EXECUTIVE SUMMARY

Dr. Andrew McKinley, Consultant, is working through DST Consulting Engineers Inc. (DST) on behalf of the Kanata North Landowners Group (the Owners) to create a Blanding's Turtle (*Emydoidea blandingii*) Habitat Compensation Plan (the Compensation Plan) in collaboration with Novatech Engineering Consultants (Novatech) and Muncaster Environmental Planning (MEP). This Compensation Plan will inform the development of the Kanata North Community Design Plan (KNCDP). As previously discussed with the Ontario Ministry of Natural Resources and Forestry (OMNRF) Kemptville District staff in our joint meeting on September 23rd, 2014, the purpose of this report is to create an overall habitat management and compensation plan that will be acceptable to the regulatory agencies and which will establish a coordinated approach among the Owners to fulfill future permitting and compensation requirements. It is understood that the individual landowners will be required to pursue their own authorizations under the Ontario Endangered Species Act (ESA) and will also conduct their own Environmental Impact Statements (EIS) and other analyses to complete the approvals process. The Compensation Plan will inform the final Community Design Plan and will establish an overall compensation approach that will ensure the success of future permit applications for each individual subdivision within the Community Design Plan area. The Compensation Plan will also coordinate the design of habitat compensation features to improve the overall functionality of Blanding's Turtle habitat within the KNCDP area. This Compensation Plan has been developed in consultation with the OMNRF.

Throughout this report the analysis is broken into four (4) separate Quadrants, following the major landowners in the KNCDP area. The impact assessment and habitat compensation plan have been subdivided among these four (4) separate Quadrants throughout this report. The habitat compensation plan has been designed in such a way that each landowner can independently implement their portion of the habitat compensation plan within their Quadrant to achieve an overall benefit.

Several potential impacts to individual turtles were identified that can be mitigated during the construction and operational phases. A suite of mitigation measures were proposed to address these potential impacts. The *General Habitat Description for the Blanding's Turtle (Emydoidea blandingii)* was used to describe the extent of potential Blanding's Turtle habitat within the KNCDP area. A single Blanding's Turtle was observed during surveys in a small farm pond west of March Road. Due to the early nature of the sighting in this pond, it is presumed that this pond has the potential to function as a hibernacula habitat and is hence shown as Category 1 habitat. Because the entirety of the KNCDP area is within 2 km of the noted occurrences, all suitable waterbodies and wetland areas are shown as Category 2 habitat. This includes the two tributaries of Shirley's Brook which are referred to as the North Branch and the North Tributary, as well as a pond

along the North Branch. Category 3 habitat has been identified generically around the Category 2 habitat as the area between 30 m and 250 m from the edge of the Category 2 habitat (e.g. by applying a buffer of 220 m around the Category 2 habitat).

In general, the quality of Category 2 & 3 habitat within the KNCDP area is currently very poor. This is because the majority of the North Tributary and North Branch within the KNCDP area currently flow through highly developed agricultural areas. In many areas high intensity agricultural operations occur very close to the channel and are buffered only by a thin hedgerow, particularly east of March Road. It should also be noted that in several sections the North Tributary has historically been channelized and realigned for agricultural purposes. In addition, there are no large areas of wetland vegetation along both tributaries under existing conditions, and in general aquatic plants are currently limited to those growing within the channel itself. The only significant areas of deeper water are: the Category 1 pond along the North Tributary and the Category 2 pond along the North Branch. Approximately 19% of the Category 2 habitat is occupied by wetland habitats and the rest is predominantly terrestrial areas that are moderately degraded (treed areas and fallow/regenerating fields) to severely degraded (pasture and row crop).

The current Community Design Plan proposes a watercourse corridor 40 m wide, which will retain the tributaries and the majority of Category 2 habitat throughout the KNCDP area. Within this corridor some sections of the tributaries will be realigned and habitat enhancement as well as restoration work will be undertaken. The 40 m corridor will result in the loss of the Category 1 pond (-0.08 ha) as well as an average of 20 m of Category 2 habitat along the length of the corridor, with a net loss of Category 2 habitat of -5.39 ha estimated. In addition to this, nearly all Category 3 habitat in the KNCDP area would be lost. Approximately 34% of the lost Category 2 habitat is the highly degraded 'marginal areas' (row crops and pasture) which currently provide relatively little habitat value. Approximately 49% of the lost Category 2 habitat is fallow/regenerating fields and treed areas which provide limited buffer functions but no core wetland habitat functionality. The actual wetland areas that will be lost (the ponds and channel/bank), account for only 17% of the lost Category 2 area. The portion of the lost Category 2 habitat which is currently wetland is hence as little as approximately -1.13 ha.

Summary of Overall Benefit Plan

Habitat Type	Existing Conditions (Table A)		Post Development Habitat (Table B)		Habitat Loss (Table C)		Proposed Compensation (Table D)	Net Gain/Loss	
	Size (m or ha)	% of Cat. 2 Total	Size (m or ha)	% of Cat. 2 Total	Size (m or ha)	% of Cat. 2 Total	Size (m or ha)	Size (m or ha)	% Change
Watercourse Length (m)	2884	NA	2856	NA	-28	NA	0	-28	-1%
Category 1 Habitat (ha)*	0.08	NA	0.00	NA	-0.08	NA	0.39	0.31	381%
Pond Size (Category 1 and 2 Ponds)**	0.34	NA	0.26	NA	-0.08	NA	0.27	0.19	56%
Category 2 - Wetland Areas (ha) (Functional Habitat)	3.16	19%	2.03	20%	-1.13	17%	0.51	-0.62	-20%
Category 2 - Terrestrial Habitat (ha) (Buffer Areas)	8.99	53%	5.61	55%	-3.38	49%	0.00	-3.38	-38%
Category 2 - Terrestrial Habitat (Marginal Areas) (ha)	4.82	28%	2.50	25%	-2.32	34%	0.00	-2.32	-48%
Total - All Category 2 (ha)	16.97	100%	10.14	100%	-5.39	NA	0.51	-4.88	-29%
Total - All Category 2 (Excluding Marginal Areas)	12.15	72%	7.64	75%	-3.07	NA	0.51	-2.56	-21%

*Pond Size Only Counts Pond Surface, Buffer Area Counted in Other Categories

**Includes both Category 1 and Category 2 Ponds to Illustrate Total Area of Open Water

Several habitat enhancement features are proposed to be built within the 40 m corridor to provide habitat compensation. This includes digging deep pockets along the channel to provide refuge areas, creation of shallow wetland pans that will form hemi-marsh conditions, creation of new deep ponds that will function as potential hibernacula sites, and building of artificial nesting areas. In total, 0.39 ha of Category 1 habitat enhancement features (artificial nesting areas and deep ponds) will be built, while 0.51 ha of other Category 2 enhancements (deep channel pockets and shallow pans) will also be built. This represents a total of 0.9 ha of habitat enhancement features. Additional less quantifiable habitat enhancement measures will be undertaken including seeding with native species (replacing the riparian areas that currently exist which are largely dominated by invasive species), adding cover objects and structural habitat components, selective planting, and the realignment of sections of the tributaries according to natural channel design principles.

The new artificial nesting areas and deep ponds replace the loss of the one Category 1 hibernacula pond at an approximately 5:1 ratio (+0.39 ha to -0.08). Therefore there will be an increase in the size of Category 1 habitat. This plan also increases the total size of open water ponds within the KNCDP area from the current 0.34 ha (the combined size of the two ponds) to 0.53 ha (the combined size of the four (4) new ponds and the one (1) retained pond). Therefore pond size increases by approximately 56%, while the loss of the 0.08 ha hibernacula pond is in fact replaced at an approximately 3.5:1 ratio (+0.27 ha of new ponds to -0.08 ha of the lost pond). Category 1 habitat and larger open water ponds with marsh and wetland elements are the most valuable features on the landscape in terms of Blanding's Turtle habitat functionality, and hence the increase in the size of these features supports the rationale that an overall improvement of functionality will be achieved, despite a net loss in the size of Category 2 habitat. The other habitat enhancement and improvement measures including the deep channel pockets, the shallow pans and pools, seeding with native species, adding cover objects and structural habitat elements, selective planting, and the realignment of sections of the tributaries according to natural channel design principles will all serve to rehabilitate the tributaries and improve their overall functionality.

Because it is likely that these tributaries provide the main viable movement corridor for Blanding's Turtle under current conditions, and that adjacent upland areas shown as Category 3 habitat likely offer only a hazardous movement corridor with little functional benefit, it is believed that enhancing and protecting the tributaries is the most feasible way to improve the overall functionality of turtle movement across the Kanata North area. The new habitat enhancement features will be placed every approximately 50 to 100 m along each tributary, and are expected to improve the movement function. This represents an improved habitat condition that will ultimately have an overall benefit through improved functionality and habitat quality. On a larger scale this plan has the potential to contribute to restoring the connection between the South March Highlands and the Shirley's Bay regional sub-populations, which would be a benefit to the regional population as a whole. The tributaries of the KNCDP area would contribute approximately 40% of the distance required to link Shirley's Bay to the South March Highlands. It should also be noted that road related mortality poses a significant risk to Blanding's Turtles in the KNCDP area due to existing high traffic volumes and roads that have no wildlife passage systems. Under current conditions this risk is essentially unmitigated. Following development, the risk of road related mortality will be better controlled and mitigated through the construction of a turtle exclusion fence that will be installed on both sides of the 40 m watercourse corridor, as well as new wildlife passage culverts. This will provide a benefit to Blanding's Turtle by mitigating and controlling the existing threat of road mortality. This serves to both reduce the risk of road related mortality and improve the functionality of the movement corridor compared to existing conditions.

It is proposed that following implementation of this habitat compensation plan, a post construction monitoring program will be undertaken in alternating years for a five (5) year period, such that three (3) years of monitoring will be undertaken. This will primarily involve basking surveys to document the occurrence of Blanding's Turtles, as well as monitoring of the retained and constructed habitat features and adaptive management recommendations.

It is expected that the habitat compensation and enhancement features outlined above will achieve an overall benefit in each of the four Quadrants, through an improvement in the size of key habitat features, a reduction in the risk of road related mortality, and an improvement in overall quality and functionality of Blanding's Turtle habitat. We believe that these measures will allow each individual Owner to prepare an Overall Benefit Permit application that will meet the requirements under clause 17(2) (c) of the Endangered Species Act (2007).

Table of Contents

1.0 Introduction

Dr. Andrew McKinley, Consultant, is working through DST Consulting Engineers Inc. (DST) on behalf of the Kanata North Landowners Group (the Owners) to create a Blanding's Turtle (*Emydoidea blandingii*) Habitat Compensation Plan (the Compensation Plan) in collaboration with Novatech Engineering Consultants (Novatech) and Muncaster Environmental Planning (MEP). This Compensation Plan will inform the development of the Kanata North Community Design Plan (KNCDP). The KNCDP area is shown in Figure 1. As previously discussed with the Ontario Ministry of Natural Resources and Forestry (OMNRF) Kemptville staff in our joint meeting on September 23, 2014, the purpose of this report is to create an overall habitat management and compensation plan that will be acceptable to the regulatory agencies and which will establish a coordinated approach among the Owners to fulfill future permitting and compensation requirements. The Compensation Plan will inform the final KNCDP and will establish an overall compensation approach that will ensure the success of future permit applications for each individual subdivision within the KNCDP area. The Compensation Plan will also coordinate the design of habitat compensation features to improve the overall functionality of Blanding's Turtle habitat throughout the KNCDP area. This Compensation Plan has been developed in consultation with the OMNRF.

1.1 Site Context

The KNCDP area is approximately 186 ha in size and is bordered on the south and west by existing residential developments. These include the Brookside Subdivision (southeast), Morgan's Grant (southwest), and the Marchbrook Circle (west), while the Hillsview Estates Subdivision borders the KNCDP area on the northeast. The areas east and northwest of the KNCDP area are largely undeveloped and are primarily occupied by agricultural fields with some isolated woodlots also being present (Figure 1).

The Kanata North Landowners Group is made up of several different landowners who are working collaboratively to create the Kanata North Community Design Plan. For design and analysis purposes, the KNCDP area has been divided into four (4) quadrants representing the four (4) largest landowners in each of these areas (Figure 1). March Road passes through the KNCDP area in a north-south direction and divides the KNCDP area in half (approximately) with Quadrant A and C being west of March Road, and Quadrants B and D being east of March Road. Quadrant A is primarily owned by Junic/Multivesco and represents the northwest quadrant of the KNCDP area. Quadrant B is entirely owned by Valecraft and represents the northeast quadrant. Quadrant C is primarily owned by Brigil and represents the southwest quadrant, and Quadrant D is entirely owned by Metcalfe Realty Company Limited and represents the southeast quadrant. The sizes of each Quadrant are approximately as follows: Quadrant A – 64 ha, Quadrant B – 41 ha, Quadrant C – 28 ha, and Quadrant D – 53 ha.

Two (2) tributaries of Shirley's Brook are present within the KNCDP area. These include the North Tributary, which enters the KNCDP area in Quadrant A, crosses March Road, and then proceeds through Quadrant B and Quadrant D before exiting the Site at the southern side of Quadrant D. The North Branch enters and exits the KNCDP area through Quadrant C and converges with the North Tributary just south of Quadrant D (Figure 1). Both tributaries traverse through the Site and ultimately converge with the main branch of Shirley's Brook south of the KNCDP area and then flow east towards their outlet at Shirley's Bay (the Ottawa River).

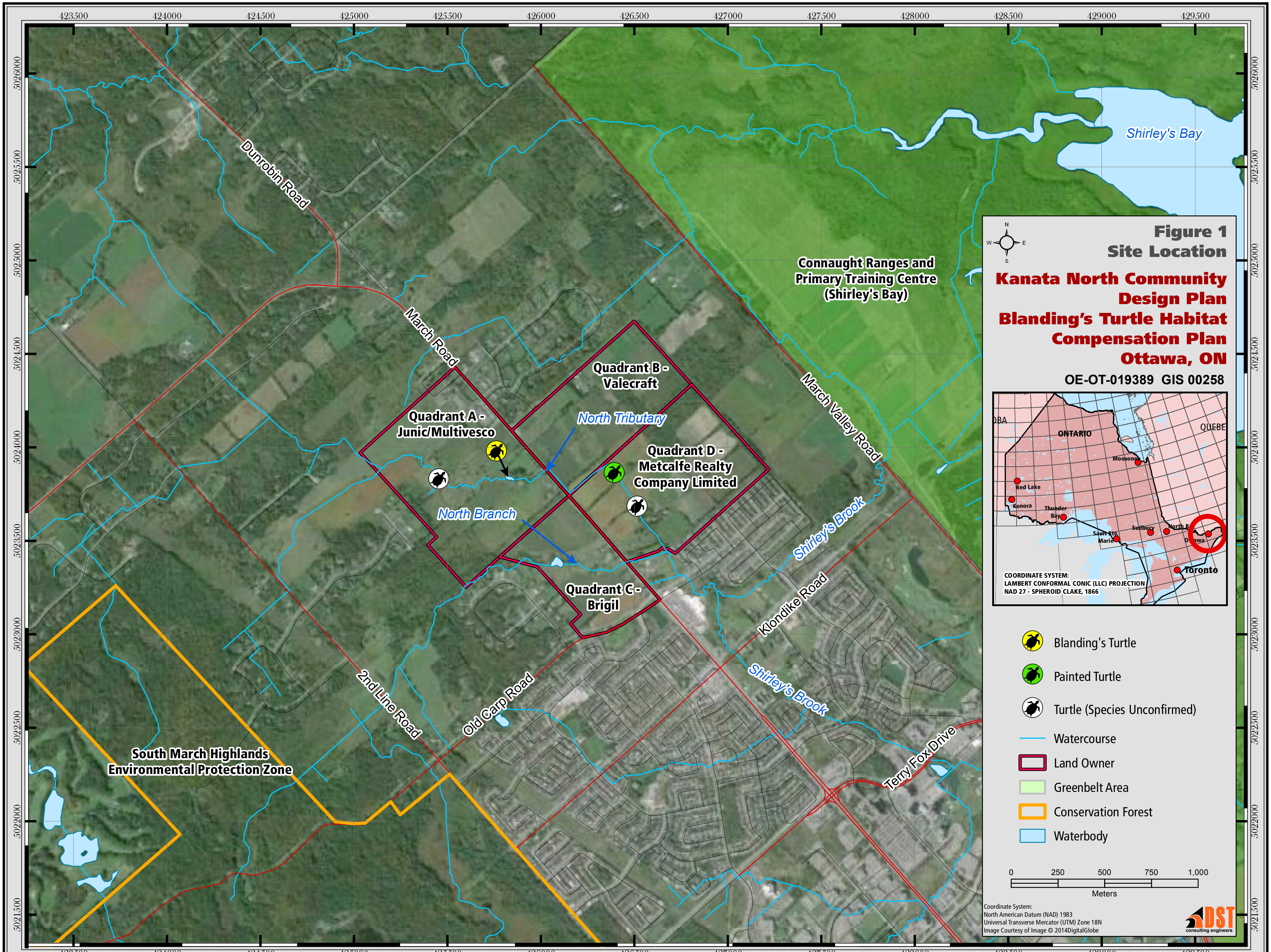
The KNCDP area is primarily occupied by operational agricultural fields and hedgerows between those fields. A small area of regrowth vegetation is present at the western portion of the KNCDP area, and a T-shaped woodlot is present in the eastern portion of the KNCDP area. This woodlot is labelled as S-20 by the City of Ottawa. Quadrant A is primarily occupied by agricultural fields and a small artificial farm pond that has been identified as Category 1 habitat (discussed in greater detail below). At the southwest side of Quadrant A there is a small regrowth woodlot labelled as S-12 by the City. Quadrant B is also primarily agricultural fields but also includes the T-Shaped Woodlot S-20 at the east side of the Quadrant. This woodlot extends into the northern portion of Quadrant D and the remainder of Quadrant D is also primarily agricultural fields. Quadrant C is primarily occupied by agricultural fields. The entirety of the KNCDP area is within the City's expanded urban area.

1.2 Description of Undertaking

The Community Design Plan will ultimately lay out the overall concept for the Kanata North area including road alignments, overall land usage, parkland commitments, stormwater management features, watercourse corridors, and natural areas. The Preliminary Demonstration Plan for the Kanata North Community Design Plan is shown in Figure 2. As shown in Figure 2, the KNCDP area will see a diverse mixture of development uses including community parks, schools, transportation infrastructure including major roads, a park and ride, commercial land use, high density and mixed density residential, and associated stormwater and servicing infrastructure. Typically, at the Community Design level of planning, final design details such as lot alignments, grading, final densities, etc. are not presented. This information will ultimately be presented by individual landowners when they develop and submit their own Draft Plan of Subdivision. The purpose of the Community Design plan is to provide an overall planning document that will guide detailed design. The overall permitting and planning approach is discussed in greater detail below.

Stormwater infrastructure for the KNCDP area will include two (2) new ponds west of March Road (in Quadrants A and C) as well as a stormwater facility east of the KNCDP area in lands owned by the landowners group.

The Preliminary Demonstration Plan (Figure 2) currently includes a watercourse corridor for the North Branch and North Tributary of Shirley's Brook that will be, at minimum, 40 m wide. In some locations the corridor width may be adjusted to accommodate habitat compensation features, but overall a 40 m wide corridor (at minimum) will be maintained along the length of the watercourses. This 40 m corridor will serve as the major natural feature throughout the KNCDP area and will protect and enhance the functionality of the Shirley's Brook tributaries (discussed below). This corridor will be paired with a 6 m wide recreational trail, so that the total corridor width will be a minimum of 46 m. However, for the purposes of Blanding's Turtle habitat planning, it is assumed that the 40 m watercourse corridor will be considered separate of the 6 m wide recreational trail. As shown in Figure 2, it is anticipated that some sections of the tributaries will be realigned, and in general the habitat quality throughout the corridor will be enhanced through habitat compensation works (discussed in subsequent sections).



A:\GIS\OE-OT-019389 KANATA NORTH\MAP DOCUMENTS\20140728_FIGURE1_SITE LOCATION.MXD

Kanata North Community Design Plan

FIGURE 2: PRELIMINARY DEMONSTRATION PLAN "A-7"

C.E.P.E.O. - Conseil des écoles publiques de l'Est de l'Ontario

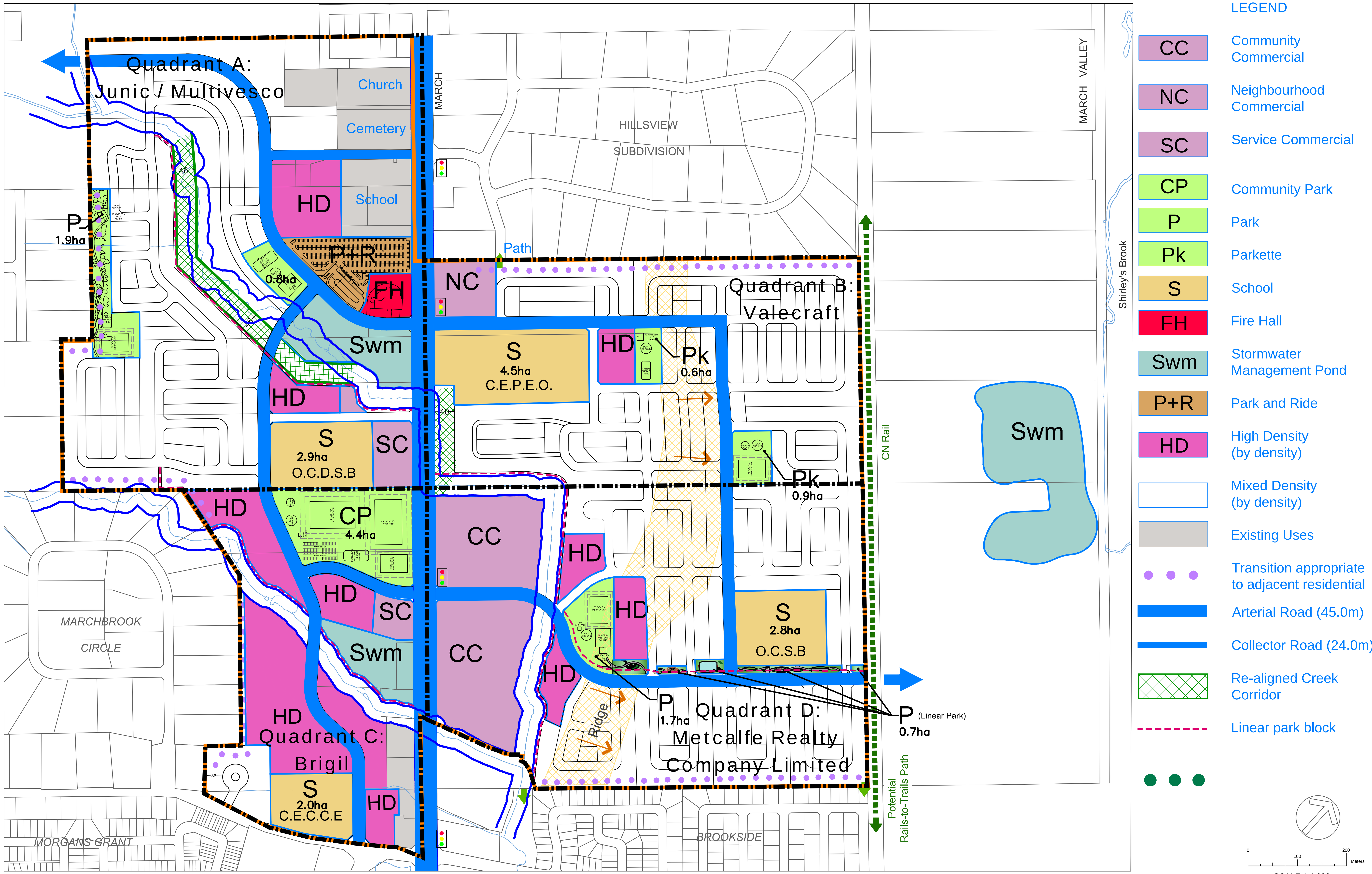
C.E.C.C.E - Conseil des écoles catholiques du Centre-Est

O.C.S.B - Ottawa Catholic School Board

O.C.D.S.B - Ottawa-Carleton District School Board

Parkland Required = 10.4ha
(2% of Total Commercial [0.25ha]
+ 1ha/300 units [per 3038 estimate in Novatech Memo dated August 12,2013]) [10.13]

Parkland Total = 10.9ha



March 04, 2015

1.3 Summary of Permitting Approach and Report Purpose

As discussed previously, the purpose of the current undertaking is to create an overall habitat management and compensation plan that will be acceptable to the regulatory agencies and which will establish a coordinated approach to fulfill future permitting and compensation requirements for the landowners. This report does not, in itself, represent a permit application. It is anticipated that, in consultation with OMNRF, the information presented in this report will ultimately provide an overall framework that will achieve several objectives:

- Provide a habitat balance sheet showing anticipated levels of impact and compensation required, based on the Preliminary Demonstration Plan (Figure 2). This analysis is subdivided among the four (4) quadrants to provide the rationale by which each major landowner may apply for an authorization under the Ontario Endangered Species Act (ESA). Each landowner will be responsible for updating this information based on the detailed designs that they develop, and will ultimately be required to obtain their own *Overall Benefit Permit* (OBP) under clause 17(2)(c) of the ESA (2007), as amended by the recently revised regulations of the ESA effective July 2013;
- Provide detail on the size and number of habitat compensation features that are likely to be required to demonstrate overall benefit, so that these can be integrated (conceptually) within the Community Design Plan;
- Provide certainty that the current Community Design Plan has allowed for sufficient space to accommodate anticipated habitat compensation requirements;
- Provide a framework, including habitat balance calculations, quantification methodology, and description of habitat compensation features, which each landowner can utilize to prepare and obtain their own OBP applications;
- This analysis has been conducted and designed so that each quadrant (e.g. each major landowner) may independently demonstrate an overall benefit through the compensation approach outlined in this report, and hence is intended to enable each major landowner to independently achieve their own OBP. The primary benefit of a coordinated approach is that this will allow for a large scale corridor to be created across the KNCDP area (discussed in subsequent sections);
- Identify and suggest mitigation measures for any other potential impacts to Blanding's Turtle (e.g. potential impacts to individuals); and
- Reach an *Agreement in Principle* with OMNRF that it is understood that the compensation features and framework outlined in this plan, if appropriately updated and translated into an OBP application, would likely be supported by OMNRF.

It is understood that the individual landowners will be required to pursue their own authorizations under the Ontario ESA and will also conduct their own Environmental Impact Statements (EIS) and other analyses to complete the approvals process. The habitat balance sheet and associated calculations included in this report are based on the Community Design Plan (Figure 2 – Preliminary Demonstration Plan). It is understood that the individual landowners, during the detailed design phase, may adjust or deviate from what is shown in the Preliminary Demonstration Plan as required to complete detailed design. However, they will each be responsible for updating the analysis outlined in this report to match their final design details, and will be required to demonstrate through their OBP applications that the final design achieves the objectives and compensation requirements outlined in this report.

This Compensation Plan will inform the final Community Design Plan and will establish an overall compensation approach that will ensure the success of future permit applications for each individual subdivision within the KNCDP area. This plan has been developed in consultation with the OMNRF.

1.4 Summary of Consultation with OMNRF

Consultation with the OMNRF was initiated with a joint meeting held on September 23rd, 2014 where the Community Design Plan process was discussed and the need for a coordinated Blanding's Turtle Habitat Compensation Plan was identified. Minutes from this meeting are included in Appendix A. During this meeting OMNRF, DST, and Novatech agreed that a Blanding's Turtle Habitat Compensation Plan to support the Community Design Plan process would be necessary and would ultimately help to coordinate the permitting and compensation approach for each of the landowners within the Kanata North Landowners Group. It was identified that while this plan would establish a coordinated approach and framework for Blanding's Turtles habitat throughout the KNCDP area, ultimately each individual landowner would be required to obtain their own permits. It was discussed that the Blanding's Turtle Habitat Compensation Plan would demonstrate the impacts and compensation requirements for each landowner separately, within the context of a larger coordinated plan, and that this information would form the basis of the permits that will ultimately be submitted by each individual landowner in the future.

It was also discussed that the core of the habitat compensation plan would involve establishment of a 46 m wide corridor along both tributaries of Shirley's Brook. This would include a 6 m wide recreational path and 40 m of protected habitat along the tributaries within which habitat enhancement and compensation work would be undertaken. OMNRF acknowledged that they were supportive of the 40 m watercourse corridor and that this plan was feasible. It was discussed and agreed that habitat compensation including creation of wetland areas, inline ponds, etc. would be undertaken within the 40 m corridor to enhance this area. OMNRF also identified the need for additional information surrounding the potential presence of habitat in woodlot S-20 and the functionality of habitat within the agricultural lands throughout the Site. It was initially agreed that a functional habitat mapping exercise would be undertaken whereby 'non-functional' Category 2 and 3 habitat would be removed from further consideration.

The functional habitat mapping exercise was completed and submitted to OMNRF in late 2014, along with additional information describing woodlot S-20. It was submitted that woodlot S-20 and non-functional areas of the agricultural fields should not be considered Category 2 habitat. Initially, OMNRF disagreed and identified that these areas should be shown as Category 2 habitat. Additional information was provided to OMNRF including a formal review request letter dated February 26, 2015, within which concerns were outlined regarding the designation of S-20 and the degraded areas of the agricultural fields as Category 2 habitat. OMNRF responded to this review request formally in a letter dated May 1, 2015 (Refer to Appendix A). This letter identified that the woodlot S-20 and S-23 would not be considered Category 2 habitat at this time. It also identified that 'non-functional' areas of Category 2 habitat adjacent to the tributaries could not be removed from the pre-development habitat mapping and must be shown as Category 2 habitat if they are within 30 m of the tributaries. It was determined that regardless of habitat quality, areas within 30 m of the wetland/watercourse feature must be included within the Category 2 habitat mapping. It was however acknowledged that the low quality of this habitat would be taken into consideration during the evaluation of overall benefit and compensation requirements.

1.5 Blanding's Turtle Background, Regional Context, and Occurrence

The Great Lakes/St. Lawrence Population of the Blanding's Turtle was listed as a threatened species under the Ontario Endangered Species Act (ESA) in 2007, and also as a threatened species under the federal *Species at Risk Act* in 2004. These designations prohibit activities that would harm, injure, harass, or otherwise interfere with individual Blanding's Turtles. Protection of this species' habitat under Ontario's ESA came into full effect in July of 2013, imposing restrictions on land usage in areas of designated turtle habitat (OMNRF 2012b).

Blanding's Turtles are a medium sized turtle which prefers shallow wetland areas including ponds, marshes, and streams with soft bottoms and abundant aquatic vegetation. These wetlands are usually shallow (e.g. under 110 cm deep) and are often eutrophic or nutrient enriched. While they primarily forage in wetland areas, Blanding's Turtles are highly terrestrial and utilize upland wooded and grassland habitats. Blanding's Turtles seasonally travel over land primarily to find suitable basking, overwintering, or nesting sites. This species is one of the most terrestrially mobile turtles in Ontario, and they may travel seasonally as far as 7 km in search of a nesting, overwintering, or foraging sites (OMNRF 2012c).

The main threats to the Blanding's Turtle in Ontario are mortality of breeding adults due to vehicle impacts, and habitat destruction. Secondary threats include poaching (e.g. illegal collection or harvesting) and invasive species (OMNRF 2012a). Because Blanding's Turtles are highly terrestrial and undertake seasonal movements overland, they are frequently found on or near roads. As a result, turtles are frequently killed by vehicle impacts. This species exhibits exceptional longevity, with some individuals living as long as 80 years. However, they do not sexually mature until 14-20 years of age and even when they are mature, many females do not breed every year. As such, Blanding's Turtles have very low fecundity (they breed very slowly) and are hence very sensitive to increased mortality of mature individuals (OMNRF 2012a; OMNRF 2012c). For this reason, protecting the breeding stock of sexually mature females in a Blanding's Turtle population is seen as one of the highest management priorities for conserving this species.

It is well documented that a comparatively large subpopulation of Blanding's Turtles occurs in the area of the South March Highlands in western Ottawa (west of the KNCDP area – refer to Figure 1). The management of this subpopulation received significant attention during the Environmental Impact Assessment (EIA) and the Canadian Environmental Assessment (CEAA) screening process for the extension of Terry Fox Drive (TFD) (Dillon 2010). The mitigation measures identified for the Blanding's Turtle subpopulation in the South March Highlands as part of the TFD Extension included the installation of a sophisticated wildlife guide wall, passage culverts, and a wildlife fencing system, monitoring of that system for a three year period, and monitoring of the Blanding's Turtle subpopulation for a four year period beginning in 2010 (Dillon 2012). Both monitoring programs have been conducted by Dillon Consulting and the subpopulation monitoring program concluded at the end of the 2013 active season (Dillon 2013b). As a result, a great deal of information exists describing the size of this subpopulation and their habitat usage. After three years of monitoring, it was confirmed that approximately 98 to 115 adult and juvenile Blanding's Turtles are living in the South March Highlands study area, which includes the southern portion of the South March Highlands Conservation Forest (SMHCF), the Trillium Woods, areas adjacent to the Carp River, and privately held lands associated with the KNL Phases 5, 7, 8, and 9 developments, as well as lands owned by other landowners. Dillon's subpopulation estimate of 115 individuals is likely to be low, as methods used for surveying are not effective for detecting young or juvenile turtles and it is also suspected that additional turtles may be present on properties north or west of their study area (Dillon 2013a).

There is also a substantial Blanding's Turtle subpopulation known to exist east of the KNCDP area along the southern shore of the Ottawa River. This subpopulation has previously been surveyed by DST (2014) within the Connaught Ranges and Primary Training Center (CRPTC), which is a large Department of Defense property (1200 ha) that includes all of Shirley's Bay and large areas of surrounding wetland. DST (2014) documented a large subpopulation of Blanding's Turtles within this area but did not conduct a mark-recapture study to create a detailed subpopulation estimate. However, a comparatively large number of individuals have been documented through the monitoring records of the Ottawa Duck Club (more than 80 unique individuals documented through incidental encounters) and DST (2014) conducted nest searches and basking surveys that demonstrated a high density of turtle nesting and basking activity within CRPTC. It is known that this Blanding's Turtle subpopulation occurs throughout the CRPTC lands along the southern shore of the Ottawa River and that the subpopulation and habitat is contiguous with turtles documented in the Mud Lake and Constance Bay areas to the northwest. While a detailed population estimate has not been conducted, the subpopulation along the southern shore of the Ottawa River is known to occupy a large habitat area stretching from CRPTC to Shirley's Bay, and beyond to Mud Lake and Constance Bay. Turtles in this area are believed to form a contiguous subpopulation that occupies a large area, and the overall population size is estimated to exceed that of the South March Highlands (DST 2014). It is likely that the Blanding's Turtle subpopulation living along the southern shore of the Ottawa River is the largest remaining population in the Ottawa area (DST 2014).

The KNCDP area exists within agricultural lands that are located between the South March Highlands and the Shirley's Bay Blanding's Turtle subpopulations (Figure 1). The KNCDP area was likely historically an important linkage habitat between the large wetlands that serve as core wetland habitat for these two subpopulations, and the habitat between them may have been continuous prior to agricultural development. Currently the area between the South March Highlands and Shirley's Bay is extensively modified by agricultural activities and there are no significant natural wetlands within the KNCDP area. However, Shirley's Brook and its tributaries continue to provide a potential movement corridor and ecological connection between these subpopulations, as Shirley's Brook and its tributaries flow directly from the South March Highlands to Shirley's Bay. Due to an absence of radio tracking data east of the South March Highlands, it is not currently known whether Shirley's Brook provides sufficient functional habitat to provide linkage between the two large subpopulations. In general, the area between the South March Highlands and Shirley's Bay can be characterized as a highly degraded area with comparatively little intact Blanding's Turtle habitat.

The degree to which these major subpopulation areas remain connected is a significant management and conservation planning concern, as isolation of these subpopulations from one another may result in a gradual loss of genetic diversity. The loss of genetic diversity (inbreeding) is known to be a major conservation threat to small remnant populations for many rare species and populations. Over time, this loss of genetic diversity may precipitate negative population effects such as reduced fertility, reduced survivorship, increased prevalence of genetic diseases, etc. through the effects of inbreeding. Because the total size of the two major subpopulations, and the degree to which they remain genetically connected, is not known with certainty, currently the degree to which loss of genetic diversity is a threat cannot be conclusively quantified. In the field of population genetics, there is a generally accepted rule that in order for populations to remain genetically connected, a breeding migrant must move from one subpopulation to the other at least once per generation (Mills & Allendorf 1996; Wang 2004). It is not known at the current time whether this level of genetic exchange is still being achieved between the two major subpopulations.

Until recently no confirmed sightings of Blanding's Turtle in the lands between the South March Highlands and Shirley's Bay were documented. This led to the assumption that the highly degraded habitat between these areas was not sufficiently functional to provide linkage between these areas. Muncaster Environmental Planning (MEP) completed surveying in spring 2014 and identified the presence of one Blanding's Turtle and its habitat within the KNCDP area (MEP 2014a). This consisted of an early season sighting (May 5th, 2014) of a single Blanding's Turtle in a small farm pond west of March Road (Figure 1 & 3). Due to the early nature of the sighting in this pond, it is presumed that this pond has the potential to function as a hibernacula habitat and is hence shown as Category 1 habitat in Figure 3 (see subsequent sections). During the survey a second sighting of a single Blanding's Turtle was also noted in the same location on May 12th, 2014 (presumed to be the same individual) and also two unidentified turtles were noted (MEP 2014a). The turtle was not seen during later survey events in late May and June. These sightings occurred in the small farm pond west of March Road, which is comparatively far from any large wetlands and is approximately halfway between Shirley's Bay and the South March Highlands (Figure 1). The pond itself, and wetland habitats around it, are presumed to be too small to support this turtle for the entire year, and so it is believed that it is likely that this turtle utilizes the pond seasonally for hibernation purposes, but must return to larger foraging areas during the active season. These sightings suggest that the KNCDP area continues to provide some degree of functional Blanding's Turtle habitat, and has the potential to provide a linkage function between the major regional subpopulations of the South March Highlands and Shirley's Bay. However, under current conditions any turtle travelling through the KNCDP area would face a high risk due to the absence of any significant turtle exclusion or passage systems. Turtles passing through the area would currently be required to traverse large areas of heavily degraded habitat; there are few significant wetland features or refuge ponds in which to rest during overland movement, and a significant risk to the turtles is likely posed by the high levels of road traffic and agricultural machinery activities.

2.0 Existing Conditions – Pre-Development Habitat Features

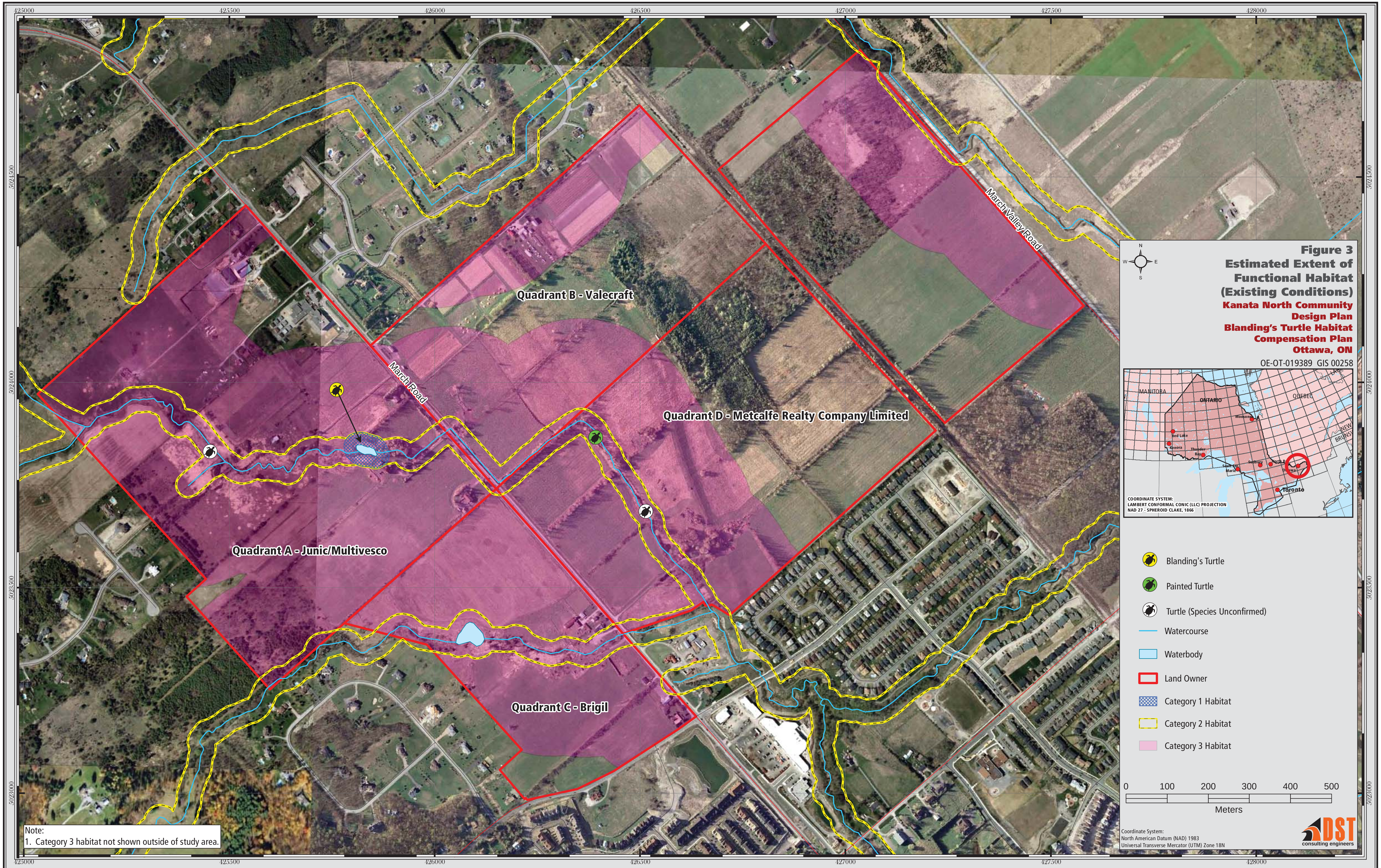
2.1 Mapping Methodology and Habitat Summary

The *General Habitat Description for the Blanding's Turtle (Emydoidea blandingii)* (OMNRF 2013) was used to describe the extent of potential Blanding's Turtle habitat within the KNCDP area. MEP completed surveying in spring 2014 and identified the presence of a Blanding's Turtle and its habitat within the KNCDP area (MEP 2014a). This included an early season sighting (May 5th, 2014) of a single Blanding's Turtle in a small farm pond west of March Road (Figure 1). Due to the early nature of the sighting in this pond, it is presumed that this pond has the potential to function as a hibernacula habitat and is hence shown as Category 1 habitat in Figure 3. During the survey a second sighting of a single Blanding's Turtle was also noted in the same location on May 12th, 2014 (presumed to be the same individual). Two unidentified turtles were also noted (MEP 2014a).

As outlined in the *General Habitat Description*, the wetland complex, which is defined as all suitable wetlands and waterbodies within 500 m of one another extending up to 2 km from an occurrence, qualify as Category 2 habitat. Because the entirety of the KNCDP area is within 2 km of the noted occurrences, all suitable waterbodies and wetland areas are shown as Category 2 habitat. This includes the two tributaries of Shirley's Brook which are referred to as the North Branch and the North Tributary (Figures 3) as well as a pond along the North Branch and the Category 1 pond along the North Tributary (Figure 3).

As discussed with OMNRF Kemptville and confirmed formally in their letter dated May 1, 2015 (Refer to Appendix A) the woodlot S-20 located in Quadrant B and D does not meet the definition of Category 2 habitat and hence is not shown as Category 2 habitat in Figure 3. The woodlot S-20 was judged to not meet the definition of Category 2 habitat for several reasons. These included the absence of significant standing water beyond the early spring, the absence of aquatic plants, and the absence of core permanent wetland features such as ponds, marshes, watercourses, etc. Refer to MEP (2013b) for further detail regarding the woodlot S-20.

As shown in Figure 3, Category 3 habitat has been identified generically around the Category 2 habitat as the area between 30 m and 250 m from the edge of the Category 2 habitat (e.g. by applying a buffer of 220 m around the Category 2 habitat).



A:\GIS\OE-OT-019389 KANATA NORTH\MAP DOCUMENTS\20150206_FIGURE3_ESTIMATED EXTENT OF FUNCTIONAL HABITAT_UPDATE.MXD

2.2 Category 1 and Category 2 Habitat Quality

As shown in Figures 3 and 4, the only area of Category 1 habitat within the KNCDP area is the small artificially dug farm pond in Quadrant A west of March Road. The precise age of this pond is not known, but a review of historic air photos available through Geo-Ottawa shows that the pond has existed since at least 1991 but was not present in 1976. The pond was therefore dug sometime between 1976 and 1991 (City of Ottawa 2015). The pond is an oval feature approximately 45 m x 15 m in size and is shallower on its western side, where there is dense coverage of aquatic plants in the summer. The eastern portion of the pond is deeper and has an open water patch. A small treed area exists east of the pond, but otherwise there is relatively little riparian vegetation around it.

In general, the quality of Category 2 habitat within the KNCDP area is currently very poor. This is because the majority of the North Tributary and North Branch within the KNCDP area currently flow through highly developed agricultural areas. In many areas high intensity agricultural operations occur very close to the channel and are buffered only by a thin hedgerow, particularly east of March Road. The stretches of both tributaries west of March Road have marginally better habitat conditions, but even in these areas the riparian vegetation which exists is primarily the result of regenerating (fallow) agricultural fields, which have a high proportion of invasive plant species. While some areas west of March Road show up to 60 m of functional habitat, in reality these represent fallow fields that have not been able to regenerate over the long term and would be periodically cleared and planted. It should also be noted that in several sections the North Tributary has historically been channelized and realigned for agricultural purposes, including in a north-south stretch west of March Road, and in two large stretches immediately east of March Road (Figure 3). In addition, there are no large areas of wetland vegetation along both tributaries under existing conditions, and in general aquatic plants are currently limited to those growing within the channel itself. The only significant areas of deeper water are the Category 1 pond along the North Tributary and the Category 2 pond along the North Branch.

While OMNRF has advised that the areas within 30 m of the tributaries should be shown as Category 2 habitat regardless of habitat quality, it was also acknowledged that many of these areas are highly degraded. In order to provide an estimate of the level of degradation and the relative size of different vegetative habitats within the Category 2 area, vegetative communities have been mapped and quantified according to several broad categories. This mapping is shown in Figures 4 to 7. The results of this analysis are summarized in Table A (see below). As shown in Figures 4 to 7, the Category 2 habitat within each quadrant is classified either as pond (e.g. permanent open water), channel/bank (the wetted channel of the tributary), fallow/regenerating field (fields which are currently fallow), pasture (areas utilized for intensive cattle grazing), treed areas (including hedgerows and small woodlots), and row crops (which includes areas of high density planting including soy bean and corn fields). The pasture and row crop are the most intensively modified areas which are highly degraded and unlikely to provide significant functional benefits to Blanding's Turtle. These areas are labelled as 'marginal habitat' in Table A and throughout this report. Fallow/regenerating fields and the treed areas are also generally highly degraded and fragmented throughout the study area, but may provide some level of buffering of aquatic features. The ponds and channel/bank are the wetland habitats that provide the greatest level of habitat functionality, but none of these wetland areas are in good condition.

The vegetation classification was undertaken using a combination of aerial photo interpretation and site inspections. It is acknowledged that this is an estimate, and also that the land usage may change from year to year, particularly with regards to the total size of fallow/regenerating fields. Nonetheless, this analysis provides a reasonable indication of the current level of habitat degradation.

As summarized in Table A – the total size of open water ponds is currently only 0.26 ha. The area of the channel/bank is estimated to be approximately 2.9 ha across all quadrants. Combined, these habitats account for approximately 19% of the Category 2 habitat across the study area. Treed areas and fallow/regenerating fields account for the largest proportion of the Category 2 habitat, totaling approximately 53%. The most degraded areas (row crops and pasture) account for approximately 28% of the Category 2 habitat. It should be noted that the proportion of the habitat in these different categories is not evenly distributed between quadrants. For example, Quadrant A has approximately 2/3rds of the wetland habitats (channel/bank and open water), whereas the Category 2 habitat in Quadrant B is approximately 69% row crop and pasture.

Clearly these results suggest that the Category 2 habitat is highly degraded, with approximately 19% of the Category 2 habitat being occupied by wetland habitats and the rest being predominantly terrestrial areas that are moderately degraded (treed areas and fallow/regenerating fields) to severely degraded (pasture and row crop). To put this in context, a typical intact wetland of a medium size that is shown as Category 2 habitat, for example a circular shaped 5 ha wetland with 30 m of terrestrial habitat on all sides, would have approximately 65% of the Category 2 habitat occupied by the wetland while the remaining 35% would be the terrestrial 30 m buffer around the wetland feature. This would represent a more typical ratio of wetland to terrestrial habitat for a Category 2 area that is not highly degraded.

Table A: Pre-Development (Existing Conditions)

	Habitat Type	Quadrant A Junic Multivesco		Quadrant B Valecraft		Quadrant C Brigil		Quadrant D Metcalfe Realty		All Quadrants	
		Size (m or ha)	% of Cat. 2 Total	Size (m or ha)	% of Cat. 2 Total	Size (m or ha)	% of Cat. 2 Total	Size (m or ha)	% of Cat. 2 Total	Size (m or ha)	% of Cat. 2 Total
Watercourse	Watercourse Length (m)	1328	NA	357	NA	551	NA	648	NA	2884	NA
Category 1	**Pond Size - Category 1 (ha)***	**0.08**	**NA**	**0.00**	**NA**	**0.00**	**NA**	**0.00**	**NA**	**0.08**	**NA**
Category 2	Pond Size - Category 2 (ha)*	0.00	0%	0.00	0%	0.26	7%	0.00	0%	0.26	2%
Wetland Areas	Channel/Bank (ha)	2.10	29%	0.11	8%	0.34	9%	0.35	8%	2.90	17%
(Functional Habitat)	**Subtotal - Wetland Areas (ha)**	**2.10**	**29%**	**0.11**	**8%**	**0.60**	**15%**	**0.35**	**8%**	**3.16**	**19%**
Category 2	Fallow/Regenerating Field (ha)	2.77	38%	0.00	0%	2.13	54%	0.45	10%	5.35	32%
Terrestrial Habitat	Treed Area (ha)	0.43	6%	0.28	22%	1.00	25%	1.93	44%	3.64	21%
(Buffer Areas)	**Subtotal - Terrestrial Habitat (ha)**	**3.20**	**43%**	**0.28**	**22%**	**3.13**	**79%**	**2.38**	**54%**	**8.99**	**53%**
Category 2	Pasture (ha)	1.06	14%	0.00	0%	0.00	0%	0.00	0%	1.06	6%
Terrestrial Habitat	Row Crop (ha)	1.00	14%	0.88	69%	0.23	6%	1.65	38%	3.76	22%
(Marginal Areas)	**Subtotal - Terrestrial Habitat (Marginal Areas) (ha)**	**2.06**	**28%**	**0.88**	**69%**	**0.23**	**6%**	**1.65**	**38%**	**4.82**	**28%**
Category 2 - Total	**Total - All Category 2 Habitat**	**7.36**	**100%**	**1.27**	**100%**	**3.96**	**100%**	**4.38**	**100%**	**16.97**	**100%**

*Pond Size Only Counts Pond Surface, Buffer Area Counted in Other Categories

2.3 Category 3 Habitat Quality

As discussed previously, while large portions of the KNCDP area are shown as Category 3 habitat, nearly all of this area is devoid of wetland environments and is severely degraded. The majority of Category 3 habitat within the KNCDP area consists of operational agricultural fields (row crops) which are likely to provide little functional habitat. While Blanding's Turtles could theoretically traverse the KNCDP area in a direct east-west path, turtles passing through the area would currently be required to traverse large areas of heavily degraded habitat, in which there are few significant wetland features or refuge ponds to rest during overland movement. Also, a risk to the turtles is posed by road traffic and agricultural machinery activities. It is therefore likely that the majority of the upland Category 3 habitat offers little functionality. Under current conditions the primary functional movement corridor is likely provided by the two tributaries of Shirley's Brook. These are the only areas within the KNCDP area which are believed to provide a relatively safe movement corridor and which would be sufficiently wet in the spring season to provide some resting, basking, and feeding habitat. It is likely that these tributaries provide the main viable movement corridor for Blanding's Turtle that attempt to traverse the KNCDP area.

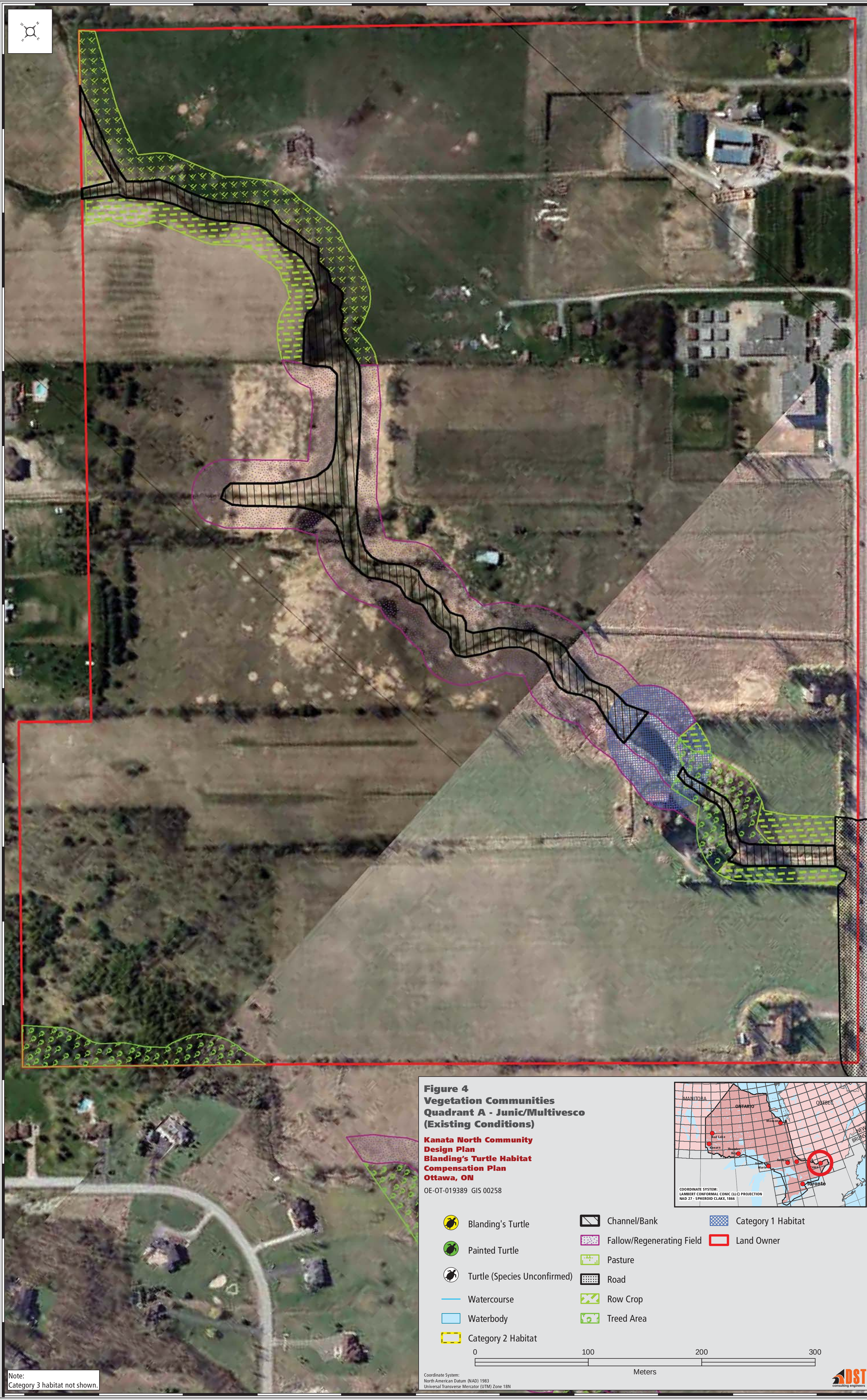


Figure 4
Vegetation Communities
Quadrant A - Junic/Multivesco
(Existing Conditions)

Kanata North Community Design Plan
Blanding's Turtle Habitat Compensation Plan
Ottawa, ON

OE-OT-019389 GIS 00258

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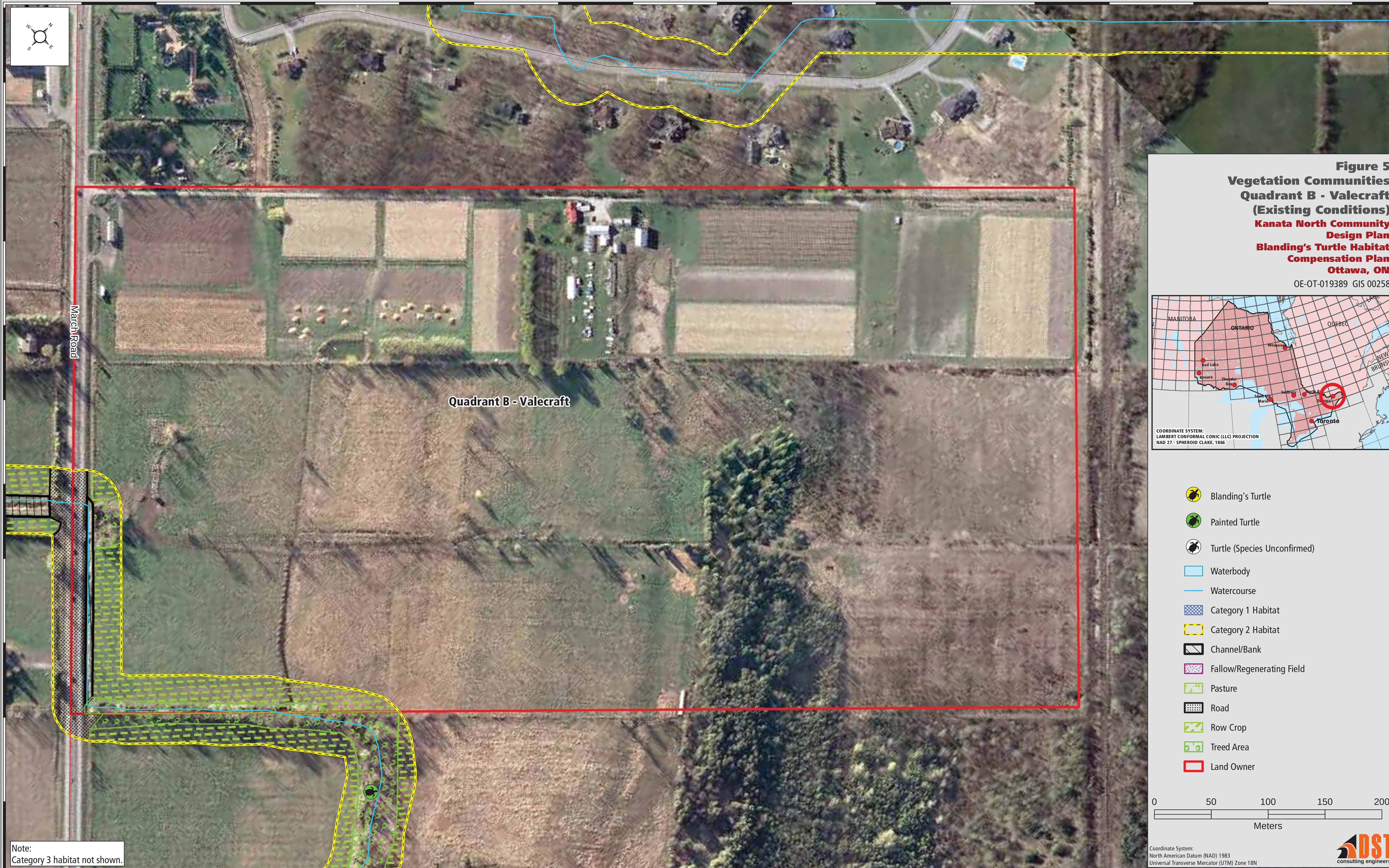

A:\GIS\OE-OT-019389 KANATA NORTH\MAP DOCUMENTS\20150213_FIGURE5_QUADRANT B - VALECRAFT.MXD

A:\GIS\OE-OT-019389 KANATA NORTH\MAP DOCUMENTS\20150213_FIGURE6_QUADRANT C - BRIGIL.MXD

A:\GIS\OE-OT-019389 KANATA NORTH\MAP DOCUMENTS\20150213_FIGURE7_QUADRANT D - METCALFE REALTY.MXD

2.4 Blanding's Turtle Habitat Quantification

The estimated extent of habitat (pre-development) is shown in Figure 3, while the vegetative habitat details are shown in Figures 4 to 7. Table A (above) summarizes the estimated spatial extent of each habitat category during pre-development (existing) conditions. These results are subdivided into each of the four quadrants. The spatial extent of each habitat category was measured by calculating the surface area (hectares) of each habitat category utilizing GIS based analysis. Each habitat category is calculated based on the habitat mapping shown in Figure 3.

3.0 Avoidance Measures

As shown in Figure 2, the Preliminary Demonstration Plan proposes a watercourse corridor 40 m wide. Maintenance of this corridor avoids impacts to the majority of Category 2 habitat and will maintain the current tributary alignment for most of the North Tributary and essentially all of the North Branch. The maintenance of the existing watercourses within the proposed 40 m corridor for the majority of the tributary lengths represents an avoidance measure.

4.0 Potential Habitat Impacts

Table B (below) summarizes all habitats following the proposed development, while Table C summarizes the quantification of potential habitat loss. The quantification of habitat loss is based on the Preliminary Demonstration Plan (Figure 2) and shows the net loss of habitat *prior to* the implementation of any habitat compensation features. As such, Table C represents the anticipated loss of habitat if no additional compensation features were implemented other than maintaining a 40 m watercourse corridor. This information is shown for illustrative purposes, so that the rationale for the size and placement of habitat compensation features is understood. The overall balance of habitat (the actual proposed post development conditions), with habitat compensation features implemented, is discussed in Section 6.0.

While the existing tributary alignment will likely be maintained in several stretches, as noted in the previous section, the Preliminary Demonstration Plan (Figure 2) identifies two stretches of the North Tributary which will be realigned. This includes most of the North Tributary alignment west of March Road as well as a north-south section shown immediately east of March Road (Figure 2). The effect of this realignment is to relocate the habitat in order to accommodate the subdivision design and stormwater infrastructure. The realignment, as well as the proposed stormwater management pond, will likely result in the loss of the Category 1 hibernacula pool (Figure 2 & 3). The loss of this Category 1 hibernacula pool is shown in Table C (below) as an anticipated impact. Because there are no known Category 1 nesting areas within the KNCDP area, there is no loss of nesting habitat shown in Table C.

The realignment of the tributaries will result in some new areas being shown as Category 2 habitat that are not currently shown as habitat. This is because the position of the watercourse will have changed. These are shown in Table C as 'new areas'. These 'new areas' will be entirely terrestrial areas that are brought within the realigned 40 m corridor, and hence will be Category 2 habitat. The full extent of Category 2 habitat loss is -6.83 ha, but with these 'new areas' taken into account (+1.44 ha), the net loss of Category 2 habitat is -5.39 ha. It is appropriate to factor in the 'new areas' as they will primarily include fallow/regenerating fields and row crops that will be within the new 40 m watercourse corridor, and these areas will be similar to those terrestrial buffer areas that are lost during the realignment.

As shown in Table C, approximately 34% of the lost Category 2 habitat are the 'marginal areas' (row crops and pasture) which currently provide relatively little habitat value. Approximately 49% of the lost Category 2 habitat is fallow/regenerating fields and treed areas which provide limited buffer functions but no core wetland habitat functionality. The actual wetland areas that will be lost (the ponds and channel/bank), account for only 17% of the lost Category 2 area. The portion of the lost Category 2 habitat which is currently wetland is hence as little as approximately -1.13 ha.

It is expected that the realignment of sections of the North Tributary will have an overall positive effect on the functionality of the Category 2 habitat. This is because the realignment will include channel naturalization and rehabilitation elements which are expected to improve the overall functionality of the realigned stretches. While there will be a net loss in the size of the habitat as the watercourse corridor is narrowed to 40 m, the overall habitat quality and functionality will be improved as the entire 40 m will be made functional higher quality habitat, compared to the largely degraded habitat with limited functionality that currently exists. Habitat enhancement measures are discussed in detail in Section 6.0 and are designed to improve the quality and functionality of habitat throughout the post development watercourse corridor.

The majority of Category 3 habitat in upland areas outside of the watercourse corridor will be lost. Category 3 habitat is defined by the *General Habitat Description for Blanding's Turtle* as the area from 30 m to 250 m from the edge of Category 2 habitat. Because none of the area outside of the proposed 40 m watercourse corridor will be retained (Refer to Figure 2), the majority of Category 3 habitat will be lost. However, as discussed previously, nearly all of the area shown as Category 3 habitat is devoid of wetland environments and is heavily degraded. The majority of Category 3 habitat within the KNCDP area consists of operational agricultural fields which are likely to provide little functional habitat. While Blanding's Turtles could theoretically traverse the KNCDP area in a direct east-west path, turtles passing through the area would currently be required to traverse large areas of heavily degraded habitat, in which there are few significant wetland features or refuge ponds in which to rest during overland movement. Also, a risk to the turtles is posed by road traffic and agricultural machinery activities. It is therefore likely that the majority of the upland Category 3 habitat offers little functionality. Under current conditions, the primary functional movement corridor is likely provided by the two tributaries of Shirley's Brook. The tributaries are the only features within the KNCDP area which are believed to provide a relatively safe movement corridor and which would be sufficiently wet in the spring season to provide some resting, basking, and feeding habitat. It is likely that these tributaries provide the main viable movement corridor for Blanding's Turtle that attempt to traverse the KNCDP area.

Table B (below) shows the estimated size of habitat features following development and Table C (below) shows the size of potential habitat impacts. Both tables do not include habitat enhancement measures, which are discussed in Section 6.0.

Table B: Post Development Conditions (40 m Corridor) (Without Habitat Enhancement Measures)

	Habitat Type	Quadrant A Junic Multivesco		Quadrant B Valecraft		Quadrant C Brigil		Quadrant D Metcalfe Realty		All Quadrants	
		Size (m or ha)	% of Cat. 2 Total	Size (m or ha)	% of Cat. 2 Total	Size (m or ha)	% of Cat. 2 Total	Size (m or ha)	% of Cat. 2 Total	Size (m or ha)	% of Cat. 2 Total
Watercourse	Watercourse Length (m)	1293	NA	357	NA	551	NA	655	NA	2856	NA
Category 1	**Pond Size - Category 1 (ha)***	**0.00**	**NA**	**0.00**	**NA**	**0.00**	**NA**	**0.00**	**NA**	**0.00**	**NA**
Category 2	Pond Size - Category 2 (ha)*	0.00	0%	0.00	0%	0.26	9%	0.00	0%	0.26	3%
	Channel/Bank (ha)	0.99	32%	0.09	7%	0.34	12%	0.35	12%	1.77	17%
	Subtotal - Wetland Areas (ha)	**0.99**	**32%**	**0.09**	**7%**	**0.60**	**22%**	**0.35**	**12%**	**2.03**	**20%**
Category 2	Fallow/Regenerating Field (ha)	0.93	30%	0.00	0%	1.15	42%	0.31	10%	2.39	24%
	Treed Area (ha)	0.27	9%	0.29	24%	0.96	35%	1.70	56%	3.22	32%
	Subtotal - Terrestrial Habitat (ha)	**1.20**	**38%**	**0.29**	**24%**	**2.11**	**76%**	**2.01**	**66%**	**5.61**	**55%**
Category 2	Pasture (ha)	0.23	7%	0.00	0%	0.00	0%	0.00	0%	0.23	2%
	Row Crop (ha)	0.70	22%	0.84	69%	0.05	2%	0.68	22%	2.27	22%
	Subtotal - Terrestrial Habitat (Marginal Areas) (ha)	**0.93**	**30%**	**0.84**	**69%**	**0.05**	**2%**	**0.68**	**22%**	**2.50**	**25%**
Category 2 - Total	**Total - All Category 2 Habitat**	**3.12**	**100%**	**1.22**	**100%**	**2.76**	**100%**	**3.04**	**100%**	**10.14**	**100%**
Category 2 (New Areas)	New Areas (Re-Aligned Corridor - Not Classified) (ha)	1.36	NA	0.06	NA	0.00	NA	0.02	NA	1.44	NA

*Pond Size Only Counts Pond Surface, Buffer Area Counted in Other Categories

Table C: Post Development Habitat Loss (40 m Corridor) (Without Habitat Enhancement Measures)

	Habitat Type	Quadrant A Junic Multivesco Size (m or ha)	Quadrant A Junic Multivesco % of Cat. 2 Total	Quadrant B Valecraft Size (m or ha)	Quadrant B Valecraft % of Cat. 2 Total	Quadrant C Brigil Size (m or ha)	Quadrant C Brigil % of Cat. 2 Total	Quadrant D Metcalfe Realty Size (m or ha)	Quadrant D Metcalfe Realty % of Cat. 2 Total	All Quadrants Size (m or ha)	All Quadrants % of Cat. 2 Total
Watercourse	Watercourse Length (m)	-35	NA	0	NA	1	NA	7	NA	-28	NA
Category 1	**Pond Size - Category 1 (ha)***	**-0.08**	**NA**	**0.00**	**NA**	**0.00**	**NA**	**0.00**	**NA**	**-0.08**	**NA**
Category 2 Wetland Areas (Functional Habitat)	Pond Size - Category 2 (ha)*	0.00	0%	0.00	0%	0.00	0%	0.00	0%	0.00	0%
	Channel/Bank (ha)	-1.11	26%	-0.02	36%	0.00	0%	0.00	0%	-1.13	17%
	Subtotal - Wetland Areas (ha)	**-1.11**	**26%**	**-0.02**	**36%**	**0.00**	**0%**	**0.00**	**0%**	**-1.13**	**17%**
Category 2 Terrestrial Habitat (Buffer Areas)	Fallow/Regenerating Field (ha)	-1.84	43%	0.00	0%	-0.98	82%	-0.14	10%	-2.96	43%
	Treed Area (ha)	-0.16	4%	0.01	-21%	-0.04	3%	-0.23	17%	-0.42	6%
	Subtotal - Terrestrial Habitat (ha)	**-2.00**	**47%**	**0.01**	**-21%**	**-1.02**	**85%**	**-0.37**	**28%**	**-3.38**	**49%**
Category 2 Terrestrial Habitat (Marginal Areas)	Pasture (ha)	-0.83	20%	0.00	0%	0.00	0%	0.00	0%	-0.83	12%
	Row Crop (ha)	-0.30	7%	-0.04	86%	-0.18	15%	-0.97	72%	-1.49	22%
	Subtotal - Terrestrial Habitat (Marginal Areas) (ha)	**-1.13**	**27%**	**-0.04**	**86%**	**-0.18**	**15%**	**-0.97**	**72%**	**-2.32**	**34%**
Category 2 - Total	**Total - All Category 2 Habitat Loss****	**-4.24**	**100%**	**-0.05**	**100%**	**-1.20**	**100%**	**-1.34**	**100%**	**-6.83**	**100%**
Category 2 (New Areas)	New Areas (Re-Aligned Corridor - Not Classified) (ha)	1.36	NA	0.06	NA	0.00	NA	0.02	NA	1.44	NA
Category 2 -Net Habitat Loss	**Total - Category 2 Net Habitat Loss*****	**-2.88**	**NA**	**0.01**	**NA**	**-1.20**	**NA**	**-1.32**	**NA**	**-5.39**	**NA**
	Total - Category 2 Net Habitat Loss* Excluding Marginal Areas**	**-1.75**	**NA**	**0.05**	**NA**	**-1.02**	**NA**	**-0.35**	**NA**	**-3.07**	**NA**

*Pond Size Only Counts Pond Surface, Buffer Area Counted in Other Categories
** This Is The Total Loss of Habitat Before Factoring in New Habitat Areas (Not Classified Areas) Brought in by Re-aligning the Corridor
***Net Loss Assumes All New Areas Brought in By Realigning The Corridor Are Made Into Category 2 Habitat

5.0 Potential Impacts to Individuals

Ultimately, the OBP applications for each individual subdivision will be required to assess and address potential impacts to individual turtles, in addition to the potential habitat impacts discussed above. Potential impacts to individual turtles are discussed generically in the following sections. These potential impacts will be considered and addressed in greater detail through the Environmental Impact Statements (EIS) and OB Permit applications for each individual subdivision.

5.1 Potential Impacts during Construction

During the land clearing and construction stages of the future developments, there is potential for short term impacts to individual Blanding's Turtles resulting directly from construction activities. Potential impacts may include:

- Injury or mortality of adults in terrestrial habitats due to vehicle impacts, during excavations, or during land clearing;
- Injury or mortality of adults in aquatic habitats (e.g. Tributaries of Shirley's Brook) during excavations, diversion or dewatering for the realignment;
- Destruction of previously unidentified nesting areas during site preparation and excavation;
- Interruption of movement to essential foraging, breeding, or overwintering areas due to site fencing or sediment and erosion control fencing;
- Potential interference with overwintering individuals during realignment of tributaries;
- Potential entrapment of individuals within terrestrial areas as a result of fencing; and
- Potentially decreased water quality within the tributaries during adjacent work (e.g. increased turbidity, suspended solids loading, etc.).

The risks associated with many of these impacts will be minimized through the implementation of construction staging and timing restrictions, as discussed in Section 7.1. Potential impacts will be further mitigated through the implementation of construction stage mitigation measures and monitoring, as outlined in Section 7.1.

5.2 Vehicle Impacts

A cumulative impact that may result from increased urban development is increased road traffic, which may increase the likelihood of mortality from vehicle impacts. New and upgraded roads will cross the tributaries in at least five (5) locations (as shown in Figure 2). The existing situation in terms of potential vehicle impacts is already such that the risk of road related mortality for turtles moving through the area would likely be significant. The main road access through the area under existing conditions is March Road, which already has significant traffic volumes, moving at high speeds. The two locations where March Road currently passes over the two tributaries were not designed for safe wildlife movement and do not feature wildlife passage systems that would significantly reduce the risk to Blanding's Turtles. The potential for road mortality along March Road and other secondary roads under existing conditions is essentially unmitigated. While road related mortality poses a significant risk to Blanding's Turtles in general, the development of the Kanata North area will likely reduce this risk overall. While there will be greater traffic volumes and more arterial roads with more tributary crossings following development (as shown in Figure 2), mitigation measures including fencing and modern wildlife passage systems will ensure that the potential for road mortality is better mitigated and controlled following development compared to existing conditions. Mitigation measures to reduce the risk of road mortality are discussed in greater detail in Section 7.2, and it is expected in general that the creation of a controlled and fenced movement corridor, with modern wildlife passage systems, will reduce the risk of road mortality following development.

5.3 Increased Predation and Urban Wildlife

Blanding's Turtles, like all wild turtles, experience naturally occurring predation. Predation is a natural part of any ecological system, though anthropogenic factors may influence predation rates and the abundance of predatory species. Adult Blanding's Turtles over 10 cm in size have comparatively few natural predators and generally full grown adults are rarely predated, though the risk of predation increases during egg laying and overland movement through open areas (Congdon et al. 2008). The primary influence of predation on Blanding's Turtles is through predation of nests and also predation of juveniles and hatchlings. Blanding's Turtles' reproductive success is limited by high natural predation rates and inherent vulnerability of nests and hatchlings (Congdon et al. 2008).

Juveniles and hatchlings may be impacted by a variety of medium to large predators including snapping turtles, fox, raccoons, snakes, skunks, mink, herons, etc. Nest predation is very common and is primarily undertaken by animals which are effective at rapidly locating new nests, including foxes, raccoons and skunks. In many cases nest predation occurs within minutes of eggs being laid and most predation occurs within three days of egg laying (Congdon et al. 1983, 2000). A long term mark recapture study undertaken in Michigan (Congdon et al. 1993) found that on average 43.8% of nests are predated, but also that nest predation rates can show a high degree of natural variability. In addition to nest predation, parasitism of eggs by a sarcophagid fly has been shown to contribute to low nest success in some populations (Congdon et al. 2008).

Suburban and urban areas, particularly those close to retained natural features (such as Kanata North), can experience increased densities of some medium sized predatory species. This is due to several factors including loss of apex predators in suburban environments (e.g. wolves), food subsidies from urban garbage, increased availability of suitable anthropogenically created nesting/overwintering sites, increased availability of prey species, etc. A wide variety of species in many taxonomic groups have been shown to increase in abundance in suburban and urban areas, including some of Blanding's Turtle's predators such as skunks, foxes, and raccoons (Prange et al. 2003). The development of Kanata North (and other surrounding developments) may increase the abundance of some of the predatory species which target Blanding's Turtles. However, the specific impact of Kanata North on the abundance of predatory species would be difficult to accurately predict, and it is not known how this will translate to influence predation rates. In light of the fact that surrounding areas to the south and west are already developed, it is difficult to quantify what effect Kanata North will have on predator populations and how this will translate directly to increased predation of Blanding's Turtles. Mitigation measures to reduce the potential impact of increased predator density are discussed in Section 7.3. Notably, the new nesting areas that are proposed as habitat compensation features (Refer to Section 6.0) will be within the 40 m watercourse corridor which will be fenced on the development side. This placement will likely reduce the potential for nests in these areas to be predated. In addition, the general improvements in habitat quality, increase in the size and distribution of deeper ponds, and improved vegetative cover along the 40 m corridor will help provide refuge from predation for Blanding's Turtles to mitigate potential predation impacts.

5.4 Recreational Usage and Human Interference

The increased human population in the area as a result of the development of Kanata North may increase the recreational usage of the watercourse corridor, and the new ponds created for habitat compensation may become attractive to residents for a variety of recreational uses. An increased number of residents in the area will likely increase the number of people who utilize natural features, including the 40 m watercourse corridor and adjacent 6 m pathway, for recreational purposes. Development will likely lead to increased numbers of people using trails for dog walking, biking, hiking, and for other recreational uses. Increased utilization of the trails and buffer areas may degrade the habitat, and it may also increase the risk of impacts by bikes, harassment by residents or their pets, and the risk of collection of Blanding's Turtles by residents. Mitigation measures to address this potential impact are discussed in Section 7.4.

6.0 Habitat Compensation

New habitat enhancement and compensation features will be created within the 40 m watercourse corridor to compensate for the potential habitat impacts discussed in Section 4.0 and summarized in Table C. A description of the different types of habitat compensation features that will be undertaken are outlined in the following sections. The minimum number and size of these features that are recommended to achieve an overall benefit is outlined below in Table D. These features have been sized and designed with the intention that each individual Quadrant (e.g. each of the major landowners) can independently implement and provide an overall benefit within their quadrant. To simplify the detailed design process, the number of each type of habitat feature that is recommended in each Quadrant is summarized in Table D (below), and the size of each feature is described in the following sections. This will allow each landowner to move forward independently with their own OBP and to implement their habitat compensation without being required to coordinate these activities with the other landowners. The compensation and achievement of overall benefit has been designed for implementation within each Quadrant independent of the other Quadrants, and this will reduce the complexity of applying for, obtaining, and implementing OBPs for each major landowner.

In order to maintain flexibility for the detailed design process, the position of the proposed compensation features have not been finalized and are not shown in the figures in this report. The final position of features is not shown in order to allow for flexibility in the landscaping, grading, recreational trail design, lot size and alignment, and other detailed design features. The number and size of the features to be included, as well as the Quadrants where they should be placed, have been outlined in this Compensation Plan and are summarized in Table D. In general, the number of features outlined in Table D is such that a feature will be built every approximately 50 to 100 m along the length of the tributaries. During the preparation of detailed design and preparation of their OBP, each individual landowner will identify the position and final design of these habitat features.

It is likely that the completion of detailed design, draft plan of subdivision, application for the OBP, and implementation of compensation features will occur at different times for each of the landowners, depending on their development schedules. This Compensation Plan has been designed in such a way that implementation of the habitat compensation works within any individual Quadrant will not be dependent on the timing of work completed in the other Quadrants. Throughout the compensation works for each Quadrant, the watercourse corridor will remain connected to the watercourse in adjacent Quadrants, even if the compensation works in those adjacent Quadrants have not yet commenced. This ensures that the habitat compensation works, watercourse corridor, and overall habitat functionality is maintained throughout the KNCDP area even if one or more of the Quadrants undertake compensation works and development at a later date. Seasonal and construction stage timing limitations are discussed in Section 7.1.

6.1 Summary of Habitat Compensation Features

Several types of habitat compensation features have been proposed to achieve an overall benefit to Blanding's Turtle and improve the functionality and extent of habitat. These features are divided between those that are intended to improve the overall *quality* of habitat by adding functionality and generally improving the character of the habitat for the species, and those that improve the *quality and size* of different habitat categories. These are summarized below and discussed in greater detail in the following sections:

Features to Improve Habitat Quality:

- Natural channel design within the 40 m watercourse corridor;
  - Includes planting/seeding, landscaping, and vegetation improvements;
  - Improves overall habitat functionality, improves quality of Category 2 habitat, and creates a large scale functional movement corridor to compensate for Category 3 habitat loss.

Features to Improve Category 1 Habitat Size and Function:

- Deep pools (Potential Category 1 hibernacula sites);
  - Provide large areas for mating, feeding, basking, and overwintering;
  - Designed to function as potential hibernacula sites;
  - Increases the extent of Category 1 habitat;
  - Increases the extent of deep pond habitats;
- Artificial Nesting Area (Category 1 nesting sites);
  - Provides suitable locations for nesting; and
  - Increases the extent of Category 1 habitat.

Features to Improve Category 2 Habitat Size and Function:

- Shallow pans/shallow pools;
  - Adds shallow marsh areas within the 40 m watercourse corridor, providing feeding areas, basking locations, refuge, etc.;

  - Improves quality and functionality of Category 2 habitat and improves functionality of Category 3 movement corridor;
- Deeper pockets within the channel itself;
  - Designed to retain water during late season/drought and provide refuge, basking locations, and sites for thermoregulation; and
  - Small deep pockets that improve quality and functionality of Category 2 habitat and improve functionality of the movement corridor.

Table D (below) summarizes the anticipated number of each feature within each quadrant.

For most of their life cycle, Blanding's Turtles tend to prefer relatively shallow wetlands (on average 30 cm deep and usually ranging from 25 to 120 cm deep), though they require access to deeper pools for vital life processes including hibernation (Kiviat 1997; Hartwig 2004; Millar & Blouin-Demers 2011). Blanding's Turtles will utilize different water depths at various times of year depending on weather, and may prefer shallower areas during early spring when they need to frequently bask, while they will utilize deeper waters for foraging later in the summer (Kiviat 1997). It is anticipated that a range of depth conditions will be created along the tributaries by implementing the various habitat compensation features outlined below. This includes the shallow pans/shallow pools and deep pockets, which will create areas up to 45 cm deep along the channel and will provide opportunities for late season refuge habitat and growth of aquatic vegetation. In contrast, the deep pools will provide permanent pond habitat with water depths up to 2.0 m deep, to fulfill a variety of biological functions including feeding, overwintering, and mating. These features are discussed in greater detail in the following sections.

Table D: Summary of Anticipated Number and Size of Habitat Compensation Features in Each Quadrant

		Habitat Features	Quadrant A Junic Multivesco	Quadrant B Valecraft	Quadrant C Brigil	Quadrant D Metcalfe Realty	All Quadrants
Number of Features	**Category 1 Habitat Features**	Deep Pools (15 x 45 m)	2	0	1	1	4
		Artificial Nesting Areas (10 x 30 m)	2	0	1	1	4
	Category 2 Habitat	Shallow Pans/Shallow Pools (10 x 60 m)	3	2	1	2	8
		Deep Channel Pockets (5 m diameter)	5	2	3	4	14
		Total Number of Features	12	4	6	8	30
Total Size of Features (ha)	**Category 1 Habitat Features**	Deep Pools (15 x 45 m)	0.14	0.00	0.07	0.07	0.27
		Artificial Nesting Areas (10 x 30 m)	0.06	0.00	0.03	0.03	0.12
		Total - New Category 1 Habitat (ha)*	**0.20**	**0.00**	**0.10**	**0.10**	**0.39**
	Category 2 Habitat Features	Shallow Pans/Shallow Pools (10 x 60 m)	0.18	0.12	0.06	0.12	0.48
		Deep Channel Pockets (5 m diameter) (ha)	0.01	0.00	0.01	0.01	0.03
		Total - Other Enhancement Features (ha)**	**0.19**	**0.12**	**0.07**	**0.13**	**0.51**

*Includes New Deep Pools and Artificial Nesting Areas

**Includes Shallow Pans/Shallow Pools and Deep Channel Pockets

6.2 Natural Channel Design, Watercourse Corridor and Tributary Realignment

The major component of the proposed habitat compensation and enhancement project within the Kanata North lands will be the establishment of a 40 m wide watercourse corridor that will run the entire course of the North Tributary and North Branch through the Kanata North lands. This corridor will be realigned in sections to accommodate the subdivision design and stormwater management ponds, as shown in Figure 2. The quality of Category 2 habitat (e.g. its functionality) will be improved within the watercourse corridor. As discussed in detail in Section 2.2, the majority of Category 2 habitat is currently considered to be of poor quality throughout the KNCDP area. This is because most of the areas shown as Category 2 habitat are heavily degraded. They have few large areas of aquatic vegetation, there are only two ponds with deep water, and sections of the watercourse are highly channelized. Furthermore, riparian vegetation is insufficient to buffer the watercourse in most areas, and where present, consists primarily of either thin hedgerows or fallow fields with a high proportion of invasive plants. These conditions are discussed in greater detail in Section 2.2.

As shown in Figure 1, the stretches of the North Tributary immediately west and east of March Road are highly channelized. In these areas the tributary will be realigned and will feature a more natural channel design. Most of the stretch of the North Tributary west of March Road will be realigned to accommodate stormwater management ponds and the subdivision design. A portion of the stretch that will be realigned is currently channelized. As such, the realignment will primarily affect areas which are currently highly channelized. The realignment will therefore be beneficial as it will allow the realigned channel to be designed and constructed according to natural channel design principles, which will include natural meanders, stable banks, and more natural flow rates. Natural channel design principles will be utilized to restore the realigned sections of the tributaries during the realignment project (Doll et al. 2003) and this is expected to improve the overall habitat quality and functionality of these areas. Design principles and features are discussed at a high level in the following paragraphs. These design principles and features will be utilized during the detailed design phase in order to create final designs for the realigned channel.

In the realigned portions of the tributaries, the channel will be designed to create a moderately meandering stream. A meandering stream design will help slow water velocity during storm events, provide riparian storage during flood conditions, be self-maintaining, and create a diversity of habitat features in the bed, bank, and overbank. It will be in dynamic equilibrium, so that it reacts to changing conditions by evolving appropriately (Doll et al. 2003). The stream will be realigned within the 40 m corridor with a low flow bottom channel width of 1 to 4 m and the remainder of the corridor will serve as terrestrial vegetative buffer/riparian vegetation, and will also feature additional habitat features (discussed in following sections). The exact position of the realigned channel will be determined in the detailed design phase and may be influenced by hydrological factors, micro-topographical features, existing vegetation conditions, and substrate conditions. The channel itself will be dug (using bedrock blasting where required) close to the grade of the existing tributary stretches that are being realigned to largely maintain the existing drainage grade. The channel will be dug (using bedrock blasting where required) so that there is a broad and very shallow bank angle throughout the majority of its course. This design is conducive to turtles as it allows them to easily enter and exit the watercourse and utilize banks for basking (Doll et al. 2003). Within the wetted channel, in most sections the maximum bank angle will be dug to approximately 25 degrees (2:1) (maximum) and the bank beyond the wetted channel should be approximately 10 to 15 degrees maximum (4:1 to 6:1) and should be nearly flat to 6 degrees (10% slope). These banks will be suitable for basking and terrestrial movement and will allow turtles to move easily between the creek and surrounding terrestrial habitat (Doll et al. 2003). Limited portions of the stream may have a steeper bank angle where final grades would require extensive excavation to create a shallow angle, but the majority of the watercourse will feature a shallow bank. The wetted channel itself will be designed to have an approximately 1 to 4 m low flow bottom width with shallow broad banks that may flood during periods of high water (e.g. during the spring melt). The water depth profile along the channel will be similar to the existing channel, with bankfull depths ranging from 30 cm to 75 cm during periods of high water (maximum 1 m), and generally speaking depths will be less than 30 cm during low flow periods. It is anticipated that the maximum flow velocity within the tributaries during major storm events will be approximately 1 meter per second following development. During the majority of the year (e.g. outside of spring melt and major storm events) the watercourse is anticipated to be shallow with low stream velocity bordering on stagnant conditions. Given the relatively dry conditions and ephemeral nature of water flow through these tributaries under current conditions, deep pockets and some deep ponds will be dug to create refuge areas in times of low water (discussed in following sections).

The realigned channel will be seeded with a native wetland/riparian seed mix. This will encourage re-establishment of native vegetation and will improve habitat quality compared to the riparian vegetation that currently exists, which has a high proportion of invasive species and few aquatic plants. It is also anticipated that natural seed dispersal from upstream areas and adjacent wetlands will lead to relatively rapid regeneration of aquatic vegetation once conditions are made suitable. Where possible, the new channel will be dug to take advantage of existing shade trees and surrounding woody vegetation in hedgerows, and this vegetation will also be maintained along the tributary stretches which are not being realigned. As discussed, portions of the tributaries are currently buffered by hedgerows. Shade trees and bushes will be planted selectively adjacent to the realigned channel portions and along the other stretches of the channel (if required). However, a fully shaded channel will receive less sunlight than a partially shaded channel, which may make the habitat less desirable to Blanding's Turtles as it will create lower water temperatures and fewer areas for basking. As such, shade tree planting will be selective and generally speaking the goal will not be to create a fully shaded riparian corridor. During the final detailed design, landscaping and grading features, including potentially live plantings of shrubs/trees, will be identified to ensure that critical basking and nesting areas are well separated from the adjacent recreational trail. This will also ensure that some portions of the watercourse corridor and key habitat features remain undisturbed by recreational usage.

Lastly, in wide sections of the realigned channel (e.g. >2 m low flow bottom width) as well as in wider areas of the channel that will not be realigned, woody debris such as logs, root wads, or cut trees will be placed within the channel. Woody debris, grubbed stumps, logs, flat rocks, rock piles and other cover materials will be interspersed along the banks of the realigned channel as well. These materials will provide cover for nestlings and juveniles, and will also provide basking areas within (or adjacent) to the main channel (Standing et al. 1997). These features will also be placed throughout the watercourse corridor both in realigned and non-realigned stretches, and also within the new deep ponds (see below). Cover materials will be salvaged from tree clearing and grubbing operations within the Kanata North area and can be made from natural materials.

These design principles will be implemented for the portions of the channel which are to be realigned. As noted above, seeding/planting and placement of wood, rock, and other debris materials for basking will also be implemented (where required) within the portions of the watercourse corridor which are not being realigned. Additional habitat compensation features will also be implemented throughout the watercourse corridor, and these are discussed in greater detail in the following sections.

6.3 New Deep Pools – Category 1 Habitat (Hibernacula) Features

As discussed previously, for most of their life cycle, Blanding's Turtles tend to prefer relatively shallow wetlands (on average 30 cm deep and usually ranging from 25 to 120 cm deep), though they require access to deeper pools for vital life processes including hibernation, mating, and foraging (Kiviat 1997; Hartwig 2004; Millar & Blouin-Demers 2011). Currently there are only two ponds within the study area which are believed to provide deeper water to fulfill these habitat requirements. These include the Category 1 pond on the North Tributary (which will be removed) and the Category 2 pond on the North Branch (which will be reduced in size). Both are artificial ponds created by the construction of water control structures and neither was designed to function as a habitat feature. Blanding's Turtles have only been documented utilizing the Category 1 pond. In order to ensure that deeper habitats are available to turtles, four (4) new deep pools measuring approximately 15 m x 45 m (e.g. 675 m^2) will be built in several locations as summarized in

Table D (above). These pools are intended to function as potential hibernacula sites, while also providing general foraging habitat.

Hibernacula are permanent pools that Blanding's Turtles enter late in the active season for the purposes of overwintering. Depending on seasonal conditions, Blanding's Turtles generally enter hibernacula between late September and November and overwinter in these areas until the following spring (OMNRF 2012c). Blanding's Turtles are generally believed to be very habitual in their usage of hibernacula sites and may utilize the same pools each year for overwintering. Most hibernation occurs in areas of organic substrate with water depths of approximately 1 m, and pools must remain ice free at the bottom with sufficient dissolved oxygen throughout the winter (Edge 2010). Generally speaking, Blanding's Turtles do not appear to be sensitive to anoxic conditions during hibernation or during other parts of their life cycle, and can generally be considered tolerant of low dissolved oxygen levels (Newton & Herman 2009). In overwintering sites, dissolved oxygen has been found to range from 2.8 to 11.3 mg/L. They have been documented overwintering in severely hypoxic conditions for at least 3 months (Newton & Herman 2009). Median winter temperatures range from 0.8 to 8.6 °C when overwintering in organic substrates (Newton & Herman 2009). Available evidence suggests that hatchlings select overwintering sites primarily based on temperature (Paterson et al. 2012) though substrate and water depth are also important variables dictating habitat selection. Most studies have found that Blanding's Turtles generally prefer organic substrates compared to mineral substrates (Hartwig 2004; Edge 2010; Millar & Blouin-Demers 2011). As such, an imported organic substrate will be required to simulate natural hibernacula conditions in the new deep ponds. Substrate material may be salvaged from suitable locations within the region where such materials are being produced as spoil. At most times it is usually possible to salvage such material from excavations within the region.

The new deep pools that will be created will be designed to function as new hibernacula habitat, while also providing habitat for the other life processes discussed above (e.g. foraging, mating, etc.). These pools will be dug in areas which are suitable for a larger pool with deeper water depths, and will be situated based on hydrological and geological conditions. Each pool will be dug within the watercourse corridor and may be dug as either inline or offline ponds, depending on final design details. Whether the pools are dug as inline or offline will not likely affect their usage by Blanding's Turtles. They will be in close proximity to the channel in either case and are capable of moving the short distance between the channel and adjacent ponds. Each pool will be dug with a depth gradient so that their deepest point is approximately 2 m deep and so that the overall average depth of the deep pool will be approximately 1 m. A gradient in depth will ensure that different depths are available to turtles and that water levels within the pool vary in order to allow adaptation to weather conditions. Approximately 2/3^{rds} of each pool will be taken up by areas of 1 m water depth or greater, and the features will be graded so that the remaining 1/3rd of the area transitions to an approximate average depth of 30 cm, which will provide shallow hemi-marsh habitat suitable for basking. This hemi-marsh habitat will be similar as previously described for the shallow pans/shallow pools (see below). As discussed, the deeper pools and hemi-marsh habitat will also feature a mixture of woody debris, grubbed stumps, logs, rock piles, flat rocks, and other cover materials that will be interspersed along the banks and within the wetland to provide cover for nestlings and juveniles, as well as basking locations (Standing et al. 1997). The construction of the wetland and deep pools will include similar substrate and vegetation characteristics and construction techniques as previously discussed in relation to the channel realignment (see above), including seeding with a native wetland restoration mix/riparian vegetation mix. During the final detailed design, landscaping and grading features including potentially live plantings of shrubs/trees, will be identified to ensure that critical basking areas are well separated from the adjacent recreational trail. This will ensure that some portions of the ponds remain undisturbed by recreational usage. The number of these features proposed in each Quadrant is summarized in Table D (above).

6.4 New Nesting Sites - Category 1 Habitat Features

Currently there are no known nesting areas for Blanding's Turtle within the Kanata North area. As a means of increasing the overall habitat quality, improving habitat diversity, and improving the size of Category 1 habitat, new nesting areas will be created within the 40 m watercourse corridor. Four (4) new nesting areas will be built and will each measure approximately 10 x 30 m (300 m^2). The number and location of these features within each Quadrant are summarized in Table D (above).

Blanding's Turtles seasonally travel over land to nest in upland nesting areas, which usually consist of open areas or along tree lines. This species is one of the most terrestrially mobile turtles in Ontario, and they may travel as far as 7 km seasonally in search of a nesting site (Beaudry et al. 2010). However, in most cases nesting areas are located closer to core wetlands than 7 km and Beaudry et al. (2010) found that the average distance travelled for nesting activity was approximately 1 km. Areas utilized for nesting generally include open sections within a forest or along a forest edge, that have appropriate substrate with sparse vegetative cover. Appropriate substrates include patches of loose gravel, sand, or dry soils, where they can easily dig nests for egg laying (Beaudry et al 2010).

Significant evidence exists indicating that Blanding's Turtle will nest in appropriate substrate within anthropogenically created nesting sites. This includes both sites which are created intentionally (e.g. habitat enhancement or compensation projects) and those created unintentionally through road construction, stockpiling, clearing, and other activities. Beaudry (et al.) 2010 conducted one of the only *in situ* studies comparing usage of anthropogenic nesting sites to natural nesting locations. Beaudry (et al.) 2010 radio tracked twenty three (23) gravid females at several field sites in Maine and noted that 84% of all nests were built at anthropogenically created sites, and that 58% of these sites had been available for 5 years or less. Beaudry (et al.) 2010 concluded that *"…the ability to use newly disturbed areas signals that artificial nesting sites can be detected and used rapidly by turtles and that the quality of artificial sites could be managed to enhance nesting success for these at-risk turtle species."* Beaudry et al. (2010) further note that "…*the judicious placement of artificial nest sites could modify or reduce upland movements by adult females during the nesting season, a period when the impact of adult loss is particularly damaging to local population viability*."

The Beaudry et al. (2010) study suggests that turtles are willing and able to locate and utilize anthropogenic nesting areas, that such areas could be intentionally created, and also that careful placement of artificial nesting locations may have benefits to the population in terms of reducing mortality to adult females from overland movement, while also potentially increasing nest and hatchling survivorship.

The new nest areas will all be built in locations that are likely to be dry throughout the nesting season (early June to late October) and which are close to the tributaries. These new nest areas will expose nesting females to comparatively little risk during nesting, as they will not need to travel long distances overland to reach them from the tributaries. By placing the new nesting areas near the major movement corridors (the tributaries) it is reasonably likely that female turtles will be able to detect and utilize these nesting areas and may encounter them while travelling along the adjacent tributaries. While the relatively small number of turtles believed to occur within the Kanata North area currently makes it unlikely artificial nesting areas will be used, it is hoped that the overall effect of the habitat compensation plan will be to increase turtle usage of the area and movement through the area. If successful, increased turtle usage of the Kanata North watercourse corridors will improve the probability that nesting areas will be used by females. The new nesting areas therefore have the potential to provide a benefit to the Blanding's Turtle population by reducing the need for overland movement due to their closer proximity to core watercourses, and by providing nesting habitat within the Kanata North lands, where currently none is known to exist. This benefit will include potentially reduced metabolic demand for nesting activity (due to shorter overland movement distances), decreased likelihood of predation and road mortality for nesting females, and increased likelihood of hatchling survival by providing a shorter distance for hatchlings to travel to wetland environments following hatching. Blanding's Turtle hatchlings orient themselves towards riparian habitats and disperse to wetlands shortly after hatching (Pappas et al. 2009). Reducing the overland distance between nesting areas and wetlands will likely reduce the risk of predation, human interference, and road mortality for hatchlings as they disperse to wetland environments (Pappas et al. 2009).

The design specifications for new nesting areas have been informed by the *Advisory Guidelines for Creating Turtle Nesting Habitat* (2009) provided by the Massachusetts Division of Fisheries and Wildlife. These advisory guidelines include specific recommendations for the creation of Blanding's Turtle artificial nesting habitat. Based on the advisory guidelines, newly created nesting areas will consist of the following:

- Newly created habitat will be within 300 m of wetlands or watercourses utilized by Blanding's Turtle (as discussed above);
- Nesting sites should be built near existing tree lines or near planted trees;
- Nesting sites should be on level ground with full southern exposure. Where possible, selected sites will be graded to approximately level conditions;
- The sites should be above the spring/summer flood plain;
- A single large site is generally more favorable than several smaller sites, as a larger site will have greater sun exposure. As such, large continuous nesting areas (minimum 200 m^2) should be designated wherever possible within each nesting zone;
- Predation and human interference should be minimized by placing sites within isolated or difficult to access locations as much as possible, and/or designing/landscaping the recreational trail to provide privacy for the nest area and discourage human usage;
- If possible, nesting areas should consist of locations with well-drained soil, sand or gravel. If natural substrate conditions do not meet this requirement, imported fill should consist of washed sand or gravel. Imported material will be spread approximately 30 cm deep;
- Imported substrate will consist of fine sand with <5% clay and <25% gravel;
- Ground vegetation should be sparse and should include native sedges, grasses, and a few low growing shrubs. Shrub cover should be less than 2-5% of the site;
    - A native seed mix consisting of sedges and grasses will be spread on new nesting areas. The composition of the seed mix will be determined during the permit drafting phase;
    - The plant list provided in the MDFW (2009) guidelines will be considered when creating a seed mix, however, the ultimate planting list will be informed by selection of species which are native to Ontario and also those which are available at reasonable cost;
    - Some tree/shrub cover will be retained and/or planted to ensure partial tree/shrub cover.
- Imported substrate will be deposited on top of low growing vegetation where possible;
- If deemed necessary, a permeable tarp may be placed over low growing vegetation to reduce regrowth of unwanted groundcover; and
- The MDFW guidelines indicate that maintenance should not be required in most cases. Maintenance requirements will be evaluated during the post-construction monitoring program and the area will be adaptively managed. If required, maintenance will be undertaken to ensure that

invasive plants occupy <25% of the nesting area, herbaceous and woody species occupy <50% of the area, and shrubs grow no taller than 60 cm in height.

The number of these features proposed in each Quadrant is summarized in Table D (above).

6.5 Shallow Pans/Shallow Pools

Shallow pans/shallow pools will be dug around the channel in order to expand the wetted area, and to provide areas where aquatic and semi-aquatic vegetation can grow. The primary purpose of the shallow pans/shallow pools is to create wetland habitat within the watercourse corridor, as currently there are very few areas of aquatic vegetation present. Each of these shallow pans/shallow pools will measure approximately 10 m wide (5 m on either side of the channel) and approximately 60 m long (e.g. approximately 600 m^2). These areas will be placed in the path of the main channel and will be included in each Quadrant as summarized in Table D (above), with a total of eight (8) shallow pans being dug across all quadrants. These shallow wetlands will be dug to an average of approximately 30 cm below the channel grade so that they maintain an average water depth of approximately 30 cm. These wetlands will be graded to pool shallow water and will provide refuge areas during dry weather. They will also provide shallow hemi-marsh habitat and will be seeded with a native wetland restoration mix. Logs and other emergent features (as described above) will also be placed within these wetland patches to provide basking habitat. The number of these features proposed in each Quadrant is summarized in Table D (above).

6.6 Deep Channel Pockets

Small deeper pockets (approximately 30 to 45 cm below the main channel grade) will be dug selectively along the length of the channel to ensure that some deeper refuge pools are present within the watercourse corridor. These deeper pockets will be small in size (approximately 5 m in diameter) and will be semi-randomly placed along the channel length. The purpose of these deeper pockets is to provide small refuge areas where water will be maintained in periods of low flow and where aquatic vegetation may grow. A total of fourteen (14) of these features will be dug across all quadrants. The number of these features proposed in each Quadrant is summarized in Table D (above).

6.7 Enhancement of Movement Corridor - Category 3 Habitat

While all of the habitat compensation features discussed previously are intended to provide a direct quantifiable improvement/expansion of Category 1 and Category 2 habitat, the effect on the functionality of Category 3 habitat is more difficult to quantify. As discussed previously, the majority of Category 3 habitat in upland areas outside of the watercourse corridor will be lost. However, nearly all of the area shown as

Category 3 habitat is currently devoid of wetland environments and is heavily degraded. The majority of Category 3 habitat within the KNCDP area consists of operational agricultural fields which are likely to provide little functional habitat. While Blanding's Turtles could theoretically traverse the KNCDP area in a direct east-west path, turtles passing through the area would currently be required to traverse large areas of heavily degraded habitat with few significant wetland features or refuge ponds in which to rest. Also, a significant risk to the turtles is posed by the high levels of road traffic and agricultural machinery activities. It is therefore likely that the majority of the upland Category 3 habitat offers little functionality, and that the primary functional Category 3 habitat is provided by the two tributaries of Shirley's Brook. These are the only sections within the KNCDP area which are believed to provide a relatively safe movement corridor and which would be sufficiently wet in the spring season to provide some resting, basking, and feeding habitat.

Because it is likely that these tributaries provide the main viable movement corridor for Blanding's Turtle under current conditions, and that adjacent upland areas shown as Category 3 habitat likely offer only a hazardous movement corridor with little functional benefit, it is believed that enhancing and protecting the tributaries is the most feasible way to improve the overall functionality of turtle movement across the Kanata North area. While the overall habitat balance shows the spatial extent of Category 3 habitat declining due to the loss of low quality upland areas, it is expected that the overall functionality as a movement corridor will be improved by adding the various habitat enhancement features discussed in the previous sections. This includes the wetland and aquatic vegetation patches, deeper refuge pockets in the main channel, and the new deep pools discussed above – all of which improve functionality by increasing the availability of habitats for shelter, basking, feeding, etc. along the main movement corridor route. Therefore, it is expected that the overall functionality and quality of movement habitat will be improved.

On a larger scale, the rehabilitation of the movement corridor through the Kanata North lands may provide a significant benefit by helping to reconnect the major Blanding's Turtle subpopulations of the South March Highlands and Shirley's Bay. As discussed in Section 1.4, these major subpopulations represent the most important core Blanding's Turtle subpopulations in the area, and it is not currently clear whether these subpopulations remain genetically linked. The main potential linkage between these areas is Shirley's Brook, which flows from the South March Highlands, through Kanata North, to areas of Blanding's Turtle habitat in the Connaught Ranges and Primary Training Center, and then outlets into Shirley's Bay. Shirley's Brook is the most viable link between these subpopulations. However, most of the area between the South March Highlands and Shirley's Bay is highly degraded (Refer to Section 1.4). The rehabilitation of the tributaries in the Kanata North lands would represent approximately 40% of the distance between these subpopulations, and hence would contribute to the overall connection. In addition, the subdivision immediately south of Quadrant D has already had the stretch of Shirley's Brook that runs through it recently rehabilitated. While this area was not specifically designed for Blanding's Turtle, the improved habitat quality will likely provide a functional movement corridor for another approximately 10% of the distance between the South March Highlands and Shirley's Bay. It will also connect directly to the stretch of Shirley's Brook that exits the Kanata North area through the south side of Quadrant D.

The proposed enhancement to the watercourse corridor within Kanata North, taken in context of the work already completed in the Brookside Subdivision, may ultimately provide enhanced movement habitat for approximately 50% of the distance required to link the South March Highlands to Shirley's Bay. If successful, this would improve the connectivity between the regional sub-populations and would hence have a significant benefit to the species.

6.8 Summary of Overall Benefit Measures

Table D identifies the proposed number of each habitat compensation feature that would be built within each Quadrant. As noted previously, the objective of this habitat compensation plan is to achieve an overall benefit through an improvement in habitat quality and total functionality, while acknowledging that the overall size of the habitat will decline. As noted previously, the net loss of Category 1 habitat is -0.08 ha while the net loss of Category 2 habitat is -5.39 ha. As described in Section 4.0, approximately 34% of the lost Category 2 habitat are the 'marginal areas' (row crops and pasture) which currently provide relatively little habitat value. Approximately 49% of the lost Category 2 habitat is fallow/regenerating fields and treed areas which provide limited buffer functions but no core wetland habitat functionality. The actual wetland areas that will be lost (the ponds and channel/bank), account for only 17% of the lost Category 2 area. The portion of the lost Category 2 habitat which is currently wetland is hence as little as approximately -1.13 ha.

This habitat loss is compensated for through the proposed habitat enhancement measures outlined in Table D and summarized in the previous sections. In total, 0.39 ha of Category 1 habitat enhancement features (artificial nesting areas and deep ponds) will be built, while 0.51 ha of other Category 2 enhancements (deep channel pockets and shallow pans) will also be built. This represents a total of 0.9 ha of habitat enhancement features, in addition to the other less quantifiable habitat enhancement measures described in the previous sections including seeding with native species (replacing the riparian areas that currently exist which are largely dominated by invasive species), adding cover objects and structural habitat components, selective planting, and the realignment of sections of the tributaries according to natural channel design principles.

The new artificial nesting areas and deep ponds replace the loss of the one Category 1 hibernacula pond at an approximately 5:1 ratio (+0.39 ha to -0.08). Therefore there will be an increase in the size of Category

1 habitat. This plan also increases the total size of open water ponds within the KNCDP area from the current 0.34 ha (the combined size of the two ponds) to 0.53 ha (the combined size of the four (4) new ponds and the one (1) retained pond). Therefore, pond size increases by approximately 56%, while the loss of the 0.08 ha hibernacula pond is in fact replaced at an approximately 3.5:1 ratio (+0.27 ha of new ponds to -0.08 ha of the lost pond). Category 1 habitat and larger open water ponds (with marsh and wetland elements) are the most valuable features on the landscape in terms of Blanding's Turtle habitat functionality. Hence, the increase in the size of these features supports the rationale that an overall improvement of functionality has been achieved, despite a net loss in the size of Category 2 habitat. The other habitat enhancement and improvement measures (deep channel pockets, shallow pans and pools, seeding with native species, adding cover objects and structural habitat elements, selective planting, and realigning sections of the tributaries according to natural channel design principles) will all serve to rehabilitate the tributaries and improve their overall functionality.

Currently the tributaries can be characterized as highly degraded habitats close to high intensity agricultural usage, with unmitigated turtle access to roads. These tributaries offer very little truly functional wetland habitat, low quality riparian habitats, very few significant areas of aquatic plant growth, large sections that are highly channelized, and large sections that are entirely dry during periods of low flow. Following implementation of this habitat enhancement plan, these tributaries could be characterized as a continuous area of suitable turtle habitat within a protected corridor that reduces road access and road related mortality risks through fencing. The enhanced tributaries will include a diverse mixture of depth conditions, improved extent of wetland areas and aquatic plants, a diversity of wetland types, several valuable habitat features for key life processes, and new habitat enhancement features placed every approximately 50 to 100 m to improve movement functionality. This represents an improved habitat condition that will ultimately have an overall benefit through improved functionality and habitat quality.

Because it is likely that these tributaries provide the main viable movement corridor for Blanding's Turtle under current conditions (and that adjacent upland areas shown as Category 3 habitat likely offer only a hazardous movement corridor with little functional benefit), it is believed that enhancing and protecting the tributaries is the most feasible way to improve the overall functionality of turtle movement across the Kanata North area. While the spatial extent of Category 3 habitat will decline due to the loss of low quality upland areas, it is expected that the overall functionality as a movement corridor will be improved by adding the various habitat enhancement features discussed above. Therefore, it is expected that the overall functionality and quality of movement habitat will be improved. As discussed previously, on a larger scale this plan has the potential to contribute to restoring the connection between the South March Highlands and the Shirley's Bay regional sub-populations, which would be a significant benefit to the regional population as a whole. It should also be noted that road related mortality poses a significant risk to Blanding's Turtles in the KNCDP area due to existing high traffic volumes and roads that have no wildlife passage systems. Under current conditions this risk is essentially unmitigated. Following development, the risk of road related mortality will be better controlled and mitigated through the construction of a turtle exclusion fence that will be installed on both sides of the 40 m watercourse corridor, as well as new wildlife passage culverts. This will provide a benefit to Blanding's Turtle by mitigating and controlling the existing threat of road mortality. This serves to both reduce the risk of road related mortality and improve the functionality of the movement corridor compared to existing conditions. This is discussed in greater detail in Section 7.2 (below).

It is expected that the habitat compensation and enhancement features outlined above will achieve an overall benefit in each of the four Quadrants, through an improvement in the size of key habitat features, reduction in the risk of road related mortality, and an improvement in overall quality and functionality of Blanding's Turtle habitat.

7.0 Mitigation of Potential Impacts to Individuals

7.1 Construction Timing and Mitigation Measures

The following mitigation measures will be undertaken at the construction stage to avoid potential injury or mortality of Blanding's Turtles:

- Minimize the risk of interfering with turtle life processes and also minimize the risk of directly impacting turtles by undertaking initial site preparation activities including installation of construction fencing, vegetation clearing, and tree removal outside of the turtle active season (outside of April to end of October);
- Any areas where construction will occur during the active season (April to end of October) should be isolated by installing temporary exclusion fencing (silt fencing) prior to April 15th to prevent turtles from entering the work area;
- Silt fencing will be arranged to function as temporary wildlife exclusion fencing to reduce the likelihood of turtles, frogs, mammals and other wildlife from entering the work area;
- The fencing and work area will be inspected prior to commencement of work to ensure that the arrangement will reduce the likelihood of wildlife entering the work area;
- Silt fencing will be put in place prior to the turtle active season (prior to thawing of ponds in April);
- Prior to vegetation clearing, preconstruction sweeps of vegetated areas will be undertaken to ensure wildlife are not present;
- Prior to vegetation clearing, significant habitat features will be marked by a qualified biologist or arborist. Trees to be retained will be marked, and contractors will be advised of the position of features to be retained;
- Where necessary, features/trees to be retained will be identified through the installation of snow fencing to mark their position;
- The Owner will educate contractors on the appearance of Blanding's Turtles and instruct them to avoid injuring turtles. This will include mandatory daily checks of equipment and work areas by the contractor to ensure no turtles are present;
- Monitoring by a qualified biologist will be undertaken to supervise critical stages of the construction of the habitat enhancement and compensation features;
- Dewatering of the tributaries (if required) will be undertaken outside of the turtle active season (outside of April to end of October). Because the tributaries are generally shallow without any deeper pockets, it is highly unlikely that turtles would be encountered during dewatering if this is done outside of the active season, as these areas are not likely to be suitable for hibernation. As such, the risk to turtles if dewatering is done in the winter will be minimal;

- The exception to this are the two (2) ponds along the tributaries including the Category 2 pond on the North Branch and the Category 1 pond on the North Tributary. If dewatering were undertaken during the winter in these ponds, there would be a risk that hibernating turtles could be encountered. Removal of these ponds will not be undertaken until after the compensation ponds in the associated quadrant have been built and have grown in. This will provide alternate hibernation sites, which will be in place and accessible prior to pond removal. Ideally, the new ponds will be constructed in the winter prior to the removal of the old ponds, and will be allowed to 'grow in' over the spring and early summer prior to removal of the old ponds. Once the new deep ponds have grown in, the old ponds will be dewatered during the mid to late summer (between June 30th and September 1st) prior to the hibernation season. This will ensure that turtles will not be trapped in these ponds during winter dewatering, when relocation poses a greater risk of mortality. Once water draw down is complete, the ponds will be fenced to ensure turtles cannot re-enter these ponds;
- During all dewatering operations, monitoring by a qualified biologist during dewatering set-up and water draw-down is required. During dewatering, any fish, turtles, or other wildlife will be relocated by a qualified biologist to a safe location in order to facilitate completion of the work;
- Permits for wildlife relocation must be obtained from the OMNRF prior to dewatering to ensure that the qualified biologist can complete relocation. The timing outlined above will reduce the likelihood that Blanding's Turtles will need to be relocated during dewatering. A contingency plan to relocate Blanding's Turtles found during dewatering will be developed and will include relocation over a short distance to a nearby pond (either a retained or constructed pond) within the KNCDP area; and
- The specific timing for development of each quadrant and implementation of these mitigation measures will be outlined in the future Overall Benefit Permit applications for that quadrant.

7.2 Fencing, Road Crossings, and Vehicle Impact Mitigation

As discussed in Section 5.2, road related mortality poses a significant risk to Blanding's Turtles (OMNRF 2012a, Dillon 2013a). It was noted in Section 5.2 that this risk already exists in the KNCDP area due to existing high traffic volumes and roads that have no wildlife passage systems. Under current conditions this risk is essentially unmitigated.

Following development, the risk of road related mortality will be better controlled and mitigated through the construction of a turtle exclusion fence that will be installed on both sides of the 40 m watercourse corridor, except where adjacent to park blocks. The proposed 6 m wide recreational pathway will be within this fencing, so that the fencing will enclose both the 6 m wide pathway and the 40 m watercourse corridor. The detailed design and placement of the fence will be outlined during the detailed design stage, but could include conventional fencing such as a 1.5 m tall chain link fence. The fencing will be designed to prevent turtles from entering the development. Fencing must be flush with the ground to prevent turtles from going underneath it, and must also be a minimum of 1 m tall. The fence will mitigate the risk of road mortalities and will ensure that turtles moving through the area are confined to the 40 m corridor. This will provide a benefit to Blanding's Turtle by mitigating and controlling the existing threat of road mortality. Experience has shown that Blanding's Turtles are very persistent animals, and so even with a fence in place there is a risk that turtles will find a way into the development through gaps in the system that may result from weather, wear and tear, or burrowing activities from urban wildlife and pets. The risk of turtles entering the development may be greater during the first few years that the system is in place, when turtles may try to reach lost habitat features that they have habitually accessed in the past. While these risks may remain even with a fencing system in place, the turtle exclusion fence will nonetheless reduce the risk of road mortality significantly.

New and upgraded roads will cross the tributaries in at least five (5) locations (as shown in Figure 2). Three (3) of these are anticipated as crossings for new roads. For new roads, the Owners will be responsible for installing wildlife passage culverts and implementing a fencing system that prevents turtles from accessing the roads. The fencing on both sides of the 40 m corridor will be extended up to the edge of the roads, to ensure there is no gap through which turtles could access the road. The only gap in the fencing should be at designated pedestrian access points, where fencing can be angled backwards for a suitable distance to discourage turtles from entering pedestrian access points. The road grading and elevation may also be designed to prevent turtles from accessing the road. Within the future road design, the details regarding fencing, grading and elevation will be outlined. Sufficiently sized wildlife passage culverts will be installed to ensure Blanding's Turtle and other wildlife can safely cross beneath the road. Two (2) existing water crossings exist along March Road, where March Road crosses both the North Tributary and the North Branch. Both of these existing crossings feature culverts that are too small to significantly mitigate the risk of Blanding's Turtle crossing the road, and no fencing system is in place in these locations. It is assumed that the City will build wildlife passage culverts and implement a fencing system at these locations during future road upgrading.

7.3 Predation and Urban Wildlife Mitigation

In Section 5.3 it was noted that the development of Kanata North has the potential to influence predator populations and hence predation rates for Blanding's Turtle. It was also noted that quantifying the influence on predation from Kanata North, compared to existing and planned urban developments and agricultural lands, would be extremely difficult. Overall, it is likely that Kanata North will have a minor additive effect on populations of urban predators, given the regional context of existing and planned urban developments.

One way in which the potential for increased predation rates will be mitigated is through the habitat enhancement and mitigation measures discussed in Section 6.0. Notably, the new nesting areas that are proposed as habitat compensation features (Refer to Section 6.4) will be within the 40 m watercourse corridor. This placement will ensure that gravid females travelling through the corridor looking for a nesting site do not need to travel far overland from the shelter of the watercourse. This reduces the predation risk to adult females and their hatchlings compared to other nesting sites which are likely to be further than 40 m from an aquatic habitat feature. In addition, the general improvements in habitat quality, increase in the size and distribution of deeper ponds, and improved vegetative cover along the 40 m corridor will help provide refuge for Blanding's Turtles and will mitigate potential predation impacts. Overall, the proposed habitat enhancement measures will improve aquatic and terrestrial vegetative cover, water depth, and will place refuge features every 50 to 100 m along each tributary. This will reduce exposure of Blanding's Turtle to overland movement through exposed terrestrial habitats, thereby reducing their vulnerability to predation compared to existing conditions. In addition, the placement of cover objects such as rock piles, logs, wood debris, etc. around the constructed wetlands will provide further cover for turtles.

7.4 Recreational Usage and Human Interference Mitigation

As noted previously, the entire perimeter of the 40 m watercourse corridor will be fenced. This will reduce the likelihood of residents impacting the corridor through activities at the back of their lots and will reduce edge effects. It will also ensure that residents access the corridor at designated access points. As noted previously, a 6 m wide recreational path will exist adjacent to the 40 m watercourse corridor. This will allow residents to utilize the area adjacent to the watercourse corridor for recreational purposes. The impact of recreational usage on Blanding's Turtles will be mitigated through landscaping and the configuration of the habitat enhancement features. The details of this mitigation will be developed during the detailed design stage, but will include planting of trees and shrubs adjacent to key retained or built habitat features to discourage human entry or disturbance to the turtles. Notably – the new deep ponds and artificial nesting areas will be configured so that their deep side is adjacent to the recreational path and so that any shallow areas are on the opposite side of the pond. Structural elements such as basking logs and rock piles will be placed on the far side of the ponds away from the recreational path. This will reduce the likelihood that residents will encounter the turtles at close range and ensure that basking can be undertaken without disturbance. Landscaping features including trees, shrubs, and grading will be placed adjacent to some portions of the deep ponds, nesting areas, and shallow pans to ensure that some of these features are well separated from the 6 m path and screened from human disturbance. The detailed design of the recreational path will include designated observation points for pond features that are strategically placed to reduce disturbance to turtles. The Owners will also work with the City to develop public information signs that will be erected around the recreational trails. These materials will incorporate information about Blanding's Turtles and potential impacts that residents may have on this species.

8.0 Post Construction Monitoring and Maintenance Program

Following completion of habitat compensation and enhancement work within each quadrant, the new habitat compensation and enhancement features will be monitored through basking surveys. These surveys will be undertaken in alternating years over a five year period. This will include monitoring in Years 1, 3 and 5 following construction, and no monitoring in Years 2 and 4. Depending on the timing of work in each quadrant, monitoring may be undertaken separately for each quadrant. It may also be combined to address more than one quadrant with the same monitoring program. Basking surveys will be undertaken following the OMNRF Blanding's Turtle Survey Protocol (OMNRF 2012c) which includes five (5) basking survey visits in the spring and early summer each year.

This monitoring program will include all retained and constructed Category 1 and 2 features within each quadrant including the tributaries, the newly built shallow pans, deep pockets, deep ponds, the artificial nesting areas, and the retained Category 2 pond on the North Branch. This monitoring program will provide information on the utilization of these habitats by Blanding's Turtle. The condition of the retained and built habitat features will also be monitored and information including vegetative cover, aquatic plants, presence of invasive species, stability of the banks/slopes, and water levels will be monitored in each of the three (3) monitoring years. If any deficiencies are identified in the habitat enhancement and compensation features, these will be reported to the Owners. This will allow for adaptive management and maintenance of the 40 m watercourse corridor. Maintenance requirements will primarily be identified adaptively through the monitoring program.

Following each monitoring year, an annual report will be produced documenting the monitoring results. This will include monitoring dates and methodology, as well as a description of the condition of the habitat, Species at Risk sightings, GPS coordinates, and site photographs.

9.0 Closure

We trust that the above meets your present requirements; should you have any questions or concerns regarding this report, please feel free to contact the undersigned at your convenience.

Sincerely,

For **DST CONSULTING ENGINEERS INC.**

COLLEGE OF APPLIED BIOLOGY
Andrew
McKinley
R.P. Bio
2602
CAB

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11.0 Reliance

This report has been prepared for Novatech Engineering Consultants Ltd., on behalf of the Kanata North Landowner's Group and in support of the Kanata North Community Design Plan. It is hereby acknowledged that Metcalfe Realty Company Limited, J.G Rivard Limited and 8409706 Canada Inc. (Valecraft Homes), 3223701 Canada Inc. and 7089121 Canada Inc. (Junic/Multivesco) can rely upon and utilize this report for the purpose of obtaining approval of the community design plan, and for their own use to seek development approval.

It is further acknowledged that future confirmed participating landowners within the Kanata North Landowner's Group can rely upon and utilize this report for the purpose of obtaining approval of the community design plan, and for their own use to seek development approvals.

APPENDIX A

OMNRF Records of Correspondence

NOVATECH
Engineers, Planners & Landscape Architects

MINUTES / NOTES OF MEETING

		Project No.:	112117-0
Project:	Kanata North Community Design Plan	**Meeting No.:**	1
Location:	Ministry of Natural Resources, Kemptville District	**Date:**	September 23, 2014

Present: Mary Dillon, OMNR (MD)
Shaun Thompson, OMNR District Ecologist (ST)
Laura Melvin, OMNR District Planner (LM)
Erin Seabert, OMNR Natural Heritage Biologist (ES)
Andrew McKinley, DST Senior Biologist (AM)
Greg Winters, Novatech Project Manager (GW)

Distribution: All
Next Meeting: TBD

ITEM	DESCRIPTION	ACTION
1.0	(GW) Provided general overview of the Community Design Plan process schedule, description of each of the five participating landowners	
	(AM) Landowners plan to coordinate on an overall plan through the CDP process prior to applying for individual overall benefit permits.	
	(AM) Only one Blandings Turtle found in pond on North Tributary. Other turtles noted as shown on habitat mapping provided but they were not identified	
	(AM) Pond is Category One, the tributaries to Shirley's Brook are Category 2 and the balance of the surrounding lands are Category 3	
	(GW) We recognize that there is movement potential along the tributaries between South March Highlands and Shirley's Bay even in absence of evidence of turtle kills along March Road	
	(GW) Some improvements have already been made to Shirley's Brook through the development of the Brookside Subdivision, and there may be some further rehabilitation to Shirley's Brook through DND lands as part of the current CDP process	
	(LM) How will the permitting work to show overall benefit? How will it work with stormwater ponds?	
	(AM) There will be ponds but they will not provide habitat, although there may be some benefit. We will not include stormwater ponds in our habitat calculations but there may be side benefits to having them there.	
	(GW) The plan is to provide a 46 metre wide corridor as a minimum, 40 metres for tributary and a 6 metre pathway. There will be areas where the habitat will be bigger around ponds etc. There will be one overall roadmap to guide future permitting applications by the individual landowners as they develop each subdivision or phase.	
	(ST) What Category is the woodlot? It is understood that there may be vernal pools and that it may be something of value.	
	(AM) Woodlot is not mapped as habitat as it is outside of the Category 3 buffer from the mapped Category 2 features.	

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ITEM	DESCRIPTION	ACTION
	(ST) One overall plan is feasible and should look at linkages to Shirley's Bay. More information regarding the woodlot is needed to determine the habitat category.	
	(ST) May consider some compensation off-site on Multivesco between the CDP area Second Line Road along tributary outside study area should it be necessary to provide additional compensation. This option may be more desirable to create a marsh rather than trying to compensate within the CDP study area	
	(ST) OMNR supportive of investigating appropriateness of a 40/46 metre corridor with pathway. This needs to be investigated and supported through consideration of current conditions (habitat suitability and function), final plan and GHD. OMNR has no problem with the roadmap plan being phased.	
	(ST) The study needs to look at existing habitat categories and provide a plan showing net loss and gains. Study will look at phasing and possibly temporary phasing	
	(AM) Our goal is to provide a way to copy the design through from EMP to permitting	
	(ST) The challenge will be in the determination of the 2 above (ST) boxes.	
	(ST) There may be 40 metres in some places but there may be an argument (which needs to be developed and supported through analysis) that there is nothing there now due to agricultural up to the edge of the watercourse. OMNR agreed that revised mapping should be done to estimate the functional extent of habitat.	
	(ST) Plans should have on-line ponds and on-line marshes to show safe and effective corridor with hibernating opportunities	
	(ST) Off-site compensation would be a backup plan if necessary	
	(ST) OMNR would like to get an update on the woodlot	
	(GW) Muncaster Environmental Planning is completing an update to the previous studies and is further studying the woodlot	
	(ST) Would like to know what is the Category of the woodlot. May be Category 2 but not Category 1. Question is how to treat seasonal swamps. General Habitat description is stretched if swamps not found there. Woodlots are used by turtles but it may not meet the Category description	
	(ST) Woodlot is not likely Category 1. May be Category 2 or 3. Similar situation talked about with KNL. GHD are guidelines. There can be exceptions or variances from them if supported by evidence of situation and biology of the species. KNL had telemetry that suggested connections or travel corridors outside of Category 3 habitat as defined by GHD.	
	(AM) There is a reasonable chance that turtles will go along Shirley's Brook	
	(ST) Turtles may bask in woodlot, provided sunlight and woody place to hide. Category 2 is not just for foraging. Muncaster additional studies should be able to provide evidence to determine habitat suitability or potential.	
	(ST) OMNR will want to see photos of habitat to support calculations.	
	(AM) Category 2 is 60 metres around watercourse and Category 3 is between 30 and 250 metres from watercourse. How should we assess if there is farming up the edge of the tributary? The "functional" habitat is	

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ITEM	DESCRIPTION	ACTION
	small. The general habitat description is overstated. Proposal is to map the actual habitat based on the functional extent.	
	(ST) This is a fair approach. Example of KNL where turtle population was more dense, habitat more natural and expansive, and areas already developed were much more urban than the Kanata North situation.	
	(ST) The study needs to be documented but reasonable. Main fields could possibly be developed. It appears there is potentially limited function there. Needs to be defended with rationale and discussion.	
	(ST) Study has to be mathematical, with maps, good imagery, and showing ploughed areas. May include GIS	
	(ST) Study should not use average but prefer GIS/mapping but could be described as average	
	(ST) Proposal to preserve travel corridor is good. Opportunities for on-line marshes also good.	
	(GW) Proposal is to study, prepare mapping, prepare design and review with OMNR	
	(AM) Proposal to have variety of depths and potential nesting areas. Fill is cheap for nesting areas. Will record loss of existing Category 1 pond	
	(ST) Show history of pond. As with KNL, we need to strategize the transition of the ponds	
	(AM) Category 1 and 2 will likely show overall benefit in the final calculations based on the current plan. Category 3 will likely show a habitat loss	
	(ST) Category 3 function is primarily travel. Could contain nesting habitat or other is some cases. Need to make case that use is currently restricted to Category 1 and 2. This is referring to the presumption (as of yet undemonstrated) that the fields surrounding riparian and wetland habitat outside of 30m from wetland/stream – e.g. 220 m beyond by application of GHD – are not Cat.3. habitat. Category 1 and 2 can also function as Category 3 – stream and online marsh are both 1(farm pond), 2, and 3 for example.	
	(ST) Study needs to talk about restriction of urban uses and conflict with turtles	
	(ST) Study could make recommendations for study, lookouts, education and signage	
	(AM) Compensation will be done through Category 1 and 2 and includes habitat enhancement and habitat creation work only, and doesn't currently include other forms of providing compensation.	
	(ST) Agreed, but may be provided later. Opportunities to demonstrate overall benefit here. No need to do further telemetry or other intensive studies or nests.	
	(AM) What will monitoring involve?	
	(ST) Occupation and use is key. Not the same as KNL, as we are not dealing with the same level of habitat or turtles (as KNL).	
	(ST) Monitoring professionally for a few years through basking surveys. Possibility of Encourage public to do monitoring as lands develop and to report these to the consultant. Homeowners awareness package should be distributed for new homeowners.	
	(AM) Next steps?	
	(AM) Summary, Category 1	
	(ST) Provide feedback further evaluation of the woodlot; GIS, aerial photos, site visit, to narrow down existing watercourse habitat.	

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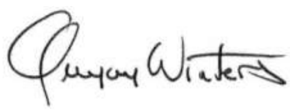
ITEM	DESCRIPTION	ACTION
	(ES) Overall benefit and how to compensate needs to be explained	
	(ES) Process needs to be vetted by OMNR regional office	
	(ST) Eventually each separate permit will have to stand on its own	

Report any errors and/or omissions to the undersigned.

Prepared by:

NOVATECH



Gregory Winters
Project Manager-Planner, MCIP, RPP

Ministry of Natural Resources and Forestry

Kemptville District

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Ontario

DST Consulting Engineers Inc.
203-2150 Thurston Drive
Ottawa, Ontario K1G 5T9

May 1, 2015

Attention: Dr. Andrew McKinley, Senior Biologist, McKinley Environmental Solutions
Bernie Muncaster, Principal, Muncaster Environmental Planning

Re: Request for Review of Interpretation of Blanding's Turtle General Habitat Description

Dear Sirs:

In your letter dated February 26, 2015, you requested additional detail and clarification regarding the interpretation of Blanding's turtle General Habitat Description (GHD). We have sought input from a number of different sources within the Ministry of Natural Resources and Forestry (MNRF) (including District staff and management, Southern Region staff, and Species at Risk Branch (SARB) Policy Officers) and are pleased to provide the following response.

The responses below address the points raised in the DST letter.

HABITAT MAPPING – TRIBUTARIES OF SHIRLEY'S BROOK – AND SUMMARY POINTS 1, 3, 4, 5 and 6

Based on best available scientific information, the entire 30 m area around wetlands and other suitable aquatic features has been identified in the GHD as Category 2 habitat for Blanding's turtle. Turtles are dependent on this habitat for several life processes, but most notably thermoregulation. Open areas within 30 m of suitable wetlands and watercourses are used for basking (Joyal et al. 2001), while vegetated or treed areas contribute to thermoregulation by providing cooler microhabitats within and around the aquatic or wetland habitat. These areas also provide shelter and protection from predators and are important habitat for movement and even overwintering of hatchling Blanding's turtles. Buffers of 30 m are also widely recognized as essential in maintaining microhabitat conditions and a range of functional benefits to wetland features (e.g., filtering of sediment and nutrients, input of woody debris etc.)(OMNR 2010). Taking all of these functions into account, 30 m is generally accepted as the minimum buffer size required for the maintenance of these important life processes and/or habitat characteristics for Blanding's turtle.

In considering habitat mapping for the proposed development site, Kemptville District staff requested additional information on the quality of habitat within the 30 m buffer. However, following consultation with staff in Southern Region and SARB it was determined that once an area is identified as general habitat under the Endangered Species Act (ESA), section 10 of the ESA applies regardless of the relative quality of the protected habitat. It was learned that habitat quality is taken into consideration at the overall benefit application stage of the ESA permitting process. In cases where habitat is determined to be of relatively lower quality, an activity (e.g., associated with residential development) may be less likely to further impair the function of that habitat, or the impact of an activity may be less than if it were affecting a higher quality habitat area or feature. This information was communicated by Kemptville District staff at the January 20, 2015 meeting and confirmed in email communications sent January 28, 2015.

It is acknowledged that row cropping and cattle pasturing do affect the ability of the 30 m buffer to provide the functional benefits to aquatic and wetland features described above. These disturbances, however, are not considered to impair the use of the habitat in supporting life processes for Blanding's turtle such as thermoregulation. The impacts of row cropping and cattle pasturing on habitat are not permanent and are considered largely reversible within a relatively short period of time if those disturbances cease to take place.

EASTERN WOODLOT AND SUMMARY POINTS 2, 3, 4, and 6

Blanding's turtle is a habitat generalist. While there are classic habitats used during summer, they can also occur in a variety of wetland habitats including lakes, permanent ponds, temporary ponds, slow flowing brooks, creeks, marshes, river sloughs, marshy meadows, man-made channels, farm fields, coastal areas etc. (COSEWIC 2005). Radio tracking by MNRF staff has identified Blanding's turtles in all types of wetland habitat, including at times when no standing water is present (Cameron, 2014). Blanding's turtle occurrence information in LIO suggests the same (MNRF, 2015).

The GHD does indicate that *suitable wetlands used during the active season are typically eutrophic (mineral or organic nutrient-rich), shallow with a soft substrate composed of decomposing materials, and often having emergent vegetation, such as water lilies and cattails (COSEWIC 2005, Congdon et al. 2008)*. It also recognizes, however, a variety of wetland types (including swamp) as suitable habitat for the species during the active season and acknowledges the range of functions that these wetlands are depended upon to provide (e.g., life processes including thermoregulation, movement, and protection from predators).

Discussions among MNRF staff regarding Category 2 habitat are ongoing. A decision to not include the cedar swamp (Community 6), willow swamp (Communities 3 and 11), and the cleared hardwood swamp (Community 12) as Category 2 habitat has been made for this site and at this time. The decision is considered site-specific and takes into consideration conditions and characteristics observed during the site visit on April 16, 2015. The decision is intended to allow planning for this residential development to move forward, but should not be considered indicative of what may be considered as suitable habitat at another site, or pending the outcome of the internal MNRF discussions regarding Category 2 habitat.

We trust that this addresses your concerns at this time. If there are any questions, or additional concerns, please contact Mary Dillon at 613-258-8267 or at Mary.Dillon@ontario.ca.

Sincerely,

Scott Lee
Resource Operations Supervisor,
Kemptville District

References:

Cameron, G. 2014. Unpublished data. Species at Risk Biologist. Ontario Ministry of Natural Resources and Forestry.

Congdon, J.D., Graham, T.E., Herman, T.B., Lang, J.W., Pappas, M.J., and Brecke, B.J. 2008. Emydoidea blandingii (Holbrook 1838) – Blanding's Turtle. In: Rhodin, A.G.J., Pritchard, P.C.H., van Dijk, P.P., Saumure, R.A., Buhlmann, K.A., and Iverson, J.B. (Eds.). Conservation Biology of Freshwater Turtles and Tortoises: A Compilation Project of the IUCN/SSC Tortoise and Freshwater Turtle Specialist Group. Chelonian Research Monographs No. 5, pp. 015.1-015.12, doi:10.3854/crm.5.015. blandingii.v12008, http://www.iucn-tftsg.org/cbftt/.

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Joyal, L.A., M. McCollough and M.L. Hunter Jr. 2001. Landscape ecology approaches to wetland species conservation: a case study of two turtle species in southern Maine. Conservation Biology 15(6):1755-1762.

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Andrew McKinley <mckinleyenvironmental@gmail.com>

S-23 Follow-up

Dillon, Mary (MNRF) <Mary.Dillon@ontario.ca> Mon, May 25, 2015 at 9:01 AM
To: Andrew McKinley <mckinleyenvironmental@gmail.com>, Murray Chown <m.Chown@novatech-eng.com>, Greg Winters <G.Winters@novatech-eng.com>, John Riddell <J.Riddell@novatech-eng.com>, Bernie Muncaster <bmuncaster@rogers.com>

Hi Andrew,

In terms of suitable Category 2 habitat for BLTU, there are no concerns with the woodlot east of the rail line at this time.

I hope this helps.

Mary

From: Andrew McKinley [mailto:mckinleyenvironmental@gmail.com]
Sent: May 21, 2015 5:30 PM
To: Dillon, Mary (MNRF); Murray Chown; Greg Winters; John Riddell; Bernie Muncaster
Subject: S-23 Follow-up

[Quoted text hidden]

Andrew

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mckinleyenvironmental@gmail.com | www.mckinleyenvironmental.com

Appendix U

Kanata North Community Design Plan

Blanding's Turtle Compensation Plan – Offsite Compensation Concept (Memo)

(DST Consulting Engineers – November 12, 2015)

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Ontario Ministry of Natural Resources and Forestry
Kemptville District
Provincial Government Building, 1st Floor
10 Campus Drive, Kemptville, Ontario, K0G 1J0

January 25, 2016
DST File No.: OE-OT-019389

Attn: Chris Lewis, OMNRF Kemptville

CC: Mary Dillon, OMNRF Kemptville
CC: Scott Lee, OMNRF Kemptville
CC: Murray Chown, Greg Winters, John Riddell – Novatech Engineering Consultants

RE: Kanata North Community Design Plan – Blanding's Turtle Habitat Compensation Plan – Offsite Compensation Submission #2

1.0 BACKGROUND

Dr. Andrew McKinley of McKinley Environmental Solutions is currently working through DST Consulting Engineers Inc. (DST) in collaboration with Novatech Engineering Consultants (Novatech) to finalize the Blanding's Turtle Habitat Compensation Plan (the Compensation Plan) that supports the Kanata North Community Design Plan (the Community Design Plan). This work has been conducted on behalf of the Kanata North Landowners Group (the Owners). As previously discussed with OMNRF Kemptville staff, the purpose of the current undertaking is to create an overall habitat management and compensation plan that will be acceptable to the regulatory agencies and which will establish a coordinated approach to fulfill future permitting and compensation requirements for the landowners in the planning area. The Compensation Plan will support the final Community Design Plan (CDP) and will establish an overall compensation approach that will ensure the success of future permit applications for each individual subdivision within the CDP area. It is anticipated that each individual subdivision within the CDP area will ultimately be required to obtain their own Overall Benefit Permits under Clause 17(2)(c) of the Endangered Species Act. The Compensation Plan will inform the preparation of these permits by providing pre-development habitat mapping, a coordinated compensation approach, compensation measures, and recommended mitigation measures to be incorporated into future permit applications.

The report entitled *Kanata North Community Design Plan – Blanding's Turtle Habitat Compensation Plan* (DST 2015) (the Habitat Compensation Plan Report) was previously submitted to the Ontario Ministry of Natural Resources and Forestry (OMNRF) Kemptville District staff in June 2015. A joint meeting was held on September 16, 2015 to discuss OMNRF's comments on this report. Documentation of the meeting has been provided to the OMNRF as

Meeting Notes/Minutes. During the September 16th joint meeting it was understood that OMNRF had requested no revisions to the Habitat Compensation Plan Report.

The habitat compensation plan included the preservation of a 40 m corridor along the two tributaries of Shirley's Brook within the CDP area, as well as multiple habitat enhancement measures to create and enhance Category 1 and 2 habitat within the 40 m corridor. OMNRF did not request any revisions to the Habitat Compensation Plan Report and the habitat enhancement measures that were proposed. OMNRF also stated that they believed insufficient compensation for habitat loss had been provided within the 40 m corridor, and that additional compensation was required to provide an overall benefit. It was agreed that because the land use within the CDP is final, an offsite compensation submission would be developed to provide additional compensation for habitat impacts.

The first offsite compensation submission was provided to OMNRF in a letter dated November 19th, 2015 (see below). The purpose of this letter is to present a revised offsite compensation submission for review and discussion with OMNRF.

2.0 OFFSITE COMPENSATION SUBMISSION #1 - PROPOSED SHIRLEY'S BROOK REALIGNMENT – EAST OF MARCH VALLEY ROAD

The first offsite compensation submission was provided to OMNRF in a letter titled *Kanata North Community Design Plan – Blanding's Turtle Habitat Compensation Plan – Offsite Compensation Concept* (November 19th, 2015). This first submission outlined a proposal to realign a segment of Shirley's Brook east of March Valley Road in order to restore the watercourse to a more natural state. This would also include adding new Category 1 and 2 habitat features. Additional detail is provided in the letter dated November 19th, 2015.

OMNRF responded to the first submission by email on December 17th, 2015. OMNRF stated that the proposed offsite compensation did not adequately provide compensation for the loss of Category 3 habitat. It was acknowledged that while some aspects of the compensation proposal may provide benefits to the species, OMNRF believed the proposal did not adequately address the need to support the movement of turtles in a west-east direction. It was stated that while the offsite compensation strategy can incorporate elements of Category 1 and 2 habitat compensation, the higher priority is to address Category 3 habitat compensation (movement functionality). OMNRF identified opportunities to improve the movement function in the area north of the Kanata North Community Design Plan (KNCDP) lands. This area is located along March Valley Road south of the intersection with Riddell Drive, and has had documented occurrences of at least three (3) turtle road mortalities. The second offsite compensation submission has been developed based on this recommendation (discussed below).

3.0 QUANTIFICAITON OF CATEGORY 3 HABITAT LOSS IN THE KNCDP

The OMNRF response to the first offsite compensation submission (response received by email December 17th, 2015) suggested that the Habitat Compensation Plan Report had not adequately quantified the impacts on turtle movement and the loss of Category 3 habitat within the KNCDP. We believe that the Habitat Compensation Plan Report has adequately and accurately mapped the extent of Category 3 habitat as defined by the *General Habitat Description for Blanding's Turtle* (OMNRF 2013). This mapping is shown in Figure 3. There are two important points that should be emphasized:

1. Under existing conditions there is no continuous west-east corridor of Category 3 habitat through the KNCDP lands. As shown in Figure 3, the eastern portion of Quadrant B and Quadrant D are beyond the areas that are defined as Category 3 habitat according to the *General Habitat Description for Blanding's Turtle* (OMNRF 2013). Category 3 habitat is defined as habitat extending up to 250 m from a wetland feature (OMNRF 2013). As shown in Figure 3, there is a gap approximately 620 m wide between adjacent areas of Category 3 habitat within the eastern part of the KNCDP. This habitat mapping was confirmed in a written response from OMNRF received May 1st, 2015. Because the lands in the eastern portion of Quadrant B and D do not meet the definition of habitat outlined by the *General Habitat Description*, these areas are not subject to the habitat regulations of the Endangered Species Act (ESA). Lands which do not meet the OMNRF definition of Blanding's Turtle habitat should not factor into the quantification of habitat loss or the requirements for overall benefit.
2. Although OMNRF has emphasized the importance of the KNCDP lands in providing a west-east movement corridor, there is little evidence showing turtle movement through this area. To date only one confirmed occurrence of a Blanding's Turtle has been documented within the KNCDP within a pond in Quadrant A (Refer to Figure 3). There is no evidence to indicate which direction this turtle may have come from. OMNRF has provided road mortality data which indicated that at least three (3) Blanding's Turtles have been killed on March Valley Road south of the intersection with Riddell Drive. These road mortalities occurred approximately 700 m northeast of the KNCDP. The road mortalities indicate that under existing conditions turtles are more likely to be moving in an east-west direction along a northerly path beyond the KNCDP. To our knowledge, there have been no confirmed mortalities along the stretch of March Valley Road which is adjacent to the KNCDP. Although there is limited evidence available, road mortalities indicate that turtles are more likely to be moving in a west-east direction in the area north of the KNCDP, rather than through the KNCDP lands.

OMNRF has stated repeatedly that compensation should reflect the loss of the west-east movement corridor through the KNCDP. As noted above, the definition of habitat under the *General Habitat Description* does not support the existence of a movement corridor of habitat in this area. Furthermore, no evidence exists to indicate that turtles are moving through this area.

Although there is not substantial evidence to support the idea that the development of the KNCDP lands will significantly impact Blanding's Turtle movement or that the KNCDP lands contain a movement corridor, the proponents acknowledge that enhancement of the existing movement corridor north of the KNCDP does present an opportunity to provide a benefit to the species. As discussed below, the enhancement of the movement corridor north of the KNCDP could help to alleviate the existing risk of road mortality for Blanding's Turtle.

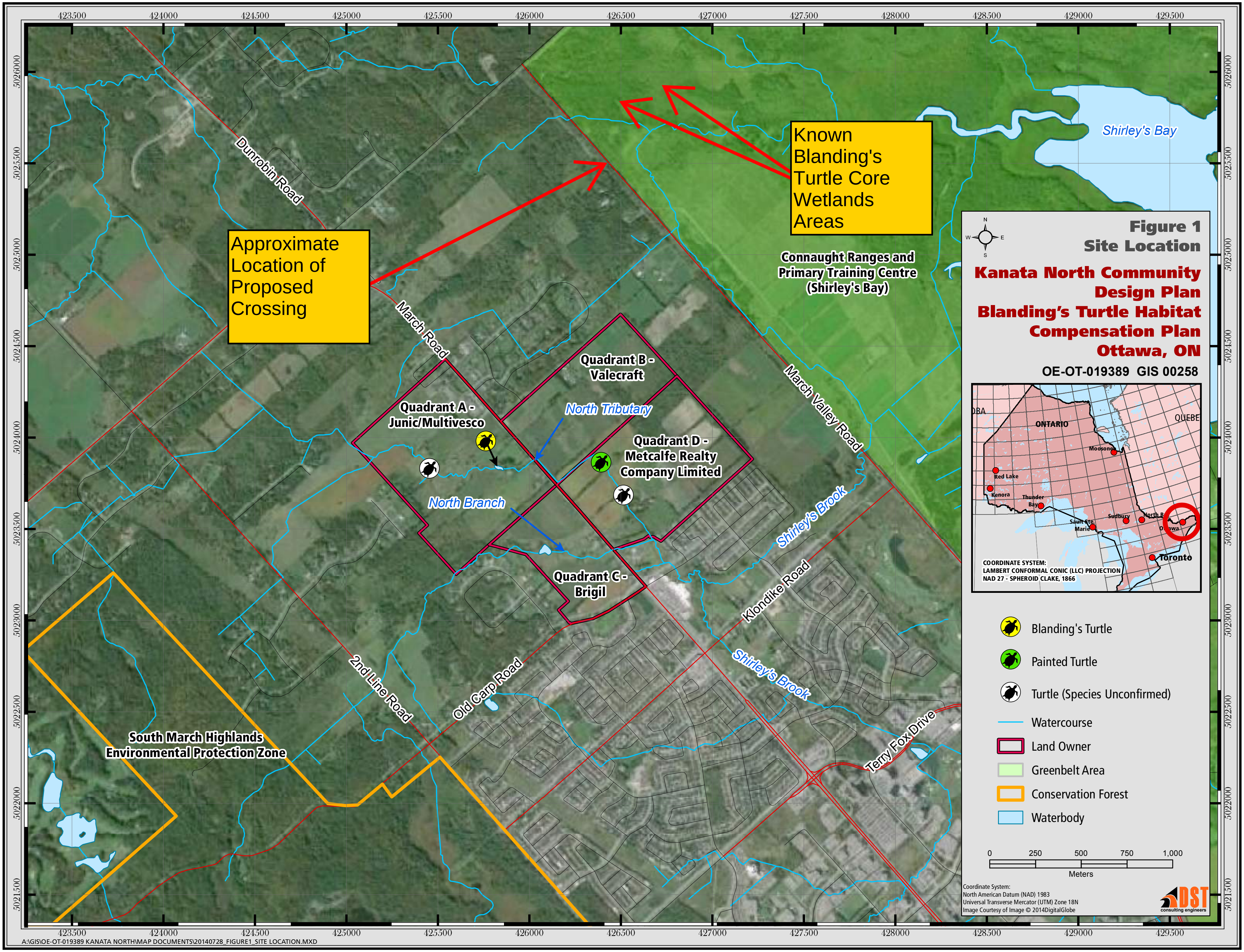
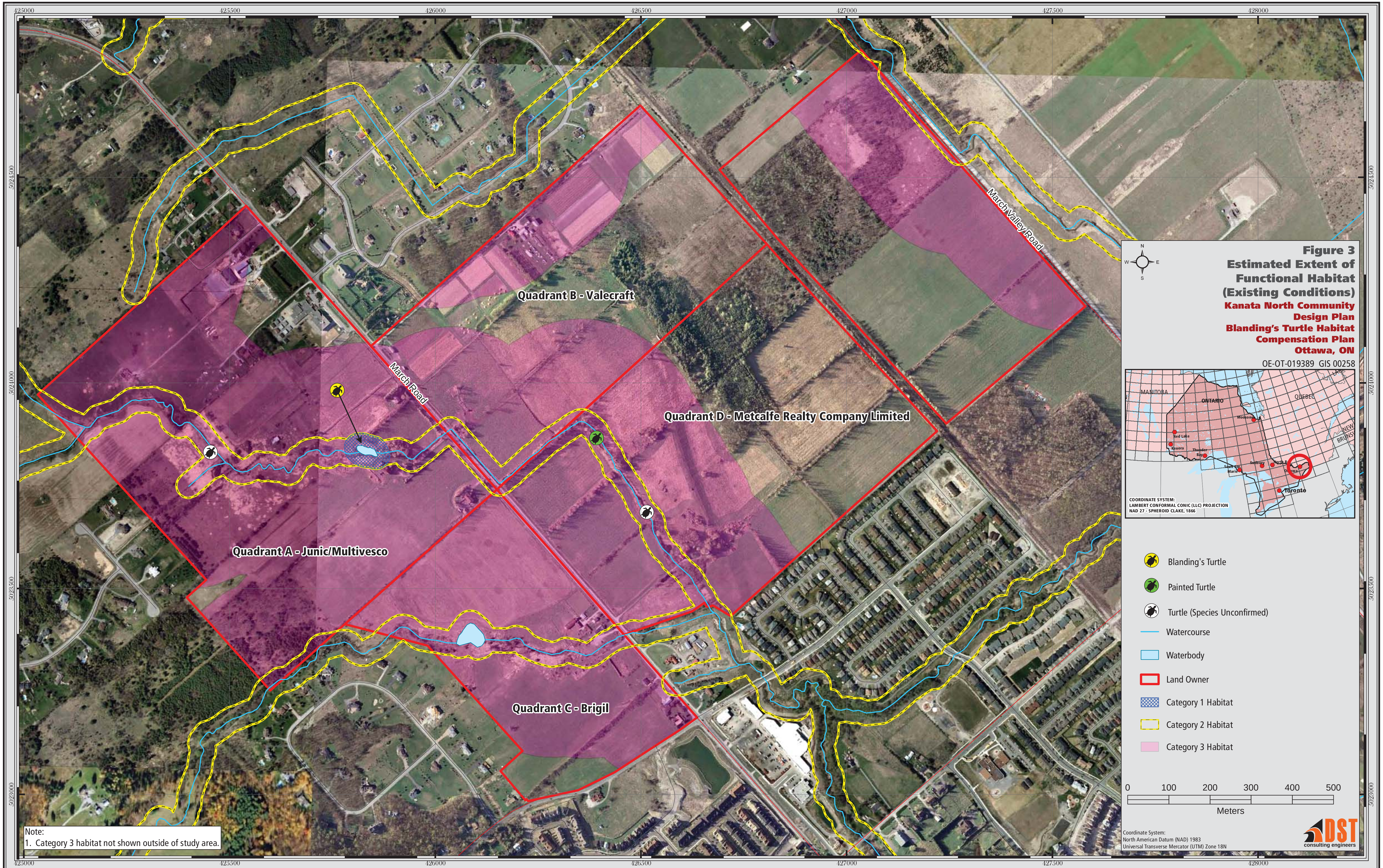


Figure 1
Site Location
Kanata North Community Design Plan
Blanding's Turtle Habitat Compensation Plan
Ottawa, ON
OE-OT-019389 GIS 00258
Known Blanding's Turtle Core Wetlands Areas
Approximate Location of Proposed Crossing
Connaught Ranges and Primary Training Centre (Shirley's Bay)
Shirley's Bay
Dunrobin Road
March Road
March Valley Road
Quadrant A - Junic/Multivesco
Quadrant B - Valecraft
Quadrant C - Brigil
Quadrant D - Metcalfe Realty Company Limited
North Tributary
North Branch
Shirley's Brook
Klondike Road
Old Carp Road
2nd Line Road
Terry Fox Drive
South March Highlands Environmental Protection Zone
ONTARIO
Red Lake
Kenora
Thunder Bay
Moosonee
Sault Ste Marie
Sudbury
Toronto
COORDINATE SYSTEM:
LAMBERT CONFORMAL CONIC (LLC) PROJECTION
NAD 27 - SPHEROID CLAKE, 1866
Blanding's Turtle
Painted Turtle
Turtle (Species Unconfirmed)
Watercourse
Land Owner
Greenbelt Area
Conservation Forest
Waterbody
0 250 500 750 1,000
Meters
Coordinate System:
North American Datum (NAD) 1983
Universal Transverse Mercator (UTM) Zone 18N
Image Courtesy of Image © 2014DigitalGlobe
DST consulting engineers
A:\GIS\OE-OT-019389 KANATA NORTH\MAP DOCUMENTS\20140728_FIGURE1_SITE LOCATION.MXD



A:\GIS\OE-OT-019389 KANATA NORTH\MAP DOCUMENTS\20150206_FIGURE3_ESTIMATED EXTENT OF FUNCTIONAL HABITAT_UPDATE.MXD

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KANATA NORTH
COMMUNITY DESIGN PLAN

TURTLE CROSSING

SCALE 1 : 5000 (0, 50m, 100m, 200m)

DATE JAN 2016 | JOB 112117 | FIGURE TRTL-XING

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SHT11X17.DWG - 279mmX432mm

4.0 OFFSITE COMPENSATION SUBMISSION #2 - PROPOSED MARCH VALLEY ROAD CROSSING

As recommended by OMNRF, the possibility of developing a road crossing for Blanding's Turtle along the northern section of March Valley Road has been investigated. This forms the foundation of our second submission. The second submission is meant to be read as an alternative to our initial submission, and would be undertaken *instead* of the works described in the first submission.

A preliminary investigation of the March Valley Road section adjacent to the documented Blanding's Turtle road mortalities has been conducted. There are three (3) existing culverts in the vicinity of the road mortalities. All of these culverts are too small for Blanding's Turtle to use for road crossing. The three (3) existing culverts are all hydraulic culverts which convey waterflow under March Valley Road. The southernmost culvert is a perched 600 mm CSP culvert which receives flow from a tributary of Shirley's Brook. It appears likely that Blanding's Turtle are moving up the tributary of Shirley's Brook and are forced to cross the road when they reach the culvert. This is because the culvert is both too small to allow passage and also because it is perched. The culvert immediately north of this is also perched and is an 800 mm CSP culvert. A third 800 m CSP culvert is found further north. The lack of suitable culverts that would allow safe passage beneath the road is the likely cause of Blanding's Turtle road mortality.

A safe road crossing for Blanding's Turtle in the area will require a new wildlife passage culvert. It is proposed to provide this culvert at the location shown in the Potential Wildlife Crossing figure. This location lies immediately north of the tributary of Shirley's Brook, between the two existing perched culverts. The proposed location is in the approximate center of the area where road mortalities have been documented, and is presumed to be in the center of the movement corridor.

A dry culvert is believed to be the superior design option as it allows construction with minimal disturbance to existing habitat, it does not require interruption or alteration to existing drainage patterns, and it allows for installation of a culvert in the center of the area shown to have Blanding's Turtle road mortalities. As discussed below, dry culverts also allow for the placement of soft substrate (soil) as opposed to rock, as well as cover objects within the culvert. Hydraulic culverts generally would not allow for the placement of an erodible substrate or cover objects, due to the potential maintenance requirements and impacts on waterflow.

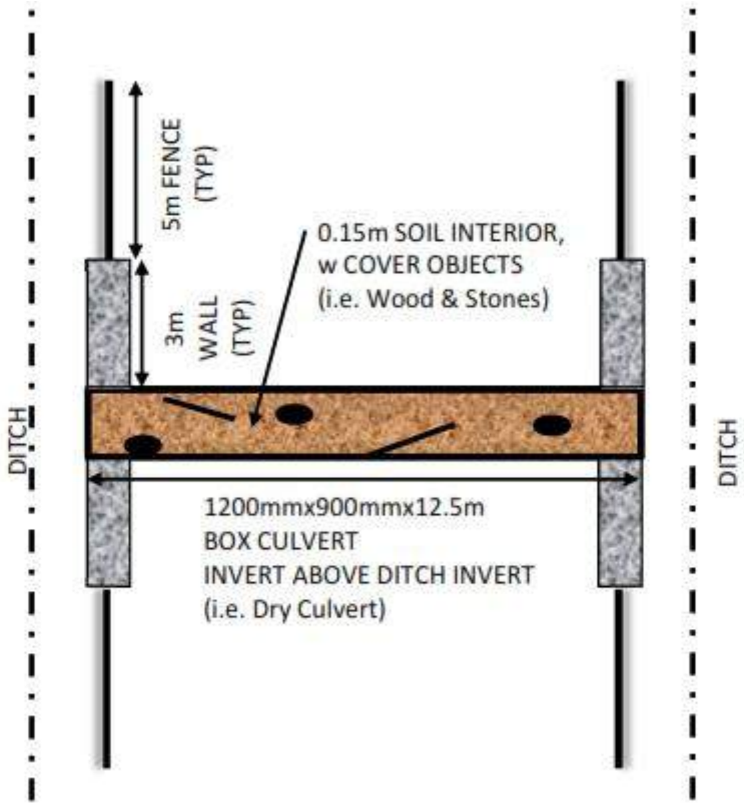


Diagram 1: Schematic Layout of Proposed Passage Culvert (Novatech 2016)

The new culvert will include the following:

- A 1200 mm by 900 mm rectangular concrete box culvert. The culvert will be installed beneath March Valley Road and will span approximately 12.5 m, connecting the ditches on either side of the road;
- The installation of the culvert will require excavation of the existing road and road resurfacing following installation;
- The bottom of the culvert will be lined with 15 cm of topsoil;
- The culvert will be positioned and designed to not receive waterflow;
- Cover objects will be placed selectively within the culvert. This will include wood, larger stones, and other cover objects. Cover objects will be distributed to provide some cover within the culvert but will not block movement;
- On each side of the culvert a 3 m long rock wall will be installed. This wall will be made from rock gabion baskets, concrete, cut blast rock, or other suitable rock material and will be a minimum of 60 cm tall;
- Beyond the rock wall, 5 m of fencing will be installed on either side of the culvert. This fencing will consist of rolled plastic one way turtle exclusion fencing that is a minimum of 60 cm tall and buried at the bottom. This fencing design has previously been discussed with OMNRF. The fencing will be constructed of durable materials designed for a minimum 20 year deployment; and

- In combination, the rock walls, fencing, and culvert will create an approximately 19 m wide passage system on either side of the road (Refer to Diagram #1 above). The rock walls and fencing will be in place to increase the likelihood that the crossing will be utilized by turtles.

The primary benefit associated with the installation of a wildlife passage culvert is the potential reduction in the risk of road related mortality. The passage culvert will provide a safe movement corridor that will allow turtles to cross March Valley Road. This will help to encourage turtle movement, genetic exchange, and population connectivity between the Blanding's Turtle population living in the Shirley's Bay area and those within the Carp Hills and South March Highlands. In general, reducing the risk of road related mortality helps to support maintenance of the population by reducing one of the primary anthropogenic risk factors. Road related mortality is known to be among the primary threats to the Blanding's Turtle population (OMNRF 2013).

5.0 CLOSURE

We look forward to receiving your comments and insights on this offsite habitat compensation submission. Should you have any questions or require further information, please do not hesitate to contact the undersigned, at your convenience.

Sincerely,

For **DST CONSULTING ENGINEERS INC.**

Andrew McKinley, Ph.D., MA, BA (Hons.), EP, RP Bio
Senior Biologist, Consultant

Milan Makusa, P.Geo.
Senior Technical Advisor

6.0 REFERENCES

Dillon Consulting (2011) Terry Fox Drive Extension Project: Wildlife Guide System Monitoring Report, Year 1 of 3.

Novatech Engineering Consultants (2016) Kanata North Preliminary Wildlife Crossing Cost Estimate.

Ontario Ministry of Natural Resources and Forestry (OMNRF) (2013) General Habitat Description for Blanding's Turtle (Emydoidea blandingii).

7.0 RELIANCE

This report has been prepared for Novatech Engineering Consultants Ltd., on behalf of the Kanata North Landowners Group and in support of the Kanata North Community Design Plan. It is hereby acknowledged that Metcalfe Realty Company Limited, J.G Rivard Limited and 8409706 Canada Inc. (Valecraft Homes), 3223701 Canada Inc. and 7089121 Canada Inc. (Junic/Multivesco) and future members of the Kanata North Landowners Group can rely upon and utilize this report for the purpose of obtaining approval of the community design plan and for their own use to seek development approval.

Appendix V

Kanata North Community Design Plan
Water Budget Analysis

(Novatech – May, 2016)

KANATA NORTH URBAN EXPANSION AREA

WATER BUDGET ANALYSIS

Prepared for the:

Kanata North Community Design Plan

Prepared By:

NOVATECH
Suite 200, 240 Michael Cowpland Drive
Ottawa, Ontario
K2M 1P6

November 9, 2015
Revised February 22, 2016
Revised May 26, 2016

Novatech File: 112117
Ref: R-2015-150

May 26, 2016, 2016

City of Ottawa
Planning & Growth Management Department
110 Laurier Avenue West, 4th Floor
Ottawa, ON K1P 1J1

Attention: **Wendy Tse, MCIP, RPP, LEED Green Associate**
Planner II

Reference: **Kanata North Urban Expansion Area – Water Budget Analysis**
Our File No.: 112117

Please find enclosed the revised Water Budget Analysis for the proposed Kanata North Urban Expansion Area (KNUEA). This report outlines the water budget analysis undertaken as part of the Kanata North Environmental Management Plan (EMP) and Community Design Plan (CDP). The site specific water budget assessment was performed to characterize the groundwater flow conditions and estimate infiltration and runoff within the proposed KNUEA lands and evaluate the potential impacts of development.

Please contact the undersigned should you have any questions or comments pertaining to the enclosed report.

Yours truly,

NOVATECH

Conrad Stang

Conrad Stang, M.A.Sc., P.Eng.
Water Resources Engineer

cc: Michel Kearney, City of Ottawa
Claire Milloy, RVCA / MVCA

Suite 200, 240 Michael Cowpland Drive, Ottawa ON K2M 1P6 Tel: 613.254.9643 Fax: 613.254.5867 www.novatech-eng.com

TABLE OF CONTENTS

List of Tables

List of Figures

Appendices

1.0 INTRODUCTION

This report outlines the site specific water budget analysis completed for the Kanata North Urban Expansion Area (KNUEA lands). The purpose of the water budget analysis is discussed in this section, along with the study procedures, site description and list of supporting documents. The supporting documents should be read in conjunction with this report.

1.1 Purpose

An increase in impervious surfaces in a watershed is typically associated with urban development, resulting in changes to the existing hydrologic functions. Natural features and private drinking wells that rely on surface water and groundwater resources can potentially be impacted by development.

The water budget approach aims to identify the connection between surface water and groundwater resources. As specified in the Ontario Clean Water Act (2006), a water budget measures the components of the hydrologic cycle (water balance) and characterizes water flow pathways within the watershed. The water budget completed for the Kanata North Urban Expansion Area:

- Documents existing conditions including: geology, hydrogeology, stream flow, and aquatic ecology.
- Identifies any significant groundwater recharge / discharge areas.
- Evaluates the impact of the proposed development and quantify changes in surface water and groundwater resources.
- Identifies any recommended mitigation measures for maintaining or enhancing infiltration to ensure that development does not impact existing water users in the vicinity of the study area.

1.2 Study Procedures

The water budget analysis uses an interdisciplinary approach that integrates the following disciplines:

- Geotechnical / hydrogeology
  - Identify the surficial geology and hydrogeology within the KNUEA lands.
  - Perform a bedrock characterization study to characterize the groundwater flow regime and identify potential groundwater recharge areas.
- Fluvial geomorphology
  - Evaluate surface water channel stability and channel forming processes.
- Environmental Systems
  - Assess aquatic habitat.
- Water Resources Engineering
  - Obtain and analyze streamflow monitoring data.
  - Develop and implement water budget model.

1.3 Site Information

Land use

The proposed Kanata North Urban Expansion Area (KNUEA) lands currently consist of a rural landscape, which includes an existing school, church, cemetery and sparse residential homes within agricultural lands and pockets of forested areas. The KNUEA lands are bounded by existing residential housing to the northwest and southeast; and, the western and eastern portions of the site are primarily agriculture with some forested areas.

The KNUEA lands are located within the Shirley's Brook watershed. Land use in the Northwest Branch of Shirley's Brook generally fall under three main categories:

1) The upper reaches of the Northwest Branch are largely undeveloped, and consist mainly of forest/wetland areas.
2) The mid-reaches of the Northwest Branch are comprised mainly of rural residential developments with some row crops.
3) The lower reaches of the Northwest Branch are comprised mainly of agricultural row crops and pasture.

Refer to **Figure 1** (Existing Land Cover) and **Figure 2** (Proposed Conditions Land Cover).

Watercourses

Storm drainage for the western portion of the development area is provided by two (2) watercourses, which comprise the Northwest Branch of Shirley's Brook:

- Tributary 2 – North Tributary
- Tributary 3 – North Branch

The eastern portion of the development area is drained by a series of agricultural ditches crossing under the former CN Rail corridor towards March Valley Road, and ultimately into the Main Branch of Shirley's Brook.

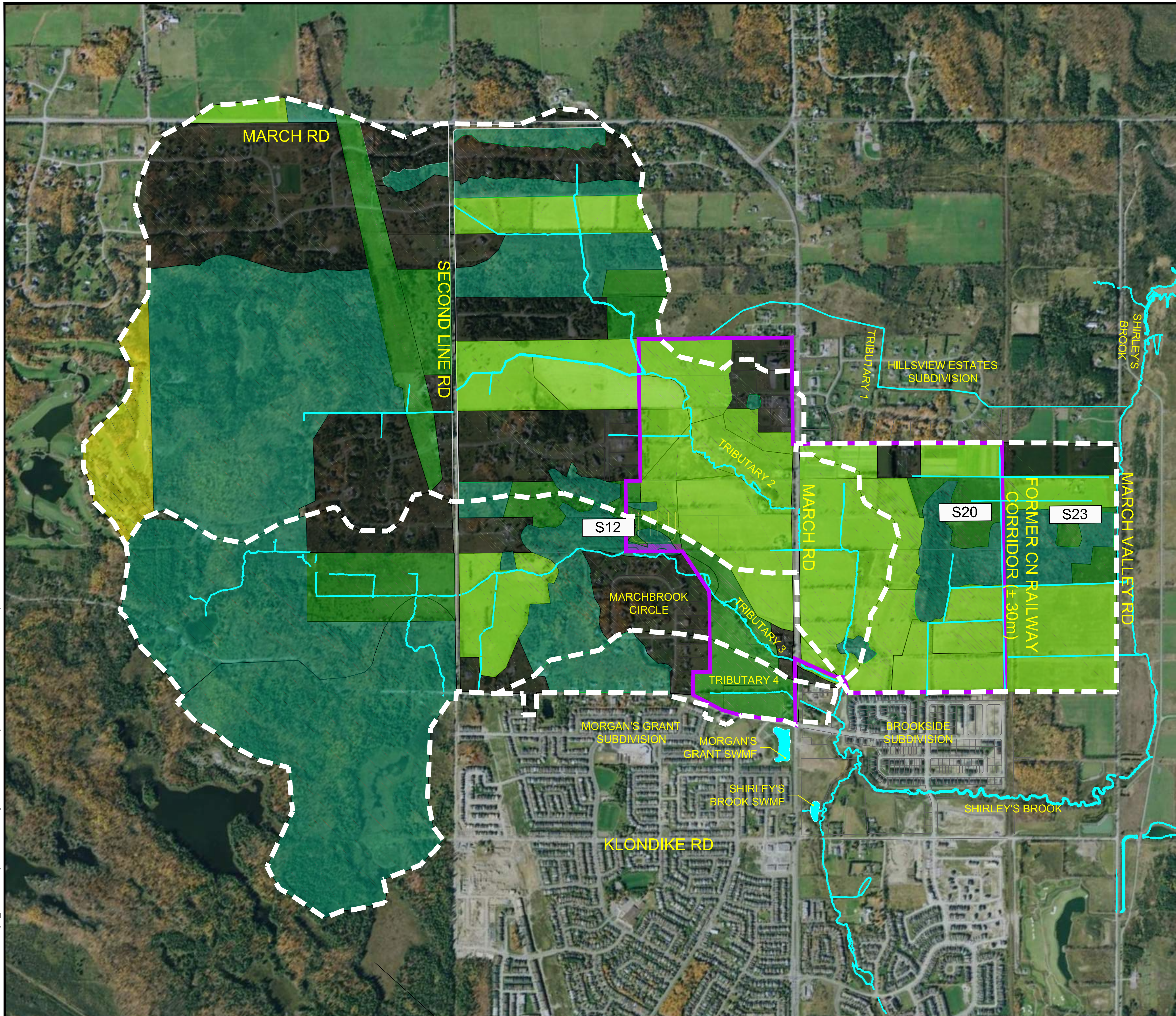
A portion of land within the northwestern quadrant drains to Tributary 1 under existing conditions. Under post-development conditions this area will drain to Tributary 2.

The southwestern quadrant and the existing southern portion of Marchbrook Circle currently drains to Tributary 4 (drainage feature ID 'G'), which crosses a 1200mm culver under March Road and into the Northwest Branch of Shirley's Brook. Under post-development conditions this area will be directed to Tributary 3.

Refer to **Figure 3** (Pre-Development Drainage Area Plan) and **Figure 4** (Post-Development Drainage Area Plan).

Surficial Soils

The surficial soils within and upstream the site are primarily 'Dalhousie' silty clay (Hydrologic Soils Group 'D') or 'Nepean' sandy loam (Hydrologic Soil Group 'B'). There is a pocket of fine to medium coarse sand near woodlot S20 west of the CN Rail corridor; however, the sandy soil is underlain by the stiff silty clay. Refer to **Figure 5** (Surficial Soils: Surrounding Area) and **Figure 6** (Test Pit & Borehole Location Plan).



LEGEND

- KNUEA
- WATER COURSE
- SUBCATCHMENT DRAINAGE BOUNDARIES
- EXISTING RESIDENTIAL
- PASTURE/MEADOW
- ROW CROPS
- FOREST/WETLAND
- GOLF COURSE
- S12 WOOD LOT

KANATA NORTH
COMMUNITY DESIGN PLAN

FIGURE NO. 1
EXISTING CONDITIONS
LAND COVER

DATE
MAY 2016

JOB
112117

SCALE
NTS

NOVATECH
Engineers, Planners & Landscape Architects

M:\2012\112117\CAD\Design_EMP\WB Figures\112117-Fig 1-5-6 - WB-PRE.dwg, FIGURE-1, Feb 23, 2016 - 2:51pm, bthurber

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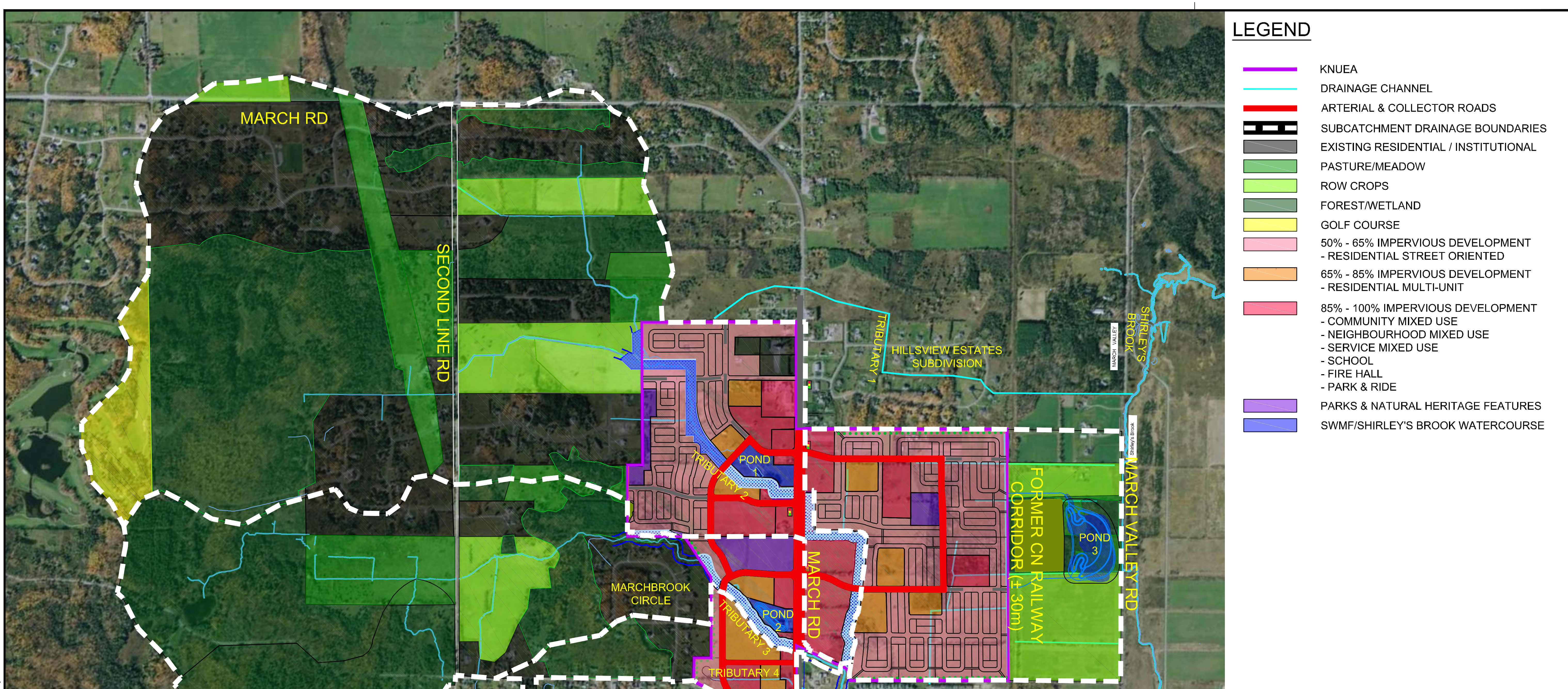

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KANATA NORTH
COMMUNITY DESIGN PLAN

FIGURE NO. 2
PROPOSED CONDITIONS
LAND COVER

DATE
MAY 2016

JOB
112117

SCALE
NTS

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Engineers, Planners & Landscape Architects

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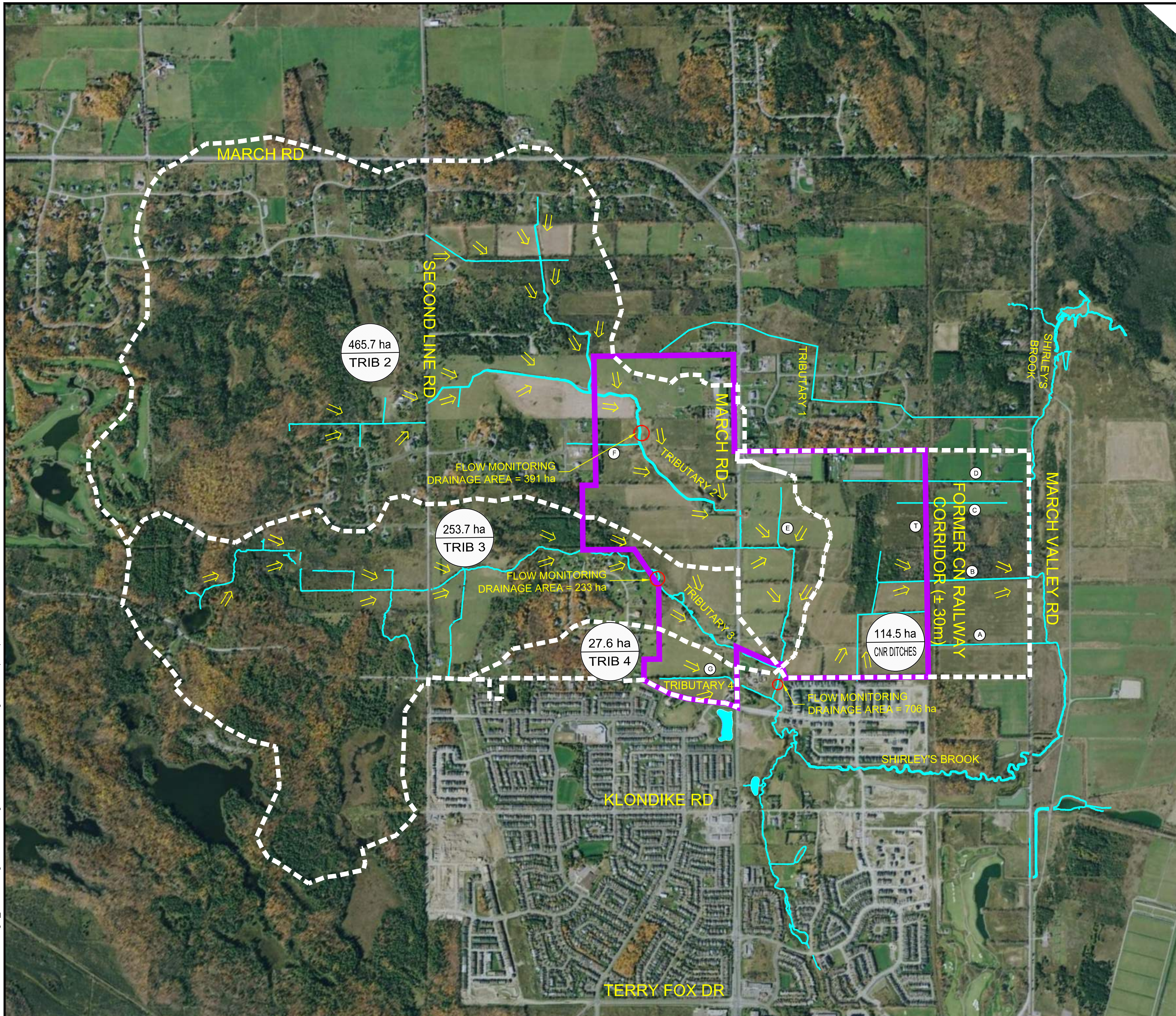

LEGEND

- KNUEA
- WATER COURSE
- SUBCATCHMENT DRAINAGE BOUNDARIES
- DIRECTION OF FLOW
- FLOW MONITORING LOCATION
- DRAINAGE FEATURE ID
- 114.5 ha — CATCHMENT AREA (ha)
- AREA — CATCHMENT NAME

KANATA NORTH
COMMUNITY DESIGN PLAN

FIGURE NO. 3
PRE-DEVELOPMENT DRAINAGE AREA PLAN

DATE: MAY 2016
JOB: 112117
SCALE: NTS

NOVATECH
Engineers, Planners & Landscape Architects

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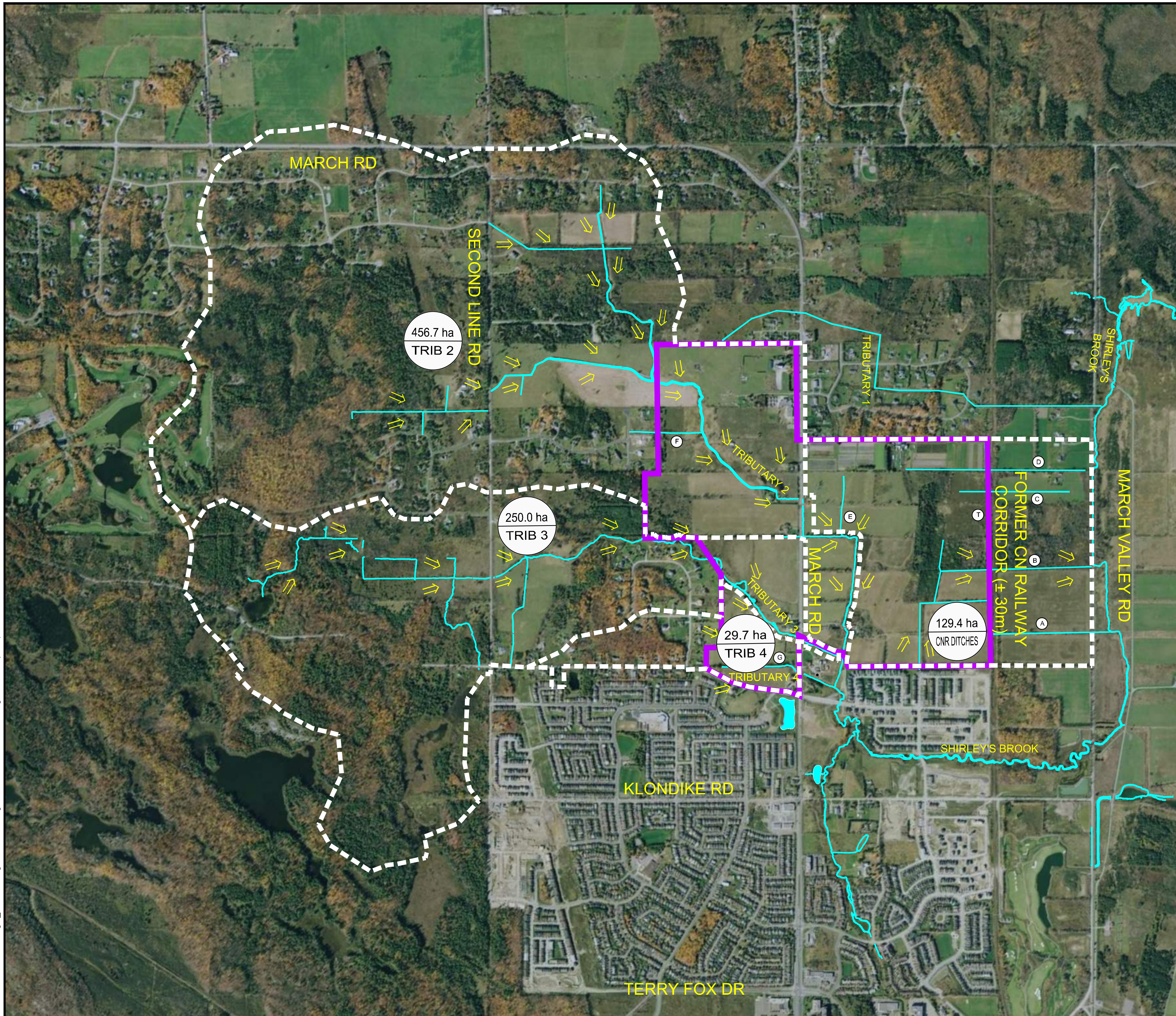

LEGEND

- KNUEA
- WATER COURSE
- SUBCATCHMENT DRAINAGE BOUNDARIES
- DIRECTION OF FLOW
- (A) DRAINAGE FEATURE ID
- 114.5 ha — CATCHMENT AREA (ha)
- AREA — CATCHMENT NAME

KANATA NORTH
COMMUNITY DESIGN PLAN

FIGURE NO. 4
POST DEVELOPMENT
DRAINAGE AREA PLAN

DATE
MAY 2016

JOB
112117

SCALE
NTS

NOVATECH
Engineers, Planners & Landscape Architects

SHT11x17.DWG - 279mmx432mm

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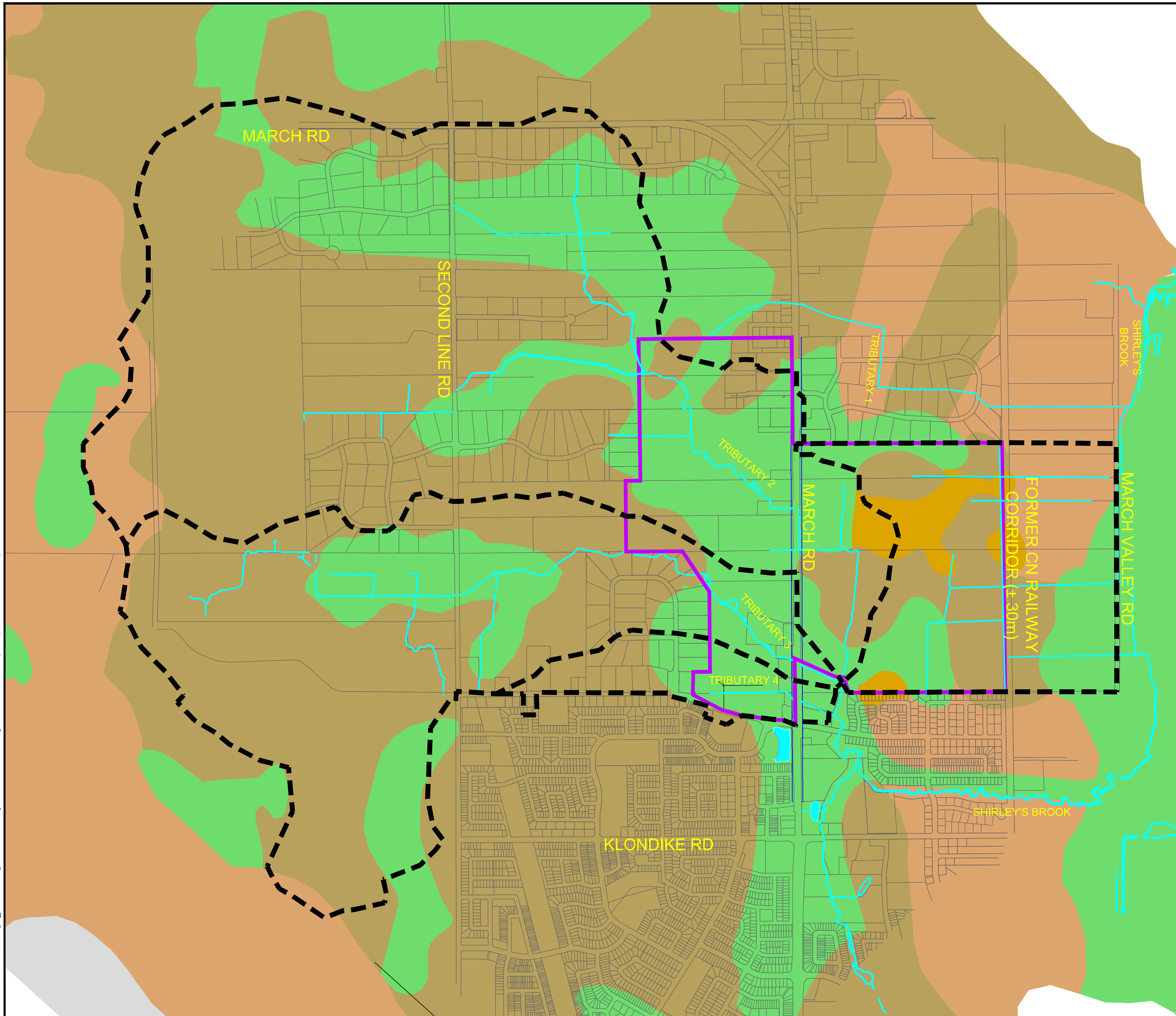

LEGEND

- KNUEA
- WATER COURSE
- PRE-DEVELOPMENT DRAINAGE BOUNDARIES

SURFICIAL SOIL TYPE (HSG)

- MEDIUM/COASE SAND (HSG 'AB')
- SANDY LOAD OR LOAMY SAND (HSG 'B')
- FINE SANDY LOAM OR LOAMY FINE SAND (HSG 'C')
- SILT LOAM, SILTY CLAY, SILTY CLAY LOAM, CLAY LOAMS OR CLAY (HSG 'D')

SOURCE OF INFORMATION

1. INTERNAL AREAS (BASED ON GEOTECHNICAL REPORTS - REFER TO FIGURE 6)
2. EXTERNAL AREAS (BASED ON SOILS OF THE REGIONAL MUNICIPALITY OF OTTAWA-CARELTON (ONTARIO). 1987. SOIL SURVEY REPORT No. 58 (SHEET 3)

KANATA NORTH
COMMUNITY DESIGN PLAN

FIGURE NO. 5
SURFICIAL SOILS HYDROLOGIC SOIL GROUP (HSG)

DATE: MAY 2016
JOB: 112117
SCALE: NTS

NOVATECH
Engineers, Planners & Landscape Architects

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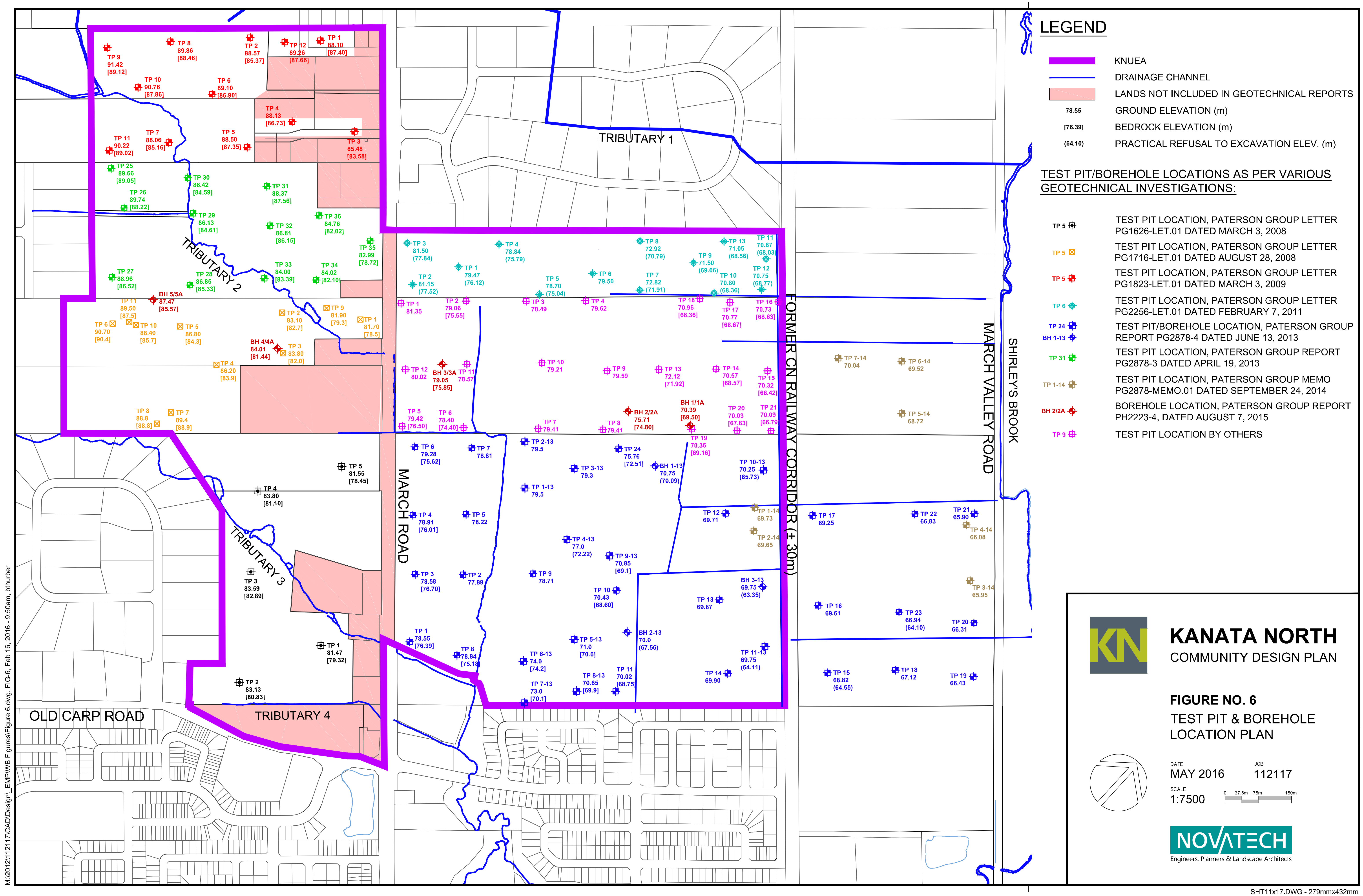
LEGEND
KNUEA
DRAINAGE CHANNEL
LANDS NOT INCLUDED IN GEOTECHNICAL REPORTS
78.55 GROUND ELEVATION (m)
[76.39] BEDROCK ELEVATION (m)
(64.10) PRACTICAL REFUSAL TO EXCAVATION ELEV. (m)
TEST PIT/BOREHOLE LOCATIONS AS PER VARIOUS GEOTECHNICAL INVESTIGATIONS:
TP 5 TEST PIT LOCATION, PATERSON GROUP LETTER PG1626-LET.01 DATED MARCH 3, 2008
TP 5 TEST PIT LOCATION, PATERSON GROUP LETTER PG1716-LET.01 DATED AUGUST 28, 2008
TP 5 TEST PIT LOCATION, PATERSON GROUP LETTER PG1823-LET.01 DATED MARCH 3, 2009
TP 6 TEST PIT LOCATION, PATERSON GROUP LETTER PG2256-LET.01 DATED FEBRUARY 7, 2011
TP 24 BH 1-13 TEST PIT/BOREHOLE LOCATION, PATERSON GROUP REPORT PG2878-4 DATED JUNE 13, 2013
TP 31 TEST PIT LOCATION, PATERSON GROUP REPORT PG2878-3 DATED APRIL 19, 2013
TP 1-14 TEST PIT LOCATION, PATERSON GROUP MEMO PG2878-MEMO.01 DATED SEPTEMBER 24, 2014
BH 2/2A BOREHOLE LOCATION, PATERSON GROUP REPORT PH2223-4, DATED AUGUST 7, 2015
TP 9 TEST PIT LOCATION BY OTHERS
TRIBUTARY 1
TRIBUTARY 2
TRIBUTARY 3
TRIBUTARY 4
OLD CARP ROAD
MARCH ROAD
FORMER CN RAILWAY CORRIDOR (± 30m)
MARCH VALLEY ROAD
SHIRLEY'S BROOK
KANATA NORTH
COMMUNITY DESIGN PLAN
FIGURE NO. 6
TEST PIT & BOREHOLE LOCATION PLAN
DATE MAY 2016
JOB 112117
SCALE 1:7500
NOVATECH
Engineers, Planners & Landscape Architects
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Bedrock

The underlying bedrock consists of interbedded sandstone and limestone of the March Formation; with the exception that the bedrock in the northern quadrant of the site consists of limestone of the Oxford Formation. As per the Hydrogeologiocal Existing Conditions Report (Paterson Group, 2016), there is very little overburden in the location of the watercourses, upstream March Road, and along and at the bottom of the escarpment. The overburden thickness is greatest at the top of the escarpment, east of March Road and along the CN Rail corridor.

1.4 Supporting Documentation

The following additional documents for the Kanata North Urban Expansion Area (KNUEA) were reviewed to become more familiar with the site specific conditions that relate to the water budget:

- Shirley's Brook and Watts Creek Subwatershed Study
  Dillon Consulting (1999)
- Stormwater Management and Planning Manual
  Ontario Ministry of the Environment (2003)
- Technical Rules: Assessment Report – Clean Water Act
  Ontario Ministry of the Environment (2006)
- Greater Shirley's Brook Constance Creek Environmental Management Study
  Aquafor Beech Ltd. (October, 2006)
- Shirley's Brook & Watt's Creek Stormwater Management Study – Phase 2
  AECOM (March, 2013)
- South March Highlands Blanding's Turtle Conservation Needs Assessment
  Dillon Consulting Ltd. (January 31, 2013)
- Consolidated Preliminary Geotechnical Investigation: KNUEA
  Paterson Group (October 7, 2013)
- Sensitive Groundwater Assessment: Discharge and Recharge Area Evaluation
  Woodlot S20
  Paterson Group (October 24, 2014)
- Blanding's Turtle Habitat Compensation Plan: KNUEA
  DST Consulting Engineers (June, 2015)
- Headwaters Assessment: KNUEA
  Bowfin Environmental & Muncaster Environmental Planning Inc. (September, 2015)
- Existing Conditions Natural Environment Features: KNUEA
  Muncaster Environmental Planning Inc. (January, 2016)
- Headwater Drainage Features Geomorphic Assessment: KNUEA
  Parish Aquatic Services (March, 2016)
- Fluvial Geomorphic Assessment: KNUEA
  Parish Aquatic Services (March, 2016)

- Hydrogeological Existing Conditions Report: KNUEA
  Paterson Group (May 18, 2016)

2.0 REVIEW OF EXISTING WATER BUDGET RELATED STUDIES

The following existing studies were reviewed with respect to the water budget analysis:

- Shirley's Brook and Watts Creek Subwatershed Study
  Dillon Consulting (1999)
- Greater Shirley's Brook Constance Creek Environmental Management Study
  Aquafor Beech Ltd. (October, 2006)
- Shirley's Brook & Watt's Creek Stormwater Management Study – Phase 2
  AECOM (March, 2013)

2.1 Shirley's Brook and Watts Creek Subwatershed Study (Dillion, 1999)

The Shirley's Brook and Watt's Creek Subwatershed Study (Dillon, 1999) calculated a water budget for the entire Shirley's Brook Subwatershed using continuous hydrologic modelling (QUALHYMO). The results from the Dillon (1999) water budget determined that runoff greatly dominates over infiltration within the Shirley's Brooks Subwatershed by a ratio of about 2:1. The following were the results of the Dillon (1999) water budget analysis for Shirley's Brook:

- Mean annual precipitation (1986-1992): 923 mm
- Mean annual evapotranspiration: 611 mm
- Mean annual water surplus (infiltration and runoff): 312 mm

Rainfall events of less than 9mm generally did not result in measurable runoff due to initial abstractions related to interception, depression storage and infiltration (prior to runoff). The Dillon (1999) water budget used measured potential evapotranspiration (i.e. lake evaporation) data, which was not converted into actual evapotranspiration that takes into account soil moisture storage.

The results of this water budget are consistent with the low permeable soils present within the Shirley's Brook Subwatershed. The average annual infiltration rate over the Shirley's Brook Subwatershed as determined by Dillion (1999) was approximately 100mm.

2.2 Greater Shirley's Brook Constance Creek EMP (Aquafor Beech, 2006)

The Greater Shirley's Brook Constance Creek Environmental Management Study completed by Aquafor Beech Ltd. (October 2006) indicated a potential area of groundwater recharge between March Road and March Valley Road – Refer to **Appendix A** (excerpt from Aquafor Beech, 2006). This area was shown as a potential area of groundwater recharge because the surficial soils information used by Aquafor Beech only incorporates the surficial soil and is not based on geotechnical information.

2.3 Shirley's Brook and Watts Creek SWM Study: Phase 2 (AECOM, 2013)

The Shirley's Brook and Watts Creek Stormwater Management Study – Phase 2 was prepared by AECOM (2013). While this report was primarily focused on the Main Branch of Shirley's Brook, the storm drainage areas for the Northwest Branch delineated as part of this study were used in the site specific water balance calculations for the KNUEA lands.

3.0 SITE SPECIFIC WATER BUDGET ANALYSIS FOR KNUEA LANDS

The site specific water budget analysis for the KNUEA lands consists of a review of the natural environmental systems and hydrogeology / geology studies to determine any significant features. In addition, the results of the water budget model are summarized with respect to the flow monitoring data to determine the long term hydrologic regime for the site and tributary areas.

3.1 Review of Natural Environmental Systems

The following existing conditions studies were reviewed with respect to the review of the Natural Environmental Systems:

- Shirley's Brook and Watts Creek Subwatershed Study
  Dillon Consulting (1999)
- Greater Shirley's Brook Constance Creek Environmental Management Study
  Aquafor Beech Ltd. (October, 2006)
- South March Highlands Blanding's Turtle Conservation Needs Assessment
  Dillon Consulting Ltd. (January 31, 2013)
- Blanding's Turtle Habitat Compensation Plan: KNUEA
  DST Consulting Engineers (June, 2015)
- Headwaters Assessment: KNUEA
  Bowfin Environmental & Muncaster Environmental Planning Inc. (September, 2015)
- Existing Conditions Natural Environment Features: KNUEA
  Muncaster Environmental Planning Inc. (January, 2016)
- Headwater Drainage Features Geomorphic Assessment: KNUEA
  Parish Aquatic Services (March, 2016)
- Fluvial Geomorphic Assessment: KNUEA
  Parish Aquatic Services (March, 2016)

An environmental assessment was completed by Muncaster Environmental Planning Inc. A detailed summary of the work done and of the existing fish habitat and aquatic / terrestrial features has been provided in the report *Natural Environment Features: Kanata North Urban Expansion Area (Muncaster, January 2016)*. The *Headwaters Assessment: Kanata North Urban Expansion Area (Muncaster, October 2015)* provides an evaluation of the natural environmental features for the existing drainage features within the KNUEA lands. The geofluvial evaluation of the existing drainage features is provided in the *Headwaters Drainage Features Geomorphic Assessment: Kanata North Urban Expansion Area (Parish, March 2016)*. The Fluvial

Geomorphic Assessment: Kanata North Urban Expansion Area (Parish, March 2016) provides a fluvial geomorphic assessment of Tributary 1, 2, and 3 and Shirley's Brook. These reports are summarized for each tributary / drainage feature below. Refer to **Figure 3** (Pre-Development Drainage Area Plan) for the location of the tributaries and drainage features.

3.1.1 Tributary 1

Tributary 1 is located north of the KNUEA lands and flows through the Hillsview Estates Subdivision before discharging into Shirley's Brook. An existing portion of the northwest quadrant within the KNUEA lands currently drains towards Tributary 1. Under post-development conditions this area will be redirected to Pond 1 for stormwater management and ultimately to Tributary 2.

Tributary 1 was not evaluated by Existing Conditions Natural Environmental Features report by Muncaster (January, 2016). The Fluvial Geomorphic Assessment by Parish Aquatic Services (March, 2016) provides an analysis of three (3) reaches of Tributary 1. Tributary 1 runs through the existing Hillsview Estates Subdivision and did not receive and Rapid Geomorphic Assessment (RGA) score because it is a channelized drainage ditch with few natural channel features present. The channel is highly vegetated and received Rapid Stream Assessment Technique (RSAT) scores ranging from 18 to 23, indicating the reach is of low to moderate ecological health.

3.1.2 Tributary 2

Tributary 2 of Shirley's Brook on the west side of March Road is considered to have no discernable fish habitat (Dillon, 1999), but has the potential to support a tolerant warmwater fish community (Aquafor Beech, 2006). Despite this, the watercourse appears to add to the overall productivity of the Shirley's Brook system, particularly during the spring period. Much of the fish community may migrate downstream to Shirley's Brook during lower flow periods. Tributary 2 was considered a low priority for restoration and enhancement (Dillon, 1999).

The environmental investigation by Muncaster in 2013 also indicated that based on the fish sampling and fish habitat assessments Tributary 2 (North Tributary) supports direct fish habitat for the majority of the KNUEA lands. A summary of the fish species captured is provided in **Table 1**. A total of five (5) species were captured within Tributary 2 during both the spring and summer 2013 sampling periods. All of the fish species listed are commonly found in cool and warm water fish habitats in eastern Ontario. None of the fish species identified are sensitive species.

Table 1: Summary of Fish Captured per Season within Tributary 2 (2013)

Species Name	Scientific Name	Number Caught (Size range, mm)		Location
		Spring	Summer	
Central mudminnow	*Umbra limi*	5	1	Tributary 2/3
		(64-109)	(56)	
Finescale dace	*Phoxinus neogaeus*	1	1	Tributary 2
		(57)	(61)	
		(80)		
Fathead minnow	*Pimephales notatus*	-	1	Tributary 2
			(15)	
Creek chub	*Semotilus atromaculatus*	7	72	Tributary 2/3
		(46-119)	(30-157)	
Brook stickleback	*Culaea inconstans*	38	28	Tributary 2/3
		(35-56)	(15-48)	

East of March Road, Tributary 2 enters the north branch of Shirley's Brook approximately 200m east of March Road. This area provides habitat for a diversity of cool and warm water forage and coarse fish. Much of Tributary 2 is composed primarily of bedrock. In areas with substrate it is dominated by silt in the upstream reach and bedrock and sand in the downstream reach with some clay, pebbles, gravel and hard packed clay.

As per the Environmental Report (Muncaster, 2016) Tributary 2 generally flows through pasture lands and often meanders through dense patches of reed canary grass, purple loosestrife, and spotted jewelweed. The banks are generally vegetated with herbaceous species and also with scattered woody species. None of these aquatic or terrestrial habitat features are sensitive to changes within hydrologic regimes.

Based on the Fluvial Geomorphic Assessment (Parish, 2016) Tributary 2 is in regime and in adjustment based on the RGA scores ranging from 0.20 to 0.41. RSAT scores ranged from 26 to 27 meaning that Tributary 2 has moderate ecological health.

3.1.3 Tributary 3

Tributary 3 is considered to support a moderately tolerant to tolerant warmwater fish community upstream of the confluence with the North Tributary (Aquafor Beech, 2006). The reach of the North Branch (Tributary 3) that runs through the KNUEA lands is considered to be a high priority area for restoration and enhancement, and it is recommended that barriers be removed to enhance fish movement (Dillon, 1999). The barriers to fish passage are a series of three (3) concrete weirs. Exposed bedrock is also common in the channel, especially downstream of the three (3) pond areas upstream the concrete weirs along the watercourse. The remainder of the channel generally consists of a channel over bedrock, with limited wetted widths in glade habitats.

Based on the environmental investigation performed by Muncaster in 2013 Tributary 3 (North Branch) supports direct fish habitat for the majority of the KNUEA lands. A summary of the fish species captured is provided in **Table 2**. A total of eight (8) species were captured within

Tributary 3 during both the spring and summer 2013 sampling periods. All of the fish species listed are commonly found in cool and warm water fish habitats in eastern Ontario. None of the fish species identified are sensitive species.

Table 2: Summary of Fish Captured per Season within Tributary 3 (2013)

Species Name	Scientific Name	Number Caught (Size range, mm)		Location
		Spring	Summer	
White sucker	*Catostomus commersonii*	3	2	Tributary 3
		(180-212)	(46-53)	
Central mudminnow	*Umbra limi*	5	1	Tributary 2/3
		(64-109)	(56)	
Northern redbelly dace	*Phoxinus eos*	4	2	Tributary 3
		(41-54)	(10-62)	
Longnose dace	*Rhinichthys cataractae*	-	21	Tributary 3
			(27-86)	
Blacknose dace	*Rhinichthys obtusus*	1	-	Tributary 3
		(80)		
			(15)	
Creek chub	*Semotilus atromaculatus*	7	72	Tributary 2/3
		(46-119)	(30-157)	
Brook stickleback	*Culaea inconstans*	38	28	Tributary 2/3
		(35-56)	(15-48)	
Pumpkinseed	*Lepomis gibbosus*	1	-	Tributary 3
		(62)		

As per the Environmental Report (Muncaster, 2016), Tributary 3 is generally on exposed bedrock. Large ponds are the dominant features of this channel. The pond habitat was created and divided into three habitats by concrete weirs which block potential fish movement except during high flows. The ponds include deep pool habitat. It is anticipated that the ponds will remain after the proposed development.

Aquatic vegetation consists of broad-leaved cattail, common arrowhead, chara species, giant bur-reed and sago pondweed). Woody vegetation was intermittent. There is no appreciable canopy cover over the ponds. Terrestrial habitat includes pussy willow, Manitoba maple, white cedar, white spruce and white ash. None of these aquatic or terrestrial habitat features are sensitive to changes within hydrologic regimes.

Based on the Fluvial Geomorphic Assessment (Parish, 2016) Tributary 3 is adjustment based on the RGA score of 0.30. An RSAT score of 22 was given to Tributary 3 meaning that the tributary has moderate ecological health.

3.1.4 Tributary 4

Tributary 4 (also referred to as drainage feature 'G') is located within the southwest quadrant of the site. This drainage feature acts as the outlet for the southern portion of Marchbrook Circle and the Morgan's Grant Stormwater Management Facility. Tributary 4 crosses March Road via a 1200mm culvert and drains to the Northwest Branch of Shirley's Brook immediately downstream the confluence of Tributaries 2 and 3. Under post-development conditions the portion of this tributary upstream March Road will be directed to Tributary 3. Downstream of March Road flow contributions are primarily outflows from the Morgan's Grant Stormwater Management Facility. As such, redirection of the drainage area upstream March Road will have negligible impact on the flow regime downstream March Road.

As per the Environmental Report (Muncaster, 2016) this tributary was not sampled in 2013 due to a lack of water. In addition, the channel was filled with woody debris.

Based on the Headwater Drainage Features Geomorphic Assessment (Parish, 2016) this reach has good riparian cover with mixed tree cover and shrubs. Parish did not perform a site visit to provide an RGA or RSAT score for this drainage feature.

3.1.5 Drainage Features

On both the west and each side of March Road are a series of channels and ditches (labelled A – G & T on **Figure 3**), which have been dug for agricultural purposes. The primary function of the channels is to convey surface runoff from the agricultural fields. All of the watercourses are intermittent (i.e. dry up) during the summer months; therefore, fish passage would be primarily during the spring and fall.

A summary of the existing drainage features as per the Headwater Drainage Features Geomorphic Assessment (Parish, 2016) is provided in **Table 3**. Ditches B and D were found to have the highest value in terms of their potential to contain aquatic habitat and to provide flow conveyance.

Table 3: Summary of Existing Drainage Features

Drainage Feature ID	Development of Geomorphic Features	Aquatic Habitat Considerations	RSAT Score	Notes
A	Ditch highly vegetated Few geomorphic features	No natural stream features	21 (low-moderate)	Recently dredged
B	Contains sinuosity / pools due to vegetation	Excellent Riparian cover	24 (moderate)	Possibly piped
C	No developed geomorphic features	Lots of organic debris in ditch	20 (low)	Culvert perched
D	Contains sinuosity / flow type variability	Excellent Riparian cover	24 (moderate)	Lined with trees / shrubs
E	No developed geomorphic features	Minimal cover and vegetation	15 (low)	Recently dredged
F	Contains sinuosity / low flow path	Substrate variability	24 (moderate)	Un-vegetated banks

Drainage Feature ID	Development of Geomorphic Features	Aquatic Habitat Considerations	RSAT Score	Notes
G (Tributary 4)	Some sinuosity observed	Good riparian cover	N/A	No field investigation
T	Few geomorphic features present.	Good riparian cover	22 (low-moderate)	Stagnant water

Ditch ‘B’ was further investigated in the Headwaters Report by Bowfin & Muncaster (2016). Ditch ‘B’ represents the longest drainage feature with a total length of 1.2 km. Under post development conditions the length of channel will be reduced by approximately 50%; however, this is limited to the ‘dry’ portion west of the CNR corridor. Ditch ‘B’ is a man-made drainage ditch with poor connectivity, which would restrict fish movement to the spring. The biota species listed in the Headwaters Report (Bowfin & Muncaster, 2016), such stickleback fish species found near Shirley’s Brook, are relatively insensitive.

3.1.6 Woodlots

The study area is comprised mainly of existing and former agricultural lands, including corn and soybean crops, hay fields, and pasture lands. Several wooded areas and hedgerows can be found throughout the site, with the majority being on the east side of March Road and beyond the CN rail line (outside the CDP area). These areas are populated by a variety of trees, and provide habitat to several species of wildlife.

There are three (3) woodlots in or adjacent to the KNUEA lands: Woodlots S12, S20, and S23 – refer to **Figure 1**.

Woodlot S12

The eastern limit of Woodlot S12 overlaps the western edge of the KNUEA lands just north of the Marchbrook Circle subdivision. Shirley’s Brook Northwest Branch Tributary 2 enters the KNUEA lands in this area. The majority of the woodlot is upstream of the site and will not be significantly impacted by the proposed development.

Woodlot S20

Woodlot S20 is located in the eastern portion of the KNUEA lands, just west of the CN Rail corridor. Water at ground surface has historically been observed within Woodlot S20, in the vicinity of the alluvial silty sand deposits. No natural drainage outlets are present within Woodlot S20. Drainage channels are negatively graded in areas and the culverts crossing the former rail corridor are perched, allowing water to pond.

To determine whether this area represents a significant location for groundwater recharge or discharge, A shallow piezometer installation and groundwater monitoring program was completed in 2014. Soil samples were obtained by hand augering in various locations, and shallow piezometers were installed to measure vertical hydraulic gradients in overburden soils. Site soils consisted of topsoil and sandy silt overlying a silty clay layer of lower permeability.

The Sensitive Groundwater Assessment: Discharge and Recharge Area Evaluation Woodlot S20 (Patterson Group – October 24, 2014) concluded that localized recharge and discharge within the topsoil and silty sand layers was occurring, with the silty clay layer preventing significant recharge to the bedrock aquifer within Woodlot S20. Any areas of discharge and recharge between overburden and bedrock units are considered to be highly localized, due to the prevalence of the low-conductivity silty clay and glacial till layers throughout the subject site.

Woodlot S23

Woodlot S23 is located just east of the KNUEA lands, between the CN Rail corridor and March Valley Road. While outside the development area, a portion of Woodlot S23 is being considered as a potential location for a SWM facility that would service the KNUEA lands east of March Road.

Blanding's Turtle

A population of Blanding's Turtle inhabits the South March Highlands Conservation Forest, which is located west of the KNUEA Lands. The forest is bounded by Old Carp Road, Old Second Line Road, and Terry Fox Drive. This turtle population is part of a larger population in the surrounding areas of northwest Ottawa. Although there was not an observed Blanding's turtle population specifically within the KNUEA lands, it is understood that the turtles may use Shirley's Brook and its tributaries for passage between habitats.

Under post-development conditions the alterations to the watercourses will include enhanced turtle habitat in the form of deep and shallow pools.

3.2 Geology / Hydrogeology Investigations

The following hydrogeological / geotechnical studies were performed to classify the surficial and bedrock geology for the KNUEA lands and surrounding area:

- Consolidated Preliminary Geotechnical Investigation: KNUEA
  Paterson Group (October 7, 2013)
- Sensitive Groundwater Assessment: Discharge and Recharge Area Evaluation *Woodlot S20*
  Paterson Group (October 24, 2014)
- Hydrogeological Existing Conditions Report: KNUEA
  Paterson Group (May 18, 2016)

Figure 5 and **Figure 6** show the surficial soils and test pit / borehole locations, respectively. The soils within the limits of the planned urban expansion were determined based on test pit and borehole data. Surficial soils generally consist of silty clay and glacial till with some isolated trace deposits of silty sand with trace clay. Upstream of the KNUEA lands, the surficial soils generally consist of Rideau Clay (Dalhousie formation) and Nepean Sand, as per the 'Ontario Soil Survey Report No. 58 (Ottawa-Carleton)'[1], which is provided in **Appendix A**.

Bedrock is present just beneath the topsoil and glaciofluvial soil veneer in the southwest corner of the subject area, as well as within the North Tributary and North Branch. The bedrock is generally flat-lying and primarily consists of interbedded sandstone and limestone of the March Formation. The exception is the northern quadrant where the bedrock consists of limestone of

[1] Soils of the Regional Municipality of Ottawa-Carleton, Soil Survey Report No. 58 (sheet 3), Ontario Institute of Pedology, Agriculture Canada, 1987.

the Oxford Formation. Based on the Ontario Geological Survey (OGS) mapping, the March and Oxford Formations within the subject site are not considered to contain potential or inferred karst features. Areas of exposed bedrock may have a greater potential for groundwater recharge.

3.2.1 Significant Groundwater Recharge / Discharge Areas

Surface and groundwater flow are dependent upon the infiltration capabilities of the surficial and underlying soils, and bedrock. For example, development on soils with naturally low infiltration capabilities (i.e. fine grained silt and clay soils) will have a small reduction in infiltration rates. Areas with permeable soils (i.e. coarse sandy soils) have greater infiltration rates and may act as important groundwater recharge or discharge areas. The proximity of development to natural features, such as streams and wetlands can also influence the hydrologic connection between surface water and groundwater resources.

The Greater Shirley's Brook Constance Creek Environmental Management Study completed by Aquafor Beech Ltd. (October 2006) indicated a potential area of groundwater recharge between March Road and March Valley Road – Refer to **Appendix A** (excerpt from Aquafor Beech, 2006). The overburden soils within this area consist of high permeable alluvial sandy soils overlaying silty clay soils with low permeability. The sand deposit is quite thin and since it is underlain by a confining silty clay layer it is of little importance in terms of well water supply, as most wells are founded in the Paleozoic bedrock layer. The observation that this area is important for groundwater recharge is based on looking at the surficial sandy soils and not taking into account the underlaying silty clay soils, which prevents water from vertically moving to and from the underlaying bedrock.

The geotechnical investigations indicate that there is a large alluvial soils deposit that runs approximately parallel to March Road. Further investigation was performed by the Paterson Group as indicated in the *Hydrogeological Existing Conditions Report: Kanata North Urban Expansion Area (Paterson, May 18, 2016).* Based on hydraulic conductivity testing undertaken in the bedrock unit, and hydraulic conductivity estimates based on grain size analysis of overburden soils, the bedrock unit is considered to have a higher hydraulic conductivity than the silty clay and glacial till overburden soils, which are generally considered to act as a confining layer. As such, groundwater will generally flow laterally through the fractured bedrock aquifer units or through localized shallow silty sand deposits, as opposed to vertically upwards or downwards through the overburden soils of lower hydraulic conductivity. The borehole and piezometer locations used in the groundwater recharge/discharge assessment are shown on **Figure 6.**

- In areas where downward hydraulic gradients were observed (BH1/BH1A, BH4/ BH4A), the presence of overburden soils of lower hydraulic conductivity overlying the bedrock aquifer units are considered to limit the potential for significant groundwater recharge in these areas.
- In areas where upward hydraulic gradients were observed (BH2/BH2A, BH3/BH3A, BH5/BH4A), the presence of overburden soils of lower hydraulic conductivity overlying the bedrock aquifer units are considered to limit the potential for significant groundwater discharge in these areas.

Furthermore, the presence of groundwater levels in the vicinity of BH1/BH1A and BH5/BH5A at elevations above ground surface supports the conclusion that overburden soils are acting as a confining layer above the bedrock aquifer units in these specific locations.

Watercourses

Tributary 2 and the Main Branch of Shirley's Brook serve to intercept shallow overburden groundwater moving laterally with the topography, either through the upper zones of the soil matrix or along the overburden and bedrock interface. The presence of low permeable surficial soils where the bedrock is not shallow or exposed suggests that the overburden groundwater flow will follow the topographic relief of the land towards Shirley's Brook and its tributaries.

Field investigations indicate no significant groundwater discharge contributions to baseflow in the Northwest Branch Tributaries of Shirley's Brook. Excepting the spring freshet, water levels are generally quite low and there is very little baseflow during the summer months.

3.2.2 Aquifer Vulnerability

Aquifer vulnerability is assessed based on methodology provided by the Ministry of the Environment and Climate Change, and the intrinsic susceptibility index for the KNUEA was calculated based on the conditions on site. Given the depth of the surficial soils within the study area and the low permeability of said soils, combined with the thickness of competent bedrock which overlies the confined aquifer systems of the March/ Nepean Formation and the Oxford Formation, these bedrock aquifer systems are considered to be of low intrinsic vulnerability.

No concerns were identified with respect to actual or potential sources of contamination at the time of completion of the hydrogeological investigation.

3.3 KNUEA Lands Water Budget Model

The water budget analysis for the KNUEA lands characterizes the various components of the hydrologic cycle: precipitation, evapotranspiration, runoff and infiltration. A combination of the Thornthwaite and Mather (1957) and MOECC (2003) approaches are used in the calculations. The site specific water budget does incorporate changes in storage, but other components such as groundwater and surface water inflow and outflow, and water takings and returns are not taken into account due to the lack of available data.

Water budget calculations have been prepared using 30-years (1971-2000) of monthly precipitation and evaporation data recorded at the Environment Canada meteorological station at the Ottawa Macdonald Cartier International Airport (Environment Canada Station ID: 6106001). This period of data was chosen as there is corresponding mean daily lake evaporation data provided with this time period.

The water budget model integrates a GIS approach by combining land use, surficial soils, and topography information into homogeneous hydrologic units. Calculations are performed on each hydrologic unit and area weighted to provide a summary for the catchment or area being modeled. Refer to **Appendix B** for a detailed description of the water budget model and parameters. The water budget models, parameters, and results are provided on the attached CD.

3.3.1 Water Budget Model Results

The results of the monthly water budget analysis are summarized in the following tables and **Figure 7 – 12**:

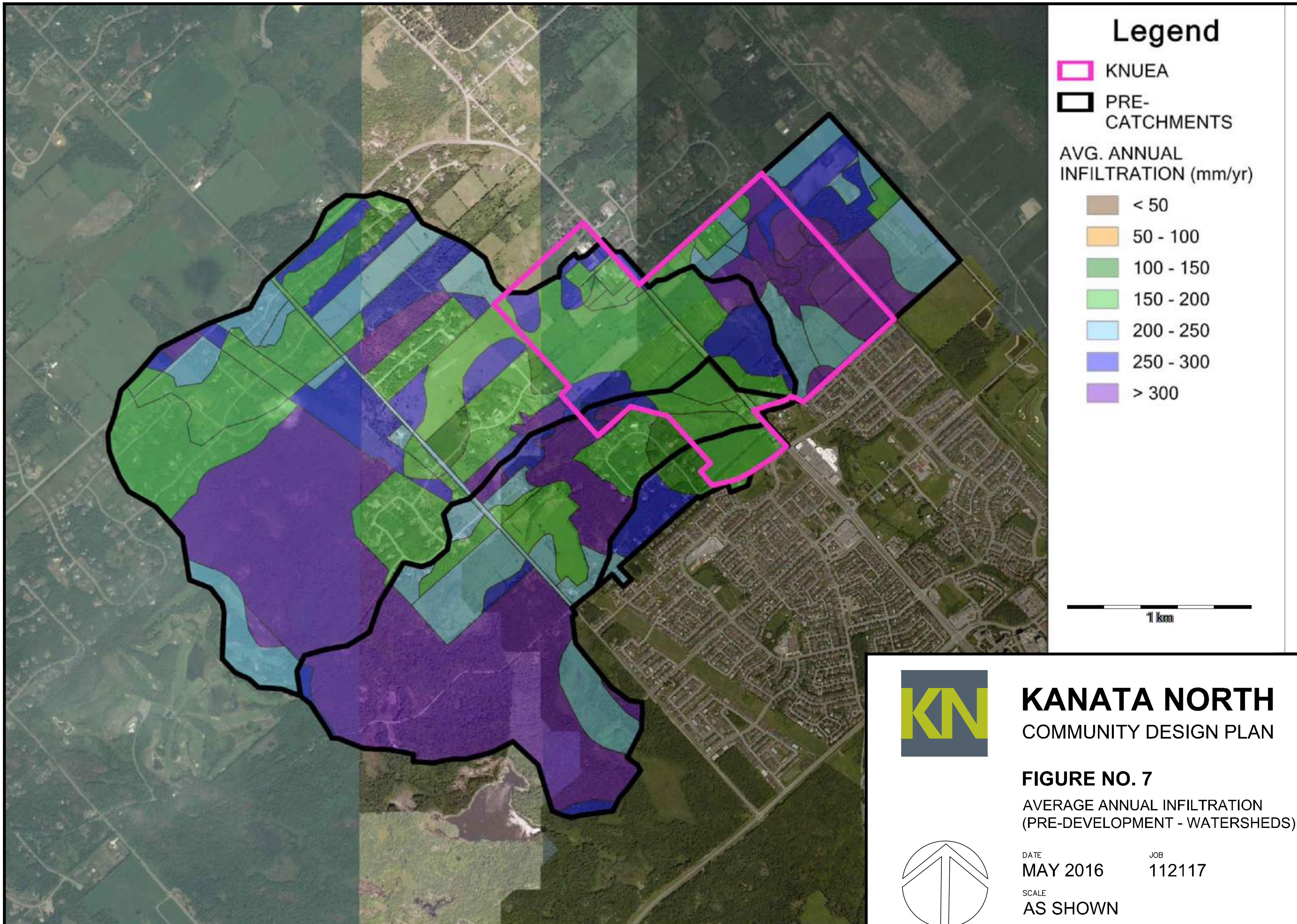
- Table 4 (KNUEA Lands)
- Table 5 (Tributary 2 – North Tributary)
- Table 6 (Tributary 3 – North Branch)

- Table 7 (Shirley's Brook Northwest Branch – Confluence of Tributaries 2 & 3)
- Table 8 (Tributary 4 – March)
- Table 9 (CNR Ditches)

The water budget does not include calculations for the Main Branch of Shirley's Brook at March Valley Road. When the upstream drainage area (1,767 ha) is taken into consideration, the increase in annual runoff resulting from development of the KNUEA will be negligible (<1%).

Table 4: Monthly Water Balance summary - KNUEA Lands

Month	Total Precipitation (mm/month)	KNUEA Lands (187 ha)					
		Infiltration (mm/month)		Runoff (mm/month)		Evapotranspiration (mm/month)	
		PRE	POST	PRE	POST	PRE	POST
January	64.2	24.5	14.3	24.7	34.8	0.0	0.0
February	51.6	26.2	15.3	26.4	37.2	0.0	0.0
March	64.9	48.3	28.3	48.7	68.7	0.0	0.0
April	67.7	36.5	21.1	36.8	51.2	10.4	11.8
May	81.0	11.7	6.5	11.8	16.5	75.7	66.1
June	91.2	3.5	4.8	3.7	13.7	109.8	77.2
July	88.9	0.7	3.3	0.9	10.2	103.0	74.6
August	87.6	2.5	6.1	2.8	17.0	80.2	63.6
September	86.8	5.5	9.0	6.0	23.4	34.5	44.0
October	79.1	23.3	14.5	24.1	34.5	14.7	26.9
November	77.0	32.8	19.4	33.3	46.9	1.6	3.3
December	74.1	24.7	14.5	25.0	35.3	0.0	0.0
Annual Total	***914.2 mm***	***240.2 mm***	***157.2 mm***	***244.2 mm***	***389.5 mm***	***429.9 mm***	***367.4 mm***



KANATA NORTH
COMMUNITY DESIGN PLAN

FIGURE NO. 7

AVERAGE ANNUAL INFILTRATION
(PRE-DEVELOPMENT - WATERSHEDS)

DATE
MAY 2016

JOB
112117

SCALE
AS SHOWN

NOVATECH
Engineers, Planners & Landscape Architects

M:\2012\112117\CAD\Design_EMP\WB Figures\FIG'S 9-20\112117 -FIG 7 -INFIL-PREDEV-W.dwg, EMP FIG 8.3, May 24, 2016 - 8:21am, cstang

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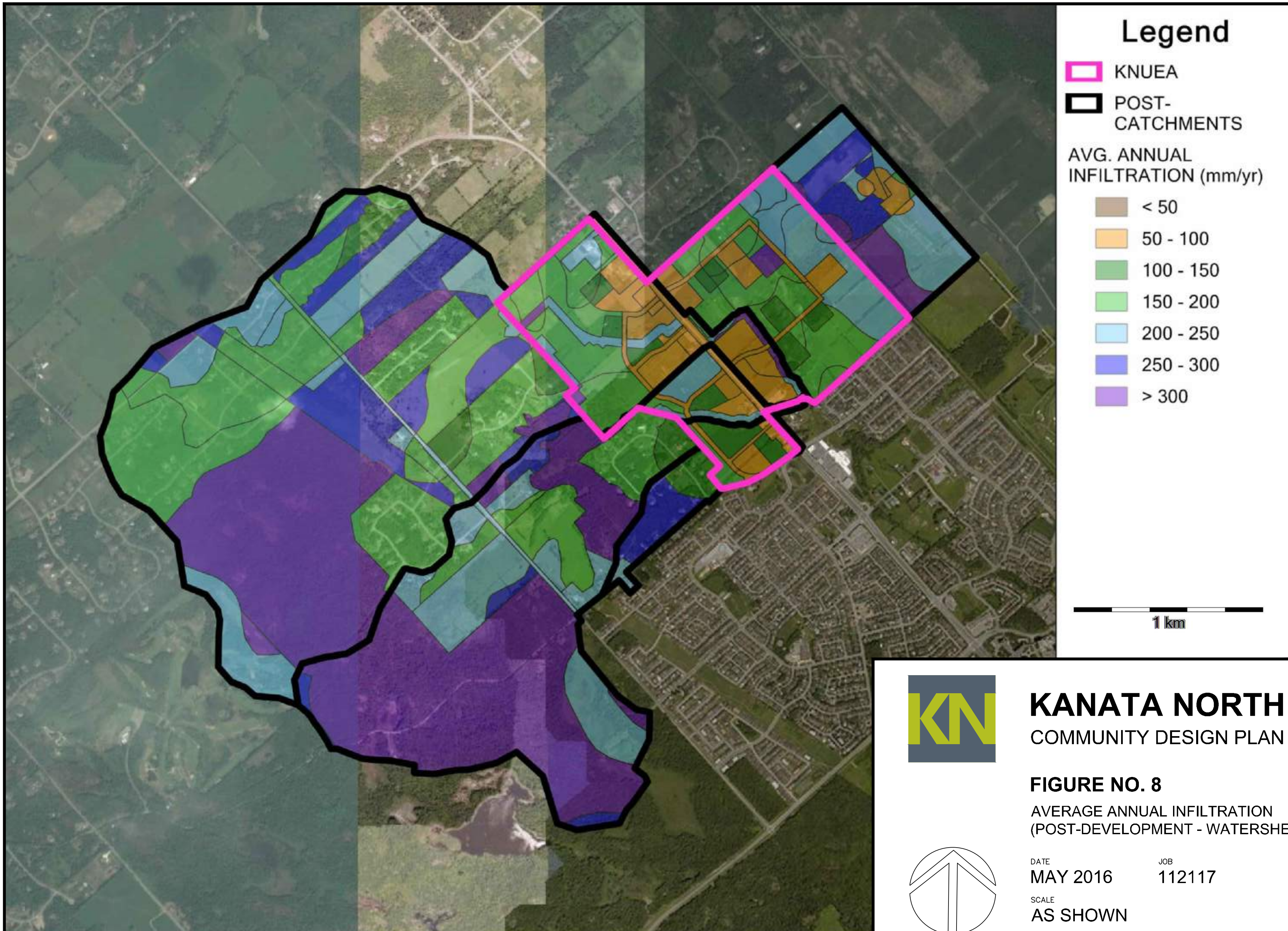


KANATA NORTH

COMMUNITY DESIGN PLAN

FIGURE NO. 8

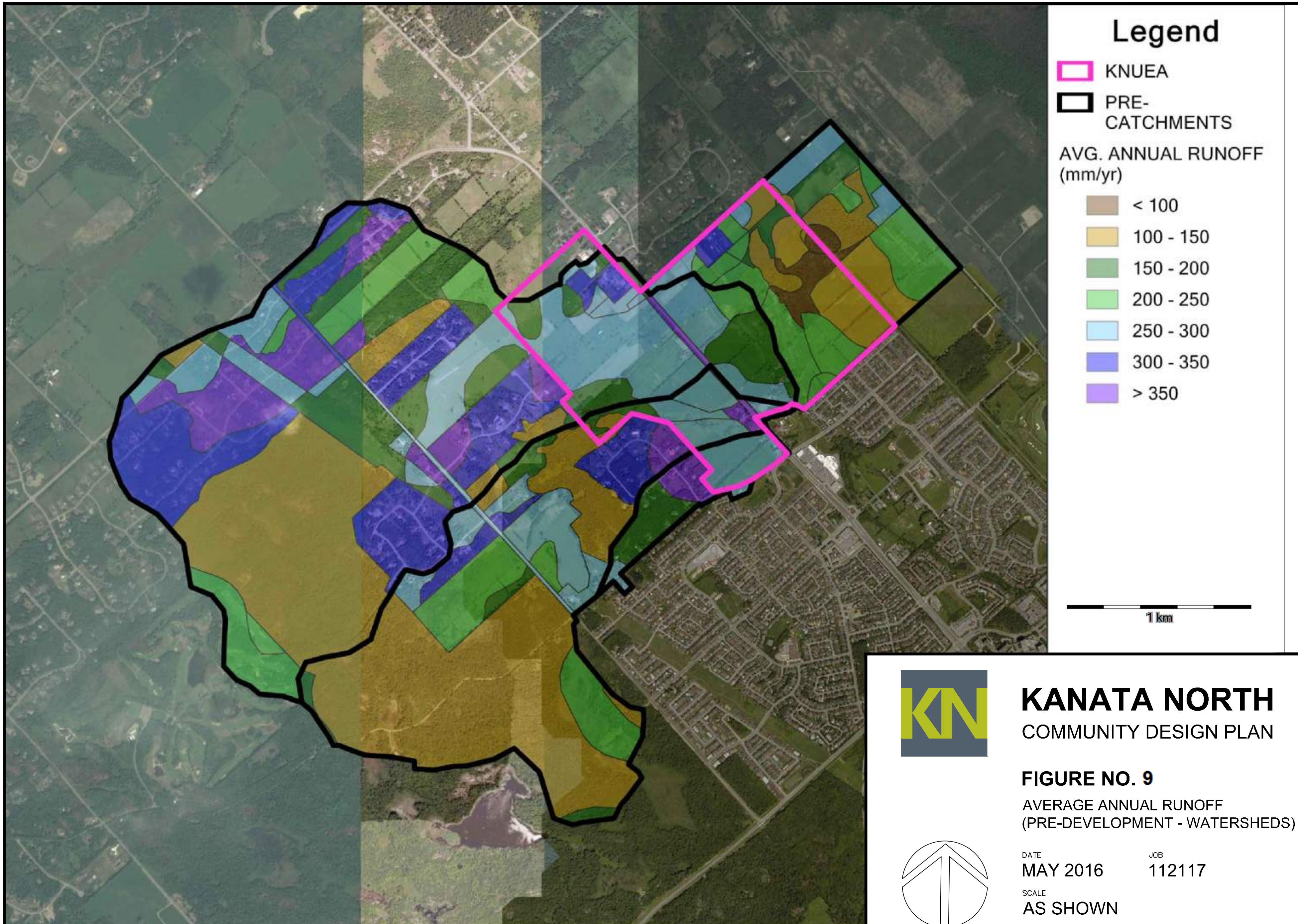
AVERAGE ANNUAL INFILTRATION (POST-DEVELOPMENT - WATERSHEDS)

DATE: MAY 2016

JOB: 112117

SCALE: AS SHOWN

NOVATECH
Engineers, Planners & Landscape Architects



KANATA NORTH

COMMUNITY DESIGN PLAN

FIGURE NO. 9

AVERAGE ANNUAL RUNOFF
(PRE-DEVELOPMENT - WATERSHEDS)

DATE
MAY 2016

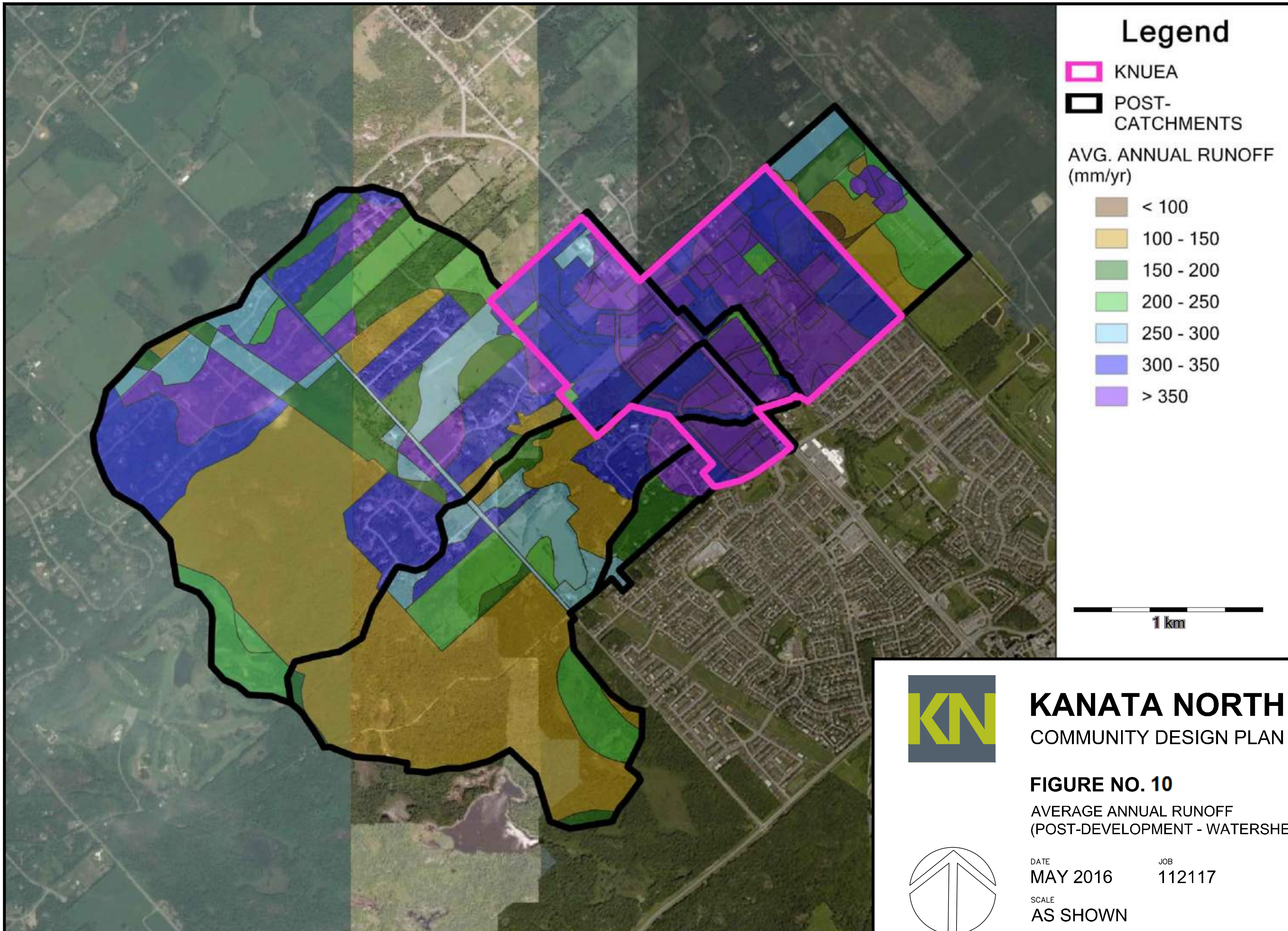
JOB
112117

SCALE
AS SHOWN

NOVATECH
Engineers, Planners & Landscape Architects

M:\2012\112117\CAD\Design_EMP\WB Figures\FIG'S 9-20\112117 -FIG 9-RUNOFF-PREDEV-W.dwg, EMP FIG 8.5, Feb 23, 2016 - 7:47pm, cstang

SHT8x11.DWG - 216mmx279mm



KANATA NORTH
COMMUNITY DESIGN PLAN

FIGURE NO. 10

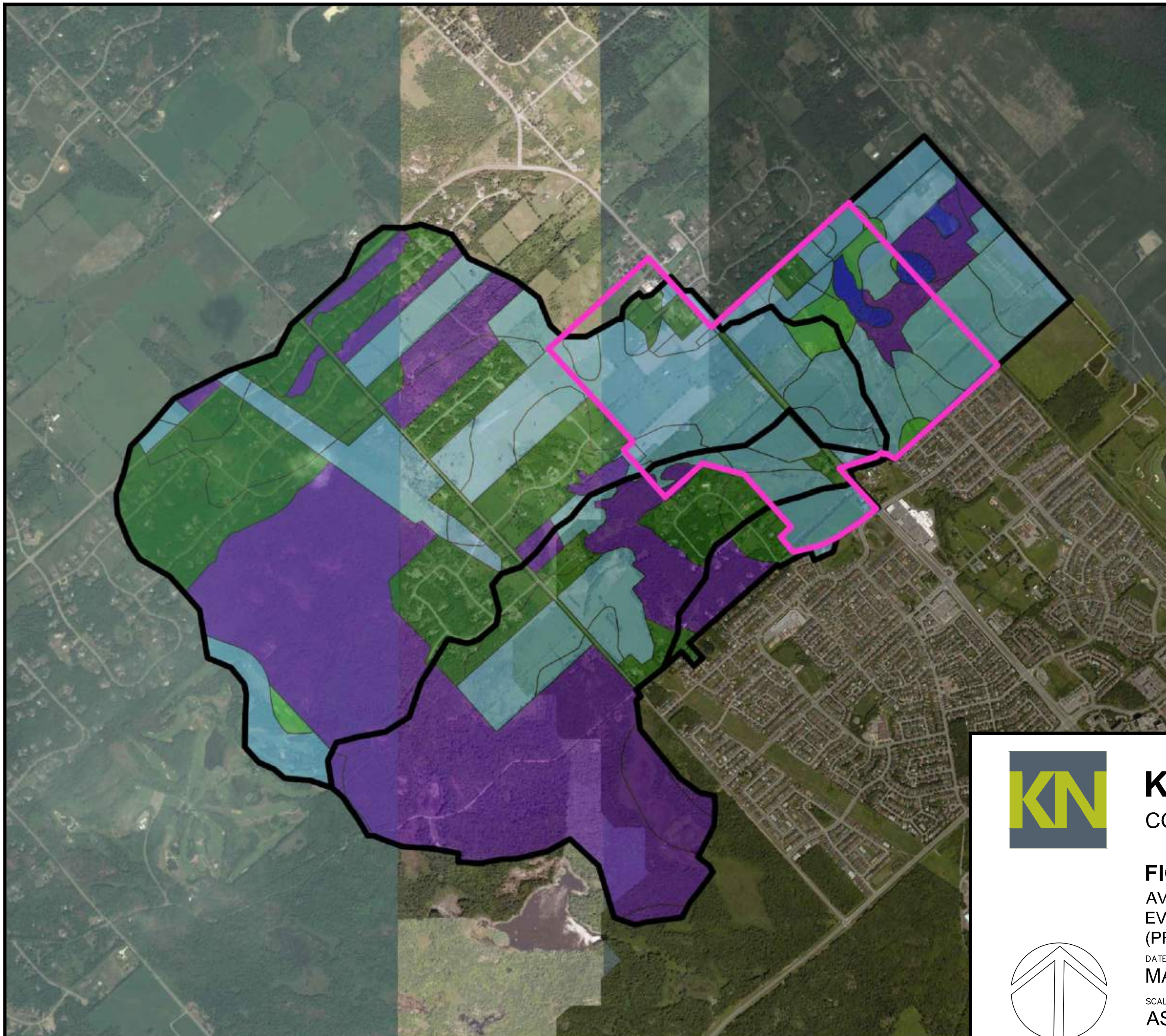
AVERAGE ANNUAL RUNOFF
(POST-DEVELOPMENT - WATERSHEDS)

DATE
MAY 2016

JOB
112117

SCALE
AS SHOWN

NOVATECH
Engineers, Planners & Landscape Architects



Legend

- KNUEA
- PRE-CATCHMENTS

AVG. ANNUAL EVAPOTRANSPIRATION (mm/yr)

- < 350
- 350 - 375
- 375 - 400
- 400 - 425
- 425 - 450
- 450 - 475
- > 475

KANATA NORTH

COMMUNITY DESIGN PLAN

FIGURE NO. 11

AVERAGE ANNUAL EVAPOTRANSPIRATION (PRE-DEVELOPMENT - WATERSHEDS)

DATE	JOB
MAY 2016	112117

SCALE
AS SHOWN

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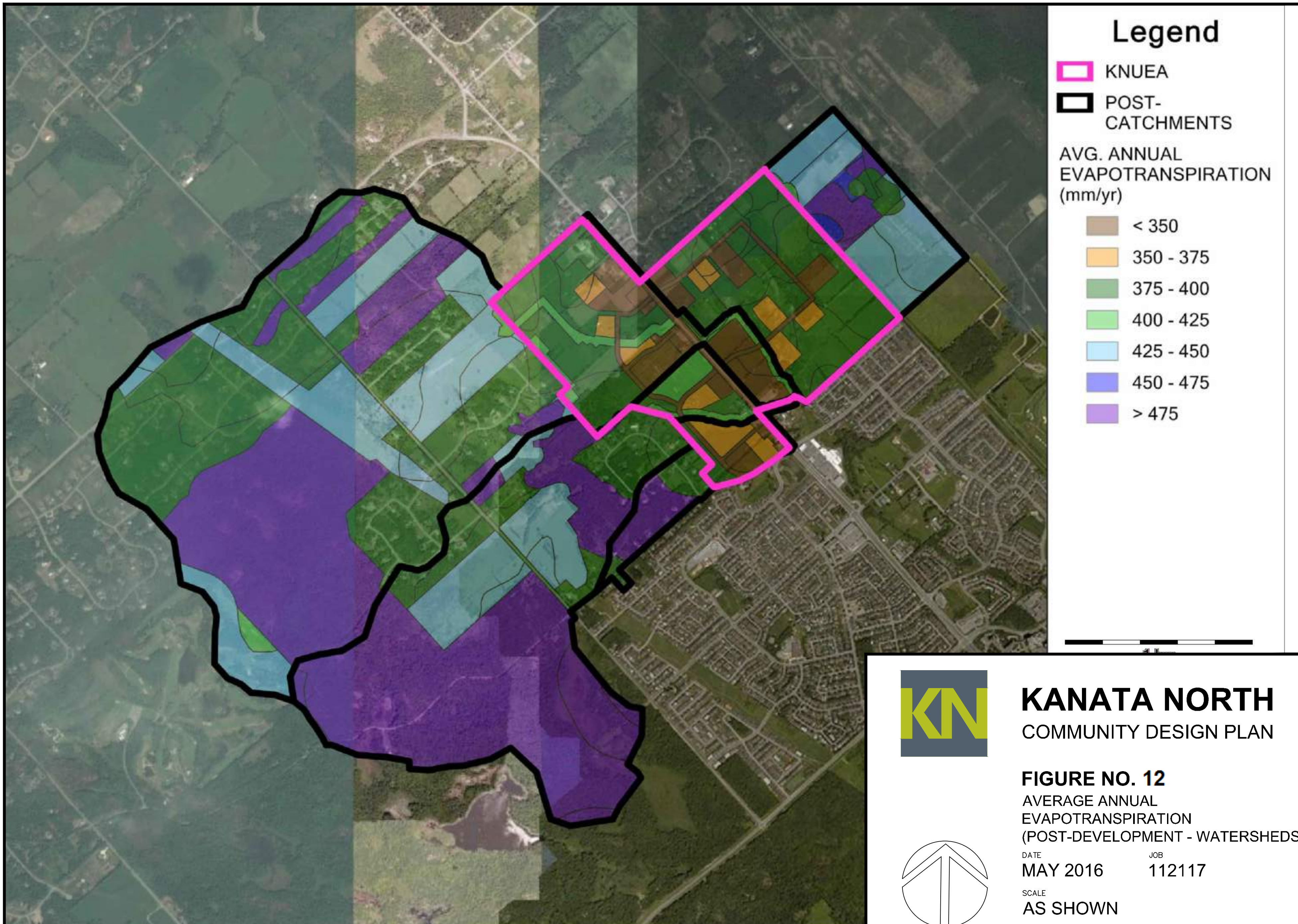

KANATA NORTH
COMMUNITY DESIGN PLAN

FIGURE NO. 12
AVERAGE ANNUAL EVAPOTRANSPIRATION (POST-DEVELOPMENT - WATERSHEDS)

DATE: MAY 2016
JOB: 112117
SCALE: AS SHOWN

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M:\2012\112117\CAD\Design_EMP\WB Figures\FIG'S 9-20\112117 -FIG 12-ET-POSTDEV-W.dwg, EMP FIG 8.8, May 24, 2016 - 8:28am, cstang

SHT8x11.DWG - 216mmx279mm

Table 5: Monthly Water Balance Summary – Tributary 2 (North Tributary)

Month	Total Precipitation (mm/month)	Shirley's Brook Northwest Branch: Tributary 2 (North Tributary) (466 ha)					
		Infiltration (mm/month)		Runoff (mm/month)		Evapotranspiration (mm/month)	
		PRE	POST	PRE	POST	PRE	POST
January	64.2	24.6	23.2	24.6	26.0	0.0	0.0
February	51.6	26.3	24.8	26.3	27.8	0.0	0.0
March	64.9	48.5	45.7	48.4	51.3	0.0	0.0
April	67.7	36.6	34.4	36.5	38.5	10.9	11.1
May	81.0	11.2	10.5	11.1	11.8	77.0	75.2
June	91.2	3.4	3.7	4.0	5.8	108.8	103.1
July	88.9	0.9	1.3	1.3	3.0	103.0	98.2
August	87.6	2.9	3.5	4.1	6.7	80.5	77.8
September	86.8	5.9	6.4	7.9	10.9	34.7	36.9
October	79.1	20.1	18.4	22.8	24.0	16.4	18.7
November	77.0	31.8	29.7	32.6	34.5	1.9	2.2
December	74.1	24.7	23.2	24.7	26.2	0.0	0.0
Annual Total	***914.2 mm***	***236.8 mm***	***224.8 mm***	***244.3 mm***	***266.4 mm***	***433.2 mm***	***423.0 mm***

Table 6: Monthly Water Balance Summary – Tributary 3 (North Branch)

Month	Total Precipitation (mm/month)	Shirley's Brook Northwest Branch: Tributary 3 (North Branch) (253 ha)					
		Infiltration (mm/month)		Runoff (mm/month)		Evapotranspiration (mm/month)	
		PRE	POST	PRE	POST	PRE	POST
January	64.2	28.9	28.6	20.3	20.6	0.0	0.0
February	51.6	30.9	30.5	21.7	22.0	0.0	0.0
March	64.9	57.0	56.3	40.0	40.7	0.0	0.0
April	67.7	43.0	42.5	30.2	30.7	10.7	10.8
May	81.0	13.1	12.9	9.3	9.4	78.8	78.5
June	91.2	3.4	3.4	2.8	3.3	118.4	117.1
July	88.9	0.6	0.6	0.7	1.2	113.9	112.6
August	87.6	2.0	2.1	2.3	3.0	86.0	85.2
September	86.8	4.3	4.6	4.3	5.3	32.4	32.1
October	79.1	18.3	18.1	15.0	15.6	14.4	14.7
November	77.0	35.5	35.0	25.6	26.1	1.6	1.7
December	74.1	28.7	28.4	20.3	20.6	0.0	0.0
Annual Total	***914.2 mm***	***265.7 mm***	***262.9 mm***	***192.4 mm***	***198.5 mm***	***456.2 mm***	***452.8 mm***

Table 7: Monthly Water Balance Summary – Shirley's Brook Northwest Branch

Month	Total Precipitation (mm/month)	Shirley's Brook Northwest Branch: Confluence of Tributaries 2 & 3 (719 ha)					
		Infiltration (mm/month)		Runoff (mm/month)		Evapotranspiration (mm/month)	
		PRE	POST	PRE	POST	PRE	POST
January	64.2	26.1	25.1	23.1	24.1	0.0	0.0
February	51.6	27.9	26.8	24.6	25.8	0.0	0.0
March	64.9	51.5	49.4	45.5	47.5	0.0	0.0
April	67.7	38.9	37.3	34.3	35.7	10.8	11.0
May	81.0	11.8	11.3	10.4	11.0	77.6	76.3
June	91.2	3.4	3.6	3.6	4.9	112.2	108.0
July	88.9	0.8	1.1	1.1	2.4	106.9	103.3
August	87.6	2.6	3.0	3.4	5.4	82.5	80.4
September	86.8	5.3	5.8	6.7	8.9	33.9	35.2
October	79.1	19.4	18.3	20.0	21.0	15.7	17.3
November	77.0	33.1	31.6	30.2	31.5	1.8	2.0
December	74.1	26.1	25.0	23.2	24.2	0.0	0.0
Annual Total	***914.2 mm***	***247.0 mm***	***238.2 mm***	***226.0 mm***	***242.5 mm***	***441.3 mm***	***433.5 mm***

Table 8: Monthly Water Balance Summary – Tributary 4 (March)

Month	Total Precipitation (mm/month)	Shirley's Brook Northwest Branch: Tributary 4 (27.5 ha)					
		Infiltration (mm/month)		Runoff (mm/month)		Evapotranspiration (mm/month)	
		PRE	POST	PRE	POST	PRE	POST
January	64.2	21.5	16.9	27.7	32.2	0.0	0.0
February	51.6	23.0	18.1	29.6	34.4	0.0	0.0
March	64.9	42.4	33.4	54.6	63.5	0.0	0.0
April	67.7	32.0	25.1	41.2	47.5	10.6	11.5
May	81.0	10.1	7.6	13.1	15.1	75.7	70.6
June	91.2	3.2	3.7	4.8	10.9	109.0	92.4
July	88.9	0.7	2.1	1.4	7.8	105.6	89.1
August	87.6	2.4	3.9	4.4	12.9	82.7	71.5
September	86.8	3.8	6.1	6.9	18.1	40.4	38.8
October	79.1	14.6	12.8	21.6	29.3	17.5	22.5
November	77.0	26.9	21.5	35.6	42.5	1.9	2.7
December	74.1	21.5	17.0	27.9	32.5	0.0	0.0
Annual Total	***914.2 mm***	***202.1 mm***	***168.3 mm***	***268.8 mm***	***346.8 mm***	***443.2 mm***	***399.2 mm***

Table 9: Monthly Water Balance Summary – KNUEA East Headwater Features

Month	Total Precipitation (mm/month)	KNUEA East Headwater Features to Main Branch of Shirley's Brook (114 ha)					
		Infiltration (mm/month)		Runoff (mm/month)		Evapotranspiration (mm/month)	
		PRE	POST	PRE	POST	PRE	POST
January	64.2	29.2	20.0	20.0	29.2	0.0	0.0
February	51.6	31.2	21.4	21.4	31.2	0.0	0.0
March	64.9	57.6	39.4	39.4	57.6	0.0	0.0
April	67.7	43.5	29.6	29.8	43.0	10.5	11.5
May	81.0	13.6	9.1	9.3	13.4	77.2	71.0
June	91.2	3.7	4.5	2.7	9.1	114.0	91.1
July	88.9	0.6	2.4	0.5	6.1	107.3	87.3
August	87.6	2.4	4.9	1.9	11.0	82.3	71.1
September	86.8	5.7	8.0	4.3	16.0	32.3	39.9
October	79.1	25.6	18.3	18.5	28.0	13.9	22.5
November	77.0	38.1	26.3	26.5	39.0	1.5	2.7
December	74.1	29.3	20.1	20.1	29.5	0.0	0.0
Annual Total	***914.2 mm***	***280.7 mm***	***203.9 mm***	***194.4 mm***	***313.2 mm***	***439.1 mm***	***397.2 mm***

Table 4 shows the changes to the hydrologic cycle components within the limits of the development area.

Table 7 reflects the changes to the hydrologic cycle in relation to the overall watershed area for the Northwest Branch of Shirley's Brook. The development of the KNUEA lands will decrease infiltration and increase runoff, but there will be only minor changes to the overall evapotranspiration rates. The water budget model indicates that evapotranspiration is approximately 55% - 58% of the annual water budget with the remainder being water surplus (infiltration and runoff).

The seasonal fluctuations of the water budget are consistent with watersheds within Eastern Ontario. Due to the low evapotranspiration rates in the winter, spring and fall the soil moisture storage is full, which increases the water surplus. During the summer months the evapotranspiration rates are greater and the water surplus decreases as precipitation re-saturates the surficial soils.

3.3.2 Annual Changes to Hydrologic Cycle

Table 10 provides a summary of the annual changes to the hydrologic cycle following development of the KNUEA lands.

Table 10: Annual Changes to Hydrologic Cycle

Land Use	Infiltration (mm/yr)	Runoff (mm/yr)	Evapotranspiration (mm/yr)
KNUEA (187 ha)			
Pre	240.2 mm	244.2 mm	429.9 mm
Post	157.2 mm	389.5 mm	367.4 mm
Difference	-83.0	145.3	-62.5
% Change	-35%	60%	-15%
Tributary 2 – West of March Road (466 ha)			
Pre	236.8 mm	244.3 mm	433.2 mm
Post	224.8 mm	266.4 mm	423.0 mm
Difference	-12.0	22.1	-10.2
% Change	-5%	9%	-2%
Tributary 3 – West of March Road (253 ha)			
Pre	265.7 mm	192.4 mm	456.2 mm
Post	262.9 mm	198.5 mm	452.8 mm
Difference	-2.8	6.1	-3.4
% Change	-1%	3%	-1%
Shirley's Brook Northwest Branch - Confluence of Tributary 2/3 (719 ha)			
Pre	247.0 mm	226.0 mm	441.3 mm
Post	238.2 mm	242.5 mm	433.5 mm
Difference	-8.8	16.5	7.8
% Change	-4%	7%	-2%
Tributary 4 - West of March Road (27.5 ha)			
Pre	202.1 mm	268.8 mm	443.2 mm
Post	168.3 mm	346.8 mm	399.2 mm
Difference	-33.8	78	-44
% Change	-20%	22%	-11%
Headwater Drainage Channels – East of March Road (114 ha)			
Pre	280.7 mm	194.4 mm	439.1 mm
Post	203.9 mm	313.2 mm	397.2 mm
Difference	-76.8	118.8	-41.9
% Change	-27%	61%	-10%

Infiltration

The proposed development will reduce annual infiltration from the KNUEA by approximately 35%, but this will only translate to a reduction of approximately 4% over the Shirley's Brook Northwest Branch drainage area (719 ha).

Based on the findings of the hydrogeologic investigation, the water surplus categorized as "infiltration" will consist primarily of shallow groundwater interflow through the weathered bedrock, which will contribute to baseflow in the watercourses, but will provide minimal contribution to groundwater recharge of the underlying aquifer.

Runoff

Annual runoff from the KNUEA will increase by 60% under post-development conditions. Due to the size of the Northwest Branch watershed (719 ha), the total annual runoff volume to the Northwest Branch of Shirley's Brook will only increase by approximately 7%.

The increase in runoff to the Main Branch of Shirley's Brook at March Valley Road will be less than 1%, as the upstream area (1,767 ha) is already heavily urbanized.

Evapotranspiration

Under pre-development conditions, the crop cover coefficient (used to calculate actual evapotranspiration) for vegetated lands will fluctuate over the course of the year during the dormant season and growing season. Under post-development conditions, the impervious surfaces increase the potential evapotranspiration rates during the dormant season and at the beginning and end of the growing season. However, this increase in annual potential evapotranspiration is offset by the reduction in soil moisture storage, leaving less available water for evapotranspiration.

Refer to **Appendix B** and the attached CD for further details and supporting calculations.

3.4 Flow Monitoring

A streamflow monitoring program for the Northwest Branch of Shirley's Brook was initiated in May 2014, consisting of stream level loggers installed in three locations (refer to **Figure 3**).

- Tributary 2 (North Tributary);
- Tributary 3 (North Branch); and,
- Downstream of the confluence of the Tributaries 2 & 3.

Continuous flow monitoring was performed with pressure transducers, which measure air and water pressure to determine water levels within the watercourse. Instantaneous flow monitoring was performed using a Flow Probe to develop a stage-discharge curve to convert measured water level data to flow data based on an adapted version of the *Velocity-Area Procedure for Determining Steam Discharge* (US Environmental Protection Agency, September 1998). Field measurements of instantaneous streamflow were performed on a monthly basis, during both wet and dry periods to gather a range of high/low flow data points for the rating curves.

The continuous monitoring data is shown on **Figure 13**. The monthly results of the streamflow monitoring program are summarized in **Table 11**. Additional information on the flow monitoring methodology and results are provided in **Appendix C**.

Table 11: 2014 Streamflow Monitoring Results (Shirley's Brook Northwest Branch)

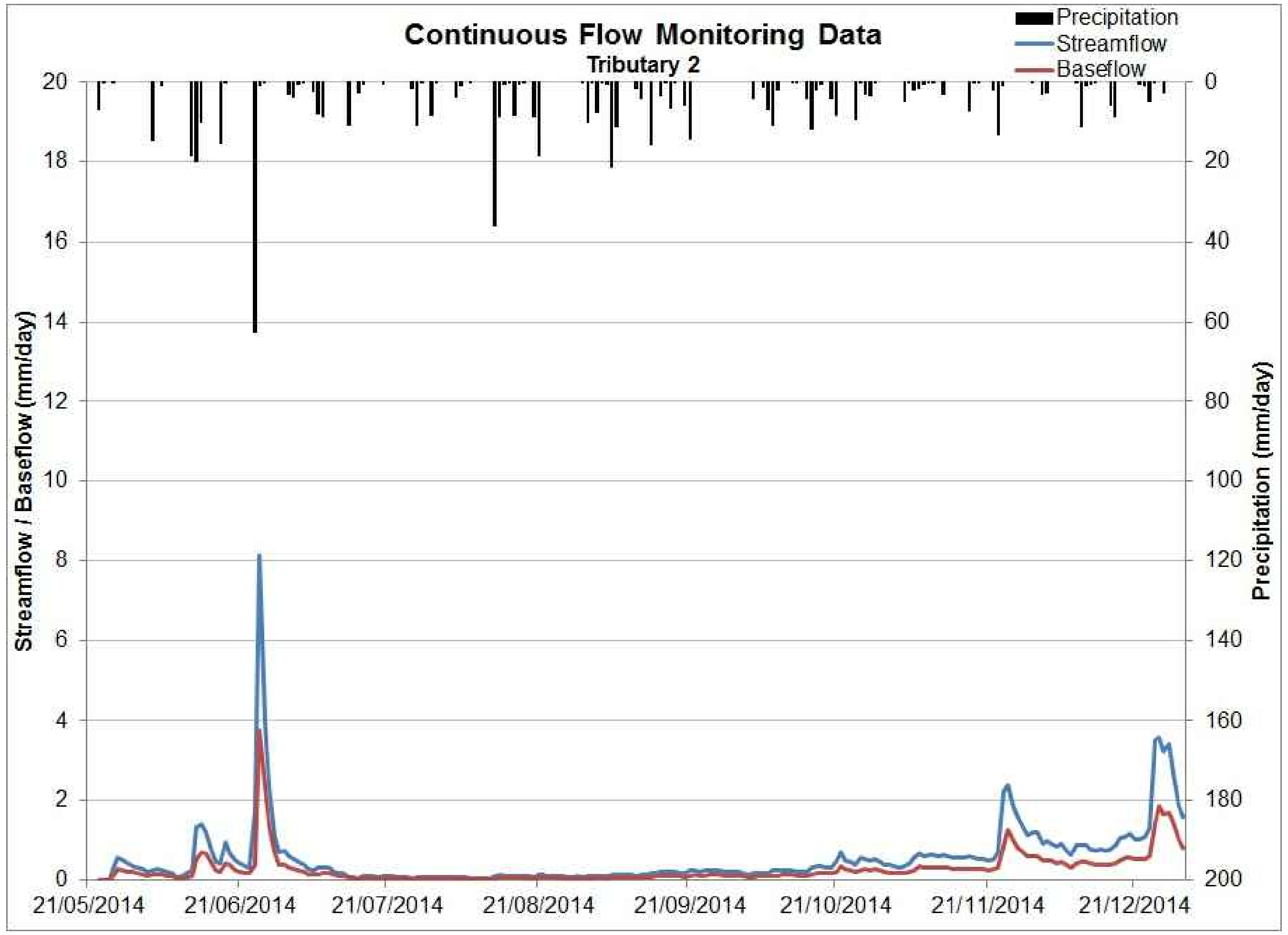
Month	Total Precip. (mm/mo)	Tributary 2 (466 ha)		Tributary 3 (253 ha)		Confluence of Tributaries 2 and 3 (719 ha)	
		Streamflow (L/s)	Baseflow (L/s)	Streamflow (L/s)	Baseflow (L/s)	Streamflow (L/s)	Baseflow (L/s)
Jun.[1]	143.2	45.2	22.5	9.8	22.4	137.8	69.1
Jul.	61.8	8.0	4.1	44.9	2.0	19.2	9.7
Aug.	96.8	3.8	1.9	3.9	0.0	1.9	1.0
Sep.	93.0	8.0	4.0	0.0	0.5	8.6	4.3
Oct.	72.3	15.1	7.5	1.0	2.6	35.8	17.7
Nov.	37.2	36.5	18.1	5.2	2.1	52.7	26.3
Dec.	42.1	61.8	30.8	4.3	6.1	83.4	41.8
Jul-Dec	**403.2**	**22.2**	**11.1**	**4.5**	**2.2**	**33.6**	**16.8**

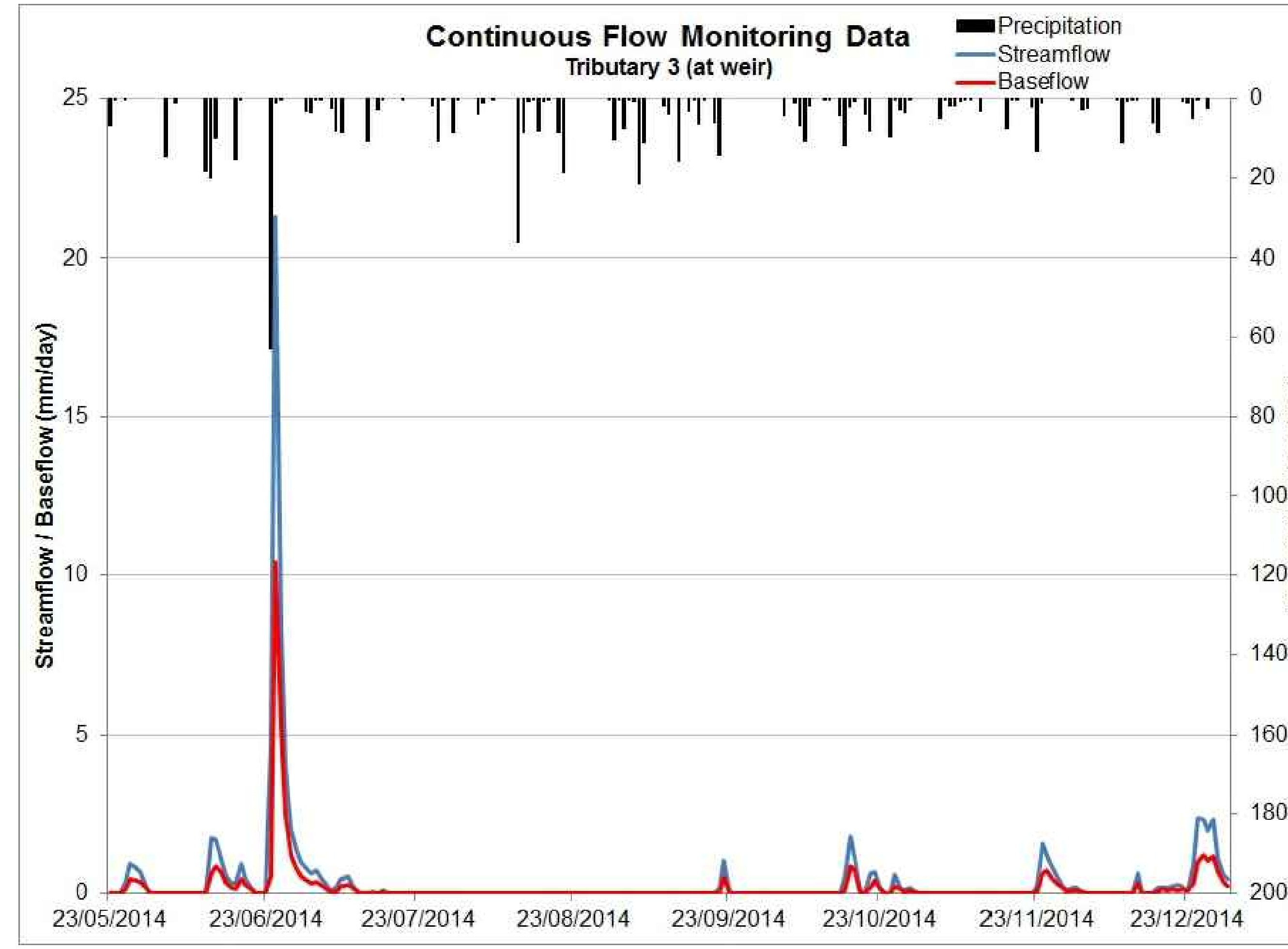
[1]The storm event in June 2014 is roughly equivalent to a 50-year storm event.

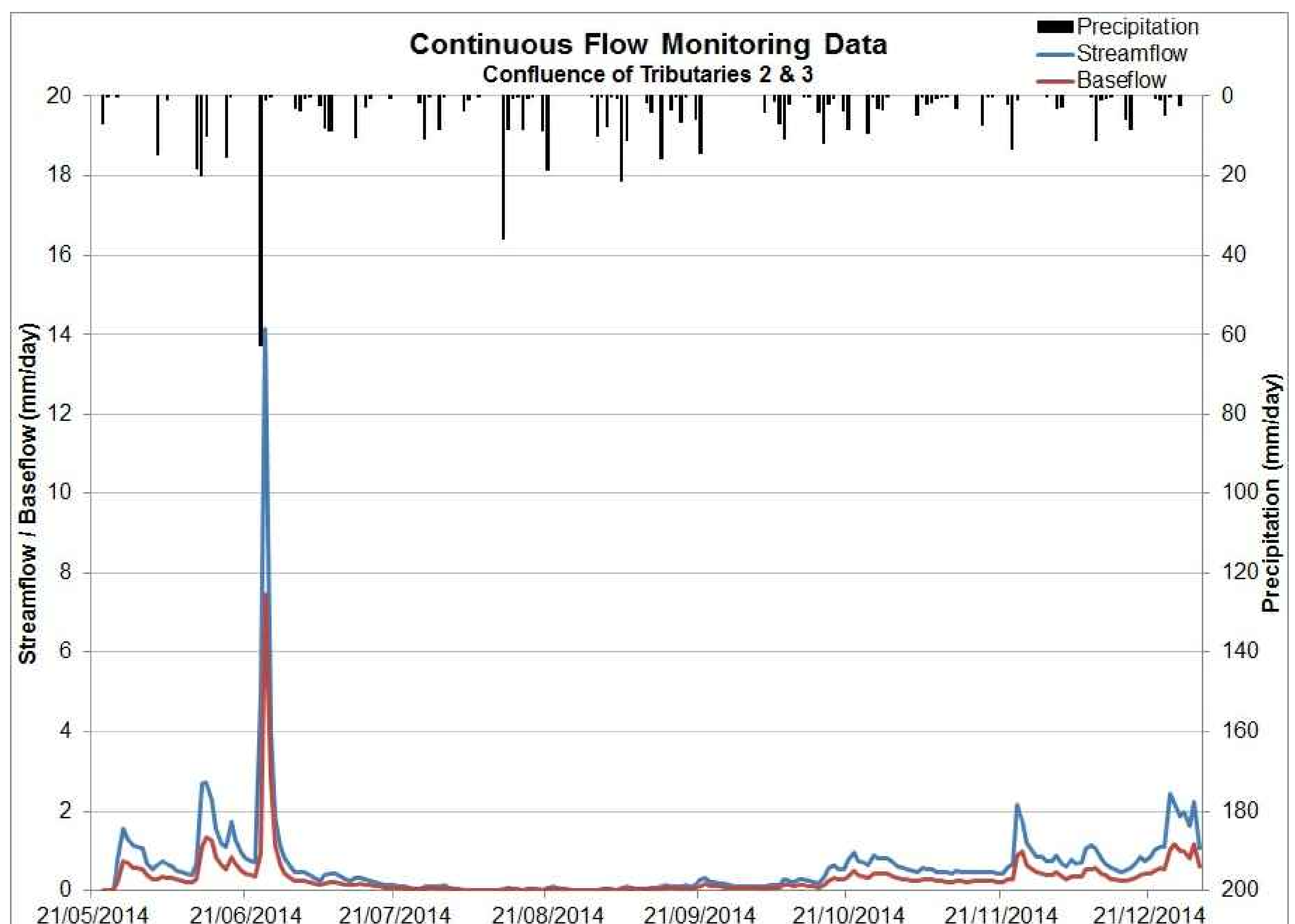
<u>*Baseflow*</u>

Baseflows in the tributaries comprising the Northwest Branch of Shirley's Brook were observed to vary significantly over the course of the year. Flows during the spring months are relatively high, sustained by the snow and water retained in the wetland areas in the upper portion of the watershed. Over the course of the summer, the baseflows in the Northwest Branch tributaries steadily decrease until the channels are dry, only flowing for short durations following storm events. In the fall, the wetland areas gradually replenish their storage as evapotranspiration rates decrease and the tributaries begin to flow for longer durations following storm events.

These observations are reflected in the following photographs, taken on April 10 and August 24, 2015.







KANATA NORTH
COMMUNITY DESIGN PLAN

FIGURE NO. 13
DAILY STREAMFLOW MONITORING RESULTS

DATE
MAY 2016

JOB
112117

SCALE
NTS

NOVATECH
Engineers, Planners & Landscape Architects

M:\2012\112117\CAD\Design_EMP\WB Figures\112117-Fig 13 - Streamflow Monitoring.dwg, FLOW MONITORING, Feb 16, 2016 - 10:35am, bthurber

SHT11x17.DWG - 279mmx432mm

Image 1: Northwest Branch - Tributary 2 (April 10, 2015)

Image 2: Northwest Branch - Tributary 2 (August 24, 2015)

Image 3: Northwest Branch - Tributary 3 (April 10, 2015)

Image 4: Northwest Branch - Tributary 3 (August 24, 2015)

Image 5: Northwest Branch Confluence (April 10, 2015)

Image 6: Northwest Branch Confluence (August 24, 2015)

<u>Note</u>: *There was approximately 22mm of rain between August 20 and August 24. Even so, the Northwest Branch Tributaries were observed to be dry on August 24, 2015.*

Streamflow vs. Rainfall

Field observations taken over the course of 2014 and 2015 indicate that the highest annual flows in the Northwest Branch Tributaries typically occur during the spring freshet and significant rainfall events. The spring snowmelt of 2015 was considered to be relatively low in the region, generating lower than average spring runoff responses. However, the observed flow rate on April 10, 2015 was roughly equivalent to the 10-year peak flow for a summer rainfall event.

A comparison of spring versus summer runoff responses in the Northwest Branch of Shirley's Brook is provided below:

- The observed flow rate on April 10, 2015 was approximately 1.2 m^3/s, resulting from approximately 22mm of precipitation over a period of 48 hours.

The recorded peak flow on June 25, 2014 was approximately 2.8 m3/s, resulting from a high-intensity storm generating 62.7mm of rainfall over a period of 12 hours.

As shown in **Figure 9**, the streamflow response from summer rain events recedes rather quickly. By contrast, the streamflow response during the spring freshet spring is sustained over a number of days at relatively high flows and depths.

Summary

Stream flow in the tributaries comprising the Northwest Branch of Shirley's Brook is primarily derived from surface water runoff. The wetland areas in the upper portions of the watershed store and attenuate runoff during the spring freshet and contribute to relatively high sustained flows during the spring and early summer. As the soil moisture deficit increases through the summer, the upstream areas have the capacity to retain a significant amount of water. Consequently, The Northwest Branch tributaries have been observed to go dry during the summer low flow period.

Field observations of the Northwest Branch tributaries have shown that the channel beds in some reaches are situated directly on the bedrock. The fractures in the bedrock may provide a potential conduit between surface and groundwater. Fractures in the bedrock could provide baseflow contributions in the watercourses during periods of high groundwater levels. During low flow periods, the shallow/exposed bedrock along the channel beds could divert streamflow into the groundwater.

3.5 Model Validation

As a means of validating the results of the water budget, the calculated values were compared against field derived stream baseflow values, which represent the amount of water leaving the watershed. Water budget model assumptions are described in greater detail in **Appendix B**.

For model validation purposes daily precipitation and evapotranspiration data from 2014 was used to compare with the streamflow monitoring data. The calculated infiltration rate over the drainage area for the North Tributary and North Branch converted to baseflow and compared with measured baseflow is presented in **Table 12.**

Table 12: Stream Baseflow Summary and Comparison (2014)

Catchment	Month	Average Infiltration Rate (mm/month)	Estimated Baseflow (L/s)	Observed Baseflow (L/s)	*Difference (Est - Obs) (L/s)*
North Tributary (upstream site) (466 ha)	*June*[1]	1.3	2.2	22.5	-20.3
	July	0.0	0.0	4.1	-4.1
	August	5.0	8.3	1.9	6.4
	September	4.7	7.9	4.0	3.9
	October	5.5	9.0	7.5	1.5
	November	18.2	30.9	18.1	12.8
	December	19.4	31.8	30.8	1.0
	July – Dec.	**52.8**	14.6	**11.1**	**3.5**
North Branch (upstream site) (253 ha)	*June*[1]	0.0	0.0	22.4	-22.4
	July	0.0	0.0	2.0	-2
	August	0.0	0.0	0.0	0.0
	September	3.8	3.7	0.5	3.2
	October	5.7	5.4	2.6	2.8
	November	20.3	19.8	2.1	17.7
	December	21.6	20.4	6.1	14.3
	July – Dec.	**51.4**	8.2	**2.2**	**6.0**
Confluence of North Tributary / North Branch (719 ha)	*June*[1]	0.0	0.0	69.1	-69.1
	July	0.0	0.0	9.7	-9.7
	August	3.0	8.1	1.0	7.1
	September	4.4	12.2	4.3	7.9
	October	5.3	14.3	17.7	-3.4
	November	18.2	50.5	26.3	24.2
	December	19.4	52.1	41.8	10.3
	July – Dec.	**50.4**	**22.9**	**16.8**	**6.1**

[1]The storm event in June 2014 is roughly equivalent to a 50-year storm event.

The cumulative baseflow based on the water budget analysis closely resembles the measured values observed in the field, which supports the estimated water surplus and infiltration factors used in the site specific water budget.

Since the calculated baseflow and measured baseflow values are similar, it can be concluded that baseflow is primarily derived from shallow groundwater interflow in the surficial soil layers. This also supports the findings from the hydrogeological study, which indicates that groundwater recharge and discharge is occurring on a localized scale within the silty sandy soils and not primarily from the underlying bedrock aquifer.

Limitations

Over-estimations in the calculated baseflow values may be attributed to an over-estimation of the infiltration capacity of the soils within the drainage area, or attributed to the loss of groundwater to deeper regional groundwater recharge that does not discharge within the subwatershed. Under-estimations in the calculated baseflow values may be attributed to uncertainty in baseflow estimates and/or infiltration values or flow through karst features that are adding to stream flow.

3.6 Synthesis of Water Budget Model Results and Monitoring

The water budget model correlates well with the data obtained from the streamflow monitoring program of the Shirley's Brook Northwest Branch Tributaries. The results of the water budget model are consistent with the hydrologic response of a typical clay-dominated watershed in Eastern Ontario. From this analysis, it is apparent that the hydrologic response of the watershed follows a seasonal pattern, as summarized below:

- Winter and early spring
    - Soils are fully saturated, the upstream wetlands are full and evapotranspiration / sublimation rates are low; therefore, precipitation and snowmelt during the spring freshet result in water surplus that contributes directly to storm runoff. Streamflows in the Northwest Branch Tributaries are sustained by the storage provided by the wetlands in the upper portions of the watershed.
- Summer
    - Soil moisture storage becomes depleted as evapotranspiration exceeds precipitation. The water holding capacity of the predominantly clay soil is relatively high, and little to no runoff is generated from small storm events (< 5mm). Streamflow in the tributaries becomes intermittent without the sustained flow contribution from groundwater or the upstream wetland areas. Stream response to large storm events (>25mm) is relatively quick with a steep slope along the receding limp of the streamflow hydrograph. Summer streamflow is primarily derived from rainfall, and there is no significant contribution to/from groundwater, apart from interflow in the surficial soil layers.
- Fall
    - Evapotranspiration rates decrease, allowing precipitation to gradually replenish the water within the soil moisture storage zone. This increases the hydrologic response of the watershed, resulting in more frequent and sustainted streamflow following precipitation events.

Based on the findings of the hydrogeologic investigation, the streamflow monitoring program, and the site-specific water balance model, development of the KNUEA lands is not anticipated to have any significant impact on groundwater resources. There will be an increase in runoff resulting from the higher imperviousness of the development area, but the impact on the receiving watercourses will be mitigated by the proposed stormwater management facilities, as well as any channel stabilization and/or erosion protection BMPs that may be implemented as part of the overall stormwater management strategy. The overall reduction in infiltration to the receiving watercourses will also be minimal as there is no proposed development planned for the upstream areas including the wetlands. As per the City of Ottawa Official Plan the upstream drainage areas to Tributary 2 and 3 may not be included within the urban boundary due to their location and vicinity to rural estate subdivisions. In addition the upstream wetlands are protected and will not be developed.

4.0 SUMMARY AND RECOMMENDATIONS

A site specific water budget assessment was performed to characterize the groundwater flow conditions and estimate infiltration and runoff within the proposed KNUEA lands and evaluate the potential impacts of development. The following conclusions are presented:

- The dominant surficial soil type is silty clay / glacial till, which have low infiltration potential.
- Bedrock outcrops of the March and Oxford Formations are assumed to have low infiltration potential as they have not exhibited the presence of karst features.
- No high recharge areas have been identified. An alluvial soils deposit is present in the vicinity of March Road, but it is underlain by stiff silty clay and does not provide any significant groundwater recharge/discharge function.
- The water budget for the North Tributary and North Branch indicated that the average annual infiltration rate under pre-development conditions is 247 mm/year. Under post-development conditions the annual infiltration rate across the watershed is anticipated to decrease by approximately 4% to 238 mm/year.
- Annual runoff volumes within the Northwest Branch Tributaries will increase by approximately 7%. The stormwater management design will utilize wet pond stormwater management facilities to ensure no adverse impacts on the receiving watercourses resulting from development.
- The fish species and aquatic / terrestrial species identified within the site are not particularly sensitive to changes in the anticipated changes in the flow regime.

4.1 Mitigation Measures

To protect groundwater resources and the hydrologic function of natural features, the following mitigation measures should be considered:

Permanent Measures

- Design stormwater management facilities to provide baseflow augmentation and erosion control storage, in addition to water quality and quantity control storage.
- Install seepage barriers in trenches to reduce the potential for lowering the groundwater table.
- Consider the use of low impact development techniques and infiltration best management practices (where conditions are appropriate).

Construction Measures

- Implement a groundwater monitoring program to evaluate the impact of construction on groundwater resources in association with an approved blasting plan.
- Ensure dewatering during construction does not adversely impact

4.2 Low-Impact Development (LID)

The City of Ottawa has recently implemented several LID pilot projects to evaluate the performance and maintenance requirements of LID designs, with the expectation that LID designs will become more prevalent in the near future.

The MOECC have indicated their intention to update the Environmental Compliance Approval (ECA) process to incorporate low impact development practices. The MOECC have stated that it is critical to consider options and opportunities for the incorporation of LID practices during the watershed and subwatershed planning process, and early in the development planning process, and not left to the preparation of the detailed stormwater management plan submission.

Based on the findings of the geotechnical and hydrogeological investigations and feedback from the City, there are areas within the KNUEA where LID designs should be considered. While the majority of the surficial soils within the KNUEA are underlain by clay and/or bedrock, this does not necessarily preclude the use of LIDs. For areas with tight, slow draining soils, it is recommended that any LID infrastructure be designed with overflows or subdrains to provide an engineered outlet for excess water.

East of March Road

The alluvial sand deposits east of March Road represent the most suitable areas for LID within the KNUEA. The alluvial soils are relatively shallow and underlain by clay and/or bedrock, and do not provide any significant contribution to groundwater recharge. However, these soils can provide storage and attenuation of runoff, and contribute to baseflow in Shirley's Brook.

West of March Road

The soils west of March Road generally consist of tight clays with relatively shallow depths to bedrock. While this does not preclude the use of LIDs in this area, infiltration based stormwater best management practices should be considered a low priority west of March Road.

5.0 CLOSURE

This report has been prepared for Novatech Engineering Consultants Ltd., on behalf of the Kanata North Landowner's Group and in support of the Kanata North Community Design Plan. It is hereby acknowledged that Metcalfe Realty Company Limited, J. G. Rivard Limited and 8409706 Canada Inc. (Valecraft Homes), 3223701 Canada Inc. and 7089121 Canada Inc. (Junic/Multivesco) can rely upon and utilize this report for the purpose of obtaining approval of the community design plan and for their own use to seek development approval.

It is further acknowledged that future confirmed participating landowners within the Kanata North Landowner's Group can rely upon and utilize this report for the purpose of obtaining approval of the community design plan and for their own use to seek development approval.

NOVATECH

Conrad Stang, MASc., P.Eng.
Water Resources Engineer

Mike Petepiece, P.Eng.
Project Manager

APPENDIX A

Excerpts from Previous Studies

SHIRLEYS BROOK ENVIRONMENTAL MANAGEMENT PLAN

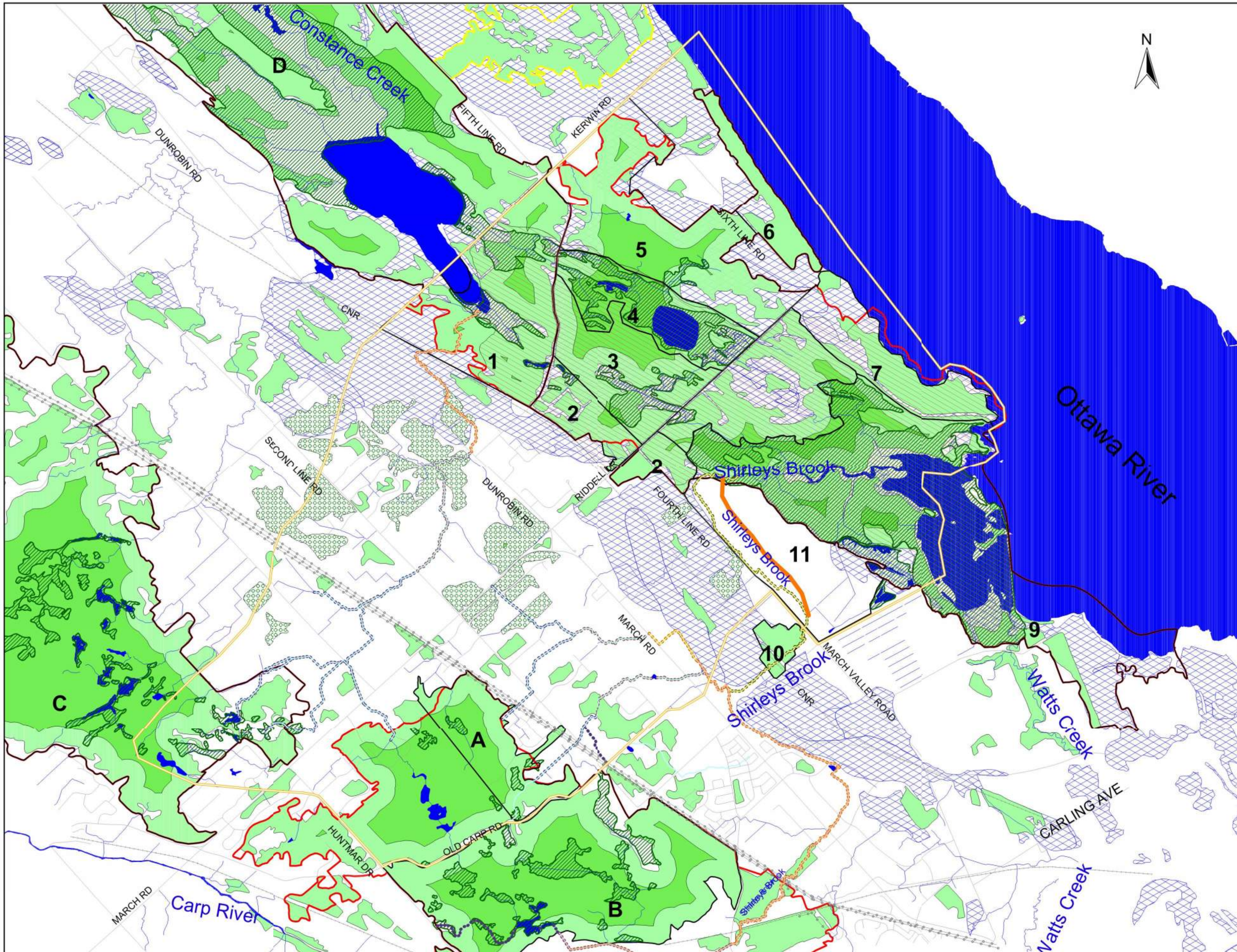


FIGURE 1
EXISTING ENVIRONMENT

Study Area
Powerlines
Railways
Roads

TARGET FISH COMMUNITIES
Diverse Warm Water Fish Community
Moderately Tolerant Fish Community
Tolerant Fish Community

MEANDER BELT CORRIDOR WIDTH
25 M
35 M
45 M
55 M

AREAS FOR PROTECTION/ENHANCEMENT
1 - 9 & 11 Centres of Ecological Significance
10 Inventoried Feature
D NESS Areas
Areas for Further Study
Proposed Natural Channel Design

ANSI
Shirley's Bay-Constance Lake Wetland

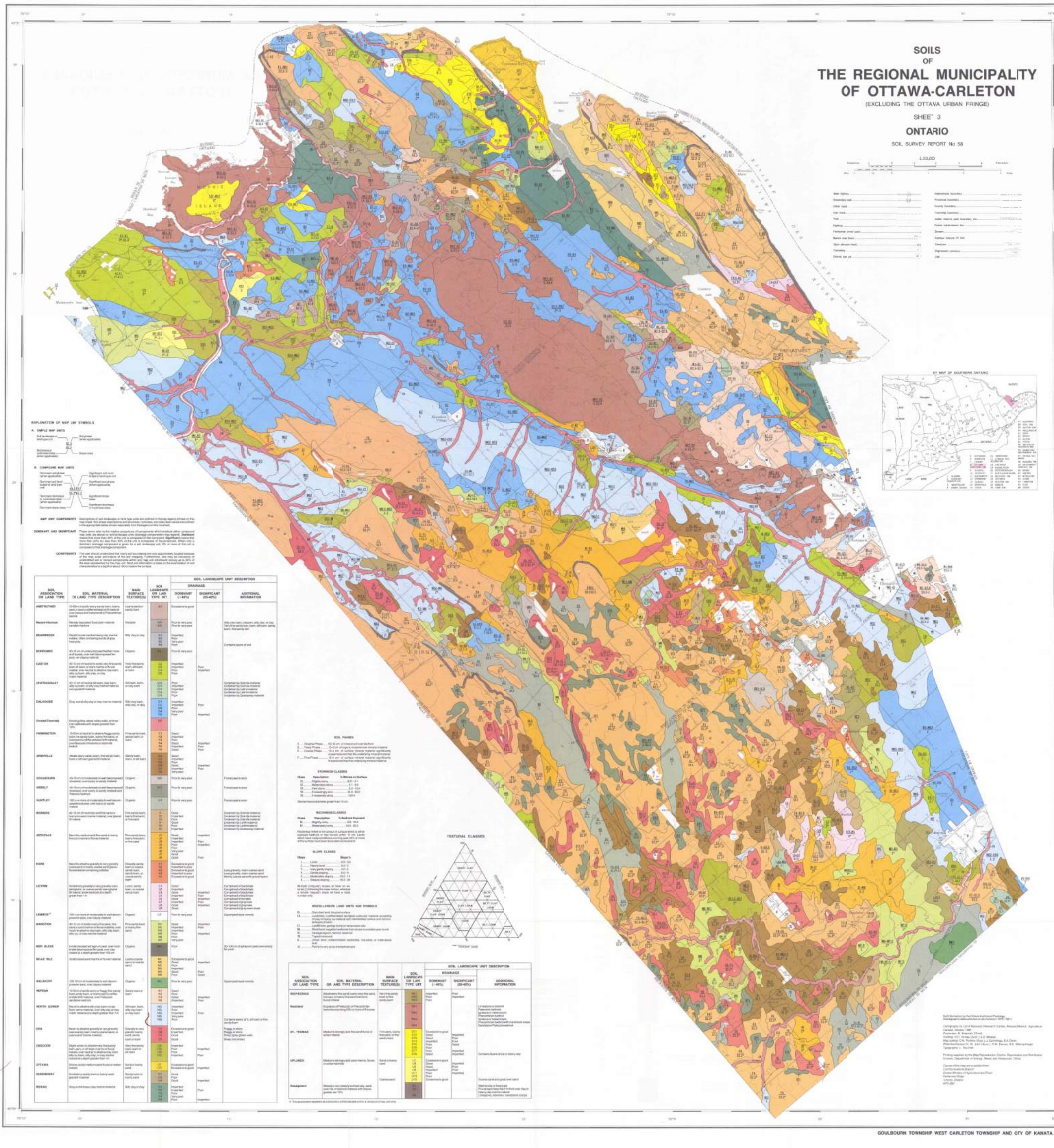
NESS CORE AREAS
High
Low

WETLANDS
Wetland

WOODLANDS
Woodland Interior
Woodland

RECHARGE
High Recharge

500 0 500 1000 1500 Meters



SOILS
OF
THE REGIONAL MUNICIPALITY
OF OTTAWA-CARLETON
(EXCLUDING THE OTTAWA URBAN FRINGE)
SHEET 3
ONTARIO
SOIL SURVEY REPORT No 58
TEXTURAL CLASSES
GOULBOURN TOWNSHIP WEST CARLETON TOWNSHIP AND CITY OF KANATA SHEET 3

APPENDIX B

Water Budget Model Description

Water Balance Model Description

The Thornthwaite-Mather (1957) water balance models are conceptual models that are used to simulate steady-state climatic averages or continuous values of precipitation (rain + snow), snowpack, snowmelt, soil moisture, evapotranspiration, and water surplus (infiltration + runoff) (refer to **Figure 1)**. Input parameters consist of daily precipitation *(PRECIP),* temperature *(MAX / MIN TEMP),* potential evaportranspiration *(PET)*, and the available water content *(AWC)* that can also be referred to as the water holding capacity of the soil. All water quantities in the model are based on monthly calculations and are represented as depths (volume per unit area) of liquid water over the area being simulated. *All model units are in millimetres (mm)*.

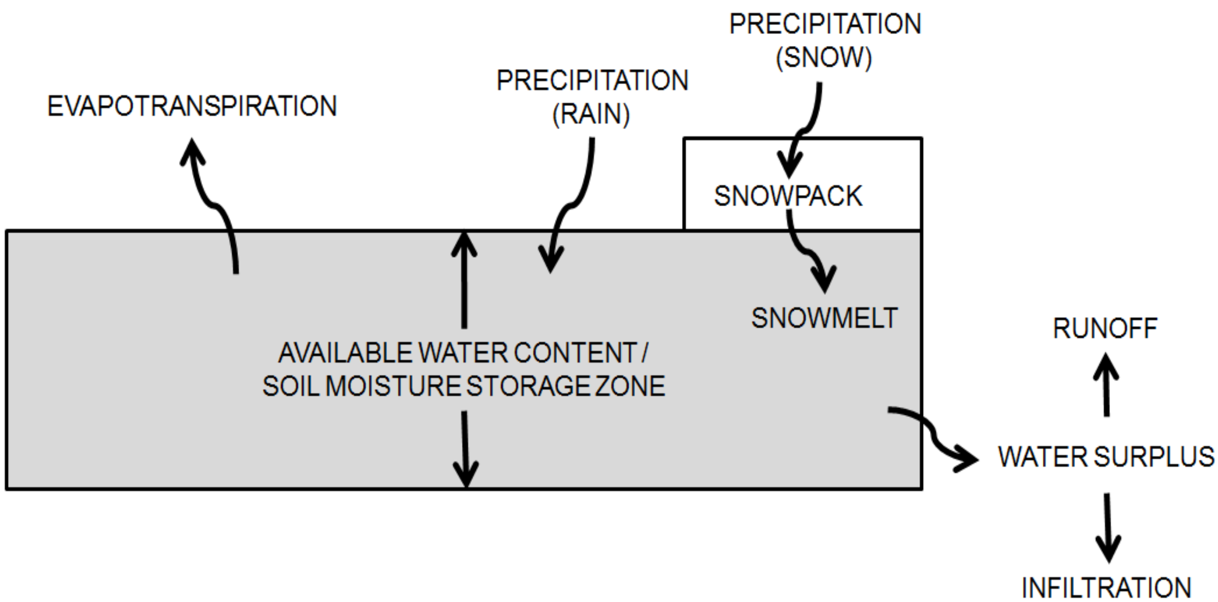


Figure 1: Conceptual Water Balance Model

Available Water Content (Water Holding Capacity)

The available water content (AWC) or water holding capacity of the soil was taken from Table 3.1 from the *Stormwater Management and Planning Manual (MOE, 2003)*, which has been reproduced in **Table 1** below. The available water content is the soil-moisture storage zone or the zone between the field capacity and vertical extent of the root zone.

Table 1: Water Holding Capacity Values (MOE, 2003)

Land Use / Soil Type	Hydrologic Soil Group	Water Holding Capacity (mm)
Urban Lawns / Shallow Rooted Crops (spinach, beans, beets, carrots)		
Fine Sand	A	50
Fine Sandy Loam	B	75
Silt Loam	C	125
Clay Loam	CD	100
Clay	D	75

Water Balance Model Description

Land Use / Soil Type	Hydrologic Soil Group	Water Holding Capacity (mm)
Moderately Rooted Crops (corn and cereal grains)		
Fine Sand	A	75
Fine Sandy Loam	B	150
Silt Loam	C	200
Clay Loam	CD	200
Clay	D	150
Pasture and Shrubs		
Fine Sand	A	100
Fine Sandy Loam	B	150
Silt Loam	C	250
Clay Loam	CD	250
Clay	D	200
Mature Forests		
Fine Sand	A	250
Fine Sandy Loam	B	300
Silt Loam	C	400
Clay Loam	CD	400
Clay	D	350

Precipitation

Daily precipitation *(PRECIP)* values consist of the total daily rainfall and water equivalent of snowmelt that fell on that day. Based on the mean daily temperature *(MEAN TEMP)* precipitation falls either as rainfall *(RAIN)* or the water equivalent of snowfall *(SNOW)*:

- *RAIN: If (MEAN TEMP >= 0, RAIN, SNOW)*
- *SNOW: If (MEAN TEMP < 0, SNOW, RAIN)*

Snowmelt / Snowpack / Water Input

Snowmelt *(MELT)* occurs if there is available snow (water equivalent) in the snowpack *(SNOWPACK)* and the maximum daily temperature *(MAX TEMP)* is greater than 0. The available snowmelt is limited to the available water in the snowpack.

Snowmelt is computed by a degree-day equation (Haith, 1985):

SNOWMELT (cm/d) = MELT COEFICIENT x [AIR TEMP (^{O}C) – MELT TEMP(^{O}C)]

The melt coefficient is typically 0.45 for northern climates (Haith, 1985). The melt temperature is assumed to be 0^{O}C. The air temperature is assumed to be the max temperature multiplied by a ratio of the max to min temperatures:

AIR TEMP = *MAX TEMP / (MAX TEMP – MIN TEMP)*

Therefore the snowmelt equation is:

- *MELT: If (MAX TEMP > 0, IF(SNOWPACK > 0, MIN((MAX TEMP*0.45*MAX TEMP/(MAX TEMP – MIN TEMP)*10mm/cm), SNOWPACK), 0), 0)*

Snow accumulates in the snowpack from the previous day if precipitation falls as snow and there is no snowmelt or the amount of snow that falls in a day exceeds the daily snowmelt:

$SNOWPACK_N = SNOWPACK_{N-1} + SNOW - MELT$

The initial snowmelt on day 1 (i.e. January 1) is assumed to be 0. The initial snowpack on day 1 is assumed to be the snowpack on the last day of simulation (i.e. December 31).

The total water input (W) is rain + snowmelt. This is the available water that fills the soil moisture storage zone each day.

Evaporation

Measured potential evaporation (PE) data (i.e. lake evaporation) is provided with the Environment Canada Climate Normals (see example below). The data represents daily averages for each month over a 20+ year period.

▼ Evaporation

Evaporation														
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	Code
Lake Evaporation (mm)	0	0	0	0	3.6	4.3	4.5	3.7	2.4	1.4	0	0	0	C

The daily evaporation data was assumed to represent the middle or 15^{th} of each month and ‘smoothed’ to represent the transition from month to month (see **Figure 2** below). As shown in **Figure 2** this produces a more realistic curve of potential evapotranspiration.

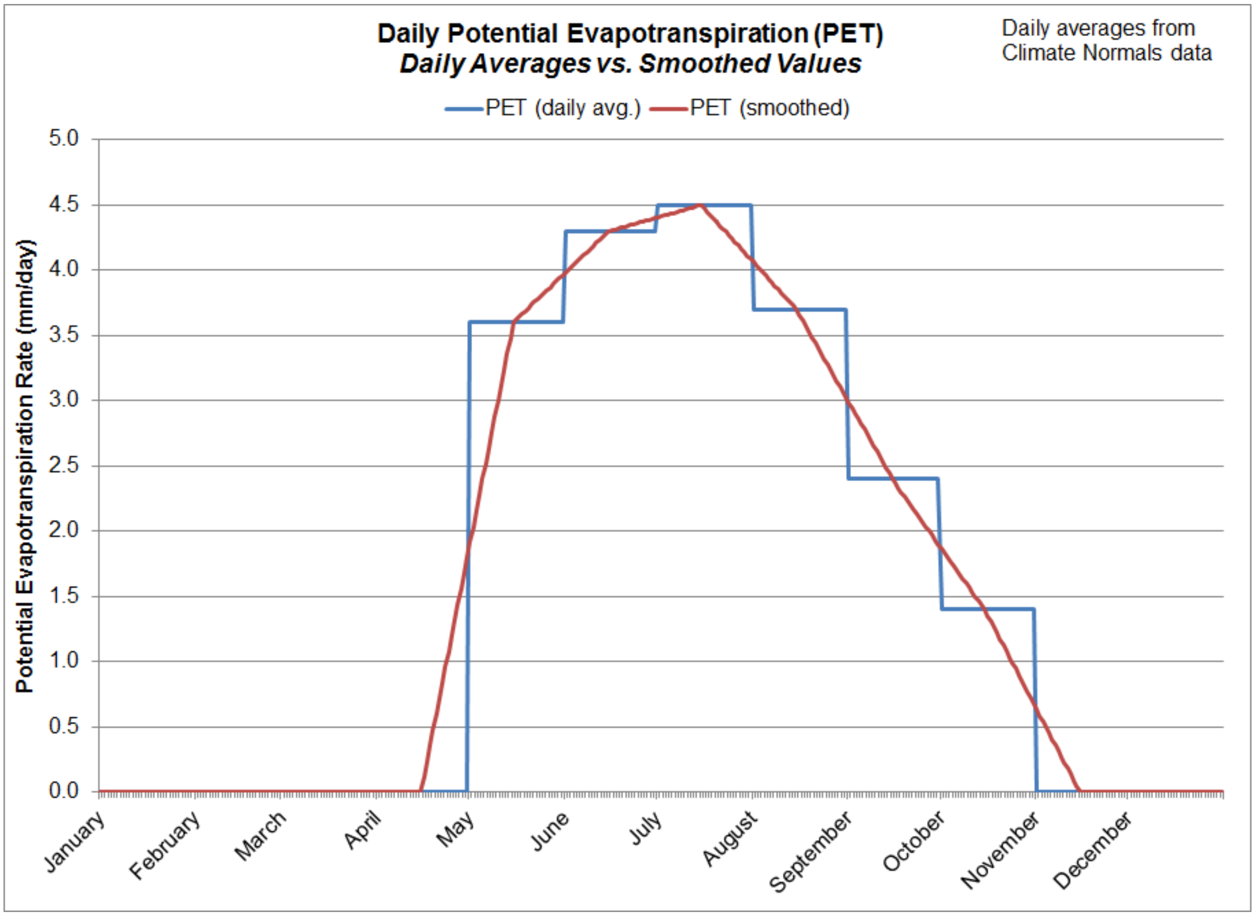


Figure 2: Daily Potential Evapotranspiration Rates (Daily Averages vs. Smoothed Values)

Potential Evapotranspiration

To convert potential evaporation data to potential crop evapotranspiration (PET) data a cover coefficient is applied based on land use and growing / dormant seasons:

PET = PE x Crop Cover Coefficient

Crop cover coefficients are based on the crop growth stages for different crop types (see **Figure 3**). A typical crop coefficient curve is shown in **Figure 4**, which depicts a crop that provides transpiration above the potential evaporation rates during the growing season.

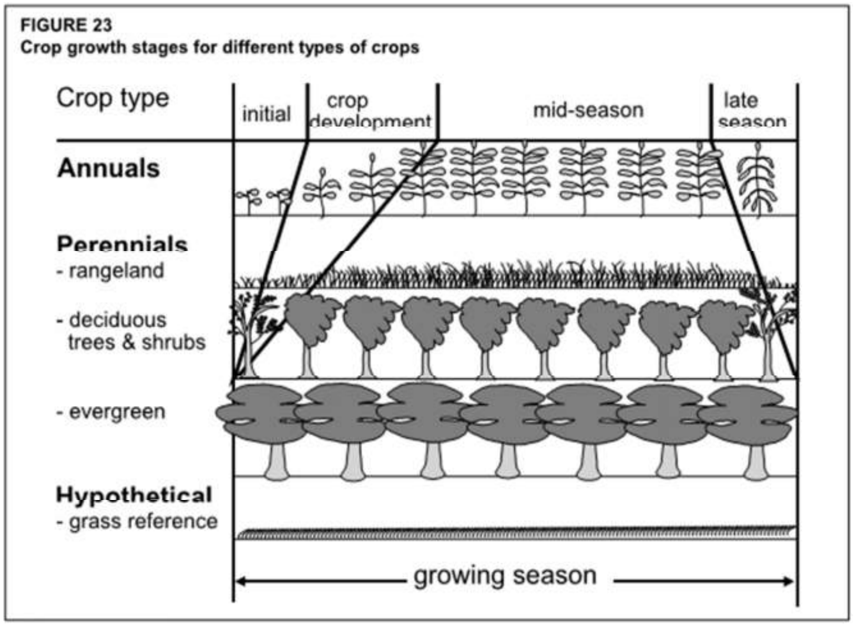


Figure 3: Crop Growth Stages for Different Types of Crops

Source: Food and Agriculture Organization of the United Nations (FAO), 1998, Crop Evapotranspiration - Guidelines for Computing Crop Water Requirements. FAO Irrigation and Drainage paper 56.

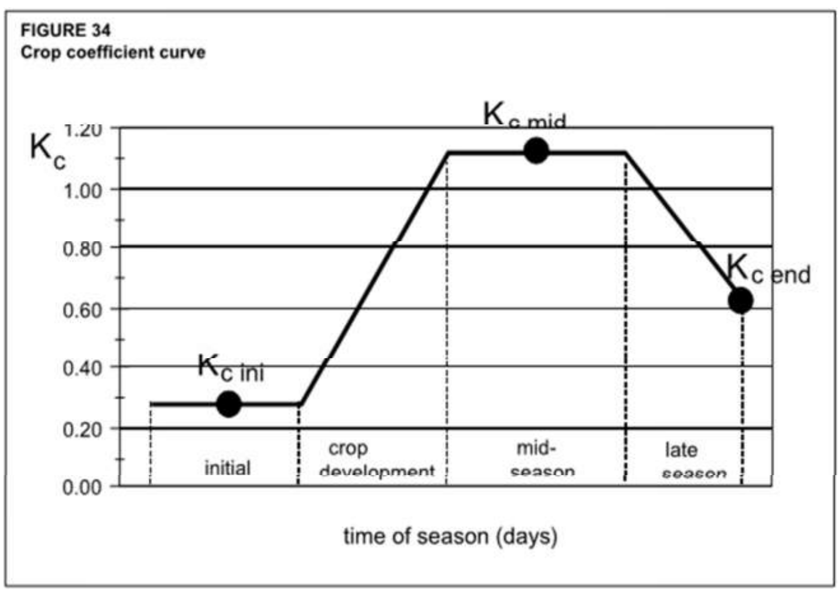


Figure 4: Crop Coefficient Curve

Source: Food and Agriculture Organization of the United Nations (FAO), 1998, Crop Evapotranspiration - Guidelines for Computing Crop Water Requirements. FAO Irrigation and Drainage paper 56.

Water Balance Model Description

The crop cover coefficients used in the water budget model for the various land use types is shown in **Table 2**. The growing / dormant seasons are shown in **Table 3**. The crop cover coefficients for the initial growing season are based on the average value of the dormant and middle of the growing season.

Table 2: Crop Cover Coefficients

Land Use	Dormant Season	Initial Growing Season	Middle of Growing Season	End of Growing Season
Urban Lawns / Shallow Rooted Crops	0.40	0.78	1.15	0.55
Moderately Rooted Crops	0.30	0.73	1.15	0.40
Pasture and Shrubs	0.40	0.68	0.95	0.90
Mature Forest	0.3	0.75	1.20	0.30
Impervious Areas	1.00	1.00	1.00	1.00

Reference: Data is based on Table 12 from the Food and Agriculture Organization of the United Nations (FAO), 1998, Crop Evapotranspiration - Guidelines for Computing Crop Water Requirements. FAO Irrigation and Drainage paper 56.

Table 3: Crop Growing Season

Month(s)	Crop Growing Season
January – April	Dormant Season
May	Initial Growing Season
June - August	Middle of Growing Season
September	End of Growing Season
October - December	Dormant Season (harvest in October)

Reference: Food and Agriculture Organization of the United Nations (FAO), 1977, Crop Water Requirements. FAO Irrigation and Drainage paper 24.

Actual Evapotranspiration

Following Alley (1984), if the monthly water input (i.e. rain + snowmelt) is greater than the potential evapotranspiration (PET) rate, the actual evapotranspiration (AET) rate takes place at the potential evapotranspiration rate:

IF W > PET, then AET = PET

If the monthly water input is less than the potential evapotranspiration rate (i.e. W < PET) then the actual evapotranspiration rate is the sum of the water input and an increment removed from the available water in the soil moisture storage zone (SOIL WATER):

IF W < PET, then AET = W + ΔSOIL WATER

WHERE: $\Delta SOIL\ WATER = SOIL\ WATER_{N-1} - SOIL\ WATER_N$

Figure 5 shows a comparison of the average monthly potential evapotranspiration and actual evapotranspiration rates.

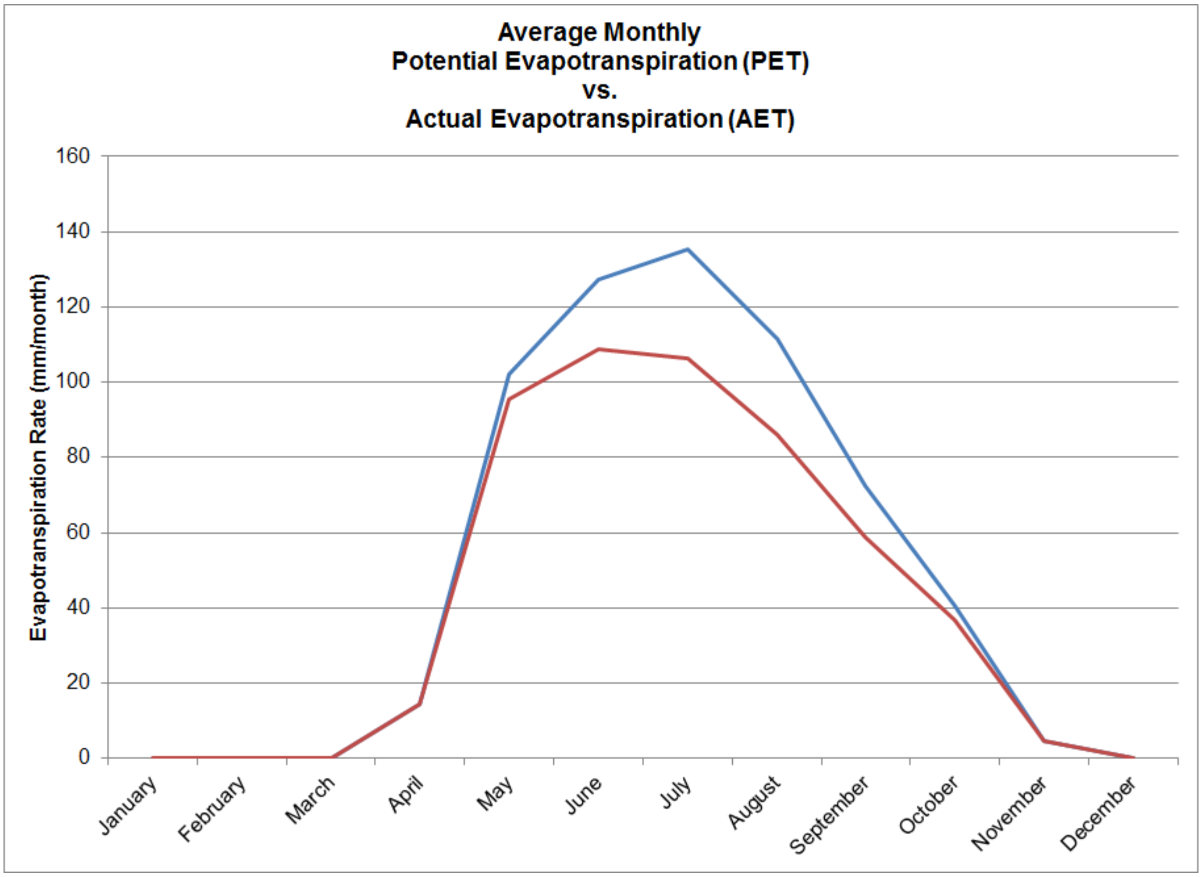


Figure 5: Average Monthly Potential Evapotranspiration vs. Actual Evapotranspiration

Soil Moisture

The soil moisture storage zone (SOIL WATER) is the amount of water available for actual evapotranspiration, but actual evapotranspiration is limited by the potential evapotranspiration rate.

The decrease / change in the soil moisture storage zone (ΔSOIL WATER) is based on the following relationship (Thornthwaite,1948), where AWC represents the available water content:

$$\Delta SOIL\ WATER = SOIL\ WATER_{N-1} \times [1-\exp(-((PET - W) / AWC))]$$

The soil moisture storage zone is replenished with rainwater and snowmelt (i.e. the water input) to the maximum value of the available water content (AWC):

$$SOIL\ WATER_N = \min[(W - PET) + SOIL\ WATER_{N-1}),\ AWC]$$

Water Balance Model Description

Water Surplus

The water surplus (SURPLUS) is defined as the excess water that is greater than the available water content (AWC).

SURPLUS = W – AET - ΔSOIL WATER

The water surplus represents the difference between precipitation and evapotranspiration. It is an estimate of the water that is available to contribute to infiltration and runoff (i.e. streamflow).

Infiltration / Runoff

The amount of water surplus that is infiltration was determined by summing the infiltration factors (IF) based on topography, soils and land cover. Since the water surplus represents infiltration and runoff; direct runoff is the amount of water surplus remaining after taking into account infiltration: (1.0 – infiltration factor = runoff factor). The infiltration and runoff factors were applied to the average monthly water surplus values:

INFILTRATION = IF x SURPLUS

RUNOFF = (1.0 – IF) x SURPLUS

The infiltration factors are shown in **Table 4**, which was reproduced from Table 3.1 in the *Stormwater Management and Planning Manual (MOE, 2003)*. These infiltration factors were initially presented in the document *"Hydrogeological Technical Information Requirements for Land Development Applications" (MOE, 1995)*.

Table 4: Infiltration Factors (MOE, 2003)

Description	Value of Infiltration Factor
Topography	
Flat Land, average slope < 0.6 m/km	0.3
Rolling Land, average slope 2.8 m/km to 3.8 m/km	0.2
Hilly Land, average slope 28 m/km to 47 m/km	0.1
Surficial Soils	
Tight impervious clay	0.1
Medium combination of clay and loam	0.2
Open sandy loam	0.4
Land Cover	
Cultivated Land	0.1
Woodland	0.2

Each soil type been assigned a corresponding infiltration factor as per Table 3.1 in the *Stormwater Management and Planning Manual (MOE, 2003),* as shown in **Table 5** below.

Water Balance Model Description

Table 5: Soils Infiltration Factors

Soil Type	Hydrologic Soil Group	Infiltration Factor
Coarse Sand	A	0.40
Fine Sand	AB	0.40
Fine Sandy Loam	B	0.30
Loam	BC	0.30
Silt Loam	C	0.20
Clay Loam	CD	0.15
Clay	D	0.10

The land use was combined into five (5) main categories (mature forest, row crops, pasture / meadow, urban lawns, and impervious areas) to be consistent with Table 3.1 in the *Stormwater Management and Planning Manual (MOE, 2003)*. The land use infiltration factors are shown in **Table 6** below.

Table 6: Land Use Infiltration Factor

Land Use	Infiltration Factor
Urban Lawns	0.10
Row Crops	0.10
Pasture / Meadow	0.10
Mature Forest	0.20
Impervious Areas	0.00

Land Use / Soils / Topography

Developed areas represent a combination of impervious areas and urban lawns as shown in **Table 7** below.

Table 7: Land Use Designations for Developed Areas

Land Use (developed areas)	% Impervious (impervious areas)	% Pervious (urban lawns)
Existing Residential (rural estate lots)	25%	75%
Low Density Development	50%	50%
Medium Density Development	65%	35%
High Density Development / Roads	80%	20%
Stormwater Management Facility (SWMF)	50%	50%

The available water content (AWC) and infiltration factors (IF), and crop cover coefficients (CROP COEF) are determined based on the combination of land use, soils and topography, as shown in **Table 8** (existing areas) and **Table 9** (developed areas) below.

Water Balance Model Description

Table 8: Model Parameters based on Land Use / Soils (existing areas)

Land Use	Soils (HSG)	AWC (mm)	IF (Land Use)	IF (Soils)	Crop Cover Coefficient			
					Dormant Season	Initial Growing Season	Middle of Growing Season	End of Growing Season
Urban Lawns	A	50	0.10	0.40	0.40	0.78	1.15	0.55
	AB	62.5		0.40				
	B	75		0.30				
	BC	100		0.30				
	C	125		0.20				
	CD	100		0.15				
	D	75		0.10				
Row Crops	A	75	0.10	0.40	0.30	0.73	1.15	0.40
	AB	112.5		0.40				
	B	150		0.30				
	BC	175		0.30				
	C	200		0.20				
	CD	200		0.15				
	D	150		0.10				
Pasture / Meadow	A	100	0.10	0.40	0.40	0.68	0.95	0.90
	AB	125		0.40				
	B	150		0.30				
	BC	200		0.30				
	C	250		0.20				
	CD	250		0.15				
	D	200		0.10				
Mature Forest	A	250	0.20	0.40	0.30	0.75	1.20	0.30
	AB	275		0.40				
	B	300		0.30				
	BC	350		0.30				
	C	400		0.20				
	CD	400		0.15				
	D	350		0.10				
Impervious Areas *(see Table 9)*	A	0	0.00	0.00	1.00	1.00	1.00	1.00
	AB	0						
	B	0						
	BC	0						
	C	0						
	CD	0						
	D	0						

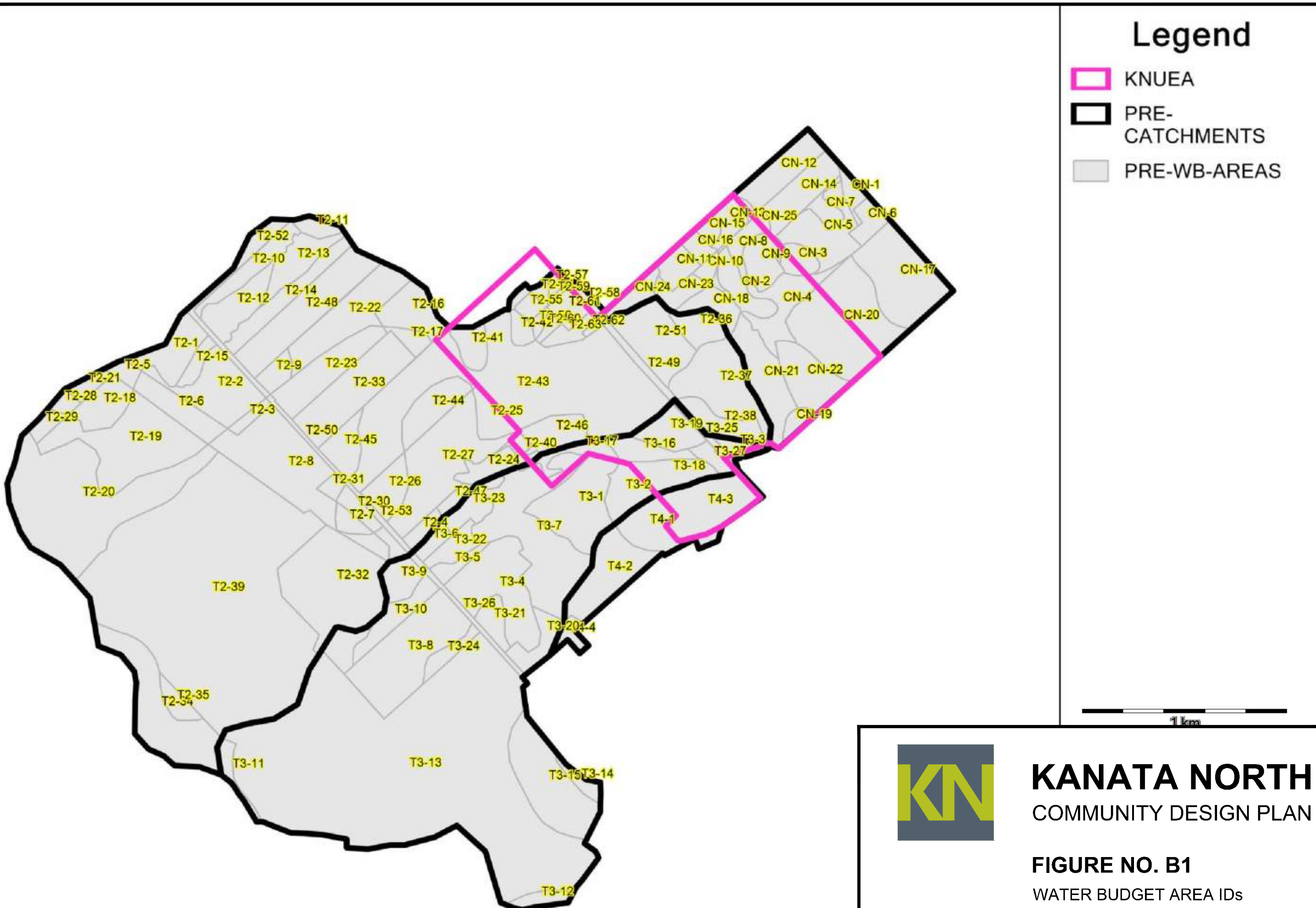
*For impervious areas, potential evapotranspiration is equal to potential evaporation (i.e. crop cover coefficient = 1.00).

Table 9: Model Parameters based on Land Use / Soils (developed areas)

Land Use	Soils (HSG)	AWC (mm)	IF (Land Use)	IF (Soils)	Crop Cover Coefficient			
					Dormant Season	Initial Growing Season	Middle of Growing Season	End of Growing Season
Existing Residential *(25% Imp.)*	A	38	0.08	0.30	0.55	0.84	1.11	0.66
	AB	47		0.30				
	B	56		0.23				
	BC	75		0.23				
	C	94		0.15				
	CD	75		0.11				
	D	56		0.08				
Low Density Development *(50% Imp.)*	A	25	0.05	0.20	0.70	0.89	1.08	0.78
	AB	31		0.20				
	B	38		0.15				
	BC	50		0.15				
	C	63		0.10				
	CD	50		0.08				
	D	38		0.05				
Medium Density Development *(65% Imp.)*	A	18	0.04	0.14	0.79	0.92	1.05	0.84
	AB	22		0.14				
	B	26		0.11				
	BC	35		0.11				
	C	44		0.07				
	CD	35		0.05				
	D	26		0.04				
High Density Development / Roads *(80% Imp.)*	A	10	0.02	0.08	0.88	0.96	1.03	0.91
	AB	13		0.08				
	B	15		0.06				
	BC	20		0.06				
	C	25		0.04				
	CD	20		0.03				
	D	15		0.02				
SWMF's *(50% imp.)*	A	25	0.05	0.20	0.70	0.89	1.08	0.78
	AB	31		0.20				
	B	38		0.15				
	BC	50		0.15				
	C	63		0.10				
	CD	50		0.08				
	D	38		0.05				

**Example calculation of AWC (HSG 'A') for existing residential areas:*

- *Existing residential areas are 25% impervious areas, 75% pervious (i.e. urban lawns):*
- *AWC (HSG 'A') for impervious areas = 0 mm; AWC (HSG 'A') for urban lawns = 50 mm*
- *Therefore, AWC (HSG 'A') for existing residential areas = 25% x 0 mm + 75% x 50 mm = 38 mm*



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KANATA NORTH

COMMUNITY DESIGN PLAN

FIGURE NO. B1

WATER BUDGET AREA IDs
(PRE-DEVELOPMENT - WATERSHEDS)

DATE
MAY 2016

JOB
112117

SCALE
AS SHOWN

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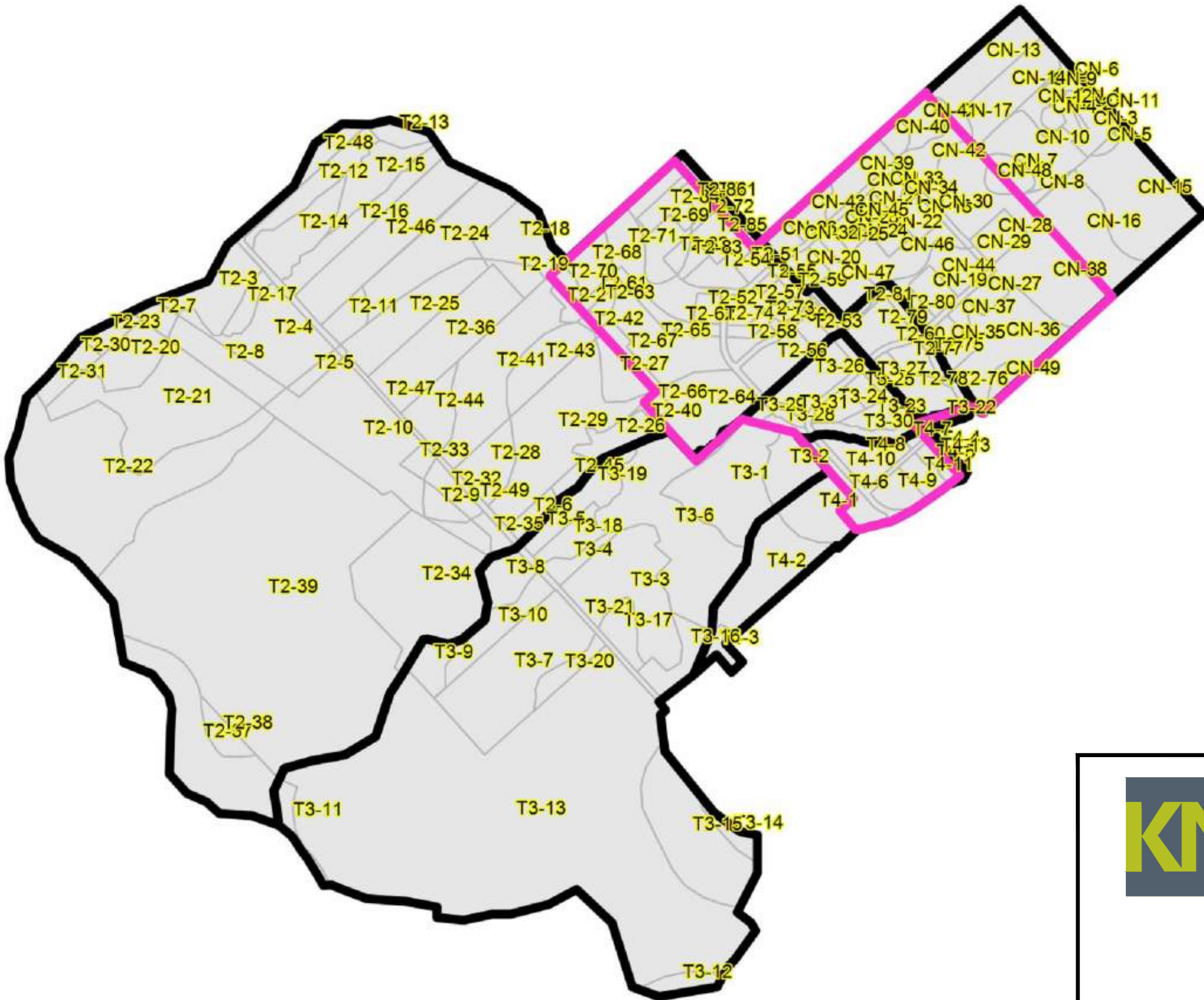
SHT8x11.DWG - 216mmx279mm



Legend

- KNUEA
- POST-CATCHMENTS
- POST-WB-AREAS

1 km

KANATA NORTH

COMMUNITY DESIGN PLAN

FIGURE NO. B2

WATER BUDGET AREA IDs
(POST-DEVELOPMENT - WATERSHEDS)

DATE
MAY 2016

JOB
112117

SCALE
AS SHOWN

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APPENDIX C
Flow Monitoring Data

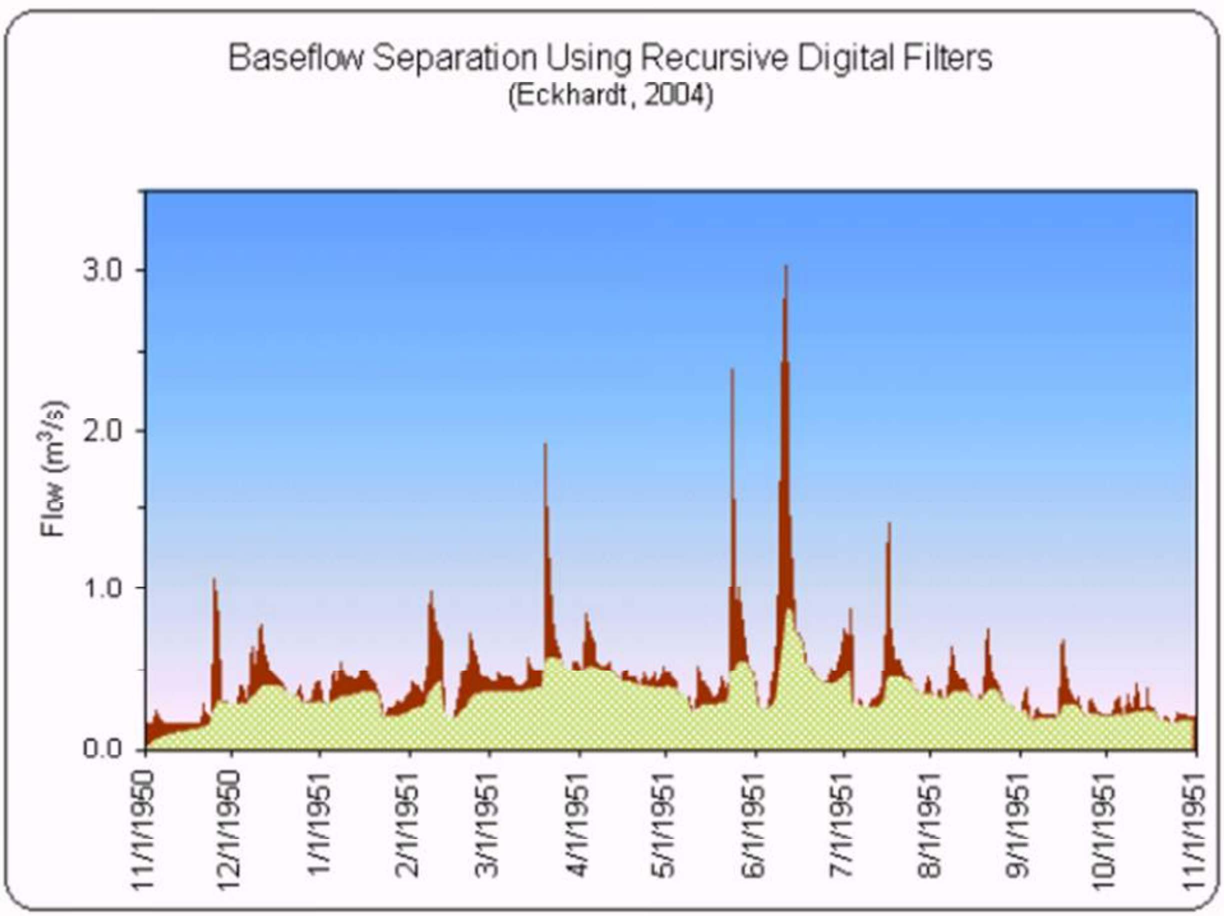
Baseflow Separation Methodology

Recursive Digital Filter Method (Eckhardt, 2004)

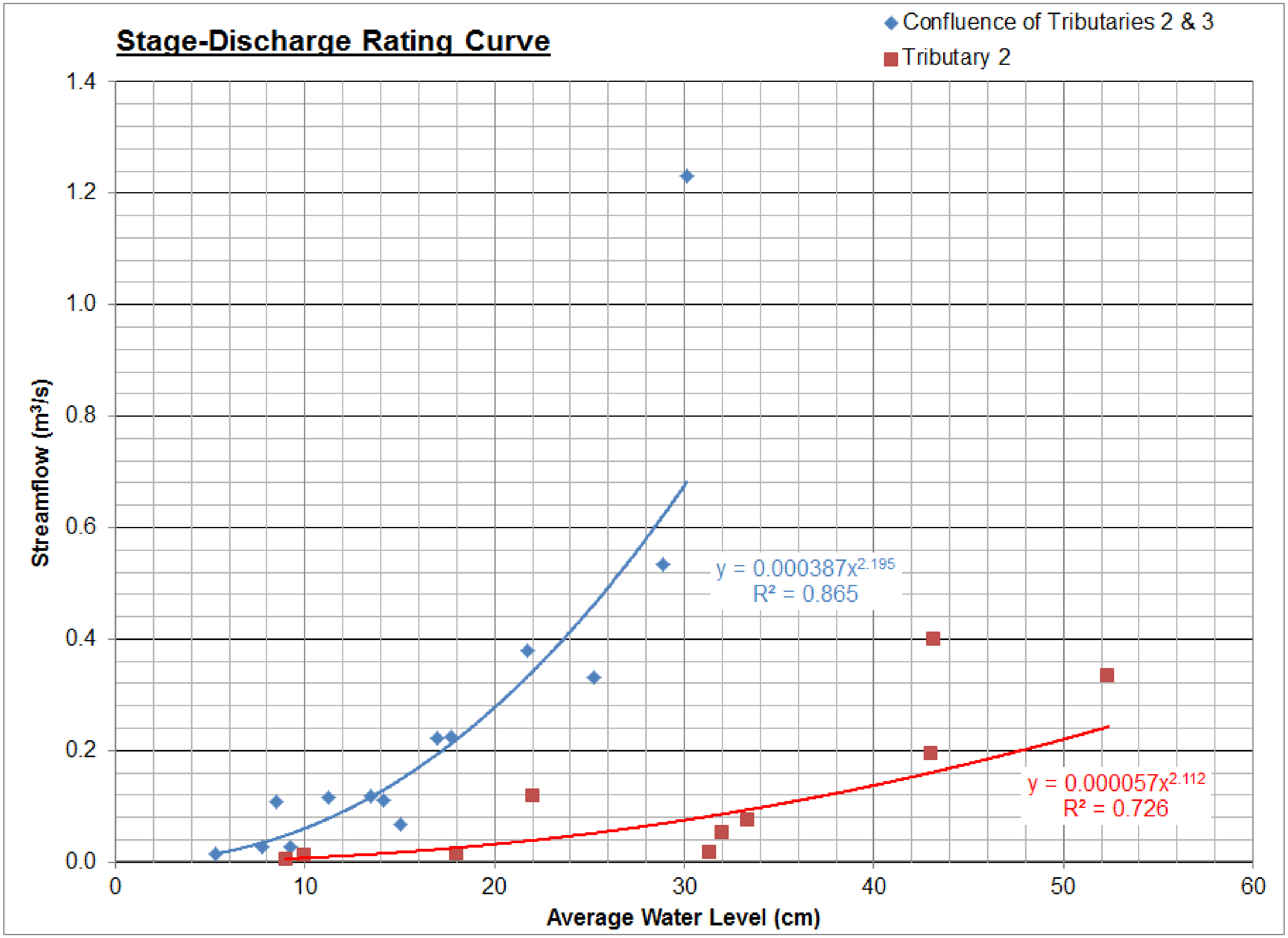
$$b_k = [(1 - BFI_{max}) * a * b_{k-1} + (1 - a) * BFI_{max} * y_k] / (1 - a * BFI_{max})$$

Where,

b_k: Baseflow at time step k,
b_{k-1}: Baseflow at time step k-1,
y_k: Total streamflow at time step k,
BFI_{max}: Baseflow Index (ratio of baseflow to the total flow),
a : Filter parameter.



Kanata North Urban Expansion Area
Water Budget Analysis



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Monthly Summaries of ContinuousStreamflow Monitoring Data

Month	Total Monthly Rainfall (mm)	Average Monthly Streamflow (L/s)			Average Monthly Baseflow (L/s)		
		Tributary 2	Tributary 3	Tributaries 2&3	Tributary 2	Tributary 3	Tributaries 2&3
May	91.9	13.4	9.8	67.2	6.5	4.9	32.3
June	143.2	45.2	44.9	137.8	22.5	22.4	69.1
July	61.8	8.0	3.9	19.2	4.1	2.0	9.7
August	96.8	3.8	0.0	1.9	1.9	0.0	1.0
September	93.0	8.0	1.0	8.6	4.0	0.5	4.3
October	72.3	15.1	5.2	35.8	7.5	2.6	17.7
November	37.2	36.5	4.3	52.7	18.1	2.1	26.3
December	42.1	61.8	12.3	83.4	30.8	6.1	41.8
TOTAL (May - Dec.)	**638.3**	**25.0**	**10.1**	**48.9**	**12.4**	**5.1**	**24.4**

Month	Total Monthly Rainfall (mm)	Total Monthly Streamflow (mm)			Total Monthly Baseflow (mm)		
		Tributary 2	Tributary 3	Tributaries 2&3	Tributary 2	Tributary 3	Tributaries 2&3
May	91.9	2.4	3.0	6.9	1.2	1.5	3.3
June	143.2	29.8	49.9	51.5	14.8	24.8	25.8
July	61.8	5.4	4.4	7.4	2.8	2.3	3.8
August	96.8	2.6	0.0	0.7	1.3	0.0	0.4
September	93.0	5.3	1.1	3.2	2.6	0.6	1.6
October	72.3	10.3	6.0	13.8	5.1	3.0	6.8
November	37.2	24.0	4.8	19.7	11.9	2.4	9.8
December	42.1	42.0	14.2	32.2	21.0	7.1	16.1
TOTAL (May - Dec.)	**638.3**	**121.8**	**83.4**	**135.5**	**60.7**	**41.7**	**67.7**

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Daily Summaries of Continuous Streamflow Monitoring Data

Date	Total Daily Rainfall (mm)	Average Daily Streamflow (L/s)			Average Daily Baseflow (L/s)		
		Tributary 2	Tributary 3	Tributaries 2&3	Tributary 2	Tributary 3	Tributaries 2&3
23/05/2014	6.9	0.0	0.0	0.0	0.0	0.0	0.0
24/05/2014	0.3	0.0	0.0	0.0	0.0	0.0	0.0
25/05/2014	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26/05/2014	0.3	13.5	10.8	61.4	3.9	3.0	17.3
27/05/2014	0.0	25.2	24.8	124.0	12.4	12.0	60.1
28/05/2014	0.0	21.7	21.6	106.5	11.2	11.2	55.5
29/05/2014	0.0	19.4	17.9	89.9	9.9	9.5	46.6
30/05/2014	0.0	16.6	5.9	87.8	8.7	4.7	44.0
31/05/2014	0.0	14.0	0.0	84.8	7.2	0.3	42.9
01/06/2014	0.0	12.0	0.0	52.8	6.4	0.0	30.8
02/06/2014	0.0	9.9	0.0	41.9	5.1	0.0	22.4
03/06/2014	14.6	11.8	0.0	49.8	5.5	0.0	22.9
04/06/2014	0.0	13.0	0.0	59.1	6.6	0.0	29.6
05/06/2014	0.9	11.1	0.0	52.7	5.7	0.0	26.7
06/06/2014	0.0	9.5	0.0	46.8	5.0	0.0	24.6
07/06/2014	0.0	7.8	0.0	40.9	4.4	0.0	21.5
08/06/2014	0.0	3.4	0.0	36.9	1.9	0.0	18.5
09/06/2014	0.0	5.0	0.0	34.8	2.2	0.0	17.8
10/06/2014	0.0	8.1	0.0	30.9	3.7	0.0	15.9
11/06/2014	18.4	11.0	0.0	54.6	4.8	0.0	21.7
12/06/2014	20.1	61.7	46.8	215.9	24.1	16.9	87.1
13/06/2014	10.0	64.5	46.1	218.4	31.4	23.1	108.6
14/06/2014	0.0	53.8	28.9	186.1	30.3	17.9	102.7
15/06/2014	0.0	32.8	15.7	126.5	18.7	9.1	69.3
16/06/2014	0.0	21.1	8.5	92.8	11.7	5.1	50.0
17/06/2014	15.3	19.6	8.1	87.6	9.3	3.5	42.4
18/06/2014	0.1	44.0	25.8	140.3	19.6	11.6	66.7
19/06/2014	0.0	30.4	12.5	101.8	17.2	7.5	54.8
20/06/2014	0.0	21.9	5.2	75.6	11.8	3.7	40.7
21/06/2014	0.0	18.6	0.0	65.7	9.6	0.3	33.8
22/06/2014	0.0	16.2	0.0	59.4	8.5	0.0	31.0
23/06/2014	0.0	14.2	0.0	55.5	7.3	0.0	28.4
24/06/2014	62.7	78.7	124.8	395.2	17.1	15.0	76.2
25/06/2014	1.0	370.7	575.2	1137.2	172.1	281.5	596.7
26/06/2014	0.1	180.7	224.4	322.3	107.4	142.0	227.9
27/06/2014	0.0	109.3	108.1	149.3	62.2	66.3	90.9
28/06/2014	0.0	50.2	54.5	88.4	32.5	33.0	50.8
29/06/2014	0.0	31.4	36.3	65.4	16.9	19.9	34.9
30/06/2014	0.0	33.9	26.7	48.5	16.9	14.4	26.2
01/07/2014	3.1	27.0	20.2	36.1	14.0	10.8	19.1
02/07/2014	3.7	24.3	16.9	37.6	12.5	8.8	18.7
03/07/2014	0.4	21.5	18.8	36.4	11.1	9.2	18.4
04/07/2014	0.2	17.2	12.7	32.4	9.2	7.2	16.8
05/07/2014	0.0	12.7	6.5	26.7	6.8	3.9	14.1
06/07/2014	2.4	10.6	0.5	21.1	5.5	0.8	11.3
07/07/2014	8.1	14.7	6.2	32.2	6.5	1.6	13.9
08/07/2014	8.6	14.4	12.4	34.1	7.4	6.2	17.3
09/07/2014	0.0	14.4	14.9	34.0	7.5	7.5	17.5
10/07/2014	0.0	10.1	7.3	27.7	5.5	4.5	14.6
11/07/2014	0.0	8.1	0.1	23.0	4.2	0.6	12.0
12/07/2014	0.0	7.8	0.0	19.8	4.0	0.0	10.3
13/07/2014	10.6	3.5	0.0	25.3	2.3	0.0	11.2
14/07/2014	0.0	2.3	0.7	25.5	1.3	0.3	13.3
15/07/2014	2.8	1.9	0.0	23.5	0.9	0.1	11.7
16/07/2014	0.4	3.9	2.6	19.9	1.7	1.0	10.7
17/07/2014	0.0	4.6	0.0	17.9	2.3	0.3	9.1
18/07/2014	0.0	4.0	0.0	15.2	2.1	0.0	8.0
19/07/2014	0.0	3.2	0.0	12.5	1.7	0.0	6.5
20/07/2014	0.4	5.0	0.0	12.4	2.2	0.0	6.2
21/07/2014	0.0	5.1	0.0	10.8	2.6	0.0	5.7
22/07/2014	0.0	4.0	0.0	9.1	2.1	0.0	4.7
23/07/2014	0.0	3.5	0.0	6.9	1.9	0.0	3.8
24/07/2014	0.0	2.7	0.0	5.0	1.4	0.0	2.7
25/07/2014	0.0	2.4	0.0	3.9	1.2	0.0	2.1
26/07/2014	1.7	2.2	0.0	2.7	1.1	0.0	1.4
27/07/2014	10.7	3.5	0.0	8.5	1.5	0.0	3.2
28/07/2014	0.1	3.0	0.0	9.6	1.6	0.0	4.9
29/07/2014	0.0	2.8	0.0	7.2	1.5	0.0	4.3
30/07/2014	8.4	3.5	0.0	8.0	1.6	0.0	3.3
31/07/2014	0.2	3.1	0.0	10.1	1.6	0.0	5.2

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Daily Summaries of Continuous Streamflow Monitoring Data

Date	Total Daily Rainfall (mm)	Average Daily Streamflow (L/s)			Average Daily Baseflow (L/s)		
		Tributary 2	Tributary 3	Tributaries 2&3	Tributary 2	Tributary 3	Tributaries 2&3
01/08/2014	0.0	2.8	0.0	5.7	1.4	0.0	3.4
02/08/2014	0.0	2.6	0.0	2.7	1.3	0.0	1.7
03/08/2014	0.0	2.3	0.0	1.4	1.1	0.0	0.8
04/08/2014	3.8	2.4	0.0	0.1	1.1	0.0	0.1
05/08/2014	1.0	2.3	0.0	1.1	1.2	0.0	0.4
06/08/2014	0.0	2.5	0.0	0.2	1.3	0.0	0.2
07/08/2014	0.1	1.8	0.0	0.6	0.9	0.0	0.2
08/08/2014	0.0	1.8	0.0	0.4	0.9	0.0	0.2
09/08/2014	0.0	1.6	0.0	0.4	0.8	0.0	0.2
10/08/2014	0.0	1.5	0.0	0.2	0.8	0.0	0.1
11/08/2014	0.0	1.1	0.0	0.1	0.6	0.0	0.1
12/08/2014	36.0	5.4	0.0	1.7	1.6	0.0	0.3
13/08/2014	8.5	6.5	0.0	5.7	3.8	0.0	3.0
14/08/2014	0.6	4.6	0.0	2.7	2.3	0.0	1.4
15/08/2014	0.3	4.4	0.0	1.5	2.3	0.0	1.0
16/08/2014	8.2	4.9	0.0	0.8	2.3	0.0	0.3
17/08/2014	0.6	4.9	0.0	3.0	2.6	0.0	1.4
18/08/2014	0.1	4.5	0.0	2.0	2.3	0.0	1.1
19/08/2014	0.0	4.0	0.0	1.1	2.1	0.0	0.6
20/08/2014	8.7	3.7	0.0	0.7	1.8	0.0	0.3
21/08/2014	18.5	6.3	0.0	5.8	2.7	0.0	2.1
22/08/2014	0.0	6.2	0.0	7.1	3.3	0.0	3.7
23/08/2014	0.0	5.4	0.0	5.2	2.8	0.0	2.8
24/08/2014	0.0	5.0	0.0	3.2	2.5	0.0	1.9
25/08/2014	0.0	4.7	0.0	1.9	2.4	0.0	1.0
26/08/2014	0.0	4.2	0.0	1.0	2.2	0.0	0.6
27/08/2014	0.0	3.7	0.0	0.2	1.9	0.0	0.2
28/08/2014	0.0	3.6	0.0	0.7	1.8	0.0	0.3
29/08/2014	0.0	3.9	0.0	0.5	1.9	0.0	0.3
30/08/2014	0.2	3.8	0.0	0.9	2.0	0.0	0.4
31/08/2014	10.2	4.1	0.0	0.9	1.9	0.0	0.4
01/09/2014	0.2	3.9	0.0	2.3	2.1	0.0	1.1
02/09/2014	7.5	5.0	0.0	1.8	2.3	0.0	0.9
03/09/2014	0.3	4.3	0.0	2.1	2.3	0.0	1.1
04/09/2014	0.7	4.3	0.0	1.0	2.1	0.0	0.6
05/09/2014	21.5	6.7	0.0	4.1	2.8	0.0	1.1
06/09/2014	11.1	6.8	0.0	8.4	3.6	0.0	4.3
07/09/2014	0.0	6.3	0.0	5.1	3.2	0.0	2.9
08/09/2014	0.0	6.2	0.0	3.7	3.1	0.0	2.0
09/09/2014	0.0	5.5	0.0	2.6	2.8	0.0	1.5
10/09/2014	1.6	5.4	0.0	2.4	2.8	0.0	1.3
11/09/2014	4.0	6.0	0.0	4.9	2.8	0.0	2.0
12/09/2014	0.0	6.1	0.0	4.4	3.0	0.0	2.4
13/09/2014	15.7	7.5	0.0	8.5	3.4	0.0	3.1
14/09/2014	0.0	7.7	0.0	9.9	4.0	0.0	5.5
15/09/2014	3.3	9.1	0.0	8.3	4.3	0.0	4.3
16/09/2014	0.2	9.1	0.0	8.0	4.6	0.0	4.0
17/09/2014	6.5	8.7	0.0	6.9	4.3	0.0	3.4
18/09/2014	0.1	8.8	0.0	9.7	4.5	0.0	4.7
19/09/2014	0.0	7.7	0.0	7.2	3.9	0.0	3.7
20/09/2014	6.0	7.8	0.0	9.9	3.9	0.0	4.7
21/09/2014	14.3	11.4	3.5	21.4	5.1	0.3	8.4
22/09/2014	0.0	11.0	27.2	24.0	5.8	13.7	13.0
23/09/2014	0.0	9.9	0.0	18.0	5.0	1.4	9.5
24/09/2014	0.0	11.1	0.0	16.4	5.4	0.0	8.4
25/09/2014	0.0	11.2	0.0	15.3	5.6	0.0	7.7
26/09/2014	0.0	11.6	0.0	13.0	5.7	0.0	6.8
27/09/2014	0.0	11.1	0.0	11.7	5.6	0.0	6.0
28/09/2014	0.0	10.2	0.0	9.3	5.3	0.0	5.0
29/09/2014	0.0	10.0	0.0	8.5	5.0	0.0	4.3
30/09/2014	0.0	9.8	0.0	7.9	5.0	0.0	4.0

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Engineers, Planners & Landscape Architects

Daily Summaries of Continuous Streamflow Monitoring Data

Date	Total Daily Rainfall (mm)	Average Daily Streamflow (L/s)			Average Daily Baseflow (L/s)		
		Tributary 2	Tributary 3	Tributaries 2&3	Tributary 2	Tributary 3	Tributaries 2&3
01/10/2014	0.0	9.2	0.0	8.6	4.6	0.0	4.2
02/10/2014	0.0	8.7	0.0	8.1	4.5	0.0	4.1
03/10/2014	0.0	5.8	0.0	7.8	3.1	0.0	4.0
04/10/2014	4.2	7.5	0.0	7.8	3.5	0.0	3.7
05/10/2014	0.0	7.8	0.0	9.9	3.9	0.0	4.9
06/10/2014	1.1	8.4	0.0	12.5	4.2	0.0	5.8
07/10/2014	6.9	8.7	0.0	12.5	4.2	0.0	6.3
08/10/2014	10.8	11.4	0.0	23.5	5.4	0.0	10.5
09/10/2014	1.9	10.8	0.0	19.0	5.4	0.0	9.9
10/10/2014	0.0	11.0	0.0	17.8	5.5	0.0	9.1
11/10/2014	0.0	11.2	0.0	21.6	5.6	0.0	9.9
12/10/2014	0.1	11.9	0.0	22.1	5.8	0.0	11.7
13/10/2014	0.1	10.2	0.0	18.8	5.3	0.0	9.5
14/10/2014	0.0	9.3	0.0	15.5	4.7	0.0	8.5
15/10/2014	4.2	10.2	0.0	13.9	4.9	0.0	6.6
16/10/2014	11.8	14.2	14.5	28.7	6.5	2.5	11.4
17/10/2014	2.0	16.7	48.5	43.9	8.2	22.9	20.9
18/10/2014	0.7	16.4	29.9	49.6	8.4	19.6	24.9
19/10/2014	0.0	15.1	0.0	43.1	7.6	1.4	22.3
20/10/2014	3.9	14.9	0.0	42.7	7.5	0.0	21.3
21/10/2014	8.3	22.9	16.3	62.3	9.7	4.9	26.9
22/10/2014	0.0	32.7	18.6	77.8	16.4	10.8	39.3
23/10/2014	0.0	23.1	4.6	59.7	12.4	3.9	31.6
24/10/2014	0.0	20.2	0.0	56.9	10.4	0.2	28.8
25/10/2014	9.5	17.7	0.0	51.5	8.9	0.0	25.9
26/10/2014	0.2	25.0	15.7	72.1	11.5	5.8	33.7
27/10/2014	3.0	23.6	4.3	66.1	12.3	4.0	34.0
28/10/2014	3.4	22.9	2.4	65.6	11.3	0.8	32.7
29/10/2014	0.2	23.9	5.0	65.0	12.0	2.5	32.7
30/10/2014	0.0	20.7	1.3	56.2	10.7	1.1	29.2
31/10/2014	0.0	17.5	0.0	48.0	9.1	0.0	24.9
01/11/2014	0.0	17.2	0.0	44.0	8.6	0.0	22.4
02/11/2014	0.0	15.1	0.0	41.7	7.9	0.0	21.2
03/11/2014	0.0	14.8	0.0	39.3	7.4	0.0	19.9
04/11/2014	4.9	15.8	0.0	37.4	7.6	0.0	18.6
05/11/2014	0.2	18.8	0.0	45.4	9.2	0.0	22.1
06/11/2014	1.9	25.4	0.0	43.0	11.2	0.0	21.6
07/11/2014	1.7	30.3	0.0	42.2	15.2	0.0	21.3
08/11/2014	0.7	27.9	0.0	37.9	14.1	0.0	19.5
09/11/2014	0.3	28.3	0.0	37.8	14.1	0.0	19.0
10/11/2014	0.3	28.2	0.0	35.3	14.2	0.0	18.0
11/11/2014	0.0	27.4	0.0	34.9	13.7	0.0	17.4
12/11/2014	3.1	29.1	0.0	39.4	14.4	0.0	19.3
13/11/2014	0.0	27.1	0.0	37.9	13.7	0.0	19.1
14/11/2014	0.0	26.1	0.0	35.7	13.2	0.0	17.7
15/11/2014	0.0	24.8	0.0	35.9	12.6	0.0	18.3
16/11/2014	0.0	25.1	0.0	37.5	12.5	0.0	18.4
17/11/2014	7.4	26.4	0.0	37.6	13.0	0.0	18.7
18/11/2014	0.2	26.0	0.0	37.0	13.3	0.0	18.9
19/11/2014	0.2	24.7	0.0	36.8	12.4	0.0	18.6
20/11/2014	0.0	24.5	0.0	33.2	12.4	0.0	16.8
21/11/2014	0.0	22.6	0.0	34.1	11.5	0.0	16.6
22/11/2014	2.0	24.4	0.0	44.7	12.0	0.0	21.7
23/11/2014	13.4	31.7	6.0	53.0	14.1	1.5	22.9
24/11/2014	1.0	100.9	42.5	172.3	39.0	16.3	69.7
25/11/2014	0.0	109.0	32.7	138.1	58.1	19.1	78.7
26/11/2014	0.0	83.2	21.3	95.5	44.1	11.8	51.7
27/11/2014	0.0	71.7	14.7	79.6	37.1	8.3	41.5
28/11/2014	0.0	61.3	6.3	67.5	32.2	4.2	35.6
29/11/2014	0.0	51.9	2.6	67.2	26.7	1.5	33.9
30/11/2014	0.2	53.7	4.1	59.1	26.5	1.8	29.6

NOVATECH
Engineers, Planners & Landscape Architects

Daily Summaries of Continuous Streamflow Monitoring Data

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		Tributary 2	Tributary 3	Tributaries 2&3	Tributary 2	Tributary 3	Tributaries 2&3
01/12/2014	0.0	54.2	5.3	58.8	27.5	2.8	29.9
02/12/2014	3.0	41.8	0.0	72.2	22.2	0.5	36.0
03/12/2014	2.6	45.2	0.0	53.9	22.1	0.0	28.2
04/12/2014	0.0	42.2	0.0	47.8	21.8	0.0	23.6
05/12/2014	0.0	38.2	0.0	61.6	19.2	0.0	29.3
06/12/2014	0.0	40.8	0.0	53.5	20.3	0.0	28.5
07/12/2014	0.0	33.9	0.0	56.1	17.9	0.0	26.8
08/12/2014	0.0	28.9	0.0	85.9	14.7	0.0	41.6
09/12/2014	0.2	39.8	0.0	91.2	18.5	0.0	41.9
10/12/2014	11.1	40.7	0.0	84.6	20.5	0.0	44.7
11/12/2014	0.8	39.8	0.0	65.6	20.1	0.0	34.1
12/12/2014	0.4	35.6	0.0	55.0	18.4	0.0	30.0
13/12/2014	0.2	33.2	17.0	44.7	16.7	8.2	23.0
14/12/2014	0.0	34.5	0.0	43.4	17.1	0.3	22.5
15/12/2014	0.0	34.4	0.0	37.9	17.1	0.0	19.0
16/12/2014	6.0	35.2	0.0	39.8	17.4	0.0	19.7
17/12/2014	8.5	39.6	4.7	46.3	19.1	1.0	21.9
18/12/2014	0.0	47.8	5.2	55.2	22.9	3.4	26.7
19/12/2014	0.0	49.3	4.8	69.3	24.9	2.3	31.5
20/12/2014	0.0	52.3	6.5	60.6	25.8	3.3	33.5
21/12/2014	0.0	46.3	7.5	68.7	23.6	2.4	32.7
22/12/2014	0.7	46.9	5.7	83.6	23.5	3.5	39.9
23/12/2014	1.0	49.4	1.5	87.0	24.3	1.8	44.0
24/12/2014	4.9	59.2	24.1	87.6	27.8	8.5	41.3
25/12/2014	0.2	159.8	64.2	196.8	64.4	26.1	83.4
26/12/2014	0.0	164.0	62.4	177.2	85.6	32.7	94.6
27/12/2014	2.5	148.2	53.7	150.1	75.5	27.9	78.2
28/12/2014	0.0	155.6	62.6	158.0	77.4	31.3	79.1
29/12/2014	0.0	121.3	29.7	130.9	65.5	18.6	66.2
30/12/2014	0.0	85.5	16.1	178.3	46.7	9.6	93.8
31/12/2014	0.0	72.3	11.4	84.6	37.2	6.4	49.2

NOVATECH
Engineers, Planners & Landscape Architects

Daily Summaries of Continuous Streamflow Monitoring Data

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		Tributary 2	Tributary 3	Tributaries 2&3	Tributary 2	Tributary 3	Tributaries 2&3
23/05/2014	6.9	0.0	0.0	0.0	0.0	0.0	0.0
24/05/2014	0.3	0.0	0.0	0.0	0.0	0.0	0.0
25/05/2014	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26/05/2014	0.3	0.3	0.4	0.8	0.1	0.1	0.2
27/05/2014	0.0	0.6	0.9	1.5	0.3	0.4	0.7
28/05/2014	0.0	0.5	0.8	1.3	0.2	0.4	0.7
29/05/2014	0.0	0.4	0.7	1.1	0.2	0.4	0.6
30/05/2014	0.0	0.4	0.2	1.1	0.2	0.2	0.5
31/05/2014	0.0	0.3	0.0	1.1	0.2	0.0	0.5
01/06/2014	0.0	0.3	0.0	0.7	0.1	0.0	0.4
02/06/2014	0.0	0.2	0.0	0.5	0.1	0.0	0.3
03/06/2014	14.6	0.3	0.0	0.6	0.1	0.0	0.3
04/06/2014	0.0	0.3	0.0	0.7	0.1	0.0	0.4
05/06/2014	0.9	0.2	0.0	0.7	0.1	0.0	0.3
06/06/2014	0.0	0.2	0.0	0.6	0.1	0.0	0.3
07/06/2014	0.0	0.2	0.0	0.5	0.1	0.0	0.3
08/06/2014	0.0	0.1	0.0	0.5	0.0	0.0	0.2
09/06/2014	0.0	0.1	0.0	0.4	0.0	0.0	0.2
10/06/2014	0.0	0.2	0.0	0.4	0.1	0.0	0.2
11/06/2014	18.4	0.2	0.0	0.7	0.1	0.0	0.3
12/06/2014	20.1	1.4	1.7	2.7	0.5	0.6	1.1
13/06/2014	10.0	1.4	1.7	2.7	0.7	0.9	1.4
14/06/2014	0.0	1.2	1.1	2.3	0.7	0.7	1.3
15/06/2014	0.0	0.7	0.6	1.6	0.4	0.3	0.9
16/06/2014	0.0	0.5	0.3	1.2	0.3	0.2	0.6
17/06/2014	15.3	0.4	0.3	1.1	0.2	0.1	0.5
18/06/2014	0.1	1.0	1.0	1.7	0.4	0.4	0.8
19/06/2014	0.0	0.7	0.5	1.3	0.4	0.3	0.7
20/06/2014	0.0	0.5	0.2	0.9	0.3	0.1	0.5
21/06/2014	0.0	0.4	0.0	0.8	0.2	0.0	0.4
22/06/2014	0.0	0.4	0.0	0.7	0.2	0.0	0.4
23/06/2014	0.0	0.3	0.0	0.7	0.2	0.0	0.4
24/06/2014	62.7	1.7	4.6	4.9	0.4	0.6	0.9
25/06/2014	1.0	8.1	21.3	14.2	3.8	10.4	7.4
26/06/2014	0.1	4.0	8.3	4.0	2.4	5.3	2.8
27/06/2014	0.0	2.4	4.0	1.9	1.4	2.5	1.1
28/06/2014	0.0	1.1	2.0	1.1	0.7	1.2	0.6
29/06/2014	0.0	0.7	1.3	0.8	0.4	0.7	0.4
30/06/2014	0.0	0.7	1.0	0.6	0.4	0.5	0.3
01/07/2014	3.1	0.6	0.7	0.5	0.3	0.4	0.2
02/07/2014	3.7	0.5	0.6	0.5	0.3	0.3	0.2
03/07/2014	0.4	0.5	0.7	0.5	0.2	0.3	0.2
04/07/2014	0.2	0.4	0.5	0.4	0.2	0.3	0.2
05/07/2014	0.0	0.3	0.2	0.3	0.1	0.1	0.2
06/07/2014	2.4	0.2	0.0	0.3	0.1	0.0	0.1
07/07/2014	8.1	0.3	0.2	0.4	0.1	0.1	0.2
08/07/2014	8.6	0.3	0.5	0.4	0.2	0.2	0.2
09/07/2014	0.0	0.3	0.6	0.4	0.2	0.3	0.2
10/07/2014	0.0	0.2	0.3	0.3	0.1	0.2	0.2
11/07/2014	0.0	0.2	0.0	0.3	0.1	0.0	0.1
12/07/2014	0.0	0.2	0.0	0.2	0.1	0.0	0.1
13/07/2014	10.6	0.1	0.0	0.3	0.1	0.0	0.1
14/07/2014	0.0	0.0	0.0	0.3	0.0	0.0	0.2
15/07/2014	2.8	0.0	0.0	0.3	0.0	0.0	0.1
16/07/2014	0.4	0.1	0.1	0.2	0.0	0.0	0.1
17/07/2014	0.0	0.1	0.0	0.2	0.0	0.0	0.1
18/07/2014	0.0	0.1	0.0	0.2	0.0	0.0	0.1
19/07/2014	0.0	0.1	0.0	0.2	0.0	0.0	0.1
20/07/2014	0.4	0.1	0.0	0.2	0.0	0.0	0.1
21/07/2014	0.0	0.1	0.0	0.1	0.1	0.0	0.1
22/07/2014	0.0	0.1	0.0	0.1	0.0	0.0	0.1
23/07/2014	0.0	0.1	0.0	0.1	0.0	0.0	0.0
24/07/2014	0.0	0.1	0.0	0.1	0.0	0.0	0.0
25/07/2014	0.0	0.1	0.0	0.0	0.0	0.0	0.0
26/07/2014	1.7	0.0	0.0	0.0	0.0	0.0	0.0
27/07/2014	10.7	0.1	0.0	0.1	0.0	0.0	0.0
28/07/2014	0.1	0.1	0.0	0.1	0.0	0.0	0.1
29/07/2014	0.0	0.1	0.0	0.1	0.0	0.0	0.1
30/07/2014	8.4	0.1	0.0	0.1	0.0	0.0	0.0
31/07/2014	0.2	0.1	0.0	0.1	0.0	0.0	0.1

NOVATECH
Engineers, Planners & Landscape Architects

Daily Summaries of Continuous Streamflow Monitoring Data

Date	Total Daily Rainfall (mm)	Total Daily Streamflow (mm)			Total Daily Baseflow (mm)		
		Tributary 2	Tributary 3	Tributaries 2&3	Tributary 2	Tributary 3	Tributaries 2&3
01/08/2014	0.0	0.1	0.0	0.1	0.0	0.0	0.0
02/08/2014	0.0	0.1	0.0	0.0	0.0	0.0	0.0
03/08/2014	0.0	0.0	0.0	0.0	0.0	0.0	0.0
04/08/2014	3.8	0.1	0.0	0.0	0.0	0.0	0.0
05/08/2014	1.0	0.1	0.0	0.0	0.0	0.0	0.0
06/08/2014	0.0	0.1	0.0	0.0	0.0	0.0	0.0
07/08/2014	0.1	0.0	0.0	0.0	0.0	0.0	0.0
08/08/2014	0.0	0.0	0.0	0.0	0.0	0.0	0.0
09/08/2014	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10/08/2014	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11/08/2014	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12/08/2014	36.0	0.1	0.0	0.0	0.0	0.0	0.0
13/08/2014	8.5	0.1	0.0	0.1	0.1	0.0	0.0
14/08/2014	0.6	0.1	0.0	0.0	0.1	0.0	0.0
15/08/2014	0.3	0.1	0.0	0.0	0.0	0.0	0.0
16/08/2014	8.2	0.1	0.0	0.0	0.0	0.0	0.0
17/08/2014	0.6	0.1	0.0	0.0	0.1	0.0	0.0
18/08/2014	0.1	0.1	0.0	0.0	0.1	0.0	0.0
19/08/2014	0.0	0.1	0.0	0.0	0.0	0.0	0.0
20/08/2014	8.7	0.1	0.0	0.0	0.0	0.0	0.0
21/08/2014	18.5	0.1	0.0	0.1	0.1	0.0	0.0
22/08/2014	0.0	0.1	0.0	0.1	0.1	0.0	0.0
23/08/2014	0.0	0.1	0.0	0.1	0.1	0.0	0.0
24/08/2014	0.0	0.1	0.0	0.0	0.1	0.0	0.0
25/08/2014	0.0	0.1	0.0	0.0	0.1	0.0	0.0
26/08/2014	0.0	0.1	0.0	0.0	0.0	0.0	0.0
27/08/2014	0.0	0.1	0.0	0.0	0.0	0.0	0.0
28/08/2014	0.0	0.1	0.0	0.0	0.0	0.0	0.0
29/08/2014	0.0	0.1	0.0	0.0	0.0	0.0	0.0
30/08/2014	0.2	0.1	0.0	0.0	0.0	0.0	0.0
31/08/2014	10.2	0.1	0.0	0.0	0.0	0.0	0.0
01/09/2014	0.2	0.1	0.0	0.0	0.0	0.0	0.0
02/09/2014	7.5	0.1	0.0	0.0	0.1	0.0	0.0
03/09/2014	0.3	0.1	0.0	0.0	0.1	0.0	0.0
04/09/2014	0.7	0.1	0.0	0.0	0.0	0.0	0.0
05/09/2014	21.5	0.1	0.0	0.1	0.1	0.0	0.0
06/09/2014	11.1	0.1	0.0	0.1	0.1	0.0	0.1
07/09/2014	0.0	0.1	0.0	0.1	0.1	0.0	0.0
08/09/2014	0.0	0.1	0.0	0.0	0.1	0.0	0.0
09/09/2014	0.0	0.1	0.0	0.0	0.1	0.0	0.0
10/09/2014	1.6	0.1	0.0	0.0	0.1	0.0	0.0
11/09/2014	4.0	0.1	0.0	0.1	0.1	0.0	0.0
12/09/2014	0.0	0.1	0.0	0.1	0.1	0.0	0.0
13/09/2014	15.7	0.2	0.0	0.1	0.1	0.0	0.0
14/09/2014	0.0	0.2	0.0	0.1	0.1	0.0	0.1
15/09/2014	3.3	0.2	0.0	0.1	0.1	0.0	0.1
16/09/2014	0.2	0.2	0.0	0.1	0.1	0.0	0.1
17/09/2014	6.5	0.2	0.0	0.1	0.1	0.0	0.0
18/09/2014	0.1	0.2	0.0	0.1	0.1	0.0	0.1
19/09/2014	0.0	0.2	0.0	0.1	0.1	0.0	0.0
20/09/2014	6.0	0.2	0.0	0.1	0.1	0.0	0.1
21/09/2014	14.3	0.3	0.1	0.3	0.1	0.0	0.1
22/09/2014	0.0	0.2	1.0	0.3	0.1	0.5	0.2
23/09/2014	0.0	0.2	0.0	0.2	0.1	0.1	0.1
24/09/2014	0.0	0.2	0.0	0.2	0.1	0.0	0.1
25/09/2014	0.0	0.2	0.0	0.2	0.1	0.0	0.1
26/09/2014	0.0	0.3	0.0	0.2	0.1	0.0	0.1
27/09/2014	0.0	0.2	0.0	0.1	0.1	0.0	0.1
28/09/2014	0.0	0.2	0.0	0.1	0.1	0.0	0.1
29/09/2014	0.0	0.2	0.0	0.1	0.1	0.0	0.1
30/09/2014	0.0	0.2	0.0	0.1	0.1	0.0	0.1

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Date	Total Daily Rainfall (mm)	Total Daily Streamflow (mm)			Total Daily Baseflow (mm)		
		Tributary 2	Tributary 3	Tributaries 2&3	Tributary 2	Tributary 3	Tributaries 2&3
01/10/2014	0.0	0.2	0.0	0.1	0.1	0.0	0.1
02/10/2014	0.0	0.2	0.0	0.1	0.1	0.0	0.1
03/10/2014	0.0	0.1	0.0	0.1	0.1	0.0	0.1
04/10/2014	4.2	0.2	0.0	0.1	0.1	0.0	0.0
05/10/2014	0.0	0.2	0.0	0.1	0.1	0.0	0.1
06/10/2014	1.1	0.2	0.0	0.2	0.1	0.0	0.1
07/10/2014	6.9	0.2	0.0	0.2	0.1	0.0	0.1
08/10/2014	10.8	0.2	0.0	0.3	0.1	0.0	0.1
09/10/2014	1.9	0.2	0.0	0.2	0.1	0.0	0.1
10/10/2014	0.0	0.2	0.0	0.2	0.1	0.0	0.1
11/10/2014	0.0	0.2	0.0	0.3	0.1	0.0	0.1
12/10/2014	0.1	0.3	0.0	0.3	0.1	0.0	0.1
13/10/2014	0.1	0.2	0.0	0.2	0.1	0.0	0.1
14/10/2014	0.0	0.2	0.0	0.2	0.1	0.0	0.1
15/10/2014	4.2	0.2	0.0	0.2	0.1	0.0	0.1
16/10/2014	11.8	0.3	0.5	0.4	0.1	0.1	0.1
17/10/2014	2.0	0.4	1.8	0.5	0.2	0.8	0.3
18/10/2014	0.7	0.4	1.1	0.6	0.2	0.7	0.3
19/10/2014	0.0	0.3	0.0	0.5	0.2	0.1	0.3
20/10/2014	3.9	0.3	0.0	0.5	0.2	0.0	0.3
21/10/2014	8.3	0.5	0.6	0.8	0.2	0.2	0.3
22/10/2014	0.0	0.7	0.7	1.0	0.4	0.4	0.5
23/10/2014	0.0	0.5	0.2	0.7	0.3	0.1	0.4
24/10/2014	0.0	0.4	0.0	0.7	0.2	0.0	0.4
25/10/2014	9.5	0.4	0.0	0.6	0.2	0.0	0.3
26/10/2014	0.2	0.5	0.6	0.9	0.3	0.2	0.4
27/10/2014	3.0	0.5	0.2	0.8	0.3	0.1	0.4
28/10/2014	3.4	0.5	0.1	0.8	0.2	0.0	0.4
29/10/2014	0.2	0.5	0.2	0.8	0.3	0.1	0.4
30/10/2014	0.0	0.5	0.0	0.7	0.2	0.0	0.4
31/10/2014	0.0	0.4	0.0	0.6	0.2	0.0	0.3
01/11/2014	0.0	0.4	0.0	0.5	0.2	0.0	0.3
02/11/2014	0.0	0.3	0.0	0.5	0.2	0.0	0.3
03/11/2014	0.0	0.3	0.0	0.5	0.2	0.0	0.2
04/11/2014	4.9	0.3	0.0	0.5	0.2	0.0	0.2
05/11/2014	0.2	0.4	0.0	0.6	0.2	0.0	0.3
06/11/2014	1.9	0.6	0.0	0.5	0.2	0.0	0.3
07/11/2014	1.7	0.7	0.0	0.5	0.3	0.0	0.3
08/11/2014	0.7	0.6	0.0	0.5	0.3	0.0	0.2
09/11/2014	0.3	0.6	0.0	0.5	0.3	0.0	0.2
10/11/2014	0.3	0.6	0.0	0.4	0.3	0.0	0.2
11/11/2014	0.0	0.6	0.0	0.4	0.3	0.0	0.2
12/11/2014	3.1	0.6	0.0	0.5	0.3	0.0	0.2
13/11/2014	0.0	0.6	0.0	0.5	0.3	0.0	0.2
14/11/2014	0.0	0.6	0.0	0.4	0.3	0.0	0.2
15/11/2014	0.0	0.5	0.0	0.4	0.3	0.0	0.2
16/11/2014	0.0	0.6	0.0	0.5	0.3	0.0	0.2
17/11/2014	7.4	0.6	0.0	0.5	0.3	0.0	0.2
18/11/2014	0.2	0.6	0.0	0.5	0.3	0.0	0.2
19/11/2014	0.2	0.5	0.0	0.5	0.3	0.0	0.2
20/11/2014	0.0	0.5	0.0	0.4	0.3	0.0	0.2
21/11/2014	0.0	0.5	0.0	0.4	0.3	0.0	0.2
22/11/2014	2.0	0.5	0.0	0.6	0.3	0.0	0.3
23/11/2014	13.4	0.7	0.2	0.7	0.3	0.1	0.3
24/11/2014	1.0	2.2	1.6	2.1	0.9	0.6	0.9
25/11/2014	0.0	2.4	1.2	1.7	1.3	0.7	1.0
26/11/2014	0.0	1.8	0.8	1.2	1.0	0.4	0.6
27/11/2014	0.0	1.6	0.5	1.0	0.8	0.3	0.5
28/11/2014	0.0	1.3	0.2	0.8	0.7	0.2	0.4
29/11/2014	0.0	1.1	0.1	0.8	0.6	0.1	0.4
30/11/2014	0.2	1.2	0.2	0.7	0.6	0.1	0.4

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		Tributary 2	Tributary 3	Tributaries 2&3	Tributary 2	Tributary 3	Tributaries 2&3
01/12/2014	0.0	1.2	0.2	0.7	0.6	0.1	0.4
02/12/2014	3.0	0.9	0.0	0.9	0.5	0.0	0.4
03/12/2014	2.6	1.0	0.0	0.7	0.5	0.0	0.4
04/12/2014	0.0	0.9	0.0	0.6	0.5	0.0	0.3
05/12/2014	0.0	0.8	0.0	0.8	0.4	0.0	0.4
06/12/2014	0.0	0.9	0.0	0.7	0.4	0.0	0.4
07/12/2014	0.0	0.7	0.0	0.7	0.4	0.0	0.3
08/12/2014	0.0	0.6	0.0	1.1	0.3	0.0	0.5
09/12/2014	0.2	0.9	0.0	1.1	0.4	0.0	0.5
10/12/2014	11.1	0.9	0.0	1.1	0.5	0.0	0.6
11/12/2014	0.8	0.9	0.0	0.8	0.4	0.0	0.4
12/12/2014	0.4	0.8	0.0	0.7	0.4	0.0	0.4
13/12/2014	0.2	0.7	0.6	0.6	0.4	0.3	0.3
14/12/2014	0.0	0.8	0.0	0.5	0.4	0.0	0.3
15/12/2014	0.0	0.8	0.0	0.5	0.4	0.0	0.2
16/12/2014	6.0	0.8	0.0	0.5	0.4	0.0	0.2
17/12/2014	8.5	0.9	0.2	0.6	0.4	0.0	0.3
18/12/2014	0.0	1.0	0.2	0.7	0.5	0.1	0.3
19/12/2014	0.0	1.1	0.2	0.9	0.5	0.1	0.4
20/12/2014	0.0	1.1	0.2	0.8	0.6	0.1	0.4
21/12/2014	0.0	1.0	0.3	0.9	0.5	0.1	0.4
22/12/2014	0.7	1.0	0.2	1.0	0.5	0.1	0.5
23/12/2014	1.0	1.1	0.1	1.1	0.5	0.1	0.5
24/12/2014	4.9	1.3	0.9	1.1	0.6	0.3	0.5
25/12/2014	0.2	3.5	2.4	2.5	1.4	1.0	1.0
26/12/2014	0.0	3.6	2.3	2.2	1.9	1.2	1.2
27/12/2014	2.5	3.3	2.0	1.9	1.7	1.0	1.0
28/12/2014	0.0	3.4	2.3	2.0	1.7	1.2	1.0
29/12/2014	0.0	2.7	1.1	1.6	1.4	0.7	0.8
30/12/2014	0.0	1.9	0.6	2.2	1.0	0.4	1.2
31/12/2014	0.0	1.6	0.4	1.1	0.8	0.2	0.6