01 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 91.44 **Static Level (m)** 0.91 **Deepest Water Found** 3.05 **Well Depth** 3.66
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm 9.00 **Pump Time(h:m)** 2 **:** 0 **Depth (end of 60 min)** 3.35
Specific Capacity: 1.10 **Recommended Pump Setting (gpm) :** 11.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	0.30	Topsoil Clay	Black	fill (incl topsoil, waste)
2	0.30	2.74	Clay	Brown	clay, silty clay
3	2.74	3.66	Gravel Sand	Brown	gravel, gravelly sand

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Well Number 1903962 **Construction Date** 27-Sep-1974 **Primary Water Use** Domestic **Well Type** Overburden
Easting (NAD83) 679748 **Northing (NAD83)** 4863366 **UTM Zone** 17
Positional Reliability margin of error : 30 m - 100 m **Elevation(mASL)** 128.63
Lot 026 **Concession** 02 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 76.20 **Static Level (m)** 3.05 **Deepest Water Found** 3.05 **Well Depth** 8.84
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm 6.00 **Pump Time(h:m)** 1 **:** 0 **Depth (end of 60 min)** 7.62
Specific Capacity: 0.40 **Recommended Pump Setting (gpm) :** 27.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	0.30	Topsoil	Black	fill (incl topsoil, waste)
2	0.30	3.05	Clay Stones	Brown	diamicton: si to sa/si matrix
3	3.05	3.35	Sand	Brown	sand, silty sand
4	3.35	8.84	Clay Boulders	Blue	diamicton: si to sa/si matrix

Well Number 1904281 **Construction Date** 22-Nov-1975 **Primary Water Use** Domestic **Well Type** Overburden
Easting (NAD83) 678015 **Northing (NAD83)** 4863273 **UTM Zone** 17
Positional Reliability margin of error : 30 m - 100 m **Elevation(mASL)** 134.11
Lot 030 **Concession** 02 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 76.20 **Static Level (m)** 4.57 **Deepest Water Found** 4.57 **Well Depth** 10.36
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm 6.00 **Pump Time(h:m)** 1 **:** 0 **Depth (end of 60 min)** 9.75
Specific Capacity: 0.40 **Recommended Pump Setting (gpm) :** 32.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	2.44	Topsoil		fill (incl topsoil, waste)
2	2.44	4.57	Clay	Brown	clay, silty clay
3	4.57	10.36	Clay Sand	Blue	silt, sandy silt, clayey silt

Well Number 1904370 **Construction Date** 06-Oct-1975 **Primary Water Use** Stock **Well Type** Overburden
Easting (NAD83) 678795 **Northing (NAD83)** 4862943 **UTM Zone** 17
Positional Reliability margin of error : 30 m - 100 m **Elevation(mASL)** 128.63
Lot 029 **Concession** 02 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 91.44 **Static Level (m)** 3.05 **Deepest Water Found** 4.27 **Well Depth** 7.01
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm 6.00 **Pump Time(h:m)** 4 **:** 0 **Depth (end of 60 min)** 6.71
Specific Capacity: 0.50 **Recommended Pump Setting (gpm) :** 21.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	0.30	Topsoil	Black	fill (incl topsoil, waste)
2	0.30	4.27	Clay Stones Soft	Brown	diamicton: si to sa/si matrix
3	4.27	7.01	Clay Gravel Layered	Brown	diamicton: si to sa/si matrix

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Well Number 1904552 **Construction Date** 19-Jul-1976 **Primary Water Use** Stock **Well Type** Overburden
Easting (NAD83) 680015 **Northing (NAD83)** 4865443 **UTM Zone** 17
Positional Reliability margin of error : 30 m - 100 m **Elevation(mASL)** 145.08
Lot 024 **Concession** 02 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 76.20 **Static Level (m)** 3.05 **Deepest Water Found** 3.05 **Well Depth** 8.53
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm) 6.00 **Pump Time(h:m)** 0 : 30 **Depth (end of 60 min)** 7.62
Specific Capacity: 0.40 **Recommended Pump Setting (gpm) :** 25.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	0.30	Topsoil		fill (incl topsoil, waste)
2	0.30	1.22	Clay Stones Packed	Brown	diamicton: si to sa/si matrix
3	1.22	3.05	Sand Packed	Brown	sand, silty sand
4	3.05	8.53	Sand Water-bearing Loose	Brown	sand, silty sand

Well Number 1905036 **Construction Date** 21-Jan-1978 **Primary Water Use** Commercial **Well Type** Overburden
Easting (NAD83) 680475 **Northing (NAD83)** 4860903 **UTM Zone** 17
Positional Reliability margin of error : 30 m - 100 m **Elevation(mASL)** 103.63
Lot 027 **Concession** Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 76.20 **Static Level (m)** 6.10 **Deepest Water Found** 9.45 **Well Depth** 10.06
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm) 6.00 **Pump Time(h:m)** 0 : 30 **Depth (end of 60 min)** 7.62
Specific Capacity: 1.20 **Recommended Pump Setting (gpm) :** 28.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	4.57	Clay Stones Packed	Brown	diamicton: si to sa/si matrix
2	4.57	9.45	Clay Stones Cemented	Blue	diamicton: si to sa/si matrix
3	9.45	10.06	Gravel Water-bearing Loose		gravel, gravelly sand

Well Number 1905057 **Construction Date** 23-Jun-1978 **Primary Water Use** Domestic **Well Type** Overburden
Easting (NAD83) 680115 **Northing (NAD83)** 4861223 **UTM Zone** 17
Positional Reliability margin of error : 30 m - 100 m **Elevation(mASL)** 105.16
Lot 027 **Concession** Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 15.24 **Static Level (m)** 3.66 **Deepest Water Found** 13.11 **Well Depth** 14.33
Top of Screen (m): 13.11 **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm) 15.00 **Pump Time(h:m)** 5 : 30 **Depth (end of 60 min)** 9.14
Specific Capacity: 0.80 **Recommended Pump Setting (gpm) :** 42.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	7.62	Clay Stones	Brown	diamicton: si to sa/si matrix
2	7.62	13.11	Clay Gravel	Grey	diamicton: si to sa/si matrix
3	13.11	14.02	Medium Sand Gravel	Brown	gravel, gravelly sand
4	14.02	14.33	Clay	Grey	clay, silty clay

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Well Number 1905069 **Construction Date** 06-Jul-1978 **Primary Water Use** **Well Type** Bedrock
Easting (NAD83) 678755 **Northing (NAD83)** 4861083 **UTM Zone** 17
Positional Reliability margin of error : 30 m - 100 m **Elevation(mASL)** 99.06
Lot 030 **Concession** 01 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 15.24 **Static Level (m)** **Deepest Water Found** 3.05 **Well Depth** 64.62
Top of Screen (m): **WaterKind** Unknown **Depth to Bedrock (m)** 29.57
Pump Rate(Igpm **Pump Time(h:m)** : **Depth (end of 60 min)**
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :**

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	4.57	Clay	Brown	clay, silty clay
2	4.57	29.57	Clay Stones	Grey	diamicton: si to sa/si matrix
3	29.57	33.53	Shale	Black	shale
4	33.53	64.62	Limestone	Brown	limestone

Well Number 1905077 **Construction Date** 12-Jul-1978 **Primary Water Use** Commercia **Well Type** Overburden
Easting (NAD83) 678795 **Northing (NAD83)** 4861103 **UTM Zone** 17
Positional Reliability margin of error : 30 m - 100 m **Elevation(mASL)** 99.06
Lot 030 **Concession** 01 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 15.24 **Static Level (m)** 3.05 **Deepest Water Found** 28.65 **Well Depth** 29.26
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm 3.00 **Pump Time(h:m)** 3 **:** 0 **Depth (end of 60 min)** 27.43
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :** 90.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	6.10	Clay Boulders	Brown	diamicton: si to sa/si matrix
2	6.10	28.65	Clay Gravel	Grey	diamicton: si to sa/si matrix
3	28.65	28.96	Medium Gravel	Black	gravel, gravelly sand
4	28.96	29.26	Unknown Type		miscellaneous; no obvious material c

Well Number 1905079 **Construction Date** 17-Jul-1978 **Primary Water Use** Commercia **Well Type** Overburden
Easting (NAD83) 678835 **Northing (NAD83)** 4861023 **UTM Zone** 17
Positional Reliability margin of error : 30 m - 100 m **Elevation(mASL)** 100.58
Lot 030 **Concession** 01 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 15.24 **Static Level (m)** 6.10 **Deepest Water Found** 28.96 **Well Depth** 29.26
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm 10.00 **Pump Time(h:m)** 3 **:** 30 **Depth (end of 60 min)** 18.29
Specific Capacity: 0.20 **Recommended Pump Setting (gpm) :** 91.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	9.14	Clay Stones	Brown	diamicton: si to sa/si matrix
2	9.14	15.24	Clay Gravel Hardpan	Grey	diamicton: si to sa/si, stoney
3	15.24	28.96	Clay	Grey	clay, silty clay
4	28.96	29.26	Gravel Loose	Grey	gravel, gravelly sand

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Well Number 1905080 **Construction Date** 24-Jul-1978 **Primary Water Use** Stock **Well Type** Overburden
Easting (NAD83) 680175 **Northing (NAD83)** 4863023 **UTM Zone** 17
Positional Reliability margin of error : 30 m - 100 m **Elevation(mASL)** 126.49
Lot 026 **Concession** 01 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 15.24 **Static Level (m)** 3.05 **Deepest Water Found** 19.51 **Well Depth** 20.12
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm 10.00 **Pump Time(h:m)** 4 **:** 0 **Depth (end of 60 min)** 12.19
Specific Capacity: 0.30 **Recommended Pump Setting (gpm) :** 60.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	9.14	Clay Gravel Hardpan	Brown	diamicton: si to sa/si, stoney
2	9.14	19.51	Gravel Clay	Brown	gravel, gravelly sand
3	19.51	19.81	Gravel Loose	Brown	gravel, gravelly sand
4	19.81	20.12	Unknown Type		miscellaneous; no obvious material c

Well Number 1905142 **Construction Date** 12-Oct-1978 **Primary Water Use** **Well Type** Bedrock
Easting (NAD83) 678775 **Northing (NAD83)** 4861003 **UTM Zone** 17
Positional Reliability margin of error : 30 m - 100 m **Elevation(mASL)** 99.06
Lot 030 **Concession** 01 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 15.24 **Static Level (m)** **Deepest Water Found** **Well Depth** 44.20
Top of Screen (m): **WaterKind** **Depth to Bedrock (m)** 29.87
Pump Rate(Igpm **Pump Time(h:m)** **:** **Depth (end of 60 min)**
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :**

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	4.57	Clay Gravel	Brown	diamicton: si to sa/si matrix
2	4.57	9.14	Clay Gravel	Grey	diamicton: si to sa/si matrix
3	9.14	29.87	Clay Gravel Stones	Grey	diamicton: si to sa/si matrix
4	29.87	44.20	Limestone	Black	limestone

Well Number 1905143 **Construction Date** 18-Oct-1978 **Primary Water Use** Domestic **Well Type** Overburden
Easting (NAD83) 678795 **Northing (NAD83)** 4861063 **UTM Zone** 17
Positional Reliability margin of error : 30 m - 100 m **Elevation(mASL)** 99.06
Lot 030 **Concession** 01 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 15.24 **Static Level (m)** 6.10 **Deepest Water Found** 28.96 **Well Depth** 28.96
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm 5.00 **Pump Time(h:m)** 3 **:** 0 **Depth (end of 60 min)** 27.43
Specific Capacity: 0.10 **Recommended Pump Setting (gpm) :** 92.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	4.57	Clay Gravel	Brown	diamicton: si to sa/si matrix
2	4.57	9.14	Clay Gravel	Grey	diamicton: si to sa/si matrix
3	9.14	18.29	Clay Gravel Hard	Grey	diamicton: si to sa/si matrix
4	18.29	28.35	Clay Gravel	Grey	diamicton: si to sa/si matrix
5	28.35	28.96	Gravel Hard	Grey	gravel, gravelly sand

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Well Number 1905144 **Construction Date** 25-Oct-1978 **Primary Water Use** Domestic **Well Type** Bedrock
Easting (NAD83) 678935 **Northing (NAD83)** 4861123 **UTM Zone** 17
Positional Reliability margin of error : 30 m - 100 m **Elevation(mASL)** 103.63
Lot 030 **Concession** 01 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 15.24 **Static Level (m)** 9.14 **Deepest Water Found** 31.09 **Well Depth** 31.09
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)** 30.18
Pump Rate(Igpm 20.00 **Pump Time(h:m)** 2 : 0 **Depth (end of 60 min)** 18.29
Specific Capacity: 0.60 **Recommended Pump Setting (gpm) :** 97.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	4.88	Clay Gravel Stones	Brown	diamicton: si to sa/si matrix
2	4.88	25.91	Clay Gravel Stones	Grey	diamicton: si to sa/si matrix
3	25.91	30.18	Clay Gravel	Blue	diamicton: si to sa/si matrix
4	30.18	31.09	Shale Gravel	Black	gravel, gravelly sand

Well Number 1905173 **Construction Date** 31-Oct-1978 **Primary Water Use** Industrial **Well Type** Overburden
Easting (NAD83) 680055 **Northing (NAD83)** 4861203 **UTM Zone** 17
Positional Reliability margin of error : 30 m - 100 m **Elevation(mASL)** 105.16
Lot 027 **Concession** Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 15.24 **Static Level (m)** 4.57 **Deepest Water Found** 10.67 **Well Depth** 13.11
Top of Screen (m): 10.36 **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm 20.00 **Pump Time(h:m)** 4 : 30 **Depth (end of 60 min)** 7.62
Specific Capacity: 2.00 **Recommended Pump Setting (gpm) :** 35.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	4.57	Clay Stones	Brown	diamicton: si to sa/si matrix
2	4.57	10.67	Clay Gravel Hard	Grey	diamicton: si to sa/si matrix
3	10.67	11.28	Sand Gravel Loose	Brown	gravel, gravelly sand
4	11.28	13.11	Clay	Grey	clay, silty clay

Well Number 1905540 **Construction Date** 31-Oct-1979 **Primary Water Use** Industrial **Well Type** Overburden
Easting (NAD83) 679235 **Northing (NAD83)** 4861043 **UTM Zone** 17
Positional Reliability margin of error : 30 m - 100 m **Elevation(mASL)** 99.06
Lot 029 **Concession** 01 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 15.24 **Static Level (m)** 0.61 **Deepest Water Found** 12.80 **Well Depth** 13.72
Top of Screen (m): 10.67 **WaterKind** Unknown **Depth to Bedrock (m)**
Pump Rate(Igpm 3.00 **Pump Time(h:m)** 5 : 0 **Depth (end of 60 min)** 12.19
Specific Capacity: 0.10 **Recommended Pump Setting (gpm) :** 40.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	9.14	Clay Stones Medium-grained	Brown	diamicton: si to sa/si matrix
2	9.14	12.80	Clay Hardpan Hard	Grey	diamicton: cl to cl/si matrix
3	12.80	13.72	Medium Sand Clay	Grey	sand, silty sand

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Well Number 1905912 **Construction Date** 01-Nov-1980 **Primary Water Use** Domestic **Well Type** Overburden
Easting (NAD83) 679915 **Northing (NAD83)** 4865143 **UTM Zone** 17
Positional Reliability margin of error : 30 m - 100 m **Elevation(mASL)** 143.26
Lot 025 **Concession** 02 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 76.20 **Static Level (m)** 1.52 **Deepest Water Found** 1.52 **Well Depth** 4.27
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm 6.00 **Pump Time(h:m)** 0 **:** 30 **Depth (end of 60 min)** 3.96
Specific Capacity: 0.70 **Recommended Pump Setting (gpm) :** 12.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	0.30	Topsoil	Black	fill (incl topsoil, waste)
2	0.30	2.44	Sand	Brown	sand, silty sand
3	2.44	4.27	Sand	Grey	sand, silty sand

Well Number 1905939 **Construction Date** 12-Nov-1980 **Primary Water Use** Commercial **Well Type** Overburden
Easting (NAD83) 679215 **Northing (NAD83)** 4861063 **UTM Zone** 17
Positional Reliability margin of error : 30 m - 100 m **Elevation(mASL)** 100.58
Lot 029 **Concession** 01 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 15.24 **Static Level (m)** 6.10 **Deepest Water Found** 32.00 **Well Depth** 32.00
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm 12.00 **Pump Time(h:m)** 4 **:** 20 **Depth (end of 60 min)**
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :** 102.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	21.34	Clay Sand Hard	Grey	silt, sandy silt, clayey silt
2	21.34	31.09	Clay Hard	Black	clay, silty clay
3	31.09	32.00	Sand Gravel	Black	gravel, gravelly sand

Well Number 1906046 **Construction Date** 20-Aug-1980 **Primary Water Use** Domestic **Well Type** Overburden
Easting (NAD83) 679235 **Northing (NAD83)** 4860603 **UTM Zone** 17
Positional Reliability margin of error : 30 m - 100 m **Elevation(mASL)** 91.44
Lot 030 **Concession** Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 15.24 **Static Level (m)** 18.29 **Deepest Water Found** 24.38 **Well Depth** 24.38
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm 10.00 **Pump Time(h:m)** 5 **:** 0 **Depth (end of 60 min)** 18.29
Specific Capacity: 20.00 **Recommended Pump Setting (gpm) :**

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	0.61	Topsoil		fill (incl topsoil, waste)
2	0.61	23.77	Clay Stones		diamicton: si to sa/si matrix
3	23.77	24.38	Gravel		gravel, gravelly sand

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Well Number 1906180 **Construction Date** 06-Aug-1981 **Primary Water Use** Domestic **Well Type** Overburden
Easting (NAD83) 680975 **Northing (NAD83)** 4862223 **UTM Zone** 17
Positional Reliability margin of error : 30 m - 100 m **Elevation(mASL)** 124.97
Lot 024 **Concession** 01 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 76.20 **Static Level (m)** 6.10 **Deepest Water Found** 6.10 **Well Depth** 11.58
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm 5.00 **Pump Time(h:m)** 0 **:** 30 **Depth (end of 60 min)** 7.62
Specific Capacity: 1.00 **Recommended Pump Setting (gpm) :** 36.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	0.30	Topsoil		fill (incl topsoil, waste)
2	0.30	1.83	Gravel		gravel, gravelly sand
3	1.83	6.10	Clay Stoney Packed	Brown	diamicton: si to sa/si matrix
4	6.10	6.40	Sand		sand, silty sand
5	6.40	11.58	Clay Stones Cemented	Blue	diamicton: si to sa/si matrix

Well Number 1906355 **Construction Date** 28-May-1982 **Primary Water Use** Domestic **Well Type** Overburden
Easting (NAD83) 679195 **Northing (NAD83)** 4862163 **UTM Zone** 17
Positional Reliability margin of error : 30 m - 100 m **Elevation(mASL)** 115.82
Lot 029 **Concession** 01 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 76.20 **Static Level (m)** 4.57 **Deepest Water Found** 9.14 **Well Depth** 11.89
Top of Screen (m): **WaterKind** Unknown **Depth to Bedrock (m)**
Pump Rate(Igpm 6.00 **Pump Time(h:m)** 0 **:** 30 **Depth (end of 60 min)** 7.62
Specific Capacity: 0.60 **Recommended Pump Setting (gpm) :** 36.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	0.30	Topsoil	Black	fill (incl topsoil, waste)
2	0.30	4.57	Clay Stones Packed	Brown	diamicton: si to sa/si matrix
3	4.57	6.10	Clay Sand Layered	Blue	silt, sandy silt, clayey silt
4	6.10	9.14	Clay Stones Cemented	Blue	diamicton: si to sa/si matrix
5	9.14	10.67	Clay Sand Layered	Blue	silt, sandy silt, clayey silt
6	10.67	11.89	Clay Stones Cemented	Blue	diamicton: si to sa/si matrix

Well Number 1906356 **Construction Date** 20-Apr-1982 **Primary Water Use** Industrial **Well Type** Overburden
Easting (NAD83) 680195 **Northing (NAD83)** 4861203 **UTM Zone** 17
Positional Reliability margin of error : 30 m - 100 m **Elevation(mASL)** 103.63
Lot 027 **Concession** Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 15.24 **Static Level (m)** 12.19 **Deepest Water Found** 51.82 **Well Depth** 54.86
Top of Screen (m): **WaterKind** Unknown **Depth to Bedrock (m)**
Pump Rate(Igpm 10.00 **Pump Time(h:m)** 2 **:** 0 **Depth (end of 60 min)** 30.48
Specific Capacity: 0.10 **Recommended Pump Setting (gpm) :** 170.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	0.61	Topsoil Soft	Brown	fill (incl topsoil, waste)
2	0.61	22.56	Clay Boulders Hard	Grey	diamicton: si to sa/si matrix
3	22.56	33.53	Clay Hard Very	Grey	clay, silty clay
4	33.53	54.86	Stones Hard Very	Grey	gravel, gravelly sand

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Well Number 1906479 **Construction Date** 05-Nov-1982 **Primary Water Use** Domestic **Well Type** Overburden
Easting (NAD83) 679955 **Northing (NAD83)** 4863283 **UTM Zone** 17
Positional Reliability margin of error : 30 m - 100 m **Elevation(mASL)** 118.87
Lot 026 **Concession** 02 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 76.20 **Static Level (m)** 3.66 **Deepest Water Found** 3.66 **Well Depth** 7.62
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm 6.00 **Pump Time(h:m)** 0 **:** 30 **Depth (end of 60 min)** 6.71
Specific Capacity: 0.60 **Recommended Pump Setting (gpm) :** 22.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	0.30	Topsoil		fill (incl topsoil, waste)
2	0.30	2.44	Clay Packed	Brown	clay, silty clay
3	2.44	3.66	Clay Stones Packed	Blue	diamicton: si to sa/si matrix
4	3.66	4.27	Sand	Brown	sand, silty sand
5	4.27	7.62	Clay Stones Packed	Blue	diamicton: si to sa/si matrix

Well Number 1906827 **Construction Date** 27-Aug-1983 **Primary Water Use** Industrial **Well Type** Overburden
Easting (NAD83) 680195 **Northing (NAD83)** 4861203 **UTM Zone** 17
Positional Reliability margin of error : 30 m - 100 m **Elevation(mASL)** 103.63
Lot 027 **Concession** Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 76.20 **Static Level (m)** 4.57 **Deepest Water Found** 6.10 **Well Depth** 9.45
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm 7.00 **Pump Time(h:m)** 0 **:** 30 **Depth (end of 60 min)** 5.49
Specific Capacity: 2.30 **Recommended Pump Setting (gpm) :** 29.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	3.05	Clay Packed	Brown	clay, silty clay
2	3.05	6.10	Clay Stones Packed	Blue	diamicton: si to sa/si matrix
3	6.10	9.45	Clay Sand Layered	Blue	silt, sandy silt, clayey silt

Well Number 1906828 **Construction Date** 08-Sep-1983 **Primary Water Use** Domestic **Well Type** Overburden
Easting (NAD83) 679715 **Northing (NAD83)** 4863123 **UTM Zone** 17
Positional Reliability margin of error : 30 m - 100 m **Elevation(mASL)** 121.92
Lot 027 **Concession** 01 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 76.20 **Static Level (m)** 0.00 **Deepest Water Found** 11.58 **Well Depth** 11.58
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm 10.00 **Pump Time(h:m)** 0 **:** 30 **Depth (end of 60 min)**
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :** 35.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	1.52	Clay Packed	Brown	clay, silty clay
2	1.52	11.58	Clay Sand	Blue	silt, sandy silt, clayey silt

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Well Number 1906830 **Construction Date** 19-Oct-1983 **Primary Water Use** Stock **Well Type** Overburden
Easting (NAD83) 679935 **Northing (NAD83)** 4865423 **UTM Zone** 17
Positional Reliability margin of error : 30 m - 100 m **Elevation(mASL)** 143.26
Lot 024 **Concession** 02 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 76.20 **Static Level (m)** 1.52 **Deepest Water Found** 1.52 **Well Depth** 4.88
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm 8.00 **Pump Time(h:m)** 0 **:** 30 **Depth (end of 60 min)** 1.83
Specific Capacity: **Recommended Pump Setting (gpm) :** 14.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	1.52	Sand	Brown	sand, silty sand
2	1.52	4.88	Sand Water-bearing	Brown	sand, silty sand

Well Number 1907065 **Construction Date** 05-Oct-1984 **Primary Water Use** Domestic **Well Type** Overburden
Easting (NAD83) 679655 **Northing (NAD83)** 4863563 **UTM Zone** 17
Positional Reliability margin of error : 30 m - 100 m **Elevation(mASL)** 131.06
Lot 026 **Concession** 02 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 15.24 **Static Level (m)** 3.05 **Deepest Water Found** 17.68 **Well Depth** 19.20
Top of Screen (m): 17.07 **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm 10.00 **Pump Time(h:m)** 2 **:** 0 **Depth (end of 60 min)** 15.24
Specific Capacity: 0.20 **Recommended Pump Setting (gpm) :** 61.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	0.30	Topsoil	Brown	fill (incl topsoil, waste)
2	0.30	17.68	Clay Stones	Grey	diamicton: si to sa/si matrix
3	17.68	19.20	Fine Sand	Grey	sand, silty sand

Well Number 1907320 **Construction Date** 12-Jul-1985 **Primary Water Use** Domestic **Well Type** Overburden
Easting (NAD83) 679595 **Northing (NAD83)** 4863743 **UTM Zone** 17
Positional Reliability margin of error : 30 m - 100 m **Elevation(mASL)** 134.11
Lot 026 **Concession** 02 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 15.24 **Static Level (m)** 3.66 **Deepest Water Found** 12.19 **Well Depth** 16.15
Top of Screen (m): 13.41 **WaterKind** Unknown **Depth to Bedrock (m)**
Pump Rate(Igpm 18.00 **Pump Time(h:m)** 5 **:** 0 **Depth (end of 60 min)** 7.62
Specific Capacity: 1.30 **Recommended Pump Setting (gpm) :** 40.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	0.91	Clay Topsoil Medium-grained	Brown	fill (incl topsoil, waste)
2	0.91	12.19	Medium Sand Clay Stones	Grey	gravel, gravelly sand
3	12.19	16.15	Sand Gravel Loose	Brown	gravel, gravelly sand

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Well Number 1907408 **Construction Date** 12-Jul-1985 **Primary Water Use** Domestic **Well Type** Overburden
Easting (NAD83) 679695 **Northing (NAD83)** 4863463 **UTM Zone** 17
Positional Reliability margin of error : 30 m - 100 m **Elevation(mASL)** 131.06
Lot 026 **Concession** 02 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 76.20 **Static Level (m)** 4.57 **Deepest Water Found** 9.14 **Well Depth** 10.67
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm) 6.00 **Pump Time(h:m)** 0 **:** 30 **Depth (end of 60 min)** 7.62
Specific Capacity: **Recommended Pump Setting (gpm) :** 34.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	0.30	Topsoil	Black	fill (incl topsoil, waste)
2	0.30	4.57	Clay Stones Packed	Brown	diamicton: si to sa/si matrix
3	4.57	7.62	Clay Stones Packed	Blue	diamicton: si to sa/si matrix
4	7.62	9.14	Clay Stones Cemented	Grey	diamicton: si to sa/si matrix
5	9.14	9.45	Sand Dark-coloured Water-be		sand, silty sand
6	9.45	10.67	Clay Stones Cemented	Grey	diamicton: si to sa/si matrix

Well Number 1907415 **Construction Date** 23-Aug-1985 **Primary Water Use** Domestic **Well Type** Overburden
Easting (NAD83) 679955 **Northing (NAD83)** 4865343 **UTM Zone** 17
Positional Reliability margin of error : 30 m - 100 m **Elevation(mASL)** 143.26
Lot 024 **Concession** 02 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 76.20 **Static Level (m)** 1.52 **Deepest Water Found** 1.52 **Well Depth** 4.57
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm) 6.00 **Pump Time(h:m)** 0 **:** 30 **Depth (end of 60 min)** 3.05
Specific Capacity: 1.20 **Recommended Pump Setting (gpm) :** 13.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	1.22	Sand	Brown	sand, silty sand
2	1.22	1.52	Clay Silt Packed	Grey	silt, sandy silt, clayey silt
3	1.52	2.44	Sand	Brown	sand, silty sand
4	2.44	3.05	Clay	Grey	clay, silty clay
5	3.05	4.57	Sand Gravel Hard		gravel, gravelly sand

Well Number 1907908 **Construction Date** 11-Sep-1986 **Primary Water Use** Commercial **Well Type** Bedrock
Easting (NAD83) 680385 **Northing (NAD83)** 4861271 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 106.98
Lot 027 **Concession** Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 15.24 **Static Level (m)** 10.67 **Deepest Water Found** 33.22 **Well Depth** 33.22
Top of Screen (m): **WaterKind** Unknown **Depth to Bedrock (m)** 32.61
Pump Rate(Igpm) 8.00 **Pump Time(h:m)** 4 **:** **Depth (end of 60 min)** 27.43
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :** 95.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	6.10	Clay Stones Medium-grained	Brown	diamicton: si to sa/si matrix
2	6.10	32.61	Clay Gravel Medium-grained	Grey	diamicton: si to sa/si matrix
3	32.61	33.22	Shale Layered	Black	shale

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Well Number 1907909 **Construction Date** 05-Sep-1986 **Primary Water Use** Not Used **Well Type** Bedrock
Easting (NAD83) 680380 **Northing (NAD83)** 4861273 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 106.98
Lot 027 **Concession** Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 15.24 **Static Level (m)** **Deepest Water Found** **Well Depth** 43.59
Top of Screen (m): **WaterKind** **Depth to Bedrock (m)** 33.53
Pump Rate(Igpm **Pump Time(h:m)** **:** **Depth (end of 60 min)**
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :**

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	33.53	Clay Gravel Medium-grained	Grey	diamicton: si to sa/si matrix
2	33.53	35.05	Shale Medium-grained	Black	shale
3	35.05	43.59	Limestone Layered Hard	Brown	limestone

Well Number 1908374 **Construction Date** 25-Jun-1987 **Primary Water Use** Domestic **Well Type** Overburden
Easting (NAD83) 679444 **Northing (NAD83)** 4864023 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 134.11
Lot 027 **Concession** 02 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 15.24 **Static Level (m)** 3.35 **Deepest Water Found** 29.57 **Well Depth** 32.61
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm 7.00 **Pump Time(h:m)** 1 **:** 30 **Depth (end of 60 min)** 28.35
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :** 103.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	6.40	Clay Stones	Brown	diamicton: si to sa/si matrix
2	6.40	14.33	Clay Stones	Grey	diamicton: si to sa/si matrix
3	14.33	26.21	Clay Gravel Hard	Grey	diamicton: si to sa/si matrix
4	26.21	29.57	Silt Sand	Grey	silt, sandy silt, clayey silt
5	29.57	32.61	Fine Sand	Grey	sand, silty sand

Well Number 1908648 **Construction Date** 09-Nov-1987 **Primary Water Use** Domestic **Well Type** Overburden
Easting (NAD83) 679659 **Northing (NAD83)** 4863633 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 134.11
Lot 026 **Concession** 02 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 15.24 **Static Level (m)** 4.57 **Deepest Water Found** 16.15 **Well Depth** 16.15
Top of Screen (m): 13.72 **WaterKind** Unknown **Depth to Bedrock (m)**
Pump Rate(Igpm 6.00 **Pump Time(h:m)** 2 **:** 0 **Depth (end of 60 min)** 13.72
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :** 48.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	9.14	Clay Stones Medium-grained	Brown	diamicton: si to sa/si matrix
2	9.14	14.94	Clay Gravel Medium-grained	Grey	diamicton: si to sa/si matrix
3	14.94	16.15	Sand Water-bearing Medium-	Brown	sand, silty sand

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Well Number 1909080 **Construction Date** 20-Feb-1988 **Primary Water Use** Domestic **Well Type** Overburden
Easting (NAD83) 679423 **Northing (NAD83)** 4864038 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 134.11
Lot 027 **Concession** 02 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 15.24 **Static Level (m)** 2.74 **Deepest Water Found** 22.86 **Well Depth** 24.99
Top of Screen (m): 23.47 **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm 20.00 **Pump Time(h:m)** 3 **:** 0 **Depth (end of 60 min)** 6.10
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :** 75.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	0.30	Topsoil	Brown	fill (incl topsoil, waste)
2	0.30	6.10	Clay Gravel	Brown	diamicton: si to sa/si matrix
3	6.10	19.81	Clay Gravel	Grey	diamicton: si to sa/si matrix
4	19.81	22.86	Clay Sandy	Grey	silt, sandy silt, clayey silt
5	22.86	24.99	Fine Sand	Grey	sand, silty sand

Well Number 1909088 **Construction Date** 10-Jun-1988 **Primary Water Use** Commercial **Well Type** Overburden
Easting (NAD83) 679245 **Northing (NAD83)** 4861179 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 96.93
Lot 029 **Concession** 01 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 15.24 **Static Level (m)** **Deepest Water Found** 10.67 **Well Depth** 11.28
Top of Screen (m): **WaterKind** Unknown **Depth to Bedrock (m)**
Pump Rate(Igpm 3.00 **Pump Time(h:m)** 2 **:** 0 **Depth (end of 60 min)** 9.14
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :** 32.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	10.06	Clay Stones Medium-grained	Brown	diamicton: si to sa/si matrix
2	10.06	10.67	Sand Medium-grained	Grey	sand, silty sand
3	10.67	11.28	Clay Gravel Dense	Grey	diamicton: si to sa/si matrix

Well Number 1909578 **Construction Date** 10-Jan-1989 **Primary Water Use** Commercial **Well Type** Bedrock
Easting (NAD83) 680278 **Northing (NAD83)** 4861213 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 103.94
Lot 027 **Concession** Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 15.24 **Static Level (m)** 12.19 **Deepest Water Found** 33.53 **Well Depth** 41.15
Top of Screen (m): **WaterKind** Unknown **Depth to Bedrock (m)** 32.92
Pump Rate(Igpm 1.00 **Pump Time(h:m)** 21 **:** 0 **Depth (end of 60 min)** 36.27
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :** 130.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	9.14	Clay Medium-grained	Brown	clay, silty clay
2	9.14	32.92	Clay Medium-grained	Grey	clay, silty clay
3	32.92	36.58	Limestone Medium-grained	Black	limestone
4	36.58	41.15	Limestone Medium-grained	Black	limestone

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Well Number 1909579 **Construction Date** 11-Jan-1989 **Primary Water Use** Commercial **Well Type** Overburden
Easting (NAD83) 680033 **Northing (NAD83)** 4861102 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 100.89
Lot 027 **Concession** Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 15.24 **Static Level (m)** 1.52 **Deepest Water Found** 7.32 **Well Depth** 8.23
Top of Screen (m): **WaterKind** Unknown **Depth to Bedrock (m)**
Pump Rate(Igpm) 3.00 **Pump Time(h:m)** 2 **:** **Depth (end of 60 min)** 7.62
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :** 26.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	2.44	Clay Medium-grained	Brown	clay, silty clay
2	2.44	6.10	Clay Gravel Medium-grained	Brown	diamicton: si to sa/si matrix
3	6.10	7.32	Clay Gravel Medium-grained	Grey	diamicton: si to sa/si matrix
4	7.32	8.23	Sand Gravel Water-bearing	Black	gravel, gravelly sand

Well Number 1909677 **Construction Date** 08-Mar-1989 **Primary Water Use** Domestic **Well Type** Overburden
Easting (NAD83) 679449 **Northing (NAD83)** 4863949 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 134.11
Lot 027 **Concession** 02 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 76.20 **Static Level (m)** 6.10 **Deepest Water Found** 6.10 **Well Depth** 13.72
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm) 8.00 **Pump Time(h:m)** 1 **:** 0 **Depth (end of 60 min)** 8.53
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :** 43.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	0.30	Topsoil		fill (incl topsoil, waste)
2	0.30	3.05	Clay	Brown	clay, silty clay
3	3.05	13.72	Hardpan Stones		diamicton: si/sa to sa, stoney

Well Number 1909761 **Construction Date** 05-Apr-1989 **Primary Water Use** Domestic **Well Type** Overburden
Easting (NAD83) 679530 **Northing (NAD83)** 4861157 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 96.01
Lot 029 **Concession** 01 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 76.20 **Static Level (m)** 6.10 **Deepest Water Found** 7.62 **Well Depth** 14.33
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm) 8.00 **Pump Time(h:m)** 1 **:** 0 **Depth (end of 60 min)** 8.53
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :** 45.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	0.30	Topsoil		fill (incl topsoil, waste)
2	0.30	4.57	Clay	Brown	clay, silty clay
3	4.57	14.33	Clay	Blue	clay, silty clay

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Well Number 1909810 **Construction Date** 15-Apr-1989 **Primary Water Use** Domestic **Well Type** Bedrock
Easting (NAD83) 679370 **Northing (NAD83)** 4864168 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 135.03
Lot 027 **Concession** 02 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 76.20 **Static Level (m)** 3.05 **Deepest Water Found** 4.57 **Well Depth** 6.10
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)** 0.30
Pump Rate(Igpm) 8.00 **Pump Time(h:m)** 1 **:** 0 **Depth (end of 60 min)** 4.88
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :** 18.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	0.30	Topsoil		fill (incl topsoil, waste)
2	0.30	1.52	Basalt Clay		gravel, gravelly sand
3	1.52	4.57	Clay	Blue	clay, silty clay
4	4.57	6.10	Clay Stones	Grey	diamicton: si to sa/si matrix

Well Number 1909887 **Construction Date** 23-May-1989 **Primary Water Use** Commercial **Well Type** Bedrock
Easting (NAD83) 680267 **Northing (NAD83)** 4861212 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 103.94
Lot 027 **Concession** Newcastle Town (Darlington) **Durham**
Well Diameter(cm) **Static Level (m)** **Deepest Water Found** **Well Depth** 33.22
Top of Screen (m): **WaterKind** **Depth to Bedrock (m)** 33.22
Pump Rate(Igpm) **Pump Time(h:m)** **:** **Depth (end of 60 min)**
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :**

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	3.35	Clay Stones Sandy	Brown	diamicton: si to sa/si matrix
2	3.35	5.79	Clay Gravel Loose	Brown	diamicton: si to sa/si matrix
3	5.79	7.92	Clay Stones Sandy	Grey	diamicton: si to sa/si matrix
4	7.92	10.67	Clay Stones Packed	Grey	diamicton: si to sa/si matrix
5	10.67	14.02	Sand Gravel Packed	Brown	gravel, gravelly sand
6	14.02	33.22	Clay Packed	Grey	clay, silty clay
7	33.22	33.22	Shale Hard	Black	shale

Well Number 1909888 **Construction Date** 17-May-1989 **Primary Water Use** Domestic **Well Type** Bedrock
Easting (NAD83) 679015 **Northing (NAD83)** 4860992 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 96.01
Lot 030 **Concession** 01 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 15.24 **Static Level (m)** 7.62 **Deepest Water Found** 37.19 **Well Depth** 37.19
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)** 29.57
Pump Rate(Igpm) 8.00 **Pump Time(h:m)** 3 **:** 30 **Depth (end of 60 min)**
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :** 105.00

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Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	2.74	Clay Stones Sandy	Brown	diamicton: si to sa/si matrix
2	2.74	4.88	Clay Stones Silty	Grey	diamicton: si to sa/si matrix
3	4.88	12.80	Clay Gravel Packed	Brown	diamicton: si to sa/si matrix
4	12.80	27.74	Clay Stones Packed	Grey	diamicton: si to sa/si matrix
5	27.74	29.57	Gravel Loose	Brown	gravel, gravelly sand
6	29.57	37.19	Shale Hard	Black	shale

Well Number 1909889 **Construction Date** 25-May-1989 **Primary Water Use** Commercial **Well Type** Overburden
Easting (NAD83) 680285 **Northing (NAD83)** 4861204 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 103.94
Lot 027 **Concession** Newcastle Town (Darlington) **Durham**
Well Diameter(cm) **Static Level (m)** **Deepest Water Found** **Well Depth** 18.29
Top of Screen (m): **WaterKind** **Depth to Bedrock (m)**
Pump Rate(Igpm **Pump Time(h:m)** **:** **Depth (end of 60 min)**
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :**

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	1.52	Clay Sand Loose	Brown	silt, sandy silt, clayey silt
2	1.52	5.79	Clay Gravel Loose	Brown	diamicton: si to sa/si matrix
3	5.79	9.45	Sand Gravel Loose	Brown	gravel, gravelly sand
4	9.45	13.72	Clay Stones Sandy	Grey	diamicton: si to sa/si matrix
5	13.72	18.29	Clay Stones Packed	Grey	diamicton: si to sa/si matrix

Well Number 1910026 **Construction Date** 12-Jul-1989 **Primary Water Use** Commercial **Well Type** Overburden
Easting (NAD83) 680340 **Northing (NAD83)** 4861202 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 106.07
Lot 027 **Concession** Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 45.72 **Static Level (m)** 1.52 **Deepest Water Found** 7.92 **Well Depth** 10.97
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm 14.00 **Pump Time(h:m)** 1 **:** 40 **Depth (end of 60 min)** 8.53
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :** 35.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	1.52	Clay Stones Packed	Brown	diamicton: si to sa/si matrix
2	1.52	4.57	Clay Stones Cemented	Brown	diamicton: si to sa/si matrix
3	4.57	7.92	Clay Packed Hard	Grey	clay, silty clay
4	7.92	10.36	Sand Water-bearing Packed	Grey	sand, silty sand
5	10.36	10.97	Clay Stones Cemented	Grey	diamicton: si to sa/si matrix

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Well Number 1910027 **Construction Date** 11-Jul-1989 **Primary Water Use** Commercial **Well Type** Overburden
Easting (NAD83) 680316 **Northing (NAD83)** 4861175 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 106.07
Lot 027 **Concession** Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 76.20 **Static Level (m)** 1.83 **Deepest Water Found** 11.89 **Well Depth** 12.80
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm) 14.00 **Pump Time(h:m)** 1 **:** 10 **Depth (end of 60 min)** 8.84
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :** 41.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	3.05	Sand Gravel Packed		gravel, gravelly sand
2	3.05	5.49	Sand Gravel Cemented		gravel, gravelly sand
3	5.49	7.01	Sand Silt Hard	Grey	sand, silty sand
4	7.01	8.53	Silt Sandy Packed	Grey	silt, sandy silt, clayey silt
5	8.53	12.80	Clay Silt Packed	Grey	silt, sandy silt, clayey silt

Well Number 1910028 **Construction Date** 21-Jun-1988 **Primary Water Use** Domestic **Well Type** Overburden
Easting (NAD83) 680326 **Northing (NAD83)** 4861212 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 106.07
Lot 027 **Concession** Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 45.72 **Static Level (m)** 2.13 **Deepest Water Found** 6.71 **Well Depth** 10.97
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm) **Pump Time(h:m)** **:** **Depth (end of 60 min)** 8.23
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :** 28.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	1.52	Clay Stones Packed		diamicton: si to sa/si matrix
2	1.52	4.57	Clay Stones Cemented	Brown	diamicton: si to sa/si matrix
3	4.57	6.71	Clay Stones Packed	Grey	diamicton: si to sa/si matrix
4	6.71	10.36	Stones Water-bearing Packed	Grey	gravel, gravelly sand
5	10.36	10.97	Clay Stones Cemented	Brown	diamicton: si to sa/si matrix

Well Number 1910029 **Construction Date** 11-Jul-1989 **Primary Water Use** Commercial **Well Type** Bedrock
Easting (NAD83) 680336 **Northing (NAD83)** 4861196 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 106.07
Lot 027 **Concession** Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 76.20 **Static Level (m)** 3.35 **Deepest Water Found** 9.14 **Well Depth** 10.67
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)** 6.71
Pump Rate(Igpm) 14.00 **Pump Time(h:m)** **:** 45 **Depth (end of 60 min)** 8.53
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :** 34.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	2.44	Clay Packed	Brown	clay, silty clay
2	2.44	6.71	Clay Sandstone Cemented	Brown	diamicton: si to sa/si matrix
3	6.71	9.14	Clay Sandstone Layered	Brown	diamicton: si to sa/si matrix
4	9.14	10.67	Sand Water-bearing	Brown	sand, silty sand

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Well Number 1910031 **Construction Date** 30-Jul-1989 **Primary Water Use** Domestic **Well Type** Overburden
Easting (NAD83) 680223 **Northing (NAD83)** 4861535 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 106.98
Lot 027 **Concession** 01 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 15.24 **Static Level (m)** 3.66 **Deepest Water Found** 13.72 **Well Depth** 13.72
Top of Screen (m): 12.80 **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm 1.00 **Pump Time(h:m)** 10 **:** 45 **Depth (end of 60 min)**
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :** 42.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	1.22	Clay Stones Sandy	Brown	diamicton: si to sa/si matrix
2	1.22	4.88	Clay Stones Silty	Brown	diamicton: si to sa/si matrix
3	4.88	9.14	Clay Gravel Sandy	Grey	diamicton: si to sa/si matrix
4	9.14	10.97	Clay Sand Packed	Grey	silt, sandy silt, clayey silt
5	10.97	11.58	Clay Boulders Hard	Grey	diamicton: si to sa/si matrix
6	11.58	13.72	Gravel Sand Packed	Brown	gravel, gravelly sand

Well Number 1910032 **Construction Date** 24-Jul-1989 **Primary Water Use** Not Used **Well Type** Bedrock
Easting (NAD83) 680237 **Northing (NAD83)** 4861528 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 106.98
Lot 027 **Concession** 01 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) **Static Level (m)** **Deepest Water Found** **Well Depth** 45.72
Top of Screen (m): **WaterKind** **Depth to Bedrock (m)** 33.53
Pump Rate(Igpm **Pump Time(h:m)** **:** **Depth (end of 60 min)**
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :**

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	1.22	Clay Stones Sandy	Brown	diamicton: si to sa/si matrix
2	1.22	3.05	Clay Silty	Brown	silt, sandy silt, clayey silt
3	3.05	6.10	Clay Gravel Sandy	Brown	diamicton: si to sa/si matrix
4	6.10	7.62	Clay Stones Packed	Grey	diamicton: si to sa/si matrix
5	7.62	10.67	Clay Gravel Silty	Grey	diamicton: si to sa/si matrix
6	10.67	32.31	Clay Stones Packed	Grey	diamicton: si to sa/si matrix
7	32.31	33.53	Gravel Sandy Packed	Brown	gravel, gravelly sand
8	33.53	39.62	Limestone Hard	Black	limestone
9	39.62	45.72	Limestone Hard	Grey	limestone

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Well Number 1910203 **Construction Date** 09-Oct-1989 **Primary Water Use** Commercial **Well Type** Bedrock
Easting (NAD83) 679272 **Northing (NAD83)** 4861236 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 99.97
Lot 030 **Concession** 01 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 15.24 **Static Level (m)** 12.80 **Deepest Water Found** 29.87 **Well Depth** 30.48
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)** 29.87
Pump Rate(Igpm) 20.00 **Pump Time(h:m)** 2 **:** 30 **Depth (end of 60 min)** 16.76
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :** 90.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	3.66	Topsoil	Brown	fill (incl topsoil, waste)
2	3.66	5.49	Topsoil Sandy	Brown	fill (incl topsoil, waste)
3	5.49	29.87	Clay Stones	Grey	diamicton: si to sa/si matrix
4	29.87	30.48	Limestone Shale	Grey	gravel, gravelly sand
5	30.48	30.48	Gravel	Black	gravel, gravelly sand

Well Number 1910281 **Construction Date** 30-Oct-1989 **Primary Water Use** Domestic **Well Type** Overburden
Easting (NAD83) 679220 **Northing (NAD83)** 4861113 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 100.89
Lot 030 **Concession** 01 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 15.24 **Static Level (m)** 0.30 **Deepest Water Found** 10.06 **Well Depth** 10.06
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm) 3.00 **Pump Time(h:m)** 2 **:** 0 **Depth (end of 60 min)** 9.14
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :** 32.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	0.61	Topsoil	Brown	fill (incl topsoil, waste)
2	0.61	9.45	Clay Sand Layered	Grey	silt, sandy silt, clayey silt
3	9.45	10.06	Gravel	Grey	gravel, gravelly sand

Well Number 1910282 **Construction Date** 29-Oct-1989 **Primary Water Use** Not Used **Well Type** Bedrock
Easting (NAD83) 679255 **Northing (NAD83)** 4861064 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 100.89
Lot 030 **Concession** 01 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) **Static Level (m)** **Deepest Water Found** **Well Depth** 42.67
Top of Screen (m): **WaterKind** **Depth to Bedrock (m)** 30.78
Pump Rate(Igpm) **Pump Time(h:m)** **:** **Depth (end of 60 min)**
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :**

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	0.30	Topsoil	Brown	fill (incl topsoil, waste)
2	0.30	6.71	Gravel Loose Dry	Brown	gravel, gravelly sand
3	6.71	30.78	Clay Gravel Layered		diamicton: si to sa/si matrix
4	30.78	42.67	Shale Limestone Soft	Brown	interbedded limestone/shale

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Well Number 1910283 **Construction Date** 29-Oct-1989 **Primary Water Use** Not Used **Well Type** Bedrock
Easting (NAD83) 679234 **Northing (NAD83)** 4861151 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 99.97
Lot 030 **Concession** 01 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 15.24 **Static Level (m)** **Deepest Water Found** **Well Depth** 54.86
Top of Screen (m): **WaterKind** **Depth to Bedrock (m)** 30.78
Pump Rate(Igpm **Pump Time(h:m)** **:** **Depth (end of 60 min)**
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :**

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	0.30	Topsoil	Brown	fill (incl topsoil, waste)
2	0.30	6.71	Gravel Loose Dry	Brown	gravel, gravelly sand
3	6.71	30.78	Clay Gravel Layered		diamicton: si to sa/si matrix
4	30.78	54.86	Shale Limestone Soft	Black	interbedded limestone/shale

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Well Number 1910331 **Construction Date** 12-Jan-1990 **Primary Water Use** Stock **Well Type** Overburden
Easting (NAD83) 679080 **Northing (NAD83)** 4864579 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 136.86
Lot 027 **Concession** 02 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 15.24 **Static Level (m)** **Deepest Water Found** 25.91 **Well Depth** 25.91
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm 8.00 **Pump Time(h:m)** 4 **:** 30 **Depth (end of 60 min)** 22.86
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :** 80.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	0.61	Topsoil	Brown	fill (incl topsoil, waste)
2	0.61	3.05	Sand	Brown	sand, silty sand
3	3.05	13.41	Sand Gravel	Grey	gravel, gravelly sand
4	13.41	15.24	Gravel Sand	Grey	gravel, gravelly sand
5	15.24	24.38	Clay Gravel Hard	Grey	diamicton: si to sa/si matrix
6	24.38	25.91	Gravel Sand	Brown	gravel, gravelly sand

Well Number 1910370 **Construction Date** 26-Jan-1990 **Primary Water Use** Stock **Well Type** Bedrock
Easting (NAD83) 678911 **Northing (NAD83)** 4862754 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 124.97
Lot 029 **Concession** 01 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) **Static Level (m)** **Deepest Water Found** **Well Depth** 60.96
Top of Screen (m): **WaterKind** **Depth to Bedrock (m)** 45.72
Pump Rate(Igpm **Pump Time(h:m)** **:** **Depth (end of 60 min)**
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :**

MOE Water Well Records Report

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	6.10	Sand Gravel Hard	Brown	gravel, gravelly sand
2	6.10	12.19	Sand Gravel Soft	Grey	gravel, gravelly sand
3	12.19	21.34	Sand	Grey	sand, silty sand
4	21.34	45.72	Clay Gravel Hard	Grey	diamicton: si to sa/si matrix
5	45.72	53.34	Shale Limestone Hard	Black	interbedded limestone/shale
6	53.34	60.96	Limestone	Grey	limestone

Well Number 1910371 **Construction Date** 26-Jan-1990 **Primary Water Use** Stock **Well Type** Overburden
Easting (NAD83) 678920 **Northing (NAD83)** 4862749 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 124.97
Lot 029 **Concession** 01 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 15.24 **Static Level (m)** 3.05 **Deepest Water Found** 21.34 **Well Depth** 21.34
Top of Screen (m): 18.59 **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm 2.00 **Pump Time(h:m)** 6 **:** 0 **Depth (end of 60 min)** 20.73
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :** 68.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	6.10	Sand Gravel Hard	Brown	gravel, gravelly sand
2	6.10	12.19	Sand Gravel Soft	Grey	gravel, gravelly sand
3	12.19	21.34	Sand	Grey	sand, silty sand

Well Number 1910499 **Construction Date** 01-Feb-1990 **Primary Water Use** Domestic **Well Type** Overburden
Easting (NAD83) 679441 **Northing (NAD83)** 4864214 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 135.03
Lot 027 **Concession** 02 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 76.20 **Static Level (m)** 6.10 **Deepest Water Found** 10.67 **Well Depth** 13.72
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm 5.00 **Pump Time(h:m)** 1 **:** 0 **Depth (end of 60 min)** 8.23
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :** 42.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	0.61	Topsoil	Black	fill (incl topsoil, waste)
2	0.61	6.10	Clay Stones Packed	Brown	diamicton: si to sa/si matrix
3	6.10	10.67	Clay Stones Packed	Grey	diamicton: si to sa/si matrix
4	10.67	13.72	Sand Water-bearing	Grey	sand, silty sand

MOE Water Well Records Report

112956 Tooley

Well Number 1911063 **Construction Date** 13-May-1991 **Primary Water Use** Domestic **Well Type** Overburden
Easting (NAD83) 679896 **Northing (NAD83)** 4865400 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 145.08
Lot 024 **Concession** 02 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 15.24 **Static Level (m)** 2.13 **Deepest Water Found** 29.57 **Well Depth** 32.00
Top of Screen (m): 29.57 **WaterKind** Unknown **Depth to Bedrock (m)**
Pump Rate(Igpm 3.00 **Pump Time(h:m)** 1 **:** 0 **Depth (end of 60 min)** 13.72
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :** 85.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	0.30	Topsoil Stones		fill (incl topsoil, waste)
2	0.30	3.35	Fine Sand Gravel Stones	Brown	gravel, gravelly sand
3	3.35	6.71	Fine Sand Clay Gravel	Grey	gravel, gravelly sand
4	6.71	22.56	Clay	Grey	clay, silty clay
5	22.56	27.43	Clay Pea Gravel	Grey	diamicton: si to sa/si matrix
6	27.43	29.57	Coarse Sand Pea Gravel	Grey	gravel, gravelly sand
7	29.57	31.39	Coarse Sand Pea Gravel	Grey	gravel, gravelly sand
8	31.39	32.00	Clay Sand	Grey	silt, sandy silt, clayey silt

Well Number 1911129 **Construction Date** 23-May-1991 **Primary Water Use** Domestic **Well Type** Bedrock
Easting (NAD83) 679897 **Northing (NAD83)** 4864691 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 127.10
Lot 025 **Concession** 02 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 15.24 **Static Level (m)** 3.05 **Deepest Water Found** 39.93 **Well Depth** 53.04
Top of Screen (m): 40.23 **WaterKind** Unknown **Depth to Bedrock (m)** 53.04
Pump Rate(Igpm 10.00 **Pump Time(h:m)** 23 **:** 0 **Depth (end of 60 min)** 30.48
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :** 100.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	2.13	Clay	Brown	clay, silty clay
2	2.13	39.93	Clay Stones	Grey	diamicton: si to sa/si matrix
3	39.93	42.67	Clay Silt	Grey	silt, sandy silt, clayey silt
4	42.67	53.04	Clay	Grey	clay, silty clay
5	53.04	53.04	Shale	Black	shale

Well Number 1911373 **Construction Date** 31-Dec-1991 **Primary Water Use** Domestic **Well Type** Overburden
Easting (NAD83) 678494 **Northing (NAD83)** 4861367 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 117.04
Lot 031 **Concession** 01 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) **Static Level (m)** **Deepest Water Found** **Well Depth**
Top of Screen (m): **WaterKind** **Depth to Bedrock (m)**
Pump Rate(Igpm **Pump Time(h:m)** **:** **Depth (end of 60 min)**
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :**

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1			Previously Dug		

MOE Water Well Records Report

Well Number 1911401 **Construction Date** 08-Jan-1992 **Primary Water Use** Domestic **Well Type** Overburden
Easting (NAD83) 678477 **Northing (NAD83)** 4861336 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 116.13
Lot 031 **Concession** 01 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 15.24 **Static Level (m)** 2.44 **Deepest Water Found** 6.40 **Well Depth** 9.45
Top of Screen (m): 4.88 **WaterKind** Fresh **Depth to Bedrock (m)**
Pump Rate(Igpm 4.00 **Pump Time(h:m)** 4 **:** 0 **Depth (end of 60 min)** 8.53
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :** 29.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	1.22	Clay Topsoil	Brown	fill (incl topsoil, waste)
2	1.22	6.40	Gravel Clay	Grey	gravel, gravelly sand
3	6.40	9.45	Medium Sand Coarse-grainec	Brown	sand, silty sand

Well Number 1911568 **Construction Date** 25-Jul-1992 **Primary Water Use** Domestic **Well Type** Bedrock
Easting (NAD83) 679282 **Northing (NAD83)** 4864707 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 138.07
Lot 026 **Concession** 02 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 15.24 **Static Level (m)** 1.22 **Deepest Water Found** 24.38 **Well Depth** 26.21
Top of Screen (m): 23.47 **WaterKind** Fresh **Depth to Bedrock (m)** 5.79
Pump Rate(Igpm 4.00 **Pump Time(h:m)** 5 **:** 0 **Depth (end of 60 min)** 21.34
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :** 75.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	0.30	Topsoil	Brown	fill (incl topsoil, waste)
2	0.30	4.57	Sand	Brown	sand, silty sand
3	4.57	5.79	Clay Sand	Grey	silt, sandy silt, clayey silt
4	5.79	11.89	Clay Sandstone	Grey	diamicton: si to sa/si matrix
5	11.89	24.38	Sand Silt	Grey	sand, silty sand
6	24.38	26.21	Sand Water-bearing	Grey	sand, silty sand

Well Number 1911662 **Construction Date** 15-Jan-1993 **Primary Water Use** Domestic **Well Type** Bedrock
Easting (NAD83) 679851 **Northing (NAD83)** 4865336 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 145.08
Lot 025 **Concession** 02 Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 15.24 **Static Level (m)** 6.10 **Deepest Water Found** 56.39 **Well Depth** 57.91
Top of Screen (m): **WaterKind** Fresh **Depth to Bedrock (m)** 55.47
Pump Rate(Igpm 25.00 **Pump Time(h:m)** 4 **:** 0 **Depth (end of 60 min)** 22.86
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :** 150.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	0.61	Topsoil Medium-grained	Brown	fill (incl topsoil, waste)
2	0.61	6.10	Clay Medium-grained	Brown	clay, silty clay
3	6.10	42.67	Clay Sand Medium-grained	Grey	silt, sandy silt, clayey silt
4	42.67	55.47	Clay Sand Layered	Grey	silt, sandy silt, clayey silt
5	55.47	57.91	Limestone Hard	Black	limestone

MOE Water Well Records Report

Well Number 1911762 **Construction Date** 05-Aug-1993 **Primary Water Use** Commercia **Well Type** Bedrock
Easting (NAD83) 680492 **Northing (NAD83)** 4860935 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 100.89
Lot 027 **Concession** Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 15.24 **Static Level (m)** 2.44 **Deepest Water Found** 6.71 **Well Depth** 34.44
Top of Screen (m): 32.92 **WaterKind** Fresh **Depth to Bedrock (m)** 6.71
Pump Rate(Igpm 3.00 **Pump Time(h:m)** 4 **:** **Depth (end of 60 min)** 21.64
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :** 108.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	1.52	Topsoil	Brown	fill (incl topsoil, waste)
2	1.52	6.71	Clay Stones	Grey	diamicton: si to sa/si matrix
3	6.71	10.36	Clay Sandstone Water-bearin	Grey	diamicton: si to sa/si matrix
4	10.36	20.73	Clay Stones Hard	Grey	diamicton: si to sa/si matrix
5	20.73	32.31	Clay Stones Soft	Grey	diamicton: si to sa/si matrix
6	32.31	32.92	Gravel Sandy Water-bearing	Grey	gravel, gravelly sand
7	32.92	34.44	Stones Clay Sandy	Grey	gravel, gravelly sand
8	34.44	34.44	Shale Rock		shale

Well Number 1911762 **Construction Date** 05-Aug-1993 **Primary Water Use** Commercia **Well Type** Bedrock
Easting (NAD83) 680492 **Northing (NAD83)** 4860935 **UTM Zone** 17
Positional Reliability margin of error : 100 m - 300 m **Elevation(mASL)** 100.89
Lot 027 **Concession** Newcastle Town (Darlington) **Durham**
Well Diameter(cm) 15.24 **Static Level (m)** 2.44 **Deepest Water Found** 32.92 **Well Depth** 34.44
Top of Screen (m): 32.92 **WaterKind** Gas **Depth to Bedrock (m)** 6.71
Pump Rate(Igpm 3.00 **Pump Time(h:m)** 4 **:** **Depth (end of 60 min)** 21.64
Specific Capacity: 0.00 **Recommended Pump Setting (gpm) :** 108.00

Well Stratigraphy

Layer	Formation Top (m)	Formation Bottom (m)	Driller's Description	Colour	Standardized Description
1	0.00	1.52	Topsoil	Brown	fill (incl topsoil, waste)
2	1.52	6.71	Clay Stones	Grey	diamicton: si to sa/si matrix
3	6.71	10.36	Clay Sandstone Water-bearin	Grey	diamicton: si to sa/si matrix
4	10.36	20.73	Clay Stones Hard	Grey	diamicton: si to sa/si matrix
5	20.73	32.31	Clay Stones Soft	Grey	diamicton: si to sa/si matrix
6	32.31	32.92	Gravel Sandy Water-bearing	Grey	gravel, gravelly sand
7	32.92	34.44	Stones Clay Sandy	Grey	gravel, gravelly sand
8	34.44	34.44	Shale Rock		shale

E.3 Groundwater Monitor Sampling Results

Table A.3 - Groundwater Monitor Sampling Results

Parameter	Unit	RDL	ODWS	TC-BH1D	TC-BH1S	TC-BH2D	TC-BH2S
INORGANICS AND METALS							
Alkalinity (as CaCO3)	mg/L	5	30-500	86	429	162	192
Aluminum	mg/L	0.004	0.1	0.022	0.004	0.007	0.005
Ammonia (as N)	mg/L	0.02	NA	0.79	0.65	0.03	0.13
Arsenic	mg/L	0.003	0.025	0.005	<0.003	<0.003	<0.003
Barium	mg/L	0.002	1.0	0.042	0.164	0.045	0.049
Bicarbonate (as CaCO3)	mg/L	5	NA	76	429	151	192
Boron	mg/L	0.01	5.0	0.15	0.31	0.07	0.04
Bromide	mg/L	0.05	NA	<0.05	<0.05	<0.05	<0.05
Cadmium	mg/L	0.002	0.005	<0.002	<0.002	<0.002	<0.002
Calcium	mg/L	0.05	NA	4.7	148.0	47.7	95.7
Calculated Total Dissolved Solids	mg/L	5	NA	116	675	-	-
Carbonate (as CaCO3)	mg/L	5	NA	10	<5	11	<5
Chloride	mg/L	0.1	250	1.22	59.90	16.90	40.20
Colour	TCU	5	5	**10**	5	<5	<5
Copper	mg/L	0.003	1.0	0.015	0.008	<0.003	<0.003
Electrical Conductivity	uS/cm	2	NA	183	1,070	2.90	2.70
Field Conductivity	uS/cm	N/A	NA	168	1,065	416	658
Fluoride	mg/L	0.05	1.5	0.53	<0.05	0.21	0.09
Hydroxide	mg/L	5	NA	<5	<5	<5	<5
Iron	mg/L	0.005	0.3	<0.005	<0.005	<0.005	<0.005
Langelier Index	N/A	N/A	NA	0.44	1.29	0.97	1.01
Lead	mg/L	0.002	0.01	<0.002	<0.002	<0.002	<0.002
Magnesium	mg/L	0.05	NA	2.02	14.20	18.90	31.60
Manganese	mg/L	0.002	0.05	<0.002	**0.085**	**0.071**	**0.120**
Molybdenum	mg/L	0.002	NA	0.013	0.002	0.005	<0.002
Nickel	mg/L	0.003	NA	<0.003	<0.003	<0.003	<0.003
Nitrate as N	mg/L	0.05	10	<0.05	0.69	<0.05	<0.05
Nitrite as N	mg/L	0.05	1.0	<0.05	<0.05	<0.05	<0.05
Orthophosphate as P	mg/L	0.1	NA	<0.10	<0.10	<0.10	<0.10
pH	N/A	N/A	6.5-8.5	**9.10**	7.92	8.30	8.02
Field pH	N/A	N/A	NA	8.35	6.90	-	-
Potassium	mg/L	0.05	NA	1.08	1.87	2.49	2.96
Reactive Silica	mg/L	0.05	NA	17.20	12.70	16.60	16.00
Saturation pH	N/A	N/A	NA	8.66	6.63	7.33	7.01
Selenium	mg/L	0.004	0.01	<0.004	<0.004	<0.004	<0.004
Silver	mg/L	0.002	NA	<0.002	<0.002	<0.002	<0.002
Sodium	mg/L	0.05	20 (200)	**31.30**	**78.90**	14.70	7.49
Strontium	mg/L	0.005	NA	0.10	0.43	0.29	0.22
Sulphate	mg/L	0.1	500	5.94	101.00	43.20	129.00
Thallium	mg/L	0.006	NA	<0.006	<0.006	<0.006	<0.006
Titanium	mg/L	0.002	NA	<0.002	0.002	<0.002	0.002
Total Dissolved Solids	mg/L	20	500	1,430	668	278	500
Total Hardness (as CaCO3)	mg/L	10	80-100	**20**	**428**	**197**	**369**
Total Organic Carbon	mg/L	0.5	NA	21.30	17.90	-	-
Total Phosphorus	mg/L	0.05	NA	0.05	5.89	0.05	7.57
Turbidity	NTU	0.5	5.0	**>1000**	**190.00**	2.10	**6.40**
Uranium	mg/L	0.002	0.02	<0.002	0.004	<0.002	<0.002
Vanadium	mg/L	0.002	NA	0.002	<0.002	<0.002	<0.002
Zinc	mg/L	0.005	5.0	0.025	0.038	0.006	<0.005
Field Temp	ºC	N/A	NA	7.30	6.80	-	-

NOTES:
- paramter not analyzed
RDL - Reportable Detection Limit;
NA = No Standard Under ODWS
ODWS - Ontario Drinking Water Standards
Bold and highlighted font indicates ODWS exceedence
** Table modfied from 407 East EA (MTO,2009).*

Appendix E.3 - Robinson Creek Mini-Piezometer Data

MP ID	date dd-mm-yy	DTW (mBTOP) IN[1] (gw or deep)	Out[2] (sw or shallow)	IN - OUT (dh)	Gradient (dh/dL)	SU (m)	DTW (mBGS)	Notes
RC-MP1 Nest								
RC-MP1	10-Jul-09	2.50	0.46	-2.04	-1.69	-	-	Downwards Gradient at Nest
RC-MP1	31-Jul-09	1.90	-0.03	-1.94	-1.61	-	-	Downwards Gradient at Nest
RC-MP1	24-Aug-09	1.59	-0.02	-1.61	-1.33	-	-	Downwards Gradient at Nest
RC-MP1	09-Sep-09	1.42	0.17	-1.25	-1.03	-	-	Downwards Gradient at Nest
RC-MP1	30-Sep-09	1.37	0.19	-1.18	-0.98	-	-	Downwards Gradient at Nest
RC-MP1	9-Mar-10	0.57	-0.03	-0.60	-0.50	-	-	Downwards Gradient at Nest
RC-MP1s								
RC-MP1s	10-Jul-09	1.42	0.96	-0.46	-0.79	0.96	0.46	AD-out moist
RC-MP1s	31-Jul-09	0.93	0.96	0.03	0.06	0.96	-0.03	AD-out moist
RC-MP1s	24-Aug-09	0.95	0.96	0.02	0.03	0.96	-0.02	AD
RC-MP1s	09-Sep-09	1.13	0.96	-0.17	-0.29	0.96	0.17	JC
RC-MP1s	30-Sep-09	1.15	0.96	-0.19	-0.32	0.96	0.19	AD
RC-MP1s	9-Mar-10	0.93	0.90	-0.03	-0.05	0.96	-0.03	AD
RC-MP1d								
RC-MP1d	10-Jul-09	3.43	0.93	-2.50	-1.17	0.93	2.50	AD
RC-MP1d	31-Jul-09	2.83	0.93	-1.90	-0.89	0.93	1.90	AD
RC-MP1d	24-Aug-09	2.52	0.93	-1.59	-0.74	0.93	1.59	AD
RC-MP1d	09-Sep-09	2.35	0.93	-1.42	-0.66	0.93	1.42	JC
RC-MP1d	30-Sep-09	2.30	0.93	-1.37	-0.64	0.93	1.37	AD
RC-MP1d	9-Mar-10	1.50	0.91	-0.59	-0.28	0.93	0.57	AD
RC-MP2								
RC-MP2	10-Jul-09	0.92	0.69	-0.23	-0.41	1.00	-0.08	AD
RC-MP2	31-Jul-09	0.57	0.70	0.13	0.23	1.00	-0.43	AD
RC-MP2	24-Aug-09	0.62	0.69	0.07	0.13	1.00	-0.38	AD
RC-MP2	09-Sep-09	0.65	0.69	0.04	0.07	1.00	-0.35	JC
RC-MP2	30-Sep-09	0.66	0.68	0.02	0.04	1.00	-0.34	AD
RC-MP2	9-Mar-10	0.68	0.70	0.02	0.04	1.00	-0.32	AD
RC-MP3								
RC-MP3	10-Jul-09	2.42	1.25	-1.17	-1.00	1.62	0.81	JC/AD
RC-MP3	31-Jul-09	2.14	1.22	-0.92	-0.78	1.62	0.53	AD
RC-MP3	24-Aug-09	1.95	1.28	-0.67	-0.57	1.62	0.33	Double checked values-AD
RC-MP3	09-Sep-09	1.86	1.40	-0.47	-0.40	1.62	0.25	JC
RC-MP3	30-Sep-09	1.77	1.23	-0.54	-0.46	1.62	0.16	AD
RC-MP3	9-Mar-10	1.25	1.20	-0.05	-0.04	1.62	-0.37	AD
RC-MP4								
RC-MP4	09-Sep-09	1.84	1.16	-0.68	-1.28	1.30	0.54	installation
RC-MP4	30-Sep-09	1.84	1.15	-0.70	-1.31	1.30	0.54	AD - dry at bottom
RC-MP4	9-Mar-10	1.82	1.13	-0.70	-1.31	1.30	0.52	AD
RC-MP5								
RC-MP5	09-Sep-09	2.20	1.24	-0.97	-1.01	1.24	0.97	installation
RC-MP5	30-Sep-09	1.65	1.25	-0.40	-0.41	1.24	0.41	AD
RC-MP5	9-Mar-10	1.61	1.23	-0.38	-0.39	1.24	0.37	AD

mBTOP - metres below top of pipe mBGS - metres below ground surface DTW - depth to water

1 - IN measurement refers to the groundwater level or deep groundwater level at a nest

2 - OUT measurement refers to the surface water measurement or shallow groundwater level at a nest

- upwards hydraulic gradient

Appendix E.3 - Tooley Creek Mini-Piezometer Data

MP ID	date dd-mm-yy	DTW (mBTOP) IN[1] (gw or deep)	Out[2] (sw or shallow)	IN - OUT (dh)	Gradient (dh/dL)	SU (m)	DTW (mBGS)	Notes
TC-MP1								
TC-MP1	09-Jul-09	1.71	0.95	-0.76	-0.73	1.15	0.56	JC/AD
TC-MP1	31-Jul-09	1.11	0.94	-0.17	-0.16	1.15	-0.04	AD
TC-MP1	24-Aug-09	0.94	0.97	0.03	0.03	1.15	-0.22	AD
TC-MP1	30-Sep-09	0.88	0.95	0.08	0.07	1.15	-0.28	AD
TC-MP1	09-Mar-10	0.86	0.84	-0.02	-0.02	1.15	-0.29	AD
TC-MP2								
TC-MP2	09-Jul-09	1.05	0.53	-0.51	-0.65	0.77	0.28	JC/AD
TC-MP2	31-Jul-09	0.33	0.52	0.19	0.24	0.77	-0.44	AD
TC-MP2	24-Aug-09	0.25	0.56	0.31	0.39	0.77	-0.52	AD
TC-MP2	30-Sep-09	0.23	0.54	0.31	0.39	0.77	-0.54	AD
TC-MP2	09-Mar-10	0.24	0.44	0.20	0.25	0.77	-0.53	AD
TC-MP3								
TC-MP3	09-Jul-09	1.01	0.81	-0.20	-0.36	1.08	-0.06	JC/AD
TC-MP3	31-Jul-09	0.72	0.79	0.07	0.13	1.08	-0.36	AD
TC-MP3	24-Aug-09	0.76	0.84	0.08	0.14	1.08	-0.32	AD
TC-MP3	30-Sep-09	0.80	0.80	0.01	0.01	1.08	-0.28	AD
TC-MP3	09-Mar-10	0.65	0.72	0.07	0.13	1.08	-0.43	AD
TC-MP4 Nest								
TC-MP4	21-Aug-08	0.16	-0.01	0.17	0.14	-	-	Upwards Gradient at Nest
TC-MP4	04-Sep-08	0.08	-0.47	0.55	0.46	-	-	Upwards Gradient at Nest
TC-MP4	10-Oct-08	0.04	-0.46	0.50	0.42	-	-	Upwards Gradient at Nest
TC-MP4	11-Nov-08	0.08	-0.21	0.29	0.24	-	-	Upwards Gradient at Nest
TC-MP4	08-Jan-09	0.18	0.14	0.04	0.03	-	-	Upwards Gradient at Nest
TC-MP4	09-Jun-09	0.14	-0.24	0.38	0.32	-	-	Upwards Gradient at Nest
TC-MP4	31-Jul-09	0.15	-0.46	0.60	0.50	-	-	Upwards Gradient at Nest
TC-MP4	24-Aug-09	-0.10	-0.94	0.84	0.70	-	-	Upwards Gradient at Nest
TC-MP4	30-Sep-09	-0.52	-1.22	0.71	0.59	-	-	Upwards Gradient at Nest
TC-MP4	09-Mar-10	0.00	0.00	0.00	0.00	-	-	Neutral
TC-MP4s								
TC-MP4s	21-Aug-08	1.16	1.00	-0.16	-0.15	1.17	-0.01	Out measurement to ground
TC-MP4s	04-Sep-08	1.64	1.17	-0.47	-0.45	1.17	-0.47	out dry
TC-MP4s	10-Oct-08	1.63	1.17	-0.46	-0.44	1.17	-0.46	JC
TC-MP4s	11-Nov-08	1.38	1.17	-0.21	-0.20	1.17	-0.21	ou tdry
TC-MP4s	08-Jan-09	1.03	1.03	0.00	0.00	1.17	0.14	out dry
TC-MP4s	09-Jun-09	1.41	1.17	-0.24	-0.23	1.17	-0.24	out dry
TC-MP4s	31-Jul-09	1.63	1.15	-0.48	-0.46	1.17	-0.46	out dry-AD
TC-MP4s	24-Aug-09	2.11	1.15	-0.96	-0.92	1.17	-0.94	out dry- AD
TC-MP4s	30-Sep-09	2.39	1.15	-1.24	-1.19	1.17	-1.22	AD
TC-MP4s	09-Mar-10	0.96	1.11	0.16	0.15	1.17	0.22	AD
TC-MP4d								
TC-MP4d	21-Aug-08	0.89	1.05	0.16	0.07	1.05	0.16	Out measurement to ground
TC-MP4d	04-Sep-08	0.97	1.05	0.08	0.03	1.05	0.08	out dry
TC-MP4d	10-Oct-08	1.01	1.05	0.04	0.02	1.05	0.04	JC
TC-MP4d	11-Nov-08	0.97	1.05	0.08	0.03	1.05	0.08	out dry
TC-MP4d	08-Jan-09	0.87	0.82	-0.05	-0.02	1.05	0.18	out dry
TC-MP4d	09-Jun-09	0.91	1.05	0.14	0.06	1.05	0.14	out dry
TC-MP4d	31-Jul-09	0.91	1.05	0.15	0.06	1.05	0.15	out dry- AD
TC-MP4d	24-Aug-09	1.15	1.05	-0.10	-0.04	1.05	-0.10	out dry-aD
TC-MP4d	30-Sep-09	1.57	1.05	-0.52	-0.22	1.05	-0.52	AD
TC-MP4d	09-Mar-10	0.86	0.86	0.00	0.00	1.05	0.19	AD
TC-MP5								
TC-MP5	21-Aug-08	1.67	0.85	-0.82	-0.58	1.07	0.60	JC
TC-MP5	04-Sep-08	1.61	0.91	-0.70	-0.50	1.07	0.54	lots of GW sheen
TC-MP5	10-Oct-08	1.25	0.85	-0.40	-0.28	1.07	0.18	JC
TC-MP5	11-Nov-08	1.05	0.86	-0.20	-0.14	1.07	-0.02	JC
TC-MP5	08-Jan-09	0.58	0.76	0.18	0.13	1.07	-0.49	JC
TC-MP5	09-Jun-09	0.64	0.92	0.28	0.20	1.07	-0.43	JC
TC-MP5	31-Jul-09	0.75	0.91	0.16	0.11	1.07	-0.32	AD
TC-MP5	24-Aug-09	0.81	0.95	0.14	0.10	1.07	-0.26	AD
TC-MP5	30-Sep-09	1.05	0.92	-0.13	-0.09	1.07	-0.02	AD
TC-MP5	09-Mar-10	0.73	0.81	0.08	0.06	1.07	-0.34	AD
TC-MP 6 Nest								
TC-MP 6	09-Jul-09	-3.05	-1.28	-4.33	-3.02	-	-	Downwards Gradient at Nest
TC-MP 6	31-Jul-09	-1.75	0.52	-1.23	-0.86	-	-	Downwards Gradient at Nest
TC-MP 6	24-Aug-09	-1.22	0.51	-0.72	-0.50	-	-	Downwards Gradient at Nest
TC-MP 6	30-Sep-09	-0.71	0.49	-0.22	-0.15	-	-	JC
TC-MP 6	09-Mar-10	0.31	0.29	0.60	0.42	-	-	AD
TC-MP 6s								
TC-MP 6s	09-Jul-09	2.24	0.96	-1.28	-1.02	0.96	-1.28	JC/AD
TC-MP 6s	31-Jul-09	0.44	0.93	0.49	0.39	0.96	0.52	AD
TC-MP 6s	24-Aug-09	0.46	0.95	0.50	0.39	0.96	0.51	AD- out saturated
TC-MP 6s	30-Sep-09	0.47	0.95	0.48	0.38	0.96	0.49	AD
TC-MP 6s	09-Mar-10	0.67	0.95	0.28	0.22	0.96	0.29	AD
TC-MP6d								
TC-MP6d	09-Jul-09	4.15	1.10	-3.05	-1.05	1.10	-3.05	JC/AD
TC-MP6d	31-Jul-09	2.85	1.09	-1.76	-0.61	1.10	-1.75	AD
TC-MP6d	24-Aug-09	2.32	1.10	-1.22	-0.42	1.10	-1.22	out saturated-AD
TC-MP6d	30-Sep-09	1.81	1.08	-0.73	-0.25	1.10	-0.71	AD
TC-MP6d	09-Mar-10	0.79	1.11	0.32	0.11	1.10	0.31	AD

mBTOP - metres below top of pipe
mBGS - metres below ground surface
DTW - depth to water
1 - IN measurement refers to the groundwater level or deep groundwater level at a nest
2 - OUT measurement refers to the surface water measurement or shallow groundwater level at a nest
- upwards hydraulic gradient