Former CFB Rockcliffe Redevelopment

Stormwater Management Existing Conditions & LID Pilot Project Scoping

Final Report
August 2015

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ACCOMPANYING DOCUMENTS / APPENDICES

The following documents have been used as source and reference documents for subsequent sections of this report and have been submitted as supporting documents for the Former CFB Rockcliffe CDP. As such, the documents listed below are considered appendices to this document and are referenced to as such.

APPENDIX A – DST GEOTECHNICAL & HYDROGEOTECHNICAL REPORTS

1. Community Design Plan Geotechnical Investigation Former CFB Rockcliffe Development, Ottawa, Ontario (DST, June 2014)
2. Former CFB Rockcliffe Stormwater Management Ponds Ottawa, Ontario (DST, June 2014)
3. Former CFB Rockcliffe Storm Water Infiltration Ponds Ottawa, Ontario (DST, November 11, 2013)
4. Hydrogeological Report Stormwater Management Support Studies, Former CFB Rockcliffe, Ottawa, Ontario (DST, June 2014)

APPENDIX B – FLUVIAL GEOMORPHOLOGY ASSESSMENT – WESTERN AND EASTERN CREEKS, FORMER CFB ROCKCLIFFE (DST, SEPTEMBER 2013)

APPENDIX C– ROCKCLIFFE REDEVELOPMENT AREA - HYDROLOGIC AND HYDRAULIC ANALYSIS OF EXISTING SITE CONDITIONS AND PROPOSED DEVELOPMENT MEMORANDUM (IBI, JUNE 17, 2014)

APPENDIX D- AQUATIC HABITAT ASSESSMENT WESTERN AND EASTERN CREEKS FORMER CFB ROCKCLIFFE (DST, AUGUST 2013)

APPENDIX E- PRELIMINARY TERRESTRIAL HABITAT ASSESSMENT FOR PROPOSED STORMWATER PONDS AT THE FORMER CFB ROCKCLIFFE (DST, AUGUST 26, 2013)

APPENDIX F- BUTTERNUT SURVEY FOR PROPOSED STORMWATER PONDS AT THE FORMER CFB ROCKCLIFFE (DST, AUGUST 26, 2013)

APPENDIX G - CFB ROCKLIFFE VEGETATION SURVEY – ARBORIST REPORT (BAKER, JANUARY 2013)

INTRODUCTION

Canada Lands Company Ltd. acquired the former Canadian Forces Base (CFB) Rockcliffe site from the Department of National Defense in 2011, with a mandate to optimize the financial and community value of the site. Toward this goal, Canada Lands Company in partnership with the City of Ottawa and the Algonquins of Ontario, is preparing a Community Design Plan (CDP) to establish a broad planning framework to guide the development of the site. Involvement of the City, the surrounding communities, and the Algonquins of Ontario as partners in this process is intended to ensure that the CDP and ultimately the redeveloped site meet and exceed planning policy and best practices. The CDP will set out the broad framework for those subsequent more detailed planning applications and approvals.

Canada Lands Company is renewing a planning and consultation process which was conducted between 2005 and 2007. In 2007, work was ceased on the project due to ongoing land claim negotiations between the federal government and the Algonquins of Ontario First Nation. In 2010, a Participation Agreement was reached between Canada Lands Company and the Algonquins of Ontario, in collaboration with the Government of Canada. Following acquisition of the site by Canada Lands Company in 2011, Canada Lands Company reinitiated planning and design efforts for the former CFB Rockcliffe.

Existing Conditions Reports have been prepared for other study disciplines under separate cover. The content of this report is intended to provide an overview of existing conditions from the perspective of water resources and stormwater management (SWM) to provide context and direction for the development of the Former CFB Rockcliffe site using Low Impact Development (LID) as part of a demonstration project in cooperation with the City of Ottawa.

This report aims to describe the project context and the existing environmental conditions as they relate specifically to SWM in addition to providing direction for future studies and next steps.

2.1 REPORT PURPOSE

This report serves to summarize the following:

1. Characterisation of Existing Conditions - to summarize the existing conditions as they relate specifically to the water resources and stormwater management (SWM) of the Former CFB Rockcliffe CDP (Section 3).

2. Overview of the Conceptual SWM System Concept and Details - per the MSS (IBI, 2015) (Section 4).

3. LID Demonstration Project - to provide a scope for the Low Impact Development (LID) demonstration project which is proposed for the Former CFB Rockcliffe CDP (Section 5).

Existing Conditions

The existing drainage features within the study area summarized in Section 3 AND include study area geology, hydrogeology, surface water features, existing drainage (major drainage system, minor drainage system, system outlets), hydraulics, hydrology, fluvial geomorphology, aquatic and terrestrial ecology relating to water resources and stormwater management (SWM) of the Former CFB Rockcliffe CDP site.

Descriptions and mapping of the area geology, hydrogeology, surface water features, existing drainage (major drainage system, minor drainage system, system outlets), hydraulics, hydrology, fluvial geomorphology, aquatic and terrestrial ecology as well as an overall summary are presented in Section 3.0.

Overview of the Conceptual SWM System Concept and Details

As detailed in the Master Servicing Study (MSS) an integrated environmental assessment and planning process has been completed by IBI (2015) under separate cover.

Section 4.0 of this document provides a summary of the conceptual SWM system systems concepts as detailed within the MSS. The summary presented herein is not intended to be comprehensives, rather to provide context for the development of the LID Demonstration Project.

For more detailed information in regards to the analysis, modelling, function, phasing and infrastructure sizes etc., refer to Section 6.0 of the MSS (IBI, 2015).

LID Demonstration Project

The City of Ottawa and CLC have agreed to pursue a phased stormwater management demonstration project for the former CFB Rockcliffe using LID Best Management Practices (BMPs). An integral component of this process is the City of Ottawa and CLC's desire to advance the Rockcliffe CDP as a demonstration (or pilot) project for Low Impact Development (LID).

- CLC`s Goal – is for the Former CFB Rockcliffe development to be a model community for LID.
- City of Ottawa`s Goal – is to implement LID as part of development, monitor, gain experience, answer key questions and build capacity in a phased and controlled setting with a willing partner.

Overview of LID

LID is an innovative state of the art approach to managing stormwater by first and foremost treating runoff (precipitation) at its source, as a resource to be managed and protected rather than a waste. In this regard, the emphasis in managing runoff is to retain/maintain the existing infiltration of water into the ground by managing runoff through lot level (source) and conveyance (street level) measures using what is referred to by the Ministry of the Environment (MOE) as a "treatment train" approach to stormwater management. LID measures implemented on individual lots, and combined with additional LID measures within road rights-of-way (ROW) encourage infiltration and reduce the quantity of runoff reaching local drainage features.

LID Demonstration Process

As part of the pursuit of the phased stormwater management demonstration project for the former CFB Rockcliffe using LID, traditional servicing and LID alternatives were reviewed in parallel as two independent, but interrelated, studies. This was done recognizing that LID alternatives would be identified for implementation on a trial basis, phase by phase. To maintain this flexibility, the LID alternatives were evaluated independently by Aquafor Beech. The two independent, but interrelated, studies include:

1. CFB Rockcliffe (MSS) Master Servicing Study (IBI, February 2015) – under separate cover.
2. Stormwater Management Existing Conditions & LID Demonstration Project Scoping Document (Aquafor Beech, February, 2015) – this document.

This report should be read in parallel with this MSS document.

CFB Rockcliffe (MSS) Master Servicing Study (IBI, February 2015)

The MSS has been completed using sound engineering principles in the development of the preferred stormwater solution applying conventional stormwater practices including, but not limited to, piped stormwater infrastructure and stormwater management facilities. The preferred stormwater solution using conventional stormwater practices has been developed in accordance with regulatory requirements to service the proposed development as a stand-alone system and to accommodate the potential LID practices identified in the second independent study detailed below.

Stormwater Management Existing Conditions & LID Demonstration Project Scoping Document (Aquafor Beech, February, 2015)

The 'LID Pilot Project Study' is intended to permit the implementation, monitoring, and evaluation of alternative stormwater management systems based upon the principles of Low Impact Development (LID). The work program for the LID Stormwater Pilot Project Study was developed in consultation with the City of Ottawa and will provide direction for the implementation of LID controls in parallel with the conventional storm servicing presented in the MSS.

A SWM Working Group has been formed, consisting of key members of the City of Ottawa, CLC staff, and consultants engaged by CLC. The SWM Working Group will:

- Make recommendations
- Determine the information required to design the integrated LID SWM system
- Determine the information to be collected during the monitoring programs
- Review the collected monitoring data from each successive phase of development
- Determine the type and extent of the stormwater management 'credits' to be applied to subsequent phases of development and servicing for water quality, water quantity, erosion and water balance control. The credits will be based on the cumulative collected monitoring data from each successive phase of development

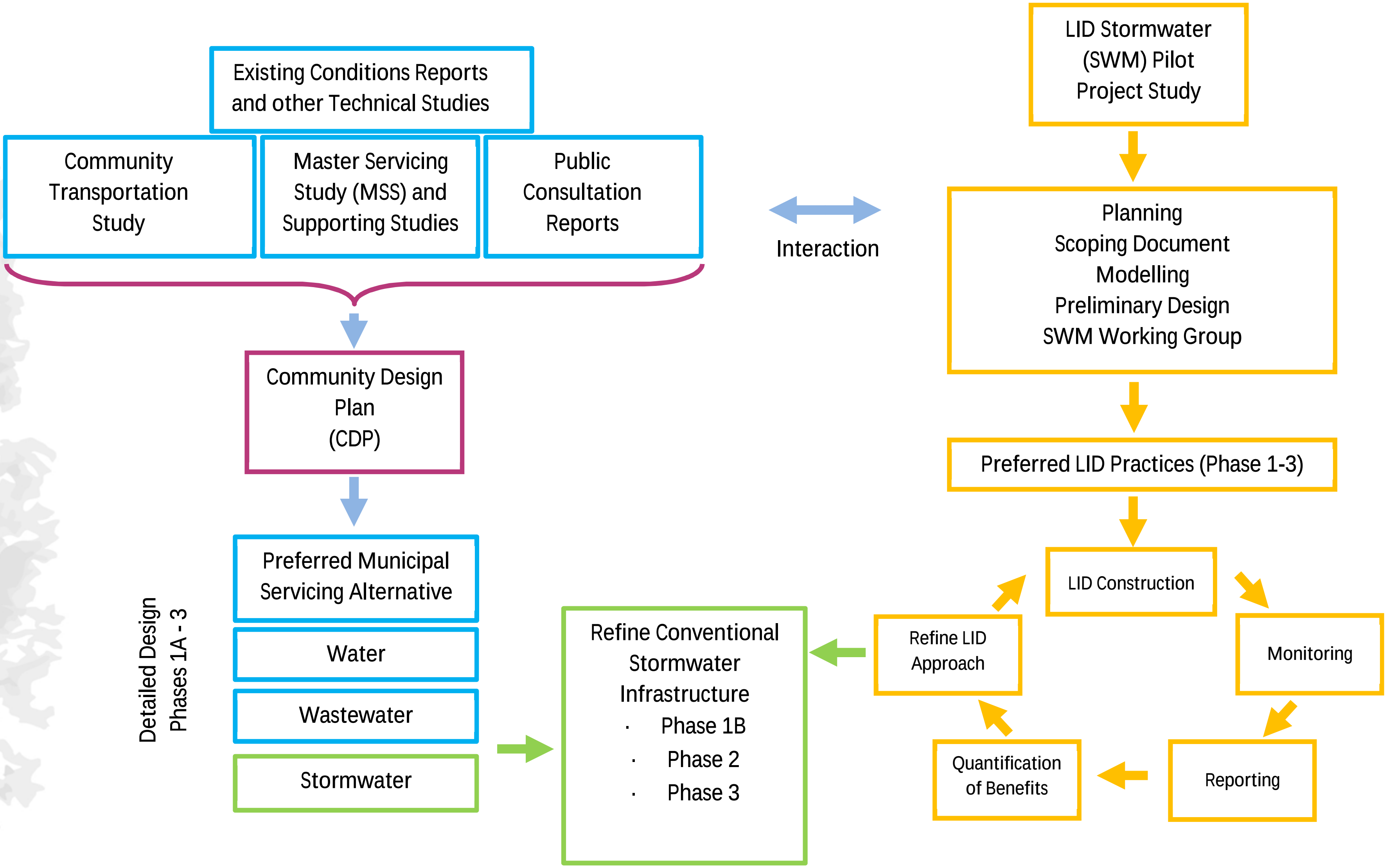
The proposed LID implementation process for former CFB Rockcliffe was developed using a phased Adaptive Management System (AMS) approach whereby a science-based methodology is developed and applied to understand and quantify the function, potential benefits and drawbacks from the proposed LID approaches. In this regard, each phase of potential LID implementation corresponding to the phases of development will involve the completion of six (6) steps:

1. Planning (subject of the LID SWM Demonstration Project Study)
2. Construction
3. Monitoring
4. Reporting
5. Quantification of benefits
6. Refinement of the LID approach prior to the subsequent phase of LID implementation

Steps 5 and 6 (Quantification of benefits and Refinement) are critical process elements, allowing 'real-world' results to be communicated to and vetted by City of Ottawa staff and agencies and subsequently translated into direction for both the refinement of future LID implementation and refinement of the conventional storm servicing presented in the MSS. In this manner, it is only the quantifiable benefits that will influence stormwater servicing of former CFB Rockcliffe.

The LID SWM Pilot Project Study report should be read in parallel with this MSS document as it relates to storm sewer servicing. Furthermore, forthcoming monitoring reports which quantify the performance of LID practices as it relates to water quality, water balance, volume, and peak flows should also be considered and related to the aforementioned two independent documents. The implementation of stormwater servicing for redevelopment of former CFB Rockcliffe will be flexible and realizes that stormwater BMPs, techniques and approaches will change as the knowledge base advances, that future phases and associated monitoring will refine the findings from the MSS and LID SWM Demonstration Project Study and that this overall stormwater servicing approach is not static.

An overall study process is detailed in the diagram below. It summarizes the MSS, CDP, LID SWM Demonstration Project Study and the proposed LID implementation process for former CFB Rockcliffe and uses the AMS approach. Additional information relating to the LID demonstration project is presented in Section 5.



Overall Study Process

2.2 POLICY CONTEXT

The following describes the policy framework governing the study area, specifically, the Provincial Policy Statement (PPS) and the City of Ottawa Policies. Where relevant, Provincial and agency policies are highlighted.

The Provincially Policy Statement (PPS)

The Provincial Policy Statement (PPS) establishes a broad vision for how communities should grow over time. To ensure that the policies in the PPS are applied in all communities as a key component of the planning process, the Planning Act requires that all decisions affecting land use planning matters "shall be consistent with" the PPS. This also means that all local Official Plans are to be prepared to be consistent with the PPS.

The PPS provides policy direction on matters of provincial interest related to land use planning and development. It sets the policy foundation for regulating the use of land. Regional and Municipal OPs are to build on this policy foundation with more detailed policy direction that is consistent with the PPS policies.

In regards to Infrastructure and Public Service Facilities, Section 1.6.2 of the PPS states that Planning authorities should promote green infrastructure to complement and augment infrastructure.

The PPS defines Green Infrastructure as natural and human-made elements that provide ecological and hydrological functions and processes. Green infrastructure can include components such as natural heritage features and systems, parklands, stormwater management systems, street trees, urban forests, natural channels, permeable surfaces, and green roofs.

In regards to stormwater, Section 1.6.6.7 of the PPS states that "Planning for Stormwater Management shall:"

a) minimize, or, where possible, prevent increases in contaminant loads;
b) minimize changes in water balance and erosion;

c) not increase risks to human health and safety and property damage;
d) maximize the extent and function of vegetative and pervious surfaces; and
e) promote stormwater management best practices, including stormwater attenuation and re-use, and low impact development.

In regards to water resources (Section 2.2) specifically, Section 2.2.1 of the PPS (2014) states that: "Planning authorities shall protect, improve or restore the quality and quantity of water by:

f) using the watershed as the ecologically meaningful scale for integrated and long-term planning, which can be a foundation for considering cumulative impacts of development;
g) minimizing potential negative impacts, including cross-jurisdictional and cross-watershed impacts;
h) identifying water resource systems consisting of ground water features, hydrologic functions, natural heritage features and areas, and surface water features including shoreline areas, which are necessary for the ecological and hydrological integrity of the watershed;
i) maintaining linkages and related functions among ground water features, hydrologic functions, natural heritage features and areas, and surface water features including shoreline areas;
j) implementing necessary restrictions on development and site alteration to:
   1. protect all municipal drinking water supplies and designated vulnerable areas; and
   2. protect, improve or restore vulnerable surface and ground water, sensitive surface water features and sensitive ground water features, and their hydrologic functions;
k) planning for efficient and sustainable use of water resources, through practices for water conservation and sustaining water quality;
l) ensuring consideration of environmental lake capacity, where applicable; and
m) ensuring stormwater management practices minimize stormwater volumes and contaminant loads, and maintain or increase the extent of vegetative and pervious surfaces.

Section 2.2.2 of the PPS (2014) states that: Development and site alteration shall be restricted in or near sensitive surface water features and sensitive ground water features such that these features and their related hydrologic functions will be protected, improved or restored.

Mitigative measures and/or alternative development approaches may be required in order to protect, improve or restore sensitive surface water features, sensitive ground water features, and their hydrologic functions.

City of Ottawa Policies

The City of Ottawa Official Plan (2003) contains policies for Maintaining Environmental Integrity (Section 2.4) and Environmental Protection (Section 4.7) which contain relevant policies for the provision of stormwater management controls including LID controls. Relevant policies have been summarized below:

Section 2.4 - Maintaining Environmental Integrity ensures the protection and enhancement of the quality of the environment in the city by:

- Improving air quality and reducing greenhouse gas emissions;
- Identifying and protecting natural features;
- Planning on the basis of the natural systems defined by watersheds;
- Managing groundwater resources;
- Planning for forests and other greenspaces.

Section 2.4.1 Air Quality & Climate Change the City will take measures to adapt to the effects of climate change by:

Policy 3d) Reducing the urban heat island effect through landscaping, tree planting, and encouragement of courtyards and innovative green spaces with permeable surfaces and trees and of green building measures such as the use of green roofs, living walls and light coloured building materials

Section 2.4.2 – Natural Features & Functions addresses both natural features as well as natural functions, including groundwater recharge, provision wildlife habitat, temperature moderation, and the natural cleansing and filtration of surface water. Section 2 b) ensures protection of the NHS by Protecting the quality and quantity of groundwater.

Section 2.4.4– Groundwater Management ensures the protection, improvement and restoration of quality and quantity of groundwater. It acknowledges that groundwater contributes to the baseflow of streams as well as to the quantity and quality of potable well-water.

Section 2.4.5 – Greenspaces acknowledges that greenspaces come in many forms including the casually tended grass around stormwater management ponds.

Section 4.7 – Environmental Protection ensures that lands be developed in ways that support natural features and functions on individual sites and across large new development areas for the following objectives:

- Increasing forest cover across the city;
- Maintaining and improving water quality;
- Maintaining base flows and reducing peak flows in surface water;
- Protecting and improving the habitat for fish and wildlife in stream corridors;
- Protecting springs, recharge areas, headwater wetlands and other hydrological areas;
- Managing resources by using low-maintenance, natural solutions.

This section of the City OP is based on design with natural principles.

Section 4.7.3 – Erosion Prevention & Protection of Surface Water ensure the protection of stream corridors and the surface water environment, such that the dual purpose of preserving and enhancing the environmental quality of stream and river corridors and their aquatic habitat, as well as reducing risks from natural hazards associated with watercourse.

Policy 11 - Under the Development, Interference with Wetlands and Alterations to Shorelines and Watercourses Regulation, pursuant to the Conservation Authorities Act of Ontario, the approval of the Conservation Authority is required for works such as site grading, the placement of fill, the alteration of existing channels of watercourses, and certain construction projects.

Policy 13 - An erosion and sediment control plan will be provided that shows how erosion on the site will be minimized during construction through application of established standards and procedures. Measures to maintain vegetative cover along the slope during and after construction will be addressed.

Policy 14 - Natural watercourses should be maintained in their natural condition. Where an alteration is assessed as being environmentally appropriate and consistent with an approved subwatershed plan, environmental management plan or a storm water site management plan, watercourse alterations must follow natural channel design and meet relevant federal, provincial and agency regulations.

Policy 15 - Development and site alteration will not be permitted in fish habitat except in accordance with federal and provincial requirements. Development applications near or adjacent to water bodies that provide fish habitat will be required to demonstrate that the proposed development will not have a negative impact on fish habitat. Fish habitat is defined as those areas on which fish depend directly or indirectly to carry out their life processes. Fish habitat includes spawning grounds, nursery and rearing areas, areas that supply food, and features that allow migration. In the event that a negative impact is unavoidable, the proposal must be reviewed and authorized by the federal Department of Fisheries and Oceans (DFO).

Section 4.7.6 – Stormwater Management ensures planning in completed on a watershed and subwatershed basis pursuant to Section 2.4.3 and confirms that the City will implement the recommendations of the relevant watershed, subwatershed or environmental management plan and require that stormwater site management plans be submitted in accordance with the guidance set out in the environmental management, subwatershed and watershed plans.

Policy 1 - A stormwater site management plan will be required to support subdivision and site-plan applications.

Policy 2 - Stormwater site management plans will be prepared in accordance with the guidance set out in a subwatershed or watershed plans (see Section 2.4.3). Generally, stormwater site management plans will include details on subdivision management, specific best management practices for stormwater, erosion and sediment control, and details for enhancement and rehabilitation of natural features. Where no subwatershed plan or environmental management plan exists, the City will review stormwater site management plans to ensure that:

n) Flows are not altered in a way that would increase the risk of downstream flooding or channel erosion in the receiving watercourse or municipal drain;

o) Base flow in the watercourse is not reduced;
p) The quality of water that supports aquatic life and fish habitat is not adversely affected;
q) The quality of water that supports water-based recreational uses is not affected;
r) Natural habitat linkages that are located in or traverse the site are maintained or enhanced;
s) Groundwater is not negatively impacted;
t) Any other impacts on the existing infrastructure or natural environment are addressed in a manner consistent with established standards and procedures;
u) Objectives related to the optimization of wet weather infrastructure management are realized.

Policy 3 - In areas of intensification the City will encourage new development or redevelopment to incorporate on-site stormwater management and/or retention measures. Where onsite measure cannot be provided other alternative measures identified in the document 'Managing Capacity to Support Intensification and Infill' contained in Section 6 of the Infrastructure Master Plan may be considered.

Policy 4 - Where insufficient stormwater and/or sewer capacity is available to support the development the proponent may be required to contribute to the advancement of any relevant sewer rehabilitation project of the City and/or undertake the rehabilitation of the sewer system on the City's behalf.

Provincial, Agency & City of Ottawa Stormwater Management Criteria

The design of stormwater management systems shall be in accordance with the relevant Provincial, Agency and City of Ottawa standards, per the following documents:

- The MOE Stormwater Management Planning and Design Manual (March 2003)
- City of Ottawa Sewer Design Guidelines (November 2004) and Technical Bulletin ISDTB-2012-4 (June 2012)

Relevant criteria have been summarized in Table 1.

Table 1: Relevant SWM Criteria

Criteria	Source
The 5 year flow (or the 10 year flow from arterial roads and Transitway corridors) is conveyed by the storm sewers. Storm sewer sizing is based on rational method with an initial time of concentration of 10 minutes.	City of Ottawa, MOE
Inlet control devices (ICDs) are utilized to control the surcharge in the minor system during infrequent storm events, as well as to maximize use of available surface ponding.	City of Ottawa
Surface ponding on roads and in parking lots is utilized during events less frequent than the 5 year event to a maximum depth of 0.3 m (includes static and dynamic depth).	City of Ottawa

Criteria	Source
The SWM facilities control flow to meet existing conditions levels in receiving creeks for 2, 5, 100 year storm events.	MOE, Conservation Authority
SWM facility storage volumes provide an Enhanced Level of Protection, corresponding to a long-term average removal of 80% of suspended solids.	MOE
The fluvial geomorphological assessment is to be completed to inform erosion control and baseflow requirements.	City of Ottawa
A sensitivity analysis is to be completed to determine the most critical storms. The City of Ottawa provides IDF curves; Chicago, AES, and SCS storm distributions; historical storms; and stress test requirements. The MOE Manual	City of Ottawa, MOE

Criteria	Source
provides guidelines on establishing water quality targets.	
The aquatic/terrestrial habitat assessment to be completed to inform whether temperature mitigation measures are required for outflow from SWM facilities.	City of Ottawa
Where feasible, structural and non-structural BMPs are to be implemented across the development.	City of Ottawa
A water balance is to be completed, informed by a hydrogeological report.	City of Ottawa

2.3 OVERVIEW OF EXISTING LAND USE

The Rockcliffe site has had a long and historic life as a military base, rifle range, aerodrome and experimental photography station and was home to more than 600 residential dwellings.

The following information was retrieved through the Canada Lands Company's archives. The Rockcliffe site long history began in 1898, when CFB Rockcliffe was originally established by the Department of National Defense (DND). In 1920 the Ministry of National Defence Air Board approved redevelopment of the rifle range as an aerodrome and experimental photography station and expanded the land holdings which grew to approximately 183ha (453 acres). At its peak, following World War II, land holdings totalled more than 326ha (800 acres) and approximately 600 housing units were built on the airbase to accommodate the short-term needs of returning military personnel.

In 1989, CFB Ottawa North (Rockcliffe) was reduced in size and occupancy, as a result of implementation of the Infrastructure Adjustment Program (IAP). The residential component of the Base was, however, to be retained for the following five to ten years.

In 1996, following the identification by the Treasury Board Secretariat (TBS) that CFB Rockcliffe was a potential "managed land disposal" candidate, the lands were transferred to the Canada Lands Company for redevelopment.

In 1999, following the completion of an existing conditions analysis by CLC, the Rockcliffe site had some 599 residential dwelling units in 469 buildings on the Former CFB Rockcliffe CDP site, with total a population of 1,510.

The ownership of the former CFB Rockcliffe was officially transferred to CLC in 2011. Since the official closure of CFB Rockcliffe in 2009, all of the buildings and houses on the site have been demolished. Today the total area of the Former CFB Rockcliffe CDP site is approximately 131ha (Figure 1).

Legend

Site Limits

Aquafor Beech Limited

Canada Lands Company
Société Immobilière du Canada

Rockcliffe Redevelopment

Project Area Delimitation

Figure 1

2.4 OVERVIEW OF PROPOSED LAND-USE

The vision statement for the "Former CFB Rockcliffe" as stated in the draft Community Design Plan (CDP) is the following:

"The redevelopment of the former Canadian Forces Base (CFB) Rockcliffe will be a contemporary mixed-use community. It will be walkable, cycling-supportive, transit-oriented and built at a human scale. These principles will be realized through improved connectivity to the surrounding neighbourhoods, and by providing access to open space for everyone. The site will connect to the history of the Algonquin people. It will celebrate its military heritage. Redevelopment of the former CFB Rockcliffe will demonstrate urban design and landscape excellence, innovation in sustainability, cultural/social dynamism, and a high quality of life. It will be forward-looking in its development approach by integrating the site's natural ecological functions into the design"

Upon completion the Former CFB Rockcliffe CDP site will be a mixed-use community with integrated:

- Residential,
- Retail,
- Employment,
- Open space, and
- Recreational development.

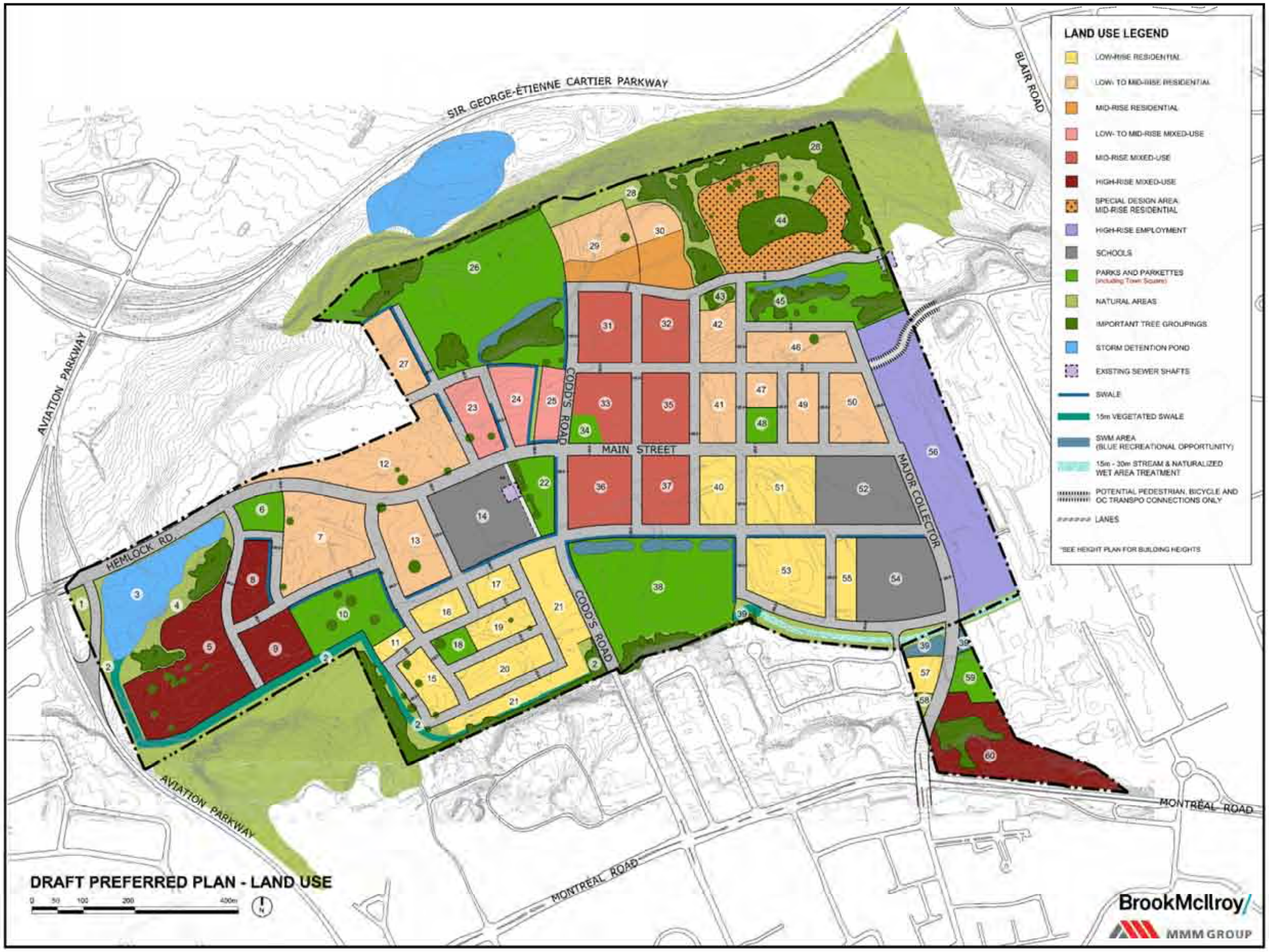
Active transportation and Low Impact Development (LID) stormwater management will be two of the key elements in the integration of sustainable development with the natural systems on and surrounding the site.

Land Use

The mixed-use community of the Former CFB Rockcliffe CDP site will contain sixty-one (61) development blocks (See Figure 2). Table 2 summarizes the proposed land uses as part of the overall plan.

Table 2 – Proposed Land Uses

Land Uses	Area (ha)	% of Total
Low-Rise Residential	25.60	19.5%
Mid-Rise Residential	3.02	2.3%
Low-Rise Mixed-Use	3.56	2.7%
Mid-Rise Mixed-Use	13.17	10.0%
High-Rise Mixed-Use **	7.17	5.5%
Low-Rise Retail**	0.86	0.7%
School	6.77	5.1%
Employment	6.33	4.8%
Parks	18.93	14.4%
Natural Areas	6.21	4.7%
SWM Features	5.31	4.0%
Important Tree Groupings	10.07	7.7%
Roads	24.30	18.5%
Lanes	0.1	0.1%
Total Estimated Land Uses	131.4	100%
** Some Employment and Retail Parcels listed on sheet "BLOCKS" are within Mixed-Use blocks, and do not count toward the Total Estimated Land Use Areas		



Scale	Project Title	Drawing Title	Sheet No.
NTS	FORMER CFB ROCKCLIFFE LID PILOT PROJECT SCOPING	PREFERRED CONCEPT PLAN	FIGURE 2.0

2.5 GEOGRAPHICAL CONTEXT

The boundaries of the Former CFB Rockcliffe CDP site (study area) are situated on a plateau overlooking the Ottawa River and Gatineau Hills.

The Former CFB Rockcliffe CDP site (Figure 1) which is the subject of the Community Design Plan (CDP) totals some 131 hectares, divided accordingly:

- 125.3 hectares owned by the Canada Lands Corporation (CLC)
- 5.3 hectares owned by the National Research Council (NRC)

The site is bordered on the:

- North by the Aviation Parkway, Ottawa Rockcliffe Airport and the Canada Aviation and Space Museum.
- East by NRC lands which occupies two parcels of land (approx. 154 ha) with frontage on Montreal Road and extend south form the Rockcliffe Parkway, across Montreal Road, to Ogilvie Road.
- South and west by the Monfort Hospital and the Montfort Woods (an environmentally sensitive feature) and the established community of Fairhaven.

Other established neighborhood, namely, Rockcliffe-Manor Park and Rothwell Heights-Beacon Hill lie immediately to the west and east respectively.

The site can be accessed at three (3) locations:

- Codds Road from the south
- Hemlock Road from the west
- Douglas Street (through the NRC) campus from the east.

2.6 SUBWATERSHED CONTEXT

The Former CFB Rockcliffe CDP site is located within the Ottawa River East Tributary Subwatershed which drains directly to the Ottawa River (Figure 3). At present there does not exist a formal watershed plan, stormwater management criteria or targets for this subwatershed.

Within the Ottawa River East Tributary Subwatershed there are numerous smaller local catchments as defined by the City of Ottawa. The largest of which is designated as Military 1.

The vast majority of the Former CFB Rockcliffe CDP site is contained within Military 1, with a small portion located within Military 2 and catchment number 04271 (Figure 3).

2.7 LOCAL CLIMATE

The City of Ottawa has a humid continental climate. According to Environment Canada's 1981- 2010 Climate Normals for the Ottawa International Airport, the city has a mean annual temperature of 6.3 °C, with an average temperature of -10.3 °C in January and 21.0 °C in July. Normal annual precipitation is 943 mm, most of which falls as rain. Normal total annual snowfall for the 1981-2010 period is 222 cm.

Legend

Site Limits

Catchment Boundaries

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Canada Lands Company
Société Immobilière du Canada

Rockcliffe Redevelopment

Catchments Delimitations

Figure 3

CHARACTERISATION OF EXITING CONDITIONS

3.1 GEOLOGY

The following section provides an overview of the geology of the Former CFB Rockcliffe CDP site and further describes the surficial geology and bedrock geology. Figure 4 - Surficial Geology is reproduced from St. Onge (2009), supplemented with the DST logs and surface plans.

Surficial Geology

The geology of the area is summarized as follows, the Former CFB Rockcliffe CDP area from oldest to youngest (see Fulton, 1987) and Figure 4 (from St. Onge, 2009):

- Bedrock is grey flat-lying limestone, generally unweathered except for the upper 1 metre;
- The basal overburden consists of discontinuous remnants of till, composed of sand (average 67%), silt (average 26%) and clay (average 7%) with some gravel, olive to brown in colour (Kettles and Shiltz, in Fulton 1987);
- Much of the area is covered by Champlain Sea marine deposits of clay, silty clay and silt, commonly calcareous and occasionally overlain by a thin veneer of sand. Most of the clay is, in fact, not clay minerals but clay-sized (<2 μm) rock flour of quartz, feldspar, carbonate and amphiboles from source bedrock (Scott, 2003);
- Post Champlain Sea deposits consist of stratified sand with some silt, formed on fluvial terraces and in channels cut in marine clay, including former sand bars and spits (Gadd, in Fulton, 1987);
- The area marked “Landslide” on Figure 4 is a historic landslide scar mapped by the Geological Survey of Canada (Klugman and Chung, 1976)i. There was also a major landslide on April 3, 1967, involving some 30,000 cubic yards of clay at CFB Rockcliffe that slipped into the Ottawa River

(Mitchell, 1970). This event occurred when early snow cover in autumn prevented frost penetration. A major snow melt (about 20 inches) was accompanied and followed by heavy rainfall. The level clay terrace of CFB Rockcliffe slid into the Ottawa River. Geotechnical investigations in 2006, 2013 and 2014 by DST drilled a series of boreholes within this "Landslide" area. Boreholes BH9 and BH12 from the 2006 report, boreholes BH13-10 and BH13-11 from the 2013 geotechnical investigation and boreholes BH14-39 and BH14-38 completed in 2014, do not indicate weak native materials from the geotechnical point of view. Both the steepness and height of slopes are important factors influencing stability.

- The area marked "Pa" on Figure 4 is characterized by shallow overburden (thickness less than 2 metres) over Paleozoic limestone bedrock (Bélanger 2008), that covers approximately 17% of the site; and,
- Elsewhere on the site, overburden thicknesses are up to 10 metres (Belanger, 2008).

Site Stratigraphy

The Former CFB Rockcliffe CDP site contains variable thicknesses and types of overburden materials overlying the bedrock. A shallow overburden soil condition (defined as less than 2 m of overburden thickness overlying bedrock) exists in several areas, covering approximately 17% of the site. In other areas of the site the overburden thickness ranges from greater than 2m to about 10m.

The native overburden comprises clay to silt marine deposits over the Southern half of the site, silty to sandy till plain in parts of the Western and Northern portions of the site, and sand/silt alluvial sediments forming parts of the Western portion of the site (Figure 4). Various fill materials are present from previous anthropogenic activities at the Former CFB Rockcliffe CDP site.

The generalized surface geology of the NCC-owned land between the Former CFB Rockcliffe CDP site and the Rockcliffe Parkway comprises marine sediments (clay/silt, sand) and fill material, with an overburden thickness of greater than 10m.

Overburden Units

The following generally describes the overburden soil units at the Former CFB Rockcliffe CDP site.

Surficial Material and Topsoil - Grass and other organic material with roots extending about 10 cm below grade is present over much of the site, with topsoil extending up to about 20 cm in depth. Asphalt, with a thickness of about 10 cm, is present on existing roads and driveways.

Fill Material - Fill material consisting of silty sand, sand and gravel or clay is known to be present in various areas of the site. During previous field investigations by DST, fill was identified at many formerly development areas of the site, with fill thickness ranging from approximately 0.5 to 4.3 m (DST, 2006). Localized fill thickness greater than the observed values may exist. Fill material was also observed in several boreholes North of the site, at the bottom of the escarpment. There the fill, approximately 1 to 4 m thick, consists of compacted grey to orange coloured silt with sand and gravel. Concrete and asphalt materials were encountered within the fill

Clay - Grey-coloured silty clay is the dominant natural overburden type in the central and Southern portion of the Former CFB Rockcliffe CDP site. The clay layer extends from near surface to a depth of more than 6 m in the south and thins out to the northeast and north where it overlies silty till deposits at depths of 1 to 2 m. Grey-coloured clay to silty clay with minor silt, sand and gravel was encountered in the NCC land north of the escarpment.

Till - The Northern and Eastern portion of the site is generally underlain by till material consisting of grey-coloured compact silt, sand and minor gravel. Where encountered during previous drilling, the till is 1 to 3 m thick, underlying several metres of fill material.

General Summary of Overburden Units

In summary, the generalized stratigraphy for the east side of the site consists of asphalt surface treatment underlain by granular sand and gravel which is again underlain by silt or clay layer followed by bedrock. The generalized stratigraphy for the west side of the site consists of a thin layer of topsoil underlain by silty clay and sand and gravel layers followed by possible bedrock. Figure 4A identifies the general location of the site overburden materials including clay and silt/sand; clay and sand/silt/gravel regimes.

Bedrock Geology

The Former CFB Rockcliffe CDP site location is underlain by bedrock from the upper Ordovician Formations, mainly East View Formation and Ottawa Formation (Urban Geology of Canadian Cities, GAC Special Paper 42) (Figure 5). Rocks types in the East View Formation include shale, limestone, dolostone and siltstone. Rock types in the Ottawa Formation include limestone with some shaley partings and some sandstone in the basal part.

Williams (1991) subdivided the Ottawa Formation defined by Wilson (1946) into several formations such as Shadow Lake, Gull River, Bobcaygeon, Verulam and Lower Lindsay Formations. The formations, including East View Formation to Upper Lindsay Formation are often referred to as the Ottawa Group and middle to upper Ordovician in age (Belanger, 1998).

During previous field investigations by DST (see Appendix A), boreholes drilled into the bedrock at the Rockcliffe property typically encountered horizontally-bedded, grey crystalline to fossiliferous limestone with minor narrow shale bedding, interpreted to be of the Ottawa Group. Minor narrow silt-fine sandstone beds were encountered within the limestone unit in one borehole (BHMW 12, 2004). The bedrock surface is generally un-weathered, or has a narrow weathering zone, less than one metre thick and occasionally limonite-stained. The Northeastern portion of the Former CFB Rockcliffe CDP site contains blocky (jointed) limestone in the upper 5 m of bedrock, and fault gouge was observed at depths of about 2.5 m and/or 4.5 m in several boreholes in the northeast of the property. Figure 6 illustrates the bedrock contours of the Former CFB Rockcliffe CDP site as determined by subsurface investigations.

Rockcliffe Surficial Geology

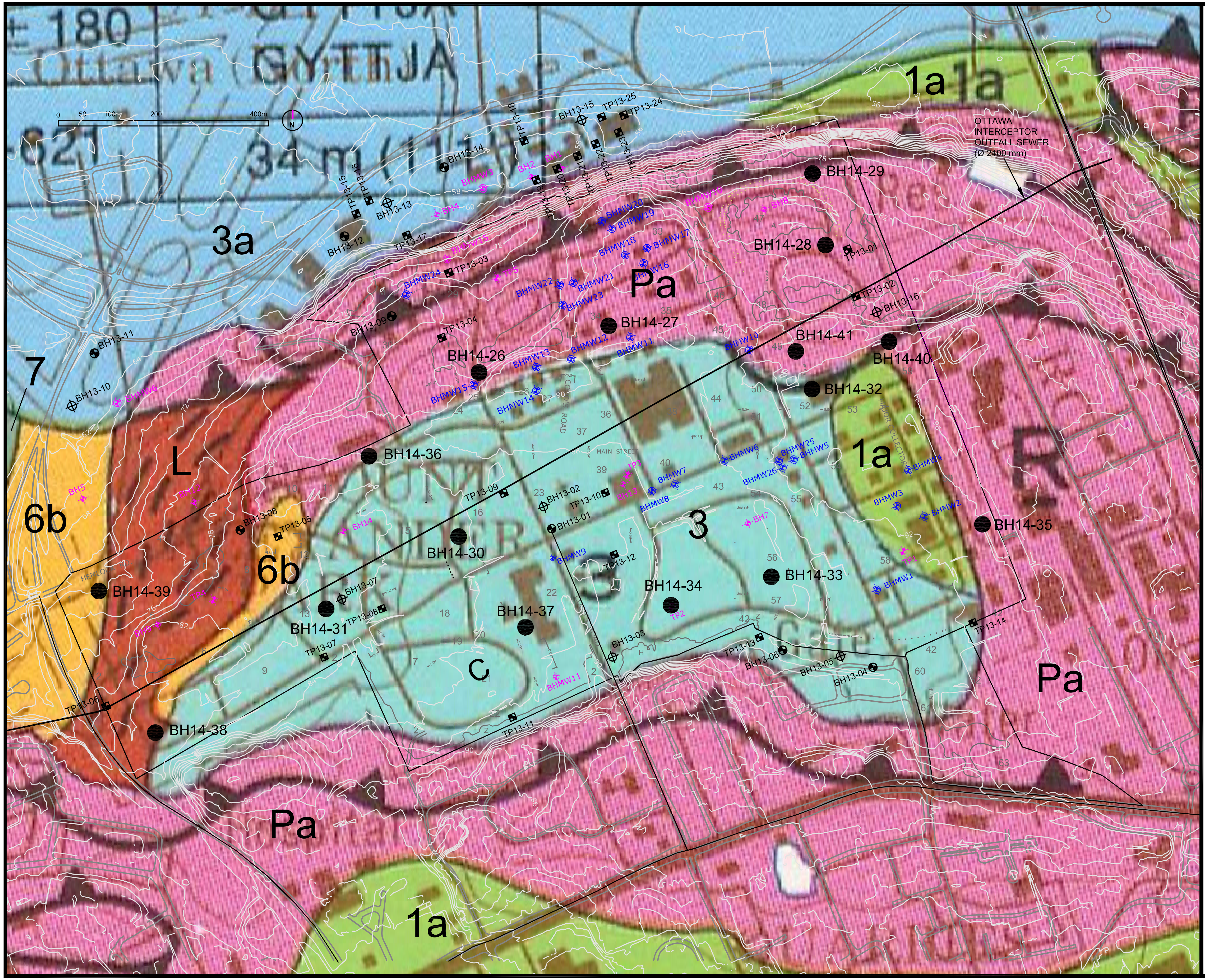


Figure 4

LEGEND

CENOZOIC–QUATERNARY

POST-CHAMPLAIN SEA DEPOSITS

7	***ORGANIC DEPOSITS:*** *mainly muck and peat in bogs, fens, swamps, and poorly drained areas.*
	ALLUVIAL DEPOSITS: *stratified sand, silt, minor gravel, disseminated organic matter, and marl.*
6a	*Silty sand, silt, sand, and clay; deposits of present floodplains and of alluvial fans in areas of low relief.*
6b	*Medium-grained, stratified sand with some silt; in the form of fluvial terraces and channels cut in marine clay, and bars and spits within abandoned channels.*

CHAMPLAIN SEA SEDIMENTS

	NEARSHORE SEDIMENTS: *gravel, sand, and coarser material, generally well sorted.*
5a	*Gravel, sand, and boulders; beaches commonly fossiliferous; nature of sediment controlled by underlying material (gravel, sand, and boulders where developed from till and glaciofluvial deposits; slabs and shingles where developed from sedimentary bedrock).*
5b	*Fine- to medium-grained sand, calcareous and commonly fossiliferous; nearshore sand generally occurs as a sheet or as bars or spits associated with glaciofluvial materials.*
4	***Deltaic and estuarine deposits:*** *medium- to fine-grained sand, in some places fossiliferous; lies outside abandoned channels; most common deposit is a combined strip delta-sand plain that developed as water levels fell.*
3	***Offshore marine deposits:*** *clay, silty clay, and silt, commonly calcareous and fossiliferous; locally overlain by thin sand. Upper parts are generally mottled or laminated reddish brown and bluish grey and may contain lenses and pockets of sand, but at depth the clay is uniform and blue-grey.*
3a	*Clay and silt underlying erosional terraces; upper part of marine deposits removed to variable depths by fluvial erosion so in places clay is uniform blue-grey; unit includes lenses, bars, and channel-fills to sand and pockets of nonmarine silt that were formed during terrace (or channel) cutting.*

GLACIAL DEPOSITS

2	***GLACIOFLUVIAL DEPOSITS:*** *gravel and sand, poorly to well sorted and bedded, mainly coarse- to medium-grained with numerous cobbles, boulders, and lenses of till, gravel and sand in the form of outwash plains, valley trains, kame terraces, outwash fans, and ridges; surface commonly pitted by closed depressions; occurs at or above marine limit (>200 m to 220 m) or subaqueous outwash sediments: sand, gravel, boulder gravel, and minor diamicton; locally fossiliferous; commonly capped by a discontinuous fossiliferous gravel and sand less than 2 m thick; interpreted as ice-contact stratified drift deposited below wave base in the Champlain Sea.*
	TILL: *sandy and silty compact diamicton, grey at depth, but brown where oxidized; calcareous where derived from sedimentary rocks and not leached; consists dominantly of lodgment till. In areas that lie below marine limit (approximately 200 m a.s.l.) it is overlain by a discontinuous lag consisting of gravel, sand, and boulders.*
1a	*Till, plain; local relief less than 5 m.*
1b	*Till, drumlinized.*
1c	*Till, hummocky to rolling; local relief 5–25 m.*

BEDROCK
PALEOZOIC

Pa	*Limestone, dolomite, sandstone, and locally shale; relatively flat-lying; mainly occurring as bare, tabular outcrops; includes areas thinly veneered by unconsolidated Quaternary sediments up to 1 m thick.*

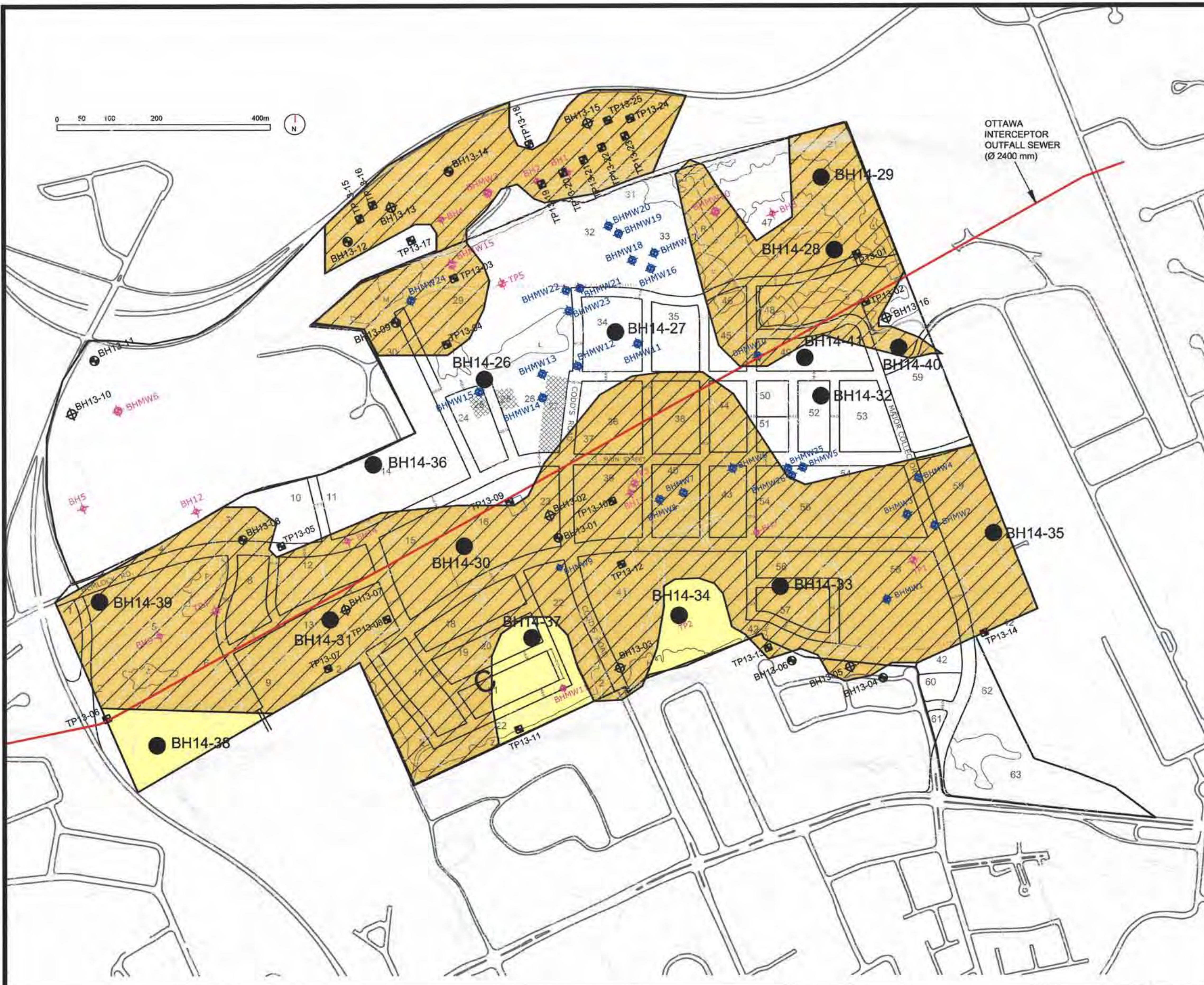
PRECAMBRIAN

Pr	*Intrusive and metamorphic rocks (Precambrian); mainly bare, hummocky, rolling or hilly rock knob upland; includes areas thinly veneered by unconsolidated sediments up to 2 m thick.*

SURFACE FEATURES

L	*Landslide area showing location of headscarp and general trend of slump ridges. Ridges generally consist of clay with overlying or admixed sand.*
	Dunes (largely stabilized) and sand deposits generally reworked by the wind.
	Dump.

Geological contact



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LEGEND:

- CLAY & SILT/SAND
- CLAY
- SAND/SILT/GRAVEL

REV	DATE	ISSUE	APPROVAL
0	APR. 10, 2014	Original	M.W.B.

PROJECT TITLE

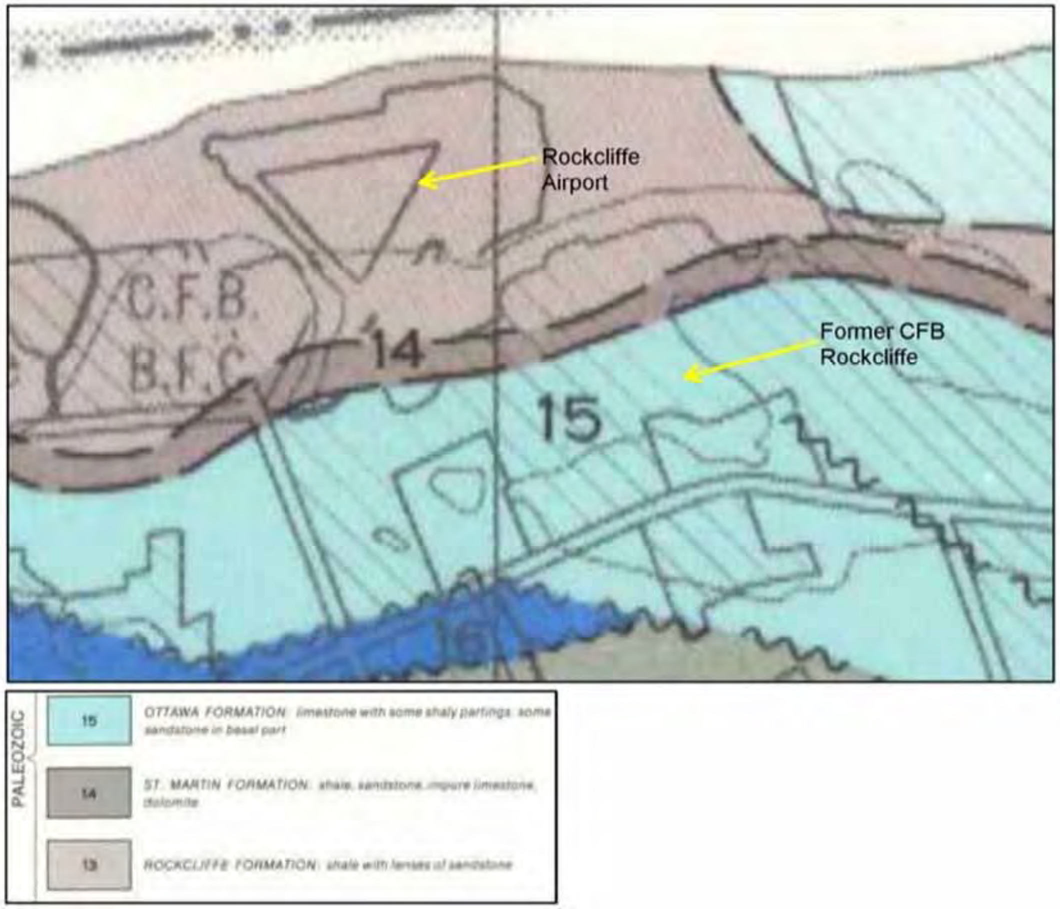
Geotechnical Investigation
Former CFB Rockcliffe
Ottawa, Ontario

DRAWING TITLE

OVERBURDEN MATERIALS

DESIGNED BY	SCALE
B.V.	As Shown
DRAWN BY	DATE
M.L.	APRIL 2014
APPROVED BY	PROJECT NO.:
M.W.B	OE-OT-015358

Figure 4A



Hydrogeological Report
Stormwater Management Support Studies
Former CFB Rockcliffe, Ottawa, Ontario
DST Reference No.: OE-OT-017184

Plate 4.2: Bedrock Geology of the Former CFB Rockcliffe Area.
(Generalized Bedrock Geology, GSC, 1976)

Figure 5 - Bedrock Geology

Rockcliffe Redevelopment

Bedrock Depth Contours

Figure 6

General Topography

The general topography of the Former CFB Rockcliffe CDP site is a gently downward slope northwards towards the Rockcliffe escarpment which runs east-west along the northern boundary of the site. The slope of the site increases to become steep at the escarpment. The elevation across the site ranges from about 70 to 90 m above sea level (asl). The base of the escarpment descends to approximately 55 m asl at the Rockcliffe Parkway, and about 45 m asl at the Ottawa River.

The majority of the Former CFB Rockcliffe CDP site was previously graded to level the land for development during its time as a military base.

Overburden Thickness

Geotechnical reports (Appendix A) suggest that sufficient overburden thickness exists across the Rockcliffe site to provide adequate rooting depth for plant material and general site drainage (Note: not referring to LID controls) with the exception of the northwest corner of the site which is characterized as having a thin overburden layer (Figure 6).

Soil Quality

The underlying silt/clay soils cover large portions of the site. These soils are composed mainly of silt rather than clay, and can make excellent planting soils as a result. This is evident in the rapid growth of trees on the site.

The pH of these soils is quite acidic (elevated above 7.5) in many areas because of the large amount of calcium they contain as a result of past construction and underlying limestone rock edges. This will require the planting of species which can tolerate elevated pH levels, and excludes many native plant types.

The cation-exchange capacity (CEC) of the soils is very good. This is evident by the high fertility of soils and the resulting good existing plant growth. CEC is a key soil parameter in regards to water quality performance of soils, specifically heavy metal capture and retention. Therefore, additional water quality performance of infiltration facilities can be expected to increase as infiltrated water passes through native soils.

Nutrient levels for the site are generally low, which means that certain shrubs and perennials may show deficiencies, and that plant selections may become important at the individual level. The higher levels of organic matter and CEC across the site will help balance these deficiencies. However, the use of fertilizers to compensate for low nutrient levels is not recommended within or adjacent to proposed SWM controls.

Maintaining Topsoil Quality

Finally, the presence of brown to grey coloured topsoil should be useful as planting soil. Areas of development will likely require the removal and stock pile of existing topsoil followed by reapplication post development for vegetated and turf areas.

To be a functioning, healthy soil it must have adequate pore space (i.e. porosity) to allow for the transport and storage of air and water (TRCA, 2012). When soil is compacted, porosity decreases and bulk density (dry mass divided by volume) increases, which affects the soil's ability to infiltrate and store water, limits diversity of soil organisms and nutrient uptake by vegetation, and impedes root growth.

Generally, once bulk density exceeds 1.7 grams per cubic centimetre (g/cm^3), roots are no longer able to penetrate through the soil (Morris and Lowery, 1988). Likewise, compacted soils have lower oxygen transfer, higher extreme summer temperatures, less nutrient retention, and less mycorrhyizal fungi compared to uncompacted soils (Bethenfalvay and Linderman, 1992).

For the purposes of the Former CFB Rockcliffe CDP site, general environmental stewardship practices for earthwork and soil management recommended by the American Association of State Highway and Transportation Officials (AASHTO) Center for Environmental Excellence should be considered (AASHTO, 2011). Regarding stockpiling and preserving topsoil the following best practices should be implemented (TRCA, 2012 adapted from AASHTO, 2011):

- Plant material and leaf litter generated by clearing the construction site of vegetation should be stockpiled separately from site topsoil. Large woody material (branches or trunks of 30 centimetres diameter or greater should be separated and set aside for use on natural heritage restoration sites. Remaining plant material and leaf litter should be processed and used as an organic material source for composting operations.

- Information regarding pre-construction topsoil depth (i.e. soil horizon A) over the construction site should be used to guide the depth to which topsoil is stripped to minimize incorporation of subsoil in stockpiles.

- All soils stripped during the first pass of equipment (if applicable) should be placed into topsoil stockpiles at locations designated on the Grading and Erosion and Sediment Control Plans.

- When stockpiling topsoil, mound soil no higher than 1.3 metres (4 feet) high for less than one (1) year and preferably less than six (6) months (AASHTO, 2011), where feasible. Cover with tarps or woven geotextile material to prevent soil erosion and contamination by weeds during storage. Alternatively, topsoil stockpiles can be stabilized by temporarily establishing groundcover vegetation composed of non-invasive species (see OIPC, 2011 for list of suitable groundcovers) either by application of seeded compost or seeded biodegradable mats. To help keep topsoil stockpiles contained, mounds should be completely surrounded by erosion and sediment control fencing or compost filter socks.

- Where space limitations necessitate higher mounds, topsoil stockpile mound height should not exceed three (3) metres where feasible (AASHTO, 2011). Stockpiling topsoil will result in the disruption and partial loss of beneficial soil organisms, and if stockpiled in mounds over 1.3 metres in height over a length of time greater than six (6) months, may result in total loss of soil organisms. When reapplying stockpiled topsoil from mounds of 1.3 metres in height or less, the top 30 centimetres of the mound should be mixed with the remainder of the stockpile to help distribute living soil organisms throughout the topsoil material (AASHTO, 2011). Topsoil stockpiled in mounds greater than 1.3

metres in height for longer than six (6) months should be amended with compost to re-establish healthy soil structure and help restore soil organism populations;

Soil Re-use within Infiltration Controls
Although soils at the Former CFB Rockcliffe CDP site are currently draining well it is not recommended that these soils be reused in the manufacturing of infiltration media (i.e. bioretention/ bioswale media) due to the relatively high proportion of fines (silts and clays).

Development Setbacks/ Slope Stability

From the DST report (Appendix A) entitled Community Designs Plan Geotechnical Investigation Former CFB Rockcliffe Development (June, 2014) the following has been summarized in regards to development setbacks and slope stability.

The footprint of the future building structures must be set a safe distance from the crest of the North Escarpment and the North Boundary of Blocks 4, 6, 27 and 31. Safe setback distances should be determined during the final investigation based on an assessment of the slope conditions.

For the purpose of this study, a preliminary opinion with respect to stable slope setback distance as it relates to development limits has been provided. The work is based on a limited visual observation and review of limited subsurface geology at the Former CFB Rockcliffe CDP site.

Based on the preliminary geotechnical investigation and limited subsurface boreholes, the generalized geology at the North Escarpment area (from East to West) is found to be variable and consists of the following:

1. Borehole/monitoring well location BHMW20: an upper shallow silty sand layer (~1.5m thick) underlain by limestone bedrock. The overburden at the toe of the slope is found to be variable comprising a sand layer (~3.7m) at borehole location BH5 and silt, gravel and clay (~4.6m) at borehole/monitoring well location BHMW6.

2. Borehole/monitoring well location BHMW15 overburden (soil)/bedrock (OB/BR): an upper shallow clay layer (~2.8m thick) underlain by limestone bedrock. The overburden at the toe of the slope is found to be variable comprising a gravel layer (> 6.1m) at borehole location BH3 and silt, sand, gravel underlain by clay (> 21.0m) at borehole location BH4.

3. Borehole/monitoring well location BHMW10 OB/BR: an upper shallow compact to dense sand fill layer and native sand layer (~4.4m thick) underlain by limestone bedrock. The overburden at the toe of the slope comprises silt and clay layers (> 11.4m) at borehole location BH1.

4. Borehole/monitoring well location BHMW8: an upper clay layer (~7.0m thick) underlain by limestone bedrock. The toe area has not been investigated at this location.

5. Boreholes BH13-12, BH13-13, BH13-14 and BH13-15: layer of sand and clay up to 12.2m depth, no refusal was encountered.

Considering these geotechnical factors, the presence of silty clay, sand silt and till, and observed bedrock conditions, a preliminary stable slope allowance of 3 to 4 times the height of bank is recommended for overburden slopes and 1 x time the height of bank is recommended for the underlying bedrock. The erosion allowance for the subject slope considering the subsurface soil materials encountered range from 5 to 10m for the overburden soil and up to 10m for the weathered bedrock. Thus the setback distances (stable slope allowance plus erosion allowance) for the subject site would range from 75 to 100 metres measured landward from the toe of the slope (See Figure 7, reproduced from Appendix A - Figure 10). To assess more accurately the setback distance further geotechnical investigation and slope stability analyses including an assessment of seismic effects (based on site classification of the site specific characteristics) will be required to confirm this preliminary assessment. The slopes should be monitored for any signs of instability. Should reduction of the setback be required, a site specific slope stability assessment should be carried out.

Any future slope stability analyses should be undertaken in accordance with the City of Ottawa document titled, "Slope Stability Guidelines for Development Applications".

Grade Raise

A geotechnical assessment has been completed by DST with the report entitled Community Design Plan Geotechnical Investigation for Former CFB Rockcliffe Development (June 2014) – Appendix A (1).

An assessment for the anticipated grade raise scenarios was completed in order to support the next step in the planning process. The investigation included site characterization through a field and laboratory program, the assessment of ground settlement under several grade raise scenarios (1.0, 1.5 and 2.0m grade raise), an assessment of impacts on various aspects of the development and a review of available alternative solutions.

The investigation assessed the Former CFB Rockcliffe CDP site. It should be noted that this preliminary assessment was not completed however to assess settlement of individual structures, buried utilities and other facilities for final design purposes.

Results of the analysis and the respective impacts are summarized below:

Impact on Development

The predicted settlements as a result of the grade raise will impact on the performance of residential and low raise development to be built on the site, however the relative differential settlement within a single structure or group of structure will be minimal if grade raise plan is uniform across the individual building area. Should a different grade raise plan/scenario be developed with very specific locations or areas of grade raise, site specific settlement analysis should be performed to confirm that the angular distortion and total settlement are within the tolerances.

Impacts on Streets

Settlement as a result of the grade raise will affect streets including sidewalks and curbs. Low speed limit roads, are generally quite tolerant to settlement and settlement predictions indicate that differential settlement is not expected to exceed the 1:100 angular distortion suggested as a reasonable criteria.

Impacts on Buried Services

Given that the sewers and watermains will be buried within the streets, the street settlement will also be reflected as deflections in the pipes. Settlement predictions indicate that differential settlement is not expected to exceed the 1:100 angular distortion suggested as reasonable criteria for pipes. This tolerance should be confirmed by the designers, who should also check that a 1:100 change in sewer slope will not adversely affect its gravity flow performance. Service connections are not expected to be a problem if the buildings are designed to settle less than 25 mm under foundation loads alone.

Other Impacts

Settlement as a result of the grade raise will also affect ancillary features on lots. These include fences, driveways, pools, decks, sidewalks, etc. The impact will depend on individual design details and tolerances. Overall, the impact will involve settlement in the 11 to 693 mm range, and if grades are to be maintained over the design life the initial grades will need to be over-built to accommodate the settlement.

Selection of construction methods and sequencing will also need a consideration of settlement. These can either exacerbate or reduce settlements. In the event settlements and angular distortions exceed the tolerable limits due to site specific conditions, the following section outlines the approach and solutions to complete a feasible grade raise.

Grade Raise Solutions

The main geotechnical risk to the proposed grade raise for the site is related to consolidation settlement with respect to the design criteria to even small changes in fill loads. If a grade raise thicker than the recommended 1.0 m or non-uniform grade raise thickness is required some methods can be applied to minimize the impacts on the developments.

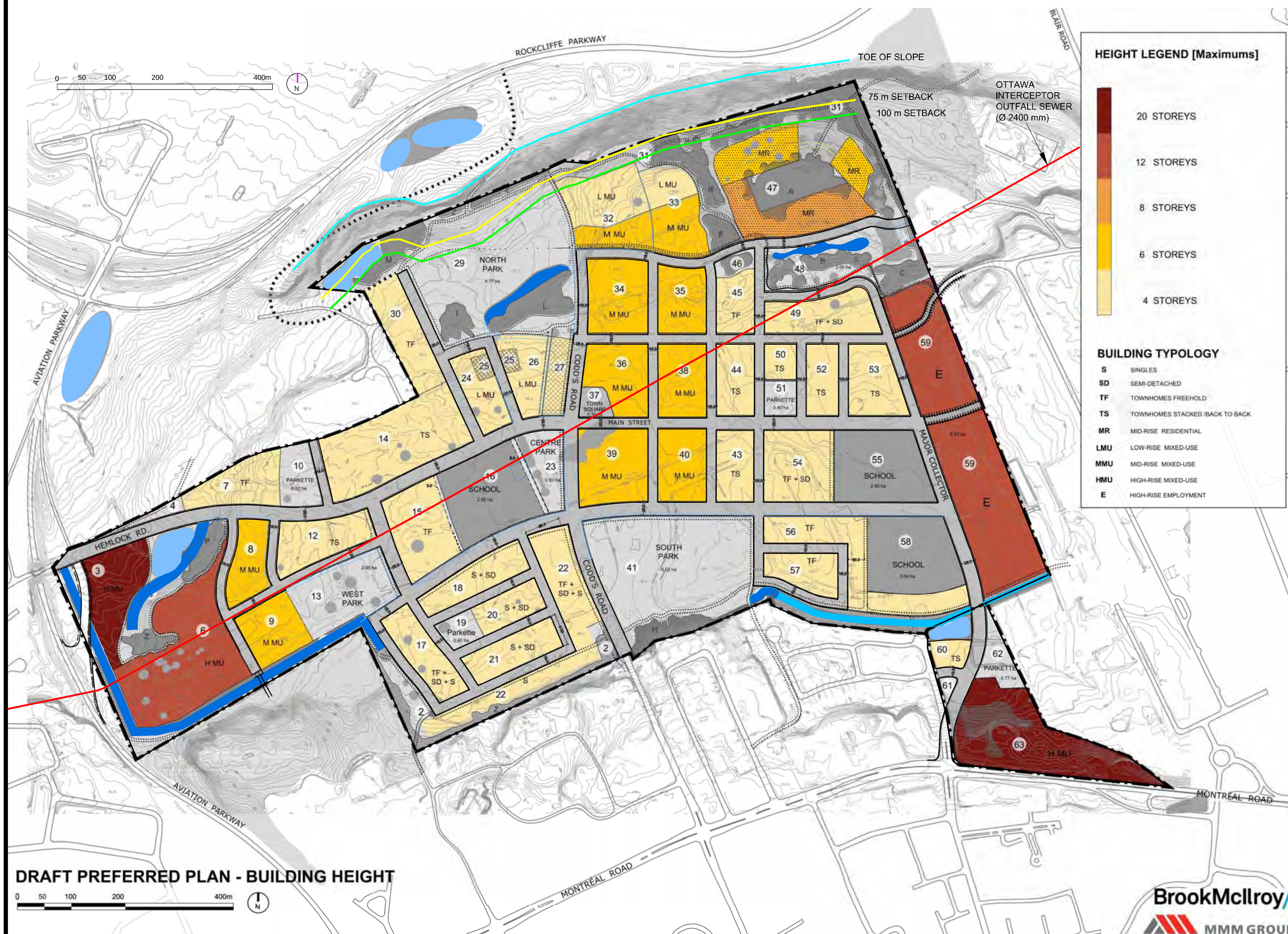
There are various ways solutions available which minimize post construction total and differential settlement within manageable magnitudes and a reasonable time frame. While some methods are simple with limited effectiveness, others are complex and more effective. In general more effective methods are more costly but buy time required for settlement duration so that development can be carried out almost immediately after grade raise is complete.

Two (2) methods available for reducing impacts from grade raises are:

- Load reduction method using lightweight fill
- Ground improvement methods:
- Application of preload
- Hydraulic modification
- Electrokinetic stabilization
- Chemical modification
- Inclusion

Maximum Allowable Grade Raise

Based on the results of the settlement analyses for the three (3) different grade raise thicknesses, in order to limit potential subsurface settlement after site development, it is recommended that grade raises be restricted to a maximum of 2 m through the north and central parts of the site where bedrock overburden is shallowest. In other areas of the site that contain clay layers on top of the site bedrock, grade raises of 1 m are recommended (Figure 8). The details of the approach to establishing these grade raises are included in the above referenced DST reports.



Base map and survey drawing provided by BrookMcIlroy/MMM GROUP

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LEGEND:

- Toe of Slope
- 75 m Setback
- 100 m Setback

REV	DATE	ISSUE	APPROVAL
0	MAR. 27, 2014	Original	M.W.B.

PROJECT TITLE

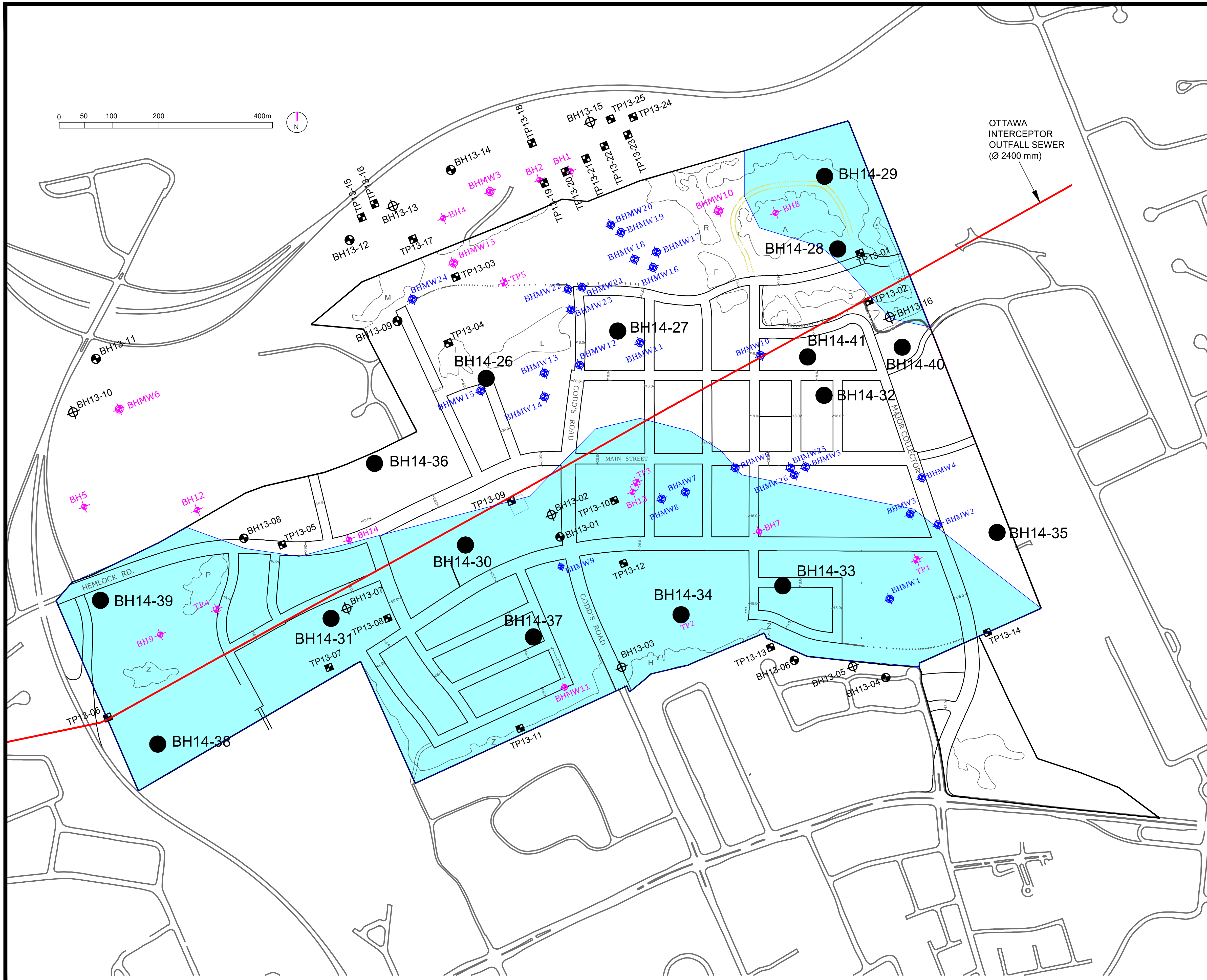
Geotechnical Investigation
Former CFB Rockcliffe
Ottawa, Ontario

DRAWING TITLE

SETBACK DISTANCES
NORTH ESCARPMENT

DESIGNED BY B.V.	SCALE As Shown
DRAWN BY M.L.	DATE MARCH 2014
APPROVED BY M.W.B	PROJECT NO.: OE-OT-015358

Figure 7



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LEGEND:

MAXIMUM GRADE RAISE AREA (1 m)

MAXIMUM GRADE RAISE AREA (2 m)

REV	DATE	ISSUE	APPROVAL
0	MAY. 20, 2014	Original	G.T.

PROJECT TITLE

Geotechnical Investigation
Former CFB Rockcliffe
Ottawa, Ontario

DRAWING TITLE

MAP OF MAXIMUM GRADE RAISE AREAS

DESIGNED BY B.V.	SCALE As Shown
DRAWN BY M.L.	DATE MAY 2014
APPROVED BY G.T.	PROJECT NO.: OE-OT-015358

Figure 8