Greenbank Road Watermain Municipal Class Environmental Assessment Summary Report

Prepared For:

Ottawa

Prepared By:

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Consulting Engineers

Project No.15054
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EXECUTIVE SUMMARY

A. Project Background

The City of Ottawa (City) identified the need for a new 610 mm diameter watermain on Greenbank Road from Market Place to south of the Jock River. The requirement for a new watermain was identified in the *2013 City of Ottawa Infrastructure Master Plan* as a necessary link to improve water supply and reliability in the Barrhaven South Development Area. In 2006 the City completed the *Greenbank Road Class EA Environmental Study Report* that recommended Greenbank road be widened and realigned from Strandherd Drive to Cambrian Road, included is a new bridge structure over the Jock River. The proposed planning and construction for the 610 mm diameter transmission watermain will be closely coordinated with the Greenbank Road widening project.

Figure A1: Project Study Area

B. Problem/Opportunity Statement

Robinson Consultants Inc. (RCI) was retained by the City of Ottawa to complete phases 1 and 2 of the Municipal Class Environmental Assessment (MCEA) process and a Functional Design of the preferred alternative. The proposed alignment for the new watermain will require crossing the Jock River, in conjunction with the new bridge construction. For this assignment, trenchless construction strategies and traditional open-cut methods were investigated.

C. MCEA Planning Schedule

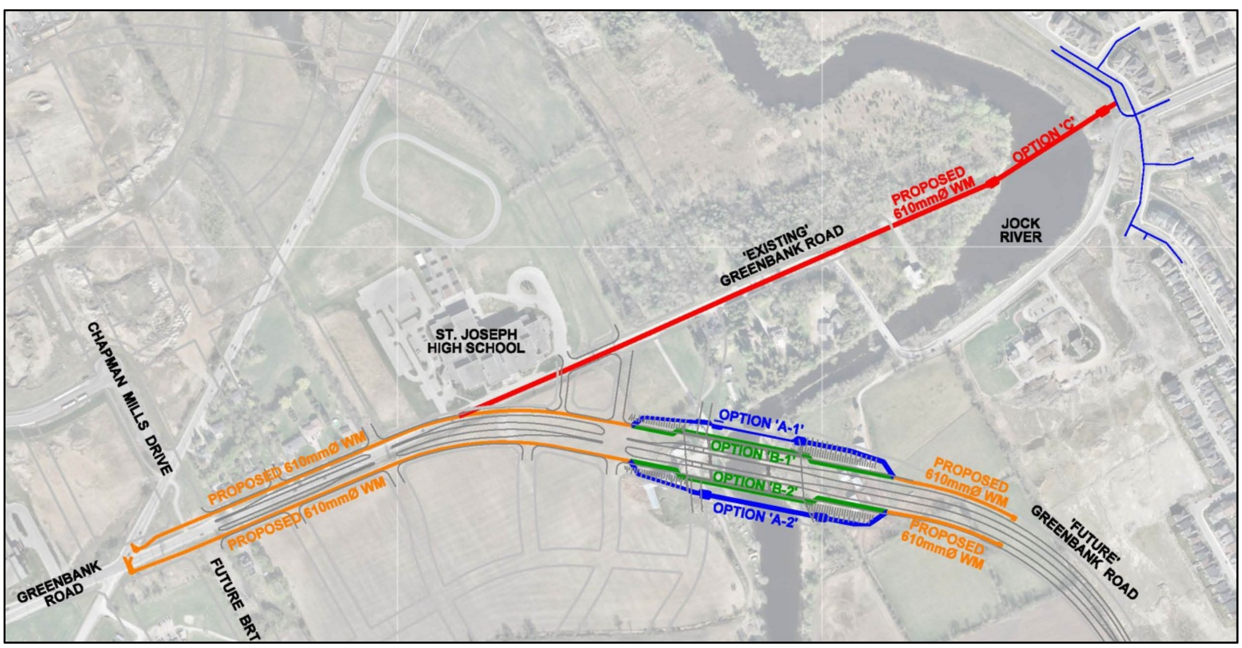
This assignment was initiated based on the potential for the requirement of a Schedule 'B' Municipal Class Environmental Assessment (MCEA). A Notice of Study Commencement was issued and a formal public consultation process initiated. The evaluation of alternative solutions for a new watermain crossing the Jock River included trenchless technologies as well as open-cut construction techniques. The result of selecting a trenchless technology as the preferred alternative was that the project could proceed based on Schedule A+ of the MCEA process. If a trenchless technology had not been feasible or additional property acquisition was required, the project would have proceeded based on Schedule B of the MCEA process. Proceeding on a Scheduled A+ basis would allow this project to proceed directly to the functional design stage.

D. Watermain Alignment Options

The long list of watermain alternatives was screened and alternatives that did not meet the basic requirements were eliminated. Figure D1 is a graphical representation of each trenchless, bridge and open-cut watermain crossing alternative. The trenchless and open cut alternatives were located on each side of the bridge and along the existing Greenbank Road alignment. The bridge alternative alignments were located on either side of the bridge.

1. Open Cut Construction: Alignment Alternatives A-1, A-2 and C.
2. Trenchless Alignment Alternatives A-1, A-2 and C.
3. Bridge: Alternatives B-1 and B-2.

Figure D1: Jock River Crossing Alignment Options



E. Jock River Crossing Alternatives

Alternatives for crossing the Jock River were developed utilizing trenchless technologies and open-cut construction methods. They include:

1. Open-cut Construction

2. Trenchless River Crossing, including:
    a. Horizontal Directional Drilling (HDD)
    b. Micro-tunnelling
    c. Pipe Jacking and Horizontal Auger Boring
    d. Pipe Ramming
    e. TBM Tunnelling
    f. Horizontal Rock Bore
3. Pipeline Crossing on Bridge

F. Public Consultation

During the course of the study, a variety of communications and consultation methods were undertaken to engage the project stakeholders. The stakeholders included various City of Ottawa business units, external government review agencies, the Rideau Valley Conservation Authority, adjacent property owners, and interested members of the public. Steps were taken to inform these stakeholders study, obtain their input, and address comments and concerns that arose through the process. The majority of stakeholders, including the public, strongly supported the selected alignment and the use of trenchless methods to cross the Jock River.

G. Preferred Alternative

Based on the completed evaluation, the preferred alternative for the 610 mm diameter watermain crossing of the Jock River is along Alignment A1 using horizontal directional drilling (HDD). Crossing the Jock River by open-cut methods would be very challenging due to significant concerns about constructability, impacts to the natural environment and the potential for schedule and cost overruns. Although micro-tunnelling was not selected as the preferred alternative, it is considered feasible, but would require a full assessment of the challenges involved with the shaft construction.

H. Summary

As a result of selecting a trenchless technology along Alignment A1, as the preferred alternative the construction of the 610 mm diameter watermain from Market Place to the south side of the Jock River could proceed as a MCEA Schedule ‘A+’ process if the detail design and construction of this watermain would be integrated within the overall Greenbank Road Widening and Realignment project. However, if the Greenbank watermain (or parts of it) would need to constructed ahead of Greenbank Road widening and the new bridge over the Jock River construction, there would be a requirement to acquire right-of-way and construction easements for the 600 mm dia. watermain. For this reason the Greenbank watermain project is going to be completed as a Schedule ‘B’ process. Report to Planning Committee and Council will be prepared to approve issuing Class EA Study Notice of Completion for a 30 day public review period. If there are no objections to the Greenbank Watermain Class EA the project functional design report will be finalized and project will be ready for the detailed design and construction phase. The trenchless crossing of the Jock River by means of horizontal directional drilling (HDD) will require additional field investigations, including a detailed borehole drilling program, updated river bathymetry and a risk assessment of the HDD methodology. Class C capital cost estimate for this project is $11.3 million.

TABLE OF CONTENTS

Executive Summary ..... **I**
A. Project Background I
B. Problem/Opportunity Statement I
C. MCEA Planning Schedule II
D. Watermain Alignment Options II
E. Jock River Crossing Alternatives II
F. Public Consultation III
G. Preferred Alternative III
H. Summary III

1.0 Introduction **1**
1.1 Study Scope and Objectives 1
1.2 Study Team Organization 1
1.3 Report Organization 1
1.4 MCEA Planning Process 2
1.4.1 Overview 2
1.4.2 Mandatory Principals 3
1.4.3 Project Classification 3

2.0 Identification and description of the problems and opportunities **5**
2.1 Problem/Opportunity Statement 5

3.0 Communications and Consulting Program **5**
3.1 Technical Advisory Committee Meetings 6
3.2 Public and Stakeholder Communication Plan 6
3.3 Public Open House 6
3.4 Web based Consultation 6
3.5 Consultation Summary 7

4.0 Development of Alternative Solutions **7**
4.1 Long List of Alternatives 7
4.2 Jock River Crossing Alternatives 8
4.2.1 Open-Cut Construction 8
4.2.2 Trenchless River Crossing 10
4.2.3 Pipeline Crossing of Bridge 18

5.0 Study Area Features and Considerations **19**
5.1 Study Area 20
5.2 Greenbank Road Realignment 20
5.3 City of Ottawa Water Distribution System 21
5.4 Existing Land Use 23
5.5 Future Land Use and Infrastructure Projects 23
5.6 Geotechnical Overview 25
5.6.1 Site and Subsurface Conditions 25

5.7 Natural Environment Constraints 25
5.7.1 Methods 25
5.7.2 Background Review 25
5.7.3 Field Surveys 26
5.7.4 Species at Risk Screening 27

6.0 Study contraints and opportunities 27
6.1 Technical Constraints 27
6.2 Social Environment 28
6.3 Natural Environment Constraints 28
6.4 Physical Constraints 28
6.5 Costs 28

7.0 Assesment of Jock River Crossing Alternatives 29
7.1 Supporting Technical Studies 29
7.2 Short List of Alternatives 29
7.2.1 Coarse Screening Discussion 30
7.2.2 Summary of Coarse Screening 31
7.2.3 Watermain Alignment Options 31
7.3 Evaluation of Jock River Crossing Alternatives 31
7.4 Evaluation Discussion 32
7.4.1 Technical Performance 32
7.4.2 Social Environment 32
7.4.3 Natural Environment and Heritage 33
7.4.4 Physical Constraints 33
7.4.5 Comparative Costs 35

8.0 Prefered Alternative 35
8.1 Municipal Class Environmental Assessment (MCEA) 35

9.0 Recommendations for further study 36

LIST OF FIGURES

Figure 1: MCEA Phase Flowchart 3
Figure 2: Web Based Consultation Website 7
Figure 3: Long List of Alternatives 8
Figure 4: Open-Cut Construction using Cofferdams 9
Figure 5: Auger Boring 11
Figure 6: Pipe Ramming 12
Figure 7: Micro-tunnelling 13
Figure 8: Horizontal Directional Drilling 14
Figure 9: TBM Tunnelling 15
Figure 10: Horizontal Rock Bore 15
Figure 11: Watermain on Bridge 19
Figure 12: Study Area 20
Figure 13: Greenbank Road Recommended Plan 21

Figure 14: Existing Watermain Layout 22
Figure 15: Proposed Barrhaven South Pipe Layout 23
Figure 16: Nepean Town Centre Land Use Plan 24
Figure 17: Barrhaven South Land Use Plan 24
Figure 18: Long List of Alternatives 29

LIST OF TABLES

Table 1: Study Team Organization 1
Table 2: Coarse Screening Summary 31
Table 3: Evaluation Criteria Weighting 32

LIST OF APPENDICES

Appendix A Technical Advisory Committee Presentations
Appendix B Communications Plan
Appendix C Public and Stakeholders Consultation
Appendix D Long List of Alternatives
Appendix E Geotechnical Overview Report
Appendix F Natural Environment Constraints Report
Appendix G Bridge Assessment Report
Appendix H Alignment Options – Short List of Alternatives
Appendix I Proposed Claridge Subdivision
Appendix J Evaluation Table
Appendix K Comparative Cost Table
Appendix L Preferred Alternative

1.0 INTRODUCTION

1.1 Study Scope and Objectives

The City of Ottawa (City) has identified the need for a new 610 mm diameter watermain on Greenbank Road from Market Place to the south side of the Jock River. The requirement for this new watermain was identified in the 2013 City of Ottawa Infrastructure Master Plan as a necessary link to improve water supply and reliability in the Barrhaven South development area. In 2006 the City completed the Greenbank Road Municipal Class Environmental Assessment (MCEA) and Environmental Study Report, with the recommendation to widen and realign Greenbank Road from Strandherd Drive to Cambrian Road, including a new bridge structure over the Jock River. The proposed planning and construction for the 610 mm diameter transmission watermain is to be closely coordinated with the Greenbank Road widening project.

Responding to development pressures in the Nepean Town Centre Development Area the Greenbank Road watermain planning will allow for one or more watermain sections to be constructed in coordination with development north of the Jock River in advance of the road project.

Robinson Consultants Inc. (RCI) was retained by the City to complete phases 1 and 2 of the MCEA process and a Functional Design of the preferred alternative. The proposed alignment for the new watermain will require crossing the Jock River, in conjunction with the new bridge construction.

1.2 Study Team Organization

This MCEA study was completed as a collaborative effort between the City of Ottawa and RCI. The City's representatives provided general direction during meetings at key points throughout the planning process. **Table 1** outlines key people from each of the City of Ottawa and Robinson Consultants.

Table 1: Study Team Organization

City of Ottawa		Robinson Consultants	
Joseph Zagorski, P.Eng.	Senior Engineer	Patrick Leblanc, P.Eng.	Project Manager
		Derek Potvin, P.Eng.	Trenchless Design Lead

1.3 Report Organization

This report was prepared to meet the requirements of the Ontario Municipal Engineers Association (MEA) MCEA planning process. The report documents all phases of the planning process and incorporates the steps required for compliance with the Environmental Assessment Act (EAA) in the following Sections:

- **Section 1** provides background information about the initiation of the study, provides an outline of the formatting of the report and describes the study purpose and team organization, as well as a summary of the MCEA process;
- **Section 2** identifies and describes the problems and opportunities that will be addressed in this MCEA study;
- **Section 3** provides an overview of the communications and consultation program followed during the planning process;

- **Section 4** describes the development of alternative solutions.
- **Section 5** describes the environmental conditions of the study area that are considered during the planning process of this study. The section includes a description of the study area, the physical constraints, the social environment, the natural environment and the operations and maintenance factors that will be used to evaluate the alternate solutions.
- **Section 6** provides the study constraints and opportunities;
- **Section 7** provides an evaluation of alternative solutions;
- **Section 8** identifies the preferred alternative; and,
- **Section 9** Provides recommendations for future study.

1.4 MCEA Planning Process

1.4.1 Overview

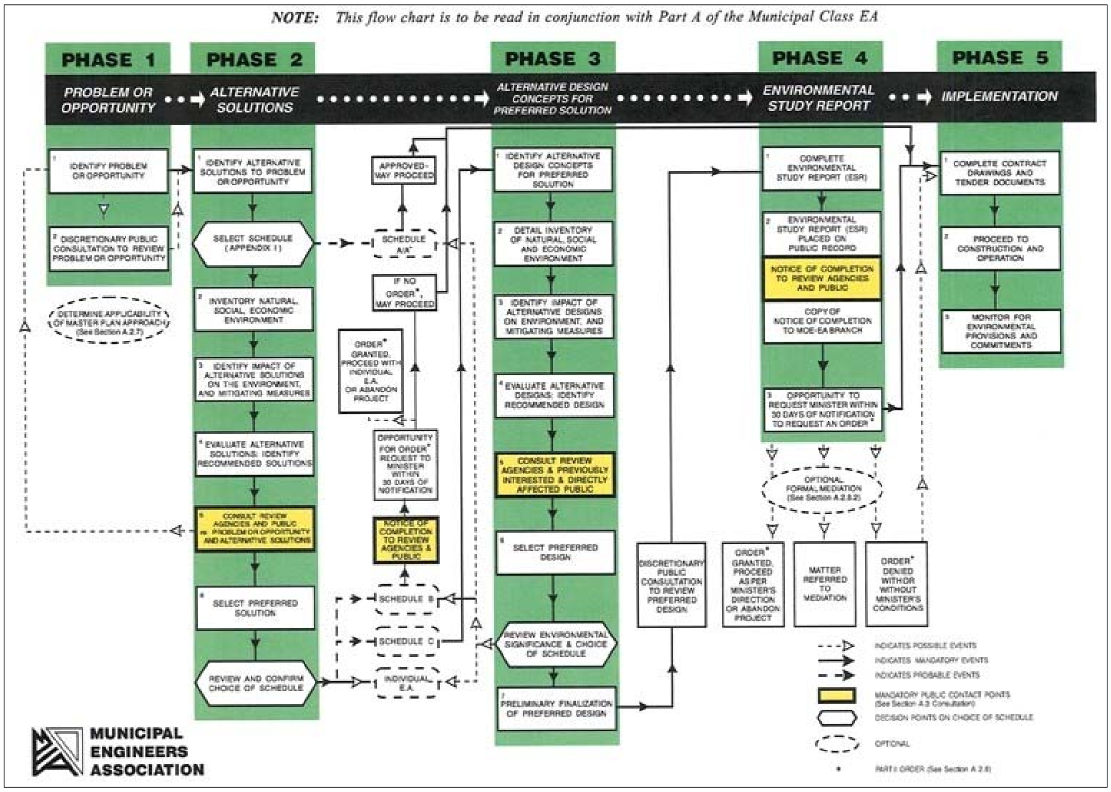
Ontario municipalities are subject to the Environmental Assessment Act and the requirements it sets forth to prepare an Environmental Assessment for applicable public works projects. A five phase planning procedure is prescribed by the Ontario MCEA document (October 2011, as amended in 2015) for municipalities, approved under condition 3 by the Environmental Assessment Act. The phased approach is to be conducted for all municipal sewage, water, stormwater management and transportation undertakings that occur regularly are usually limited in scale and have a predictable range of environmental impacts and applicable mitigation measures.

The MCEA consists of five phases which are summarized below;

- **Phase 1 – Problem or Opportunity:** Identify the problem or opportunity to be addressed and the needs.
- **Phase 2 – Alternative Solutions:** Develop and identify alternative solutions to the problem or opportunity identified. The alternative solutions should take into consideration the existing environment and establishes the preferred solution by taking into account public and review agency input.
- **Phase 3 – Alternative Design Concepts for the Preferred Solution:** Examine alternative methods of implementation of the preferred solution, based upon the existing environment, public comment and review agency input.
- **Phase 4 – Environmental Study Report:** Document, in an Environmental Study Report the rationale, planning, design and consultation process of the project that was established in previous phases. The Environmental Study Report is made available to the public for scrutiny.
- **Phase 5 – Implementation:** Complete the contract drawings and documents, proceed to construction and operation. Monitor construction and ensure adherence to environmental provisions. When special conditions dictate, monitor the operation of the completed facilities.

Figure 1 shows the flow chart of MCEA process.

Figure 1: MCEA Phase Flowchart



1.4.2 Mandatory Principals

The planning process followed adheres to the guidelines set out by the MCEA document and reflects the five mandatory principles of the Class EA planning under the EAA:

- Consultation of the affected parties early in the planning process, such that the process is cooperative in nature;
- Consideration of a reasonable range of potential alternatives;
- Identification and consideration of the impacts of each alternative of all aspects of the environment;
- Follows a systematic evaluation of each alternative considering the advantages and disadvantages in determining the net environmental effects;
- Provide clear and complete documentation of the planning process, to allow for "traceability" of the decision making process with respect to the project; and,
- Adherence to the five mandatory principles of the Class EA the process ensures that problems and environmental damage is prevented. This is accomplished through a planning and decision making process that has researched and evaluated the possible impacts prior to implementation.

1.4.3 Project Classification

The MCEA document has defined four types of projects and the planning processes required for each type. The different types of projects are referred to as Schedule A, A+, B and C. The Greenbank Road Watermain project completed under the MCEA planning process as a Schedule B.

If the evaluation of alternatives for the crossing of the Jock River was to find that a trenchless crossing method (including bridge crossing) is viable, the project proceed as a Schedule A+ and move directly to the functional design.

The selection of the appropriate project planning schedule is dependent on the anticipated level of environmental impact and for some projects, the anticipated construction costs. The planning methodology employed varies based on the class type as described within the MCEA document. The planning methodologies are described as follows:

Schedule A: Projects are limited in scale, have minimal adverse environmental effects and include a number of municipal maintenance and operational activities. These projects are pre-approved and may proceed to implementation with following the Class EA planning process. Schedule A projects generally include normal or emergency operational maintenance activities where the environmental effects of these activities are usually minimal. Examples of Schedule A projects include watermain repairs, reconstruction or installation of new service connections or hydrants from existing watermains. Schedule A projects are pre-approved and consequently do not require any further planning and public consultation.

Schedule A+: The purpose of Schedule A+ is to ensure some type of public notification or certain projects that are pre-approved under the MCEA. The proponent is required to inform the affected public of municipal infrastructure projects prior to being constructed or implemented. However, there is no ability for the public to request a Part II Order. Examples of Schedule A+ projects include watermain or sewer extensions where all such facilities are located within an existing municipal road allowance or utility corridor, or where there are pipe water crossings based on the use of trenchless technology.

Schedule B: These projects have the potential for some adverse environmental effects. The proponent is required to undertake a screening process involving mandatory contact with directly affected public and with relevant government agencies to ensure they are aware of the project and that their concerns are addressed. If there are no outstanding concerns, the project may proceed to implementation. Schedule B projects generally include improvements and minor expansions to existing facilities. Examples include watermain extensions where such facilities are located outside of an existing municipal road allowance or utility corridor or involve water crossings by non-trenchless methods (e.g., open cut). As a result, the proponent is required to proceed through a screening process (Phases 1 and 2 of the MCEA process), including consultation with those who may be affected.

At the end of Phase 2, a Project File documenting the planning process followed through Phases 1 and 2 is finalized and made available for public and agency review. If the screening process raises a concern which cannot be resolved, a Part II Order may be requested and considered by the Minister of Environment. Alternatively, the proponent may elect to voluntarily plan the project as a Schedule C undertaking.

Schedule C: These projects have the potential for significant adverse environmental effects and must proceed under the full planning and documentation procedures (Phases 1 to 4) specified in the MCEA document. Schedule C projects require that an Environmental Study Report (ESR) be prepared and filed for review by the public and review agencies. If concerns are raised that cannot be resolved, a Part II Order may be requested. Schedule C projects typically include the construction of new facilities and major expansions to existing facilities, such as water or wastewater treatment plants.

2.0 IDENTIFICATION AND DESCRIPTION OF THE PROBLEMS AND OPPORTUNITIES

Phase 1 of the five-phase MCEA planning process requires the proponent of an project (e.g. the City of Ottawa) to first document factors leading to the conclusion that the improvement is needed and develop a clear statement of the identified problems or opportunities to be investigated. As such, the *Problem/Opportunity Statement* is the principle starting point in the undertaking of a MCEA and becomes the central theme and integrating element of the project. It also assists in setting the scope of the project.

2.1 Problem/Opportunity Statement

The Problem/Opportunity Statement for the 610 mm diameter Greenbank Road Watermain is as follows:

- Improve the reliability of water supply to the Barrhaven South Development Area by constructing a new 610 mm diameter watermain on the widened and realigned Greenbank Road and crossing the Jock River; and
- Determine the best method of construction for crossing the Jock River. i.e. trenchless technologies versus open-cut construction.

In order to address the above, the City of Ottawa initiated this Class EA planning process to identify and evaluate alternative solutions and design concepts and accordingly address the above problem statement. This Municipal EA has been prepared to determine how to best construct the 610 mm diameter watermain within the future widened and realigned Greenbank Road and the crossing of the Jock River.

3.0 COMMUNICATIONS AND CONSULTING PROGRAM

Several steps have been undertaken to inform the general public, government agencies, affected landowners and the local community as a part of the MCEA planning process.

The Municipal Engineers Association MCEA document specifies mandatory consultation points and methods of contacting identified stakeholders. In order to communicate the project and seek feedback and comment throughout the planning process, the following activities were undertaken.

- Published a Notice of Study Commencement;
- Provided ongoing material related to the study activities in English and French on the City of Ottawa's website (http://ottawa.ca/en/city-hall/public-consultations/greenbank-road-watermain and http://ottawa.ca/fr/hotel-de-ville/consultations-publiques/conduite-deau-principale-du-chemin-greenbank).
- Held informal meetings and presentations with residents, community groups and associations to explore local concerns;
- Held a public open house to present alternatives and seek public feedback for the project;
- Compiled a list of primary stakeholders and responded to questions or concerns as required; and,

- Updating stakeholders with project updates via e-mail; and,
- Published a Notice of Study Completion.

During the planning process a variety of communications and consultation methods were undertaken with the stakeholders of this project. The stakeholders included the City of Ottawa, external government review agencies, the local conservation authority, adjacent property owners and interested members of the public. Steps were taken to proactively inform the identified stakeholders of the Municipal Class Environmental Study being completed, obtain their input and address comments and concerns. A notice of project commencement was published to inform interested parties of the project. The following subsections provide expanded documentation of the communications and consultation activities.

3.1 Technical Advisory Committee Meetings

Two Technical Advisory Committee (TAC) meetings were held during the planning stage of this MCEA with the primary stakeholders for this project. The TAC committee consisted of representatives from various City of Ottawa departments that included: Infrastructure Services, Asset Management, Planning and Growth Management, Environmental Services and Drinking Water Services. In addition, a representative from the Rideau Valley Conservation Authority was present to address any concerns related to the Jock River. During both TAC meetings members provided technical input and guidance on stakeholder needs regarding the development of the various design alternatives. The presentations slides from TAC meetings are located in **Appendix A**.

3.2 Public and Stakeholder Communication Plan

A Communication Plan report was prepared in November 2015 to document the consultation plan to be undertaken as a part of this MCEA study. The report outlines the communication and consultation activities approach the study followed. The communication plan is located in **Appendix B**.

3.3 Public Open House

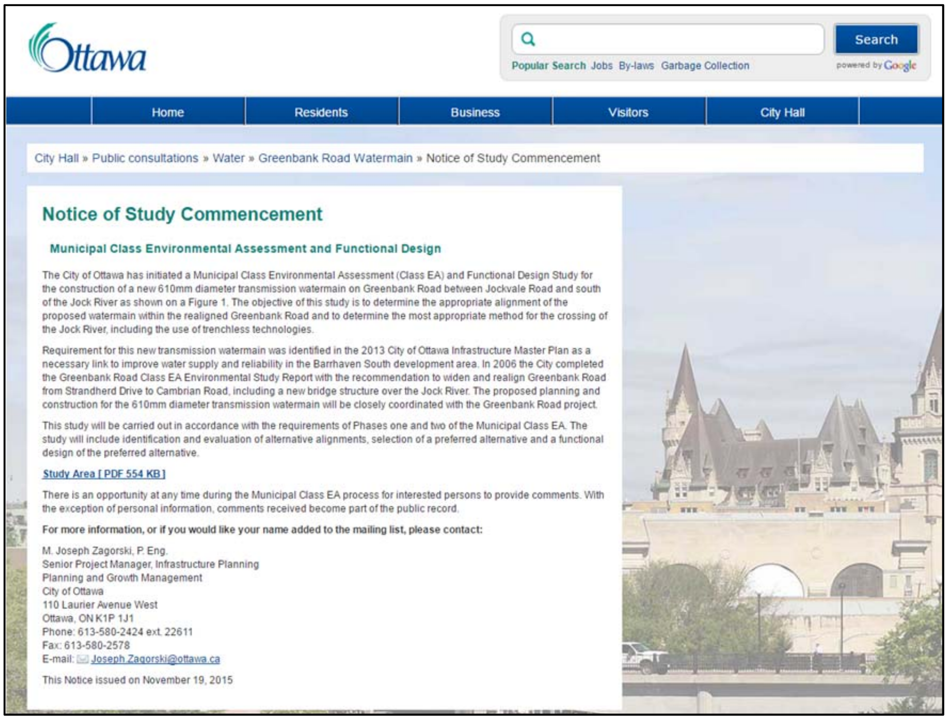
One Public Open House was held on March 21, 2016 at the Walter Baker Sports Complex. The location and crossing method options were presented. An outline of the next steps was also provided. The public was provided an opportunity to comment on the project by filling out a comment sheet or by emailing the City's Project Manager. Display boards from the Public Open House and the Public Open House report are located in **Appendix C**.

3.4 Web based Consultation

Webpages located on the city of Ottawa's website (http://ottawa.ca/en/city-hall/public-consultations/greenbank-road-watermain and http://ottawa.ca/fr/hotel-de-ville/consultations-publiques/conduite-deau-principale-du-chemin-greenbank) were created to provide ongoing material related to the study activities. These websites were the primary source of communication with members of the public. The website provided an opportunity for members of the public to offer feedback on the project. The study website is shown in **Figure 2**.

Project stakeholders were updated about project major steps and recommendations (and provided comments) by direct e-mails to the City project manager.

Figure 2: Web Based Consultation Website



3.5 Consultation Summary

Several steps were taken to proactively engage and inform the general public and interested stakeholders about this MCEA study. Stakeholder comments and concerns were obtained and addressed during the study. Additional comments and concerns are expected to be received as this project progresses through preliminary and detailed design from parties with direct interest in this project. If required, further meetings with concerned stakeholders will be convened to discuss comments, address concerns and resolved issues, if required.

4.0 DEVELOPMENT OF ALTERNATIVE SOLUTIONS

As a part of the Class EA study, the evaluation of alternative watermain crossing locations and routes was reviewed. An initial long list of alternatives was developed for coarse screening, with a short list of alternatives moved forward for a detailed evaluation.

4.1 Long List of Alternatives

The development of the long list of alternatives included various alignment options for each distinct section of the watermain. Alignment options were developed based on the widened and realigned Greenbank Road and an option to utilize existing Greenbank Road to Half Moon Bay Drive. The study area can be broken up into discrete sections that have unique characteristics, including:

Widened and Realigned Greenbank Road

- Open-cut section from Market Place to the alignment shift;
- Open-cut section from the alignment shift to the Jock River;
- Crossing of the Jock River (open-cut or trenchless);

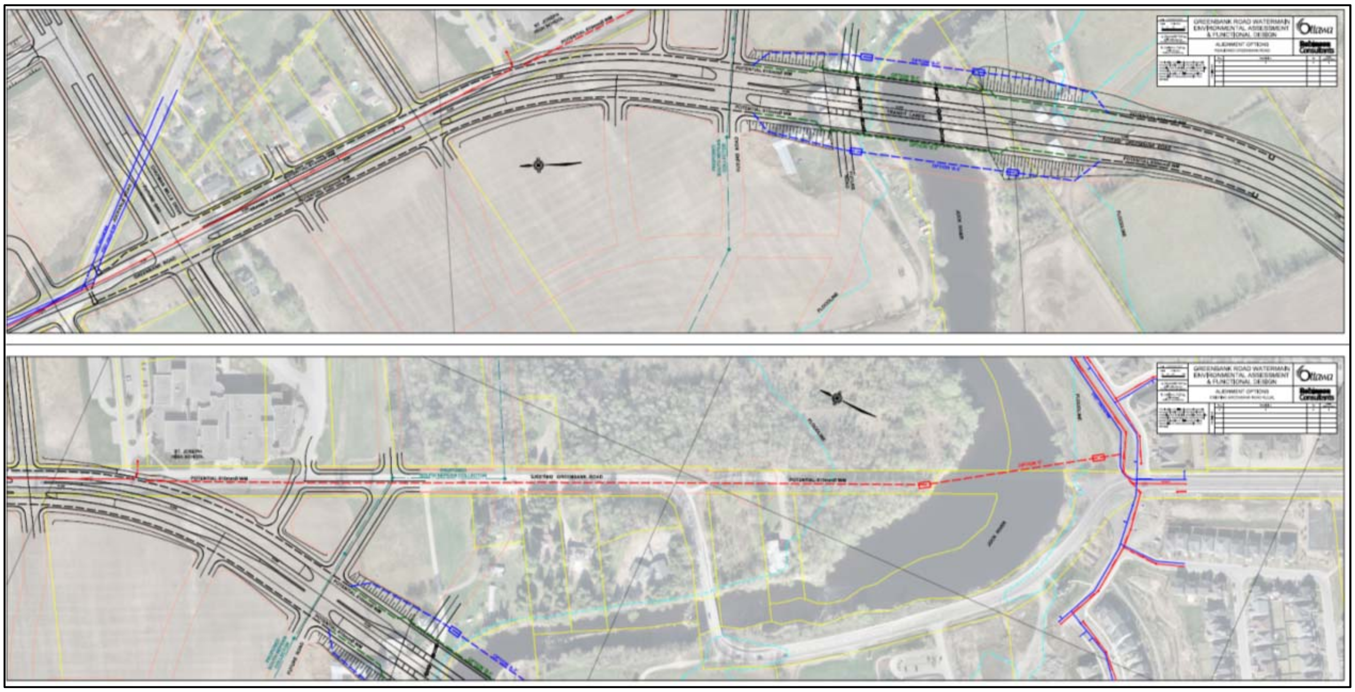
- Open-cut section from the Jock River to the proposed Pearl Dace Crescent within the Half Moon Bay subdivision where it divides into two 406 mm diameter branches; and

Alignment Along Existing Greenbank Road to Half Moon Bay Drive

- Open-cut section from Market Place to Greenbank Forest;
- Trenchless crossing of the Jock River;

The long list of alternatives is shown in **Figure 3** below as well as in **Appendix D**.

Figure 3: Long List of Alternatives



4.2 Jock River Crossing Alternatives

Alternatives for crossing the Jock River were developed utilizing trenchless technologies, as well as open-cut construction methods. They include:

- Open-cut Construction
- Trenchless River Crossing
- Pipeline Crossing on Bridge

4.2.1 Open-Cut Construction

Open-cut construction will involve traditional excavation methods across the Jock River. To achieve this, it will be necessary to utilize cofferdams to isolate the river flow, so that the excavation can be completed. This concept is shown in **Figure 4** below:

Figure 4: Open-Cut Construction using Cofferdams

For open-cut river crossings, there is the challenge of controlling surface water (and groundwater) during construction. The following general comments are provided in relation to open-cut crossings of the Jock River:

- **Issue 1 – Surface Water Management:** There are two alternatives for the control of surface water for open cut excavations across the Jock River – cofferdams and in-the-wet construction. Cofferdams could potentially be constructed upstream and downstream of the crossing to allow the pipe to be installed in relatively “dry” conditions. Based on the bathymetry information provided, the water at the crossing locations is anticipated to be between 2 and 5 metres deep, which are at the upper limit for practical routine cofferdam construction. Cofferdams have previously been constructed for open cut crossings of the Jock River using rip-rap stone with a membrane, but this has not been very successful. Key challenges were constructing staged coffer dams part way across the river (to allow for ongoing conveyance of river flow) and sealing of the junction of the cofferdam systems as the cofferdam is flipped from one side of the river to the other. Sheet piling could also be considered where clay soils are present, but would not be feasibly advanced and properly aligned within bouldery glacial till or in areas of shallow bedrock. Aquadams (water filled bags) could also be potentially considered for use as cofferdams; however, their effectiveness when placed on a bouldery river bed will also be limited. Based on the experience with previous river crossings, it may not be permitted to remove the substrate in the river in advance of cofferdam construction, which will make it difficult to properly prevent water from flowing into the excavations from beneath the base of any cofferdam.

- **Issue 2 – Groundwater Management:** The rate of groundwater inflow into open cut excavations within the Jock River will likely be very high, particularly where permeable sand seams are prevalent in the glacial till, or within the upper fractured bedrock. Groundwater inflows in areas underlain by clay would be lower.
- **Issue 3 – Bedrock Excavation:** Bedrock excavation may be required for the river crossings at the future Greenbank Road alignment where bedrock is expected to be encountered at or just below the river bottom within the river channel. It may be possible to remove the very upper portions of the bedrock by mechanical means (e.g. hoe ramming). However, unconfined compressive strength testing indicates that the dolomite bedrock is very to extremely strong and excavations extending into the bedrock may require drilling and blasting for removal. Bedrock removal, particularly by blasting, within the river channel would be expensive and would be subject to additional environmental restrictions/approvals.
- **Issue 5 – Environmental Considerations:** Open cut construction methods will need to strictly limit the introduction of total suspended solids (TSS) into the river channel and will need to have contingency measures in place to deal with inadvertent fuel spills into the river. All open cut excavation work in the river channel would need to be carried out within the available fishery windows. For more information on the potential natural environment constraints on open cut installation of the watermain across the Jock River, the Natural Environment Constraints memo in **Appendix F** should be consulted.

4.2.2 Trenchless River Crossing

4.2.2.1 Trenchless Construction Methods and Related Geotechnical Issues

For the proposed 610 mm diameter watermain pipe that is to be installed for this project, the discussion below has been based on the following possible trenchless construction methods: pipe jacking and horizontal auger boring; pipe ramming; micro-tunnelling; horizontal directional drilling; tunnelling; and rock boring. In brief, these construction methods involve the following:

- **Horizontal Auger Boring:** An auger boring operation involves pushing casing horizontally into the ground by jacking. The cutting head is driven by and is positioned at, the lead end of an auger string that is established within the casing pipe. The spoil is generally removed from within the casing using an auger boring machine. The profile needs to be approximately horizontal. Jacking and receiving pits are required. This method is only applicable to construction in the overburden and is well suited to clay crossings, but may not be feasible in bouldery soils (e.g., glacial till). Auger boring is not steerable, so there is no control over the profile and alignment of the bore once it has started. A typical auger boring operation is shown in **Figure 5** below:

Figure 5: Auger Boring

- **Pipe Ramming:** Pipe ramming uses a pneumatic tool to hammer up to (typically) 1500 mm diameter steel pipes or casings through the ground. Depending on the length of the installation, the soils inside the pipe can be removed either during or after the installation by auger (most common), compressed air, or water jetting. This method is only applicable to construction in the overburden. The profile needs to be approximately horizontal. Jacking and receiving pits are required. Pipe ramming is not-steerable, so there is no control over the profile and alignment of the bore once the pipe ramming has started. This method is feasible in clay and has been used within mixed success in glacial till with boulders, but the maximum length is 100m. A typical pipe ramming operation is shown in **Figure 6** below:

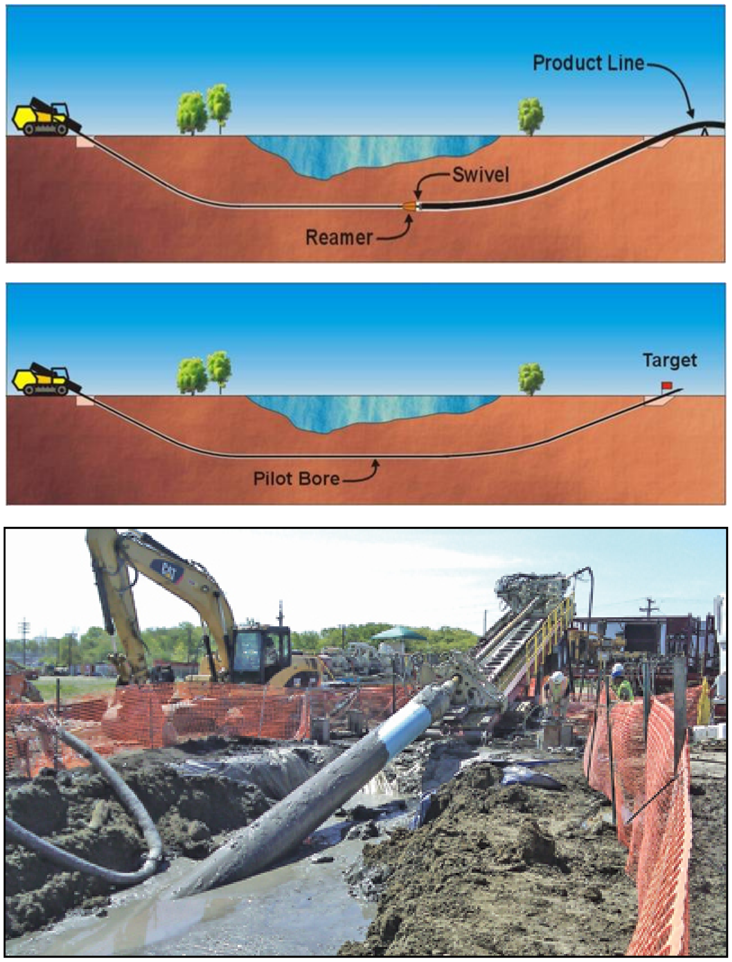
Figure 6: Pipe Ramming

- **Micro-tunnelling:** Micro-tunnelling is a method of installing pipes in bores typically ranging from 0.6 to 2.0 metres in diameter behind a steerable remote controlled shield for which the face can be pressurized with a bentonitic fluid to minimize ground losses. The process is essentially remote controlled pipe jacking where all operations are controlled from the surface, cuttings are removed by the circulating slurry and the necessity for personnel to enter the bore is eliminated. The tunnel profile needs to be approximately horizontal. Shafts are required. Micro-tunnelling is suitable for most overburden conditions; however productivity can be affected by conditions such as till. Micro-tunnelling is also suitable for soft to hard rock (250 MPa). Micro-tunnelling in rock harder than 250 MPa has been successfully completed. A typical micro-tunnelling operation is shown in **Figure 7** below:

Figure 7: Micro-tunnelling

- **Horizontal Directional Drilling (HDD):** HDD involves the drilling of a pilot hole, from ground surface, using a steerable drill bit on a flexible string of drill rods while the bore is supported using a bentonite slurry. Once the pilot hole is complete, the bore would be reamed in one or more passes to a larger diameter and then the pipe would be pulled through the bore (using the drill rods to pull the pipe into place). The bore diameter for HDD is typically 1.5 times the outside diameter of the product pipe. The annulus space between the bored diameter and the product pipe may be grouted. HDD equipment is available for drilling in both bedrock and overburden but the method is very challenging (and at risk of not being feasible) in bouldery ground (e.g., glacial till). There can be a potential for inadvertent returns (i.e., ‘frac-out’) of the drilling fluids to ground surface through the overburden or rock as well as due to soil permeability. Such a loss could result in a loss of downhole drill pressure, which could impair the removal of cuttings and slow progress. It could also result in an inadvertent return of drilling fluid into the overlying river, which could have negative environmental impacts. Deep entrance and exit pits are generally not required, however, larger laydown areas are required to install the product pipe and the crossing typically needs to be longer to accommodate the shallow entry and exit angles for the drilling equipment. For rock HDDs, depending on thickness of overburden, an oversized, shallowly-inclined casing pipe may need to be installed on the entrance (and/or exit) side to support the bore in the overburden and advance it in the bedrock. Bores are typically limited to less than 1500 millimetres in diameter. A typical HDD operation is shown in **Figure 8** below:

Figure 8: Horizontal Directional Drilling



- **TBM Tunnelling:** Tunnelling operations would involve the advance of a steerable tunnel boring machine (TBM) horizontally into the ground with successive sections of either an oversized liner pipe or the final product pipe advanced behind the TBM by pipe jacking. The spoil is removed from the tunnel as the TBM is advanced, using augers, conveyor belts or mucking carts. The cutting head is driven and steered by an operator inside the TBM and may be partially open to allow for access to the face. The tunnel profile needs to be approximately horizontal. Jacking and receiving pits are required. Locally, this method is generally used for construction in overburden and open-faced machines have been used in bouldery soils (e.g., glacial till), although rock TBM tunnels have also been constructed. Excavations through sandy soils below the water table typically require dewatering to maintain face stability when using open faced machines, or specialized earth pressure balance or slurry shield TBMs which pressurize the face of the excavation and improve face stability. Common bore diameter is 1.5m and larger. A typical TBM tunnelling operation is shown in **Figure 9** below:

Figure 9: TBM Tunnelling

- **Horizontal Rock Bore:** Rock boring generally involves the initial drilling of a pilot hole in the bedrock and then back-reaming the bore to the required diameter. The equipment is generally not steerable and can drift off alignment. Conventional drilling methods use roller-cone bits, an air percussion hammer/down-the-hole-hammer, or disk cutters and bores of up to 1.8 metres diameter have been completed locally. If excessive amounts of groundwater inflow are encountered within the bore, significant amounts of pumping would be required and treatment of the groundwater inflow to remove suspended solids could be costly. A typical horizontal rock bore operation is shown in **Figure 10** below:

Figure 10: Horizontal Rock Bore

The significant geotechnical issues should be considered in evaluating the suitability of the above trenchless methods at this preliminary stage are:

- **Issue 1 – 'Mixed Face' conditions**: Most trenchless equipment is suited to only construction in rock, or in soil, not both. A transition from rock to soil or vice-versa can be problematic, particularly if tunnelling through both materials simultaneously (i.e., along the vertical transition between soil and bedrock). To a lesser extent, mixed face conditions can also be an issue where the composition of adjacent soil deposits varies significantly.
- **Issue 2 –Rock or ground conditions**: There is a range of potential ground conditions which could be unsuitable for trenchless construction, or at least unsuitable for certain methods of trenchless construction. Some common examples applicable to this site are as follows:
    - The glacial till can be bouldery and those boulders cannot feasibly or economically be penetrated/ removed by some types of tunnelling equipment. Boulders can also slow the rate of advance such that it exceeds the 'stand up' time of the face and can result in face instability when 'open faced' equipment is used.
    - Silty clay is generally well suited to trenchless construction if stiff in consistency. However, if the clay is soft, or the bore is deep, there is the potential for instability of an open working face (i.e., 'squeezing' conditions could be experienced if tunnelling using open faced equipment).
    - 'Flowing' ground conditions could be encountered if tunnelling below the groundwater level in sand, unless 'closed face' equipment is used (such as a slurry shield), or if some form ground improvement (such as grouting) is carried out in advance of tunnelling, which would be impractical for a river crossing.
    - The rate of advance of bores in bedrock is largely controlled by the rock quality, strength, structure and abrasiveness of the bedrock formation. The presence of faults, gouge, or open water-bearing joints can also significantly impact the performance and risks of tunnelling and boring operations.
- **Issue 3 –Excessive groundwater (or surface water) inflow into the tunnel face or shafts:** Significant groundwater management could be required where tunnelling in permeable sand or fractured bedrock below the groundwater and river level (depending on the equipment used) and there is a risk of flooding of the tunnel or entrance pit/shafts if the groundwater inflow is excessive.
- **Issue 4** –**Ground movements (i.e., settlements above the bore) that may impact on roadways, utilities, or structures.**
- **Issue 5** - **The potential issues associated with excavation, groundwater management, temporary support and impacts to adjacent structures due to construction of deep access shafts, including;**
    - The shoring requirements for overburden excavations, such as may be required due to: shaft depth; the proximity to the river; and, the presence of weak or permeable ground conditions.

- The potential for basal heaving of the excavation floor if made in soils underlain by more permeable deposits with a high groundwater level/pressure.
- The potential for excessive groundwater inflow if the shaft will be made through permeable overburden or bedrock, which is important in regards to: the significant pumping that could be required; the need for a dewatering discharge of suitable capacity (and which meets MOECC and City requirements for water quality); and, the associated potential for settlement of surrounding structures due to the groundwater level lowering.

4.2.2.2 General Comments on Trenchless Profile and Alignment Selection

In regards to the selection of the profile/alignment of a trenchless crossing, the following minimum depth/cover and separation requirements should be adhered to (at least at this preliminary stage of the project design). These preliminary guidelines can potentially be refined/reduced on a site-specific basis (depending on the ground conditions, groundwater level, planned construction method, bore/tunnel diameter, settlement sensitivity, etc.), but are generally required in order to provide adequate stability to the tunnel face (particularly where 'open face' methods are used).

- As a general guideline, trenchless crossings should only be considered where the cover above the crown of the tunnel is at least twice the tunnel bore diameter relative to the ground surface. Lesser amounts of cover could jeopardize the stability of the tunnel working face (depending on the tunnelling method/technology). At river crossings, three or more tunnel diameters of cover between the crown of the tunnel and the river bottom are preferred depending on the subsurface conditions below the river and the level of confidence in the river bottom profile. For HDD crossings beneath rivers, a minimum depth of cover beneath the river bottom of 6 metres is recommended. Bathymetric record data can be used to initially assess the river bottom profile along the river crossings, but should be confirmed for the preferred alignment with additional surveys.
- For trenchless crossings entirely within bedrock, one tunnel diameter of competent rock cover above the crown would generally be acceptable provided that man-entry into the tunnel is not planned. Lesser thicknesses of bedrock cover could potentially compromise the stability of the tunnel roof. Any highly fractured rock directly beneath the bedrock surface would not be considered as suitable cover in the calculations. At river crossings where the bedrock is not hydraulically separated from the river (i.e., where a thick layer of low permeability soil separating the river from the bedrock is not present), excessive amounts of water inflow into the bore could be encountered and additional rock crown cover would be required. Similarly, to avoid inadvertent returns (i.e., 'frac out') of the drill fluid along pre-existing joints and fractures in the bedrock, HDD crossings beneath rivers should be provided with additional cover. Where the crossing is wide and there is less confidence/certainty in the rock profile within the river, additional cover is recommended.
- The bore should be kept outside of the zone of influence of any adjacent structural foundations (e.g., the future Greenbank Road Bridge foundations), which is generally defined by a line projected downwards and outwards from the foundations at 1 horizontal to 1 vertical. A minimum separation of two bore diameters (vertical and horizontal) should also be maintained from existing services (e.g., the South Nepean Collector Sewer).

- The final bore diameter for trenchless installations will depend on the type of product pipe being installed (e.g., steel, concrete, FPVC, HDPE), the installation methodology (e.g., jack and bore, pipe ramming, micro-tunnelling, HDD, etc.), the ground conditions and the local availability of the tunnel boring equipment.

4.2.2.3 General Comments on Shaft Construction and Related Geotechnical Issues

The following general comments are offered in regards to construction of the shafts for this project:

- For preliminary planning purposes, it is recommended that shafts be located at least 10 metres from the river banks and outside of the seasonal flood plain wherever possible.
- Although very short-term open-cut excavation sides slopes constructed to shallow depth in the overburden soils might be feasible (if not located overly close to the river bank), it is generally considered that the tunnel shafts will need to be shored (due to their depth and the duration that the shafts will be open). Shoring may be achieved using conventional techniques (e.g., soldier pile and lagging, sheet piling, secant wall, etc.), however boulders in the glacial till may limit the ability to drive sheet piling and may present challenges for driving soldier piles. Excavations for HDD pits could likely be excavated in open cut with the lower portions supported with trench boxes.
- Excavation of the bedrock in the shafts could be carried out using drill-and-blast techniques or potentially mechanical excavation in the upper portion of the bedrock.
- Groundwater inflow from the overburden soils should be expected and, within sandy seams in the glacial till, could be significant. The hydraulic conductivity of the bedrock is also very high (likely controlled by the joints/fractures) and thus significant groundwater inflow from fractures in the bedrock should also be expected. The rate of groundwater inflow from the rock could be excessive and could make work within the shafts impractical without first lowering the groundwater level in advance of excavation or grouting the bedrock to limit inflows. Where silty clay soils are present within the zone of influence of dewatering, the potential impacts to adjacent structures resulting from temporary lowering of the groundwater table will need to be considered. Underdrainage can result in widespread and far-reaching drawdowns hundreds of metres away from the shaft locations which could result in settlement of overlying structures such as those residential developments located north and south of the study area. Naturally occurring elements (e.g., manganese) in the groundwater will be an issue for disposal and it may be prudent to construct water-tight shoring systems to limit the volume of groundwater to be removed and treated to meet discharge requirements.
- Dewatering of the shafts may not be sufficient to prevent significant groundwater inflows from the bore itself and then into the shafts. A hydrogeological assessment will be required at the detailed design stage to assess the rate of groundwater pumping at the shafts and bore as part of the PTTW application. A Category 3 Permit-to-Take-Water (PTTW) from the MOECC will likely be required for the shafts for all watermain alignments.

4.2.3 Pipeline Crossing of Bridge

A potential trenchless technology for crossing the Jock River is to attach the proposed 610mm diameter watermain on one of the future bridges. In this alternative, the pipe is attached to hangers that are fastened to the underside of the bridge structure. Pipelines on bridges have commonly been constructed by municipalities, but have not historically been permitted within the City of Ottawa.

To evaluate the potential for a pipeline crossing on the future bridges, an assessment was completed by COWI North America. The COWI report, which is attached in **Appendix** G, discusses issues related to attaching the pipeline to the bridge including:

- Confirmation that the Canadian Highway Bridge Design Code allows a water pipe on the proposed bridge;
- Preliminary conceptual design of the hanging system for the water pipe; and
- Functional assessment of the implications of hanging the water pipe on the bridge structure that has been proposed in the Environmental Assessment, including:
  - Structure alterations;
  - Cost implications; and
  - Long-term maintenance implications to the bridge.
- Input on potential movement of the bridge structure based on seismic, wind and temperature, as it relates to the design of any required expansion joints on the water pipe.

Figure 11: Watermain on Bridge

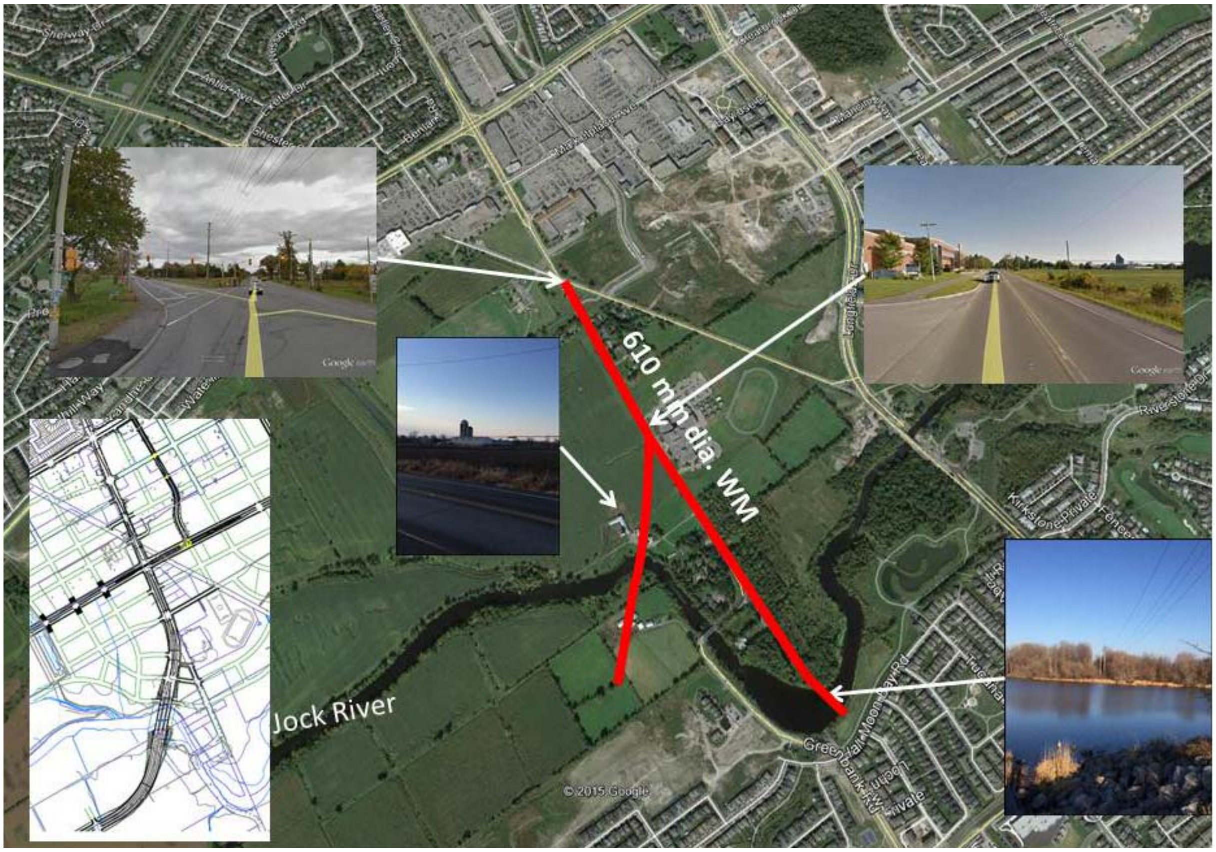
5.0 STUDY AREA FEATURES AND CONSIDERATIONS

Section 5.0 describes the project study area considerations including: the location, existing land uses, future land uses, socioeconomic environment, natural environment, cultural environment, geotechnical and natural environment. This information was used in the evaluation of alternative crossing methods and routes of the Greenbank Road watermain.

5.1 Study Area

The location of this project is on Greenbank Road corridor from Market Place to south side of the Jock River. **Figure 12** shows the study area, including the two alignments considered as part of this Class EA.

Figure 12: Study Area

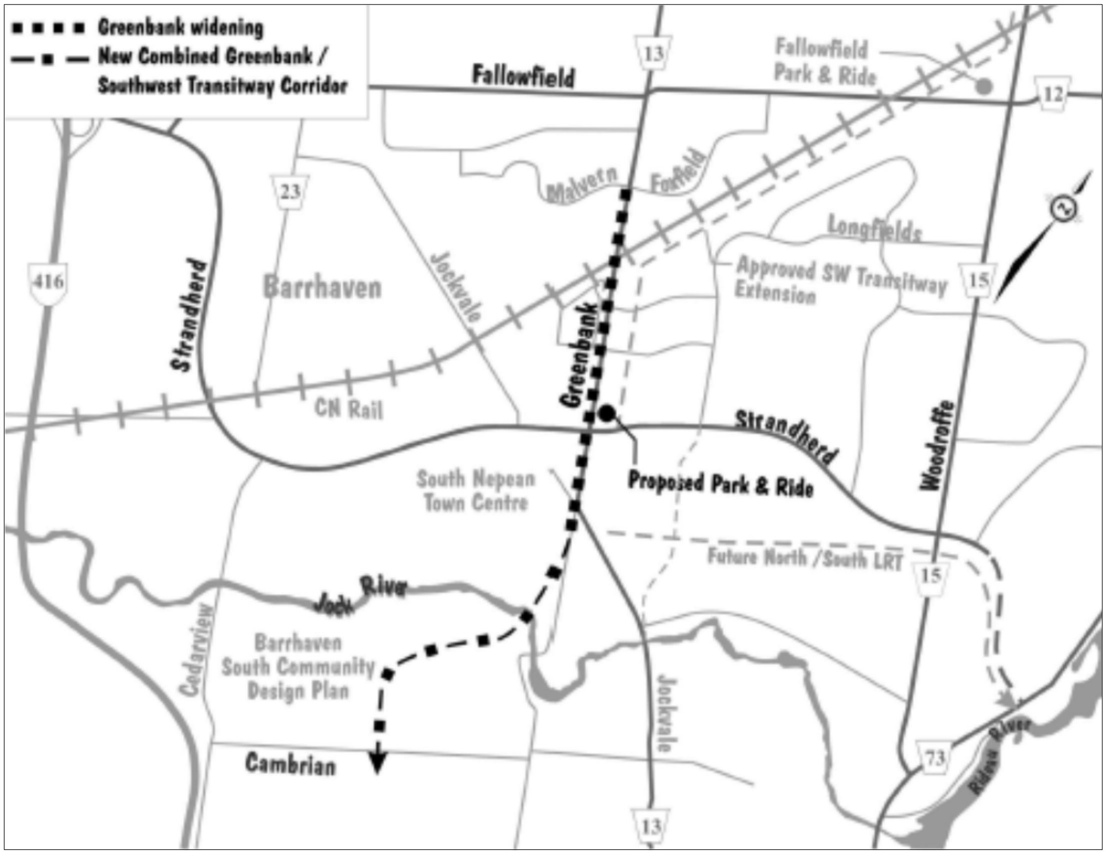


5.2 Greenbank Road Realignment

In 2006 the City of Ottawa completed the *Greenbank Road – Malvern Drive to Cambrian Road Class EA Environmental Study Report*. The proposed roadway design elements include four vehicular lanes and two transit lanes, transit platforms, transit stations and three new bridge structures crossing the Jock River. The MCEA and functional design included a new 610 mm diameter watermain from Market Place to Cambrian Road, but did not include an evaluation of the crossing methodologies of the Jock River. It is recognized, that the design and construction of the new 610 mm diameter watermain must be closely coordinated with the proposed widened and realigned Greenbank Road, including the crossing of the Jock River.

The recommended plan for Greenbank Road from the 2006 MCEA is shown in **Figure 13**.

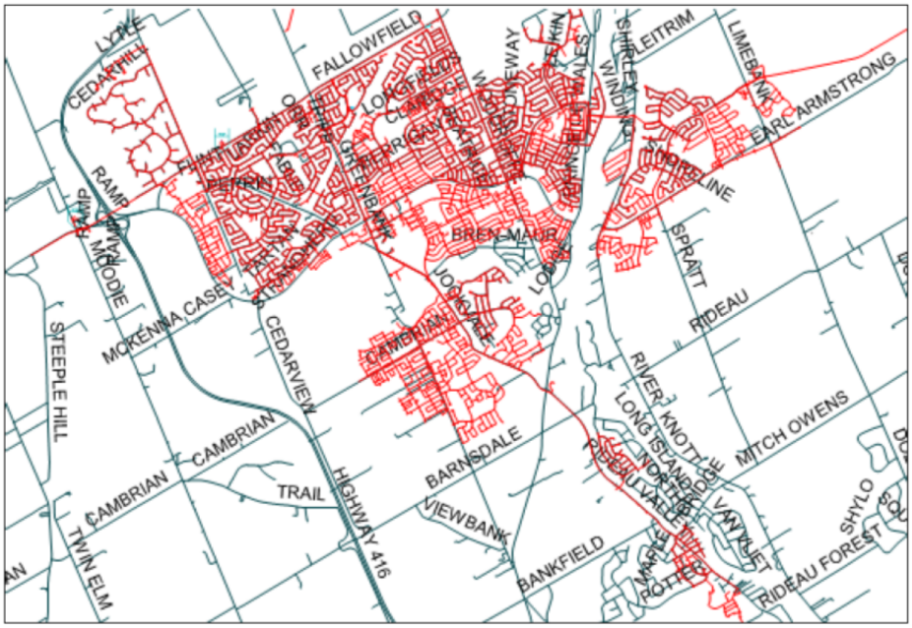
Figure 13: Greenbank Road Recommended Plan



5.3 City of Ottawa Water Distribution System

Currently, the entire Barrhaven South Development Area, Stonebridge and the Village of Manotick are supplied by existing 406 mm diameter watermains from the 762 mm diameter watermain on Greenbank Road at Marketplace and by a single 406 mm diameter watermain on Longfields Drive. This configuration has limited reliability and additional capacity is required to support ongoing growth in the near future. The existing watermain layout is shown in **Figure 14**.

Figure 14: Existing Watermain Layout



An update to the Barrhaven South Master Servicing Study was completed by the City in 2014. Highlights from this assessment included:

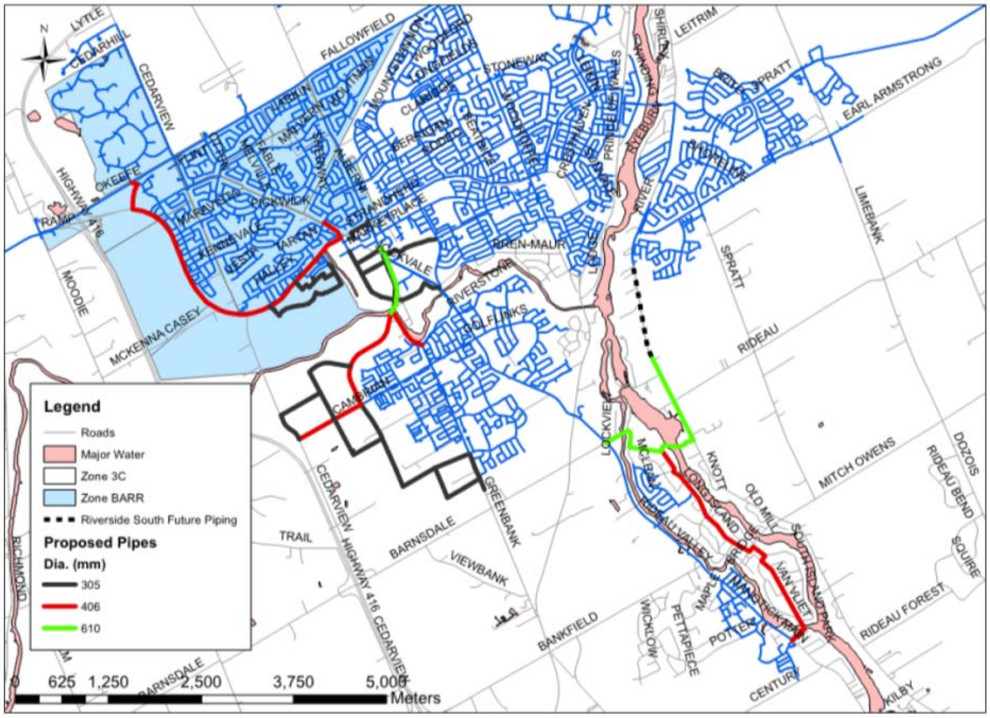
Barrhaven South

- The preferred solution to service existing and future residents of Barrhaven South is to construct a future 610 mm and 406 mm watermain from the future 610 mm Greenbank Road watermain crossing the Jock River.
- The timing of the 610 mm Jock crossing is immediate for reliability and redundancy purposes. A failure of the twin 406 mm watermain would result in a complete loss of service to all areas south of the Jock River. The watermain is also required to maintain pressures in Barrhaven South above 40/50 psi beyond 2021.

The update of the Barrhaven South Master Servicing Study confirmed the requirements and the timeline for the new 610 mm diameter watermain from Market Place to the south side of the Jock River, including the crossing of the Jock River. The proposed pipe layout for Barrhaven South is shown in **Figure 15**.

Since the Greenbank road project has been deferred a number of years additional Barrhaven watermain distribution system modeling study was done in summer of 2017. This 2017 study determined that the watermain project can also be deferred without risk to service levels as development proceeds in the Barrhaven South area since proposed North Island Link watermain will provide additional capacity and reliability to the Barrhaven South area from the Riverside South distribution system via an existing watermain on Rideau Valley Drive (North Island Link watermain project is planned for construction in 2019).

Figure 15: Proposed Barrhaven South Pipe Layout



5.4 Existing Land Use

Existing land use within the study area consists of a mix of agricultural, residential developments, rural residential and transportation corridors. The prominent institutional facility is St. Joseph High School located on the existing alignment of Greenbank Road, 400 m South of Jockvale Road. South of the Jock River, the existing land use consists of residential greenfield development land, which has been under construction for quite a few years.

5.5 Future Land Use and Infrastructure Projects

The study area for the proposed 610 mm diameter watermain is within the future road allowance of the widened and realigned Greenbank Road. North of the Jock River, the existing agricultural land will be developed as part of the Nepean Town Centre Development Area. As part of the consultation process for this MCEA, the study team met with Claridge Developments, who will be constructing a medium to high density subdivision just north of the Jock River as early as 2017.

Figures 16 and 17 from the South Nepean Town Centre Community Design Plan and the Barrhaven South Community Design Plan, show the proposed land uses within the study area.

Figure 16: Nepean Town Centre Land Use Plan

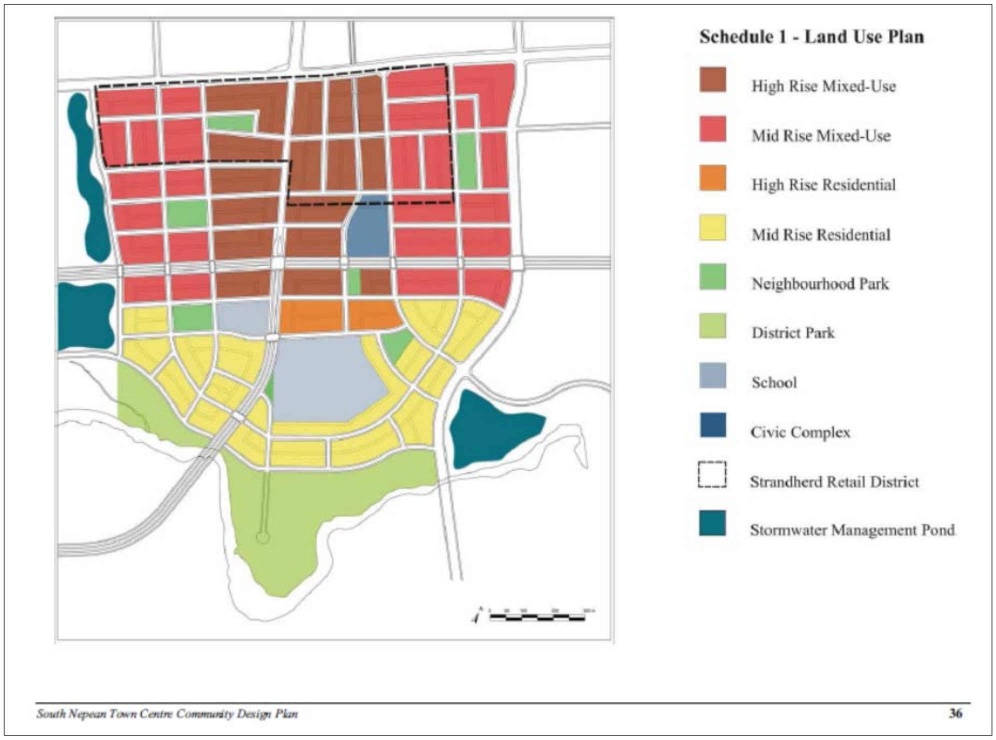


Figure 17: Barrhaven South Land Use Plan

5.6 Geotechnical Overview

5.6.1 Site and Subsurface Conditions

The description of the subsurface conditions provided in this overview is based primarily on a review of existing available published surficial geology, bedrock geology and trends in depth to bedrock mapping and on the available borehole records within or in the vicinity of the study area.

5.6.1.1 Available Information

For this assessment, information on the site subsurface conditions was obtained from the following sources:

- Topographic and bathymetric cross-sections obtained from the Rideau Valley Conservation Authority;
- Reports in Golder Associates' records, including subsurface investigations carried out for the South Nepean Collector Sewer project, Claridge Homes, the Kennedy Burnett Stormwater Management Facility, the future bridge crossing of the Jock River along the realigned Greenbank Road and the residential developments on the south side of the Jock River; and,
- Boreholes drilled on the north and south sides of the Jock River along the Jock River crossing alignment.
- Published Geological Survey of Canada and Ontario Geological Survey mapping for the study area. It should be noted that the published mapping does not always accurately reflect the actual contacts between different stratigraphic units as determined by the project subsurface investigations. Where previous site specific geotechnical investigations have been carried out, the subsurface conditions along the alignments have been better defined in the text below, based on a review of existing borehole data. Published mapping is referenced to the pre-development ground surface and, as such, the depths to bedrock shown on the published geology mapping may not reflect the current depths to bedrock in areas where fill (such as along existing roadway corridors) has been placed.

The Geotechnical Overview report is attached in **Appendix E**.

5.7 Natural Environment Constraints

5.7.1 Methods

This constraints summary was prepared using existing information and background data relevant to the Study Area and supplemented with a single site reconnaissance on December 14, 2015 and a site visit on June 29, 2016. Site reconnaissance surveys allowed for the documentation of flora and fauna through incidental or casual observation. A comprehensive taxa-specific field program was not within the scope of this study. Requirements for additional taxa-specific protocols will depend on the design and timing of the proposed construction and input from relevant agencies such as the City of Ottawa, the Department of Fisheries and Oceans and the Ministry of Natural Resources and Forestry.

5.7.2 Background Review

Background information collected during the desktop assessment was used to identify significant natural features and Species at Risk (SAR) previously reported as occurring, or potentially occurring in the local landscape around the Study Area. SAR considered for this review include those species assessed as special concern, threatened, or endangered under the Ontario Endangered Species Act (ESA) and the Canada Species at Risk Act (SARA). The background review was also used to complete a cursory-level assessment of whether or not there is suitable habitat for SAR in the Study Area. The information gathered from the following sources was used to inform the site reconnaissance visit:

- Provincial Policy Statement (PPS) (MMAH 2014);
- City of Ottawa Official Plan (Ottawa 2003);
- City of Ottawa Wildlife Protocol (Ottawa 2015);
- Rideau Valley Conservation Authority – Jock River Subwatershed Report (RVCA 2010);
- Natural Heritage Information Centre (NHIC) online database and tools (NHIC 2016);
- Environment Canada SAR Public Registry website, associated documents and online tools (EC 2016);
- Atlas of Breeding Birds of Ontario (Cadman et al. 2007);
- Atlas of the Mammals of Ontario (Dobbyn 1994);
- Ontario's Reptile and Amphibian Atlas (Ontario Nature 2016);
- eBird Online database and mapping tools (eBird 2012)
- Bat Conservation International (BCI 2016);
- Royal Ontario Museum (ROM) range maps (ROM 2010);
- Ontario Butterfly Atlas (Jones et al. 2016);
- Information and data contained in natural heritage related map layers from Ontario Base Map series, Natural Resource Values Information System (NRVIS) mapping and Land Information Ontario; and,
- Existing aerial imagery and mapping.

Several natural environment studies and reports have been previously completed for the general area of the Study Area. Where relevant, these studies were reviewed and where applicable the information is referenced in this report. Where the studies were either desktop in nature, or many years outdated, they have been considered background information. Many of these studies occurred prior to the passing of the 2007 ESA. These studies do not take the place of up-to-date field surveys, inventories and habitat assessments.

5.7.3 Field Surveys

Winter Site Reconnaissance

A winter reconnaissance was completed on December 14, 2015. Portions of the Study Area, where access was obtained were traversed, to characterize the natural features and, where possible, verify the findings of the background review. Because the reconnaissance was conducted outside of the active season for much of Ontario's flora and fauna, limited information on the Study Area could be gathered for plant and wildlife species directly, but wildlife habitat suitability was assessed. Although a few species of plants and wildlife were identified, a full inventory could not be conducted.

Early Summer Site Visit

An early summer site visit was completed on June 29 2016. Portions of the Study Area, where access was obtained, were traversed, starting early in the morning, when many birds and other wildlife are easily detectable. The woodlot on the eastern side of Greenbank Road and abandoned buildings west of Greenbank Road and north of the Jock River, were not accessed. These areas were observed from the road and other adjacent accessible properties. An inventory of all wildlife and plants that could be identified was conducted during this site visit and a species list was made.

Habitats in the Study Area, particularly those that may be suitable for SAR, were observed and noted.

5.7.4 Species at Risk Screening

The potential for SAR to occur was assessed based on species range information, known records, review of the habitat and species observations made during the site visits, historic land use practices and the preferred habitat requirements of these species.

The potential for the species to occur was determined through a probability of occurrence. A ranking of low indicates no suitable habitat availability for that species in the Study Area and no specimens identified. Moderate probability indicates greater potential for the species to occur, as suitable habitat appeared to be present in the Study Area, but no occurrence of the species was recorded. High potential indicates a known species record in the Study Area (including observations during the site reconnaissance or through the background data review) and the presence of good quality habitat. Where a species could not easily be assessed using the aforementioned criteria, professional judgement and experience was used to determine potential.

The Natural Environment Constraints report is attached in **Appendix F**.

6.0 STUDY CONTRAINTS AND OPPORTUNITIES

The investigation of constraints and opportunities for the assessment of crossing methodologies of the Jock River, as well as the alignment of the watermain within the widened and realigned Greenbank Road are divided into the following categories:

- Technical Requirements
- Social Environment
- Natural Environment
- Physical Constraints
- Cost

6.1 Technical Constraints

The technical constraints are based on issues related to the compatibility with existing and future transportation infrastructure, including roadway design, bridge design and planning approvals related to subdivision development.

Specific issues for evaluation included:

- Compatibility with Barrhaven South Master Servicing Study;
- Watermain alignment considerations for the future Greenbank Road widening and realignment;
- Coordination with future subdivision development within the South Nepean Development Area and the Barrhaven South Development Area;

- Integration with the proposed Greenbank Road bridge structures; and
- Coordination with the future South Nepean Collector Sewer.

6.2 Social Environment

The social environment constraints are based on the impact of the proposed watermain on the surrounding area, including the following:

- Land acquisition;
- Impacts to adjacent property owners along the future Greenbank Road;
- Impact on existing and planned utilities;
- Impact on planned communities;
- Impact on planned parkland; and
- Construction disruption.

6.3 Natural Environment Constraints

The natural environment constraints primarily focus on issues related to the crossing of the Jock River. Issues related to impacts to the natural environment of the planned roadway construction, were addressed in the previously completed MCEA for the Greenbank Road Widening. Therefore, issues related to the natural environment will be assessed based on the comparison between trenchless technology construction and open-cut construction. These natural environment constraints are as follows:

- Effects on natural heritage features;
- Effects on fisheries;
- Effects on surface water quality;
- Effects on terrestrial features; and
- Species at Risk (SAR).

6.4 Physical Constraints

The physical constraints were very important in determining the best method for crossing the Jock River and vary based on the crossing method being evaluated. Physical constraints included:

- Geotechnical and hydrogeological conditions for a trenchless crossing of the Jock River;
- Geotechnical and hydrological conditions for an open-cut crossing of the Jock River;
- Bathymetrical data for an open-cut crossing of the Jock River; and
- Design considerations for construction in conjunction with the proposed bridge, including bridge approach embankments and retaining walls.

6.5 Costs

The development of cost estimates will included the ultimate capital cost, operation and maintenance cost and the potential for construction cost and schedule over-runs due to the complexities based on constructability. For the purposes of the MCEA, cost estimates were first developed to compare the alternative solutions only and did not account for the overall capital cost of the proposed watermain that will be constructed as part of the Greenbank Road contract. Subsequently a high level Class C total capital cost estimate of $11.3 million was developed for the selected project preferred solution. More detailed total capital cost estimate of the entire watermain project will be developed as part of the Functional Design Report.

7.0 ASSESEMENT OF JOCK RIVER CROSSING ALTERNATIVES

7.1 Supporting Technical Studies

The MCEA study was developed based on investigation and studies completed as part of this assignment. As well, information from the approved ESR for Greenbank Road – Malvern Drive to Cambrian Road was utilized in the completion of this assignment. The supporting investigations and studies completed for this assignment include:

1. "Geotechnical Overview and Design Input Greenbank Road Watermain Environmental Assessment Study and Functional Design", Golder Associates, July 2016;
2. "Natural Environmental Constraints – Greenbank Road Watermain", Golder Associates, July 2016;
3. "Assessment of the implications of installing a water pipe on the Greenbank Road bridge", COWI Bridge (Buckland & Taylor), December 2015;

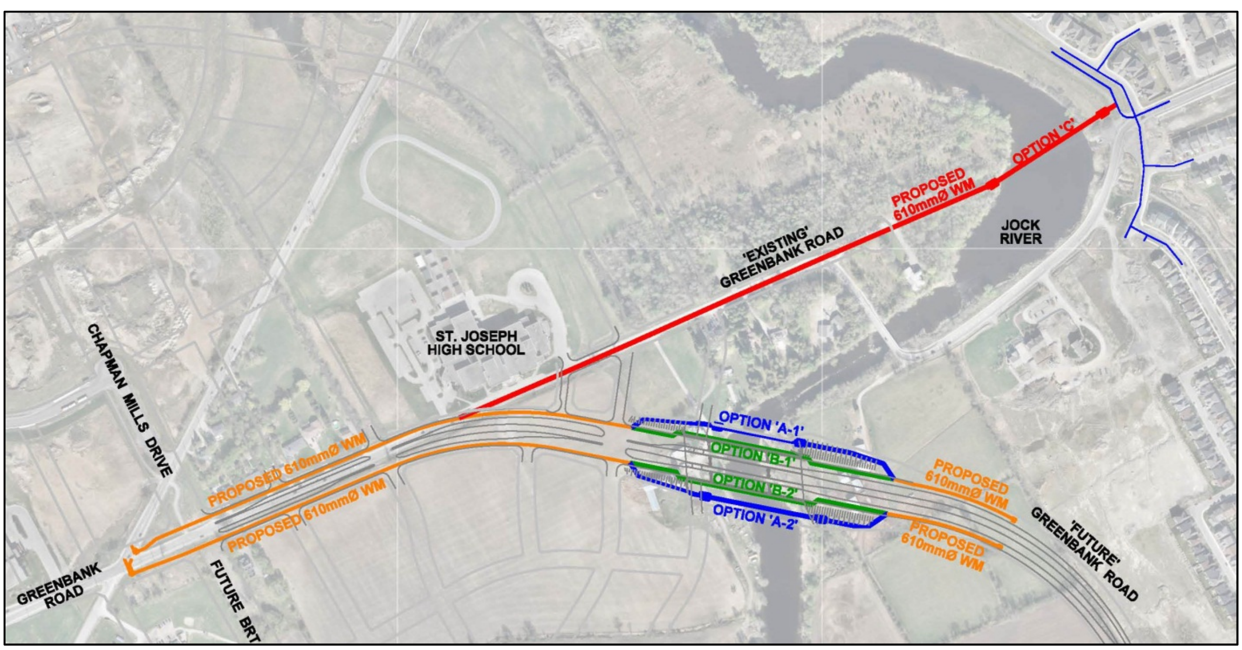
7.2 Short List of Alternatives

A coarse screening was completed of the long list of alternatives to eliminate alternatives that could not meet basic criteria. As shown in the Jock River alignment options figure in **Figure 18**, the alternatives were graphically represented showing open-cut, trenchless and bridge options on both sides of the bridge structure and roadway, as well as the existing Greenbank Road right-of-way alternative.

The naming convention for the various alternatives is as follows:

1. Open-cut construction – Option A1/A2/C (Open-cut)
2. Horizontal Directional Drilling – Option A1/A2/C (HDD)
3. Tunnelling – Option A1/A2/C (Tunnel)
4. Pipeline Crossing of Bridge – Option B1/B2 (Bridge)

Figure 18: Long List of Alternatives



7.2.1 Coarse Screening Discussion

Since the construction of the proposed watermain within the existing and re-aligned Greenbank Road is typical open-cut construction techniques, the alignment options referenced in 6.2 above concentrate on the alignment and construction technique for the crossing of the Jock River.

Widened and re-aligned Greenbank Road – The open-cut and trenchless alternatives along the future Greenbank Road alignment is feasible and can meet the study objectives. Although a detailed screening may ultimately show that some alternatives are better than others, they can all be considered constructable.

Alignment along Existing Greenbank Road to Half Moon Bay Drive – The open-cut option for this crossing of the Jock River would very difficult to construct without significant environmental impact and cost. This section of the Jock River is the widest and deepest and is a cold weather refuge for fisheries. The connection to the existing watermain on Half Moon Bay Drive would require additional watermain construction to connect to the distribution system and provide the transmission capacity that was outlined in the Barrhaven South Master Servicing Study. For this reason, this alternative does not meet the overall hydraulic objectives of the study and will not be evaluated further.

Greenbank Road Bridge

An assessment of the implications of attaching the proposed 610 mm diameter watermain to the future bridge structures was completed. The scope of the investigation is as follows:

- Confirmation that the Canadian Highway Bridge Design Code (CHBDC) allows a watermain on the proposed bridge.
- Preliminary conceptual design of the hanging system for the watermain.
- Functional assessment of the implications of hanging the watermain on the bridge structure that has been proposed in the Environmental Assessment, including:
  - Structure alterations;
  - Cost implications; and
  - Long-term maintenance implications to the bridge.
- Input on potential movement of the bridge structure based on seismic, wind and temperature, as it relates to the design of any required expansion joints on the watermain.

The assessment of the implications of installing the watermain on the bridge prepared by COWI determined that the CHBDC allows the installation of a watermain from a bridge structure provided approval is given and certain conditions are met. The structural implications of installing the hanger system to support the watermain require minimal alterations to the proposed bridge designs. The addition of a watermain will not significantly affect the long-term maintenance of the bridge, provided the provisions outlined in the report are taken.

The technical memorandum prepared by COWI was reviewed by the City of Ottawa Asset Management Branch (AMB). Comments received from AMB were that they would not provide approval for the watermain to be attached to a City of Ottawa bridge structure. For this reason, it was determined that this alternative could not be evaluated further for regulatory reasons.

The Bridge Assessment report is attached in **Appendix G**.

7.2.2 Summary of Coarse Screening

Following a review of the long list of alternatives, the number of alternatives that will be moved forward for a detailed assessment was reduced to include only the alignment options A1/A2. The coarse screening is summarized in **Table 2** below and shown in **Appendix H**.

Table 2: Coarse Screening Summary

Alternative	Rationale	Recommended
Option A1/A2 (Open-cut, HDD, Tunnelling)	All options feasible and meet objectives.	✓
Option B1/B2 (Bridge)	Option is feasible and meets all objectives. From a regulatory perspective, option would not be approved by the City of Ottawa.	X
Option C (Open-cut, HDD, Tunnelling)	Open-cut not feasible due to length of crossing and depth of water. Connecting to existing watermain on Half Moon Bay Drive will not meet hydraulic objectives.	X

7.2.3 Watermain Alignment Options

Following the coarse screening of the long list of alternatives, a short list was developed that include both open-cut and trenchless options. From a geotechnical perspective, there is very little difference between the east and west side of the future bridges for both open-cut and trenchless construction. The location of these alternatives within the right-of-way (west or east side of roadway and bridges), was determined based on the required connection to the existing 762 mm diameter watermain at Market Place and on the configuration of the future Claridge subdivision north of the Jock River. Since the future Claridge subdivision will have homes fronting onto Greenbank Road, sewer laterals will be connected to the mainline sewers on Greenbank Road and would therefore cross underneath the proposed 610 mm diameter watermain. For this reason, it would be prudent to locate the watermain on the eastern lanes of Greenbank Road (northbound). The alignment of the 610 mm diameter watermain was determined to be in the eastern lanes (northbound) of Greenbank Road and on the eastern side of the future bridges.

The proposed Claridge subdivision layout can be seen in **Appendix I**.

7.3 Evaluation of Jock River Crossing Alternatives

The shortlist of the Jock River Crossing alternatives was evaluated based on Alignment A-1 which follows the east side of Greenbank Road and the bridge structure.

Each alternative was given a rating of 1-10 for each evaluation criteria. The ratings given to each evaluation criteria were averaged to give an overall rating to each of the criteria. The weighted averages were calculated for each of the alternatives and they were ranked accordingly. The following sections provide a brief reasoning for the ratings that were given to each alternative.

The criteria weighting used for the evaluation is shown in **Table 3** below:

Table 3: Evaluation Criteria Weighting

Criteria	Weighting
Technical Performance	10%
Social Environment	10%
Natural Environment	30%
Physical Constraints	40%
Costs	10%
Total	**100%**

Physical Constraints were given a high weighting to ensure that the recommended alternative was constructable, considering the challenging geotechnical conditions for the Jock River crossing. As well, the Natural Environment had a high weighting, to ensure that preference would be given to alternatives that utilized construction methods with the least risk of impact to the environment.

7.4 Evaluation Discussion

The following is a discussion for each of the criteria used to assess the three alternatives (Open-cut, HDD, Tunnelling on Alignment A-1). Rationale and indicators, which describe each of the criteria is shown in the evaluation table in **Appendix J**.

7.4.1 Technical Performance

- **Operation and Maintenance** – All three options have similar long term O&M characteristics. Although HDD will result in a deeper watermain profile, a failure of all three construction techniques will be difficult to repair. All three options can have fully accessible valve chambers.
- **Compatibility with Barrhaven South Master Water Supply Plan** – All three options will have the same connectivity both north and south of the Jock River.
- **Compatibility with existing and future utilities** – The open-cut and micro-tunnelling options are clear of all utilities. The profile of the HDD option must be offset to the south to ensure that the northern pit is not in conflict with the South Nepean Collector sewer.
- **Compatibility with Greenbank Road Widening** – The open-cut option can easily be constructed in the Greenbank Road R.O.W. For both HDD and micro-tunnelling, the shafts/pits will require temporary construction easements on future development land.

7.4.2 Social Environment

- **Construction Issues/Reliability** – The construction staging for HDD and micro-tunnelling will require coordination for the location and timing of the shafts/pits. The open-cut option may add significant time to the construction schedule, due to the dewatering of the crossing for tunnelling options. Ensuring the tunnel shafts are dry may also add significant time to the construction schedule.
- **Compatibility with existing/planned communities** – Open-cut and micro-tunnelling will not require any additional land. HDD and micro-tunnelling will require temporary construction easements for the staging compound.
- **Construction Disruption** – Open-cut has the most potential for extended construction duration for river de-watering. It is also the only option that will significantly impact the Jock River. HDD and micro-tunnelling will require a temporary construction easement. HDD and

micro-tunnelling will have the potential for slightly higher traffic disruption. (Depends on the state of development at the time of construction)

- **Land Acquisition and Easements** – HDD will require temporary construction easement for staging compound.

7.4.3 Natural Environment and Heritage

- **Natural Heritage Features** – The open-cut option will require additional removal of woodlots and natural areas on both the north and south sides of the Jock River.
- **Fisheries** – The open-cut option may significantly disrupt fisheries in the Jock River. There is the potential for significant sediment transport during construction.
- **Species at Risk** – None of the options will significantly impact SAR.

7.4.4 Physical Constraints

Geotechnical and Hydrogeological Constraints

Open-Cut

- Cofferdam construction will be challenging with the existing soil conditions.
- The cofferdam cannot be constructed on the glacial till surface. Significant hydraulic short-circuiting could occur.
- Earth cofferdam not feasible due to the risk of sediment transport to the river.
- Considering the irregular substrate, installing the watermain on the river bottom will not be possible without significant substrate removal.
- The RVCA will not permit substrate to be removed during construction.
- Watermain construction will require rock excavation to ensure adequate cover.
- Overall depth to rock will result in high cofferdam and would potentially be unconstructable.
- Sediment control will be extremely challenging.

HDD

- This method will require a thorough understanding of the soil stratigraphy and the potential HDD profile.
- Entry and exit through the glacial till must be accomplished using a combination of pit excavation and steel casings.
- Groundwater must be controlled during the casing installation.
- Boreholes indicated that the rock is fractured. Risk of frac-out must be assessed. The risk of frac-out will be better defined through the completion of additional inclined boreholes within the bedrock.
- Rock strength is high (280MPa).
- Understanding HDD profile is important. For plastic pipe, the drill rods dictate the bend radius. For steel pipe, the pipe dictates the bend radius.
- HDD profile results in long drill length at great depth. Although the depth seems great, HDD contractors routinely drill at this depth, with no negative bearing on success.

Micro-Tunnelling/Rock Boring

- The costs and associated constructability will be governed by the shaft construction through the glacial till and into rock.
- Shafts will be deep (~10-12m)
- High K (i.e. groundwater inflow) in fractured rock (10^{-3} to 10^{-4})

- Pressure balance will be required to control water in bore.
- Shafts will require rock grouting for control of groundwater.
- Secant pile construction is an option, but with high cost.
- Sheet pile construction difficult or impossible in soil conditions.
- Rock Boring would require dewatering over the full length of bore.

Constructability

Open-Cut

- Considering the difficulty of installing cofferdams, open-cut may not be a constructable option.
- Dewatering may be impractical in the glacial till and boulder conditions.

HDD

- This construction methodology is feasible and not considered a complicated application of HDD.
- Strength of rock will impact production.
- Passing through the glacial till with steel casings will impact productivity.
- HDD profile must be understood.
- The proposed bore profile has been selected to provide cover to mitigate frac-out, but a full frac-out analysis is recommended at detail design stage.

Micro-tunnelling

- The constructability of micro-tunnelling is dictated by the construction methodology used for shaft construction.
- Water containment method is important.
- Shaft construction will be expensive.
- Micro-tunnelling may be feasible, but may not be cost competitive with HDD.

Impacts to Bridge

Open-Cut

- Since open-cut construction will take place very close to the bridge construction. Sequencing and overall construction schedule may be an issue.

HDD

- The entrance and exit pits can be positioned so that they are clear of any bridge construction.
- The depth of the HDD bore as it passes the bridge foundations will have to be assessed during the detail design of the bridge structure and will depend on the construction sequencing of which infrastructure is constructed first.

Micro-tunnelling

- The entrance and exit shafts can be positioned so that they are clear of any bridge construction.
- The depth of the micro-tunnelling bore as it passes the bridge foundations will have to be assessed during the detail design of the bridge structure and will depend on the construction sequencing of which infrastructure is constructed first.

Public/Private Property

- Only the HDD option could have an impact on private property. A temporary construction easement will be required for the staging compound.

7.4.5 Comparative Costs

The estimated hard construction costs and operation & maintenance costs were compared to give a comparative cost for each alternative. In addition, the constructability was taken into consideration. The comparative cost breakdown is shown in **Appendix K**. It is important to note, that the estimated costs are for comparison purposes only and are only calculated for the Jock River Crossing. A detailed cost estimate for the entire watermain from Market Place to the south side of the Jock River is provided in the functional design report.

For the section of watermain on the re-aligned and widened Greenbank Road, the alignment of the proposed watermain has been developed based on the location of existing underground utilities, the connection to the existing 762mm diameter watermain and the coordination with the proposed Claridge development on the north side of the Jock river.

Of the three alternatives in the short list, the comparative costs for the Jock River Crossing are as follows:

- Open-cut - $1,256,000
- HDD - $1,667,500.00
- Micro-tunnelling - $2,010,000.00

The scoring of each alternative can be seen in the evaluation table in **Appendix J**.

8.0 PREFERED ALTERNATIVE

Based on the evaluation completed, the preferred alternative for the 610 mm diameter watermain crossing of the Jock River is by horizontal directional drilling (HDD). It was determined that crossing the Jock River by open-cut methods would be very challenging, with significant concerns about constructability, impacts to the natural environment and the potential for schedule and cost overruns. Although micro-tunnelling was not chosen as the preferred alternative, it can be considered feasible, but would require a full assessment of the challenges involved with the shaft construction.

The preferred alternative of crossing the Jock River with HDD methods is shown in the profile drawing in **Appendix L**.

8.1 Municipal Class Environmental Assessment (MCEA)

Based on the selected preferred solution for crossing the Jock River by horizontal directional drilling (HDD) methods, it can be considered a trenchless construction method and therefore can be classified as a Schedule ‘A+’ process if the detail design and construction of this watermain would be integrated within the overall Greenbank Road widening and realignment project. However if the Greenbank watermain (or parts of it) would need to constructed ahead of Greenbank Road widening and the new bridge over the Jock River construction there would be a requirement to acquire property right-of-way and construction easement for the 600 mm dia. watermain. For this reasons the Greenbank watermain project is going to be completed as a Schedule ‘B’ process. Report to Planning Committee and Council will be prepared to approve issuing Class EA Study Notice of Completion for a 30 day public review period. If there are no objections to the Greenbank Watermain Class EA the project functional design report will be finalized and project will be ready for the detailed design and construction phase. The trenchless crossing of the Jock River by means of horizontal directional drilling (HDD) will require additional field investigations, including a detailed borehole drilling program, updated river bathymetry and a risk assessment of the HDD methodology. Class C capital cost estimate for this project is $11.3 million.

9.0 RECOMMENDATIONS FOR FURTHER STUDY

As part of the detail design stage of this project, it is recommended that the following additional investigations be carried out:

- Additional boreholes will need to be advanced to provide information on the soil, rock and rock mass properties along the selected alignment. The conventional borehole spacing along the alignment for trenchless crossings is typically 50 metres. Boreholes should be advanced along, but just outside of, the planned alignment and should extend at least 3 excavation diameters below the proposed invert. Additional bedrock laboratory testing should be carried out to better assess the strength, hardness and abrasiveness of the rock (e.g., UCS testing, elastic moduli, Brazilian Tensile strength, Cerchar abrasion test, slake durability, petrographic analysis). This information would be used by the contractor to determine the appropriate bits and tooling for the project.
- It will be important to obtain additional information on the overburden conditions at the entry/exit pits for an HDD bore. Furthermore, for an HDD bore, the ground conditions in the zone where the HDD bore path is expected to transition from soil to rock should be investigated. This information would be useful in assessing the potential for sloping bedrock (which might affect the ability for the HDD to "bite" into the bedrock) and to characterize the ground conditions at the soil/rock interface (since, in the case of an HDD crossing, it will likely be necessary to seat a casing into the rock to facilitate HDD boring in the rock).
- Additional information should be obtained on the hydraulic conductivity of the bedrock. For an HDD crossing, the additional hydraulic conductivity data would be used to assess the potential for inadvertent returns (i.e., "frac-out") of HDD drilling mud, which will influence the vertical profile (and thus length) of the bore.
- Inclined borings would provide additional information on the spacing of vertical or sub-vertical joints in the rock mass and would allow for hydraulic conductivity testing (i.e., packer testing) of these vertical features (which are difficult to intersect with vertical boreholes). Obtaining information on the frequency of vertical joints will help with the assessment of "frac-out" potential in the bedrock.
- The Jock River bathymetry should be updated to provide a cross-section at the proposed watermain crossing location.

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